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July 1, 2015

VIA EMAIL AND OVERNIGHT MAIL

Andrew Barnsdale
California Public Utilities Commission
c/o Environmental Science Associates
550 Kearny Street, Suite 800
San Francisco, CA 94108
Email: mpwsp-eir@esassoc.com

Re: Comments on the Draft Environmental Impact Report for the Proposed Monterey Peninsula Water Supply Project

Dear Mr. Barnsdale:

We are writing on behalf of California Unions for Reliable Energy ("CURE") to provide comments on the Draft Environmental Impact Report ("DEIR") prepared by the California Public Utilities Commission ("CPUC"), pursuant to the California Environmental Quality Act ("CEQA"),[1] for the Monterey Peninsula Water Supply Project ("Project"). The Project is being proposed by the California American Water Company ("CalAm" or "Applicant") and will include the construction and operation of a seawater desalination plant and conveyance system with an initial capacity of 9.6 million gallons per day ("mgd") to provide a supplemental source of water to the Monterey Bay area.

The Project includes the construction of up to ten subsurface slant wells and a desalination plant, producing approximately 9,752 acre feet per year ("AFY") to meet service area demand and approximately 875 afy to return to the Salinas Valley Groundwater Basin. The Project would also include improvements to the existing Seaside Groundwater Basin aquifer storage and recovery ("ASR") system facilities to enable CalAm to inject desalinated product water into the groundwater basin for subsequent extraction and distribution to customers. The Project also includes over 30 miles of pipelines, two pump stations, and water storage tanks.

[1] Pub. Resources Code, §§ 21000 et seq.

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The Project area extends approximately 14 miles, from the Project site located in unincorporated Monterey County in the north to the western terminus of the proposed Monterey Pipeline in the city of Pacific Grove, and east approximately 8 miles to the unincorporated community of Hidden Hills along Highway 68.

An estimated 24.1 mgd of raw seawater is needed to reliably generate 9.6 mgd of product water at the desalination plant.[2] The plant would utilize a reverse osmosis system to desalinate pretreated seawater, resulting in the generation of up to 13.98 mgd of brine with a much higher saline concentration than seawater.[3] The brine is proposed to be blended with treated wastewater from the Monterey Regional Water Pollution Control Agency ("MRWPCA") Regional Wastewater Treatment Plant during certain times of the year.[4] During the irrigation season (April through October), treated wastewater is diverted to the Salinas Valley Reclamation Project's treatment facility and subsequently used for crop irrigation as part of the Castroville Seawater Intrusion Project ("CSIP"). The brine mixing would occur during the non-irrigation season (November through March), when the CSIP is not in operation. During the remaining part of the year, the brine stream would be discharged to Monterey Bay without dilution.[5]

The Project requires coastal development, encroachment, grading, building and other related permits from various local government agencies including Monterey County, City of Monterey, City of Seaside, City of Marina, City of Sand City and City of Pacific Grove. The Project also requires a section 404 permit from the U.S. Army Corps of Engineers ("Corps"), incidental take permits from the U.S. Fish and Wildlife Service ("FWS"), the National Marine Fisheries Service and the California Department of Fish and Wildlife ("CDFW"), and various water-related permits from the Central Coast Regional Water Quality Control Board, among other federal, state and local entitlements and approvals.[6]

In addition to evaluating the Project's impacts, the DEIR also evaluates a variation of the project ("Variant") that would be capable of meeting the total demand of 15,296 afy as well as all other project objectives by combining a reduced-capacity desalination plant (a 6.4-mgd rated capacity plant that would produce 6.1

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[2] Draft Environmental Impact Report ("DEIR"), p. 3-20.
[3] *Id.*, at 3-27.
[4] *Id.*
[5] *Id.*
[6] *Id.*, at 3-58.

mgd of desalinated water supplies with a water purchase agreement for 3,500 afy of product water from the MRWPCA's proposed Pure Water Monterey Groundwater Replenishment project. Although the Variant would require fewer subsurface slant wells and produce less water than the Project, the Variant would still require most of the Project facilities and, therefore, would result in many of the same environmental impacts. In some instances, the Variant would cause even more significant environmental impacts than the Project.

Based upon our review of the DEIR and pertinent agency records, we conclude that the DEIR is inadequate under CEQA and must be withdrawn. The DEIR fails to include a complete, stable and accurate Project description because it fails to identify the Project's decommissioning phase and fails to describe important aspects of the Project design that are dependent on the test slant well results. The DEIR also fails to adequately establish the environmental setting for biological resources and hazards within Project disturbance areas. In addition, the DEIR fails to adequately analyze and mitigate the Project's impacts related to ocean water quality, worker and public health, biological resources, air quality, jurisdictional waters and decommissioning activities. Finally, the DEIR proposes mitigation measures that are deferred, unenforceable or otherwise inadequate. The CPUC must revise the DEIR consistent with the comments, and recirculate the revised DEIR for public review.

We prepared these comments with the assistance of Phyllis Fox, Ph.D.,[7] Matt Hagemann, P.G. C.Hg.[8] and biologist Renee Owens.[9] Their technical comments are attached hereto and submitted in addition to the comments in this letter. Accordingly, the CPUC must address and respond to the comments of Dr. Fox, Mr. Hagemann, and Ms. Owens separately.

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[7] *See* Letter from Phyllis Fox, to Laura Horton re: Draft Environmental Impact Report for the Monterey Peninsula Water Supply Project, July 1, 2015 (hereinafter, "Fox Comments"), **Attachment A.**

[8] *See* Letter from Matt Hagemann, to Laura Horton re: Draft Environmental Impact Report for the Monterey Peninsula Water Supply Project, June 25, 2015 (hereinafter, "Hagemann Comments"), **Attachment B.**

[9] *See* Letter from Renee Owens, to Laura Horton re: Draft Environmental Impact Report for the Monterey Peninsula Water Supply Project, June 25, 2015 (hereinafter, "Owens Comments"), **Attachment C.**

I. STATEMENT OF INTEREST

CURE is a coalition of labor unions whose members construct, operate, and maintain industrial facilities throughout California. CURE has an interest in enforcing environmental laws that encourage sustainable development and ensure a safe working environment for its members. Environmentally detrimental projects can jeopardize future jobs by making it more difficult and more expensive for industry to expand along the Monterey Bay, and by making it less desirable for businesses to locate and people to live in the area, including the Project vicinity. Continued degradation can, and has, caused construction moratoriums and other restrictions on growth that, in turn, reduce future employment opportunities.

CURE members live, work, recreate and raise their families in the Project vicinity along the Monterey Bay. Accordingly, CURE's members would be directly affected by the Project's adverse environmental impacts. The members of CURE's member unions may also work on the Project itself. They will, therefore, be first in line to be exposed to any hazardous materials, air contaminants and other health and safety hazards that exist on the Project sites.

II. THE DEIR FAILS TO INCLUDE A COMPLETE PROJECT DESCRIPTION

The DEIR does not meet CEQA's requirements because it fails to include a complete Project description, rendering the entire analysis inadequate. CEQA places the burden of environmental investigation on the government rather than the public. Accordingly, a lead agency may not hide behind its failure to obtain a complete and accurate project description.[10] An accurate and complete project description is necessary to perform an adequate evaluation of the potential environmental effects of a proposed project. In contrast, an inaccurate or incomplete project description renders the analysis of environmental impacts inherently unreliable. Without a complete project description, the environmental analysis under CEQA will be impermissibly narrow, thus minimizing the project's impacts and undercutting public review.[11]

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[10] *Sundstrom v. County of Mendocino* (1988) 202 Cal.App.3d 296, 311.
[11] *See, e.g., Laurel Heights Improvement Association v. Regents of the University of California* (1988) 47 Cal.3d 376.

A. The DEIR Fails to Describe the Decommissioning Phase of the Project

A complete project description must include the "later phases of the project, and any secondary, support, or off-site features necessary for its implementation."[12] The requirements of CEQA cannot be avoided by chopping a large project into many small parts or by excluding reasonably foreseeable future activities that may become part of the project.[13] The DEIR must supply enough information so that the decision makers and the public can fully understand the scope of the Project.[14] The CPUC, as the lead agency, must fully analyze the whole Project in a single environmental review document and may not piecemeal or split the Project into pieces for purposes of analysis.

The DEIR fails to describe the full scope of the Project, and thus fails to disclose the full range and severity of the Project's environmental impacts. Throughout the document, the DEIR states that the Project will have an approximately "40-year operations phase."[15] The analysis of impacts is based on a 40-year Project lifetime.[16] Thus, the Project has three distinct phases: construction, operation and decommissioning the Project after its 40-year life. The decommissioning phase would likely consist of using equipment and manpower for dismantling, destroying, and/or disposing of materials related to decommissioning the slant wells and other associated infrastructure.[17] These decommissioning activities are a part of the "whole of the project," and as a matter of common sense they will result in environmental impacts, including impacts to air quality, biological resources, water, and solid waste capacity. The DEIR underestimates the Project's potentially significant impacts because it does not analyze impacts from the decommissioning phase.

The DEIR acknowledges that Project decommissioning could occur for well cluster #1 and for the test slant well. For well cluster #1, the DEIR proposes

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[12] *Bozung v. Local Agency Formation Com.* (1975), 13 Cal.3d 263, 283-84.
[13] Pub. Resources Code § 21159.27 (prohibiting piecemealing); *see also, Rio Vista Farm Bureau Center v. County of Solano*, 5 Cal.App.4th 351, 370 (1992).
[14] *Dry Creek Citizens Coalition v. County of Tulare*, 70 Cal.App.4th 20, 26 (1999).
[15] DEIR, pp. 5-14, 5-56, 5-60, 5-63, 5-64, ES-63.
[16] *Id.*, at 4.11-10, ES-63 ("The sum of GHG emissions generated by MPWSP construction amortized over the 40-year [P]roject lifetime and the net annual emissions generated by project operation would total approximately 6,181 metric tons CO2e per year.").
[17] DEIR, p. 2-88.

Mitigation Measure 4.2-6a (Slant Well Abandonment Plan) for impacts related to coastal erosion.[18] The measure requires CalAm to monitor coastal retreat rates and initiate well decommissioning before the subsurface slant wells become exposed on the active beach.[19] However, the DEIR does not describe or analyze the impacts from decommissioning well cluster #1. For the test slant well, the DEIR states that a "Coastal Development Permit... granted CalAm permission to construct, operate and ***decommission*** a test slant well."[20] Indeed, separate environmental review for the test slant well provided a description and evaluation of the decommissioning phase of the test slant well project.[21] However, here the DEIR does not provide any further discussion of decommissioning.

In short, the DEIR's description and analysis of Project decommissioning do not come close to satisfying CEQA's requirements. The DEIR acknowledges that some Project components could be decommissioned, but completely fails to analyze the associated impacts. Further, the DEIR fails to even mention, let alone analyze, impacts from decommissioning the rest of the Project. As a result, the DEIR fails to identify the Project's potentially significant impacts from Project decommissioning and fails to incorporate mitigation measures to reduce those impacts to a less than significant level. The CPUC must prepare a revised DEIR that fully describes, analyzes and mitigates impacts from Project decommissioning.

B. The DEIR Fails to Incorporate the Results of the Test Slant Well into its Analysis and Mitigation

The DEIR states that CalAm constructed a test slant well "[t]o inform the final design of the subsurface slant wells and MPWSP Desalination Plant treatment systems."[22] The construction and operation of the test slant well was evaluated under a separate environmental review process. The test slant well is intended to "confirm (or deny) the viability of the proposed subsurface slant wells at the CEMEX active mining area for source water production."[23] Should the test slant

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[18] *Id.*, at 4.2-64.
[19] *Id.*
[20] *Id.*, at 5-24 (emphasis added).
[21] http://www.watersupplyproject.org/Websites/coastalwater/files/Content/4503543/Slant_Test_Well_Draft_IS-MND_051614_2014.pdf; http://montereybay.noaa.gov/resourcepro/resmanissues/pdf/140912calam-slantwell_ea-final.pdf .
[22] DEIR, p. 3-3.
[23] *Id.*

well prove viable, the DEIR states that the slant well would be incorporated into the Project, and analysis of the conversion and long-term operation of the well is included in the DEIR. However, the failure to complete testing of the slant well before the DEIR was produced results in an incomplete Project description.

Several important components of the Project design are dependent on the results of the test slant well and are, therefore, not included in the Project description. For example, the DEIR states that the "pretreatment requirements for seawater collected by the proposed slant wells will be determined through the operation of the test slant well and pilot program..."[24] The DEIR then lists potential pretreatment processes but does not provide the public with a complete understanding of what the Project will actually require. Furthermore, the DEIR states that "[t]he final design of post-treatment facilities would be based on the water quality data collected during operation of the test slant well and pilot program and the results of a geochemical mixing study."[25] Although the DEIR asserts that this "would not affect any of [its] analyses or conclusions,"[26] the public has no opportunity to evaluate that statement given the lack of an accurate and complete description of the Project's facilities.

Further, other components of the Project are dependent on the test slant well results, including the composition of the Project's source water[27] and the pump system used to pump desalinated product water to the Salinas Valley,[28] among others. The DEIR makes various assumptions for the Salinas Valley pump system, but conditions its assumptions on the final results from the test slant well,[29] which are not yet complete.

The DEIR violates CEQA because it fails to include important information regarding Project design features. The slant well testing should have been completed prior to the DEIR's release and the results should have been incorporated into the DEIR's analyses. Indeed, CalAm's application to the City of Marina for the test slant well project states that the information gleaned from the test slant well would be used to:

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[24] *Id.*, at 3-22.
[25] *Id.*, at 3-26.
[26] *Id.*
[27] *Id.*, at 3-28.
[28] *Id.*
[29] *Id.*

> finalize the number, capacity, location, and design criteria of the potential future Monterey Peninsula Water Supply Project (MPWSP) intake wells, and also to improve the precision of ground water modeling that is required to determine the fraction of the extracted water that will come from inland sources. Furthermore, the information obtained from this temporary slant test well project will be utilized in the design and permitting of the separate MPWSP.[30]

It is unclear why the CPUC prepared and released the DEIR before CalAm gathered this crucial data from the test slant well. What is clear is that, without this necessary information from the test slant well project, the Project description is incomplete and the environmental analysis under CEQA is "impermissibly narrow," thus "minimizing the project's impacts and undercutting public review."[31] The CPUC must prepare a revised DEIR that incorporates the results of the test slant well into its analyses.

III. THE DEIR FAILS TO PROVIDE AN ADEQUATE DESCRIPTION OF THE ENVIRONMENTAL SETTING

The DEIR employs an incomplete baseline, thereby skewing the impact analysis. An accurate description of the environmental setting is important because it establishes the baseline physical conditions against which a lead agency can determine whether an impact is significant. The failure to adequately describe the existing setting contravenes the fundamental purpose of the environmental review process, which is to determine whether there is a potentially substantial, adverse change compared to the existing setting.

CEQA requires the lead agency to include a description of the physical environmental conditions in the vicinity of a project as they exist at the time environmental review commences.[32] The EIR must also describe the existing environmental setting in sufficient detail to enable a proper analysis of project impacts. "The adequacy of an EIR is determined in terms of what is reasonably feasible, in light of factors such as the magnitude of the project at issue, the severity

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[30] Test Slant Well Application to the City of Marina, July 2, 2013, **Attachment D.**

[31] *See, e.g., Laurel Heights Improvement Association v. Regents of the University of California* (1988) 47 Cal.3d 376.

[32] CEQA Guidelines, § 15125, subd. (a); *see* also *Communities For A Better Environment v. South Coast Air Quality Management Dist.* (2010) 48 Cal.4th 310, 321.

of its likely environmental impacts, and the geographic scope of the project."[33] "A legally adequate EIR . . . must contain sufficient detail to help ensure the integrity of the process of decisionmaking by precluding stubborn problems or serious criticism from being swept under the rug."[34]

The description of the environmental setting in the DEIR is inadequate because it omits highly relevant information regarding potential biological resources and hazards on the Project site. The CPUC is required to gather the relevant data and provide an adequate description of the existing environmental setting in a revised DEIR.

A. The DEIR Fails to Set Forth an Adequate Environmental Setting for Biological Resources

According to independent expert biologist Renee Owens, the Project area is "uniquely high biodiversity and sensitivity.". Despite the clear importance of the area to many species of plants and wildlife, the DEIR "fails to present current, ground-truthed data for the many sensitive wildlife species for which there is the potential to occur on-site or in nearby habitat, or have historically been present."[35]

The DEIR states that the impact analyses for terrestrial biological resources are "based on special-status species observations available to [consultant] Environmental Science Associates (ESA) as of May 9, 2014."[36] However, Ms. Owens finds that "the 'observations' reported as such are far from sufficient for such impact analysis."[37] According to the DEIR, all terrestrial Project site surveys conducted were "reconnaissance-level" surveys, not protocol-level surveys.[38] Ms. Owens states that the DEIR "merely referred to biologists conducting plant and habitat assessments to indicate, via anecdotal observations... protected species status determinations."[39] She goes on to characterize this approach as a "clear oversight in the DEIR" because "species presence/absence, and indications of 'likelihood to occur'

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[33] CEQA Guidelines, § 15024 subd. (a).
[34] *Kings County Farm Bureau v. City of Handford* (1990) 221 Cal.App.3d 692, 733.
[35] Owens Comments, p. 3.
[36] DEIR, p. 4.6-3.
[37] Owens Comments, p. 4.
[38] DEIR, p. 4.6-3.
[39] *Id.*, at 5.

are guidelines intended to assist consultants in determining where site-specific, protocol level surveys are warranted..."[40]

Further, even the reconnaissance surveys were not conducted for the entire site. The DEIR notes that the consultant's biologists did not survey an entire segment of the proposed pipeline that traverses the Presidio of Monterey and the Terminal Reservoir/ASR Pump Station site "due to access restrictions."[41] In addition, Ms. Owens provides that "necessary details regarding survey methodology and the biologists who conducted each survey are lacking."[42] According to Ms. Owens, there are several federally endangered and threatened species in the Project area for which protocol surveys should be conducted by experienced permitted biologists.[43]

The DEIR also relies "largely on databases, including the CNDDB, not only to predict presence/absence of species, but the degree to which such a predicted species' status may be mitigated."[44] These predictions are not supported by actual, formal scientific observations made on the ground. As a result, the DEIR fails to accurately or adequately describe the environmental setting against which to measure the Project's impacts on biological resources.

According to Ms. Owens, using databases is a standard part of gathering site-specific data, but it cannot replace protocol surveys in its specificity or accuracy.[45] For example, the DEIR relies heavily upon the CNDDB to make species impact determinations. However, as Ms. Owens points out, "the CNDDB is limited in its ability to predict species currently present at any given locale [and] many species sightings are not actually reported on the public CNDDB."[46] Furthermore, "CNDDB records are voluntarily reported and only exist for locations that have been surveyed."[47] Thus, the lack of CNDDB records, or records from any other database, does not mean a species is absent. This is also confirmed by both the California Department of Fish and Wildlife ("CDFW"), which states that "we cannot and do not portray the CNDDB as an exhaustive and comprehensive inventory of

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[40] *Id.*
[41] *Id.*, at 4.6-4.
[42] Owens Comments, p. 4.
[43] *Id.*, at 4-5.
[44] *Id.*
[45] *Id.*
[46] *Id.*
[47] *Id.*

all rare species and natural communities statewide,"[48] and the California Native Plant Society's Inventory of Rare and Endangered Species, which states that "[s]pecies not recorded for a given area may nonetheless be present, especially where favorable conditions occur."[49]

Finally, the DEIR acknowledges that several protected terrestrial species have the potential to occur in the Project area, and could be significantly impacted by the Project.[50] These include the Smith's blue butterfly, California tiger salamander, California red-legged frog, Western snowy plover, Western pond turtle, black legless lizard, silvery legless lizard, coast horned lizard, tricolored blackbird, Western burrowing owl, red-shouldered hawk, red-tailed hawk, white-tailed kite, American peregrine falcon, American kestrel, loggerhead shrike, pallid bat, Western red bat, Monterey dusky-footed woodrat, Monterey shrew, American badger, among other species. However, the DEIR fails to provide specific, scientifically-supported information regarding the presence of these species. The DEIR merely assumes some of these special status species *may* be encountered. Ms. Owens states that, "without knowledge of the actual breeding status, specific locations, [and] density... along with details regarding the survey methodology... it is impossible to analyze or verify the degree to which any given mitigation measures will be sufficient to reduce impacts"[51] Thus, Ms. Owens finds that "all conclusions that impacts would be less than significant due to the lack of documented occurrences are invalid."[52] To establish the environmental setting for biological resources, CEQA requires the DEIR to include results from adequate surveys.

B. The DEIR Fails to Set Forth an Adequate Environmental Setting for Soil Hazards and Potential Contamination in Areas Proposed for Disturbance

The CPUC failed to conduct the requisite due diligence to investigate and disclose in the DEIR the presence and character of potential contamination within the Project impact area. Project construction, including excavation, grading, trenching, and pipeline construction in areas used for agriculture, military and industrial activities, will result in the disturbance of contaminated soil and groundwater. However, independent hazards expert Matt Hagemann states in his

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[48] http://www.dfg.ca.gov/biogeodata/cnddb/cnddb_info.asp.
[49] Owens Comments, p. 6.
[50] DEIR, Table 4.6-4.
[51] Owens Comments, p. 6.
[52] *Id.*

attached comments that "[c]haracterization of many of the areas impacted by Project construction has not been undertaken or is incomplete in the DEIR."[53] Although the DEIR does provide limited descriptions of Project construction activities in potentially hazardous areas, no sampling was conducted to identify specific contaminants. Because "soils will be disturbed that may contain contaminant concentrations that are harmful to workers or to adjacent residents,"[54] the DEIR should have included more detailed information regarding the environmental setting, as required by CEQA.

At a minimum, the CPUC is required to conduct an independent investigation and characterize potential contamination in a revised DEIR in sufficient detail to enable meaningful public review. The CPUC's failure to disclose potential hazards on the Project site "renders the DEIR inadequate as an informational document under CEQA."[55] The DEIR must be revised to include this information.

IV. THE DEIR FAILS TO ADEQUATELY ANALYZE AND MITIGATE THE PROJECT'S POTENTIALLY SIGNIFICANT IMPACTS

CEQA has two basic purposes, neither of which the DEIR satisfies. First, CEQA is designed to inform decision-makers and the public about the potential, significant environmental effects of a project.[56] CEQA requires that an agency analyze potentially significant environmental impacts in an EIR.[57] The EIR should not rely on scientifically outdated information to assess the significance of impacts, and should result from "extensive research and information gathering," including consultation with state and federal agencies, local officials, and the interested public.[58] To be adequate, the EIR should evidence the lead agency's good faith effort at full disclosure.[59] Its purpose is to inform the public and responsible officials of the environmental consequences of their decisions *before* they are made. For this reason, the EIR has been described as "an environmental 'alarm bell' whose purpose it is to alert the public and its responsible officials to environmental changes before

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[53] Hagemann Comments, p. 3.
[54] *Id.*
[55] *Id.*
[56] Cal. Code Regs., tit. 14, § 15002, subd. (a)(1) (hereafter "CEQA Guidelines").
[57] *See* Pub. Resources Code § 21000; CEQA Guidelines § 15002.
[58] *Berkeley Keep Jets Over the Bay Comm. v. Board of Port Comm.* (2001) 91 Cal. App.4th 1344, 1367 and *Schaeffer Land Trust v. San Jose City Council*, 215 Cal.App.3d 612, 620.
[59] CEQA Guidelines § 15151; *see also Laurel Heights I* (1998) 47 Cal.3d 376, 406.

they have reached ecological points of no return.[60] Thus, the EIR protects not only the environment but also informed self-government."[61]

Second, CEQA directs public agencies to avoid or reduce environmental damage when possible by requiring alternatives or mitigation measures.[62] The EIR serves to provide public agencies, and the public in general, with information about the effect that a proposed project is likely to have on the environment and to "identify ways that environmental damage can be avoided or significantly reduced."[63] If a project has a significant effect on the environment, the agency may approve the project only upon a finding that it has "eliminated or substantially lessened all significant effects on the environment where feasible," and that any unavoidable significant effects on the environment are "acceptable due to overriding concerns" specified in CEQA section 21081.[64]

The DEIR fails to satisfy the basic purposes of CEQA. Specifically, the DEIR fails to reflect a good faith effort at public disclosure by failing to adequately analyze and mitigate the Project's potentially significant impacts to ocean water quality, worker and public health, biological resources, air quality, jurisdictional waters, and other resources. The DEIR also fails to propose measures that could reduce these Project impacts to a less than significant level. In sum, the DEIR fails to inform decision-makers and the public of the Project's potentially significant environmental effects and to reduce damage to the environment *before* it occurs.

A. The DEIR Fails to Adequately Analyze and Mitigate Potentially Significant Impacts to Ocean Water Quality

The DEIR states that ambient polychlorinated biphenyls ("PCB") concentrations in Monterey Bay (along with chlordane and dichlorodiphenyltrichloroethane ("DDT")) exceed the water quality objective for PCBs set forth in the Water Quality Control Plan for Ocean Waters of California ("Ocean Plan").[65] However, according to Mr. Hagemann, no estimate of the effluent PCB concentration from the Project is provided in the DEIR and therefore "the

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[60] *County of Inyo v. Yorty* (1973) 32 Cal.App.3d 795, 810.
[61] *Citizens of Goleta Valley v. Bd. of Supervisors* (1990) 52 Cal.3d 553, 564 (citations omitted).
[62] CEQA Guidelines, § 15002(a)(2)-(3); *Berkeley Keep Jets Over the Bay Comm.*, 91 Cal.App.4th at 1354.
[63] CEQA Guidelines, § 15002 subd. (a)(2).
[64] CEQA Guidelines, § 15092 subd. (b)(2)(A)-(B).
[65] http://www.swrcb.ca.gov/water_issues/programs/ocean/docs/cop2012.pdf.

DEIR fails to adequately disclose the impact of the PCB discharge."[66] Mr. Hagemann points out that "[d]ata indicate that waters of Monterey Bay exceeded the Ocean Plan 30-day average PCB water quality objective for protection of human health of 0.000019 micrograms per liter (µg/L or ppb) for most of the years between 2004 and 2013."[67] The desalination process and the generation and release of brine into the Bay will cause more PCBs to enter the Bay, as acknowledged in the DEIR.[68] Despite the DEIR's failure to provide a specific estimate, the DEIR concludes that the impact from PCBs could be significant and requires mitigation.

According to the National Oceanic and Atmospheric Administration, PCBs can cause "fluctuations in nutrient levels, and changing ocean conditions," and "may inhibit the development of assemblages and may cause measurable declines in living resources and habitats."[69] In addition, PCBs can have "deleterious effects" on the marine environment including "decreased abundance of some benthic infauna" and "risk of sea otter death due to infectious agents and trauma."[70]

The CPUC included Mitigation Measure 4.3-4 in the DEIR to address the impact of the predicted elevated PCB concentrations in the brine discharge. The mitigation would incorporate design features and operational measures prior to Project operation, but would not be finalized until after EIR approval. Examples of the design features and operational measures considered in Mitigation Measure 4.4-4 include "temporary storage of brine and timed release at higher flow rates, treatment of the source water and/or the discharge(s), and temporary storage of brine and its release along with the greater than 20-mgd- wastewater in the case of the combined discharge."[71] As noted by Mr. Hagemann, the DEIR contemplates treatment methods to remove PCBs and other organic compounds from the source water, including additional filtration or use of granular activated carbon ("GAC"). The DEIR's analysis includes building a GAC facility. According to the DEIR, implementation of this mitigation measure would reduce the impacts from PCBs to less than significant levels.[72]

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[66] Hagemann Comments, p. 2.
[67] *Id.*, at 1.
[68] *Id.*, at 2.
[69] http://sanctuaries.noaa.gov/science/condition/mbnms/state_offshore.html, **Attachment E.**
[70] *Id.*
[71] Hagemann Comments, p. 2.
[72] DEIR, p. 4.3-74.

Mr. Hagemann explains that "because Mitigation Measure 4.3-4 relies upon testing only 'prior to operating the MPWSP Desalination Plant,' mitigation is improperly deferred because the DEIR offers no assurance that test results will sufficiently reduce PCB contamination."[73] Furthermore, Mr. Hagemann states that "[t]he effectiveness of the technology that was identified in the DEIR (GAC) in meeting effluent limits is uncertain at the scale of the project (14 mgd of brine) and with concentrations of PCB that continue to increase."[74] In fact, Mr. Hagemann cites a recent study that "casts doubt on the ability of GAC treatment systems in meeting the Ocean Plan Water Quality Objective of 0.000019 ppb."[75] The study states that effluent from a 5 mgd facility would be as high as 0.00041 ppb, an order of magnitude higher than the Ocean Plan limit.[76]

Mr. Hagemann points out that "[o]nly vague and various protocol are offered in describing Mitigation Measure 4.3-4 which discusses 'several alternative feasible methods' for treatment without describing the feasibility of uses such methods to meet Ocean Plan water quality objectives."[77] Mitigation Measure 4.3-4 also discusses how storage and timed release of brine may be effective "but does not provide any discussion of estimated PCB effluent concentrations using this management technique."[78]

In addition, according the Mr. Hagemann and other sources, use of GAC technology to treat the massive volume of brine (14 mgd) is "extremely expensive" and "no cost considerations were made in the DEIR to make assurances that such a treatment system is economically feasible."[79] A recent report reveals a cost of $290 million to remove less than a pound of PCBs from wastewater with a 5 mgd discharge (approximately one-third the 14 mgd brine discharge from the Project).[80]

Mr. Hagemann concludes that the DEIR "does not provide substantial evidence supporting its conclusion that impacts from PCB contamination will be mitigated to less than significant levels."[81] Thus, a revised DEIR should be

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[73] Hagemann Comments, p. 2.
[74] *Id.*
[75] *Id.*
[76] https://www.awb.org/file_viewer.php?id=2903, p. 44, **Attachment F.**
[77] Hagemann Comments, p. 2
[78] *Id.*
[79] *Id.*, at 3.
[80] https://www.awb.org/file_viewer.php?id=2903, p. 45.
[81] Hagemann Comments, p. 3.

prepared to include "a thorough feasibility study to demonstrate that the PCB concentrations in brine effluent can be reduced through treatment to meet the Ocean Plan Water Quality Objective of 0.000019 ppb."[82] Mr. Hagemann states that the feasibility study should include "consideration of all applicable technologies and management strategies that are available to treat PCBs, the implementabilty of the technologies, how likely each technology would be in achieving the Ocean Plan limits and other applicable regulations, and the impacts of construction and operation of each technology on the environment."[83] The revised DEIR should also demonstrate, as part of the feasibility study, that PCB treatment can be economically achieved. Without adequately addressing these flaws, the DEIR cannot be lawfully approved under CEQA.

B. The DEIR Fails to Adequately Analyze and Mitigate Potentially Significant Impacts Related to On-site Hazards

As explained above, the DEIR does not contain adequate information for the public to have a full understanding of hazards on the Project site. Even so, from the information that is provided in the DEIR, Mr. Hagemann finds that workers and the public could be exposed to several different contaminants which may result in significant adverse health effects. For example, Mr. Hagemann states that "[p]esticide contamination from past agricultural practices may include residual soil contamination from organochlochlorine pesticides such as DDT, DDE, Chlordane and Toxaphene," with DDT being a particularly dangerous chemical and likely carcinogen.[84] Mr. Hagemann also notes that "Chlordane has also been classified as a probable human carcinogen by the U.S. EPA and exposure can result in neurological effects such as headaches, irritability, dizziness, and nausea."[85] He further states that "[t]hese pesticides can persist for hundreds of years at concentrations that would pose a risk to human health.[86] The DEIR fails to include any analysis of the potential presence of pesticides in these areas and "makes no provision to sample for pesticides."[87]

In addition to areas of potential pesticide contamination, Project construction will likely disturb other areas of contaminated soil and "may expose construction

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[82] *Id.*
[83] *Id.*
[84] Hagemann Comments, p. 4.
[85] U.S. EPA, Chlordane. http://www.epa.gov/ttnatw01/hlthef/chlordan.html .
[86] http://www.epa.gov/pbt/pubs/ddt.htm.
[87] Hagemann Comments, p. 4.

workers and the public to chemicals which include: tetrachloroethylene, petroleum hydrocarbons, trichloroethylene, and explosive hazards."[88] Mr. Hagemann points out that because "[t]he exact locations of these chemicals is not known... workers may be unprepared and may be unknowingly subjected to exposure."[89] Furthermore, "the public may also be unknowingly subjected to exposure if dust is generated during disturbance of contaminated soils."[90]

To mitigate potential hazards, the DEIR proposes Mitigation Measure 4.7-2b (Soil and Groundwater Management Plan). The Soil and Groundwater Management Plan only requires construction contractors to comply with relevant environmental regulations and plan for handling and disposal of excavated soil and groundwater, when encountered. Mr. Hagemann states that "[n]o provisions for sampling soil or groundwater in areas that are suspected to be contaminated are included in Mitigation Measure 4.7-2b."[91] According to Mr. Hagemann, "[s]ampling is essential to characterize the contaminants in soil and groundwater that are likely to be encountered during pipeline construction, foundation excavation, grading activities, utility trenching and other excavation."[92] Therefore, Mitigation Measure 4.7-2b fails to reduce the Project's potentially significant health impacts from hazardous materials to a less than significant level.

The DEIR also includes Mitigation Measure 4.7-2a requiring the preparation of a Health and Safety Plan that specifies protective equipment for workers and "measures to reduce the potential for workers' exposures to hazardous materials in soil and groundwater" and procedures for handling "accidental hazardous materials releases and unanticipated contamination."[93] Along with being improperly deferred, Mr. Hagemann finds that this measure "is impermissibly vague."[94] Mr. Hagemann states that these mitigation measures "do not require any specific procedures to safeguard against encountering various contaminants that are likely during construction" and do not contain "specific provisions about what chemicals would be likely contacted or what specific protective measures" would be needed.[95]

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[88] *Id.*, at 5; DEIR, Table 4.7-1.
[89] Hagemann Comments, p. 5.
[90] *Id.*
[91] *Id.*, at 4.
[92] *Id.*
[93] *Id.*
[94] *Id.*
[95] *Id.*, at 5.

Thus, Mitigation Measure 4.7-2a fails to reduce the Project's potentially significant health impacts from hazardous materials to a less than significant level.

According to Mr. Hagemann, "[c]ontaminants like the organochlorine pesticides, can't be seen or smelled so the health and safety of construction workers and the public may be at risk without proper safeguards for specific chemicals that are likely to be encountered."[96] Thus, a revised DEIR should include "the identification of the maximum values of each of the contaminants that are likely to be encountered during earth-moving activities based on a review of data available for soil and groundwater." Or, "if data are not available or if data gaps exist such that hazards cannot be determined, soil and groundwater sampling should be undertaken."[97] The results of the data review and/or sampling should be included in a revised DEIR, along with an assessment of impacts to worker and public health and safety.[98]

In short, Mr. Hagemann concludes that the DEIR's analysis of health impacts from hazardous materials on the Project site is "inadequate" and that the proposed mitigation fails to include necessary performance standards.[99] Because the DEIR relies upon a future, undefined plan for mitigation, it violates CEQA's prohibition against deferred mitigation and fails to adequately mitigate the Project's significant impacts.

C. The DEIR Fails to Adequately Analyze and Mitigate Potentially Significant Impacts to Biological Resources

1. Impacts to the Snowy Plover

a. Species Status

Historically, thousands of western snowy plovers (*Charadrius nivosus nivosus*) nested along the California coast. By the late 1970s, the snowy plover had disappeared from significant parts of its coastal California breeding range, and biologists estimate the breeding population along the coast is now less than 1,500 birds.[100] The Pacific Coast population of the western snowy plover was listed as a

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[96] *Id.*
[97] *Id.*
[98] *Id.*
[99] *Id.*, at 6.
[100] Owens Comments, p. 10.

federally threatened species in 1993,[101] and is a Bird Species of Special Concern in California. FWS published a Recovery Plan for the species in 2007 and published a Final Rule for the revised designation of critical habitat in June of 2012.[102]

Ms. Owens notes that the primary threats to the snowy plover are decreased habitat availability and anthropogenic disturbances to habitat, including fragmentation, degradation and loss of habitat due to encroachment, habitat erosion, expansion of urban development and increased recreational beach use.[103] The impacts of climate change and resultant sea level rise are increasingly contributing to the cumulative impacts on the species.

In addition to causing direct loss of habitat, urban development causes other direct and indirect impacts that adversely affect plovers. For example, Ms. Owens states that "the value of breeding and wintering habitat is diminished by increased levels of illumination at night (e.g., for parking, construction activities); increased sound and vibration levels; increased attraction of predators due to increased sources of garbage and other anthropogenic food attractants, and pollution drift."[104] Because anthropogenic disturbance is the primary threat to the snowy plover, the general consensus among biologists, according to Ms. Owens, is that protecting occupied sites from human disturbance during both breeding and non-breeding season is essential to the conservation and recovery of the species.[105] However, the snowy plover has continued to decline despite various protections.

Point Blue Conservation Science, in collaboration with the FWS and California Department of Parks and Recreation, has monitored the status of nesting snowy plovers along the coast of Monterey Bay for the past 30 years, and in northern Santa Cruz County since 1988.[106] At the end of 2012, the agencies issued a report of the snowy plover's nesting status in these areas, including an assessment of the species' response to management agencies efforts to enhance

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[101] http://www.fws.gov/arcata/es/birds/WSP/documents/1993Mar5%20Determination%20of%20Threatened%20Status%20for%20WSP%2058%20FR%2012864.pdf.
[102] http://www.fws.gov/arcata/es/birds/WSP/documents/WSPCH_June2012/6-19-2012_FR_rule.pdf.
[103] Owens Comments, p. 11.
[104] *Id.*, at 12.
[105] *Id.*, at 21.
[106] Point Blue Conservation Science. 2014. Nesting of the Snowy Plover in the Monterey Bay Area, California in 2013. Point Blue Conservation Science, Petaluma (CA). 32 pp.

breeding success and population size.[107] According to the report, the plovers experienced a 10% decrease from the previous year, with no plovers detected at Santa Cruz beaches for the third year in a row, thus reinforcing the elevated importance of the nearby population in Monterey Bay area where the Project site is located.

Ms. Owens explains that "[i]t is important to have detailed information regarding just how close [the Monterey Bay] nesting site is to the Project."[108] Yet, the DEIR completely lacks focused, protocol surveys for snowy plovers, lacks data for public review regarding nest monitoring by other research agencies, and contains poor map detail...[109] Thus, Ms. Owens finds that it is "impossible for the public to thoroughly and accurately assess the impact of the Project's activities in this area to this segment of the plover population, and thus the regional population as a whole."[110]

b. Lack of Data in DEIR on Snowy Plovers

According to Ms. Owens, the DEIR's lack of site-specific data and detailed maps based upon snowy plover protocol surveys results in "insufficient information necessary to analyze the degree to which the Project may impact the local populations."[111] Even the DEIR itself points out that protocol surveys should be conducted within specific coastal areas that are close to the Project site.[112] As discussed above, Ms. Owens finds that the lack of adequate surveys and data is "clearly an oversight not just for the snowy plover, but other sensitive species that may occur" in the Project area.[113] Ms. Owens states that "[e]ven the available recent survey reports by Point Blue do not cover all the potential snowy plover habitat within and near the Project site."[114] For example, according to Point Blue biologists, Western snowy plovers have nested at the inland dune area, south of the main Cemex plant operations, including part of the Project footprint. However, the

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[107] Page G. W, Neuman K. K., Warriner J. C., Warriner J. S., Eyster C., Erbes, Dixon D., and Palkovic A., (December 2012). Nesting of the Snowy Plover in the Monterey, California in 2012. PRBO Conservation Science Publication # 1898.
[108] Owens Comments, p. 12.
[109] *Id.*, at 13.
[110] *Id*
[111] *Id.*, at 26.
[112] DEIR, Table 4.6-2.
[113] Owens Comments, p. 26.
[114] *Id.*

biologists expressed in a personal communication to Ms. Owens that the recent use of this site by plovers is difficult to assess because the area has not been surveyed by Point Blue.[115] [116] This lack of data further necessitates the need for site-specific surveys for the Project.

c. The DEIR's Analysis of Snowy Plover Impacts is Inadequate

Due to increasingly low reproductive success, the snowy plover has become a management-dependent species. According to Ms. Owens, sustaining the breeding population "requires provision of undisturbed nesting areas and wintering habitat, as well as protection from predators," which the DEIR fails to adequately address.[117] The DEIR admits that construction, which will be year-round, would occur during the snowy plover's breeding season. The DEIR also states that "[c]onstruction during the snowy plover wintering season (October 1 through February 28) could directly or indirectly impact individual birds if present within or adjacent to the construction area. This would be a significant impact."[118] However, the DEIR dismisses this potential impact, stating that "[t]here is abundant wintering habitat along the Monterey Bay shoreline north and south of the subsurface slant wells site. Any displaced birds would only be temporarily displaced to these areas... Therefore, installation of the subsurface slant wells would have less than significant impacts on wintering habitat."[119] Ms. Owens concludes that the DEIR's analysis contains "spurious and circular argument[s]"[120] for several reasons.

First, the year-round construction in snowy plover habitat would clearly result in highly significant impacts to breeding birds during the breeding season. However, the DEIR fails to adequately analyze this and relies on inadequate mitigation (discussed further below) to reduce impacts. Ultimately, Ms. Owens states that "the only reliable way to prevent such impacts is to prohibit construction

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[115] *Id.*
[116] The DEIR briefly mentions these Point Blue biologists, who have been monitoring plovers in the area for the past 30 years, but failed to provide information as to why there was no coordination with them to analyze impacts or develop adequate mitigation measures.
[117] *Id.*
[118] DEIR 4.6-104.
[119] DEIR 4.6-104.
[120] Owens Comments, p. 14.

activities during the entire snowy plover breeding season,"[121] without allowing flexibility for construction during breeding season based on FWS "approval."[122]

Second, Ms. Owens finds that the DEIR makes an "illogical determination that because wintering season construction would be temporary... impacts would somehow be rendered insignificant."[123] The DEIR fails to provide any support for its conclusion.

Third, the DEIR's statement that harassed birds can simply move elsewhere due to there being "abundant" wintering habitat nearby is "biologically flawed and should be summarily dismissed."[124] According to Ms. Owens, the DEIR completely fails to provide evidence that "nearby" habitat is adequate for displaced birds.

Fourth, Ms. Owens states that "[r]esearch demonstrates that when birds and other vertebrates emigrate to a new location, risk of mortality increases due to factors such as increased visibility, decreased familiarity with a new area relative to competitors, predators, and resources."[125] The CPUC completely failed to address this in the DEIR.

The DEIR's approach is counter to CEQA. For these reasons, and others discussed in detail in Ms. Owens' comments, the DEIR's conclusion regarding impacts to snowy plovers is not supported. Ms. Owens concludes that "[t]his impact analysis conclusion is fatally flawed."[126]

d. Snowy Plover Critical Habitat

The Project site not only supports snowy plovers, but is also located adjacent to federally designated critical habitat for the species. Critical habitat is defined as a specific geographic area that is essential for the conservation of a threatened or endangered species and that may require special management and protection.[127]

Within designated critical habitat, the FWS protects areas that provide

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[121] *Id.*, at 17.
[122] DEIR, p. 4.6-129.
[123] Owens Comments, p. 14.
[124] *Id.*
[125] *Id.*, at 15.
[126] *Id.*
[127] USFWS. 2002. Critical Habitat: What is it? Publication 703/358 2105. http://endangered.fws.gov.

primary constituent elements ("PCEs"), which are the physical and biological features of a landscape that a species needs to survive and reproduce.[128] According to Ms. Owens, "[t]he Project site currently provides these PCEs."[129] In addition, despite the DEIR's assertion that the Project will not overlap with any snowy plover critical habitat, the DEIR's map appears to show critical habitat at the proposed slant well site and at the west end of the proposed seawater intake system, as noted by Ms. Owens. The DEIR should provide more detailed maps of the critical habitat around the Project site.

Development will also occur along approximately 9 miles of coastal snowy plover critical habitat from the northern slant well proposed site to Monterey State Beach. Ms. Owens notes that critical habitat will occur "within less than 400 feet off the development footprint, with virtually no major visual, structural, or auditory barriers (from existing development or geographic topography) between the proposed construction footprint and critical habitat."[130]

Thus, the Project, regardless of whether it is during breeding or non-breeding season, "could significantly reduce the quality of snowy plover critical habitat as defined by these PCEs."[131] The CPUC must prepare a revised DEIR that adequately discloses, analyzes and mitigates this significant impact.

e. Cumulative Impacts to Snowy Plovers

According to Ms. Owens, three other projects have been proposed for the coastal zone in the vicinity of the Project site, and in proximity to snowy plover critical habitat. The DEIR fails to list these projects in its description of cumulative impacts.[132] These projects include:

1. The Collection at Monterey Bay project (development of a 342-room coastal resort on a 26.46-acre site located west of State Route 1 in Sand City);
2. A new campground at Fort Ord Dunes State Park (development of 100 campsites, parking areas, an internal trail network with beach access, and various other infrastructures); and
3. The Monterey Bay Shores Resort project (development of a 40 acre parcel in Sand City, including approximately 680,000 cubic yards of grading).

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[128] *Id.*
[129] Owens Comments, p. 19.
[130] *Id.*
[131] *Id.*
[132] DEIR p. 5-4.

Ms. Owens states that "[t]he Fort Ord coastal HCP includes the creation of a new campground at Fort Ord beach and will greatly increase human use in plover habitat, causing significant impacts to wintering and breeding birds and habitat within the general region of this Proposed Project's pipeline development."[133] In addition, she states that the Monterey Bay Shores Resort will also cause further impacts on the plovers.[134] The Collections is another hotel proposed slightly south of the Monterey Bay shores Resort, and is also in Sand City, with similar significant impacts to snowy plovers.

Ms. Owens finds that "[t]he Project, in conjunction with these other projects, would result in significant cumulative impacts to the western snowy plover and its critical habitat."[135] Ms. Owens provides that "the DEIR lacks fundamental details necessary for the public to evaluate the relative status of this snowy plover breeding and wintering population, recent breeding success (or lack thereof), and resultant impact of any and all development within and near their occupied habitat with any reasonable level of certainty."[136] Thus, the DEIR fails to evaluate all cumulative impacts to the snowy plover.

f. Snowy Plover Mitigation

Mitigation Measure 4.6-1d, which is specific to the snowy plover, is flawed for several reasons. First, the DEIR states that impacts during breeding season will be minimized under Measure 4.6-1d by having an onsite biologist survey for nests and then "consult with USFWS to determine any additional avoidance or minimization measures should be implemented prior to initiating construction activities."[137] However, the DEIR fails to describe the potential avoidance or minimization measures, leaving the public in the dark as to what measures will be implemented and whether they would be effective at mitigating the Project's significant impacts.

Second, the measure states that "*CalAm shall consult* with the USFWS under [s]ection 7 of the FESA..."[138] However, this is the wrong characterization of section 7 consultation, which requires a federal permitting agency, such as the

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[133] Owens Comments, p. 25.
[134] *Id.*
[135] *Id.*
[136] *Id.*
[137] DEIR, p. p. 4.6-129 – 130.
[138] DEIR, p. 4.6-129 (emphasis added).

Corps, to initiate consultation with the FWS, not a private permittee.[139]

Third, for construction *during the breeding season*, visual barriers are proposed to reduce impacts. According to Ms. Owens, "[i]n light of the complex causes and results of anthropogenic disturbances to breeding pairs and chicks, such barriers will not serve to significantly reduce the direct and indirect impacts of noise on breeding birds."[140] Based upon the abundant evidence regarding the negative impact of human proximity to nesting birds, Ms. Owens states that "all construction during breeding season should simply be avoided."[141]

Finally, the Applicant's proposal to develop a Habitat Mitigation and Monitoring Plan ("HMMP") is inadequate. Ms. Owens points out that the description of specific components of the plan is inappropriately deferred, and the public "is unable to determine the adequacy of the measures given that no site-specific or species-specific details or methodology have been provided for a plan that has yet to be created."[142] She goes on to state that "[n]ot only does it prohibit thorough analysis, it provides no guarantee that the HMMP will actually be developed and function as promised to reduce impacts... nor are any success criteria... presented."[143] Therefore, the mitigation measures proposed to reduce the Project's significant impacts to snowy plovers are ineffective, deferred or otherwise inadequate under CEQA.

g. Compensatory Mitigation for Snowy Plovers

Under Mitigation Measure 4.6-1n, the DEIR states that the HMMP would include a "[d]escription of any compensation in the form of land purchase or restoration."[144] As discussed above, deferral of the HMMP is contrary to CEQA, which requires that plan details be included in an EIR that is circulated for public review and comments. In light of the Project's direct, indirect and cumulative significant impacts to snowy plovers, the significant impacts to critical habitat, the rapid decline of the species and the broad geographic scope of this Project that is within and near snowy plover breeding pairs and critical habitat, Ms. Owens finds that "impact mitigation should go beyond deferment of consideration of 'a land

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[139] 16 U.S. C. § 1536(a)(2).
[140] Owens Comments, p. 16.
[141] *Id.*
[142] *Id.*, at 18.
[143] *Id.*
[144] DEIR, p. 4.6-140.

purchase of restoration' to include a conservation fund."[145]

According to Point Blue snowy plover biologist Kriss Neuman:

> There is currently no dedicated funding to support the monitoring and conservation activities that are conducted to support this regional plover population and in particular at this site. The landowner [of the Cemex site] gladly allows Point Blue, California State Parks, and USFWS refuge staff to access habitat, and we jointly install protective fencing, manage habitat and predators, and monitor nesting. A dedicated conservation fund supporting these activities on the site and possibly in the region as well would help to ensure population stability in the region.[146]

Therefore, Ms. Owens concludes that the "most effective measures that could be taken to truly reduce the cumulative impacts to this sensitive species"[147] would be for the Applicant to:

> (1) Create a conservation fund, to be overseen by the appropriate oversight agency, that will be used for monitoring, habitat restoration, and other conservation actions that are key to the populations' viability over time, and (2) Contribute to a region-wide Snowy plover Habitat Management Plan that incorporates all of the relevant municipalities and agencies that are stakeholders for this regional plover population's habitat and conservation. Any such Plan should coordinate and consult with the Point Blue, California State Parks, and USFWS biologists who have been researching this region's snowy plovers for decades.[148]

As it stands, the Project would result in significant, unmitigated cumulative impacts to the snowy plover.

2. Wildlife Corridors

The DEIR asserts that there would be no impacts to established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery

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[145] Owens Comments, p. 27.
[146] *Id.*
[147] *Id.*
[148] *Id.*, at 28.

sites because "the proposed project does not include the placement of structures within creeks, rivers, or other waterways and there are no established native resident or migratory wildlife corridors or wildlife nurseries within the project area."[149] The DEIR further states that "[t]he terrestrial wildlife habitat in the project area is fragmented by agricultural fields, residential developments, commercial/industrial developments, and roads and does not serve as wildlife movement corridors."[150]

According to Ms. Owens, "[w]ildlife corridors and nurseries certainly can and do occur in agricultural and industrial areas."[151] For example, Mr. Owens notes that research on peregrine falcons, a sensitive species known to have occurred recently within or near the Project area according to the CNDDB, have been observed to utilize non-forested and agricultural habitat as important post-fledgling corridors.[152] Ms. Owens provides further examples of how the DEIR's conclusion regarding corridors is not supported by substantial evidence and she concludes that the analysis in the DEIR is "completely insufficient."[153]

3. Insufficient Mitigation

Ms. Owens highlights "various incidences where impacts proposed as significant are considered mitigated to below significance ... even though the specifics of [the mitigation] measures are not identified, and at times deferred to the biologist, [FWS], or CDFW."[154]

For Mitigation Measure 4.6-1a (biologist oversight of construction),[155] Ms. Owens explains that in the case of a potential sensitive species take or harassment, the biologist will not have direct stop work authority, but may report to the site supervisor who does have this authority.[156] In her experience, "[t]his in itself is a serious problem on these construction sites, due largely to the delays inherent within the process, and the conflicts inherent when relying on 'construction or

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[149] DEIR 4.6-97
[150] *Id.*
[151] Owens Comments, p. 6.
[152] *Id.*, at 7.
[153] *Id.*
[154] *Id.*
[155] DEIR 4.6-125.
[156] Owens Comments, p. 7.

operational site supervisors' to stop work on projects..."[157] This can lead to unreported or underreported impacts to species. The measure also allows the lead biologist to relocate any special status species that are "at risk."[158] However, according to Ms. Owens, the DEIR "does not specify what at risk entails, nor any protocol for relocation methodology, nor even which species or taxa are being referred to in the first place."[159] Thus, the measure is meaningless.

For Mitigation measure 4.6-1e (avoidance of special plants),[160] the DEIR states that sensitive plants will be flagged and avoided where possible, or salvaged, or impacts will be otherwise mitigated by consulting with FWS and/or CDFW. Ms. Owens states that "[b]ecause this is a deferral to the future, mitigation actions to be taken are indeterminate and unspecified, and thus inadequate to determine efficacy of the mitigation."[161] The measure also states that "compensation for temporary or permanent loss of special status plant occurrences, in the form of land purchase or restoration [on or off site], shall be provided to a level acceptable to the resource agencies with jurisdiction over those species."[162] Ms. Owens also characterizes this as improperly deferred because it "provides no information for the reviewer to determine if and how impacts will be adequately reduced below significant, nor does it make any mention of what success criteria will be used to determine impacts have been adequately reduced."[163]

For Mitigation measure 4.6-1g (avoidance of black legless lizard, silvery legless lizard, and coast horned lizard),[164] the lead biologist is presumed to prepare a relocation plan and use relocation as a primary mitigation measure. The DEIR states that "only relocation sites that are not over-populated and have suitable habitat conditions shall be used," but provides no basis for determining the adequacy of the relocation destination.[165] According to Ms. Owens, "[t]here is no information provided about the existence of such sites anywhere, nor is there data on likelihood of survival."[166] She further states that the "mitigation descriptions

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[157] *Id.*
[158] *Id.*, at 8.
[159] *Id.*
[160] DEIR 4.6-130.
[161] Owens Comments, p. 8.
[162] DEIR, p. 4.6-131.
[163] Owens Comments, p. 8.
[164] DEIR 4.6-132.
[165] Owens Comments, p. 9.
[166] *Id.*

and methods are inadequate, poorly supported, and poorly described, and result in the reviewer being unable to reasonably determine their efficacy."[167] In short, the measure is inadequate under CEQA.

Ms. Owens also finds that the DEIR's deferral of measures for impacts to various other species, including the Smith's blue butterfly, to future section 7 consultation is inadequate and improperly states that the Applicant would conduct the section 7 consultation with the FWS. As explained above, this is an incorrect characterization of section 7 and fails to satisfy CEQA's mitigation requirements.

4. Impacts to Coastal Dunes

According to Ms. Owens, "[c]oastal dune habitat has been virtually extirpated from most parts of southern California [and] in California it is one of our most impacted, most rare, and most fragile habitats."[168] Part of the Project site is considered "primary" habitat according to the City of Marina's Local Coastal Plan, with some "secondary" habitat (habitat adjacent to primary), and constitutes a an Environmentally Sensitive Habitat Area ("ESHA") pursuant to the Coastal Act. In accordance with the Local Coastal Plan and the Coastal Act, the ESHA must be protected against habitat losses and "only uses dependent on coastal resources shall be permitted in such areas."[169]

The Project would significantly impact ESHA. The DEIR fails to adequately analyze this significant impact. According to Ms. Owens, the hydrology of sand systems, such as those found in dune habitats, is complicated and "the effect and resultant impacts of imposing the construction of ten extraction wells through this intricate and sensitive hydrological system, and providing a strong pull toward the ocean, is not addressed but should be for adequate impact analysis." [170] The DEIR fails to adequately address impacts to coastal dunes, which are considered ESHA under the Local Coastal Plan and the Coastal Act. The CPUC must prepare a revised DEIR that adequately discloses, analyzes and mitigates the Project's significant impacts to ESHA.

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[167] *Id*
[168] *Id.*
[169] *Id.*
[170] *Id.*, at 10.

D. The DEIR Fails to Adequately Analyze and Mitigate Potentially Significant Impacts to Air Quality

1. The DEIR Fails to Evaluate the Significance of All Pollutants

Under CEQA, a lead agency has discretion to determine how to classify the significance of impacts. However, an agency's judgment must be supported by scientific information and other factual data, and the agency does not have discretion to simply not evaluate the significance of impacts.[171] According to air quality expert Phyllis Fox, the DEIR fails to evaluate the significance of pollutants for which the Monterey Bay Unified Air Pollution Control District ("MBUAPCD") has not set official CEQA significance thresholds.[172] Specifically, the DEIR fails to evaluate the significance of impacts from three pollutants: PM2.5, NO_2 emissions for impacts other than its contribution to ozone, and ROG for its impacts other than its contribution to ozone.

a. PM2.5

Dr. Fox explains that PM2.5 (fine particulate matter) is considered highly dangerous to human health, even more than PM10, due to its ability to lodge more deeply into lung tissue.[173] Short term exposure to particulate matter from construction activities can "aggravate lung disease, cause asthma attacks and acute bronchitis, may increase susceptibility to respiratory infections and has been linked to heart attacks."[174] Thus, the importance of evaluating the significance of the Project's PM2.5 emissions is clear.

The DEIR does not use a significance threshold for PM2.5, despite the fact that there were several threshold options available for the CPUC to use.[175] One of the significance criteria for evaluating air quality impacts in Appendix G of the CEQA Guidelines is whether a project would "violate any air quality standard or contribute substantially to an existing or proposed air quality violation."[176] As acknowledged in the DEIR, federal and state air quality standards have been set for

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[171] CEQA Guidelines §15064(b).
[172] Fox Comments, p. 1.
[173] *Id.*
[174] *Id.*, at 2.
[175] *Id.*
[176] DEIR, p. 4.10-15.

PM2.5.[177] However, the DEIR does not use these criteria to evaluate the significance of PM2.5 emissions. Rather, the CPUC concludes in the DEIR that it was only required to disclose the amount of PM2.5 emissions.[178] The CPUC is wrong; the CPUC is required to evaluate the Project's significant impacts from PM2.5 emissions.

The CPUC could have used PM2.5 significance thresholds adopted by other air districts, as it did for GHG emissions. Districts that have adopted PM2.5 thresholds include the South Coast Air Quality Management District ("SCAQMD") (both regional and local, as reported in lookup tables), the Mendocino County Air Quality Management District, and the Bay Area Air Quality Management District ("BAAQMD").[179]

Regardless of which thresholds are used, Dr. Fox concludes that DEIR's emissions calculations are unsupported. Dr. Fox provides her own revised PM2.5 emissions (explained further below). Based on her review of the calculations in Appendix G to the DEIR, construction PM2.5 emissions and revised mitigated construction emissions "are highly significant under all of these thresholds and must be mitigated."[180]

b. NOx

The MBUAPCD's significance criteria for NOx (137 lb/day) is based only on ozone, thus the DEIR only evaluates NOx as an ozone precursor. However, as Dr. Fox points out, NOx "can also causes adverse health effects, acid rain, form particulate matter, and contribute to global warming, water quality deterioration, and visibility impairment."[181] The American Lung Association explains that "NOx can irritate the lungs and lower resistance to respiratory infections such as influenza."[182] The DEIR acknowledges that there are primary and secondary state and federal ambient air quality standards for nitrogen oxides established using NO_2

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[177] DEIR, Table 4.10-2.
[178] DEIR, p. 4.10-16.
[179] Fox Comments, p. 3. As explained by Dr. Fox, "[t]he Project's daily increase in PM2.5 emissions as estimated in the DEIR is less than these regional thresholds, but exceed several of SCAQMD's local thresholds in the lookup tables, suggesting that similar tables should be created for the Project site."
[180] *Id.*
[181] *Id.*, at 4.
[182] http://www.lung.org/associations/charters/mid-atlantic/air-quality/outdoor-air-quality.html?referrer=https://www.google.com/.

as a surrogate for all nitrogen oxides.[183] The primary standards (1-hour) are set to protect public health, including the health of sensitive populations. The secondary standards (annual) are set to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.[184] The DEIR fails to evaluate these primary and secondary impacts of NOx, and is, therefore, "deficient as a public disclosure document."[185]

The absence of a MBUAPCD "CEQA significance threshold" for non-ozone precursor NOx impacts does not obviate the need to evaluate this impact as the ambient air quality standards themselves can be used as CEQA significance thresholds. According to Dr. Fox, when a CEQA significance threshold is missing, a lead agency can model emissions to determine if they cause or contribute to an exceedance of the ambient standards or look to other sources, such as other air districts, for significance criteria expressed as emission rates.[186]

In *Bakersfield Citizens For Local Control v. City of Bakersfield*, the Fifth District appellate court held that an EIR was inadequate because it failed to correlate adverse air quality impacts to resulting adverse health impacts.[187] In that case, a local citizens group filed a CEQA petition challenging the EIRs for two retail shopping centers planned for the southwestern portion of Bakersfield, California.[188] Both EIRs concluded that the shopping center projects would have significant and unavoidable adverse impacts on air quality, yet the court found:

> neither EIR acknowledges the health consequences that necessarily result from the identified adverse air quality impacts. Buried in the description of some of the various substances that make up the soup known as 'air pollution' are brief references to respiratory illnesses. However, there is no acknowledgement or analysis of the well-known connection between reduction in air quality and increases in specific respiratory conditions and illnesses. After reading the EIR's, the public would have no idea of the health

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[183] DEIR, Table 4.10-2.
[184] National Ambient Air Quality Standards (NAAQS), Available at: http://www.epa.gov/air/criteria.html.
[185] Fox Comments, p 5.
[186] *Id.*
[187] *Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 1219–1220.
[188] *Id.* at p. 1193.

> consequences that result when more pollutants are added to a nonattainment basin.[189]

The court concluded that the disclosures were inadequate and stated that the health impacts resulting from the adverse air quality impacts must be identified and analyzed in new EIRs.[190]

Here, although the DEIR acknowledges the *ozone* impacts of NOx, it fails to identify the respiratory impacts and other impacts resulting from NOx emissions. The CPUC must prepare a revised DEIR that adequately discloses, analyzes and mitigates all potentially significant impacts from the Project's NOx emissions.

c. *Reactive Organic Gases (ROG)*

Reactive Organic Gases ("ROG"), in addition to forming ozone, can cause "severe eye, nose, and throat [irritation] and increases susceptibility to respiratory infections."[191] As with NOx, the DEIR only evaluates ROG as an ozone precursor. The Volatile Organic Compounds ("VOCs") present in ROG before it is converted into ozone include compounds that are hazardous to human health.[192] The DEIR does not include a health risk assessment and, thus , the impacts from toxic air pollutants ("TACs") in ROG were not evaluated. According to Dr. Fox, these TACs include "carcinogens such as benzene, formaldehyde, acrolein, and acetaldehyde."[193]

Dr. Fox states that significance thresholds "for ROG by air districts that are in attainment with ozone standards can be used as a first step to evaluate non-ozone construction and operational ROG impacts of the Project."[194] The DEIR does not take this approach. The DEIR fails to meet CEQA standards because it does not evaluate the Project's non-ozone impacts from ROG emissions.

2. <u>Construction Criteria Pollutant Emissions</u>

The DEIR estimates maximum daily emissions of ROG, NOx, PM10, and PM2.5 from Project construction for all construction equipment and for "non-

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[189] *Id.* at p. 1220.
[190] *Id.*
[191] Fox Comments, p. 6.
[192] *Id.*
[193] *Id.*, at 7.
[194] *Id.*

typical" construction equipment.[195] However, the DEIR only evaluates the significance of the NOx and ROG emissions from "non-typical" equipment for ozone impacts. Dr. Fox concludes that "[t]hese construction emissions were unsupported and significantly underestimated... When all the errors and omissions in the DEIR's analysis are cured, Project construction results in significant impacts that are not mitigated by the measures proposed in the DEIR."[196]

a. Construction Emissions from Off-Road and On-Road Construction Equipment Are Not Supported by Substantial Evidence

The DEIR refers to Appendix G for "[a]ssumptions and emission factors used to estimate construction emissions."[197] According to Dr. Fox, "Appendix G is not the starting point for the construction emission calculations, but rather the output from unidentified models whose inputs and outputs are not in the record."[198] Dr. Fox continues, stating that "[t]he DEIR fails to identify the specific model(s), [consultant ESA's] inputs to the model(s), and the model output spreadsheet(s) or other documentation prepared by ESA to support the starting point for the emission calculations in Appendix G."[199] The CPUC's lack of documentation violates CEQA because it deprives the public of the opportunity for independent review of the DEIR's conclusions regarding the significance of the Project's construction emissions.

For example, the DEIR states that "[f]or off-road equipment, emissions modeling, construction equipment inventories, equipment hp ratings, and construction activity schedule assumptions were developed by the CPUC's CEQA consultant... as part of this EIR effort."[200] Dr. Fox explains that "[t]his information is not in the record... While horsepower (hp) ratings of construction equipment are reported in Appendix G, the actual hp inputs to the model(s) used to generate the emissions in pounds per hour (lb/hr) in Appendix G are unknown."[201] The on-road construction emissions analysis is similarly flawed, as Dr. Fox explains in her comments.

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[195] DEIR, Table 4.10-5.
[196] Fox Comments, p. 7.
[197] DEIR, p. 4.10-19.
[198] Fox Comments, p. 7.
[199] *Id.*, at 8.
[200] DEIR, p. 4.10-15.
[201] Fox Comments, p. 8.

While Dr. Fox states that "the use of models that have been approved by a regulatory agency is a reasonable starting point," she also explains that "the mere claim that such a model was used does not by itself establish substantial evidence to support the emission estimates and conclusions presented in DEIR Appendix G."[202] The DEIR fails to provide any support to demonstrate how ESA calculated the starting point for construction emissions in Appendix G. According to Dr. Fox, "[t]he DEIR should be recirculated with enough relevant information to verify the DEIR's estimates of construction emissions including:

> (1) identification of all Project-specific assumptions and input parameters; (2) a copy of the model run inputs and outputs; and (3) any other documentation prepared by ESA or other CPUC consultants, such as original Excel spreadsheet model inputs and outputs plus Appendix G spreadsheets used to make the final construction emission calculations, i.e., the record should include unlocked Excel spreadsheets that correspond to those in Appendix G.[203]

CURE requested from the CPUC the unlocked Excel spreadsheets referred to by Dr. Fox, both under CEQA (requiring disclosure of documents referenced or relied upon in an EIR) and the California Public Records Act.[204] As of the date of submission of these comments, the CPUC has not provided CURE with the requested spreadsheet. As Dr. Fox points out, these documents are routinely provided to support EIRs and other CEQA-equivalent documents, as required under CEQA and the California Public Records Act.[205] The CPUC must provide the public with the underlying technical data to support the DEIR's conclusions regarding the significance of construction emissions. Until then "the DEIR's conclusions regarding construction impacts on air quality are not supported by substantial evidence."[206]

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[202] *Id.*, at 9-10.
[203] *Id.*
[204] Letters from Laura Horton to CPUC, May-June, 2015, **Attachment G.**
[205] Fox Comments, p. 10-11.
[206] *Id.*, at 11.

b. The DEIR Fails to Properly Evaluate Ozone Precursor (ROG, NOx) Emissions from Construction Equipment

The Air Basin in which the Project is located currently violates California's 8-hour ambient air quality standards for ozone.[207] Thus, it is an ozone nonattainment area. The DEIR asserts that "[c]onstruction projects that use typical construction equipment such as dump trucks, scrappers, bulldozers, and front-end loaders that temporarily emit precursors of ozone (i.e., ROG and NOx), are already accounted for in the emission inventories of state- and federally-required air quality plans (MBUAPCD, 2008)."[208] Thus, the DEIR only evaluates the significance of construction ROG and NOx emissions from "non-typical construction equipment."[209] While this may be consistent with the MBUAPCD CEQA guidelines,[210] it is not consistent with CEQA. CEQA requires the CPUC to evaluate the Project's actual increase in emissions. A brief reference to other documents that may contain those emissions, without a clear demonstration that they are actually there, is not adequate.

Dr. Fox states that "[t]he DEIR does not contain a shred of evidence that the emissions from typical construction equipment that would be used to construct this Project are in fact included in these emission inventories."[211] Although the DEIR does contain a letter from a MBUAPCD employee in support of its assertion, the letter is not a valid substitute for demonstrating clearly on the record that Project emissions are included in these inventories. Dr. Fox also reviewed the subject air quality plans and found no evidence that the inventories include Project emissions.[212]

Dr. Fox explains that construction emissions in these inventories do not support the DEIR's assertion for several reasons. First, "[a]n estimate at only the 'county level' of emissions from a portion of the year when construction will last 2.5 to 3 years is not adequate to assure that maximum day Project emissions have been

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[207] DEIR, Table 4.10-2.
[208] DEIR, p. 4.10-15.
[209] DEIR, p. 4.10-16, Table 4.10-6.
[210] Monterey Bay Unified Air Pollution Control District (MBUAPCD), CEQA Air Quality Guidelines, 2006, p. 5-3; Available at: http://mbuapcd.org/pdf/CEQA_full%20(1).pdf.
[211] Fox Comments, p. 13.
[212] *Id.*

included."[213] Second, these inventories indicate that the emissions of many classes of equipment are assumed to drop to zero over the time horizon that this Project would be built.[214] Third, "the models are based on outdated equipment surveys in which future emissions are estimated based on the decline in annual use, average age, and an annual growth rate of 1.96%."[215] Fourth, the models project significant decreases in NOx and ROG, due to the introduction of cleaner fuels and improved control technologies.[216] However, the DEIR does not require that Project construction equipment use cleaner fuels or improved control technologies, such as diesel particulate traps and cleaner engines including Tier 4 Interim diesel technology, which have been commercially available for years.

CEQA requires the CPUC to disclose, analyze and mitigate the Project's significant impacts on air quality, including increases in emissions from all Project construction equipment. The DEIR fails to comply with CEQA.

c. *Construction Equipment NOx and ROG Emissions Are Significant*

Given Dr. Fox's conclusion that there is no substantial evidence in the record that construction NOx and ROG emissions are accounted for in the ozone attainment plans, the DEIR must evaluate the significance of the total average daily NOx emissions of 400.16 lb/day and ROG emissions of 28.28 lb/day from all Project construction equipment. These total NOx emissions exceed the MBUAPCD CEQA significance threshold of 137 lb/day and are a significant impact that was not identified or mitigated in the DEIR. The total ROG emissions exceed the 25 lb/day significance thresholds established by two ozone-attainment air districts.

Feasible mitigation was identified in the Draft Initial Study and Mitigated Negative Declaration ("IS/MND") for the slant test well[217] for NOx and ROG impacts, but most of these measures were not identified in the DEIR. These measures include replacing diesel-powered equipment with electric or gasoline-powered equipment, maintaining all construction equipment in proper tune

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[213] *Id.*
[214] *Id.*
[215] *Id.*
[216] *Id.*
[217] SWCA Environmental Consultants, Draft Initial Study and Mitigated Negative Declaration for the California American Water Slant Test Well Project, Prepared for City of Marina, May 20 (IS/MND).

according to manufacturer's specifications, and using cleaner technology (such as Tier 4), among other measures.[218]

Additional feasible mitigation is identified in the MBUAPCD's CEQA guidelines, which were relied on by the DEIR to develop mitigation for PM10 emissions. Dr. Fox also cites the recently approved Final EIR for the Chevron Modernization Program, which includes feasible mitigation measures for NOx and ROG emissions from construction equipment.[219] The DEIR should include these feasible mitigation measures in its analysis of significant air quality impacts.

d. Average vs. Maximum Daily Emissions

According to Dr. Fox, "[t]he DEIR compares the 'average' daily emissions from construction equipment to significance thresholds based on the 'maximum' day, but misleadingly captions the emission table as 'maximum daily.'"[220] The DEIR's use of average emissions rather than the maximum day hides peak emissions, and CEQA requires analysis of all potential impacts. Thus, emissions should be compared to the "maximum" day, not the average day. Dr. Fox explains that "[m]aximum day emissions would be much higher than the average day, as multiple pieces of equipment can work simultaneously at different sites."[221]

An email from a MBUAPCD employee appears to grant an exception to the use of the maximum "since the actual phasing is unknown."[222] However, this email was written over two years ago and is outdated. In addition, as noted by Dr. Fox,[223] there is a construction schedule in Appendix G that could and should have been used to determine phasing. The DEIR thus provides no legitimate reason for not using the maximum day. Dr. Fox concludes that the DEIR should include revised "daily construction emission calculations based on the current construction schedule to estimate maximum daily emissions and compare the resulting sum of ROG and NOx to the significance threshold of 137 lb/day."[224]

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[218] *Id.*
[219] Fox Comments, p. 17.
[220] *Id.*, at 11; DEIR, Table 4.10-5.
[221] Fox Comments, p. 11.
[222] MCUAPCD 2013b: Email from Amy Clymo, MBUAPCD, to Matthew Fagundes, April 17, 2013, Re: CO Emission Factors for EIR Analysis.
[223] Fox Comments, p. 11-12.
[224] *Id.*

e. The DEIR Omits Some Sources of Exhaust NOx and ROG Emissions

According to Dr. Fox, "[t]he estimated maximum daily construction emissions reported in DEIR... excludes the NOx and ROG exhaust emissions from the source water pipeline, Salinas Valley pipeline, transmission main, transfer pipeline, ARS conveyance and pump to waste pipeline, and Valley Green pump station." [225] These additional emissions are estimated in Appendix G, but are not included in the unmitigated and mitigated total construction emissions included in DEIR summary in Table 4.10-5. The DEIR fails to discuss the exclusion of these emissions. Dr. Fox presumes the exclusion is based on the assumption that "daily emissions would not overlap in time."[226] However, the construction phasing diagram in Appendix G indicates that all of these activities can overlap.[227]

Given that all of these components could be under construction on the maximum day, "emissions from all of them must be included in the construction emission estimate, unless the DEIR conditions the Project to prohibit the simultaneous construction of all them on the same day."[228] Dr. Fox concludes that the omitted NOx emissions from these exhaust sources are high enough taken alone to exceed the MBUAPCD NOx significant threshold of 137 lb/day.[229] Thus, Dr. Fox concludes that "this is a significant impact that was not disclosed or mitigated in the DEIR."[230]

3. <u>The DEIR Underestimates Construction PM10 and PM2.5 Emissions</u>

The DEIR concludes that "construction of the proposed project could contribute to an exceedance of a state and/or federal standard for PM10 based on the estimated maximum daily mass emissions levels presented in Table 4.10-5, which would exceed the MBUAPCD significance threshold for PM10."[231] The DEIR

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[225] DEIR, Table 4.10-5; DEIR, Appendix. G.
[226] Fox Comments, p. 16.
[227] DEIR, Appendix. G.
[228] Fox Comments, p. 23.
[229] *Id.*
[230] *Id.*, at 16.
[231] DEIR, p. 4.10-23.

then concludes that this impact would be reduced to a less-than-significant level with implementation of mitigation measures.[232]

Dr. Fox explains that "the DEIR underestimated construction PM10 and PM2.5 emissions" for four reasons.[233] First, the DEIR fails to base its grading emissions on the maximum amount of soil that would be graded per day. Second, the DEIR fails to base its pipeline earth moving emissions on the maximum amount of soil that would be disturbed per day. Third, the DEIR's mitigated emissions assume a control measure (road paving) that is not required as a mitigation measure. Fourth, the DEIR excludes exhaust emissions from many on- and off-road vehicles that could occur simultaneously on the maximum day.

When Dr. Fox corrected these errors and omissions, "the mitigated PM10 construction emissions greatly exceed the MBUAPCD's 82 lb/day PM10 significance threshold."[234] In addition, "when PM2.5 significance thresholds from other air districts are consulted, the corrected and mitigated PM2.5 emissions are also significant."[235] The DEIR does not include any mitigation measures for PM2.5, which "requires more aggressive controls [than PM10] to adequately limit its emissions."[236] Thus, the Project's impacts from PM2.5 and PM10 construction emissions remain significant and unmitigated.

a. Grading and Earthmoving Emissions Are Unsupported and Underestimated

The fugitive PM10 and PM2.5 emissions from grading and earthmoving at the Desalination Plant, Terminal Reservoir, and ASR Facilities were calculated from an assumed maximum disturbance of 4 acres per day.[237] According to Dr. Fox, "[t]he DEIR contains inadequate support for the 4 acre per day assumption,"[238] asserting only that it is based on 2 acres for the Desalination Plant and 1 acre each for the ASR Facilities and Terminal Reservoir. However, Dr. Fox states that "an estimate of acres graded should be calculated from information on the subject

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[232] DEIR, p. 4.10-23-24.
[233] Fox Comments, p. 19.
[234] *Id.*
[235] *Id.*
[236] *Id.*
[237] DEIR, Appendix. G.
[238] Fox Comments, p. 20.

equipment horsepower ratings and other factors coupled with the condition of the site, not based on unsupported assertions."[239]

Dr. Fox notes that it generally takes a 200-hp dozer one to two hours to grade an acre.[240] The DEIR indicates that one 200-hp grader, working 12 hr/day would be used for the Desalination Plant; one 200-hp grader, working 8 hr/day for 42 days at the Terminal Reservoir and ARS Pump Station; one 200-hp grader working 8 hr/day for 42 days at the ARS Wells/Settling Basin; and one 200-hp grader working 8 hrs/day for 2 days at the Valley Greens Pump Station.[241] According to Dr. Fox, "[a]ssuming it takes a 200-hp grader 1-2 hours to grade an acre, the maximum day would occur during grading of the Desalination Plant, estimated as 12 hr/day x 2 acre/hr = 24 acres per day..."[242] Total acres graded could be even higher if two or more areas were graded simultaneously. However, assuming no simultaneous grading, 24 acres is ***six times higher*** than assumed in the DEIR's grading and earthmoving emission calculations in Appendix G (4 acres). This one change alone would increase grading and earthmoving emissions to beyond significance thresholds, as described by Dr. Fox.[243] Dr. Fox concludes that the DEIR's proposed mitigation measures do not reduce the significant PM10 impact to less than significant because they are based on 4 acres/day. Furthermore, the DEIR requires no PM2.5 mitigation.

The DEIR similarly underestimates PM10 and PM2.5 emissions from pipeline construction earth moving activities. The calculations assume a maximum of 2,311 cubic yards of soil material would be handled each day to excavate and backfill pipeline trenches.[244] The maximum cubic yards of soil disturbed assumes two pipelines are simultaneously laid.[245] However, the DEIR allows for multiple pipelines to be installed simultaneously. Dr. Fox explains that, when accounting for multiple pipelines at a time, fugitive dust from pipeline construction would also be increased.[246] This increase in pipeline fugitive dust emissions is not disclosed or mitigated in the DEIR.

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[239] *Id.*
[240] *Id.*
[241] DEIR, Appendix G
[242] Fox Comments, p. 20.
[243] *Id.*
[244] DEIR, p. 4.10-20.
[245] *Id.*
[246] Fox Comments, p. 21.

The DEIR must be revised to correct its analysis of construction fugitive dust emissions and to require mitigation for PM2.5 and additional mitigation for PM10.

b. The DEIR Overestimates the Reduction in Truck Travel Fugitive PM10 and PM2.5 Emissions from Proposed Mitigation

According to Dr. Fox, the major source of PM10 and PM2.5 emissions is fugitive dust from truck travel on unpaved roads. The DEIR proposes mitigation measures intended to reduce fugitive dust emissions from earth disturbing activities by 65% and from truck travel on unpaved roads in the vicinity of the subsurface slant wells and the CEMEX active mining area by as much as 75%.[247] Dr. Fox's review of the emission calculations in Appendix G and supporting information indicates that "these claims are misleading" for several reasons.[248]

First, Dr. Fox points out that fugitive PM10 and PM2.5 emissions calculations from truck travel on unpaved roads assume that the unpaved road to the Terminal Reservoir site would be "paved," eliminating 100% of its fugitive dust emissions.[249] However, the DEIR suggests this road may only be "stabilized"[250] with gravel *or* pavement.[251] Dr. Fox notes that simply graveling the road would result in higher emissions than paving.

Second, Dr. Fox explains that the DEIR "incorrectly asserts paving a haul road eliminates PM10 and PM2.5 emissions."[252] As indicated in the source relied on in the DEIR (MBUAPCD 2008), paving roads could reduce emissions to 90% but not eliminate them completely. Furthermore, another source relied on in the DEIR (SCAQMD 2007) indicates that graveling only reduces PM10 emissions by 54%.[253] Thus, according to Dr. Fox, the assumption of 100% control from "paving" the Terminal Reservoir haul road "is neither feasible nor enforceable and cannot be

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[247] DEIR, p.4.10-20.
[248] Fox Comments, p. 24.
[249] DEIR, Appendix G.
[250] DEIR, p. 4.10-21.
[251] DEIR, p. 4.10-24.
[252] Fox Comments, p. 24.
[253] South Coast Air Quality Management District (SCAQMD), WRAP Fugitive Dust Handbook, Table XI-A, Mitigation Measure Examples: Fugitive Dust from Construction and Demolition. Revised April 2007. 2007.

relied on to estimate 'mitigated' emissions from truck travel on unpaved haul roads."[254]

Third, Dr. Fox notes that "while the DEIR admits that paving itself would generate emissions (including potentially ROG emissions which were not included in the emission calculations), it does not include these emissions in its calculations..."[255] The DEIR merely states that these emissions would occur prior to the start of construction activities at the Terminal Reservoir/ASR Pump Station site.[256] Therefore, implementation of this measure would not change the worst-case daily emission scenario presented in Table 4.10-5."[257] As explained by Dr. Fox, this is an unsupported assumption because "paving or graveling of the Terminal Reservoir haul road could overlap with other Project components, contributing to the maximum day."[258]

After correcting these flaws, Dr. Fox revised the mitigated PM10 and PM2.5 emissions from truck travel on unpaved roads. Her calculations indicate that graveling the road to the Terminal Reservoir (rather than assuming 100% control by paving) would increase mitigated fugitive emissions from truck travel on unpaved roads from 17.5 lb/day to 52.01 lb/day and total mitigated PM2.5 emissions from 1.7 lb/day to 5.2 lb/day.[259] Dr. Fox concludes that "[t]his error, together with other errors and omissions in PM10 and PM2.5 construction emission calculations discussed elsewhere indicate that significant additional mitigation is required to reduce these emissions below the CEQA significance thresholds."[260]

c. Revised Construction PM10 and PM2.5 Emissions

Dr. Fox concludes that overall "PM10 and PM2.5 emissions from constructing the Project were underestimated, as well as inadequately supported."[261] She provides revised construction emissions which show that corrected PM10 and PM2.5 emissions (included in the table below) are nearly three times higher than

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[254] Fox Comments, p. 24.
[255] *Id.*, at 25.
[256] DEIR, p. 4.10-21.
[257] *Id.*
[258] Fox Comments, p. 25.
[259] *Id.*
[260] *Id.*, at 25-26.
[261] *Id.*, at 26-27.

those disclosed in the DEIR and exceed the CEQA significance thresholds for both PM10 and PM2.5.[262]

Dr. Fox's Revised PM10 and PM2.5 Construction Emissions (lb/day)

Increase in Emissions Relative to Table 4.10-5	**PM10**	**PM2.5**
Grading: Desal. Plant+Term. Res.+ASR Facilities	400	83
Pipeline Construction	17.1	2.7
Source Water Pipeline	1.91	1.66
Salinas Valley Pipeline	1.73	1.55
Transmission Main	1.93	1.69
Transfer Pipeline	1.91	1.66
ARS Conveyance/Pump to Waste Pipeline	1.89	1.65
Valley Green Pump Station	0.84	0.72
Total Increase in Construction Emissions	**425.4**	**94.6**
DEIR Construction Emissions, Table 4.10-5	233.55	44.18
REVISED CONSTRUCTION EMISSIONS	**657.1**	**189.2**
Significance Criteria	**82**	**54**

Dr. Fox's Revised Mitigated PM10 and PM2.5 Construction Emissions (lb/day)

Increase in Mitigated Emissions Relative to Table 4.10-5	**PM10**	**PM2.5**
Grading: Desal. Plant+Term. Res.+ASR Facilities	168	45
Truck Travel Fugitive Dust	52.0	5.2
Pipeline Construction	17.1	2.7
Source Water Pipeline	1.91	1.66
Salinas Valley Pipeline	1.73	1.55
Transmission Main	1.93	1.69
Transfer Pipeline	1.91	1.66
ARS Conveyance/Pump to Waste Pipeline	1.89	1.65
Valley Green Pump Station	0.84	0.72
Total Increase in Mitigated Construction Emissions	**247.3**	**61.8**
DEIR Mitigated Construction Emissions	**46.78**	**9.49**
REVISED MITIGATED CONSTRUCTION EMISSIONS	**294.1**	**71.3**
Significance Threshold	**82**	**54**

[262] *Id.*

As shown in the tables, the revised PM10 and PM2.5 emissions result in significant, unmitigated impacts. Dr. Fox states that "[t]he mitigation proposed in the DEIR is not adequate to reduce these emissions below the CEQA significance threshold..."[263]

d. CEQA Requires All Feasible Mitigation for PM10 and PM2.5

The DEIR incorrectly concludes that Mitigation Measures 10.4-1a and 1c will reduce PM10 emissions to less than significant levels and fails to address mitigation specific to PM2.5.[264] Dr. Fox explains that, because the DEIR underestimates construction PM10 and PM2.5 emissions and overestimates the reduction in PM10 and PM2.5 emissions from proposed mitigation, the Project's impacts from PM10 and PM2.5 emissions remain significant. Thus, additional feasible mitigation is required.

Dr. Fox provides an extensive list of potential feasible mitigation measures not included in the DEIR.[265] All of these measures "are feasible and various combinations of them are routinely required elsewhere to reduce fugitive PM10 emissions."[266] Even with the additional measures, Dr. Fox concludes that the Project's fugitive PM10 and PM2.5 emissions would remain above the significance thresholds. Thus, the impacts would be considered significant and unavoidable.[267] The CPUC must revise the DEIR accordingly and recirculate it for public review.

4. Operational Criteria Pollutant Emissions

a. The DEIR Omits Indirect Emissions

The DEIR estimates operational emissions from on-road vehicle exhaust and emergency generator testing.[268] However, according to Dr. Fox, the major source of Project emissions is indirect emissions from the generation of electricity. The DEIR does not include those emissions. The CPUC argues that "[i]t is generally not

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[263] *Id.*, at 27.
[264] DEIR, pp. 4.10-23 – 24.
[265] Fox Comments, p. 28-32.
[266] *Id.*, at 32.
[267] *Id.*
[268] DEIR, Table 4.10-7.

possible to determine the exact generator source(s) of electricity on the power grid that would supply the proposed project, or whether or not the electricity would even be generated within the Air Basin."[269] The CPUC is wrong.

CEQA does not allow the CPUC to exclude this major source of emissions from the DEIR. As noted by Dr. Fox, EIRs routinely include indirect emissions from electricity generation.[270] In fact, the GHG section of this DEIR includes indirect GHG emissions from power generation.[271] Furthermore, the MBUAPCD's CEQA guidelines state: "The following thresholds apply to all indirect and direct emissions, whether or not they are subject to District permit authority, unless noted otherwise."[272] The MBUAPCD's guidelines indicate that the NOx and ROG significance thresholds should be compared to "direct + indirect" emissions.[273] Thus, Dr. Fox finds that "the DEIR must include the increase in emissions from the net increase in power production to support the Project."[274]

Furthermore, Dr. Fox explains that indirect emissions need not be limited to the Project's Air Basin. Dr. Fox states that "[e]lectricity from any generator in California could be used at the Project site... As the significance criteria are based on the maximum day, finding the 'maximum' is all that is required."[275]

The DEIR indicates that PG&E would supply the power for the Project. According to Dr. Fox, the sources of PG&E's power are known and "emissions should be estimated for the plausible worst case daily maximum emissions..."[276] However, the DEIR does not include any of the information required to estimate these emissions. Thus, it fails as an informational document under CEQA, leaving the public to generate independent emissions estimates in order to evaluate the Project's impacts.

Dr. Fox again provides her own estimates. Dr. Fox finds that "the Project would increase NOx emissions by up to 284 lb/day, which exceeds the MBUAPCD's

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[269] DEIR, p. 4.10-25.
[270] See, e.g., The Carlsbad Desalination Project EIR, pp. 4.2-18/20 & Table 4.2-9; Available at: http://carlsbaddesal.com/eir.
[271] DEIR, p. 4.10-11; DEIR, Table 4.11-4.
[272] MBUAPCD 2006, p. 5-4.
[273] MBUAPCD 2006, Table 5-3. Table 5-3.
[274] Fox Comments, p. 33.
[275] *Id.*
[276] *Id.*

NOx significance threshold of 137 lb/day."[277] The NOx emissions from producing a net increase of 40,500 MWh per year of electricity "is large enough taken alone to exceed the MBUAPCD's NOx significance threshold."[278] This is a significant impact not disclosed or mitigated in the DEIR.

In addition, Dr. Fox identified all PG&E owned power plants in California, determining the maximum daily emissions from each, using EPA's CAMD daily data for 2014. She then concludes, assuming 1,152 lb of NOx is emitted on the maximum day, operational NOx emissions would increase to 1,198 lb/day,[279] which exceeds the MBUAPCD's NOx and ROG (which are evaluated together) significance threshold of 137 lb/day by a clearly significant amount.[280] Therefore, the NOx and ROG emissions from producing a net increase of 40,500 MWh per year of electricity is also large enough taken alone to exceed the MBUAPCD's NOx and ROG significance threshold. This significant impact is not disclosed or mitigated in the DEIR.

Dr. Fox offers suggestions for mitigating this impact, including "purchasing local and contemporaneous emission reduction credits or by collaborating with a nearby NOx or ROG source to reduce their NOx and ROG emissions" or "enter[ing] into a power purchase agreement to obtain its electricity from a renewable source."[281] The DEIR proposes Mitigation Measure 4.11-1b, which requires CalAm to "make good faith efforts to obtain "clean" renewable energy for operations of the Project..."[282] As discussed in detail below, this is not an adequate measure to mitigate significant impacts. Rather, the applicant must *commit* to powering the Project with renewable energy.

CEQA requires the CPUC to analyze and mitigate the Project's indirect electricity generation emissions for all criteria pollutants. The CPUC must revise the DEIR accordingly.

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[277] *Id.*, at 34.
[278] *Id.*
[279] *Id.*
[280] *Id.*
[281] *Id.*
[282] DEIR, p. 4.11-15.

b. The DEIR Fails To Evaluate All Operational NOx Impacts

The DEIR does not evaluate the significance of emissions if a pollutant, such as NOx as a respiratory irritant, does not have a MCUAPCD significance threshold. Given the various impacts from NOx, in addition to forming ozone, the DEIR's failure to analyze these impacts renders it inadequate as an informational document. Dr. Fox found that "[w]hen indirect NOx emissions from power production are added, as discussed above, total NOx emissions increase from 45.63 lb/day to 1,198 lb/day, which exceeds the non-ozone attainment NOx significance thresholds (25 lb/day to 250 lb/day) by a huge amount..."[283] Thus, Dr. Fox concludes that operational NOx emissions from power production, when evaluated for impacts other than ozone formation, "are significant under the NOx significance thresholds established by other air districts."[284] The DEIR must disclose, analyze and mitigate this significant impact.

5. <u>The DEIR Fails to Adequately Evaluate Health Risks</u>

The DEIR fails to adequately evaluate health risks from diesel particulate matter ("DPM"). The DEIR concludes that the Project's DPM emissions would not result in a significant impact because DPM emissions are less than 3 lb/day for 25 months or less, sensitive receptors are 2,000 feet away at most locations, the receptors are upwind and construction would last only 2 to 18 months at any given site.[285] However, as explained by Dr. Fox, "there are exceptions to all of these assumptions, which requires that a formal health risk assessment be prepared to quantify the risk, particularly for the pipelines, ASR injection/extraction wells, and Green Valley Pump Station, where sensitive receptors are within 50 to 100 feet."[286] For example, Dr. Fox states that "the wind does not blow in just one direction all of the time and all of the sensitive receptors are not 2,000 feet away."[287] In addition, construction is projected to last longer than 25 months at the Desalination Plant,[288] and the DEIR underestimates construction DPM by excluding several sources.[289] Furthermore, the DEIR fails to consider toxic air contaminants that are present in ROG.

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[283] Fox Comments, p. 36.
[284] *Id.*
[285] DEIR, pp. 4.10-25 – 26.
[286] Fox Comments, p. 36.
[287] *Id.*
[288] DEIR, Appendix G.
[289] Fox Comments, p. 35.

The DEIR asserts that the California Office of Environmental Health Hazard Assessment ("OEHHA") requires that health risk assessments be based on 70 years, while construction would last a much shorter time, implying that risk assessment is not required for short-term exposures, such as construction.[290] However, Dr. Fox notes that the DEIR relies on outdated OEHHA guidance from 2003.[291] This guidance has been superseded twice, in 2012 and in March of 2015. The updated guidance specifically recommends health risk assessment for short-term exposures and explains that these impacts may be more severe than exposures over a longer period. The OEHHA 2012 risk assessment guidelines explicitly states for short-term projects, such as construction: "We recommend that exposure from projects lasting more than 6 months be evaluated for the duration of the project."[292] The OEHHA's 2015 guidelines recommend that "exposure from projects longer than 2 months but less than 6 months be assumed to last 6 months (e.g., a 2-month project would be evaluated as if it lasted 6 months)... Exposure from projects lasting more than 6 months should be evaluated for the duration of the project..."[293]

The DEIR's conclusions regarding the health risks are not supported by substantial evidence.[294] The CPUC must revise the DEIR to provide an adequate health risk assessment that includes DPM and all TACs from construction equipment.

E. The DEIR Fails to Adequately Analyze and Mitigate Potentially Significant Impacts from Greenhouse Gas Emissions

The DEIR concludes that GHG emissions from construction and operation of the Project are significant and unavoidable.[295] The DEIR then proposes Mitigation Measure 4.11-1 to reduce the Project's GHG emissions from construction and

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[290] DEIR, p. 4.10-18.
[291] Fox Comments, p. 35; DEIR, p. 4.10-13.
[292] OEHHA, Air Toxics Hot Spots Program Risk Assessment Guidelines, Technical Support Document for Exposure Assessment and Stochastic Analysis, August 2012, p. 2012; Available at: http://www.oehha.ca.gov/air/hot_spots/pdf/2012tsd/TSDportfolio2012.pdf.
[293] OEHHA, Air Toxics Hot Spots Program Risk Assessment Guidelines Guidance Manual for Preparation of Health Risk Assessments, February 2015, Section 8.2.10: Cancer Risk Evaluation of Short Term Projects, pp. 8-17/18; Available at: http://oehha.ca.gov/air/hot_spots/2015/2015GuidanceManual.pdf.
[294] Fox Comments, p. 37.
[295] DEIR, p. 4.11-14.

operation and Mitigation Measure 4.18-1 for construction GHG emissions.[296] The DEIR concludes that because the "CPUC cannot substantiate numerically that the mitigated GHG emissions would be reduced to a less-than- significant level," the impacts would remain significant.[297] According to Dr. Fox, "[t]he DEIR failed to identify all applicable regulations, failed to adequately support its GHG emission calculations, and failed to include all feasible mitigation measures."[298]

1. DEIR's GHG Analysis

The CPUC's inability to numerically substantiate the Project's mitigated emissions is a result of its improper deferral of the identification of mitigation measures. Indeed, as Dr. Fox points out, other applicants and lead agencies have successfully quantified GHG emission reductions. The DEIR must further explain its conclusion that the Project's GHG emissions impacts are significant and unavoidable. In *Keep Berkeley Jets Over the Bay Com. v. Board of Port Comrs.*, the First Appellate court concluded that "simply labeling the effect 'significant' without accompanying analysis" violates "the environmental assessment requirements of CEQA."[299] Before the CPUC can make a "significant and unavoidable" finding, it must specifically identify the GHG mitigation measures and estimate the reduction in GHG achieved by each. Furthermore, it must explain the Project's consistency with the State's energy and climate objectives.

The DEIR does identify Executive Order S-3-05, Assembly Bill 32, the AB 32 Scoping Plan, Mandatory Reporting Requirements and the Cap-and-Trade Program. However, it excludes others including California's Low Carbon Fuel Standard Program, the Zero Emission Vehicle Program and the Sustainable Communities Strategies Act (SB 375). The revised DEIR should include evidence and analysis addressing whether and how this Project is consistent with these laws and policies. For example, Dr. Fox finds that "the proposed mitigation fails to address methods to reduce GHG emissions from worker trips (carpooling or vans could be required to transport construction workers from regional hubs) and construction equipment (Tier 4 engines could be required for all construction equipment)."[300]

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[296] DEIR, pp. 4.11-15 – 16.
[297] DEIR, p. 4.11-16.
[298] Fox Comments, p. 50.
[299] *Berkeley Keep Jets Over the Bay Com. v. Board of Port Comrs.* (2001) 92 Cal.App.4th 1016.
[300] Fox Comments, p. 51.

According to Dr. Fox, "[t]he GHG construction emission calculations in Appendix E are inadequately supported for all of the reasons previously described for criteria pollutant construction emissions."[301] In addition, the emissions in Appendix G are based on various models, the inputs and outputs of which are not provided in the record, preventing any meaningful review. Furthermore, EMFAC2011 was superseded by EMFAC2014, which was used to estimate construction criteria pollutant emissions.[302] As stated above, Appendix G only includes PDF versions of the GHG emission calculation spreadsheets, preventing review of underlying calculations, and the CPUC refused to provide us with the unlocked Excel spreadsheets that correspond to those in Appendix G. Dr. Fox explains that "an accurate estimate of GHG emissions is important as it is required to determine the amount of mitigation required to reduce the emissions to below significance thresholds."[303]

2. <u>GHG Mitigation</u>

In *CBE v. Richmond*,[304] an EIR for a Chevron refinery project was deemed legally inadequate in part because the mitigation measures for GHG emissions were impermissibly deferred. The EIR in that case was "legally required to describe, evaluate and ultimately adopt feasible mitigation measures which would 'mitigate or avoid' [GHG] impacts."[305]

The mitigation measure at issue in the Chevron project EIR stated that "[n]o later than one (1) year after approval of this Conditional Use Permit, Chevron shall submit to the City, for approval by the City Council, a plan for achieving complete reduction of GHG emissions. . ."[306] As the court explained, the mitigation measure "required Chevron, within one year of Project approval, to hire and fully fund 'a qualified independent expert' to complete an inventory of greenhouse gas emissions and to identify potential emissions reduction opportunities."[307] Furthermore, the measure stated that Chevron "shall consider implementation of measures that achieve GHG reductions including, but not limited to, the following measures . . ."[308]

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[301] *Id.*
[302] *Id.*, at 51-52.
[303] *Id.*, at 52.
[304] In *Communities for a Better Environment v. City of Richmond* (2010) 184 Cal.App.4th 70, 95.
[305] *Id.*, at 91.
[306] *Id.*
[307] *Id.*, at 92.
[308] *Id.*

The measure then listed several potential mitigation measures. The respondents in the case argued that the EIR failed to adequately formulate a plan to mitigate GHG emissions, but instead offered "a menu of potential mitigation measures, with the specific measures to be selected by Chevron and approved by the City Council a year after Project approval."[309]

The court found that the measure was deferred mitigation, which is impermissible under CEQA. The court stated, in part, that the measure amounted to "a generalized goal of no net increase in greenhouse gas emissions and. . . a handful of cursorily described mitigation measures for future."[310] Furthermore, the court found that "[n]o effort [was] made to calculate what, if any, reductions in the Project's anticipated greenhouse gas emissions would result from each of these vaguely described future mitigation measures" and that the list of potential mitigation measures was "nonexclusive, undefined, untested and of unknown efficacy."[311]

Here, the CPUC deemed the Project's GHG emissions to be significant and unavoidable. Thus, CEQA requires the CPUC to include all feasible mitigation and may not defer mitigation to a later time. However, Dr. Fox explains that the DEIR's mitigation measures "are fundamentally flawed as they are unenforceable, ambiguous, and do not reduce impacts to a less than significant level."[312]

a. Mitigation Measure 4.11-1

Mitigation Measure 4.11-1 requires CalAm to prepare a "GHG Emissions Reduction Plan" and submit it to the CPUC for approval prior to the start of construction.[313] The Plan "shall include a commitment by CalAm to incorporate all available feasible energy recovery and conservation technologies..." In addition, CalAm "shall make good faith efforts to obtain "clean" renewable energy for operations of the project..."[314] This measure is inadequate mitigation under CEQA for several reasons.[315]

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[309] *Id.*
[310] *Id.*, at 93.
[311] *Id.*
[312] Fox Comments, p. 52.
[313] DEIR, p. 4.11-15.
[314] *Id.*
[315] Fox Comments, p. 52.

First, preparation of the Emissions Reduction Plan is deferred until after Project approval, preventing public review and input. The Plan must be prepared as part of a revised DEIR and circulated for public review. Otherwise, the public does not have an opportunity to evaluate the effectiveness of the GHG reduction measures.

Second, under CEQA, an EIR must not only discuss measures to avoid or minimize adverse impacts, it also must ensure that mitigation measures are fully enforceable through permit conditions, agreements, or other legally binding instruments.[316] Mitigation measures cannot be vague or have uncertain effectiveness or feasibility.[317] Thus, for example, "good faith efforts" to obtain "clean" renewable energy for project operation is a vague, unenforceable measure. Rather, a meaningful, enforceable measure would be to require CalAm to commit to using a certain amount of solar energy, which is a feasible measure proposed by Dr. Fox.[318]

Third, there is no assurance that all feasible measures will be identified unless the Plan is developed by a "qualified professional" as required in Mitigation Measure 4.18-1. Dr. Fox notes that "[t]he analyses and judgements required to draft this Plan fall under California's engineering licensing laws, specifically for Mechanical Engineers" and that the measure "should be modified to require that a registered professional engineer (mechanical) in California confirm by stamp and signature that the Plan includes all feasible measures."[319]

Fourth, Dr. Fox finds that the Plan does not provide adequate monitoring, which is a "key component of successful mitigation under CEQA... This measure should therefore be modified to require that a registered professional engineer (mechanical) in California confirm by stamp and signature that the Plan has been implemented."[320] Furthermore, Dr. Fox states that "annual tracking/reporting on

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[316] CEQA Guidelines § 15126.4, subd. (a)(2).
[317] *Kings County Farm Bur. v. County of Hanford* (1990) 221 Cal.App.3d 692, 727-28 ("a groundwater purchase agreement was inadequate mitigation because there was no record evidence that replacement water was available); *San Franciscans for Reasonable Growth v. City & County of San Francisco* (1984) 151 Cal.App.3d 61, 79.
[318] Fox Comments, p. 52-53.
[319] *Id.*, at 53.
[320] *Id.*

implementation of all measures should be required via a compliance checklist or similar documentation."[321]

Finally, the Plan focuses only on Project "operational components" including the desalination plant, pipelines, and pumping system. There are other opportunities for CalAm to reduce GHG emissions, which Dr. Fox proposes in her comments, including energy audits and retrofits at existing CalAm buildings, community energy efficiency building retrofits, funding of carbon offset programs, additional water conservation efforts and more on-site solar.[322]

b. Mitigation Measure 4.18-1

Mitigation Measure 4.18-1 requires CalAm to contract a "qualified professional" to prepare a "Construction Equipment Efficiency Plan" to identify specific measures that CalAm will implement as part of Project construction "to increase the efficient use of construction equipment to the maximum extent feasible."[323] According to Dr. Fox, this measure has deficiencies similar to Mitigation Measure 4.11-1.[324]

First, preparation of the Efficiency Plan is deferred until after the Project is approved, preventing public review. The Plan must be prepared as part of the DEIR and circulated for public review, as required under *CBE v. Richmond.*

Second, the measure does not clarify what constitutes a "qualified professional." Dr. Fox proposes that the measure "be modified to require that the qualified professional be a registered professional engineer (civil) in California and the Efficiency Plan should be confirmed by stamp and signature that the Plan includes all feasible construction equipment efficiency measures."[325]

Third, the Efficiency Plan does not include all feasible mitigation measures.[326] Dr. Fox provides a list of additional measures that were recently required as GHG construction mitigation in the Chevron Modernization Final

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[321] *Id.*
[322] *Id.*
[323] DEIR, p. 4.18-12.
[324] Fox Comments, p. 56.
[325] *Id.*
[326] *Id.*

EIR,[327] including maintenance of construction equipment, further idling restrictions and other measures.[328]

Fourth, the measure fails to identify any method to verify compliance. Dr. Fox proposes "a comprehensive inventory of all off-road equipment that will be used to construct the Project... The inventory should include the horsepower rating, engine production year, hours of use, and amount and type of fuel used."[329] Furthermore, "[a]t least 48 hours prior to the use of heavy-duty off-road equipment at a new construction site, the project representative shall provide the inspector and MBUAPCD with the construction timeline, including start date and name and phone number of project manager and on-site foreman."[330]

Finally, the Efficiency Plan fails to provide adequate monitoring, according to Dr. Fox, who suggests a similar monitoring program as stated above.[331] Dr. Fox concludes that the Efficiency Plan "fails to adequately mitigate the air quality impacts resulting from Project construction."[332]

The CPUC must ensure that all feasible mitigation is incorporated in the DEIR to address the significant and unavoidable GHG impacts. As stated in *CBE v. Richmond*, "the time... to formulate mitigation measures to minimize or avoid those impacts [is] during the EIR process, before the Project was brought to the [approving body] for final approval."[333] The DEIR must be revised in accordance with these comments and recirculated before the Project can be lawfully approved under CEQA.

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[327] Chevron Refinery Modernization Project EIR, March 2014, Chapter 4.8, Greenhouse Gases; Available at: http://chevronmodernization.com/wp-content/uploads/2014/03/4.8_Greenhouse-Gases.pdf and Chapter 5, Mitigation Measure Monitoring and Reporting Program; Available at: https://s3.amazonaws.com/chevron/Final+EIR/5_MMRP.pdf.
[328] Fox Comments, p. 57.
[329] *Id.*
[330] *Id.*, at 57-58.
[331] *Id.*
[332] *Id.*, at 58.
[333] *Communities for a Better Environment v. City of Richmond* (2010) 184 Cal.App.4th 70.

F. The DEIR Fails to Adequately Analyze and Mitigate Potentially Significant Impacts from Valley Fever

The DEIR states that digging, excavation, well-drilling and other ground-disturbing work will occur during Project construction.[334] However, the DEIR makes no mention whatsoever of the existence of Valley Fever, which is an infectious disease that is caused by inhaling the spores of *Coccidioides ssp.*, a soil-dwelling fungus.[335] Monterey County, including the Project site, is located within the established endemic range of Valley Fever and has one of the highest infection rates in California.[336] The DEIR completely fails to inform the public of the potentially significant Valley Fever health impacts from Project construction, in violation of CEQA. The DEIR must be revised and recirculated.

As explained by Dr. Fox, the fungus lives in the top 2 to 12 inches of soil. Soil disturbing activities such as digging, driving vehicles, construction activities, agricultural operations, dust storms and earthquakes can cause the fungal spores to become air borne.[337] The disease has become an increasing concern for the Monterey County Health Department.[338] In 2013, there were 70 new cases of Valley Fever reported among Monterey County residents.[339] The rate of new cases in 2013 was 15.7 cases per 100,000 individuals, well above the California statewide rate of 10.8 in 2012. Between 2009 and 2011, there were 145 hospital admissions in Monterey County due to Valley Fever, costing over $32 million. Forty one percent of these cases occurred in the north county area, which includes most of the Project facilities.[340]

Typical symptoms of Valley Fever include fatigue, fever, cough, headaches, shortness of breath, rash, muscle aches and joint pain. Symptoms of advanced Valley Fever include chronic pneumonia, meningitis, skin lesions and bone or joint

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[334] DEIR, p. 3-42.
[335] Fox Comments, p. 38.
[336] *Id.*
[337] *Id.*
[338] Valley Fever Cases Prompt Health Warning, At: http://www.valley-fever.org/.
[339] Fox Comments, p. 38.
[340] Monterey County Health Department (MCHD), Coccidioidomycosis in Monterey County. Quick Facts, May 2014, At: https://www.mtyhd.org/wp-content/uploads/2014/09/Cocci-Fact-Sheet-2013.pdf .

infections. No vaccine or known cure exists for the disease.[341] In recent years, reported Valley Fever cases in the southwestern United States have increased dramatically.[342] Between 1990 and 2008, more than 3,000 people have died in the United States from Valley Fever with about half in California.[343] There were 7 fatal cases in Monterey County between 2011 and 2013.[344]

1. Exposure to Valley Fever

Dust exposure is one of the primary risk factors for contracting Valley Fever.[345] As Dr. Fox explains, specific outdoor occupations including construction and road work increase the risk of exposure and infection. The Monterey County Health Department notes that "[w]orkers who disturb the soil by digging, operating earth-moving equipment, driving vehicles or working in dusty, wind-blown areas are more likely to breathe in the fungal spores and become infected."[346]

The most at-risk populations are construction and agricultural workers,[347] the former being the very population that would be directly exposed to Valley Fever spores by the Project. Dr. Fox cites a refereed journal article on occupational exposures stating that "[l]abor groups where occupation involves close contact with the soil are at greater risk, especially if the work involves dusty digging

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[341] Rebecca Plevin, National Public Radio, *Cases Of Mysterious Valley Fever Rise In American Southwest*, May 13, 2013; http://www.npr.org/blogs/health/2013/05/13/181880987/cases-of-mysterious-valley-fever-rise-in-american-southwest.
[342] *See* Center for Disease Control; *Fungal Pneumonia: A Silent Epidemic*, Coccidioidomycosis (Valley Fever); http://www.cdc.gov/fungal/pdf/cocci-fact-sheet-sw-us-508c.pdf.
[343] Jennifer Y. Huang, Benjamin Bristow, Shira Shafir, and Frank Sorvillo, *Coccidioidomycosis-associated Deaths*, United States, 1990–2008; http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3559166/.
[344] Fox Comments, p. 39-40.
[345] Rafael Laniado-Laborin, *Expanding Understanding of Epidemiology of Coccidioidomycosis in the Western Hemisphere*, Ann. N.Y. Acad. Sci., v. 111, 2007, pp. 20-22; Frederick S. Fisher, Mark W. Bultman, Suzanne M. Johnson, Demosthenes Pappagianis, and Erik Zaborsky, *Coccidioides Niches and Habitat Parameters in the Southwestern United States, a Matter of Scale*, Ann. N.Y. Acad. Sci., No. 1111, 2007, pp. 47-72; http://www.researchgate.net/publication/6461426_Coccidioides_niches_and_habitat_parameters_in_the_southwestern_United_States_a_matter_of_scale/file/72e7e51c9b9f058a45.pdf?origin=publication_detail.
[346] MCHD 2014, p. 2.
[347] Lawrence L. Schmelzer and R. Tabershaw, Exposure Factors in Occupational Coccidioidomycosis, Am. J. Public Health Nations Health, v. 58, no. 1, 1968, pp. 107-113, Table 3; http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1228046/?page=1.

operations."[348] One study reported that at study sites, "generally 50% of the individuals who were exposed to the dust or were excavating dirt at the sites were infected."[349] The California Department of Public Health cites the following example:

> In October 2007, a construction crew excavated a trench for a new water pipe. Within three weeks, 10 of 12 crew members developed coccidioidomycosis (Valley Fever), an illness with pneumonia and flu-like symptoms. Seven of the 10 had rashes, and one had an infection that had spread beyond his lungs and affected his skin. Over the next few months, the 10 ill crew members missed at least 1660 hours of work and two workers were on disability for at least five months.[350]

Valley Fever spores have been documented to travel as much as 500 miles[351] and, thus, dust raised during construction could potentially expose a large number of people hundreds of miles away. Therefore, the Project puts the public at large at risk for inhaling Valley Fever spores.

"Hispanics, Asians, and Native Americans are often considered to suffer from Valley Fever with the worst symptoms more often than Caucasians."[352] The most recent California Department of Public Health report indicates that Hispanics accounted for more than a quarter of all reported cases statewide in 2012, the last year for which data was recorded.[353] As explained by Dr. Fox, "the most recent census data indicates that 56.8% of the population is Hispanic in Monterey County."[354] Hispanic people are therefore likely to be present in the work force.

Other risk factors include diabetes, malnutrition and socioeconomic status. "Even the risk of 'socioeconomic status' with an annual income below $15,000 was seen to be a risk factor for the most serious Valley Fever conditions. As Dr. Fox

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[348] *Id.*, at 110.
[349] Fisher et al., 2007.
[350] CDPH June 2013, p. 1.
[351] David Filip and Sharon Filip, Valley Fever Epidemic, Golden Phoenix Books, 2008, p. 24.
[352] Filip and Filip, 2008, p. 29.
[353] California Department of Public Health, Coccidioidomycosis Yearly Summary 2012, p. 4; available at http://www.cdph.ca.gov/programs/sss/Documents/COCCI-UPDATED2012YEARLY.pdf.
[354] Fox Comments, p. 42.

noted, "Monterey County has a poverty rate of 17.9%, again indicating a high proportion of sensitive populations."[355]

Dr. Fox concludes that "[t]he DEIR fails to inform the public of the potential significant consequences of Project construction and fails to address the associated environmental justice issues,"[356] in violation of CEQA. The CPUC must revise the DEIR to disclose, analyze and mitigate the public health impacts from Valley Fever.

2. A Conventional Dust Control Plan Is Inadequate to Address Health from Valley Fever

Dr. Fox explains that "[c]onventional dust control measures that are included in the mitigation measures for the Project in Mitigation Measures 4.10-1 and 4.10-2 are not effective at controlling Valley Fever as they largely focus on visible dust or larger dust particles (PM10) and not the fine particles where the Valley Fever spores are found."[357] While dust exposure is one of the primary risk factors for contracting Valley Fever and dust-control measures are an important defense against infection, PM10 and visible dust are only indicators that Valley Fever spores may be airborne in a given area. Freshly generated dust clouds usually contain a larger proportion of the more visible coarse particles. However, according to Dr. Fox, "these larger particles settle more rapidly and the remaining fine respirable particles may be difficult to see and are not controlled by conventional dust control measures."[358]

Valley Fever spores have slow settling rates in air due to their small size (2 to 5 micrometers), low terminal velocity, and possibly also due to their buoyancy, barrel shape and commonly attached empty hyphae cell fragments.[359] Spores, whose size is well below the limits of human vision, may be present in air that appears relatively clear and dust free and they can remain aloft for long periods and be carried hundreds of kilometers from their point of origin. Thus, as explained by

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[355] *Id.*, at 43.
[356] *Id.*
[357] *Id.*
[358] *Id.*
[359] Frederick S. Fisher, Mark W. Bultman, and Demosthenes Pappagianis, *Operational Guidelines (version 1.0) for Geological Fieldwork in Areas Endemic for Coccidioidomycosis* (Valley Fever), U.S. Geological Survey Open-File Report 00-348, 2000; http://geopubs.wr.usgs.gov/open-file/of00-348/of00-348.pdf.

Dr. Fox, "implementation of conventional dust control measures will not provide sufficient protection for both on-site workers and the general public."[360]

The majority of cases of Valley Fever occur during the months of June through December. Typically, the risk of catching Valley Fever begins to increase in June and continues an upward trend until it peaks during the months of August, September and October.[361] Drought periods can have an especially potent impact on Valley Fever if they follow periods of rain.[362] It is thought that during drought years the number of organisms competing with Valley Fever decreases and the fungus remains alive but dormant. When rain finally occurs, the arthroconidia germinate and multiply more than usual because of a decreased number of other competing organisms.[363] When the soil dries out in the summer and fall, the spores can become airborne and potentially infectious.[364] Dr. Fox notes that "[t]he current drought conditions in California may well increase the occurrence of Valley Fever cases... Thus, major onsite and offsite soil-disturbing construction activities should be timed to occur outside of a prolonged dry period."[365]

3. Recommended Measures to Reduce Risk of Valley Fever

In response to an outbreak of Valley Fever in construction workers in 2007 at a construction site for a solar facility within San Luis Obispo County, its Public Health Department[366] in conjunction with the California Department of Public Health[367] developed recommendations to limit exposure to Valley Fever based on scientific information from the published literature. Dr. Fox explains that "[t]he recommended measures go far beyond the conventional dust control measures

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[360] Fox Comments, p. 44.
[361] Kern County Public Health Services Department, *What Is Valley Fever, Prevention, Valley Fever Risk Factors*; http://kerncountyvalleyfever.com/what-is-valley-fever/risk-factors/.
[362] Gosia Wozniacka, Associated Press, *Fever Hits Thousands in Parched West Farm Region*, May 5, 2013, citing Prof. John Galgiani, Director of the Valley Fever Center for Excellence at the University of Arizona; http://abcnews.go.com/m/story?id=19113795.
[363] Fox Comments, p. 44.
[364] Theodore N. Kirkland and Joshua Fierer, *Coccidioidomycosis: A Reemerging Infectious Disease, Emerging Infectious Diseases*, Vol. 3, No. 2, July-September 1996; http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2626789/pdf/8903229.pdf.
[365] Fox Comments, p. 44.
[366] San Luis Obispo County Health Agency, *Recommendations for Workers to Prevent Infection by Valley Fever in SLO County*; http://www.slocounty.ca.gov/Assets/PH/Epidemiology/Cocci+Recomendations.pdf.
[367] CDPH June 2013, pp. 4-6.

recommended in the DEIR to control PM10 emissions."[368] The measures include working with a medical professional with expertise in Valley Fever to develop a training program for all employees, implementing dust control measures specifically geared toward Valley Fever, preventing transport of the spores outside endemic areas through various measures and improving medical surveillance for employees, among other measures. Dr. Fox provides further details on these measures and recommends their implementation in order to reduce the Project's significant impacts from Valley Fever.[369]

In addition, two other studies have developed complementary recommendations to minimize the incidence of Valley Fever. The U.S. Geological Survey ("USGS") has developed recommendations to protect geological field workers in endemic areas.[370] An occupational study of Valley Fever in California workers also developed recommendations to protect those working and living in endemic areas.[371] These two sources identified several measures, in addition to those identified by the San Luis Obispo County Public Health Department, to minimize the exposure to Valley Fever. The measures include implementing a vigorous program of medical surveillance, aggressive enforcement of respiratory [equipment] use where exposures from manual digging are involved and other measures further which are detailed in Dr. Fox's comments.

Dr. Fox explains that the DEIR's PM10 control measures do not include these measures. Some similar measures are required, but they do not go far enough to prevent Valley Fever. Dr. Fox notes that "[p]rojects that have implemented conventional PM10 dust control measures, such as those proposed here, have experienced several incidences of severe dust storms and reported cases of Valley Fever."[372] For example, construction of First Solar's Antelope Valley Solar Ranch One ("AVSR1") was officially halted in April 2013 due to the company's failure to bring the facility into compliance with ambient air quality standards, despite similar dust control measures.[373] In addition, at two photovoltaic solar energy projects in San Luis Obispo

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[368] Fox Comments, p. 45.
[369] *Id.*
[370] Fisher et al. 2000.
[371] Schmelzer and Tabershaw, 1968, pp. 111 - 113.
[372] Fox Comments, p. 49.
[373] *Id.*

County, Topaz Solar Farm and California Valley Solar Ranch, 28 construction workers contracted Valley Fever. One man was digging into the ground and inhaled dust and subsequently became ill. A blood test confirmed Valley Fever.[374]

In sum, Dr. Fox concludes that "[a]ll of the above health-protective measures recommended by the San Luis Obispo County Public Health Department and the California Department of Public Health are feasible for the Project and must be required in an enhanced dust control plan to reduce the risk to construction workers, on-site employees and the public of cont[r]acting Valley Fever."[375] Many of these measures have been required by the County of Monterey in other EIRs.[376] The CPUC must include these measures in a revised DEIR.

G. The DEIR Fails to Adequately Describe, Analyze and Mitigate Potentially Significant Impacts to Jurisdictional Waters

The DEIR fails to adequately describe, analyze and mitigate impacts to the jurisdictional washes on the Project site. According to the DEIR, "[a] formal wetland delineation has not been conducted for the [P]roject."[377] The Project area was informally evaluated for state and federal jurisdictional waters "through examination of the United States Geological Survey (USGS) topographic quadrangles containing the project area, National Wetland Inventory (NWI) maps, and reconnaissance-level field surveys conducted for the MPWSP in 2012 and 2013..."[378] For the potential waters that were identified through these means, the DEIR concludes that the Project "may have direct effects on these potential waters of the U.S. and/or waters of the State."[379]

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[374] Julie Cart, Los Angeles Times, *28 Solar Workers Sickened by Valley Fever in San Luis Obispo* County May 01, 2013; available at http://articles.latimes.com/2013/may/01/local/la-me-ln-valley-fever-solar-sites-20130501.
[375] Fox Comments, p. 49-50.
[376] County of Monterey, California Flats Solar Project Final Environmental Impact Report, December 2014; Available at: http://www.co.monterey.ca.us/Planning/major/California%20Flats%20Solar/FEIR/FEIR_PLN120294_122314.pdf.
[377] DEIR, p. 4.6-159.
[378] *Id.*
[379] *Id.*

However, without an accurate description of jurisdictional waters, the public is precluded from assessing all impacts to jurisdictional waters. This is particularly important in light of the Clean Water Rule clarifying the protection of navigable waters and their tributaries, which was recently finalized by the EPA and Corps.[380] For example, the rule clarifies that western vernal pools are considered jurisdictional waters. The DEIR states that "[v]ernal ponds (including the pond associated with Locke-Paddon Park) occur in the vicinity of the proposed Desalinated Water Pipeline alignment and could be adversely affected by pipeline construction."[381] However, in the DEIR's discussion of impacts to potential jurisdictional waters within the Desalinated Water Pipeline area, there does not appear to be an analysis of impacts to the vernal ponds, but only to riparian woodland and scrub.[382]

In addition, the DEIR improperly relies on compliance with the NPDES Construction General Permit and implementation of a SWPPP to conclude that many of the impacts to jurisdictional waters would be less than significant. For example, the DEIR states that "mandatory compliance with the NPDES Construction General Permit, including implementation of BMPs in the project's SWPPP, would manage soil erosion and protect water quality, thereby avoiding significant impacts to water quality in the drainage ditch and the Salinas River."[383] The DEIR then concludes that "the impact to the Salinas River and the drainage ditch would be less than significant and no mitigation is necessary."[384] CEQA prohibits the CPUC from basing its significance determinations on the Project's compliance with regulations and laws.[385]

In addition, Mitigation Measure 4.6-3 does not adequately mitigate impacts to jurisdictional waters because it (1) defers a wetlands delineation, (2) defers important design elements of the Project, (3) defers a Wetland Mitigation and Monitoring Plan, (4) defers other mitigation elements to "project permits issued by the U.S. Army Corps of Engineers, Regional Water Quality Control Board, California Department of Fish and Wildlife, and/or the California Coastal

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[380] 40 CFR 230.3.
[381] DEIR, p. 4.6-72.
[382] *Id.*, at 4.6-162.
[383] *Id.*, at 4.6-161.
[384] *Id.*
[385] *See Communities for a Better Env't v. California Res. Agency* (2002) 126 Cal.Rptr.2d 441, 453; *Keep our Mountains Quiet v. County of Santa Clara* (2015) Case No. H039707, p. 21.

Commission,"[386] and (5) is vague in its reference to mitigation through in-lieu fees, which requires more detailed information to satisfy CEQA requirements.[387] The CPUC may not approve the Project until impacts to jurisdictional waters are accurately described, analyzed and mitigated in a revised DEIR.

H. The DEIR Fails to Adequately Analyze and Mitigate Potentially Significant Impacts from Decommissioning Activities

At the end of the Project's 40-year life,[388] the Project would be decommissioned. As explained above, the decommissioning phase of the Project is part of the whole Project. CEQA requires the CPUC to analyze all phases of the Project. Despite this requirement, the DEIR provides no analysis of the Project's decommissioning activities and, thefore, violates CEQA.

As explained above, the DEIR only briefly mentions decommissioning in the context of Mitigation Measure 4.2-6a for impacts relating to coastal erosion.[389] Furthermore, the DEIR and other environmental documents relating to the Project appear to acknowledge a decommissioning phase, at least for the slant wells.[390] But this is the extent of the discussion.

Project components include the slant wells, pipelines, injection wells and other associated materials. During Project decommissioning, well materials may have to be removed or destroyed in accordance with state well destruction standards. For example, California Well Standards Bulletin 74-81 and 74-90 requires removal or destruction of wells that are no longer useful or are abandoned.[391] Assuming the slant wells would no longer be used at the end of the Project's 40-year life, these standards would apply to the slant wells. The MRWPCA expressed concerns during the test slant well environmental review that

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[386] *Id.*, at 4.6-169.
[387] *See California Native Plant Society v. County of El Dorado* (2009) 170 Cal. App. 4th 1026 (Where an appellate court held that the payment of an in-lieu fee for impacts to rare plants, where the in-lieu project was not reviewed under CEQA, failed to establish that the environmental impacts of the development project were fully mitigated).
[388] DEIR, p. 4.11-9.
[389] *Id.*, at 4.2-64.
[390] *Id.*, at 5-24; http://montereybay.noaa.gov/resourcepro/resmanissues/pdf/140912calam-slantwell_ea-final.pdf.
[391] http://www.water.ca.gov/groundwater/well_info_and_other/california_well_standards/wws/wws_combined_sec20-22.html#22.

removal of the well could adversely affect Land and Ocean Outfalls even more than construction,[392] likely because of the type of activities needed for well destruction. The California Well Standards describe an intensive process for destroying wells, including cleaning, excavation, removing materials, filling, sealing and other activities.[393]

The CPUC must provide a complete description of the decommissioning activities necessary to assess all of the Project's impacts. Decommissioning of desalination facilities has been associated with noise, air quality, biological resources, hazardous materials and waste management, human health and safety, soils and geologic resources, transportation, water resources and water quality impacts, and has been included as part of the project in other desalination plant environmental reviews around the world.[394] The public and decision makers cannot engage in a meaningful assessment of these potential impacts without a proper description and analysis of decommissioning-related impacts.

Furthermore, the CPUC has enough information, such as the type of equipment to be utilized and range of activities to be performed, as well as baseline knowledge of impacts resulting from the Project's construction and operation, to make a reasonable assessment of impacts from decommissioning. The courts may not look for "perfection" but would expect "adequacy, completeness, and a good faith effort at full disclosure,"[395] which has not occurred here. Moreover, the CPUC is open to a "prejudicial abuse of discretion ... if the failure to include relevant information precludes informed decision-making and informed public participation, thereby thwarting the statutory goals of the EIR process."[396]

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[392] MRWPCA Comments on Test Slant Well IS/MND, June 17, 2014, **Attachment H.**

[393] http://www.water.ca.gov/groundwater/well_info_and_other/california_well_standards/wws/wws_combined_sec23.html.

[394] Test Slant Well IS/MND ("Earthwork (i.e., trenching and excavation) would generate fugitive dust during construction *and decommissioning* activities") (emphasis added), http://www.watersupplyproject.org/Websites/coastalwater/files/Content/4503543/Slant_Test_Well_Draft_IS-MND_051614_2014.pdf; https://www.miga.org/documents/Befesa_Desalination_EIA_Report.pdf; http://www.transnet.net/BusinessWithUs/EnvPubDoc/Saldanha/RevOsmPlant/FinalForPublicComment/RO%20Plant%20-%20Desalination%20Plant%20Final.pdf.

[395] CEQA Guidelines, section 15151.

[396] *Laurel Heights Improvement Assn. v. Regents of University of California* 47 Cal.3d at pp. 403-405, 253 Cal.Rptr. 426, 764 P.2d 278.

For example, the DEIR fails to adequately investigate and mitigate air quality impacts related to decommissioning, which may be similar in nature to construction emissions. The construction phase already produces emissions beyond an acceptable threshold, as explained above, and it is unclear whether the mitigation measures for construction would be required during decommissioning. To properly disclose the Project's impacts from decommissioning, the CPUC must revise the DEIR to include the type (i.e., direct, indirect, or cumulative), the duration (i.e., temporary or permanent), the nature (i.e., source) and extent (i.e. scale) of the associated potential impacts. The CPUC must then develop mitigation measures that are certain, enforceable and linked to measurable performance standards. Absent additional information, the CPUC cannot conclude that the Project's impacts have been fully assessed and properly mitigated.

V. MITIGATION MEASURES PROPOSED IN THE DEIR ARE DEFERRED, UNENFORCEABLE OR OTHERWISE INADEQUATE

In enacting CEQA, the Legislature declared that it is "the policy of the state that public agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects."[397] An EIR is inadequate unless it includes "a detailed statement setting forth . . . mitigation measures proposed to minimize [the project's] significant effects on the environment."[398] CEQA requires lead agencies to incorporate all feasible mitigation measures into a project to reduce the project's potentially significant impacts to a level of insignificance.[399] Finally, CEQA requires the lead agency to find, based on substantial evidence, "that the mitigation measures are required in or incorporated into the project; or that the measures are the responsibility of another agency and have been, or can and should be, adopted by the other agency."[400]

Courts have imposed several parameters for the adequacy of mitigation measures. We address some of the relevant criteria here. First, the lead agency may not defer the formulation of mitigation measures until a future time, unless the EIR also specifies the specific performance standards capable of mitigating the

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[397] Pub. Resources Code § 21002.
[398] Pub. Resources Code § 21100(b)(3); CEQA Guidelines §§ 15126(e).
[399] *See* Pub. Resources Code § 21081(a)(1)-(3); CEQA Guidelines §§ 15002(a)(3), 15021(a)(2), 15091(a)(1).
[400] *Federation of Hillside & Canyon Associations v. City of Los Angeles* (2000) 83 Cal.App.4th 1252, 1260 (internal quotations omitted).

project's impacts to a less than significant level.[401] Deferral is impermissible where an agency "simply requires a project applicant to obtain a . . . report and then comply with any recommendations that may be made in the report."[402] Second, a public agency may not rely on mitigation measures of uncertain efficacy or feasibility.[403] Third, "[m]itigation measures must be fully enforceable through permit conditions, agreements, or other legally binding instruments."[404] Fourth, mitigation measures that are vague or so undefined that it is impossible to evaluate their effectiveness are legally inadequate.[405]

As explained in the following paragraphs, there are several mitigation measures in various sections of the DEIR that are deferred, unenforceable or otherwise inadequate. The DEIR must be revised to include effective and enforceable mitigation for all significant impacts.

A. The DEIR Does Not Adequately Incorporate Compliance with Laws as Enforceable Mitigation

The DEIR concludes in several sections that the Project's compliance with laws and regulations are sufficient to mitigate potentially significant impacts to a level of insignificance. In many cases, the DEIR simply concludes that impacts are less than significant by assuming compliance with laws. However, compliance with a regulation or law is not an indication of the sufficiency of mitigation measures where there is substantial evidence that the project may result in significant impacts.[406] CEQA requires a lead agency to fully assess the significance of a Project's impacts in light of substantial evidence "notwithstanding compliance with the adopted regulations or requirements."[407] Furthermore, the DEIR may not simply assert "a bare conclusion ... not supported by facts or analysis."[408]

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[401] CEQA Guidelines, § 15126.4(a)(1)(B); *Endangered Habitats League v. County of Orange* (2005) 131 Cal.App.4th 777, 793-94; *Defend the Bay v. City of Irvine* (2004) 119 Cal.App.4th 1261, 1275.
[402] *Defend the Bay v. City of Irvine* (2004) 119 Cal.App.4th 1261, 1275.
[403] *Kings County Farm Bureau v. City of Hanford* (1990) 221 Cal.App.3d 692, 727 (finding groundwater purchase agreement inadequate mitigation measure because no record evidence existed that replacement water was available).
[404] CEQA Guidelines § 15126.4(a)(2).
[405] *San Franciscans for Reasonable Growth v. City & County of San Francisco* (1984) 151 Cal.App.3d 61,79.
[406] *Keep our Mountains Quiet v. County of Santa Clara* (2015) Case No. H039707; *Communities for a Better Env't v. California Res. Agency* (2002) 126 Cal.Rptr.2d 441.
[407] CEQA Guidelines § 15064.4.
[408] *Association of Irritated Residents v. County of Madera* (2003) 107 Cal.App.4th 1383, 1390-1391.

In *Communities for a Better Env't v. California Res. Agency*, the court struck down a CEQA Guideline because it "impermissibly allow[ed] an agency to find a cumulative effect insignificant based on a project's compliance with some generalized plan rather than on the project's actual environmental impacts."[409] The court concluded that "[i]f there is substantial evidence that the possible effects of a particular project are still cumulatively considerable notwithstanding that the project complies with the specified plan or mitigation program addressing the cumulative problem, an EIR must be prepared for the project."[410] Thus, the ruling supports the notion that compliance with an applicable standard outside of the CEQA process does not automatically obviate a lead agency's obligation to consider substantial evidence and analyze and mitigate potentially significant impacts.

In *Keep our Mountains Quiet v. County of Santa Clara*, neighbors of a wedding venue sued over the County's failure to prepare an EIR due to significant noise impacts. The court concluded that "a fair argument [exists] that the Project may have a significant environmental noise impact" and reasoned that although the noise levels would likely comply with local noise standards, "compliance with the ordinance does not foreclose the possibility of significant noise impacts."[411] The court ordered the County to prepare an EIR.

Here, the DEIR abdicates its duty under CEQA in several resource areas. For example, under Impact 4.2-1 (increased soil erosion or loss of topsoil during construction), the DEIR finds that the Project "could result in increased soil erosion or loss of topsoil."[412] However, the DEIR concludes that "Project construction activities would be subject to the requirements of the NPDES Construction General Permit, the Monterey County Grading Ordinance, the Monterey County Erosion Control Ordinance and similar grading and erosion control ordinances of the affected incorporated areas;" therefore, "impacts associated with substantial increases in soil erosion during construction would be less than significant for all project components."[413] The DEIR fails to provide further substantive analysis and mitigation for soil erosion impacts aside from requirements under the applicable laws. In addition, compliance with these laws is not encapsulated as enforceable mitigation. Simply assuming the Applicant will comply with laws outside of CEQA

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[409] *Communities for a Better Env't v. California Res. Agency* (2002) 126 Cal.Rptr.2d 441, 453.
[410] *Id.*
[411] *Keep our Mountains Quiet v. County of Santa Clara* (2015) Case No. H039707, p. 21.
[412] DEIR, p. 4.2-50.
[413] *Id.*

does not satisfy CEQA's requirement for a full analysis and mitigation of potentially significant impacts.

Additional impacts that are assumed to be less than significant based on compliance with other laws include:

> damage to structural elements from earthquake (Impact 4.2-3); exposure of people or structures to substantial adverse effects related to liquefaction and lateral spreading (Impact 4.2-4); water quality impact associated with construction activities (Impact 4.3-1); discharges of treated water and disinfectant from existing and newly installed pipelines during construction (Impact 4.3-3); degradation of water quality due to discharges associated with maintenance of the subsurface intake wells and ASR injection/extraction wells (Impact 4.3-6); alteration of drainage patterns such that there is a resultant increase in erosion, siltation, or the rate or amount of surface runoff (Impact 4.3-7); adverse effects on the water quality of critical habitat along the Salinas River and impacts to steelhead within the Salinas River (Impact 4.6-1); and construction-related impact to water quality in jurisdictional waters related to increased soil erosion and/or inadvertent releases of toxic construction chemicals (Impact 4.6-3).

In the analyses for all of these impacts, the DEIR acknowledges the impacts could be significant, but then concludes no significant impact based on compliance with laws without actually incorporating any enforceable mitigation. For example, under Impact 4.3-3, the DEIR states:

> The treated water generated from the draining of existing pipelines and the effluent generated from disinfection of newly installed pipelines would be discharged to the local storm drainage system. Without proper controls, these discharges could adversely affect water quality in downstream receiving water bodies by increasing turbidity (if discharged directly without appropriate treatment) or due to high chlorine (the primary disinfectant used for drinking water) concentrations.[414]

The DEIR further states that "General [Waste Discharge Requirements] WDRs require that CalAm neutralize the residual chlorine remaining in disinfection effluent such that detectable chlorine levels are less than 0.02 mg/L,

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[414] *Id.*, at 4.3-62.

and require that the total dissolved solids be within surface water and groundwater quality objectives."[415] The DEIR then concludes that "[c]ompliance with the General WDRs and the conditions therein would protect water quality in receiving water bodies [and] the impact would be less than significant,"[416] without requiring any mitigation. Under CEQA, the DEIR must actually analyze the potential for the increased turbidity and high chlorine levels, and incorporate compliance with the WDR standards as enforceable mitigation.

The CPUC may not rely solely on compliance with regulations or laws as reducing impacts to less than significant levels without a full analysis of impacts or enforceable mitigation. As the DEIR is currently presented, the CPUC cannot conclude that the Project's impacts have been fully assessed and properly mitigated.

B. The DEIR Improperly Treats Mitigation as Part of the Project

In *Lotus v. Department of Transportation*, an EIR approved by CalTrans contained several measures "[t]o help minimize potential stress on the redwood trees" during construction of a highway.[417] Although those measures were clearly separate mitigation, the project proponents considered them "part of the project," and the EIR concluded that because of the planned implementation of those measures, no significant impacts were expected.[418] However, the appellate court found that because the EIR had "compress[ed] the analysis of impacts and mitigation measures into a single issue, the EIR disregard[ed] the requirements of CEQA."[419] The Court continued, stating "[a]bsent a determination regarding the significance of the impacts... it is impossible to determine whether mitigation measures are required or to evaluate whether other more effective measures than those proposed should be considered."[420]

Similarly, the DEIR improperly relies on measures that are not enforceable mitigation, but merely part of the Project description. For example, the DEIR indicates that slant wells would need maintenance for a period of 9 to 18 weeks every 5 years.[421] The DEIR asserts that "[m]aintenance activities would be

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[415] *Id.*
[416] *Id.*
[417] *Lotus v. Department of Transportation*, 223 Cal.App.4th at 650.
[418] *Id.*, at 651.
[419] *Id.*, at 656.
[420] *Id.*
[421] DEIR, p. 3-52.

conducted between October and February to avoid the nesting season for snowy plover."[422] The DEIR then concludes that "[w]ork during the non-breeding season would avoid potential impacts to breeding snowy plovers... [t]herefore, impacts to wintering western snowy plover habitat would be less than significant."[423] However, this measure is not incorporated into Mitigation Measure 4.6-1d (mitigation for snowy plovers). The measure appears to only apply to construction, and while there is a general reference to "work" at the slant wells, it only requires avoidance of nesting season "to the extent practicable."[424] The DEIR's conclusion that impacts to the snowy plover are less than significant is based on a measure that is not incorporated as fully enforceable mitigation, but rather is incorporated as part of the Project.

The slant well cleaning measure is comparable to the risk avoidance measures at issue in *Lotus*.[425] In addition, the measures described above that rely on compliance with laws to reduce impacts to less than significant levels are also comparable to the *Lotus* measures. For those measures, the DEIR again fails to acknowledge a potentially significant impact that requires enforceable mitigation, but rather assumes there are less than significant impacts based on compliance with laws that are not necessarily enforceable under CEQA.

The DEIR must separately identify and analyze the significance of the Project's impacts *before* proposing mitigation measures. If the CPUC's less than significant conclusions rely on compliance with avoidance or impact reduction measures, then it should characterize such compliance as mitigation for the significant impact, rather than treating the impact as less than significant and claiming that no mitigation is required.

VI. THE DEIR FAILS TO CARRY FORWARD THE MONTEREY BAY REGIONAL WATER PROJECT AND PEOPLES' MOSS LANDING WATER DESALINATION PROJECT AS ALTERNATIVES

The Agency is required to consider project alternatives that might eliminate or reduce the Project's significant adverse environmental effects. CEQA requires that an EIR "[d]escribe a range of reasonable alternatives . . . which could feasibly attain the basic objectives of the project and evaluate the comparative merits of the

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[422] *Id.*
[423] *Id.*, at 4.6-177.
[424] *Id.*, at 4.6-129.
[425] *Id.*, at 4.9-26.

alternatives."[426] An EIR must "produce information sufficient to permit a reasonable choice of alternatives so far as environmental aspects are concerned."[427] The key issue is whether the alternatives analysis fosters informed decision-making and informed public participation.[428]

The discussion must focus on alternatives capable of either eliminating any significant adverse environmental effects or reducing them to a level of insignificance, even if such alternatives would be more costly or to some degree would impede the project's objectives. One of the most substantive aspects of CEQA is that section 21002 of the statute forbids agencies from approving projects with significant adverse impacts when feasible alternatives (or feasible mitigation measures) can substantially lessen such impacts.[429]

Here, the DEIR provides some background in the alternatives analysis on the Monterey Bay Regional Water Project ("MBRWP") and the Peoples' Moss Landing Water Desalination Project ("Peoples' Project"), but states for both:

> This desalination proposal has not been carried forward as an alternative to the MPWSP because the CPUC has no jurisdiction, the applicant has not yet engaged in any formal environmental review processes, project effects cannot be reasonably ascertained and the timing of its implementation remains uncertain.[430]

Thus, the DEIR does not evaluate the full MBRWP or the full Peoples' Project as alternatives.

However, on June 24, 2015 the Board of Directors of the Moss Landing Harbor District unanimously voted to authorize the Notice of Preparation ("NOP")

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[426] CEQA Guidelines § 15126(d); *Village Laguna of Laguna Beach v. Board of Supervisors*, 134 Cal.App.3d 1022, 1028 (1982); *Citizens of Goleta Valley v. Board of Supervisors (Goleta I)*, 197 Cal.App.3d 1167, 1180-81 (1988).
[427] *San Bernardino Valley Audubon Soc'y v. County of San Bernardino*, 155 Cal.App.3d 738, 750-51 (1984).
[428] CEQA Guidelines § 15126.6.
[429] *Sierra Club v. Gilroy City Council*, 222 Cal.App.3d 30, 41 (1990); *Citizens for Quality Growth v. City of Mount Shasta*, 198 Cal.App.3d 433, 440-41 (1988); *Kings County Farm Bureau v. City of Hanford*, 221 Cal.App.3d 692, 711, 730-31 (1990); Pub. Res. Code section 21081.
[430] DEIR, p. 7-12, 7-14.

for the Peoples' Project, which contains a project description and background.[431] In addition, an NOP was released on June 1, 2015 for the MBRWP, which also contains details on that project.[432] Furthermore, alternatives analyses in environmental reviews are not necessarily exempt from considering alternatives outside the jurisdiction of the lead agency.[433]

Although the DEIR does evaluate some common components of the project as options for these projects, the DEIR's failure to consider the projects as "whole alternative[s]"[434] does not satisfy CEQA's requirement to fully consider all feasible alternatives. The DEIR must be revised to incorporate this new information regarding the NOP and must include an analysis of the whole MBRWP and Peoples' Project.

VII. CONCLUSION

The DEIR does not satisfy CEQA's procedural and evidentiary standards for the preparation of an EIR. The DEIR fails to include an adequate description of the Project and fails to adequately describe the environmental setting. The DEIR also fails to address the Project's potentially significant impacts to worker and public health as well as several resources on and around the Project site including the ocean and other jurisdictional waters, biological resources, air quality and other resources. Furthermore, the DEIR proposes mitigation measures that are deferred, unenforceable, or otherwise inadequate to mitigate impacts to below a level of significance, or in the case of significant and unavoidable impacts, the DEIR fails to propose all feasible mitigation. For these reasons, the CPUC must withdraw the DEIR and prepare a revised DEIR that adequately analyzes and proposes all necessary and feasible mitigation to reduce the Project's potentially significant environmental impacts.

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[431] Notice of Preparation, Environmental Impact Report for People's Moss Landing Water Desalination Project, **Attachment I.**
[432] Notice of Preparation / Notice of Intent of a Draft Environmental Impact Report/Environmental Impact Statement and Notice of Public Scoping Meeting, June 1, 2015, **Attachment J.**
[433] CEQA Guidelines Section § 15126.6(f)(1) ("No one of these factors establishes a fixed limit on the scope of reasonable alternatives.").
[434] DEIR, p. 7-199.

Sincerely,

Laura E. Horton

LEH:clv

Attachments

ATTACHMENT A

Comments

on

Draft Environmental Impact Report

for the

CalAm Monterey Peninsula

Water Supply Project

Prepared

for

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Prepared by

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July 1, 2015

I reviewed the air quality and greenhouse gas sections of the Draft Environmental Impact Report (DEIR) for the California American Water Company (CalAm) Monterey Peninsula Water Supply Project (Project).[1] The purpose of the Project is to replace existing water supplies that were limited by the adjudication of the Carmel River and Seaside Groundwater Basin. The Project would replace the lost water with desalinated sea water and increase the CalAm storage capacity in the Seaside Groundwater Basin. The Project includes construction of up to ten subsurface slant wells, a 9.6-MGD desalination plant to produce about 10,267 ac-ft/yr of desalinated water, improvements to the existing Seaside Groundwater Basin Aquifer Storage and Recovery (ASR) system facilities, 30 miles of pipeline, two pump stations, a Terminal Reservoir, and water storage tanks. DEIR, Table ES-2 & Chapter 2.

I. CRITERIA POLLUTANT EMISSIONS

The Project would emit pollutants limited by state and federal ambient air quality standards during construction and operation. These include: carbon monoxide (CO), reactive organic gases (ROG), nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter equal to or smaller than 10 microns (PM10), and particulate matter equal to or smaller than 2.5 microns (PM2.5).

A. The DEIR Fails to Evaluate the Significance of All Pollutants

The DEIR did not evaluate the significance of pollutants for which the Monterey Bay Unified Air Pollution Control District (MBUAPCD) had not set official CEQA significance thresholds. A lead agency has discretion to determine how to classify the significance of impacts. However, it does not have discretion to simply not evaluate the significance of impacts. Further, its judgment must be supported by scientific information and other factual data. CEQA Guidelines §15064(b). Here, the CPUC has simply failed to evaluate the significance of impacts from three pollutants, PM2.5, NO_2 for impacts other than its contribution to ozone, and ROG for its impacts other than its contribution to ozone.

The significance criteria discussed below will be used in subsequent sections to evaluate construction and operational impacts of the Project.

1. PM2.5 Significance Criteria

Fine particulate matter, PM2.5, is considered even more dangerous to human health than PM10 due to its ability to lodge more deeply into lung tissue. Short term

[1] ESA, Monterey Peninsula Water Supply Project Draft Environmental Impact Report, Prepared for California Public Utilities Commission, April 2015; Available at: http://www.cpuc.ca.gov/Environment/info/esa/mpwsp/deir_toc.html.

exposure to particulate matter, such as occur during construction, can aggravate lung disease, cause asthma attacks and acute bronchitis, may increase susceptibility to respiratory infections and has been linked to heart attacks. Further, when fugitive dust enters the atmosphere, the larger particles of dust, such as PM10, typically fall quickly to the ground, but smaller particles less than 10 microns in diameter may remain suspended for longer periods, travelling across a regional area and affecting receptors at large distances from the original source. Thus, it is important to assess the significance of the Project's PM2.5 emissions.

The DEIR did not establish a significance threshold for PM2.5, even though the BAAQMD and other air districts have established PM2.5 thresholds based on substantial evidence that the CPUC could have and should have relied on. However, the DEIR cites one criterion from the CEQA Guidelines that is applicable to PM2.5, which could have and should have been used here to evaluate the significance of PM2.5 emissions.

a. PM2.5 Ambient Air Quality Standards

Appendix G of the CEQA Guidelines recommends one of the significance criteria for evaluating air quality impact as: "violate any air quality standard or contribute substantially to an existing or proposed air quality violation." DEIR, p. 4.10-15. Federal and state air quality standards have been set for PM2.5. DEIR, Table 4.10-2. The DEIR could have used conventional dispersion modeling to determine if Project PM2.5 construction and operational emissions would exceed these air quality standards. However, the DEIR did not use these criteria to evaluate the significance of PM2.5 emissions, but rather argued that all it was required to do by MBUAPCD was disclose the amount of PM2.5 emissions. DEIR, p. 4.10-16. Regardless of MBUAPCD procedures, CEQA requires an in-depth impacts analysis, rather than simply disclosing emissions.

b. PM2.5 CEQA Significance Thresholds from Other Air Districts

Alternatively, the CPUC could have used PM2.5 significance thresholds adopted by other air districts, as it did for GHG emissions.

The South Coast Air Quality Management District (SCAQMD) has established two PM2.5 significance thresholds which apply to both construction and operational emissions: (1) a regional threshold of 55 lb/day and localized thresholds, reported in lookup tables as a function of location within the SCAQMD, receptor distance, and

project size.[2] The DEIR relied on this SCAQMD document to establish PM2.5 fractions used to calculate PM2.5 emissions and other SCAQMD CEQA guidance to establish the greenhouse gas (GHG) emission significance threshold (DEIR, p. 4.11-9) but failed to mention the SCAQMD's significance thresholds for PM2.5. DEIR, p. 4.10-17.

The Mendocino County Air Quality Management District (MCAQMD) has established a PM2.5 CEQA significance threshold of 54 lb/day.[3] The Bay Area Air Quality Management District (BAAQMD) has also established PM2.5 CEQA significance thresholds of 10 ton/yr and 54 lb/day for exhaust emissions,[4] but their formal adoption has been stayed due to an appeal to the California Supreme Court. However, the appeal deals with whether adoption of the thresholds was a project under CEQA, rather than the merits of the thresholds themselves.

The Project's daily increase in PM2.5 emissions as estimated in the DEIR is less than these regional thresholds, but exceed several of SCAQMD's local thresholds in the lookup tables, suggesting that similar tables should be created for the Project site.

However, the revised PM2.5 emissions, based on my review of the calculations in Appendix G discussed further below, indicate that revised construction PM2.5 emissions (Table 3) and revised mitigated construction emissions (Table 4) are highly significant under all of these thresholds and must be mitigated.

2. Nitrogen Oxides (NOx) Significance Criteria

Nitrogen oxides (NOx) is a family of seven highly reactive gases. The EPA only regulates nitrogen dioxide (NO_2) as a surrogate for this family, because it is the most prevalent in the atmosphere. NO_2 forms quickly from emissions from cars, trucks and buses; power plants; and off-road equipment. In addition to contributing to the formation of ground-level ozone, and fine particulate pollution, NO_2 is linked with a number of adverse effects on the respiratory system.[5]

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[2] SCAQMD, Final – Methodology to Calculate Particulate Matter (PM) 2.5 and PM 2.5 Significance Threshold, October 2006, p. 8 and Table B-1; Available at: http://www.aqmd.gov/home/regulations/ceqa/air-quality-analysis-handbook. (SCAQMD 2006).

[3] http://www.co.mendocino.ca.us/aqmd/pdf_files/MCAQMDCEQARecomendations.pdf.

[4] http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CEQA/Summary_Table_Proposed_BAAQMD_CEQA_Thresholds_May_3_2010.ashx?la=en. See also: Proposed Air Quality CEQA Thresholds of Significance, May 3, 2010, Available at: http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CEQA/Summary_Table_Proposed_BAAQMD_CEQA_Thresholds_May_3_2010.ashx?la=en.

[5] EPA, Nitrogen Dioxide, Available at: http://www.epa.gov/airquality/nitrogenoxides/.

The DEIR only evaluated NOx as an ozone precursor, as the MBUAPCD's significance criteria for NOx (137 lb/day) is based only on this endpoint. However, NOx can not only contribute to ground-level ozone, it can also causes adverse health effects, acid rain, form particulate matter, and contribute to global warming, water quality deterioration, and visibility impairment.

Thus, there are primary and secondary state and federal ambient air quality standards for nitrogen oxides established using NO_2 as a surrogate for all nitrogen oxides. DEIR, Table 4.10-2. The primary standards (1-hour) are set to protect public health, including the health of sensitive populations. The secondary standards (annual) are set to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.[6] The DEIR did not evaluate these primary and secondary impacts of NOx.

First, NOx is harmful to public health. Children, people with lung diseases such as asthma, people who work or exercise outside, children, and the elderly are susceptible to adverse effects such as damage to lung tissue and reduction in lung function.[7] Thus, the Project's NOx emissions also should have been evaluated to determine if the existing primary NO_2 ambient air quality standards, set to protect public health, would be violated. As these standards are based on a 1-hour average, it is plausible that they would be exceeded during construction.

Second, some of the emitted NOx (as well as SO_2) can be converted in the atmosphere to sulfate and nitrates, which contribute to acid rain and fine particulate matter (PM10, PM2.5). These fine particulates can be breathed in and lodged deep in the lungs, leading to a variety of health problems and even premature death. The NOx and SOx contribution to PM10 and PM2.5 should have been estimated and added to total PM10 and PM2.5 emissions, but was not. The DEIR failed to evaluate these impacts of NOx and thus fails as a public disclosure document.

Third, NOx emissions contribute to visibility reduction and damages animals, crops, vegetation, and buildings.[8] As the Project is near prime farmland, the DEIR should have evaluated the potential impacts of construction emissions on these endpoints to determine if the secondary NO_2 ambient air quality standards, set to

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[6] National Ambient Air Quality Standards (NAAQS), Available at: http://www.epa.gov/air/criteria.html.

[7] U.S. EPA, Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, EPA/600/R-08/071, July 2008, Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=194645#Download.

[8] EPA, Review of the National Ambient Air Quality Standards for Nitrogen Dioxide: Assessment of Scientific and Technical Information, OAQPS Staff Paper, EPA-452/R-95-005, September 1995; Available at: http://www.epa.gov/ttn/naaqs/standards/nox/data/noxsp1995.pdf.

protect public welfare, were violated. The DEIR failed to evaluate these secondary NOx impacts and thus is deficient as a public disclosure document. Appendix G of the CEQA Guidelines indicates a project would have a significant impact if it also violates any air quality standard or exposes sensitive receptors to substantial pollutant concentrations. DEIR, p. 4.10-15. This determination can be made for NOx using dispersion modeling, which was not included in the DEIR, or CEQA significance thresholds from other air districts that are in attainment with ozone standards.

There are both federal and state 1-hour and annual average ambient NO_2 air quality standards, set to protect public health and welfare. DEIR, Table 4.10-2. NO_2 is a respiratory irritant and may affect those with existing respiratory illness, including asthma. Elevated concentrations increase the risk of acute and chronic respiratory disease. The annual average state NOx standard is 0.030 ppm. DEIR, Table 4.10-2. The DEIR indicates that the maximum hourly average NOx concentration for the period 2009 to 2013 has been 0.04 ppm, but fails to report any annual average NOx concentration data. DEIR, Table 4.10-1. As construction will last for more than one year and emissions from construction equipment are released at ground level, in the breathing zone of nearby sensitive receptors, the DEIR should have evaluated whether construction emissions violate the ambient NOx standards or expose sensitive receptors to substantial pollutant concentrations in the vicinity of construction activities.

The absence of a MBUAPCD "CEQA significance threshold" for non-ozone precursor NOx impacts is not an impediment to evaluating this impact as the ambient air quality standards themselves are the CEQA significance thresholds. A significance threshold is just a surrogate or short cut for avoiding the more time intensive modeling required to evaluate compliance with the ambient standard. When a CEQA significance threshold is missing, a lead agency must model emissions to determine if they cause or contribute to an exceedance of the ambient standards or look to other sources for significance criteria expressed as emission rates, e.g., other air districts.

CEQA significance thresholds established by other air districts that are in attainment with ozone standards could be used to evaluate NOx health and other impacts. Four air districts that are in attainment with ozone standards have established CEQA significance thresholds for NOx and ROG based on other considerations:

- Mendocino County AQMD construction: 110 lb/day[9] for NOx and ROG[10]

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[9] BAAQMD, California Air District CEQA Significance Thresholds, Appendix A, Available at: http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CEQA/Thresholds_Report_Revised_Appendices_082309.ashx?la=en.

[10] MCAQMD, Advisory, District Interim CEQA Criteria and GHG Pollutant Thresholds, Available at: http://www.co.mendocino.ca.us/aqmd/pdf_files/ceqa-criteria-and-ghg.pdf.

- Mendocino County AQMD operation: 180 lb/day for ROG and 42 lb/day for NOx[11]
- Colusa County APCD construction: 25 lb/day for NOx and ROG[12]
- Modoc County APCD construction & operation: 250 lb/day for NOx and ROG[13]
- Shasta County AQMD construction & operation: 25 – 137 lb/day for NOx and ROG[14]

These other NOx and ROG significance thresholds are used below to evaluate non-ozone, construction and operational NOx and ROG impacts of the Project.

3. Reactive Organic Gases (ROG) Significance Criteria

Reactive Organic Gases or ROG is a collection of volatile organic compounds (VOCs) that form ozone in the atmosphere in the presence of sunlight. The ROG emissions from construction of the Project originate largely from diesel exhaust, which is a known Toxic Air Contaminant.[15] Ozone is an oxidant that attacks synthetic rubber, textiles, and other materials and causes extensive damage to plants by leaf discoloration and cell damage. It is also a severe eye, nose, and throat irritant and increases susceptibility to respiratory infections. Ozone is not emitted directly, but rather forms from photochemical reactions in the atmosphere involving VOCs and NOx.

However, the reactions can be slow and not all of the VOCs are converted into ozone under all conditions. The original VOCs emitted from the source can remain in the atmosphere for significant periods, where they result in health impacts of a different nature than ozone, depending upon the specific Toxic Air Pollutants (TAPs) present. The DEIR only evaluated ROG as an ozone precursor.

The VOCs present in ROG, before it is converted into ozone, include volatile organic compounds that are additionally hazardous to human health.[16] As the DEIR

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[11] BAAQMD, Appendix A.

[12] BAAQMD, Appendix A.

[13] BAAQMD, Appendix A.

[14] BAAQMD, Appendix A.

[15] California Air Resources Board (CARB), Initial Statement of Reasons for Rulemaking, Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Staff Report, June 1998. See summary: Findings of the Scientific Review Panel on The Report on Diesel Exhaust as Adopted at the Panel's April 22, 1998, Meeting; Available at: http://www.arb.ca.gov/toxics/dieseltac/de-fnds.pdf.

[16] CARB 1998; H. Ogawa and T. Li, Volatile Organic Compounds in Exhaust Gas from Diesel Engines under Various Operating Conditions, International Journal of Engine Research, 2011, v. 12, 30-40; K. Tanaka et al., Simultaneous Measurements of the Components of VOCs and PAHs in Diesel Exhaust Gas using a Laser Ionization Method, SAE Technical Paper 2009-1, 2009; Y. Yamamoto et al., Measurement of Volatile Organic Compounds in Vehicle Exhaust Using Single-Photon Ionization Time-of-Flight Mass Spectrometry, Anal. Sci., v. 28, no. 4, 2012, 385-90; G.J. Sheng et al., GS-MS Determination of Volatile

does not include a health risk assessment (HRA), the impacts from toxic air pollutants subsumed in ROG that are not converted to ozone when they reach sensitive receptors, such those only 50 to 100 feet away from active construction sites was not evaluated. These include acutely and chronic toxic chemicals such as toluene, xylene, ethylbenzene, and 1,3 butadiene and carcinogens such as benzene, formaldehyde, acrolein, and acetaldehyde. The conversion of ROG to ozone is a slow process, so nearby receptors would initially be exposed to unconverted VOCs. The significance thresholds discussed above for ROG by air districts that are in attainment with ozone standards can be used as a first step to evaluate non-ozone construction and operational ROG impacts of the Project. However, a health risk assessment should be conducted due to the proximity of sensitive receptors.

B. Construction Criteria Pollutant Emission Estimating Methodology Is Flawed

The DEIR estimated maximum daily emissions of ROG, NOx, PM10, and PM2.5 from Project construction for all construction equipment (DEIR, Table 4.10-5) and for "non-typical" construction equipment. DEIR, Table 4.10-5. The DEIR only evaluated the significance of the NOx and ROG emission from the "non-typical" equipment only for their ozone impacts. These construction emissions were unsupported and significantly underestimated. When all the errors and omissions in the DEIR's analysis are cured, Project construction results in significant impacts that are not mitigated by the measures proposed in the DEIR.

1. Construction Emissions from Off-Road and On-Road Construction Equipment Are Not Supported by Substantial Evidence

The construction emissions are summarized in Table 4.10-5 (all equipment) and 4.10-6 (non-typical equipment). The DEIR refers the reader to Appendix G for "[a]ssumptions and emission factors used to estimate construction emissions". DEIR, p. 4.10-19/22, 26 and notes to Table 4.20-5/6. However, Appendix G is not the starting point for the construction emission calculations, but rather the output from unidentified models whose inputs and outputs are not in the record.

For off-road construction equipment, Appendix G starts with estimates of emissions in pounds per hour (lb/hr) that were prepared by Environmental Science Associates (ESA) using various models developed by the California Air Resources Board (CARB). DEIR, p. 4.10-17. The DEIR fails to identify the specific model(s), ESA's

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Organic Compounds in Gasoline and Diesel Emissions, Spring 2006; Available at: http://dujs.dartmouth.edu/wp-content/uploads/2008/05/sheng.pdf (**Exhibit 1**); K.E. Ho et al, Vehicular Emissions of Volatile Organic Compounds (VOCs) from a Tunnel Study in Hong Kong, Atmos. Chem. Phys., v. 9, 7491-7504, 2009, Available at: http://www.atmos-chem-phys.net/9/7491/2009/acp-9-7491-2009.pdf.

inputs to the model(s), and the model output spreadsheet(s) or other documentation prepared by ESA to support the starting point for the emission calculations in Appendix G. This lack of documentation deprives the public of the opportunity for independent review of the CPUC's conclusions regarding the significance of the Project's construction emissions.

The DEIR, for example, states that "For off-road equipment, emissions modeling, construction equipment inventories, equipment hp ratings, and construction activity schedule assumptions were developed by the CPUC's CEQA consultant (Environmental Science Associates) as part of this EIR effort. " DEIR, p. 4.10-15. This information is not in the record. While horsepower (hp) ratings of construction equipment are reported in Appendix G, the actual hp inputs to the model(s) used to generate the emissions in pounds per hour (lb/hr) in Appendix G are unknown.

The DEIR continues: "Emission factors for off-road vehicles were derived from emissions inventory data using CARB's off-road emissions inventory database model." DEIR, p. 4.10-15. The specific model (and there are several versions) that was used and the emissions inventory data are not identified and the model inputs are not disclosed.

Rather, the off-road construction emission calculations in Appendix G only report emissions in pounds per hour (lb/hr) for each piece of construction equipment. DEIR, Appx. G, pdf 5-13. However, lb/hr is the output from the unidentified model(s). The output is calculated from inputs for each piece of construction equipment. These include: the horsepower rating of the equipment, its load factor, and an emission factor in pounds of each pollutant emitted per brake-horsepower-hour (bhp-hr). Other important assumptions imbedded in the lb/hr starting point in Appendix G, but not disclosed, include the assumed age of the equipment (which affects emissions) and any emission controls, e.g., new equipment or engines. As the DEIR does not require any controls for either NOx or ROG emissions from construction, old equipment with higher emissions, and higher-emitting fuels could be used than assumed in the Appendix G emission calculations.

Elsewhere, the DEIR indicates the CalEEMod model was used to calculate fugitive dust emissions from construction activities. DEIR, p. 4.10-17. Appendix G indicates that this model was used to develop pipeline fugitive dust emission factors in pounds per cubic yard and load factors for the emergency generator. DEIR, Appx. G, pdf 12, 27. The specific version of this model was not identified. The 2011 version of this model has been superseded three times by versions 2013.2, 2013.2.1, and 2013.2, which were released in July 2013, September 2013, and October 2013, respectively. Compared to version 2011.1.1, these versions incorporated revised emission factors for entrained fugitive road dust emissions; incorporated the CARB's EMFAC2011 and OFFROAD databases; added nitrous oxide (N_2O) calculations from off-road and on-

road sources; corrected the unmitigated fugitive dust emissions of PM10 from haul trucks, updated climate zone options; and modified the running loss equation for emissions of ROG from on-road vehicles to match emission factors (per vehicle trip instead of per mile driven).[17] Which version did the DEIR rely on? In other cases, the DEIR relies on the 2011 version of models.

This vital information – the specific model, equipment size, assumed load, age, controls and fuel type -- must be known to calculate off-road construction emissions in lb/hr, the starting point of the Appendix G spreadsheets. DEIR, Appx. G, pdf 5-13. All of this primary input information is missing. Instead, the DEIR reports only the output from this unidentified model calculation, in lb/hr. This prevents any meaningful public review of the CPUC's construction equipment impacts analysis. Thus, the DEIR fails as an informational document under CEQA.

A similar situation exists for on-road construction emissions. Emissions from on-road trucks and worker vehicles were derived using CARB's EMFAC2014 Burden Model. DEIR, p. 4.10-17. This model generates emissions in (1) grams per mile for running exhaust, (2) grams per hour for running loss and diurnal/resting loss, (3) grams per idle-hour for idling exhaust, and (4) grams per trip for hot soak and start. These four sources of emissions cannot be simply summed to come up with a total emissions factor for on-road emissions as they are reported in different units. The starting point for the Appendix G on-road emissions is an emission factor in pounds per mile. However, the DEIR does not explain how it combined the EMFAC output, expressed in four different units, into pounds per mile.

In order to run the EMFAC2014 model to generate these four outputs, the user must specify a number of input parameters including region type (statewide average, air basin, air district, metropolitan planning organization, county, or sub area); calendar year; season (annual average, summer, or winter); vehicle category; model year (aggregated or all years); speed (aggregated, all speeds, or pick); and fuel (all, diesel, or gasoline).[18] The DEIR does not disclose any of this information. Rather, the starting point in Appendix G for on-road emission calculations is the summed output from this model expressed in pounds per mile (lb/mi).

While the use of models that have been approved by a regulatory agency is a reasonable starting point, the mere claim that such a model was used does not by itself establish substantial evidence to support the emission estimates and conclusions

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[17] CalEEMod, List of Revisions; Available at: http://www.aqmd.gov/docs/default-source/caleemod/Model/2013.2.2/revisions-2013-2-2.pdf?sfvrsn=0.

[18] CARB, EMFAC2014 Volume I – User's Guide, April 13, 2014; Available at: http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol1-users-guide-052015.pdf.

presented in DEIR Appendix G. Models are merely tools which can be used correctly or incorrectly depending on the assumptions made to develop project-specific input parameters and the accuracy of parameter inputs into the model. As such, the assumptions used to run the CARB models, whose outputs were then used to estimate construction emissions should be subject to public review. Here, they are not.

The DEIR does not provide any support to demonstrate how ESA calculated the starting point for construction emissions in Appendix G. The DEIR should be recirculated with enough relevant information to verify the DEIR's estimates of construction emissions including: (1) identification of all Project-specific assumptions and input parameters; (2) a copy of the model run inputs and outputs; and (3) any other documentation prepared by ESA or other CPUC consultants, such as original Excel spreadsheet model inputs and outputs plus Appendix G spreadsheets used to make the final construction emission calculations, i.e., the record should include unlocked Excel spreadsheets that correspond to those in Appendix G. These documents are routinely provided to support EIRs[19] and other CEQA-equivalent documents,[20] as required under

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[19] *See*, for example, City of Los Alamitos, General Plan Update, Draft Environmental Impact Report, August 2014, SCH No. 2013121055, Appendix C, Air Quality and GHG Modeling; Available at: http://losalgeneralplan.org/documents/; County of Los Angeles, Los Angeles County General Plan Update, Draft Environmental Impact Report, SCH No. 2011081042, June 2014, Appendix G; Available at: http://planning.lacounty.gov/generalplan/ceqa; The Town of Los Gatos, Los Gatos Sustainability Plan, October 15, 2012, Available at: Appendix B; http://www.losgatosca.gov/1860/Sustainability-Plan.

[20] **Victorville 2 Solar Gas-Hybrid Power Project**: Construction and operational criteria pollutant and TAC emission estimates were provided on CD as password-protected Excel spreadsheets in response to California Unions for Reliable Energy ("CURE") data requests. *See* http://www.energy.ca.gov/sitingcases/victorville2/documents/applicant/2007-07-02_APPLICANTS_OBJECTIONS_TO_CURE_DATA_REQUEST_SET_01.PDF and http://www.energy.ca.gov/sitingcases/victorville2/documents/applicant/2007-07-12_RESPONSES_TO_CURE_DATA_REQUEST_SET_01.PDF;

Blythe Solar Power Project: Operational emissions were provided as unprotected Excel spreadsheets in response to CEC staff data requests. http://www.energy.ca.gov/sitingcases/solar_millennium_blythe/documents/applicant/data_responses_set_1/Air%20Quality/Air%20Quality%20Supporting%20Documentation/Blythe%20DR%20Operating%20Emissions.xlsx and http://www.energy.ca.gov/sitingcases/solar_millennium_blythe/documents/applicant/data_responses_set_1/Air%20Quality/Air%20Quality%20Supporting%20Documentation/Blythe%20Data%20Rrespons e%20Emissions.xlsx;

Palen Solar Power Project: Construction and operational emission estimates were provided as unprotected Excel spreadsheets in response to CEC staff data requests. *See* http://www.energy.ca.gov/sitingcases/solar_millennium_palen/documents/applicant/data_responses_set_1/Air%20Quality/Air%20Quality%20Supporting%20Documentation/Palen%20DR%20Construction%20Emissions.xlsx and http://www.energy.ca.gov/sitingcases/solar_millennium_palen/documents/applicant/data_responses_set_1/Air%20Quality/Air%20Quality%20Supporting%20Documentation/Palen%20DR%20Operating%20Emissions.xlsx;

CEQA and California public records laws. They must be provided here to support the DEIR's conclusions regarding the significance of construction emissions.

Thus, the DEIR's conclusions regarding construction impacts on air quality are not supported by substantial evidence. As it stands, the reviewer has no choice but to simply accept the DEIR's analysis without any opportunity to verify the CPUC's conclusions regarding the significance of construction CO, SO2, ROG, NOx, PM10, and PM2.5 emissions. This frustrates the public review requirements under CEQA.

2. The DEIR Estimates Average Daily Emissions Rather than Maximum Daily Emissions

The MBUAPCD's CEQA Guidelines establish significance thresholds based on maximum daily emissions in pounds per day (lb/day). The DEIR compares the "average" daily emissions from construction equipment to significance thresholds based on the "maximum" day, but misleadingly captions the emission table as "maximum daily". DEIR, Table 4.10-5. An average smooths out and thus hides peak emissions, which the MBUAPCD thresholds were designed to capture.

Maximum is the correct metric. The threshold is stated in MBUAPCD's CEQA Guidance as "[p]roject which would emit 137 pounds per day or more of direct and indirect VOC emissions...Similarly, projects which emit 137 pounds per day or more of direct and indirect NOx emissions would generate substantial emissions and have a significant impact on regional air quality." Thus, emissions should be compared to the "maximum" day, not the average day. Maximum day emissions would be much higher than the average day, as multiple pieces of equipment can work simultaneously at different sites.

An email from a MBUAPCD employee, Amy Clymo (Clymo email), grants an exception to the use of the maximum "since the actual phasing is unknown."[21] However, this email was written over two years ago. Further, there is a construction

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Bullard Energy Center: Operational emission estimates were provided as unprotected Excel spreadsheets in response to CEC staff data requests. *See* http://www.energy.ca.gov/sitingcases/bullard/documents/applicant/DA-response-1/appendix-A/Attachment-7-1.xls and http://www.energy.ca.gov/sitingcases/bullard/documents/applicant/DA-response-1/appendix-A/Attachment-19-1.xls; and

Riverside Energy Resource Center: Estimates for startup, shutdown, maintenance emissions from turbines and emissions estimates for on-road vehicle travel were provide as unprotected Excel spreadsheets in response to CURE data requests. *See* http://www.energy.ca.gov/sitingcases/riverside/documents/applicants_files/2004-08-10_CURE_DATA_REQ4.PDF and http://www.energy.ca.gov/sitingcases/riverside/documents/applicants_files/cure_set4.

[21] MCUAPCD 2013b: Clymo Email, April 17, 2003.

schedule in Appendix G, pdf 25 that could have been used to determine phasing. Additionally, contracts may have already been let,[22] so much more must be known than is disclosed in the DEIR.

Regardless, as construction is scheduled to start in October 2016 (DEIR, p. 3-50), it is not believable that a construction schedule does not currently exist, as it would be necessary to develop bid documents to hire contractors, which is very likely currently underway. The applicant should revise the daily construction emission calculations based on the current construction schedule to estimate maximum daily emissions and compare the resulting sum of ROG and NOx to the significance threshold of 137 lb/day. Further, an email from a MBUAPCD employee does not override CEQA statutes and written CEQA guidance adopted by the MBUAPCD.

C. Construction Criteria Pollutant Emissions Are Significant: NOx and ROG

The combustion of fuel (diesel, gasoline) in the engines of on-road and off-road trucks and off-road construction equipment emits NOx and ROG. The DEIR underestimated the emissions of both NOx and ROG. Further, it failed to evaluate the significance of NOx and ROG emissions, and failed to address the potentially significant public health impacts of individual volatile organic compounds contained within ROG.

1. Ozone Precursor (ROG, NOx) Emissions from Construction Equipment Are Improperly Excluded

Ozone, the primary constituent of smog, is formed in the atmosphere through complex chemical reactions involving reactive organic gases (ROG) and nitrogen oxides (NOx). Ozone concentrations are limited by both state and federal ambient air quality standards. The Air Basin in which the Project is located currently violates California's 8-hour ambient air quality standards for ozone. DEIR Table 4.10-2. Thus, it is an ozone nonattainment area.

The DEIR asserts that "[c]onstruction projects that use typical construction equipment such as dump trucks, scrappers, bulldozers, and front-end loaders that temporarily emit precursors of ozone (i.e., ROG and NOx), are already accounted for in the emission inventories of state- and federally-required air quality plans (MBUAPCD, 2008)." DEIR, p. 4.10-15. Thus, the DEIR only evaluates the significance of construction ROG and NOx emissions from "non-typical construction equipment."

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[22] CDM Smith to Design-Build Monterey Peninsula Desalination Facility, February 1, 2014, Available at: http://cdmsmith.com/en-US/Discover-Us/News-and-Events/CDM-Smith-Awarded-Monterey-Peninsula-Project.aspx.

DEIR, p. 4.10-16, Table 4.10-6. While this is consistent with the MBUAPCD CEQA guidelines[23], it is not consistent with CEQA. CEQA requires the actual increase in emissions from the Project to be evaluated. A brief reference to other documents that may contain those emissions, without a clear demonstration that they are actually there, is not adequate.

The DEIR does not contain a shred of evidence that the emissions from typical construction equipment that would be used to construct this Project are in fact included in these emission inventories. The assertion by a MBUAPCD employee[24] is not a valid substitute for demonstrating clearly on the record that Project emissions are included in these inventories and for evaluating the significance of actual Project emissions.

I reviewed the subject air quality plans and found no evidence of the inclusion of Project emissions in these inventories. Construction emissions in these inventories are calculated using CARB models that estimate summer seasonal daily emissions at the county level. An estimate at only the "county level" of emissions from a portion of the year when construction will last 2.5 to 3 years is not adequate to assure that maximum day Project emissions have been included. These inventories indicate that the emissions of many classes of equipment are assumed to drop to zero over the time horizon that this Project would be built.[25] Further, the models are based on outdated equipment surveys in which future emissions are estimated based on the decline in annual use, average age, and an annual growth rate of 1.96%.[26] Finally, the models project significant decreases in NOx and ROG, due to the introduction of cleaner fuels and improved control technologies.[27]

The DEIR does not require that Project construction equipment use cleaner fuels or improved control technologies, such as diesel particulate traps and cleaner engines including Tier 4 Interim diesel technology, which have been commercially available for years. Despite language in the MBUAPCD's CEQA guidelines, CEQA requires the

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[23] Monterey Bay Unified Air Pollution Control District (MBUAPCD), CEQA Air Quality Guidelines, 2006, p. 5-3; Available at: http://mbuapcd.org/pdf/CEQA_full%20(1).pdf. (MBUAPCD 2006).

[24] MCUAPCD 2013b: Email from Amy Clymo, MBUAPCD, to Matthew Fagundes, April 17, 2013, Re: CO Emission Factors for EIR Analysis. Amy Clymo is reported as the "Supervising Air Quality Planner" on the MBUAPCD website at http://mbuapcd.org/district/staff-directory/.

[25] See, for example, MBUAPCD, 2008 Air Quality Management Plan for the Monterey Bay Region, Sixth Revision to the 1991 Air Quality Management Plan for the Monterey Bay Region, August 2008, Appendix A; Available at: http://www.mbuapcd.org/mbuapcd/pdf/Planning/2008AirQualityManagementPlan1.pdf.

[26] CARB, Off-Road Motor Vehicles, 2007 Documentation, Appendix E, Emissions Inventory Methodology and Results, pp. E-11 to E-13; Available at: http://www.arb.ca.gov/regact/2007/ordiesl07/tsdappe.pdf.

[27] MBUAPCD 2008, p. 4-6 and Tables 4-1 & 4-2.

CPUC to disclose, analyze and mitigate the Project's significant impacts on air quality, including increases in emissions from all construction equipment.

2. Total NOx and ROG Emissions from All Construction Equipment Are Significant

The DEIR estimated NOx and ROG emissions from all Project construction equipment (DEIR, Table 4.10-5) and from the subset of "non-typical" construction equipment (DEIR, Table 4.10-6), but only evaluated the significance of the "non-typical" subset, based on the assertion that typical construction emissions are included in ozone attainment plans. DEIR, p. 4.10-16. There are two problems with this approach.

First, the assumption that the Project's "typical" construction emissions are included in ozone attainment plans and thus need not be evaluated is legally and factually wrong, as explained above. Thus, the significance of the sum of total ROG plus NOx emissions of 428.44 lb/day (Table 4.10-5) should have been compared to the MBUAPCD's significance threshold of 137 lb/day. This comparison indicates that these emissions are significant.

Second, the "typical" versus "non-typical" emission issue only applies to NOx and ROG as ozone nonattainment pollutants. In addition to its role in forming ozone, NOx is an independent pollutant with its own ambient air quality standards, as explained elsewhere in these comments. DEIR, Table 4.10-1. Further, ROG includes toxic air pollutants (TAPs) that should have been separately evaluated for their toxic effects. The DEIR fails to evaluate NOx and ROG as independent pollutants for impacts other than ozone, and thus is deficient as a public disclosure document.

As to NOx, Appendix G of the CEQA Guidelines indicates a project would have a significant impact if it also violates any air quality standard or exposes sensitive receptors to substantial pollutant concentrations. DEIR, p. 4.10-15. The DEIR should have evaluated the significance of NOx emissions independent of ozone, based on the NO_2 ambient air quality standards. This determination can be made using dispersion modeling, which was not included in the DEIR, or CEQA significance thresholds from other air districts that are in attainment with ozone standards as MBUAPCD's NOx and ROG significance thresholds are based solely on ozone attainment[28].

As to ROG, Appendix G of the CEQA Guidelines indicates a project would have a significant impact if it exposes sensitive receptors to substantial pollutant

[28] MBUAPCD 2008, pp. 3-1, 3-2, 4-2, 5-3, 5-5 ("Projects which would emit 137 pounds per day or more of direct and indirect VOC emissions would have a significant impact on regional air quality by emitting substantial amounts of ozone precursors...Similarly, projects which emit 137 pounds per day or more of direct and indirect NOx emissions would generate substantial emissions and have a significant impact on regional air quality.")

concentrations. DEIR, p. 4.10-15. The DEIR should have evaluated the health risks of hazardous air pollutants included in ROG that are emitted by construction and operation of the Project. However, the DEIR does not contain a health risk assessment. Rather, it identified only diesel particulate matter (DPM) as a potential TAC and dismisses it without any analysis. DEIR, p. 4.10-18. The DEIR does not disclose that ROG emissions include numerous volatile organic compounds that could result in significant health impacts to nearby sensitive receptors. The DEIR thus fails to evaluate individual toxic air pollutants subsumed in ROG. The significance thresholds developed by four ozone attainment air districts are used below to evaluate these additional impacts of ROG.

As construction of some Project facilities can occur 24 hr/day, 7 days per week, for up to 18 months (the slant wells) (DEIR, p. 3-42) and are located close to sensitive receptors (DEIR, p. 4.10-5), just 50 to 100 feet from some (DEIR, p. 4.10-25), adverse health impacts could result from exposure to ground level emissions of NOx and ROG. The construction of the Desalination Plant and drilling of the slant wells are special concerns, as the NOx and ROG emissions are large (DEIR, Table 4.10-5) and sensitive receptors are nearby. The DEIR should have conducted dispersion modeling to determine if the hourly and annual state and federal NO_2 NAAQSs would be violated by construction activities. It also should have conducted a health risk assessment to determine if any of the TAPs in engine exhaust pose a health risk to nearby sensitive receptors. As the DEIR does not contain these analyses, it fails as a public disclosure document.

Alternatively, the lead agency could have adopted CEQA significance thresholds from other air districts that are in attainment with ozone standards. Four air districts that are in attainment with ozone standards have established CEQA significance thresholds for NOx and ROG during construction that are based on other considerations. As discussed elsewhere, these range from 25 lb/day to 250 lb/day. for both NOx and ROG.

The total NOx construction emissions from the Project (400.16 lb/day or 73 ton/yr: DEIR, Table 4.10-5) exceed both of these significance thresholds. Further, the total ROG construction emissions (28.28 lb/day: Table 4.10-5) exceeds the 25 lb/day threshold set by Colusa County APCD and Shasta County AQMD for construction emissions. Thus, construction NOx and ROG emissions from all equipment are significant, independent of their status in MBUAPCD as ozone precursors. The significance of these emissions must be acknowledged and mitigated. They can be mitigated using measures listed above.

3. Some Sources of NOx and ROG Emissions Are Omitted

The estimated maximum daily construction emissions reported in DEIR Table 4.10-5 excludes the NOx and ROG exhaust emissions from the source water pipeline, Salinas Valley pipeline, transmission main, transfer pipeline, ARS conveyance and pump to waste pipeline, and Valley Green pump station (DEIR, Appx. G, pdf 11) as follows:

Table 1.
Total ROG and NOx Exhaust Emissions
Excluded from Maximum Daily Construction Emissions
in Table 4.10-5
(lb/day)

Exhaust Emission Source	ROG	NOx
Source Water Pipeline	3.41	44.0
Salinas Valley Pipeline	3.15	38.4
Transmission Main	3.47	44.9
Transfer Pipeline	3.41	44.0
ARS Conveyance/Pump to Waste Pipeline	3.36	43.4
Valley Green Pump Station	1.51	20.4
Total Omitted Exhaust Emissions	**18.3**	**235.1**

These additional emissions were estimated in Appendix G, pdf 5-11, but were not included in the unmitigated and mitigated total construction emissions included in DEIR summary Table 4.10-5. The exclusion of these emissions is not discussed in the DEIR, but presumably is based on the assumption that daily emissions would not overlap in time. However, the construction phasing diagram in Appendix G indicates that all of these activities can overlap. DEIR, Appx. G, pdf 25. As all of these components could be under construction on the maximum day, emissions from all of them must be included in the construction emission estimate, unless the DEIR conditions the Project to prohibit the simultaneous construction of all them on the same day.

The omitted NOx emissions from these exhaust sources are high enough taken alone to exceed the MBUAPCD NOx significant threshold of 137 lb/day and significance thresholds for several attainment air districts (25 lb/day). Thus, this is a significant impact that was not disclosed or mitigated in the DEIR.

4. Construction Equipment NOx and ROG Emissions Are Significant

The DEIR must evaluate the significance of the total average daily NOx emissions of 400.16 lb/day and ROG emissions of 28.28 lb/day from all Project construction (DEIR, Table 4.10-5) plus the omitted exhaust emissions in Table 1 (total of

18.3 lb/day ROG; 235.1 lb/day NOx) as there is no substantial on-the-record evidence that the Project's construction NOx and ROG emissions are accounted for in the ozone attainment plans. These total NOx plus ROG emissions (400.16+28.28=428.41 lb/day) exceed the MBUAPCD CEQA significance threshold of 137 lb/day and thus are a significant impact that was not identified or mitigated in the DEIR. The NOx and ROG emissions additionally exceed the 25 lb/day significance thresholds established by two ozone attainment air districts and the NOx emissions exceed all of the CEQA significance thresholds for five ozone attainment zones. Thus, mitigation for ROG and ROG is required. None is identified in the DEIR.

The Draft Initial Study and Mitigated Negative Declaration for the slant test well (IS/MND)[29] concluded air quality impacts would be "less than significant with mitigation incorporation" (IS/MND, p. 38) and imposed mitigation measures for NOx and ROG impacts. IS/MND, p. 44, AQ/mm-2. However, most of these measures were not identified in the DEIR. The omitted measures are all feasible and are listed below, identified by "(IS/MND)". Additional mitigation is identified in the MBUAPCD's CEQA Guidelines,[30] which were relied on by the DEIR to develop mitigation for PM10 emissions. The recently approved FEIR for the Chevron Modernization Program (Chevron) also includes mitigation measures for NOx and ROG emissions from construction equipment.[31] Feasible mitigation measures from these and other sources for NOx and ROG as ozone precursors as well as other endpoints include:

- Maintain all construction equipment in proper tune according to manufacturer's specifications (IS/MND; Chevron).
- Diesel powered equipment shall be replaced by electric equipment whenever feasible to reduce NOx emissions (IS/MND, Chevron)
- Diesel-powered equipment shall be replaced by gasoline-powered equipment whenever feasible (IS/MND, Chevron)
- The number of construction equipment operating simultaneously shall be minimized through efficient management practices to ensure that the smallest practical number is operating at any one time (IS/MND)
- The engine size of construction equipment shall be the minimum practical size (IS/MND)

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[29] SWCA Environmental Consultants, Draft Initial Study and Mitigated Negative Declaration for the California American Water Slant Test Well Project, Prepared for City of Marina, May 20 (IS/MND).

[30] MBUAPCD 2008, Table 8-2 to 8-4, and 8-7.

[31] Chevron Refinery Modernization Project EIR, March 2014, Chapter 4.8, Greenhouse Gases; Available at: http://chevronmodernization.com/wp-content/uploads/2014/03/4.8_Greenhouse-Gases.pdf and Chapter 5, Mitigation Measure Monitoring and Reporting Program; Available at: https://s3.amazonaws.com/chevron/Final+EIR/5_MMRP.pdf.

- Catalytic converters shall be installed on gasoline-powered equipment (IS/MND)
- Signs shall be posted in designated queuing areas and job sites to remind drivers and operators of the idling limit (IS/MND, Chevron)
- Diesel equipment idling shall not be permitted within 1,000 feet of sensitive receptors (IS/MND)
- Engine size of construction equipment shall be the minimum practical size (IS/MND)
- The number of construction equipment operating simultaneously shall be minimized through efficient management practices to ensure that the smallest practical number is operating at any one time (IS/MND)
- Construction worker trips shall be minimized by providing options for carpooling and by providing for lunch onsite (ISMND, Chevron)
- Use electric fleet or alternative fueled vehicles where feasible including methanol, propane, and compressed natural gas (Chevron)
- Use alternative diesel fuels, such as Aquazole fuel, Clean Fuels Technology (water emulsified diesel fuel), or O2diesel ethano-diesel fuel (O2 Diesel) in existing engines (SCAQMD)
- Modify engines with ARB verified retrofits
- Repower engines with Tier 4 Interim diesel technology
- Convert part of the construction truck fleet to natural gas[32]
- Use new or rebuilt equipment

[32] This is a mitigation measure used by PG&E to offset NOx emissions from its Otay Mesa Generating Project. See: GreenBiz, Natural Gas Trucks to Offset Power Plant Emissions, September 12, 2000; Available at: http://www.greenbiz.com/news/2000/09/12/natural-gas-trucks-offset-power-plant-emissions.

D. Construction Criteria Pollutant Emissions Are Significant: PM10 and PM2.5

The DEIR concludes that "construction of the proposed project could contribute to an exceedance of a state and/or federal standard for PM10 based on the estimated maximum daily mass emissions levels presented in Table 4.10-5, which would exceed the MBUAPCD significance threshold for PM10." DEIR, p. 4.10-23. The DEIR then concludes that this impact would be reduced to a less-than-significant level with implementation of Mitigation Measures 4.10-1a through 4.10-1c. DEIR, p. 4.10-23/24. However, the DEIR underestimated construction PM10 and PM2.5 emissions for four major reasons:

First, the DEIR failed to base its grading emissions on the maximum amount of soil that would be graded per day.

Second, the DEIR failed to base its pipeline earth moving emissions on the maximum amount of soil that would be disturbed per day.

Third, the DEIR failed to include emissions from dust control mitigation measures, e.g., watering of roads and storage piles.

Fourth, the DEIR's mitigated emissions assume a control measure (road paving) that is not required as mitigation and fails to include entrained road dust from travel on paved roads.

Fifth, the DEIR excludes exhaust emissions from many on- and off-road vehicles that could occur simultaneously on the maximum day.

When these errors and omissions are corrected, the mitigated PM10 construction emissions greatly exceed the MBUAPCD's 82 lb/day PM10 significance threshold. Further, the DEIR fails to evaluate the significance of construction PM2.5 emissions. When PM2.5 significance thresholds from other air districts are consulted, the corrected and mitigated PM2.5 emissions are also significant. The DEIR does not include any mitigation measures for PM2.5, which is a separate pollutant from PM10 and requires more aggressive controls to adequately limit its emissions.

1. Grading and Earthmoving Emissions Are Unsupported and Underestimated

a. Area Disturbed in Acres Underestimated

The fugitive PM10 and PM2.5 emissions from grading and earthmoving at the Desalination Plant, Terminal Reservoir, and ASR Facilities were calculated from an

assumed maximum disturbance of 4 acres per day.[33] The DEIR contains inadequate support for the 4 acre per day assumption, asserting only that it is based on 2 acres for the Desalination Plant and 1 acre each for the ASR Facilities and Terminal Reservoir.[34] However, an estimate of acres graded should be calculated from information on the subject equipment horsepower ratings and other factors coupled with the condition of the site,[35] not based on unsupported assertions.

It generally takes a 200-hp dozer 1-2 hours to grade an acre.[36] Appendix G indicates that one 200-hp grader, working 12 hr/day would be used for the Desalination Plant (pdf 4); one 200-hp grader, working 8 hr/day for 42 days at the Terminal Reservoir and ARS Pump Station (pdf 9); one 200-hp grader working 8 hr/day for 42 days at the ARS Wells/Settling Basin (pdf 9); and one 200-hp grader working 8 hrs/day for 2 days at the Valley Greens Pump Station (pdf 11). Assuming it takes a 200-hp grader 1-2 hours to grade an acre, the maximum day would occur during grading of the Desalination Plant, estimated as 12 hr/day x 2 acre/hr = 24 acres per day, assuming no other areas are simultaneously graded. Total acres graded could be even higher if two or more areas were graded simultaneously. Simultaneous grading is likely as grading will occur for 42 days at the Desalination Plant, so overlap with other areas is plausible. The construction phasing diagram in Appendix G indicates many over activities overlap with constructing the Desalination Plant, so simultaneous grading of other areas is likely. In fact, the DEIR concedes grading overlap of three areas.

However, assuming no simultaneous grading, 24 acres is six times higher than assumed in the DEIR's grading and earthmoving emission calculations in Appendix G (4 acres). This one change alone would increase grading and earthmoving emissions as follows (Appx. G, pdf 12):

- Unmitigated PM10 from 80 lb/day of PM10 to >**480 lb/day**
- Unmitigated PM2.5 from 16.6 lb/day to >**99.6 lb/day**
- Mitigated PM10 from 28.0 lb/day to >**168 lb/day**
- Mitigated PM2.5 from 7.5 lb/day to >**45 lb/day.**

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[33] DEIR, Appx. G, pdf 12, Table: "Fugitive Dust from Desalination Plant, Terminal Reservoir, and ASR Facilities Soil Disturbance".

[34] *Ibid.*, Table note.

[35] See, for example, I. Assakkaf, Dozers, ENCE 420 – Construction Equipment and Methods, Spring 2003, pdf 49; Available at: http://www.assakkaf.com/courses/ence420/lectures/chapter6.pdf.

[36] Assakkaf 2003, pdf 49; See also: https://answers.yahoo.com/question/index?qid=20080614132732AAdCraT.

Maximum day emissions could be even higher (>) as more than one site could be graded at the same time as the Desalination Plant. Thus, both mitigated and unmitigated grading PM10 emissions alone exceed the PM10 significance threshold of 82 lb/day. Further, unmitigated PM2.5 grading emissions (99.6 lb/day) exceed the significance threshold of 54 lb/day. Therefore, the DEIR's proposed mitigation measures (DEIR, pp. 4.10-23/24) do not mitigate the significant PM10 impact reported in the DEIR, Table 4.10-5 to less than significant, as they are based on 4 acres/day. Further, no PM2.5 mitigation is required.

The DEIR must be revised to correct its construction PM10 and PM2.5 fugitive dust emissions and to require mitigation for PM2.5 and additional mitigation for PM10, as discussed elsewhere in these comments. The additional mitigation should limit daily grading Project-wide to no more than 4 acres per day or another revised value, based on these comments. This grading limit should be confirmed by on-site monitoring by a qualified observer and reporting to assure that it is achieved.

b. Soil Disturbed in Cubic Yards per Day from Pipeline Construction Underestimated

The fugitive PM10 and PM2.5 emissions during pipeline construction earth moving activities were calculated assuming a maximum of 2,311 cubic yards of soil material would be handled each day (yd^3/day) to excavate and backfill pipeline trenches. DEIR, p. 4.10-20.[37] The maximum cubic yards of soil disturbed was based on daily trench dimensions of 6 ft by 8 ft by 650 ft and assumes two pipelines are simultaneously laid.[38]

However, the DEIR indicates that "Pipeline installation would be ongoing throughout the entire 30-month construction period, with *multiple pipelines being installed simultaneously*." DEIR, p. 3-47 (emphasis added). This does not say two, but rather "multiple". The construction phasing diagram in Appendix G shows four pipelines could be constructed simultaneously. DEIR, Appx. G, pdf 25. Nothing in the DEIR would prevent more than the "two" pipelines per day assumed in the DEIR's calculations from been installed on the maximum day. Thus, the DEIR should include a mitigation measure that limits pipeline construction as assumed in the emission calculations to no more than two pipelines per day, or the pipeline construction earth moving emissions should be revised to use the maximum number of pipelines that could be installed on the maximum day, which would be nine. DEIR, Table 3-4.

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[37] See also: DEIR Appx. G, pdf 12, Table: "Fugitive Dust from Pipeline Construction Earth Moving Activities".

[38] Id. note 4.

This one change alone would increase fugitive dust from pipeline construction earth moving by a factor of 4.5 (9/2=4.5) as follows:

- Unmitigated PM10 from 3.8 lb/day of PM10 to **17.1 lb/day**
- Unmitigated PM2.5 from 0.6 lb/day to **2.7 lb/day**
- Mitigated PM10 from 1.3 lb/day to **5.8 lb/day**
- Mitigated PM2.5 from 0.3 lb/day to **1.4 lb/day.**

This increase in pipeline fugitive dust emissions is not disclosed or mitigated in the DEIR.

c. Dust Control Emissions Omitted

Mitigation Measure 4.10-1a requires that all active construction areas be watered at least twice daily; that unpaved access roads, parking areas, and staging areas be watered three times daily; and that stockpiles be watered. DEIR, p. 4.10-23. All of these activities generate PM10, PM2.5, ROG, and VOC emissions that were not included in mitigated emissions. The first three use off-road watering trucks which generate fugitive dust and diesel exhaust emissions. Stockpile watering may be done with either watering trucks or a sprinkler system. The production and transport to the site of water also generates emissions. These additional sources of emissions should have been disclosed and included in the mitigated emission totals, but were not. Thus, mitigated emissions are underestimated. Thus, the DEIR fails as an informational document.

d. Some Sources of Exhaust PM10 and PM2.5 Emissions Are Omitted

The estimated maximum daily construction emissions reported in DEIR Table 4.10-5 excludes the exhaust emissions from the source water pipeline, Salinas Valley pipeline, transmission main, transfer pipeline, ARS conveyance and pump to waste pipeline, and Valley Green pump station (DEIR, Appx. G, pdf 11) as follows:

Table 2.
Total PM10 and PM2.5
Exhaust Emissions Excluded from
Maximum Daily Construction Emissions
in Table 4.10-5
(lb/day)

Exhaust Emission Source	**PM10**	**PM2.5**
Source Water Pipeline	1.91	1.66
Salinas Valley Pipeline	1.73	1.55
Transmission Main	1.93	1.69
Transfer Pipeline	1.91	1.66
ARS Conveyance/Pump to Waste Pipeline	1.89	1.65
Valley Green Pump Station	0.84	0.72
Total Omitted Exhaust Emissions	**10.21**	**8.93**

These additional emissions were estimated in Appendix G, pdf 5-11, but were not included in the unmitigated and mitigated total construction emissions included in DEIR summary Table 4.10-5. The exclusion of these emissions is not discussed in the DEIR, but presumably is based on the assumption that daily emissions would not overlap in time. However, the construction phasing diagram in Appendix G indicates that all of these activities can overlap. DEIR, Appx. G, pdf 25. As all of these components could be under construction on the maximum day, emissions from all of them must be included in the construction emission estimate, unless the DEIR conditions the Project to prohibit the simultaneous construction of all them on the same day.

2. Mitigated Fugitive PM10 and PM2.5 Emissions from Truck Travel on Unpaved Roads Are Overestimated

The major source of PM10 and PM2.5 emissions is fugitive dust from truck travel on unpaved roads, amounting to 133.9 lb/day of PM10 (57% of the total) and 13.4 lb/day of PM2.5 (30% of the total).[39] DEIR Table 4.10-5 & Appx. G, pdf 12.

The DEIR asserts that its proposed Mitigation Measures 4.10-1a/c were based on reducing fugitive dust emissions during earth disturbing activities by 65% and from truck travel on unpaved roads in the vicinity of the subsurface slant wells and the CEMEX active mining area by as much as 75%, based on mitigation control efficiency factors published in SCAQMD 2007 and in URBEMIS 2007. DEIR, p. 4.10-20 & Appx. G,

[39] Percent of total PM10 and PM2.5 from truck travel on unpaved roads: PM10: (133.9/233.55)100 =**57.3%**. PM2.5: (13.4/44.18)100 = **30.3%**.

pdf 12. However, my review of the emission calculations in Appendix G and supporting information indicates that these claims are misleading.

First, Appendix G indicates that fugitive PM10 and PM2.5 emissions from truck travel on unpaved roads was calculated assuming that the unpaved road to the Terminal Reservoir site would be "paved", eliminating 100% its fugitive dust emissions.[40] However, the DEIR text clarifies that this haul road would only be "stabilized". DEIR, p. 4.10-21. Construction Mitigation Measures 4.10-1a/1c do not require that the unpaved road to the Terminal Reservoir site, or any other haul road, be "paved". DEIR, pp. 4.10-23/24. Rather, Mitigation Measure 4.10-1b only requires this road to be "stabilized" without defining its current condition and allows the contractor to "gravel or pave" the existing access road, giving the contractor the option of implementing the lowest cost option, highest emission option, which would be graveling. DEIR, p. 4.10-24.

Second, the DEIR incorrectly asserts paving a haul road eliminates PM10 and PM2.5 emissions. However, this is wrong. Paving (or graveling) only reduces them; it does not eliminate them. The source relied on in the DEIR (MBUAPCD 2008) indicates that paving haul roads would reduce PM10 emissions by 90%.[41] The source relied on in the DEIR (SCAQMD 2007) indicates that graveling only reduces PM10 emissions by 54%.[42]

The excuse for eliminating paved road fugitive emissions, buried in the text of the DEIR, is that [t]he MBUAPCD does not recommend that CEQA documents present quantification of entrained road dust from travel on paved roads" in spite of the fact that the very same guidance reports only 90% control, i.e., 10% of the emissions would still be emitted. DEIR, p. 4.10-17. However, there can be no excuse for eliminating emissions unless they are demonstrated to be de minimus. They are not.

Thus, the assumption of 100% control from "paving" the Terminal Reservoir haul road is neither feasible nor enforceable and cannot be relied on to estimate "mitigated" emissions from truck travel on unpaved haul roads. Mitigation Measure 4.10-1b must be modified to eliminate the "gravel" option to claim even a 90% control efficiency from paving. Otherwise, 54% of the estimated haul road fugitive dust

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[40] DEIR, Appendix G, pdf 12, Table: MGD Project – Unpaved Road Fugitive Dust from Trucks, footnote (2). See also DEIR, p. 4.10-21: "This measure [Mitigation Measure 4.10-1b] would decrease unpaved road travel dust emissions along this access road by 100 percent."

[41] MBUACP 2008, Table 8-2, Mitigation Measures Construction Emissions, Pollutant: PM10 (Fugitive Dust), p. 8-15.

[42] South Coast Air Quality Management District (SCAQMD), WRAP Fugitive Dust Handbook, Table XI-A, Mitigation Measure Examples: Fugitive Dust from Construction and Demolition. Revised April 2007. 2007.

emissions from the Terminal Reservoir haul road must be included in the mitigated total if this haul road is graveled.

Further, neither graveling nor paving eliminate 100% of the fugitive emissions, which arise from resuspension of dust on the road itself, as well as entrainment and suspension of the dust from roadway shoulders and fallout from trucks. Other mitigation programs, for example, require site access to a distance of 100 feet from the paved road to be treated with a 6- to 12-inch compacted layer of wood chips, mulch, or gravel to prevent suspension of dust in the roadway shoulders.[43]

Third, while the DEIR admits that paving itself would generate emissions (including potentially ROG and NOx emissions which were not included in the emission calculations), it does not include these emissions in its calculations, arguing that "these emissions would occur prior to the start of construction activities at the Terminal Reservoir/ASR Pump Station site. Therefore, implementation of this measure would not change the worst-case daily emission scenario presented in Table 4.10-5." DEIR, p. 4.10-21.

This is incorrect as paving or graveling of the Terminal Reservoir haul road could overlap with other Project components, contributing to the maximum day. For example, grading of the Desalination Plant site would occur over 42 days. It is entirely plausible that graveling or paving of the Terminal Reservoir haul road, which would release significant amounts of PM10/PM2.5 as well as NOx and ROG, would occur during this period, unless the DEIR is revised to require that the Terminal Haul road be graveled/paved prior to the start of any construction at the site. There is no responsive mitigation measure in the DEIR.

Thus, I revised the mitigated PM10 and PM2.5 emissions from track travel on unpaved roads. As the DEIR does not require that the haul road to the Terminal Reservoir be paved, but allows "graveling", mitigated PM10 and PM2.5 emissions from truck travel on this road should be based on graveling. My calculations indicate that graveling the road to the Terminal Reservoir (rather than assuming 100% control by paving) would increase total mitigated PM10 emissions from truck travel on unpaved roads from 17.5 lb/day to **52.01 lb/day** and total mitigated PM2.5 emissions from 1.7 lb/day to **5.2 lb/day**.[44]

This error, together with other errors and omissions in PM10 and PM2.5 construction emission calculations discussed elsewhere indicate that significant

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[43] Chevron Modernization RDEIR, Table 5-1.

[44] Revised mitigated unpaved haul road fugitive emissions: PM10 = (69.8)(0.25) + (64)(0.54) = **52.01 lb/day**; PM2.5 = (7.0)(0.25) + (6.4)(0.54) = **5.20 lb/day**.

additional mitigation is required to reduce these emissions below the CEQA significance thresholds.

3. Revised Construction PM10 and PM2.5 Emissions

As discussed above, PM10 and PM2.5 emissions from constructing the Project were underestimated, as well as inadequately supported. The revised construction emissions are summarized in Table 3. This table shows that corrected PM10 and PM2.5 emissions are nearly three times higher than disclosed in the DEIR. The revised emissions exceed the CEQA significance thresholds for both PM10 and PM2.5.

Table 3.
Revised PM10 and PM2.5
Construction Emissions
(lb/day)

Increase in Emissions Relative to Table 4.10-5	**PM10**	**PM2.5**
Grading: Desal. Plant+Term. Res.+ASR Facilities	400	83
Pipeline Construction	17.1	2.7
Source Water Pipeline	1.91	1.66
Salinas Valley Pipeline	1.73	1.55
Transmission Main	1.93	1.69
Transfer Pipeline	1.91	1.66
ARS Conveyance/Pump to Waste Pipeline	1.89	1.65
Valley Green Pump Station	0.84	0.72
Total Increase in Construction Emissions	**427.31**	**94.6**
DEIR Construction Emissions, Table 4.10-5	233.55	44.18
REVISED CONSTRUCTION EMISSIONS	**660.9**	**138.8**
Significance Criteria	**82**	**54**

The revised PM10 and PM2.5 emissions are both highly significant. The mitigation proposed in the DEIR is not adequate to reduce these emissions below the CEQA significance threshold, as demonstrated in Table 4. Thus, all feasible mitigation must be required. Additional feasible mitigation is discussed below.

Table 4.
Revised Mitigated PM10 and PM2.5
Construction Emissions
(lb/day)

Increase in Mitigated Emissions Relative to Table 4.10-5	**PM10**	**PM2.5**
Grading: Desal. Plant+Term. Res.+ASR Facilities	168	45
Truck Travel Fugitive Dust	52.0	5.2
Pipeline Construction	17.1	2.7
Source Water Pipeline	1.91	1.66
Salinas Valley Pipeline	1.73	1.55
Transmission Main	1.93	1.69
Transfer Pipeline	1.91	1.66
ARS Conveyance/Pump to Waste Pipeline	1.89	1.65
Valley Green Pump Station	0.84	0.72
Total Increase in Mitigated Construction Emissions	**247.3**	**61.8**
DEIR Mitigated Construction Emissions[45]	**46.78**	**9.49**
REVISED MITIGATED CONSTRUCTION EMISSIONS	**294.1**	**71.3**
Significance Threshold	**82**	**54**

Further, there may be other errors and omissions that I have not discovered due to inadequate document production by the CPUC. Appendix G of the DEIR contains emission estimates for Project construction. These estimates are contained in a large number of Excel spreadsheets presented in pdf format. The pdf format hides the underlying assumptions and calculations. The calculations, which sometimes extend over several linked spreadsheets, are difficult to follow without access to the underlying calculations. While most spreadsheets can be reverse engineered, presuming all assumptions are documented, this is intensely time consuming. Interested parties should not bear this burden when the information is readily available to the lead agency and the applicant. Further, this information is routinely produced to support DEIRs as noted elsewhere in these comments. Finally, some calculations cannot be verified because all inputs are not shown in the pdfed files in Appendix G.

4. <u>All Feasible Mitigation Is Required for PM10 and PM2.5</u>

The DEIR incorrectly concludes that Mitigation Measure 10.4-1a/1c reduce PM10 emissions to a less-than-significant level, but is silent as to PM2.5. DEIR, pp. 4.10-23/24. However, as discussed elsewhere in these comments, the DEIR underestimated construction PM10 and PM2.5 emissions and overestimated mitigated PM10 and PM2.5 emissions. The revised mitigated PM10 and PM2.5 emissions (Table 4) indicate that these emissions remain highly significant even with the DEIR's mitigation measures . Thus, additional mitigation is required.

[45] DEIR, Appx. G, pdf 12, Table: Total Fugitive Dust, Applies to Both 9.5 MGD and 6.1 MGD Projects.

Several agencies have conducted comprehensive studies of fugitive dust control measures to bring their region into compliance with national ambient air quality standards on PM10. For example, SCAQMD has sponsored research, passed regulations (e.g., Rule 403[46]), and published guidelines that identify best management practices for controlling fugitive dusts at construction sites. The Rule 403 Implementation Handbook[47] contains a comprehensive list of such measures. The SCAQMD also maintains a list of mitigation measures, including for fugitive dust sources.[48]

Clark County, Nevada, has also sponsored research, passed regulations (Rule 94), and published best management practices for controlling fugitive dust from construction activities.[49] Clark County's *Construction Activities Notebook* contains a comprehensive list of best management practices. Similarly, Arizona has developed guidance to control fugitive PM10 emissions.[50]

Several of the measures included in these agency guidelines are feasible and much more effective, especially for PM2.5, than the mitigation measures included in the DEIR. Therefore, they should be considered for adoption here under CEQA Guidelines §§15126.4, 15091. Further, additional feasible measures have recently been required in the Chevron Modernization FEIR.[51] Examples of such feasible mitigation measures not included in the DEIR are listed below:

- For backfilling during earthmoving operations, water backfill material or apply dust palliative to maintain material moisture or to form crust when not actively handling; cover or enclose backfill material when not actively handling; mix backfill soil with water prior to moving; dedicate water truck

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[46] South Coast Air Quality Management District ("SCAQMD"), Revised Final Staff Report for Proposed Amended Rule 403—Fugitive Dust and Proposed Rule 1186—PM10 Emissions from Paved and Unpaved Roads, and Livestock Operations, February 14, 1997.

[47] South Coast Air Quality Management District ("SCAQMD"), January 1999.

[48] SCAQMD, Mitigation Measure Resources, Available at: http://webcache.googleusercontent.com/search?q=cache:CNeTjv1E5d8J:www.aqmd.gov/docs/default-source/ceqa/handbook/localized-significance-thresholds/particulate-matter-(pm)-2.5-significance-thresholds-and-calculation-methodology/pm2-5-working-group-meeting-2-construction-mitigation-measures.doc%3Fsfvrsn%3D2+&cd=1&hl=en&ct=clnk&gl=us.

[49] P.M. Fransioli, PM10 Emissions Control Research Sponsored by Clark County, Nevada, Proceedings of the Air &Waste Management Association's 94th Annual Conference & Exhibition, Orlando, FL, June 24-28, 2001.

[50] Arizona Department of Environmental Quality ("ADEQ"), Air Quality Exceptional and Natural Events Policy PM10 Best Available Control Measures, June 5, 2001.

[51] Chapter 5, Mitigation Measure Monitoring and Reporting Program; Available at: https://s3.amazonaws.com/chevron/Final+EIR/5_MMRP.pdf.

or large hose to backfilling equipment and apply water as needed; water to form crust on soil immediately following backfilling; and empty loader bucket slowly; minimize drop height from loader bucket. (CCHD)[52]

- During clearing and grubbing, prewet surface soils where equipment will be operated; for areas without continuing construction, maintain live perennial vegetation and desert pavement; stabilize surface soil with dust palliative unless immediate construction is to continue; and use water or dust palliative to form crust on soil immediately following clearing/grubbing. (CCHD). This is more effective that the DEIR's MM 4.10-1a(10), which only requires replanting vegetation in disturbed areas as "soon as possible".
- While clearing forms, use single stage pours where allowed; use water spray to clear forms; use sweeping and water spray to clear forms; use industrial shop vacuum to clear forms; and avoid use of high pressure air to blow soil and debris from the form. (CCHD)
- During cut and fill activities, prewater with sprinklers or wobblers to allow time for penetration; prewater with water trucks or water pulls to allow time for penetration; dig a test hole to depth of cut to determine if soils are moist at depth and continue to prewater if not moist to depth of cut; use water truck/pull to water soils to depth of cut prior to subsequent cuts; and apply water or dust palliative to form crust on soil following fill and compaction. (CCHD)
- For large tracts of disturbed land, prevent access by fencing, ditches, vegetation, berms, or other barrier; install perimeter wind barriers 3 to 5 feet high with low porosity; plant perimeter vegetation early; and for long-term stabilization, stabilize disturbed soil with dust palliative or vegetation or pave or apply surface rock. (CCHD, Chevron) In addition, the Chevron measure requires that the wind breaks be installed on the windward side(s) of actively disturbed area and that wind breaks have 50% porosity.
- In staging areas, limit size of area; apply water to surface soils where support equipment and vehicles are operated; and limit ingress and egress points. (CCHD). The DEIR includes applying water, but omits the rest of these measures. DEIR, MM 4.10-1a(3).
- For stockpiles, maintain at optimum moisture content; remove material from downwind side; avoid steep sides or faces; and stabilize material following

[52] The following acronyms are used in this listing of mitigation measures: ADEQ = Arizona Department of Environmental Quality; BCAQMD = Butte County Air Quality Management District; CCHD = Clark County (Nevada) Health Department; MBUAPCD = Monterey Bay Unified Air Pollution Control District; SBCAPCD = Santa Barbara County Air Pollution Control District; SJVUAPCD = San Joaquin Valley Unified Air Pollution Control District; SLOCAPCD = San Luis Obispo County Air Pollution Control District.

stockpile-related activity (CCHD). This is much more effective than the DEIR's "Enclose, cover, or water twice daily exposed stockpiles..." DEIR, MM 4.10-1a(7).

- To prevent trackout, pave construction roadways as early as possible; install gravel pads; install wheel shakers or wheel washers, and limit site access. (CCHD)
- When materials are transported off-site, in addition to covering all material and maintaining at least 6 inches of freeboard space from the top of the container shall be maintained, assure all material is effectively wetted to limit visible dust emissions (BAAQMD, SJVUAPCD, Rule 403 Handbook, ADEQ). This is much more effective than the DEIR's MM 4.10-1a which only requires: "Cover all trucks hauling soil, sand, and other loose materials and require trucks to maintain at least 2 feet of freeboard."
- Where feasible, use bedliners in bottom-dumping haul vehicles. (Rule 403 Handbook)
- Grade each phase separately, timed to coincide with construction phase or grade entire project. (Rule 403 Handbook)
- All operations shall limit or expeditiously remove the accumulation of mud or dirt from adjacent public streets at least once every 24 hours when operations are occurring. (BAAQMD) *(The use of dry rotary brushes is expressly prohibited except where preceded or accompanied by sufficient wetting to limit the visible dust emissions.) (Use of blower devices is expressly forbidden.).* (SJVUAPCD)
- Following the addition of materials to, or the removal of materials from, the surface of outdoor storage piles, said piles shall be effectively stabilized of fugitive dust emissions utilizing sufficient water or chemical stabilizer/suppressant. (SJVUAPCD, ADEQ) This is much more effective than the DEIR's MM 4.10-1a, which requires: "Enclose, cover, or water twice daily exposed stockpiles..."
- During initial grading, earth moving, or site preparation, projects 5 acres or greater may be required to construct a paved (or dust palliative treated) apron, at least 100 ft in length, onto the project site from the adjacent site if applicable. (BCAQMD)
- Post a publicly visible sign with the telephone number and person to contact regarding dust complaints. This person shall respond and take corrective action within 24 hrs (48 hrs in the DEIR, MM 4.10-1a, p. 4.10-23). (BCAQMD, MBUAPCD, CCHD, Chevron)

- Prior to final occupancy, the applicant demonstrates that all ground surfaces are covered or treated sufficiently to minimize fugitive dust emissions. (BCAQMD)
- The contractor or builder shall designate a person or persons to monitor the dust control program and to order increased watering and other controls, as necessary, to prevent transport of dust offsite. (SBCAPCD, SLOCAPCD)
- Prior to land use clearance, the applicant shall include, as a note on a separate informational sheet to be recorded with map, these dust control requirements. All requirements shall be shown on grading and building plans. (SBCAPCD, SLOCAPCD)
- All roadways, driveways, sidewalks, etc. to be paved should be completed as soon as possible. In addition, building pads should be laid as soon as possible after grading unless seeding or soil binders are used. (SLOCAPCD)
- Barriers with 50% or less porosity located adjacent to roadways to reduce windblown material leaving a site. (Rule 403 Handbook)
- Limit fugitive dust sources to 20% opacity. (ADEQ)
- Require a dust control plan for earthmoving operations. (ADEQ)
- All exposed surface shall be watered at a frequency adequate to maintain minimum soil moisture of 12%. Moisture content can be verified by lab samples or moisture probe. (Chevron) This is much more effective than the DEIR's "twice daily" watering. DEIR, MM 4.10-1a.
- All excavation, grading, and/or demolition activities shall be superseded when average wind speeds exceed 20 mi/hr. (Chevron)
- Vegetative ground cover (e.g., fast-germinating native grass seed) shall be planted in disturbed areas as soon as possible and watered appropriately until vegetation is established. (Chevron) This is more effective than the DEIR's measure, which does not require watering. DEIR, MM 4.10-1a.
- The simultaneous occurrence of excavation, grading, and ground-disturbing construction activities on the same area at any one time shall be limited. Activities shall be phased to reduce the amount of disturbed surface at any one time. (Chevron)
- Site accesses to a distance of 100 feet from the paved road shall be treated with a 6- to 12-inch compacted layer of wood chips, mulch, or gravel. (Chevron)
- Apply non-toxic chemical soil stabilizers according to manufacturer' specifications, to all inactive construction areas (previously graded area inactive for 10 days or more). (SCAQMD). This is more effective than the DEIR's MM 4.10-1(3) which only requires: either water or stabilizers on

"unpaved access roads, parking area, and staging areas" rather than "all inactive construction area."

- Enclose, cover, water twice daily, or apply non-toxic soil binders, according to manufacturer's specifications, to exposed stockpiles (i.e., gravel, sand, dirt) with 5% or greater soil content. (SCAQMD)
- Monitor for particulate emissions according to District-specified procedures. (SCAQMD)
- Apply water three times daily, or non-toxic stabilizer according to manufacturers' specifications to all unpaved parking or staging areas or unpaved road surfaces. (SCAQMD)

All of these measures are feasible and various combinations of them are routinely required elsewhere to reduce fugitive PM10 emissions. See the fugitive dust control program for the Big Dig (Kasprak and Stakutis 2000[53]), for the El Toro Reuse Draft EIR[54], and for the Padres Ballpark Final EIR[55]. The implementation of all of these measures likely would not reduce fugitive PM10 and PM2.5 emissions below the significance thresholds of 82 lb/day for PM10 and 54 lb/day for PM2.5. Thus, those impacts would be considered significant and unavoidable, requiring the CPUC to impose all feasible mitigation. The DEIR should be revised accordingly and recirculated for public review.

II. OPERATIONAL CRITERIA POLLUTANT EMISSIONS

A. The DEIR Omits Indirect Emissions

The DEIR estimated emissions from operation of the Project from two sources: on-road vehicle exhaust and emergency generator testing. DEIR, Table 4.10-7. However, the major source of Project emissions is indirect emissions from the generation of electricity. The DEIR did not include those emissions, arguing that "[i]t is generally not possible to determine the exact generator source(s) of electricity on the

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[53] A. Kasprak and P.A. Stakutis, A Comprehensive Air Quality Control Program for a Large Roadway Tunnel Project, Proceedings of the Air & Waste Management Association's 93rd Annual Conference 7 Exhibition, June 18-22, 2000.

[54] County of Orange, Draft Environmental Impact Report No. 573 for the Civilian Reuse of MCAS El Toro and the Airport System Master Plan for John Wayne Airport and Proposed Orange County International Airport, Draft Supplemental Analysis, Volume 1, April 2001, pp. 2-121 to 2-123.

[55] City of San Diego, Final Subsequent Environmental Impact Report to the Final Master Environmental Impact Report for the Centre City Redevelopment Project and Addressing the Centre City Community Plan and Related Documents for the Proposed Ballpark and Ancillary Development Projects, and Associated Plan Amendments, V. IV. Responses to Comments, September 13, 1999, pp. IV-254 to IV-256.

power grid that would supply the proposed project, or whether or not the electricity would even be generated within the Air Basin." DEIR, p. 4.10-25.

These are not valid reasons under CEQA to exclude the major source of emissions from this Project. EIRs routinely include indirect emissions from electricity generation.[56] In fact, the GHG section of this DEIR includes indirect GHG emissions from power generation. DEIR, p. 4.10-11 & Table 4.11-4. Further, the MBUAPCD's CEQA guidelines state: "The following thresholds apply to all indirect and direct emissions, whether or not they are subject to District permit authority, unless noted otherwise."[57] The "following thresholds" are in Table 5-3, which indicates that the NOx and ROG significance thresholds of 137 lb/day are to be compared to "direct + indirect" emissions.[58] Thus, the DEIR must include the increase in emissions from the net increase in power production to support the Project.

Further, CEQA does not require that indirect emissions be limited to the Project's "Air Basin." Electricity from any generator in California could be used at the Project site. As the significance criteria are based on the maximum day, finding the "maximum" is all that is required.

The DEIR indicates that PG&E would supply the power. The sources of PG&E's power are known. As any source within PG&Es system and elsewhere on the grid could be used via purchases by PG&E, unless the EIR includes a condition limiting power sources, emissions should be estimated for the plausible worst case daily maximum emissions,[59] which is the basis of MBUAPCD's significance thresholds for NOx and ROG. As the DEIR does not provide substantial evidence that these emissions are de minimus, they must be estimated. Further, the DEIR does not include any of the information required to estimate these emissions. Thus, it fails as an informational document under CEQA and forces the public to generate its own estimates in order to properly evaluate the Project's impacts.

As the DEIR contains none of the information required to estimate these emissions, I bounded the maximum plausible NOx emissions using two methods.

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[56] See, e.g., The Carlsbad Desalination Project EIR, pp. 4.2-18/20 & Table 4.2-9; Available at: http://carlsbaddesal.com/eir.

[57] MBUAPCD 2006, p. 5-4.

[58] MBUAPCD 2006, Table 5-3. Table 5-3.

[59] As noted elsewhere, the DEIR underestimated GHG emissions from power production as it based its estimate on an annual average over its entire fleet, rather than the maximum day.

First, I used AP-42 emission factors for natural gas fired turbines,[60] the most likely electricity source for the Project. The maximum daily emissions would occur at an uncontrolled gas turbine plant, i.e., during a startup/shutdown or uncontrolled operation.

The NOx emission factor for an uncontrolled natural gas turbine plant is 2.56 lb/MWh.[61] The net increase in annual electrical power demand due to the Project is 40,500 MWh per year, relative to the baseline. DEIR, p. 4.18-13. Thus, assuming a maximum day NOx emission factor of 2.56 lb/MWh, the Project would increase NOx emissions by up to 284 lb/day,[62] which exceeds the MBUAPCD's NOx significance threshold of 137 lb/day. Therefore, the NOx emissions from producing a net increase of 40,500 MWh per year of electricity is large enough taken alone to exceed the MBUAPCD's NOx significance threshold. This is a significant impact not disclosed in the DEIR that must be mitigated.

Second, I identified all PG&E owned power plants in California.[63] I then determined the maximum daily emissions from each, using EPA's CAMD daily data for 2014. This analysis identified two fossil fuel fired PG&E owned power plants in California with the follow maximum daily emissions in 2014:

- Colusa Generating Station: 432 lb/day
- Gateway Generating Station: 1,152 lb/day

Thus, assuming 1,152 lb of NOx is emitted on the maximum day, operational NOx emissions would increase to 1,198 lb/day,[64] which exceeds the MBUAPCD's NOx and ROG (which are evaluated together) significance threshold of 137 lb/day by a significant amount. Therefore, the NOx + ROG emissions from producing a net increase of 40,500 MWh per year of electricity is large enough taken alone to exceed the MBUAPCD's NOx + ROG significance threshold. This is a significant impact not disclosed in the DEIR that must be mitigated.

This impact could be mitigated by purchasing local and contemporaneous emission reduction credits or by collaborating with a nearby NOx or ROG source to

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[60] U.S. EP, Compilation of Air Pollutant Emission Factors, (AP-42), Chapter 3.1: Stationary Gas Turbines, April 2000, Table 3.1-1; Available at: http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf.

[61] NOx emission factor from Table 3.1-1: (0.32 lb/10^6 Btu)(8000 Btu/KWh)(1000 KW/MW) = **2.56 lb/MWh**.

[62] (2.56 lb/MWh)(40,500 MWh/yr)/365 day/yr = **284 lb/day NOx.**

[63] Power_Plants.xlsx; Available at: http://energyalmanac.ca.gov/powerplants/.

[64] Revised operational NOx emissions (DEIR, Table 4.10-7), to include electricity generation: 45.63 + 1,152 = **1,197.6 lb/day.**

reduce their NOx and ROG emissions. Alternatively, CalAm could enter into a power purchase agreement to obtain its electricity from a renewable source.

The DEIR includes Mitigation Measure 4.11-1b, which requires CalAm to "make good faith efforts to obtain "clean" renewable energy for operations of the Project..." DEIR, p. 4.11-15. However, as explained elsewhere, "good faith efforts" are not adequate to mitigate significant impacts. The applicant must commit to powering the Project with renewable energy.

The DEIR should be revised to include indirect electricity generation emissions for all criteria pollutants and to mitigate the resulting significant NOx+ROG impacts.

B. The DEIR Fails To Evaluate All NOx Impacts

As discussed above, the DEIR does not evaluate the significance of emissions if a pollutant, such as NOx as respiratory irritant, does not have a MCUAPCD significance threshold. NOx emissions have three separate impacts.

First, NOx forms ozone in the atmosphere and thus contribute to violations of ozone ambient air quality standards. The MBUAPCD NOx significance threshold was developed specifically to address this impact.[65]

Second, NOx is a respiratory irritant. Separate, air quality standards to protect public health and welfare apply to NO_2 as itself, rather than just as an ozone precursor. The MBUAPCD's CEQA significance threshold for NOx is based on its impacts as an ozone precursor.[66] The MBUAPCD CEQA Guidelines do not include a significance threshold for this second set of impacts. These impacts are addressed by the primary NO_2 ambient air quality standards.

Third, NO_2 is a PM10/PM2.5 precursor, reduces visibility, and damages animals, crops, vegetation, and buildings. These impacts are addressed by the secondary NO_2 ambient air quality standards.

The DEIR is totally silent on these additional NOx impacts. Thus, it fails as a public disclosure document.

Other air districts that are in attainment with the state and federal ozone ambient air quality standards have established significance thresholds for NOx of 25 lb/day to 180 lb/day. The operational NOx emissions estimated in the DEIR of 45.63 lb/day

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[65] MBUAPCD 2006, p. 5-3.

[66] MBUAPCD 2006, p. 5-5 ("Projects which would emit 137 pounds per day or more of direct and indirect VOC emissions would have a significant impact on regional air quality by emitting substantial amounts of ozone precursors.")

(DEIR, Table 4.10-7), which excludes indirect emissions, exceed the 25 lb/day operational NOx significance threshold set by Shasta County AQMD. Thus they are *per se* significant without considering any other indiscretions. The DEIR failed to identify this significant impact, which must be mitigated.

When indirect NOx emissions from power production are added (1,152 lb/day), as discussed above, total NOx emissions increase from 45.63 lb/day to 1,198 lb/day, which exceeds the non-ozone attainment NOx significance thresholds (25 lb/day to 250 lb/day) by a huge amount for all air districts that have established NOx significance thresholds for operational emissions and are attainment for ozone. Thus, NOx emissions from power production, when evaluated for impacts other than ozone formation are significant under the NOx significance thresholds established by other air districts. The DEIR must disclose and analyze this significant impact.

III. HEALTH RISKS

The DEIR dismissed the possibility of health risks for diesel particulate matter (DPM) only by arguing: (1) DPM emissions are less than 3 lb/day for 25 months or less; (2) sensitive receptors are 2,000 feet away at most locations; (3) the receptors are upwind; and (4) construction would last only 2 months up to 18 months at any given site. DEIR, pp. 4.10-25/26.

However, there are exceptions to all of these assumptions, which requires that a formal health risk assessment be prepared to quantify the risk, particularly for the pipelines, ASR injection/extraction wells, and Green Valley Pump Station, where sensitive receptors are within 50 to 100 feet. For example, the wind does not blow in just one direction all of the time and all of the sensitive receptors are not 2,000 feet away. Further, construction is projected to last longer than 25 months at the Desalination Plant. DEIR, Appx. G, pdf 25. The DEIR underestimated construction DPM by excluding several sources (Table 2)[67]. Further, this unsupported dismissal of health risks failed to consider toxic air contaminants that are present in ROG.

The DEIR further asserted that the California Office of Environmental Health Hazard Assessment (OEHHA) requires that health risk assessments be based on 70 years, while construction would last a much shorter time, implying that risk assessment is not required for short-term exposures, such as construction. DEIR, p. 4.10-18. However, the DEIR erroneously bases this conclusion on outdated OEHHA guidance, OEHHA 2003. DEIR, p. 4.10-13. This guidance has been superseded twice, in 2012 and more recently in March 2015. The updated guidance specifically recommends health risk assessment for short-term exposures and explains that these impacts may be more

[67] PM2.5 from diesel-fueled on-road and off-road equipment is DPM. DEIR, p. 4.10-18.

severe than exposures over a longer period. Thus, the DEIR's arm-waving health risk assessment conclusion is fatally flawed.

The OEHHA 2012[68] risk assessment guidelines explicitly states for short-term projects, such as construction: "We recommend that exposure from projects lasting more than 6 months be evaluated for the duration of the project."

The OEHHA's new guidelines for preparation of health risk assessments, adopted in March 2015, are even more explicit with respect to short-term projects:

> "We recommend that exposure from projects longer than 2 months but less than 6 months be assumed to last 6 months (e.g., a 2-month project would be evaluated as if it lasted 6 months). Exposure from projects lasting more than 6 months should be evaluated for the duration of the project
>
> ....
>
> Finally, the risk manager may want to consider a lower cancer risk threshold for risk management for very short-term projects...There is a valid scientific concern that the rate of exposure may influence the risk – in other words, a higher exposure to a carcinogen over a short period of time may be a greater risk than the same total exposure spread over a much longer time period. In addition, it is inappropriate from a public health perspective to allow a lifetime acceptable risk to accrue in a short period of time (e.g., a very high exposure to a carcinogen over a short period of time resulting in a 1×10^{-5} cancer risk). Thus, consideration should be given for very short term projects to using a lower cancer risk trigger for permitting decisions."[69]

The DEIR's categorical dismissal of health risks to nearby sensitive receptors, some as close as 50 to 100 feet away, based on its short-term exposure and other arm-waving arguments, is not justified. The DEIR should be revised to include a proper health risk assessment that includes DPM and all TACs included in ROG, emitted from construction equipment.

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[68] OEHHA, Air Toxics Hot Spots Program Risk Assessment Guidelines, Technical Support Document for Exposure Assessment and Stochastic Analysis, August 2012, p. 2012; Available at: http://www.oehha.ca.gov/air/hot_spots/pdf/2012tsd/TSDportfolio2012.pdf.

[69] OEHHA, Air Toxics Hot Spots Program Risk Assessment Guidelines Guidance Manual for Preparation of Health Risk Assessments, February 2015, Section 8.2.10: Cancer Risk Evaluation of Short Term Projects, pp. 8-17/18; Available at: http://oehha.ca.gov/air/hot_spots/2015/2015GuidanceManual.pdf.

IV. VALLEY FEVER

A. The DEIR Fails To Analyze Potentially Significant Health Impacts Due to Valley Fever and Fails to Require Adequate Mitigation

Valley Fever, or coccidioidomycosis (short cocci), is an infectious disease caused by inhaling the spores of *Coccidioides ssp.*[70], a soil-dwelling fungus. The fungus lives in the top 2 to 12 inches of soil. When soil containing this fungus is disturbed by activities such as digging, vehicles, construction activities, agricultural operations, dust storms, or during earthquakes, the fungal spores become air borne. The Valley Fever fungal spores are too small to be seen by the naked eye, and there is no reliable way to test the soil for spores before working in a particular area.[71] The disease is endemic (native and common, regularly found in a particular area) in the semiarid regions of the southwestern United States.[72] As there is no reliable test, presence is assessed based on the known occurrence of the disease in a particular area. Valley Fever is endemic to Monterey County where the Project will be constructed.[73]

Monterey County, including the Project site, is located within the established endemic range of Valley Fever, as shown in Figure 1 below, with one of the highest infection rates in California. The disease has become an increasing concern for Monterey County Health Department.[74] In 2013, there were 70 new cases of Valley Fever reported among Monterey County residents. The rate of new cases in 2013 was 15.7 cases per 100,000 individuals, well above the California statewide rate of 10.8 in 2012. Between 2009 and 2011, there were 145 hospital admissions in Monterey County, costing over $32 million. Forty one percent of these cases occurred in the north county area, which includes most of the project facilities.[75]

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[70] Two species of *Coccidioides* are known to cause Valley Fever: *C. immitis*, which is typically found in California, and *C. posadasii*, which is typically found outside California. *See* Center for Disease Control, Coccidioidomycosis (Valley Fever), Information for Health Professionals; Available at: http://www.cdc.gov/fungal/coccidioidomycosis/health-professionals.html.

[71] California Department of Public Health, Preventing Work-Related Coccidioidomycosis (Valley Fever), June 2013; Available at: http://www.cdph.ca.gov/programs/hesis/Documents/CocciFact.pdf.

[72] San Luis Obispo County Public Health Department, What Is Valley Fever? July 20, 2011; Available at: http://www.slocounty.ca.gov/Assets/PH/Epidemiology/ValleyFever_Info.pdf.

[73] CDPH June 2013.

[74] Valley Fever Cases Prompt Health Warning, Available At: http://www.valley-fever.org/.

[75] Monterey County Health Department (MCHD), Coccidioidomycosis in Monterey County. Quick Facts, May 2014, Available at: https://www.mtyhd.org/wp-content/uploads/2014/09/Cocci-Fact-Sheet-2013.pdf.

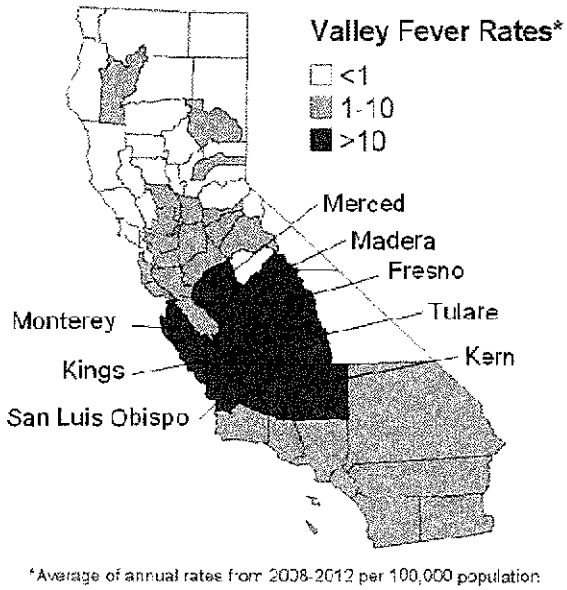

Figure 1. Endemic areas for Valley Fever in California.[76]

Typical symptoms of Valley Fever include fatigue, fever, cough, headache, shortness of breath, rash, muscle aches, and joint pain. Symptoms of advanced Valley Fever include chronic pneumonia, meningitis, skin lesions, and bone or joint infections. The most common clinical presentation of Valley Fever is a self-limited acute or subacute community-acquired pneumonia that becomes evident 13 weeks after infection.[77] No vaccine or known cure exists for the disease.[78] Between 1990 and 2008, more than 3,000 people have died in the United States from Valley Fever with about half in California.[79] There were 7 fatal cases in Monterey County between 2011 and

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[76] California Department of Public Health , What you Need to Know About Valley Fever in California, May 2014, Available at: http://www.cdph.ca.gov/HealthInfo/discond/Documents/EnglishValleyFeverBrochure.pdf.

[77] *See, e.g.*, Lisa Valdivia, David Nix, Mark Wright, Elizabeth Lindberg, Timothy Fagan, Donald Lieberman, Prien Stoffer, Neil M. Ampel, and John N. Galgiani, Coccidioidomycosis as a Common Cause of Community-acquired Pneumonia, Emerging Infectious Diseases, v. 12, no. 6, June 2006; Available at: http://europepmc.org/articles/PMC3373055.

[78] Rebecca Plevin, National Public Radio, Cases Of Mysterious Valley Fever Rise In American Southwest, May 13, 2013; Available at: http://www.npr.org/blogs/health/2013/05/13/181880987/cases-of-mysterious-valley-fever-rise-in-american-southwest.

[79] Jennifer Y. Huang, Benjamin Bristow, Shira Shafir, and Frank Sorvillo, Coccidioidomycosis-associated Deaths, United States, 1990–2008; Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3559166/.

2013.[80] In recent years, reported Valley Fever cases in the southwestern United States have increased dramatically.[81]

Digging, grading, trenching, and other earth disturbing activities will occur during construction of all of the Project's components over the 30 month construction period, including site clearing and preparation (p. 3-46); the slant wells (9 acres: p. 3-42); desalination plant (25 acres, p. 3-46); pipeline construction (30 miles of trenching, p. 3-46); pump stations (>7 acres, p. 3-48); tanks (p. 3-49); injection/extraction wells (1 acre, p. 3-49 & Appx. G, pdf 12); Terminal Reservoir (7 acre, p. 3-48); power poles (p. 3-50); underground power lines (p. 3-50) and spoils management and disposal (p. 3-50). DEIR, pp. 3-42 – 3-50.

However, the DEIR makes no mention whatsoever of the existence of Valley Fever in the area or of the potential health risks posed by Valley Fever from construction and/or operation of the Project and does not require any mitigation to limit the public's or workers' potential exposure to cocci. Thus, the DEIR utterly fails to inform the public of the significant consequences of Project construction and operation. This failure violates CEQA. As a result, the DEIR must be amended to provide this significant new information, requiring recirculation of the DEIR.

1. At-risk Populations

Dust exposure is one of the primary risk factors for contracting Valley Fever.[82] Specific occupations and outdoor activities associated with dust generation such as construction, farming, road work, military training, gardening, hiking, camping, bicycling, or fossil collecting increase the risk of exposure and infection. The risk appears to be more specifically associated with the amount of time spent outdoors than with doing specific activities.[83] The Monterey County Health Department notes:

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[80] MCHD 2014.

[81] *See* Center for Disease Control; Fungal Pneumonia: A Silent Epidemic, Coccidioidomycosis (Valley Fever); Available at: http://www.cdc.gov/fungal/pdf/cocci-fact-sheet-sw-us-508c.pdf.

[82] Rafael Laniado-Laborin, Expanding Understanding of Epidemiology of Coccidioidomycosis in the Western Hemisphere, Ann. N.Y. Acad. Sci., v. 111, 2007, pp. 20-22; Frederick S. Fisher, Mark W. Bultman, Suzanne M. Johnson, Demosthenes Pappagianis, and Erik Zaborsky, Coccidioides Niches and Habitat Parameters in the Southwestern United States, a Matter of Scale, Ann. N.Y. Acad. Sci., No. 1111, 2007, pp. 47-72 ("All of the examined soil locations are noteworthy as generally 50% of the individuals who were exposed to the dust or were excavating dirt at the sites were infected."); Available at: http://www.researchgate.net/publication/6461426_Coccidioides_niches_and_habitat_parameters_in_the_southwestern_United_States_a_matter_of_scale/file/72e7e51c9b9f058a45.pdf?origin=publication_detail.

[83] CDPH June 2013; Center for Disease Control, Coccidioidomycosis (Valley Fever); Available at: http://www.cdc.gov/fungal/coccidioidomycosis/ and Kern County Public Health Services Department, Valley Fever (Coccidioidomycosis) in Kern County; Available at: http://kerncountyvalleyfever.com/.

"Workers who disturb the soil by digging, operating earth-moving equipment, driving vehicles, or working in dusty, wind-blown areas are more likely to breathe in the fungal spores and become infected."[84]

The most at-risk populations are construction and agricultural workers,[85] the former being the very population that would be directly exposed by the Project. A refereed journal article on occupational exposures notes that "[l]abor groups where occupation involves close contact with the soil are at greater risk, especially if the work involves dusty digging operations."[86] One study reported that at study sites, "generally 50% of the individuals who were exposed to the dust or were excavating dirt at the sites were infected."[87] The California Department of Public Health cites this as a typical example:

> "In October 2007, a construction crew excavated a trench for a new water pipe. Within three weeks, 10 of 12 crew members developed coccidioidomycosis (Valley Fever), an illness with pneumonia and flu-like symptoms. Seven of the 10 had rashes, and one had an infection that had spread beyond his lungs and affected his skin. Over the next few months, the 10 ill crew members missed at least 1660 hours of work and two workers were on disability for at least five months."[88]

The disease debilitates the population and thus prevents them from working.[89] The longest period of disability from occupational exposure in California is to construction workers, with 62% of the reported cases resulting in over 60 days of lost work.[90] Another study estimated the average hospital stay for each (non-construction work) case of coccidioidomycosis at 35 days.[91] Further, the potentially exposed population is much larger than construction and agricultural workers because the non-selective raising of dust during Project construction will carry the very small spores –

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[84] MCHD 2014, p. 2.

[85] Lawrence L. Schmelzer and R. Tabershaw, Exposure Factors in Occupational Coccidioidomycosis, Am. J. Public Health Nations Health, v. 58, no. 1, 1968, pp. 107-113, Table 3; Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1228046/?page=1.

[86] *Ibid*, p. 110.

[87] Fisher et al., 2007.

[88] CDPH June 2013, p. 1.

[89] Frank E. Swatek, Ecology of *Coccidioides Immitis*, Mycopathologia et Mycologia Applicata, v. 40, Nos. 1-2, pp. 3-12, 1970.

[90] Schmelzer and Tabershaw, 1968, Table 4.

[91] Demosthenes Pappagianis and Hans Einstein, Tempest from Tehachapi Takes Toll or Coccidioides Conveyed Aloft and Afar, West J. Med., v. 129, Dec. 1978, pp. 527-530; Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1238466/pdf/westjmed00256-0079.pdf.

0.002-0.005 millimeters ("mm") – into non-endemic areas, potentially exposing large non-Project-related populations.[92,93] See Figure 2.

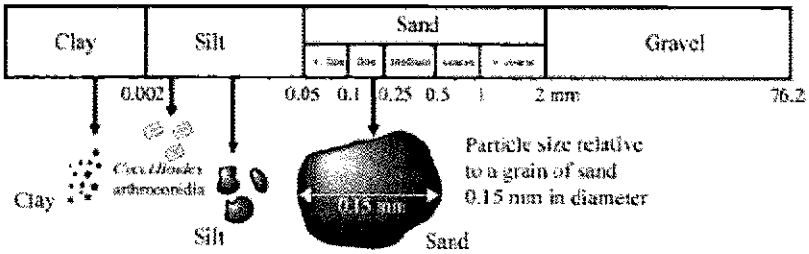

Figure 2. Size of cocci spores compared to soil particles (in mm)
(from: Fisher et al., 2007, Fig. 3)

Valley Fever spores have been documented to travel as much as 500 miles[94] and, thus, dust raised during construction could potentially expose a large number of people hundreds of miles away.

"Hispanics, Asians, and Native Americans are often considered to suffer from Valley Fever with the worst symptoms more often than Caucasians."[95] The most recent California Department of Public Health report indicates that Hispanics accounted for more than a quarter of all reported cases statewide in 2012, the last year for which data was recorded.[96] One study speculated that "[t]he use of transient farm laborers in the San Joaquin Valley and the gradual westward movement in the U.S.A. has produced a steady supply of susceptible individuals."[97] The most recent census data indicates that 56.8% of the population is Hispanic in Monterey County.[98] Hispanics are therefore likely to be present in the work force.

Other risk factors include diabetes, malnutrition and socioeconomic status. "Even the risk of 'socioeconomic status' with an annual income below $15,000 was seen

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[92] Schmelzer and Tabershaw, 1968, p. 110; Pappagianis and Einstein, 1978.

[93] Pappagianis and Einstein, 1978, p. 527 ("The northern areas were not directly affected by the ground level windstorm that had struck Kern County but the dust was lifted to several thousand feet elevation and, borne on high currents, the soil and arthrospores along with some moisture were gently deposited on sidewalks and automobiles as "a mud storm" that vexed the residents of much of California." The storm originating in Kern County, for example, had major impacts in the San Francisco Bay Area and Sacramento).

[94] David Filip and Sharon Filip, Valley Fever Epidemic, Golden Phoenix Books, 2008, p. 24.

[95] Filip and Filip, 2008, p. 29.

[96] California Department of Public Health, Coccidioidomycosis Yearly Summary 2012, p. 4; Available at http://www.cdph.ca.gov/programs/sss/Documents/COCCI-UPDATED2012YEARLY.pdf.

[97] Swatek, 1970, p. 5.

[98] Monterey County Demographics Starter Report, p. 4, **Exhibit 2.**

to be a risk factor for the most serious Valley Fever conditions. This finding may be due to any number of reasons, from increased likelihood to work in dusty environments where high doses of spores could be inhaled, to a lack of ability to pay for medical care and thus only visiting doctors when symptoms are at their worst."[99] Monterey County has a poverty rate of 17.9%,[100] again indicating a high proportion of sensitive populations.

The DEIR fails to inform the public of the potential significant consequences of Project construction and fails to address the associated environmental justice issues. The PUC should amend and recirculate the DEIR to provide an adequate assessment of Valley Fever and propose adequate mitigation.

2. A Conventional Dust Control Plan Is Inadequate to Address Potential Health Risks Posed by Exposure to Valley Fever

Conventional dust control measures that are included in the mitigation measures for the Project in Mitigation Measures 4.10-1 and 4.10-2 are not effective at controlling Valley Fever[101] as they largely focus on visible dust or larger dust particles, the PM10 fraction, not the fine particles where the Valley Fever spores are found. While dust exposure is one of the primary risk factors for contracting Valley Fever and dust-control measures are an important defense against infection, it is important to note that PM10 and visible dust are only indicators that *Coccidioides ssp.* spores may be airborne in a given area. Freshly generated dust clouds usually contain a larger proportion of the more visible coarse particles. However, these larger particles settle more rapidly and the remaining fine respirable particles may be difficult to see and are not controlled by conventional dust control measures.

Spores of *Coccidioides ssp.* have slow settling rates in air due to their small size (2 to 5 micrometers), low terminal velocity, and possibly also due to their buoyancy, barrel shape and commonly attached empty hyphae cell fragments.[102] Thus spores, whose size is well below the limits of human vision, may be present in air that appears relatively clear and dust free. Such ambient, airborne spores with their low settling rates can remain aloft for long periods and be carried hundreds of kilometers from their

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[99] Filip and Filip, 2008, pp. 33, 37.

[100] Monterey County Demographics Starter Report, p. 9, **Exhibit 2.**

[101] *See, e.g.*, Cummings and others, 2010, p. 509; Schneider et al., 1997, p. 908 ("Primary prevention strategies (*e.g.*, dust-control measures) for coccidioidomycosis in endemic areas have limited effectiveness.").

[102] Frederick S. Fisher, Mark W. Bultman, and Demosthenes Pappagianis, Operational Guidelines (version 1.0) for Geological Fieldwork in Areas Endemic for Coccidioidomycosis (Valley Fever), U.S. Geological Survey Open-File Report 00-348, 2000; Available at: http://geopubs.wr.usgs.gov/open-file/of00-348/of00-348.pdf.

point of origin. Thus, implementation of conventional dust control measures will not provide sufficient protection for both on-site workers and the general public.

Further, infections by *Coccidioides ssp.* frequently have a seasonal pattern with infection rates that generally spike in the first few weeks of hot dry weather that follow extended milder rainy periods. In California, infection rates are generally higher during the hot summer months especially if weather patterns bring the usual winter rains between November and April.[103] The majority of cases of Valley Fever accordingly occur during the months of June through December. Typically, the risk of catching Valley Fever begins to increase in June and continues an upward trend until it peaks during the months of August, September and October.[104] Drought periods can have an especially potent impact on Valley Fever if they follow periods of rain.[105] It is thought that during drought years the number of organisms competing with *Coccidioides ssp.* decreases and the fungus remains alive but dormant. When rain finally occurs, the arthroconidia germinate and multiply more than usual because of a decreased number of other competing organisms. When the soil dries out in the summer and fall, the spores can become airborne and potentially infectious.[106] The current drought conditions in California may well increase the occurrence of Valley Fever cases. Thus, major onsite and offsite soil-disturbing construction activities should be timed to occur outside of a prolonged dry period. After soil-disturbing activities conclude, all disturbed soils should be sufficiently stabilized to prevent air-borne dispersal of cocci spores.

3. Recommended Measures to Reduce Risk of Valley Fever

In response to an outbreak of Valley Fever in construction workers in 2007 at a construction site for a solar facility within San Luis Obispo County, its Public Health Department[107] in conjunction with the California Department of Public Health[108] developed recommendations to limit exposure to Valley Fever based on scientific

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[103] *Ibid.*

[104] Kern County Public Health Services Department, What Is Valley Fever, Prevention, Valley Fever Risk Factors; Available at: http://kerncountyvalleyfever.com/what-is-valley-fever/risk-factors/.

[105] Gosia Wozniacka, Associated Press, Fever Hits Thousands in Parched West Farm Region, May 5, 2013, citing Prof. John Galgiani, Director of the Valley Fever Center for Excellence at the University of Arizona; Available at: http://abcnews.go.com/m/story?id=19113795.

[106] Theodore N. Kirkland and Joshua Fierer, Coccidioidomycosis: A Reemerging Infectious Disease, Emerging Infectious Diseases, Vol. 3, No. 2, July-September 1996; Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2626789/pdf/8903229.pdf.

[107] San Luis Obispo County Health Agency, Recommendations for Workers to Prevent Infection by Valley Fever in SLO County; Available at: http://www.slocounty.ca.gov/Assets/PH/Epidemiology/Cocci+Recomendations.pdf.

[108] CDPH June 2013, pp. 4-6.

information from the published literature. The recommended measures go far beyond the conventional dust control measures recommended in the DEIR to control PM10 emissions. They include the following measures that are not required in the DEIR to mitigate PM10 emissions from the Project:

1. *Implement comprehensive Injury and Illness Prevention Program (required by Title 8, Section 3203) ensuring safeguards to prevent Valley Fever are included.*
2. *Work with a medical professional with expertise in cocci to develop a training program for all employees discussing the following issues: potential presence of C. immites in soils; the risks involved with inhaling spores; how to recognize common symptoms (which resemble common viral infections, and may include fatigue, cough, chest pain, fever, rash, headache, and body and joint ache); requesting prompt reporting of suspected symptoms to a supervisor and health care provider; discussing worker entitlement to receive prompt medical care if they suspect symptoms of work-related Valley Fever; and requesting the use of personal protection measures as outlined below.*
3. *Control exposure to dust:*
   - Consult with local Air Pollution Control District Compliance Assistance programs and with California Occupational Safety and Health Administration ("Cal/OSHA") compliance program regarding meeting the requirements of dust control plans and for specific methods of dust control.
   - Continuously wet the soil before and while digging or moving the earth. Landing zones for helicopters and areas where bulldozers, graders, or skid steers operate are examples where wetting the soil is necessary.
   - Wetting methods should use processes that do not raise dust or adversely affect the construction process.
   - Provide high-efficiency particulate ("HEP")-filtered, air-conditioned enclosed cabs on heavy equipment. Train workers on proper use of cabs, such as turning on air conditioning prior to using the equipment and keeping windows closed.
   - Provide communication methods, such as 2-way radios, for use in enclosed cabs.
   - When exposure to dust is unavoidable, use National Institute for Occupational Safety and Health ("NIOSH")-approved respirators rated as N95, N99, N100, P100, or HEPA. Respirators must be used within a Cal/OSHA compliant respiratory protection program that covers all respirator wearers and includes medical clearance to wear a respirator, fit testing, training, and procedures for cleaning and maintaining respirators.
   - Employees should be medically evaluated, fit-tested, and properly trained on the use of the respirators, and a full respiratory protection

program in accordance with the applicable Cal/OSHA Respiratory Protection Standard (8 CCR 5144) should be in place.[109]

- Prohibit eating and smoking at the worksite, and provide separate, clean eating areas with hand-washing facilities.
- Promptly secure graded areas using seeding, soil binders or paving and by laying building pads as soon after grading as possible.
- When digging a trench or fire line or performing other soil-disturbing tasks, position workers upwind when possible.
- Place overnight camps, especially sleeping quarters and dining halls, away from sources of dust such as roadways.
- Stop outdoor construction operations during unusually windy conditions or in dust storms.
- Minimize the amount of digging by hand. Instead, use heavy equipment with operator in an enclosed, air-conditioned, HEP-filtered cab.
- Consider limiting outdoor construction during the fall to essential jobs only, as the risk of cocci infection is higher during this season.

4. *Prevent transport of cocci outside endemic areas:*

- Thoroughly clean equipment, vehicles, and other items before they are moved off-site to other work locations.
- Provide workers with coveralls daily, lockers (or other system for keeping work and street clothing and shoes separate), daily changing and showering facilities.
- Keep street clothes and work clothes separate by providing separate lockers or other storage areas.
- Clothing should be changed after work every day, preferably at the work site.
- Encourage workers to shower and wash their hair at the workplace or as soon as they get home if no on-site facilities are available.
- Train workers to recognize that cocci may be transported offsite on contaminated equipment, clothing, and shoes; alternatively, consider installing boot-washing.
- Train workers to recognize symptoms and ways to minimize exposure.
- Post warnings onsite and consider limiting access to visitors, especially those without adequate training and respiratory protection.

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[109] Short-term skin tests that produce results within 48 hours are now available. See Nick VinZant, New Skin Test for Valley Fever Produces Results within 48 Hours, April 15, 2015, Available at: http://www.abc15.com/news/region-west-valley/sun-city/new-skin-test-for-valley-fever-produces-results-within-48-hours.

5. *Improve medical surveillance for employees*

   - Employees should have prompt access to medical care, including suspected work-related illnesses and injuries.
   - Work with a medical professional to develop a protocol to medically evaluate employees who have symptoms of Valley Fever.
   - Consider preferentially contracting with 1-2 clinics in the area and communicate with the health care providers in those clinics to ensure that providers are aware that Valley Fever has been reported in the area. This will increase the likelihood that ill workers will receive prompt, proper and consistent medical care.
   - Respirator clearance should include medical evaluation for all new employees, annual re-evaluation for changes in medical status, and annual training, and fit-testing.
   - Skin testing is not recommended for evaluation of Valley Fever.
   - If an employee is diagnosed with Valley Fever, a physician must determine if the employee should be taken off work, when they may return to work, and what type of work activities they may perform.

Two other studies have developed complementary recommendations to minimize the incidence of Valley Fever. The U.S. Geological Survey ("USGS") has developed recommendations to protect geological field workers in endemic areas.[110] An occupational study of Valley Fever in California workers also developed recommendations to protect those working and living in endemic areas.[111] These two sources identified the following measures, in addition to those identified by the San Luis Obispo County Public Health Department, to minimize the exposure to Valley Fever:

- Evaluate soils to determine if each work location is within an endemic area.
- Implement a vigorous program of medical surveillance.
- Implement aggressive enforcement of respiratory use where exposures from manual digging are involved.
- Test all potential employees for previous infection to identify the immune population and assign immune workers to operations involving known heavy exposures.
- Hire resident labor whenever available, particularly for heavy dust exposure work.

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[110] Fisher et al. 2000.

[111] Schmelzer and Tabershaw, 1968, pp. 111 - 113.

- All workers in endemic areas should use dust masks to protect against inhalation of particles as small as 0.4 microns. Mustaches or beards may prevent a mask from making an airtight seal against the fact and thus should be discouraged.
- Establish a medical program, including skin tests on all new employees, retesting of susceptibles, prompt treatment of respiratory illness in susceptibles; periodic medical examination or interview to discover a history of low grade or subclinical infection, including repeated skin testing of susceptible.

In addition to these generic measures that apply to all construction projects that disturb soil, others are feasible that specifically address Project components. For example, the majority of the earthmoving, which will generate 33,766 cubic yards of excess spoils and construction debris, or 96% of the total (DEIR, Table 3-4), is from pipeline construction. Pipeline construction will disturb 2,311 cubic yards per day of soil (Appx. G, pdf 12) for the entire 30-month construction period and thus is a potential major source of exposure to Valley Fever. DEIR, p. 3-47. Further, sensitive receptors are 50 to 100 feet away. DEIR, p. 4.10-25. The pipelines will be installed using conventional open-trench technology, except where these methods are not feasible. DEIR, p. 3-46. Where not feasible, trenchless methods would be used. DEIR, Sec. 3.5.4.2.

However, trenchless methods are feasible for most all pipelines. These methods are preferable as they do not generate as much fugitive dust. These include jack-and-bore, drill-and-burst, horizontal directional drilling, and/or microtunnelling. DEIR, p. 3-47. These alternate methods should be used to minimize fugitive dust and the release of Valley Fever spores. The applicant should evaluate each Project component to determine whether modifications in construction methods can be implemented to minimize the amount of soil that will be disturbed.

The DEIR's PM10 control measures do not include these measures. Some similar measures are required, but they do not go far enough to control Valley Fever. Some examples follow.

Mitigation Measures 4.10-1a(1,7) require that all active construction areas and stockpiles be watered at least twice daily. DEIR, p. 4.10-23. The CDPH, on the other hand, recommends for Valley Fever control, that "[w]hen soil will be disturbed by heavy equipment or vehicles, wet the soil before disturbing it and continuously wet it while digging to keep dust levels down."[112] The watering trucks themselves used in twice daily watering generate fugitive dust, which is

[112] CDPH June 2013, p. 4.

not addressed by the DEIR's measure, but is addressed by CDPH by requiring the use of wetting methods that do not raise dust."

Mitigation Measure 4.10-1a(4,5) requires daily sweeping, which generates fugitive dust that may contain spores.

Mitigation Measure 4.10-1a(8) only requires hydroseeding or use of soil stabilizers in inactive construction areas (defined as previously graded areas that are inactive for 10 days or more) while CDPH's Valley Fever controls require "prompt" securing of graded areas.

Mitigation Measure 4.10-1a(11) only requires wheel washers on trucks while CDPH Valley Fever control requires "[t]horoughly clean equipment, vehicles, and other items before they are moved off-site to other work locations." DEIR, p. 4.10-23.

In sum, the PM10 mitigation measures in the DEIR are not adequate to control Valley Fever or even PM10, as explained above. Projects that have implemented conventional PM10 dust control measures, such as those proposed here, have experienced several incidences of severe dust storms and reported cases of Valley Fever.

For example, construction of First Solar's Antelope Valley Solar Ranch One ("AVSR1") was officially halted in April 2013 due to the company's failure to bring the facility into compliance with ambient air quality standards, despite dust control measures similar to those proposed here. A dust storm in Antelope Valley on April 8, 2013 was so severe that it resulted in multiple car pileups in the sparsely populated region, as well as closure of the Antelope Valley Freeway. The company was issued four violations by the Antelope Valley Air Quality Management District. Dust from the project led to complaints of respiratory distress by local residents and a concern of Valley Fever. [113]

At two photovoltaic solar energy projects in San Luis Obispo County, Topaz Solar Farm and California Valley Solar Ranch, 28 construction workers contracted Valley Fever. One man was digging into the ground and inhaled dust and subsequently became ill. A blood test confirmed Valley Fever.[114]

All of the above health-protective measures recommended by the San Luis Obispo County Public Health Department and the California Department of

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[113] Herman K. Trabish, Green Tech Media, Construction Halted at First Solar's 230 MW Antelope Valley Site, April 22, 2013, Available at: http://www.greentechmedia.com/articles/read/Construction-Halted-At-First-Solars-230-MW-Antelope-Valley-Site.

[114] Julie Cart, Los Angeles Times, 28 Solar Workers Sickened by Valley Fever in San Luis Obispo County May 01, 2013; available at http://articles.latimes.com/2013/may/01/local/la-me-ln-valley-fever-solar-sites-20130501.

Public Health are feasible for the Project and must be required in an enhanced dust control plan to reduce the risk to construction workers, on-site employees and the public of contacting Valley Fever. Many of these measures have been required by the County of Monterey in other EIRs.[115] Even if all of the above measures are adopted, a recirculated DEIR is required to analyze whether these measures are adequate to reduce this significant impact to a level below significance.

V. GREENHOUSE GAS (GHG) EMISSIONS

The DEIR concluded that greenhouse gas (GHG) emissions from construction and operation of the Project are significant. DEIR, p. 4.11-14. Thus, it imposed Mitigation Measure 4.11-1 for Project GHG emissions and Mitigation Measure 4.18-1 for construction GHG emissions. DEIR, pp. 4.11-15/16. The DEIR concludes that GHG emissions remain significant and unmitigated after compliance with these measures as the "CPUC cannot substantiate numerically that the mitigated GHG emissions would be reduced to a less-than- significant level." DEIR, p. 4.11-16.

The DEIR failed to identify all applicable regulations, failed to adequately support its GHG emission calculations, and failed to include all feasible mitigation measures.

A. The DEIR Failed to Adequately Explain Why the Project's GHG Impacts Are Significant and Unavoidable

The DEIR jumps to the conclusion that GHG impacts are significant and unavoidable because "the CPUC cannot substantiate numerically that the mitigated GHG emissions would be reduced to a less-than-significant level." DEIR, p. 4.11-15. The only reason the CPUC cannot substantiate mitigated emissions numerically is because it has improperly deferred identification of mitigation measures to future plans, as discussed below. Other applicants and lead agencies have succeeded in quantifying GHG emission reductions.[116]

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[115] County of Monterey, California Flats Solar Project Final Environmental Impact Report, December 2014; Available at: http://www.co.monterey.ca.us/Planning/major/California%20Flats%20Solar/FEIR/FEIR_PLN120294_122314.pdf.

[116] See, for example, Chevron Refinery Modernization Project EIR, March 2014, Section 4.8, Available at: http://chevronmodernization.com/wp-content/uploads/2014/03/4.8_Greenhouse-Gases.pdf and resulting mitigation program, Final Environmental Impact Report, Chapter 5. Mitigation Measure Monitoring and Reporting Program, Available at: https://s3.amazonaws.com/chevron/Final+EIR/5_MMRP.pdf.

The DEIR must explain "why" the impact is significant and unavoidable. See *Keep Berkeley Jets Over the Bay Com. V. Board of Port Comrs.* (2001) which concluded: "simply labeling the impact "significant" without accompanying analysis" violates "the environmental assessment requirement of CEQA." Before the DEIR can make the "significant and unavoidable" finding, it must specifically identify the GHG mitigation measures and estimate the reduction in GHG achieved by each. Further, it must explain how the Project is or is not consistent with the State's energy and climate objectives.

B. The DEIR Does Not Address All GHG State Regulations and Policies

The DEIR must identify all applicable regulations and policies and explain how the Project complies with each. The DEIR identifies Executive Order S-3-05; Assembly Bill 32; the AB 32 Scoping Plan; Mandatory Reporting Requirements; and the Cap-and-Trade Program. However, it excludes others.

The DEIR fails to note and address numerous state laws and policies specifically designed to reduce emissions from high-carbon transportation fuels, such as those that will be used in on-road trucks and construction equipment used to build the Project. These include California's Low Carbon Fuel Standard Program, its Zero Emission Vehicle Program, and the Sustainable Communities Strategies Act (SB 375), whose purpose is to reduce vehicle miles traveled.

The revised DEIR should include evidence and analysis addressing whether and how this Project meets these laws and policies as California transitions to low- and zero-carbon transportation fuels and to renewable energy sources. For example, the proposed mitigation fails to address methods to reduce GHG emissions from worker trips (carpooling or vans could be required to transport construction workers from regional hubs) and construction equipment (Tier 4 engines could be required for all construction equipment).

C. GHG Construction Emissions Are Not Adequately Supported

The GHG construction emission calculations in Appendix E are inadequately supported for all of the reasons previously described for criteria pollutant construction emissions.

First, the emissions in Appendix G are based on outputs from various models, EMFAC2011 (Appx. G, pdf 15-22) and OFFROAD2011 (Appx. G, pdf 23). The inputs and outputs from these models are not provided in the record, preventing any meaningful review. Further, EMFAC2011 has been superseded by EMFAC2014,[117]

[117] CARB, Mobile Source Emissions Inventory – Categories; Available at: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles.

which was used to estimate construction criteria pollutant emissions. The text of the DEIR states that EMFAC2014 was used for GHG emissions from commuting workers (DEIR, p. 4.11-11), but supporting calculations in Appendix G indicate that EMFAC2011 was used. This discrepancy should be resolved.

Second, Appendix G only includes pdf versions of the GHG emission calculation spreadsheets. This prevents review of underlying calculations. The record should include unlocked Excel spreadsheets that corresponds to those in Appendix G.

An accurate estimate of GHG emissions is important as it is required to determine the amount of mitigation required to reduce the emissions to below significance thresholds. Further, an accurate estimate is required to determine whether reporting is required under various federal and state regulations. DEIR, pp. 4.11-4/6.

D. The Proposed GHG Mitigation Measures Are Inadequate

The DEIR concluded the greenhouse gas (GHG) emissions from construction and operation of the Project are significant. DEIR, p. 4.11-14. Thus, it imposed Mitigation Measure 4.11-1 for Project GHG emissions and Mitigation Measure 4.18-1 for construction GHG emissions. DEIR, pp. 4.11-15/16. These mitigation measures are fundamentally flawed as they are unenforceable, ambiguous, and do not reduce impacts to a less than significant level.

1. Mitigation Measure 4.11-1: GHG Emission Reductions

This measure requires CalAm to do two things. First, it must prepare a "GHG Emissions Reduction Plan" and submit it to the CPUC for approval prior to start of construction. The Plan "shall include a commitment by CalAm to incorporate all available feasible energy recovery and conservation technologies..." Second, CalAm "shall make good faith efforts to obtain "clean" renewable energy for operations of the project..." This measure is not adequate mitigation under CEQA.

First, preparation of the Emissions Reduction Plan is deferred until after Project approval, pre-empting public review. The Plan must be prepared as part of the DEIR and circulated for public review. Otherwise, the public does not have an opportunity to evaluate the effectiveness of the GHG reduction measures.

Second, under CEQA, an EIR must not only discuss measures to avoid or minimize adverse impacts, it also must ensure that mitigation measures are fully enforceable through permit conditions, agreements, or other legally binding instruments.[118] Mitigation measures that are vague or so undefined [as here] that it is

[118] CEQA Guidelines § 15126.4, subd. (a)(2).

impossible to evaluate their effectiveness are inadequate.[119] A CEQA lead agency cannot make the required CEQA findings unless the record shows that all uncertainties regarding mitigation of impacts have been resolved. Further, an agency may not rely on mitigation measures of uncertain effectiveness or feasibility.[120] Thus, for example, "good faith efforts" to obtain "clean" renewable energy for project operation is not adequate. An enforceable condition requires that the CPUC obtain a commitment to use solar energy, which is a feasible measure. The required findings cannot be made based on a Plan that will be prepared in the future, after the EIR has been certified, and "good faith efforts" to use "clean" renewable energy.

Third, there is no assurance that all feasible measures will be identified unless the Plan is developed by a "qualified professional" as required in Mitigation Measure 4.18-1. The analyses and judgements required to draft this Plan fall under California's engineering licensing laws[121], specifically for Mechanical Engineers. This measure should be modified to require that a registered professional engineer (mechanical) in California confirm by stamp and signature that the Plan includes all feasible measures.

Fourth, the Plan does not require any post-Project construction confirmation and on-going verification that the approved Plan has in fact been implemented and is being complied with. Monitoring is a key component of successful mitigation under CEQA. This measure should therefore be modified to require that a registered professional engineer (mechanical) in California confirm by stamp and signature that the Plan has been implemented. Further, annual tracking/reporting on implementation of all measures should be required via a compliance checklist or similar documentation.

Fifth, the Plan focuses only on Project operational facilities, i.e., "operational components" including the desalination plant, pipelines, and pumping system. There are other opportunities for CalAm to reduce GHG emissions.

CalAm provides water and wastewater services to over 600,000 people at multiple locations in California. It operates other water facilities in the Monterey area, including facilities to secure water from the Carmel River and Seaside Groundwater Basin. DEIR, p. 4.18-13/14. CalAm also operates water and wastewater facilities elsewhere including in Sacramento, San Diego, Larkfield, Los Angeles, and Ventura[122]

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[119] See *San Franciscans for Reasonable Growth v. City & County of San Francisco* (1984) 151 Cal.App.3d 61, 79.

[120] Kings County Farm Bur. V. County of Hanford (1990) 221 Cal.App.3d 692, 727-28 ("a groundwater purchase agreement was inadequate mitigation because there was no record evidence that replacement water was available).

[121] Business & Professions Code §§ 6700 – 6799. See especially, §6731.6 (Mechanical Engineering Defined) and 6735.4 (Signing and Sealing of Mechanical Engineering Documents).

[122] CalAm News, See: http://www.amwater.com/caaw/About-Us/news.html.

and is actively acquiring additional water production and service facilities elsewhere in California[123]. Thus, CalAm has opportunities throughout its system to reduce GHG emissions, not only at the Project facilities. These opportunities include:

- **Energy Audits and Retrofits at Existing CalAm Buildings:** Mitigation could include offsetting the Project's GHG emissions through a comprehensive audit of existing buildings owned by CalAm throughout California and processes to identify and implement energy saving measures, including improving the efficiency of existing equipment so that it uses less electricity or burns less fuel. As an example, in September 2007, the California Attorney General's office came to an agreement with ConocoPhillips, in which ConocoPhillips agreed to mitigate greenhouse gas emissions for a planned hydrogen facility by, among other measures, undertaking an energy efficiency audit and carbon emissions audit for all of its California facilities.[124]

- **Community Energy Efficiency Building Retrofits:** Mitigation could include funding programs that provide for energy efficiency retrofits of existing buildings and housings in the local Project area, with a particular focus on rental and low-income housing. As one example, the Chula Vista Energy Upgrade Project included $210,000 worth of mitigation funds "for energy efficiency and related improvements to local homes and business, ... intended to directly benefit the residents potentially most affected by the proposed project."[125] These upgrades could include installation of a heat-reflecting "cool roof" and heat-reducing window awnings, high-efficiency air conditioning systems with programmable thermostats, and energy-saving fluorescent lighting fixtures that feature daylight and occupancy sensors.

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[123] See, e.g., California American Water Enters into Contract to Purchase Adams Ranch Mutual Water Company, June 16, 2015; Available at: http://files.shareholder.com/downloads/AMERPR/337273308x0x835654/79470B9D-7EE8-488D-9392-66C25DA01B25/Adams_Ranch_Acquisition_PR_FINAL_061615.pdf and California Public Utilities Commission Approves California American Water Acquisition of Ox Bow Marina Mutual Water Company, June 15, 2015; Available at: http://files.shareholder.com/downloads/AMERPR/337273308x0x835474/94F6DA33-7B68-4E41-87E6-49F5499C9777/AL_1066_-_Ox_Bow_PR_FINAL_061115_CS.pdf.

[124] ConocoPhillips and California Attorney General Settlement Agreement, September 10, 2007); Available at: http://ag.ca.gov/globalwarming/pdf/ConocoPhillips_Agreement.pdf.

[125] California Energy Commission, Docket No. 07-AFC-4, Chula Vista Energy Upgrade Project, Final Staff Assessment, Addendum, p. 3, September 30, 2008; Available at: http://www.energy.ca.gov/sitingcases/chulavista/documents/2008-09-29_FINAL_STAFF_ASSESSMENT_ADENDUM_TN-48266.PDF.

- **Funding of Carbon Offset Programs:** Mitigation could include providing funds to the MBUAPCD, Audubon Society, California Wildlife ReLeaf, or other organizations to fund off-site carbon reduction or sequestration projects. AB 32 allows CARB to give credit for voluntary GHG reductions that are undertaken before the regulations require specific GHG reductions are adopted.[126] For example, the 2007 ConocoPhillips settlement included an agreement to mitigate and offset greenhouse gas emissions by providing: (1) $7 million to the BAAQMD to create a fund for carbon offsets, (2) $200,000 to the Audubon Society for restoration of wetlands in the San Pablo Bay for purposes of carbon sequestration, and (3) $2.8 million to California Wildlife ReLeaf for reforestation projects, estimated to sequester 1.5 million metric tons of CO_2 over the lifetime of the forest. As another example, Chevron agreed to a $30 million GHG reduction plan to offset the increase in GHG from its modernization project which included working with others to develop transportation and transit programs and a roof-top solar and energy retrofit program.[127] These programs also could include electric vehicle (EV) rebate; installation of EV charging stations; reserved parking for EV vehicles; clunker scraping programs with incentives for purchasing or leaving new or used EVs; and financing options for EVs for people with limited credit, among many other.

- **Water Conservation**: CalAm's Monterey system is among the best in California at conserving water. Its daily per-capita water use in the SWRCB's most recent statewide survey for October 2014 to April 2015 is 55.8 gallons per person, while its facilities in San Diego reported 65 gallons per person; in Sacramento 80.2 gallons per person; and in Los Angeles, 126.2 gallons per person.[128] The Monterey Division has implemented an aggressive water conservation program under a settlement agreement.[129] This program includes residential audits, leak detection, a house call pilot program, residential and commercial

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[126] Health & Safety Code, §38562, subd. (b)(2).

[127] Chevron Richmond Refinery Modernization, Environmental and Community Investment Agreement, October 7, 2014; Available at: http://www.ci.richmond.ca.us/DocumentCenter/View/29755 and Chevron Refinery Modernization Project Environmental and Community Investment Agreement between City of Richmond, CA and Chevron Products Company, pp. 12-15, Available at: http://www.ci.richmond.ca.us/DocumentCenter/View/30667.

[128] Excel Spreadsheet: October 2014 – April 2015 Urban Water Supplier Report, Available at: http://www.waterboards.ca.gov/water_issues/programs/conservation_portal/conservation_reporting.

[129] 2014 Monterey Peninsula Water Conservation Program Annual Report, Available at: http://www.montereywaterinfo.org/documents/2014%20Conservation%20Report_FINAL%20SUBMITTED.pdf.

plumbing retrofits, large landscape audits and water budgets, a landscape grant program, and rain sensor and soil moisture sensor installation programs. CalAm should expand these measures to its other systems which use substantially more water. This would significantly reduce GHG emissions by reducing water demand, which requires significant amounts of electricity to supply. Reducing electrical demand throughout CalAm's system could significantly offset GHG emissions from the Project. CalAm should also agree to make these measures in its Monterey District permanent.

- **On-Site Solar:** A UC Berkeley study found that in order to meet the State of California's existing goal of 80% GHG reduction by 2050,[130] California must: (1) completely phase out fossil-fueled *electricity* and (2) electrify *transportation*. Thus, to comply with Executive Order S-3-05, the Project could install and operate a 5 MW solar plant at its facilities to supply 100%

2. Mitigation Measure 4.18-1: Construction Equipment Efficiency Plan

This measure requires CalAm to contract a "qualified professional" to prepare a "Construction Equipment Efficiency Plan" to identify specific measures that CalAm will implement as part of Project construction "to increase the efficient use of construction equipment to the maximum extent feasible." DEIR, p. 4.18-12. This measure has the same deficiencies as Mitigation Measure 4.11-1, discussed above.

First, preparation of the Efficiency Plan is deferred until after the Project is approved, pre-empting public review. The Plan must be prepared as part of the DEIR and circulated for public review.

Second, the measure does not clarify what constitutes a "qualified professional". This measure should be modified to require that the qualified professional be a registered professional engineer (civil[131]) in California and the Efficiency Plan should be confirmed by stamp and signature that the Plan includes all feasible construction equipment efficiency measures.

Third, the Efficiency Plan does not include all feasible mitigation measures. This measure as well as Mitigation Measures 4.9-7 and 4.10-1a/1c do list a few feasible measures, including properly tuned and maintained equipment; use of electricity where

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[130] James H. Williams et al., The Technology Path to Deep Greenhouse Gas Emissions Cuts, Science, v. 335, pp. 53-59, January 6, 2012; Abstract available at http://www.sciencemag.org/content/335/6064/53.

[131] Business & Professions Code §§ 6700 – 6799. See especially, §6731 (Civil Engineering Defined) and 6735 (Preparation, Signing, and Sealing of Civil Engineering Documents).

feasible; idling restrictions; a measure to promote carpooling and public transportation; and reduction of haul distances.

Many other such measures should have been identified in the DEIR as all feasible mitigation is required when the impact is not fully mitigated. These include the NOx and ROG mitigation measures identified above, plus measures recently required as GHG construction mitigation in the Chevron Modernization FEIR[132] (annotated here by "Chevron"):

- All construction equipment shall be maintained and properly tuned in accordance with manufacturer's specifications. All equipment shall be checked by a certified visible emissions evaluator (Chevron).
- The idling time of diesel-powered construction equipment shall be limited to 2 minutes rather than the 5 minutes in Mitigation Measure 4.10-1c, as required in the Chevron FEIR. Clear signage shall be provided for construction workers at all access points as required in the Chevron FEIR (Chevron).
- All contractors shall be required to use equipment that meets CARB's most recent certification standard for off-road heavy duty diesel engines (Chevron).
- Reuse and recycle construction and demolition waste, including, but not limited to soil, vegetation, concrete, lumber, metal, and cardboard (Chevron).
- Using alternative fueled, e.g., biodiesel, construction vehicles/equipment on at least 15% of the fleet (Chevron).
- Consolidate truck deliveries.
- Require a certified on-site inspector (licensed general contractor or similar) to confirm that the construction mitigation program is properly implemented.

Fourth, no method to verify compliance is identified. To facilitate confirmation of compliance with the construction mitigation measures, and to verify the DEIR's estimated construction emissions, the FEIR should include a comprehensive inventory of all off-road equipment that will be used to construct the Project. The inventory should include the horsepower rating, engine production year, hours of use, and amount and type of fuel used. At least 48 hours prior to the use of heavy-duty off-road equipment at a new construction site, the project representative shall provide the

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[132] Chevron Refinery Modernization Project EIR, March 2014, Chapter 4.8, Greenhouse Gases; Available at: http://chevronmodernization.com/wp-content/uploads/2014/03/4.8_Greenhouse-Gases.pdf and Chapter 5, Mitigation Measure Monitoring and Reporting Program; Available at: https://s3.amazonaws.com/chevron/Final+EIR/5_MMRP.pdf.

inspector and MBUAPCD with the construction timeline, including start date and name and phone number of project manager and on-site foreman.

Fifth, the Efficiency Plan does not require any monitoring during construction to assure that the measures are implemented. The Efficiency Plan should require an on-site construction mitigation manager to oversee and enforce implementation of all mitigation measures and to proactively ensure that construction activities do not result in noise, odor, dust, or other complaints. The monitor should be a licensed and qualified professional (QEP, CIH, PE) who is continuously present at the construction site(s) to confirm that the Efficiency Plan is implemented. Further, annual tracking/reporting on implementation of all measures should be required via a compliance checklist or similar documentation.

Therefore, the Efficiency Plan fails to adequately mitigate the air quality impacts resulting from Project construction. The DEIR must be revised in accordance with these comments and recirculated before the Project can be lawfully approved under CEQA.

A - 1

CHEMISTRY:

GS-MS Determination of Volatile Organic Compounds in Gasoline and Diesel Emissions

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Abstract: *In light of environmental concerns over volatile organic compounds (VOCs) in the atmosphere, we investigated those found in gasoline and diesel emissions using gas chromatography-mass spectrometry (GC-MS). We took tailpipe samples from two gasoline and three diesel vehicles for 4 minutes after cold-start ignition. Two sampling methods were compared in this study: pumping exhaust through an absorbent charcoal tube and directly collecting VOCs via solid phase microextraction (SPME). SPME was determined to be more effective than pump sampling as it afforded longer sample retention times and higher chromatogram quality. Of the twenty chromatograms analyzed in this study, gasoline emissions contained higher abundances of the lower-boiling aromatic hydrocarbons, such as benzene, toluene, ethylbenzene, xylenes, styrene, 1,2,4-trimethylmethylbenzene, than diesel. Large n-alkane derivatives of decane, undecane, and hexadecane were detected in diesel exhaust. Vegetable oil was also analyzed and found to contain compounds similar to diesel. Compounds identified in all three fuel emissions correlated with those detected from headspace analysis of pure standards.*

Introduction

This paper investigates the emission of volatile organic compounds (VOCs) in the exhaust of three fuels: gasoline, diesel, and waste vegetable oil.

Gasoline and diesel fuels are derived from petroleum, a product of decomposed plants and animals. Hydrocarbons in the fuel react with oxygen in the air to form carbon dioxide (CO_2) and water (H_2O) by the following combustion reaction:

$$C_xH_y\,(g) + O_2\,(g) \rightarrow CO_2\,(g) + H_2O\,(g)$$

This reaction is exothermic and has the capability to power motor vehicles. Since combustion does not always proceed to completion, poisonous gases such as carbon monoxide (CO) and volatile organics are emitted. In addition, sulfur (S_2) in the fuel and nitrogen (N_2) in the air react in the engine to form sulfur oxides (SO_x)—a major contributor to acid rain—and nitrogen oxides (NO_x)—a cause of ground-level ozone and smog. The emissions from motor vehicles contribute significantly to the air pollution problem in most large cities.

Gasoline mostly contains hydrocarbons in the range of C7-8 while diesel is composed of heavier petroleum fractions of C9-10. In addition to containing simple alkanes, both fuels also include cycloalkanes, benzene, and other aromatic hydrocarbons. Since gasoline contains more lower-molecular weight components, it has a lower boiling point than diesel fuel (1). Diesel engines tend to be more powerful than gasoline engines and are often used in heavy-duty vehicles such as buses, trucks, ships, and locomotives. Despite its advantages as a source of power, diesel is considered to be dirtier than gasoline and produces large amount of soot (2). Studies have shown that soot can cause respiratory problems such as chronic bronchitis, asthma, and cancer (3).

In order to reduce gasoline emissions of poisonous gases, modern cars are equipped with catalytic converters that produce rather benign products by the following reactions (1):

$$2CO\,(g) + O_2\,(g) \rightarrow 2CO_2\,(g)$$
$$NO_x\,(g) \rightarrow O_2\,(g) + N_2\,(g)$$
$$C_xH_y\,(g) + O_2\,(g) \rightarrow CO_2\,(g) + H_2O\,(g)$$

Catalytic converters use sensors to ensure that there is a stoichiometrically equivalent presence of oxygen relative to products in the exhaust. Once the catalytic converter warms up, usually to 300 °C, it is very effective at driving the above reactions to completion. In fact, around 80% of all vehicular emissions occur in the first few minutes after ignition, before the catalytic converter is ready (1). As a cleaner alternative fuel, vegetable oil has received significant attention (4). Although its combustion properties are very similar to those of diesel fuel, vegetable oil cannot be injected directly into an engine because of its high viscosity. Sunflower oil, for example, is one of the most popular choices for this substitution (4). At 27 °C its viscosity is 58.5 mm^2/s, while that of diesel is 4.3 mm2/s at the same temperature (5). Heating the oil immediately before it passes through the engine can solve this problem and diesel engines can easily be reconfigured to accept vegetable oil with the addition of a new, heated fuel tank (6, 7, 8). Another

possibility is to chemically convert the vegetable oil into less viscous compounds by cracking it, performing a transesterification, blending it with other fuels, or creating a micro-emulsification (5).

As for the environmental consequences of burning vegetable oil as fuel, studies have shown that it emits lower levels of particulate pollutants than diesel (4). However, some studies show a general tendency for vegetable oil based fuels to emit more nitrogen oxides (NOx) (4), while other studies (5) have shown a slight decrease in NOx emissions. Recycling waste vegetable oil may offer the benefits of being inexpensive and renewable, but its environmental effects must be further investigated.

Among the numerous air pollutants in auto exhaust, this study focuses on volatile organic compounds such as benzene, toluene, and o, m, p-xylenes. VOCs react with sunlight and nitrogen oxides to produce ground-level ozone, which causes lung and tissue damage upon prolonged exposure (9, 10). In addition, acute inhalation of VOCs may lead to irritation of the eyes, nose, and throat, gastrointestinal effects, eye irritation, and neurological effects in humans. Chronic inhalation can adversely interfere with the central nervous system, causing headaches, dizziness, fatigue, tremors, and loss of coordination (11).

In this study, two methods were used to collect VOCs n car exhaust: solid phase microextraction (SPME) and activated carbon in the form of charcoal. The SPME procedure can be used in the field to sample VOCs from air. SPME samplers, which retain samples for up to three days when stored at -4 °C, are easily transported to lab for direct injection into a gas chromatograph (GC) (12). The SPME fiber is coated with a 75 _m layer of Carboxen™/ polydimethylsiloxane (PDMS) and can be retracted behind a septum to prevent contamination (12). The second method involves the use of activated charcoal to trap organic molecules. Exhaust is pumped across charcoal in glass tubes which can be sealed and transported to lab (13). Before the samples are injected into the GC, they must be desorbed from the charcoal with an appropriate solvent—in this study, carbon disulfide (CS_2) was used.

Vehicle	Mileage/ Fuel Type	Sampling Date	Ambient Temperature	Sample ID	Sampling Duration
1999 Ford Taurus SE	200,590mi/ Reg. Gasoline	18 Jul 05	33 °C	Tau1A, Tau1B, Tau2A, Tau2B	4 min; 8 min
		25 Jul 05	29 °C	3A, 3A2, 3A3, 3B1, 3B2, 3C, S2A, R2A	4 min
		28 Jul 05	25 °C	S4A, R4A, 4A, 4B	4 min
		12 Aug 05	32 °C	S5A, R5A, 5A, 5B	4 min
1990 Volvo 240DL	116,376mi/ Reg. Gasoline	01 Aug 05	30 °C	RV1, SV1, V1, V2	3 min 30 s
2004 Coach Bus	150,000/ Diesel	04 Aug 05	35 °C	SD1	30 s
1984 Mercedes 190D	190,162mi/ Diesel	05 Aug 05	30°C	SMDO1	4 min
	190,162mi/ Vegetable Oil	05 Aug 05	30 °C	RMO1	4 min
Diesel Truck International 4700 T444E	Diesel	09 Aug 05	35 °C	RT1, ST1, T1, T1B, T1C, T2	3 min 30 s; 4 min
Standard	**Condition**	**Sampling Date**	**Ambient Temperature**	**Sample ID**	**Sampling Duration**
Diesel	New	11 Aug 05	21 °C	RDIESEL2	10 min
Gasoline	New	11 Aug 05	21 °C	RGAS2	10 min
Vegetable Oil	New	12 Aug 05	150 °C	SNEWOIL1	10 min
	Used	12 Aug 05	150 °C	RWSTEOIL	5 min

Table I: Sample Sources, Conditions and Methodology

Experimental Procedure

Tailpipe Sampling for Pump and SPME

An Escort®LC Pump (MSA) was calibrated with a Buck Mini-Calibrator™ (A.P. Buck, Inc.) to 210 ± 5 cc/min. For the collection of tailpipe emissions, the pump was connected to the tailpipe via 180 cm of Tygon® tubing (Fisher Scientific, 3/16 in. ID) with a hollow, metal terminus that hooked on to the tailpipe. An ORBO™ 32 standard charcoal tube (Supelco) was incorporated into the length of the tubing. Samples were collected for approximately 4 minutes after igniting the engine from a cold start. The charcoal tube was immediately capped after sampling.

SPME and pump sampling techniques. Image courtesy of the authors.

A Solid-Phase Microextraction (SPME) (Supelco) field sampler was concurrently introduced into the tailpipe during the sampling process for 4 minutes.

Carbon Disulfide Preparation for Charcoal

The contents of each charcoal tube were transferred to a 2 ml amber glass vial (National Scientific). The vials were crimped with Teflon-faced Neoprene® Septa (Supelco). 1.0 ml of carbon disulfide (99+% redistilled, Aldrich) was injected into the vial and the vial was placed on ice for at least 30 minutes before GC-MS analysis.

Standards for Gasoline, Diesel and Vegetable Oil

Standard chromatograms of pure gasoline, diesel, and vegetable oil were generated from sampling headspace volatiles by SPME. Gasoline and diesel samples were obtained courtesy of C. Ciambra. Unused and waste vegetable oil samples were provided by the Dartmouth Dining Services' Courtyard Café. 5.0 ml of each standard was transferred to a 20 ml EPA amber vial (Fisher Scientific), capped with a septum seal, and stirred for 20 minutes. Vegetable oil samples were heated to 150 °C. Headspace volatiles were collected via SPME for an additional 10 minutes.

GC-MS Analysis

GC-MS analyses were performed on a HP 5890 Series 2 gas chromatograph and a HP 5971 mass selective detector (Hewlett Packard, Avondale, PA, USA). Helium, with a linear velocity of 30 cm/s, was used as a carrier gas for the 30.0 m x 0.25 mm x 1 _m film thickness capillary column (Supelco). The MS was maintained at 4.8 x 10-5- torr. For the pump samples, 1 _l of the carbon disulfide solution was injected into the GC injector port at 250 °C. SPME samples were introduced to the injector port at 275 °C. Peaks were computer-integrated at their apexes and mass spectra were automatically compared to those spectra in the NBS75K library for identification purposes.

Results and Analysis

Commonly integrated compounds identified by GC-MS analysis are summarized in Table II for gasoline, diesel, and vegetable oil emissions. The samples in each category were compared to standard "un-combusted" samples containing pure gasoline, diesel, or waste vegetable oil. Since fuel samples come in a variety of different hydrocarbon mixtures, the compounds in the standards do not necessarily correspond to the compounds in the emissions. However, these pure standards still provide a frame of reference for which candidate compounds are likely to appear in the exhaust samples.

The most common compounds observed in the various gasoline samples were benzene, toluene, and isomers of xylene. None of the diesel samples exhibited significant levels of these volatile organics with the exception of the Mercedes diesel sample, which may have been contaminated by vegetable oil in the engine. However, the diesel standard indicates that a sizeable percentage of all three compounds were likely to have been present in the original diesel fuel. The results, although curious, can be explained by the fact that the tailpipe temperatures of the larger diesel vehicles far exceeded the temperatures of the smaller gasoline automobiles, thereby volatizing the more lower-boiling compounds before they reached the sampling devices. This assumption is supported by the diesel chromatograms, in which no significant peaks appear until after 14 minutes, while larger n-paraffins and iso-paraffins such as undecane and decane were detected in abundance.

Higher-boiling, aromatic derivatives of benzene containing two, three, or four extra carbons were prevalent in gasoline and diesel samples, but not found in the vegetable oil. The most common of these derivatives detected were 1,2,4-trimethyl-benzene, 1,2,3-trimethyl-benzene, 1-ethyl-2-methyl-benzene, 1-ethyl-4-methyl-

Gasoline Vehicle Emissions		Gasoline Standard	
Toluene	7.07 – 21.44%	Xylene	22.26%
Xylene	5.88 – 21.42%	1,2,4-Trimethylbenzene	15.46%
1-Ethyl-2-methyl-benzene	8.06 – 12.49%	Toluene	10.82%
1,2,4-Trimethylbenzene	1.29 – 11.64%	1-Ethyl-2-methyl-benzene	9.27%
Benzene	1.37 – 6.74%	Ethylbenzene	6.04%
1-Ethyl-2,3-dimethyl-benzene	6.14%	Benzene	2.82%
1,2,3-Trimethylbenzene	4.04 – 5.90%		
Ethylbenzene	2.74 – 4.57%		
1-Ethyl-4-methylbenzene	4.23%		
Naphthalene	3.20%		
Styrene	1.80%		
Benzaldehyde	1.24 – 1.67%		
Indane	1.48 – 1.50%		
Diesel Vehicle Emissions		**Diesel Standard**	
Benzene	0.50 – 9.79%	Xylene	11.23%
3,6-Dimethyl-undecane	7.43%	3,9-Dimethyl-undecane	10.79%
Phenol	1.42 – 6.08%	Toluene	8.75%
1,2,3-Trimethylbenzene	6.04%	1,2,4-Trimethylbenzene	6.55%
Benzocycloheptatriene	4.49%	1-Ethyl-2,3-dimethyl-benzene	1.19%
Decane	1.23 – 4.33%	Benzene	0.60%
2,6-Dimethyl-undecane	4.01%		
Azulene	1.49 – 3.86%		
Benzoic acid	2.16 – 3.65%		
1,2-Dithiacyclopentane	3.45%		
Naphthalene	3.03%		
2,6,7-Trimethyldecane	2.24 – 2.96%		
3-Methyl-hexadecane	2.80%		
Undecane	2.71%		
Phthalan	1.97%		
4,6-Dimethyl-undecane	1.49%		
Vegetable Oil Vehicle Emissions		**Vegetable Oil Standard**	
Phenol	14.12%	2,4-Hexadienal	9.67%
Benzene	6.08%	Toluene	6.35%
Styrene	4.73%	p-Xylene	4.80%
Toluene	3.11%	Hexanal	4.29%
		Benzaldehyde	2.06%
		Ethylbenzene	1.36%
		Benzene	0.77%

Table II: List of VOCs Identified by GC-MS Analysis by Increasing Peak Area Percentages

benzene, 1-ethyl-2,3-dimethyl-benzene, and styrene. Oxidized derivatives of benzene (benzaldehyde, benzoic acid, phenol) and polycyclic aromatic hydrocarbons (PAHs) (naphthalene, indane, azulene, phthalan) were also detected, though in lower abundance levels, for gasoline and diesel samples.

In the remainder of this section, a descriptive summary of select chromatograms is given.

1990 Volvo 240DL

SPME: Benzene (1.39%, 6.07 min), toluene (14.83%, 8.98 min), p-/m-xylene (24.43%, 11.84 min), styrene (1.80%, 12.28 min), 1,3-dimethyl-benzene (3.91%, 12.43 min), benzaldehyde (1.24%, 13.76 min), 1-ethyl-4-methyl-benzene (4.23%, 14.20 min), 1,2,4-trimethylbenzene (11.64%, 15.05 min).

Pump: Benzene (4.35%, 6.15 min), toluene (21.44%, 9.53 min), o-/m-/p-xylene (7.09%, 11.71 min; 16.14%, 11.88 min), ethylbenzene (4.40%, 12.34 min).

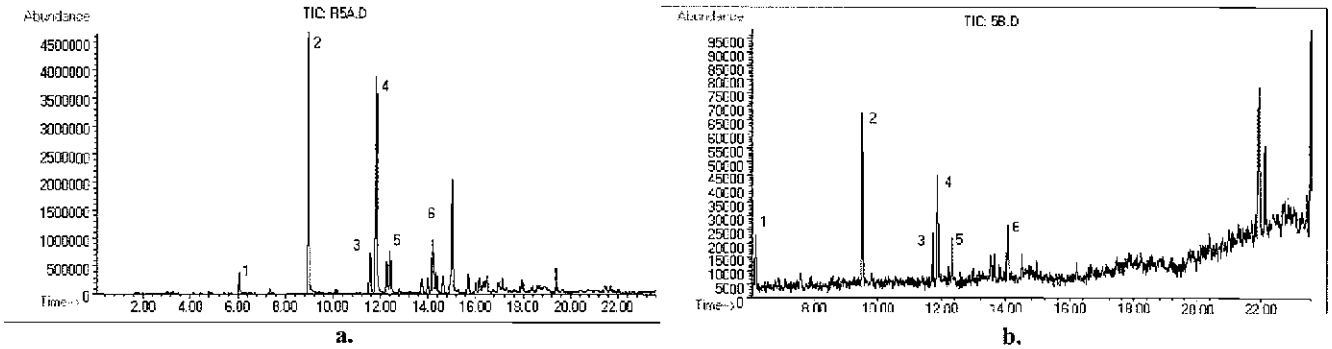


Figure I. Corresponding peaks in Taurus chromatograms collected by (a) SPME, and (b) pump. 1. Benzene 2. Toluene 3. Ethylbenzene 4. Xylenes 5. 1,2,4-Trimethylbenzene 6. 1-ethyl-2-methyl-benzene

2004 Large Coach Bus

SPME: 1,2,3-trimethylbenzene (6.04%, 14.99 min), 1-methyl-2,2-propenyl-benzene (1.37%, 18.65 min) naphthalene (4.04%, 19.37 min), benzocycloheptatriene (4.49%, 21.69 min).

International 4700 T444E Diesel Construction Truck

SPME: Benzene (0.50%, 6.08 min), phenol (1.42%, 14.11 min), phthalan (1.97%, 16.41 min), decane (4.33%, 17.55 min), benzoic acid (3.65%, 18.23 min), undecane (2.71%, 18.92 min), azulene (3.86%, 19.37 min), 3-methyl-hexadecane (2.80%, 19.69 min).

1984 Mercedes 190D

SPME (Vegetable Oil): Benzene (12.21%, 6.08 min), toluene (3.11%, 8.95 min), styrene (4.73%, 12.28 min), phenol (5.38%, 14.12 min).

SPME (Diesel): Benzene (9.79%, 6.07 min), 2-cyclopenten-1-one (1.76%, 10.10 min), 1,2-dithiacyclopentane (3.45%, 13.73 min), phenol (6.08%, 14.13 min), 2,6,7-trimethyl-decane (2.96%, 15.74 min), decane (1.23%, 17.57 min), azulene (1.49%, 19.37 min).

1999 Ford Taurus SE

SPME: Benzene (1.84%, 6.07 min), toluene (8.96%, 15.44 min), ethylbenzene (4.57%, 11.56 min; 4.57%, 12.42 min), m-/p-xylene (21.42%, 11.82 min), benzaldehyde (1.67%, 13.73 m), propyl-benzene (1.60%, 14.00 min), 1,2,4-trimethylbenzene (2.19%, 14.36 min) 1-ethyl-4-methyl-benzene (1.71%, 14.64 min), 1-ethyl-2-methyl-benzene (12.49%, 15.03 m; 2.09%, 15.70 min), indane (1.09%, 16.01 min), naphthalene (3.20%, 19.40 min).

Pump: Benzene (6.74%, 6.17 min), toluene (16.92%, 9.51 min), o-/m-/p-xylene (5.88%, 11.71 min; 17.14%, 11.87 min; 6.59%, 12.32 min), 1,2,3-trimethyl-benzene (5.90%, 14.06 min).

Gasoline Standard

SPME: Benzene (2.82%, 6.07 min), toluene (10.41%, 8.98 min), ethylbenzene (6.04%, 11.61 min), o-/p-xylene (11.96%, 11.90 min; 10.30%, 12.55 min), 1-ethyl-2-methyl-benzene (7.12%, 14.29 min; 2.15%, 14.34 min), 1,2,4-trimethylbenzene (2.50%, 14.47 min; 1.55%, 14.72 min; 9.91%, 15.17 min; 1.50%, 15.78 min).

Diesel Standard

SPME: Toluene (8.75%, 8.98 min), p-xylene (11.23%, 11.85 min), 1,2,4-trimethylbenzene (6.55%, 15.05 min), 3,9-dimethyl-undecane (10.79%, 17.66 min). Benzene (0.60%, 6.07 min) was detected in low quantities and with a low quality match of 58. Other less notable compounds with high quality matches included 1-ethyl-2,3-dimethyl-benzene (0.70%, 17.95 min; 1.19%, 18.03 min), 1,2,3,4-tetrahydro-naphthalene (1.18%, 18.97 min), parachlorophenol (1.37%, 19.43 min), cyclopropyl-benzene (1.10%, 21.14 min).

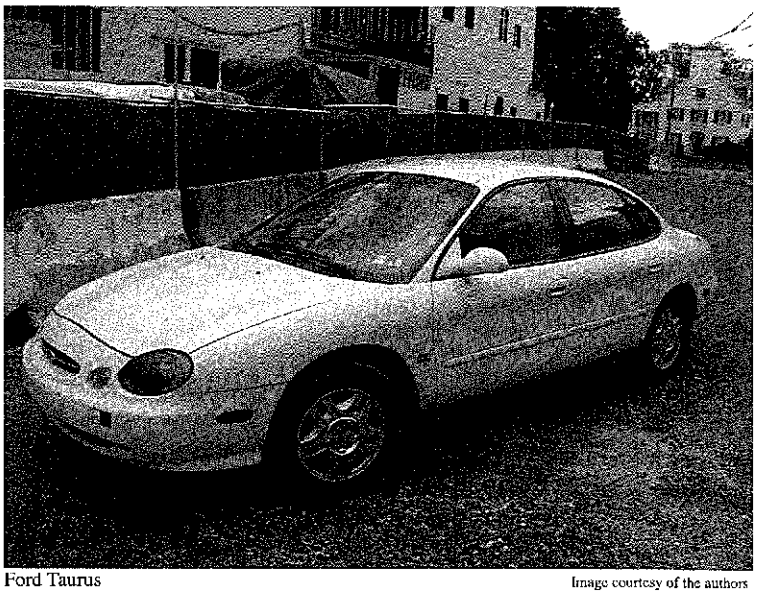
Vegetable Oil Standard

SPME: Benzene (0.77%, 6.13 min), toluene (6.35%, 8.98 min), ethylbenzene (1.36%, 11.61 min), 1,3-dimethyl-benzene (4.80%, 11.85 min), benzaldehyde (2.06%, 13.86 min), 2,4-hexadienal (9.67%, 15.04 min), hexanal (4.29%, 9.61 min).

Discussion

The ultimate goals of this investigation were to draw a comparison between the VOCs in gasoline, diesel, and vegetable fuel emissions, and to qualify the relative abundances of an array of hydrocarbon compounds. In the process of drawing these comparisons, two sampling methods were used to trap volatile organics in this approach: direct sampling of exhaust via SPME and pumping exhaust across a charcoal-containing tube for analysis. Sampling via SPME and pump was conducted concurrently for each vehicle, offering a basis of comparison for the two methods (Table I). Both methods were found to be reproducible, reliable, and, in respect to final data, almost analogous.

Figure I compares the chromatogram results from the sampling of a Ford Taurus via SPME and pump method. Both trials were sampled at the same time, and analyses were performed on the same day. While pump abundances were 50 times higher for SPME, the retention times and relative abundances of the peaks of the two chromatograms do correspond. The higher signal-to-noise ratio (S/N) and level baseline in the first chromatogram, however, allowed the analysis program to identify peaks with a higher quality match. Additionally, the baseline of the latter chromatogram increased in slope starting at 16 minutes, limiting the computer's ability to integrate the peaks which appear after 22 minutes (peaks which do not appear in the first chromatogram).



Ford Taurus

Image courtesy of the authors

In general, SPME produced superior chromatograms with higher S/Ns, more abundant peaks, and a steady baseline for all samples. The nature of the SPME instrument also allows for injection into the GC-MS immediately after sampling, requiring no intermediate preparation step such as the carbon disulfide dissolution required for analyzing pump samples. In addition, it was demonstrated that the abundances of compounds collected via the pump method dissipated over time. This dissipation was not the case for SPME samples, which were shown to preserve abundances for at least 24 hours. The one advantage of pump sampling is its repeatability. Multiple injections can be analyzed from the same preparation of charcoal to produce duplicate results, provided that the user does not wait too long in between injections, which is not the case for single-injection SPME. However, the overall advantages of SPME (higher efficiency, cleaner chromatograms, and longer sample life) make it a better sampling method for volatile organic exhaust.

Three fuel types were examined over the course of this investigation: gasoline, diesel, and waste vegetable oil. As discussed previously, gasoline exhaust samples generally contained low-boiling point compounds that were not present in diesel sample. This trend is seen in the diesel and gasoline standards as well, perhaps indicating that the initial composition of the fuel has a direct consequence on which types of compounds may be found in its exhaust. By the same comparison, diesel exhaust samples contained many more high-boiling, higher molecular weight compounds than their gasoline counterparts. These larger compounds, however, do not appear in the pure diesel standard. There are two explanations which may account for this observation. The first is that when sampling the diesel standard, the diesel was not heated to the same temperatures as it would reach in an engine; thus, higher molecular weight compounds could not volatize and appear in the chromatogram. The second is that the high temperatures of a diesel engine promote reactions between smaller hydrocarbon chains to form higher molecular weight organics.

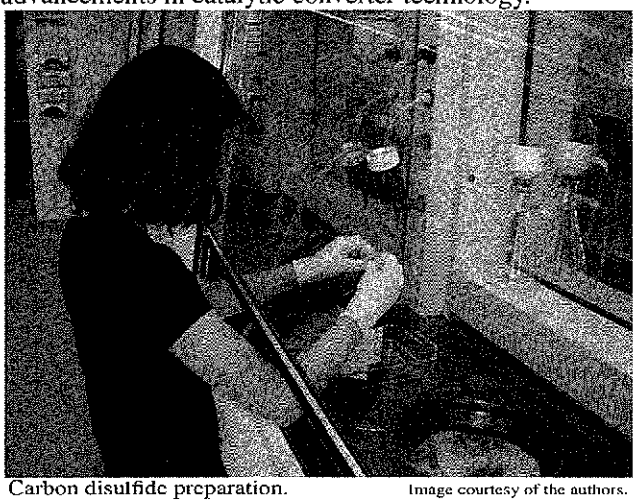
Of the compounds which were detected in gasoline and diesel emissions, many pose serious health hazards after acute or chronic levels of exposure (11). According to the EPA, acute exposure to styrene, ethylbenzene, xylenes, naphthalene, benzaldehyde, and phenol can cause an assortment of neurological, respiratory and gastrointestinal conditions, as well as eye and dermal irritation. Benzene is also a known carcinogen. Toluene is found to be disruptive to central nervous system functions. Larger hydrocarbons present in diesel fuel, such as decane and undecane, have been found to cause dizziness and irritation. All of the above compounds were detected

Volvo 240

Image courtesy of the authors.

by SPME and pump sampling methods and are listed in Table II.

As an attempt to mediate the emission levels of aromatic hydrocarbons, fuel additives such as oxygenates have been incorporated into different fuel types (14). Catalytic converters are another solution to lowering VOC concentrations in fuel exhaust. In this investigation, samples from repeated testing of a 1999 Ford Taurus with a catalytic converter and a 1990 Volvo with an older one were compared. Using the SPME method, the abundances from the Volvo samples were 2 to 4 times higher than the abundances for the Taurus samples. Although this discrepancy may likely have been due to inconsistencies in sampling method, it is not unreasonable to posit that significant differences in abundance are also due to advancements in catalytic converter technology.



Carbon disulfide preparation. Image courtesy of the authors.

A third method for lowering VOC concentrations in fuel exhaust is to switch to vegetable oil as an alternative fuel source. Although Table II seems to suggest that the vegetable oil burns more cleanly than diesel fuel because less VOCs were detected in its emissions, this data may be misleading. In fact, the data is insufficient for drawing such a conclusion. Vegetable oil and diesel emissions sampled from the same Mercedes vehicle produced two similar chromatograms. In both chromatograms, 61 peaks were identified, and the abundance values were in the same range. However, due to a higher S/N in the diesel chromatogram, the computer was able to integrate more peaks above the quality threshold for that particular sample, giving the appearance that the diesel sample contained more VOCs than the vegetable oil sample. By just comparing the chromatograms alone and not the computer-generated analyses, the similarities in the two samples seem to suggest that cross-contamination of the two samples may have occurred in the engine. Therefore, it is reasonable to conclude that neither chromatogram represents a pure diesel or a pure vegetable oil sample. The waste vegetable oil standard shows that although vegetable oil contains aromatic hydrocarbons (namely benzene, toluene, ethylbenzene, xylenes, benzaldehyde), the one advantage that it has over diesel is a lack of decane, undecane and other such long alkanes. The overall prospects for vegetable oil as an alternative fuel source seem promising, but further research is still needed to investigate exhaust from engines running solely on vegetable oil.

Conclusion

The scope of this investigation was large, comparing volatiles in exhaust from three different fuel types using two different sampling methods. Chromatograms produced by SPME sampling were generally easier to integrate than chromatograms produced by the pump and charcoal tubes method, and sample abundances could be preserved for longer periods of time before GC-MS analysis. Unless repeatability is an issue and a large number of SPME field samplers could not be obtained, then SPME is preferred over the pump method.

The VOCs identified in the exhaust via GC-MS depended largely on fuel type, purity of the sample, and the techniques used to obtain the sample. Many of the aromatics detected in the emissions have potential respiratory, neurological, gastrointestinal, or dermal consequences. Even vegetable oil, though hailed as an environmentally-safe alternative fuel source, has potential for harm. Further investigation is required in quantifying each of the VOCs identified, and expanding the study to a greater array of vehicles.

References

1. C. Baird and M. Cann. Environmental Chemistry, 3rd ed. (W.H. Freeman, New York, 2005).
2. Diesel Pollution. Available at http://www.sierraclub.org/cleanair/factsheets/diesel.asp (August 2005).
3. J. L. Mauderly. Toxicol. Environ. Chemistry 49, 167-180 (1995).
4. M. Lapuerta, O. Armas, R. Ballestero, and J. Fernandez. Fuel 84, 773-780 (2005).
5. A. S.Ramadhas, S. Jayaraj, and C. Muraleedharan. Renewable Energy 29, 727-742 (2004).
6. Vegetable Oil-Kit. Available at http://www.diesel-therm.com/veggie-kit.htm (August 2005).
7. Diesel to Vegetable Oil Engine Conversions. Available at http://www.dieselveg.com (August 2005).
8. Vegetable Oil Conversion Kits. Available at http://www.fusel.com/kits.html (August 2005).
9. Q. Yang, Y. Chen, Y. Shi, R.T. Burnett, K.M. McGrail, and D. Krewski. Inhalation Toxicology 15, 1297 (2003).
10. P. J. Crutzen. Annual Review of Earth and Planetary Sciences 7, 443 (1979).
11. U.S. Environmental Protection Agency Air Toxics Website. Available at http://www.epa.gov/ttn/atw (August 2005).
12. Air Sampling of VOCs by SPME for Analysis by Capillary GC; Application Note 141; Supelco: Bellefonte, PA, 1998.
13. National Institute for Occupational Safety and Health. Hydrocarbons, BP 36°-216 °C: Method 1500; NIOSH Manual of Analytical Methods, 4th ed.; Mar 2003.
14. K. E. Nord, D. Haupt. Environmental Science and Technology 39, 6260-6265 (2005).

A - 2

DEMOGRAPHICS STARTER REPORT

Monterey County

CALIFORNIA

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CUBIT

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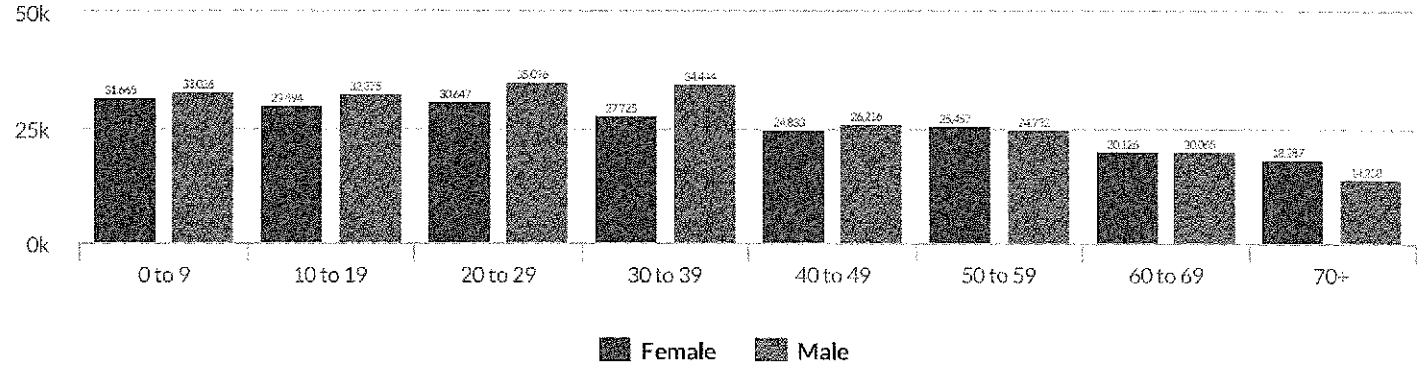
2014 POPULATION

431,344

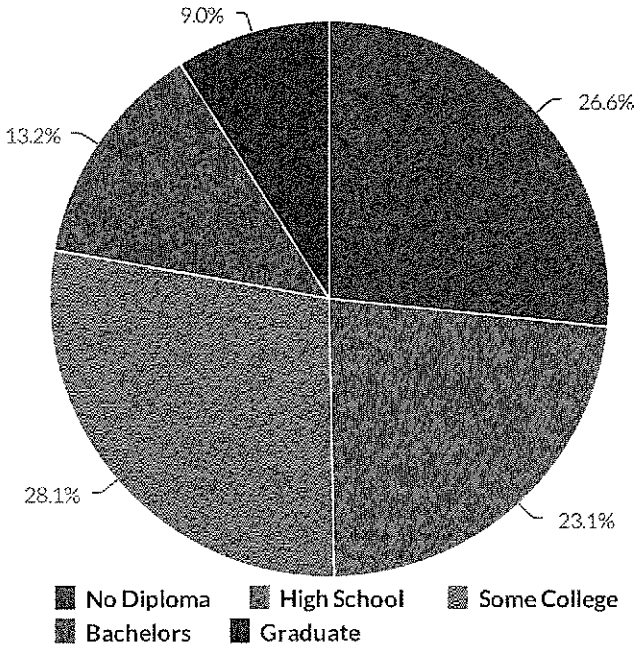
MEDIAN HOUSEHOLD INCOME

$57,052

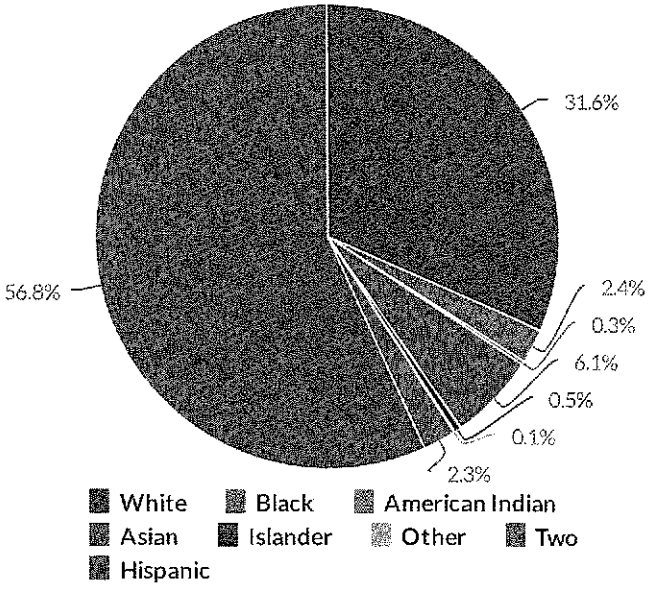
SEX BY AGE



EDUCATIONAL ATTAINMENT



RACE & ORIGIN



POVERTY

13.6%

for all families whose income in the past 12 months is below the poverty level

UNEMPLOYMENT

4.8%

for the population 16 years & over in the labor force

HOUSING UNITS

139,386

houses, apartments, mobile homes, group of rooms or single rooms that serve as separate living quarters

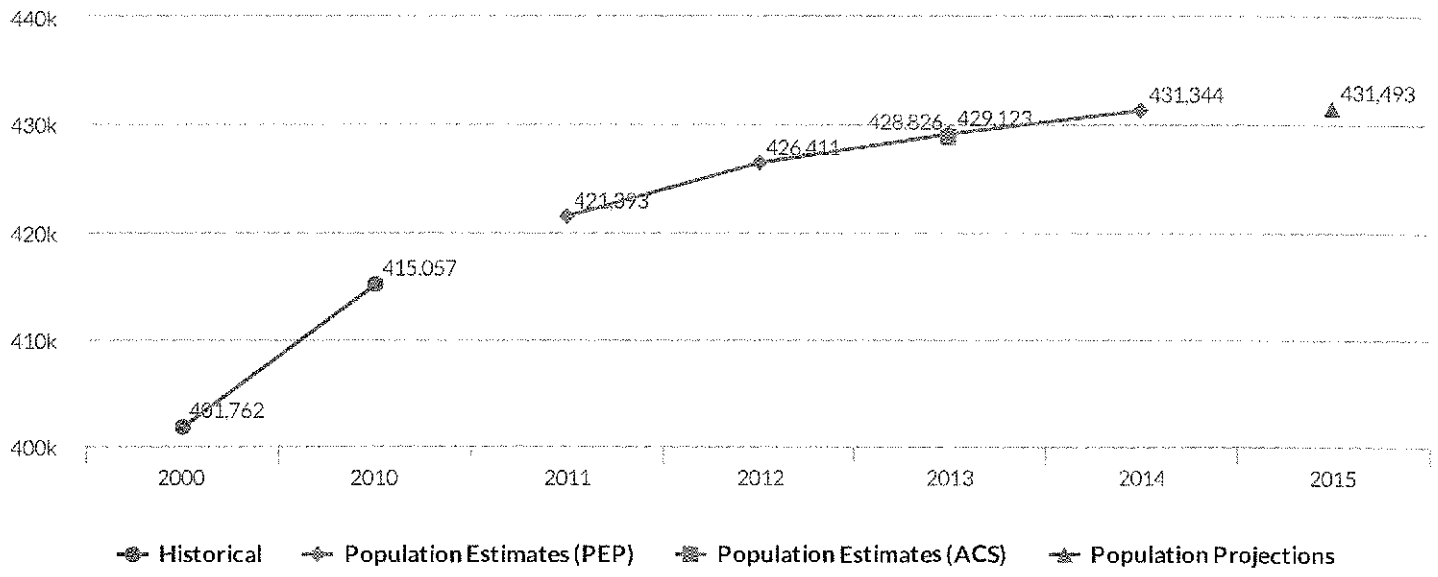
HOUSEHOLDS

125,553

all the people who occupy a housing unit

Source: United States Census Bureau. The US Census Bureau's 2014 Population Estimates dataset has the most current population estimate data. The US Census Bureau's 2013 American Community Survey dataset has the most current demographic data (i.e. race).

POPULATION



Population Projections

	Projection
2015	431,493

Source: California Department of Finance, Report P-2: State and County Population Projections - Race/Ethnicity and 5-Year Age Groups, 2010-2060 (by year). Released January 2013. Downloaded March 2014.

Population Estimates (ACS)

	#	% Change
2013 1-yr estimate	428,826	-

Source: American Community Survey 2013

Population Estimates (PEP)

	#	% Change
2011	421,393	-
2012	426,411	1.2%
2013	429,123	0.6%
2014	431,344	0.5%

Source: Annual Estimates of the Resident Population: July 1, 2011 to July 1, 2014

Historical Population Counts

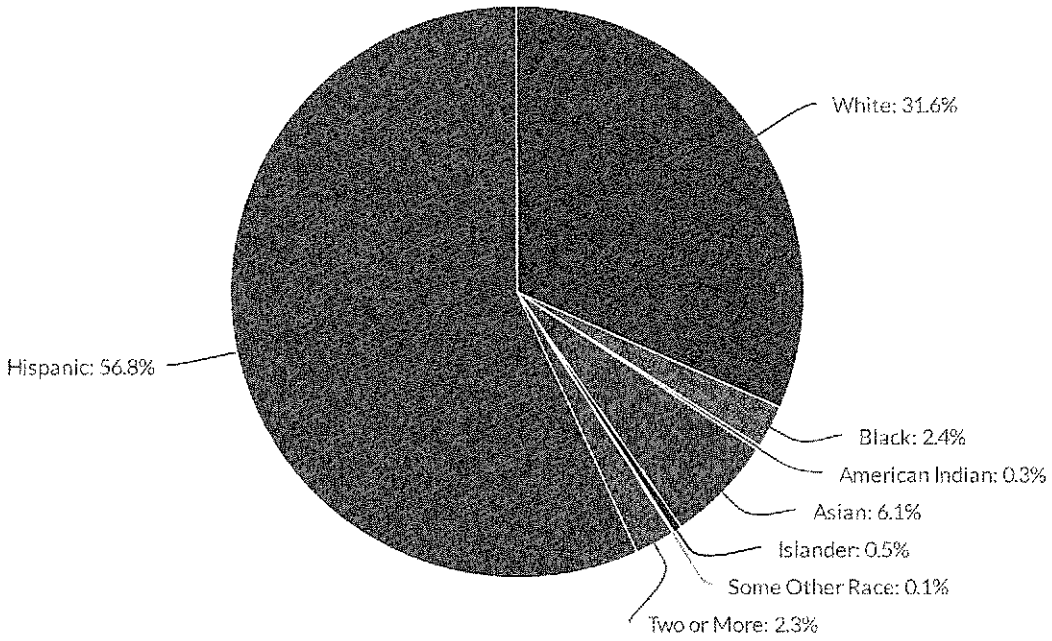
	#	% Change
2000	401,762	-

2010	415,057	3.3%

Source: Decennial Census 2010, 2000, 1990

RACE

Race & Origin (Hispanic)



	#	%
Non-Hispanic	185,191	43.2%
White	135,474	31.6%
Black	10,358	2.4%
American Indian	1,110	0.3%
Asian	26,084	6.1%
Islander	2,122	0.5%
Other	339	0.1%
Two or More	9,704	2.3%
Hispanic	243,635	56.8%
Total Population	428,826	-

The complete Census race descriptions are as follows: White alone; Black or African American alone; American Indian and Alaska Native alone; Asian alone; Native Hawaiian and Other Pacific Islander alone; Some Other Race alone; and Two or More Races. Hispanics may be of any race. For more information, visit the American Community Survey Data & Documentation page: http://www.census.gov/acs/www/data_documentation/documentation_main/.

Source: American Community Survey 2013

Detailed Race

'N' means that data cannot be displayed because the number of sample cases is too small.

	#	%
One race	413,833	96.5%
White	333,814	77.8%
Black or African American	11,376	2.7%
American Indian and Alaska Native	4,140	1.0%
Cherokee tribal grouping	N	N
Chippewa tribal grouping	N	N
Navajo tribal grouping	N	N
Sioux tribal grouping	N	N
Asian	26,772	6.2%
Asian Indian	1,792	0.4%
Chinese	2,392	0.6%
Filipino	13,810	3.2%
Japanese	3,007	0.7%
Korean	1,926	0.4%
Vietnamese	1,718	0.4%
Other Asian	2,127	0.5%
Native Hawaiian and Other Pacific Islander	2,267	0.5%
Native Hawaiian	180	0.0%
Guamanian or Chamorro	626	0.1%
Samoan	818	0.2%
Other Pacific Islander	643	0.1%
Some other race	35,464	8.3%
Two or more races	14,993	3.5%
White and Black or African American	2,604	0.6%
White and American Indian and Alaska Native	3,244	0.8%
White and Asian	3,159	0.7%
Black or African American and American Indian and Alaska Native	186	0.0%
Total Population	428,826	-

Source: American Community Survey 2013

Hispanic or Latino

	#	%
Non-Hispanic	185,191	43.2%
Hispanic or Latino (of any race)	243,635	56.8%
Mexican	228,867	53.4%
Puerto Rican	2,007	0.5%
Cuban	480	0.1%
Other	12,281	2.9%
Total Population	428,826	-

Source: American Community Survey 2013

SEX

	#	%
Male	220,192	51.3%
Female	208,634	48.7%
Total Population	428,826	-

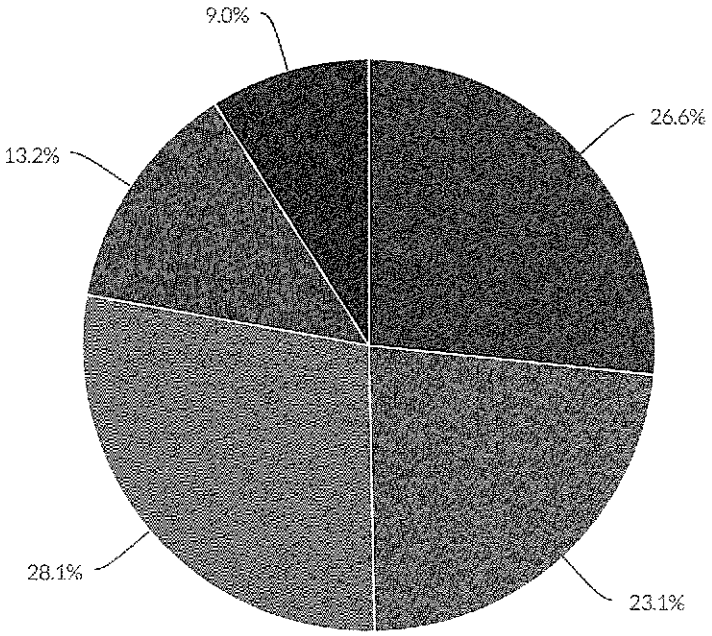
Source: American Community Survey 2013

AGE BREAKDOWN

	#	%
0 to 9 years	64,691	15.1%
10 to 19 years	62,269	14.5%
20 to 29 years	65,743	15.3%
30 to 39 years	62,169	14.5%
40 to 49 years	51,049	11.9%
50 to 59 years	50,189	11.7%
60 to 69 years	40,191	9.4%
70+ years	32,525	7.6%
Total Population	428,826	-

Source: American Community Survey 2013

EDUCATIONAL ATTAINMENT



No Diploma High School Some College Bachelors Graduate

	#	%
No diploma	71,448	26.6%
High school graduate & equivalency	62,068	23.1%
Associate degree & some college, no degree	75,390	28.1%
Bachelor's degree	35,424	13.2%
Graduate or Professional degree	24,248	9.0%
Population 25 Years and Over	268,578	-

Source: American Community Survey 2013

HOUSEHOLDS

Average Household Size	3.27 persons
Average Family Size	3.84 persons

A household includes all the people who occupy a housing unit. (People not living in households are classified as living in group quarters.) A family household consists of a householder and one or more other people living in the same household who are related to the householder by birth, marriage, or adoption. For more information, visit the American Community Survey Data & Documentation page: http://www.census.gov/acs/www/data_documentation/documentation_main/.

Source: American Community Survey 2013

Household Types

	#	%
Family households (families)	90,367	72.0%
With own children under 18 years	44,299	35.3%
Married-couple family	66,463	52.9%
With own children under 18 years	30,822	24.5%
Male householder, no wife present	7,414	5.9%
With own children under 18 years	3,877	3.1%
Female householder, no husband present	16,490	13.1%
With own children under 18 years	9,600	7.6%
Nonfamily households	35,186	28.0%
Householder living alone	27,344	21.8%
65 years and over	10,542	8.4%
Total households	125,553	-

A family household consists of a householder and one or more other people living in the same household who are related to the householder by birth, marriage, or adoption. A nonfamily household is a householder living alone or with nonrelatives only. Same-sex couple households with no relatives of the householder present are tabulated in nonfamily households. For more information, visit the American Community Survey Data & Documentation page: http://www.census.gov/acs/www/data_documentation/documentation_main/.

Source: American Community Survey 2013

INCOME

Median Household Income

Census 2000 in 1999 dollars	$48,305
American Community Survey (ACS) 2013 in 2013 inflation adjusted dollars	$57,052

Source: Decennial Census 2000, American Community Survey 2013

Household Income Distribution

The 2015 Federal Poverty Guideline for a family of 4 in California is $24,250.

Income in thousands.	#	%
Less than $10	7,723	6.2%
$10 to $14.9	5,117	4.1%
$15 to $24.9	11,691	9.3%
$25 to $34.9	12,986	10.3%
$35 to $49.9	18,171	14.5%
$50 to $74.9	21,585	17.2%
$75 to $99.9	17,219	13.7%
$100 to $149.9	17,479	13.9%
$150 to $199.9	6,785	5.4%
$200K+	6,797	5.4%

Source: American Community Survey 2013, Federal Register

POVERTY

	#	%
Families with Income in the past 12 months below poverty level	(X)	13.6%
Population with Income in the past 12 months below poverty level	(X)	17.9%

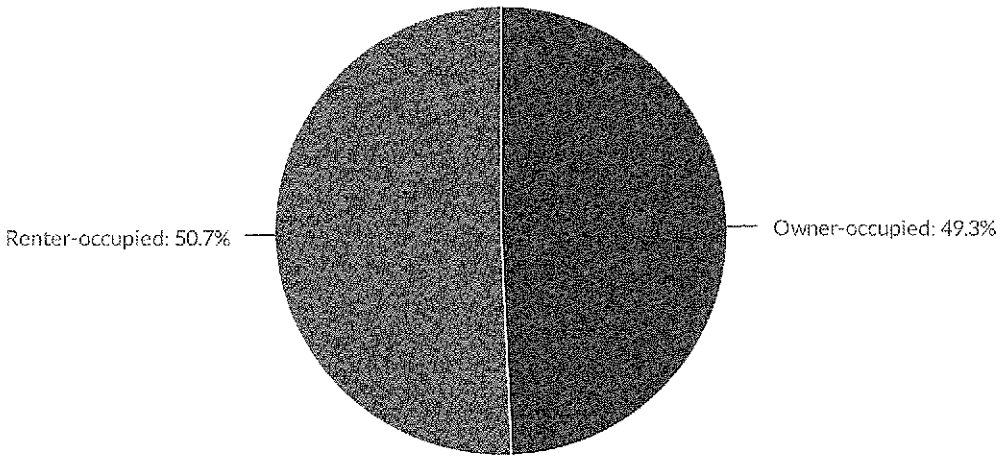
Source: American Community Survey 2013

HOUSING

Occupancy

	#	%
Occupied Housing Units	125,553	90.1%
Owner-occupied Housing Units	61,919	49.3%
Renter-occupied Housing Units	63,634	50.7%
Vacant Housing Units	13,833	9.9%
Total Housing Units	139,386	-

Source: American Community Survey 2013



Value

	#	%
Median Value of Owner-occupied Housing Units	$363,800	-

Source: American Community Survey 2013

CITATIONS & NOTES

Citations

United States Census Bureau. Annual Estimates of the Resident Population: July 1, 2011 to July 1, 2014.

United States Census Bureau / American FactFinder. "DP02: SELECTED SOCIAL CHARACTERISTICS IN THE UNITED STATES". *2013 American Community Survey* . U.S. Census Bureau's American Community Survey Office. Web. 18 September 2014 http://factfinder2.census.gov.
United States Census Bureau / American FactFinder. "DP03: SELECTED ECONOMIC CHARACTERISTICS". *2013 American Community Survey* . U.S. Census Bureau's American Community Survey Office. Web. 18 September 2014 http://factfinder2.census.gov.
United States Census Bureau / American FactFinder. "DP04: SELECTED HOUSING CHARACTERISTICS". *2013 American Community Survey* . U.S. Census Bureau's American Community Survey Office. Web. 18 September 2014 http://factfinder2.census.gov.
United States Census Bureau / American FactFinder. "DP05 : ACS DEMOGRAPHIC AND HOUSING ESTIMATES". *2013 American Community Survey* . U.S. Census Bureau's American Community Survey Office. Web. 18 September 2014 http://factfinder2.census.gov.
United States Census Bureau. "B01001 Sex by Age." *2013 American Community Survey* . U.S. Census Bureau's American Community Survey Office. Web. 18 September 2014 http://ftp2.census.gov/.

United States Census Bureau. *1990 Census* . U.S. Census Bureau, 2007.Web. 17 October 2012 ftp://ftp.census.gov/census_1990/.
United States Census Bureau. *2000 Census* . U.S. Census Bureau, 2011.Web. 17 October 2012 ftp://ftp.census.gov/census_2000/.
United States Census Bureau. *2010 Census* . U.S. Census Bureau, 2012.Web. 17 October 2012 ftp://ftp.census.gov/census_2010/.

California Department of Finance. Report P-2: State and County Population Projections - Race/Ethnicity and 5-Year Age Groups, 2010-2060 (by year). Released January 2013. Downloaded March 2014.

Federal Register. Vol. 80, No. 14. January 22, 2015. pp.3236-3237

Notes

American Community Survey data are estimates, not counts.

Although the American Community Survey (ACS) produces population, demographic and housing unit estimates, it is the Census Bureau's Population Estimates Program that produces and disseminates the official estimates of the population for the nation, states, counties, cities and towns and estimates of housing units for states and counties.

Supporting documentation on code lists, subject definitions, data accuracy, and statistical testing can be found on the American Community Survey website in the Data and Documentation section.

Sample size and data quality measures (including coverage rates, allocation rates, and response rates) can be found on the American Community Survey website in the Methodology section.

Data are based on a sample and are subject to sampling variability. The degree of uncertainty for an estimate arising from sampling variability is represented through the use of a margin of error. The value shown here is the 90 percent margin of error. The margin of error can be interpreted roughly as providing a 90 percent probability that the interval defined by the estimate minus the margin of error and the estimate plus the margin of error (the lower and upper confidence bounds) contains the true value. In addition to sampling variability, the ACS estimates are subject to nonsampling error (for a discussion of nonsampling variability, see Accuracy of the Data). The effect of nonsampling error is not represented in these tables.

The ACS questions on Hispanic origin and race were revised in 2008 to make them consistent with the Census 2010 question wording. Any changes in estimates for 2008 and beyond may be due to demographic changes, as well as factors including questionnaire changes, differences in ACS population controls, and methodological differences in the population estimates, and therefore should be used with caution. For a summary of questionnaire changes see http://www.census.gov/acs/www/methodology/questionnaire_changes/. For more information about changes in the estimates see http://www.census.gov/population/www/socdemo/hispanic/reports.html.

For more information on understanding race and Hispanic origin data, please see the Census 2010 Brief entitled, Overview of Race and Hispanic Origin: 2010, issued March 2011. (pdf format)

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ATTACHMENT B

SWAPE Technical Consultation, Data Analysis and Litigation Support for the Environment

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Santa Monica, California 90405

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Email: mhagemann@swape.com

June 25, 2015

Laura Horton
Adams Broadwell Joseph & Cardozo
601 Gateway Boulevard, Suite 1000
South San Francisco, CA 94080

Subject: Comments on the Monterey Peninsula Water Supply Project

Dear Ms. Horton:

We have reviewed the Draft Environmental Impact Report (DEIR) for the Monterey Peninsula Water Supply Project ("Project"). The Project involves the construction of up to ten subsurface slant wells and a desalination plant to produce approximately 10,627 acre feet per year (afy) of desalinated water, including 9,752 afy to meet service area demand and approximately 875 afy to return to the Salinas Valley Groundwater Basin. The Project would also include improvements to the existing Seaside Groundwater Basin Aquifer Storage and Recovery system, to allow for the injection of desalinated water into the groundwater basin for subsequent extraction and distribution. The Project also includes over 30 miles of pipelines, two pump stations, and water storage tanks.

Our review has identified issues with water quality and with hazards and hazardous waste. The DEIR fails to meet CEQA requirements to disclose, analyze, and mitigate all potentially significant impacts. A revised DEIR should be prepared to adequately identify impacts in these issue areas and to include adequate mitigation measures.

Disposal of Brine Will Degrade Ocean Water Quality

The DEIR describes current ambient polychlorinated biphenyls (PCB) concentrations in Monterey Bay (the source water for the Project) as exceeding the water quality objective for PCBs set forth in the Ocean Plan. Data indicate that waters of Monterey Bay exceeded the Ocean Plan 30-day average PCB water quality objective for protection of human health of 0.000019 micrograms per liter (µg/L or ppb) for most of the years between 2004 and 2013. The National Oceanic and Atmospheric Administration (NOAA) has determined Monterey Bay water quality to be "fair, with a declining trend" in part due to increasing PCB concentrations, stating:

> Stressors on water quality in the offshore environment, specifically persistent organic pollutants (POPs) [which include PCBs], fluctuations in nutrient levels, and changing ocean conditions, may inhibit the development of assemblages and may cause measurable declines in living resources and habitats. There is recent evidence of the deleterious effects of POPs in the marine environment ... cumulative concentrations of POPs were associated with decreased abundance of some benthic infauna ... and some POPs may contribute to the risk of sea otter death due to infectious agents and trauma.[1]

The DEIR states that since water in Monterey Bay shows an exceedance over the water quality objective for PCBs, concentrating the constituents present in the source water through the desalination process will result in an exceedance of the Ocean Plan water quality objectives for PCBs upon the discharge of the brine, a byproduct of desalination. This analysis concluded that the impact due to the exceedance in PCBs could be significant and would require mitigation.

Mitigation Measure 4.3-4 was included in the DEIR to address the impact of the predicted elevated PCB concentrations in the brine discharge. The mitigation would incorporate design features and operational measures prior to operating the MPWSP Desalination Plant. Examples of the design features and operational measures considered in Mitigation Measure 4.4-4 include temporary storage of brine and timed release at higher flow rates, treatment of the source water and/or the discharge(s), and temporary storage of brine and its release along with the greater than 20-mgd- wastewater in the case of the combined discharge. The DEIR contemplates treatment methods to remove PCBs and other organic compounds from the source water to include additional filtration or use of granular activated carbon (GAC). According to the DEIR, implementation of this mitigation measure would result in a less-than-significant impact with mitigation (p. 4.3-74).

Because Mitigation Measure 4.3-4 relies upon testing only "prior to operating the MPWSP Desalination Plant," mitigation is improperly deferred because the DEIR offers no assurance that test results will sufficiently reduce PCB contamination. The effectiveness of the technology that was identified in the DEIR (GAC) in meeting effluent limits is uncertain at the scale of the project (14 mgd of brine) and with concentrations of PCB that continue to increase. In fact a recent study casts doubt on the ability of GAC treatment systems in meeting the 2102 Ocean Plan Water Quality Objective of 0.000019 ppb. The study states that effluent from a 5 mgd facility would be as high as 0.00041 ppb, an order of magnitude higher than the Ocean Plan limit.[2] No estimate of the effluent PCB effluent concentration is provided in the DEIR and therefore the DEIR fails to adequately disclose the impact of the PCB discharge. Only vague and various protocol are offered in describing Mitigation Measure 4.3-4 which discusses "several alternative feasible methods" for treatment without describing the feasibility of uses such methods to meet Ocean Plan water quality objectives. Mitigation Measure 4.3-4 also discusses how storage and timed release of bine may be effective but does not provide any discussion of estimated PCB effluent concentrations using this management technique. The omission of estimates of PCB concentrations

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[1] http://sanctuaries.noaa.gov/science/condition/mbnms/state_offshore.html
[2] https://www.awb.org/file_viewer.php?id=2903, p. 44

using the treatment and management techniques that are discussed in Mitigation Measure 4.3-4 constitutes a failure to disclose impacts of PCBs on the marine environment.

Also, and utmost importance to the viability of the Project, use of such technology to treat the massive volume of brine (14 mgd) is extremely expensive and no cost considerations were made in the DEIR to make assurances that such a treatment system is economically feasible. A recent report[3] shows that it costs $290 million to remove less than a pound of PCBs from wastewater with a 5 mgd discharge, approximately one-third the 14 mgd brine discharge from the MPWSP Desalination Plant that will require treatment for PCBs.

Also, the DEIR does not contemplate that increasing concentrations of PCBs that have been noted may render treatment even less effective and more expensive. Recent tests show nearshore waters of Monterey Bay to have exceeded the Ocean Plan objective for PCBs for the protection of human health in 23 samples out of 34 samples. PCBs at the North Monterey Bay site have increased significantly since 2006 and annual average concentrations across all samples have increased exponentially (p. 4.3-7). The reasons for the PCB increases are not well understood and therefore there is no reasonable assurance that source control measures can be undertaken to stem the ongoing rapid rise in PCB concentrations.

As it currently stands, the DEIR does not provide substantial evidence supporting its conclusion that impacts from PCB contamination will be mitigated to less than significant levels. A revised DEIR should be prepared to include a thorough feasibility study to demonstrate that the PCB concentrations in brine effluent can be reduced through treatment to meet the Ocean Plan Water Quality Objective of 0.000019 ppb. The feasibility study should include consideration of all applicable technologies and management strategies that are available to treat PCBs, the implementabilty of the technologies, how likely each technology would be in achieving the Ocean Plan limits and other applicable regulations, and the impacts of construction and operation of each technology on the environment. The revised DEIR should also include, as part of the feasibility study, a demonstration that PCB treatment can be economically achieved.

Impact from Construction in Areas of Contaminated Soil and Groundwater not Evaluated

The construction of Project infrastructure will result in the disturbance of contaminated soil and groundwater. Construction will require excavation, grading, trenching, and pipeline construction in areas used for agriculture, military and industrial activities. Characterization of many of the areas impacted by Project construction has not been undertaken or is incomplete in the DEIR. This failure to disclose potential hazards on the Project site renders the DEIR inadequate as an informational document under CEQA. As a result, soils will be disturbed that may contain contaminant concentrations that are harmful to workers or to adjacent residents who may be exposed to dust that is generated during disturbance of contaminated soil.

[3] https://www.awb.org/file_viewer.php?id=2903, p. 45

The DEIR describes Project construction activities on areas used for commercial/industrial, agricultural, railroad, mining, and military activities and ranks the potential for Project construction to encounter contaminated soil and groundwater in Table 4.7-1. To mitigate potential hazards associated with the numerous known contaminated sites in and near the Project, the DEIR proposes Mitigation Measure 4.7-2b: Soil and Groundwater Management Plan. The Soil and Groundwater Management Plan only requires construction contractors to comply with all relevant environmental regulations and plan appropriately for the safe and lawful handling and disposal of excavated soil and groundwater, when encountered. No provisions for sampling soil or groundwater in areas that are suspected to be contaminated are included in Mitigation Measure 4.7-2b. Sampling is essential to characterize the contaminants in soil and groundwater that are likely to be encountered during pipeline construction, foundation excavation, grading activities, utility trenching and other excavation.

Additionally, the DEIR provides for Measure 4.7-2a (Health and Safety Plan) to specify protective equipment for workers and "measures to reduce the potential for workers' exposures to hazardous materials in soil and groundwater" and "procedures" for handling "accidental hazardous materials releases and unanticipated contamination." This is impermissibly vague and the DEIR fails to provide further details on, or drafts of, the Soil and Groundwater Management Plan and the Health and Safety Plan.

These vague mitigation measures are inadequate in addressing contamination that will likely be encountered during construction:

1. *Unknown areas of contamination likely exist*: Numerous unknown areas of contamination may exist in areas that will undergo soil disturbance during Project construction (i.e. trenching, excavation and grading). One example is areas formerly used for agriculture. The DEIR states that portions of the proposed Transmission Main, Seawater Intake System, and Brine Discharge Pipeline are located within agricultural areas, and that "historical agricultural land uses often leave behind residual pesticides and herbicides in soils" (p. 4.7-2). The DIER includes no analysis of the potential presence of pesticides in these areas, other than this broad statement makes no provision to sample for pesticides. Pesticide contamination from past agricultural practices may include residual soil contamination from organochlochlorine pesticides such as DDT, DDE, Chlordane and Toxaphene. The use of the Project site for agriculture extending to periods that predate the DDT ban in the 1970s, may indicate harmful concentrations in Project soils because these compounds can persist in soil for hundreds of years.[4] The California Department of Toxic Substances Control (DTSC) states: "DDT is ubiquitous to California soil due to heavy agricultural usage prior to cancellation in 1972. Therefore, agricultural land which is currently being developed or considered for new uses [...] frequently contains DDT."[5] The U.S. EPA has

[4]Agency for Toxic Substances and Disease Registry, Public Health Statement for DDT, DDE, and DDD http://www.atsdr.cdc.gov/phs/phs.asp?id=79&tid=20

[5] Office of the Science Advisor, DDT in Soil: Guidance for the Assessment of Health Risks to Humans. http://www.dtsc.ca.gov/AssessingRisk/upload/chap8.pdf, p. 11.

determined DDT and DDE, are probable human carcinogens.[6] DDT is also known to affect the nervous system.[7] Exposure to DDT can result in headaches, nausea, and convulsions[8] as well as damage to the liver and nervous and reproductive system impairments.[9] Chlordane has also been classified as a probable human carcinogen by the U.S. EPA and exposure can result in neurological effects such as headaches, irritability, dizziness, and nausea.[10] These pesticides can persist for hundreds of years at concentrations that would pose a risk to human health.[11]

In addition to areas of potential pesticide contamination, Project construction will likely disturb other areas of contaminated soil, including those areas identified in Table 4.7-1. Construction in these areas may expose construction workers and the public to chemicals which include: tetrachloroethylene, petroleum hydrocarbons, trichloroethylene, and explosive hazards (Table 4.7-1). The exact locations of these chemicals is not known and therefore workers may be unprepared and may be unknowingly subjected to exposure. The public may also be unknowingly subjected to exposure if dust is generated during disturbance of contaminated soils.

2. *Mitigation Measures are not specific for protection against likely contaminants*: Mitigation Measures that include a Health and Safety Plan and a Soil and Groundwater Management Plan do not require any specific procedures to safeguard against encountering various contaminants that are likely during construction. No specific provisions about what chemicals would be likely contacted or what specific protective measures (i.e., respiratory levels of protection, or chemical specific protective clothing) is included in Mitigation Measures Measure 4.7-2a and 4.7-2b. Contaminants like the organochlorine pesticides, can't be seen or smelled so the health and safety of construction workers and the public may be at risk without proper safeguards for specific chemicals that are likely to be encountered. Essential information to include in a revised DEIR would include the identification of the maximum values of each of the contaminants that are likely to be encountered during earth-moving activities based on a review of data available for soil and groundwater. If data are not available, or if data gaps exist such that hazards cannot be determined, soil and groundwater sampling should be undertaken. The results of the data review, along with the results of necessary sampling, should be included in a revised DEIR. A human health risk assessment should be included to evaluate health impacts that would be posed to construction workers and to adjacent residents during construction.

The DEIR is inadequate because it relies upon mitigation measures in an undisclosed Health and Safety Plan and an undisclosed Soil and Groundwater Management Plan to address contamination that is likely

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[6] U.S. EPA, DDT. http://www.epa.gov/pbt/pubs/ddt.htm; and U.S. EPA, DDE http://www.epa.gov/ttnatw01/hlthef/dde.html
[7] Agency for Toxic Substances and Disease Registry, ToxFAQs, *DDT, DDE, DDD*, http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=80&tid=20
[8] U.S. EPA, DDE. http://www.epa.gov/ttnatw01/hlthef/dde.html
[9] U.S. EPA, DDT. http://www.epa.gov/pbt/pubs/ddt.htm
[10] U.S. EPA, Chlordane. http://www.epa.gov/ttnatw01/hlthef/chlordan.html
[11] http://www.epa.gov/pbt/pubs/ddt.htm

to be encountered at numerous locations in the Project area during construction. Furthermore, the DEIR fails to provide any details regarding the content of the yet-to-be developed Soil and Groundwater Management Plan and the Health and Safety Plans or the performance standards that the plans must meet. Therefore, the measures are improperly deferred. Because the DEIR relies upon a future, undefined plan for mitigation, it violates CEQA's general prohibition against deferred mitigation.

Sincerely,

Matt Hagemann, P.G., C.Hg.

DISSERTATION

Matthew Richard Dzialak

The Graduate School

University of Kentucky

2003

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PEREGRINE FALCON, *FALCO PEREGRINUS*, REINTRODUCTION IN CLIFF HABITAT IN KENTUCKY

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Agriculture
at the University of Kentucky

By
Matthew Richard Dzialak

Lexington, Kentucky

Director: Dr. Michael J. Lacki, Associate Professor of Forestry

Lexington, Kentucky

2003

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Chapter One

Introduction

Background

The peregrine falcon (*Falco peregrinus*) is a medium-sized raptor with a nearly global distribution (White and Boyce 1988, Ratcliffe 1993). Peregrine falcon populations have been the focus of research in the natural sciences for four decades. Research emerged largely in response to the widespread extirpation of temperate peregrine falcons in the post-World War II era (Hickey 1969) and evolved into recovery programs that were initiated in the mid 1970s (Cade et al. 1988). Habitat alteration, disturbance of eyries by egg collectors, and poaching contributed to the decline and extirpation of these populations (Ganier 1931, Hickey 1942, Bond 1946, Hickey 1969), but contamination by organochloride pesticides such as DDT (1,1,1-trichloro-2,2-bis(p-chlorphenyl)-ethane) and concomitant reproductive failure attributable to DDT's principal metabolite, DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)-ethylene was most devastating (Ratcliffe 1967, Hickey and Anderson 1968, Peakall 1976, Newton 1979, Ratcliffe 1993). As a consequence of contamination by organochloride pesticides such as DDT, breeding peregrine falcons were eliminated in the eastern United States (U.S.) by the mid 1960s where, historically, more than 350 breeding pairs occurred (Hickey 1942).

Efforts to restore peregrine falcon populations in the U.S. included banning the use of DDT in 1972, federal listing as an endangered species in 1975, and recovery projects initiated by state agencies, private organizations, and falcon breeders (Ratcliffe 1993, Cade et al. 1996). Captive-produced peregrine falcons were first

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released in the U.S. in 1974. By 1994, more than 4,600 peregrine falcons had been released as part of four regional programs: (1) The Peregrine Fund in the East; (2) The Raptor Center at the University of Minnesota in the Midwest and Great Lakes region; (3) the Peregrine Fund in the West; (4) and the Santa Cruz Predatory Bird Research Group in the Pacific Northwest (Enderson et al. 1995a, Cade et al. 1996). Concurrently, researchers in Canada released more than 1,500 peregrine falcons. As a consequence of these recovery efforts, approximately160 pairs of peregrine falcons occupied eyries from the Mississippi River eastward by the mid 1990s (Cade et al. 1996).

In 1994, the arctic peregrine falcon (*F.p. tundrius*) was removed from the Endangered Species List. In 1999, the American peregrine falcon (*F. p. anatum*) was removed from the Endangered Species List, bypassing down-listing to threatened status (U.S. Fish and Wildlife Service 1999). In 2003, a cooperative federal and state effort was initiated to monitor peregrine falcon populations nationwide pursuant to section 4(g)(1) of the Endangered Species Act (ESA). This section of the Act requires the United States Fish and Wildlife Service (FWS) to develop and implement a system to monitor species in the wake of their removal from the federal endangered species list. In the southeastern U.S (FWS Region 4) peregrine falcon population recovery goals based on the number of active annual breeding locations have not been reached (U.S. Fish and Wildlife Service 1979). Among regions designated by FWS, Region 4 supports the fewest breeding pairs of peregrine falcons despite the presence of numerous historic eyries. For this reason, removal of *anatum* peregrine falcons from the endangered species list aroused some degree of controversy (e.g., Cade et al. 1997,

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Pagel and Bell 1997). Also for this reason, efforts in the recovery of *anatum* peregrine falcons continue in several portions of the southeast including Kentucky (Pagel et al. 1996, Cade et al. 1997, Pagel and Bell 1997, Cade 1998, Millsap et al. 1998, Pagel et al. 1998, Tordoff et al. 1998).

Taxonomy and Physical Description

White (1986) recognized 19 subspecies of peregrine falcon, 3 of which occur in North America – *F. p. tundrius*, *F. p. pealei*, and *F. p. anatum* (Hickey 1969, White and Boyce 1988, Ratcliffe 1993). *F. p. tundrius* breeds in arctic regions of northern North America and is migratory, often over-wintering in Central and South America. *F. p. pealei* is a relatively sedentary resident in the Aleutian Islands and other regions of the Pacific northwest. *F. p. anatum* originally bred from the subarctic boreal forest southward to northern Mexico. It became extirpated in the eastern U.S. and southern Canada by the mid 1960s (Berger et al. 1969, Fyfe 1969, Herbert and Herbert 1969).

The peregrine falcon exhibits considerable sexual dimorphism. Typically, adult males weigh 0.58-0.77 kg, and adult females weigh 0.93-1.3 kg. Wingspan of adult males is 0.79-0.89 m and adult females is 0.93-1.0 m. From tip of bill to tip of tail males females are 0.4-0.45 m, and 0.45-0.49 m in length, respectively (Ratcliffe 1993). Peregrine falcon populations exhibit variation in external morphology across geographic regions, with some populations being well differentiated (White and Boyce 1988). For example, sedentary *pealei* peregrines are considerably larger and darker in plumage than migratory *tundrius* peregrines. Morphologic variation may result from environmental conditions, local prey availability, migratory habits, and isolation. General coloration includes regions of solid slate-gray and blue on dorsal portions of

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the head, back and rump. Dark coloration extends from the head to the base of the bill and below the eye forming a 'moustache' that varies in size and shape among individuals and subspecies. Tail feathers, primaries and secondaries are faintly to strongly barred. Ventrally, the breast is white or cream, often with pink tinting and slate vertical ticks. The lower breast, underwing coverts, and undertail coverts are strongly barred (Hickey and Anderson 1969, Ratcliffe 1993).

North American Distribution, Habitat, and Diet

Peregrine falcon nesting substrates vary regionally (Ratcliffe 1993). Historically, these sites included cut banks, trees, ground scrapes, cliffs, and human-made structures (Spofford 1942, Spofford 1943, Grebence and White 1989, Ratcliffe 1993). Hickey (1942) determined that eastern peregrine falcons depended on rocky cliffs and cut banks and, therefore, likely were absent from the Great Plains, glaciated regions of the Midwest, and coastal plains of the deep south. Bond (1946) determined that the breeding range of western peregrine falcons extended from the Rockies westward to the Pacific coast, northward to the Aleutian Islands and Point Barrow, Alaska, and southward to Baja, California. U.S. peregrine falcons now nest exclusively on cliffs and human-made structures.

Peregrine falcons prey on other birds (Hickey 1942, Ratcliffe 1993). They are opportunistic, pursuing and capturing nearly any bird that is of equal or smaller size. Consequently, avian prey abundance and susceptibility to capture largely influence the composition of the peregrine falcon's diet (Ratcliffe 1993, Schneider and Wilden 1994). Prey selection and hunting strategies vary geographically, seasonally, and among age classes (Ward and Laybourne 1985, Ratcliffe 1993). As a result of their

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wide distribution and mobility, the peregrine falcon interacts with a variety of habitats, but generally requires non-forested habitats (e.g., tundra or mixed agricultural areas) for hunting (Hickey 1942, Ratcliffe 1993). The species has preyed on at least 70 avian species in the western hemisphere (Peakall 1976, Bird and Aubry 1982, Enderson et al. 1982, Baril et al. 1990, Paine et al. 1990, Fyfe et al. 1991, Banasch et al. 1992, Bockoven 1999, Corser et al. 1999). In inland regions of the northeastern U.S., avian species comprising ≥2% of total dietary biomass included Blue Jay (*Cyanocitta cristata*), Common Grackle (*Quiscalus quiscula*), European Starling (*Sturnus vulgaris*), Killdeer (*Charadrius vociferus*), Mourning Dove (*Zenaida macroura*), Northern Flicker (*Colaptes auratus*), Red-winged Blackbird (*Agelaius phoenicius*), and Rock Dove (*Columbia livia*; Corser et al. 1999). In the Southern Appalachians, among 33 species in the peregrine falcon's diet, Blue Jays, Common Grackles, Northern Flickers, Mourning Doves, and Rock Doves were most common (Boynton and Currie 1993, Bockoven 1999). Carter et al. (2003) determined that although the diet of peregrine falcons in northern Kentucky was diverse, European Starlings and Rock Doves comprised ≥90% of total biomass.

Population density of peregrine falcons is highest in regions of high prey abundance such as coastal cliffs (Newton 1979, Ratcliffe 1993). However, the extent to which local (≤1 km from nest site) food abundance affects nest-site selection and productivity is unknown (Hickey 1942, Bond 1946, Bird and Aubry 1982). Nelson (1987) suggested that low prey density caused peregrine falcons to expand territories, and may cause nest failures. Barclay (1980) and Holroyd and Banasch (1990) suggested that available prey at release sites must be abundant to facilitate survival of

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fledglings or returning residents. In the White Mountains of New Hampshire, Corser et al. (1999) observed that peregrine falcon reproductive output was low compared to peregrine falcons in northern New York and other New England ecoregions. They suspected that poor reproductive output in New Hampshire was a result of consumption of small passerines such as Blue Jay and Red-winged Blackbird ($\bar{x}$ = 52.6 g and 87 g, respectively; Dunning 1984), instead of doves (*C. livia* and *Z. macroura* ($\bar{x}$ = 119 g and 542 g, respectively; Dunning 1984) which comprised ≥2/3 of prey biomass in other ecoregions. Historically, the Mourning Dove (*Z. macroura*) and likely the Passenger Pigeon (*Ectopistes migratorius*) were important prey items of inland peregrine falcons (Gonterman 1929, Beebe 1969, Hickey and Anderson 1969). Doves are important to the reproductive output of peregrines in the northeastern U.S. (Corser et al. 1999), and are used commonly as prey by peregrines in the southern Appalachians and northern Kentucky (Bockoven 1999, Carter et al. 2003).

North American Population Density, Home Range, and Dispersal

Peregrine falcon breeding density varies by region, prey abundance, and nest site availability (Fyfe 1969, Hickey and Anderson 1969). In Alaska, a linear breeding density of one pair per 0.6-13 km, depending on prey availability, was reported by Cade (1960) and White and Cade (1971). Enderson et al. (1995b) estimated that Texas peregrine falcons occurred at a minimum density of 1 bird/50.0 km^2. The peregrine falcon exhibits variation in movement patterns throughout North America (Enderson and Craig 1997). Porter and White (1973) estimated that hunting occurred ≤15 km from the nest. Enderson and Kirven (1983) estimated that nesting California peregrine falcons hunted within 5 km of the nest. Mearns (1985) used telemetry to

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determine that home ranges of two nesting females varied according to brood size, age of young, success of prey capture, and average weight of prey captured. White and Nelson (1991) estimated that a male peregrine falcon in Alaska had a hunting range of 319 km^2. In Colorado, Enderson and Craig (1997) used telemetry to estimate that peregrine falcon home ranges were 358.0-1508.0 km^2. Peregrine falcons in Colorado usually hunted within 8 km of the nest, however, 20% of hunts were > 20 km from the nest, and one such flight was > 79 km from the nest (Enderson and Craig 1997).

Peregrine falcons disperse from the post fledging area and often become nomadic. Burnham et al. (1988) recovered peregrine falcons that were banded in the northern Rockies an average of 1600 km, and up to 4600 km, from banding locations. Barclay and Cade (1983) observed that many peregrine falcons released in the eastern U.S. exhibited latitudinal movements generally within 500 km of release location, but up to 2800 km from release locations. Dispersal distance, or movement of individuals from natal to breeding locations (Greenwood 1980), is variable and long distance dispersal is not uncommon (Mearns and Newton 1984, Tordoff and Redig 1988, Tordoff and Redig 1997). Mearns and Newton (1984) determined that peregrine falcons in Scotland dispersed up to 185 km from the natal site, but some individuals remained in close proximity to the natal area. In Alaska, Ambrose and Riddle (1988) reported dispersal ranging from 2-370 km. In the Midwestern U.S., females dispersed an average of 354 km, and males 174 km from hack site to first breeding site (Tordoff and Redig 1997). Dispersal varied among individuals though. After fledging, some individuals remained near the hack site, but others dispersed >800 km from the hack

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site (Redig and Tordoff 1989, Tordoff and Redig 1997). Generally, dispersal in peregrine falcons is female biased, meaning females tend to disperse greater distances than males (e.g., Tordoff and Redig 1997, Restani and Mattox 2000).

Breeding Cycle

Peregrine falcons in the northern hemisphere pair bond and mate between late January and early April (Cade 1960). Extra-pair breeding is uncommon. Courtship includes flight and hunting displays, ledge ceremonies, and feeding displays (Ratcliffe 1993). Copulation occurs at any time of day from mid-March through mid-April, and continues until eggs are produced (Wrege and Cade 1977). Territorial defense, where either sex behaves aggressively towards other raptors that approach the nest, occur from early February to mid-April (Ratcliffe 1993). Egg laying occurs in March or April. Clutch size ranges from 2-6 and a clutch of 3-4 eggs is typical (Cade 1960, Martin and North 1993, Ratcliffe 1993). Incubation usually lasts 28-33 days. Although both sexes incubate, the female is the predominant incubator during which time the male hunts for the pair (Cade 1960, Ratcliffe 1993). Fledging occurs 5-6 weeks after hatching (Sherrod et al. 1982). Ratcliffe (1993) estimated June 20 as an average fledging date for peregrine falcons in Britain. In several portions of the U.S. (e.g., southern Appalachians, urban or industrial areas in the Midwest) the peregrine falcon is non-migratory and begins courtship in late January, nests in February and March, hatches young in April and May, and fledges young in June and July (Spofford 1950, Bockoven 1999, Carter et al. 2003).

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The Peregrine Falcon in Kentucky

Pre-decline peregrine falcons occurred statewide in Kentucky. In western Kentucky, Wilson (1942) and Berger et al. (1969) reported nests in bottomland forests near Reelfoot Lake. Wilson (1940) observed peregrine falcons in March, April and June in Warren County, Kentucky. Mengel (1965) observed peregrine falcons in Jefferson County, but like Wilson (1940), attributed the sighting to unpaired or transient individuals. Pindar (1924) observed peregrine falcons at cliffs along the Kentucky River but was unable to locate an eyrie. Similarly, Mengel (1965) observed juvenile and adult peregrine falcons near cliffs in Powell and Wolfe Counties in eastern Kentucky but was unable to locate an eyrie. Mengel's observations in eastrn Kentucky probably represent an actual breeding location – cliff habitat is extensive in this region and locating an eyrie would be difficult. Mengel (1939; 1965) also observed an eyrie in Laurel County at the head of the Rockcastle River Narrows. He observed breeding peregrine falcons near Cumberland Gap, but it is possible that the actual eyrie was in Virginia. Mengel (1965) described the historic breeding range of peregrines in Kentucky as cliffs associated with the Pine Mountain thrust fault in Bell, Harlan, Letcher, and Pike counties, as well as rugged portions of the Cumberland Plateau in Powell, Wolfe, Menifee, Laurel, Pulaski, Wayne, Whitley, and McCreary counties. Palmer-Ball (1996) suggested the historic breeding distribution of the peregrine falcon in Kentucky was the cliff regions of the Cumberland Mountains and Cumberland Plateau, and bottomland forests of western Kentucky.

In 1993, efforts were initiated by the Kentucky Department of Fish and Wildlife Resources (KDFWR) to restore *anatum* peregrine falcons in Kentucky. At

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that time, the *anatum* subspecies was federally endangered and no breeding location occurred in the Commonwealth. Since its initiation, the program has expanded to include partnerships with the University of Kentucky (UK), the USDA Daniel Boone National Forest (DBNF), and the Kentucky State Nature Preserves Commission (KSNPC). As of 2003, there were 4 breeding pairs in the state, in addition to several unpaired male territories. The *anatum* subspecies is no longer federally endangered as *anatum* peregrine falcons were delisted in 1999. Prior to delisting (1993-1999), 82 peregrine falcons had been released at 3 urban and industrial hack sites in Kentucky.

Efforts to restore *anatum* peregrine falcons in Kentucky shifted to cliff habitats in 2000. This phase of the program is the focus of this dissertation. Chapters 2-5 summarize much of the research conducted as part of this cliff release phase. I provide a comprehensive overview of Kentucky peregrine falcon restoration in Chapter 6. This research was conducted concurrently with the work of K.M. Carter (Carter 2003), who examined the behavior and ecology of the peregrine falcon in Kentucky. Taken together, these works represent many of the research accomplishments of the program. Specific components of the program included research on planning and development phases of the program, the fates of reintroduced peregrine falcons, landscape influences on movement patterns, comparative behavioral ecology of wild-produced and hacked peregrine falcons, feeding ecology, and scale-dependent habitat selection. As of 2003, research shifted to post-release and post-delisting monitoring, and to emerging issues in peregrine falcon conservation in the southeast such as the potential threat of chemical exposure at urban eyries.

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Chapter Two

Demographic Influences on Peregrine Falcon Reintroduction

Synopsis

As part of a program to restore the peregrine falcon (*Falco peregrinus*) in Kentucky cliff habitat, I initiated a series of pre-release evaluations designed to promote efficient allocation of program resources, and to provide empirical support for decision-making. Pre-release evaluations included development of a demographic model examining the relative influence of first-year mortality, rate of philopatry, and founder cohort size on metapopulation persistence for 20 years. Using VORTEX (a computer simulation of the extinction process), I simulated reintroductions in which 6-96 peregrine falcons were released annually for three consecutive years under conditions of first-year mortality and rate of philopatry that were 0.45-0.65 and 0.03-0.15, respectively. I used logistic regression to conduct sensitivity analysis. I compared standardized regression coefficients (b_n/SE$_n$) to quantify and rank the magnitude of effect on model outcomes at year 20 associated with changes in input parameter values. Founder cohort size accounted for the most variability (b/SE = 9.85) in the probability of persistence at year 20. First-year mortality and rate of philopatry affected the persistence of reintroduced peregrine falcon populations to a lesser extent (b/SE = 4.86 and -0.11, respectively). High first-year mortality (0.65) precluded population reestablishment regardless of founder cohort size. Similarly, releasing < 48 peregrine falcons annually for three consecutive years resulted in high extinction probability (≥ 0.8) and low population size at year 20 (≤ 0.6), regardless of variation in first-year mortality and rate of philopatry. To address the influence of

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high first-year mortality on population recovery, I recommend a formal assessment of risk of predation or other sources of mortality at potential release sites. However, program financial resources should be allocated largely to maximizing founder cohort size because, given identification and avoidance of potential release habitats where first-year mortality likely would be high (i.e., ≥ 0.65), successful restoration of peregrine falcons in Kentucky cliff habitat will be predicated on maximizing the number of peregrine falcons released.

Introduction

In 1993, efforts were initiated to restore the peregrine falcon in Kentucky. As part of the project, 82 peregrine falcons were released during 1993-1999 at three urban or industrial locations in central Kentucky (i.e., one skyscraper and two coal-fired power plants). One Kentucky-released peregrine falcon has returned to breed in the Commonwealth and several Kentucky-released peregrine falcons occupy territories in the adjacent states of Ohio and Indiana (L. Burford, pers. commun.). Similarly, peregrine falcons hacked or wild-produced in other regions of North America have established territories in Kentucky; four pairs of peregrine falcons occupy urban or industrial breeding locations in the Ohio River valley in northern portions of the state. In 1999 the American peregrine falcon was removed from the federal endangered species list (United States Fish and Wildlife Service 1999). Nonetheless, historic habitats in Kentucky, including cliffs throughout the eastern portion of the state (Mengel 1939; 1965), remain unoccupied and the peregrine falcon retains endangered status statewide. In 2000, efforts to restore the peregrine falcon in Kentucky shifted to historic cliff habitats. For peregrine falcons, attributes of the natal site influence

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choice of breeding site (Tordoff and Redig 1988, Tordoff et al. 1998), so efforts to reintroduce the peregrine falcon in Kentucky cliff habitat represent a distinct component of the program in terms of conservation and research objectives.

As a regional program, cliff releases in Kentucky will be conducted without the broad logistical and financial support that characterized peregrine falcon management under the Endangered Species Act (Cade et al. 1996, Restani and Marzluff 2001). Accordingly, a key strategy in development of the program will be inclusion of protocols designed to promote efficient allocation of resources and management effort (*see* Goodman 1980, Tordoff and Redig 1988, Holroyd and Banasch 1990, Kleiman et al. 1991, Bustamante 1996). Initial considerations in implementing this strategy included identifying facets of the program that would be both amenable to management influence and that had implications for program resource allocation and success. For these considerations, I identified release site selection and determination of optimal founder cohort size as important because both facets yield various management options in their implementation and can incur logistical, financial, and demographic consequences that affect program success. For example, physiography, intensity of recreational use, and the abundance of prey, predators, and refugia at release sites can affect first-year mortality and influence the rate and scale of philopatry among reintroduced peregrine falcons (Hickey 1942, Barclay and Cade 1983, Sherrod 1983, Hunt 1988; Tordoff and Redig 1988, Black 1991). Similarly, founder cohort size, or the number of animals released, strongly influences the probability of successfully reestablishing peregrine falcons (Burnham et al. 1988, Grier and Barclay 1988, Griffith et al. 1989). A comprehensive assessment of

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Kentucky cliff habitat for release site suitability, while potentially advantageous in terms of reducing first-year mortality and promoting philopatry, would be cost prohibitive because cliff habitat is extensive and occurs throughout the state (e.g., Inner Bluegrass, Cumberland Plateau, and Cumberland Mountains). Likewise, the average cost of juvenile peregrine falcons suitable for hacking can exceed $1000 each.

Population viability analysis (PVA) is applied widely in conservation science as a quantitative tool to assess demographic factors that contribute to the decline or extinction of populations (e.g., Shaffer 1981, *see* Reed et al. 2002). Applications of PVA include modeling the effects of different management strategies (Plissner and Haig 2000), and evaluation of reintroduction options (Southgate and Possingham 1995, Bustamante 1996, Green et al. 1996, South et al. 2000). My objective was to use PVA to quantify the relative magnitude of effect that potential demographic consequences of release site choice (i.e., rates of first-year mortality and philopatry) and founder cohort size have on restoring a breeding cohort of peregrine falcons. As proposed, the program included release of 5 peregrine falcons in Kentucky cliff habitats in each of three consecutive years.

Materials and methods

Input Parameters

I used VORTEX 8.21 (Miller and Lacy 1999) to construct metapopulation simulations of peregrine falcon reintroduction. I modeled population viability for 20 years (Beissinger and Westphal 1998, Tordoff et al. 2000). I derived demographic values from the peregrine falcon literature (Table 2.1). I simulated metapopulation structure under seven supplementation schedules characterized by the release of 6, 12,

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24, 48, 60, 72 and 96 peregrine falcons, respectively, in each of three consecutive years (*see* Beissinger and Westphal 1998). I chose these supplementation schedules to reflect the proposed design of the program (*e.g.*, release of a low number of peregrine falcons per year for 3 consecutive years) and my capacity to manipulate founder cohort size (I chose multiples of six to enable even sex ratios and for potential interpretive purposes). I constructed 21 metapopulation models by combining low first-year mortality with a high rate of philopatry, median rates for first-year mortality and philopatry, and high first-year mortality with a low rate of philopatry in each of the seven respective supplementation schedules. I nullified implications of carrying capacity (K) by specifying K at 500 (Bustamante 1996). This enabled simulating release of large numbers of peregrine falcons without model truncation, as VORTEX eliminates individuals if K is exceeded. I estimated a density dependence function that emphasized Allee effects, such as decreased fecundity or survival because of low population numbers ($\beta = 4$, $A = 4$; Nelson 1988, Miller and Lacy 1999). I did not include inbreeding in the models because I will obtain young peregrine falcons from several unrelated sources. I did not include catastrophes (i.e., extreme environmental variation affecting reproduction and/or survival) in the models.

Metapopulation Structure

In raptors, non-breeding individuals, or floaters, can comprise a considerable portion of a population (Hunt 1998). Floaters have implications for modeling raptor reintroduction because they can augment reintroduced populations, mask population trends, or incur density dependent pressures (Hunt 1998). VORTEX enables modeling of metapopulation dynamics based on rates of dispersal and migration among

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metapopulations. I considered floaters part of a metapopulation interacting with reintroduced cohorts via migration and dispersal. Reintroduced peregrine falcons exhibit a pattern of unoriented wandering, or floating, during their first year after dispersal from the natal area (Ratcliffe 1993). Often a small proportion of the reintroduced cohort returns to the release area to establish territories. Thus, I modeled the reintroduced-floater metapopulation based on the concept of temporal variance in peregrine falcon fitness, promoting the floater strategy for individuals < age two, and subsequent migration to breeding populations at age two at known or estimated rates (Table 2.1; Barclay and Cade 1983, Smith and Arcese 1989). For purposes of the simulations, I defined philopatry as migration from floating to breeding, or reintroduced, cohorts. I estimated extant floater population size based on the equation of Hunt (1998); $Y = (j + 1)C$, where, under conditions of population equilibrium, Y is the number of non-adults at fledging time, j is the estimated annual survival rate of juveniles, and C is the size of the annual cohort fledging within a given area. To calculate C, I identified all peregrine falcon breeding locations within 300 km of an estimate of the geographic center of the Cumberland Plateau in Kentucky. I used 300 km in an effort to include peregrine falcon breeding locations in nearby states, but given the nomadic movement patterns of subadult peregrine falcons, this distance was arbitrary. I used the geographic center of Kentucky's Cumberland Plateau in deriving this estimate because initial hacking could occur in locations in eastern Kentucky. I identified 21 breeding locations within this distance (M. Dzialak, unpubl. data). Using $j = 0.30$ and a reproductive rate of two young fledged per pair annually (Table 2.1), I estimated floater cohort size at approximately 55 individuals. I began each simulation

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with a stable age distribution within the floater population; however, each simulation began with a reintroduced population of zero. I identified extinction (quasi-extinction) as a reintroduced population size at year 20 of < two individuals.

Sensitivity Analysis

I randomly generated 100 values for first-year mortality and rate of philopatry, bound by their respective ranges of variation as presented in the literature, and I randomly generated 100 values for founder cohort size bound by the seven supplementation schedules. Following McCarthy et al. (1995; 1996), Biessinger and Westphal (1998), and Cross and Beissinger (2001), I conducted 10 iterations of VORTEX for each parameter set to produce a data set of 1000 observations of ending population size classified as extinct or persisting at year 20. I assessed the relationship between independent variables and the logit of the probability of extinction, and found the relationship to be linear (Hosmer and Lemeshow 2000). I performed logistic regression on the data set of 1000 observations using SAS® (SAS Institute, Cary, North Carolina, USA). The binary dependent variable for logistic regression was extinction or persistence. I calculated standardized regression coefficients (b_n/SE_n) by dividing the regression coefficient b of variable n by its estimated standard error (Cross and Beissinger 2001). I compared standardized regression coefficients to quantify and rank the magnitude of effect on model outcomes associated with changes in input parameter values (McCarthy et al. 1995; 1996, Cross and Beissinger 2001).

Results

Mean population growth rate r for reintroduced peregrine falcons was negative under all reintroduction scenarios. The effects of founder cohort size and release site

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choice on extinction probability and population size at year 20 were not independent (Table 2.2). For example, when a median rate of first-year mortality was combined with a median rate of philopatry, and when low first-year mortality was combined with a high rate of philopatry, large annual founder cohorts (≥ 48) provided considerably lower extinction probability, and greater population size at year 20 than smaller annual founder cohorts (< 48; Table 2.2). However, the combination of high first-year mortality and a low rate of philopatry nullified any advantage of large founder cohorts because extinction probability was high and population size was low at year 20, regardless of founder cohort size (Table 2.2). Similarly, when large annual founder cohorts (≥ 48) were released, reductions in mortality and increases in rate of philopatry reduced extinction probability and increased population size at year 20 (Table 2.2). However, releasing smaller annual cohorts (< 48) rendered improved survival and philopatry from low to high rates inconsequential, because extinction probability remained high and population size remained below quasi-extinction threshold (Table 2.2). Based on logistic regression, the size of the reintroduced cohort accounted for the most variability in the probability of extinction at year 20 (b/SE = 9.85). Reintroduced cohort size had over twice the effect of first-year mortality in terms of population persistence (b/SE = 4.68). Rate of philopatry contributed little in accounting for variability in population persistence (b /SE = -0.11).

Discussion

Reed et al. (1998, 2002) recommended that researchers discuss demographic model results in terms of uncertainty because a number of factors can render demographic estimates and management recommendations unreliable (e.g., White

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2000). For example, in this study, the reintroduced-floater metapopulation behavior used in the model, including estimation of the rate of migration from reintroduced to floating cohorts and of initial floater population size, involved some conjecture and represented considerable simplification of raptor ecology (Newton 1979). Spatial and temporal attributes of the flow of immigrants between populations are important aspects of metapopulation behavior (Gilpin 1987). Uncertainty in these estimates has implications for the reliability of demographic inferences based on the model. Similarly, the assumption of a general association between attributes of release sites and mortality and philopatry, while reasonable (Barclay and Cade 1983, Tordoff and Redig 1988, Holroyd and Banasch 1990), is a simplification of peregrine falcon ecology. Moreover, implicit in this study was the assumption that biologists in Kentucky (including myself) can discriminate between low- and high-quality release sites accurately. Nonetheless, the demographic data upon which this study was based are extensive and reliable; model inferences invariably reflect the data upon which they are based. Further, using logistic regression to assess parameter sensitivity may enable more reliable inferences compared to conventional sensitivity analyses because the standardized regression coefficients are scaled by an estimate of variability or uncertainty (SE).

One previous study reported use of VORTEX to model reintroduction and viability of cliff-nesting raptor populations (Bustamante 1996). Bustamante (1996) considered VORTEX able to simulate realistically most management options associated with reintroducing Bearded Vultures (*Gypaetus barbatus*) in cliff habitat. However, the ability of VORTEX to account for long-term monogamy typical of many raptor

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species and its genetic implications was questionable. Although I did not examine inbreeding in the model, it should be noted that VORTEX likely overestimates the extent of genetic interchange among monogamous raptors, and thus underestimates the extent of inbreeding (Bustamante 1996).

A negative mean growth rate of reintroduced peregrine falcon cohorts that characterized all simulations was expected based on the specified metapopulation dynamics. These specifications, including dispersal of reintroduced peregrine falcons and comparatively low rates of migration from floating to reintroduced cohorts, simulated some of the challenges associated with hacking peregrine falcons in unoccupied habitats. Upon dispersal, peregrine falcons can exhibit nomadic behavior for several years. Territorial establishment by floating individuals in suitable, but unoccupied cliff habitat is uncommon because floaters often are attracted more to conspecifics than to unoccupied habitats (see Tordoff et al. 1999; 2000; 2001). In this study, release site choice, modeled as first-year mortality and rate of philopatry, and founder cohort size interacted to influence population persistence. First-year mortality, rather than philopatry, was the more influential aspect of release site choice. Among demographic parameters, the rate of adult mortality most influences extant raptor populations (Newton 1979, Grier 1980a, Wooten and Bell 1992, Hiraldo et al. 1996), so it would be expected that first year mortality rates are similarly influential among reintroduced cohorts comprised entirely of juveniles. Philopatry had little influence on population persistence because, as modeled, philopatry was governed by both mortality and founder cohort size. Generally, this study demonstrated that (1) in conditions of high first-year mortality (i.e., ≥ 0.65), recruitment of individuals into the

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breeding class was insufficient to enable population persistence for 20 years, and (2) given avoidance of high first-year mortality, the number of peregrine falcons released influenced population reestablishment to a greater extent than potential demographic consequences of release site choice. Moreover, when first-year mortality was < 0.65, founder cohort size governed the practical utility of efforts to identify high-quality release habitats. For example, I found that releasing < 48 peregrine falcons annually for three consecutive years rendered the demographic consequences of release site choice inconsequential because the probability of extinction was ≥ 0.8 and the population size at year 20 was ≤ 0.6 individuals, regardless of mortality and philopatry rates. Griffith et al. (1989) identified a direct relationship between founder population size and the probability of reintroduction success. In avian reintroduction, Griffith et al. (1989) demonstrated that increases in the probability of success were associated with releasing large numbers of individuals, and this association became asymptotic only after releasing approximately 100 individuals. I did not evaluate this relationship quantitatively, but my results suggested that for peregrine falcons, a greater number of individuals must be released to arrive at such an asymptote. Grier (1980b), Barclay and Cade (1983), and Grier and Barclay (1988) developed stochastic models that predicted the outcome of peregrine falcon reintroductions in the eastern United States. Using data encompassing the variability observed in extant populations, their model indicated that the probability of persistence was highest when the reintroduced cohorts exceeded 100 individuals. Field data also demonstrated the importance of founder population size in peregrine falcon reintroduction. For example, regionally, (e.g., Southern Appalachia and eastern Canada), successful reestablishment of peregrine

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falcons populations has been associated with release of ≥ 349 peregrine falcons over a period of ≥ five years (Holroyd and Banasch 1990, Boynton and Currie 1993).

Recommendations

Project resource allocation should be skewed to maximizing founder cohort size. Successful restoration of peregrine falcons in Kentucky cliff habitat is predicated on releasing a large number of individuals (Barclay and Cade 1983, Burnham et al. 1988, Grier and Barclay 1988). This does not, however, negate the value of efforts to identify suitable release sites. Clearly, peregrine falcons must be released in habitats in which the probability of excessive first-year mortality has been determined to be low. To identify release sites, I recommend a strategy combining *a priori* knowledge of peregrine falcon habitat associations and formal surveys estimating risk of predation or other sources of mortality. For example, abundance of great horned owls or dangerous competitors such as red-tailed hawks (*Buteo jamaicensis*), should be estimated at potential release sites. Given the comparably short period of supplementation that characterizes the program, release of approximately 50 peregrine falcons in each of three consecutive years would be a preferred strategy. An alternate strategy would be to extend the duration of supplementation because duration often governs the feasibility of releasing large numbers of peregrine falcons. For example, releasing 20-22 falcons during the course of seven years may be more feasible logistically than releasing larger cohorts over a shorter period.

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Table 2.1. Parameters, initial estimates, and sources for demographic data used in simulating peregrine falcon reintroduction.

Parameter	Reintroduced	Floating (non-breeding)	Source
Type of mating system	monogamous		
Age at first reproduction	2		Ratcliffe 1993, Tordoff and Redig 1997
Maximum breeding age	15		Tordoff et al. 2000
Sex ratio at birth	1:1		Ratcliffe 1993
Maximum brood size at fledging	4		Hickey 1942, Cade et al. 1988, Redig and Tordoff 1989, Steidl et al. 1991, Boynton and Currie 1993, Ratcliffe 1993
Density dependent fecundity?	Yes		Hunt 1988; 1998
Survival during migration[a]	26-45%		Barclay and Cade 1983, Burnham

Table 2.1 (continued)

			et al. 1988, Holroyd and Banasch 1990, Boynton and Currie 1993
Migration rate between populations[b]	95%	3-15%	Barclay and Cade 1983, Burnham et al. 1988, Holroyd and Banasch 1990, Boynton and Currie 1993
Adult females that produce young each year	65 ± 5.2%	0.0%	Grier and Barclay 1988
Females raising 0 fledgling		100%	
Females raising 1 fledgling	23%		Ratcliffe 1993
Females raising 2 fledgling	39%		Ratcliffe 1993
Females raising 3 fledgling	29%		Ratcliffe 1993
Females raising 4 fledgling	9%		Ratcliffe 1993

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Table 2.1 (continued)

Juvenile (age 0-1) mortality	55-84 ± 3.8%	55-84 ± 3.8%	Enderson 1969, Lindberg 1977, Grier and Barclay 1988, Mearns and Newton 1984, Nelson 1988, Wooten and Bell 1992, Ratcliffe 1993, Tordoff and Redig 1997
Immature (age 1-2) and adult	21 ± 8%	21 ± 8%	Enderson 1969, Enderson and mortality Craig 1988, Newton and Mearns 1988, Olsen and Olsen 1988, Tordoff and Redig 1997
Initial population size	0	55	Hunt 1998
Carrying capacity	500	500	Bustamante 1996
Supplementation schedule[c]	6-96		

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Table 2.1 (continued)

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[a] Based on estimated first-year mortality.

[b] Based on estimated average return rates.

[c] I simulated reintroduction of 6, 12, 24, 48, 60, 72, and 96 peregrine falcons in each of 3 consecutive years.

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Table 2.2. Population viability analysis of a reintroduced peregrine falcon population with effects of variation in founder cohort size, and low, median, and high values for rate of philopatry[a] and first-year mortality[b].

Factor	Founder cohort size	High mortality rate and low philopatry rate ($\bar{x}$ ± SE)	Median mortality and philopatry rates ($\bar{x}$ ± SE)	Low mortality rate and high philopatry rate ($\bar{x}$ ± SE)
Probability of extinction at year 20	6	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0
	12	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0
	24	1.0 ± 0.0	1.0 ± 0.0	0.8 ± 0.1
	48	1.0 ± 0.0	0.7 ± 0.1	0.5 ± 0.2
	60	1.0 ± 0.0	0.4 ± 0.1	0.4 ± 0.1
	72	0.8 ± 0.1	0.5 ± 0.2	0.2 ± 0.1
	96	0.7 ± 0.1	0.2 ± 0.1	0.1 ± 0.1
Population size	6	0.0 ± 0.0	0.2 ± 0.1	0.3 ± 0.1

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Table 2.2 (continued)

at year 20	12	0.2 ± 0.1	0.1 ± 0.1	0.2 ± 0.1
	24	0.1 ± 0.1	0.4 ± 0.2	0.6 ± 0.2
	48	0.5 ± 0.2	0.7 ± 0.3	1.8 ± 0.3
	60	0.3 ± 0.1	1.9 ± 0.4	2.4 ± 0.5
	72	0.9 ± 0.4	2.1 ± 0.5	3.2 ± 0.6
	96	0.9 ± 0.3	3.8 ± 0.7	4.4 ± 0.8

[a] Rate of migration from non-breeding floating population to reintroduced population was 0.03, 0.09, and 0.15 for low, median, and high classes, respectively.

[b] Rate of first-year mortality for floating and reintroduced populations was 0.25, 0.45, and 0.65 for low, median, and high classes, respectively.

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Chapter Three

Pre-release considerations in peregrine falcon reintroduction: evaluation and characterization of potential release sites

Synopsis

As part of a program to restore the peregrine falcon (*Falco peregrinus*) in Kentucky cliff habitat, I implemented a pre-release habitat evaluation designed to identify habitats suited as reintroduction sites. The evaluation included: 1) a literature review of peregrine falcon ecology and personal communication with raptor biologists; 2) field and Geographic Information Systems (GIS) analyses of available habitat; 3) development of an eyrie correlate model; and 4) field surveys estimating available prey and predation risk. I evaluated 32 potential release sites in 3 physiographic regions. Large cliffs occurred throughout central and eastern portions of Kentucky. Generally, cliff habitats in central Kentucky were distinguished from those in eastern Kentucky by a greater $\bar{x} \pm$ SD proportion of non-forested habitat throughout surrounding landscapes (0.5 ± 0.02 and 0.08 ± 0.05, respectively), a greater proportion of potential prey that I considered available to peregrine falcons (0.56 and 0.32, respectively), and greater risk of Great Horned Owl (*Bubo virginianus*) predation (0.48 and 0.00 owl detections/hr survey effort, respectively). I selected the Red River Gorge Geologic Area in eastern Kentucky's Daniel Boone National Forest as a primary reintroduction site because this region best enabled me to address key considerations in raptor reintroduction including post-fledging survival and logistics of hack site attendance and research. This region is characterized by abundant cliff habitat, historic breeding locations, and features facilitating research and efficient hack

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site attendance such as storage facilities, trail systems, and good observation areas. A tradeoff that may exemplify other portions of the mid-Atlantic and southeastern region – low predation risk but poor prey availability – also characterized the Red River Gorge release sites to some extent. Although initial releases should focus on Red River Gorge sites, I will continue to evaluate the feasibility of using carefully selected central Kentucky sites as the program develops.

Introduction

Peregrine falcons have reoccupied historic habitats throughout much of their distribution (Hickey 1942, Corser et al. 1999, Tordoff et al. 2001). However, in mid-Atlantic and southeastern portions of the United States, reoccupancy of historic breeding locations including cliffs and low-elevation forests has been limited (Table 3.1). In this region, the *anatum* subspecies retains state endangered status (except in West Virginia where there is no state endangered species legislation) and efforts toward its recovery continue in 3 states, including Kentucky (Table 3.1).

During 1993-1999, 82 peregrine falcons were released among 2 coal-fired power plants and 1 skyscraper in central Kentucky. One Kentucky-released peregrine falcon is confirmed to occupy a territory at a coal-fired power plant in northern Kentucky. Also, several Kentucky-released peregrine falcons occupy breeding locations in the adjacent states of Ohio and Indiana (L. Burford, KDFWR, pers. commun.). Similarly, peregrine falcons hacked or wild-produced in other regions of North America have established territories in Kentucky. Four pairs (including the pair with the Kentucky-released individual) occupy bridges and coal-fired power plants in the Ohio River valley in northern portions of the state. Nonetheless, historic habitats, including cliffs

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throughout eastern Kentucky (Mengel 1939; 1965) remain unoccupied. Recently, efforts to restore the peregrine falcon in Kentucky shifted to historic cliff habitats.

Release site selection is recognized widely as a key protocol in reintroduction (e.g., Kleiman et al. 1994, IUCN/SCC 1995). In earlier efforts to restore peregrine falcon populations, known historic eyries were used as release sites or cliffs were selected based on assessments of general habitat attributes (Barclay 1988, Burnham et al. 1988, Martell et al. 1994). Earlier studies contributed to an understanding of natal site influences on peregrine falcon ecology and behavioral development (Newton 1979, Sherrod 1983, Ratcliffe 1993, Tordoff et al. 1998). However, more detailed data on release site attributes and protocols used in their quantification could contribute to retrospective evaluation of factors associated with reintroduction program outcome. Such studies may also lead to a better understanding of reoccupancy patterns of historic breeding locations in the mid-Atlantic and southeastern regions. As part of a program to restore the peregrine falcon in Kentucky cliff habitat, I initiated a pre-release habitat evaluation with the objectives of (1) measuring the physiography, prey availability, and risk of predation at potential release sites, and (2) identifying habitats suited as release (hack) sites.

Methods

I implemented a hierarchical strategy to identify suitable hack sites in which results of initial tiers guided the application of subsequent tiers. Successive tiers of the strategy were: 1) a literature review of peregrine falcon ecology and personal communication with raptor biologists; 2) field and GIS analyses of cliff habitat; 3)

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development of an eyrie correlate model; and 4) estimation of available prey base and risk of predation.

I supplemented a review of published literature on raptor ecology and reintroduction by communicating with biologists in the Southern Appalachians and the upper Midwest who had raptor reintroduction experience. Tier 1 largely focused on identifying perceptions among the raptor research community on factors limiting reoccupancy of historic breeding locations in portions of the mid-Atlantic and southeastern United States. Also, to estimate public perception of the program, I communicated with citizens who resided in proximity to potential reintroduction sites, and with local recreational organizations that were active in these areas (e.g., rock climbers).

I defined a cliff as a contiguous expanse of unvegetated precipitous rock, disjoined from other cliffs by ≥ 300 m. I used United States Geologic Survey topographic maps, aerial photographs, and extensive ground and boat reconnaissance to measure cliff physiography and vegetative characteristics, and to assess site-specific logistical considerations of hacking peregrine falcons (Dunn et al. 1980, Christopher 1981, Sherrod et al. 1982, Grebence and White 1989). Logistical considerations included my perceived ability to design and conduct research, such as behavioral studies, at potential sites (i.e., quality of the research environment). Variables that I measured in the field included cliff height, estimated horizontal extent of the cliff, predominant orientation of the cliff, estimated number of suitable hacking ledges, a terrain shape index (McNab 1989), historical documentation of peregrine falcon eyrie(s) at the cliff, the presence of a suitable area from which to observe reintroduced peregrine falcons,

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and the presence of avian species with which peregrine falcons are known to interact at roost or nest sites (i.e., Common Raven [*Corvus corax*], Black Vulture [*Coragyps atratus*], Turkey Vulture [*Cathartes aura*]). Using a GIS (Arcview®, ESRI, Redlands, California, USA) and Kentucky GAP Analysis Data (Mid-American Remote Sensing Center 2001) I determined the proportion of 5 land use classes, including forest, agriculture, development, permanent open water, and total non-forest habitat, within an 8-km radius of the potential hack sites (Enderson and Craig 1997). I determined the distance from potential hack sites to the nearest agricultural area ≥ 2 ha in size, municipal area (incorporated city or town), and permanent water source. I recorded several variables categorically, including cliff orientation, number of suitable ledges, historical references, presence of observation area, and presence of common ravens or vultures.

I identified correlates of peregrine falcon eyries by conducting field and GIS analyses at eyries in the Southern Appalachians (North Carolina, $n = 7$; and South Carolina, $n = 1$; Table 3.2), and I combined these data with field and GIS data collected in Kentucky to develop a discriminant model (M. Dzialak, unpublished data). Using SAS® (SAS Institute, Cary, North Carolina, USA), and following the model building techniques outlined by Hosmer and Lemeshow (2000), I performed multiple regression and used Akaike's information criterion corrected for bias (AIC_c) to derive a discriminant rule that distinguished Southern Appalachian eyrie cliffs from Kentucky cliffs in terms of physiography and local landscape attributes.

I surveyed the potential prey base by conducting modified fixed-radius point counts at 4 sampling points per cliff (Hutto et al. 1986). All sampling points were ≤

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800 m of the cliff and points at the same cliff were > 200 m from each other. I conducted all surveys during favorable weather conditions (Robbins 1981) between 06:30 and 09:30 h in May and June 2000. All survey periods were of 12-min duration, preceded by a 3-min waiting period to allow disturbed birds to resume singing. I calculated the total abundance of birds at each site. I classified birds as available or unavailable prey based on my knowledge of the ecology of local bird species, and on studies of peregrine falcon food habits (Carter et al. 2003). Based on total abundance recorded at each site, I calculated proportions and biomass of available prey (Dunning 1984, Corser et al. 1999). Using SAS® I performed analysis of variance and Tukey multiple comparisons to test for differences in prey availability among sites.

Great Horned Owls pose a considerable risk of predation to reintroduced peregrine falcons in the region (Sherrod et al. 1982, Barclay and Cade 1983). Following the protocols of McGarigal and Fraser (1984), I surveyed owl abundance by conducting point-count broadcasts of Great Horned Owl vocalizations during favorable weather conditions between 18:00 and 22:00 h in January-February 2001 using a wildlife caller (Johnny Stewart, Waco, Texas, USA). Broadcast points were 800-2000 m from the cliff, and points at the same cliff were > 800 m apart. I calculated and compared total Great Horned Owl detections per hour of survey effort among sites.

Results

Published literature on peregrine falcons focused largely on issues associated with population recovery, including contaminants, and population status and demography (e.g., Cade et al. 1988). Predation on reintroduced peregrine falcons and its implications for population recovery was a key concept in the literature (Barclay and

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Cade 1983, Cade et al. 1989). Raptor biologists with whom I communicated corroborated the literature in emphasizing risk of predation. However, biologists placed greater emphasis on logistical aspects of hack site management than was presented in the literature. Key considerations emphasized by biologists in the recovery of peregrine falcons in historic habitats included prey availability, predation at the natal site, and the potential degree of conspecific interaction among reintroduced and extant cohorts. Generally, citizens with whom I communicated viewed environmental issues favorably and suggested that the presence of peregrine falcons would enhance recreational experiences.

Based on the literature review and communications, I focused remaining tiers of the strategy on 3 general regions: the Kentucky River palisades south of Lexington in central Kentucky's Bluegrass region, the Daniel Boone National Forest south of Interstate 64 in the Cumberland Plateau region in eastern Kentucky, and cliff habitats on public lands in the Cumberland Mountains in southeastern Kentucky. I conducted field assessments and GIS analyses at 32 cliffs throughout these regions. Among general physiographic, vegetative, and landscape attributes, cliff height was 6.1 – 80.0 m, estimated horizontal extent of cliffs was 15.2 – 2769.2 m, and elevation at cliff summits was 164.0 – 670.3 m (Appendix A). Typically, landscapes at the base of cliffs included mature forest or forest adjacent to a riparian corridor, but landscapes at cliff summits often included recently harvested, regenerating forest stands, and in several cases, agricultural clearings. I detected the presence of Common Ravens, vultures, or Osprey (*Pandion haliaetus*) at 22% of cliffs. Landscapes within 8-km of cliffs in the central portion of the state ($n = 3$) were a mixture of agriculture ($\bar{x} \pm$ SD =

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0.48 ± 0.02) and forest ($\bar{x}$ ± SD = 0.50 ± 0.02; Appendix A). However, landscapes within 8-km of cliffs in the eastern portion of the state (n = 29) were predominantly forested ($\bar{x}$ ± SD = 0.92 ± 0.22), with little agriculture ($\bar{x}$ ± SD = 0.05 ± 0.05). Sites I evaluated were on lands managed by the National Park Service, United States Forest Service, Kentucky State Nature Preserves Commission, Kentucky Department of Parks, The Nature Conservancy, and private ownership.

Based on the eyrie-correlate model, Southern Appalachian eyries were distinguished from Kentucky cliffs by greater height (135.4 ± 46.6 m and 37.9 ± 21.5 m, respectively). When central Kentucky cliffs (27-29; Appendix A) were excluded from the analysis, Southern Appalachian eyries were characterized by a greater proportion of non-forested habitat within an 8-km radius than Kentucky cliffs (0.12 ± 0.06 and 0.07 ± 0.08, respectively; Tables 3.2 and 3.3). Also, I noticed considerably more residential, vacation, and summer property development in the Southern Appalachians (e.g., Whiteside and Panthertail Mountains) compared to Kentucky. This type of development is difficult to quantify in a GIS, but I suspect that the proportion of non-forested habitat near Southern Appalachian breeding locations is greater than I reported. Large Kentucky cliffs occurred in northern and southern portions of the Daniel Boone National Forest and along the Kentucky River in central Kentucky. Large cliffs characterized by adjacent non-forested habitats were situated mainly along the Kentucky River.

Based on previous tiers of the strategy, I limited assessment of prey availability to 12 sites on the Daniel Boone National Forest and along the Kentucky River. At these

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12 cliffs, I conducted 48 point-count surveys (4 per cliff). Total abundance of available prey was greater in central Kentucky than on the Daniel Boone National Forest ($P < 0.05$), but abundance of available prey did not differ among sites within regions ($P > 0.05$; Appendix B). Available prey comprised a higher proportion of total avian biomass in central Kentucky (0.85) than on the Daniel Boone National Forest (0.69). Based on total abundance, available prey comprised a large proportion (0.56) of observations in central Kentucky compared to observations on the Daniel Boone National Forest (0.32). On the Daniel Boone National Forest, cliffs at which available prey comprised the highest proportion of observations (0.35) occurred in the Red River Gorge Geologic Area (cliffs 10 and 12 in Appendix B).

I conducted 49 point-broadcast owl surveys in these 2 regions. Total survey effort included 8.4 h at Kentucky River sites and 19.4 h at Daniel Boone National Forest sites. I detected Great Horned Owls visually or audibly on 4 of 16 surveys at Kentucky River sites (0.48 detections/hour survey effort), and 0 of 33 surveys at Daniel Boone National Forest sites. Based on all facets of the study, but emphasizing risk of predation and the logistics of hacking and studying released peregrine falcons, I selected the Red River Gorge Geologic Area and adjacent Clifty Wilderness on the Daniel Boone National Forest (hereafter, Red River Gorge) as an initial site for reintroduction of peregrine falcons in Kentucky.

The Red River Gorge comprises approximately 10,500 ha and is located on the western fringe, or cliff section (Braun 1950), of eastern Kentucky's Cumberland Plateau (Figure 3.1). The region is highly dissected with rugged, complex topography. Elevations range between about 200 - 400 m. Mild temperatures, considerable

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precipitation, high humidity and no distinct dry season characterize the climate. Mean annual precipitation is about 117 - 122 cm, and mean annual temperature is about 13 C (United States Forest Service 1989). Steep slopes dominated by mixed mesophytic and northern hardwood forest (*Tsuga canadensis*, *Liriodendron tulipifera*, *Fagus grandifolia*), and abundant, massive sandstone outcrops that often form broad, level ridge-tops dominated by oak-pine forest (*Quercus* spp., *Pinus* spp., *Carya* spp.) characterize the region (Figure 3.2). Unique floral and faunal assemblages occur in the Red River Gorge including endemic species (white-haired goldenrod; *Solidago albopilosa*), endangered species (e.g., Indiana bat; *Myotis sodalis*), relict species (e.g., mountain maple; *Acer spicatum*, canadian yew; *Taxus canadensis*), and other species representing unique or isolated populations (e.g., snuffbox; *Epioblasma triquetra*, eastern spotted skunk; *Spilogale putorius*, Red-breasted Nuthatch; *Sitta canadensis*). The Geologic Area was designated a National Natural Landmark in 1974, and the Wilderness Area was designated in 1985.

Discussion

An implicit objective of this work was to acquire information that could contribute to retrospective evaluation of factors influencing the success of reintroducing peregrine falcons in cliff habitat. Often, ineffective documentation and dissemination of planning or pre-release phases of reintroduction programs hinders this understanding (e.g., Breitenmoser et al. 2001). Straightforward methodology and nested succession of tiers enabled a fairly comprehensive yet efficient evaluation of Kentucky cliff habitat that could facilitate this objective. Some considerations in raptor reintroduction site selection that I addressed in this study included natal site

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influences on post-fledging survival and behavioral development (Sherrod 1983, Ims 1994, Tordoff et al. 1998, Todd 2001), and quality of the research environment (*sensu* Soderquist 1994).

Survival and behavioral development of peregrine falcons reintroduced in cliff habitat, including habitat-type imprinting, social behavior, prey recognition and pursuit, and defensive behavior, probably are influenced by a suite of interdependent factors. These factors include the presence of predators or dangerous competitors (e.g., Red-tailed Hawk; *Buteo jamiacensis*) at the natal site, local physiography, and natal site prey availability (Sherrod 1983, Hunt 1988, Holroyd and Banasch 1990). A general tradeoff associated with some of these factors that I identified in Kentucky – low predation risk but poor prey availability – characterized the Red River Gorge to some extent, and may characterize forested regions throughout the peregrine falcon's distribution, including portions of the mid-Atlantic and southeastern United States where restoration efforts continue (*e.g.*, the Blue Ridge Mountains in Virginia). Poor prey availability at the natal site can result in impaired development of prey recognition and pursuit behavior (Sherrod 1983), large home ranges or post-fledging areas (Nelson 1987), and limited productivity of breeding locations established by philopatric individuals (Holroyd and Banasch 1990, Boynton and Currie 1993, Corser et al. 1999). Nonetheless, Lanier et al. (1983), Henry (1987), and Corser et al. (1999) demonstrated that reintroductions conducted in forested cliff habitats characterized by less-than-optimal prey availability could achieve success in terms of reestablishing active breeding locations. The Red River Gorge is heavily forested, but compared to prey estimates at other forested Kentucky sites, estimates at the Red River Gorge

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indicated higher prey availability. High cliff line density (Figure 3.2) in combination with wildlife clearings and low intensity recreational developments maintained by the United States Forest Service likely provided some degree of habitat variability that contributed to this prey availability. For example, species uncharacteristic of extensive forest coverage including Eastern Phoebe (*Sayornis phoebe*), Eastern Towhee (*Pipilo erythrophthalmus*), and Prairie Warbler (*Dendroica discolor*; although unlikely to be an important prey item), were detected frequently at cliff summits in the Red River Gorge (cliffs 10 and 12; Appendix B). The eyrie correlate model I developed that indicated some level of habitat variability associated with Southern Appalachian breeding locations, may allude to a similar situation in the heavily forested Southern Appalachians. Bockoven (1999) reported that peregrine falcons in the Southern Appalachians preyed upon species typically associated with fragmented landscapes, including Blue Jays (*Cyanocitta cristata*), Rock Doves (*Columbia livia*), and Common Grackles (*Quiscalus quiscula*).

Post-fledging period survival of reintroduced raptors should be a primary concern of biologists conducting the program. In natural environments, predation at the natal site is the most important source of mortality (Barclay and Cade 1983, Cade et al. 1988). Mesocarnivores (e.g., raccoon; *Procyon lotor*) and diurnal raptors are difficult to avoid when choosing release sites because of their general abundance, but fortunately peregrine falcons often are capable of evading or aggressively excluding them. Great Horned Owls are effective predators of peregrine falcons reintroduced in low elevation (< 1000 m) cliff habitats and are more difficult to address once they have emerged as a source of mortality (Barclay and Cade 1983), hence my proactive

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efforts in their estimation. In Kentucky, failure to detect Great Horned Owls on the Daniel Boone National Forest probably did not indicate absence; however, my results and knowledge of Great Horned Owl ecology enabled me to infer reasonably that predation risk was greater in central Kentucky. Powell et al. (2002) reported high survival rates among peregrine falcons reintroduced on a cliff along the Mississippi River in Iowa that also supported nesting Great Horned Owls. They reported that the presence of Great Horned Owls might have affected the behavior of reintroduced peregrine falcons but not their survival. Tordoff et al. (2000) suggested that the abrupt reestablishment of 5 pairs of peregrine falcons on Mississippi River cliffs in 2000 indicates that Great Horned Owl populations in the region may have become 're-educated' in terms of the potential costs of interacting with peregrine falcons. Local Great Horned Owl populations in Kentucky and other mid-Atlantic and southeastern regions may lack this 'humility'(Tordoff et al. 2000). Based on these reports, the most prudent course of action in regions where Great Horned Owls have not interacted with territorial peregrine falcons for many years is to consider risk of predation above estimated prey availability for initial releases.

Researchers considering raptor reintroduction should assess logistical concerns associated with experimental design and data collection (Morrison 2002); raptors are difficult to study and their reintroduction requires considerable pre-release planning. Favorable attributes of the research environment at the Red River Gorge included numerous observation areas, extensive visual survey capacity at these areas, an extensive trail system linking upper and lower slopes, equipment storage facilities, and extensive public land. In contrast, observation areas were less conducive to large

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viewsheds at central Kentucky cliffs, visual survey capacity at these areas was dependent upon the position of the observer relative to the Kentucky River corridor, accessibility often was limited, and adjacent land was predominantly in private ownership (Figure 3.3). Nonetheless, central Kentucky sites provided good habitat and may offer unique research opportunities. I will continue to monitor the feasibility of releasing peregrine falcons at carefully selected central Kentucky sites. Attributes of the Red River Gorge and several cliff habitats in central Kentucky, such as the composition and configuration of adjacent landscapes may lend themselves to research investigating influences of landscape structure on movements and population recovery. I suspect that insufficient influx of non-breeding individuals and consequent low rates of conspecific interaction is a key factor affecting reoccupancy of historic breeding locations and recovery efforts in the region (Hunt 1998, Tordoff et al. 2000). I predict that the composition and configuration of landscapes adjacent to the Red River Gorge, characterized by extensive forest coverage to the east and fragmented agricultural lands to the west, will promote dispersal biased westward (*sensu* Fuller et al. 1998) and consequent interaction with individuals comprising the large Midwestern population. Future research will examine behavioral ecology and dispersal characteristics of peregrine falcons released at the Red River Gorge, and will examine the feasibility of releasing peregrine falcons at carefully selected central Kentucky sites.

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Table 3.1. Status of peregrine falcon (*Falco peregrinus*) restoration in the mid-Atlantic region of the eastern United States [a].

State	Known historic eyries[b]	Restoration efforts	Number released	Current eyries[c]: Cliff	Forest	Constr.
Pennsylvania	44	1976-1998	88	1	0	12
Maryland	10	1975-present	>90	0	0	12
Virginia	22	1978-present	>120	0	0	17
West Virginia	9	1987-1990	53	1	0	0
Kentucky	3	1993-2003	115	0	0	4
Tennessee	35	1984-1993	54	1	0	1
North Carolina	10	1984-1997	93	9	0	0
South Carolina	2	1985-1990	47	1	0	0
Georgia	1	1987-1993	22	0	0	1
Totals	136		>682	13	0	47

[a] Table comprised using information from Bellrose 1938, Mengel 1939, Jones 1946, Mengel 1965, Berger and others 1969, Rice 1969, Gabler 1983, Knight 1983, and

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Table 3.1 (continued)

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personal communication with H. B. Tordoff, R. Wilson, C. McGrath, R. Fernald, C. Stihler, G. Therres, J. Cooper, E.J. Williams, D. Brawning, and M. Bunch.

[b] Pre-decline observations of breeding locations. These were cliff-nesting peregrine falcons with the following exceptions: 1 eyrie in dowtown Philadelphia, Pennsylvania, several eyries in coastal Virginia where peregrine falcons may have used the nests of Osprey (*Pandion haliaetus*), and 1 eyrie in Mississipppi River bottomland forests of western Kentucky.

[c] Constr. refers to human-made structures including skyscrapers, power plants, bridges, and coastal towers for which no pre-decline records exist.

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Table 3.2. Southern Appalachian cliffs used to construct a discriminant model and physiographic attributes that distinguished them from Kentucky cliffs. Peregrine falcon eyries were located on these cliffs in 2000.

Site/State	Zone 17 UTM		Estimated	Land use:
	X	Y	height (m)	non-for[a]
Devil's Courthouse/NC	3908190	327720	92.0	0.21
Looking Glass Rock/NC	3908100	336800	84.9	0.07
Panthertail Mt./NC	3892790	320250	106.2	0.18
Whiteside Mt./NC	3883950	305180	181.4	0.12
Blue Rock/NC	3922390	384410	112.5	0.10
Shortoff Mt./NC	3965150	418580	160.0	0.13
Big Lost Cove/NC	3986705	423195	125.8	0.06
Table Rock/SC	3880170	344605	228.7	0.06

[a] Proportion of landscape within an 8-km radius of the cliff (20096 ha) for which land use was non-forest.

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Table 3.3. Categorization and comparison of selected variables recorded at Kentucky cliffs (n = 32) and Southern Appalachian cliffs (n = 8) used in model development.

Variable	Kentucky cliffs $\bar{x}$ (SD)	Southern Appalachian cliffs $\bar{x}$ (SD)	Estimate	SE	t	P
Estimated height (m)	37.9 (21.5)	135.4 (46.6)	0.009	0.002	5.3	<0.001
Estimated horizontal extent (m)[a]	294.5 (475.0)	977.6 (942.3)	-0.025	0.038	-0.65	0.523
Estimated number of suitable hacking ledges	2.1 (1.1)	4.0 (0.0)	0.017	0.037	0.45	0.654
Historical documentation of eyrie(s) at the cliff	0.57 (0.3)	0.93 (0.6)	0.200	0.211	0.95	0.351
Land use: non-forested[b]	0.07 (0.08)	0.12 (0.06)	10.03	3.078	3.3	0.003

Table 3.3 (continued)

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[a] Termed length in Appendix A.

[b] Proportion of landscape within an 8-km radius of the cliff (20096 ha) for which land use was non-forest, excluding central Kentucky cliffs 27-29 (Appendix A).

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Figure 3.1. Location of the Red River Gorge Geologic Area, Daniel Boone National Forest (DBNF) and the Kentucky River Palisades (KRP) with reference to regional land use. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

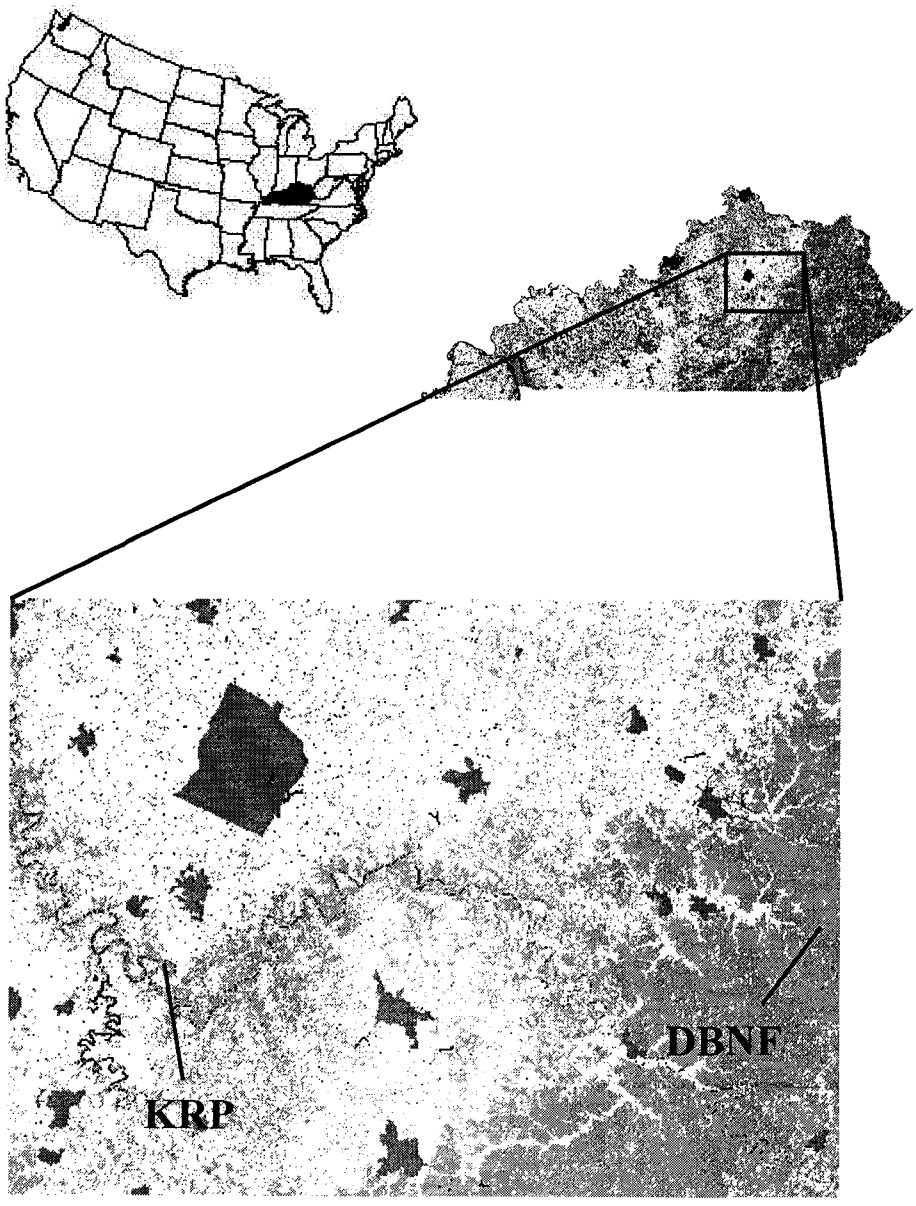

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Figure 3.2. Aerial view of the Red River Gorge Geologic Area, Daniel Boone National Forest, Kentucky. Numerous massive sandstone outcrops within a largely forested matrix characterize the region. Photo by J.L. Larkin.

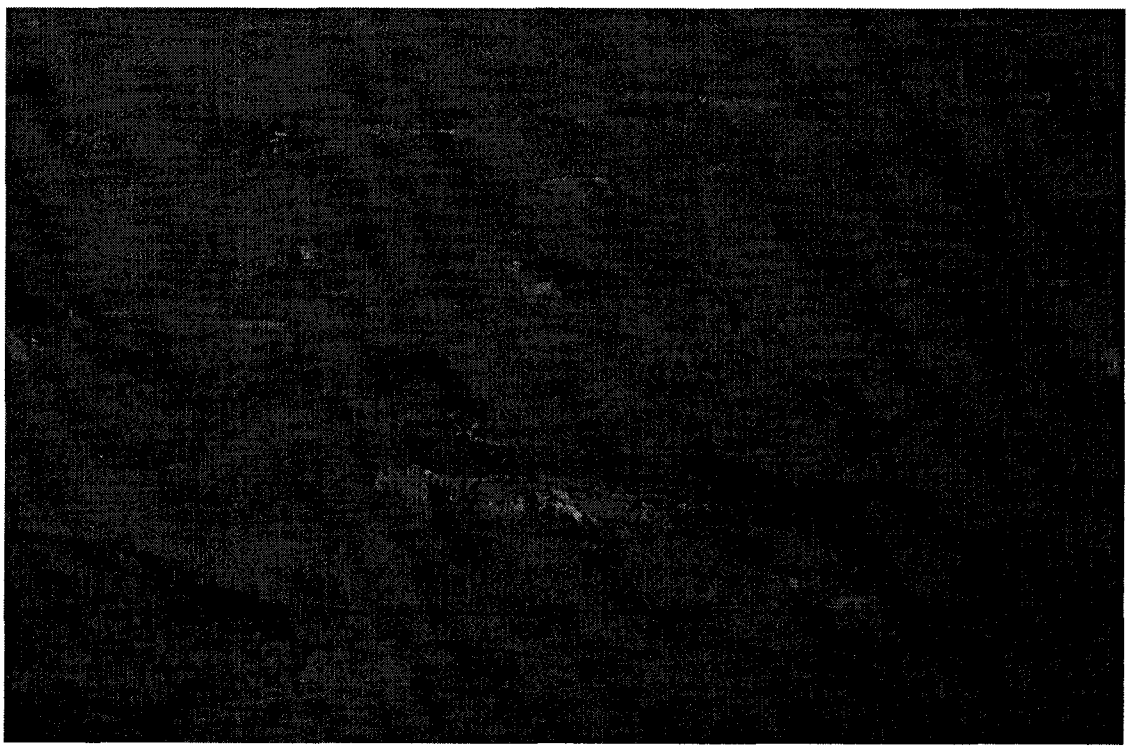

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Figure 3.3. Aerial view of cliffs along the Kentucky River in the Bluegrass Physiographic region of central Kentucky. Limestone cliffs in the foreground are approximately 60 m in height. The region is characterized by the largely forested Kentucky River drainage within a mixed agricultural matrix.

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Chapter Four

Influence of landscape pattern on dispersal initiation in a wide-ranging raptor: a comparative observational study in wildlife reintroduction

Synopsis

As part of a program to augment the recovery of the peregrine falcon (*Falco peregrinus*) in historic southeastern U.S. habitats, 33 peregrine falcons were reintroduced among cliffs in Kentucky. They were released at 2 sites with contrasting landscape configurations. Daniel Boone National Forest (DBNF) provided low elevation non-forested corridors within a forested matrix, whereas Tom Dorman State Nature Preserve (TDSNP) provided forested riparian valleys within a mixed agricultural landscape. I compared dispersal initiation, including timing of dispersal, orientation of dispersal movements, foray distances, post-fledging area (PFA) size, and habitat selection, at these 2 release sites and as peregrine falcons develped behaviorally. The presence of non-forested corridors at DBNF influenced post-fledging movements and initiation of dispersal in reintroduced peregrine falcons. Peregrine falcons released at DBNF localized many of their movements along non-forested (i.e., largely agricultural) corridors, occupied large PFAs, made long forays within corridors, and dispersed rapidly. In contrast, TDSNP peregrine falcons exhibited no apparent orientation of movements, occupied smaller PFAs, and exhibited delayed dispersal. Functional landscape connectivity, or species-specific behavioral responses to landscape structure, can influence the movements, distribution, and recovery of highly mobile organisms, and provide empirical support for the value of habitat connectivity in their conservation.

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Introduction

The peregrine falcon (*Falco peregrinus*) is a wide-ranging, long-lived raptor that typically exhibits nomadic movements after dispersing from the post-fledging area (PFA). Some individuals establish a breeding territory in their first year after natal dispersal, while others may spend several seasons exploiting habitats over large spatial scales (i.e., unoriented wandering; Barclay and Cade 1983, Cade et al. 1988). Natal dispersal in the peregrine falcon has been examined in several regions (Mearns and Newton 1984; Ambrose and Riddle 1988; Tordoff and Redig 1988, 1997; Restani and Mattox 2000). Generally, these were long-term studies using band recovery data to examine the demography and geography of dispersal (e.g., Restani and Mattox 2000). Specific attributes of behavior and movement during post-fledging that initiate dispersal have received less attention (Powell et al. 2002). Yet, movements during the period that precedes dispersal are inherent components of subsequent ecological processes and, logically, influence future colonization or distributional patterns (Bélisle et al. 2001).

Connectivity, the degree to which landscape structure facilitates movements of organisms, is central to the recovery of many wildlife populations. Research and debate have focused largely on structural connectivity, or habitat contiguity, and its role in promoting the viability of populations isolated by fragmentation (Simberloff et al. 1992, Tewksbury et al. 2002). A considerable body of research has emerged demonstrating the value of structural connectivity in facilitating movements of small mammals (Bolger et al. 2001), passerine birds (Robichaud et al. 2002), and invertebrates (Tewksbury et al. 2002). A related element of landscape connectivity

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that has received much recent attention is the concept of functional connectivity, or species-specific behavioral responses to landscape structure (Tischendorf and Fahrig 2000). There is evidence that organisms with the ability to traverse inhospitable habitats, especially birds, may express a behavioral reluctance or propensity to use or avoid certain landscape features (Machtans et al. 1996, Gobeil and Villard 2002, Robichaud et al. 2002). These responses appear to be expressed to a greater extent in juveniles than in adults, possibly because juveniles lack experience. Functional connectivity in the PFA may play a role in initiation of dispersal by juvenile birds and, consequently, in selection of future breeding locations (Machtans et al. 1996).

As part of a program to recover the peregrine falcon in historic habitat in the southeastern U.S., 33 peregrine falcons were released in cliff habitats in Kentucky. Based on the results of a habitat assessment (Chapter 3), I identified 2 release sites that I considered appropriate in terms of: 1) the overall conservation objectives of the reintroduction program (population augmentation and recovery), and 2) understanding the influence of landscape features on initiation of dispersal (functional connectivity). In this chapter I examine the initiation of dispersal by peregrine falcons reintroduced in 2 different landscapes specifically chosen for their contrasting habitat features. I evaluated timing of dispersal, orientation of movements, foray distances, size of PFA, and habitat selection.

Study areas

Peregrine falcons were released at the Red River Gorge Geologic Area, Daniel Boone National Forest (DBNF) in eastern Kentucky, and at Tom Dorman State Nature Preserve (TDSNP) in central Kentucky. The DBNF site comprises approximately

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10,500 ha and is located on the western fringe, or cliff section (Braun 1950), of eastern Kentucky's Cumberland Plateau. The region is highly dissected with rugged, complex topography. Elevations range between about 200-400 m. Mild average temperatures (13 C), high annual precipitation (117-122 cm), high humidity, and no distinct dry season characterize the climate (United States Forest Service 1989). Steep slopes dominated by mixed mesophytic and northern hardwood forest (*Tsuga canadensis*, *Liriodendron tulipifera*, *Fagus grandifolia*), and numerous, massive sandstone outcrops that often form broad, level ridge-tops dominated by oak-pine forest (*Quercus* spp., *Pinus* spp., *Carya* spp.) characterize the region. Unique floral and faunal assemblages occur in the Red River Gorge including endemic species (white-haired goldenrod; *Solidago albopilosa*), endangered species (e.g., Indiana bat; *Myotis sodalis*), relict species (e.g., mountain maple; *Acer spicatum*, canadian yew; *Taxus canadensis*), and other species representing unique or isolated populations (e.g., snuffbox; *Epioblasma triquetra*, eastern spotted skunk; *Spilogale putorius*, Red-breasted Nuthatch; *Sitta canadensis*). The Geologic Area was designated a National Natural Landmark in 1974.

Tom Dorman State Nature Preserve comprises 229 ha and is located adjacent to the Kentucky River in the Bluegrass physiographic region of central Kentucky. Elevations range between about 250-340 m. Like DBNF, mild average temperatures (13 C) and no distinct dry season characterize the climate at TDSNP (McGrain 1983). Gently rolling terrain and karst formations characterize the Bluegrass. In some areas, the Kentucky River carves a deep channel exposing Ordovician limestone bluffs (palisades) that, at TDSNP, exceed 70 m. Dominant flora includes mixed mesophytic

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and riparian forests (*Liriodendron tulipifera*, *Fraxinus quadrangulata*, *Quercus muehlenbergii*, *Acer sacharum*, *Ulmus thomasi*, *Cladrastis lutea*, *Acer sacharinum*, and *Planatus occidentalis*). Unique floral assemblages include starry cleft phlox (*Phlox bifida* ssp. *stellaria*), and Eggleston's violet (*Viola septemloba* var. *egglestonii*). The preserve was dedicated in 1996.

Although release sites were chosen based on several considerations (Chapter 3), the contrast in landscape composition and configuration at these cliff habitats provided an opportunity to study landscape-scale influences on natal dispersal in a wide-ranging predator. Land use in proximity to the DBNF hack site was largely forested, with several non-forested valleys associated with the Red River and its tributaries that extend generally westward from the hacking location (Figures 4.1 and 4.2). These non-forested valleys are linear features in the landscape that may be best described as habitat peninsulas (Bolger et al. 2001). These corridors increase in spatial extent from east to west across the Pottsville Escarpment (i.e., the transition between Cumberland Plateau and Bluegrass physiographic regions). Thus, DBNF provides non-forested corridors at low elevation within a forested matrix (Figure 4.1). In contrast, land use at TDSNP is largely agricultural, with forested habitat along the Kentucky River corridor and its tributaries. Thus, TDSNP provides forested corridors within a largely agricultural matrix (Figure 4.3). The design of this study can be considered comparative observational. The choice of release sites was largely motivated by the research hypothesis, generally stated as landscape pattern will affect dispersal. However, it is non-manipulative and unreplicated in the sense that response units (DBNF and TDSNP) already display different levels of the design factor, or the

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presence of corridors as landscape features (Stewart-Oaten et al. 1992, Feinsinger 2001). In general, peregrine falcons prefer non-forested habitats (Ratcliffe 1993). Thus, response units were specifically chosen because they display a 'test' (DBNF) and a 'control' (TDSNP) for the influence of functional landscape connectivity in peregrine falcons (see Stewart-Oaten et al. 1992, Block et al. 2001). If functional landscape connectivity influences post-fledging movements and the initiation of dispersal in peregrine falcons, I predict that movements and dispersal at DBNF will occur within habitat corridors, whereas movements and dispersal at TDSNP will exhibit uniformity throughout the landscape.

Methods

Delineation of dispersal behavior, viewsheds, and analyses

As part of the reintroduction program, Carter (2003) studied the behavioral ecology of peregrine falcons reintroduced at DBNF and TDSNP. By combining her data with my telemetry locations, I found that initiation of dispersal in reintroduced peregrine falcons developed in 4 stages (*sensu* Small et al. 1993, Miller et al. 1997). The first stage, *fledging*, was the period in which young peregrine falcons rapidly developed flight and defensive skills. At this stage, peregrine falcons generally restricted their movements within several km of the hacking station (Carter 2003). The second stage, *foray*, was the period during which young peregrine falcons explored the surrounding landscape, often making prolonged flights from and back to the hacking station. Key behaviors of this stage included frequent movements beyond the survey capacity of researchers at the hacking station, and their subsequent return to the hacking station. The third stage, *transience*, occurred when a reintroduced

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peregrine falcon initiated nomadic behavior and did not return to the hacking station. The final stage, *colonization*, occurred when a reintroduced peregrine falcon established a defended territory (e.g., Howard 1960). I identified these phases for each peregrine falcon that I released based on observations of individual behavior (Carter 2003). The average behavior of a population would be the most straightforward basis for setting management policy; however, variation in behavior among individuals can be considerable and using this variation as a basis for biological understanding and management policy is potentially more accurate (Marzluff et al. 1997).

Using a Geographic Information System (GIS; ArcView®, Esri, Redlands, CA) I delineated and quantified the area within the field of view (viewshed) of ground-based researchers at DBNF and TDSNP, respectively. Viewshed area was 56.0 km^2 and 26.4 km^2, respectively, at these sites (Carter 2003). Delineating stages of dispersal based on the behavior of individuals enabled me to associate specific telemetry locations with respective dispersal stages. Delineating viewshed area enabled me to differentiate movements within and external to viewsheds. Together, these criteria enabled: 1) evaluation of dispersal attributes along a developmental gradient, and 2) detailed examination of the *foray* stage which included movements within and external to respective viewsheds. For analyses based on movements beyond viewsheds, I first buffered viewsheds with an estimate of telemetry error (0.36 km; see Chapter 6). I excluded locations within buffers from these analyses. I emphasized *fledging*, *foray*, and *transience* stages of dispersal in this study. Although I have identified *colonization* as part of the program, sample size is too low for consideration in analyses.

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Unless specified otherwise, I used multivariate analysis of variance (MANOVA) and repeated measures MANOVA to analyze data. Response variables included stage-specific measures of dispersal including timing, area use, movement distances, movement orientation, and habitat selection. The classification variable of interest was release site, but to identify potential confounding factors I also examined sex, release age (days), and release date (standardized using the Julian calendar). I chose these specific demographic and procedural parameters for evaluation based on the results of Chapter 5. I also evaluated sex by release site, sex by release age, and release site by release age interaction terms. No other interactions were considered because I did not foresee reasonable biological explanations for their significance. In all analyses but one, I considered only peregrine falcons that survived and dispersed. The analysis in which I included peregrine falcons that died before dispersal was an evaluation of habitat selection during the *fledging* stage. Since all mortalities during the program occurred during this stage (see Chapter 5 for survival analyses), it was reasonable to examine possible differences in habitat selection between peregrine falcons that dispersed or died before dispersal. Data for all dispersal characteristics were not available for all peregrine falcons, so sample sizes differ among analyses (Tables 4.1-4.3; Appendices C-F).

Telemetry

Before placing peregrine falcons in hack boxes, I fitted each individual with a tarsal-mounted dummy transmitter that approximated the size, shape, and attachment of actual transmitters. On the day before release, I replaced dummy transmitters with tarsal-mounted modified RI-2CM transmitters (Holohil Systems, Ltd., Ontario,

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Canada). Modifications included construction of a bracket to receive a 12.0 × 0.15 × 1.0-cm leather strap that facilitated tarsal attachment of transmitters (bewit mount; Sherrod t al. 1982, Cade et al. 1996). In each leather strap, two 0.75-cm diameter fastening holes were punched near strap termini. By wrapping the strap through the bracket and around the tarsus, the fastening holes aligned to enable insertion of 2 small plastic cable ties (10.2 × 0.07 × 0.2-cm; APW Tools and Supplies, Milwaukee, WI 53209). Cable ties were tightened and trimmed to complete transmitter attachment. The diameter of the fastening holes nearly equaled the height of the leather straps, reducing the overall strength of the strap at the fastening holes. This design was intended to improve instrument retention during the study period but allow a timely shedding of the device. Radiotransmitters were equipped with mortality sensors set to alter the transmission rate after 12 h of inactivity. Transmitter life was 90 days, and total unit weight including transmitter, leather, and cable ties was approximately 10.0 g (1.0-3.0 % of average peregrine falcon body weight).

I initiated monitoring of reintroduced peregrine falcons immediately after release. Reintroduced peregrine falcons were located 1-5 times daily ($\bar{x}$ ± SD = 1.5 ± 0.8) using aerial telemetry and ground reconnaissance. Telemetry flights were conducted in a Cessna 182 equipped with wing strut-mounted 2-element yagi antennae, generally at altitudes of 2000-4000 feet above sea level. I used an R-1000 telemetry receiver (Communications Specialists, Inc., Orange CA 92865) to relocate peregrine falcons, and location estimates (Universal Trans Mercator; UTM) were recorded using a hand-held Global Positioning System (GPS; Garmin GPS III, Olathe, KS 66062). I recorded date, time, and general habitat attributes at each estimated location. Location

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estimates obtained during ground reconnaissance were plotted on topographic maps and later converted to UTM coordinates. During a telemetry flight, if initial efforts to relocate a peregrine falcon were unsuccessful, I initiated a search grid centered on the last known location. Generally, search efforts were designed to cover approximately 625-900 km^2 by flying transects separated by 10-40 km depending on terrain. In data analyses, I used all unique locations at which peregrine falcons occurred during a given data collection session rather than attempting to select 'independent' locations. Thus, I eliminated redundant locations recorded within a given data collection session. For example, I considered the hacking stations to constitute respective single observations during a given data recording session even though they often were visited by peregrine falcons multiple times. For a discussion on aerial telemetry as a research tool in raptor restoration, including assessment of telemetry error, readers should consult Chapter 6. For details on hacking protocols readers should consult Chapters 5 and 6.

Dispersal timing, post-fledging area size, and foray distances

Starting with release of each peregrine falcon, I examined the number of days that comprised *fledging* and *foray* stages of dispersal. I combined the number of days comprising these stages to examine total number of days that elapsed before peregrine falcons initiated *transience*. Using ArcView®, I examined telemetry data corresponding to *fledging* and *foray* dispersal stages. Based on location estimates that corresponded to these respective stages, I used the minimum convex polygon (100% MCP) method to estimate area use for each peregrine falcon. For each peregrine falcon, I also pooled telemetry locations between these stages to construct a MCP

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estimate representing area use during the entire post-fledging period. Marzluff et al. (1997) considered the MCP method inferior to minimum concave polygons for estimating area use by Golden Eagles (*Aquila chrysaetos*) because the MCP extrapolated beyond known locations and suggested territorial overlap among eagles. Because PFA movements of reintroduced peregrine falcons in my study often seemed exploratory (e.g., Ferrer 1993) and were not affected by territorial constraints, I considered the MCP method appropriate. Frequent movements beyond viewsheds (Carter 2003) were typical of peregrine falcons in the *foray* stage of dispersal. During this stage of dispersal, I calculated the mean distance between locations beyond viewsheds and hacking stations for each peregrine falcon. Additionally, I identified the maximum distance from respective hacking stations at which I was able to obtain a location estimate for each peregrine falcon. For these analyses, I made comparisons between sites and I evaluated influences of potential confounding factors including sex, release age, release date, and interaction terms using MANOVA and repeated measures MANOVA.

Orientation of movements

I examined the orientation of peregrine falcon movements (degrees) during *foray* and *transience* stages separately. I re-examined the *foray* stage by separately evaluating movements beyond the viewsheds. Using these data sets (i.e., all *foray* locations, all *transience* locations, and *foray* locations beyond viewsheds), I calculated the $\bar{x}$ angle ± angular deviation of movements for each peregrine falcon, and I calculated second-order $\bar{x}$ angle ± 95% confidence intervals grouping data by release site and dispersal stage. To examine whether movements were distributed uniformly

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(versus localized in specific directions), I calculated Rayleigh's *z* by release site and stage of dispersal (Zar 1996). For all analyses of movement orientation, I considered the respective hacking stations to be the point of origin.

Habitat selection

I used ArcView® and Kentucky Gap Analysis Data (Mid-American Remote Sensing Center 2001) to evaluate habitat selection. I delineated (e.g., reclassified from land use data) habitats at DBNF and TDSNP based on current management practices or on vegetative features. Pastures, hay fields, grazing lots, and other agricultural fields were classified as agriculture because of management and structural similarity. All forest types, including deciduous, coniferous, and mixed were classified as forest. Roads, buildings, towns, and cities were classified as developed. Open bodies of water were classified as such.

I compared habitat selection by peregrine falcons at DBNF and TDSNP during *fledging* and *foray* stages of dispersal using Euclidean distance analysis (Conner and Plowman 2001, Conner et al. 2003). I performed 3 habitat selection analyses: the first analysis examined the *fledging* stage of dispersal; the second analysis examined the *foray* stage; the third analysis re-examined the *foray* stage based on movements beyond the viewsheds. Unlike all other analyses, I included peregrine falcons that died before dispersal in the assessment of habitat selection in the *fledging* stage. I delineated available habitat for each analysis separately (i.e., analysis of *fledging* data, all *foray* data, and *foray* data beyond viewsheds, respectively). At each site, I pooled telemetry locations corresponding to these respective dispersal stages among all peregrine falcons and I constructed MCPs. Thus, the combined movement of all

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peregrine falcons at DBNF and TDSNP, respectively, was used to determine availability of stage-specific PFAs. Although the home range concept is of limited utility for post-fledging raptors, areas I measured were analogous to an overall home range during the *fledging* stage, an overall home range during the *foray* stage, and an additional overall home range during the *foray* stage beyond the viewsheds at each site (e.g., third-order habitat selection; Johnson 1980). Based on this delineation, availability differed between dispersal phases (i.e, availability changed to reflect peregrine falcon ontogeny) and release sites. Using Arcview®, I simulated 50 locations from a uniform random distribution for each use area. With the Nearest Feature extension, I calculated for each peregrine falcon the distance from each random point and location estimate to the nearest representative of each habitat type. I averaged these values creating vectors of mean distances from random points ($\mathbf{r}_i$) and from actual locations ($\mathbf{u}_i$) to each habitat type (Connor et al. 2003). For each peregrine falcon I created a vector of ratios ($\mathbf{d}_i$) by dividing each element in $\mathbf{u}_i$ by the corresponding element in $\mathbf{r}_i$. To test for nonrandom habitat use, I used MANOVA to examine whether the mean vector (ρ), calculated as the mean of the $\mathbf{d}_i$, differed from a vector of 1s. Response variables included ρ, and classification variables included sex, release site, release date, and interaction terms (and individual fate for the assessment of *fledging* stage habitat selection). If ρ differed from the vector of 1s, habitat selection occured. If an element in ρ is < 1, then the corresponding habitat was preferred. If ρ is > 1, then the corresponding habitat was avoided. The elements in ρ provide a ranking of habitat use relative to availability (Conner et al. 2003). The habitat with the lowest value among elements in ρ was used most relative to its

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availability, or peregrine falcon locations were closest to this habitat relative to random points. In contrast, the habitat with the largest value was used least relative to its availability. Significance of this ranking was assessed using F statistics.

I used different methods to measure habitat associations during *transience* because delineating habitat availability for nomadic peregrine falcons is problematic. For movements corresponding to *transience*, I buffered location estimates with a radius representing average telemetry error occurring during the study (see Chapter 6 for telemetry error assessment) and I tabulated the proportion of each habitat element within buffers. I averaged these proportions among locations for each peregrine falcon. Proportions were arcsine transformed and repeated measures MANOVA was used to examine release site, sex, and site by sex interaction effects on habitat proportions. Thus, for *transience* I examined habitat use, not selection.

Results

Dispersal timing, post-fledging area use, and foray distances

I used 542 qualified location estimates for analyses. Among all peregrine falcons, $\bar{x} \pm$ SD number of days comprising *fledging*, *foray*, and the entire post fledging period was 7.1 ± 3.5 days, 12.3 ± 10.9 days, and 18.3 ± 12.5 days, respectively. Although the *foray* stage was longer than the *fledging* stage, the difference was not significant ($F_{1,19} = 1.2$, $P = 0.33$). Number of days comprising *fledging* and the entire post fledging period did not differ significantly between release sites or sexes, and was not affected by release age or release date ($F_{7,14} = 0.49$, $P = 0.83$ and $F_{7,14} = 0.93$, $P = 0.51$, respectively). I found a difference in the number of days comprising *foray* between release sites ($F_{1,14} = 4.83$, $P = 0.02$), with DBNF

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peregrine falcons spending fewer days and exhibiting greater variability in *foray* (15.8 ± 8.5 days) compared to TDSNP peregrine falcons (24.4 ± 2.8 days; Table 4.1). I detected no sex, release age, or release date effects during *foray*. I detected an overall time by release site effect ($F_{4,38} = 7.14$, $P < 0.01$) reflecting a considerably longer *foray* stage in TDSNP peregrine falcons (Table 4.1).

Among all peregrine falcons, $\bar{x} \pm$ SD MCP estimates for *fledging*, *foray*, and the entire post-fledging period were 75.8 ± 87.7 ha, 1922.2 ± 2191.6 ha, and 1985.1 ± 2206.9 ha, respectively. As expected, size of PFA was significantly larger during the *foray* stage than during the *fledging* stage ($F_{1,19} = 42.2$, $P = 0.01$). I detected no sex, release age, or release date effects for size of PFA during *fledging* ($F_{2,5} = 3.3$, $P = 0.24$). I was unable to obtain a meaningful estimate for size of PFA during *fledging* at TDSNP (Table 4.2). I detected significant site effects for *foray* and entire post-fledging period PFA sizes ($F_{1,12} = 6.0$, $P = 0.04$; $F_{1,12} = 6.5$, $P = 0.03$, respectively) with DBNF peregrine falcons occupying a considerably larger $\bar{x} \pm$ SD PFA than TDSNP peregrine falcons during *foray* (2556.6 ± 2597.9 ha and 907.3 ± 712.1 ha, respectively) and overall (2643.5 ± 2599.0 ha and 931.7 ± 732.1 ha, respectively; Table 4.2). Although males generally occupied somewhat larger PFAs than females (Table 4.2), I detected no other sex, release age, release cohort size, or interaction effects ($P > 0.05$).

Overall maximum movement exceeded mean movement distances, but the difference between maximum and mean distances was not significant ($F_{1,9} = 2.2$, $P = 0.17$). I detected significant differences between release sites in mean ($F_{1,14} = 11.6$, $P = 0.01$) and maximum ($F_{1,14} = 6.2$, $P = 0.03$) distances from hacking stations.

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Considering all location estimates recorded beyond the viewsheds, DBNF peregrine falcons were located a greater distance from the hacking station than TDSNP peregrine falcons (4.7 ± 3.1 km and 2.1 ± 1.9 km, respectively). Among maximum foray distances, DBNF peregrine falcons typically traveled farther than TDSNP peregrine falcons (12.9 ± 13.9 km and 6.1 ± 4.7 km, respectively; Table 4.3). The greatest single distance a peregrine falcon traveled during a foray was 48.2 km. This was a male released at DBNF. I detected no sex, release age, or release date effect on mean or maximum foray distances ($P > 0.05$), but I found a significant time by release site effect on maximum foray distance ($F_{1,9} = 5.1$, $P = 0.05$), reflecting the greater maximum foray distances exhibited by DBNF peregrine falcons (Table 4.3).

Orientation of movements

Peregrine falcons released at DBNF tended to orient many of their movements westward and northward (Figure 4.4), whereas peregrine falcons released at TDSNP displayed no apparent orientation of movements (Figure 4.5). I evaluated orientation of movements using data sets representing all locations corresponding to the *foray* stage, all locations corresponding to *transience*, and locations beyond the viewsheds during the *foray* stage. Peregrine falcons released at DBNF tended to orient many of their movements westward or northward during the *foray* stage (Figure 4.6). Second-order $\bar{x}$ angle ± 95% CI of movements calculated among all DBNF peregrine falcons was 256.2 ± 62.9, but considering all foray locations, these movements were random (Rayleigh's $z_{0.05,\ 128} = 1.49$; $P > 0.05$). At TDSNP peregrine falcons displayed no apparent pattern in the orientation of movements during the *foray* stage (Figure 4.7). Second-order $\bar{x}$ angle ± 95% CI was 128.2 ± 68.7 and, like DBNF, movements were

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random (Rayleigh's $z_{0.05,\ 86} = 1.89$; $P > 0.05$). A similar pattern emerged when considering *foray* locations beyond the viewsheds. As before, peregrine falcons released at DBNF oriented their movements westward or northward, whereas TDSNP peregrine falcons displayed no apparent pattern in movement orientation. Second-order $\bar{x}$ angle ± 95% CI were 280.8 ± 58.6 and 358.8 ± 98.8 for DBNF and TDSNP peregrine falcons, respectively. These movements at TDSNP were again distributed uniformly around the hacking station (Rayleigh's test $z_{0.05,\ 17} = 2.84$; $P > 0.05$). In contrast, movements beyond the viewshed by DBNF peregrine falcons were not distributed randomly. Those at DBNF exhibited a tendency to move along non-forested landscape features in westward and northward directions from the hacking location (Rayleigh's $z_{0.05,\ 46} = 5.13$; $P < 0.05$). Similarly, to *transience* was nonrandom at DBNF (Rayleigh's $z_{0.05,\ 31} = 10.6$; $P < 0.05$) and was usually oriented north and west. *Transience* at TDSNP was random (Rayleigh's test $z_{0.05,\ 16} = 0.01$; $P > 0.05$; Figures 4.8 and 4.9). Second-order $\bar{x}$ ± 95% CI angle of movements during *transience* were 310.2 ± 38.2 and 2.5 ± 29.0 for DBNF and TDSNP, respectively.

Habitat selection

Fledging

At DBNF, the average distance from 1150 random points to forest, agriculture, water, and development was 0.2 m, 168.5 m, 2982.1 m, and 12373.3 m, respectively. At TDSNP, the average distance from 150 random points to forest, agriculture, water, and development was 32.5 m, 22.9 m, 269.9 m, and 7684.2 m, respectively. The analysis of distance ratios (Appendices C and D) demonstrated that peregrine falcon locations differed from random locations ($F_{4,18} = 26.5$, $P < 0.001$). I observed no

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difference in habitat selection between sexes ($F_{4,18} = 1.4$, $P = 0.27$), between peregrine falcons that dispersed or those that died ($F_{4,18} = 0.33$, $P = 0.86$), and I detected no significant interaction term ($P > 0.28$). I found a significant difference in habitat selection between sites ($F_{4,18} = 189.3$, $P < 0.001$). Differences between sites occurred in selection of developed ($F_{4,21} = 17.0$, $P < 0.001$), agricultural ($F_{4,21} = 9.9$, $P < 0.001$), and forest ($F_{4,21} = 202.7$, $P < 0.001$) habitats. DBNF peregrine falcons were found closer to forest habitats and farther from agricultural habitats than expected, and they selected developed areas and open water habitats in proportion to their availability. At TDSNP, peregrine falcons were found closer to agriculture than expected and farther from forest and developed habitats (Appendix D). A ranking of habitats based on values of ρ indicated that at DBNF, peregrine falcons used forest the most followed by developed, water, and agricultural habitats. At TDSNP, peregrine falcons used agriculture the most followed by developed, water, and forest habitats. Generally, peregrine falcons during *fledging* selected habitats in close proximity to hacking stations.

Foray

At DBNF, the average distance from 450 random points to forest, agriculture, water, and development was 42.8 m, 119.1 m, 2217.1 m, and 2702.1 m, respectively. At TDSNP, the average distance from 250 random points to forest, agriculture, water, and development was 59.7 m, 9.1 m, 482.0 m, and 9188.7 m, respectively. Peregrine falcon locations differed from random locations ($F_{4,7} = 104.8$, $P < 0.001$; Appendices C and E). I observed no sex effect ($F_{4,7} = 0.48$, $P = 0.75$) or interaction ($F_{4,7} = 0.94$, $P = 0.49$), but I detected a difference in habitat selection between sites ($F_{4,18} = 571.5$, P

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< 0.001). Differences between sites occurred in selection of developed ($F_{3,10} = 124.3$, $P < 0.001$), agricultural ($F_{3,10} = 7.6$, $P = 0.006$), forest ($F_{3,10} = 3.9$, $P = 0.04$), and water ($F_{3,10} = 137.6$, $P < 0.001$) habitats. At DBNF, peregrine falcons were found closer to forest habitats, but farther from agricultural, developed, and water habitats than expected. At TDSNP, peregrine falcons were found closer to water and forest than expected, farther from agriculture than expected, and used developed habitat in proportion to its availability (Appendix E). A ranking of habitats based on values of ρ indicated that at DBNF, peregrine falcons used forest the most followed by agriculture, water, and developed habitats, whereas at TDSNP, peregrine falcons used water the most followed by forest, developed, and agricultural habitats.

***Foray* beyond viewsheds**

At DBNF, the average distance from 450 random points to forest, agriculture, water, and development was 49.9 m, 102.9 m, 2189.2 m, and 2003.2 m, respectively. At TDSNP, the average distance from 250 random points to forest, agriculture, water, and development was 68.8 m, 9.0 m, 434.1 m, and 8917.1 m, respectively. Peregrine falcon locations differed from random locations ($F_{4,5} = 5.8$, $P = 0.039$; Appendices C and F). Differences between sites occurred in selection of developed ($F_{3,8} = 9.0$, $P = 0.006$) and agricultural ($F_{3,8} = 17.1$, $P < 0.001$) habitats. Agricultural habitats were selected by DBNF peregrine falcons but avoided by TDSNP peregrine falcons. Developed habitats were selected by TDSNP peregrine falcons, but avoided by DBNF peregrine falcons. I detected significant sex ($F_{4,5} = 5.9$, $P = 0.04$), site ($F_{4,5} = 13.4$, $P = 0.007$), and sex by site interactions ($F_{4,5} = 6.0$, $P = 0.038$). Sex and sex by site effects were associated with selection of agricultural habitat. Agriculture was

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proportionally used more by males than by females ($F_{1,8} = 23.1$, $P = 0.001$). Females at DBNF tended to use agriculture more than females at TDSNP, whereas males at DBNF used less agriculture than males at TDSNP ($F_{1,8} = 25.1$, $P = 0.001$). At DBNF, peregrine falcons generally were found closer to agricultural habitats than expected, farther from developed and water habitats than expected, and used forest in proportion to its availability. At TDSNP, peregrine falcons were found closer to water, forest, and developed habitats than expected, but farther from agriculture than expected (Appendix F). A ranking of habitats based on values of ρ indicated that at DBNF, peregrine falcons used agriculture the most followed by forest, water, and developed habitats, whereas at TDSNP, peregrine falcons used water the most followed by forest, developed, and agricultural habitats.

Transience

Average telemetry error for the study was 0.36 km. (Chapter 6). Habitats included within telemetry error buffers differed between sites ($F_{4,8} = 9.3$, $P < 0.001$). I found no significant sex or interaction effect ($P > 0.05$). Significant site differences occurred in the amount of agricultural habitat and forest habitat comprising error ellipses ($F_{1,11} = 12.3$, $P = 0.01$ and $F_{1,11} = 6.7$, $P = 0.03$, respectively). During *transience*, TDSNP peregrine falcons were located in habitats comprised of considerably more agriculture and less forest than DBNF peregrine falcons (Figures 4.8a, 4.8b, 4.8c, and 4.9). Peregrine falcons released at TDSNP also appeared to be located in habitats with less development compared to DBNF peregrine falcons, but the difference was not significant.

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Discussion

In nearly every measure of dispersal initiation, I found differences between peregrine falcons released at DBNF and TDSNP. Demographic or procedural elements of the reintroduction program could not adequately explain these differences (also see Chapter 5). Instead, the multivariate framework within which I evaluated dispersal initiation provided a reasonable basis to infer that differences between peregrine falcons released at DBNF and TDSNP were related to differences in landscape attributes between the sites.

During the period immediately after release I observed no notable demographic, procedural, or site effect on movement attributes, or habitat selection. This was expected given the behavioral characteristics by which I delineated this pre-dispersal stage. In contrast, the presence of non-forested corridor-like landscape features extending westward from the DBNF hacking station (Figure 4.1) appeared to influence the orientation of movements, foray distances, size of PFA, timing of dispersal, and habitat selection during *foray* and *transience* stages of dispersal initiation. Detailed examination of the *foray* dispersal stage was critical in understanding landscape influences on peregrine falcon movement because, unlike *fledging* or *transience* stages, the *foray* stage included locations that were in close proximity to and far from hacking stations. When I analyzed the *foray* stage without differentiating between locations that were near or far, the character and magnitude of landscape influences at DBNF were not as clear. For example, because this stage was characterized by exploration or sampling of habitats throughout the landscape by peregrine falcons, analyses depicted movements at DBNF as random in orientation

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and suggested that these falcons selected forest, while avoiding other habitats. Similarly, at TDSNP analyses conducted without differentiating between near and far movements suggested that peregrine falcons selected forest and water habitats; the two habitat types that were closest to the hacking station. Analyzing movements beyond the viewsheds during the *foray* stage suggested that at DBNF, non-forested corridors extending westward from the Cumberland Plateau into the Bluegrass were implicated in the observed differences in dispersal attributes of peregrine falcons between sites.

The overall PFA at DBNF (2644 ha) was nearly 3 times the size of the PFA at TDSNP (932 ha). In the only other study examining PFA size in reintroduced peregrine falcons, Powell et al. (2002) reported that peregrine falcons released at a cliff in Iowa used 682 ha during the post-fledging period. Powell et al. (2002) used ground-based telemetry to estimate PFA size so their estimate may be low. Initial trials in this study suggested that ground-based methods underestimated PFA use compared to aerial methods. Nonetheless, the estimate of Powell et al. (2002) is comparable to our data at TDSNP, but not at DBNF. The absence of nearby, non-forested habitats at DBNF likely promoted expansion of the PFA (Nelson 1987) and, once the nearest non-forested habitats were found and explored, movements toward them occurred repeatedly (i.e., selected). At TDSNP, agricultural habitats comprised the surrounding matrix, thus, a localized orientation of movements or a large PFA were unnecessary to encounter preferred habitat types. Interestingly, when peregrine falcons at TDSNP moved beyond the viewshed, they were found closer to water, forest, and developed habitats than expected, but farther from agriculture than expected. Based on observations I made during telemetry flights, this appeared to

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demonstrate selection of edge habitats (Connor et al. 2003) at the periphery of small towns (e.g., Danville and Harrodsburg) and lakes (e.g., Lake Herrington). Using the home-range analogy, species often occupy home-ranges that differ in size in different portions of their distribution. Often, these differences reflect patterns in the abundance and distribution of prey. Similarly, post-fledging movements of some raptors appear to be strongly related to the distribution of prey (Kopimarki and Norrdahl 1991, Kenward et al. 1993). In Kentucky, estimated prey availability for peregrine falcons is better in agricultural areas than in heavily forested areas (Chapter 3). Perhaps expansion of the PFA, orientation of movements throughout non-forested conduits extending westward, and selection of agricultural habitats by DBNF peregrine falcons reflected prey accessibility (Barclay and Cade 1983). Observations on the influence of landscape features on the movements of raptors have been made previously, but not within a comparative framework. Enderson and Kirven (1983) monitored a nesting pair of peregrine falcons in California and commented that movements appeared centered on corridors related to landscape topography. Apparently these corridors provided topographic relief and peregrine falcons often favored ridges following them, but habitat composition in the study area was not mentioned (Enderson and Kirven 1983). In my study, topography associated with riparian areas was a factor at both sites; however, valley corridors at TDSNP were largely forested. I observed no apparent influence of forested valley corridors at TDSNP on peregrine falcon movements. King and Belthoff (2001) reported an overall southward dispersal tendency among post-fledging Burrowing Owls (*Athene cunicularia hypugaea*) in Idaho and speculated that urban development northward of

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the PFA and better habitat southward contributed to this pattern. However, inferences based on these observations were limited to examining habitat use and not landscape structure. Fuller et al. (1989) tracked the migratory patterns of peregrine falcons (*F. p. tundrius*) and Swainson's Hawks (*Buteo swainsoni*) using satellite telemetry and observed that the Appalachian Mountains created a migratory divide between birds using Atlantic coastal and mid-Continental flyways. When examined at large spatial scales, functional connectivity of landscapes appears to influence organisms with high mobility.

Peregrine falcons remained on the PFA at DBNF for an average of only about 16 days compared to about 31 days at TDSNP. It is unclear whether there is a survival or reproductive advantage associated with remaining on the PFA for an extended period. Some research suggests that individuals that disperse earlier are in better physical condition than late dispersers (Belthoff and Dufty 1998, Willey and van Riper 2000). Although inherent physical condition likely varied among the individuals in this study, it is unknown whether physical condition influenced the differences I observed. At DBNF, peregrine falcons remained on the PFA for considerably fewer days than reported in previous studies. Fyfe (1988) reported that hacked peregrine falcons remained on the PFA for 23-28 days in Canada. Powell et al. (2002) reported a post-fledging period of 24-30 days in Iowa. Dispersal timing among TDSNP peregrine falcons was comparable to these studies but timing among DBNF peregrine falcons was not. At DBNF, several individuals 'skipped' the *foray* dispersal stage, transitioning from *fledging* directly to *transience*. Landscape features seemed to affect other attributes of post-fledging movements, but the association between landscape

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differences and dispersal timing was unclear. Like size of the PFA, timing differences may reflect the absence of a critical habitat element at heavily forested eyries. Although many observations of *transient* peregrine falcons occurred in the Bluegrass physiographic region, peregrine falcons released at DBNF were located in areas that seemed to have more forest compared to peregrine falcons released at TDSNP (this excludes a DBNF-released *transient* peregrine falcon identified in northern Michigan for which habitat assessment was not performed). The biological significance of the differences I observed in habitat associations during *transience* between peregrine falcons released at DBNF and TDSNP is unclear, but could reflect habitat-type imprinting.

Wildlife reintroduction is a largely untapped source for examining ecological theory, improving wildlife techniques, or advancing general principles about the conservation value of landscape connectivity. Several studies have demonstrated that wide-ranging vertebrates will occupy habitat corridors, but as Beier and Noss (1998) pointed out, observational studies can be confounded by numerous effects (e.g., seasonality, reproductive status, human-induced pressures) that weaken inferences derived from observation. I am aware of no other study examining the influence of landscape connectivity on the movements of a wide-ranging vertebrate within a comparative framework. True replication as part of a study that includes demographic responses would enable the strongest inference (Haddad et al. 2000) on the value of conservation strategies that seek to enhance the viability of wildlife populations by facilitating connectivity. Nonetheless, results of this study provide empirical support

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for the concept of landscape connectivity as a component of efforts to conserve wide-ranging vertebrates.

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Table 4.1. Timing of dispersal (days) in peregrine falcons reintroduced in cliff habitat in Kentucky, 2001-2003.

	DBNF[a]				TDSNP[b]				All[c]			
Stage	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max
Fledging[d]												
Males	7.29	3.50	3	14	6.33	1.15	5	7	7.15	3.25	3	14
Females	7.45	3.80	2	14	4.50	4.95	1	8	7.0	3.92	1	14
Both sexes	7.36	3.55	2	14	5.60	2.79	1	8	7.09	3.47	1	14
Foray[d]												
Males	8.0	10.39	0	27	24.67	2.52	22	25	10.94	11.46	0	27
Females	12.33	9.75	0	27	24.0	4.24	21	27	14.45	10.0	0	27
Both sexes	9.70	10.75	0	27	24.4	2.79	21	27	12.32	10.86	0	27
Total[d]												
Males	14.53	12.78	3	39(2)	32.0	2.65	30	35	17.15	13.39	3	39(2)

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Table 4.1 (continued)

Females	18.36	11.45	3	35	29.5	0.71	29	30	20.07	11.23	3	35
Both sexes	16.04	12.21	3	39(2)	31.0	3.35	29	35	18.30	12.49	3	39(2)

[a] Daniel Boone National Forest (n=23).

[b] Tom Dorman State Nature Preserve (n=5).

[c] Calculations combining DBNF and TDSNP peregrine falcons.

[d] See page 57 for a description of dispersal stages.

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Table 4.2. Post-fledging area (ha) occupied by peregrine falcons reintroduced in cliff habitats in Kentucky, 2001-2003.

	DBNF[a]				TDSNP[b]				All[c]			
Stage	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max
Fledging[d]												
Males	82.7	95.9	7.3	276.7	-	-	-	-	82.7	95.9	7.3	276.7
Females	66.1	80.7	2.4	181.6	-	-	-	-	66.1	80.7	2.4	181.6
Both	75.8	87.7	22.4	276.7	-	-	-	-	75.8	87.7	22.4	276.7
Foray[d]												
Males	3280.2	4155.1	26.0	7960.5	905.3	787.0	31.1	1557.3	2092.7	2974.2	26.0	7960.5
Females	2122.4	1596.8	526.4	4643.6	910.3	888.4	282.1	1538.5	1776.1	1476.9	282.1	4643.6
Both	2556.6	2597.9	26.0	7960.5	907.3	712.1	31.1	1557.3	1922.2	2191.6	26.0	7960.5
Total[d]												
Males	3371.4	4161.4	59.7	8042.5	945.9	822.4	31.1	1624.0	2158.6	2993.7	31.1	8042.5

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Table 4.2 (continued)

Females	2206.8	1589.6	526.4	4643.6	910.3	888.4	282.1	1538.5	1836.4	1488.7	282.1	4643.6
Both	2643.5	2599.0	59.7	8042.5	931.7	732.1	31.1	1624.0	1985.1	2206.9	31.1	8042.5

[a] Daniel Boone National Forest (n=16).

[b] Tom Dorman State Nature Preserve (n=5).

[c] Calculations combining DBNF and TDSNP peregrine falcons.

[d] See page 57 for a description of dispersal stages.

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Table 4.3. Mean and maximum distances between movements[a] (km) of peregrine falcons reintroduced in cliff habitat in Kentucky, 2001-2003.

	DBNF[b]				TDSNP[c]				All[d]			
	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max
Mean												
Males	4.5	3.5	0.8	48.2	2.7	2.6	0.3	11.6	3.7	3.1	0.3	48.2
Females	4.9	3.0	0.6	22.8	2.5	0.8	0.3	9.5	4.1	2.9	0.3	22.8
Both	4.7	3.1	0.8	48.2	2.1	1.9	0.3	11.6	3.9	2.8	0.3	48.2
Maximum												
Males	16.3	21.7	1.6	48.2	6.1	5.6	0.5	11.6	11.9	16.6	0.5	48.2
Females	10.6	7.2	3.1	22.8	6.1	4.9	2.6	9.5	9.5	6.7	2.6	22.8
Both	12.9	13.9	1.6	48.2	6.1	4.6	0.5	11.6	10.6	11.9	0.5	48.2

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Table 4.3 (continued)

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[a] Movements external to the viewsheds of Carter (2003).

[b] Daniel Boone National Forest (n=16).

[c] Tom Dorman State Nature Preserve (n=5).

[d] Calculations combining DBNF and TDSNP peregrine falcons.

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Figure 4.1. Kentucky land use patterns illustrating contrasting land use matrices between a release site at Tom Dorman State Nature Preserve (TDSNP) in the Bluegrass physiographic region and a release site at the Red River Gorge Geologic Area, Daniel Boone National Forest (DBNF) in the Cumberland Plateau physiographic region. Dark gray represents developed areas (e.g., Lexington), light gray represents forested areas, black represents open water (e.g., Kentucky River), and white represents mixed agricultural areas.

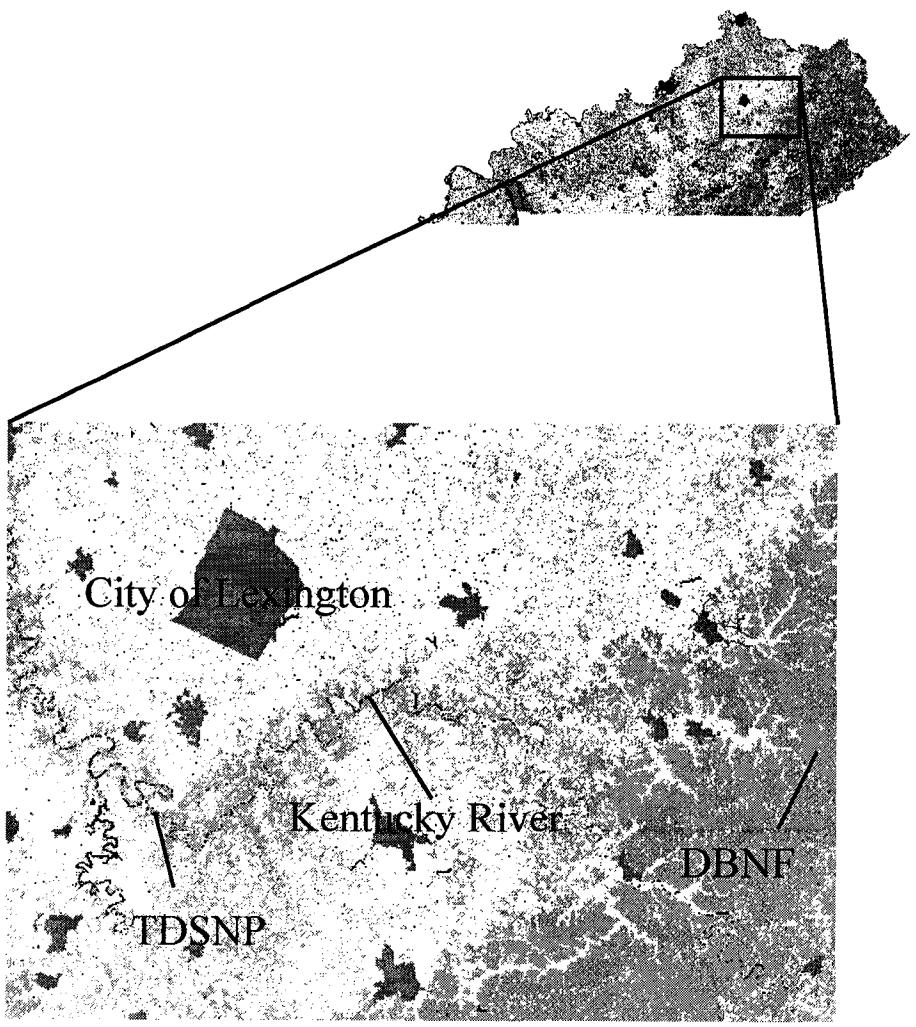

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Figure 4.2. Looking southeastward, aerial views of largely non-forested corridor-like landscape features increasing in spatial extent from the Cumberland Plateau into the Knobs and Bluegrass physiographic regions near the Red River Gorge Geologic Area.

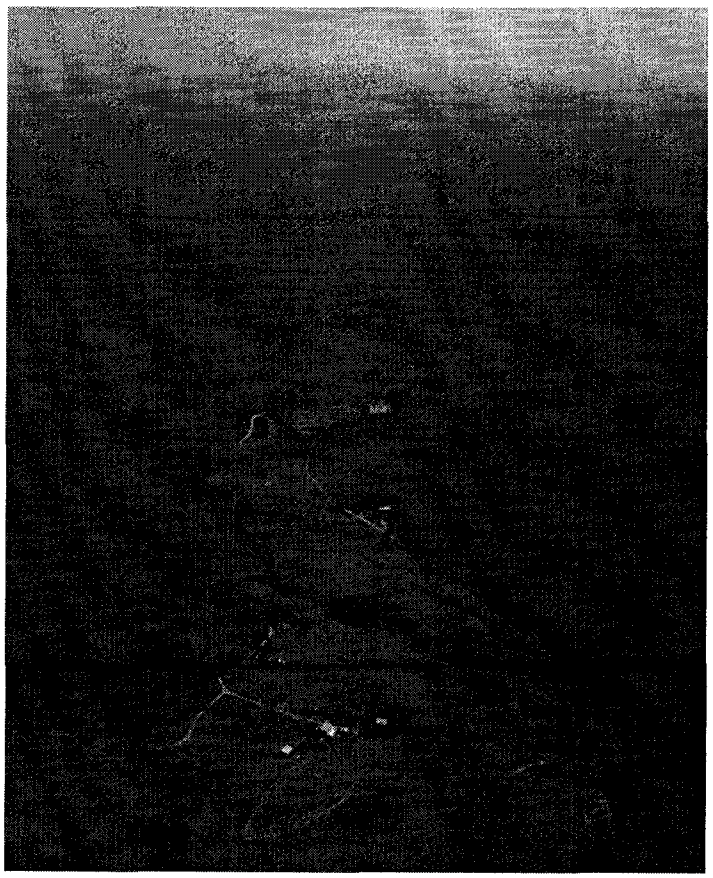

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Figure 4.3. Looking westward (A) and southward (B), aerial views of the largely forested Kentucky River drainage within a mixed agricultural landscape.

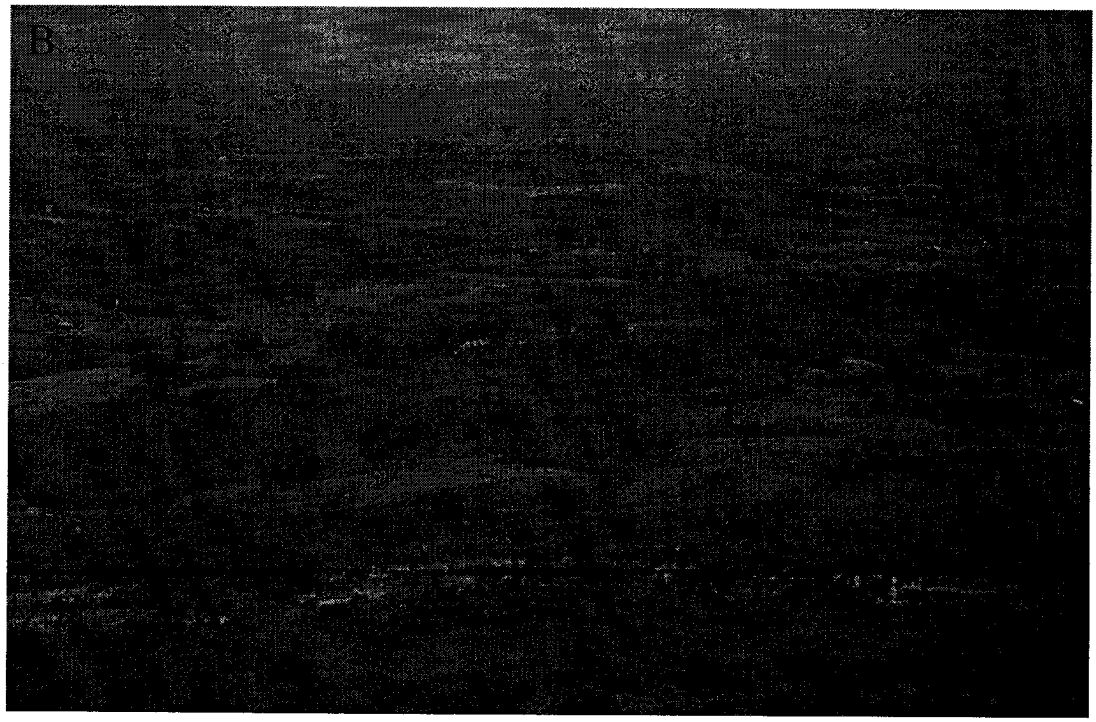

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Figure 4.4. Movements by peregrine falcons released at DBNF during *foray* and *transience* stages of dispersal initiation. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

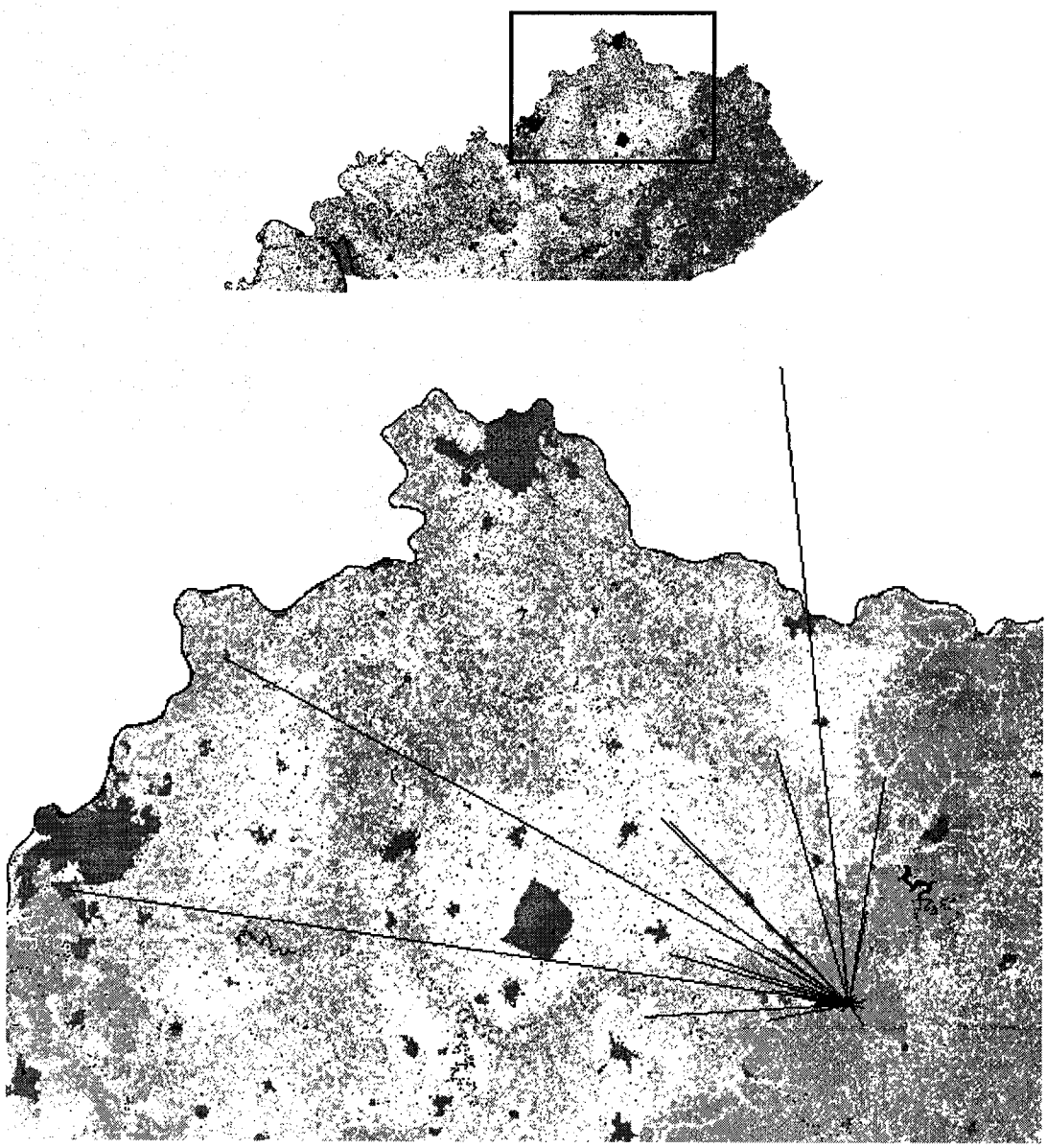

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Figure 4.5. Movements by peregrine falcons released at TDNSP during *foray* and *transience* stages of dispersal initiation. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

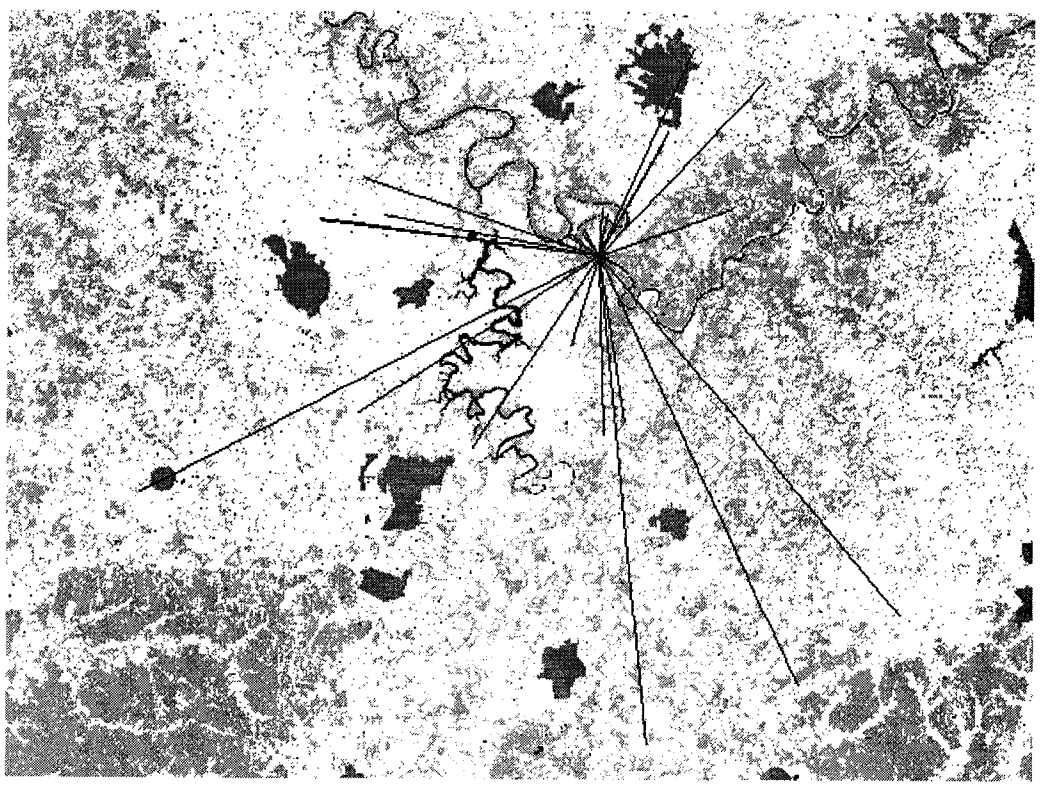

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Figure 4.6. Orientation of movements during the *foray* dispersal stage examining all *foray* locations (A) for peregrine falcons released on Daniel Boone National Forest. Note use of the non-forested valley (B) where Stanton (S), Clay City (CC), and the Mountain Parkway are located. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

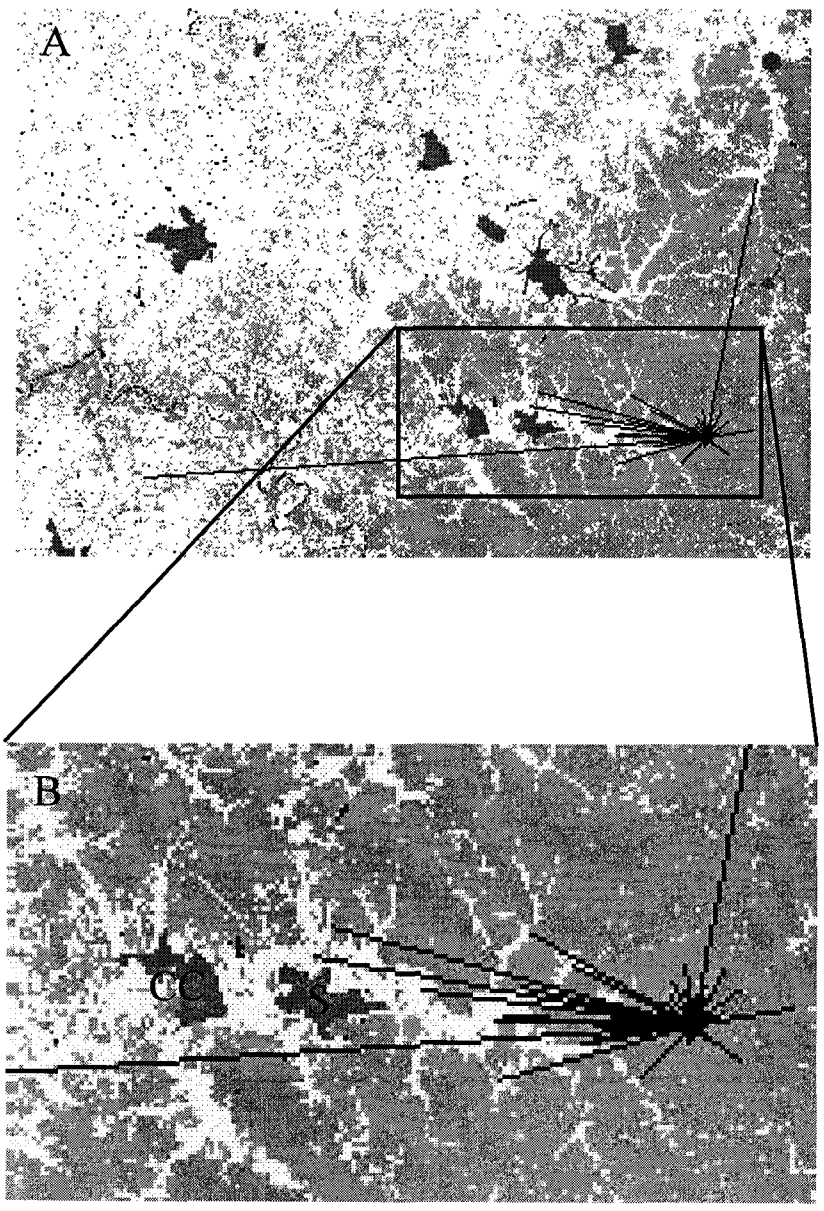

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Figure 4.7. Orientation of movements during the *foray* dispersal stage examining all *foray* locations (A) for peregrine falcons released at Tom Dorman State Nature Preserve. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

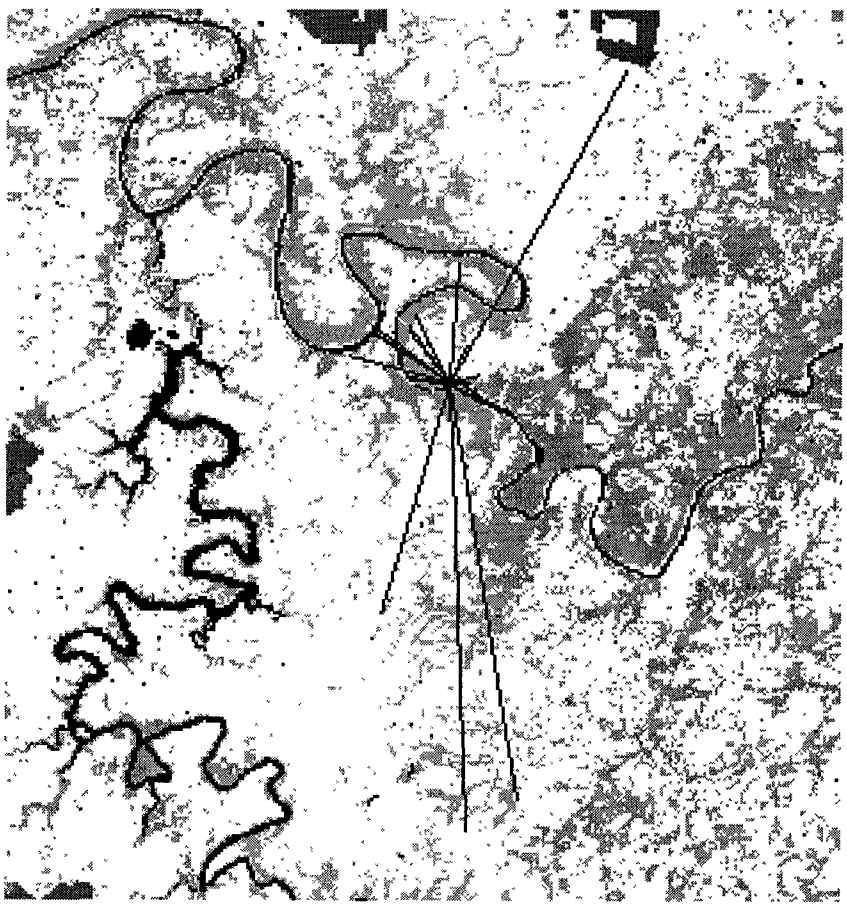

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Figure 4.8a. Buffers (0.36 km) around location estimates corresponding to *transient* peregrine falcons initiating their dispersal from DBNF. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

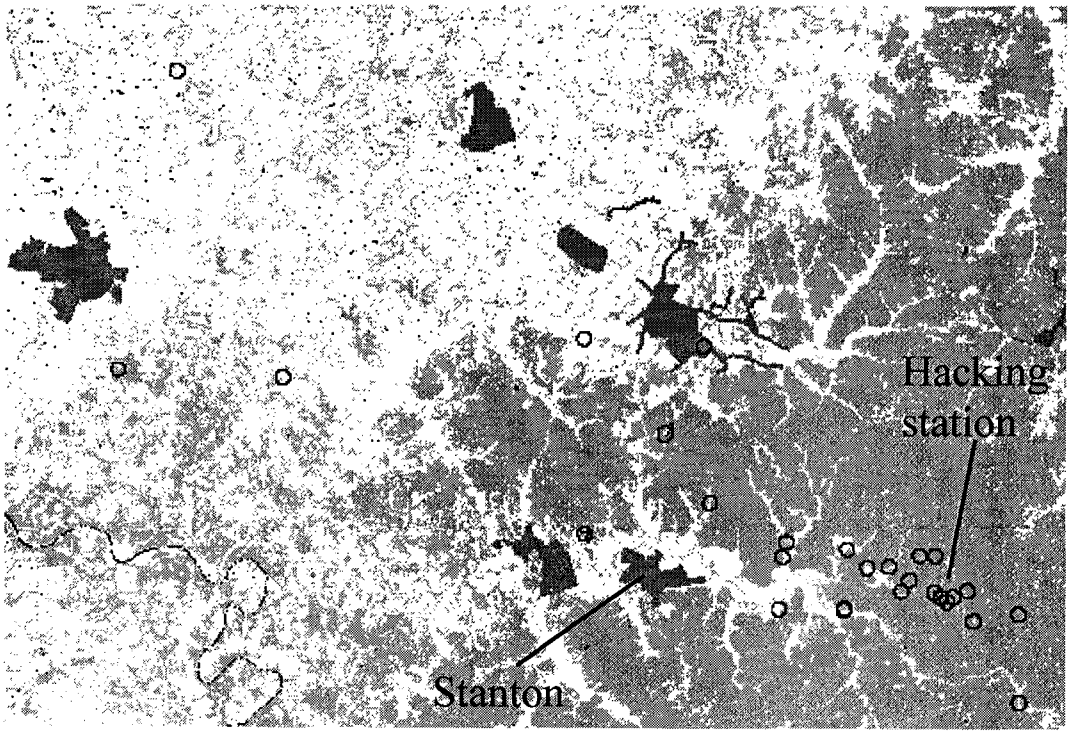

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Figure 4.8b. Buffers (0.36 km) around location estimates (arrows) corresponding to *transient* peregrine falcons initiating their dispersal from DBNF. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

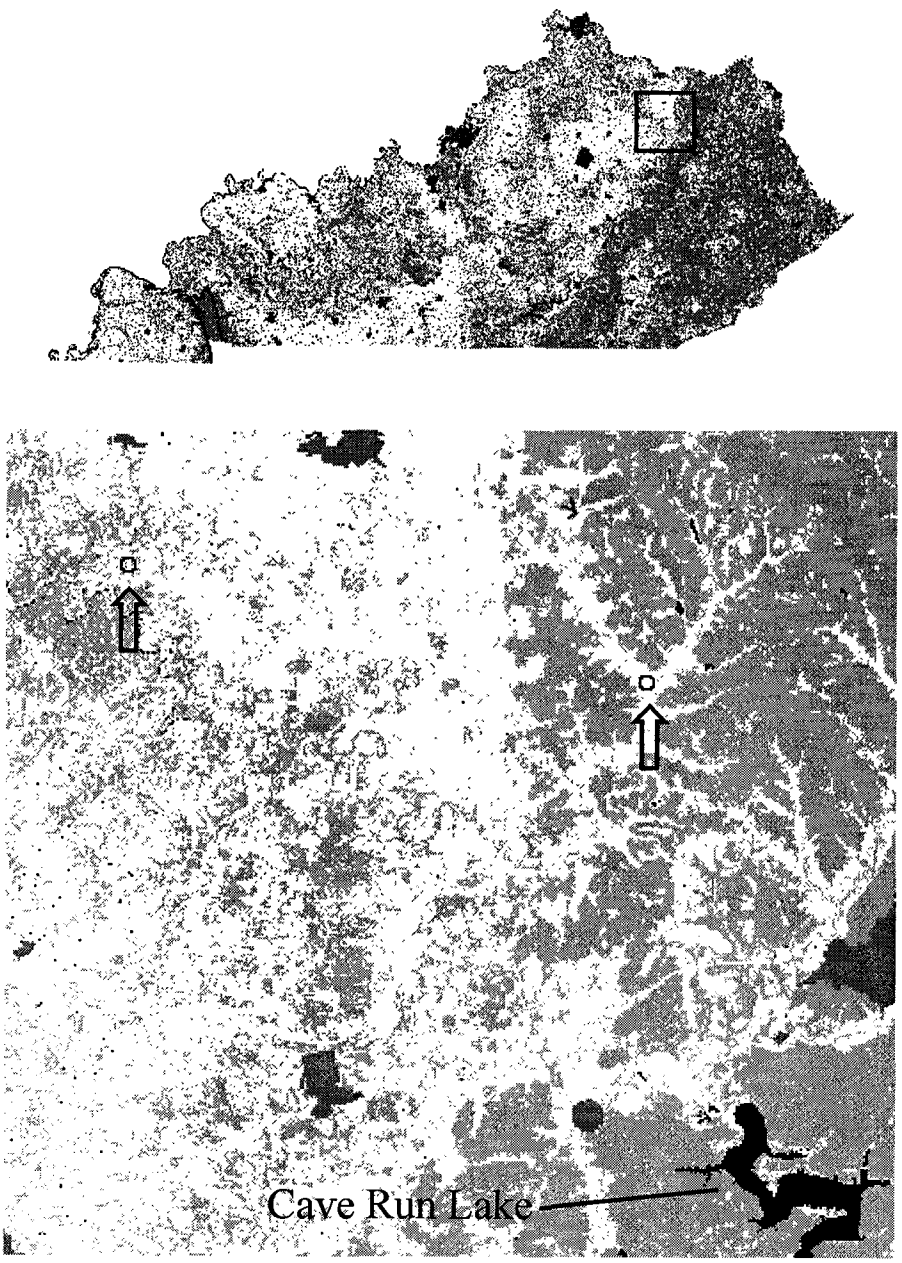

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Figure 4.8c. Buffers (0.36 km) around location estimates (arrow) corresponding to *transient* peregrine falcons initiating their dispersal from DBNF. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.

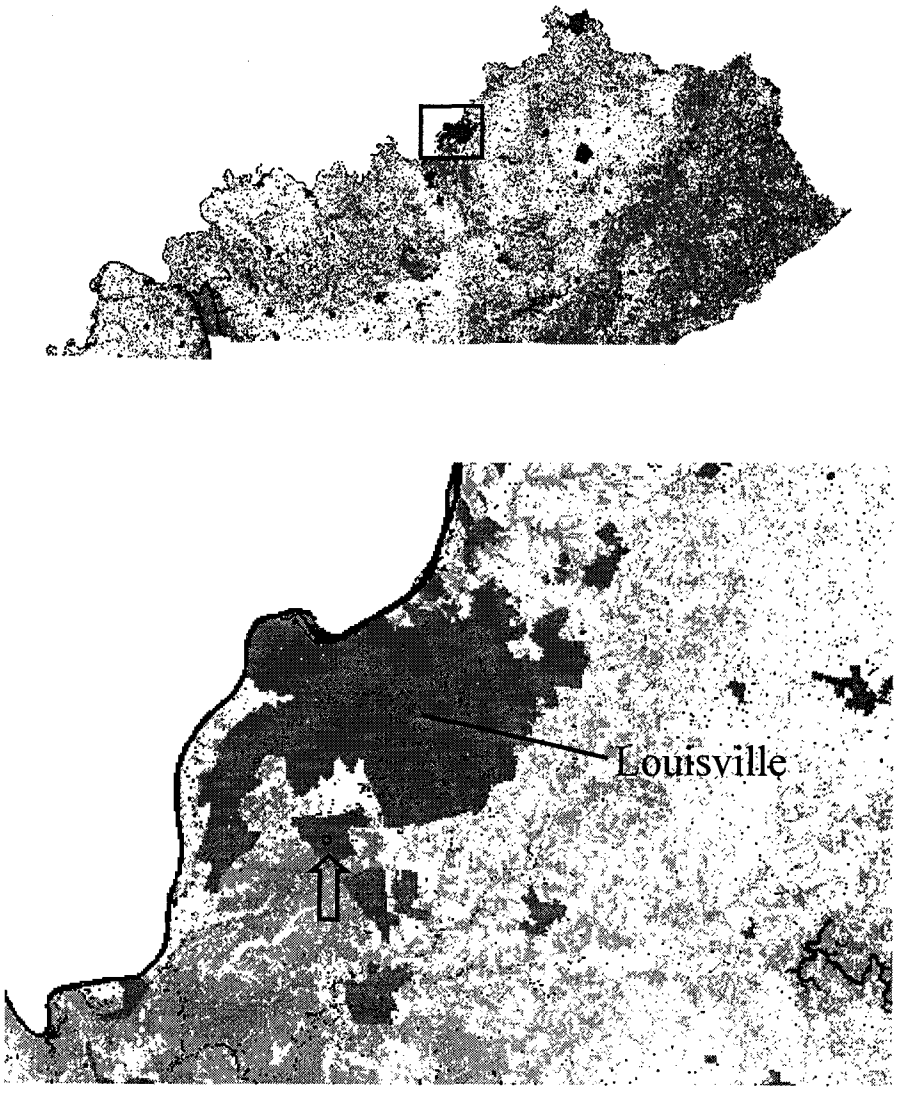

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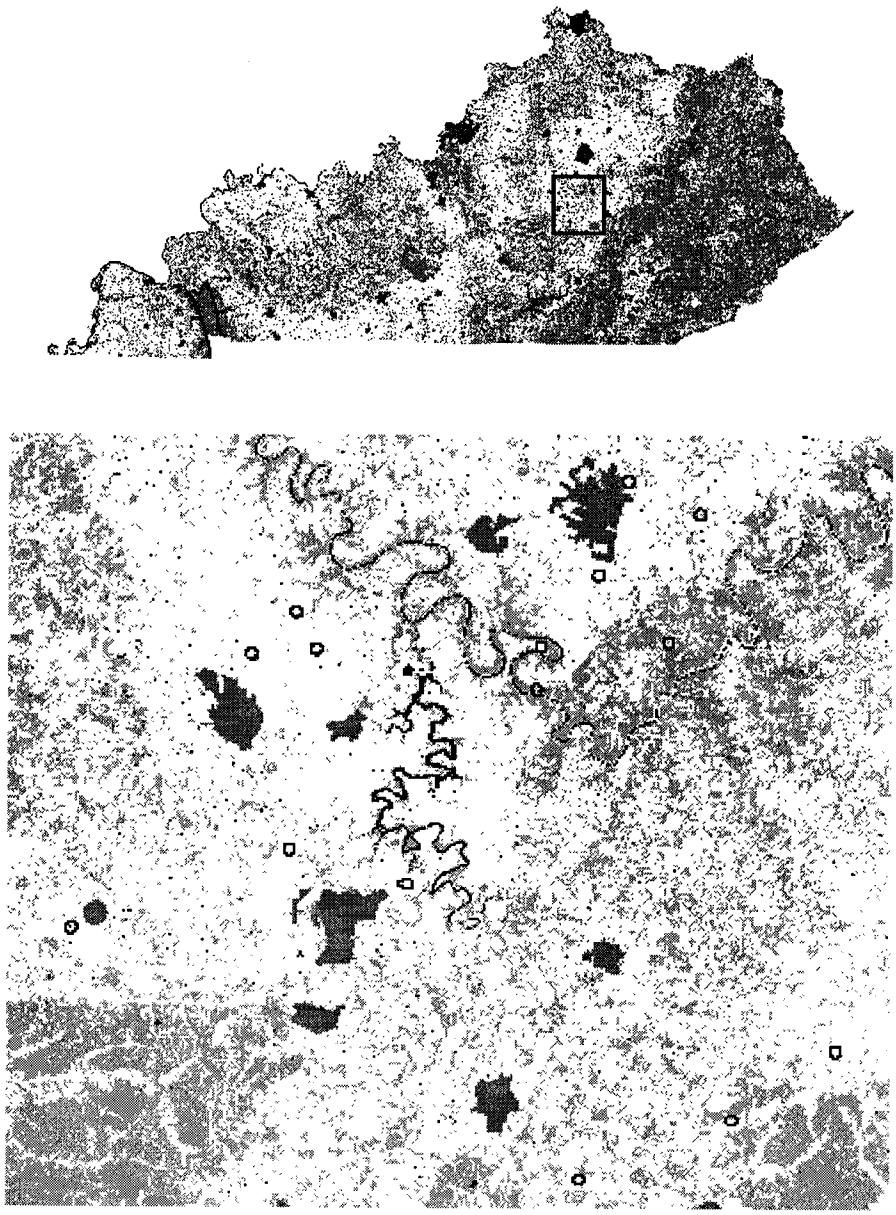
Figure 4.9. Buffers (0.36 km) around location estimates corresponding to *transient* peregrine falcons initiating their dispersal from TDSNP. Dark gray represents developed areas, light gray represents forested areas, black represents open water, and white represents mixed agricultural areas.



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Chapter Five

Demographic and procedural influences on hacking success and post-fledging survival in reintroduced peregrine falcons

Synopsis

Peregrine falcon (*Falco peregrinus*) populations have recovered throughout much of their historic distribution; however, recovery in historic breeding locations such as cliffs and low elevation forests in the southeastern United States has been limited. As part of a program to augment the recovery of peregrine falcons in historic southeastern habitats, I reintroduced 33 peregrine falcons in cliff habitats in Kentucky. I examined how variation in demographic and procedural elements of reintroduction protocol affected the fates of reintroduced peregrine falcons. Also, I monitored survival during the 6-week post-fledging period. Compared to peregrine falcons that dispersed normally, individuals that died before dispersal or dispersed prematurely tended to be male, older at release, released later in the summer hacking season, and released onto a post-fledging area (PFA) that was occupied by a greater number of peregrine falcons released previously in the season. An alternate-day feeding regimen in which twice the quantity of food was provided during a feeding event was associated with a lower frequency of premature dispersal or pre-dispersal mortality than daily food provision. Overall program survival was 0.55 and 0.85 (95% CI: 0.38-0.72 and 0.73-0.97) for worst case and best case estimates, respectively. Risk of mortality decreased after the second week of the post-fledging period ($\chi^2 = 6.59$, df=1, $P = 0.01$). These results provide useful information in efforts to identify and evaluate the causes of program outcome and for future hacking programs, but these data should

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be interpreted with caution because the extent to which they demonstrated discrimination among fate classes was rendered questionable due to inherent variability among peregrine falcons (Cohen's Kappa ± SE = 0.45 ± 0.13; 95% CI: 0.19-0.71; $P = 0.57$) and low sample size (n=28-33). Biologists may be able to improve hacking success by avoiding release of raptors that are at the upper end of the range for recommended release age, by releasing raptors earlier in the season (for summer programs), by avoiding sex ratios that are heavily male-biased, and by reducing disturbance or habituation associated with food provision by providing food on alternate days during the post-fledging period. The observed trends notwithstanding, robust suggestions for improving demographic and procedural elements in hacking protocol were not apparent based on our data. All else being equal, I suspect that the fate of reintroduced raptors also is associated to a considerable extent with local and regional habitat attributes (see Chapter 4).

Introduction

Peregrine falcons have reoccupied breeding locations throughout much of their historic distribution (Hickey 1942, Corser et al. 1999, Tordoff et al. 2002). However, in portions of the mid-Atlantic and southeastern United States, reoccupancy of historic breeding locations such as cliffs and low-elevation forests (Ganier 1931, Jones 1946) has been limited. For example, 123 historic breeding locations are documented in cliff and forest habitats throughout the region encompassed by Pennsylvania, Maryland, West Virginia, Kentucky, Virginia, and Tennessee, but only three breeding locations in historic habitat occur in this region (Table 3.1). These include cliff eyries in Pennsylvania, West Virginia, and Tennessee. As part of an effort to augment *anatum*

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peregrine falcon metapopulations in historic habitats in the southeastern U.S., we initiated a program to reintroduce peregrine falcons among cliff habitats in Kentucky.

Research in wildlife reintroduction during the past two decades has identified a suite of factors thought to influence reintroduction success (Griffith et al. 1989, Kleiman 1989, Phillips 1991, Kleiman et al. 1994, Cade 2000). These concepts have provided the basis for development and application of widely accepted general reintroduction guidelines (IUCN 1995). Yet, apparently most wildlife reintroductions have been judged as being either unsuccessful or of uncertain outcome, and trends in success have changed little over the past 20 years (Fischer and Lindenmayer 2000). Retrospective review of published literature on wildlife reintroduction has been the primary source of insight into factors associated with program success. Unfortunately, there are biases in the type of results published – positive outcomes likely are reported more frequently than negative outcomes. Further, summarizing outcomes and their correlates provides little information on specific causes of program outcome. These data generally are not available because the use of experimental procedures in wildlife reintroduction is uncommon (Armstrong et al. 1994). The most meaningful way to improve success and enhance reintroduction as a conservation tool in the long term is to incorporate controlled manipulation in reintroduction program design. The challenge is to generate data enabling assessment of the causes of program outcome, while not compromising the conservation objectives of the program (i.e., population reestablishment).

Hacking is an effective and well-established technique in the restoration of several raptor species including peregrine falcons (Sherrod et al. 1982). General

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hacking protocols include housing juveniles at a site chosen for release in large hack boxes, then releasing them at an age coinciding with their ability to fledge and sustain flight. Generally, food (Coturnix quail [*Coturnix coturnix*] carcasses) is provided to peregrine falcons by biologists daily during pre- and post-fledging periods. In 2003, researchers with the American Ornithologists Union (AOU) initiated efforts to review scientific bases of avian captive breeding and release protocols. Hacking as a raptor restoration tool falls within the purview of this initiative. In addition to promoting a better understanding of the causes of reintroduction program outcome, research on hacking as part of my efforts to reintroduce peregrine falcons in Kentucky may provide a timely contribution to this AOU initiative (J. Walters, Virginia Tech, personal commun.). In this study, I evaluated demographic and procedural influences on hacking success by evaluating inherent variation and incorporating controlled manipulation in hacking protocol. I examined existing variation and I imposed variation on sex ratio, release age, release cohort size, release date, post-fledging feeding regimen, occurrence of recently released peregrine falcons on the PFA, sex ratio of release cohorts, and subspecies used. I evaluated this variation in terms of three fate classifications: normal dispersal, premature dispersal, and pre-dispersal mortality. Additionally, I estimated the survival of reintroduced peregrine falcons and I included description of causes and characteristics of mortality and morbidity.

Methods and materials

Hacking

I followed and evaluated variation in hacking protocols outlined in Sherrod et al. (1982). During 2001-2003 I obtained either *anatum* or *anatum×tundrius* juvenile

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peregrine falcons from falcon propagators in the upper Midwest. Pre-release veterinary evaluation and health certification of all peregrine falcons was coordinated through the University of Minnesota College of Veterinary Medicine Raptor Center. I constructed four plywood hack boxes (152.4 × 96.5 × 121.9 cm). The front pieces were constructed of a 2 × 4 frame, a series of 1.6-cm diameter dowel rods, and an interior lining of 1.25-cm mesh hardware cloth. Food chutes were comprised of three interconnected 304.5-cm segments of thin walled 10.2-cm diameter polyvinyl chloride piping. Food (quail carcasses) was provided daily or on alternate days (at twice the quantity). Hack boxes and other supplies were transported by vehicle, then carried to hack sites on foot, or airlifted to sites. Airlifting was administered and supervised by DBNF personnel. Hack boxes were lowered to cliff ledges 5-10 m below cliff apexes using ropes and pulleys. Once on ledges, hack boxes were positioned on short stilts, leveled, and anchored to the surrounding substrate. Hack boxes were filled to a depth of 10-11cm with a mixture of pea gravel, river rock, and egg rock. Short segments of 15-20-cm diameter logs were placed on the gravel as perches. Large rubber water pans were provided and filled periodically through 2.54-cm diameter tubing that extended through a hole drilled in a lateral surface of the hack box. Like the food chutes, this water chute enabled the remote provision of water. Several 1-cm diameter peepholes were drilled in lateral and posterior surfaces of hack boxes to facilitate remote observation of peregrine falcons before release. Peephole covers, attached near each peephole, enabled opening and closure of peepholes. Hack sites were chosen based on numerous criteria, including habitat attributes, estimated risk of predation, estimated prey base, and logistical considerations (Chapter 3). For a

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detailed description of the study areas and telemetry protocols, readers should consult Chapter 4.

Variation in hacking protocol

Considering only peregrine falcons released at DBNF (n=28), I classified the fate of each reintroduced peregrine falcon as having dispersed normally (n=14), dispersed prematurely (n=9), or died before dispersal (n=5). I excluded TDSNP peregrine falcons (n=5) from this analysis because of differences in habitat between the two sites. Premature dispersal was defined as dispersing within 14 days of release (Sherrod 1983, Powell et al. 2002, Carter 2003). During the program I structured releases to provide some degree of variation in release age, release date, release time, release cohort size, and release cohort sex ratio. I imposed variation in post-fledging feeding regimen by providing food either daily or on alternate days. Also, I evaluated fate in terms of sex, subspecies, and the number of recently released peregrine falcons remaining on the PFA. I performed a non-parametric nearest neighbor discriminant analysis (DA) with fate as the polychotomous dependent variable. This approach did not assume multivariate normality and facilitated evaluation of categorical variables. Before analysis, I examined the dichotomous independent variables sex, subspecies, and feeding regimen to compare differences in the proportions at which they occurred overall in the study with proportions at which they occurred among fate classes. If these proportions were nearly identical for a given categorical variable, I eliminated it from further analysis. I created design variables for remaining categorical variables. I examined continuous data using box and whisker plots that included measures of central tendency and 5th, 25th, 75th, and 95th percentiles. Using these plots, I included

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in DA variables for which the central tendency varied with fate. I calculated a correlation matrix to evaluate multicollinearity. I eliminated variables involved in high pairwise correlations (e.g., Pearson's Correlation Coefficients $r \geq 0.7$). For each observation the nearest neighbor DA calculates Mahalanobis distances (D^2) between pairs of observation vectors and assigns the observation to the group for which D^2 is smallest. For the analysis, I specified the number of nearest neighbors (i.e., the smallest D^2's upon which assignment to groups is based) as three. Using a cross-validation procedure, I determined the fate category to which observations would be assigned based on the data. I judged the magnitude of the correct classification rate relative to the proportion of correct classifications that would be expected if group assignments had been made randomly. I assessed improvement in classification accuracy over that expected by random assignment using Cohen's Kappa Statistic (κ; Cohen 1960, Titus et al. 1984). Kappa varies from 0 to 1 indicating no improvement over chance to perfect assignment, respectively. Values between 0 and 1 indicate the percent improvement in classification accuracy associated with the discriminating variables compared to chance assignment. All analyses were performed using SAS® (SAS Institute, Cary, NC 27513) and results were considered significant if $P \leq 0.05$.

Survival

I used the Kaplan-Meier product-limit method to estimate post-fledging survival (Kaplan and Meier 1958, Pollock et al. 1989). Using data on all peregrine falcons released during the program (n=33), I considered the time of origin to be the date of release and I examined survival for six weeks post-release. I estimated survival functions for what I considered best case, intermediate case, and worst case

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scenarios. Best case survival functions included only known mortalities. Intermediate functions included known mortalities and censorship of individuals dispersing within 14 days of release. Worst case functions considered individuals dispersing within 14 days of release to be mortalities in addition to known mortalities. I used the Tarone-Ware log-rank test to assess differences in survival between sexes (Cox and Oakes 1984). Sample size was too low to reliably assess and compare survival among years (n=10-12) or between sites (n=28 and n=5). I examined whether risk of mortality varied during the post-fledging period by converting Kaplan–Meier survival functions to a cumulative hazard function (Todd et al. 2003). I delineated intervals of constant slope based on visual examination of the cumulative hazard function and I tested for differences between intervals using the log-rank chi-squared statistic.

Mortality and morbidity

I located peregrine falcons ≥ 1 time per day until dispersal and subsequent movement beyond the range of aerial telemetry, or until mortality. I attempted to recover transmitters in mortality mode as soon as possible. Deceased peregrine falcons or peregrine falcons recovered in poor health were examined by participating veterinarians, raptor rehabilitators, or wildlife professionals to determine causes of mortality or morbidity.

Results

Variation in hacking protocols

Based on data plots (Appendix G) I eliminated the continuous variables release time, release cohort size, and release cohort sex ratio because variation in central tendencies for these variables was minimal among fate classes. I eliminated the

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categorical variable subspecies; we released 20 *anatum* and eight *anatum×tundrius* peregrine falcons at DBNF. The *anatum*:*anatum×tundrius* ratio of peregrine falcons that dispersed normally, dispersed prematurely, or died before dispersal was 9:5, 7:2, and 4:1. Among the remaining variables (release age, release date, the number of recently released peregrine falcons remaining on the PFA, sex, and feeding regimen), Pearson's Correlation Coefficient was < 0.7 (0.02-0.68) indicating a reasonable degree of singularity among variables. Only the variables release date and number of recently released peregrine falcons on the PFA exhibited moderate correlation ($r = 0.68$); however, I retained both variables for DA. The DA resulted in 10 of 28 peregrine falcons being misclassified in fate. Among misclassifications, six of 14 peregrine falcons that dispersed normally were classified as either dead (n=3) or having dispersed prematurely (n=3). Three of five pre-dispersal mortalities were classified correctly; the incorrect classifications were into premature dispersal (n=1) and pre-dispersal mortality (n=1). Seven of nine premature dispersals were classified correctly; the incorrect classifications were into normal dispersal (n=1) and pre-dispersal mortality (n=1; Table 5.1). Cohen's Kappa statistic ± SE was 0.45 ± 0.13 (95% CI: 0.19-0.71, df=3, $P = 0.57$). Examination of continuous variables indicated that peregrine falcons that dispersed prematurely or died before dispersal tended to be older at release, released later in the summer hacking season, and released among a greater number of recently released peregrine falcons occupying the PFA compared to peregrine falcons that dispersed normally (Table 5.2; Appendix G). Seventeen males and 11 females were released at DBNF. The male:female ratio of peregrine falcons that dispersed normally, dispersed prematurely, or died before dispersal was 7:7, 7:2,

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and 3:2. Twenty-two peregrine falcons were provided food daily whereas six peregrine falcons were provided food on alternate days. The daily feeding:alternate day feeding ratio of peregrine falcons that dispersed normally, dispersed prematurely, or died before dispersal was 9:5, 7:2, and 5:0. Thus, for categorical variables, males tended to disperse prematurely at a higher frequency than females, and an alternate-day feeding regimen was associated with a low frequency of pre-dispersal mortality.

Survival

In all, I released 33 peregrine falcons. Among these, 12 were released in 2001, 10 in 2002, and 11 in 2003. I released 28 peregrine falcons at DBNF and five at TDSNP. I recorded six confirmed mortalities during the program; five mortalities occurred pre-dispersal and one occurred after premature dispersal. In addition to these six mortalities, eight peregrine falcons dispersed from the PFA prematurely (e.g., spent > 14 days on the pfa) for a total of nine premature dispersals. I found no difference in survival functions between sexes ($\chi^2 = 0.54$, df=1, $P = 0.46$). Overall post-fledging survival for the program was 0.55, 0.81, and 0.85 for worst case, intermediate case, and best case scenarios, respectively (95% CI: 0.38-0.72, 0.65-0.97, and 0.73-0.97, respectively; Table 5.3, Figures 5.1a, 5.1b, and 5.1c). Risk of mortality was not constant throughout the post-fledging period. Based on the cumulative hazard function, I identified two intervals that described different daily risks of mortality ($\chi^2 = 6.59$, df=1, $P = 0.01$). The first phase included the first 14 days after release and was associated with the greatest daily mortality risk. The second phase included time spent on the PFA beyond 14 days post release (Figure 5.2). All confirmed mortalities

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occurred during the first phase (within 13 days of release) and no mortality occurred during the second phase.

Mortality and morbidity

Among the five pre-dispersal mortalities, I was able to speculate reasonably on the cause of death for only one peregrine falcon. I suspect that a bobcat (*Lynx rufus*) killed this peregrine falcon while roosting. Cause of death of the other four peregrine falcons was unknown; however, I suspect mammalian predation. I recovered one peregrine falcon that died after dispersing prematurely. A wildlife conservation officer for KDFWR recovered this peregrine falcon two days after release and approximately 165 km from the hacking station. The cause of death was dehydration and hypoglycemia leading to starvation.

I recovered two peregrine falcons alive after dispersing normally. One male peregrine falcon, released at DBNF in July 2002, was recovered after having been shot near Louisville, Kentucky in October 2002 (Appendix H). The other peregrine falcon, a male released at DBNF in June 2003, was recovered in a weakened condition near Cheboygan, Michigan in July 2003 (Appendix H). I removed one male peregrine falcon from the hacking station before scheduled release. This peregrine falcon exhibited signs of clinical illness and was transported to a veterinarian immediately after removal from the station (Appendix H).

Discussion

Controlled manipulation as part of program design in wildlife reintroduction is the best way to gain insight into causes of program outcome. In the long term, a better understanding of these causes will advance development of widely accepted criteria by

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which reintroduction success should be judged (Fischer and Lindenmayer 2000), and will likely improve trends in overall success (Armstrong et al. 1994). Ethical or practical constraints associated with conservation objectives of wildlife reintroduction can render experimentation difficult. In raptor restoration, releasing individuals too soon or retaining them in the hack box too long would be unethical and, ultimately, could compromise population reestablishment. Similarly, wildlife reintroduction often is replete with circumstances that can affect program design. In this study, the presence of predators (e.g., *Procyon lotor*, *Lynx rufus*) delayed release of several peregrine falcons beyond an age at which we would consider ideal in terms of ethical and practical considerations (Sherrod et al. 1982). In other instances, timing of release was affected by public relations events in a manner that reduced variability. In wildlife reintroductions, ethical treatment of the animals should be the foremost consideration. Under no circumstance should experimentation compromise this consideration. In this study, my goal was to achieve a balance between existing variability, controlled manipulation, ethical considerations, and program success. I was not always successful, as unexpected circumstances resulted in the release of several individuals that were too old. In the future, I recommend that controlled manipulation be implemented more conservatively to provide a buffer in the likely event of unforeseen circumstances.

Pre-dispersal mortality was infrequent in this study, but there was a relatively high rate of premature dispersal at DBNF. In the U.S., hacking success, or the proportion of hacked peregrine falcons that dispersed normally, ranged from 0.67-0.80 (Lanier et al. 1983, McCarthy et al. 1986, Henry 1987, Craig et al. 1988, Therres et al.

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1993, Powell et al. 2002). These estimates should be scrutinized because in several cases they represent absolute survival-to-dispersal estimates that do not differentiate between normal and premature dispersal. Also, hacking success varies considerably based on the type of site. Barclay and Cade (1983) reported hacking success of 0.79, 0.83, and 0.63 for peregrine falcons hacked at tower sites, urban sites, and cliff sites, respectively. Hacking success during this study was 0.58; 19 of 33 peregrine falcons dispersed normally, 9 dispersed prematurely, and 5 died before dispersal. This was similar to the hacking success reported by Barclay and Cade (1983) at other cliff sites in the eastern U.S. Had I not distinguished between normal and premature dispersal, hacking success would be reported at 0.85. In my view, this latter figure poorly represents the actual contribution my efforts made to peregrine falcon recovery. In this study, general trends in demographic and procedural influences on hacking success were apparent. Examining these trends may provide useful information in efforts to identify and evaluate the causes of program outcome and for future hacking programs. These data should be interpreted with caution, however, because the extent to which they demonstrated discrimination among fate classes was rendered questionable largely due to high variability (i.e., wide confidence intervals associated with Cohen's kappa statistic) and low sample size.

Peregrine falcons that died before dispersal tended to be older at release, with males dispersing prematurely at a relatively high frequency compared to females. Sherrod (1983) reported typical release ages of 39-51 days. Sherrod et al. (1982) noted that peregrine falcons exceeding 51 days of age were more likely to disperse prematurely. It is unclear why older hacked juvenile peregrine falcons tend to

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abandon the PFA. It has been suggested that they simply are more capable flyers than younger juveniles (Sherrod et al. 1982), but I suspect this response may be associated with prolonged confinement coupled with an innate tendency to fledge. Sherrod (1983) observed that hacked males consistently dispersed before females, and that males occurred among premature dispersers more frequently than females. This trend likely reflects observations that males develop at a faster rate than females during the pre-fledging stage (Sherrod et al. 1982, Sherrod 1983, Weaver and Cade 1991, Cade et al. 1996). In this study, most release cohorts were comprised of both sexes so in hindsight it may seem intuitive that males may be more prone to premature dispersal if females required more time to develop. Potential solutions would be to house males and females separately at the hack site or place only the youngest males in hack boxes with females. However, as Sherrod et al. (1982) cautioned, the larger more aggressive females may 'bully' the smaller younger males. A reasonable means of addressing this situation would be to construct and install multiple hack boxes at each site to facilitate the most appropriate sex and age composition of cohorts.

An alternate-day post-fledging feeding regimen appeared to be a preferred alternative to daily feeding. Sherrod et al. (1982) provided hacked peregrine falcons with food on a daily basis during the first five weeks after release and they switched to alternate days during the sixth and final week of food provisioning. In this study, feeding peregrine falcons on alternate days reduced disturbance to individuals that frequently perched near the hacking station (Carter 2003). Also, it seemed the alternate day regimen reduced habituation or the perception of humans as a food source. To some extent nearly all hacked raptors will associate food with the presence

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of humans at the hacking station. If an alternate day regimen reduced this perception, dispersing peregrine falcons may avoid humans and thus human-caused injury more effectively.

Pre-dispersal mortality was associated with a greater number of recently released peregrine falcons occupying the PFA at the time of release, and with being released later in the summer. Although later release dates and occupation of the PFA by recently released peregrine falcons were modestly correlated, neither of these trends has been reported in previous restoration efforts. In wild-produced raptors, later hatch dates generally are associated with a reduction in the length of the post-fledging period (Donázar and Ceballos 1990, Ferrer 1992), but I am unaware of any study demonstrating an association between pre-dispersal mortality and timing of the post-fledging period. Even if the effects of release date were masked to some extent by the presence of recently released peregrine falcons on the PFA, associations with pre-dispersal mortality remain unclear. Generally, it is thought that the presence of recently released peregrine falcons on the PFA stimulates newly released individuals to remain on the area as well. This type of conspecific attraction is well documented in peregrine falcons (Ratcliffe 1993). In cliff habitat in Kentucky, we achieved better success on initial releases when the PFA was vacant.

Worst case estimated survival during the post-fledging period in this study was 0.55; considerably lower than values of 0.81 and 0.89 reported by Burnham et al. (1988) and Powell et al. (2002). Pre-dispersal mortality was infrequent, so this survival estimate largely reflects the relatively high rate of premature dispersal. All peregrine falcons that dispersed prematurely in this study were released at DBNF; no

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peregrine falcons released at TDSNP dispersed prematurely or died before dispersal. Procedural influences on hacking success provide some insight into this observation, as peregrine falcons released at TDSNP generally were at the lower end of the recommended range of release age, were provided food on alternate days, were release onto a PFA vacant of conspecifics, and were released relatively early in the summer season. Nonetheless, perhaps the most remarkable programmatical differences between DBNF and TDSNP was habitat. In Chapter 3, I characterized DBNF as being heavily forested with a high abundance of suitable nesting habitat and a low estimated risk of predation, but a less-than-optimal estimated prey base. I characterized TDSNP as mixed agricultural and forested with a high abundance of suitable nesting habitat, a high estimated risk of predation, and an excellent estimated prey base. Chapter 4 provides a more comprehensive discussion on potential habitat influences on program outcome.

Five peregrine falcons died before dispersal, all at DBNF. I was able to speculate reasonably on cause of death for only one of these peregrine falcons. I located the partially-consumed carcass of this peregrine falcon shortly after observing a bobcat feeding on quail carcasses at the hacking station. This peregrine falcon frequently roosted overnight on conspicuous and easily accessible rock outcrops, often remaining inactive (asleep?) in a laterally recumbent position until arising in the morning. The partially consumed carcass was characteristic of mammalian predation as opposed to avian predation. It was located in a dense rhododendron (*Rhododendron* sp.) thicket with primary feathers scattered in proximity to the carcass, no indication of plucking of secondary or downy feathers, and nearly complete

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consumption except for sacral and tarsal regions. Cause of death of the other four peregrine falcons is unknown. Despite considerable ground reconnaissance and rock climbing, I was unable to recover the remaining carcasses. This portion of the DBNF (Red River Gorge Geologic Area and adjacent Clifty Wilderness) is exceedingly difficult to traverse on foot, particularly on slopes below cliff bases. Telemetry suggested that unrecovered peregrine falcon carcasses had been removed to crevasses and caves above cliff bases. I suspect that these mortalities also were the result of mammalian predation. In addition to the bobcat observed near the hacking station, I observed raccoons (*Procyon lotor*), gray fox (*Urocyon cinereoargenteus*), and tracks of a skunk (likely *Mephitis mephitis*) and long-tailed weasel (*Mustela frenata*); each of these species are capable of successfully capturing juvenile peregrine falcons.

Results of this study are probably insufficient to offer robust suggestions for improving demographic and procedural elements in raptor hacking. Biologists considering peregrine falcon reintroduction in the future may be able to improve hacking success, however, by examining these results together with results of the demographic model presented in chapter 2. For example, the demographic model demonstrated that a large founder cohort is desirable. This study suggested that hacking success could be improved by releasing raptors earlier in the season (for summer programs), and by avoiding sex ratios that are heavily male-biased. If a large founder cohort were attainable, perhaps extending the duration of the release phase would better enable the avoidance of late summer releases. Also, releasing an even sex ratio overall yet skewing the ratio towards males early in the program could promote

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pair bonding if males released early in the program exhibit philopatry and interact with the later-released females.

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Table 5.1. Classification rates among peregrine falcons that dispersed normally, dispersed prematurely, or died before dispersal (n=14, n=9, and n=5, respectively), based on nearest neighbor non-parametric discriminant analysis.

Classified from	Dispersed normally	Dispersed prematurely	Pre-dispersal mortality	Totals
Dispersed normally	8 (57.1)	3 (21.4)	3 (21.4)	14 (100.0)
Dispersed prematurely	1 (11.1)	7 (77.8)	1 (11.1)	9 (100.0)
Pre-dispersal mortality	1 (20.0)	1 (20.0)	3 (60.0)	5 (100.0)
Totals	10 (35.7)	11 (39.3)	7 (25.0)	28 (100.0)
Prior proportions	(50.0)	(32.1)	(17.9)	-

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Table 5.2. Variation in reintroduction protocol treated as continuous variables in discriminant analysis.

	Normal Dispersal (n=14)				Premature Dispersal (n=9)				Pre-dispersal Mortality (n=5)			
	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max
Release age (days)	46.2	2.4	43	50	46.6	4.5	43	54	49.8	3.2	46	54
Release cohort size	4.8	2.5	2	8	4.8	1.9	3	8	4.6	1.9	3	8
Release date[a]	6/27	12.7	6/14	7/25	6/30	13.6	6/20	7/25	7/2	11.1	6/18	7/13
Release time (h)[a]	1141	1.4	0930	1330	1048	1.4	0900	1220	1052	1.3	0900	1220
Release cohort sex ratio[b]	0.71	0.43	0.25	1.0	0.53	0.19	0.25	0.75	0.66	0.10	0.50	0.75
Number of juveniles occupying PFA[c]	0.57	0.76	0	2	1.2	1.3	0	3	1.4	1.5	0	3

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Table 5.2 (continued)

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[a] Data were converted to a circular distribution for analysis. SD for release date and release time is days and hours, respectively.

[b] Data represent the proportion of each release cohort comprised of males.

[c] The number of peregrine falcons released previously in the season at that site that occupy the PFA upon release.

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Table 5.3. Survival $\hat{S}[t]$ of reintroduced peregrine falcons during a 6-week post-fledging period in Kentucky, 2001-2003.

					Worst case[a]		With censoring[a]		Best case[a]	
Year	Week (t)	N	Deaths	Censored	$\hat{S}$ [t]	95% CI	$\hat{S}$ [t]	95% CI	$\hat{S}$ [t]	95% CI
2001	1	12	2	4	0.50	0.30-0.70	0.83	0.64-1.03	0.83	0.45-1.22
	2		1	0	0.42	0.16-0.67	0.69	0.39-1.00	0.75	0.52-0.98
	3		0	0	0.42	0.14-0.70	0.69	0.36-1.03	0.75	0.51-1.00
	4		0	0	0.42	0.14-0.70	0.69	0.36-1.03	0.75	0.51-1.00
	5		0	0	0.42	0.14-0.70	0.69	0.36-1.03	0.75	0.51-1.00
	6		0	0	0.42	0.14-0.70	0.69	0.36-1.03	0.75	0.51-1.00
2002	1	10	0	3	0.70	0.46-0.94	1.00	-	1.00	-
	2		2	0	0.50	0.24-0.76	0.71	0.43-1.00	0.80	0.56-1.02
	3		0	0	0.50	0.19-0.81	0.71	0.38-1.05	0.80	0.55-1.05
	4		0	0	0.50	0.19-0.81	0.71	0.38-1.05	0.80	0.55-1.05

Table 5.3 (continued)

	5		0	0	0.50	0.19-0.81	0.71	0.38-1.05	0.80	0.55-1.05
	6		0	0	0.50	0.19-0.81	0.71	0.38-1.05	0.80	0.55-1.05
2003	1	11	0	2	0.82	0.61-1.02	1.00	-	1.00	-
	2		0	0	0.82	0.59-1.05	1.00	-	1.00	-
	3		0	0	0.82	0.59-1.05	1.00	-	1.00	-
	4		0	0	0.82	0.59-1.05	1.00	-	1.00	-
	5		0	0	0.82	0.59-1.05	1.00	-	1.00	-
	6		0	0	0.82	0.59-1.05	1.00	-	1.00	-
Pooled[b]	1	33	2	9	0.67	0.54-0.80	0.94	0.86-1.02	0.94	0.86-1.02
	2		3	0	0.55	0.39-0.70	0.81	0.66-0.96	0.85	0.73-0.96
	3		0	0	0.55	0.38-0.72	0.81	0.65-0.97	0.85	0.73-0.97
	4		0	0	0.55	0.38-0.72	0.81	0.65-0.97	0.85	0.73-0.97
	5		0	0	0.55	0.38-0.72	0.81	0.65-0.97	0.85	0.73-0.97

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Table 5.3 (continued)

6	0	0	0.55	0.38-0.72	0.81	0.65-0.97	0.85	0.73-0.97

[a] Worst case scenario considers premature dispersal to represent mortality in survival calculations, best case scenario includes only known mortalities in survival calculations, with censoring censors premature dispersals from survival calculations.

[b] Pooled among years.

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Figure 5.1a. Worst case Kaplan-Meier survival estimate for peregrine falcons (n=28) reintroduced in Kentucky 2001-2003.

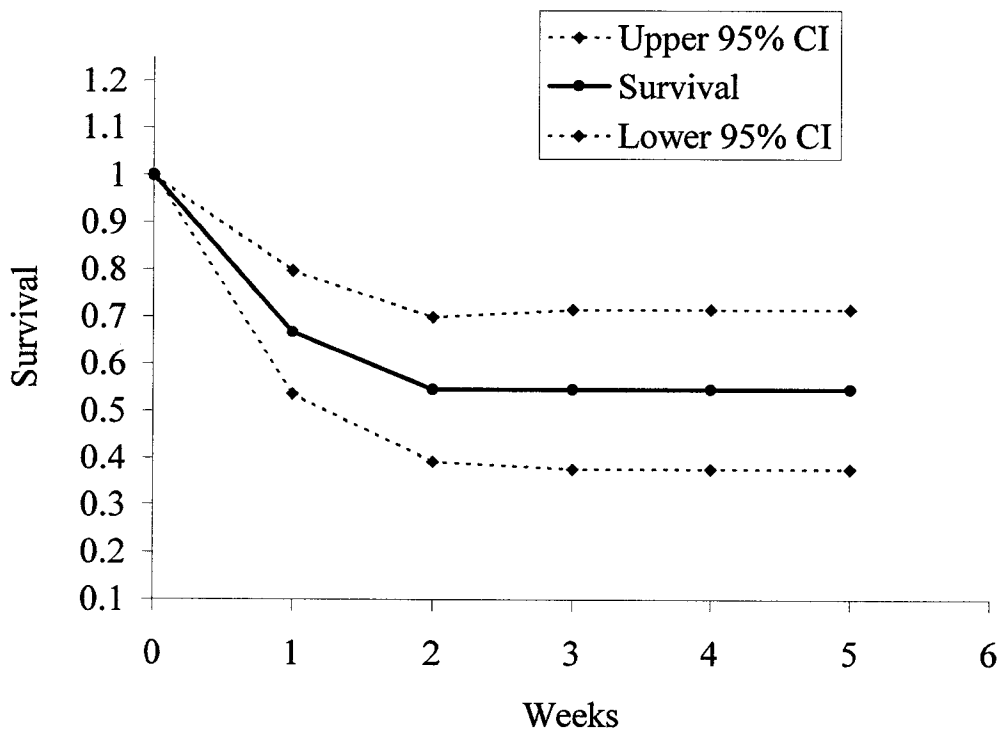

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Figure 5.1b. Intermediate Kaplan-Meier survival estimate for peregrine falcons (n=28) reintroduced in Kentucky 2001-2003.

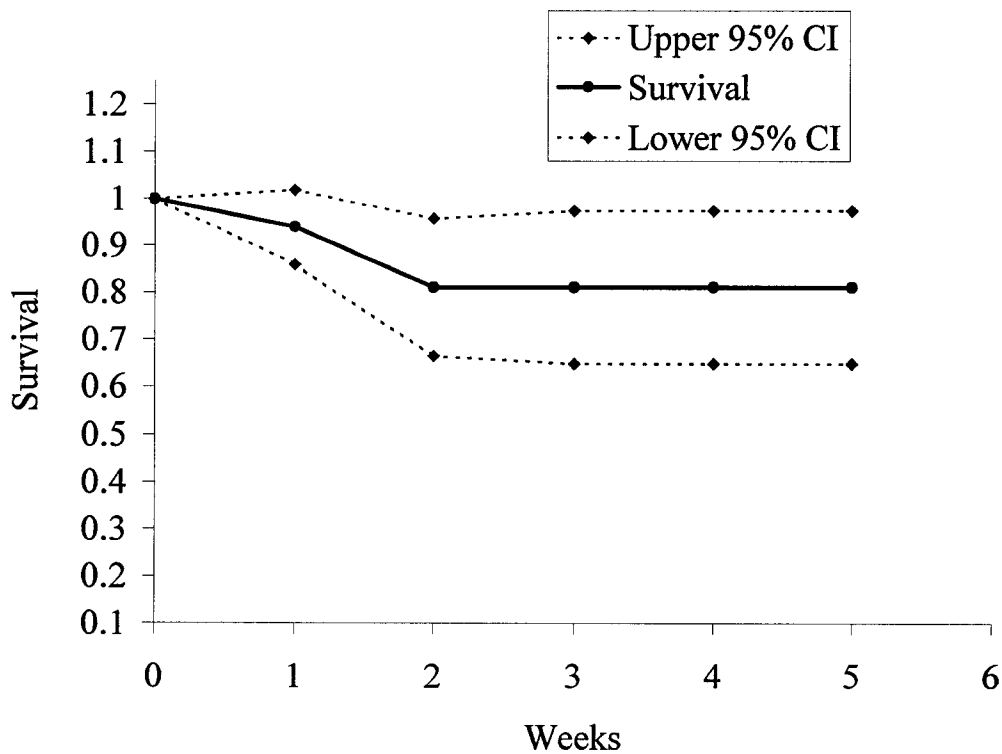

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Figure 5.1c. Best case Kaplan-Meier survival estimate for peregrine falcons (n=28) reintroduced in Kentucky 2001-2003.

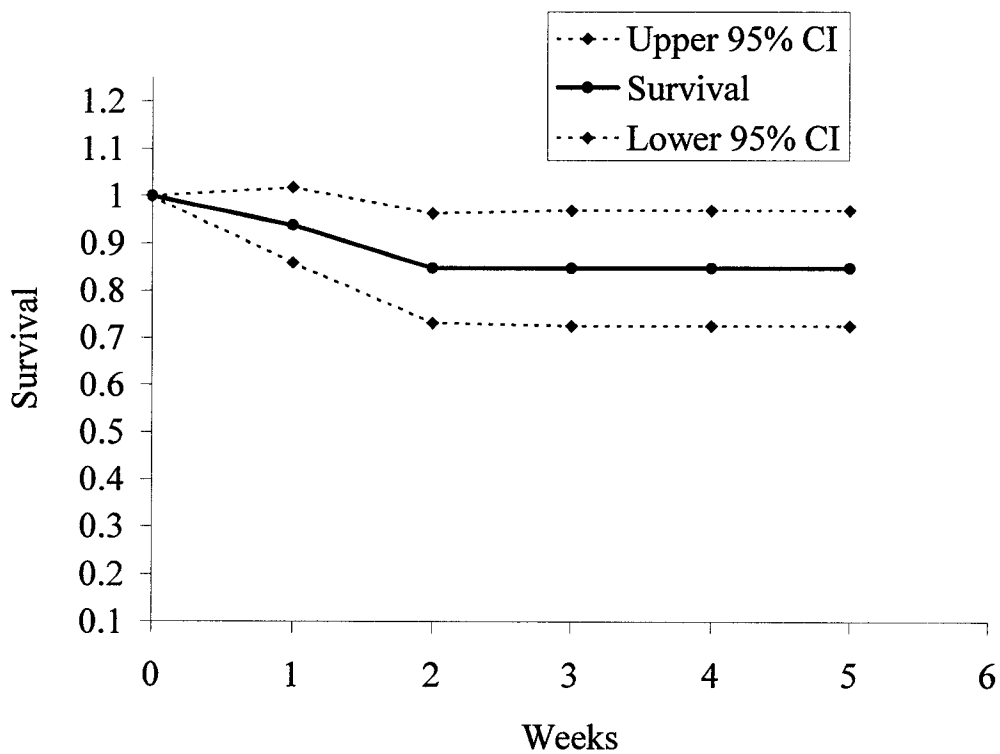

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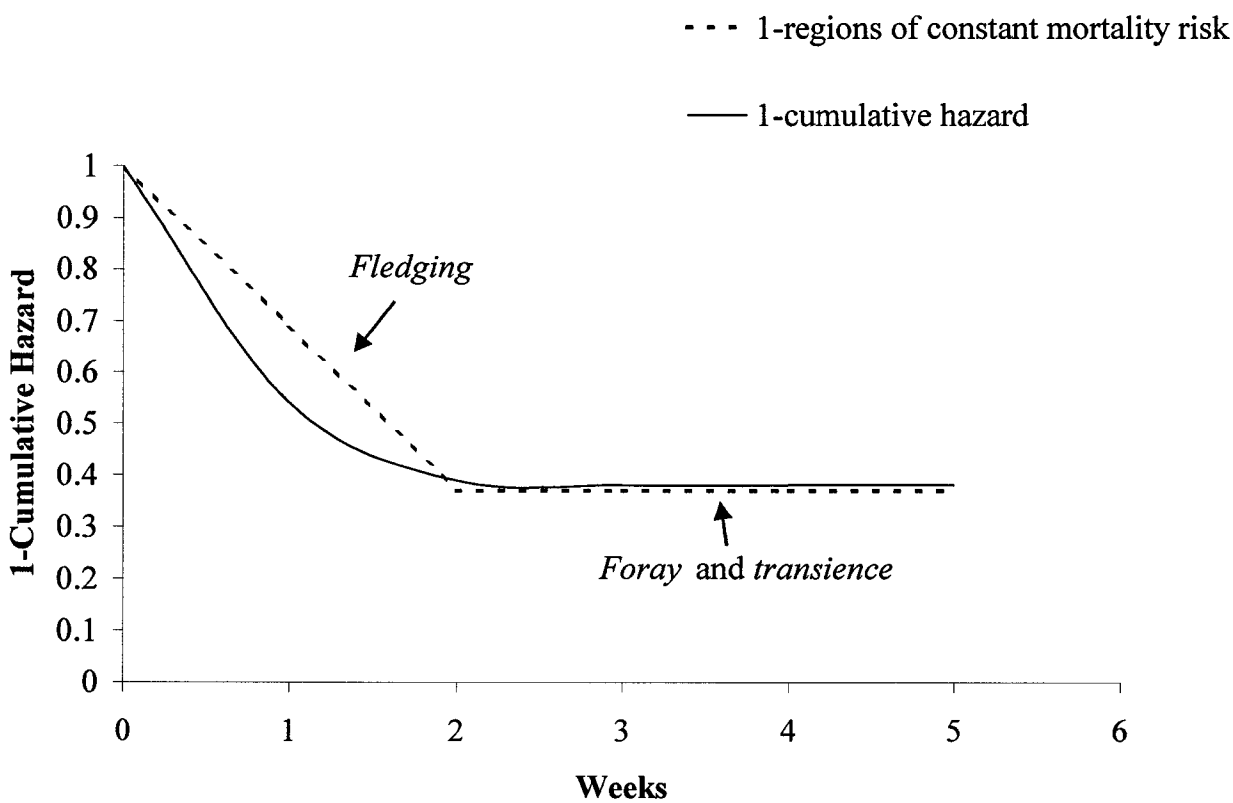
Figure 5.2. Cumulative hazard function (1-cumulative hazard) depicting post-fledging periods during which estimated risk of mortality varied.



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Chapter Six

Peregrine falcon reintroduction in Kentucky: program summary

Synopsis

As part of an effort to restore the peregrine falcon (*Falco peregrinus*) as a breeding species in Kentucky and to augment regional peregrine falcon population numbers, the Kentucky Department of Fish and Wildlife Resources, the University of Kentucky, the USDA Daniel Boone National Forest, and the Kentucky State Nature Preserves Commission collaborated in the release of 115 peregrine falcons among 3 human-made and 3 cliff habitats in the Commonwealth during 1993-2003. At the program's inception, the American peregrine falcon (*F. p. anatum*) was federally endangered and no peregrine falcon breeding location occurred in the Commonwealth. As of 2003 there were 4 active peregrine falcon breeding locations in the state, unpaired territorial males occupy several sites in the Commonwealth including the cities of Lexington (Fayette County) and Maysville (Mason County), and on the Daniel Boone National Forest (Powell County). Further, *anatum* peregrine falcons were removed from the federal endangered species list in 1999. Approximately 78% and 85% of peregrine falcons released at human-made and cliff sites in Kentucky, respectively, dispersed. In this chapter, I provide a summary of the program that includes technical details on release protocols, active eyries and occupied territories, numbers and demographic attributes of cliff-released peregrine falcons, observations on challenges associated with the cliff release phase of the program, and my perception on emerging issues in peregrine falcon conservation in Kentucky. Also, in a profile of each peregrine falcon

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released in cliff habitat, I provide details on technical and demographic attributes of cliff-released peregrine falcons.

Introduction

Historical records indicate that the American peregrine falcon occupied breeding locations in cliff habitats and lowland forests in eastern and western portions of Kentucky, respectively (Mengel 1939, Berger et al. 1969). By the mid 1960s *anatum* peregrine falcons in Kentucky and throughout the eastern United States had become extinct because of contamination by organochloride pesticides such as DDT. Efforts to restore *anatum* populations included banning use of DDT in 1972, listing of the subspecies as federally endangered in 1975, and a suite of recovery projects initiated by state agencies, private raptor organizations, and falcon breeders (Ratcliffe 1993, Cade et al. 1996). In 1993, efforts were initiated by the Kentucky Department of Fish and Wildlife Resources (KDFWR) to restore *anatum* peregrine falcons in Kentucky. At that time, the *anatum* subspecies was federally endangered and no peregrine falcon breeding location occurred in the Commonwealth. Since its initiation, the program expanded to include partnerships with the University of Kentucky (UK), the USDA Daniel Boone National Forest (DBNF), and the Kentucky State Nature Preserves Commission (KSNPC). As of 2003 there were 4 active peregrine falcon breeding locations in the state, with unpaired territorial males occupying several sites in the Commonwealth (see Breeding locations and occupied territories below). In this chapter, I provide an overview of Kentucky's peregrine falcon reintroduction program. Emphasizing the cliff-release phase, I summarize technical aspects of the program,

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and outline what I perceive to be emerging issues in peregrine falcon conservation in the Commonwealth.

1993-1999: Releases in urban and industrial areas

During 1993-1999, 82 peregrine falcons were released among 3 urban and industrial hack sites in the Commonwealth. Thirty peregrine falcons were released at the Vine Center Building in Lexington (Fayette County), 31 were released at the Kentucky Utilities E.W. Brown Generating Station in Burgin (Mercer County), and 21 were released at Kentucky Utilities Ghent Station (Carroll County; Burford 1999). Human-made structures in urban or industrial areas were used as initial release sites because these areas often have abundant prey such as European Starlings (*Sturnus vulgaris*) and few predators such as Great Horned Owls (*Bubo virginianus*). Abundant prey at the natal site is important in the development of prey recognition and pursuit behavior in young peregrine falcons (Sherrod 1983). Urban and industrial areas often support large numbers of European Starlings and Rock Doves (*Columbia livia*) - species that peregrine falcons prey heavily on in these areas (Carter et al. 2003). Human-made structures also facilitate logistical considerations such as accessibility for daily feeding by hack-site attendants. Goals of this phase of the program included achieving high survival-to-dispersal rates, and ultimately, reestablishing peregrine falcon breeding locations in the state. Research was not a primary focus during this phase. Burford (1999) reported that nearly 78% of the peregrine falcons released at these locations survived to disperse. Moreover, these efforts resulted in the establishment, in part, of a breeding pair at the Ghent generating station in Carroll County (see Breeding locations and occupied territories below). Predominant sources

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of mortality included collisions with vehicles or buildings, or becoming trapped in industrial structures (Burford and Yancy 1994). Although incidence of predation was low during this phase of the program, Burford (1996) reported that three peregrine falcons were killed by a Great Horned Owl at Kentucky Utilities E.W. Brown Generating Station in Burgin in 1995.

2000-2003: Cliff releases

During 2000-2003, 33 peregrine falcons were released among cliff habitats on DBNF and the Tom Dorman State Nature Preserve (TDSNP) in eastern and central Kentucky, respectively. Efforts to reintroduce the peregrine falcon in cliff habitats represented a novel phase of the program because research was a primary focus. Twelve peregrine falcons were released at a large rock arch near the junction of highways 77 and 715 in the Red River Gorge Geologic Area on DBNF in 2001 (Menifee County). Sixteen peregrine falcons were released at a large cliff ledge at the terminus of tunnel ridge road in the Red River Gorge Geologic Area in 2002 and 2003 (Powell County). Five peregrine falcons were released at TDSNP on the Kentucky River in 2003 (Jessamine County). Twenty-eight of 33 peregrine falcons released at these areas (85%) survived and dispersed from the natal area (Table 6.1; Appendix H; but see Chapter 5 for details on dispersal and survival).

Hacking

General hacking protocols were described in Chapter 5. I constructed 4 hack boxes (152.4 × 96.5 × 121.9 cm) for use during the cliff release phase. Two hack boxes were placed on a large cliff ledge situated beneath a rock arch near the junction of highways 77 and 715 in the Red River Gorge Geologic Area in 2001. The

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predominant orientation of this ledge was ENE. This site was not accessible by road. Hack boxes and other supplies were airlifted to this site by helicopter. Airlifting was administered and supervised by DBNF personnel. The other 2 hack boxes were placed on a large cliff ledge at the terminus of Tunnel Ridge Road in the Red River Gorge Geologic Area in 2002. The predominant orientation of this ledge was SW. This site was accessible by road and trail, so hack boxes were carried to the site by UK and KDFWR personnel. Hack boxes were positioned and anchored as described in Chapter 5.

Hack boxes were not constructed for use at TDSNP. UK and KSNPC personnel had considered TDSNP in 2000 as a potential release site (also see Chapter 3), but its use in 2003 was related to the presence of an adult male on DBNF and had not been planned for specifically (see Breeding locations and occupied territories below). I considered it inappropriate to release juvenile peregrine falcons on the adult male's territory so I transferred 5 peregrine falcons from a hack box on DBNF to TDSNP. TDSNP is a linear distance of approximately 79 km from the DBNF release site. To facilitate the immediate release of peregrine falcons at TDSNP, I positioned 2 large portable kennels (Petmate®, Arlington, Texas 76004; 57 × 28 × 60-cm) on a ledge near the apex of the cliff. I modified the kennels to facilitate hack box-style release of the falcons. Modifications included eliminating the permanent attachment of the metal front piece and then re-fastening the front piece to the body of the kennel with large cable ties that could be quickly cut and removed. By cutting the cable ties, the front piece could be removed much like the front piece of a hack box. In the dorsal surface of each kennel, I cut a 1.5-cm wide slot posterior and parallel to the re-attached metal

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front piece. The slot functioned to enable insertion of a 52 × 1 × 70-cm plywood slide immediately posterior to the front piece. Similar to standard hacking procedures (Sherrod et al. 1982), the slide enable removal of the front piece while precluding visibility and escape of the falcons. I was able to remove the front piece of each kennel, remove the slides, and escape into cover before any falcons emerged. In fact, no falcons fledged for approximately 2 h. Kennels were 'anchored' to the cliff by placing large, flattened slabs of limestone on the floor of each kennel. Hack boards were placed and anchored to the substrate at the hack site, including on top of the kennels. Despite this cohort of falcons having been in a hack box on DBNF for 8 days, abruptly removed from DBNF and released approximately 4 h later at TDSNP, this impromptu approach to falcon release resulted in no apparent complications or abnormalities in terms of falcon behavior, survival, or dispersal. No mortalities occurred at TDSNP and all 5 falcons were observed in the natal area for 27-36 days.

Predators

Predation on reintroduced peregrine falcons was a concern. Juveniles that are used in reintroduction programs are naïve to predators and do not have parental protection and instruction like their wild-produced counterparts. Great Horned Owls were the biggest concern (Barclay and Cade 1983, Burford 1996, *but see* Powell et al. 2002). These nocturnal predators have been known to prey on roosting peregrine falcons, and once Great Horned Owls emerge as a source of mortality they are difficult to address. Before choosing reintroduction sites I conducted Great Horned Owl surveys throughout cliff habitats in the state. The DBNF release sites that I used were chosen for initial releases, in part, because densities of Great Horned Owls appeared to be low

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in these areas compared to other portions of the state (Chapter 3). Nonetheless, I released five peregrine falcons in central Kentucky where Great Horned Owls likely occurred at higher densities than on the DBNF without conflict. Although Great Horned Owls likely were a greater threat at TDSNP compared to DBNF, TDSNP provided excellent habitat (Chapter 3) and its use as an alternate release site was characterized by few administrative constraints or logistical concerns. Use of an alternate release site was caused by the presence of the adult male on DBNF, but the specific choice of TDSNP was motivated by research hypotheses related to landscape influences on dispersal initiation (Chapter 4). Fortunately, no Great Horned Owl was observed at any natal site during the cliff release phase. Other predators emerged as likely sources of mortality. I suspect that a bobcat (*Lynx rufus*) and a raccoon (*Procyon lotor*) were the sources of peregrine falcon mortalities at the Red River Gorge Geologic Area in 2001 and 2002, respectively. I found evidence of nocturnal interactions between these predators and reintroduced peregrine falcons. Bobcat or raccoon tracks were found near falcon carcasses. Carcasses exhibited characteristics of mammalian predation such as removed limbs, and feathers scattered over the forest floor. Using Soft Catch® traps (padded foothold trap; Woodstream Corp., Lititz, PA, 17543), I captured and removed a bobcat from the hack site in 2001. Using a box trap (Havahart®; Woodstream Corp., Lititz, PA, 17543), I captured and removed 3 raccoons from the hack site in 2002. In addition to a bobcat and raccoons, I observed gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*) timber rattlesnake (*Crotalus horridus*), copperhead (*Agkistrodon contortrix*), and vultures (*Coragyps*

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atratus; *Cathartes aura*) consuming quail carcasses placed out for the peregrine falcons. None of these, however, were associated with falcon mortality.

Telemetry

Aerial telemetry was an effective tool for examining dispersal initiation in reintroduced peregrine falcons, however, it had several limitations that should be considered before its application in future studies on dispersing raptors. Like all aviation, the effectiveness of aerial telemetry can be influenced strongly by weather. During summer in the southeastern U.S., morning valley fog in rugged regions, and widespread afternoon thunderstorms often limited consistent telemetry flights to 1030-1530 h. When dispersing peregrine falcons enter *transience*, they provide only a brief opportunity for relocation. Missed telemetry flights as a consequence of poor weather or other factors such as routine aircraft maintenance can render relocating transient peregrine falcons nearly impossible. Assessing dispersal initiation in wide-ranging raptors with aerial telemetry requires a considerable investment in effort and funding. One or more flights must be conducted daily. Given sufficient funds and efforts, aerial telemetry can enable acquisition of good data, although satellite telemetry may be a preferred alternative.

The radiotransmitter attachment was designed to provide reasonable assurance that peregrine falcons would retain instruments during the study period yet shed instruments in coming months. The life span of the leather attachment was variable. All but 1 radiotransmitter remained affixed to peregrine falcons during the study period. This peregrine falcon was able to remove its transmitter after 25 days on the post-fledging area. I had 2 other opportunities to assess the life span of the

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attachment. In one instance the transmitter was shed within 90 days, but in another instance the transmitter remained affixed for > 13 months. Individual variation in the extent to which peregrine falcons pick at the attachment likely plays a role in its life span.

I assessed telemetry accuracy in late summer 2003 by locating 6 transmitters placed in the field by colleagues at locations unknown to me. Transmitters were affixed to tree limbs; 3 were placed at the DBNF study area and 3 were placed at the TDSNP study area. At DBNF my $\bar{x} \pm$ SD telemetry error was 0.34 ± 0.37 km, and at TDSNP error was 0.39 ± 0.18 km.

Breeding locations and occupied territories

Since 1995, 4 pairs of peregrine falcons have established breeding locations in industrial and urban areas in the northern portion of the Commonwealth. These pairs occur on the Interstate 65 bridge in Louisville (Jefferson County), the route 421 bridge in Milton (Trimble County), a smokestack at Louisville Gas and Electric Trimble County Station, and a smokestack at Kentucky Utilities Ghent Station (Carroll County), respectively. A male falcon released at Ghent generating station in 1998 by KDFWR returned to the site, attracted a female (wild-produced in Manitwoc, Wisconsin in 1999), and has reproduced successfully each year since 2000, producing > 13 fledglings during 2000-2003. Since 1995, more than 26 young peregrine falcons have fledged from Kentucky eyries. I suspect that the other Kentucky pairs may be comprised of a mixture of Kentucky-released peregrine falcons and falcons that were released as part of other state or regional restoration efforts. Although I have been unable to confirm the identification of all individuals based on tarsal bands, several

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peregrine falcons nesting in Kentucky were hacked in Ohio and Missouri. Also, it is known that several Kentucky released peregrine falcons have established breeding locations in the adjacent states of Indiana and Ohio (L. Burford, pers. comm.). Clearly, efforts among states and regions to restore *anatum* populations have interacted in Kentucky and throughout North America in the peregrine falcon's recovery.

Unpaired male peregrine falcons occupy territories in several locations in the Commonwealth. Since 1998, an unpaired male has been observed in downtown Lexington (Fayette County). Little is known about this falcon. Since its arrival, Craig Royce (Royce 2002) of the Lexington Financial Center has coordinated efforts to monitor the status of this falcon. He reported that the falcon is observed frequently perching on the southwest-facing portion of the Central Bank Building on top of the massive "C" logo (Royce 2002), where it preys on European Starlings and Rock Doves. In 2002, KDFWR coordinated efforts to install a nest box on top of the neighboring Vine Center Building. It is hoped that the box will provide a favorable nesting location should the male attract a female. A similar situation occurs in Maysville (Mason County), where an unpaired male peregrine falcon has been observed since 2001. Nearly nothing is known about this falcon. An unpaired male peregrine falcon also occupies a territory in cliff habitat in the Red River Gorge Geologic Area on DBNF (Powell County). This falcon (black/green tarsal band read 75/K) established a territory at the terminus of Tunnel Ridge Road in June 2003 following its release on DBNF during the previous year on 28 June.

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Emerging issues in peregrine falcon conservation in Kentucky

Since 1993, 115 peregrine falcons have been released in both urban and natural settings in Kentucky. 2003 marks the 10th and final year of the peregrine falcon restoration program in the Commonwealth and the start of a cooperative federal and state effort to monitor peregrine falcon populations nationwide pursuant to section 4(g)(1) of the Endangered Species Act (U.S Fish and Wildlife Service 2003). This section of the Act requires the United States Fish and Wildlife Service (FWS) to develop and implement a system to monitor species in the wake of their removal from the federal endangered species list; *anatum* peregrine falcons were delisted in 1999. The federal draft post-delisting monitoring plan (Amaral et al. 2003) seeks to support and facilitate existing efforts (e.g., State Agency) to monitor regional peregrine falcon populations by providing a framework under which monitoring and data collection protocols may be standardized among contributing partners. The plan calls for 5 monitoring periods, conducted at 3-year intervals, during 2003-2015. In Kentucky (and throughout FWS Region 4 – the southeastern U.S.) the number of occupied breeding locations is low. Further, the 10-year commitment by KDFWR to peregrine falcon recovery represents a considerable contribution and investment in species conservation. This investment should undergo annual assessment in the short term because peregrine falcons that have been reintroduced in the Commonwealth, or that have fledged from our breeding locations during the past several years will transition from nomadic to territorial stages at 1-4 years of age (Ratcliffe 1993, Tordoff and Redig 1997). Consequently, efforts have been initiated to monitor peregrine falcons in Kentucky annually during 2003-2008, and thereafter at 3-year intervals coinciding

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with FWS monitoring protocols. The annual monitoring protocol will be designed to enable better assessment of Kentucky's peregrine falcon restoration program and facilitate FWS post-delisting assessment objectives. Elements of the protocol will include determination of territory occupancy, identification of newly established territories (i.e., Red River Gorge), evaluation of nest success and productivity at existing eyries, and collection of data facilitating contaminant analyses (e.g., opportunistic collection of addled eggs and tissue samples such as the distal 1.5 cm of the fourth secondary feather of nestlings).

A central principle in wildlife reintroduction is determining that the original causes of population declines have been remedied and likely would not threaten restored populations. Although pesticide-caused extirpation of peregrine falcon populations likely is an event of the past, there is evidence that other industrial contaminants such as heavy metals may adversely affect restored peregrine falcons in some urban areas. For example, in Louisville, Kentucky (Jefferson County), two resident adult peregrine falcons have died of lead poisoning after 1995 (S. Vorisek, KDFWR, unpublished data). In a female Louisville peregrine falcon that died in May 2003, lead tissue concentration was 41.8ppm. Normal lead tissue concentration is about 6ppm. To better understand potential routes of exposure to lead in Louisville peregrine falcons, I collaborated in a study examining their food habits during 1999-2001 (Carter et al. 2003). We determined that Rock Doves comprised nearly 100% of the biomass consumed by these falcons. Rock Doves are known to feed at ground level in urban areas and, as a consequence, they have the potential to acquire body burdens of industrial contaminants (DeMent et al. 1986, Scheuhammer 1987, Cade and Bird

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1990, Mora et al. 2002). I suspect that Rock Doves are a primary source of lead bioaccumulation in Louisville peregrine falcons and perhaps in other urban raptors as well. Monitoring food habits and other detailed aspects of feeding ecology in restored peregrine falcon populations can be useful in detecting long-term population exposure to food-related threats leading to development of proactive management strategies.

About 75% of the restored Midwest peregrine falcon population uses human-made structures for nesting. Recently, cliff habitats in the Midwest have become occupied apparently because suitable human-made structures have become saturated. In fact, in 2000, five pairs of peregrine falcons established territories on Mississippi River cliffs where, a year earlier, there were none (Tordoff et al. 2000). I expect a similar trend of occupancy in Kentucky, with human-made structures occupied first followed by cliff habitats. It is reasonable to expect cliff habitats in central Kentucky (i.e., TDSNP) and northern DBNF (i.e., Red River Gorge) to become occupied before cliff habitats in heavily forested portions of southern and southeastern Kentucky. I speculate that in the next 10-15 years, a reasonable statewide estimate of active peregrine falcon breeding locations could include up to 5-7 on human-made structures, and 3-5 in cliff habitat.

Assessing success in wildlife reintroduction

The establishment of a self-sustaining population is a primary measure of success in wildlife reintroduction (e.g., Griffith et al. 1989, Kleiman 1989). Undoubtedly, population reestablishment is a fundamental objective in wildlife reintroduction, but a singular focus on this overlooks numerous biological and cultural implications of wildlife reintroduction as a conservation tool (Durrell and Mallinson 1987). For

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example, it may be difficult to define discrete populations in some taxa making the determination of population reestablishment difficult, especially if a metapopulation structure is involved. I would argue that peregrine falcons occupying breeding locations throughout the eastern and Midwestern U.S. exhibit considerable genetic interchange and can be considered a single population or metapopulation (Wooten and Bell 1992). Clearly, in reintroduction of species that exhibit high mobility or nomadic (sub)adult behavior like the peregrine falcon, efforts among states and regions interact locally and regionally in population recovery.

Dissemination of research results and new hypotheses also is a measure of success in wildlife reintroduction (*sensu* Soderquist 1994). The amount and quality of biological knowledge gained as part of a wildlife reintroduction, and the advancement of new wildlife techniques contributes to better species management and to the development of improved reintroduction protocols (Phillips 1991). Wildlife reintroduction research can also bridge biology and culture in regions where reintroductions occur. The primary determinants of success in wildlife reintroduction are cultural factors, and programs must include efforts to facilitate education and participation of local publics. In one of many examples during this program, a family from Letcher County, Kentucky, traveled by vehicle for nearly 3 hours to the reintroduction area then carried a sizable telescope and tripod for 40 minutes along the footpath to the hack site for the opportunity to glimpse a peregrine falcon. The fact that peregrine falcons spend most of their time perching did not diminish their viewing experience in the slightest. Nor did the fact that perching peregrine falcons appeared upside down through their reflecting telescope. Charismatic species such as the

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peregrine falcon are a valuable conservation currency. As part of wildlife reintroduction, interactions between biologists and citizens perhaps contribute in promoting a culture that embraces wildlife diversity and restoration, and arouses awareness in key conservation issues such as habitat loss.

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Table 6.1 Peregrine falcons (*Falco peregrinus*) released in cliff habitat in Kentucky, 2001-2003.

Peregrine falcon USFWS	B/G[a]	Sex	Release location[b]	Released	Age at Release[c]	Dispersed	Mortality	Age at dispersal/ mortality[c]	Days on PFA[f]	Fate
2206-62804	55/K	M	DBNF	6/26/01	43	7/4/01	-	51	8	dispersed
2206-62807	58/K	M	DBNF	6/26/01	44	7/24/01	-	73	29	dispersed
1807-77726	X/E	F	DBNF	6/26/01	48	7/14/01	-	66	18	dispersed
1807-77725	X/K	F	DBNF	6/26/01	47	7/10/01	-	61	14	dispersed
2206-47629	59/K	F	DBNF	6/26/01	48	-	7/10/01	61	13	mortality
2206-62805	56/K	M	DBNF	6/26/01	43	7/11/01	-	58	15	dispersed
2206-62806	57/K	M	DBNF	6/26/01	44	7/24/01	-	73	29	dispersed
2206-62803	54/K	M	DBNF	6/26/01	43	7/14/01	-	61	18	dispersed
1807-77724	X/P	F	DBNF	7/13/01	52	-	7/17/01	56	4	mortality
2206-62801	16/H	M	DBNF	7/13/01	54	-	7/22/01	63	9	mortality

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Table 6.1 (continued).

2206-47630	49/K	M	DBNF	7/13/01	53	7/21/01	-	61	8	dispersed
2206-47631	15/H	M	DBNF	7/13/01	54	7/14/01	-	55	1	dispersed
1807-77720	02/B	F	DBNF	6/18/02	46	-	6/27/02	55	9	mortality
2206-62815	73/K	M	DBNF	6/18/02	43	6/25/02	-	50	7	dispersed
2206-62819	77/K	M	-	-	-	-	-	-	-	rehabilited
1807-77723	05/B	F	DBNF	6/28/02	48	7/22/02	-	72	24	dispersed
2206-62818	76/K	M	DBNF	6/28/02	49	-	7/9/02	60	11	mortality
2206-62817	75/K	M	DBNF	6/28/02	49	8/5/02	-	87	38	dispersed
1807-77721	03/B	F	DBNF	6/18/02	46	7/18/02	-	76	30	dispersed
1807-77728	79/K	M	DBNF	7/25/02	50	8/12/02	-	68	18	dispersed
2206-62820	78/K	M	DBNF	7/25/02	50	8/1/02	-	57	7	dispersed
1807-77727	06/B	F	DBNF	7/25/02	50	8/10/02	-	66	16	dispersed
1807-77722	04/B	F	DBNF	6/18/02	44	-	6/27/02	53	9	mortality

Table 6.1 (continued).

2206-69829	25/P	M	DBNF	6/14/03	44	7/1/03	-	61	17	dispersed
2206-69830	26/P	M	DBNF	6/14/03	44	7/1/03	-	61	17	dispersed
1807-77729	03/E	F	DBNF	6/20/03	45	6/27/03	-	52	7	dispersed
1807-77741	04/E	F	DBNF	6/20/03	45	7/25/03	-	80	35	dispersed
1807-77743	05/E	F	DBNF	6/20/03	45	7/25/03	-	80	35	dispersed
1807-77742	27/P	M	DBNF	6/20/03	44	6/24/03	-	48	4	dispersed
1807-77744	28/P	M	TDSNP	6/26/03	43	7/30/03	-	77	34	dispersed
1807-77745	29/P	M	TDSNP	6/26/03	45	7/30/03	-	79	34	dispersed
1807-77746	30/P	M	TDSNP	6/26/03	45	8/1/03	-	81	36	dispersed
1807-77747	06/E	F	TDSNP	6/26/03	47	7/26-30/03[d]		77-82	30-35	dispersed
1807-91967	07/E	F	TDSNP	6/26/03	50-55[e]	7/23/03	-	77-82	27	dispersed

[a] Black over green identifyer.

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Table 6.1 (continued).

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[b] Red River Gorge Geologic Area, Daniel Boone National Forest (DBNF); Tom Dorman State Nature Preserve (TDSNP).

[c] Days.

[d] This falcon dropped its transmitter on 7/24/03. See Appendix H.

[e] This falcon was wild-produced in Milton, Kentucky. See Appendix H.

[f] Post-fledging area.

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Appendix A. General characteristics of potential peregrine falcon (*Falco peregrinus*) release areas (n = 32 cliffs) in Kentucky[a].

Cliff[b]	Height (m)	Length (m)	Elevation (m)	Predominant Aspect	Suitable Perches[c]	Summit Land use[d]	Base Land use[e]	Nearest Agricultural Area > 2.0 ha (m)
1	21.3	200.0	340.2	E	1	dec	dec	1450.3
2	16.5	175.0	311.0	NE	2	dec	dec	1460.6
3	27.4	60.0	314.0	S	numerous	dec	dec/wat	1355.4
4	25.6	70.0	301.2	W	3	dec/con	dec/wat	2735.0
5	9.2	230.8	298.8	NW	1	dec/con	dec	2081.8
6	13.7	307.7	337.8	E	1	dec	dec	1895.9
7	12.2	269.2	331.7	W	1	dec	dec	1848.7
8	6.1	22.9	329.3	E	1	dec/con	dec	956.7
9	30.0	384.6	243.9	SE	2	dec/con	dec	2338.7
10	54.0	274.4	359.8	NW	numerous	dec/con	dec	3775.5

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Appendix A. (continued)

11	30.5	338.5	280.5	SE	3	dec/con	dec	2610.4
12	64.0	200.0	371.7	SW	numerous	dec/con	dec	3764.4
13	22.9	115.4	304.9	SE	2	dec/con	dec/wat	2033.3
14	45.7	190.0	335.0	SW	2	dec/con	dec	2051.5
15	61.0	384.6	335.4	W	4	dec/con	dec/wat	1828.7
16	22.9	192.3	334.8	SE	2	dec/con	dec/wat	2590.5
17	30.1	307.7	274.4	S	1	dec/con	dec/wat	1848.9
18	63.0	254.0	366.2	W	numerous	dec/con	dec/wat	432.0
19	14.6	15.2	396.3	NW	1	dec	dec	461.1
20	15.2	21.3	414.6	NW	1	dec	dec	527.3
21	48.8	538.5	304.9	SE	numerous	dec/con	dec	4744.3
22	24.4	153.8	347.6	NE	1	dec/con	dec	2135.5
23	54.0	312.4	375.0	E	numerous	dec/con	dec/agr	390.0

Appendix A (continued).

24	28.0	61.0	164.0	N	numerous	dec/con	dec/wat	6930.6
25	75.1	80.0	311.3	S	2	dec/con	dec/wat	1027.4
26	80.0	150.0	304.9	NW	numerous	dec/con	dec/wat	1042.3
27	64.0	487.8	231.7	S	numerous	dec/agr	dec/wat	301.0
28	27.5	547.8	169.3	SW	numerous	dec/agr	dec/wat	276.0
29	57.9	2769.2	222.6	SW	numerous	dec/agr	dec/wat	156.0
30	61.0	67.1	670.3	SW	2	dec/con	dec	3795.6
31	40.0	200.0	550.8	NW	numerous	dec	dec	1848.6
32	66.5	41.2	630.3	E	numerous	dec	dec	2130.5

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Appendix A (continued).

Cliff	Nearest Development[f] (m)	Nearest Water Source (m)	Roost Competitors	Land use: Forest[g]	Land use: Agriculture[h]	Land use: Development[i]	Land use: Total Non-forested[j]
1	16694.8	600.8	No	85.0	5.0	0.2	15.0
2	16929.6	290.9	No	84.9	4.9	0.2	15.1
3	15446.5	99.8	Yes[k]	87.9	8.0	0.3	12.1
4	16099.5	70.6	No	89.7	6.0	0.3	10.4
5	16909.4	884.1	No	85.0	6.0	0.2	15.0
6	15435.8	741.7	No	89.2	6.7	0.4	10.8
7	15319.5	818.3	No	89.2	6.7	0.4	10.8
8	21382.4	910.4	No	86.9	8.5	0.2	13.1
9	10146.1	204.8	No	92.9	6.7	0.2	6.9
10	8995.3	611.6	Yes[k]	93.7	6.0	0.2	6.3

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Appendix A (continued)

11	9366.7	234.2	No	93.2	6.6	0.3	6.9
12	11606.3	972.1	No	93.3	6.4	0.2	6.7
13	9971.0	160.6	No	92.7	7.0	0.2	7.2
14	9681.6	234.2	No	92.7	7.0	0.3	7.3
15	9544.9	56.8	No	92.3	7.5	0.2	7.7
16	9590.6	127.0	No	93.2	6.5	0.3	6.8
17	9814.1	113.6	No	92.5	7.3	0.2	7.5
18	8989.5	197.3	No	91.1	8.4	0.3	8.9
19	5071.1	10564.2	No	95.4	4.1	0.2	4.4
20	5213.9	10651.3	No	95.9	4.0	0.2	4.1
21	19940.9	107.0	No	95.7	2.7	0.1	4.3
22	23349.6	1107.8	No	89.5	8.4	0.2	10.5
23	10202.2	1047.1	Yes[k]	97.0	2.0	0.3	3.0

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Appendix A (continued).

24	10220.7	93.7	No	96.7	0.8	0.8	3.3
25	18728.3	58.4	No	95.8	2.1	0.2	4.2
26	18300.0	30.1	Yes[k]	95.6	2.1	0.2	4.4
27	9399.0	25.0	Yes[k]	49.3	46.8	0.5	50.6
28	7498.0	16.0	No	49.1	48.5	0.5	51.0
29	7864.0	16.0	No	50.5	47.1	0.7	49.5
30	3869.5	9064.9	Yes[k]	95.5	0.8	0.7	4.5
31	3128.2	3122.5	Yes[k]	96.2	0.8	2.3	3.8
32	2896.3	540.0	No	97.5	0.4	0.6	2.5

[a] Cliffs 1-18 occur in northern portions of the Daniel Boone National Forest (DBNF; Morehead and Stanton Districts), 19-22 in central portions of DBNF (London District), 23-26 in southern portions of DBNF (Stearns District), 27-29 along the Kentucky River in central Kentucky, and 30-32 in the Cumberland Mountains of southeastern Kentucky.

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Appendix A (continued).

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[b] Cliffs 10 and 18 were selected as hack sites. Cliffs 9, 11, 12, 13, 14, 15, 16, and 17 are within 8.0 km of these hack sites.

[c] Visual estimation of suitable hacking ledges on cliff.

[d] Predominant, general land use type at cliff apex; dec refers to deciduous forest (commonly including *Acer*, *Quercus*, and *Fagus* spp.), dec/con refers to both deciduous and coniferous forest types (commonly including *Quercus*, *Carya* and *Pinus* spp.), dec/agr refers to both deciduous forest and arable land (pasture, crops, or orchards).

[e] Predominant, general land use type at cliff base; dec/wat refers to both deciduous forest and open water. Water sources included Cave Run Lake and the Red River and associated tributaries on the northern DBNF, the South Fork of the Cumberland River and the Rockcastle River on the southern DBNF, and the Kentucky River in central Kentucky.

[f] Restricted to incorporated city, town, borough, or locality.

[g] Proportion of landscape within an 8-km radius of the cliff (20096 ha) for which land use was primarily forest.

[h] Proportion of landscape within an 8-km radius of the cliff (20096 ha) for which land use was primarily agriculture.

[i] Proportion of landscape within an 8-km radius of the cliff (20096 ha) for which land use was primarily developed/residential.

[j] Proportion of landscape within an 8-km radius of the cliff (20096 ha) for which land use was non-forest.

Appendix A (continued).

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[k] Turkey Vulture (*Cathartes aura*) at cliffs 3, 10, 23, 27, and 31. Black Vulture (*Coragyps atratus*) at cliffs 10, 23, and 27. Osprey (*Pandion haliaetus*) at cliff 26, and Common Raven (*Corvus corax*) at cliff 30.

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Appendix B. Likely prey availability at potential peregrine falcon (*Falco peregrinus*) restoration sites in Kentucky; results of point-count surveys ($n = 48$) conducted at 12 potential release sites during May-June 2000[a,b,c].

	Potential release site (cliff)[d]											
Species	1	2	3	4	10	12	23	25	26	27	28	29
Blue Jay (*Cyanocitta cristata*)	1		4	1	2	3	3	5		3	8	
Brown-headed Cowbird (*Molothrus ater*)	1	1	1	1						1		1
Common Grackle (*Quiscalus quiscula*)										4	2	1
Eastern Meadowlark (*Sturnella magna*)										2	2	2
Eastern Phoebe (*Sayornis phoebe*)	1	1	2		3		2		1			
Eastern Towhee (*Pipilo erythrophthalmus*)		1			4							
European Starling (*Sturnus vulgaris*)										8	13	9
Mourning Dove (*Zenaida macroura*)	3		1			3		2		2	3	2
Northern Cardinal (*Cardinalis cardinalis*)	4			1		1		2	1		3	

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Appendix B (continued).

Species	Potential release site (cliff)											
	1	2	3	4	10	12	23	25	26	27	28	29
Northern Flicker (*Colaptes auratus*)	2	1		1	2	2	3	2	1	2	2	1
Northern Mockingbird (*Mimus polyglottos*)							1				3	
Pileated Woodpecker (*Dryocopus pileatus*)	1	4	4	2	3	6	3	2	2			
Red-bellied Woodpecker (*Melanerpes carolinus*)	2	4	3		2			2			4	2
Summer Tanager (*Piranga rubra*)		1	1	2						1	1	
Scarlet Tanager (*Piranga olivacea*)	3	1	2		3	2	4	5	4			
Tufted Titmouse (*Parus bicolor*)		4		5	5	4	3	2	2	3	2	1
Yellow-billed Cuckoo (*Coccyzus americanus*)		1			2	1	1			1	1	
Acadian Flycatcher (*Empidonax virescens*)	1					7		5	5			
American Crow (*Corvus brachyrhynchos*)	6	4	4	5	6	9	9	3	7	2	3	4

Appendix B (continued).

Species	Potential release site (cliff)											
	1	2	3	4	10	12	23	25	26	27	28	29
Bank Swallow (*Riparia riparia*)										3		3
Barn Swallow (*Hirundo rustica*)										5	1	18
Black and White Warbler (*Mniotilta varia*)	1	2	2	2	4	2		3	1			
Black-throated Green Warbler (*Dendroica virens*)	3			1	4	6	4		3			
Carolina Chickadee (*Parus carolinensis*)	1	1	1		1				1	1	2	
Carolina Wren (*Thryothorus ludovicianus*)	1						2	1	1	1	2	1
Chimney Swift (*Chaetura pelagica*)				3							1	2
Chipping Sparrow (*Spizella passerina*)	1	1	1	1					1		1	
Eastern Bluebird (*Sialia sialis*)											2	2
Eastern Wood Peewee (*Contopus virens*)	1	1	5	2		1		1			1	

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Appendix B (continued).

Species	Potential release site (cliff)											
	1	2	3	4	10	12	23	25	26	27	28	29
Hooded Warbler (*Wilsonia citrina*)	6	4	3		3	2	2	6	2			
Indigo Bunting (*Passerina cyanea*)		3		3	1	1	6	2	3	2	4	2
Northern Parula (*Parula americana*)	3	1					1	2				
Ovenbird (*Seiurus aurocapillus*)	4	3	6	4	5	2						
Pine Warbler (*Dendroica pinus*)				2	2	5		2				
Prairie Warbler (*Dendroica discolor*)					4	1	4		1			
Red-eyed Vireo (*Vireo olivaceus*)	7	8	5	7	5	8	6	6	8			
Turkey Vulture (*Cathartes aura*)						1			1	1		1
White-breasted Nuthatch (*Sitta carolinensis*)							2	1	1			
Wood Thrush (*Hylocichla mustelina*)		1	4	2	5	6	1	1	3			

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Appendix B (continued).

Species	Potential release site (cliff)											
	1	2	3	4	10	12	23	25	26	27	28	29
Worm-eating Warbler (*Helmitheros vermivorus*)				1	2			3	1			
Yellow-breasted Chat (*Icteria virens*)							6				4	

[a] First 17 species listed were considered available prey based on Richards (1919), Ganier (1931)Barber and Barber (1988), Boynton and Currie (1993), Myers and Pease (1995), Bockoven (1999), Corser and others (1999), and on 465 prey samples obtained at 3 breeding locations in northern Kentucky (Carter et al. 2003).

[b] Available prey for which we made ≤ 3 total observations included American Robin (*Turdus migratorius*; 3 at cliff 28), Belted Kingfisher (*Ceryle alcyon*; 1 at cliff 2 and 1 at cliff 25), Great-crested Flycatcher (*Myiarchus crinitus*; 2 at cliff 28), Hairy Woodpecker (*Picoides villosus*; 1 at cliff 3 and 1 at cliff 12), Killdeer (*Charadrius vociferus*; 1 at cliff 28, 2 at cliff 29), Northern

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Appendix B (continued).

Oriole (*Icterus galbula*; 1 at cliff 1), Red-winged Blackbird (*Agelaius phoeniceus*; 1 at cliff 28, 2 at cliff 29), Rose-breasted Grosbeak (*Pheucticus ludovicianus*; 1 at cliff 2).

[c] Unavailable prey for which we made ≤ 3 total observations included American Goldfinch (*Carduelis tristis*; 2 at cliff 29), Black Vulture (*Coragyps atratus*; 3 at cliff 3), Blue-grey Gnatcatcher (*Polioptila caerulea*; 1 at cliff 23 and 1 at cliff 25), Canada Goose (*Branta canadensis*; 2 at cliff 3), Cliff Swallow (*Hirundo pyrrhonota*; 1 at cliff 2), Common Yellowthroat (*Geothlypis trichas*; 1 at cliff 23), Field Sparrow (*Spizella pusilla*; 1 at cliff 23 and 1 at cliff 27), Grasshopper Sparrow (*Ammodramus savannarum*; 1 at cliff 28 and 2 at cliff 29), Grey Catbird (*Dumetella carolinensis*; 1 at cliff 25), Kentucky Warbler (*Oporornis formosus*; 1 at cliff 2, 1 at cliff 3, and 1 at cliff 12), Northern Bobwhite (*Colinus virginianus*; 1 at cliff 27 and 2 at cliff 28), Red-tailed Hawk (*Buteo jamaicensis*; 2 at cliff 3), Ruby-throated Hhummingbird (*Archilochus colubris*; 1 at cliff 4), Swainson's Warbler (*Limnothlypis swainsonii*; 1 at cliff 23), White-eyed Vireo (*Vireo griseus*; 2 at cliff 23 and 1 at cliff 25), White-throated Sparrow (*Zonotrichia albicollis*; 1 at cliff 27), Yellow-throated Vireo (*Vireo flavifrons*; 1 at cliff 25), Yellow-throated Warbler (*Dendroica dominica*; 1 at cliff 23, 1 at cliff 25, 1 at cliff 26).

[d] Cliff numbers correspond to Appendix A.

Appendix C. Average distance (km) between habitat elements and peregrine falcon locations corresponding to *fledging* and *foray* dispersal stages.

Peregrine Falcon	Release Site	Stage[a]	Water	Developed	Agriculture	Forest
PF280	DBNF	*Fledging*	2874.1	12385.4	138.2	0
		Foray	3157.1	11986.6	179.0	0
		Foray 2	-	-	-	-
PF338	DBNF	*Fledging*	3096.0	12322.5	191.6	0
		Foray	3414.1	10973.1	117.6	16.4
		Foray 2	3236.7	5125.6	41.2	82.7
PF379	DBNF	*Fledging*	3250.8	12556.9	149.1	0
		Foray	3305.3	9248.5	131.2	23.8
		Foray 2	3332.7	6212.4	52.3	53.4
PF409	DBNF	*Fledging*	2892.0	12171.1	274.9	0
		Foray	3690.6	11862.4	129.9	0.7
		Foray 2	5319.8	9559.3	185.3	0
PF429	DBNF	*Fledging*	2797.4	12374.9	125.6	0.02
		Foray	-	-	-	-
		Foray 2	-	-	-	-
PF457	DBNF	*Fledging*	2928.6	12320.8	214.5	0
		Foray	-	-	-	-

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Appendix C (continued)

		Foray 2	-	-	-	-
PF478	DBNF	*Fledging*	2963.9	12100.9	181.5	0
		Foray	3950.1	11841.6	148.5	0
		Foray 2	5882.4	11399.5	91.3	20.2
PF565	DBNF	*Fledging*	3305.5	12332.8	234.4	0
		Foray	3810.7	10214.7	229.2	21.2
		Foray 2	4471.3	7605.3	34.9	49.4
PF686	DBNF	*Fledging*	3173.5	12214.9	282.8	0
		Foray	3336.1	12087.2	149.6	7.1
		Foray 2	430.0	10885.0	3.7	47.2
PF709	DBNF	*Fledging*	3201.5	12487.2	163.8	0
		Foray	-	-	-	-
		Foray 2	-	-	-	-
PF753	DBNF	*Fledging*	3233.0	12627.1	128.9	0
		Foray	-	-	-	-
		Foray 2	-	-	-	-
PF825	DBNF	*Fledging*	3322.2	12292.7	284.9	0
		Foray	-	-	-	-
		Foray 2	-	-	-	-
PF850	DBNF	*Fledging*	3322.2	12292.7	284.9	0
		Foray	-	-	-	-

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Appendix C (continued)

		Foray 2	-	-	-	-
PF937	DBNF	*Fledging*	3197.2	12281.9	299.2	0
		Foray	3266.0	11405.9	151.9	8.6
		Foray 2	2109.3	6893.1	85.2	60.1
PF962	DBNF	*Fledging*	3268.8	12373.9	253.3	0
		Foray	-	-	-	-
		Foray 2	-	-	-	-
PF987	DBNF	*Fledging*	3004.8	12272.2	202.5	0
		Foray	3395.9	11842.1	216.6	12.1
		Foray 2	3656.1	10393.8	54.5	52.5
PF063	TDSNP	*Fledging*	299.7	8645.9	0	77.4
		Foray	113.3	8168.3	17.0	37.6
		Foray 2	325.9	3018.1	32.5	51.3
PF089	TDSNP	*Fledging*	-	-	-	-
		Foray	128.4	8756.5	22.0	39.2
		Foray 2	-	-	-	-
PF111	TDSNP	*Fledging*	300.0	8708.8	0	79.3
		Foray	174.2	8399.7	19.1	35.9
		Foray 2	423.8	7152.5	0	59.5
PF139	TDSNP	*Fledging*	347.1	8688.9	0	109.9
		Foray	106.9	8768.2	23.8	30.7

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Appendix C (continued)

		Foray 2	218.3	8370.7	0	18.9
PF188	TDSNP	*Fledging*	-	-	-	-
		Foray	159.7	8432.2	26.9	31.8
		Foray 2	154.1	6921.4	57.8	12.9

[a] See page 58 for a description of dispersal stages. *Foray* 2 refers to movements external to the viewsheds of Carter (2003).

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Appendix D. The average distance (km) between peregrine falcon locations and a given habitat element, divided by the average distance between random locations and the same given habitat element during the *fledging* dispersal stage.

Peregrine Falcon	Release Site[a]	Water	Developed	Agriculture	Forest
PF280	DBNF	0.96	1.00	0.82	0.00
PF338	DBNF	1.04	1.00	1.14	0.00
PF379	DBNF	1.09	1.01	0.88	0.00
PF409	DBNF	0.97	0.98	1.63	0.00
PF429	DBNF	0.94	1.00	0.75	0.10
PF457	DBNF	0.98	1.00	1.27	0.00
PF478	DBNF	0.99	0.98	1.08	0.00
PF565	DBNF	1.11	1.00	1.39	0.00
PF686	DBNF	1.06	0.99	1.68	0.00
PF709	DBNF	1.07	1.01	0.97	0.00
PF753	DBNF	1.08	1.02	0.77	0.00
PF825	DBNF	1.11	0.99	1.69	0.00
PF850	DBNF	1.11	0.99	1.69	0.00
PF937	DBNF	1.07	0.99	1.78	0.00
PF962	DBNF	1.10	1.00	1.50	0.00
PF987	DBNF	1.01	0.99	1.20	0.00

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Appendix D (continued)

PF063	TDNSP	1.11	1.13	0.00	2.38
PF089	TDNSP	-	-	-	-
PF 111	TDNSP	1.11	1.13	0.00	2.38
PF 139	TDNSP	1.29	1.13	0.00	3.38
PF 188	TDNSP	-	-	-	-
Mean	Total	1.01	1.02	1.07	0.43
Mean	DBNF	1.04	0.99	1.27	0.01
Mean	TDSNP	1.17	1.13	0.0	2.71

[a] Daniel Boone National Forest and Tom Dorman State Nature Preserve.

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Appendix E. The average distance (km) between peregrine falcon locations and a given habitat element, divided by the average distance between random locations and the same given habitat element during the *foray* dispersal stage.

Peregrine Falcon	Release Site[a]	Water	Developed	Agriculture	Forest
PF280	DBNF	1.42	5.41	1.50	0.00
PF338	DBNF	1.54	4.95	0.99	0.38
PF379	DBNF	1.49	4.17	1.10	0.55
PF409	DBNF	1.66	5.35	1.09	0.02
PF429	DBNF	-	-	-	-
PF457	DBNF	-	-	-	-
PF478	DBNF	1.78	5.34	1.25	0.00
PF565	DBNF	1.72	4.61	1.92	0.49
PF686	DBNF	1.50	5.45	1.26	0.17
PF709	DBNF	-	-	-	-
PF753	DBNF	-	-	-	-
PF825	DBNF	-	-	-	-
PF850	DBNF	-	-	-	-
PF937	DBNF	1.47	5.14	1.28	0.20
PF962	DBNF	-	-	-	-
PF987	DBNF	1.53	5.34	1.82	0.28

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Appendix E (continued)

PF063	TDSNP	0.24	0.89	1.87	0.63
PF089	TDSNP	0.27	0.95	2.42	0.66
PF111	TDSNP	0.36	0.91	2.10	0.60
PF139	TDSNP	0.22	0.95	2.63	0.52
PF188	TDSNP	0.33	0.92	2.96	0.53
Mean	Total	1.11	3.60	1.73	0.36
Mean	DBNF	1.57	5.09	1.36	0.23
Mean	TDSNP	0.28	0.93	2.40	0.59

[a] Daniel Boone National Forest and Tom Dorman State Nature Preserve.

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Appendix F. The average distance (km) between peregrine falcon locations and a given habitat element, divided by the average distance between random locations and the same given habitat element during the *foray* dispersal stage using observations beyond viewsheds.

Peregrine Falcon	Release Site[a]	Water	Developed	Agriculture	Forest
PF280	DBNF	-	-	-	-
PF338	DBNF	1.48	2.55	0.40	1.65
PF379	DBNF	1.52	3.10	0.50	1.07
PF409	DBNF	2.43	4.77	1.80	0.00
PF429	DBNF	-	-	-	-
PF457	DBNF	-	-	-	-
PF478	DBNF	2.69	5.69	0.88	0.41
PF565	DBNF	2.04	3.79	0.33	0.99
PF686	DBNF	0.19	5.43	0.03	0.95
PF709	DBNF	-	-	-	-
PF753	DBNF	-	-	-	-
PF825	DBNF	-	-	-	-
PF850	DBNF	-	-	-	-
PF937	DBNF	0.96	3.44	0.82	1.20
PF962	DBNF	-	-	-	-

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Appendix F (continued)

PF987	DBNF	1.67	5.18	0.52	1.05
PF063	TDSNP	0.75	0.34	3.60	0.75
PF089	TDSNP	-	-	-	-
PF111	TDSNP	0.97	0.80	0.00	0.86
PF139	TDSNP	0.50	0.93	0.00	0.27
PF188	TDSNP	0.35	0.77	6.40	0.20
Mean	Total	1.29	3.06	1.27	0.78
Mean	DBNF	1.62	4.24	0.66	0.92
Mean	DBNF Males	1.72	4.07	0.73	0.89
Mean	DBNF Females	1.56	4.34	0.61	0.93
Mean	TDSNP	0.64	0.72	2.50	0.52
Mean	TDSNP Male	0.73	0.86	0.00	0.56
Mean	TDSNP Females	0.55	0.55	5.00	0.47

[a] Daniel Boone National Forest and Tom Dorman State Nature Preserve.

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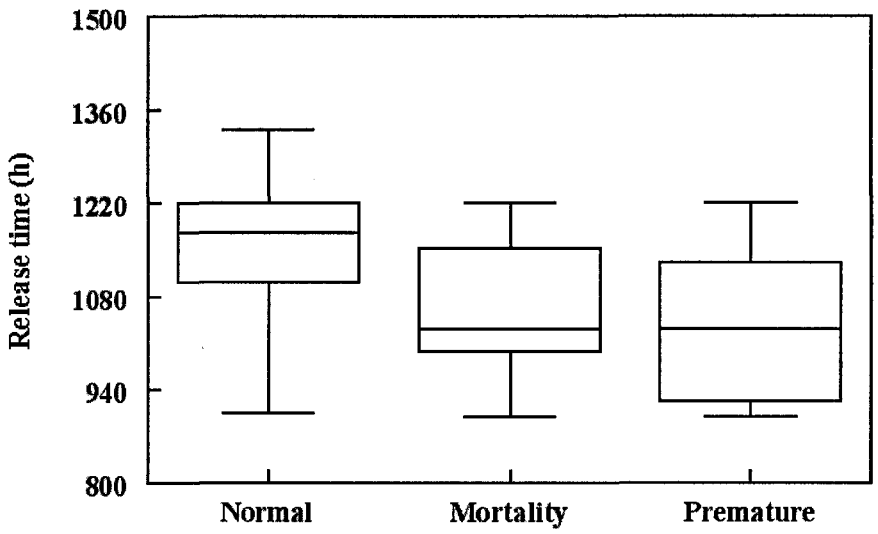
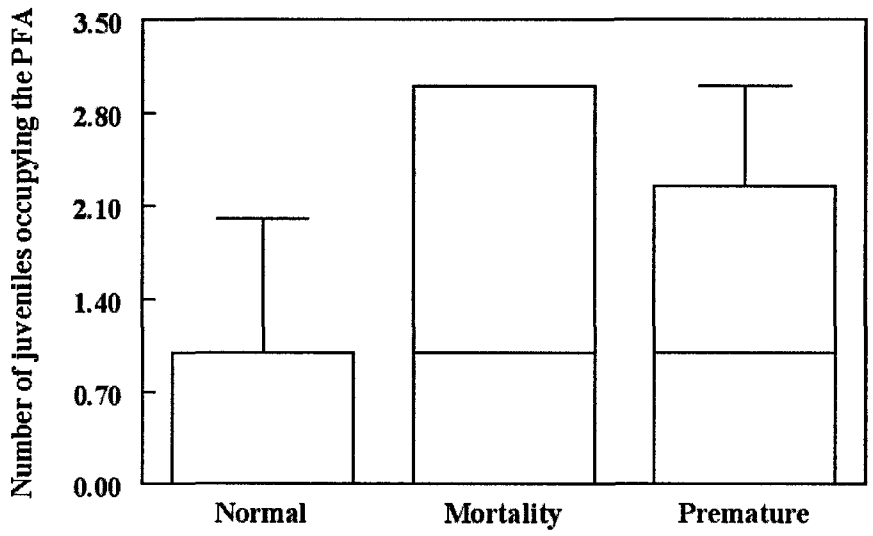
Appendix G. Box and whisker plots depicting variation in central tendencies of independent variable based on the polychotomous dependent variable fate class.





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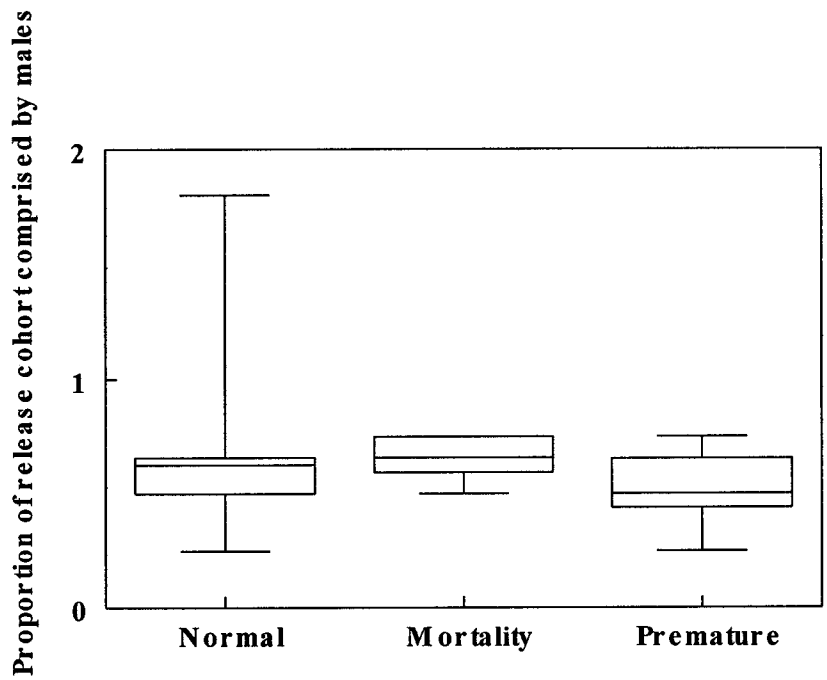
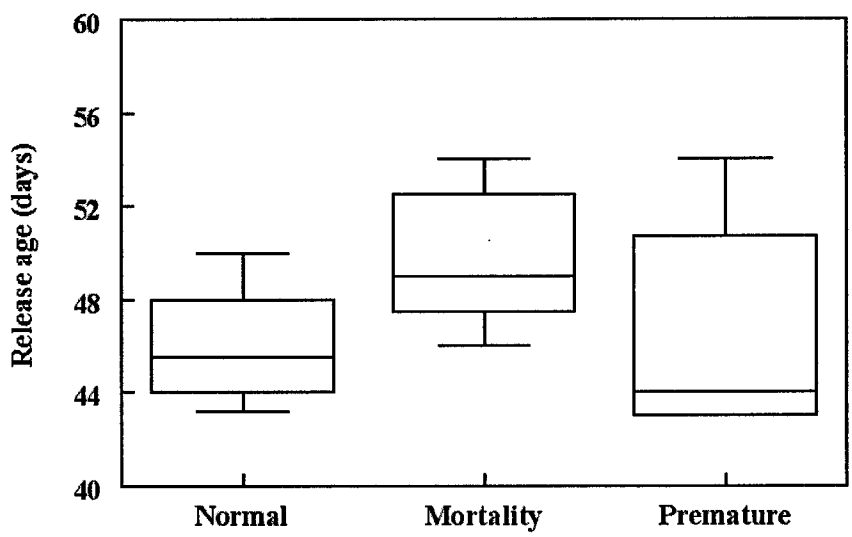
Appendix G. (continued).





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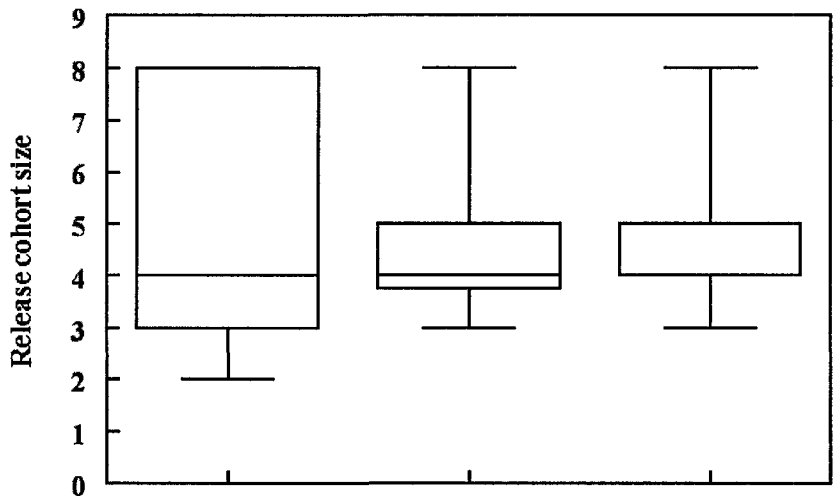
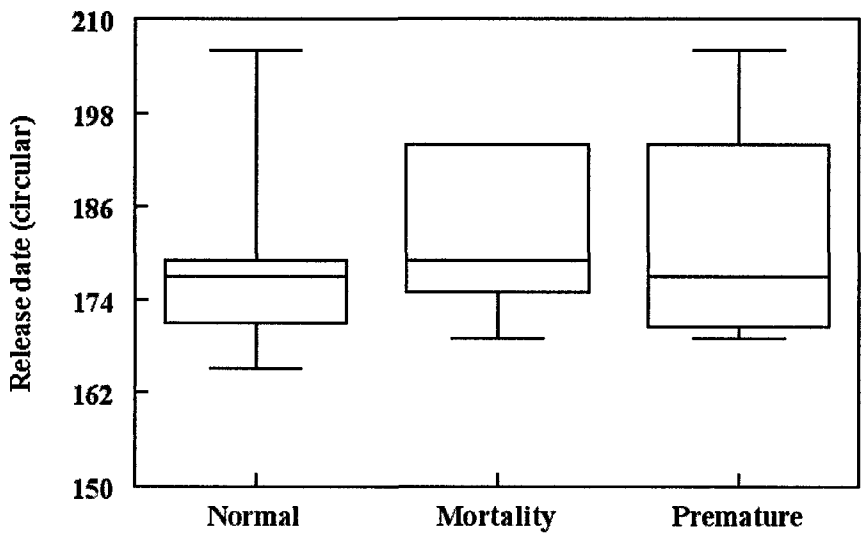
Appendix G. (continued).





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Appendix H. Profiles of peregrine falcons (*Falco peregrinus*) released in cliff habitat in Kentucky, 2001-2003.

Peregrine falcon – Male - Subspecies: *anatum* × *tundrius* - USFWS: 2206-62804 - Black/green: 55/K

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/26/01 in the Red River Gorge Geologic Area, Daniel Boone National Forest (DBNF) at age 43 days. Approximately 3 min after release this falcon fledged and aggressively pursued a Turkey Vulture (*Cathartes aura*). This falcon was extremely independent often perching >100 m from the hack site and the other falcons. I observed this falcon interacting with other falcons infrequently. This falcon was observed on the post-fledging area (PFA) for only 8 days. I observed this falcon eating at the hack site only once during this time. The last detection of this falcon on the pfa was on 7/4/01 at age 51 days.

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Appendix H. (continued)

Peregrine falcon – Male - Subspecies: *anatum* × *tundrius* - USFWS: 2206-62803 - Black/green: 54/K

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/26/01 on DBNF at age 43 days. This falcon fledged shortly after male (55/K). Two days after the release this falcon perched overnight within 20 m of my campsite. However, this was my last visual contact with this falcon. Telemetry indicated that this falcon remained in various portions of the PFA for 18 days. K. Huie, district biologist with DBNF, reported that a falcon bearing red and orange markings (matching the markings I gave to this falcon) was observed by DBNF personnel approximately 3 km N of the hack site on 7/6/01; however, I was unable to verify visually or with telemetry. This falcon was last detected with telemetry on 7/13/01.

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Appendix H. (continued)

Peregrine falcon – Male - Subspecies: *anatum* × *tundrius* - USFWS: 2206-62807 - Black/green: 58/K

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/26/01 on DBNF at age 44 days. This falcon was one of 2 falcons released in 2001 that remained on the PFA for 29 days – the longest duration among 2001 falcons. Although this falcon dropped its transmitter on 7/17/01, I maintained visual contact with this falcon daily through 7/24/01 when this falcon dispersed at age 73 days.

Peregrine falcon – Male - Subspecies: *anatum* × *tundrius* - USFWS: 2206-62805 - Black/green: 56/K

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/26/01 on DBNF at age 43 days. This falcon was observed frequently on the PFA interacting with the other peregrine falcons. On 7/11/01 this falcon dropped its transmitter. This was the last observation of this falcon – it dispersed at age 58 days.

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Appendix H. (continued)

Peregrine falcon – Male - Subspecies: *anatum* × *tundrius* - USFWS: 2206-62806 - Black/green: 57/K

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/26/01 on DBNF at age 44 days. This falcon was one of 2 falcons released in 2001 that remained on the PFA for 29 days – the longest duration among 2001 falcons. This falcon was last observed on 7/24/01 at age 73 days.

Peregrine falcon – Female - Subspecies: *anatum* × *tundrius* - USFWS: 1807-77726 - Black/green: X/E

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/26/01 on DBNF at age 48 days. This falcon remained on the PFA for 18 days and dispersed on 7/14/01 at age 66 days. This falcon was observed frequently in prolonged high (estimated > 1000 m) flight. In several instances this falcon seemed to restrict its flight path along the Red River corridor, particularly southwest of the hack site.

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Peregrine falcon – Female - Subspecies: *anatum* × *tundrius* - USFWS: 1807-77725 - Black/green: X/K

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/26/01 on DBNF at age 47 days. This falcon remained on the PFA for 14 days. This falcon dropped its transmitter on 7/6/01 but was observed on the PFA until it dispersed on 7/10/01 at age 61 days.

Peregrine falcon – Female - Subspecies: *anatum* × *tundrius* - USFWS: 2206-47629 - Black/green: 59/K

Breeder: Vic Hardaswick, Centerville, SD - Release site coordinates UTM 17 S: N 4190410 E 0267290

This falcon was mistakenly banded as a male. I released this falcon 6/26/01 on DBNF at age 48 days. I recovered the partially consumed carcass of this falcon in the valley directly below the hack site on 7/11/01. The bobcat observed occasionally since 6/27/01 may have been responsible for the death of this falcon. I observed this falcon frequently sleeping in a laterally recumbent position on an exposed, easily accessible rock at the hack site. Typically, overnight roosting locations of the falcons were more inconspicuous. This falcon would have been easy prey for a bobcat.

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Appendix H. (continued)

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-62801 - Black/green: 16/H

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 7/13/01 on DBNF at age 54 days. Originally I scheduled the release of this falcon for 7/8/01. However, I observed a bobcat at the hack site on 6/27/01 and despite considerable effort I was unable to trap and remove the bobcat until 7/13/01. I was unwilling to release this falcon (and its 3 siblings) until the bobcat was captured. On 7/22/01 I recovered this falcon's transmitter in a Rhododendron (*Rhododendron* sp.) thicket about 200 m north of the hack site. The transmitter was still intact (i.e., did not break off as designed) and found amongst several peregrine falcon feathers (primaries and retrices) that were scattered within an approximately 25-m segment of the forest valley floor. The cause of mortality was unknown. This falcon died at age 63 days.

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Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-47630 - Black/green: 49/K

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 7/13/01 on DBNF at age 53 days. Originally I scheduled the release of this falcon for 7/8/01. However, I observed a bobcat at the hack site on 6/27/01 and despite considerable effort I was unable to trap and remove the bobcat until 7/13/01. I was unwilling to release this falcon (and its 3 siblings) until the bobcat was captured. This falcon remained on the PFA for 8 days and was observed eating at the hack site on several occasions. This falcon dispersed on 7/21/01 at age 61 days.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-47631 - Black/green: 15/H

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 7/13/01 on DBNF at age 54 days. Originally I scheduled the release of this falcon for 7/8/01. However, I observed a bobcat at the hack site on 6/27/01 and despite considerable effort I was unable to trap and remove the bobcat until 7/13/01. I was unwilling to release this falcon (and its 3 siblings) until the bobcat was captured. This falcon dropped its

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transmitter almost immediately upon release and was observed on the PFA for only 1 day after release. This falcon dispersed on 7/14/01 at age 55 days. Generally, peregrine falcons that disperse prematurely have low probability of surviving.

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77724 - Black/green: X/P

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 7/13/01 on DBNF at age 52 days. This was a very large female. This falcon appeared to be healthy and vigorous; however, upon release I noticed that its left wing seemed to be injured. This falcon held its left wing in a semi-extended position and moved around the hack site mainly by walking instead of short flights. I had not yet observed this falcon to fledge by 6/16/01 and its transmitter signal was in the valley below the hack site. While searching for this falcon on 6/16/01 and 6/17/01, it was observed running on the forest floor. Apparently it had dropped its transmitter. I was unable to capture this falcon so on 7/18/01 I assembled a team for assistance, including 2 Brittany Spaniels to aid in searching. Unfortunately, this falcon was not recovered and I suspect its mortality on 7/17 or 7/18/01 at age 56 or 57 days.

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Appendix H. (continued)

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77720 - Black/green: 02/B

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/18/02 on DBNF at age 46 days. Between 6/19 and 6/26 this falcon was observed frequently in the natal area. On 6/27 the falcon's transmitter entered mortality mode – the signal was emanating from a position midway between the ridge-top and the valley floor. I searched for the transmitter by entering the valley but apparently it was in an inaccessible cave or crevice on the cliff face. This falcon was not observed after 6/26/02 – I suspect mortality on 6/27/02 of unknown causes.

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77721 - Black/green: 03/B

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/18/02 on DBNF at age 46 days. This falcon remained on the PFA for 30 days and dispersed normally on 7/18/02 at age 76 days.

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Appendix H. (continued)

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77722 - Black/green: 04/B

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/18/02 on DBNF at age 45 days. I last observed this falcon on the PFA on 6/21/02. I did not observe this falcon eating at the hack site. On 6/27/02 this falcon was recovered by a WCO in Trimble County, KY – a linear distance from the hack site of approximately 165 km. The falcon was emaciated and died on 6/27/02 likely from a combination of hypoglycemia and dehydration.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-62815 - Black/green: 73/K

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/18/02 on DBNF at age 43 days. This falcon spent 7 days on the PFA and dispersed on 6/25/02 at age 50 days.

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Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-62816 - Black/green: 74/K

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

This falcon was found 6/24/02 dead in the hack box – 4 days before its scheduled release. Apparently, the falcon sustained an injury to its right wing while in the box and bled to death. The cause of the injury is unknown.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-62817 - Black/green: 75/K

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/28/02 on DBNF at age 49 days. This falcon remained on the PFA for 38 days – longer than any falcon released during the program. On 8/5/02 this falcon dispersed at age 87 days. On 6/20/03 this falcon returned to the hack site as an adult. At the time there were 6 recently released juveniles on the PFA. This falcon behaved aggressively towards both males and females. However, 2 of the juvenile males (25/P and 26/P) had been on the wing for 7 days and were capable of defending themselves successfully. Among the other 4 juveniles on the PFA, 3 were females. All were able to defend themselves

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successfully and several (04/E and 05/E) were soon observed to aggressively exclude this falcon from the hack boards. Unfortunately, the remaining juvenile male (27/P) was an inexperienced flyer at the time of this falcon's arrival and bore the brunt of the aggressive behavior.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-62818 - Black/green: 76/K

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/28/02 on DBNF at age 49 days. Between 6/30 and 7/6 this falcon was observed frequently in the natal area. This falcon appeared to be strong and agile in flight. On 7/8 the falcon's transmitter entered mortality mode – the signal was emanating from a position midway between the ridge-top and the valley floor, similar to the location of the transmitter of 02/B. I searched for the transmitter by entering the valley but, like 02/B, apparently it was in an inaccessible cave or crevice on the cliff face. This falcon was not observed after 7/8/02 – I suspect mortality on 7/9/02 of unknown causes.

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Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77723 - Black/green: 05/B

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/28/02 on DBNF at age 48 days. This falcon spent 24 days on the PFA and dispersed on 7/22/02 at age 72 days.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-62819 - Black/green: 77/K

Breeder: Bill Murphy, Watsonville, CA - Release site coordinates UTM 17 S: N 4190662 E 0263489

While in the hack box, this falcon became noticeably less vigorous than the other 3 falcons with which it shared the box. I removed the falcon from the hack box 7/21/02 for veterinary evaluation and treatment. I coordinated treatment of this falcon through Eileen Wicker of Raptor Rehabilitation of KY Inc., and Dr. Robin Sheldon of Pets Plus Veterinary Care Center in Louisville, KY. The falcon had whitish plaques on the pharyngeal surfaces and depressed or damaged feather development near the lateral surfaces of the head and the tips of retrices. We cultured *Enterococcus faecalis* and *Proteus mirabilis* and determined

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that the falcon suffered from trichomoniasis with overgrowth of *E. faecalis* and *P. mirabilis*. The falcon was placed on a 10-day treatment regimen that included administration of clavamox, ketaconazole, and flagyl. For restoration of feather condition the falcon was transferred to the Raptor Center at the University of Minnesota College of Veterinary Medicine. Four primaries on each wing and a full set of tail retrices were replaced. The falcon made a full recovery and was hacked at the Mayo Clinic Building in Rochester Minnesota in December 2002.

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77727 - Black/green: 06/B

Breeder: Bill Murphy, Watsonville, CA - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 7/25/02 on DBNF at age 50 days. This falcon was scheduled for release 3 days earlier on 7/22, but the release was delayed until I could trap and relocate a raccoon that was observed at the hack site. This falcon spent 16 days on the PFA and dispersed on 8/10/02 at age 66 days.

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Appendix H. (continued)

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-62820 - Black/green: 78/K

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 7/25/02 on DBNF at age 50 days. This falcon was scheduled for release 3 days earlier on 7/22, but the release was delayed until I could trap and relocate a raccoon that was observed at the hack site. This falcon spent 7 days on the PFA and dispersed on 8/1/02 at age 57 days.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 1807-77728 - Black/green: 79/K

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 7/25/02 on DBNF at age 50 days. I used a female federal band for this falcon because male bands were unavailable. This falcon was scheduled for release 3 days earlier on 7/22, but the release was delayed until I could trap and relocate a raccoon that was observed at the hack site. This falcon spent 18 days on the PFA and dispersed on 8/12/02 at age 68 days. On 10/16/02 I was notified by KDFWR that Chuck Culp of Wingspan of Kentucky, Inc. recovered this falcon on 10/13/02 in

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Appendix H. (continued)

Shepherdsville, KY a short distance south of Louisville, KY. The falcon was unable to fly and apparently had sustained an injury to its right wing. The falcon was presented to Dr. Joe Deck of the Deck Veterinary Clinic in Louisville, KY. Dr. Deck noted that the falcon was alert and aggressive. Its eyes, ears, nares, and mouth were normal. On auscultation the heart rate was regular and there were no murmurs. The lungs and air sacs were clear and respiration was regular. No abnormalities were noted on abdominal palpation. The skeletal and muscular systems were normal except for a fracture of the distal right ulna and associated soft tissue swelling. There were two penetrating wounds – one superficial to the distal right ulna and one superficial to the right ventral abdomen. Radiographs were taken. There was an oblique fracture of the right distal ulna with a hairline crack running parallel in the distal segment. The right radius was intact. The fractured ulna was in good alignment and angulation, held in place by the adjacent radius. There were two metallic projectiles; one was lodged at the site of the fractured ulna and the other on the right side of and superficial to the abdominal cavity. Apparently this falcon was shot. The falcon was masked under anesthesia with isoflurane and oxygen. One metallic projectile was removed from the subcutis on the right side of the abdomen. However the other projectile associated with the ulna fracture could not be found because of the soft tissue swelling. Surgery to repair the ulna fracture was deemed unnecessary since the intact radius held the ulna segments in near-perfect reduction. The right wing was wrapped in a

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figure eight bandage to decrease movement at the fracture site. Recovery from anesthesia was uneventful and the falcon was provided the antibiotic trimethaprine-sulfa. The falcon was transferred to Chuck Culp of Wingspan of Kentucky, Inc. for rehabilitation. This peregrine falcon was successfully rehabilitated and released on 10/15/03 in Oldham County, Kentucky.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-69829 - Black/green: 25/P

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/14/03 on DBNF at age 44 days. This falcon spent 17 days on the PFA and dispersed on 7/1/03 at age 61 days. The behavior of this falcon seemed to be influenced only minimally by the presence of the adult 75/K. For example, this falcon would approach the hack boards warily and often eat more quickly than previous falcons. Also, this falcon often perched a greater distance from the hack site than was typical. Nonetheless, this falcon was capable of defending itself successfully against aggressive behavior by 75/K and I suspect that the timing of dispersal of this falcon was influenced only minimally. On 7/21/03 I was notified by Jim Fitzpatrick of the Carpenter Nature Center in Hastings, MN, that this falcon had been recovered several days prior along a highway in northern lower Michigan. Specifically, Ed Pike, a raptor rehabilitator and bird bander based in Rogers

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City, MI recovered this falcon on 7/18/03 several km SW of Cheboygan, MI. Ed Pike reported that the falcon appeared thin but not emaciated, and that no injury was apparent. After providing food, the falcon's flight ability was examined in a flight cage. The falcon was unable to sustain flight, and Ed Pike reported that he suspected that the falcon might have sustained a minor muscular or nervous injury. Presently, Mr. Pike, in association with veterinarians at Michigan State University, are rehabilitating the falcon and attempting to assess its predatory ability with the intent of releasing it upon full recovery and demonstration of killing ability.

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 2206-69830 - Black/green: 26/P

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/14/03 on DBNF at age 44 days. This falcon spent 17 days on the PFA and dispersed on 7/1/03 at age 61 days. This falcon behaved similarly to 25/P in the presence of the adult 75/K. This falcon tended to perch a greater distance from the hack site than was typical. Nonetheless, like 25/P, this falcon was capable of defending itself successfully against aggressive behavior by 75/K and I suspect that the timing of dispersal of this falcon was influenced only minimally.

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Appendix H. (continued)

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77729 - Black/green: 03/E

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/20/03 on DBNF at age 45 days. This falcon spent 7 days on the PFA and dispersed on 6/27/03 at age 52 days. This falcon was large, independent, and aggressive. It made the longest fledging flight – exceeding 1 min – among falcons released during the program. Generally, fledging flights were considerably briefer that 1 min. This falcon appeared to be affected only minimally in its behavior by the adult male 75/K.

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77741 - Black/green: 04/E

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/20/03 on DBNF at age 45 days. Despite the presence of the adult male, this falcon spent 35 days on the PFA and dispersed on 7/25/03 at age 80 days. Initially, the adult male made efforts to aggressively exclude this falcon from the hacking station. However, this falcon's large size and emerging aggressive disposition later enabled her to conduct her daily

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movements unimpeded by the adult. In fact, this falcon was aggressively excluding the adult male from hack boards and perch sites within 6 days of their co-occupancy of the territory.

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77743 - Black/green: 05/E

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190410 E 0267290

I released this falcon 6/20/03 on DBNF at age 45 days. Despite the presence of the subadult male, this falcon spent 35 days on the PFA and dispersed on 7/25/03 at age 80 days. Initially, the adult male made efforts to aggressively exclude this falcon from the hacking station. However, like 04/E, this falcon's large size and emerging aggressive disposition later enabled her to conduct her daily movements unimpeded by the adult. In fact, like 04/E, this falcon was aggressively excluding the

though this falcon and 04/E exhibited similar movement and dispersal patterns. However, by 7/25/03, I located this falcon for the last time near Winchester, Kentucky – a considerable distance from the 7/25/03 location of 04/E.

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Appendix H. (continued)

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 1807-77742 - Black/green: 27/P

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4190662 E 0263489

I released this falcon 6/20/03 on DBNF at age 44 days. This falcon spent 4 days on the PFA and dispersed on 6/24/03 at age 48 days. The behavior of this falcon, including feeding behavior and dispersal timing, likely was influenced considerably by the adult male 75/K. Among juveniles on the PFA, this falcon was the least experienced or smallest falcon in the presence of the adult. On several occasions I observed the adult knock this falcon out of the sky. It did not appear as though this falcon became injured in these conflicts. However, I observed this falcon eating at the hack site only once and its dispersal seemed premature. Unfortunately, this falcon's likelihood of survival was low.

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Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 1807-77744 - Black/green: 28/P

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4183501 E 0708897

I released this falcon 6/26/03 at the Tom Dorman State Nature Preserve (TDSNP) at age 43 days. This falcon spent 34 days on the PFA and dispersed on 7/30/03 at age 77 days. This falcon, like its siblings, retained a close association with the hacking station despite the impromptu release arrangements (see Chapter 6).

Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 1807-77745 - Black/green: 29/P

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4183501 E 0708897

I released this falcon 6/26/03 at TDSNP at age 45 days. This falcon spent 34 days on the PFA and dispersed on 7/30/03 at age 79 days. This falcon, like its siblings, retained a close association with the hacking station despite the impromptu release arrangements (see Chapter 6).

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Peregrine falcon – Male - Subspecies: *anatum* - USFWS: 1807-77746 - Black/green: 30/P

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4183501 E 0708897

I released this falcon 6/26/03 at TDSNP at age 45 days. This falcon spent 36 days on the PFA and dispersed on 8/1/03 at age 81 days. This falcon, like its siblings, retained a close association with the hacking station despite the impromptu release arrangements (see Chapter 6).

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-77747 - Black/green: 06/E

Breeder: Mark Bolton, Hugo, MN - Release site coordinates UTM 17 S: N 4183501 E 0708897

I released this falcon 6/26/03 at TDSNP at age 47 days. This falcon dropped its transmitter on 7/24/03. Final visual observations were made on this falcon at the hack site on 7/26/03; however, the precise timing of dispersal is unknown. Based on the behavior of other peregrine falcons released as part of this cohort, I suspect that this falcon spent 30-35 days on the PFA and dispersed 7/26/03 – 7/30/03 at age 77-82 days.

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Appendix H. (continued)

Peregrine falcon – Female - Subspecies: *anatum* - USFWS: 1807-91967 - Black/green: 07/E

Breeder: Wild-produced in Milton, KY. Recovered and presented by John Castrale (Indiana Department of Natural resources) and Jason Lewis (United States Fish and Wildlife Service).

Release site coordinates UTM 17 S: N 4183501 E 0708897

I released this falcon 6/26/03 at TDSNP. Being wild-produced, its precise age is unknown. However, based on its development and on the general timing of fledging among Kentucky's breeding locations (Carter 2003), I suspect that this falcon was 50-55 days old at release. This falcon spent 27 days on the PFA and dispersed on 7/23/03. If my estimate of age-at-release is accurate, this falcon dispersed at age 77-82 days. This falcon was vigorous and aggressive, and it dominated its siblings in terms of feeding and defensive behavior.

References

Amaral, M., R. Currie, P. Delphey, M. Green, R. Hazlewood, A. Matz, R. Mesta, M. Morin, and T. Swem. 2003. Post-delisting Monitoring Plan for the American Peregrine Falcon, *Falco peregrinus anatum*. U. S. Fish and Wildlife Service.

Ambrose, R.E., and K.E. Riddle. 1988. Population dispersal, turnover, and migration of Alaska peregrines. Pages 677-684 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. Peregrine Fund Inc., Boise, ID, USA.

Armstrong, D.P., T. Soderquist, and R. Southgate. 1994. Designing experimental reintroductions as experiments. Pages 27-29 *in* M. Serena, editor. Reintroduction biology of Australian and New Zealand fauna. Surrey Beatty and Sons, Chipping Norton, Australia.

Banasch, U., J. Paul Goosen, A.E. Reiz, C. Casler, and R.D. Barradas. 1992. Organochlorine contaminants in migrant and resident prey of Peregrine Falcons, *Falco peregrinus*, in Panama, Venezuela, and Mexico. Canadian Field Naturalist 106:493-498.

Barber, J.C., and M.M. Barber. 1988. Prey of an urban Peregrine Falcon-part II. Maryland Birdlife 44:37-39.

Barclay, J.H. 1980. Release of captive-produced peregrine falcons in the Eastern United States 1975-79. MS Thesis. Michigan Technological University, Houghton, MI, USA.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Barclay, J.H. 1988. Peregrine restoration in the eastern United States. Pages 549-558 *in* T.J. Cade, J.H. Enderson, C.G. Thelander and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Barclay, J.H., and T.J. Cade. 1983. Restoration of the peregrine falcon in the eastern United States. Bird Conservation 1:3-39.

Baril, A., J.E. Elliot, J.D. Sompers, and G. Erickson. 1990. Residue levels of environmental contaminants in prey species of the Peregrine Falcon, *Falco peregrinus*, in Canada. Canadian Field Naturalist 104:273-284.

Beebe, F.L. 1969. Passenger pigeons and peregrine ecology. Pages 399-402 *in* J.J. Hickey, editor. Peregrine falcon populations: their biology and decline. University of Wisconsin, Madison, Wisconsin, USA.

Beier, P., and R.F. Noss. 1998. Do habitat corridors really provide connectivity? Conservation Biology 12:1241-1252.

Beissinger, S.R., and M.I. Westphal. 1998. On the use of demographic models of population viability in endangered species management. Journal of Wildlife Management 62:821-841.

Bélisle, M., A. Desrochers, and M.-J. Fortin. 2001. Influence of forest cover on the movements of forest birds: a homing experiment. Ecology 82:1893-1904.

Bellrose, F. Jr. 1938. Duck hawks nesting in western Tennessee. Wilson Bulletin 50:139.

Belthoff, J.R., and A.M. Dufty Jr. 1998. Corticosterone, body condition and locomotor activity: a model for dispersal in screech-owls. Animal Behavior 55:405-415.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Berger, D.D., C.R. Sindelar Jr., and K.E. Gamble. 1969. The status of breeding peregrines in the Eastern United States. Pages 165-173 *in* J.J. Hickey, editor. Peregrine falcon populations: their biology and decline. University of Wisconsin, Madison, Wisconsin, USA.

Bird, D.M., and Y. Aubry. 1982. Reproductive and hunting behaviour in Peregrine Falcons, *Falco peregrinus*, in Southern Quebec. Canadian Field Naturalist 96:167-171.

Black, J.M. 1991. Reintroduction and restocking: guidelines for bird recovery programs. Bird Conservation International 1:329-334.

Block, W.M., A.B. Franklin, J.P. Ward Jr, J.L. Ganey, and G.C. White. 2001. Design and implementation of monitoring studies to evaluate the success of ecological restoration on wildlife. Restoration Ecology 9:293-303.

Bockoven, G.E.W. 1999. Peregrine falcon (Falco peregrinus) restoration in the Southern Appalachians. MS Thesis, Western Carolina University, Cullowhee, NC, USA.

Bond, R.M. 1946. The peregrine population of western North America. Condor 48:101-116.

Boynton, A.C., and R. Currie. 1993. Productivity of reintroduced peregrine falcons in western North Carolina. Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies 47:386-393.

Braun, E.L. 1950. Deciduous forests of North America. Blakiston, Philadelphia, USA.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Breitenmoser, U., C. Breitenmoser-Würsten, L.N. Carbyn, and S.M. Funk. 2001. Assessment of carnivore reintroductions. Pages 241-281 *in* J.L. Gittleman, S.M. Funk, D. Macdonald, and R.K. Wayne, editors. Carnivore conservation. Cambridge, London, UK.

Bolger, D.T., T.A. Scott, and J.T. Rotenberry. 2001. Use of corridor-like landscape structures by birds and small mammal species. Biological Conservation 102:213-224.

Burford, L.S. 1996. Peregrine falcon restoration in Kentucky: 1995-1996 summary report. Nongame Wildlife Program, Kentucky Department of Fish and Wildlife Resources, Project number W-45, Frankfort, KY, USA.

Burford, L.S. 1999. Peregrine falcon restoration: job performance report. Nongame Wildlife Program, Kentucky Department of Fish and Wildlife Resources, Project number W-45, Frankfort, KY, USA.

Burford, L.S., and D.C. Yancy. 1994. Peregrine falcon restoration in Kentucky: 1993-1994 summary report. Nongame Wildlife Program, Kentucky Department of Fish and Wildlife Resources, Project number W-45, Frankfort, KY, USA.

Burnham, W.A., W. Heinrich, C. Sandfort, E. Levine, D. O'Brien, and D. Konkel. 1988. Recovery effort for the peregrine falcon in the Rocky Mountains. Pages 565-574 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. Peregrine Fund Inc., Boise, ID, USA.

Bustamante, J. 1996. Population viability analysis of captive and released bearded vulture populations. Conservation Biology 10:822-831.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Cade, T.J. 1960. Ecology of the peregrine and gyrfalcon populations in Alaska. University of California Publications in Zoology 63:151-290.

Cade, T.J. 1998. Delisting the peregrine falcon: Management and mismanagement under the endangered species act. Transactions of the 63rd North American Wildlife and Natural Resources Conference 63:475-485.

Cade, T.J. 2000. Progress in translocation of diurnal raptors. Pages 343-372 *in* Chancellor, R.D., and B-U. Meyburg, editors. Raptors at Risk. WWGBP/Hancock House.

Cade, T.J., and D.M. Bird. 1990. Peregrine Falcons, *Falco peregrinus*, nesting in an urban environment: a review. Canadian Field-Naturalist 104:209-218.

Cade, T.J., J.H. Enderson, C.G. Thelander, and C.M. White. 1988. Peregrine falcon populations: their management and recovery. The Peregrine Fund, Inc., Boise, Idaho, USA.

Cade, T.J., P.T. Redig, and H.B. Tordoff. 1989. Peregrine falcon restoration: Expectation vs. reality. The Loon 61:160-162.

Cade, T.J., J.H. Enderson, and J. Linthicum. 1996. Guide to management of peregrine falcons at the eyrie. The Peregrine Fund Inc., Boise, ID, USA.

Cade, T.J., J.H. Enderson, L.F. Kiff, and C.M. White. 1997. Are there enough good data to justify de-listing the American peregrine falcon? Wildlife Society Bulletin 25:730-738.

Carter, K.M. 2003. Behavior and ecology of peregrine falcons in Kentucky. MS Thesis, University of Kentucky, Lexington, KY, USA.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Carter, K.M., M.J. Lacki, M.R. Dzialak, L.S. Burford, and R.O. Bethany. 2003. Food habits of peregrine falcons in Kentucky. Journal of Raptor Research 37:351-356.

Christopher, K.L. 1981. A survey of peregrine falcon habitat in upper Michigan with emphasis on reintroduction potential. MS Thesis, Michigan Technological University, Houghton, MI, USA.

Cohen, J. 1960. A coefficient of agreement for nominal scales. Education Psychology Measurements 20:37-46.

Connor, L.M., and B.W. Plowman. 2001. Using Euclidean distances to assess nonrandom habitat use. Pages 275-290 *in* J.J. Millspaugh, and J.M. Marzluff, editors. Radio tracking and animal populations. Academic Press, San Diego, CA, USA.

Connor, L.M., M.D. Smith, and L.W. Burger. 2003. A comparison of distance-based and classification-based analyses of habitat use. Ecology 84:526-531.

Corser, J.D., M. Amaral, C.J. Martin, and C.C. Rimmer. 1999. Recovery of a cliff-nesting Peregrine Falcon, *Falco peregrinus*, population in northern New York and New England, 1984-1996. Canadian Field-Naturalist 113:472-480.

Cox, D.R., and D. Oakes. 1984. Analysis of survival data. Chapman and Hall, New York, New York, USA.

Craig, G.R., D.D. Berger, and J.H. Enderson. 1988. Peregrine management in Colorado. Pages 575-586 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Cross, P.C., and S.R. Beissinger. 2001. Using logistic regression to analyze the sensitivity of PVA models: a comparison of methods based on African wild dog models. Conservation Biology 15:1335-1346.

DeMent, S.H., J.J. Chisolm Jr., J.C. Barber, and J.D. Strandberg. 1986. Lead exposure in an "urban" Peregrine Falcon and its avian prey. Journal of Wildlife Diseases 22:238-244.

Donázar, J.A., and O. Ceballos. 1990. Post-fledging dependence period and development of flight and foraging behaviour in the Egyptian Vulture *Neophron percnopterus*. Ardea 78:387-394.

Dunn, W.C., P.C. Krupin, and D.L. Anderson. 1980. Habitat survey and analysis of peregrine falcon reintroductions. United States Bureau of Land Management, Boise, ID, USA.

Dunning Jr., J.B. 1984. Body weights of 686 species of North American Birds. Western Bird Banding Association, Elden Publishing, Cave Creek, AZ, USA.

Durrell, L., and J. Mallinson. 1987. Reintroduction as a political and educational tool for conservation. Journal of Jersey Wildlife Preservation Trust 24:6-19.

Enderson, J.H. 1969. Peregrine and prairie falcon life tables based on band-recovery data. Pages 505-509 *in* J.J. Hickey, editor. Peregrine falcon populations: their biology and decline. University of Wisconsin Press, Madison, WI, USA.

Enderson, J.H., and G.R. Craig. 1988. Population turnover in Colorado peregrines. Pages 685-688 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Enderson, J.H., and G.R. Craig. 1997. Wide ranging by nesting peregrine falcons (*Falco peregrinus*) determined by radiotelemetry. Journal of Raptor Research 31:333-338.

Enderson J.H., and M.N. Kirven. 1983. Flights of nesting peregrine falcons recorded by telemetry. Journal of Raptor Research 17:33-37.

Enderson, J.H., G.R. Craig, W.A. Burnham, and D.D. Berger. 1982. Eggshell thinning and organochlorine residues in rocky mountain peregrines, *Falco peregrinus*, and their prey. Canadian Field-Naturalist 96:255-264.

Enderson, J.H., W. Heinrich, L. Kiff, and C.M. White. 1995a. Population changes in North American Peregrines. Transactions of the North American Wildlife and Natural Resources Conference 60:142-161.

Enderson, J.H., J. Larrabee, Z. Jones, C. Peper, and C. Lepisto. 1995b. Behavior of peregrines in winter in south Texas. Journal of Raptor Research 29:93-98.

Feinsinger, P. 2001. Designing field studies for biodiversity conservation. Island Press, Washington D.C., USA.

Ferrer, M. 1992. Natal dispersal in relation to nutritional condition in Spanish Imperial Eagles. Ornis Scandinavia 23:104-106.

Ferrer, M. 1993. Juvenile dispersal behaviour and natal philopatry of a long-lived raptor, the Spanish Imperial Eagle *Aquila adalberti*. Ibis 135: 132-138.

Fischer, J., and D.B. Lindenmayer. 2000. An assessment of the published results of animal relocations. Biological Conservation 96:1-11.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Fuller, M.R., W.S. Seeger, and L.S. Schueck. 1998. Routes and travel rates of migrating peregrine falcons *Falco peregrinus* and Swainson's Hawks *Buteo swainsoni* in the western hemisphere. Journal of Avian Biology 29:433-440.

Fyfe, R. 1969. The peregrine falcon in Northern Canada. Pages 101-114 *in* J.J. Hickey, editor. Peregrine falcon populations: their biology and decline. University of Wisconsin, Madison, WI, USA.

Fyfe, R.W. 1988. The Canadian peregrine falcon recovery program, 1967-1985. Pages 599-610 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Fyfe, R.W., U. Banasch, V. Benavides, N. Hilgert De Benavides, A. Luscombe, and J. Sanchez. 1991. Organochlorine residues in potential prey of Peregrine Falcons, *Falco peregrinus*, in Latin America. anadian Field Naturalist 104:285-292.

Gabler, J. 1983. The peregrine falcon in Virginia: survey of historic eyries and reintroduction effort. MS Thesis, College of William and Mary, Williamsburg, VA, USA.

Ganier, A.F. 1931. Nesting of the duck hawk in Tennessee. Wilson Bulletin 43:3-8.

Gilpin, M.E. 1987. Spatial structure and population vulnerability. Pages 125-139 *in* M.E. Soulé, editor. Viable populations for conservation. Cambridge University Press, Cambridge, UK.

Gobeil, J-F., and M.-A. Villard. 2002. Permeability of three boreal forest landscape types to bird movements as determined from experimental translocations. Oikos 98:447-458.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Gonterman, W.L. 1929. The passenger pigeon in Western Kentucky. MS Thesis, University of Kentucky, Lexington, KY, USA.

Goodman, D. 1980. Demographic intervention for closely managed populations. Pages 171-195 *in* M.E. Soulé, and B.A. Wilcox, editors. Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Inc., Sunderland, MA, USA.

Grebence, B.L., and C.M. White. 1989. Physiographic characteristics of peregrine falcon nesting habitat along the Colorado River system in Utah. Great Basin Naturalist 49:408-418.

Green, R.E., M.W. Pienkowski, and J.A. Love. 1996. Long-term viability of the re-introduced population of the white-tailed eagle *Haliaeetus albicilla* in Scotland. Journal of Applied Ecology 33:357-368.

Greenwood, P.J. 1980. Mating systems, philopatry and dispersal in birds and mammals. Animal Behavior 28:1140-1162.

Grier, J. W. 1980a. Modeling approaches to bald eagle population dynamics. Wildlife Society Bulletin 8:316-322.

Grier, J.W. 1980b. Ecology: a simulation model for small populations of animals. Creative Computing 6:116-121.

Grier, J.W., and J.H. Barclay. 1988. Dynamics of a founder population established by reintroduction. Pages 689-700 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Griffith, B., J.M. Scott, J.W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477-480.

Henry, V.G. 1987. Peregrine falcon restoration in the Southern Appalachians. Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium 1987:28-39.

Herbert, R.A., and K.G.S. Herbert. 1969. The extirpation of the Hudson River peregrine falcon population. Pages 133-154 *in* J.J. Hickey, editor. Peregrine falcon populations: their biology and decline. University of Wisconsin, Madison, WI, USA.

Hickey, J.J. 1942. Eastern population of the duck hawk. Auk 39:176-204.

Hickey, J.J. 1969. Peregrine falcon populations: their biology and decline. University of Wisconsin press, Madison, WI, USA.

Hickey, J.J., and D.W. Anderson. 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish eating birds. Science 162:271-273.

Hickey, J.J., and D.W. Anderson. 1969. The peregrine falcon: life history and population literature. Pages 3-42 *in* J.J. Hickey, editor. Peregrine falcon populations: their biology and decline. University of Wisconsin, Madison, WI, USA.

Hiraldo, F., J.J. Negro, J.A. Donázar, and P. Gaona. 1996. A demographic model for a population of the endangered lesser kestrel in southern Spain. Journal of Applied Ecology 33:1085-1093.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Holroyd, G.L., and U. Banasch. 1990. The reintroduction of the Peregrine Falcon, *Falco peregrinus anatum*, into southern Canada. Canadian Field-Naturalist 104:203-208.

Hosmer, D.W., and S. Lemeshow. 2000. Applied logistic regression. John Wiley and Sons, Inc., New York, NY, USA.

Howard, W.E. 1960. Innate and environmental dispersal of individual vertebrates. American Midland Naturalist 63:152-161.

Hunt, W.G. 1988. The natural regulation of peregrine falcon populations. Pages 667-676 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Hunt, W.G. 1998. Raptor floaters at Moffat's equilibrium. Oikos 82:191-197.

Hutto, R.L., S.M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103: 593-602.

Ims, R.A. 1994. Movement patterns related to spatial structures. Pages 85-109 *in* L. Hanson, L. Fahrig, and G. Merriam, editors. Mosaic landscapes and ecological processes. Chapman and Hall, New York, NY, USA.

IUCN/SSC Re-introduction Specialist Group. 1995. IUCN guidelines for re-introductions. Gland: IUCN.

Johnson, D.H. 1980. The comparison of usage availability data measurements for evaluating resource preference. Ecology 61:65–71.

Jones, F.M. 1946. Duck hawks of eastern Virginia. Auk 63: 592.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Kaplan,E.L., and P. Meier. 1958. Nonparametric estimation from incomplete observations. Journal of the American Statistical Association 53:457-481.

Kenward, R.E., V. Marcstöm, and M. Karlbom. 1993. Post-nestling behaviour in Goshawks, *Accipiter gentilis*: I. The causes of dispersal. Animal Behavior 46:365-370.

King, R.A., and J.R. Belthoff. 2001. Post-fledging dispersal of burrowing owls in southwestern Idaho: characterization of movements and use of satellite burrows. The Condor 103:118-126.

Kleiman, D.G. 1989. Reintroduction of captive mammals for conservation. BioScience 39:152-161.

Kleiman, D.G., B.B. Beck, J. M. Dietz, and L.A. Dietz. 1991. Costs of a reintroduction and criteria for success: accounting and accountability in the golden lion tamarin conservation program. Pages 125-142 *in* J.H.W. Gipps, editor. Beyond captive breeding: re-introducing endangered species to the wild. Oxford University Press, Oxford, UK.

Kleiman, D.G., M.R. Stanley Price, and B.B. Beck. 1994. Criteria for reintroductions. Pages 287-303 *in* P.J.S. Olney, G. M. Mace, and A.T.C. Feistner, editors. Creative conservation: Interactive Management of Wild and Captive Animals. Chapman and Hall, London, UK.

Knight, K. 1983. Historic peregrine falcon eyries in West Virginia. United States Fish and Wildlife Service, Asheville, NC, USA.

Kopimärki, E., and K. Norrdahl. 1991. Numerical and functional responses of Kestrels, short-eared owls to vole densities. Ecology 72:814-826.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Lanier, J.W., J.E. McGowan, and B. J. Hill. 1983. Peregrine falcon reintroduction program on the White Mountain National Forest. Transactions of the 40th Northeast Fish and Wildlife Conference 40:167.

Lindberg, P. 1977. The peregrine falcon in Sweden. Pages 329-338 *in* R.D. Chancellor, editor. Proceedings of the ICBP World Conference on Birds of Prey. London, UK.

Machtans, C.S., M.-A. Villard, and S.J. Hannon. 1996. Use of riparian buffer strips as movement corridors by forest birds. Conservation Biology 10:1366-1379.

Martin, C.J., and D.J. North. 1993. Peregrine falcons incubate clutch of eggs for minimum of 73 days. Journal of Raptor Research 27:173.

Martell, M.S., H.B. Tordoff, and P.T. Redig. 1994. The introduction of three native raptors into the midwestern United States. Pages 465-470 *in* B.U. Meyburg and R.D. Chancellor, editors. Raptor Conservation Today. WWGBP/The Pica, Berlin, Germany.

Marzluff, J.M., S.T. Knick, M.S. Vekasy, L.S. Schueck, and T.J. Zarriello. 1997. Spatial use and habitat selection of golden eagles in southwestern Idaho. Auk: 114:673-687.

McCarthy, C., L. Aulman, and T. Russi. 1986. Peregrine falcon reintroduction efforts in the eastern Sierra Nevada. Transactions of the Western Section of the Wildlife Society 22:1-6.

McCarthy, M.A., M.A. Burgman, and S. Ferson. 1995. Sensitivity analysis for models of population viability. Biological Conservation 73:93-100.

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McCarthy, M.A., M.A. Burgman, and S. Ferson. 1996. Logistic sensitivity and bounds for extinction risks. Ecological Modelling 86:297-303.

McGarigal, K., and J.D. Fraser. 1984. The effect of forest stand age on owl distribution in southwestern Virginia. Journal of Wildlife Management 48:1393-1397.

McGrain, P. 1983. The geologic story of Kentucky. Special Publication 8, series XI. Kentucky Geological Survey, University of Kentucky, Lexington, KY, USA.

McNab, W.H. 1989. Terrain shape index: quantifying effect of minor landforms on tree height. Forest Science 35:91-104.

Mearns, R. 1985. The hunting ranges of two female peregrines towards the end of a breeding season. Journal of Raptor Research 19:20-26.

Mearns, R., and I. Newton. 1984. Turnover and dispersal in a Peregrine *Falco peregrinus* population. Ibis 126:347-355.

Mengel, R.M. 1939. Summer records from Cumberland National Forest. The Kentucky Warbler 15:45-47.

Mengel, R.M. 1965. The birds of Kentucky. American Ornithologists' Union Monographs Number 3, The Allen Press, Lawrence, KS, USA.

Mid-American Remote Sensing Center. 2001. Vegetation map of Kentucky. Murray State University, Murray, KY, USA.

Miller, G.S., R.J. Small, and E.C. Meslow. 1997. Habitat selection by spotted owls during natal dispersal in western Oregon. Journal of Wildlife Management 61:140-150.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Miller, P.S., and R.C. Lacy. 1999. VORTEX: A stochastic simulation of the extinction process. Version 8 user's manual. Apple Valley, MN, USA.

Millsap, B.A., P.L. Kennedy, M.A. Byrd, G. Court, J.H. Enderson, and R.N. Rosenfield. 1998. Review of the proposal to de-list the American peregrine falcon. Wildlife Society Bulletin 26:522-538.

Mora, M., R. Skiles, B. McKinney, M. Paredes, D. Buckler, D. Papoulias, and D. Klein. 2002. Environmental contaminants in prey and tissues of the Peregrine Falcon in the Big Bend Region, Texas, USA. Environmental Pollution 116:169-176.

Morrison, M.L. 2002. Wildlife restoration: techniques for habitat analysis and animal monitoring. Island Press, Washington, D.C. USA.

Myers, L.M., and J.L. Pease. 1995. Analysis of Peregrine Falcon (*Falco peregrinus*) food habits. Iowa Bird Life 2: 25-29.

Nelson, R.W. 1987. Where are the Alberta-released peregrines? Alberta Naturalist 17:4-9.

Nelson, R.W. 1988. Do large natural broods increase mortality of parent peregrine falcons? Pages 719-728 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Newton, I. 1979. Population ecology of raptors. T and AD Poyser, Berkhamsted, England.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Newton, I., and R. Mearns. 1988. Population ecology of peregrines in south Scotland. Pages 651-666 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Olsen, P.D., and J. Olsen. 1988. Population trends, distribution, and status of the peregrine falcon in Australia. Pages 255-274 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, ID, USA.

Pagel, J.E., and D.A. Bell. 1997. Reply to Cade et al. regarding de-listing the American peregrine falcon. Wildlife Society Bulletin 25:739-742.

Pagel, J.E., D.A. Bell, and M.L. Johnson. 1998. When is an endangered species recovery complete: Is delisting the American peregrine falcon appropriate? Transactions of the 63rd North American Wildlife and Natural Resources Conference 63:463-474.

Pagel, J.E., D.A. Bell, and B.E. Norton. 1996. De-listing the American peregrine falcon: is it premature? Wildlife Society Bulletin 24:429-435.

Paine, R.T., J.T. Wooten, and P.D. Boersma. 1990. Direct and indirect effects of peregrine falcon predation on seabird abundance. Auk 107:1-9.

Palmer-Ball Jr., B.L. 1996. The Kentucky breeding bird atlas. The University Press of Kentucky, Lexington, KY, USA.

Peakall, D.B. 1976. The Peregrine Falcon (*Falco peregrinus*) and pesticides. Canadian Field-Naturalist 90:301-307.

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Phillips, M.K. 1991. Measures of the value and success of a reintroduction project: Red Wolf reintroduction in Alligator River National Wildlife Refuge. Endangered Species Update 8:24-26.

Pindar, L.O. 1924. An early spring trip up the Kentucky River. Oologist 41:120-122.

Plissner, J.H., and S.M. Haig. 2000. Viability of piping plover *Charadrius melodus* metapopulations. Biological Conservation 92:163-173.

Pollock K.H., S.R. Winterstein, C.M. Bunck, and P.D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management 53:7-14.

Porter, R.D., and C.M. White. 1973. The peregrine falcon in Utah, emphasizing ecology and competition with the prairie falcon. Brigham Young University Science Bulletin Biological Series 18:1-74.

Powell, L.A., D.J. Calvert, I.M. Barry, and L. Washburn. 2002. Post-fledging survival and dispersal of peregrine falcons during a restoration project. Journal of Raptor Research 36:176-182.

Ratcliffe, D.A. 1967. Decreases in eggshell weight in certain birds of prey. Nature 215:208-210.

Ratcliffe, D. 1993. The Peregrine Falcon. Second edition. Buteo Books, Vermillion, SD, USA.

Redig, P.T., and H.B. Tordoff. 1989. Peregrine falcon restoration in the midwest and upper great lakes. Proceedings of the Midwest Raptor Management Symposium and Workshop/National Wildlife Federation Scientific and Technical Series; number 15:243-251.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reed, J.M., L.S. Mills, J.B. Dunning Jr., E.S. Menges, K.S. McKelvey, R. Frye, S.R. Beissinger, M. Anstett, and P. Miller. 2002. Emerging issues in population viability analysis. Conservation Biology 16:7-19.

Reed, J.M., D.D. Murphy, and P.F. Brussard. 1998. Efficacy of population viability analysis. Wildlife Society Bulletin 26:244-251.

Restani, M., and J.M. Marzluff. 2001. Avian conservation under the endangered species act: expenditures versus recovery priorities. Conservation Biology 15:1292-1299.

Restani, M, and W.G. Mattox. 2000. Natal dispersal of peregrine falcons in Greenland. Auk 117:500-504.

Rice, J. N. 1969. The decline of the peregrine falcon in Pennsylvania. Pages 155-164 *in* J.J. Hickey, editor. Peregrine falcon populations: their biology and decline. University of Wisconsin, Madison, WI, USA.

Richards, V.F. 1919. The early history of a duck hawk. Auk 36: 348-351.

Robbins, C.S. 1981. Bird activity levels related to weather. Pages 275-286 *in* C.J. Ralph and J.M. Scott, editors. Studies in Avian Biology, 6. The Allen Press, Lawrence, KS, USA.

Robichaud I., M.-A. Villard, and C.S. Machtans. 2002. Effects of forest regeneration on songbird movements in a managed forest landscape of Alberta, Canada. Landscape Ecology: 17:247-262.

Royce, C. 2002. Peregrine falcon sightings in downtown Lexington, Kentucky: December 2001- March 2002. Unpublished Report, Lexington Falcon Watch.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Scheuhammer, A.M. 1987. The chronic toxicity of Aluminum, Cadmium, Mercury, and Lead in birds: a review. Environmental Pollution 46:263-295.

Schneider, R., and I. Wilden. 1994. Choice of prey and feeding activity of urban peregrine falcons *Falco peregrinus* during the breeding season. Pages 203-209 *in* B.U. Meyburg, and R.D. Chancellor, editors. Raptor Conservation Today. WWGBP/The Pica Press, Berlin, Germany.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.

Sherrod, S.K. 1983. Behavior of fledgling peregrines. The Peregrine Fund, Inc., Ithaca, NY, USA.

Sherrod, S.K., W.R. Heinrich, W.A. Burnham, J.H. Barclay, and T.J. Cade. 1982. Hacking: a method for releasing peregrine falcons and other birds of prey. The Peregrine Fund, Inc., Ithaca, NY, USA.

Simberloff, D., J.A. Farr, J. Cox, and D.W. Mehlman. 1992. Movement corridors: conservation bargains or poor investments. Conservation Biology 6:493-504.

Small, R.J., J.C. Holzwart, and D.H. Rusch. 1993. Are ruffed grouse more vulnerable to mortality during dispersal? Ecology 74:2020-2026.

Smith, J. N. M., and P. Arcese. 1989. How fit are floaters? Consequences of alternative territorial behaviors in a nonmigratory sparrow. American Naturalist 133:830-845.

South, A., S. Rushton, and D. MacDonald. 2000. Simulating the proposed reintroduction of the European beaver (*Castor fiber*) to Scotland. Biological Conservation 93:103-116.

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Southgate, R., and H. Possingham. 1995. Modelling the reintroduction of the greater bilby *Macrotis lagotis* using the metapopulation model analysis of the likelihood of extinction. Biological Conservation 73:151-160.

Soderquist, T.R. 1994. The importance of hypothesis testing in reintroduction biology: examples from the reintroduction of the carnivorous marsupial *Phascogale tapoatafa*. Pages 159-164 *in* M. Serena, editor. Reintroduction biology of Australian and New Zealand fauna. Surrey Beatty and Sons, Chipping Norton, Australia.

Spofford, W.R. 1942. Nesting of the peregrine falcon in Tennessee. Migrant 8:29-31.

Spofford, W.R. 1943. Peregrines in a west Tennessee swamp. Migrant 14:25-27.

Spofford, W.R. 1950. Migratory and non-migratory peregrine falcons in Tennessee. Migrant 21:48-49.

Steidl, R.J., C.R. Griffin, L.J. Niles, and K.E. Clark. 1991. Reproductive success and eggshell thinning of a reestablished peregrine falcon population. Journal of Wildlife Management 55:294-299.

Stewart-Oaten, A., J.R. Bence, and C.W. Osenberg. 1992. Assessing effects of unreplicated perturbations: no simple solutions. Ecology 73:1396-1404.

Tewksbury, J.J., D.J. Levey, N.M. Haddad, S. Sargent, J.L. Orrock, A. Weldon, B.J. Danielson, J. Brinkerhoff, E.I. Damschen, and P. Townsend. 2002. Corridors affect plants, animals, and their interactions in fragmented landscape. Proceedings of the National Academy of Science 99:12923-12926.

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Therres, G.D., S. Dawson, and J.C. Barber. 1993. Peregrine falcon restoration in Maryland. Maryland Department of Natural Resources Fish, Heritage, and Wildlife Administration Wildlife Technical Publication 93-1.

Tischendorf, L., and L. Fahrig. 2000. How should we measure landscape connectivity? Landscape Ecology 15:633-641.

Titus, K., J. Mosher, and B.K. Williams. 1984. Chance-corrected classification for use in discriminant analysis: ecological application. American Midland Naturalist 111:1-7.

Todd, L.D. 2001. Dispersal patterns and post-fledging mortality of juvenile burrowing owls in Saskatchewan. Journal of Raptor Research 35:282-287.

Todd, L.D., R.G. Poulin, T.I. Wellicome, and R.M. Brigham. 2003. Post-fledging survival of burrowing owls in Saskatchewan. Journal of Wildlife Management 67:512-519.

Tordoff, H.B., M.S. Martell, and P.T. Redig. 1998. Effect of fledge site on choice of nest site by Midwestern peregrine falcons. The Loon 70:127-129.

Tordoff, H.B., M.S. Martell, and P.T. Redig. 1998. Midwest peregrine falcon restoration, 1998 report. Bell Museum of Natural history/The Raptor Center, University of Minnesota, Minneapolis, MN, USA.

Tordoff, H.B., M.S. Martell, P.T. Redig, and M.J. Solensky. 1999. Midwest peregrine falcon restoration, 1999 report. Bell Museum of Natural History, and the Raptor Center, University of Minnesota, Minneapolis, MN, USA.

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Tordoff, H.B., M.S. Martell, P.T. Redig, and M.J. Solensky. 2000. Midwest peregrine falcon restoration, 2000 report. Bell Museum of Natural History, and the Raptor Center, University of Minnesota, Minneapolis, MN, USA.

Tordoff, H.B., M.S. Martell, P.T. Redig, and M.J. Solensky. 2001. Midwest peregrine falcon restoration, 2001 report. Bell Museum of Natural History, and the Raptor Center, University of Minnesota, Minneapolis, MN, USA.

Tordoff, H.B., M.S. Martell, P.T. Redig, and M.J. Solensky. 2002. Midwest peregrine falcon restoration, 2001 report. Bell Museum of Natural History, and the Raptor Center, University of Minnesota, Minneapolis, MN, USA.

Tordoff, H.B., and P.T. Redig. 1988. Dispersal, nest-site selection, and age of first breeding in peregrine falcons released in the upper Midwest, 1982-1988. The Loon 60:148-151.

Tordoff, H.B., and P.T. Redig. 1997. Midwest peregrine falcon demography, 1982-1995. Journal of Raptor Research 31:339-346.

U.S. Fish and Wildlife Service. 1979. Eastern Peregrine Falcon Recovery Plan. Washington, D.C., U.S. Department of the Interior, Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and plants; final rule to remove the American peregrine falcon from the federal list of endangered and threatened wildlife; and to remove the similarity of appearance provision for free-flying peregrines in the conterminous United States. U.S. Fish and Wildlife Service, Bloomington, MN, USA.

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U.S. Fish and Wildlife Service. 2003. Notice of availability of the post-delisting monitoring plan for the American peregrine falcon (*Falco peregrinus anatum*). Federal Register 68:67698-67699.

United States Forest Service 1989. Cooperative inventory of endangered, threatened, sensitive, and rare species: Daniel Boone National Forest. USDA Forest Service, Winchester, KY, USA.

Ward, F.P., and R.C. Laybourne. 1985. A difference in prey selection by adult and immature peregrine falcons during autumn migration. ICBP Technical Publication No. 5.

Weaver, J.D., and T.J. Cade. 1991. Falcon propagation: a manual on captive breeding. The Peregrine Fund, Inc., Boise, ID, USA.

White, C.M. 1986. The peregrine-systematics and evolution. Pages xii-xxx *in* R.D. Porter, M.A. Jenkins, and A.L. Gaski, editors. Working bibliography of the peregrine falcon. National Wildlife Federation Scientific and Technical Series No. 9. Washington, D.C., USA.

White, C.M., and D.A. Boyce Jr. 1988. An overview of peregrine falcon subspecies. Pages 789-810 *in* T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White, editors. Peregrine falcon populations: their management and recovery. The Peregrine Fund, Inc, Boise, ID, USA.

White, C.M., and T.J. Cade. 1971. Cliff nesting raptors and ravens along the Colville River in arctic Alaska. Living Bird 10:107-150.

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White, C.M., and R.W. Nelson. 1991. Hunting range and strategies in a tundra breeding peregrine and gyrfalcon observed from a helicopter. Journal of Raptor Research 25:49-62.

White, G.C. 2000. Population viability analysis: data requirements and essential analyses. Pages 288-331 *in* L. Boitani, and T.K. Fuller, editors. Research techniques in animal ecology: controversies and consequences. Columbia University Press, New York, NY, USA.

Willey, D.W., and C. van Riper III. 2000. First-year movements by juvenile mexican spotted owls in the canyonlands of Utah. Journal of Raptor Research 34:1-7.

Wilson, G. 1940. The McElroy Farm-a study of a transient lake. The Kentucky Warbler 16:13-21

Wilson, G. 1942. Breeding birds of Kentucky-a composite list. The Kentucky Warbler 18:17-25.

Wooten, J.T., and D.A. Bell. 1992. A metapopulation model of the Peregrine falcon in California: viability and management strategies. Ecological Applications 2:307-321.

Wredge, P.H., and T.J. Cade. 1977. Courtship behavior of large falcons in captivity. Journal of Raptor Research 11:1-27.

Zar, J.H. 1996. Biostatistical analyses. Third edition. Prentice Hall, Upper Saddle River, NJ, USA.

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Research Assistantship

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Teaching Assistantship

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Publications

Dzialak, M.R., T.L. Serfass, C.L. Brown, and J.J. Krupa. Fall and winter diet of a reintroduced fisher (*Martes pennanti*) population in West Virginia and Maryland. Southeastern Naturalist: *in press*.

Larkin, J.L., J.J. Cox, M.W. Wichrowski, M.R. Dzialak, and D.S. Maehr. 2004. Influences on release site fidelity of translocated elk. Restoration Ecology: *in press*.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Dzialak, M.R., and T.L. Serfass. 2003. Effects of flumazenil on fishers *Martes pennanti* restrained with tiletamine-zolazepam. Wildlife Biology 9:235-239.

Carter, K.M., M.J. Lacki, M.R. Dzialak, L.S. Burford, and R.O. Bethany. 2003. Food habits of peregrine falcons in Kentucky. Journal of Raptor Research 37:351-356.

Dzialak, M.R., M.J. Lacki, D.S. Maehr, and K.M. LaDeur. 2003. Demographic influences on peregrine falcon reintroduction. Journal of the Kentucky Academy of Science 64:21-28.

Dzialak, M.R., and T.L. Serfass. 2002. Chemical restraint of the fisher. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 56:275-289.

Dzialak, M.R., and T.L. Serfass. 2002. Response of fishers to three different doses of Telazol. Journal of the Pennsylvania Academy of Science 76:3-6.

Dzialak, M.R., T.L. Serfass, D.L. Shumway, L.M. Hegde, and T.L. Blankenship. 2002. Chemical restraint of fishers (*Martes pennanti*) with ketamine and medetomidine-ketamine. Journal of Zoo and Wildlife Medicine 33:45-51.

Dzialak, M.R., T.L. Serfass, and T.L. Blankenship. 2001. Reversible chemical restraint of fishers with medetomidine-ketamine and atipamezole. Journal of Wildlife Management 65:157-163.

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ECOSYSTEM STUDIES OF MARINE MAMMALS AND SEABIRDS IN MONTEREY BAY, CA, 1996-99

A Thesis

Presented to

The Faculty of Moss Landing Marine Laboratories

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Marine Science

by

Scott Robert Benson

May 2002

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ABSTRACT

ECOSYSTEM STUDIES OF MARINE MAMMALS AND SEABIRDS IN MONTEREY BAY, CA, 1996-99

by Scott Robert Benson

Ecosystem studies were conducted in Monterey Bay, California during the upwelling seasons of 1996-99 to determine the distribution, relative abundance, and community structure of marine birds and mammals relative to oceanographic, physiographic, and lower-trophic variables. Monthly surveys were conducted in conjunction with sampling of physical water characteristics and hydroacoustic zooplankton backscatter. Impacts of the strong El Niño 1997/98 and La Niña 1999 were investigated. Species occurrence varied throughout the study. Baleen whale densities were linked to the occurrence of euphausiids. Warm-water species of odontocetes were more abundant during El Niño, increasing overall diversity. Community structure of seabirds and marine mammals was explored using a unimodal ordination technique, Canonical Correspondence Analysis. Species separated along environmental gradients representing bathymetric depth and slope (Canonical axis 1), and within-season variables including mixed layer depth. Subtle differences in species-environment relationships were identified for the different oceanographic periods during this study.

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The chapters in this thesis are written in the format of the journals to which they have been or will be submitted. I was the primary researcher and author, and my co-authors provided guidance and assistance with the research presented in these chapters. Chapter 1 has been accepted for publication in Progress in Oceanography. Chapter 2 will be submitted to Marine Ecology Progress Series.

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CHAPTER 1

CHANGES IN THE CETACEAN ASSEMBLAGE OF A COASTAL UPWELLING ECOSYSTEM DURING EL NIÑO 1997-98 AND LA NIÑA 1999

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ABSTRACT

We report results of ecosystem studies in Monterey Bay, California, during the summer upwelling periods, 1996-99, including impacts of El Niño 1997/98 and La Niña 1999. Random-systematic line-transect surveys of marine mammals were conducted monthly from August to November 1996, and May to November 1997-1999. CTDs and zooplankton net tows were conducted opportunistically and at 10 predetermined locations. Hydroacoustic backscatter was measured continuously while underway to estimate prevalence of zooplankton, with emphasis on euphausiids, a key trophic link betweeen primary production and higher trophic level consumers.

Occurrence of several of the California Current's most common cetaceans varied among years. The assemblage of odontocetes became more diverse during the El Niño with a temporary influx of warm-water species. Densities of cold-temperate Dall's porpoise, *Phocoenoides dalli*, were greatest before the onset of El Niño, whereas warm-temperate common dolphins, *Delphinus* spp., were present only during the warm-water period associated with El Niño. Rorqual densities decreased in August 1997 as euphausiid backscatter was reduced. In 1998, as euphausiid backscatter slowly increased, rorqual densities increased sharply to the greatest observed values. Euphausiid backscatter further increased in 1999, whereas rorqual densities were similar to those observed during 1998. It is hypothesized that a dramatic reduction in zooplankton biomass offshore during El Niño 1997/98 led to the concentration of rorquals in the

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remaining productive coastal upwelling areas, including Monterey Bay. These patterns exemplify short-term responses of cetaceans to large-scale changes in oceanic conditions.

INTRODUCTION

The distribution, abundance, and foraging success of top trophic level predators in marine systems, such as sharks, seabirds, pinnipeds, and cetaceans, is determined by large-scale oceanographic patterns and their effects on prey distribution and abundance (Smith, Dustan, Au, Baker & Dunlap, 1986; Kenney, Winn & Macaulay, 1995; Ainley, Sydeman & Norton, 1995a; Ainley, Veit, Allen, Spear & Pyle, 1995b; Pyle, Klimley, Anderson & Henderson, 1996; Tynan, 1997; Sydeman & Allen, 1999; Forney, 2000). Variability in physical features can be seasonal (Reid, Roden & Wyllie, 1958; Barber & Smith, 1981; Hutchings, Pitcher, Probyn & Bailey, 1995), interannual, (e.g. El Niño; Barber & Chavez, 1983), or decadal (McGowan, Cayan & Dorman, 1998). Such perturbations bring changes in nutrient upwelling, primary productivity, and zooplankton biomass within coastal upwelling systems (Lenarz, Schwing, Ventresca, Chavez, & Graham, 1995; Chavez, 1996; McGowan et al., 1998).

Marine vertebrates respond to ocean variability in a number of ways, including changes in survival and fecundity (Fiedler, Methot & Hewitt, 1986; Ainley et al., 1995a; Yoklavich, Loeb, Nishimoto & Daly, 1996) and shifts in distribution (Forney & Barlow, 1998; Tynan, 1999; Forney, 2000). Several studies have demonstrated that shifts in the distribution of birds and mammals can be linked to patterns of prey availability, including

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fish, cephalopods, and zooplankton (Ainley, Spear, Allen & Ribic, 1996; Fiedler, Reilly, Hewitt, Demer, Philbrick, Smith et al., 1998; Piatt, Drew, Van Pelt, Abookire, Nielsen, Shultz et al., 1999). While the effects of El Niño events on pinniped movements and population dynamics have been well documented along the North American west coast (Trillmich & Ono, 1991; Sydeman et al., 1999), few data are available regarding responses of cetaceans (Wells, Hansen, Baldridge, Dohl, Kelly, & Defran, 1990; Reilly & Fiedler, 1994; Tynan, 1999).

This study documents the effect of habitat variability on the cetacean assemblage of a coastal upwelling area within the California Current, spanning both the strongest El Niño recorded during the 20th century and the subsequent La Niña. The study area is located in Monterey Bay, California, (36°45'N, 122° 00'W) (Fig. 1), the largest bay (approximately 1,200 km^2) on the U.S. West Coast that is entirely open to the ocean. Water temperature, current patterns, and primary production in the upper water column in Monterey Bay are strongly influenced by springtime wind-driven upwelling north of the Bay (Rosenfeld, Schwing, Garfield & Tracy, 1994; Paduan & Rosenfeld, 1996), leading to high levels of primary production and zooplankton biomass (Rosenfeld et al., 1994; Service, Rice & Chavez, 1998; Pennington & Chavez, 2000). Monterey Bay is further distinguished by the presence of the Monterey Submarine Canyon, a canyon of similar dimensions as the Grand Canyon (Shepard, 1973), creating a unique combination of deep-sea and nearshore environments. This study, documents how changes in the physical dynamics and lower-trophic level biological responses during El Niño 1997/98 and La Niña 1999 led to changes in the distribution and abundance of baleen whales

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(rorquals) and smaller cetaceans (odontocetes) in the Monterey Bay upwelling ecosystem.

METHODS

Field Methods

The study area comprised approximately 909 km^2. Twenty-seven shipboard line-transect surveys were conducted monthly from August-November 1996 and May-November 1997-1999. Each survey consisted of seven transect lines, beginning at the 55-m (30-fathom) isobath and extending WNW to 122°05.00' west longitude, totaling approximately 126 km (68 nmi). Each line ranged in length from 10 km (5.4 nmi) to 22 km (11.9 nmi) (Fig. 1). The location of the northern-most line was selected randomly from within a 3-minute latitudinal range, and subsequent lines were spaced 5.5 km (3 nmi) apart toward the south to provide uniform and representative coverage of the area. A single survey was typically completed during two consecutive days. While the ship was moving along the transect line, three observers located atop the pilot house, 4.3 m above sea level, searched for marine mammals with the aid of 7X50 binoculars fitted with a compass and reticle markings. Line-transect methods (Buckland, Anderson, Burnham & Laake, 1993) were used, with sighting distances calculated from the compass bearings and reticle readings. Surveys were conducted at a ship speed of 18.5 km/hr (10 knots) in acceptable surface conditions (Beaufort sea states 0-5) and satisfactory visibility (1- 7 km). Sighting information and environmental conditions were recorded and updated

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throughout the survey with a laptop computer connected to a GPS receiver. Marine mammals were identified to the lowest possible taxonomic level.

Zooplankton backscatter was measured along tracklines using a Simrad EY-500 echosounder operating at 200 kHz with a ping interval of two seconds. The echosounder system was calibrated before and after each survey year using the standard sphere method (Johannesson & Mitson, 1983). Identification of acoustic targets was confirmed periodically by plankton tows using paired 0.7 m bongo nets fitted with 333 μm mesh (Marinovic, Croll, Gong, Benson & Chavez, in press). Ocean temperature profiles were obtained at pre-determined stations (Fig. 1) with a Sea-Bird 19 conductivity-temperature-depth (CTD) probe lowered to a depth of 200 m or to within 10 m of the bottom.

Analytical methods

Cetacean density

Cetacean abundance was estimated using standard line-transect analysis (Buckland et al., 1993). Owing to sample size limitations, it was necessary to pool sightings of different species for estimation of the probability density function, $f(x)$. Species having similar detection properties (body size, group sizes, behavior) were subjectively combined and then evaluated using a Kolmogorov-Smirnov test of perpendicular distance distributions. Only species whose distributions were not significantly different were combined in the final analyses. For each species group, the program DISTANCE (Laake, Buckland, Anderson & Burnham, 1996) was used to evaluate models of perpendicular distance. Data were truncated to eliminate 4-6% of the

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most distant sightings, and stratifications by sea state and group size were investigated. Half-normal, Hazard, and uniform models including cosine adjustments were evaluated. The model that minimized Akaike's Information Criteria (AIC) (Akaike, 1973) was selected for each species group. The remainder of the analyses were conducted using the program ABUND4 developed by Barlow (1995), because this program more effectively allows for multi-species calculations when performing stratified analyses. Cetacean densities, D, were calculated for each species as:

$$D = \frac{n \cdot s \cdot f(0)}{2 \cdot L} \qquad (1)$$

where n = number of sightings, s = average group size, $f(0)$ = the probability density function evaluated at zero perpendicular distance (km^{-1}), and L = the length of transect surveyed (km).

Temporal patterns of density were investigated for species with adequate sample sizes. The three most common rorquals, blue (*Balaenoptera musculus)*, fin (*B. physalus*), and humpback whales (*Megaptera novaeangliae*) forage on many of the same prey items (Schoenherr, 1991; Kieckhefer, 1992; Croll et al., 1998; Fiedler et al., 1998); therefore, they were combined into a single "rorqual" category for analysis. Gray whales (*Eschrichtius robustus*) were included in this category because they were observed foraging on krill during the only month in which they were sighted, May 1999. The most frequently encountered odontocetes included in the temporal density comparisons were

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the cold-temperate Dall's porpoise (*Phocoenoides dalli*) (Jefferson, 1988) and the warm-temperate common dolphins (Heyning & Perrin, 1994). Field identification of the two species of common dolphins was not always possible. Therefore, sightings of the long-beaked common dolphin (*Delphinus capensis*), short-beaked common dolphin (*D. delphis*), and unidentified common dolphin, (*Delphinus* sp.) were combined for analyses. To evaluate temporal patterns of the odontocete assemblage, encounter rates of schools were compared for all species regardless of sample size. This, in effect, normalized each species' temporal pattern to its mean school size and allowed interspecific patterns to be detected more effectively.

Hydroacoustic and oceanographic data analyses

Analysis of acoustic data followed the methodology of Hewitt and Demer (1993) and Croll et al. (1998). Echograms were generated from the sampled data set, and portions of the echogram were attributed to echos of krill based on the morphology and density of backscattering aggregations. Although acoustic backscatter can be attributable to a variety of zooplankton and fish species, the accuracy of krill characterization criteria used in this study was verified by 38, discrete-depth, targeted zooplankton tows in areas where backscatter was attributed to euphausiids (Marinovic et al., in press). Euphausiid surface area backscatter (m^2 / km^2), was calculated for each 0.93-km (0.5-nmi) transect segment, integrated to 200 m. Average krill density for the entire survey was estimated as the mean of the individual segment values. The maximum krill value observed on all segments during each survey was obtained as a measure of euphausiid density within

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aggregations. This may be important because whales forage in areas of highest relative euphausiid density (Schoenherr, 1991; Gendron, 1992; Tershy, 1992; Croll et al., 1998; Fiedler et al., 1998). During three surveys (19 Aug 1996, 25 Nov 1996 and 18 Aug 1997), krill density estimates were not available.

CTD profiles were processed using standard SEABIRD® software, bin-averaged at 1-m intervals. Mixed layer was defined as the layer between the surface and the depth at which the rate of change in temperature was greatest. Mixed layer depth and thermocline steepness were averaged across hydrographic stations to calculate a synoptic index for each survey. Depth of the 10 °C isotherm was estimated only from deep-water CTD casts (>100 m). Average sea-surface temperature (SST) and its standard deviation, a measure of within-survey spatial variability, was estimated for each survey from all CTD stations.

To investigate the relationships between species densities and measured environmental variables, a stepwise multiple regression was performed on log-transformed densities for the 24 surveys having complete environmental data. Potential predictors included average krill, maximum krill, mixed layer depth, thermocline slope, depth of the 10 °C isotherm, average SST, and standard deviation of SST. Correlated predictor variables were not simultaneously allowed in the regression model to avoid collinearity. The level of significance was set to $\alpha = 0.05$ for all tests.

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RESULTS

Oceanographic patterns

A detailed account of the evolution of El Niño 1997/98 is given by Chavez, Pennington, Castro, Ryan, Michisaki, Schlining et al. (in press). Physical effects of El Niño were apparent in the SST record obtained at mooring M1 (Fig. 1) during the period August 1997 through September 1998, after which La Niña conditions developed (Fig. 2A). The M1 SST values were highly correlated ($r^2 = 0.97$) with average SST values obtained from the CTD stations during the surveys. In August to November 1996, SST was low and increased slightly throughout the season, with a drop in November (mean for all surveys = 13.2 °C, SD = 0.53). During early summer 1997, SST was similar to values observed in 1996, but increased abruptly between the July and August surveys (13.9 °C to 17.1 °C), yielding a higher and more variable average SST for the survey season (15.6 °C, SD = 1.7). Temperatures were elevated but variable from May through November 1998 (seasonal average 14.1 °C, SD = 1.2). The lowest SST observed in the study occurred in May 1999, followed by a gradual warming through October (seasonal average 13.4 °C, SD = 1.2).

Although the average depth of the mixed layer increased as the seasons progressed in 1996 and 1997, it remained shallow (2-15 m) during 1998 and most of 1999. Particularly shallow mixed layer depths (2 - 10 m) were recorded during August - September 1996, May, July and September 1997, May-July 1998, and May-October 1999. In all years except 1998, the mixed layer deepened in November (1996: 25 m,

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1997: 41 m, 1998: 13 m, and 1999: 45 m). Depth of the 10 °C isotherm also increased within the survey season in all years except 1998 (Fig. 2C), when the isotherm rose to shallower depths in October. The 10 °C isotherm reached the deepest depths (>120 m) during the late summer and fall (late November 1996, August - November 1997, September 1998, and November 1999).

Biological patterns

Ninety-five percent of the 38 targeted net tows yielded high krill volumes and were composed primarily of krill, verifying the accuracy of the criteria used to characterize euphausiid backscatter. Four species of euphausiid dominated the samples: *Euphausia pacifica, Thysanoessa spinifera, Nemotoscelis difficilis* and *Nyctiphanes simplex* (Marinovic et al., in press). The latter species was observed only during the warm water period associated with El Niño. Euphausiid backscatter was greatest at cooler SST's - generally below 15 °C (Fig. 2B), and least when SST's peaked near 17 °C (August - November 1997). The greatest levels of krill backscatter were observed in fall 1998 and spring 1999 with the onset of La Niña conditions.

Cetacean densities were estimated based on the selected detection function models and stratification criteria that minimized AIC. Half-normal or Hazard rate models, with up to two cosine adjustments, were selected for all species groups (Table 1). Large whales did not require stratification by group size or sea state. Dolphin sightings were stratified into small groups (1-40) and large groups (>40), with small groups further stratified by sea state. Dall's porpoise analyses were stratified by sea state.

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Densities of large whales reflected patterns of euphausiid backscatter (Fig. 2B). Rorqual densities, dominated by humpback whales, were high during August 1996, May through July 1997, and most of 1998 and 1999. Greater densities corresponded to colder SST before 1998 and during 1999; however, densities of rorquals were also elevated during 1998 when SST was high. During late summer and fall 1997, when El Niño was most apparent, krill backscatter was low and few rorquals were present. A significant relationship was identified between rorqual densities and maximum krill backscatter ($p = 0.0002$, $r^2 = 0.47$, Table 2). Blue whales were absent during the warm water period corresponding to El Niño conditions (Fig. 3). Humpback whales dominated the rorqual assemblage in all years, and were commonly encountered over Monterey Canyon. Although they were initially scarce during the early period of El Niño in 1997 (Fig. 3), they were widespread in Monterey Bay during the late stages of El Niño in 1998 and during La Niña 1999. Fin whales were seen infrequently during 1996-98 and were not observed in 1999. Gray whales appeared only during May 1999 (La Niña) and were observed feeding on large surface swarms of *Thysanoessa spinifera*.

Species composition among odontocetes, as measured by the encounter rate of schools (Fig. 4), reflected changes in SST (Fig. 2A). During cool conditions that existed before the onset of El Niño in August 1997, temperate species dominated the odontocete assemblage: Dall's porpoise, harbor porpoise (*Phocoena phocoena*) and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*). As SST increased in August 1997, warm-temperate species that previously had been virtually absent became conspicuous: common dolphins and Risso's dolphin (*Grampus griseus*). In 1999, temperate species

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dominated the assemblage again, as cooler oceanographic conditions returned during La Niña. Density estimates were calculated for the most frequently encountered odontocetes, common dolphins and Dall's porpoise, to examine potential effects of environmental correlates. The stepwise regression analysis (Table 2) indicated a significant positive relationship between densities of common dolphins and the depth of the 10 °C isotherm (Fig. 2C). This corresponded to the appearance of common dolphins as the warm surface layer deepened with the onset of El Niño in 1997, and in late summer of 1998 (Chavez et al., in press). In contrast, none of the tested environmental variables explained a significant proportion of the variability in Dall's porpoise densities. Although densities were greater before El Niño (Fig. 2D), Dall's porpoise were seen consistently throughout the study period.

DISCUSSION

Rorquals

With the arrival of El Niño in 1997, Monterey Bay experienced decreased upwelling, increased water temperatures, and increased mixed layer (Chavez et al., in press). Whereas primary productivity was depressed, zooplankton abundance remained fairly high and cetacean abundances, particularly rorquals, also were high. Off California, rorquals forage in areas characterized by dense aggregations of *Euphausia pacifica, Thysanoessa spinifera,* and *Nyctiphanes simplex* (Schoenherr, 1991; Kieckhefer, 1992; Croll et al., 1998; Fiedler et al., 1998). Blue whales generally feed exclusively on krill (reviewed in Perry, DeMaster & Silber, 1999) while humpback and fin whales also

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forage on small schooling fish in the study area (Clapham, Leatherwood, Szczepaniak & Brownell, 1997). The abundance of rorquals in Monterey Bay during 1996-99 paralleled patterns of krill abundance. Few whales were present during the initial stages of El Niño (summer 1997) when krill abundance was low. Seasonally, whale abundance was greater during the summer and early fall periods of increased krill abundance, although the magnitude of this response varied among years (Fig. 2B). For example, euphausiid aggregations in late 1998 were not markedly larger than those measured before El Niño and were below levels recorded in 1999, but peak whale densities during 1998 were the greatest observed during the 4-year study.

The ability of marine mammals to forage at varying trophic levels and switch prey can obscure patterns of local abundance relative to oceanographic and lower trophic-level processes. Prey switching between krill and schooling fish likely complicated patterns in humpback whale abundance. The regression model (Table 2) explained less than 50% of the variability in rorqual density, implying that other; unmeasured factors (such as fish abundance) may have influenced the observed patterns. It is also possible that rorquals were responding to environmental factors at scales greater than those measured in this study, i.e. insufficient prey abundance outside the study area may have caused whales to aggregate disproportionately in the only remaining productive areas, including Monterey Bay, during 1998.

Local patterns of upwelling-favorable winds and their effect on primary and secondary production during the El Niño are described elsewhere (Chavez et al., in press; Marinovic et al., in press). The frequency and amplitude of upwelling events were

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reduced during El Niño 1997-98 throughout central California waters, and productivity was limited to a narrow zone along the coast. Although primary productivity was depressed within the study area, the reduction in productivity was greater beyond 50km from shore (Chavez et al., this issue). Thus, nearshore areas such as Monterey Bay may have represented an 'oasis' of productivity for zooplankton (Marinovic et al., this issue) and rorquals (this study). This hypothesis is consistent with previously observed patterns within Monterey Bay during El Niño 1991-93 (Kudela & Chavez, 2000).

In addition to total krill abundance, patch structure may have played a role in the distribution of rorquals. The regression results (Table 2) indicated that maximum krill density, a measure of the density of krill *within* patches, was the most significant predictor of whale density. This is consistent with previous studies of baleen whales and their prey (Wishner, Schoenherr, Beardsley & Chen, 1995; Fiedler et al., 1998). High euphausiid backscatter can be caused either by a high density of individuals or by a predominance of larger life stages (Greene, Stanton, Wiebe & McClatchie, 1991; Hewitt et al., 1993; Simard & Lavoie, 1999). Rorquals in Monterey Bay could have been targeting both dense aggregations of krill and aggregations that contained a greater proportion of larger adults; both types of aggregations were observed in net samples (Marinovic et al. in press), but they could not be differentiated in the hydroacoustic record. Euphausiids from blue whale fecal samples collected in the Santa Barbara Channel, California were larger than those in corresponding net samples (Croll et al., 1998). In a study of whale foraging ecology off southern California, Fiedler et al. (1998) speculated that blue whales targeted adult euphausiids.

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Odontocetes

Odontocetes off central California feed on a wide array of fishes and cephalopods (Jones, 1981; Jefferson, 1988; Osnes-Erie, 1999). Although prey abundance for odontocetes was not measured, the effects of the oceanographic perturbation caused by El Niño were nonetheless apparent in the odontocete assemblage. Following the onset of El Niño 1997-98, both the diversity and abundance of odontocetes in Monterey Bay increased. The increase in diversity (Figure 4) was caused by an influx of warm-water species, particularly common dolphins, coupled with the persistence of temperate species typically found off central California, such as Dall's porpoise, harbor porpoise, and Pacific white-sided dolphins. The abundance increase was driven largely by the appearance of large schools of 500-1,000 common dolphins.

Previous studies along the California coast found that temperate and warm-water odontocetes change their distribution and abundance as oceanographic conditions vary seasonally (Forney et al, 1998) and interannually (Forney, 2000). SST was a significant predictor of common dolphin and Dall's porpoise abundance off California in 1991-96 (Forney, 2000). Although oceanographic conditions were a significant predictor of common dolphin abundance in this study, hydrographic variables did not explain patterns of Dall's porpoise observed in Monterey Bay during 1996-99. This may relate to the fact that Dall's porpoise are regular constituents of the marine fauna of Monterey Bay (Jefferson 1991), whereas common dolphins are intermittent visitors.

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The movements of cetaceans and other mobile marine predators are driven primarily by changes in prey resources (Angel 1994). Odontocete prey are diverse, including small fishes and cephalopods whose abundance is difficult to measure directly when conducting marine mammal surveys. Prey, however, often respond directly to physical oceanographic conditions, particularly at lower trophic levels, (Fiedler, Methot, & Hewitt 1986; Angel, 1994; Marinovic et al., this study). For this reason, oceanographic properties, such as sea surface temperature and chlorophyll, have been used as proxies when modeling cetacean distribution patterns (Smith et al 1986; Forney 2000). The correlation of common dolphin densities in Monterey Bay with oceanographic conditions suggests that the prey base may have changed during the El Niño to include species not otherwise available. By inference, prey species consumed by Dall's porpoise may have persisted throughout the period, or prey switching enabled Dall's porpoise to remain in Monterey Bay despite changing oceanographic conditions.

The results of this study shed light on the local effects of El Niño and La Niña on cetaceans in this upwelling system, but it is important to understand the scale of this study in relation to the scales at which the physical and biological processes operate. Long-lived mobile marine predators, such as marine mammals, seabirds, and predatory fishes, generally respond to oceanographic perturbations at much larger temporal and spatial scales (Angel, 1994). Thus, observations made in a particular region could be driven by unmeasured oceanographic events in other areas.

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LITERATURE CITED

Ainley, D. G., Spear, L. B., Allen, S. G., & Ribic, C. A. (1996). Temporal and spatial patterns in the diet of the Common Murre in California waters. *The Condor*, 98, 691-705.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Ainley, D. G., Sydeman, W. J., & Norton, J. (1995a). Upper trophic level predators indicate interannual negative and positive anomalies in the California Current food web. *Marine Ecology Progress Series*, 118, 69-79.

Ainley, D. G., Veit, R. L., Allen, S. G., Spear, L. B., & Pyle, P. (1995b). Variations in marine bird communities of the California Current 1986-94. *CalCOFI Report*, 36, 72-77.

Akaike, H. (1973). Information theory and an extension of the maximum likelihood principle. In B. N. Petran & F. Csàaki, *Second International Symposium on Information Theory*, (pp. 267-281). Budapest: Akadèemiai Kiadi.

Angel, M. V. (1994). Long-term, large-scale patterns in marine pelagic systems. In P. S. Giller, A. G. Hildrew, & D. G. Raffaelli, *Aquatic Ecology: Scale, Pattern and Process* (pp. 403-439). Oxford: Blackwell Scientific Publications.

Barber, R. T., & Chavez, F. P. (1983). Biological consequences of El Niño. *Science*, 222, 1203-1210.

Barber, R. T., & Smith, R. L. (1981). Coastal upwelling ecosystems. In A. Longhurst, *Analysis of Marine Ecosystems*, (pp. 31-68). New York: Academic Press.

Barlow, J. (1995). The abundance of cetaceans in California waters, Part II: Ship surveys in summer and fall of 1991. *Fishery Bulletin*, 93, 1-14.

Buckland, S. T., Anderson, D. R., Burnham, K. P., & Laake, J. L. (1993). *Distance sampling: Estimating abundance of biological populations*. London: Chapman & Hall.

Chavez, F.P. (1996). Forcing and biological impact of the onset of the 1992 El Niño in central California. *Geophysical Research Letters*, 23, 265-268.

Chavez, F. P., Pennington, T. J., Castro, C. G., Ryan, J. P., Michisaki, R. P., Schlining, B., Walz, P., Buck, K. R., McFadyen, A., & Collins, C. A. (in press). Biological and chemical consequences of the 1997-98 El Niño in central California waters. *Progress in Oceanography.*

Clapham, P. J., Leatherwood, S., Szczepaniak, I., & Brownell, R. L., Jr. (1997). Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. *Marine Mammal Science*, 13, 368-394.

Croll, D. A., Tershy, B. R., Hewitt, R., Demer, D., Hayes, S., Fiedler, P., Popp, J., & Lopez, V. L. (1998). An integrated approach to the foraging ecology of marine birds and mammals. *Deep-Sea Research II*, 45, 1353-1371.

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Fiedler, P. C., Methot, R. D., & Hewitt, R. P., (1986). Effects of California El Niño 1982-1984 on the northern anchovy. *Journal of Marine Research*, 44, 317-338.

Fiedler, P. C., Reilly, S. B., Hewitt, R. P., Demer, D., Philbrick, V., Smith, S., Armstrong, W., Croll, D. A., Tershy, B. R., & Mate, B. R., (1998). Blue whale habitat and prey in the California Channel Islands. *Deep-Sea Research II*, 45,1781-1801.

Forney, K. A. (2000). Environmental models of cetacean abundance: a step towards reducing uncertainty in population trends. *Conservation Biology*, 14, 1271-1286.

Forney, K. A., & Barlow, J. (1998). Seasonal patterns in the abundance and distribution of California cetaceans, 1991-1992. *Marine Mammal Science*, 14, 460-489.

Gendron, D. (1992). Population structure of daytime surface swarms of *Nyctiphanes simplex* (*Crustacea Euphausiacea*) in the Gulf of California, Mexico. *Marine Ecology Progress Series*, 87, 1-6.

Greene, C. H., Stanton, T. K., Wiebe, P. H., & McClatchie, S. (1991). Acoustic estimates of Antarctic krill. *Nature*, 349, 110.

Hewitt, R. P., & Demer, D. A. (1993). Dispersion and abundance of Antarctic krill in the vicinity of Elephant Island in the 1992 austral summer. *Marine Ecology Progress Series*, 99, 29-39.

Heyning, J. E., & Perrin, W. F., (1994). Evidence for two species of common dolphin (genus *Delphinus*) from the eastern North Pacific. *Los Angeles County Museum of Natural History Contributions in Science*, 442, 1-35.

Hutchings, L., Pitcher, G. C., Probyn, T. A., & Bailey, G. W., (1995). The chemical and biological consequences of coastal upwelling. In C. P. Summerhayes, K. C. Emeis, M. V. Angel, R. L. Smith, & B. Zeitzschel, *Upwelling in the ocean: modern processes and ancient records* (pp. 64-81). New York: Wiley and Sons.

Jefferson, T. A. (1988). Phocoenoides dalli. *Mammalian Species*, 319, 1-7.

Jefferson, T. A. (1991). Observations on the distribution and behaviour of Dall's porpoise (*Phocoenoides dalli*) in Monterey Bay, California. *Aquatic Mammals* 17(1), 12-19.

Johannesson, K. A., & Mitson, R. B., (1983). Fisheries acoustics: a practical manual for aquatic biomass estimation. *FAO Fisheries Technical Paper*, 240, 249.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Jones, R. E. (1981). Food habits of smaller marine mammals from northern California. *Proceedings of the California Academy of Sciences*, 42(16), 409-433.

Kenney, R. D., Winn, H. E., & Macaulay, M. C. (1995). Cetaceans in the Great South Channel, 1979-1989: right whale (*Eubalaena glacialis*). *Continental Shelf Research*, 15, 385-414.

Kieckhefer, T. R. (1992). Feeding ecology of humpback whales in continental shelf waters near Cordell Bank, California. Master's thesis, San Jose State University, San Jose, California, unpublished.

Kudela, R. M., & Chavez, F. P. (2000). Modeling the impact of the 1992 El Niño on new production in Monterey Bay, California. *Deep Sea Research II*, 47, 1055-1076.

Laake, J.L., Buckland, S.T., Anderson, D.R., & Burnham, K.P. (1996). DISTANCE 2.2. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, Colorado.

Lenarz, W. H., Schwing, F. B., Ventresca, D. A., Chavez, F., & Graham, W. M. (1995). Explorations of El Niño events and associated biological population dynamics off central California. *CalCOFI Report*, 36, 106-119.

Marinovic, B., Croll, D. A., Gong, N., Benson, S. R., & Chavez, F. (in press). Effects of the 1997-98 El Niño on zooplankton within the Monterey Bay coastal upwelling system with emphasis on the Euphausiid community. *Progress in Oceanography.*

McGowan, J. A., Cayan, D. R., & Dorman, L. M. (1998). Climate-ocean variability and ecosystem response in the Northeast Pacific. *Science*, 281, 210-217.

Osnes-Erie, E. D. (1999). Food habits of common dolphin (*Delphinus delphis* and *D. capensis*) off California. Master's thesis, San Jose State University, San Jose, California, unpublished.

Paduan, J. D. & Rosenfeld, L. K. (1996). Remotely sensed surface currents in Monterey Bay from shore-based HF radar (Coastal Ocean Dynamics Application Radar). *Journal of Geophysical Research*, 101, 20669-20686.

Pennington, T. J., & Chavez, F. P. (2000). Seasonal fluctuations of temperature, salinity, nitrate, chlorophyll, and primary production at station H3/M1 over 1989-1996 in Monterey Bay, California. *Deep-Sea Research II*, 47, 947-973.

Perry, S. L., DeMaster, D. P., & Silber, G. K. (1999). The great whales: history and status of six species listed as endangered under the U. S. Endangered Species Act of 1973. *Marine Fisheries Review*, 61, 1-74.

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Piatt, J. F., Drew, G., Van Pelt, T., Abookire, A., Nielsen, J. L., Shultz, M., & Kitaysky, A. (1999). Biological effects of the 1997/98 ENSO in Cook Inlet, Alaska. *Proceedings of the 1998 Science Board Symposium on the Impacts of the 1997/98 El Niño event on the North Pacific Ocean and its marginal seas, PICES Scientific Report* 10, 93-99.

Pyle, P., Klimley, A. P., Anderson, S. D., & Henderson, R. P. (1996). Environmental factors affecting the occurrence and behaviour of white sharks at the Farallon Islands, California. In A. P. Klimley & D. G. Ainley, *Great white sharks: The biology of Carcharodon carcharnas* (pp. 281-291). California: Academic Press.

Reid, J. L., Jr., Roden, G. I. & Wyllie, J. G. (1958). Studies of the California Current System. *California Cooperative Oceanic Fisheries Investigations Report*, 6, 28-56.

Reilly, S. B. & Fiedler, P. C. (1994). Interannual variability of dolphin habitats in the eastern tropical Pacific, I: Research vessel surveys, 1986-90. *Fishery Bulletin* 92, 434-450.

Rosenfeld, L. K., Schwing, F. B., Garfield, N., & Tracy, D. E. (1994). Bifurcated flow from an upwelling center: a cold water source for Monterey Bay. *Continental Shelf Research*, 14, 931-964.

Schoenherr, J. R. (1991). Blue whales feeding on high concentrations of euphausiids around Monterey submarine canyon. *Canadian Journal of Zoology*, 69, 583-594.

Service, S. K., Rice, J. A. & Chavez, F. P. (1998). Relationship between physical and biological variables during the upwelling period in Monterey Bay, CA. *Deep-Sea Research II*, 45, 1669-1685.

Shepard. F. P. (1973). *Submarine Geology*, New York: Harper and Row.

Simard, Y., & Lavoie, D. (1999). The rich krill aggregation of the Saguenay - St. Lawrence Marine Park: Hydroacoustic and geostatistical biomass estimates, structure, variability, and significance for whales. *Canadian Journal of Fisheries and Aquatic Sciences*, 56, 1182-1197.

Smith, R. C., Dustan, P., Au, D., Baker, K. S., & Dunlap, E. A. (1986). Distribution of cetaceans and sea-surface chlorophyll concentrations in the California Current. *Marine Biology*, 91, 384-402.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Sydeman, W. J., & Allen, S. G. (1999). Pinniped population dynamics in central California: Correlations with sea surface temperature and upwelling indices. *Marine Mammal Science*, 15, 446-461.

Tershy, B. R. (1992). Body size, diet, habitat use, and social behavior of Balaenoptera whales in the Gulf of California. *Journal of Mammalogy*, 73, 477-486.

Trillmich, F., & Ono, K. A. (1991). *Pinnipeds and El Niño: Responses to environmental stress*, Berlin: Springer-Verlag.

Tynan, C. T. (1999). Redistributions of cetaceans in the southeast Bering Sea relative to anomalous oceanographic conditions during the 1997 El Niño. *Proceedings of the 1998 Science Board Symposium on the Impacts of the 1997/98 El Niño event on the North Pacific Ocean and its marginal seas, PICES Scientific Report*, 10, 115-117.

Tynan, C. T. (1997). Cetacean distributions and oceanographic features near the Kerguelen Plateau. *Geophysical Research Letters*, 24, 2793-2796.

Wells, R. S., Hansen, L. J., Baldridge, A., Dohl, T. P., Kelly, D. L., & Defran, R. H. (1990). Northward extension on the range of bottlenose dolphins along the California coast. In S. Leatherwood, & R. R. Reeves, *The Bottlenose Dolphin*, (pp. 421-431). San Diego: Academic Press.

Wishner, K. F., Schoenherr, J. R., Beardsley, R., & Chen, C. (1995). Abundance, distribution, and population structure of the copepod *Calanus finmarchicus* in a springtime right whale feeding area in the southwestern Gulf of Maine. *Continental Shelf Research*, 15, 475-507.

Yoklavich, M. M., Loeb, V. J., Nishimoto, M., & Daly, B. (1996). Nearshore assemblages of larval rockfishes and their physical environment off central California during an extended El Niño event, 1991-1993. *Fishery Bulletin*, 84, 766-782.

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TABLE 1. Species groups, truncation distances, detection function models (number of cosine adjustments in parentheses), and group size and sea state strata used for line-transect density calculations. n = number of sightings for each species group. f(0) is the probability density function evaluated at zero perpendicular distance (see Equation 1); C.V. is the coefficient of variation of f(0).

Species Group	Truncation Distance	Selected Model	n	Group size	Beaufort sea state	f(0)	C.V.
Rorquals	3.0 km	Half-normal (1)	177	All	0 – 4	1.087	0.060
Dolphins	1.0 km	Half-normal	53	0 – 40	0 – 2	1.750	0.109
		Half-normal (2)	34	0 – 40	3 – 4	2.762	0.222
		Hazard (1)	21	> 40	0 – 4	1.362	0.115
Dall's porpoise	1.0 km	Half-normal	22	All	0 – 1	1.878	0.160
		Hazard (1)	63	All	2 – 4	4.354	0.153

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TABLE 2. Stepwise regression results for models of log-transformed cetacean density relative to measured environmental variables. Variables tested included log(average krill backscatter), log(maximum krill backscatter), SST, standard deviation of SST, depth of mixed layer, thermocline slope, and depth of 10°C isotherm (Z10).

Source	df	*F*	*P*
Rorquals			
Model	23	19.5	0.0002
Log(maximum krill)	1	19.5	0.0002
Error	22		
R-squared = 0.47			
Common dolphins			
Model	23	11.4	0.0027
Z10	1	11.4	0.0027
Error	22		
R-squared = 0.34			
Dall's porpoise			
No variables significant			

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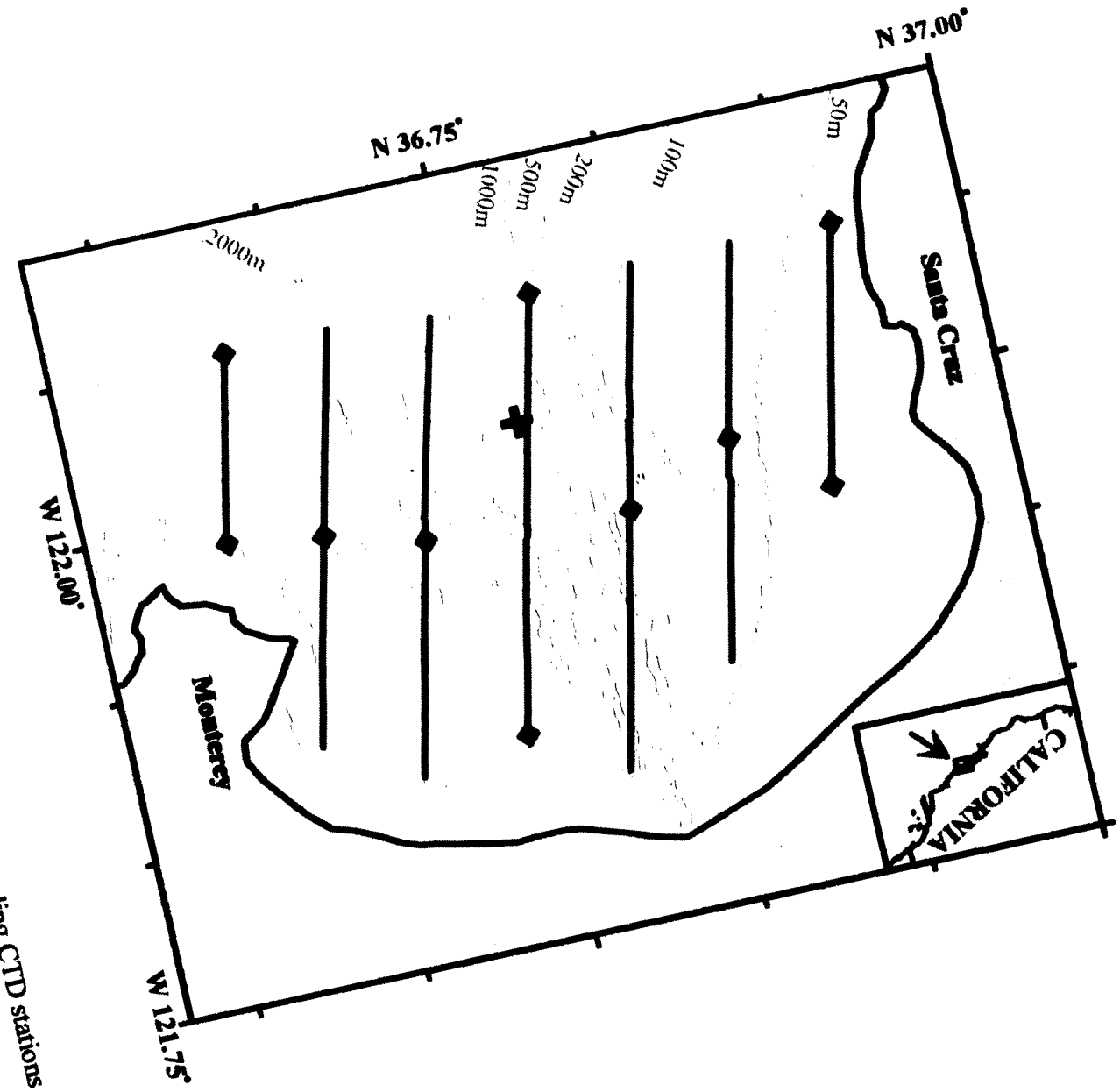

Figure 1. Study area with random set of transect lines, corresponding CTD stations (◆), and location of M1 mooring (✚).

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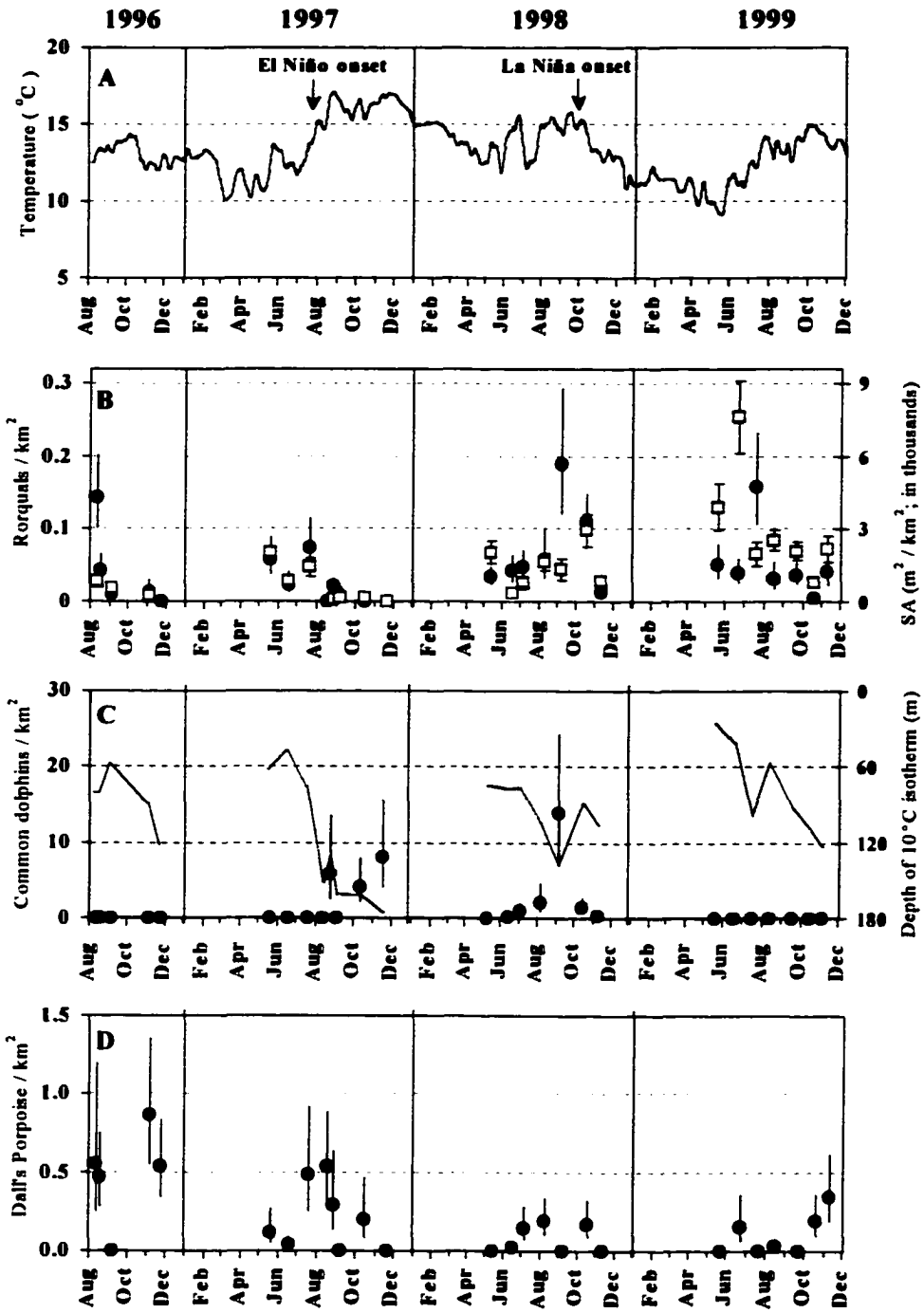

Figure 2. Sea surface temperature (A); rorqual density (●, B) and average euphausiid surface area backscatter (□, B); common dolphin density (●, C) and depth of 10 °C isotherm (line, C); and Dall's porpoise density (●, D) during the study period, August 1996 - November 1999. Vertical bars indicate one standard error for estimates of cetacean density and euphausiid backscatter.

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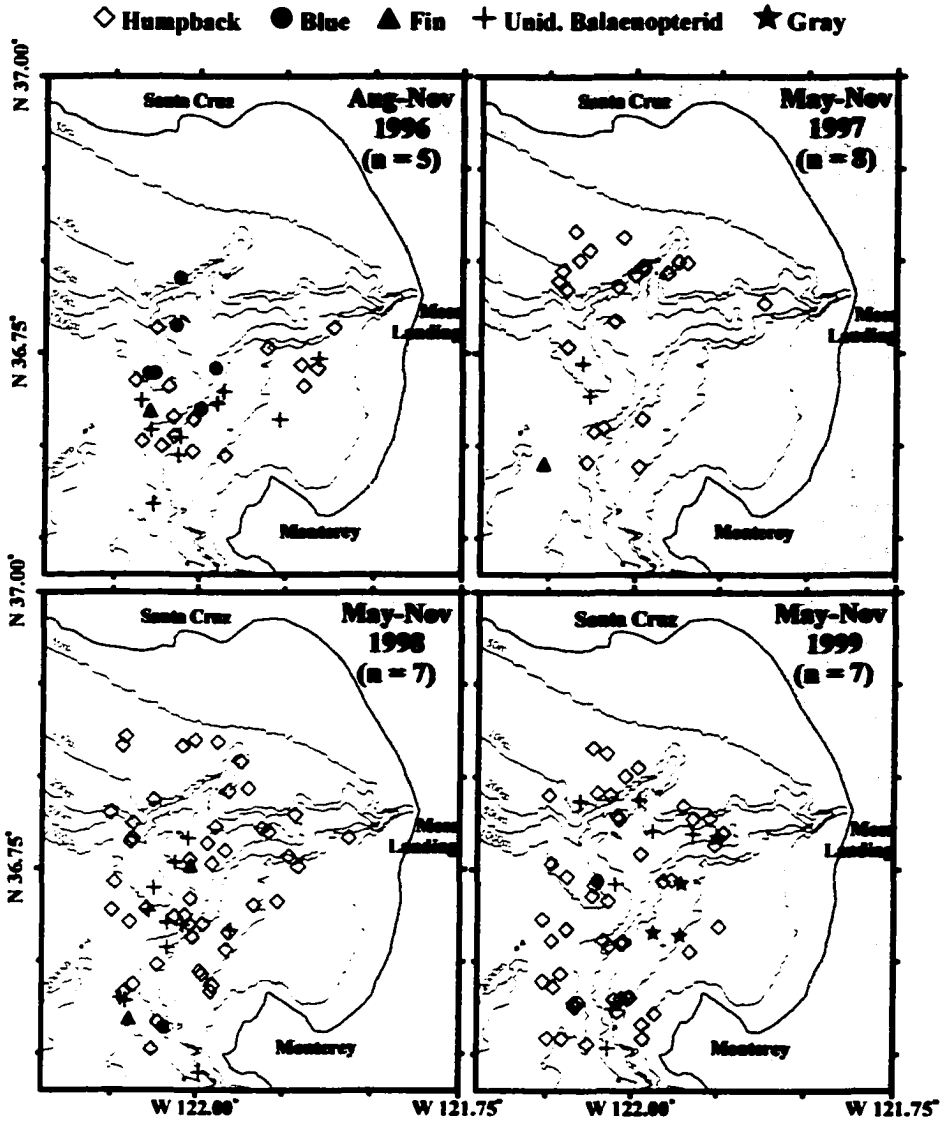

Figure 3. Distribution of baleen whale species by year, 1996-1999. Colors represent pre-El Niño (blue), El Niño (red), and La Niña (green) conditions.

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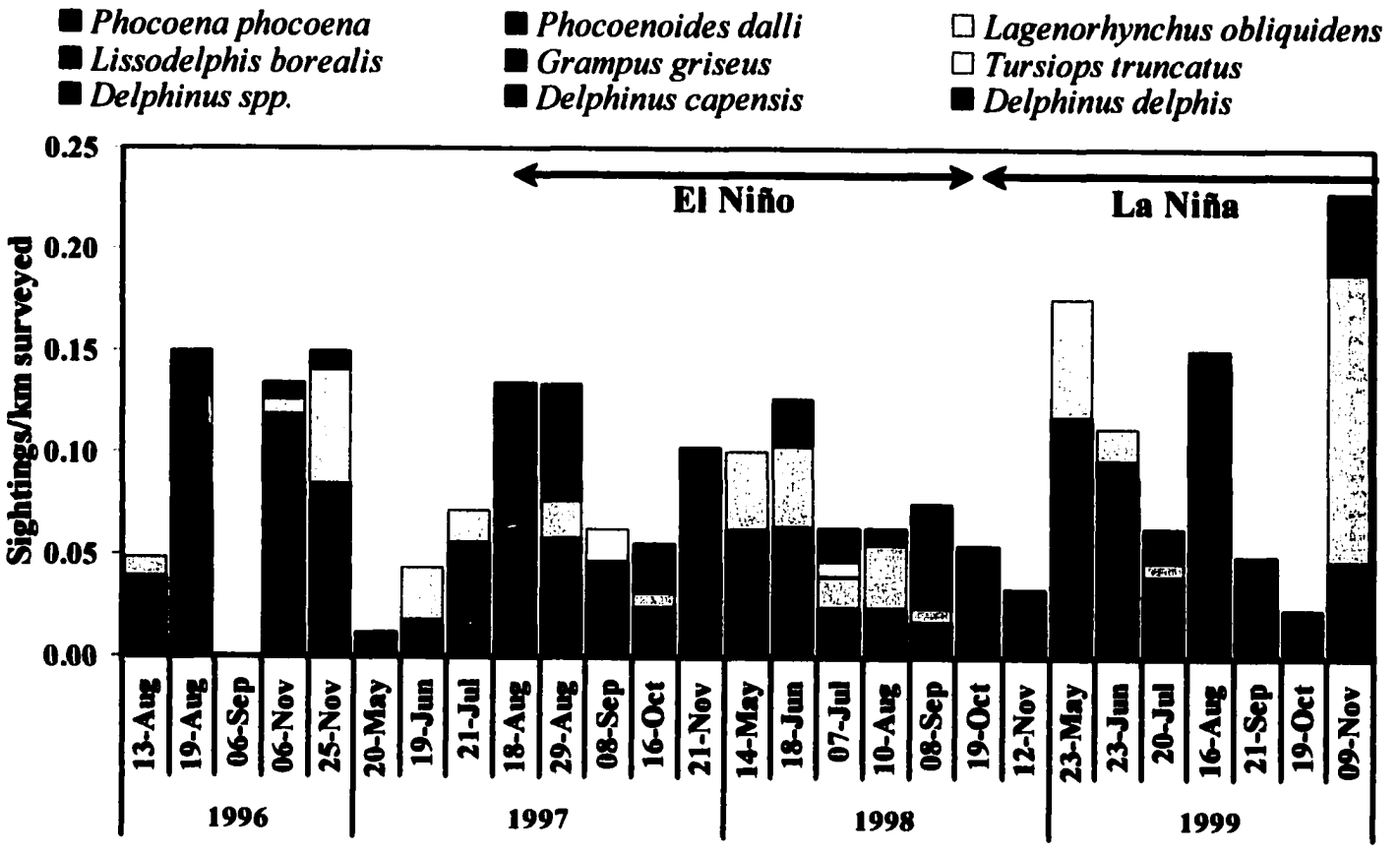

Figure 4. Odontocete species assemblage during the study period, August 1996 – November 1999. Arrows indicate the approximate duration of El Niño and La Niña conditions.

CHAPTER 2

SPECIES-ENVIRONMENT RELATIONSHIPS OF MARINE MAMMALS, SEABIRDS, AND EUPHAUSIID PREY IN MONTEREY BAY, CALIFORNIA, 1996-99.

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ABSTRACT

To determine the distribution and relative abundance of marine mammals, seabirds, and krill with respect to physical variables, monthly random-systematic transects were conducted in a coastal upwelling region, Monterey Bay, California, between May and November of 1996-1999. Canonical Correspondence Analysis (CCA), a unimodal ordination technique, was used to identify patterns of species association and habitat partitioning for the most common species. The first two canonical axes cumulatively explained 85% of the variation in species-environment patterns. Axis 1 strongly correlated with water depth and bathymetric slope. Axis 2 correlated with mixed layer depth and date. Marine birds and mammals negatively associated with Axis 1 represented species that forage on krill or krill predators, whereas species positively associated with Axis 1 were primarily piscivorous. Axis 2 separated late-season migrants that were associated with a deeper mixed layer, from an assemblage of species associated with early-season upwelling. Large-scale oceanographic processes related to El Niño and La Niña influenced the strength of species-environment relationships at the local scale. A comparison of community structure among oceanographic periods revealed both stable nearshore and dynamic offshore components. Multidisciplinary surveys and CCA were effective for describing associations of upper trophic level predators and their habitats in a highly variable coastal upwelling system.

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INTRODUCTION

A fundamental goal in ecology is to explain patterns in the distribution and abundance of populations. Due to the variable nature of marine ecosystems at many spatial and temporal scales, physical and biological relationships are often nonlinear and difficult to predict, particularly in dynamic coastal upwelling systems. This study applies a nonlinear approach to examine the relationship between upwelling community dynamics and physical factors. Multi-disciplinary methods were used during shipboard surveys to concurrently measure physical and biological features of the Monterey Bay coastal upwelling region within the California Current.

The California Current System, one of five eastern boundary currents worldwide, is among the most productive marine regions in the world (Glantz & Thompson 1981). The system is subject to large interannual and seasonal variation (Lynn & Simpson 1987, Chelton et al. 1982), and supports a diverse assemblage of marine birds and mammals (Briggs et al. 1987, Forney & Barlow 1998). Within the California Current system, previous researchers have documented the biological importance of distinct regions influenced by seasonal upwelling, including the Gulf of the Farallones, Channel Islands, and Monterey Bay (Briggs et al. 1987, Schoenherr 1991, Allen 1994, Fiedler et al. 1998).

The Monterey Bay region is further distinguished by a deep submarine canyon, which bisects the continental shelf and slope, forming two shallow (<100 m) neritic areas of almost equal size to the north and south (Breaker & Broenkow 1994). The presence of the submarine canyon produces complex bathymetry and provides deep, shallow, and

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shelf-edge habitats within only a few kilometers of the shoreline. The open bay is influenced by both neritic and offshore oceanic processes (Skogsberg 1936, Skogsberg & Phelps 1946, Breaker & Broenkow 1994), resulting in large interannual and seasonal variation in physical and biological characteristics.

Species of marine birds and mammals found in Monterey Bay reflect the large oceanographic variation, encompassing temperate and sub-tropical species including those that breed in California and far-ranging migrants that exploit seasonally abundant prey resources (Ainley 1976, Briggs et al. 1987, Forney & Barlow 1998). Locally breeding seabirds include Western Gull (*Larus occidentalis*), Caspian Tern (*Sterna caspia*), and Brandt's Cormorant (*Phalacrocorax penicillatus*) (Roberson 1985, Roberson & Tenney 1993, Parkin 1998, Scholten 1999). Temperate breeding seabird species, e.g., Common Murre (*Uria aalge*), Rhinoceros Auklet (*Cerorhinca monocerata*) and the more wide-spread Cassin's Auklet (*Ptychoramphus aleuticus*), typically form colonies to the north, and disperse southward into the Monterey Bay region for post-breeding and winter foraging (Ainley & Boekelheide 1990). Conversely, some species disperse northward along the California coast to forage in the region, including Black-vented Shearwater (*Puffinus opisthomelas*), Brown Pelican (*Pelecanus occidentalis*), Elegant Tern (*Sterna elegans*), and storm petrels (*Oceanodroma* spp.). Long-range trans-Pacific migrants are most conspicuously represented by the abundant Sooty Shearwater (*Puffinus griseus*), and Pink-footed Shearwater (*Puffinus creatopus*), Buller's Shearwater (*Puffinus bulleri*), and Black-footed Albatross (*Phoebastria nigripes*). Visiting species form some of the most dense seabird aggregations in the world (Ainley 1976, Briggs et al. 1987). Ninety-

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four species of seabirds occur regularly in central California, with about 30 dominant species (Briggs et al. 1987). The assemblage of marine birds changes from year to year due to fluctuation in marine conditions, especially related to El Niño (Ainley 1976, Allen 1994).

Marine mammal taxa found in the Monterey Bay region are similarly diverse, including five species of pinnipeds, one species of fissiped, and at least 21 species of cetaceans (Bonnell et al. 1983; Dohl et al. 1983). Among the cetaceans, many of the large whales, such as blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), and humpback (*Megaptera novaeangliae*) whales forage seasonally, whereas temperate odontocetes such as harbor porpoise (*Phocoena phocoena*) (Sekiguchi 1995) and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) occur year-round (Black 1994). Odontocetes associated with warm-water, such as common dolphin (*Delphinus* spp.), occur irregularly as oceanographic conditions fluctuate (Osnes-Erie 1999, Benson et al., in press).

The combined influence of oceanographic conditions, water depth, bathymetric slope, and distance to shore apparently determines prey availability and habitat use of these diverse species (Ainley 1976, Briggs et al. 1987, Ainley & Boekelheide 1990, Allen 1994, Ainley et al. 1995, Forney 2000, Keiper 2001). "Pelagic" species found in surface waters overlying depths >2000 m prey on oceanic squid, lanternfishes (Myctophidae) and Pacific saury (*Cololabis saira*) (Osnes-Erie 1999, Baltz and Morejohn 1977). Species associated with the shelf break prey predominantly on euphausiids, juvenile rockfish (*Sebastes* spp.), hake (*Merluccius productus*), and other fish species (Ainley &

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Boekelheide 1990, Jefferson 1991, Allen 1994, Black 1994). In shallow shelf waters, market squid (*Loligo opalescens*), anchovy (*Engraulis mordax*), juvenile rockfish (*Sebastes* spp.), sardines (*Sardinops sagax*), surfperch (Embiotocidae) and smelt (Osmeridae) tend to be the dominant prey (Baltz and Morejohn 1977, Ainley & Boekelheide 1990, Allen 1994, Sekiguchi 1995). In this diverse predator-prey system, euphausiids (krill) play a centrally important role as prey for marine vertebrates on many trophic levels. Krill swarms, especially of *Euphausia pacifica* and *Thysanoessa spinifera*, draw a variety of predators including anchovy, squid, salmon, hake, blue sharks, and blue whales (Morejohn et al. 1978, Harvey 1979, Schoenherr 1991). Distributions of krill and other zooplankton recently have been linked to mesoscale features (Huntley et al. 1995).

Understanding the physical-biological relationships in dynamic systems such as Monterey Bay is challenging and inherently difficult because of the great variability in time and space. Numerous researchers have investigated relationships between oceanographic features and the relative abundance of individual species of marine birds and mammals (Haney 1985, Haney & McGillivary 1985, Watts & Gaskin 1985, Jefferson 1991, Black 1994, Kenney et al. 1995, Decker & Hunt, 1996, Sydeman & Allen 1999, Forney 2000). More comprehensive multi-species studies have characterized community patterns of seabirds or marine mammals based on linear methods, such as correlation techniques and PCA (Ainley 1976, Schneider 1982, Kinder et al. 1983, Au & Perryman 1985, Smith et al. 1986, Briggs et al.1987, Ribic et al. 1992, Ballance et al. 1997, Baumgartner et al. 2001). Most ecological relationships, however, are unimodal and not

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linear. In recent years, non-linear techniques for community analyses (ter Braak 1996) have been applied to investigate unimodal species-environment relationships of marine communities (Oug 1998), including marine birds and mammals (Allen 1994, Reilly & Fiedler 1994, Fiedler & Reilly 1994).

The objective of this study was to characterize the community structure of marine birds and mammals in Monterey Bay, and a critical lower-trophic level link, euphausiids, with respect to several oceanographic and physiographic variables during the upwelling seasons of 1996 through 1999. A multivariate technique for unimodal species-environment relationships, Canonical Correspondence Analysis (CCA), was used to investigate community patterns. The initial intent was to characterize overall patterns of species-environment relationships, but El Niño 1997-98 and La Niña 1999 provided an opportunity to evaluate the stability of community patterns across dramatically different oceanographic periods.

METHODS

Field Methods

Twenty-seven surveys were conducted from August-November 1996 and May-November 1997-1999 (Table 1) aboard the R/V *David Johnston* (7 surveys) or the R/V *John H. Martin* (20 surveys). These two research vessels were similar in size (15-16 m length), with a viewing platform atop the pilot house about 4.3 m above sea level. Each survey consisted of seven transect lines totaling approximately 126 km (68 nmi) (Fig. 1).

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The location of the northern-most line was selected randomly from within a 3-minute latitudinal range, and subsequent lines to the south were spaced at 5.5-km (3-nmi) intervals to provide uniform and representative coverage of the study area (909 km^2). The six southern lines began at the 55-m (30-fathom) isobath and extended WNW to 122°05.00' west longitude. The northernmost line covered mostly shallow water to a minimum depth of about 30 m (16 fathoms). The lines ranged in length from 10 km (5.4 nmi) to 22 km (11.9 nmi). A single survey was typically completed during two consecutive days. Surveys were conducted at a ship speed of 18.5 km/hr (10 knots) in acceptable surface conditions (Beaufort sea states 0-5) and satisfactory visibility (1- 7 km). Sighting information and environmental conditions were recorded and updated throughout the survey with a laptop computer connected to a GPS receiver. Sea state was estimated using the Beaufort scale (Bowditch 1966).

While the ship was moving along the transect line, three observers searched for marine mammals. One observer on each side searched a 90°–arc from directly ahead to abeam of the vessel with the aid of 7x50 binoculars fitted with a compass and reticle markings. The third observer searched for mammals in the vicinity of the transect line by unaided eye. Line-transect methods (Buckland et al. 1993) were used, with sighting distances calculated from the compass bearings and reticle readings. Marine mammals were identified to the lowest taxonomic level, and only were approached if identification was not possible from the transect line or if group size estimation required a closer view. Search effort was temporarily suspended for all approaches, and effort resumed approximately at the location at which it was terminated.

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Seabirds were quantified using strip transect methods (Buckland et al. 1993), and identified to lowest possible taxon with the aid of handheld 7x35 binoculars. During 1996, search effort was variable, with 1-2 observers searching to 100 m or 200 m distance on one or both sides of the transect line, forward of the beam. Beginning in 1997, all effort was standardized to a 100 m distance with only one observer searching on the side of the vessel not impacted by glare. Standardized seabird densities (individuals per km^2) were calculated for all years to account for these methodological differences. Observers estimated the width of the transect strip using a small handheld rangefinder as described by Heinemann (1981). Search effort was concentrated ahead of the vessel to allow detection of seabirds before they potentially reacted to the vessel's presence, for example by diving evasively (e.g. alcids) or by approaching (e.g. gulls). Seabirds were only counted as being within the strip if their presence there was not a result of the vessel's movement; i.e., birds that flushed from the water because of the ship were subsequently not counted if they entered the transect strip. Ship-following was occasionally noted for some seabird species (e.g. gulls) and care was taken to avoid recording these individuals more than once.

Zooplankton backscatter was measured acoustically along tracklines using a Simrad EY-500 echosounder operating at 200 kHz with a ping interval of two seconds. The echosounder system was calibrated before and after each survey year using the standard sphere method (Johannesson & Mitson 1983). Identification of acoustic targets was confirmed periodically by plankton tows, using paired 0.7 m bongo nets fitted with 333 μm mesh (Marinovic et al., in press). Ocean temperature profiles were obtained at

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pre-determined stations (Fig. 1) with a Sea-Bird 19 conductivity-temperature-depth (CTD) probe lowered to a depth of 200 m or to within 10 m of the bottom. Underway sea surface temperature was measured by towing a temperature logger (Onset Computer Corporation, Optic Stowaway® Temp logger) about 7 m behind the vessel at a depth of approximately 0.5 m. The temperature logger was programmed to record temperatures at 5-sec intervals. Data were uploaded to a computer at the end of each day.

Data processing

Data collected from the line transect surveys were divided into uniform-length segments for analysis (see below). Only those segments that contained complete data for seabirds, marine mammals, krill, and all of the environmental variables were used in the analysis of species-environment relationships (Table 1). Environmental variables derived during the data processing included: bathymetric depth, bathymetric slope, sea surface temperature, within-survey sea surface temperature anomaly, depth of the 12°C isotherm as a measure of mixed-layer depth, distance from shore, and Julian date.

Marine Mammals: Within each segment, the number of encountered individuals was totaled by species. Unidentified individuals or groups were not included in the analysis with the exception of one category that included baleen whales other than humpback whales, and the two species of common dolphins, which are difficult to distinguish at sea (Table 2). Species seen on fewer than 20 occasions were not included in the analysis because rare species can exhibit disproportional influence in canonical correspondence analysis (ter Braak & Prentice 1988).

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Seabirds: To account for variable strip widths used during the first year of the study, seabird counts were standardized in terms of density (individuals km^{-2}) for each segment before analysis. Several seabird species groups included members that are ecologically similar and difficult to distinguish at sea. Therefore, these species were combined into higher taxonomic level groups, e.g. all storm petrels (Table 2). Gulls also presented identification difficulties because of the large variety of age-specific plumage patterns; however, this group was considered ecologically more disparate than the others, therefore, was excluded from the analysis. Seabird species seen on fewer than 20 occasions were not included in the analysis.

Krill: Krill density (KRIL), measured in terms of integrated volume backscatter strength (S_a), was calculated from the acoustic volume backscatter (SV) by integrating vertically to 200 m and horizontally over a distance of 0.1 nmi (0.185 km), following the methods of Hewitt & Demer (1993) and Croll et al. (1998). Backscatter values for individual sub-segments were subsequently combined to obtain total backscatter for the segment length chosen for the analysis.

Bathymetry: Distribution of many marine species is closely linked to bathymetry, including a variety of marine mammals and seabirds (Hui 1985, Briggs et al. 1987). In this study, bathymetric data were extracted from a data base administered by the National Oceanic Atmospheric Administration using a Geographic Information System (GIS). For each segment, the depth of the midpoint and two end points was estimated within the GIS. Bathymetric depth for each segment was defined as the midpoint depth value. Bathymetric slope was calculated as the difference between the beginning and end depth

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for each segment. Both measures were log-transformed for analysis (variables LnDep and LnSlope), because species relationships with depth and slope are expected to occur on a logarithmic scale (Tilman 1982, Palmer 1993). For example, differences in species responses between 10 and 100 m depth were expected to be of the same scale as differences between 100 and 1000 m.

Sea surface temperature: Sea surface temperatures (SST) obtained from the temperature logger were averaged over a one-minute interval and assigned to the midpoint of each segment. In an effort to identify within-survey heterogeneity, a sea surface temperature anomaly value (SSTa) was calculated for each segment by obtaining the difference between the SST value for a segment and the SST average for the entire survey.

Depth of the 12° C isotherm: Mixed layer depths were estimated using an appropriate isotherm value for the temperature profiles within the study area. For example, Reilly and Fiedler (1994) chose the depth of the 20° C isotherm for tropical waters. In this study, the most common isotherm value across all CTD casts was 12° C. Mixed layer depth, therefore, was estimated by extracting the depth of the 12° C isotherm from the CTD casts performed during each survey and creating contour maps using a Kriging algorithm in Surfer® (Golden software, Inc.). Values of the 12° C isotherm (Z12) were estimated for each segment within the survey from the derived contour grid using the *residuals* feature in Surfer®. This method can introduce errors if the contour map contains large or erratic gradients; therefore, contour maps were visually inspected for contour characteristics before estimating individual segment values.

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Distance from shore: Some seabirds and marine mammals off California are found farther from shore than other species (Briggs et al 1987, Barlow 1995, Forney & Barlow 1998). To evaluate whether this pattern may occur independently of other environmental variables, such as bathymetry, it was included as a distinct variable. Distance (in km) to shore (Km2Cst) was calculated as the minimum distance from the midpoint of each segment to all coastline points within the Monterey Bay region.

Julian Date: A variable representing within-season timing was desired, because a number of species, mostly seabirds, were restricted by the timing of breeding activities and migration (Ainley 1976). Their presence in the system, therefore, may depend on external factors rather than environmental conditions alone. Julian date (Jdate) was included as a proxy for this effect.

In the Monterey Bay study area, the above variables, especially bathymetry, can change over short spatial scales, on the order of hundreds or thousands of meters (Breaker & Broenkow 1994, Fig. 1). It is important to choose sampling units that reflect the scale of environmental gradients (Schneider 1994, Barlow 1995, Forney 2000). Therefore, a short segment length was desired in this study to allow accurate representation of the small-scale gradients observed. Longer segment lengths would potentially obscure patterns by including different habitat characteristics within each segment. Segments that are too short, however, can artificially increase variances within the samples. Therefore, an appropriate segment length was chosen based on the variance of estimates of mean krill backscatter relative to the choice of segment length. Krill distribution is highly patchy, and this measure was expected to be the most sensitive to

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choice of segment length in this study. For a range of segment lengths between 0.1 and 2.0 nmi (0.185 and 3.7 km), ten sets of 300 segments were randomly drawn from the observed data for 1996-99 and mean krill backscatter, standardized to 0.1 nmi, was calculated for each set. The coefficient of variation (CV) was then estimated for these ten means (CV = SE/mean). This process was repeated randomly ten times, and the average CV was obtained to provide a basis for selecting a segment length that was as small as possible without increasing variances in the analysis.

Analytical Methods

Canonical Correspondence Analysis (CCA) is an ordination technique that was developed specifically to investigate species-environment relationships that are unimodal (ter Braak 1986), rather than linear, as with Principal Component Analysis and many other ordination methods. CCA provides a simultaneous ordination of species and explanatory variables across sample sites, allowing community variation to be directly related to environmental variation (direct gradient analysis; ter Braak 1986). Quantitative results include a correlation matrix of 1) the environmental variables; 2) environmental axes, representing ordination scores derived from all sites as linear combinations of the explanatory variables using multiple regression; and 3) species axes, representing ordination scores for each site weighted by the relative abundance of all species present at that site. Ordination scores for the species axes and environmental axes are obtained simultaneously through an iterative process that seeks to maximize species dispersion along axes that are linear combinations of the environmental variables (Palmer 1993, ter

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Braak & Verdonschot 1995). The canonical axes (defined as ordination axes that are constrained to be linear combinations of environmental variables) are thus the environmental axes determined by the CCA.

The importance of each canonical axis is indicated by the extracted variance, termed "inertia" and expressed by the eigenvalue. The ratio of the axis eigenvalues to total variance, "total inertia" in the species data, indicates the proportion of the species variation which is attributable to the environmental data along that axis. The method does not seek to explain all variance in the data (and, in fact, mathematically often cannot), but rather teases out patterns of species-environment relationships despite the high variances commonly associated with abundance data (Palmer 1993, Økland & Eilertsen 1994). CCA is also robust with data sets containing a large proportion of zero observations (ter Braak 1985), as is typical of species abundance data.

Results are displayed graphically as combined plots (biplots) of species and explanatory variables along the canonical axes, allowing visualization of the pattern of community variation and the distribution of species along the environmental gradients. Species are marked by points that represent their distribution optima, and explanatory variables are represented by vectors pointing toward the maximum increase of the variable. Long vectors represent strong trends, and the angle between pairs of vectors approximates the correlation between the respective environmental variables. CCA does not require that explanatory variables are uncorrelated and, in fact, yields more robust results when multiple correlated variables are included in the analysis (Palmer 1993).

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CCA was performed with the software program CANOCO (ter Braak & Smilauer 1998), which includes features designed specifically for transect data that are spatially correlated. CCA can be used both for exploratory analysis and for hypothesis testing. When testing hypotheses, independence between sampling units is a common and important assumption for many statistical techniques (Zar 1984). Spatially correlated transect data are not independent, making inference from standard parametric tests invalid. Permutation tests often provide improved statistics, because they do not require some parametric assumptions; however independence of sampling units remains an important concern. A restricted permutation technique, involving cyclical random shifts (ter Braak & Smilauer 1998), circumvents spatial dependence problems for transect data by randomly drawing subsets of the data which are randomly shifted along the transect line. The technique explicitly includes the effects of spatial correlation in the set of possible outcomes from which probability values for the observed data are estimated, assuming only that each pair of consecutive samples along the line is equally correlated. CANOCO uses this technique to incorporate spatial autocorrelation (Palmer 1993) when estimating statistics and probability levels for hypothesis tests in CCA. In all runs of CANOCO, disproportionate influence of species with high variances was reduced by log-transforming numbers or densities and by down-weighting rare species (ter Braak & Smilauer 1998).

Potential differences in community structure related to impacts of the severe El Niño and following El Niña event were examined by performing CCA on partial data sets. The surveys were divided into three oceanographic periods based on external

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measures of the timing of these events (Chavez et al., in press): pre-El Niño (September 1996-July 1997), El Niño (August 1997- September 1998) and La Niña (October 1998-November 1999).

RESULTS

Surveys

Twenty-seven surveys were conducted (Table 1) between August 1996 and November 1999, spanning more than 3,257 combined kilometers of survey effort. Each complete survey averaged about 122 km and generally required 2 consecutive days for completion. In a few cases, weather or other logistic constraints resulted in incomplete surveys, or required the survey to span more than two days. Weather was variable but mostly good for visual surveys of marine birds and mammals, with about 89% of the cumulative effort in Beaufort sea states of 0-3. Marine bird and mammal taxa were diverse, encompassing at least 45 seabird species and 19 marine mammal species, including species that breed locally, long-range migrants, and species associated with temperate and sub-tropical waters. Sighting rates were variable seasonally and interannually, ranging from 12 to 113 marine mammal sightings, and 230 to 1,206 seabird sightings per survey. The most frequently encountered marine mammal was the California sea lion (*Zalophus californianus*), and the most common seabird was the Sooty Shearwater. Oceanographic conditions, including sea surface temperature and mixed layer depth (Table 1), varied seasonally as upwelling patterns developed and subsided.

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Interannual variability during the study period was unusually large due to a strong El Niño event in 1997-98 and a La Niña event in 1999 (Chavez et al., in press).

Surveys were evaluated for completeness and quality of the entire suite of data. Only survey effort during which all environmental variables were measured under acceptable conditions was included in the species-environment analyses (Table 1). Three complete surveys (two in August 1996 and one in August 1997) were excluded because hydroacoustic and/or sea surface temperature data were unavailable, and three surveys had missing data for 4 of the seven transect lines. Twenty-two surveys contained complete or near-complete data for the analyses. The combined effort that was sufficiently complete for analysis included about 2,045 km of transect coverage.

The analysis of CV of krill backscatter as a function of segment length indicated an asymptote at about 0.5 nmi (0.926 km; Fig. 2). The analyses, therefore, were conducted with a segment length of 0.5 nmi, the length that optimized the tradeoff between obtaining the greatest spatial resolution and maintaining the lowest possible variance. Leftover sections at the end of the transect lines were excluded; eliminating a small fraction of overall survey effort at the edges of the study area. The number of segments for all surveys included in the analysis was 2,208, averaging 92 per survey (Table 1).

Canonical Correspondence Analysis

A weighted correlation matrix for the CCA of the complete data set (Table 3), summarizes the relationships for the seven measured environmental variables, four

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derived species axes, and four derived environmental axes. Species-environment relationships are expressed as correlations between species axes and environmental axes. The correlation between the first (dominant) environmental axis and the first species axis was 0.76, and the correlation between the second most important axes was 0.51. The correlations between the remaining two axis pairs were 0.36 and 0.25. The ordination of all 27 species and 7 environmental variables explained 7.2% of the variance in the combined marine bird, mammal, and krill abundance data, with individual species percentages ranging from 51.4% for krill to just 0.4% for elephant seal (Table 4). The first axis accounts for 63% of the extracted variance, the second accounts for 22%, together they represent 85%. Axis 3 represented 9% and axis 4 only 4% of the variation of the species-environment data. Further results and discussion, therefore, relate primarily to axes 1 through 3.

The assumption of unimodality between species abundances and environmental gradients was evaluated following the methods of Reilly & Fiedler (1994). Species scores along the first two axes were calculated for each segment and plotted in relation to species occurrence. Relationships between some of the most commonly seen species and the first two environmental axes (Fig. 3) reveal unimodal distributions. In a few cases, such as California sea lions, evidence of bimodality was apparent; however, the technique is robust to such deviations (Reilly & Fiedler 1994). Other species included in this analysis exhibited similar patterns to the examples shown.

The null hypothesis of no relationship between the species abundance and the environmental data was rejected by the Monte Carlo randomization test generating 1000

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permutations. None of the permutations yielded an ordination with an eigenvalue greater than the observed value of 0.511 for the entire model, or 0.324 for the first axis alone ($P<0.001$ for both tests).

The species-environment biplot (Fig. 4) displays the results for the seven-variable environment ordination. Figure 5 shows corresponding species scores and tolerances along the first two canonical axes, separated and sorted by score for ease of evaluation. The first axis captured the fixed characteristics of the complex bathymetry and irregular coastline associated within the study area, whereas the second axis identified within-season effects related to upwelling strength and mixed-layer depth. The third axis captured inter-annual variability associated with El Niño and La Niña events.

Axis 1 separated krill, baleen whales (not including humpback whales), and Pacific white-sided dolphin from the other marine bird and mammal species. Negative scores on axis 1 were associated with deeper water ($r=-0.91$, Table 3), a steep bathymetric gradient ($r=-0.84$), and greater distance from shore ($r=-0.51$). Positive scores on axis 1 for sea otter, Black-vented Shearwater, loons (*Gavia* spp.), Brandt's Cormorant, Brown Pelican, harbor porpoise, California sea lion, harbor seal (*Phoca vitulina*), Common Murre, and Elegant Tern indicated they were associated with shallow water, a relatively flat bottom, and shorter distance to shore.

Positive axis-2 scores were associated with occurrence late in the season (i.e. later Julian date, $r=0.81$, Table 3) and a relatively deep mixed layer (i.e. greater Z12, $r=0.55$). These are characteristics of a seasonal signal within upwelling regions of the California Current System that occur when upwelling relaxes during the late summer and autumn

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months (Lynn & Simpson 1987, Breaker & Broenkow 1994). Loons, Rhinoceros Auklet, common dolphins, Black-vented Shearwater, storm petrels, Dall's porpoise (*Phocoenoides dalli*), Northern Fulmar (*Fulmarus glacialis*), Buller's Shearwater, and phalaropes (*Phalaropus* spp.) had large positive axis-2 scores, whereas Elegant Tern, harbor porpoise, and Black-footed Albatross had the greatest negative scores (Figs. 4, 5).

Positive axis-3 scores were associated with a deeper mixed layer (Z12, r=0.73, Table 3) as for axis 2, but also with warmer SST (r=0.81) rather than a later Julian date. Axis 3 indicates a component of the interannual variability associated with the extreme El Niño and La Niña events that occurred during the study period. Species with large positive scores on axis 3 (associated with El Niño) were: common dolphin, storm petrels, Pink-footed Shearwater, jaegers, and Elegant Tern. Negative axis-3 scores (associated with La Niña) were associated with cooler surface temperatures and a shallow mixed layer. Dall's porpoise and Rhinoceros Auklet had the largest negative axis-3 scores.

Originally, the study objective was to characterize the overall community structure of marine predators in Monterey Bay. The strongest El Niño of the century and subsequent La Niña, however, provided a unique opportunity to study the stability of the community structure as oceanographic conditions changed dramatically during the study period. The biplots (Fig. 6) indicated that the environmental gradients were oriented similarly for all three periods. The strength of the gradients, however, differed markedly, with muted gradients during the El Niño and La Niña events compared with the pre-Niño period. Species positions along the first axis were similar during the three periods for most species, including krill, Sooty Shearwater, Common Murre, California sea lion,

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Rhinoceros Auklet, harbor porpoise, and baleen whales. Positions along axis 2 exhibited more variability, most notably for species with few sightings, such as common dolphin and elephant seal (*Mirounga angustirostris*). Thus the plots should be interpreted with caution. A final observation was a difference in the apparent response of birds and mammals during the El Niño relative to the second canonical axes. This axis reflected mixed layer depth and seasonal patterns. All mammals except California sea lion were negatively associated with the vertical axis, whereas the seabirds and California sea lion exhibited more stability and are represented throughout the season (possibly due to timing of breeding).

The patterns of variance explained for the three periods differed slightly (Table 5). Before the El Niño, the model captured the greatest amount of variance in the species data (12%) on the first two axes, and 85 % of this variation is accounted for by species-environment relationships. During El Niño, species did not sort out as well, and the first two axes explained only 7% of the variation in species data. However, the species-environment relationships were slightly stronger at 89%. These results may be attributable to reduced foraging options during this period of low productivity, which concentrated animals in nearshore areas (Benson et al., in press). During La Niña, about 7% of the species variation was explained on the first two axes, but the species-environment relationships were weaker (73%). This model, however, included the 3rd and 4th axes prominently, suggesting a more heterogeneous environment during this period. Upon inclusion of all four axes, 10% of the species variance during the La Niña period was explainable, and 95% of the pattern was accounted for by the species-

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environment relationships. Monte Carlo tests for all models indicated significant relationships between species abundance and environmental variables ($P<0.003$, Table 5).

DISCUSSION

As expected, the CCA models explained a small fraction of overall variance. This could be attributable to patchiness and stochastic processes that cannot readily be characterized when measuring simple environmental variables. Jongman et al. (1987) and ter Braak and Verdonschot (1995), however, report that percentage-explained inertia for ecological data is typically low (<10%) and uninformative, especially for strong gradients. They suggested the importance of extracted gradients were better evaluated by examination of the eigenvalues and statistical significance, as judged by the Monte Carlo permutation tests. The eigenvalues for the first canonical axes for all models presented in this study were >0.30, indicating strong gradients. Results of Monte Carlo permutation tests indicated all models captured meaningful patterns of species-environment relationships, despite the large proportion of unexplained variability, and the large number of zero observations.

In this study, the first environmental axis separated deep-water or offshore species from those occurring in shallow-nearshore areas (Figs. 4, 5). The significance of water depth to marine bird and mammal assemblages off central California is well known (Dohl et al. 1983, Briggs et al. 1987, Ainley & Boekelheide 1990, Jefferson 1991, Allen 1994, Black 1994, Sekiguchi 1995). Depth, however, likely reflects more complex underlying

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relationships, rather than intrinsically influencing the distribution of surface predators. Such relationships may be related to light, currents, availability and quality of prey. In this respect, depth and slope are proxies for unmeasured processes.

The second axis captured seasonal patterns, separating species seen early in the spring upwelling season from those occurring later during fall relaxation of upwelling, when the mixed layer deepened. Seabirds with distinct timing of migration or breeding activities separated most prominently along this axis. The third axis contributed less to the overall pattern, but appeared to capture inter-annual variability introduced by the El Niño and La Niña events. These events affected the timing of the deepening of the mixed layer and sea surface temperature, the two main environmental variables represented by this axis.

Biplot interpretation revealed that community patterns roughly separated piscivorous nearshore species from species that consume krill (e.g. baleen whale, Cassin's Auklet) or krill predators such as squid (e.g. Pacific white-sided dolphin). Previous researchers have noted spatial partitioning of marine birds and mammals at sea (Abrams & Griffiths 1981, Elphick & Hunt 1993, Croll et al. 1998, Fiedler et al. 1998, Griffith 1999). The overall patterns identified in the CCA corresponded well with results from individual species analyses (Briggs et al. 1987, Black 1994, Jefferson 1991, Schoenherr 1991, Benson et al., in press) and anecdotal information. A CCA for marine birds and mammals in the Gulf of the Farallones identified similar species-environment patterns (Allen 1994) for that region, but with reduced gradients along the canonical axes. Allen (1994) explained a greater proportion of the species variation in that data set, likely

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because of the smaller number of species (8) included in the models. In the present study, the goal was to include as many species as possible to capture overall community patterns of marine birds, mammals and a key trophic link, krill. The strength of the CCA method was the ability to detect biologically meaningful patterns despite the increased variance caused by a large number of species (27) examined simultaneously, particularly when sample sizes were relatively small for the less common species. The most frequently seen species, such as Common Murre, Sooty Shearwater, and California sea lion, exhibited a greater proportional variance explained in the CCA model (Table 4) compared with the less abundant cetaceans. Nonetheless, the species ordination (Fig. 4) produced biologically meaningful distinctions for many species, including those seen infrequently.

The ability to identify multi-species patterns in this data set allowed further examination of potential changes in species-environment relationships as a function of the extreme interannual variability caused by the El Niño and La Niña events (Chavez et al in press). The three biplots representing pre-Niño, El Niño, and La Niña periods (Fig. 6) indicated that the dominant species-environment patterns were similar between the three periods, although there were some differences in individual species patterns and community complexity. Physiographic variables (water depth, bathymetric slope, and distance to shore) and seasonal effects (Jdate, Z12) were identified as the most important gradients during all periods. However, the orientation of the gradients relative to the canonical axes shifted slightly, and the strength of the gradients was reduced during El Niño and La Niña.

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During El Niño, productivity was reduced coast-wide and restricted to nearshore areas, including Monterey Bay (Chavez et al, in press). This collapse of productive waters against the coast may have served to decrease heterogeneity and cause species to be distributed more evenly within the remaining productive areas, as documented for baleen whales (Benson et al., in press). Thus, large-scale oceanographic phenomena affecting the entire California Current System may have reduced the influence of local, small-scale environmental variation on species distributions. This idea is supported by the reduced environmental gradients identified in the CCA, and the increased species diversity caused by an influx of warm-water species responding to El Niño conditions (Benson et al., in press). Combined, these factors may have muted differences in community-wide species-environment relationships within Monterey Bay.

During La Niña, the CCA identified a more complex system that was best described with additional axes (Table 5), rather than with stronger gradients along the first two axes. The first two canonical axes during La Niña correlated with the same variables as during the previous oceanographic periods, indicating similar dominant species-environment patterns. The third canonical axis, however, explained a substantial proportion of the remaining variation (eigenvalue = 0.106, Table 5), and represented the occurrence of a shallow mixed layer during late 1998 as the system transitioned rapidly from El Niño to La Niña conditions (Table 1). This created fall conditions opposite to the typical seasonal signal. The fourth axis represented extremely cold, shallow-mixed-layer conditions during early 1999 (Table 1). The oceanographic period defined by La Niña conditions thus appeared to have been characterized by increased *temporal*

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heterogeneity. As with El Niño, large-scale, remote forcing apparently dominated the system during La Niña, reducing gradients along the first two axes; however, the strong temporal patterns required two additional axes to best explain the species-environment relationships.

Throughout the study period, there appeared to be greater stability of the nearshore piscivorous assemblage than for offshore species (Fig. 6). Species diversity was also consistently greater in nearshore shallow areas. This suggests a broad and reliable prey base in the nearshore habitat, supporting a diverse suite of predators. The availability of sedentary benthic resources in addition to mobile pelagic prey may serve to stabilize this community. Furthermore, nearshore seabird species that forage primarily on fish (alcids, loons, cormorants) generally have greater energetic flight costs and may be less likely to move great distances in search of prey. In contrast, offshore species (e.g., whales, dolphins, albatross, storm petrels) feed on highly patchy, ephemeral prey resources and are far-ranging allowing location of prey across broad regions. Thus, their occurrence in Monterey Bay is subject to availability of prey resources elsewhere within their range, and the more dynamic nature of this community is not surprising. The stability of some species relative to the second axis, which represented time of year and mixed-layer depth, may reflect timing of breeding cycles (e.g., Rhinoceros Auklet and California sea lion) or migratory movements (e.g., Sooty Shearwater, Northern Fulmar, Buller's Shearwater and Elegant Tern).

The amount of variation explained by the CCA would undoubtedly increase (Reilly & Fiedler 1994) with the inclusion of additional environmental variables, such as

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forage fish, other zooplankton (copepods), primary productivity, upwelling indices, and chlorophyll. This study focused on easily measured environmental variables, but new techniques are becoming available for measuring other factors concurrently during transect surveys (i.e., continuous underway fish egg sampling, Checkley et al. 1997) or remotely from satellites, such as SeaWiFS. Scale also plays an important role in identifying species-environment patterns (Hunt & Schneider 1986, Haney 1986). In this study, the scale of the sampling unit (segment) was chosen to allow maximum detection of small-scale patterns related to krill patch structure and rapidly changing bathymetry. It is thus logical that the greatest percent of species variance was explained for krill (Table 4). Although there are broad similarities in the patterns identified in this study and by Allen (1994) and Briggs et al. (1987), the sampling scales were different and no doubt influenced model performance. Interactions between processes operating at different scales affect the ability to identify species-environment patterns (Hunt & Schneider 1986), and studies evaluating a variety of sampling scales both within a region, such as Monterey Bay, and across regions would no doubt shed further light on overall biological patterns.

In summary, the community of marine birds and mammals in Monterey Bay was well-characterized using the environmental variables measured. Despite the great oceanographic variability that exists within this system, marine bird and mammal species had considerable stability in their assemblage with respect to physiographic and seasonally influenced variables. Stability of the nearshore piscivorous assemblage likely reflects prey availability and timing of migrations and breeding. Far-ranging, offshore

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species exhibited more dynamic species-environment relationships. Interannual differences in the strength of species-environment relationships along environmental gradients within the study area appeared to be a result of large-scale oceanographic processes related to El Niño and La Niña, rather than local small-scale variation.

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LITERATURE CITED

Abrams RW, Griffiths AM (1981) Ecological structure of the pelagic seabird community in the Benguela Current region. Mar Ecol Progr Ser 5:269-277.

Ainley DG (1976) The occurrence of seabirds in the coastal region of California. Western Birds 7:33-68.

Ainley DG, Boekelheide RL (1990) Seabirds of the Farallon Islands: ecology, dynamics, and structure of an upwelling-system community. Stanford University Press, Stanford.

Ainley DG, Sydeman WJ, Norton J (1995) Upper trophic level predators indicate interannual negative and positive anomalies in the California Current food web. Mar Ecol Progr Ser 118: 69-79.

Allen SG (1994) The distribution and abundance of marine birds and mammals in the Gulf of the Farallones and adjacent waters, 1985-1992. Doctoral dissertation, University of California, Berkeley.

Au DWK, Perryman WL (1985) Dolphin habitats in the eastern tropical Pacific. Fish Bull US 83:623-643.

Ballance LT, Pitman RL, Reilly SB (1997) Seabird community structure along a productivity gradient: importance of competition and energetic constraint. Ecology 78:1502-1518.

Baltz DM, Morejohn GV (1977) Food habits and niche overlap of seabirds wintering on Monterey Bay, CA. The Auk 94:526-543.

Barlow J (1995) The abundance of cetaceans in California waters, Part II: Ship surveys in summer and fall of 1991. Fish Bull US 93:1-14.

Baumgartner MF, Mullin KD, May LN, Leming TD (2001) Cetacean habitats in the northern Gulf of Mexico. Fish Bull US 99:219-239.

Benson SR, Croll DA, Marinovic B, Chavez FP, Harvey JT (In press) Changes in the cetacean assemblage of a coastal upwelling ecosystem during El Niño 1997-98 and La Niña 1999. Prog Oceanog.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Black NA (1994) Behavior and ecology of Pacific white-sided dolphins, *Lagenorhynchus obliquidens*, in Monterey Bay California. M.S. Thesis, San Francisco State University, San Francisco, CA.

Bonnell ML, Pierson MO, Farrens GD (1983) Pinnipeds and sea otters of central and northern California 1980-83: Status, Abundance and distribution. Center for Marine Studies, University of California, Santa Cruz, CA. Report to Minerals Management Service under contract number 14-12-0001-29090.

Bowditch N (1966) American practical navigator, and epitome of navigation. U.S. Naval Oceanographic Office, H. O. Pub. No. 9. Washington DC. 1524pp.

Breaker LC, Broenkow WW (1994) The circulation of Monterey Bay and related processes. In: Ansell AD, Gibson RN, Barnes M (ed) Oceanography and marine biology: an annual review. University College London Press, p 1-64.

Briggs KT, Breck Tyler WM, Lewis DB, and Carlson DR (1987) Bird communities at sea off California: 1975-1983. Studies in Avian Biology No 11, Cooper Ornithological Society Publication. 74pp.

Buckland ST, Anderson DR, Burnham KP, Laake JL (1993). Distance sampling: Estimating abundance of biological populations. London: Chapman & Hall.

Chavez FP, Pennington TJ, Castro CG, Ryan JP, Michisaki RP, Schlining B, Walz P, Buck KR, McFadyen A, Collins CA (In press) Biological and chemical consequences of the 1997-98 El Niño in central California waters. Prog Oceanog.

Checkley DM Jr, Ortner PB, Settle LR, Cummings SR (1997) A continuous, underway fish egg sampler. Fisheries Oceanography 6:58-73.

Chelton DB, Bernal PA, McGowan JA (1982) Large-scale interannual physical and biological interaction in the California Current. Journal of Marine Research 40: 1095-1125.

Croll DA, Tershy BR, Hewitt R, Demer D, Hayes S, Fiedler P, Popp J, Lopez VL (1998) An integrated approach to the foraging ecology of marine birds and mammals. Deep-Sea Research II, 45, 1353-1371.

Decker MB, Hunt GL Jr (1996) Foraging by murres (*Uria* spp.) at tidal fronts surrounding the Pribilof Islands, Alaska, USA. Mar Ecol Progr Ser 139:1-10.

Dohl TP, Guess RC, Duman ML, Helm RC (1983) Cetaceans of central and northern California, 1980-83: Status, abundance and distribution. Report to Minerals

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Management Service under contract number 14-12-0001-29090, University of California, Santa Cruz.

Elphick CS, Hunt GL Jr (1993) Variations in the distributions of marine birds with water mass in the northern Bering Sea. Condor 95:33-44.

Fiedler PC, Reilly SB (1994) Interannual variability of dolphin habitats in the eastern tropical Pacific. II: Effects on abundances estimated from tuna vessel sightings, 1975-1990. Fish Bull US 92:451-463.

Fiedler PC, Reilly SB, Hewitt RP, Demer D, Philbrick V, Smith S, Armstrong W, Croll DA, Tershy BR, Mate BR (1998) Blue whale habitat and prey in the California Channel Islands. Deep-Sea Research II, 45,1781-1801.

Forney KA (2000) Environmental models of cetacean abundance: reducing uncertainty in population trends. Cons Biol 14(5):1271-1286.

Forney KA, Barlow J (1998) Seasonal patterns in the abundance and distribution of California cetaceans, 1991-92. Mar Mamm Sci 14:460-489.

Glantz MH, Thompson JD (1981) Resource management and environmental uncertainty. John Wiley & Sons, New York.

Griffith RB (1999) Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Mar Mamm Sci 15:33-51.

Haney JC (1985) Band-rumped storm-petrel occurrences in relation to upwelling off the coast of the southeastern United States. Wilson Bull 97:543-547.

Haney JC (1986) Seabird segregation at Gulf Stream frontal eddies. Mar Ecol Prog Ser 28: 279-285.

Haney JC, McGillivary PA (1985) Midshelf fronts in the south Atlantic Bight and their influence on seabird distribution and seasonal abundance. Biol Ocean 3:401-430.

Harvey JT (1979) Aspects of the life history of the blue shark, *Prionace glauca* L., in Monterey Bay, California. M.S. Thesis, San Jose State University, San Jose, CA.

Heinemann D (1981) A range finder for pelagic bird censusing. J Wildl Manage 45:489-493.

Hewitt RP Demer DA (1993) Dispersion and abundance of Antarctic krill in the vicinity of Elephant Island in the 1992 austral summer. Mar Ecol Progr Ser 99: 29-39.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Hui CA (1985) Undersea topography and the comparative distributions of two pelagic cetaceans. Fish Bull US 83:472-475.

Hunt GL Jr, Schneider DC (1986) Scale dependent processes in the physical and biological environment of seabirds. In: Croxall JP (ed) The feeding ecology of seabirds and their role in marine ecosystems. Cambridge University Press, Cambridge p 7-41.

Huntley ME, Zhou M, Nordhausen W (1995) Mesoscale distribution of zooplankton in the California Current in late spring, observed by Optical Plankton Counter. J Mar Res 53: 647-674.

Jefferson TA (1991) Observations on the distribution and behaviour of Dall's porpoise (*Phocoenoides dalli*) in Monterey Bay, California. Aquat Mamm 17, 12-19.

Johannesson KA, Mitson RB (1983) Fisheries acoustics: a practical manual for aquatic biomass estimation. FAO Fish Tech Pap 240.

Jongman RHG, ter Braak CJF, Van Tongeren OFR (1987) Data analysis in community and landscape ecology. Wageningen: Pudoc.

Keiper CA (2001) Marine mammals off central California relative to hydrography; 1986-94, 1997-99. M.S. Thesis, San Jose State University, San Jose, CA.

Kenney RD, Winn HE, Macaulay MC (1995) Cetaceans in the Great South Channel, 1979-1989: right whale (*Eubalaena glacialis*). Cont Shelf Res 15: 385-414.

Kinder TH, Hunt GL, Schneider D, Schumacher JD (1983) Correlations between seabirds and oceanic fronts around the Pribilof Islands, Alaska. Estuar Coast Shelf Sci 16:309-319.

Lynn RJ, Simpson JJ (1987) The California Current system: The seasonal variability of its physical characteristics. Journal of Geophysical Research 92:12,947-12,966.

Marinovic B, Croll DA, Gong N, Benson SR, Chavez F (In press) Effects of the 1997-98 El Niño on zooplankton within the Monterey Bay coastal upwelling system with emphasis on the Euphausiid community. Prog Oceanog.

Morejohn GV, Harvey JT, Krasnow LT (1978) The importance of *Loligo opalescens* in the food web of marine vertebrates in Monterey Bay, California. CA Fish & Game Fish Bull 169:67-98.

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Økland RH, Eilertsen O (1994) Canonical correspondence analysis with variation partitioning: some comments and an application. Journal of Vegetation Science 5:117-126.

Osnes-Erie LD (1999) Food habits of common dolphin (*Delphinus delphis* and *D. capensis*) off California. M.S. Thesis, San Jose State University, San Jose, CA.

Oug E (1998) Relating species patterns and environmental variables by canonical ordination; an analysis of soft-bottom macro-fauna in the region of Tromsø, northern Norway. Mar Env Res 45:29-45.

Palmer MW (1993) Putting things in even better order: the advantages of canonical correspondence analysis. Ecology 74:2215-2230.

Parkin JL (1998) Ecology of breeding Caspian terns (*Sterna caspia*) in Elkhorn Slough, California. M.S. Thesis, San Jose State University, San Jose, CA.

Reilly SB, Fiedler PC (1994) Interannual variability of dolphin habitats in the eastern tropical Pacific. I: Research vessel surveys, 1986-1990. Fish Bull US 92:434-450.

Ribic CA, Ainley DG, Spear LB (1992) Effects of El Niño and La Niña on seabird assemblages in the equatorial Pacific. Mar Ecol Prog Ser 80:109-124.

Roberson D (1985) Monterey birds: status and distribution of birds in Monterey County, California. Monterey Peninsula Audubon Society, Carmel, CA.

Roberson D, Tenney C (1993) Atlas of the breeding birds of Monterey County, California, Monterey Peninsula Audubon Society, Carmel, CA.

Schneider DC (1982) Fronts and seabird aggregations in the southeastern Bering Sea. Mar Ecol Prog Ser 10:101-103.

Schneider DC (1994) Scale-dependent patterns and species interactions in marine nekton'. In: Giller PS, Hildrew AG Rafaelli DG (eds) Aquatic ecology: scale, pattern and process. Blackwell Scientific Publications, Oxford, p 441-467.

Schoenherr JR (1991) Blue whales feeding on high concentrations of euphausiids around Monterey submarine canyon. Can J Zool 69:583-594.

Scholten JW (1998) Behavioral variations of Brandt's cormorants (*Phalacrocorax penicillatus*). M.S. Thesis, Moss Landing Marine Laboratories, Moss Landing CA.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Sekiguchi K (1995) Occurrence, behavior and feeding habits of harbor porpoises (*Phocoena phocoena*) at Pajaro Dunes, Monterey Bay, California. Aquat Mamm 21:91-103.

Skogsberg T (1936) Hydrography of Monterey Bay, California. Thermal conditions, 1929-1933. Trans Amer Phil Soc 29: 1-152.

Skogsberg T, Phelps A (1946) Hydrography of Monterey Bay, California. Thermal conditions, Part II, 1934-1937. Proc Amer Phil Soc 90:350-386.

Smith RC, Dustan P, Au D, Baker, K. S., & Dunlap, E. A. (1986). Distribution of cetaceans and sea-surface chlorophyll concentrations in the California Current. Mar Biol 91, 384-402.

Sydeman WJ, Allen SG (1999) Pinniped population dynamics in central California: Correlations with sea surface temperature and upwelling indices. Mar Mamm Sci 15:446-461.

ter Braak CJF (1985) Correspondence analysis of incidence and abundance data: properties in terms of a unimodal response model. Biometrics 41:859-873.

ter Braak CJF (1986) Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. Ecology 67: 1167-1179.

ter Braak CJF (1996) Unimodal models to relate species to environment. DLO-Agricultural Mathematics Group, Wageningen. 266pp.

ter Braak CJF and Prentice IC (1988) A theory of gradient analysis. Advances in Ecol Res: 18:271-313.

ter Braak CJF, Smilauer P (1998) CANOCO reference manual and user's guide to Canoco for Windows. Software for canonical community ordination (version 4). Center for Biometry Wageningen. 351pp.

ter Braak CJF, Verdonschot PFM (1995) Canonical correspondence analysis and related multivariate methods in aquatic ecology. Aquat Sci 57:255-289.

Tilman D (1982) Resource competition and community structure. Princeton University Press, Princeton, NJ, USA.

Watts P, Gaskin DE (1985) Habitat index analysis of the harbor porpoise (*Phocoena phocoena*) in the southern coastal Bay of Fundy. Can J Mamm 66:733-744.

Zar JH (1984) Biostatistical analysis, 2nd edition. Prentice Hall, London.

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Table 1. Summary data for all surveys conducted in Monterey Bay, 1996-99. Key: No. = Survey number; Effort = Kilometers of transect search effort for marine birds and mammals; Segs = Number of 0.5 nmi segments included in analysis; Km = Total kilometers covered on included segments; # CTD sta. = Number of CTD stations conducted; #si = Number of sightings; #ind = Number of individuals; Avg. Z12 = Average depth of the 12°C isotherm from all stations.

No.	Survey Dates	Effort (km)	Included		# CTD Sta.	Seabirds		Mammals		Avg. sea state	Avg. SST (°C)	Avg. Krill backscatter (m^2/nmi^2)	Avg. Z12 (m)
			Segs	Km		#si	#ind	#si	#ind				
1	Aug 13-14, 1996	118.2	EXCLUDED - INCOMPLETE DATA										
2	Aug 19,20,26, 1996	125.2	EXCLUDED - INCOMPLETE DATA										
3	Sep 6-7, 1996	107.0	106	98.2	9	131	623	12	21	2.9	13.9	3.2	15
4	Nov 6-7 1996	126.5	124	114.8	9	316	1634	49	324	2.4	12.9	0.3	25
5	Nov 25-26 1996	106.8	89	82.4	9	222	755	82	505	2.7	13.4	0.1	40
6	May 20-21, 1997	84.4	78	72.2	9	327	2460	9	17	2.4	14.0	7.7	16
7	Jun 19-20, 1997	116.9	108	100.0	10	423	2390	11	52	2.9	13.6	3.6	14
8	Jul 21-22, 1997	125.7	106	98.2	10	487	3846	57	134	1.8	14.1	4.9	21
9	Aug 18-19, 1997	126.1	EXCLUDED - INCOMPLETE DATA										
10	Aug 19-30, 1997	104.2	69	63.9	17	162	1711	81	1040	2.6	17.4	0.5	48
11	Sep 8-9, 1997	127.8	99	91.7	12	237	873	100	152	2.4	16.4	0.5	81
12	Oct 16-17, 1997	126.0	73	67.6	10	110	541	39	802	2.4	16.6	1.5	105
13	Nov 21-22, 1997	125.7	79	73.2	9	86	426	71	1579	2.5	17.0	0.0	116
14	May 14-15, 1998	127.7	117	108.3	10	296	1092	77	120	2.7	14.4	3.6	26
15	Jun 18-19, 1998	125.6	119	110.2	10	318	1501	61	270	2.2	15.5	2.4	20
16	Jul 7&9, 1998	125.9	77	71.3	10	159	2412	40	319	2.0	13.1	3.6	9
17	Aug 10-11, 1998	125.1	114	105.6	10	344	2971	27	748	2.8	15.4	3.8	41
18	Sep 8,11, 1998	119.8	114	105.6	11	490	2887	73	2471	2.5	15.8	2.6	69
19	Oct 19-20, 1998	127.1	76	70.4	10	105	325	48	329	2.6	13.6	4.1	20
20	Nov 12-13, 1998	119.3	33	30.6	10	62	124	10	12	1.7	12.9	1.0	17
21	May 23-24, 1999	119.2	71	65.7	10	153	4719	44	195	1.5	11.4	5.5	2
22	Jun 23-24, 1999	124.3	88	81.5	10	291	3011	35	68	2.4	12.3	4.6	1
23	Jul 20-21, 1999	126.3	86	79.6	10	331	1768	57	103	1.9	14.5	3.5	28
24	Aug 16-17, 1999	124.8	116	107.4	10	614	2747	47	70	1.5	14.0	4.6	13
25	Sep 21-22, 1999	119.6	103	95.4	10	360	1468	39	87	2.7	14.4	3.1	27
26	Oct 19-20, 1999	126.5	55	50.9	10	90	277	46	59	2.7	14.7	2.7	31
27	Nov 9-10, 1999	125.7	108	100.0	10	276	743	84	361	2.3	14.0	3.5	78

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Table 2. List of common names, scientific names, codes, number of sightings and number of individuals for all species included in the CCA.

Common name	Scientific name	Code	Sightings	Individuals
Loons		loop	115	209
Pacific Loon	*Gavia pacifica*			
Common Loon	*Gavia immer*			
Black-footed Albatross	*Phoebastria nigripes*	albf	252	414
Northern Fulmar	*Fulmarus glacialis*	funo	108	118
Buller's Shearwater	*Puffinus bulleri*	shbu	79	166
Pink-footed Shearwater	*Puffinus creatopus*	shpf	127	285
Black-vented Shearwater	*Puffinus opisthomelas*	shbv	131	276
Sooty Shearwater	*Puffinus griseus*	shso	3422	31005
Storm Petrels		spsp	68	100
Leach's Storm Petrel	*Oceanodroma leucorhoa*			
Black Storm Petrel	*Oceanodroma melania*			
Ashy Storm Petrel	*Oceanodroma homochroa*			
Least Storm Petrel	*Oceanodroma microsoma*			
Fork-tailed Storm Petrel	*Oceanodroma furcata*			
Brown Pelican	*Pelecanus occidentalis*	pebr	265	421
Brandt's Cormorant	*Phalacrocorax penicillatus*	cobr	121	436
Phalaropes		phsp	171	584
Red-necked Phalarope	*Phalaropus lobatus*			
Red Phalarope	*Phalaropus fulicaria*			
Jaegers		jasp	30	33
Pomarine Jaeger	*Stercorarius pomarinus*			
Parasitic Jaeger	*Stercorarius parasiticus*			
Long-tailed Jaeger	*Stercorarius longicaudus*			
Elegant Tern	*Sterna elegans*	teel	92	259
Common Murre	*Uria aalge*	muco	1620	5949
Cassin's Auklet	*Ptychoramphus aleuticus*	auca	236	776
Rhinoceros Auklet	*Cerorhinca monocerata*	aurh	295	580
Baleen whales		whba	37	48
Blue whale	*Balaenoptera musculus*			
Fin whale	*Balaenoptera physalus*			
Gray whale	*Eschrichtius robustus*			
Unid. baleen whales				
Humpback whale	*Megaptera novaeangliae*	whhu	116	166
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	dopw	59	861
Common dolphins	*Delphinus spp.*	doco	27	6524
Short-beaked common dolphin	*Delphinus delphis*			
Long-beaked common dolphin	*Delphinus capensis*			
Harbor porpoise	*Phocoena phocoena*	poha	89	188
Dall's porpoise	*Phocoenoides dalli*	poda	57	207
Elephant seal	*Mirounga angusirostris*	seel	25	27
Harbor seal	*Phoca vitulina*	seha	47	50
California sea lion	*Zalophus californianus*	slca	706	1732
Southern sea otter	*Enhydra lutris*	ottr	42	45
Krill	*Euphausiids*	kril	NA	NA

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Table 3. Correlation coefficients among environmental variables, canonical species axes and environmental axes estimated by canonical correspondence analysis of marine bird and mammal abundances in Monterey Bay, California during 1996-99.

	SPEC AX1	SPEC AX2	SPEC AX3	SPEC AX4	ENVI AX1	ENVI AX2	ENVI AX3	ENVI AX4	JDATE	SST	SSTA	LNDEP	LNSLOPE	Z12
SPEC AX1	1.000													
SPEC AX2	0.029	1.000												
SPEC AX3	-0.034	-0.056	1.000											
SPEC AX4	0.020	0.031	0.035	1.000										
ENVI AX1	0.756	0.000	0.000	0.000	1.000									
ENVI AX2	0.000	0.510	0.000	0.000	0.000	1.000								
ENVI AX3	0.000	0.000	0.362	0.000	0.000	0.000	1.000							
ENVI AX4	0.000	0.000	0.000	0.252	0.000	0.000	0.000	1.000						
JDATE	0.309	0.413	-0.009	-0.104	0.408	0.810	-0.026	-0.411	1.000					
SST	0.197	-0.019	0.292	-0.096	0.261	-0.037	0.806	-0.381	0.199	1.000				
SSTA	0.026	0.045	0.034	-0.004	0.034	0.088	0.093	-0.015	0.072	0.438	1.000			
LNDEP	-0.686	0.110	0.054	-0.038	-0.907	0.216	0.148	-0.151	-0.154	-0.062	-0.057	1.000		
LNSLOPE	-0.636	0.082	0.076	-0.036	-0.841	0.161	0.209	-0.142	-0.126	-0.068	-0.055	0.729	1.000	
Z12	0.259	0.279	0.263	0.003	0.342	0.547	0.726	0.010	0.545	0.654	0.119	-0.080	-0.086	1.000
KM2CST	-0.388	0.025	-0.029	-0.099	-0.514	0.050	-0.079	-0.393	-0.056	0.020	0.110	0.540	0.347	-0.032

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Table 4. Ordination results from canonical correspondence analysis of marine bird and mammal abundances in Monterey Bay, California during 1996-99, for all years.

Axis	1	2	3	4	Total
Eigenvalue	0.324	0.113	0.042	0.022	0.511
P-value	<0.001				<0.001
Species-environment correlations	0.756	0.510	0.362	0.252	
Cumulative percentage variance					
Species-environment relation	63.4%	85.4%	93.6%	97.8%	
Total species data	4.6%	6.3%	6.8%	7.2%	
Individual Species:					
Krill	50.9%	51.1%	51.4%	51.4%	
Common Murre	21.8%	22.8%	22.8%	23.8%	
Sooty shearwater	3.7%	13.0%	13.8%	14.5%	
Rhinoceros Auklet	1.0%	11.9%	14.3%	14.5%	
California sea lion	5.7%	7.5%	9.4%	9.5%	
Loons	2.1%	5.4%	5.6%	7.1%	
Brown Pelican	5.4%	6.1%	6.3%	6.7%	
Black-footed Albatross	0.0%	1.8%	3.7%	4.4%	
Storm petrel	0.1%	0.8%	3.3%	3.4%	
Pink-footed shearwater	0.3%	0.3%	3.7%	3.7%	
Brandt's Cormorant	1.7%	2.2%	2.2%	3.4%	
Black-vented shearwater	1.6%	2.4%	3.0%	3.0%	
Elegant Tern	0.6%	1.2%	1.8%	1.9%	
Cassin's Auklet	0.4%	0.7%	0.8%	0.9%	
Phalaropes	0.3%	1.4%	1.5%	1.5%	
Common dolphin	0.0%	0.3%	1.2%	1.3%	
Dall's Porpoise	0.0%	0.6%	1.0%	1.0%	
Northern Fulmar	0.1%	0.9%	0.9%	1.1%	
Buller's shearwater	0.2%	0.7%	0.7%	1.0%	
Pacific white-sided dolphin	0.4%	0.5%	0.5%	0.5%	
Harbor porpoise	0.2%	0.3%	0.4%	0.4%	
Baleen whale	0.3%	0.4%	0.4%	0.4%	
Jaegers	0.1%	0.1%	0.4%	0.4%	
Humpback whale	0.0%	0.1%	0.1%	0.1%	
Sea otter	0.1%	0.1%	0.1%	0.2%	
Harbor seal	0.1%	0.1%	0.1%	0.1%	
Elephant seal	0.0%	0.0%	0.0%	0.2%	

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Table 5. Ordination summary from canonical correspondence analysis of marine bird and mammal abundances in Monterey Bay, California during 1996-99, by oceanographic period.

PRE-NIÑO	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.309	0.151	0.044	0.020	0.543
P-value	<0.003				<0.003
Species-environment correlations	0.769	0.564	0.352	0.262	
Cumulative percentage variance					
Species-environment relation	56.9%	84.8%	92.9%	96.6%	
Total species data	8.2%	12.2%	13.3%	13.9%	

EL NIÑO	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.388	0.114	0.024	0.018	0.568
P-value	<0.003				<0.003
Species-environment correlations	0.790	0.529	0.262	0.209	
Cumulative percentage variance					
Species-environment relation	68.3%	88.5%	92.7%	95.9%	
Total species data	5.4%	7.0%	7.3%	7.6%	

LA NIÑA	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.331	0.192	0.106	0.054	0.721
P-value	<0.003				<0.003
Species-environment correlations	0.775	0.633	0.483	0.387	
Cumulative percentage variance					
Species-environment relation	45.9%	72.5%	87.2%	94.7%	
Total species data	4.6%	7.3%	8.8%	9.6%	

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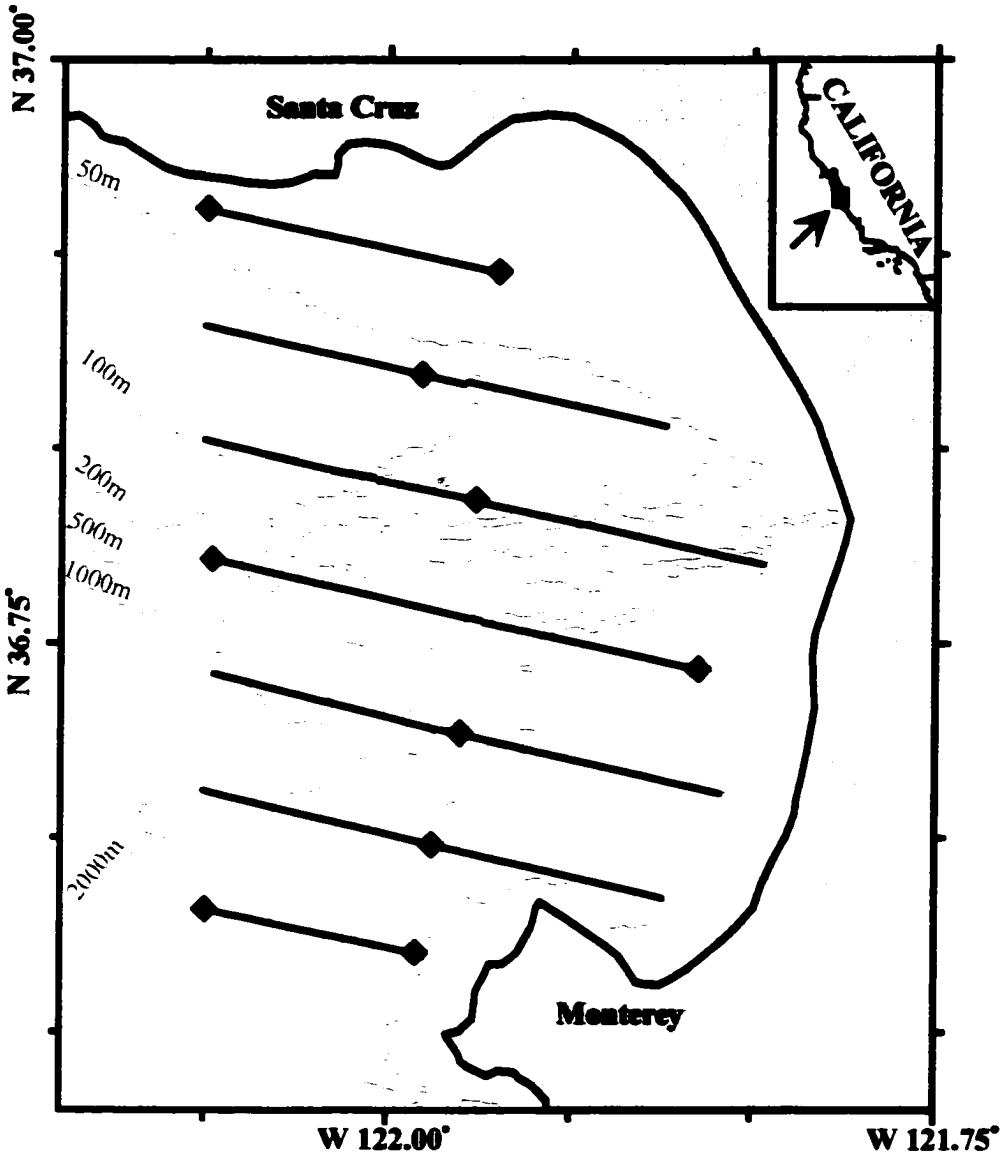

Figure 1. Monterey Bay study area with representative, randomly selected set of transect lines and corresponding hydrographic stations (◆).

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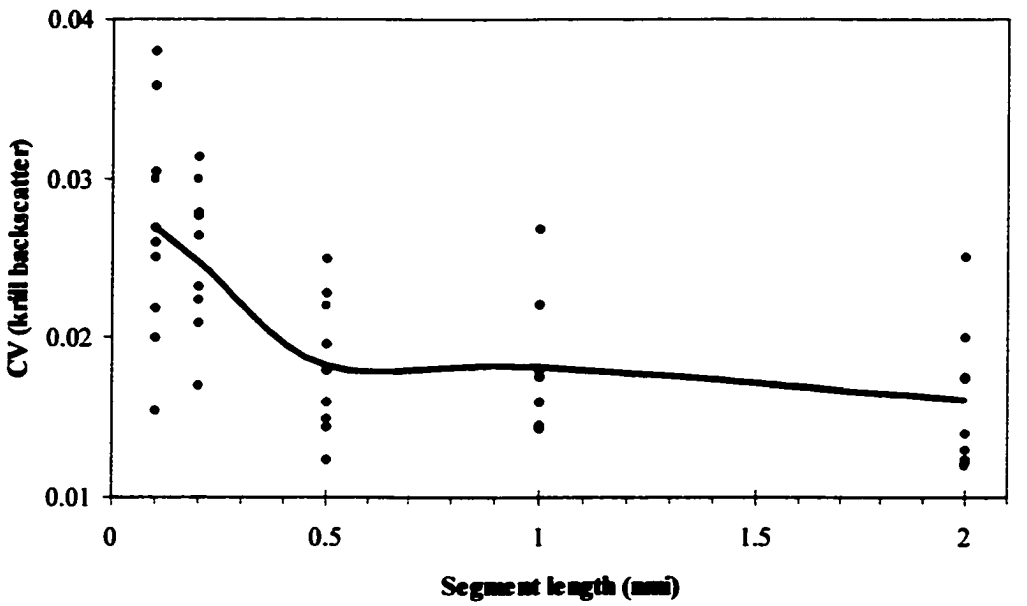

Figure 2. Simulation results of variance in krill backscatter relative to selected segment length (see Methods). Points represent estimated CVs based on 10 sets of 300 segments. Line is smoothed average CV.

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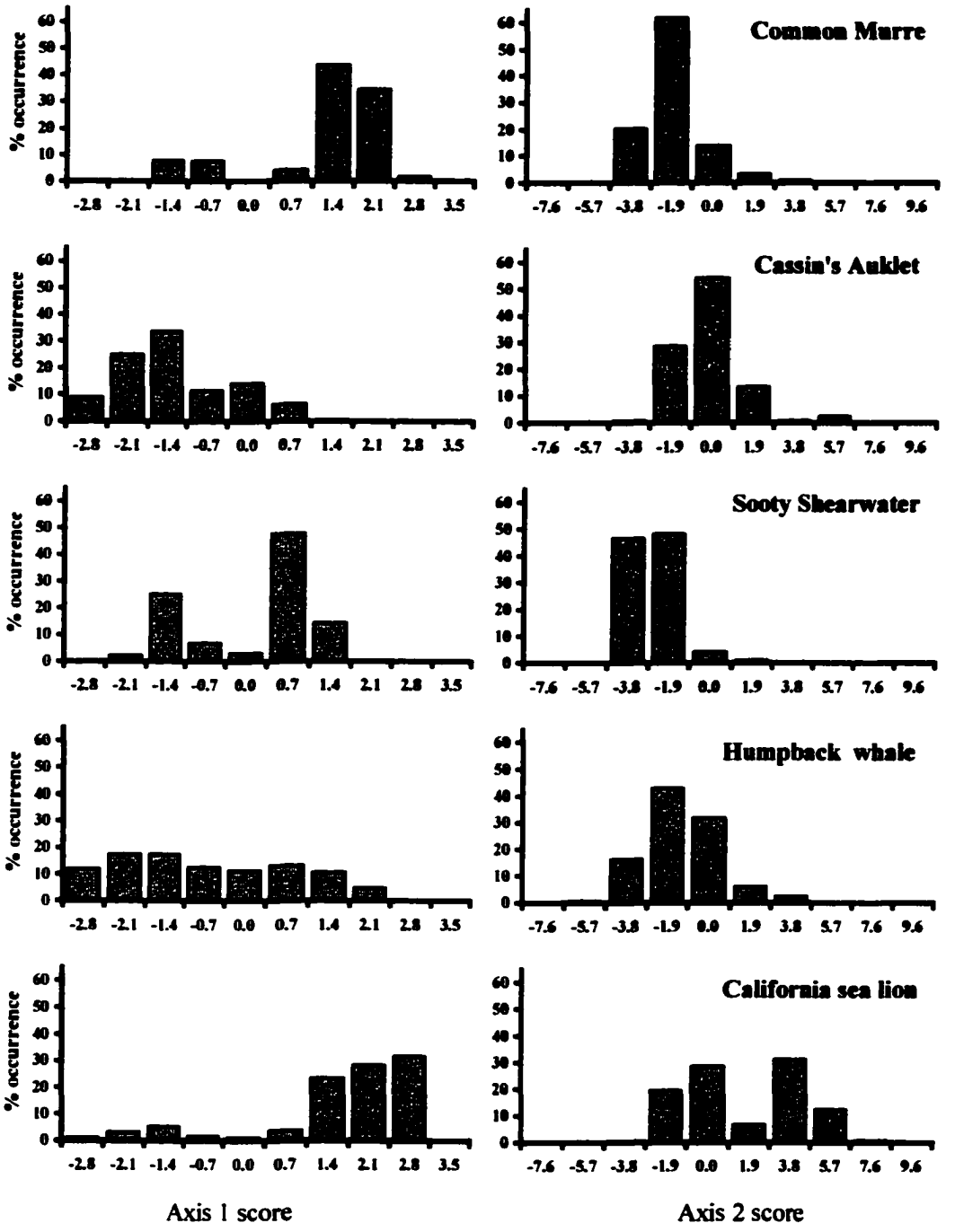

Figure 3. Representative frequency histograms of species scores for the first two environmental axes extracted by the CCA for 1996-99 Monterey Bay survey data.

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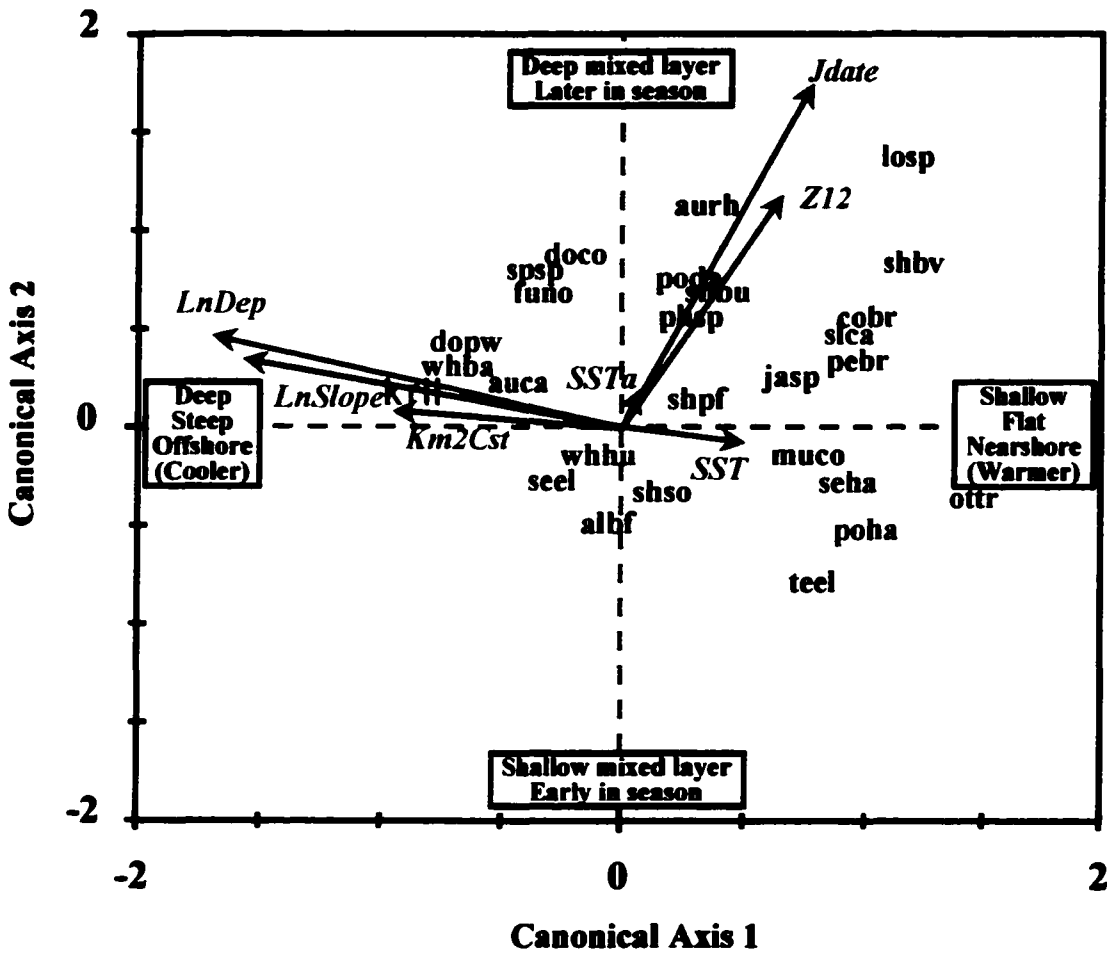

Figure 4. CCA biplot for all years combined. See Table 2 for species codes and text (Methods) for environmental variable codes. Environmental gradients are shown in green, seabirds in blue, marine mammals in red, and krill in pink.

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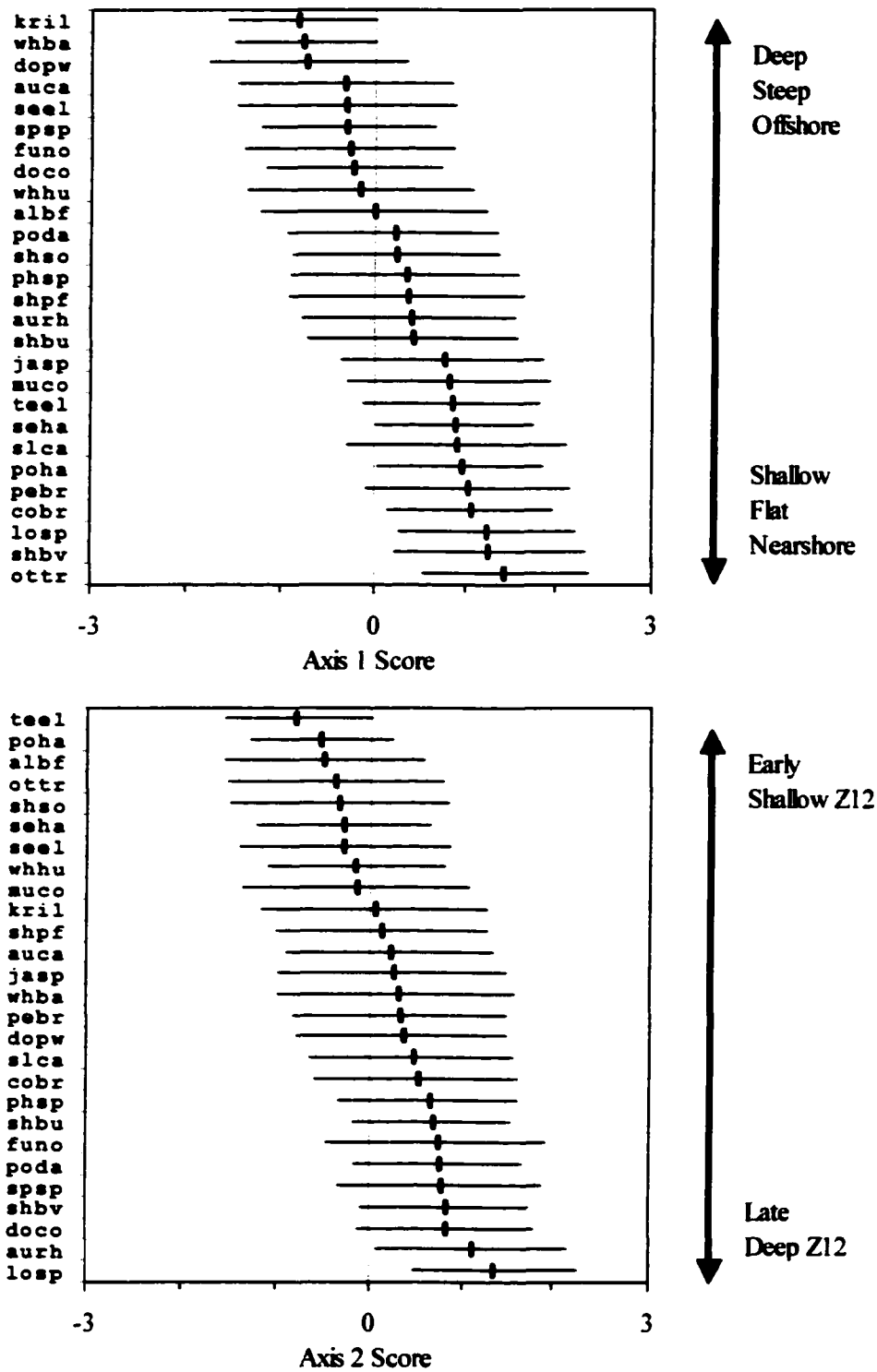

Figure 5. Species tolerances for scores along canonical axis 1 (top) and canonical axis 2 (bottom), identified in the CCA for all years, 1996-99. See Table 2 for species codes.

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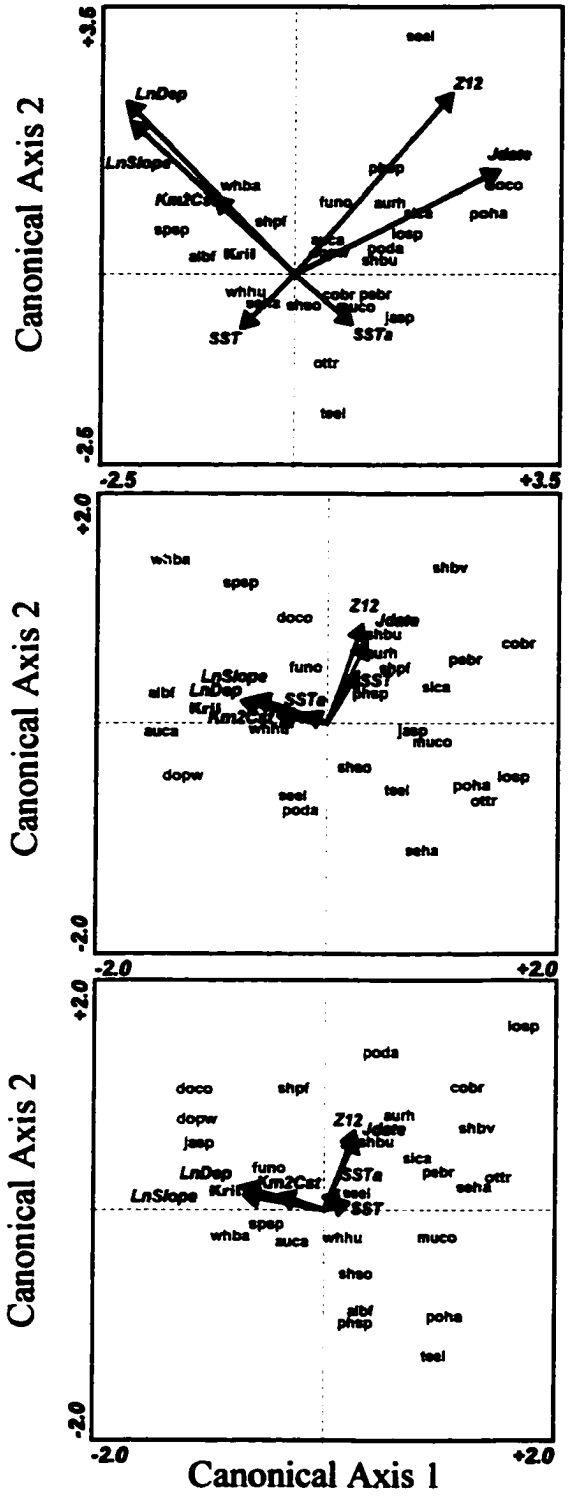

Figure 6. CCA biplots for three oceanographic periods: Pre-Niño (top), El Niño (center), and La Niña (bottom). See Table 2 for species codes; colors as in Figure 3.

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Recovery Plan for the

Pacific Coast Population of the

Western Snowy Plover

(*Charadrius alexandrinus nivosus*)

Volume 1: Recovery Plan

California/Nevada Operations Office
U.S. Fish and Wildlife Service
Sacramento, California

Approved: Steve Thompson

Manager, California/Nevada Operations Office,
U.S. Fish and Wildlife Service

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This final recovery plan was prepared by Kelly Hornaday, Ina Pisani, and Betty Warne of our Sacramento Fish and Wildlife Office. Ruth Pratt of the Sacramento Fish and Wildlife Office coordinated preparation of the draft recovery plan and acted as Recovery Team Manager.

We gratefully acknowledge the efforts of the Pacific Coast Western Snowy Plover Recovery Team in preparing this recovery plan. Special acknowledgment is also given to Nadav Nur, Point Reyes Bird Observatory, Stinson Beach, California, for his work on the population viability analysis.

DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. We, the U.S. Fish and Wildlife Service, publish recovery plans, sometimes preparing them with the assistance of recovery teams, contractors, State agencies, and others. Recovery teams serve as independent advisors to the U.S. Fish and Wildlife Service. Objectives of the recovery plan will be attained and necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific actions, and may not represent the views or the official positions or approval of any individuals or agencies involved in the recovery plan formulation other than our own. They represent our official position **only** after they have been signed by the Director, Regional Director, or Operations Manager as **approved**. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

Literature Citation Should Read As Follows:

U.S. Fish and Wildlife Service. 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). In 2 volumes. Sacramento, California. xiv + 751 pages.

An electronic version of this recovery plan also will be made available at http://www.fws.gov/cno/es/recoveryplans.html and http://endangered.fws.gov/recovery/index.html#plans

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Maps of snowy plover sites in Appendix L were prepared by Brian Cordone, Cheryl Hickam, and Joni Mitchell, Sacramento Fish and Wildlife Office, Sacramento, California.

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EXECUTIVE SUMMARY

CURRENT SPECIES STATUS: The Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*) (western snowy plover) is federally listed as threatened. The current Pacific coast breeding population extends from Damon Point, Washington, south to Bahia Magdalena, Baja California, Mexico (including both Pacific and Gulf of California coasts). The western snowy plover winters mainly in coastal areas from southern Washington to Central America.

HABITAT REQUIREMENTS AND LIMITING FACTORS: The Pacific coast population of the western snowy plover breeds primarily above the high tide line on coastal beaches, sand spits, dune-backed beaches, sparsely-vegetated dunes, beaches at creek and river mouths, and salt pans at lagoons and estuaries. Less common nesting habitats include bluff-backed beaches, dredged material disposal sites, salt pond levees, dry salt ponds, and river bars. In winter, western snowy plovers are found on many of the beaches used for nesting as well as on beaches where they do not nest, in man-made salt ponds, and on estuarine sand and mud flats.

Habitat degradation caused by human disturbance, urban development, introduced beachgrass (*Ammophila* spp.), and expanding predator populations have resulted in a decline in active nesting areas and in the size of the breeding and wintering populations.

RECOVERY OBJECTIVE: The primary objective of this recovery plan is to remove the Pacific coast population of the western snowy plover from the *List of Endangered and Threatened Wildlife and Plants* by: (1) increasing population numbers distributed across the range of the Pacific coast population of the western snowy plover; (2) conducting intensive ongoing management for the species and its habitat and developing mechanisms to ensure management in perpetuity; and (3) monitoring western snowy plover populations and threats to determine success of recovery actions and refine management actions.

RECOVERY PRIORITY: 3C, per criteria published by Federal Register Notice (U.S. Fish and Wildlife Service 1983).

RECOVERY CRITERIA: The Pacific coast population of the western snowy plover will be considered for delisting when the following criteria have been met:

1. An average of 3,000 breeding adults has been maintained for 10 years, distributed among 6 recovery units as follows: Washington and Oregon, 250 breeding adults; Del Norte to Mendocino Counties, California, 150 breeding adults; San Francisco Bay, California, 500 breeding adults; Sonoma to Monterey Counties, California, 400 breeding adults; San Luis Obispo to Ventura Counties, California, 1,200 breeding adults; and Los Angeles to San Diego Counties, California, 500 breeding adults. This criterion also includes implementing monitoring of site-specific threats, incorporation of management activities into management plans to ameliorate or eliminate those threats, completion of research necessary to modify management and monitoring actions, and development of a post-delisting monitoring plan.

2. A yearly average productivity of at least one (1.0) fledged chick per male has been maintained in each recovery unit in the last 5 years prior to delisting.

3. Mechanisms have been developed and implemented to assure long-term protection and management of breeding, wintering, and migration areas to maintain the subpopulation sizes and average productivity specified in Criteria 1 and 2. These mechanisms include establishment of recovery unit working groups, development and implementation of participation plans, development and implementation of management plans for Federal and State lands, protection and management of private lands, and public outreach and education.

ACTIONS NEEDED:

1. Monitor breeding and wintering populations and habitats of the Pacific coast population of the western snowy plover to determine progress of recovery actions to maximize survival and productivity.

2. Manage breeding and wintering habitat of the Pacific coast population of the western snowy plover to ameliorate or eliminate threats and maximize survival and productivity.

3. Develop mechanisms for long-term management and protection of western snowy plovers and their breeding and wintering habitat.

4. Conduct scientific investigations that facilitate the recovery of the western snowy plover.

5. Conduct public information and education programs about the western snowy plover.

6. Review progress towards recovery of the western snowy plover and revise recovery efforts, as appropriate.

7. Dedicate U.S. Fish and Wildlife Service staff to allow the Arcata Fish and Wildlife Office to coordinate western snowy plover recovery implementation.

8. Establish an international conservation program with the government of Mexico to protect western snowy plovers and their breeding and wintering locations in Mexico.

Appendices B and C address Actions 1 and 2, providing site-specific recommendations for breeding numbers and management actions. Appendix J addresses Action 1, providing guidelines for monitoring western snowy plovers during the breeding and wintering seasons. Appendix K addresses Action 5, providing a public information and education plan.

ESTIMATED COST OF RECOVERY: $149,946,000 plus additional costs that cannot be estimated at this time.

DATE OF RECOVERY: Delisting could occur by 2047 if the recovery criteria above have been met.

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I. INTRODUCTION

On March 5, 1993, the Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*) (western snowy plover) was listed as threatened under provisions of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*). The Pacific coast population is defined as those individuals that nest within 50 miles of the Pacific Ocean on the mainland coast, peninsulas, offshore islands, bays, estuaries, or rivers of the United States and Baja California, Mexico (U.S. Fish and Wildlife Service 1993*a*) (Figure 1). General locations of the western snowy plover's breeding and wintering locations in the United States are shown in Appendix A. Surveys, status reviews, and literature searches have identified 159 current or historical western snowy plover breeding or wintering locations on the U.S. Pacific coast. These localities include 6 in Washington, 19 in Oregon, and 134 in California (Appendix B). In Baja California, breeding western snowy plovers concentrate at coastal wetland complexes as far south as Bahia Magdalena, Mexico (Palacios *et al.* 1994). The locations listed in Appendix B are important for the recovery of the United States Pacific coast population of the western snowy plover because they represent important breeding, feeding, and sheltering habitat for the species.

In Washington, the western snowy plover was listed as endangered under Washington Department of Fish and Wildlife Policy #402 in 1981. In 1990 the Washington Fish and Wildlife Commission (Washington Administrative Code 232-12-014) reaffirmed the endangered status. In 1975, the Oregon Fish and Wildlife Commission listed the western snowy plover as threatened. Its threatened status was reaffirmed in 1989 under the Oregon Endangered Species Act and again in 1993 and 1998 by the Oregon Fish and Wildlife Commission as part of its periodic review process. Since 1978, the California Department of Fish and Game has classified both the inland and coastal population of western snowy plover as a "species of special concern." (Remsen 1978, California Natural Diversity Database 2001).

In August 2002, we received a petition from the Surf Ocean Beach Commission of Lompoc, California to delist the Pacific Coast population of the western snowy

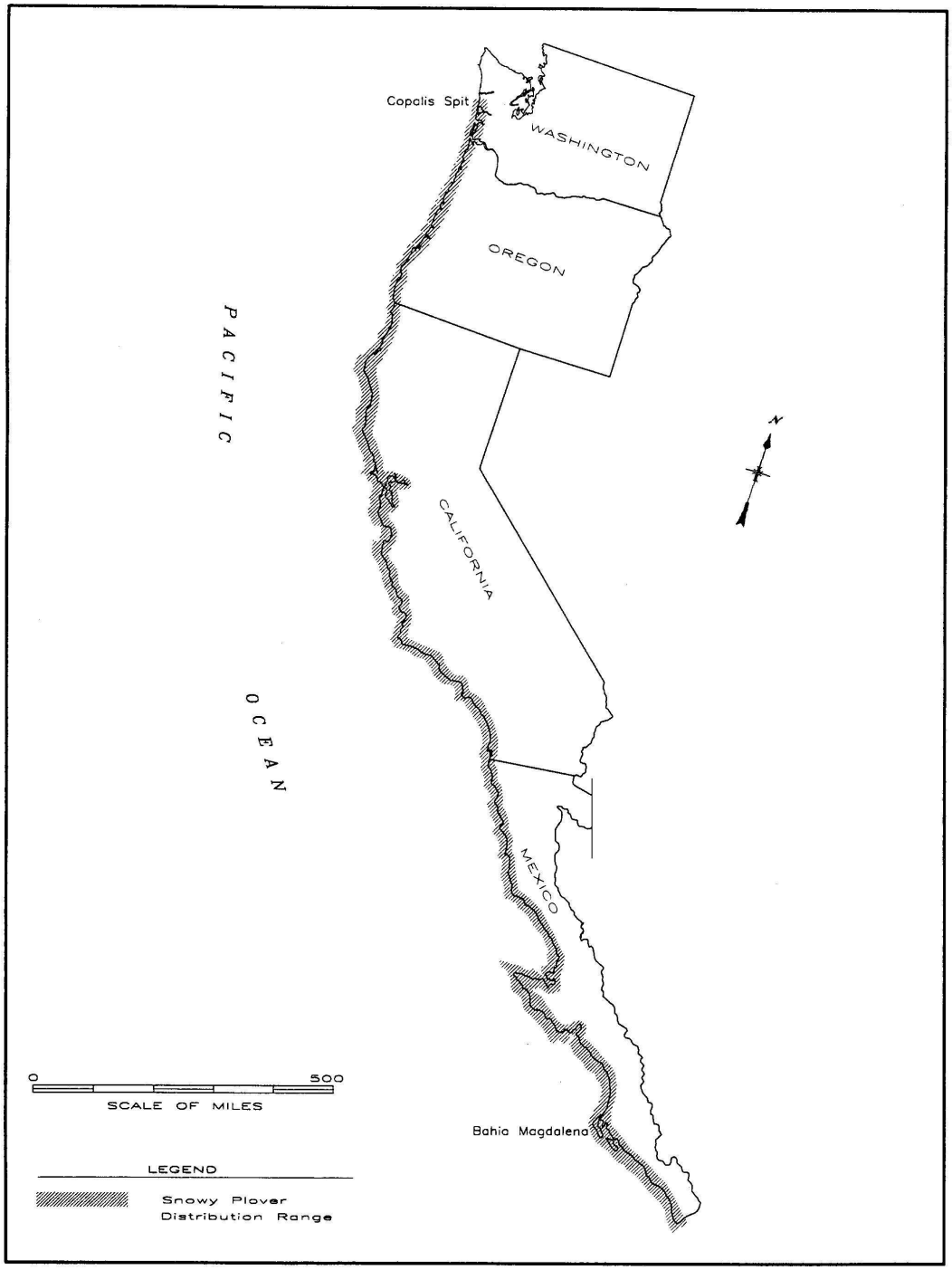

Figure 1. Map of known breeding and wintering distribution of the Pacific coast population of the western snowy plover.

plover. The City of Morro Bay, California submitted substantially the same petition dated May 30, 2003. On March 22, 2004, we published a notice that the petition presented substantial information to indicate that the delisting may be warranted (U.S. Fish and Wildlife Service 2004*a*). This notice also announced our initiation of a 5-year status review for the Pacific coast population of western snowy plover.

Under sections 4(b)(3)(B) and 4(c)(2) of the Endangered Species Act, we conducted a 5-year status review and evaluated whether the petitioned action was warranted. On April 21, 2006, we published a 12-month finding that concluded the petitioned action was not warranted (U.S. Fish and Wildlife Service 2006*a*). We also proposed a special rule pursuant to section 4(d) of the Endangered Species Act (U.S. Fish and Wildlife Service 2006*b*), which would exempt counties that have met western snowy plover recovery goals from most prohibitions on take as long as populations remain above recovery goals. The 5-year status review was completed on June 8, 2006.

Section 4 of the Endangered Species Act of 1973, as amended, requires us to develop a recovery plan for the conservation and survival of a species after it is federally listed as threatened or endangered, unless it is determined that such a plan will not promote the conservation of the species. Recovery is the process of reversing the decline of a listed species, eliminating threats, and ensuring the species' long-term survival. This recovery plan recommends actions necessary to satisfy the biological needs and assure recovery of the Pacific coast population of the western snowy plover. These actions include protection, enhancement, and restoration of all habitats deemed important for recovery; monitoring; research; and public outreach.

This recovery plan will serve as a guidance document for interested parties including Federal, State, and local agencies; private landowners; and the general public. It includes recommendations for western snowy plover management measures for all known breeding and wintering locations (Appendix C). These locations have been divided into six recovery units, as follows: (1) Oregon and Washington; (2) northern California (Del Norte, Humboldt, and Mendocino Counties); (3) San Francisco Bay (locations within Napa, Alameda, Santa Clara,

and San Mateo Counties); (4) Monterey Bay (including coastal areas along Monterey, Santa Cruz, San Mateo, San Francisco, Marin, and Sonoma Counties); (5) San Luis Obispo, Santa Barbara, and Ventura Counties; and (6) Los Angeles, Orange, and San Diego Counties. Designation of these locations and recovery units assists in identifying priority areas for conservation planning across the western snowy plover's breeding and wintering range.

This recovery plan emphasizes management on Federal and State lands, including opportunities to improve or expand upon current efforts. Because of this emphasis on public lands, the cost associated with this emphasis, and potential restrictions of public use on these lands, public support and involvement will be crucial to the recovery of the western snowy plover. Opportunities for public participation in recovery efforts are emphasized in Appendix K (Information and Education Plan).

A. DESCRIPTION AND TAXONOMY

The western snowy plover, a small shorebird in the family Charadriidae, weighs from 34 to 58 grams (1.2 to 2 ounces) and ranges in length from 15 to 17 centimeters (5.9 to 6.6 inches) (Page *et al.* 1995*a*). It is pale gray-brown above and white below, with a white hindneck collar and dark lateral breast patches, forehead bar, and eye patches (Figure 2). The bill and legs are blackish. In breeding plumage, males usually have black markings on the head and breast; in females, usually one or more of these markings are dark brown. Early in the breeding season a rufous crown may be evident on breeding males, but it is not typically seen on females. In non-breeding plumage, sexes cannot be distinguished because the breeding markings disappear. Fledged juveniles have buffy edges on their upper parts and can be distinguished from adults until approximately July through October, depending on when in the nesting season they hatched. After this period, molt and feather wear makes fledged juveniles indistinguishable from adults. Individual birds 1 year or older are considered to be breeding adults. The mean annual life span of western snowy plovers is estimated at about 3 years, but at least one individual was at least 15 years old when last seen (Page *et al.* 1995*a*).

Figure 2. Adult male western snowy plover (photo by Peter Knapp, with permission).

The species was first described in 1758 by Linnaeus (American Ornithologists' Union 1957). Two subspecies of the snowy plover have been recognized in North America (American Ornithologists' Union 1957): the western snowy plover (*Charadrius alexandrinus nivosus*) and the Cuban snowy plover (*C. a. tenuirostris*). The Pacific coast population of the western snowy plover breeds on the Pacific coast from southern Washington to southern Baja California, Mexico. Wintering birds may remain at their breeding sites or move north or south to other wintering sites along the Pacific coast. The interior population of the western snowy plover breeds in interior areas of Oregon, California, Nevada, Utah, New Mexico, Colorado, Kansas, Oklahoma, and north-central Texas, as well as coastal areas of extreme southern Texas, and possibly extreme northeastern Mexico (American Ornithologists' Union 1957). Although previously observed only as a migrant in Arizona, small numbers have bred there in recent years (Monson and Phillips 1981, Davis and Russell 1984). Interior population birds breeding east of the Rockies generally winter along the Gulf coast, while most interior population birds breeding west of the Rockies winter in coastal California and Baja

California, often intermingling with birds from the Pacific coast breeding population. The Cuban snowy plover breeds along the Gulf coast from Louisiana to western Florida and south through the Caribbean (American Ornithologists' Union 1957). More recent works recognize only subspecies *C. a. nivosus* for North America (Hayman *et al.* 1986, Binford 1989, Sibley and Monroe 1990).

A large amount of breeding data indicates that the Pacific coast population of the western snowy plover is distinct from western snowy plovers breeding in the interior (U.S. Fish and Wildlife Service 1993*a*, 2006*a*). A study conducted between 1977 and 1982 reported that western snowy plovers tend to exhibit breeding site fidelity (Warriner *et. al.* 1986). Banding and resighting data show that the Pacific Coast breeding populations and the western interior breeding populations experience limited or rare reproductive interchange (G. Page *in litt.* 2004*a*). Between 1984 and 1995, the period with the most extensive banding studies and search efforts, 907 plovers color-banded in coastal and interior populations were subsequently resighted (excluding birds banded on the coast during winter and birds resighted in their original region without evidence of nesting). Of these, 894 birds (98.6 percent) were observed during the breeding season using the same breeding range in which they were originally banded. Twelve birds (1.3 percent) were banded on the coast and later observed in the interior, only one of which was known to nest in the interior. Only one male (0.1 percent) was banded in the interior (without evidence of nesting) and later found nesting on the coast. Moreover, data from a period of less intensive surveys and banding from 1977 to 1983 corroborate this pattern (G. Page *in litt.* 2004*a*, U.S. Fish and Wildlife Service 2006*a*). During this period, of 400 birds banded in the interior, none were observed on the coast during breeding season, and of 599 birds banded on the coast only one was found nesting in the interior. Finally, 304 retrievals of numbered metal bands reported between 1969 and 2002 show no evidence of movement from interior to coast and only one bird (G. Goldsmith *in litt*. 2004, U.S. Fish and Wildlife Service 2006*a*) that moved from coast to interior (the dates being consistent with a bird from the interior population having been banded on the coast during the non-breeding season).

Thus, intensive banding and monitoring studies have documented only two clear instances of interbreeding between coastal and interior populations, and a few

cases of inter-population movement without confirmed breeding, among thousands of birds observed. These results illustrate that the amount of interchange between coastal and interior populations is likely to be extremely low, though not zero. Movement of birds from coastal to interior populations has been documented more often than the reverse (see also U.S. Fish and Wildlife Service 2006a).

Genetic studies using mitochondrial DNA and microsatellite DNA markers (Gorman 2000, Funk *et al.* 2006) have found no significant genetic differentiation between the Pacific coast and interior populations of the western snowy plover. However, because a small number of dispersing individuals per generation is sufficient to prevent genetic differentiation between two semi-isolated populations (Mills and Allendorf 1996, Funk *et al.* 2006), this result is consistent with the banding data reported above. Because the small number of dispersing individuals indicated by banding data appear insufficient to substantially affect rates of population growth or decline in either population, the two populations evidently function demographically as largely independent of one another. Moreover, the infrequency of observed dispersal from coast to interior further indicates that any declines in the coastal population are not likely to be effectively offset by immigration of interior birds to the coast. Consequently there is no evidence that existing unoccupied habitat along the Pacific coast is currently being or in future would be naturally colonized by birds from the interior population (Funk et al. 2006).

B. LIFE HISTORY AND ECOLOGY

1. Breeding

The Pacific coast population of the western snowy plover breeds primarily on coastal beaches from southern Washington to southern Baja California, Mexico (*e.g.*, Figure 3). Sand spits, dune-backed beaches, beaches at creek and river mouths, and salt pans at lagoons and estuaries are the main coastal habitats for nesting (Stenzel *et al.* 1981, Wilson 1980). This habitat is unstable because of

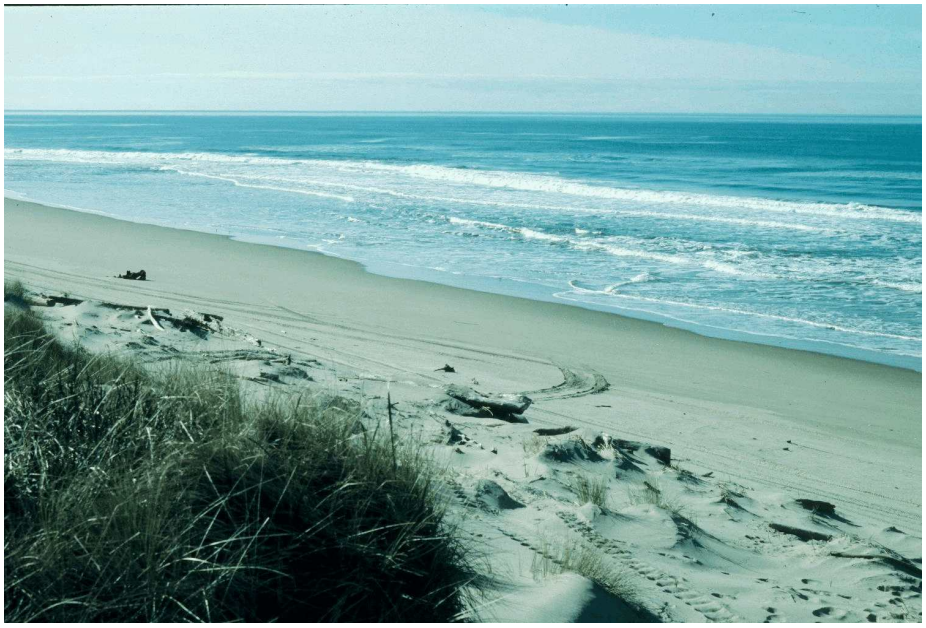

Figure 3. Coastal beach in Oregon Dunes National Recreational Area (photo by Ruth Pratt, with permission)

unconsolidated soils, high winds, storms, wave action, and colonization by plants. Less common nesting habitats include bluff-backed beaches, dredged material disposal sites, salt pond levees, dry salt ponds, and river bars (Wilson 1980, Page and Stenzel 1981, Powell *et al.* 1996, Tuttle *et al.* 1997).

a. Population Size and Distribution

Population estimates referenced below are based on window surveys as well as on more intensive studies involving repeated surveys of populations with individually identifiable color-banded birds. Window surveys are a one-time pass of a surveyor, or team of surveyors, through potential western snowy plover nesting habitat during May or June (see survey protocol in Appendix J). The surveyor counts all adult western snowy plovers in the habitat and identifies the adults as male or female, when possible. Because window surveys may not detect all birds, they are not directly comparable to more intensive studies. A correction factor can be estimated by comparing window survey data with concurrent population estimates from detailed studies of color-banded populations; currently the best

rangewide estimate of the correction factor is 1.3 (U.S. Fish and Wildlife Service 2006*a*), but it is preferable to determine corrections on a more specific regional or site basis if possible due to differences in survey efficiency in different habitats (see action 4.3.1).

Western snowy plovers concentrate in suitable habitat, with the number of adults at coastal breeding locations ranging from 1 to 315, depending in part, on the size of the area (Appendix B). The largest number of breeding birds occurs from south San Francisco Bay to southern Baja California (Page and Stenzel 1981, Palacios *et al.* 1994).

The locations of the following parenthetical references to western snowy plover breeding and wintering locations in Washington, Oregon, and California are shown in Figures A-1 through A-7 of Appendix A, and mapped in greater detail in Appendix L. Information on the numbers of breeding and wintering western snowy plovers at these locations is described in Appendix B.

Four breeding areas currently exist in southern Washington: Damon Point (Washington location 2 [WA-2]) in Grays Harbor; Midway Beach (WA-4); and Leadbetter Point (WA-5) and Graveyard Spit (discovered in 2006) in Willapa Bay. Prior to the 1998 breeding season, fewer than 25 western snowy plovers and 12 nests were found in Washington during regular, standardized surveys. However, surveys from 1998 through 2006 (Sundstrom 2003, 2005; Brennan and Fernandez 2004*a*, 2006; Pearson *et al.* 2006; Washington Department of Fish and Wildlife unpub. data) indicate greater numbers of western snowy plovers are nesting at Leadbetter Point (WA-5) and Midway Beach (WA-4), with a maximum estimated population of 70 western snowy plovers statewide in 2006.

In Oregon, nesting birds have been recorded at 14 sites since 1990 (Castelein *et al.* 2002, Lauten *et al.* 2006*a*, 2006*b*). Nesting has occurred most frequently at 9 sites, including Sutton (OR-8), Siltcoos (OR-10), Dunes Overlook (OR-10), Tahkenitch (OR-10), Tenmile Spits (OR-12), Coos Bay North Spit (OR-13), Bandon (OR-15), New River (OR-15), and Floras Lake (OR-15). An estimated 177-179 adult western snowy plovers were observed at Oregon sites during the 2006 breeding season. A total of 135 individuals were known to have nested in

2006, with 147 nests located. Individual nests have also been found between 1990 and 2002 at several other Oregon sites, including Necanicum (OR-1); Bayocean Spit (OR-3); North Siuslaw (OR-8); Threemile-Umpqua River (OR-11); and Menasha Spoils, North Bend.

Western snowy plover populations in California have fluctuated between roughly one thousand and two thousand birds over the past 30 years, as detailed in section I.C.1.c below. Eight geographic areas support over three-quarters of the California coastal breeding population: San Francisco Bay (CA-27 to CA-47), Monterey Bay (CA-63 to CA-65), Morro Bay (CA-79 to CA-81), the Callendar-Mussel Rock Dunes area (CA-83), the Point Sal to Point Conception area (CA-84 to CA-88), the Oxnard lowland (CA-96 to CA-99), Santa Rosa Island (CA-93), and San Nicolas Island (CA-100) (Page *et al.* 1991, G. Page *in litt.* 2005*a*).

A survey of breeding western snowy plovers along the Pacific coast of Baja California, Mexico between 1991 to 1992 found 1,344 adults, mostly at four coastal wetland complexes: Bahia San Quintin, Lagunas Ojo de Liebre and Guerrero Negro, Laguna San Ignacio, and Bahia Magdalena (Palacios *et al.* 1994).

b. Arrival and Courtship

Nesting western snowy plovers at coastal locations consist of both year-round residents and migrants (Warriner *et al.* 1986). Migrants begin arriving at breeding areas in southern Washington in early March (Widrig 1980) and in central California as early as January, although the main arrival is from early March to late April (Page *et al.* 1995*a*). Since some individuals nest at multiple locations during the same year, birds may continue arriving through June (Stenzel *et al.* 1994).

Mated birds from the previous breeding season frequently reunite. Pair bonds are associated with territorial defense by males and nest scraping behavior, but early in the season birds begin to associate with one another in pairs within and apart from roosting flocks before nest scraping activity is observed, suggesting that pair bonds can be established prior to overt displays (Warriner *et al.* 1986). A scrape is a depression in the sand or substrate that a male constructs by leaning forward

on his breast and scratching his feet while rotating his body axis (Page *et al.* 1995*a*). Copulations are associated with scraping behavior (Warriner *et al.* 1986). Females choose which scrape becomes the nest site by laying eggs in one of them. In California, pre-nesting bonds and courtship activities are observed as early as mid-February. Similar activities begin by March in Oregon. During courtship, males defend territories and usually make multiple scrapes.

c. Duration of Breeding Season

Along the west coast of the United States, the nesting season of the western snowy plover extends from early March through late September. Generally, the breeding season may be 2 to 4 weeks earlier in southern California than in Oregon and Washington. Fledging (reaching flying age) of late-season broods may extend into the third week of September throughout the breeding range.

The earliest nests on the California coast occur during the first week of March in some years and by the third week of March in most years (Page *et al.* 1995*a*). Peak initiation of nesting is from mid-April to mid-June (Warriner *et al.* 1986; Powell *et al.* 1997). Hatching lasts from early April through mid-August, with chicks reaching fledging age approximately 1 month after hatching (Powell *et al.* 1997). On the Oregon coast nesting may begin as early as mid-March, but most nests are initiated from mid-April through mid-July (Wilson-Jacobs and Meslow 1984); peak nest initiation occurs from mid-May to early July (Stern *et al.* 1990). In Oregon, hatching occurs from mid-April through mid-August, with chicks reaching fledging age as early as mid- to late May. Peak hatching occurs from May through July, and most fledging occurs from June through August. On the Washington coast, most adults arrive during late April, with maximum numbers present from mid-May to late June. Fledging occurs from late June through August (Washington Department of Fish and Wildlife 1995).

d. Nests and Nest Sites

Nests typically occur in flat, open areas with sandy or saline substrates; vegetation and driftwood are usually sparse or absent (Widrig 1980, Wilson 1980, Stenzel *et al.* 1981). Western snowy plovers also regularly nest on the gravel bars along the

Eel River in northern California. In southern California, western snowy plovers nest in areas with 6 to 18 percent vegetative cover and 1 to 14 percent inorganic cover; vegetation height is usually less than six centimeters (2.3 inches) (Powell *et al.* 1995, 1996). Nests consist of a shallow scrape or depression, sometimes lined with beach debris (*e.g.*, small pebbles, shell fragments, plant debris, and mud chips); nest lining increases as incubation progresses. Driftwood, kelp, and dune plants provide cover for chicks that crouch near objects to hide from predators. Invertebrates are often found near debris, so driftwood and kelp are also important for harboring western snowy plover food sources (Page *et al.* 1995*a*). Page and Stenzel (1981) found that nests were usually within 100 meters (328 feet) of water, but could be several hundred meters away when there was no vegetative barrier between the nest and water. They believed the absence of such a barrier is probably important for newly-hatched chicks to have access to the shore. Powell *et al.* (1995, 1996) also reported that nests from southern California were usually located within 100 meters (328 feet) of water, which could be either ocean, lagoon, or river mouth. Although the majority of western snowy plovers are site-faithful, returning to the same breeding area in subsequent breeding seasons, some also disperse within and between years (Warriner *et al.* 1986, Stenzel *et al.* 1994). Western snowy plovers occasionally nest in exactly the same location as the previous year (Warriner *et al.* 1986).

e. Egg Laying, Clutch Size, and Incubation

Initiation (eggs and laying) occurs from mid-February/early March through the third week of July (Wilson 1980, Warriner *et al.* 1986). The approximate periods required for nesting events are: scrape construction (in conjunction with courtship and mating), 3 days to more than a month; egg laying, usually 4 to 5 days; and incubation, 26 to 31 days (mean 27 days) (Warriner *et al.* 1986). The usual clutch size (*e.g.*, number of eggs in one nest) is three (Figure 4) with a range from two to six. (Warriner *et al.* 1986, Page *et al.* 1995*a*). Both sexes incubate the eggs, with the female tending to incubate during the day and the male at night (Warriner *et al.* 1986). Adult western snowy plovers frequently will attempt to lure people and predators from hatching eggs with alarm calls and distraction displays. Occasionally, adults behave similarly during the egg-laying period or

Figure 4. Western snowy plover clutch (photo by Bruce Casler, with permission).

incubation of completed clutches. More typical, however, is for the incubating adult to run away from the eggs without being seen. Incomplete clutches are those in which all eggs have not been laid. Partly-incubated clutches are those clutches having some degree (in days) of incubation.

Western snowy plovers will re-nest after loss of their eggs (Wilson 1980, Warriner *et al.* 1986). Re-nesting occurs 2 to 14 days after failure of a clutch, and up to five re-nesting attempts have been observed for a pair (Warriner *et al.* 1986).

Double brooding with polyandry (meaning the female successfully hatches more than one brood [*i.e.* sibling chicks of a hatched nest] in a nesting season with different mates) is common in coastal California (Warriner *et al.* 1986) and Oregon (Wilson-Jacobs and Meslow 1984). On the California coast, the breeding season is long enough for some females to triple brood and for some males to double brood (Page *et al.* 1995*a*). Triple brooding in a male has, on rare occasion, been recorded; a male triple brooded at Moss Landing salt ponds in 2001 (D. George *in litt.* 2001). After losing a clutch or brood or successfully hatching a

nest, western snowy plovers may re-nest at the same site or move up to several hundred kilometers to nest at other sites (Stenzel *et al.* 1994, Powell *et al.* 1997).

f. Clutch Hatching Success

Widely varying clutch hatching success (percent of clutches hatching at least one egg) is reported in the literature. Clutch hatching success ranging from 0 to 90 percent has been recorded for coastal western snowy plovers (Widrig 1980, Wilson 1980, Saul 1982, Wilson-Jacobs and Dorsey 1985, Warriner *et al.* 1986, Wickham unpubl. data *in* Jacobs 1986). Low clutch hatching success has been attributed to a variety of factors, including predation, human disturbance, high tides, and inclement weather. Heavy recreational beach use coincides with the peak hatching period for western snowy plover eggs (Powell 2001), adding additional pressures to western snowy plover adults and chicks that are more exposed to human disturbance. Observed clutch hatching success ranged from 12.5 to 86.8 percent and averaged 50.6 percent in eight studies of coastal breeding western snowy plovers (Page *et al.* 1995*a*). In San Diego County, estimated nesting success ranged from 43 to 68 percent between 1994 and 1998, averaging 54 percent (Powell *et al.* 2002); nesting western snowy plovers in San Diego County likely benefitted from predator management efforts for snowy plovers and California least terns (*Sternula antillarum browni*) (A. Powell, U.S. Geological Survey, pers. comm. 1998). In Monterey Bay, hatching rate was significantly increased from 43 percent (during 1984-1990) to 68 percent (during 1991-1999) by intensive control of mammalian predators and use of nest exclosures (Neuman *et al.* 2004).

g. Brood-rearing

The first chick hatched remains in or near the nest until other eggs (or at least the second egg) hatch. The adult western snowy plover, while incubating the eggs, also broods the first chick. The non-incubating adult also may brood the first-born chick a short distance from the nest. If the third egg of a clutch is 24 to 48 hours behind the others in hatching, it may be deserted. Western snowy plover chicks are precocial, leaving the nest within hours after hatching to search for food. They are not able to fly (fledge) for approximately 1 month after hatching;

fledging requires 28 to 33 days (Warriner *et al.* 1986). Broods rarely remain in the nesting area until fledging (Warriner *et al.* 1986, Stern *et al.* 1990). Western snowy plover broods may travel along the beach as far as 6.4 kilometers (4 miles) from their natal area (Casler *et al.* 1993).

Adult western snowy plovers do not feed their chicks, but lead them to suitable feeding areas. Adults use distraction displays to lure predators and people away from chicks. With vocalizations, adult western snowy plovers signal the chicks to crouch as another way to protect them (Page *et al.* 1995*a*). They also may lead chicks, especially larger ones, away from predators. Warriner *et al.* (1986) reported that most chick mortality occurs within 6 days after hatching.

Females generally desert mates and broods by the sixth day after hatching and thereafter the chicks are typically accompanied by only the male. While males rear broods, females obtain new mates and initiate new nests (Page *et al.* 1995*a*). Females typically help rear the last brood of the season.

h. Fledging success

The fledging success of western snowy plovers (percentage of hatched young that reach flying age) varies greatly by location and year. Even western snowy plovers nesting on neighboring beach segments may exhibit quite different success in the same year. For example, the percentage of chicks fledged on different beach segments of Monterey Bay in 1997 varied from 11 to 59 percent (average 24 percent) (Page *et al.* 1997). During the prior 13 years, fledging success on Monterey Bay beaches averaged 39 percent (Page *et al.* 1997). From the former Moss Landing salt ponds (now known as the Moss Landing Wildlife Area) in Monterey Bay (CA-64), fledging success ranged from 13.2 percent to 57.1 percent from 1988 to 1997. In San Diego County, fledging success ranged from 32.6 to 51.4 percent (Powell *et al.* 1997). In Oregon, annual fledging success for 1992 to 2006, for all coastal sites combined, ranged from 26 to 55 percent (Lauten *et al.* 2006*a*, 2006*b*). As in California, there is considerable variation among sites within years. For example, in 2005, the fledging success ranged from 24 percent at New River (OR-15) to 70 percent at Coos Bay South Beach (OR-13). There also is variation at individual sites among years. At the Coos Bay North Spit

(OR-13), one of the larger nesting areas in coastal Oregon, annual fledging success for 1992 to 2006 ranged from 38 to 74 percent.

i. Productivity

The productivity information most useful for this recovery plan is reproductive success (the annual number of young fledged per adult male). For the population viability analysis (Appendix D), males were used in the model because their population parameters can be estimated with greater certainty than for females. In addition, it is reasonable to consider that the availability of males is limiting reproductive success because they are responsible for post-hatching parental care, and females can lay clutches for more than one male (Warriner *et al.* 1986).

Chicks are considered fledged at 28 to 33 days after hatching. Estimates of the number of young fledged per adult male are available for Oregon; northern California from Mendocino to Del Norte Counties; Monterey Bay, California; and San Diego County, California. Along the Oregon coast, the average number of young annually fledged per male during the period between 1992 and the initiation of predator management (2002 to 2004 depending on site) was estimated as 0.87 (Lauten *et al.* 2006*b*); this fledging success significantly increased to 1.44 since implementation of predator management. Male fledging success in Oregon has annually ranged between 0.70 and 1.64 (Lauten *et al.* 2006*a*). In northern California, fledging success ranged from 0.8 to 1.7 fledglings per male between 2001-2005, with birds nesting on river gravel bars consistently achieving greater success than those nesting on beaches (Colwell *et al.* 2005). At Monterey Bay, California, from 1984 to 1990, when little effort was made to protect chicks from predators and people, males averaged 0.86 fledglings annually. When intensive efforts were undertaken to control mammalian predators from 1993 to 1999, the number of young fledged per adult male initially increased above 1.1, then declined sharply as avian predation on chicks became increasingly significant (Neuman *et al.* 2004). After live trapping and removal of avian predators was initiated, fledging success again increased in target areas (G. Page *in litt.* 2004b). Over 16 years of study at Monterey Bay, the annual number of young fledged ranged from 0.32 to 1.23 per male (Neuman *et al.* 2004). In San Diego County from 1994 to 1998, an average of 0.15 to 0.44 young were fledged per male

(Powell et al. 2002). Fledging success in Washington cannot be accurately estimated due to lack of banded chicks and adults and variable monitoring effort prior to 2006 (S. Pearson *in litt.* 2006); however it was roughly estimated at between 0.76 and 1.45 young fledged per male in 2006, excluding Leadbetter Point which was insufficiently surveyed but may have had poorer fledging success (Pearson *et al.* 2006).

j. Survival

Annual survival rates for adult and juvenile western snowy plovers have been calculated from studies of color banded birds from the coast of Oregon (M. Stern unpubl. data), the shoreline of Monterey Bay, California (Point Reyes Bird Observatory unpublished data), and the coast of San Diego County, California (A. Powell and J. Terp unpublished data) using the program SURGE (Lebreton *et al.* 1992, Cooch *et al.* 1996). Annual juvenile survival rates for fledged young average 48.5 percent (1992-2002) from the Oregon coast, 45 percent from Monterey Bay, and 45 percent from the San Diego coast. Annual survival rates for adult females and males, respectively, averaged 75 and 75 percent from the Oregon coast, 69 and 75 percent from Monterey Bay, and 72 and 71 percent from the San Diego coast. Differences between males and females were statistically significant only for the Monterey Bay area. Appendix D explains how these survival rates were incorporated into the population viability analysis.

2. Feeding Habitat and Habits

Western snowy plovers are primarily visual foragers, using the run-stop-peck method of feeding typical of *Charadrius* species. They forage on invertebrates in the wet sand and amongst surf-cast kelp within the intertidal zone, in dry sand areas above the high tide, on salt pans, on spoil sites, and along the edges of salt marshes, salt ponds, and lagoons. They sometimes probe for prey in the sand and pick insects from low-growing plants. At the Bolsa Chica wetlands in California, western snowy plovers have been observed pecking small, flying insects from mid-air and shaking one foot in very shallow water to agitate potential prey (Fancher *et al.* 1998). Western snowy plover food consists of immature and adult forms of aquatic and terrestrial invertebrates. Little quantitative information is

available on food habits. In San Diego, California, invertebrates found in western snowy plover feces during the breeding season included rove beetles (Staphylinidae), long-legged flies (Dolichopodidae), shore flies (Ephydridae), water bugs (Saldidae), hymenopterans (Braconidae), and unidentified insect larvae (Tucker and Powell 1999). During the breeding season, Jacobs (1986) observed adult western snowy plovers feeding on sand hoppers (Orchestoidea) and small fish on the Oregon coast. Other food items reported for coastal western snowy plovers include Pacific mole crabs (*Emerita analoga*), striped shore crabs (*Pachygrapsus crassipes*), polychaetes (Neridae, *Lumbrineris zonata, Polydora socialis, Scoloplos acmaceps)*, amphipods (*Corophium* ssp., *Ampithoe* spp., *Allorchestes angustus*), tanadacians (*Leptochelia dubia*), shore flies (Ephydridae), beetles (Carabidae, Buprestidae, Tenebrionidae), clams (*Transenella* sp.), and ostracods (Page *et al.* 1995*a*). In salt evaporation ponds in San Francisco Bay, California, the following prey have been recorded: brine flies (*Ephydra cinerea*), beetles (*Tanarthrus occidentalis, Bembidion* sp.), moths (*Perizoma custodiata*), and lepidopteran caterpillars (Feeney and Maffei 1991). Opportunities for foraging are directly dependent on salinity levels. Specifically, salt ponds of medium salinity seem to provide the best quality foraging habitat (M. Kolar, San Francisco Bay National Wildlife Refuge, pers. comm. 2004).

3. Migration

While some western snowy plovers remain in their coastal breeding areas year-round, others migrate south or north for winter (Warriner *et al.* 1986, Page *et al.* 1995*a*, Powell *et al.* 1997). In Monterey Bay, California, 41 percent of nesting males and 24 percent of the females were consistent year-round residents (Warriner *et al.* 1986). At Marine Corps Base Camp Pendleton in San Diego County, California, about 30 percent of nesting birds stayed during winter (Powell *et al.* 1995, 1996, 1997). The migrants vacate California coastal nesting areas primarily from late June to late October (Page *et al.* 1995*a*). There is evidence of a late-summer (August/September) influx of western snowy plovers into Washington; it is suspected that these wandering birds are migrants (S. Richardson, Washington Department of Fish and Wildlife, pers. comm. 1998).

Most western snowy plovers that nest inland migrate to the coast for the winter (Page *et al.* 1986, 1995*b*). Thus, the flocks of non-breeding birds that begin forming along the U.S. Pacific coast in early July are a mixture of adult and hatching-year birds from both coastal and interior nesting areas. During migration and winter, these flocks range in size from a few individuals to up to 300 birds (Appendix B).

4. Wintering

a. Distribution and Abundance

In western North America, the western snowy plover winters (here defined as late October to mid-February) mainly in coastal areas from southern Washington to Central America (Page *et al.* 1995*a*). Both coastal and interior populations use coastal locations in winter. Small numbers of western snowy plovers occur at two locations on the Washington coast: Midway Beach (WA-4) (S. Richardson, pers. comm. 1998, J. Grettenberger, U.S. Fish and Wildlife Service, pers. comm. 2004), and Leadbetter Point (WA-5), Willapa Bay (Washington Department of Fish and Wildlife 1995), both in Pacific County. Increasing numbers of wintering western snowy plovers are being documented along the Washington coast, with 32 counted in 2005 (L. Kelly *in litt.* 2005). As many as 97 western snowy plovers were observed wintering on the Oregon coast in 2005 (L. Kelly *in litt.* 2005). During the survey period between 1990 and 2005, at least 9 Oregon locations (Appendix B) have been used by wintering plovers. Probably as many as 2,500 plovers overwinter along the mainland California coast, and hundreds more at San Francisco Bay and in the Channel Islands (Appendix B, Page *et al.* 1986). The majority of wintering western snowy plovers on the California coast are found from Bodega Bay, Sonoma County, southward (Page *et al.* 1986). Appendix B gives the range of years over which each state's data was collected as well as the minimum and maximum number of western snowy plovers inventoried.

Nesting western snowy plovers from the Oregon coast have wintered as far south as Monterey Bay, California; those from Monterey Bay in central California have wintered north to Bandon, Oregon, and south to Laguna Ojo de Liebre, Baja California, Mexico (Page *et al.* 1995*a*); and those from San Diego in southern

California have wintered north to Vandenberg Air Force Base in Santa Barbara County and south to Laguna Ojo de Liebre, Baja California, Mexico (Powell *et al.* 1995, 1996, 1997).

In winter, western snowy plovers are found on many of the beaches used for nesting, as well as some beaches where they do not nest (Appendix B). They also occur in man-made salt ponds and on estuarine sand and mud flats. In California, the majority of wintering western snowy plovers concentrate on sand spits and dune-backed beaches. Some also occur on urban and bluff-backed beaches, which are rarely used for nesting (Page *et al.* 1986). Pocket beaches at the mouths of creeks and rivers on otherwise rocky shorelines are used by wintering western snowy plovers south, but not north, of San Mateo County, California.

b. Site Fidelity

Western snowy plovers that breed on the coast and inland are very site faithful in winter (Point Reyes Bird Observatory unpublished data). For example, after 166 adults and 204 chicks were banded at Lake Abert, Oregon during summer, many were subsequently found along the California and Baja California, Mexico coasts. Of those for which a wintering location was identified, 67 percent of the adult males, 73 percent of the adult females, and 60 percent of the birds banded as chicks (immatures) were found at the same winter location in at least 2 consecutive years; and 33 percent of the males, 32 percent of the females, and 35 percent of the immatures for at least 3 years (Page *et al.* 1995*b*).

c. Behavior

Western snowy plovers are typically gregarious in winter. Although some individuals defend territories on beaches, most usually roost in loose flocks; frequently western snowy plovers also are observed foraging in loose flocks (Page *et al.* 1995*a*). Roosting western snowy plovers usually sit in small depressions in the sand, or in the lee of kelp, other debris, or small dunes (Page *et al.* 1995*a*). Sitting behind debris or in depressions provides some shelter from the wind and probably makes the birds more difficult for predators to detect. When roosting western snowy plovers are disturbed, they frequently run a few meters to a new

spot where they sometimes displace other individuals. Alternatively, the whole flock may fly to a new location.

C. POPULATION STATUS AND TRENDS

1. Historical Trends

Historical records indicate that nesting western snowy plovers were once more widely distributed and abundant in coastal Washington, Oregon, and California.

a. Washington Coast

In Washington, western snowy plovers formerly nested at five coastal locations (Washington Department of Fish and Wildlife 1995). Three of these sites have had active nesting in recent years, as summarized in Table 1. One new site was also recently discovered in 2006. Populations appear to have increased overall since the early 1990s, although consistent, intensive surveys have been conducted only since the mid-1990s. Quantitative comparisons prior to that are not possible because of the inconsistency in surveys. Estimated numbers of breeding adults (Table 1) substantially exceed window survey data (M. Jensen *in litt.* 2006), partially because of adverse weather during window survey periods in recent years.

i. Grays Harbor County

Copalis Spit (WA-1) held 6 to 12 western snowy plover pairs in the late 1950s or early 1960s (Washington Department of Fish and Wildlife 1995). No other information on breeding at Copalis Spit is available. Suitable habitat was judged capable of supporting four pairs in 1984 (Washington Department of Fish and Wildlife 1995). Periodic surveys since 1983 have revealed just a single western snowy plover (Washington Department of Fish and Wildlife unpubl. data). Two post season juvenile western snowy plovers were observed at Copalis Spit in 2001 (Sundstrom 2002*a*). There is no longer vehicle access to the site since the road washed out several years ago, which has reduced the potential for disturbance from recreational activities. Erosion caused by the northward shift of Connor

Creek has reduced the amount of habitat, but some suitable habitat remains at the end of the spit and the area has potential as a nesting site with habitat restoration and public education (U.S. Fish and Wildlife Service 2005, M. Jensen *in litt.* 2006).

Damon Point and Oyhut Wildlife Area (WA-2) lack western snowy plover records prior to 1971, but this is likely due to limited visitation rather than western snowy plover absence. Between 1971 and 1983, birders reported up to six western snowy plovers during infrequent visits-to Damon Point (Washington Department of Fish and Wildlife 1995). Western snowy plover research in 1985 and 1986 revealed up to 20 western snowy plovers and 8 nests at Damon Point (Anthony 1987). Although most of the locality is suitable habitat, increasing levels of public use have reduced the secure nesting areas to a small portion of the site that is difficult to access, and the breeding population has declined over the last two decades (M. Jensen *in litt.* 2006). From 1993 to 2006 the number of adults at Damon Point has ranged from 2 to 10 (Table 1). Only one nest was found in 2006 (Pearson *et al.* 2006).

Westport Spit (WA-3) held low numbers of western snowy plovers from before 1915 until at least 1968, and scientific collecting was concentrated there through 1934 (Washington Department of Fish and Wildlife 1995). A single nest, poorly documented, was reported in 1983 (Washington Department of Fish and Wildlife unpublished data). No other quantitative information on abundance or nesting is available for this site. Erosion of the site has rendered the beach too narrow to support successful nesting, and there is little opportunity for habitat restoration through beachgrass removal due to private ownership of upland dune habitat (M. Jensen *in litt.* 2006). Recreational use is also substantial. This location is no longer being surveyed due to lack of suitable habitat.

ii. Pacific County

Midway Beach (WA-4) and Cape Shoalwater once contained several hundred acres of suitable western snowy plover habitat, but the area lacks historical records of these birds except for specimens collected in 1914 and 1960 and labeled “Tokeland” (Washington Department of Fish and Wildlife 1995). In

recent years, Midway Beach has been accreting sand and creating high quality habitat. Recent nesting was first documented in 1998 (Richardson *et al.* 2000). Numbers of breeding adults have increased since 1998, and during 2003-2006 the numbers of adults during the breeding season have ranged from 23-33, with a peak number of 30 nests (M. Jensen *in litt.* 2006; Pearson *et al.* 2006). Approximately one third of the habitat is on State Park land with controlled access; on the privately owned land recreational disturbance is fairly high and contributes to high rates of nest failure.

In 2006, western snowy plovers were discovered nesting on Graveyard Spit in northern Willapa Bay, which is primarily on the Shoalwater Indian Reservation and State lands (M. Jensen *in litt.* 2006; Pearson *et al.* 2006). Three pairs of plovers used the spit in 2006 and produced three fledglings.

Leadbetter Point (WA-5) was rarely visited by western snowy plover observers prior to 1964. In the 1960s and 1970s, birders reported up to 35 western snowy plovers, with nesting confirmed in 1967 by the sighting of two chicks (Washington Department of Fish and Wildlife 1995). Western snowy plover numbers were estimated at up to 24 individuals and between 7 and 11 nests during surveys done between 1978 to 1997 (Widrig 1980, 1981; Willapa National Wildlife Refuge unpublished data; Williamson 1995, 1996, 1997). Numbers increased slightly from 1998-2006, with numbers ranging from 24 to 45 adults present (Table 1). The distribution of nesting by western snowy plovers has changed, however, with recent habitat loss from erosion on the tip of Leadbetter Point and shifting of nesting southwards. Since 2002 the refuge has cleared 25 hectares (63 acres) of non-native beachgrass and the habitat restoration site has been consistently used by nesting plovers. Western snowy plovers are also nesting in Leadbetter State Park and State-owned lands south of the Park. Use of predator exclosures at the refuge since 2004 has greatly improved hatching success in the habitat restoration area and outer beach. Gunpowder Sands Island became intertidal in 2001 and no longer is suitable for nesting western snowy plovers (K. Brennan *in litt.* 2006).

Table 1. Status of western snowy plovers at four nesting sites in Washington (Sundstrom-Bagley *et. al*. 2000; Jaques 2001; Sundstrom 2001, 2002*a*, 2002*b*, 2003, 2004, 2005; Brennan and Jaques 2002; Brennan 2003; Brennan and Fernandez 2004*a*, 2004*b*, 2006; Pearson *et al.* 2006).

Year	Estimated Number of Adults Present				
	Leadbetter Point	Midway Beach	Damon Point	Graveyard Spit	Total
1993	16	-	7	-	23
1994	13	-	6	-	19
1995	25	0	9	-	34
1996	19	0	4	-	23
1997	21	0	3	-	24
1998	45	6	5	-	56
1999	26	12	5	-	43
2000	25	21	4	-	50
2001	27	14	4	-	45
2002	32	23	4	-	59
2003	30	33	5	-	68
2004	24	19	10	-	53
2005	38	25	5	-	68
2006	39	23	2	6	70

b. Oregon Coast

In Oregon, western snowy plovers historically nested at over 20 sites on the coast. At present only seven core nesting sites are consistently used, with a few additional areas occupied during some years (Lauten *et al*. 2006*a*, 2006*b*). Annual window surveys of western snowy plovers in Oregon (Table 2), including both adults and young of the year, began in 1978, with counts ranging from a high of 139 at 13 sites (1981) to a low of 30 observed at 9 sites (1992). Populations reached a low from 1991 to 1993 with a mean of 33 individuals recorded annually. From 1994 to 2006 western snowy plover numbers have generally

Table 2. Number of adult western snowy plovers observed on window surveys of the Oregon coast during the breeding season (1978-2006). Window surveys record the number of birds seen during 1-day censuses in May to June (Lauten *et al.* 2006*a*, 2006*b*).

Year	Number	Year	Number
1978	93	1993	45
1979	100	1994	51
1980	80	1995	64
1981	139	1996	85
1982	78	1997	73
1983	52	1998	57
1984	46	1999	49
1985	48	2000	no surveys conducted
1986	73	2001	71
1987	61	2002	71
1988	53	2003	63
1989	58	2004	82
1990	59	2005	100
1991	35	2006	91
1992	30		

increased, with an average of 71 plovers observed. The increase in the numbers of plovers observed in recent years is believed to be related to intensive management that began at the time of Federal listing.

Since 1993, the population on the Oregon coast has been intensively monitored, with many of the adults and chicks being uniquely color-banded. The presence of marked birds has allowed for the development of two other means of estimating the population (Table 3, Lauten *et al.* 2006b). The number of western snowy plovers, as indicated by the three indices in Table 3, has increased between 1993 and 1997, declined in 1998/1999, then increased again through 2006. The trends

Table 3. Comparison of population estimates of adult western snowy plovers on the Oregon coast during the breeding season (1993 to 2005) based on three different measures of abundance (Lauten *et al.* 2006*a*, 2006*b*).

Year	Estimates		
	A	B	C
1993	45	55 to 61	72
1994	51	67	83
1995	64	94	120
1996	85	110 to 113	134 to 137
1997	73	106 to 110	141
1998	57	75	97
1999	45	77	95 to 96
2000	no survey	89	109
2001	71	79 to 80	111 to 113
2002	71	80	99 to 102
2003	63	93	102 to 107
2004	82	120	136 to 142
2005	100	104	153 to 158
2006	91	135	177 to 179

A = Window census.

B = Estimated number of breeding adults. This number is lower than those in column C because it is an estimate of the number of individual birds thought to be breeding birds.

C = Total number of individual adults present during breeding season (includes depredated adults).

for all three indices remained relatively consistent throughout that measurement period.

Management measures (Lauten *et al.* 2006a, 2006b) have included the use of exclosures to reduce predation, predator control measures, restoration of breeding habitat by removing European beachgrass (*Ammophila arenaria*), increased presence of law enforcement personnel, additional and improved signs, additional symbolic fencing (consisting of one or two strands of light-weight string or cable

tied between posts to delineate areas where pedestrians and vehicles should not enter), and increased efforts on public information and education.

c. California Coast

i. Coastwide Perspective

In California, there also has been a significant decline in breeding locations, especially in southern California. By the late 1970s, nesting western snowy plovers were absent from 33 of 53 locations with breeding records prior to 1970 (Page and Stenzel 1981). The first quantitative data on the abundance of western snowy plovers along the California coast came from window surveys conducted during the 1977 to 1980 breeding seasons by Point Reyes Bird Observatory (Page and Stenzel 1981). An estimated 1,593 adult western snowy plovers were seen on these pioneer surveys (Table 4). The surveys suggested that the western snowy plover had disappeared from significant parts of its coastal California breeding range by 1980. It no longer bred along the beach at Mission Bay or at Buena Vista Lagoon in San Diego County. In Orange County, the only remaining breeding location was the Bolsa Chica wetlands; historically, the western snowy plover was known to breed along the beach from Upper Newport Bay to Anaheim Bay. It was absent from Los Angeles County where it formerly nested along the shores of Santa Monica Bay. In Ventura County, it had ceased breeding on Ventura Beach (San Buenaventura Beach), and in Santa Barbara County on Carpinteria, Santa Barbara (East Beach), and Goleta Beaches. Nesting no longer occurred along the northernmost portion of Monterey Bay in Santa Cruz County or on Doran Beach at Bodega Harbor in Sonoma County.

Subsequent coast-wide surveys by Point Reyes Bird Observatory in 1989 and 1991 indicated a further decline in numbers of breeding adult western snowy plovers during the decade after the 1977 to 1980 survey. Along the mainland coast, including the shores of the Channel Islands, western snowy plover populations had declined by about 5 percent, and in San Francisco Bay by about 44 percent (Table 4).

Table 4. Number of adult western snowy plovers observed during breeding season window surveys of the California coast.

Location	1977/80	1989	1991	1995	2000	2002	2003	2004	2005	2006
Del Norte County	11	8	3	0	0	0	0	0	0	0
Humboldt County	54	32	30	19	39	49	38	37	32	49
Mendocino County	15	2	0	-	1	0	1	3	9	3
Sonoma County	0	10	9	3	0	0	0	0	5	0
Marin County	40	24	25	8	21	25	17	26	22	16
San Mateo County (incl. SF beaches)	4	8	1	-	4	3	4	17	3	7
Northern Santa Cruz County	25	19	22	26	19	9	2	2	3	4
Monterey Bay	146	146	119	125	120	270	279	331	297	317
Point Sur	3	4	-	-	8	5	6	5	7	13
Northern San Luis Obispo County			9	-	1	3	0	3	12	15
Morro Bay Area	80	126	87	85	113	150	172	268	259	167
Pismo Beach/Santa Maria River	45	123	246	124	81	170	137	167	200	211
Vandenberg AFB	119	115	242	213	106	179	256	420	259	245
Jalama Beach	0	1	1	0	0	0	0	0	0	0
Hollister Ranch			8	-	-	-	-	-	-	-
Coal Oil Point (Devereaux) vicinity			-	-	-	8	26	30	30	39
Oxnard Lowland	136	175	105	69	107	164	80	119	110	125
Channel Islands	(288)[1]	217	200	196	89	79	90	82	99	115
Orange County	19	21	5	9	27	38	31	31	66	62
Northern San Diego County	160	72	48	49	63	80	145	159	107	141
Mission Beach			-	-	-	-	-	1	0	-
San Diego Bay	60	36	31	33	73	61	76	76	30	81
Tijuana Estuary	37	21	4	10	8	16	12	14	6	14
Subtotal	**1,242**	**1,160**	**1,195**	**969**	**880**	**1,309**	**1,372**	**1,791**	**1,556**	**1,624**
S San Francisco Bay	351	216	176	-	96	78	72	113	124	99
Total	**1,593**	**1,376**	**1,371**	**-**	**976**	**1,387**	**1,444**	**1,904**	**1,680**	**1,723**

[1] 260 adults during the survey; 28 additional adults extrapolated for unsurveyed portions of Santa Rosa Island.

The more recent coast-wide surveys, during the summers of 1995, 2000, and 2002-2006, were accomplished through the collaboration of researchers studying western snowy plovers along the California coast. Between the 1977 to 1980 surveys and the 1995 survey, western snowy plovers apparently ceased nesting at Los Penasquitos, and Agua Hedionda Lagoons in northern San Diego County (A. Powell, pers. comm. 1998). Nesting has been absent or sporadic at San Elijo Lagoon; Año Nuevo State Beach and Pescadero State Beach in San Mateo County; Bolinas Lagoon in Marin County; the south and north spits of Humboldt Bay and Big Lagoon in Humboldt County; and the Lake Talawa region of Del Norte County (Point Reyes Bird Observatory, unpublished data).

By 2000 populations had declined further to 71 percent of the 1977-1980 levels along the California coast and 27 percent of the 1977-1980 levels in San Francisco Bay. However, since then populations have grown substantially, roughly doubling along the coast while fluctuating irregularly in San Francisco Bay (Table 4). Recent population increases along the coast have been associated with implementation of management actions for the benefit of western snowy plovers and California least terns, including predator management and protection and restoration of habitat.

ii. Regional Perspective

Del Norte, Humboldt, and Mendocino Counties - Numbers of western snowy plover breeding adults declined and then somewhat rebounded in this northern California region since the initial Point Reyes Bird Observatory survey in 1977. In this region where there were 80 adults counted in 1977, a low of 19 were found in 1995 and 52 in 2006. In 1996, breeding was documented on the gravel bars of the Eel River, Humboldt County, and this area has continued to be a successful nesting site for western snowy plover breeding (Colwell *et al.* 2002, 2005). Even with the nest success at the gravel bars there is still a reduction in western snowy plovers from 1977; Del Norte County has no breeding birds, and Mendocino County has very few.

San Francisco Bay - As indicated in Table 4, western snowy plover numbers in San Francisco Bay declined markedly between the initial survey in 1978 and follow-up surveys. Western snowy plover numbers steadily declined over 26 years,

reaching a low of 72 in 2003, followed by a moderate but irregular increase (124 in 2005 surveys; 99 in 2006).

Recent surveys in South San Francisco Bay (Strong and Dakin 2004, Strong *et al.* 2004, Tucci *et al.* 2006) indicate that the largest breeding populations are concentrated at Eden Landing Ecological Reserve/Baumberg North (CA-33), managed by California Department of Fish and Game. Other population centers occur at Oliver Salt Ponds (CA-31), managed by Hayward Area Recreation District and East Bay Regional Parks District; and at Dumbarton (CA-36), Warm Springs (CA-39), Alviso (CA-41), and Ravenswood (CA-44), managed by Don Edwards San Francisco Bay National Wildlife Refuge. Foraging and nesting activities are concentrated in specific salt ponds within these areas. Small numbers of western snowy plovers have been observed at Ponds 7 and 7A in Napa County (CA-25 and vicinity), the only currently known nesting site in the North Bay.

Sonoma, Marin, San Francisco, San Mateo, Santa Cruz, and Monterey Counties - Along the segment of coastline from Sonoma County to Monterey Bay, numbers of western snowy plover adults during window surveys declined from 215 in 1977 to 162 in 1995, and subsequently increased to a maximum of 376 in 2004. The numbers of adults breeding on the beaches and salt ponds of Monterey Bay, and the beaches of northern Santa Cruz County, has increased dramatically since management actions have been undertaken to increase nesting success (Neuman *et al.* 2004; G. Page *in litt.* 2004*b*)

San Luis Obispo, Santa Barbara, and Ventura Counties, including Channel Islands - There is no clear evidence of an overall decline in the number of breeding western snowy plovers for this region from 1978/1980 to the present. Numbers of adults fluctuated between a high of 1089 and a low of 497 between 1978 and 2006. While numbers for the region may not have changed overall, there have been definite changes at specific locations (Table 5). Most notable are the decline and loss of the population on San Miguel Island from 1978 /1980 to 2000, the decline at Santa Rosa Island from 1991 to 2006, and the sudden increase in numbers at Vandenberg Air Force Base between 2000 and 2004 and at Coal Oil Point Reserve between 2002 and 2006 (Table 4).

Table 5. Breeding season window surveys of western snowy plover adults at selected sites along the coast of San Luis Obispo, Santa Barbara, and Ventura Counties.

Location	Year												
	1978 -80	**1989**	**1991**	**1995**	**1996**	**1997**	**1998**	**2000**	**2002**	**2003**	**2004**	**2005**	**2006**
Atascadero Beach	0	17	2	38	28	23	26	5	19	23	21	21	24
Morro Bay Spit	80	94	69	34	40	39	55	87	93	114	203	205	120
Vandenberg AFB [1]	119	115	242	213	230	238	130	106	179	256	420	259	245
Ormond Beach	25	24	34	20	19	34	19	10	35	19	28	21	22
Naval Base Ventura County (Pt. Mugu)	82	81	59	40	49	26	47	81	85	51	75	83	79
Santa Rosa Island [2]	84	91	103	71	78	79	76	17	10	---	---	37	19
San Miguel Island [2]	133	36	19	9	3	5	1	0	0	0	0	---	0
San Nicolas Island [3]	71	90	78	116	104	91	90	72	69	90	79	62	96
Total	594	548	606	541	551	535	444	378	490	553	826	688	605

Unless footnoted, the source of all data is Point Reyes Bird Observatory.

[1] The source of this data is the U.S. Air Force (Phil Persons)

[2] The source of this data is the National Park Service

[3] The source of this data is the U.S. Navy

Los Angeles, Orange, and San Diego Counties - Western snowy plover numbers detected during window surveys declined from the 276 adults tallied during the 1978 Point Reyes Bird Observatory survey to 88 during the 1991 survey. Subsequently the population has increased to 298 in 2006.

2. Current Breeding Distribution

The current Pacific coast breeding range of the western snowy plover extends from Damon Point, Washington, to Bahia Magdelena, Baja California, Mexico. The population is sparse in Washington, Oregon, and northern California. In 2006, estimated populations were 70 adults along the Washington coast (Pearson *et al*. 2006), 177-179 adults along coastal Oregon (Lauten *et al.* 2006*b*), and 2,231 adults in coastal California and San Francisco Bay (window survey including correction factor: G. Page *in litt.* 2006, U.S. Fish and Wildlife Service 2006*a*). Approximately 7 percent of the California population was observed in San Francisco Bay, and 4 percent in northern California north of the Golden Gate bridge. Along the coast of Baja California, Mexico, most nesting western snowy plovers are associated with the largest wetlands, especially Bahia San Quintin, Laguna Ojo de Liebre, and Bahia Magdelena (Palacios *et al.* 1994). No recent quantitative data exist on the western snowy plover population in Baja California, but it is probably roughly similar in size to the U.S. Pacific coast population.

3. Habitat Carrying Capacity

There is no quantitative information on carrying capacity of beaches for western snowy plovers. Determining carrying capacity of beaches is confounded by human use that affects the numbers of snowy plovers using the beaches. Beaches vary substantially in their structure, width, vegetation, and level of human use, complicating such a measurement.

The maximum reported breeding density of western snowy plovers is associated with the Moss Landing Wildlife Area, where since 1995 Point Reyes Bird Observatory staff have conducted intensive management specifically for western snowy plovers. These measures include predator control, removal of excessive vegetation, and operation of water control structures to maintain desired water

levels. With extensive management of approximately 55 hectares (138 acres) of mostly dried ponds in the Moss Landing Wildlife Area, 25 active nests, 3 pairs within 5 days of initiating nests, and 10 broods have been documented simultaneously; thus a peak of 76 nesting adults was accommodated simultaneously by 55 hectares (138 acres) of playa, or 1.4 hectares (3.6 acres) per functional pair (some of the broods were only being cared for by males) (D. George, Point Reyes Bird Observatory, pers. comm.). However, the numbers of nesting western snowy plovers at the Moss Landing Wildlife Area cannot be applied to beach areas because of the physical differences between salt pond and beach habitats and because beach habitats are typically subject to much more human disturbance. Neither can these numbers necessarily be applied to other salt ponds (*e.g.*, San Francisco Bay) because habitat and management opportunities differ.

D. REASONS FOR DECLINE AND CONTINUING THREATS

Overall, western snowy plover numbers have declined on the U.S. Pacific coast over the past century (see Population Status and Trends section). The subspecies faces multiple threats throughout its Pacific coast range. The reasons for decline and degree of threats vary by geographic location; however, the primary threat is habitat destruction and degradation. Habitat loss and degradation can be primarily attributed to human disturbance, urban development, introduced beachgrass (*Ammophila* spp.), and expanding predator populations. Natural factors, such as inclement weather, have also affected the quality and quantity of western snowy plover habitat (U.S. Fish and Wildlife Service 1993*a*). The following discussion is organized according to the five listing criteria under section 4(a)(1) of the Endangered Species Act.

1. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

a. Shoreline Stabilization and Development

The wide, flat, sparsely-vegetated beach strands preferred by western snowy plovers are an unstable habitat, subject to the dynamic processes of accretion and erosion of sand, and dependent on natural forces for replenishment and renewal. These

habitats are highly susceptible to degradation by construction of seawalls, breakwaters, jetties, piers, homes, hotels, parking lots, access roads, trails, bike paths, day-use parks, marinas, ferry terminals, recreational facilities, and support services that may cause direct and indirect losses of breeding and wintering habitat for the western snowy plover.

Beach stabilization efforts may interfere with coastal dune formation and cause beach erosion and loss of western snowy plover nesting and wintering habitat. Shoreline stabilization features such as jetties and groins may cause significant habitat degradation by robbing sand from the downdrift shoreline (U.S. Fish and Wildlife Service 1996*a*). However, jetties also can redirect sand deposition, causing an increase in available habitat. Construction of homes, resorts, and parking lots on coastal sand dunes constitutes irrevocable loss of habitat for western snowy plovers. Urban development has permanently eliminated valuable nesting habitat on beaches in southern Washington (Brittell *et al.* 1976), Oregon (Oregon Department of Fish and Wildlife 1994), and California (Page and Stenzel 1981). In addition to causing direct loss of habitat, there are additional potential adverse impacts to western snowy plovers from urban development (Figure 5). Increased development increases human use of the beach, thereby increasing disturbance to nesting plovers. When urban areas interface with natural habitat areas, the value of breeding and wintering habitat to native species may be diminished by increased levels of illumination at night (*e.g.*, building and parking lot lights); increased sound and vibration levels; and pollution drift (*e.g.*, pesticides) (Kelly and Rotenberry 1996/1997). Beach raking removes habitat features for both plovers and their prey, and precludes nests from being established. Also, construction of residential development in or near western snowy plover habitat attracts predators, including domestic cats.

b. Resource Extraction

i. Sand Removal and Beach Nourishment

Sand is mined in coastal areas such as Monterey Bay. Mining sand from the coastal mid-dunes and surf zone can cause erosion and loss of western snowy plover breeding and wintering habitat. Sand removal by heavy machinery can disturb

Figure 5. New housing development next to beach at Monterey Bay, California (photo by Peter Baye, with permission).

incubating western snowy plovers, destroy their nests or chicks, and result in the loss of invertebrates and natural wave-cast kelp and other debris that western snowy plovers use for foraging. Mining of surface sand from the 1930s through the 1970s at Spanish Bay in Monterey County degraded a network of dunes by lowering the surface elevations, removing sand to granite bedrock in many locations, and creating impervious surfaces that supported little to no native vegetation (Guinon 1988).

Beach nourishment with sand can be beneficial for the western snowy plover if it results in an increase in habitat. However, unless beach nourishment projects are properly designed, they can result in changes to beach slope from redeposition of sediments by storm waves, and result in the loss of western snowy plover breeding and wintering habitat. For example, if an inappropriate size class of sand (*e.g.*, coarser-grained sand) and range of minerals are introduced that are different from the current composition of native sand on a beach, it can alter dune slope (making it steeper or narrower), affect mobility and color of sand, decrease the abundance of beach invertebrates, and facilitate establishment of invasive exotic plants that may

have a competitive advantage over native plants. Feeney and Maffei (1991) investigated the color hues of the ground surface within San Francisco Bay salt ponds used as western snowy plover nesting habitat. Predominant soils were silty clay with varying amounts of humus, salt crystals, and shell fragments. They found a strong similarity between the color of the substrate in habitat preferred by western snowy plovers and the color of western snowy plover mantles (upper parts).

ii. Dredging and Disposal of Dredged Materials

Dredging is detrimental to western snowy plovers when it eliminates habitat or alters natural patterns of beach erosion and deposition that maintain habitat. Disturbances associated with dredging, such as placement of pipes, disposal of dredged materials, or noise, also may negatively affect breeding and wintering western snowy plovers. Dredging also is detrimental when it promotes water-oriented developments that increase recreational access to western snowy plover habitat (*e.g.*, marinas, boat ramps, or other facilities to support water-based recreation). In some cases, however, dredged materials may provide important nesting habitat for western snowy plovers such as those at Coos Bay, Oregon (Wilson-Jacobs and Dorsey 1985). Western snowy plovers also have been observed using dredged material during the winter; however, these areas are not used nearly as often as the adjacent ocean beach (E.Y. Zielinski and R.W. Williams *in litt.* 1999).

iii. Driftwood Removal

Driftwood can be an important component of western snowy plover breeding and wintering habitat. Driftwood contributes to dune-building and adds organic matter to the sand as it decays (Washington Department of Fish and Wildlife 1995). Additionally, driftwood provides western snowy plovers with year-round protection from wind and blowing sand. Often, western snowy plovers build nests beside driftwood, so its removal may reduce the number of suitable nesting sites.

Driftwood removed for firewood or decorative items can result in destruction of nests and newly-hatched chicks that frequently crouch by driftwood to hide from predators and people. Chainsaw noise may disrupt nesting, and vehicles used to

haul wood may crush nests and chicks. Removal of driftwood has been documented as a source of nest destruction at Vandenberg Air Force Base where two nests were crushed beneath driftwood dragged to beach fire sites (Persons 1994). Also, driftwood beach structures built by visitors are used by avian predators of western snowy plover chicks such as loggerhead shrikes (*Lanius ludovicianus*) and American kestrels (*Falco sparverius*), and predators of adults such as merlins (*Falco columbarius*) and peregrine falcons (*Falco peregrinus*).

Although driftwood is an important component of western snowy plover habitat, too much driftwood on a beach, which may occur after frequent and prolonged storm events, can be detrimental if there is not sufficient open habitat to induce the birds to nest.

iv. Beach Fires and Camping

Beach fires and camping may be harmful to nesting western snowy plovers when valuable driftwood is destroyed, as described above. Camping near breeding locations can cause greater impacts due to the prolonged disturbance and increased chance for possible direct mortality from associated dogs and children (S. Richardson *in litt*. 2001). Nighttime collecting of wood increases the risk of stepping on nests and chicks, which are difficult to see even during daylight hours. Fires near a western snowy plover nest could cause nest abandonment due to disturbance from human activities, light, and smoke. Fires have the potential to attract large groups of people and result in an increase of garbage, which attracts scavengers such as gulls (*Larus* spp.) and predators such as coyotes (*Canis latrans*), American crows (*Corvus brachyrhynchos*), and common ravens (*Corvus corax*). Also, after fires are abandoned, predators such as coyotes may be attracted into the area by odors lingering from the fire, particularly if it was used for cooking. Occasionally fires escape into nearby driftwood; fire suppression activities may disturb and threaten western snowy plover nests and chicks.

v. Watercourse Diversion, Impoundment, or Stabilization

Water diversion and impoundment of creeks and rivers may negatively affect western snowy plover habitat by reducing sand delivery to beaches and degrading

water quality. Water diversions are a major threat to western snowy plovers when they impair hydrologic processes (such as migration of creek and river mouths) that maintain open habitat at river and creek mouths by retarding the spread of introduced beachgrass (*Ammophila* spp.) and other vegetation. Water diversion, impoundment, or stabilization activities could include construction of dams and irrigation, flood control, and municipal water development projects (Powell *et al.* 2002).

vi. Operation of Salt Ponds

Salt ponds of San Francisco Bay and San Diego Bay, which are filled and drained as part of the salt production process, provide breeding and wintering habitat for western snowy plovers. Dry salt ponds and unvegetated salt pond levees are used as western snowy plover nesting habitat. Ponds with shallow water provide important foraging habitat for western snowy plovers, with ponds of low and medium salinity providing the highest invertebrate densities. Ponds of high salinity have reduced invertebrate densities and therefore provide lower quality foraging habitat. Nesting western snowy plovers can be attracted to an area when ponds are drained during the breeding season, but flooding can then destroy the nests when the ponds are refilled. Also, human disturbance resulting from maintenance activities associated with the operation of commercial salt ponds can result in the loss of western snowy plovers and disturbance of their habitat. If conducted during the western snowy plover breeding season, reconstruction of salt pond levees could destroy western snowy plover nests. Maintenance activities that are conducted by vehicles, on foot, or through the use of dredging equipment could result in direct mortality or harassment of western snowy plovers (See Dredging, Pedestrian, and Motorized Vehicle sections).

c. Encroachment of Introduced Beachgrass and Other Nonnative Vegetation

One of the most significant causes of habitat loss for coastal breeding western snowy plovers has been the encroachment of introduced European beachgrass (*Ammophila arenaria*) and American beachgrass (*Ammophila breviligulata*). Foredunes dominated by introduced beachgrass have replaced the original low, rounded, open mounds formed by the native American dunegrass (*Leymus mollis*)

and other beach plants. Native dune plants do not bind sand like *Ammophila* spp., and thus allow for sand movement and regenerating open expanses of sand. However, *Ammophila* spp. forms a dense cover that excludes many native taxa. On beaches dominated by this invasive grass, species richness of vegetation is halved, in comparison with foredunes dominated by native dune grass (Barbour and Major 1990). Similarly, American beachgrass greatly depresses the diversity of native dune plant species (Seabloom and Wiedemann 1994).

European beachgrass was introduced to the west coast around 1898 to stabilize dunes (Wiedemann 1987). Since then, it has spread up and down the coast and now is found from British Columbia to Ventura County in southern California. This invasive species is a rhizomatous grass that sprouts from root segments, with a natural ability to spread rapidly. Its most vigorous growth occurs in areas of wind-blown sand, primarily just above the high-tide line, and it thrives on burial under shifting sand. In 1988, European beachgrass was considered a major dune plant at about 50 percent of western snowy plover breeding areas in California and all of those in Oregon and Washington (J. Myers *in litt.* 1988).

American beachgrass is native to the East coast and Great Lakes region of North America. The densest populations of American beachgrass on the Pacific coast are currently located between the mouth of the Columbia River and Westport, Washington. Like European beachgrass, American beachgrass is dominant on the mobile sands of the foredune and rapidly spreads through rhizome fragments. American beachgrass occurs along the entire coast of Washington, ranging from Shi Shi Beach, Washington, in the north, to Sand Lake, Oregon, in the south, although its frequency decreases markedly at the northern and southern limits of this range. Currently, American beachgrass is the dominant introduced beachgrass species in much of the western snowy plover range in the State of Washington (Seabloom and Wiedemann 1994).

Stabilizing sand dunes with introduced beachgrass has reduced the amount of unvegetated area above the tideline, decreased the width of the beach, and increased its slope (Wiedemann 1987). These changes have reduced the amount of potential western snowy plover nesting habitat on many beaches and may hamper brood movements. In Oregon, the beachgrass community may provide habitat for western

snowy plover predators (*e.g.*, skunks [*Mephitis* spp.], weasels [*Mustela* spp.], coyotes [*Canis latrans*], foxes [*Urocyon cinereoargenteus* and *Vulpes vulpes*.], raccoons [*Procyon lotor*], and feral cats [*Felis domesticus*]) that historically would have been largely precluded by the lack of cover in the dune community (Stern *et al.* 1991; K. Palermo, U.S. Forest Service, pers. comm. 1998).

In areas with European beachgrass, it has caused the development of a vegetated foredune that effectively blocks movement of sand inland and creates conditions favorable to the establishment of dense vegetation in the deflation plain, which occurs behind the foredunes (Wiedemann *et al.* 1969). In natural sand dunes, deflation plains consist of open sand ridges and flat plains at or near the water table. Thus, in areas with European beachgrass, the open features that characterize western snowy plover breeding habitat are destroyed. The establishment of European beachgrass has also caused sand spits at the mouths of small creeks and rivers to become more stable than those without vegetation because of the creation of an elevated beach profile. This elevated profile, in effect, reduces the scouring of spits during periods of high run-off and storms. A secondary effect of dune stabilization has been human development of beaches and surrounding areas (Oregon Department of Fish and Wildlife 1994). This development, in turn, has reduced available beach habitat and focused human activities on a smaller area that must be shared with western snowy plovers and other shorebirds.

On the Oregon coast, the establishment of European beachgrass has produced dramatic changes in the landscape (Oregon Department of Fish and Wildlife 1994). The spread of this nonnative species was greatly enhanced by aggressive stabilization programs in Oregon in the 1930s and 1940s (Wiedemann 1987). European beachgrass spread profusely along the Washington coast, and was well established by the 1950s (Washington Department of Fish and Wildlife 1995). In 1988, the spread of beachgrass was termed an “increasing threat” to traditional western snowy plover nesting areas at Leadbetter Point, Washington, having become established where absent only 4 years earlier (Willapa National Wildlife Refuge 1988).

In California, there are many beaches where European beachgrass has established a foothold. These beaches include the dunes at Lake Earl, Humboldt Bay (from

Trinidad to Centerville Beach), MacKerricher State Beach/Ten Mile Dunes Preserve, Manchester State Beach, Bodega Bay, Point Reyes National Seashore, Golden Gate National Recreation Area, Monterey Bay, Morro Bay Beach, Guadalupe-Nipomo Dunes, and Vandenberg Air Force Base (A. Pickart *in litt.* 1996). Chestnut (1997) studied the spread of European beachgrass at the Guadalupe-Nipomo Dunes in San Luis Obispo County. He documented an increase in beachgrass from approximately 8 to 109 hectares (20 to 270 acres) between 1969 and 1997, and found that its rapid spread through native vegetation posed a serious threat to nesting western snowy plovers and rare plants.

In addition to the loss of nesting habitat, introduced beachgrass also may adversely affect western snowy plover food sources. Slobodchikoff and Doyen (1977) found that beachgrass markedly depressed the diversity and abundance of sand-burrowing arthropods at coastal dune sites in central California. Because western snowy plovers often feed on insects well above the high-tide line, the presence of this invasive grass may also result in loss of food supplies for plovers (Stenzel *et al.* 1981).

In some areas of California, such as the Santa Margarita River in San Diego County, and the Santa Clara and Ventura Rivers in Ventura County, giant reed (*Arundo donax*) has become a problem along riparian zones. During winter storms, giant reed is washed downstream and deposited at the river mouths where western snowy plovers nest (Powell *et al.* 1997). Large piles of dead and sprouting giant reed eliminate nesting sites and increase the presence of predators, which use it as perches and prey on rodents in the piles of vegetation.

Other nonnative vegetation that has invaded coastal dunes, thereby reducing western snowy plover breeding habitat, includes Scotch broom (*Cytisus scoparius*), gorse (*Ulex europaeus*), South African iceplant (*Carpobrotus edulis*), pampas grass (*Cortaderia jubata* and *Cortaderia selloana*) and iceplant (*Mesembryanthemum* sp.); shore pine (*Pinus contorta*) is a native plant species that has invaded coastal dunes and resulted in similar impacts to western snowy plovers (Schwendiman 1975, California Native Plant Society 1996, Powell 1996). Many nonnative weed species also occur on and along San Francisco Bay salt pond levees, resulting in unsuitable nesting habitat for western snowy plovers (J. Albertson *in litt.* 1999).

d. Habitat Conversion for Other Special Status Species

It is not known whether western snowy plovers historically nested in San Francisco Bay prior to the construction of salt evaporator ponds beginning in 1860 (Ryan and Parkin 1998). However, western snowy plovers have wintered on the San Francisco Bay since at least the late 1800's, as indicated by a specimen dated November 8, 1889, in the Califomia Museum of Vertebrate Zoology (Grinnell *et al.* 1918). It is possible that natural salt ponds in the vicinity of San Lorenzo once supported nesting birds, but insufficient data exist to assess this possibility (U.S. Fish and Wildlife Service 1992). Today, however, the San Francisco Bay recovery unit supports an important western snowy plover source population, representing approximately 5 to 10 percent of the total breeding population. Feeney and Maffei (1991) observed a sizable population of western snowy plovers at the Baumberg and Oliver salt ponds during the breeding and nonbreeding seasons, suggesting that these ponds are important to western snowy plovers throughout the year. They suspected that these ponds are used by western snowy plovers as both a pre-breeding and post-breeding staging area, based on the high numbers of plovers in mid-February and in late August/September, respectively.

As part of the Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (U.S. Fish and Wildlife Service, in preparation), extensive tidal marsh restoration is identified as a recovery action for listed and other sensitive species of tidal salt marshes including the California clapper rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*). A large area of San Francisco Bay salt ponds, especially within the South Bay, are proposed for tidal marsh restoration for the benefit of federally listed tidal marsh species. Salt ponds are large, persistent hypersaline ponds that are intermittently flooded with South Bay water. Some of these ponds currently provide valuable breeding and wintering habitat for western snowy plovers. However, they occur within the historical areas of tidal salt marsh, which once dominated San Francisco Bay. Endangered tidal marsh species would benefit from conversion of these ponds back to salt marsh; however, western snowy plovers would lose suitable nesting and wintering areas.

The Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California will focus primarily on management of tidal marsh species, but will also provide for some areas to be maintained as managed ponds that would provide habitat for western snowy plovers and California least terns (*Sternula antillarum browni*). The South Bay Salt Pond Restoration Project (Philip Williams & Associates *et al.* 2006) has identified sites on National Wildlife Refuge and California Department of Fish and Game lands with potential for salt marsh restoration and managed ponds under a range of alternatives; the projected area of managed ponds ranges from 647 to 3,035 hectares (1,600 to 7,500 acres). Six of the plover locations identified in Appendices B and L (CA-33, CA-34, CA-39, CA-40, CA-41, CA-44) occur within the South Bay Salt Pond Restoration Project area. These six locations comprise about 60 percent of the western snowy plover locations in San Francisco Bay by area, and currently support over 90 percent of the western snowy plover population in San Francisco Bay (Strong *et al.* 2004, Tucci *et al.* 2006). In particular, several salt ponds at Eden Landing (location CA-33 and vicinity) currently support the largest population of western snowy plovers in San Francisco Bay. Distribution of plover populations and nesting sites within San Francisco Bay can fluctuate with salt pond management and availability of appropriate habitat, such that some locations identified in Appendix L are not currently occupied and other locations not mapped in Appendix L may nonetheless support breeding birds as management practices change. Thus the boundaries of San Francisco Bay locations as mapped in Appendix L reflect current and historical conditions and should be considered as flexible in the context of planning for future tidal marsh restoration. Specific localities to be managed for plovers should be coordinated with tidal marsh restoration in an integrated fashion, and thus may not be identical with the current or historical localities identified in this recovery plan.

Thus intensive management of designated ponds within the South Bay Salt Pond Restoration Project area will be crucial to achieving success in meeting western snowy plover recovery goals in San Francisco Bay. However, establishing western snowy plover populations at a variety of sites in San Francisco Bay, both within and outside the South Bay Salt Pond Restoration Project area, is advisable to minimize their vulnerability to loss (L. Trulio *in litt.* 2007). Potential western snowy plover habitat in San Francisco Bay outside of the South Bay Salt Pond Restoration Project area includes several sites around Alameda, Napa County, Hayward Shoreline, and

Crissy Field. In addition, large salt pond tracts in the South Bay remain under the ownership of Cargill; certain areas are still managed for salt production and could incidentally provide habitat for western snowy plovers, while approximately 600 hectares (1,400 acres) of ponds near Redwood City are no longer in salt production and provide an opportunity for significantly increasing western snowy plover habitat through active management. If these locations can be managed to encourage western snowy plover nesting, they may contribute substantially to meeting the overall goal of 500 breeding birds in San Francisco Bay. Western snowy plover management targets for the South Bay Salt Pond Restoration Project should take into account the habitat quality and management potential of plover habitat elsewhere in San Francisco Bay to meet overall goals for the recovery unit.

Don Edwards San Francisco Bay National Wildlife Refuge is currently planning pilot studies to assess how best to manage salt ponds for high densities of breeding western snowy plovers. Special management for western snowy plover may include intensive control of avian predators (*e.g.*, California gull colonies, ravens); active management of water levels to control vegetation, maintain optimal salinity, and produce brine flies; timing of inundation to avoid flooding nests; and reconfiguration of shallow salt ponds with isolated islands and furrowed areas. Locations of managed salt ponds should be planned to minimize the proximity of western snowy plover populations to landfills, gull colonies, and areas with high predator densities. Intensive management of salt ponds for western snowy plovers generally appears feasible, and plovers have been observed to opportunistically disperse among sites and use habitat that becomes suitable (V. Bloom *in litt.* 2005), so we expect relocation of plover nesting concentrations away from tidal marsh restoration areas to be possible, but management success should be carefully evaluated. Those alternatives with greater acreages of tidal marsh restoration (e.g., Alternative C at 90 percent tidal habitat) would require correspondingly more intensive management and reconfiguration of the remaining salt ponds (Philip Williams & Associates *et al.* 2006), and should be implemented gradually in conjunction with evaluation of management effectiveness for western snowy plovers.

Thus, we believe tidal marsh restoration can be compatible with the recovery of western snowy plovers and should not preclude meeting a goal of 500 breeding

birds in San Francisco Bay. As described below under Recovery Action 2.6, occupied salt ponds should initially be conserved. Salt marsh restoration in occupied plover habitat, particularly at densely populated sites, should be phased in after intensive adaptive management of other compensating salt pond habitat has demonstrated success in increasing plover populations. Thus habitat quality should be continually assessed so that overall western snowy plover populations in San Francisco Bay are not adversely affected by the restoration project and can increase to meet the management goal for this recovery unit.

In southern California, unless carefully planned, conversion of western snowy plover habitat to tidal salt marsh may result in loss of western snowy plover habitat. The light-footed clapper rail (*Rallus longirostris levipes*) inhabits coastal tidal marshes from Santa Barbara County south to Baja California, Mexico. Several locations in Ventura, Orange, and San Diego Counties provide nesting and/or wintering habitat for western snowy plovers, but also provide high quality light-footed clapper rail habitat or represent high priority tidal marsh restoration sites in the recovery plan for the light-footed clapper rail (U.S. Fish and Wildlife Service 1985). These sites include Bolsa Chica, Agua Hedionda Lagoon, San Elijo Lagoon, San Dieguito Lagoon, and Los Penasquitos Lagoon. The Bolsa Chica wetlands were opened to tidal action in 2006, in a project combining tidal restoration work with construction of islands and sand flats for nesting of shorebirds and California least terns.

2. Overutilization for Commercial, Recreational, Scientific, or Education Purposes

Biologists and agency personnel monitor western snowy plovers to assess population status and evaluate management techniques. Additionally, nest searches at some sites allow for placement of predator exclosures that aid in hatching success. Measures to minimize disturbance from these activities include: time limits for surveys, exclosure construction and sign/rope maintenance; conducting walking surveys where feasible; and limited entries.

Egg collecting has been observed at several California nesting colonies (Stenzel *et al.* 1981, Warriner *et al.* 1986). Occasionally recreational birdwatchers also may

harass western snowy plovers. The significance of these factors to nesting success is uncertain but probably relatively minor.

Qualified individuals may obtain permits to conduct scientific research and population census activities on western snowy plovers under section 10(a)(1)(A) of the Endangered Species Act. Specific activities that may be authorized include: population censuses and presence/absence surveys; monitoring of nesting activity; capturing, handling, weighing, measuring, banding, and color-marking of young and adults on breeding and wintering grounds; radio-telemetry studies; translocation studies; genetic studies; contaminant studies; behavioral, ecological, and life history studies; and placing predator exclosures around active nests. Short-term impacts of these activities may include harassment and possible accidental injury or death of a limited number of individual western snowy plovers. The long-term impacts will be to contribute to recovery of the species by facilitating development of more precise scientific information on status, life history, and ecology (U.S. Fish and Wildlife Service 1993*b*).

Banding birds with metal and plastic bands to identify individuals and to monitor bird populations is a common practice. However, a number of leg injuries to western snowy plovers, possibly resulting from banding, have been reported (G. Page *in litt.* 2005*b*). These injuries include swelling and abrasion of legs possibly from sand or other particles becoming lodged between the bands and the leg. Some banding injuries appear to have resulted in foot loss and in a few instances, death of the bird. Similar injuries have been observed in piping plovers (*Charadrius melodus*) banded on the Atlantic coast and interior U.S., and resulted in a moratorium on banding of that species (Lingle *et. al.* 1999, U.S. Fish and Wildlife Service 1996*a*, U.S. Fish and Wildlife Service 2002). Despite leg injuries, several piping plovers were observed to successfully breed and fledge young (Lingle *et. al.* 1999). However, these injuries may contribute directly or indirectly to mortalities or reduce breeding performance. It should be noted that incidents of foot loss in Pacific coast western snowy plovers usually appear to result from fine fibers wrapping around the bird's ankle, and have occurred in unbanded as well as banded individuals (J. Watkins, pers. comm. 2006). Despite risk of injuries, banding remains the best technique to study population traits such as survival, recruitment, and dispersal, and may be the most effective way to monitor populations of the

western snowy plover to determine effectiveness of management strategies. Currently the percentage of banded birds range-wide that become injured from banding and the impacts of banding injuries on populations of the western snowy plover are unknown; a study was initiated in 2005 by Point Reyes Bird Observatory to assess the effectiveness of alternative banding techniques in reducing injuries and band loss (G. Page *in litt.* 2005*b*).

Concerns that color bands increase the vulnerability of western snowy plovers to predation by reducing effectiveness of camouflage do not appear to be supported by existing evidence. Because western snowy plovers crouch and flatten to the sand at the approach of avian predators, color bands are typically hidden from sight; terrestrial predators are evaded by running or taking flight at their approach (J. Watkins, pers. comm. 2006).

3. Disease or Predation

West Nile virus, a mosquito-borne disease which can infect birds, reptiles, and mammals, has spread rapidly across the United States from the initial introduction in New England (National Audubon Society 2006). The disease has killed birds of various species in all coastal California counties since its arrival in the state in 2003 (U.S. Geological Survey 2006). In 2004 to 2006 the disease was reported from two coastal counties (Lane and Lincoln) in Oregon but has not been reported from any coastal counties in Washington (U.S. Geological Survey 2006). The deadliness of the disease varies by species; however, the virus has been identified in dead piping plovers (*Charadrius melodus*) and killdeer (*C. vociferus*), both closely related to the western snowy plover (Center for Disease Control 2004).

Since 2004 numerous western snowy plovers in southern California have been found dead or exhibited neurological signs consistent with avian botulism (M. Long *in litt.* 2006). Confirmation of disease diagnosis is currently pending availability of specimens for autopsy. We are currently coordinating with the USGS National Wildlife Health Center to better understand the causes of these mortalities and to develop a program for treatment of ill birds diagnosed with botulism. Additionally, 32 western snowy plovers died in 2006 from unknown causes in San Diego County (U.S. Navy *in litt.* 2007).

Predator density is a significant factor affecting the quality of western snowy plover nesting habitat (Stenzel *et al.* 1994). Predation can result in the loss of adults, chicks, or eggs; separation of chicks from adults is also caused by the presence of predators. Powell *et al.* (2002) found that predation accounted for most nest failures in 1994, 1996, and 1997, in San Diego County, California. Western snowy plovers generally cannot defend themselves or their nests against predation but must rely on antipredator adaptation, including (1) pale coloration of adults, eggs, and young, which acts as camouflage against detection by predators; (2) a skulking retreat from the nest at a predator's approach; (3) extreme mobility and elusiveness of precocial young and; (4) maintenance of low nesting density (Page *et al.* 1983). In natural ecosystems, there is a co-evolution of the predator-prey relationship, where prey species slowly evolve with evading behavior as predator species slowly evolve effective prey-capturing behavior. However, when exotic predators are introduced into the ecosystem and thrive there, they frequently occur in much higher densities and possess more effective strategies than native predators and, hence, usually have a more severe effect.

Predation, by both native and nonnative species, has been identified as a major factor limiting western snowy plover reproductive success at many Pacific coast sites. Known mammalian and avian predators of western snowy plover eggs, chicks, or adults include the following native species: gray foxes (*Urocyon cinereoargenteus*), Santa Rosa Island foxes (*Urocyon littoralis santarosae*), coyotes, striped skunks (*Mephitis mephitis*), spotted skunks (*Spilogale putorius*), raccoons, California ground squirrels (*Citellus beecheyi*), long-tailed weasels (*Mustela frenata*), American crows, common ravens (*Corvus corax*), ring-billed gulls (*Larus delawarensis*), California gulls (*Larus californicus*), western gulls (*Larus occidentalis*), glaucous-winged gulls (*Larus glaucescens*), gull-billed tern (*Gelochelidon nilotica*), American kestrels (*Falco sparverius*), peregrine falcons (*Falco peregrinus*), northern harriers (*Circus cyaneus*), loggerhead shrikes, merlins (*Falco columbarius*), great horned owls (*Bubo virginianus*), burrowing owls (*Speotyto cunicularia*), great blue herons (*Ardea herodias*); and the following nonnative species: eastern red foxes (*Vulpes vulpes regalis*), Norway rats (*Rattus norvegicus*), Virginia opossums (*Didelphis marsupialis*), domestic and feral dogs (*Canis familiaris*), and cats (*Felis domesticus*). Loss or abandonment of eggs due to

predation by fire ants and Argentine ants (*Iridomyrmex humilis*) has also been observed (Fancher *et al.* 2002, Powell *et al.* 2002).

In Oregon, nest predation by corvids (common ravens and American crows) is the major cause of nest failures. Of 63 unexclosed nests in 2005, corvid predation accounted for 22 nest failures, by comparison with 14 failures due to mammalian or unknown predators and 10 due to abandonment (Lauten *et al.* 2006*a*). Exclosures were effective in protecting nests against this threat (0 of 83 exclosed nests failed due to nest predation).

American crows have been consistently documented as a major predator on western snowy plover nests along the California and Oregon coasts (Page 1990; Persons and Applegate 1997; T. Applegate, Bioresources, pers. comm. 1999; M. Stern, The Nature Conservancy, pers. comm. 1999). At Coal Oil Point, American crows were the most frequent predator on western snowy plover nests and experimentally placed quail eggs (Lafferty *et al.* 2006). Populations of American crows have increased in the San Francisco Bay and central California coast over the past several decades, and are positively associated with human population density (Leibezet and George 2002).

Common ravens are known predators of western snowy plover eggs (Wilson-Jacobs and Dorsey 1985, Point Reyes Bird Observatory unpublished data, George 1997, Stein 1993, Point Reyes Bird Observatory unpublished data, J. Albertson *in litt.* 1999, Point Reyes Bird Observatory unpubl. data, Stern *et al.* 1991). Ravens have consistently been the most significant nest predator at Point Reyes, accounting for 69 percent of all predation events over 5 years and destroying approximately 50 percent of nests (Hickey *et al.* 1995). Hatching success at Point Reyes National Seashore increased after exclosures were used to protect western snowy plover nests from ravens in 1996. Approximately 12 percent of nests in San Diego County were destroyed by ravens (Powell *et al.* 1996, Powell *et al.* 1997). Raven populations in coastal California have significantly increased in recent decades (Leibezet and George 2002), and as their range expands they are becoming increasingly significant as a nest predator on western snowy plovers; ravens were observed to destroy nests in Monterey Bay for the first time in 2002 and 2003 (G. Page *in litt.* 2004*b*). In northern California ravens are the single most limiting factor on western snowy

plover reproduction (Colwell *et al.* 2006). Ravens also prey on western snowy plover chicks, but not nearly to the extent that they do on eggs. However, at Point Reyes raven predation primarily affected chicks after exclosures were erected to protect snowy plover eggs (S. Allen *in litt.* 2004).

Gulls pose a special threat to breeding western snowy plovers because they not only depredate nests and chicks, but also usurp and trample western snowy plover nesting habitat and crush eggs (Persons and Applegate 1997, Point Reyes Bird Observatory unpublished data, Widrig 1980, J. Albertson *in litt.* 1999, Page *et al.* 1983).

The first time a gull-billed tern was found in San Diego County, California, was in 1985. Two years later they were nesting in south San Diego Bay (Unitt 2004). Since then, the nest colony has steadily increased with an estimated 52 pairs in 2006 (Patton 2006a). Gull-billed terns have become a concern to managers of beach-nesting birds in the region. Gull-billed terns were first documented taking California least terns (presumably chicks) in south San Diego Bay in 1992 (Caffrey 1993). Patton (2006a) summarizes recent incidents of gull-billed tern predation on both terns and western snowy plovers. He notes roughly 20 to 60 California least terns and 1 to 4 western snowy plover depredations by gull-billed terns and a greater number was suspected. Although the documented number of gull-billed tern depredations on western snow plovers is considerably lower than on California least terns, it is difficult to know the full extent of gull-billed tern impacts (Patton 2006b), especially for the plovers whose nests are more dispersed and less easily monitored.

Unlike management of other avian predators, management of gull-billed terns is problematic. The local subspecies of gull-billed tern, *G. n. vanrossemi*, is limited to western North America (Molina and Erwin 2006, but see Unitt 2004). The subspecies nests in scattered, localized colonies and "[i]n 2003 and 2005, the entire North American population of *vanrossemi* gull-billed terns ranged from about 533 to 810 pairs" (Molina and Erwin 2006). This means that this predator is considerably rarer than the listed bird species upon which it preys (California least terns and western snowy plovers), which poses a conundrum for managers of western snowy plovers and California least terns (Unitt 2004). Because of the gull-

billed tern's status, lethal predator control has not been used on this species since 1999 (Unitt 2004). Gull-billed terns will likely become a greater source of management concern as the local population of this species grows. Gull-billed terns have been observed at other locations of beach-nesting birds farther north from San Diego Bay, including Camp Pendleton, San Diego County (Foster 2005); Bolsa Chica, Orange County (Hamilton and Willick 1996), and Venice Beach, Los Angeles County (McCaskie and Garrett 2005).

Loggerhead shrikes are not known to take western snowy plover eggs, but do prey upon chicks and locally can have substantial effects on fledging success (Warriner *et al.* 1986, D. George *in litt.* 2001, Page *et al.* 1997, George 1997, Page 1988, Feeney and Maffei 1991).

Although not known to be predators of western snowy plover eggs, American kestrels are predators of chicks and possibly adults (D. George, pers. comm. 1998). Fledging success increased from 9 to 64 percent after a kestrel unexpectedly disappeared from a western snowy plover nest site in Moss Landing Wildlife Area (Page *et al.* 1998). In 1997, a merlin was suspected of taking 13 banded adults within the period of a few days at Salinas River National Wildlife Refuge. Also, western snowy plover chicks and adults are among the avian prey of the peregrine falcon (B. Walton, University of California Santa Cruz, pers. comm. 1998; D. George, pers. comm. 1998; Feeney and Maffei 1991). Northern harriers are effective predators of western snowy plover chicks and adults. In 1987, a harrier was observed hunting on the islands in the Salinas River where only approximately one third of the hatched chicks reached fledging age (Point Reyes Bird Observatory unpubl. data). At the Moss Landing Wildlife Area, fledging success dropped from 61 to 23 percent after a harrier began foraging there (Page *et al.* 1997). A northern harrier was seen capturing 2 to 4 western snowy plover chicks at Moss Landing salt ponds in 2000 (D. George *in litt.* 2001).

In recent decades, alien eastern red foxes have become a serious new predator of endangered and threatened animals in coastal habitats (Jurek 1992, Golightly *et al.* 1994, Lewis *et al.* 1993). Nonnative red foxes were imported into the southern Sacramento Valley, primarily for hunting and fur farming purposes, as early as the 1870s and experienced explosive spread in the 1970s and 1980s (Jurek 1992, Lewis

et al. 1993, 1995). The red fox now occurs throughout a significant portion of coastal California, including Marin, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Ventura, Orange, and Los Angeles Counties (California Department of Fish and Game 1994). It also occurs at Monterey Bay (G. Page *in litt.* 1988) and San Francisco Bay (Harding *et al.* 1998), including the additional San Francisco Bay area counties of Napa, Solano, Contra Costa, Alameda, and Santa Clara (California Department of Fish and Game 1994). Red foxes also are present in some areas of coastal Oregon where western snowy plovers breed (D. George *in litt.* 2001, Lauten *et al.* 2006*b*).

Red foxes have been identified as a significant predator of western snowy plover eggs in the Monterey Bay area, where they are suspected of also preying on adults and chicks. On Monterey Bay beaches, red fox depredation of western snowy plover eggs resulted in a decline in clutch hatching rate of 30 percent from 1984 to 1990. After exclosures and mammalian predator control came into use to protect nests around Monterey Bay, annual clutch hatching rates have climbed from 43 to 68 percent (Neuman *et al.* 2004).

Predation of western snowy plover nests and chicks by red fox have been documented at Bandon Beach, New River and other portions of OR-15 on the Oregon coast. Biologists have documented red fox tracks around western snowy plover nest exclosures and have followed fox tracks back to dens located within western snowy plover nest areas. As part of the emergency response to the New Carissa oil spill in February 1999, a predator program was implemented. Animal and Plant Health Inspection Service (APHIS) Wildlife Services Division personnel removed 17 red fox from the New River area over a 3 month period (S. Richardson *in litt.* 2001). Ongoing predator management since 2002 has removed an average of 15 foxes per year from Bandon Beach/New River (Lauten *et al.* 2006*b*).

The U.S. Department of Agriculture, Wildlife Services Branch, has been involved in predator damage management for protection of threatened and endangered species for over 10 years in California. The management of nonnative red foxes has become a controversial issue in many areas of California, particularly in coastal habitats near urban areas (California Department of Fish and Game 1994). In November 1998, California voters approved Proposition 4, which banned the use of

leghold traps in California. In February 1999, the U.S. District Court issued a Preliminary Declaratory Relief Order, which allows the use of padded leghold traps on Federal and non-Federal lands for the purpose of protecting threatened or endangered species. Trapping of nonnative and native predators of western snowy plovers will therefore not be affected by Proposition 4 (J. Albertson *in litt.* 1999).

Coyotes are known predators of western snowy plover eggs in the Pismo Beach/Santa Maria River area of San Luis Obispo County (T. Applegate, pers. comm. 1996). They are the main nest predator of eggs on Vandenberg Air Force Base where they were the cause of 43 percent of all clutch losses attributed to predators from 1994 to 1997 (Persons and Applegate 1997). At Vandenberg Air Force Base, coyotes may be attracted to marine mammal carcasses on the beach early in the western snowy plover nesting season (Page and Persons 1995). Coyotes also have been identified as predators of western snowy plover nests at Mono Lake, California (Page *et al.* 1983).

Striped skunks have been recorded as predators of western snowy plover eggs (Hickey *et al.* 1995, George 1997, Page *et al.* 1997, Hutchinson *et al.* 1987, Stein 1993, Stern *et al.* 1991). Skunks were believed to be the main cause of nest loss on Morro Bay Spit in 1987, the only year that the reproductive success of western snowy plovers has been monitored at that location (Hutchinson *et al.* 1987). Persons and Ellison (2001) reported that the striped skunk was the predominant predator of nests at Morro spit, destroying 87 percent of depredated nests in 2000.

Domestic and feral cats are widespread predators. The threat of predation of western snowy plovers by cats increases when housing is constructed near western snowy plover breeding habitat. As natural-appearing beaches continue to be surrounded by urban areas, western snowy plovers will increasingly be subjected to this predator in the future. Predation by cats is difficult to measure because of the difficulty in finding evidence of bird remains, but they are known to take western snowy plover adults and eggs (B. Farner, pers. comm. *in* Powell and Collier 1994; Page 1988; D. George *in litt.* 2001).

Predation, while predominantly a natural phenomenon, is exacerbated through the introduction of nonnative predators and unintentional human encouragement of

larger populations of native predators. Elevated predation pressures result from landscape-level alterations in coastal dune habitats which, in turn, now support increased predator populations within the immediate vicinity of nesting habitat for western snowy plovers. Urbanization benefits red fox population growth by eliminating coyotes, which are the red fox's most common native predator and competitor; by providing ready sources of food, water and denning sites; and by aiding dispersion of foxes into new areas. Red foxes disperse readily in urban areas because there are no predators besides the domestic dog. Red foxes traverse most urban habitats, and readily cross busy highways and travel long distances underground through culverts (Lewis *et al.* 1993). Other predators, such as corvids, attracted by the presence of human activities (*e.g.*, improper disposal of trash), may frequent beaches in increasing numbers. Gulls have greatly expanded their range and numbers, especially along the United States portion of the Pacific coast, as a result of human-supplied food sources (trash, fish offal, and dumps). Thousands of California gulls now breed in the southern part of San Francisco Bay, where only a few were present in the early 1980s (J. Albertson *in litt.* 1999). This population growth is attributed largely to the increase in landfills along the Bay within the last 20 years. Also, crows and ravens forage at landfills. Buick and Paton (1989) found that losses of hooded plover (*Charadrius rubricollis*) nests with human footprints around them were higher than at those without footprints, suggesting "that scavenging predators may use human footprints as a visual cue in locating food." Beach litter and garbage also attract predators such as skunks and coyotes (*e.g.*, N. Read *in litt.* 1998). Unnatural habitat features such as landscaped vegetation (*e.g.*, palm trees), telephone poles, transmission towers, fences, buildings, and landfills near western snowy plover nesting areas attract predators and provide them with breeding areas (*e.g.*, J. Buffa *in litt.* 2004). These alterations all combine to make the coastal environment more conducive to various native and nonnative predators that adversely affect western snowy plovers.

Substantial evidence exists that human activities are affecting numbers and activity patterns of predators on western snowy plovers. For example, increased depredation of western snowy plover nests by ravens at the Oliver Brothers salt pond, California, may be an indirect adverse impact of nearby installation of light structures by the California Department of Transportation and high-tension power lines by the Pacific Gas and Electric Company, thereby creating corvid nesting sites

(G. Page, Point Reyes Bird Observatory, pers. comm. 1997). Raven nests have also been discovered by National Wildlife Refuge biologists in transmission towers near other snowy plover nesting areas managed by the Don Edwards San Francisco Bay National Wildlife Refuge in Warm Springs, Alviso, and Mountain View (J. Buffa *in litt.* 2004). On the Oregon coast, predation risk by mammals has increased as a result of the spread of European beachgrass, Scotch broom, and shore pine, which has transformed vast areas of open sand into dense grass-shrub habitat, providing excellent habitat for native and nonnative mammalian predators, such as skunks, raccoons, foxes, and feral cats (Stern *et al.* 1991). At Vandenberg Air Force Base, coyote predation can be exacerbated by human presence when trash or debris is left behind (N. Read *in litt.* 1998).

Signing and fencing of restricted areas on the beach may provide perches for avian predators of western snowy plover adults or chicks (Hallett *et al.* 1995). Although signs and fences are important conservation tools in many areas, land managers need to be aware that modifications to them may be necessary to deter predators in some circumstances.

4. The Inadequacy of Existing Regulatory Mechanisms

The western snowy plover is protected by the Federal Migratory Bird Treaty Act (16 U.S.C. 703 *et seq.*) and, in each state, by State law as a nongame species. The western snowy plover's breeding habitat, however, receives only limited protection from these laws (*e.g.*, the Migratory Bird Treaty Act prohibition against taking "nests"). Listing of the western snowy plover under State endangered species laws generally provides some protection against direct take of birds, and may require State agencies to consult on their actions, but may not adequately protect habitat. State regulations, policies, and goals include mandates both for protection of beach and dune habitat and for public recreational uses of coastal areas; consequently they may conflict with protection of western snowy plovers in some cases. Section 404 of the Clean Water Act (33 U.S.C. 1251 et seq.) and section 10 of the Rivers and Harbors Act (33 U.S.C. 403) are the primary Federal laws that could provide some protection of nesting and wintering habitat of the western snowy plover that is determined by the U.S. Army Corps of Engineers (Corps) to be wetlands or historic navigable waters of the United States. These laws, however, would apply to only a

small fraction of the nesting and wintering areas of the western snowy plover on the Pacific coast. Aside from the Migratory Bird Treaty Act, western snowy plovers have no protection status in Mexico.

To effectively recover the western snowy plover, it is necessary to develop participation plans among cooperating agencies, landowners, and conservation organizations to assure protection and appropriate management of breeding, wintering, and migration areas. Since listing of the western snowy plover in 1993, several local working groups have been developed and local governments and State and Federal agencies have cooperated extensively to implement a wide variety of western snowy plover conservation actions. These partners continue to work to implement appropriate management of coastal areas for recovery of the western snowy plover. These conservation efforts and the environmental policies of State and Federal agencies are described in greater detail in the Conservation Efforts section, below.

For additional discussion of regulatory mechanisms and management actions taken by California State Parks and other entities, see U.S. Fish and Wildlife Service (2006a).

5. Other Natural or Manmade Factors Affecting Their Continued Existence

a. Natural Events

Western snowy plover breeding and wintering habitat is subject to constant change from weather conditions. Stenzel *et al.* (1994) reported that the quality and extent of western snowy plover nesting habitat is variable in both the short- and long-term. Coastal beaches increase in width and elevation during the summer through sand deposition, making marginal beaches more suitable for nesting later in the season. Over the longer term, an increase or decrease in habitat quality may occur after several years of winter storms. Based on the amount of flooding, the availability of dry flats at the edges of coastal ponds, lagoons, and man-made salt evaporators also varies within and between seasons. Therefore, the number of western snowy plovers breeding in some areas may change annually or even over one breeding season in response to natural alterations in habitat availability (Stenzel *et al.* 1981).

Because most western snowy plover nesting areas occur on unstable sandy substrates, nest losses caused by weather-related natural phenomena commonly occur. High tides and strong winds cause many nest losses. Events such as extreme high tides (Wilson 1980, Stenzel *et al.* 1981), river flooding (Stenzel *et al.* 1981), and heavy rain (Wilson 1980, Warriner *et al.* 1986, Page 1988) have been reported to destroy or wash away nests. The annual percentage of total nest losses attributed to weather-related phenomenon has reached 15 to 38 percent at some locations (Wilson 1980, Warriner *et al.* 1986, Page 1988).

Stormy winters can adversely affect the western snowy plover. It is suspected that the severe storms occurring during the El Niño atmospheric and oceanic phenomenon of the winter of 1997/1998 caused a 10 to 30 percent decline in the 1998 western snowy plover breeding population, depending on the coastal region. In all monitored recovery units, the number of breeding birds in 1998 was lower than in the 1997 nesting season. Additionally, a very wet spring resulted in a later than normal breeding initiation and fewer nesting attempts.

The western snowy plover population naturally varies, both spatially and temporally, because of natural changes in weather and habitat conditions from year to year. However, as described above, human influences over the past century (*e.g.*, habitat destruction, invasion of introduced beachgrass, and elevated predation levels) have reduced the western snowy plover's ability to respond to these natural perturbations.

b. Disturbance of Breeding Plovers by Humans and Domestic Animals

The coastal zone of the United States, including both open coastal areas and inland portions of coastal watersheds, is home to over one-third of the U.S. human population, and that proportion is increasing (U.S. Fish and Wildlife Service 1995*a*). The southern California coastal area, which constitutes the central portion of the western snowy plover's coastal breeding range, attracts large crowds on a regular basis (Figure 6). The increasing level of human recreation was cited as a major threat to the breeding success of the Pacific coast population of the western snowy plover at the time of listing (U.S. Fish and Wildlife Service 1993*a*).

Figure 6. Recreationists at Salt Creek Beach, California (photo by Ruth Pratt, with permission).

i. Pedestrians

Pedestrians (*e.g.*, beach walkers and joggers) can cause both direct mortality and harassment of western snowy plovers. Pedestrians on beaches may crush eggs or chicks and chase western snowy plovers off their nests. Separation of western snowy plover adults from their nests and broods can cause mortality through exposure of vulnerable eggs or chicks to heat, cold, blowing sand, and/or predators. Pedestrians have been known to inadvertently step on eggs and chicks, deliberately take eggs from nests, and remove chicks from beaches, erroneously thinking they have been abandoned. People also may cause broods of western snowy plovers to run away from favored feeding areas. These effects are described in more detail below. Trash left on the beach by pedestrians also attracts predators. In addition to public pedestrians, military personnel using the beach for maneuvers, boat launches, and landings have the potential to similarly cause adverse impacts to western snowy plovers.

Beach-related recreational activities that are concentrated in one location (*e.g.*, sunbathing, picnicking, sandcastle building, birding, and photography) can negatively affect incubating adult western snowy plovers when these activities occur too close to their nests. Recreational activities that occur in the wet sand area (*e.g.*, sand sailing) can adversely affect western snowy plovers when they disturb plover adults or broods, which feed at the edge of the surf along the wrack line. Recreational activities that occur in or over deep water (such as the beach- and water-oriented activities of surfing, kayaking, wind surfing, jet skiing, and boating, and the coastal-related recreational activity of hang gliding) may not directly affect western snowy plovers; however, they can potentially be detrimental to western snowy plovers when recreationists use the beach to take a break from these activities, or as access, exit, or landing points.

Concentrations of people may deter western snowy plovers and other shorebirds from using otherwise suitable habitats. Anthony (1985) found that intensive human activity at Damon Point had a "bracketing effect" on the distribution of nesting western snowy plovers, confining their breeding activity to a section of the spit and precluding their regular use of otherwise suitable habitat. Fox (1990) also found that western snowy plovers avoided humans at Damon Point, and the presence of fishermen and beachcombers kept them hundreds of yards away from potential habitat. Because early-nesting western snowy plovers have narrower beaches from which to select nest locations, recreational use may be more concentrated in the limited habitat available. Also, repeated intrusions by people into western snowy plover nesting areas also may cause birds to move into marginal habitats where their chances of reproductive success are reduced. Studies of the Atlantic coast population of the piping plover (*Charadrius melodus*), an eastern species with habitat requirements very similar to the snowy plover, indicate that some piping plovers that nest early in the season are forced to move elsewhere when human use becomes too intense (Cairns and McLaren 1980). These authors concluded that piping plovers that nest early, before beaches become heavily used for recreation, "cannot predict and avoid reproductive failure in habitats that otherwise appear suitable to them." Burger (1993) observed that piping plovers, in response to human disturbance, spent more energy on vigilance and avoidance behavior at the expense of foraging activity, and sometimes abandoned preferred foraging habitat.

Page *et al.* (1977) observed western snowy plovers' response to human disturbance at two coastal beaches where normal beach use ranged from light to heavy. The study included 156 hours of observation at 15 western snowy plover nests. At Point Reyes, they found that pedestrians disrupt incubation of nests. When humans approached western snowy plovers, adults left their nests 78 percent of the time when people were within 50 meters (164 feet) and 34 percent of the time when people were over 100 meters (328 feet). They also found that western snowy plovers' reaction to disturbance by humans varied, ranging from one bird remaining off the nest for less than 1 minute when a person walked within 1 meter (3 feet) of the nest on a heavily-used beach to another western snowy plover leaving the nest when three people were 200 meters (656 feet) away on a less-used beach. They noted that "birds exposed to prolonged human activity near the nest seemed to become accustomed to it." It has been speculated that predators of western snowy plovers may benefit from a decline in wariness by western snowy plovers nesting on beaches that are subject to ongoing high levels of human disturbance (Persons and Applegate 1997).

Lafferty (2001) observed western snowy plovers' response to people, pet dogs, equestrians, crows and other birds. Observations were made at Devereux Slough in Santa Barbara County, Santa Rosa Island, San Nicolas Island, and Naval Base Ventura County (Point Mugu). This study found that western snowy plover are most frequently disturbed when approached closely (within 30 meters) by people and animals. The most intense disturbance (causing the western snowy plover to fly away) were in response to crows, followed by horses, dogs, humans, and other birds. Lafferty (2001) created a management model based on his findings and estimated flight response disturbances under different scenarios. The model predicted a reduced disturbance response for buffer zones of 20 to 30 meters.

Fahy and Woodhouse (1995) quantified the levels of recreational disturbance, their effect on western snowy plovers, and the effectiveness of the Linear Restriction Program at Ocean Beach, Vandenberg Air Force Base in 1995. Under this program signs directed visitors not to cross from the outer beach into the Linear Restriction area (inland of mean high tide mark, in dune habitat used by western snowy plovers). Seventy percent of all disturbances were in compliance with restriction warning signs. The disturbance types that were most and least frequently in

compliance with the boundary were joggers or walkers and stationary visitors, respectively. The closer the disturbance occurred to the plover, the more severe the plover response. All-terrain vehicles caused the most significant alert and flight behaviors by western snowy plovers, even though they were in compliance with the Linear Restriction. The disturbance types that caused incubating western snowy plovers to flush from their nests most frequently were joggers and walkers, followed by joggers or walkers with dogs off leash, and stationary visitors. The disturbance types that kept incubating western snowy plovers off their nests for the longest period of time were stationary visitors and surf fishermen, probably because of the duration of these stationary disturbances that occurred close to nests. Weekends accounted for 60 percent of all disturbances. The enforcement personnel appeared to have a limited presence; their presence was documented during only 14 percent of all identified disturbances.

Hoopes *et al.* (1992) quantified human use and disturbance to piping plovers in Massachusetts during the 1988 and 1989 nesting seasons. They found pedestrians caused piping plovers to flush or move at an average distance of 23 meters (75 feet). Pedestrians within 50 meters (164 feet) of the birds caused piping plovers to stop feeding 31 percent of the time.

Point Reyes Bird Observatory found that management actions that included exclusion zones around nesting areas, seasonal closure to dogs, and active weekend docent programs reduced mortality of chicks and eggs during the weekend such that the weekend and weekday mortality was the same (Peterlein and Roth 2003).

At the Pajaro River mouth in California, at least 14 percent of western snowy plover clutches were destroyed by being driven over, stepped on, or deliberately taken by people (Warriner *et al.* 1986). Since exclosures have been used to protect nests at the Pajaro River mouth and other locations at Monterey Bay, a few nests have still been deliberately destroyed by vandals in most years (Point Reyes Bird Observatory unpublished data). At South Beach, Oregon, the number of western snowy plovers declined from 25 in 1969 to 0 in 1981 when a new park was constructed next to the beach and the adjacent habitat became more accessible to vehicles and people (Hoffman 1972 *in* Oregon Department of Fish and Wildlife 1994).

At Vandenberg Air Force Base, western snowy plover monitoring during 1993 at South Beach (where recreational use was high) and North Beach (where recreational use was low) found the rate of nest loss caused by humans differed markedly: 24.3 percent of South Beach nests were lost compared to only 3.0 percent of North Beach nests (Persons 1994). Persons and Applegate (1997) reported that "rates of reproductive success, combined for 1994 through 1997, were substantially higher on North Beach than on South Beach." This difference occurred despite the fact that nesting habitat was posted as off-limits during the nesting season in 1994. However, at that time restrictions were new and not strictly enforced (R. Dyste *in litt*. 2004). Since 2000, public access has been restricted and fully enforced by Vandenberg Air Force Base personnel. Additionally, Santa Barbara County-supported volunteer docents were present at Surf Station (within Vandenberg Air Force Base) during the 2001-2003 plover breeding seasons when the beach was open for public access. In 2003, plover monitors did not document the loss of any nests within Surf Station Beach as a result of trampling by humans (R. Dyste *in litt*. 2004).

Loss of western snowy plover chicks also may occur because of human activities. The number of young produced per nesting attempt increased from 0.75 in disturbed habitat to 2.0 for nests free of disturbance at Willapa National Wildlife Refuge, Washington (Saul 1982). At Vandenberg Air Force Base, the 1997 fledging success of western snowy plovers was 33 to 34 percent on North Beach where recreational activity is restricted and only 12 percent on South Beach where recreational use is high (Persons and Applegate 1997). In 1999 and 2000, Ruhlen *et al*. (2003) found that increased human activities on Point Reyes beaches had a negative effect on western snowy plover chick survival. In both 1999 and 2000, western snowy plover chick loss was about three times greater on weekends and holidays than on weekdays. In most coastal areas, beach visitation in summer months is much higher on weekends and holidays than on weekdays.

Flemming *et al*. (1988) measured the effects of human disturbance on reproductive success and behavior of piping plovers in Nova Scotia. To assess human disturbance, they recorded positions of people, pedestrian tracks, and vehicle tracks, then defined classes based on visits per week. They found significantly fewer young survived in areas of high versus low disturbance; humans elicited a

significantly higher response level from adult piping plovers than did predators or nonpredatory species; chicks fed less and were brooded less when humans were within 160 meters (525 feet); and chick peck rate during feeding was lower when humans were present. They speculated that because chicks shifted from feeding and energy conservation activities to vigilance and cryptic predator avoidance behaviors, their energy reserves would be depleted, making them more susceptible to predators and inclement weather. They postulated that a decline in piping plover abundance in Nova Scotia could be caused by human disturbance altering chick behavior. Fewer chicks survived to 17 days in areas heavily disturbed by humans.

Schultz and Stock (1993) studied the effects of tourism on colonization, distribution, and hatching success of Kentish plovers (*Charadrius alexandrinus alexandrinus*), a Eurasian subspecies of the snowy plover, at the Wadden Sea in Germany. They measured disturbance intensity by counting and mapping tourists on 50 days from April to July, during times of peak human activity (1500 to 1600 hours) and in intervals of 30 minutes throughout other days. An index of person-hours per area per day was calculated. They found that Kentish plovers did not colonize heavily-disturbed areas and that resting and sunbathing people were apparently more disruptive than walking people because the latter generally followed the high-tide line. Clutch losses were lowest in areas with little disturbance and highest in areas with heavy disturbance. They indicated that hatching success in highly disturbed areas, even with optimal habitat, is as low as in poor habitat with a low level of disturbance.

ii. Dogs

Dogs on beaches can pose a serious threat to western snowy plovers during both the breeding and nonbreeding seasons. Unleashed pets, primarily dogs, sometimes chase western snowy plovers and destroy nests. Repeated disturbances by dogs can interrupt brooding, incubating, and foraging behavior of adult western snowy plovers and cause chicks to become separated from their parents. Pet owners frequently allow their dogs to run off-leash even on beaches where it is clearly signed that dogs are not permitted or are only permitted if on a leash. Enforcement of pet regulations on beaches by the managing agencies is often lax or nonexistent.

A number of examples of disruptive ways that dogs affect western snowy plovers have been noted at beaches in Monterey County (Marina State Beach), Santa Cruz County (Laguna, Scott Creek, and Seabright Beaches) and San Mateo County (Half Moon Bay and Pacifica Beaches) (D. George, pers. comm. 1997). Incubating birds have been flushed from nests by dogs, including nests located inside areas protected by symbolic fencing. Dogs also have displaced adults from nests with newly-hatched chicks. Roosting and feeding flocks, as well as individual birds, have been deliberately and persistently pursued by dogs. At Laguna Creek Beach, Zmudowski State Beach, and Salinas River State Beach, dogs partially or entirely destroyed western snowy plover nests which were in several cases, protected with symbolic fencing (D. George, pers. comm. 1997; Point Reyes Bird Observatory unpublished data; G. Page, pers. comm. 1998). Feral dogs are suspected to have disturbed western snowy plover nests and chicks on San Francisco Bay salt ponds (J. Albertson *in litt.* 1999).

Even when not deliberately chasing birds, dogs on a beach may disturb western snowy plovers and other shorebirds that are roosting or feeding. Page *et al.* (1977) found that westem snowy plovers flushed more frequently and remained off their nests longer when a person was accompanied by a dog than when alone. They collected data during 156 hours of observation at 15 nests at Point Reyes, California, and found the following distances at which western snowy plovers flushed from their nests as a result of disturbance by people with dogs. Within 50 meters (164 feet), people with dogs caused flushing 100 percent of the time. At a distance of over 100 meters (328 feet), people with dogs caused flushing 52 percent of the time (Page *et al*. 1977). Fahy and Woodhouse (1995) found that joggers or walkers with off-leash dogs caused a significantly greater number of avoidance responses from western snowy plovers than other types of disturbances at Ocean Beach, Vandenberg Air Force Base, California. Lafferty's (2001) management model predicted that intense disturbances could be dramatically reduced by removing dogs.

At wintering sites such as Ocean Beach in San Francisco, California, off-leash dogs have caused frequent disturbance and flushing of western snowy plovers and other shorebirds. Off-leash dogs chase wintering western snowy plovers at this beach and have been observed to regularly disturb and harass birds (P. Baye, U.S. Fish and

Wildlife Service, pers. comm. 1997). Observations by National Park Service volunteers suggest that unleashed pets represent the most significant recreational threat to wintering western snowy plovers and migratory shorebirds at Ocean Beach, because of the prolonged and repeated disturbance created when they chase birds (Hatch 1997). In 1995 and 1996, during 45 hour-long observations of wintering flocks of western snowy plovers at Ocean Beach, western snowy plovers responded by moving in 73 percent of 74 instances when dogs with or without people approached to within 15 meters (50 feet) (Golden Gate National Recreation Area unpublished data). When shorebirds are flushed, they must spend more energy on vigilance and avoidance behaviors at the expense of foraging and resting activity (Burger 1993, Hatch 1997). Disruption of foraging and roosting may result in decreased accumulation of energy reserves necessary for shorebirds to complete the migration cycle and successfully breed (Burger 1986, Pfister *et al.* 1992). Dog disturbance at wintering and staging sites, therefore, may adversely affect individual survivorship and fecundity, thereby affecting the species at the population level.

iii. Motorized Vehicles

Unrestricted use of motorized vehicles on beaches is a threat to western snowy plovers and their habitat. Motorized vehicles may affect remote stretches of beach where human disturbance would be slight if access were limited to pedestrians. The magnitude of this threat is variable, depending on level of use and type of terrain covered. Use of motor vehicles on coastal dunes may also be destructive to dune vegetation, especially sensitive native dune plants.

Driving vehicles in breeding habitat may cause destruction of eggs, chicks, and adults, abandonment of nests, and considerable stress and harassment to western snowy plover family groups (G. Page, pers. comm. 1997; J. Myers *in litt.* 1988; J. Price *in litt.* 1992; Stern *et al.* 1990; Casler *et al.* 1993; S. Richardson, pers. comm. 1998; Widrig 1980). In addition to recreational vehicles, vehicles used for military activities have also caused western snowy plover mortality (Powell *et al.* 1995, 1997; Persons 1994).

Driving motor vehicles at night seems to be particularly hazardous to western snowy plovers. Drivers of all-terrain vehicles at night have run over and killed

western snowy plover adults at Vandenberg Air Force Base, and State park ranger patrol vehicles have crushed western snowy plover chicks at Oceano Dunes State Vehicular Recreation Area during night patrols (R. Mesta *in litt.* 1998).

On the Eel River gravel bars, vehicle use (including motorcycles, ATVs, and full-size 4x4s) has resulted in the crushing of nests and disturbance to nesting plovers (Colwell *et al.* 2006).

Western snowy plover adults and chicks have been observed using tire tracks and human footprints for loafing at Camp Pendleton and Naval Amphibious Base Coronado (Powell and Collier 1994). This behavior increases their chances of being run over. Western snowy plover chicks also may have difficulty getting out of tire ruts, thereby increasing their likelihood of being run over. Their cryptic coloring and habit of crouching in depressions like tire tracks makes western snowy plover chicks especially vulnerable to vehicular traffic. In Massachusetts, between 1989 and 1997, a total of 25 piping plover chicks and 2 adults were found dead in off-road vehicle tire ruts on the upper beach between the mean high tide line and the foredune (U.S. District Court of Massachusetts 1998).

Hoopes *et al.* (1992) found off-road vehicles caused piping plovers to flush or move at an average distance of 40 meters (131 feet). Off-road vehicles within 50 meters (164 feet) of the birds caused piping plovers to stop feeding 77 percent of the time. While most responses by piping plovers to off-road vehicles resulted in movement by the birds, they observed three instances where the plovers "froze" in response to the off-road vehicles. Both types of responses have a negative impact on plovers through either disturbance, interruption of feeding behavior, or increasing the risk that piping plovers will be hit or crushed by vehicles.

At wintering sites, disturbance from motorized vehicles may harass western snowy plovers and disrupt their foraging and roosting activities, thereby decreasing energy reserves needed for migration and reproduction. When motorcycles, most of which were in the wet sand zone, were driven at high speed along Ocean Beach in San Francisco, Hatch (1997) observed that western snowy plovers and other shorebirds were continually disturbed and often took flight.

iv. Beach Cleaning

Removal of human-created trash on the beach is desirable to reduce predation threats by eliminating food for predators of western snowy plovers; however, the indiscriminate nature of mechanized beach-cleaning adversely affects western snowy plovers and their habitat. Mechanized beach cleaning can be dangerous to western snowy plovers by crushing their clutches and chicks or causing prolonged disturbance from the machine's noise. Also, this method of beach cleaning removes the birds' natural wrackline (area of beach containing seaweed and other natural wave-cast organic debris) feeding habitat, reducing the availability of food. Kelp and driftwood, with their associated invertebrates, are regularly removed and the upper layer of sand is disturbed. Beach grooming also alters beach topography, removes objects associated with western snowy plover nesting, and prevents the establishment of native beach vegetation (J. Watkins *in litt.* 1999). In all of Los Angeles County and parts of Ventura, Santa Barbara, and Orange Counties, California, entire beaches are raked on a daily to weekly basis. Large rakes, with tines 5 to 15 centimeters (2 to 6 inches) apart, are dragged behind motorized vehicles from the waterline to pavement or to the low retaining wall bordering the beaches (Stenzel *et al.* 1981). Even if human activity was low on these beaches, grooming activities completely preclude the possibility of successful western snowy plover nesting (Powell 1996).

v. Equestrian Traffic

Most equestrian use on beaches is directed to wet-sand areas. However, during high tide periods, horseback riders on the beach sometimes enter coastal dunes or upper beach areas (Figure 7), where they may crush clutches or disturb western snowy plovers (Point Reyes Bird Observatory unpublished data, Page 1988, Persons 1995, Craig *et al.* 1992, Woolington 1985).

Figure 7. Equestrians on beach (photo by U.S. Forest Service, with permission).

vi. Fishing

Impacts on western snowy plover nesting may be associated with surf fishing and shellfish harvesting in and near western snowy plover habitat. The improper disposal of offal (waste parts of fish), bait, and other litter attracts crows, ravens, and gulls, which are predators of western snowy plover eggs and chicks. Also, western snowy plovers may become entangled in discarded fishing lines (G. Page, pers. comm. 1998).

Surf fishing is a commercial enterprise in many coastal locations, including the ocean smelt fishery in northern California (C. Moulton *in litt.* 1997). Recreational surf fishing occurs throughout the California coast. In Humboldt County, California, Redwood National and State Parks have proposed allowing beach vehicle use, by annual permit, for commercial fishing and tribal fishing/gathering on Gold Bluffs Beach, Freshwater Spit, and Crescent Beach (J. Watkins *in litt.* 1999). In the State of Washington, the most popular season for surf fishing is April through July (Washington Department of Fish and Wildlife 1995). At present, demand for

surf perch fishing is relatively low in Oregon. However, the Oregon Department of Fish and Wildlife is promoting a surf perch fishery to lessen the demand for anadromous fishing. This fishery would increase vehicle driving to remote and relatively undisturbed sites used by western snowy plovers (K. Palermo *in litt.* 1998*a*).

Because the earliest western snowy plover clutches in Washington are laid between mid-April and mid-May, harvesting of razor clams during the mid-March to mid-May clamming season may have adverse impacts on prospecting or nesting western snowy plovers. Clammers near nesting areas may disturb adults and chicks; human activity in feeding areas may restrict western snowy plover foraging activity, and increased motorized traffic may increase the risk of nest and chick loss (Washington Department of Fish and Wildlife 1995). However, observations of western snowy plover and human activities during the spring 1995 razor clam season showed clamming had no visible impact on western snowy plovers where clamming intensity was low (Kloempken and Richardson 1995). Instances of trespassing into the western snowy plover protection area were noted; however, movement of the western snowy plover protection area boundary about 327 meters (1,073 feet) west of its previous location seemed to benefit the birds by providing more space between them and pedestrian and vehicular disturbances.

vii. Fireworks

Fireworks are highly disturbing to western snowy plovers. All western snowy plovers flushed from Coal Oil Point Reserve during a nearby July 4, 2005, fireworks display (C. Sandoval, University of California Santa Barbara, pers. comm. 2005). At Del Monte Beach, California, a western snowy plover chick hatched on July 4, 1996, within an area demarcated by symbolic fencing, and was abandoned by its parents after a fireworks display. Disturbance from the noise of the pyrotechnics is exacerbated by disturbance caused by large crowds attracted to fireworks events. California Department of Parks and Recreation staff estimated that 6,000 people visited Del Monte Beach on that day. Because of the extensive disturbance, the adult western snowy plovers left the nest site with two chicks, abandoned the third chick, and were not seen again (K. Neuman, California Department of Parks and Recreation, pers. comm. 1997). During July 4, 1992,

observations of piping plovers that nest on the Breezy Point Cooperative and adjacent beaches of Gateway National Recreation Area in Queens, New York, the birds were disturbed by fireworks displays (Howard *et al.* 1993). Management recommendations for this area included prohibition of fireworks in or near the fenced and posted nesting and brood-rearing areas.

viii. Kite Flying and Model Airplanes

Biologists believe plovers perceive kites as potential avian predators (Hoopes *et al.* 1992, Hatch 1997). The reaction of western snowy plovers to kites at Ocean Beach in San Francisco, California, "ranged from increased vigilance while roosting in close proximity to the kite flying, to walking or running approximately 10 to 25 meters (33 to 82 feet) away and resting again while remaining alert" (Hatch 1997). It is expected that stunt-kites would cause a greater response from western snowy plovers than traditional, more stationary kites. Stunt kites include soaring-type, two-string kites with noisy, fluttering tails, which often exhibit rapid, erratic movements.

Hoopes *et al.* (1992) found that piping plovers are intolerant of kites. Compared to other human disturbances (i.e., pedestrian, off-road vehicle, and dog/pet), kites caused piping plovers to flush or move at a greater distance from the disturbance, to move the longest distance away from the disturbance, and to move for the longest duration. Piping plovers responded to kites at an average distance of 85 meters (279 feet); moved an average distance of over 100 meters (328 feet); and the average duration of the response was 70 seconds.

It is expected that model airplanes may also have a detrimental impact to western snowy plovers because western snowy plovers may perceive them as potential predators (Hatch 1997).

ix. Aircraft Overflights

Low-flying aircraft (*e.g.*, within 152 meters (500 feet) of the ground) can cause disturbances to breeding and wintering western snowy plovers. Hatch (1997) found that all types of low-flying aircraft potentially may be perceived by western snowy

plovers as predators. She also found that the general response of roosting western snowy plovers to low-flying aircraft at Ocean Beach, San Francisco, California, was to increase vigilance and crouch in depressions on the beach, whereas foraging western snowy plovers frequently took flight. Plovers may, however, become acclimated to aircraft overflights in some instances, since at Naval Air Station North Island they chose to nest repeatedly within military airfield boundaries on runway ovals next to busy military runways (S. Vissman, U.S. Fish and Wildlife Service, pers. comm. 1997). Federal Aviation Regulations, Part 91, General Operating and Flight Rules, require that over open water, aircraft may not be operated closer than 152 meters (500 feet) to any person, vessel, vehicle, or structure. Emergency operations, including those by Coast Guard helicopters, are exempted from these rules. However, helicopters may be operated at less than 152 meters (500 feet) if the operation is conducted without hazard to people or property on the surface (U.S. Federal Aviation Administration 1997). Helicopters can cause excessive noise, which can also disturb western snowy plovers, even at an altitude of 152 meters (500 feet) (Howard *et al.* 1993; J. Watkins *in litt.* 1999; D. Stadtlander, pers. comm. 1999). At Marine Corps Base Camp Pendleton, California, where military training can require aircraft (especially helicopters) to fly at very low elevations, the Marine Corps minimizes impacts to western snowy plovers and California least terns by requiring aircraft to stay at least 91 meters (300 feet) above the ground over tern and plover nesting areas during the nesting season (U.S. Marine Corps 2006).

x. Special Events

Special events which attract large crowds, such as media events, sporting events, and beach clean-ups, have a potential for significant adverse impacts when held in or near western snowy plover habitat. An example is the National Marine Debris Monitoring Program, implemented by the U.S. Environmental Protection Agency in conjunction with the National Oceanic and Atmospheric Administration, National Park Service, and the U.S. Coast Guard. This year-round program uses volunteers (including high school students) to document and collect trash and marine debris on coastal transects within western snowy plover nesting and wintering habitat. Potential threats from crowds of people attracted to special events are similar to those previously identified for pedestrians, including direct mortality and harassment of western snowy plovers.

xi. Coastal Access

Expanding public access to the coast (*e.g.*, State Coastal Trails) for recreation (*e.g.*, walking, hiking, biking) may adversely affect western snowy plovers and their breeding or wintering habitat. Expanded coastal access brings significantly greater numbers of people to the beach and other coastal habitats, exacerbating potential conflicts between human recreational activities and western snowy plover habitat needs (see Pedestrian section). Expanded coastal access may exceed the threshold of beach visitors that public resource agencies (*e.g.*, State Parks and National Park Service) can effectively manage while also meeting their responsibilities to protect natural resources.

Bicycles are known to adversely affect western snowy plovers nesting on levees and roads near San Francisco Bay salt ponds within the Don Edwards San Francisco Bay National Wildlife Refuge. Many of these levees are closed to human access, but some bicyclists trespass onto closed levees. In 1998, one western snowy plover nest, located on the main access road to the Refuge, was run over by a bicycle as biologists were putting up a barrier to protect it (J. Albertson *in litt.* 1999).

xii. Livestock Grazing

Western snowy plover nests have been trampled by cattle, causing both direct mortality of eggs and flushing of adults from the nests (U.S. Fish and Wildlife Service *in litt.* 1995). Additionally, feral pigs (*Sus scrofa*) may trample western snowy plover habitat and disturb nesting western snowy plovers (R. Klinger, The Nature Conservancy, pers comm. 1998, D. George *in litt.* 2001). Cow and horse manure can introduce seeds of non-native plants into the dunes.

c. Oil Spills

The Pacific Coast population of the western snowy plover is vulnerable to oil spills. Western snowy plovers forage along the shoreline and in sea wrack (seaweed and other natural wave-cast organic debris) at the high-tide line and are thus at risk of direct exposure to oil during spills. The loss of thermal insulation is considered to be the primary cause of mortality in oiled birds (National Research Council 1985,

Leighton 1991). Oiled feathers lose their ability to keep body heat in and cold water out, causing reduced insulation, increased metabolic rate, and hypothermia. Ingestion of oil may lead to physiological changes in birds, including pathological effects on the alimentary tract, blood, adrenal glands, kidneys, liver, and other organs (Fry and Lowenstine 1985, Khan and Ryan 1991, Burger and Fry 1993). Exposure of adult birds to oil also may impair reproduction, including reductions in egg laying and hatchability (Ainley *et al.* 1981, Fry *et al.* 1986) and reductions in survival and growth of chicks (Trivelpiece *et al.* 1984). Oil transferred to eggs from plumage or feet of incubating birds can kill embryos (Albers 1977, Albers and Szaro 1978, King and Lefever 1979). Oiled shorebirds may spend more time preening and less time feeding than unoiled birds, such that their body condition and ability to migrate to breeding grounds and reproduce may be impaired (Evans and Keijl 1993, Burger 1997).

Oil spills may result in contamination or depletion of western snowy plover food sources. Elevated concentrations of total petroleum hydrocarbons have been found in the sand crab (*Emerita analoga*), a potential western snowy plover food item, following a southern California oil spill (J.E. Dugan, unpublished data). Oil or other chemicals washed onto mudflats or sand beaches may result in reduction in the availability of invertebrate prey (Kindinger 1981). Elimination of shorebird food resources on intertidal flats of the Saudi Arabian Gulf coast as a result of the large oil spills associated with the 1991 Gulf War led to drastic reductions in the number of shorebirds supported by this habitat (Evans *et al.* 1993). Disturbance and other adverse impacts to western snowy plovers also may occur during oil clean-up activities if response teams are not careful when driving heavy equipment and vehicles or traversing on foot through western snowy plover habitat.

During the 1990s, at least six oil spill incidents in California and one in Oregon resulted in adverse impacts to western snowy plovers. The U.S. Coast Guard and various other State and Federal agencies and the responsible parties responded to these spills. One of these incidents occurred between 1984 and 1998 at Unocal's Guadalupe Oil Field in San Luis Obispo, California contaminated western snowy plover habitat with toxic hydrocarbons. In 1993, oil spilled from a ruptured oil transfer line into McGrath Lake, Ventura County, California and then flowed into the Pacific Ocean. Western snowy plover habitat and prey were contaminated with

oil and wintering western snowy plovers were displaced during the cleanup activities (S. Henry *in litt.* 1998, McGrath Oil Spill Restoration Scoping Document 1995). In 1996, the SS Cape Mohican discharged fuel oil into the San Francisco Drydock Shipyard, California, where it spread throughout the central bay and into the Pacific Ocean, oiling western snowy plovers and their beach habitat (Cape Mohican Trustee Council 2002, Point Reyes Bird Observatory unpublished data). In 1997, a pipeline extending between an offshore oil platform (Platform Irene) and the mainland ruptured near Pedernales Point, Santa Barbara County, California, oiling western snowy plovers and wrack where western snowy plovers were seen feeding (Applegate 1998, Ford 1998, Lockyer *et al.* 2002). In 1997 and 1998, large numbers of tarballs became stranded on beaches at Point Reyes National Seashore and resulted in oiling of snowy plovers and their habitat. Subsequent tarball incidents in 2001 and 2002 resulted in identification of the source of the tarballs as the SS Jacob Luckenbach, an oil tanker that sank in 1953 (Carter and Golightly 2003, Point Reyes Bird Observatory unpublished data, Hughes 2003). In 1999, the dredge M/V Stuyvesant spilled fuel oil into the Pacific Ocean off Humboldt Bay, California (U.S. Coast Guard 2001), resulting in oiling of western snowy plovers and their habitat (LeValley *et al.* 2001).

In February 1999, the freighter New Carissa went aground near the North Jetty of Coos Bay, Oregon, breaking apart and spilling 25,000 to 70,000 or more gallons of oil into coastal water. (U.S. Bureau of Land Management 2001). The incident oiled approximately 52 snowy plovers, representing at least 60 percent of the Oregon wintering population of western snowy plover (Stern *et al.* 2000). In Washington, the 1988 Nestucca oil spill and the 1991 Tenyo Maru oil spill may also have affected western snowy plovers or their habitats, although impacts are not as well documented as in the above cases (Larsen and Richardson 1990).

In addition to catastrophic spills like those described above, chronic oil pollution may affect western snowy plovers. Surveys of beached birds have shown that small-volume, chronic oil pollution is an ongoing source of avian mortality in coastal regions (Burger and Fry 1993). Dead oiled birds and tarballs are found regularly on Pacific coast beaches in the absence of reported oil spills (Roletto *et al.* 2000). Potential sources of chronic oiling include natural seeps, bilge water pumping, sunken vessels, urban runoff, and small or unreported spills from vessels,

tankers, pipelines, and offshore oil platforms. Elevated concentrations of total petroleum hydrocarbons have been found in the sand crab *(Emerita analoga*), a potential western snowy plover food item, in the vicinity of natural oil seeps (Dugan *et al.* 1997).

Intensive oil spill cleanup operations, including use of vehicles to deploy beach booms, move personnel, and remove debris, cause disturbance to nesting and foraging activities of western snowy plovers. These temporary impacts are offset by restoration of habitat and cleaning affected birds.

d. Contaminants

The most likely route of exposure of western snowy plovers to contaminants other than spilled oil is through the diet. Western snowy plovers feed on aquatic and terrestrial insects, and the bioaccumulation of environmental contaminants on western snowy plover nesting and wintering grounds may adversely affect their health and reproduction. Organochlorines are known to have caused reduced avian egg production, aberrant incubation behavior, delayed ovulation, embryotoxicosis, and mortality of chicks and adults (Blus 1982). Selenium has caused decreased hatchability of avian eggs, developmental abnormalities, altered nesting behavior, and embryotoxicosis in birds in field and laboratory studies (Ohlendorf *et al.* 1986, Heintz *et al.* 1987). Mercury can cause decreased hatchability of avian eggs (Connors *et al.* 1975), boron has been shown to reduce hatchability of waterfowl eggs in laboratory experiments (Smith and Anders 1989), and arsenic may also adversely affect avian reproduction (Stanley *et al.* 1994).

Hothem and Powell (2000) analyzed 23 western snowy plover eggs collected from 5 sites (Camp Pendleton Marine Corps Base, Batiquitos Lagoon, Naval Amphibious Base Coronado, Sweetwater Marsh National Wildlife Refuge, and Tijuana Estuary) in southern California from 1994 to 1996 for metals and trace elements, and 20 eggs for organochlorine pesticides and metabolites. All eggs were either abandoned or failed to hatch. Organochlorines, including dieldrin, o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDE, p,p'-DDT, oxychlordane, and trans-nonachlor were found above the detection limits in western snowy plover eggs. Median DDE and PCB concentrations were less than those normally associated with eggshell

thinning. deformities, or other detrimental effects on birds. Twelve metals and trace elements (arsenic, boron, chromium, copper, iron, magnesium, manganese, mercury, nickel, selenium, strontium and zinc) were detected in at least 90 percent of the samples, but generally at background levels. Mean concentrations of all contaminants were below those that would adversely affect reproduction.

Concentrations of mercury in western snowy plover eggs that failed to hatch at Point Reyes National Seashore were five to ten times higher than the mercury concentrations in the five Southern California locations studied by Hothem and Powell (Schwarzbach *et al.* 2003). The mean mercury concentration of 1.07 micrograms/gram (1.07 parts per million), wet weight, in western snowy plover eggs from Point Reyes National Seashore is probably high enough to account for egg failure through direct toxic effects to western snowy plover embryos (Schwarzbach *et al.* 2003). Because only failed and abandoned eggs were taken rather than randomly collected eggs, the extent of mercury contamination of the entire breeding western snowy plover population at Point Reyes can not be reliably assessed from these data; however, the data from the 2000 field season would suggest that about one fifth of the nests appeared to be at risk from adverse effects of mercury (Schwarzbach *et al.* 2003).

e. Litter, Garbage, and Debris

Placement of litter, garbage, and debris in the coastal ecosystem can result in direct harm to western snowy plovers and degradation of their habitats. Litter and garbage feed predators and encourage their habitation at higher levels than would otherwise occur along the coast, making predators a greater threat to western snowy plovers. For example, as noted previously, the California gull (*Larus californicus*) has become far more prevalent in the South San Francisco Bay area. Currently, the estimated 25,000 California gulls in this area feed in landfills and forage in salt marshes using habitat that once supported the western snowy plover (J. Albertson, pers. comm. 2005).

Marine debris and contaminated materials on the beach also adversely affect western snowy plovers. Marine debris is attributed to both ocean and shoreline sources. Ocean sources of marine debris and contamination include fishing boats,

ships, and cruise lines. Cruise line debris may include small plastic shampoo, conditioner, hand lotion, and shoe polish containers, plastic cups, and balloons (Center for Marine Conservation 1995). Shoreline debris is usually from land sources. Western snowy plovers may become entangled in discarded fishing line, fishing nets, plastic rings that hold together six-packs of canned drinks, and other materials on the beach. Containers of contaminated materials (*e.g.*, motor oil, cleaning fluid, and syringes) can introduce toxic chemicals to the beach. The National Marine Debris Monitoring Program, headed by the U.S. Environmental Protection Agency, was established to clean and track sources of marine debris in coastal areas. This monitoring program, while beneficial to western snowy plovers in the long-term, could potentially adversely affect nesting western snowy plovers since the program is conducted year-round. Similarly, the annual spring SOLV beach cleanup held on the Oregon Coast in late March and the annual Coastal Cleanup Day held on the California coast in September are two organized beach events that are poorly timed with respect to prospecting and nesting western snowy plovers. These programs could greatly improve western snowy plover habitat if timed appropriately.

f. Water Quality and Urban Run-off

Many coastal beaches used as habitat by western snowy plovers contain channelized streams or outfalls receiving run-off from urban, industrial, and agricultural areas. Nonpoint sources of water pollution (including hydrocarbons, heavy metals, and household chemicals) could end up at coastal beaches used as western snowy plover foraging areas. In 1995, three dead male western snowy plovers (all banded and local breeders) were found in an area containing local outfalls, including an outfall connected to a sewage treatment plant at Monterey Bay. By the beginning of the next breeding season, it was discovered that another male western snowy plover from this area disappeared and possibly died. Factors unrelated to the outfall have not been ruled out in the disappearance of this bird. One of the birds was analyzed through necropsy and found to have an enlarged liver, but it could not be determined whether there was a relationship between the mortality and the outfall (Point Reyes Bird Observatory unpublished data).

g. Management for Other Special Status Species

In several instances fencing used to enclose California least tern colonies has caused mortality of western snowy plover chicks that have become entangled within the fence mesh (Powell and Collier 1995, Powell *et al.* 1995), or prevented western snowy plover chicks from following their parents to feeding areas by blocking their movement (Powell *et al.* 1996). These issues have largely been resolved by utilizing fencing with a mesh size of less than 0.64 centimeter (0.25 inch), tightening gaps in fencing seams, and installing "gates" in tern fencing (Foster 2005). Monitoring and minimization measures to avoid these impacts continue to be implemented in coordination with the appropriate Fish and Wildlife Offices. Increasing density and abundance of California least terns within colonies may also result in western snowy plovers being displaced a short distance, but the benefits of tern management for western snowy plovers appear to outweigh such conflicts.

At the Channel Islands and other lands managed by the National Park Service and the Department of the Navy, a decline of western snowy plovers may be caused by disturbance and habitat loss resulting from the large increase in numbers of marine mammals on beaches (U.S. Fish and Wildlife Service *in litt.* 1995, U.S. Department of the Navy *in litt.* 2001). Breeding pinnipeds, including northern elephant seals (*Mirounga angustirostris*), northern fur seals (*Callorhinus ursinus*) and California sea lions (*Zalophus californianus*) at San Miguel Island and San Nicolas Island, have occupied western snowy plover nesting habitat. Beach-cast dead whales have, on occasion, posed threats to nesting western snowy plovers. At Point Reyes beaches, large, whole carcasses have washed ashore and other agencies such as the National Marine Fisheries Service have sought to collect them for scientific purposes. They also attract people who are curious about whales. These activities could potentially cause direct mortality and disturbance to western snowy plovers. In addition, mammal carcasses attract scavengers such as gulls, ravens, crows, and coyotes that are potential predators to western snowy plovers.

E. IMPLICATIONS FOR THE COASTAL BEACH-DUNE ECOSYSTEM

The western snowy plover lives in an ecosystem that has been significantly degraded. Environmental stressors (*i.e.*, development, human recreation, degraded

water quality, etc.) have adversely affected the biological diversity of the coastal dune ecosystem. Many of the characteristics that attract people to coastal areas make these areas prime habitat for fish and wildlife resources. Although they comprise less than 10 percent of the Nation, coastal ecosystems are home to over one-third of the United States human population, nearly two-thirds of the Nation's fisheries, half of the migratory songbirds, and one-third of our wetlands and wintering waterfowl (U.S. Fish and Wildlife Service 1995*a*). The coasts also provide habitat for 45 percent of all threatened and endangered species, including three-fourths of the federally-listed birds and mammals (U.S. Fish and Wildlife Service 1995*a*). Proper stewardship of this unique ecosystem is needed to maintain its ecological integrity while meeting its human demands.

1. Description of Coastal Beach-Dune Ecosystem

The coastal beach-dune ecosystem may include several features such as beaches, foredunes, deflation plains, blow-outs, and reardunes. The beach includes the expanse of sandy substrate between the tide line and the foredune or, in the absence of a foredune, to the furthest inland reach of storm waves. Beach steepness, height, and width are affected by wave height, tidal range, sand grain size, and sand supply. The beach has high exposure to salt spray and sand blast and contains a shifting, sandy substrate with low water-holding capacity and low organic matter content. Dunes include sandy, open habitat, extending from the foredune to typically inland vegetation on stabilized substrate. Major differences occur between beach and dune in salt spray, soil salinity, and air and soil temperatures (Barbour and Major 1990).

Coastal dunes generally consist of three primary zones (Powell 1981). The foredunes are the line of dunes paralleling the beach behind the high tide line. Foredunes are characterized by unstabilized sand and a simple community of low-growing native dune plant species, such as American dunegrass (*Leymus mollis*). Foredunes also support a rich community of sand-burrowing insects (Powell 1981). Behind the foredunes is the deflation plain, which is at or near the water table and is characterized by a mixture of water tolerant plants and dune species. Deflation plains are also called dune hollows and can be invaded by hydrophilic (having a strong affinity for water) trees, shrubs, or herbs (*e.g.*, species of *Carex, Juncus, Salix, Scirpus*) (Barbour and Major 1990). The inner zone of coastal dunes consists

of stabilized dunes, which are dominated by woody perennial plants (Powell 1981). Beach flora can also colonize inland dune areas, where the sand is actively moving (Barbour and Major 1990).

Barren dunes, receiving sand from the beach and losing it to wind erosion, are mobile. Older, more inland dunes are stabilized by a nearly continuous plant cover; these dunes are referred to as stable dunes or fixed dunes. Localized openings in the plant cover, which permit wind erosion, are called blowouts, but they are not deep enough to allow invasion by mesophytes (plants growing in moderately moist environments). The innermost ridge of sand is generally high and is called a precipitation ridge; sand is blown over the ridge and down the slipface, continuing the process of dune advance (Barbour and Major 1990). The conditions necessary for dune growth at the coast are partly climatic, but more important is the occurrence of strong onshore winds, abundant sand supply, and vegetation that traps sand. Low, near-shore slopes with a large tidal range providing wide expanses of sand that dries at low tide are ideal for dune growth (Pethick 1984).

Very few coastal dunes are "natural," because they have been extensively altered over time by humans for agriculture, mineral extraction, military training, and recreation (Carter 1988). Before the introduction of European beachgrass, foredunes were low and rose gradually, and a large number of native species shared this habitat. They were composed of a series of dunes alternating with swales oriented perpendicular to the coast and aligned with prevailing onshore winds. Since the introduction of European beachgrass, most systems have been replaced by a steep foredune that gives way inland to a series of dunes and swales oriented parallel to the coast (Barbour and Major 1990).

Western snowy plovers use the beach and mobile dunes as nesting habitat. Other habitat features that occur within or adjacent to the coastal beach-dune ecosystem, and serve as important foraging habitat for the western snowy plover, include river, stream, and creek mouths, river bars, lagoons, and tidal and brackish-water wetlands.

2. Sensitive Species of the Coastal Beach-Dune Ecosystem

Along with the western snowy plover, many other sensitive species inhabit the coastal beach-dune ecosystem and adjacent habitats. Appendix E contains a list of, and brief species accounts for, sensitive species associated with this ecosystem and adjacent habitats. We recognize these fish and wildlife species as endangered, threatened, candidate species, or species of concern. This list includes a number of sensitive species recognized by the states of California, Oregon, and Washington. This appendix also describes several marine mammals associated with the coastal beach-dune ecosystem and protected under the Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 *et. seq.*), as amended.

Some of these sensitive species have many threats in common with the western snowy plover. Habitat loss and degradation from shoreline development and beach stabilization, invasion of exotic species, and crushing by off-road vehicles are cited as major factors contributing to the status and listing of these species. European beachgrass is a current or potential threat to six federally-listed endangered plants that occur in coastal dunes of California: beach layia (*Layia carnosa*), Howell's spineflower (*Chorizanthe howellii*), Monterey spineflower (*Chorizanthe pungens* var. *pungens*), Menzies' wallflower (*Erysimum menziesii*), Monterey gilia *(Gilia tenuiflora* ssp. *arenaria*), and Tidestrom's lupine (*Lupinus tidestromii*) (Pickart 1997). European beachgrass is also a current and potential threat to native and sensitive plants in Washington and Oregon, including the pink sand-verbena (*Abronia umbellata* ssp. *breviflora*), which is classified as endangered in the State of Oregon. Equestrian use has also been identified as a threat to several endangered plant species, including the endangered Howell's spineflower, Menzies' wallflower, Monterey gilia, and the coastal dunes milk vetch (*Astragalus tener* var. *titi*). Off-road vehicles are cited as threats to several sensitive plant and animal species, including the endangered beach layia, Menzies' wallflower, Monterey gilia, Tidestrom's lupine, Hoffman's slender-flowered gilia (*Gilia tenuiflora* var. *hoffmanii*), and Smith's blue butterfly (*Euphilotes enoptes smithi*); the federally endangered La Graciosa thistle (*Cirsium longholepis*), and the following species considered to be of Federal concern: beach spectacle pod (*Dithyrea maritima*) and Morro blue butterfly (*Icaricia icarioides morroensis*).

The precarious status of these species is a symptom of a highly stressed ecosystem. Remedial efforts aimed at restoration of the natural processes that maintain this ecosystem, rather than single-species "fixes," are likely to have the greatest and most successful long-term benefits. Important components of ecologically-sound coastal beach-dune ecosystem management include (1) removal of exotic, invasive vegetation; (2) management of human recreation to prevent or minimize adverse impacts on dune formation, vegetation, invertebrate and vertebrate fauna; and (3) efforts to counter the effects of human-induced changes in the types, distribution, numbers, and activity patterns of predators. Implementation of more ecosystem-oriented approaches to western snowy plover protection would provide important benefits to other sensitive species within the coastal dune ecosystem and merits serious consideration.

Some western snowy plover recovery efforts implemented to date (*e.g.*, removal of European beachgrass) support the natural functions of the coastal dune ecosystem. Furthermore, many protection efforts for western snowy plovers should benefit other sensitive beach species, such as California least terns, and vice versa. Many of the same predators that take western snowy plover eggs also prey on California least tern eggs. The relatively low rate of predation of western snowy plover nests in San Diego County has been attributed to predator control programs to benefit California least terns and other species, funded primarily by the Department of Defense and National Wildlife Refuge System (Powell *et al.* 1995). These programs are implemented under contract with the U.S. Department of Agriculture, Wildlife Services branch. Control of ants at California least tern colonies probably also benefits western snowy plovers nesting nearby. Opportunities also may exist for reestablishment of special status plant species that occur in coastal dunes, including Menzies' wallflower, beach spectacle pod, Tidestrom's lupine, beach layia, and pink sand verbena.

Some conflicts have occurred in management of western snowy plovers and California least terns in southern California, including harm to western snowy plover chicks due to entanglement in the mesh of California least tern fencing as described above. These problems have now largely been minimized with the use of new methods and materials, however such management measures should continue

to be coordinated to meet the habitat needs of both western snowy plovers and California least terns.

Potential conflicts also exist between native dune restoration and western snowy plover habitat. Revegetation efforts could result in too much cover, thereby reducing the amount of suitable breeding habitat available for western snowy plovers.

Conflicting habitat requirements for western snowy plovers and pinnipeds have also occurred on lands where marine mammals haul out or breed on beaches that would otherwise be suitable for nesting western snowy plovers (U.S. Fish and Wildlife Service *in litt.* 1995, U.S. Department of the Navy *in litt.* 2001). Where this conflict continues to occur, coordination with land management agencies and NOAA's National Marine Fisheries (NMFS) may be helpful to identify methods for modifying or discouraging use by breeding pinnipeds during the western snowy plover nesting season.

Although some management measures may benefit a broad array of sensitive species within the coastal dune ecosystem (*i.e.*, control of *Ammophila*, access restrictions, and integrated predator management programs), some single-species protection measures for the western snowy plover, such as exclosures, are needed. Although exclosures can be risky to nesting western snowy plovers in some situations (see Lauten *et al.* 2006), they can be an effective way to protect nests against heavy recreational use and predation, especially where reductions in predator numbers would otherwise be temporary and difficult to achieve or would have adverse ecological effects.

F. CONSERVATION EFFORTS

Western snowy plover recovery efforts have accelerated since this population was federally listed as a threatened species in 1993. Current breeding and wintering site protection efforts are documented in Appendix C (Summary of Current and Additional Needed Management Activities). The most common management strategies include protection of nests with predator exclosures; signing and symbolic fencing of nesting areas; restrictions on motorized vehicles in the vicinity of western

snowy plover nests and broods; restrictions on dogs (even though enforcement of dogs on-leash has been problematic); and public information and outreach. These strategies are effective means of improving western snowy plover reproductive success.

1. Conservation Planning on Federal and State Lands

The direction of land management on Federal lands is often outlined in management plans or agency regulations that provide objectives and guidelines for western snowy plovers. These plans include the Naval Base Coronado Integrated Natural Resources Management Plan (U.S. Navy 2001), Camp Pendleton Integrated Natural Resources Management Plan (U.S. Marine Corps 2006), San Diego Bay National Wildlife Refuge Comprehensive Conservation Plan (U.S. Fish and Wildlife Service 2006*c*), Oregon Dunes National Recreation Area Management Plan (U.S. Forest Service 1994), the Coos Bay Shorelands Final Management Plan (U.S. Bureau of Land Management 1995*a*), the New River Area of Critical Concern Management Plan (U.S. Bureau of Land Management 1995*b*), the Draft Snowy Plover Management Plan for Ocean Beach, Golden Gate National Recreation Area (Hatch 1997), and the Western Snowy Plover Management Plan for the Point Reyes National Seashore (White and Allen 1999).

Wildlife protection, especially the preservation, restoration, and enhancement of threatened and endangered species and migratory birds, is the primary goal of national wildlife refuges, as stated in the National Wildlife Refuge System Administration Act of 1997 (16 U.S.C. 668dd *et. seq.*). Western snowy plover habitat on national wildlife refuges has been accorded intensive protection, including (1) integrated predator management and (2) closures during the nesting season where appropriate, to minimize adverse effects of disturbance. Consistent with requirements of the National Wildlife Refuge System Administration Act and the Refuge Recreation Act of 1962, as amended (16 U.S.C. 460k *et. seq.*) regarding compatibility of refuge activities, western snowy plover nesting areas within some national wildlife refuges are closed to public use during the breeding season. Western snowy plover use areas within some national wildlife refuges (such as Salinas River National Wildlife Refuge) are closed to public use year-round.

Additionally, the Department of Defense manages for western snowy plovers on military installations through actions associated with section 7 of the Endangered Species Act and through conservation planning efforts (*e.g.*, Programmatic Activities and Conservation Plans in Riparian and Estuarine/Beach Ecosystems on Marine Corps Base Camp Pendleton, 1995; see also Federal Regulatory Program, below). This includes avoidance and minimization measures, which have resulted in individual military installations placing limits on or otherwise restricting military activities and implementing management actions to specifically benefit western snowy plovers, such as monitoring, predator control, habitat improvement, and research. This management, in conjunction with other factors such as habitat availability and restricted public access, has allowed certain Department of Defense lands to significantly contribute to regional western snowy plover populations.

The *Washington State Recovery Plan for the Western Snowy Plover* recommends strategies to recover this species, including protection of the population, evaluation, and management of habitat, and initiation of research and education programs (Washington Department of Fish and Wildlife 1995).

The State of Oregon's *Conservation Program for the Coastal Population of the Western Snowy Plover*, required by the Oregon Endangered Species Act and adopted by the Oregon Fish and Wildlife Commission (Oregon Revised Statutes 496.171 through 496.192), requires a variety of actions to protect this subspecies. These actions include: (a) protecting all existing western snowy plover sites from negative impacts; (b) monitoring impacts and responding to damaging activities (*e.g.*, urban development and recreation disturbance) to minimize or eliminate their effects to western snowy plovers; (c) maintaining a long-term monitoring program to track numbers, distribution, and nesting success; (d) habitat management, such as local control of European beachgrass and maintaining predator protection measures to maximize breeding success for as long as deemed necessary; (e) conducting additional research to maintain and recover western snowy plovers; and (f) enhancing information availability, education, and awareness of western snowy plovers and their requirements for survival and recovery (Oregon Department of Fish and Wildlife 1994).

The California Public Resources Code (Section 5019.71) allows designation of natural preserves, the most protective designation given to a part of any California State Park system unit. The purpose of natural preserves is to preserve such features as rare or endangered plant and animal species and their supporting ecosystems, and representative examples of plant or animal communities existing in California prior to the impact of civilization. The Pajaro Rivermouth Natural Preserve, Wilder Creek Natural Preserve, and Salinas Rivermouth Natural Preserve were designated by the California State Park and Recreation Commission in recognition of the need to protect western snowy plovers. In addition, Section 5019.62 of the California Resources Code allows the designation of State seashores to preserve the outstanding values of the California coastline and provide for public enjoyment of those values. Within the state of California, the following California State seashores containing western snowy plover habitats have been established: Del Norte State Seashore; Clem Miller State Seashore; Sonoma Coast State Seashore; Año Nuevo State Seashore; Monterey Bay State Seashore; San Luis Obispo State Seashore; Point Mugu State Seashore; Capistrano Coast State Seashore; and San Diego Coast State Seashore. Under the California Public Resources Code, the California Department of Parks and Recreation has the authority to identify additional lands appropriate for inclusion in California State seashores and recommend land acquisition for these purposes.

Special management actions for western snowy plovers are conducted within the portions of California State Seashores that are owned by the California Department of Parks and Recreation. An example is the Monterey State Seashore, where the California Department of Parks and Recreation has conducted intensive management activities for western snowy plovers since 1991. Strategies include resource management, interpretation, law enforcement, and park operations. Resource management actions include monitoring, predator trapping, and use of exclosures, symbolic fences, and signage, and consideration of snowy plovers during planning recreational access and trails in San Francisco Bay. Interpretative efforts include informational signage at nesting areas, information brochures, small handout cards with photographs and information on western snowy plovers, several annual public outreach programs (*e.g.*, slide programs and field trips), and actions to engage community support for the western snowy plover guardian program (*i.e.*, recruitment, training, and scheduling for volunteer presence in sensitive habitat).

Enforcement actions include verbal warnings, written warnings, citations, and arrests as necessary. Key enforcement concerns include dogs off-leash and off-road vehicles, which are prohibited on all beaches. Operational management includes a permit process that screens special events to avoid the nesting season in sensitive areas, and regulation of recreational use of beaches to avoid sensitive areas (*i.e.*, kite flying, hang gliding, fishing, etc.). Other management actions on California Department of Parks and Recreation property within some other State seashores are shown in Appendix C.

2. Conservation Efforts on Federal and State Lands

a. Exclosures, Symbolic Fencing, and Signs

Since 1991, one of the primary techniques to protect nesting western snowy plovers has been the use of exclosures (Appendix F). Exclosures are small, circular, square, or triangular metal fences that can be quickly assembled and are designed to keep predators out of nests and/or prevent people from trampling nests (Figure 8). Exclosure designs are described in Appendix F; modifications to exclosure design in response to site specific predator conditions may be appropriate on a case by case basis but should be coordinated in advance with the Fish and Wildlife Service.

Nests protected from predators by exclosures have consistently had increased nest success (White and Hickey 1997, Stern *et al.* 1991, Craig *et al.* 1992, Mabee and Estelle 2000, U.S. Fish and Wildlife Service 2002, Lauten *et al.* 2006). At some locations in Oregon and California, exclosures are designed with tops consisting of parallel lengths of nylon seine lines spaced approximately 15 centimeters (6 inches) apart -or- mesh netting with a minimum spacing of approximately 10 centimeters (4 inches), designed to discourage entry by avian predators. At Eden Landing State Ecological Reserve in San Francisco Bay, nest predation decreased from 32 percent in 2000 to 3 percent in 2001, largely due to a switch from string tops to net tops on exclosures (Marriott 2001).

Figure 8. Erecting western snowy plover exclosure (photo by Sue Powell, with permission).

Although exclosures are contributing to improved productivity and population increases in some portions of the western snowy plover's Pacific coast range, problems have been noted in some localities. Potential risks associated with exclosures include vandalism, disturbance of the birds by curiosity seekers, and use of exclosures as predator perches. Over time, exclosures may provide a visual cue to predators, making it easier for them to target adults, chicks, and eggs, and requiring predator management. On several occasions depredations of adult western snowy plovers have been documented in or near exclosures, and efforts have been made to establish exclosures later in the season after the peak migration of raptors (Brennan and Fernandez 2004, Lauten *et al.* 2006). Also, predator exclosures may be impractical where western snowy plovers nest within California least tern colonies or other instances where such exclosures may conflict with the needs of other threatened or endangered species.

Symbolic fencing also is used to passively protect western snowy plover nests, eggs, and chicks during nesting season. This fencing consists of one or two strands of

light-weight cord or cable strung between posts to delineate areas where humans (*e.g.*, pedestrians and vehicles) should not enter (Figure 9). It is placed around areas where there are nests or unfledged chicks, and is intended to prevent accidental crushing of eggs, flushing of incubating adults, and, if large enough, to provide an area where chicks can rest and seek shelter when large numbers of people are on the beach. Directional signs (regarding closed areas, nesting sites, etc.) also are used within western snowy plover habitats and near protective fencing to alert the public and other beach users of the sensitivity of western snowy plover nesting and wintering areas. Installation of symbolic fencing at Coal Oil Point Reserve (CA-88) in conjunction with a docent program has allowed management of

Figure 9. Symbolic fencing on beach at Monterey Bay, California (photo by Ruth Pratt, with permission).

recreational use and resulted in successful re-establishment of a breeding population of western snowy plovers at the site (Lafferty *et al.* 2006).

Additionally, land managers may prevent or restrict access to areas used by nesting western snowy plovers. For example, military installations often curtail or redirect training activities near western snowy plover nesting areas and some State parklands

and recreation areas restrict public access in certain areas during the breeding season.

b. Law Enforcement

Management agencies recognize that law enforcement is needed for protection measures to be effective. Though a majority of beach visitors respect restrictions to protect western snowy plovers, there will always be a certain percentage who do not. Enforcement of western snowy plover area restrictions shows that managers are serious about compliance. In Oregon, biologists have established a working relationship with a variety of law enforcement agencies who have jurisdiction in western snowy plover habitat. Their goal is to increase awareness, gain advice, increase communication and coordination to alleviate jurisdictional conflicts, and train officers on how to minimize disturbance while patrolling western snowy plover habitat. Conflicting priorities and personnel turnover require perseverance to maintain effective working relationships across law enforcement jurisdictions.

c. Predator Control

Lethal and nonlethal means of predator control have been used with mixed success to protect western snowy plovers on Pacific beaches. Nonlethal methods include litter control at campgrounds (to reduce available food sources), exclosures and fencing, and trapping and relocation. Lethal methods include reducing local populations of avian predators by addling (*i.e.* killing the developing chick within the egg) of raptor and corvid eggs, trapping and euthanizing nonnative mammalian predators, and killing individual predators upon which nonlethal methods have proven ineffective.

On the Oregon Coast, snowy plover predator control has historically been in the form of nest exclosures and site specific lethal control. The use of nest exclosures, adaptively modified in response to predator behavior, has been very successful in increasing hatching success. However, because in some cases predation on adults has been linked to the presence of exclosures, their use is presently targeted to specific instances where it appears most beneficial, and the program is working toward elimination of exclosure use (Lauten *et al*. 2006a, 2006b).

In 2002, Federal and State agencies approved an integrated predator management program to improve western snowy plover nesting and fledging success in Oregon. The decision followed public review and comment on an analysis of the effects of the proposed predator control methods and alternatives to protect the western snowy plover in Oregon (U.S. Department of Agriculture 2002). To date lethal predator control has been implemented at selected plover breeding sites along the Oregon Coast at Coos Bay North Spit, Bandon Beach, New River, Siltcoos, Overlook, Tahkenitch, and Tenmile, resulting in an overall positive effect on western snowy plover productivity (Lauten *et al.* 2006*a*, 2006*b*).

Another form of predator control is fencing, which is used on the south spoils area of Coos Bay, North Spit, where the U.S. Bureau of Land Management, U.S. Army Corps of Engineers, and Oregon Department of Fish and Wildlife have fenced 8 hectares (20 acres) of western snowy plover nesting habitat. This wire mesh fence was installed to exclude mammalian predators, especially skunks, and to discourage human disturbance from off-highway vehicle use. The original fence, constructed in 1991, suffered from the effects of weathering and although it continued to deter vehicles, it was no longer an effective barrier to predators. In 1998, the U.S. Army Corps of Engineers and U.S. Bureau of Land Management jointly constructed a new fence and removed the old fence. The new fence matched the design of the 1991 fence (5-centimeter by 5-centimeter (2-inch by 2-inch) mesh fence material with an effective fence height of about 1.2 meters (4 feet) after burial of the bottom). However, the new fence has increased the protected area from 8 hectares (20 acres) to 28 hectares (71 acres), and includes both the south spoils area and the 1994 Habitat Restoration Area (E.Y. Zielinski and R.W. Williams *in litt.* 1999).

At the Don Edwards San Francisco Bay National Wildlife Refuge, fences are sometimes constructed across salt pond levees to block access by terrestrial predators (J. Albertson *in litt.* 1999). However, fences are not feasible in many areas, and do not restrict aerial predators.

Exclosures are much more effective when used in conjunction with an integrated predator management program that includes selective removal of non-native predators and other individual problem predators. Otherwise, exclosures may promote better hatching success, but not fledging success if predators such as red fox

(*Vulpes vulpes*) focus on adults protecting the nest or newly-hatched chicks that leave the exclosure to feed. These measures are also much more effective where combined with other access restrictions to increase survival of clutches and broods. Trapping the nonnative red fox has been credited with substantially increased western snowy plover abundance and productivity at Salinas River National Wildlife Refuge (E. Fernandez, U.S. Fish and Wildlife Service, pers. comm. 1998). At the Don Edwards San Francisco Bay National Wildlife Refuge, predation on western snowy plovers and California clapper rails by red foxes prompted the initiation of a predator management program targeting red foxes, feral cats, skunks, and raccoons, in conjunction with use of western snowy plover nest exclosures (J. Albertson *in litt.* 1999, Strong *et al.* 2004). This ongoing program has resulted in improved nest success. Use of exclosures has subsequently been discontinued due to the success of the trapping program and incidents of nest abandonment at exclosures. At Eden Landing Ecological Reserve selective removal of problem corvids and their nests has also been practiced by USDA Wildlife Services since 2004 (Tucci *et al.* 2006).

The U.S. Air Force has used electric fencing around the California least tern colony at Purisima Point, Vandenberg Air Force Base, California, where western snowy plovers also nest and winter. The electrified portion of this fence is approximately 273 meters (300 yards) long and 1.2 meters (4 feet) high. The electric fence contains six strands of electrified wire placed approximately 10.2 centimeters (4 inches) apart. This fence is generally effective at keeping out mammalian predators of California least terns. It has also incidentally protected a small population of western snowy plovers by deterring western snowy plover predators.

Proposals have been developed to test a conditioned taste aversion technique on predators of piping plovers (*i.e.*, red fox) by using quail eggs treated with the chemical emetine (McIvor 1991). The purpose of this technique is to condition foxes to avoid eating plover eggs, expecting that if foxes eat treated quail eggs prior to the nesting season and become sick, they might develop a conditioned aversion to eating plover eggs. This technique requires that the predator consumes the needed dose that will produce short-term illness but no mortality. Due to uncertainty in effectiveness, at this point in time we do not advocate this taste aversion technique. Proposals to test conditioned taste aversion techniques on predators of piping plovers on the east coast have not been implemented due to difficulties obtaining permission

to field test emetine (A. Hecht, U.S. Fish and Wildlife Service, pers. comm. 1996). Avery *et al.* (1995) found that deployment of quail eggs treated with the chemical methiocarb might be a useful means of reducing predation of California least terns by ravens and crows. However, subsequent tests of aversion methods have proven to be unsuccessful (E. Copper and B. Foster *in litt.* 2001).

With proper research, techniques that have been used to deter predators of other wildlife species may prove beneficial to western snowy plovers. Strategic placement of crow and gull carcasses around the perimeter of a California least tern colony has been used at Vandenberg Air Force Base (Persons and Applegate 1996), however, this method may not be effective for more loosely colonial species such as snowy plover (J. Buffa *in litt.* 2004). Moreover, the presence of gull carcasses could prove counterproductive by attracting mammalian predators (N. Read, U.S. Air Force, pers. comm. 1998).

In 1999 Vandenberg Air Force Base initiated studies of coyote ecology and movements, with the goal of developing non-lethal alternatives for reducing coyote predation on western snowy plover. Although results are preliminary, in 2001 beach access restrictions and regular pick-up of trash, in combination with availability of alternative prey such as rabbits, may have contributed to the lowest incidence of coyote predation ever recorded at Vandenberg Air Force Base, even though evidence of coyote presence continued to be observed on a daily basis.

For top-level predators such as coyotes, western snowy plover nests are not a primary food source. Vandenberg Air Force Base has avoided large-scale coyote removal to prevent exacerbated predation on listed species from mesopredators such as racoons, and to prevent expansion of non-native predators such as feral cats and red foxes into western snowy plover nesting areas (N. Read Francine *in litt.* 2001).

d. European Beachgrass Control

Experiments to find cost-effective methods to control or eradicate European beachgrass are ongoing. Control methods employed in various situations have included foredune grading and foredune breaching with front-end loaders and bulldozers, subsoiling with a winged subsoiler (essentially a heavy duty three-point

plow), discing with a standard farm tractor and disk, burning, saltwater irrigation, spraying of herbicide, and hand-pulling. Herbicide treatment is not always possible, however, when rare or federally-listed plants are present. In these cases hand-pulling or other mechanical removal may need to be employed. At Point Reyes National Seashore mechanical and hand-removal were used to remove non-native beach grass on 12 hectares (30 acres) with immediate beneficial response by nesting snowy plovers (Peterlein and Roth 2003). Some control methods are only suitable for the inland sites. Areas containing heavy growth of European beachgrass and woody vegetation are prescribed-burned prior to using heavy equipment. Areas are leveled to allow discing for maintenance. In some areas, oyster shell hash provided by a local oyster grower has been distributed after vegetation has been removed. Effectiveness of the various control methods varies, though some form of maintenance may always be required. Maintenance is critical and achieved through multiple treatments over a succession of years. Discing requires maintenance twice per year to keep beachgrass from reestablishing. Comparatively, yearly maintenance in portions of some restoration sites may not be needed after employing several years of bull-dozing, herbicides, or hand-pulling following initial mechanical removal.

Since 1994, multiple projects have been conducted in Oregon to control beachgrass on existing nest sites and to clear and maintain additional areas. These Habitat Restoration Areas (HRAs) are essential for the recovery of the western snowy plover. Three significant HRAs established on the Oregon Coast between 1994 and 2002 include the Dunes Overlook (Oregon Dunes National Recreation Area), Coos Bay North Spit, and New River. Other habitat restoration areas have recently been established or are planned at Baker Beach (140 acres), Tenmile Creek (200 acres) and Bandon Beach State Natural Area (30 acres). HRAs accounted for 34 percent of nests (Table 6) and 43 percent of fledglings (Table 7) found on the Oregon Coast between 1999 and 2004.

The Oregon Dunes National Recreation Area contains about 2,428 hectares (6,000 acres) of European beach grass and now has few remaining examples of intact native plant communities (Pickart 1997). Habitat restoration was initiated in the summer of 1998 and by 2002, the U.S. Forest Service had treated 24 hectares (60 acres) of the 208 hectares (516 acres) of habitat planned for restoration. Prior to 1999, no western

snowy plovers were found at the Overlook site, but after habitat was restored, western snowy plovers began nesting there successfully (Table 6, Table 7).

The U.S. Forest Service employs a combination of mechanical, manual, and herbicide treatments to control European beachgrass. Mechanical treatment consists of scalping off the top 1 meter (3 feet) of beachgrass and then burying it in an adjacent trench with a minimum covering of l meter (3 feet) of sand. Moderate to heavy resprouting occurs with this method, requiring manual or chemical follow-up treatment. Other mechanical treatments have consisted of placement of dredged material on the beachgrass and scalping the top half of foredunes to remove beachgrass and allow for inland sand movement and tidal action to maintain open dunes (K. Palermo *in litt.* 1998*b*).

Herbicide treatments have been conducted as a primary control method and as follow-up to mechanical control. In recent years, from 2 to 26 hectares (5 to 65 acres) of beachgrass were sprayed with an herbicide treatment of 8 percent Rodeo and nonionic surfactant (spray-to-wet) at three locations. Employees found that a follow-up application within 2 weeks of the first application was critical to obtain optimum coverage and initial die-off rates (90 percent). Additionally, herbicide treatments were most effective when conducted consecutively over 2 to 3 years depending on density. Beachgrass control at the Oregon Dunes is still considered experimental. Preliminary results suggest that maintenance will always be necessary (K. Palermo *in litt.* 1998*b*).

Table 6. Total number of nests at habitat restoration areas on the Oregon Coast 1994-2004 (J. Heaney, pers. comm. 2003; C. Burns, pers. comm.; M. VanderHeyden, pers. comm.; Castelein *et. al.* 2002; Lauten *et al.* 2006).

Site Name	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	**Total Nests**
Baker Beach									0	1	0	1
Dunes Overlook						2	8	15	8	9	14	56
Coos Bay North Spit	4	3	2	3	7	12	22	13	15	11	16	108
Bandon State NRA										4	17	21
New River						2	4	10	7	5	6	34

Table 7. Total number of fledged young at habitat restoration areas on the Oregon Coast 1994-2004. Includes fledglings from broods from undiscovered nests (J. Heaney, pers. comm. 2003; C. Burns, pers. comm; M. VanderHeyden pers. comm.; Castelein *et. al.* 2002; Lauten *et al.* 2006).

Site Name	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	**Total Nests**
Baker Beach									0	0	0	0
Dunes Overlook						3	5	2	2	3	6	21
Coos Bay North Spit	7	2	1	1	1	23	6	6	8	14	22	91
Bandon State NRA										4	15	19
New River						2	1	3	3	7	5	21

On Coos Bay North Spit, the Bureau of Land Management has cleared and maintained approximately 67 hectares (166 acres) of vegetation dominated by European beachgrass, shore pine, Sitka spruce, and Scotch broom. The objective is to remove predator cover, remove encroaching beachgrass, and expand the existing habitat. The goal is to create an area for western snowy plovers to nest that is large enough to lessen possible detection of nests and chicks by predators. Nest sites used by western snowy plovers on the North Spit include both beach habitat and inland areas of previous dredged material deposition. Many of the cleared areas were used almost immediately by nesting western snowy plovers or for brood rearing activities. Prior to 1994, western snowy plovers were not nesting in these areas, but after 1994, the Coos Bay North Spit became the most productive western snowy plover nesting sites on the Oregon Coast (Table 6, Table 7) (M. VanderHeyden, Bureau of Land Management, pers. comm.).

At the Coos Bay North Spit, an inmate crew from the Shutter Correctional Facility, hired by the U.S. Bureau of Land Management, hand pulled European beachgrass on approximately 6 hectares (15 acres) of the south spoil area. The 4-month project cost $11,500; most of these costs covered the crew supervisor's salary and transport vehicle charges. Another European beachgrass removal project around the south spoil areas of the Coos Bay North Spit, included burning European beachgrass, followed by scarification using a bulldozer in March 1994. By August, most of the area had resprouted (Oregon Department of Fish and Wildlife 1996). New beachgrass sprouts are relatively easy to remove. However, initial and maintenance work can be costly and labor intensive. At the Coos Bay North Spit, eradication of European beachgrass using 91.4 centimeters (36 inches) of sprayed seawater was attempted in 1996. The saltwater application was not effective because desiccated sand layers did not allow seawater penetration to the grass's root zone. Future experimentation using wetting agents to achieve water penetration on small-scale applications could demonstrate potential applicability of this technique (G. Dorsey, U.S. Army Corps of Engineers, pers. comm. 1997).

The New River Spit is another key nesting area for the western snowy plover that is managed by the Coos Bay U.S. Bureau of Land Management. Each year since 1998, the U.S. Bureau of Land Management has used heavy equipment (i.e., front-end loader, bulldozer) to remove European beachgrass from in and around a target

restoration site. Typically, the bulldozer is used to push the beachgrass into depressions and bury it under several feet of sand, or to push sand and beachgrass out into the surf zone. Just over two miles of foredune have been lowered and select areas along the foredune have been removed to allow ocean surf to overwash into interior portions of the spit. The overwashing aids in scouring vegetation and appears to self-maintain portions of the overwashes throughout the restoration area. By 2002, approximately 48 hectares (120 acres) of foredune and overwash were cleared of beachgrass (Jim Heaney, Bureau of Land Management, pers. comm. 2003).

Work at Lanphere-Christensen Dune Preserve in Humboldt County, California, showed that hand pulling can eliminate European beachgrass, but 3 years of multiple maintenance treatments were required (Pickart and Sawyer 1998). Use of heavy equipment (*e.g.*, "V" ripper) and herbicides may be more cost-effective; however, resprouting of the grass occurs, necessitating follow-up, manual pulling for long-term beachgrass removal (A. Pickart, The Nature Conservancy, pers. comm. 1997).

The effective strategy used by the California Department of Parks and Recreation to remove beachgrass at Marina Dunes and Salinas River State Beaches, Monterey Bay, included multiple herbicide applications of 10 percent Round-Up. Approximately 25 patches of beachgrass covering a total of approximately 0.5 hectare (1.3 acres) have been treated along a 6.4-kilometer (4-mile) section of beach. Each patch of beachgrass was sprayed every 3 months over a 3-year period. All treated sites were marked so that they could be easily located and monitored for regrowth and spread. Current plans include beachgrass removal on approximately 30 hectares (75 acres) at Zmudowski State Beach at the Pajaro River mouth (D. Dixon *in litt.* 1998).

Western snowy plover habitat restoration efforts at the Leadbetter Point Unit of the Willapa National Wildlife Refuge began in 2002 and continue. American beachgrass and some European beachgrass have been mechanically removed, clearing approximately 25 hectares (63 acres) as of 2006. In addition, cuts have been made through the foredune and oystershell placed to cover 11 hectares (28 acres) within the restored area (K. Brennan *in litt.* 2006).

Pickart (1997) suggested that chemical treatment of European beachgrass is likely to be the most cost-effective method used to date. Herbicides that have been used for

this purpose are glyphosates (trade names Rodeo and Round-Up). The most effective period for herbicide treatment of beachgrass is during its flowering stage (Wiedemann 1987); plants should be treated during periods of active growth (Pickart 1997). However, potential adverse biological impacts to other native plants and animals must be considered when using herbicides, and selective spraying may be difficult in some areas. Chemical treatment in active western snowy plover nesting areas may need to be limited to the period outside the breeding season in certain areas to avoid disturbing nesting western snowy plovers.

Additional management options for beach and dune erosion control are needed. Beachgrass continues to be used because it has been tried successfully in the past, nursery stock is available, and field planting technology is well known. However, negative aspects of its monoculture are recognized. Proper planting and management of a mixture of native vegetation, together with the provision of walkways for pedestrian traffic and the elimination of horse traffic, cattle grazing, and off-road vehicles, may result in stabilization as effective as beachgrass, yet there has been minimal experimentation with this technique (Barbour and Major 1990).

e. Off-Road Vehicle Restrictions and Management

Management strategies to reduce off-road and other vehicle impacts have been implemented at some western snowy plover breeding areas. At Pismo/Oceano Dunes State Vehicular Recreation Area, California, management strategies include fenced-off nesting areas; placement of exclosures around nests; restrictions on vehicle speed and access areas; and requirements that car campers remove all trash. At Pismo/Oceano Dunes State Vehicle Recreation Area, the California Department of Parks and Recreation, Off-Road Vehicle Division, has developed an interim management plan, which is adapted annually in coordination with us to address what effects current management measures have on hatching rates and fledging success, as well as recruitment into the western snowy plover population (California Department of Parks and Recreation 2005). The Off-Road Vehicle Division of the California Department of Parks and Recreation is now funding the development of a habitat conservation plan (in anticipation of applying for a section 10(a)(1)(B) permit under the Endangered Species Act) for the Pismo/Oceano Dunes State Vehicular Recreation

Area and other State parks within the San Luis Obispo Coast District of the California Department of Parks and Recreation.

The conservation issues for western snowy plovers and California least terns at the Pismo/Oceano Dunes State Vehicular Recreation Area are directing the development of the habitat conservation plan, but other species also will be covered. This plan will evaluate the effects that recreation and park management activities are having on the covered species.

On Camp Pendleton, the Marine Corps conducts its vehicle operations in and near nesting areas in ways that minimize impacts to western snowy plovers. Under the Marine Corps' Base Regulations all training activities, including vehicle training, are prohibited within 300 meters of fenced nesting areas during the breeding season (1 March to 15 September). Further, amphibious vehicles are directed to transit adjacent to nesting areas with tracks in the ocean whenever possible (U.S. Marine Corps 2006).

On the Don Edwards San Francisco Bay National Wildlife Refuge, part of the main access road (Marshlands Road) is closed to motorized vehicles from April 1 to August 31, to protect western snowy plovers nesting near the roadway. Highway traffic cones and ribbons are installed to discourage vehicle access to nesting areas on roads and levees (J. Albertson *in litt.* 1999).

In 1995, after the Oregon Dunes National Recreation Area completed its management plan, the U.S. Forest Service petitioned the Oregon Parks and Recreation Department to close several kilometers of beach that had been open to vehicles. Resulting closures reduced conflicts between off-highway vehicles and nonmotorized recreationists, western snowy plovers, and other wildlife (E.Y. Zielinski and R.W. Williams *in litt.* 1999).

Leadbetter State Park (immediately to the south of Willapa National Wildlife Refuge) is closed to beach driving from April 15 to the day after Labor Day. The entire beach along Willapa National Wildlife Refuge is closed to driving year round, except during razor clam openers (K. Brennan *in litt.* 2006). Diligent surveillance and enforcement by applicable agencies is extremely important due to the potential for violations.

f. Population Monitoring

Western snowy plover researchers in Washington, Oregon and California conduct intensive population monitoring programs. Tasks include some or all of the following: (1) conducting winter and breeding season window surveys; (2) banding adults and chicks; (3) determining nest success; (4) determining fledging success, (5) monitoring and documenting brood movements; and (6) collecting general observational data on predators.

The Point Reyes Bird Observatory has been monitoring the distribution and breeding success of western snowy plovers since 1977. Monitoring at Vandenberg Air Force Base has been conducted by Point Reyes Bird Observatory and SRS Technologies. Additionally, Santa Barbara County-supported volunteer docents stationed at Surf Station, within Vandenberg Air Force Base, keep tallies of numbers of visitors, violations prevented, and predators seen (R. Dyste *in litt.* 2004). The U.S. Geological Survey Biological Resources Division monitored western snowy plovers in San Diego County from 1994 to 1998. Teams led by Elizabeth Copper, Robert Patton, Shauna Wolf, and Brian Foster have monitored western snowy plovers in San Diego County since 1999 for military installations. The Oregon Natural Heritage Program and The Nature Conservancy have conducted western snowy plover monitoring since 1990 in Oregon. The Point Reyes Bird Observatory, Oregon Natural Heritage Program, and U.S. Geological Survey, Biological Resources Division, also band western snowy plovers at some locations (Figure 10). The California Department of Parks and Recreation conducts annual monitoring throughout the state and at the Pismo/Oceano Dunes State Vehicular Recreation Area (J. Didion *in litt.* 1999). Mad River Biologists and Humboldt State University are currently conducting intensive population monitoring in northern California. Department of Defense installations continue to maintain long-term programs for monitoring and management of western snowy plover populations and predators in San Diego and Ventura Counties, including programs at Camp Pendleton, Naval Amphibious Base Coronado, Naval Radio Receiving Facility Imperial Beach, North Island, and San Clemente Island.

Figure 10. Banding a western snowy plover chick (photo by Bonnie Peterson with permission)

g. Salt Pond Management

Intensive management at the Moss Landing Wildlife Area has made a major contribution to western snowy plover breeding success in the Monterey Bay area. Management by Point Reyes Bird Observatory staff, in coordination with the California Department of Fish and Game, has been ongoing since 1995. Management activities include draw-down of water levels in part of the salt ponds at the beginning of the nesting season to provide dry sites for nests, and flooding of remnant wet areas twice per month through the nesting season to maintain foraging habitat for adults and their young. Predator control is conducted by the U.S. Department of Agriculture, Wildlife Services Branch.

The Don Edwards San Francisco Bay National Wildlife Refuge manages a former salt pond called the "Crescent Pond" (within location CA-36, mapped in Appendix L) for western snowy plovers by reducing the water levels prior to the breeding season. In the early 1990s, this pond was mostly unvegetated salt flat, but since then native pickleweed (*Salicornia virginica*) has slowly increased on the site, making the areas

less valuable for western snowy plover nesting habitat. The Refuge has begun to conduct winter flooding in the Crescent Pond to reduce vegetative cover and improve western snowy plover nesting habitat.

The 2003 acquisition of Cargill's West Bay, Alviso, and Baumberg Salt Ponds in the South Bay by California Department of Fish and Game and Don Edwards San Francisco Bay National Wildlife Refuge will greatly further the goal of achieving 810 hectares (2,000 acres) of ponds managed for western snowy plover habitat (see Recovery Action 2.6). The Refuge's long-term management plans for these areas will include management that is compatible with western snowy plover and will coordinate with the recovery goals of this Recovery Plan (J. Albertson, pers. comm. 2005). Many of the salt ponds are currently used for breeding and wintering by western snowy plovers. San Francisco Bay Bird Observatory is assisting the Refuge with salt marsh management and western snowy plover monitoring.

h. Habitat Acquisition

Acquisition and management of key sites is an important conservation effort. In October 1998, The Nature Conservancy transferred the approximately 193-hectare (483-acre) Lanphere-Christensen Dunes Preserve (part of Mad River Mouth and Beach, California, CA-7) to us for conservation purposes. The area will be managed by the Humboldt Bay National Wildlife Refuge for natural resources, including the western snowy plover. In October 1998, the Port of San Diego announced an agreement enabling approximately 560 hectares (1,400 acres) of Western Salt Company land (CA-131) to be managed by the San Diego National Wildlife Refuge. The salt ponds are a western snowy plover nesting and wintering area. As noted above, Cargill's transfer of the West Bay, Alviso, and Baumberg salt ponds, including 6,110 hectares (15,100 acres), to California Department of Fish and Game and Don Edwards San Francisco Bay National Wildlife Refuge was completed in 2003; portions of this area will be managed as western snowy plover habitat.

i. Use of Volunteers

Volunteers contribute to the conservation of western snowy plovers and their habitat at many beach locations, including Morro Bay and Oceano Dunes State Vehicular

Recreation Area, Point Reyes National Seashore, and Golden Gate National Recreation Area. Volunteers and docents assist public land managers in many ways (Appendix K), including informing park visitors about threats to the western snowy plover, reducing human and pet disturbances, and assisting with direct habitat enhancement (*e.g.*, manual removal of European beachgrass; Figure 11). In 1998, the Western Snowy Plover Guardian Program was developed to assist the conservation and recovery of western snowy plovers in Monterey Bay. This program is mainly a volunteer effort by local citizens who assist in protecting western snowy plovers through monitoring, reporting, and educational activities (D. Dixon *in litt.* 1998).

Figure 11. High school students removing European beachgrass (photo by Kerrie Palermo, with permission).

j. Public Outreach and Education

Public land managers and private conservation organizations have produced public educational materials, including brochures, posters, flyers, and informational/interpretative signs regarding western snowy plovers (Appendix K). Environmental education/interpretation is recognized by land management agencies as an important tool that supports their mission of resource stewardship. Increased

understanding and appreciation of natural resources (specifically threatened and endangered species) often results in increased public support. This support is not easily measured and when the audience is children, results may not be seen until they reach adulthood. However, those agencies conducting western snowy plover education to date have found a positive response by individuals. In Oregon, on-site monitors of the U.S. Forest Service (Oregon Dunes National Recreation Area) and U.S. Bureau of Land Management report a willingness of the majority of contacted individuals to comply with restrictions after better understanding the reasons for them.

The La Purisima Audubon Society, Santa Barbara County, produced an educational video about the western snowy plover and the California least tern in 1999. It was distributed to public schools and museums within Santa Barbara County in 2000.

k. Section 6 Cooperative Agreements

Section 6 of the Endangered Species Act allows us to enter into cooperative agreements with states that establish and maintain active programs for the conservation of listed species. Through funding under section 6, those states assist the recovery of endangered and threatened species and monitor their status. Between 2000 and 2006, traditional section 6 funds have been used for creation of a docent program at Silver Strand State Beach in California ($8,300); development of a water management plan at Moss Landing Wildlife Area, California ($4,886); surveillance and protection of snowy plover nests on California beaches ($92,000); and surveys, nest monitoring, protecting nests with exclosures, collecting data on human uses of beaches, and encouraging beach uses compatible with snowy plovers in Oregon ($64,386) and Washington ($48,677). HCP Planning grants were used for development of a habitat conservation plan to address management of beach use by the Oregon Parks and Recreation Department ($103,950) and development of an Environmental Impact Statement for this Habitat Conservation Plan ($200,000). A Recovery Land Acquisition grant ($307,000) supported purchase of a conservation easement on 89 hectares (220 acres) of western snowy plover habitat along 3.7 kilometers (2.3 miles) of the Elk River Spit.

3. Conservation Efforts on Private Lands

Private landowners interested in conservation efforts for western snowy plovers and coastal dune habitats have made important contributions to recovery efforts for coastal dune species. At Ormond Beach, California, Southern California Edison has enhanced approximately 60 hectares (150 acres) of degraded wetlands and coastal dune habitat for several special status species, including the western snowy plover and California least tern (D. Pearson, Southern California Edison, pers. comm. 1996).

4. Federal Regulatory Program

a. Critical Habitat

On March 2, 1995, we published a proposed rule to designate critical habitat for western snowy plover at 28 areas along the coast of California, Oregon, and Washington (U.S. Fish and Wildlife Service 1995*b*). At that time, critical habitat was proposed to fulfill an outstanding requirement under section 4 of the Endangered Species Act to highlight important habitat areas on which activities that require Federal actions need to be evaluated under section 7 of the Endangered Species Act. A funding moratorium by the U.S. Department of the Interior for listing actions was in place during the period April 1995 to April 1996. We subsequently acknowledged a serious backlog of listing actions and the need to prioritize them (U.S. Fish and Wildlife Service 1996*b*). Hence, we developed guidance for assigning relative priorities to listing actions conducted under section 4 of the Endangered Species Act during fiscal years 1998 and 1999 (U.S. Fish and Wildlife Service 1998). Designation of critical habitat was placed in the lowest priority (Tier 3). Under this guidance, we placed higher priority on listing imperiled species that currently have limited or no protection under the Endangered Species Act than on devoting limited resources to the process of designating critical habitat for currently-listed species. In addition, we found that because the protection afforded by critical habitat designation applies only to Federal actions, such designation provides little or no additional protection beyond the "jeopardy" prohibition of section 7 of the Endangered Species Act, which also applies only to Federal actions (U.S. Fish and Wildlife Service 1998).

In December 1995, legal challenges by the Environmental Defense Center, Santa Barbara, California, against the U.S. Department of the Interior to finalize designation of critical habitat for the western snowy plover were overruled by the California District Court (U.S. District Court, Central District of California 1995). At that time, the Court's order was based on its decision that lack of funding prevented the Secretary of the Interior from taking final action on proposals for designating critical habitat. However, on November 10, 1998, the U.S. District Court for the Central District of California ruled that the Secretary of the Interior must publish a final designation of critical habitat for the western snowy plover before December 1, 1999 (U.S. District Court, Central District of California 1998).

A final rule designating critical habitat was published on December 7, 1999 (U.S. Fish and Wildlife Service 1999). In May of 2002 the Coos County Board of County Commissioners, Friends of Oceano Dunes, and Concerned Citizens for western Lane County filed a complaint asking for invalidation of the rule. The United States moved for voluntary remand to reconsider the economic analysis and for partial vacatur of the existing designation. On July 19, 2003, the District Court for the District of Oregon granted the United States' motion, ordering the Service on remand to consider the economic impact analysis and ensure that the new rule is based on the best scientific evidence available. This Order was converted to Judgment on July 2, 2003. Based on the potential for harm to the population, at the Service's request the court left most of the established units in place during the redesignation process, but vacated two units in southern California and two units in Washington.

On December 17, 2004, we published a new proposal to designate critical habitat for the Pacific coast distinct population segment of the western snowy plover (U.S. Fish and Wildlife Service 2004*b*). The final rule to designate critical habitat was published on September 29, 2005 (U.S. Fish and Wildlife Service 2005). This rule designated critical habitat in 32 units, compared to 28 units in the 1999 critical habitat final rule, but covers only 4,921 hectares (12,145 acres) compared to 7,881 hectares (19,474 acres) in the 1999 rule. Of the 32 units, 23 are in California, 5 are in Oregon, and 3 are in Washington. Of the total acreage, 1,002 hectares (2,478.5 acres), or 20 percent, are on Federal lands; 2620.5 hectares (6,474 acres), or 53 percent, are on land owned by States or local agencies; and 1294.5 hectares (3,191 acres), or 26 percent, are privately-owned.

It is important to understand what critical habitat means and how it differs from this recovery plan. Section 3 of the Endangered Species Act defines critical habitat to mean: (i) the specific areas within the geographical area occupied by the species at the time it is listed on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed, upon determination that such areas are essential for the conservation of the species. The term "conservation" is defined in section 3 as "the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary." Therefore, critical habitat is to include biologically suitable areas necessary to recovery of the species.

Section 7 of the Endangered Species Act requires Federal agencies to consult with us to evaluate the effects that any activities they fund, authorize, or carry out may have on designated critical habitat. Agencies are required to ensure that such activities are not likely to adversely modify (*e.g.*, damage or destroy) critical habitat. Because the issuance of permits under section 10(a)(1)(B) of the Endangered Species Act constitutes a Federal action or connection and is subject to an internal section 7 consultation, habitat conservation plans developed for actions on private lands must also analyze the potential for adverse modification of critical habitat. Accordingly, where Federal activities may affect western snowy plover critical habitat, we will consult with Federal agencies under section 7 to ensure that these actions do not adversely modify critical habitat.

Critical habitat designation does not create a wilderness area, preserve, or wildlife refuge, nor does it close an area to human access or use. It applies only to activities sponsored at least in part by Federal agencies. Such federally-permitted land uses as grazing and recreation may take place if they do not adversely modify critical habitat. Designation of critical habitat does not constitute a land management plan, nor does it signal any intent of the government to acquire or control the land. Therefore, if there is no Federal involvement (*e.g.*, Federal permit, funding, or license), activities of a private landowner, such as farming, grazing, or constructing a home, generally are not affected by a critical habitat designation, even if the landowner's property is within

the geographical boundaries of critical habitat (U.S. Fish and Wildlife Service 1993*c*). Without a Federal connection to a proposed action, designation of critical habitat does not require that landowners of State or other non-Federal lands do anything more than they would otherwise do to avoid take of listed species under provisions of section 9 of the Endangered Species Act.

By comparison, a recovery plan delineates site-specific management actions that we believe are required to recover and/or protect listed species, establishes objective, measurable criteria for downlisting or delisting the species, and estimates time and cost required to carry out these actions. A recovery plan is not a regulatory document and does not obligate cooperating or other parties to undertake specific tasks or expend funds.

Critical habitat designation is not necessarily intended to encompass a species' entire current range. Recovery plans, however, address all areas determined to be important for recovery of listed species and identify needed management measures to achieve recovery. Because critical habitat designations may exclude areas based on factors such as economic cost, approved or pending management plans, or encouragement of cooperative conservation partnerships with landowners, the areas identified in recovery plans as important for recovery of the species may not be identical to designated critical habitat. The recovery units described in this recovery plan include but are not restricted to the 32 areas designated as critical habitat: Damon Point, Midway Beach, Leadbetter Point, Bayocean Spit, Baker/Sutton Beaches, Siltcoos to Tenmile, Coos Bay North Spit, and Bandon to Floras Creek in Recovery Unit 1; Lake Earl, Big Lagoon, McKinleyville area, Eel River area, MacKerricher Beach, and Manchester Beach in Recovery Unit 2; Point Reyes Beach, Limantour Spit, Half Moon Bay, Santa Cruz Coast, Monterey Bay Beaches, and Point Sur Beach in Recovery Unit 4; San Simeon Beach, Estero Bay, Devereaux Beach, Oxnard Lowlands in Recovery Unit 5; and Zuma Beach, Santa Monica Bay, Bolsa Chica area, Santa Ana River Mouth, San Onofre Beach, Batiquitos Lagoon, Los Penasquitos, and South San Diego in Recovery Unit 6. Implementation of the recovery actions in this recovery plan (*e.g.*, monitoring, habitat improvement, nest protection, recreation management) may not be limited to designated critical habitat areas.

b. Section 9 Take Prohibitions

Section 9 of the Endangered Species Act of 1973, as amended, prohibits any person subject to the jurisdiction of the United States from taking (i.e., harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting) listed wildlife species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. Regulations implementing the Endangered Species Act (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding, or sheltering.

As an example under the authority of section 9 of the Endangered Species Act, on May 15, 1998, we received preliminary injunctive relief against the Town of Plymouth, Massachusetts, because their beach management failed to prevent take (killing) of a piping plover chick by an off-road vehicle (U.S. District Court for Massachusetts 1998). The judge's order prohibited off-road vehicle traffic through the piping plover's nesting season unless the town implemented specific management measures to preclude take, including twice-daily monitoring of nests and a 400-meter (1,148-foot) buffer of protected habitat for newly-hatched chicks.

The proposed special rule under section 4(d) of the Endangered Species Act (U.S. Fish and Wildlife Service 2006b) would exempt most recreational and commercial activities within a county from section 9 prohibitions on take of western snowy plovers, if documentation of conservation actions was provided and populations within the county met targets based on the Management Goal Breeding Numbers in Appendix B of the recovery plan. Research and monitoring actions would continue to require recovery permits under section 10(a)(1)(A) of the Endangered Species Act.

c. Section 10 Permits

Section 10 of the Endangered Species Act and related regulations provide for permits that may be granted to authorize activities otherwise prohibited under section 9, for scientific purposes or to enhance the propagation or survival of a listed species (i.e., section 10(a)(1)(A) permits). These permits have been granted to certain biologists of conservation organizations (*e.g.*, Point Reyes Bird Observatory and Oregon Natural Heritage Program) and Federal and State agencies to conduct western snowy plover population monitoring and banding studies and construct predator exclosures. It is also legal for employees or designated agents of certain Federal or State agencies to take listed species without a permit if the action is necessary to aid sick, injured, or orphaned animals or to salvage or dispose of a dead specimen.

Section 10(a)(1)(B) of the Endangered Species Act also allows permits to be issued for take of endangered and threatened species that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if we determine that certain conditions have been met. An applicant for an incidental take permit must prepare a habitat conservation plan that specifies the impacts of the take, the steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, alternative actions to the take that the applicant considered, and the reasons why such alternatives are not being utilized. Conditions that we must meet include a determination: (1) whether the taking will be incidental, (2) whether the applicant will minimize and mitigate the impacts of such taking to the maximum extent possible, (3) that adequate funding for the recovery will be provided, (4) that the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild, and (5) of any other measures that we may require as being necessary or appropriate for the recovery plan. Section 10(a)(1)(B) of the Endangered Species Act provides for permits that have the potential to contribute to conservation of listed species. Such permits are intended to reduce conflicts between the conservation of listed species and economic activities, and to develop partnerships between the public and private sectors.

d. Section 7 Requirements and Consultations

Section 7(a)(1) of the Endangered Species Act requires all Federal agencies to "utilize their authorities in furtherance of the purposes of [the] Act by carrying out programs for the conservation of endangered species and threatened species". Hence, Federal agencies have a greater obligation than do other parties, and are required to be pro-active in the conservation of listed species regardless of their requirements under section 7(a)(2) of the Act. Section 7(a)(2) of the Endangered Species Act requires Federal agencies to consult with us prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 obligations have caused Federal land management agencies to implement western snowy plover protection measures that go beyond those required to avoid take; for example, eradicating European beachgrass and conducting research on threats to western snowy plovers. Other examples of Federal activities that may affect western snowy plovers along the Pacific coast, thereby triggering a section 7 consultation, include permits for sand management activities or major restoration projects that affect coastal processes or that are targeted to protect other species on Federal lands such as dune plants (National Park Service, U.S. Department of the Interior); disposal of dredged materials (U.S. Army Corps of Engineers); military training (U.S. Department of Defense); and funding to public agencies for projects to repair beach facilities, such as public access paths (Federal Emergency Management Agency).

e. Other Federal Regulations, Executive Orders, and Agreements

Section 404 of the Clean Water Act, as amended, and section 10 of the Rivers and Harbors Act of 1899 are the primary Federal laws that could provide some protection of nesting and wintering habitat of the western snowy plover that is determined by the U.S. Army Corps of Engineers (Corps) to be wetlands or historic navigable waters of the United States. Excavation or placement of any fill material (including sand) below the high tide line, as defined under 33 CFR, Section 328.3(d), Definition of Waters of the United States, also requires a permit from the U.S. Army Corps of Engineers.

Executive Order 11644, Use of Off-Road Vehicles on Public Lands, and Executive Order 11989, Off-Road Vehicles on Public Lands, pertain to lands under custody of

the Secretaries of Agriculture, Defense, and Interior (except for Native American Tribal lands). Executive Order 11644 requires administrative designation of areas and trails where off-road vehicles may be permitted. Executive Order 11989 states that "... the respective agency head shall, whenever he determines that the use of off-road vehicles will cause or is causing considerable adverse effects on the soil, vegetation, wildlife, wildlife habitat ... immediately close such areas or trails to the type of off-road vehicles causing such effects, until such time as he determines that such effects have been eliminated and that measures have been implemented to prevent future recurrence". Compliance with this executive order would promote prohibitions or restrictions on off-road vehicles so that they are not allowed to adversely affect sensitive habitats used by western snowy plovers.

Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands, provide protective policies that apply to western snowy plover habitats. Executive Order 11988 mandates that all Federal agencies avoid direct or indirect support of floodplain development wherever there is a practicable alternative. Executive Order 11990 mandates that all Federal agencies shall "provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands..." Compliance with Executive Order 11988 would promote protection of beach and dune habitats through restrictions on development within floodplains. Application of Executive Order 11990 would promote protection of wetland habitats used by western snowy plovers.

Executive Order 13112, Invasive Species, directs Federal agencies to prevent the introduction of invasive species; control their populations in a cost-effective and environmentally sound manner; monitor invasive species; restore native species and habitat conditions in ecosystems that have been invaded; conduct research and develop technologies to prevent their introduction; and promote public education on invasive species and the means to address them. This executive order also requires that a Federal agency "not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species..." Compliance with this executive order would enhance western snowy plover habitats through (1) avoidance of use, approval, or funding the planting of invasive species

like European beachgrass; and (2) active programs to remove this invasive species and restore coastal dune habitats with native plant species.

The Fish and Wildlife Coordination Act (16 U.S.C. 661-667e), as amended, requires that whenever a proposed public or private water development project is subject to Federal permit, funding, or license, the conservation of fish and wildlife resources shall be given equal consideration. This Act also requires that project proponents shall consult with us and the State agency responsible for fish and wildlife resources. Compliance with the Fish and Wildlife Coordination Act highlights the importance of considering and providing for the habitat needs of fish and wildlife resources when reviewing projects that would adversely affect these resources.

The National Environmental Policy Act of 1969, (42 U.S.C. 4321-4347), as amended, requires that each Federal agency prepare an environmental impact statement on the potential environmental consequences of major actions under their jurisdiction. Environmental impact statements must include the impacts on ecological systems, any direct or indirect consequences that may result from the action, less environmentally damaging alternatives, cumulative long-term effects of the proposed action, and any irreversible or irretrievable commitment of resources that might result from the action. Compliance with the National Environmental Policy Act highlights the need to disclose, minimize, and mitigate impacts to biological resources, including western snowy plovers.

The Coastal Zone Management Act of 1972 (16 U.S.C. 1451-1464), as amended, established a program for states to voluntarily develop comprehensive programs to protect and manage coastal resources. To receive Federal approval and funding under this Act, states must demonstrate that they have programs and enforceable policies that are sufficiently comprehensive and specific to regulate land uses, water uses, and coastal development, and must have authorities to implement enforceable policies. Local coastal plans, local comprehensive plans, and implementing measures by coastal planning jurisdictions pursuant to the Coastal Zone Management Act should be developed, updated, and implemented with protective measures for western snowy plovers.

Western snowy plovers are protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712), as amended. Under the Migratory Bird Treaty Act, prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting any migratory bird, nest, or eggs without a permit from the U.S. Fish and Wildlife Service.

5. State Regulatory Protection, Policies, and Agreements

In Washington, Oregon, and California, each state holds title to, and has regulatory jurisdiction over, the coastal intertidal zone. In Washington, the area between mean high tide to extreme low tide is the seashore conservation area under the authority of the Washington State Parks and Recreation Commission. In California, the California State Lands Commission has regulatory authority to the mean high tide line along the California coast.

In Oregon, the Oregon Parks and Recreation Department administers the State beach for the ocean shore recreation area, which is defined as the area between the line of extreme low water and the statutory vegetation line, which is a line surveyed to the approximate line of vegetation that existed in 1969 (Oregon Revised Statutes 390.770). The Oregon Division of State Lands also has jurisdiction over waters of the state along the Pacific coast to the line of highest tide or the line of established vegetation, whichever is higher. Therefore, the Oregon Parks and Recreation Department has direct jurisdiction, authority, and responsibility for management of western snowy plover habitats in the State of Oregon, which owns not only to the mean high tide line, which is western snowy plover foraging habitat, but also into the vegetation line, which is essentially the dry sand area used by western snowy plovers for nesting.

State coastal planning and regulatory agencies, such as the California Coastal Commission, require preparation of local coastal zone management plans by local coastal municipalities. These local coastal zone management plans must comply with the Coastal Zone Management Act of 1972 regarding protection of coastal resources, including natural resources. Under the California Coastal Management Program, coastal resources are managed and cumulative impacts addressed through: (1) coastal permits and appeals; (2) planning and implementation of local coastal programs; and

(3) Federal consistency review. However, effective management of cumulative impacts is difficult under the existing management framework because multiple jurisdictions have varying policies and standards in different geographic areas (California Coastal Commission 1995). Through the Coastal Commission's regional cumulative assessment program, cumulative impacts to coastal resources can be addressed through the periodic review of local coastal programs. In California, most local coastal programs and general plans were completed prior to 1993 (when we listed the western snowy plover as a threatened species); therefore, many do not reflect protective measures specifically for the western snowy plover.

The Oregon Department of Land Conservation and Development is the designated coastal zone management agency for the State of Oregon. The State of Oregon's land use planning system has several elements that are related to conservation of western snowy plovers and their habitats. In Oregon, local jurisdictions (cities and counties), service districts, and State agencies are required to develop Local Comprehensive Plans and Implementing Measures, such as zoning and land division ordinances, to effect these plans. Each plan must satisfy a set of 19 goals established through Oregon land use law and policy. Plans must be reviewed by the Land Conservation and Development Commission for consistency with these goals before they can be put into effect. Several of the planning goals have application to, or should be considered during, planning for western snowy plover conservation and recovery. These goals include: Goal 5 - Open Spaces, Scenic and Historic Areas, and Natural Resources; Goal 7 - Areas Subject to Natural Disasters and Hazards; Goal 8 - Recreational Needs; Goal 16 - Estuarine Resources; Goal 17 - Coastal Shorelands; and Goal 18 - Beaches and Dunes.

Taken in aggregate, the elements of these goals that can contribute to western snowy plover recovery include:

- several requirements for protection of wildlife habitat;
- requiring protection of estuarine ecosystems including habitats, diversity, and other natural values;
- establishing that uses of beaches and dunes shall be based on factors including the need to protect areas of critical environmental concern and significant wildlife habitat;

- requiring that coastal plans provide for uses of beaches and dunes that are consistent with their ecological values and natural limitations;
- requiring an evaluation of the beneficial effects to natural resources from allowing continuation of natural events that are hazardous to human developments (such as erosion and ocean flooding);
- establishing a preference for nonstructural solutions to erosion and flooding of coastal shorelands over structural approaches (such as seawalls and rip-rap);
- requiring that development of destination resorts be compatible with adjacent land uses and maintain important natural features such as threatened and endangered species habitats;
- encouraging coordination among State, Federal, and local governmental agencies while developing recreation plans, and discouraging development of recreation plans that exceed the carrying capacity of the landscape;
- encouraging planning for Open Space, Scenic and Historic Areas, and Natural Resources (Goal 5), Recreational Needs (Goal 8), and Coastal Shorelands (Goal 17) in close coordination; and
- allowing dune stabilization programs only when in conformance with the overall comprehensive plan and after assessment of the potential impacts.

Some aspects of these planning goals could be interpreted to be contrary to western snowy plover conservation and recovery when viewed in isolation. However, when viewed in the context of the entire goal or all the planning goals, these elements should be compatible with western snowy plover conservation and carefully-planned habitat restoration activities. Two such elements are the directive to increase recreational access to coastal shorelands and the restrictions placed on dune grading and removal of vegetation. Goal 17 - Coastal Shorelands directs local governments and the Oregon Parks and Recreation Department to develop a program to increase public access. In many areas, recreational use of western snowy plover habitat during the nesting season is detrimental to or incompatible with western snowy plover conservation. However, this goal also recognizes that many shorelands have unique or exceptional natural area values, includes the objective of reducing adverse impacts to fish and wildlife habitat associated with use of coastal shorelands, clearly establishes that significant wildlife habitat shall be protected, establishes that uses of such habitat areas shall be consistent with protection of natural values, and directs recreation plans to provide for "appropriate" public access and recreational use. Goal

18 - Beaches and Dunes directs local governments and State and Federal agencies to regulate actions in beach and dune areas to minimize any resulting erosion and only allows foredune breaching to replenish interdune areas or in the case of an emergency. Western snowy plover habitat restoration efforts in areas that have been overtaken by European beachgrass (*Ammophila arenaria*) may involve foredune breaching, vegetation removal, dune grading, and other actions that will remove the European beachgrass and restore the natural beach and dune processes of sand movement, including erosion and deposition. However, this goal also recognizes the need to protect areas of critical environmental concern, areas of biological importance, and areas with significant habitat value, specifically identifies removal of "desirable" vegetation as an action requiring minimization of erosion, and requires that any foredune breaching be consistent with sound principles of conservation.

The Washington State Parks and Recreation Commission administers the Seashore Conservation Act of 1988 in accordance with the Revised Code of Washington and the Washington Administrative Code. The Seashore Conservation Area (Revised Code of Washington 43.51) emphasizes the importance of beaches to the public for recreational activities. In designating beach areas to be reserved for pedestrian use, it considers natural resources, including protection of shorebird and marine mammal habitats, preservation of native beach vegetation, and protection of sand dune topography. Chapter 352-37 (Ocean Beaches) of the Washington Administrative Code requires local governments within the Seashore Conservation Area to prepare recreation management plans that designate at least 40 percent of the ocean beach for use by pedestrians and nonmotorized vehicles from April 15 to the day after Labor Day. These regulations also identify restrictions on certain uses within ocean beaches, including motor vehicles, equestrian traffic, speed limits, aircraft, wind/sand sailers, parasails, hovercraft, group recreation events, and beach parking and camping. In 1989, an interagency agreement was signed by the Washington Department of Natural Resources, Washington State Parks and Recreation Commission, Washington Department of Wildlife, and City of Ocean Shores regarding management of mixed uses at Damon Point. The intent of the agreement was to protect western snowy plovers while allowing recreation.

State regulations, policies, and goals for the States of California, Oregon, and Washington provide many protective measures for western snowy plovers. However,

because they frequently emphasize public uses of beach habitat, there is potential for conflicts between human uses of the coastal zone and needed management measures for recovery of the western snowy plover.

The California Department of Parks and Recreation has written management guidelines for the western snowy plover which are meant to be used in conjunction with the recovery plan. Management actions will be implemented from the guidelines and may result in changes in how coastal units are operated. Increased emphasis will be required for monitoring, nest area protection, prohibition of certain activities in important nesting areas, and public education.

6. Consultations, Habitat Conservation Plans, and Other Regulatory Actions

Through consultations with Federal agencies under section 7 of the Endangered Species Act and through the development of habitat conservation plans with non-Federal agencies developed under section 10 of the Endangered Species Act, we provide nondiscretionary terms and conditions that minimize (sections 7 and 10) and mitigate (section 10) the impacts of covered activities on listed species and their habitat. Several major consultations and habitat conservation planning efforts to benefit the western snowy plover have been completed or are currently under way.

In 1995 our Sacramento Fish and Wildlife Office completed formal consultation with the National Park Service, Golden Gate National Recreation Area, on the effects of their management of Ocean Beach, San Francisco on the western snowy plover. Ocean Beach experiences tremendous visitor use year-round because of its proximity to San Francisco, yet it supports high numbers of nonbreeding western snowy plovers, which may be present from May through July. The consultation covered actions and policies the National Park Service had taken that resulted in unnecessary harassment of nonbreeding western snowy plovers. Most significant of these measures was their policy not to enforce regulations requiring pets to be leashed and under control by their owners on all National Park Service lands. Data collected by the National Park Service clearly identified that unleashed dogs were the most significant disturbance factor of the many sources of disturbance to western snowy plovers on Ocean Beach. As a result of the consultation, the National Park Service began to enforce their “leash law” along 3.2 kilometers (2 miles) of beach utilized by western snowy plovers. The

National Park Service implemented this policy despite vocal and persistent opposition by the San Francisco Society for the Prevention of Cruelty to Animals and other local advocacy groups, including the "Rovers for Plovers", which organized themselves to challenge the National Park Service's leash law. These groups were successful in advocating their position in numerous television news stories and articles in local newspapers. At the height of this discourse, the local public radio station held a round-table discussion between the National Park Service, U.S. Fish and Wildlife Service, and Society for the Prevention of Cruelty to Animals, and solicited audience members to call in and identify their viewpoint. The overwhelming majority of callers supported leash law restrictions that would minimize harassment of western snowy plovers.

Our Arcata Fish and Wildlife Office has formally consulted with the U.S. Army Corps of Engineers regarding gravel extraction on the Eel River, California. Gravel mining operations are subject to permits from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. The western snowy plover breeds on the Eel River gravel bars. Impacts to the western snowy plover and its designated critical habitat associated with gravel mining operations have been assessed based on nesting surveys and changes to habitat resulting from gravel extraction. The Arcata Fish and Wildlife Office has also worked with Humboldt County, the California Department of Fish and Game, and the California Department of Parks and Recreation to implement additional protections for nesting western snowy plovers at MacKerricher, Manchester, Little River, Humboldt Lagoons, and Prairie Creek State Parks; Clam Beach County Park, and the Eel River Wildlife Area. These measures include installation of nest exclosures, signing, and development of educational material for kiosks. Technical assistance has also been provided to Prairie Creek State Park and MacKerricher State Park on exotic vegetation management programs (J. Watkins *in litt.* 1999, pers. comm. 2001). A section 7 consultation with the Bureau of Land Management on finalization of a management plan for Humboldt Bay South Spit is expected to be initiated soon (J. Watkins, pers. comm. 2006).

Our Ventura Fish and Wildlife Office is attempting to initiate a regional approach to habitat conservation planning for western snowy plovers and other listed species along Monterey Bay in Monterey County, California. Currently, there are several proposed development projects within the city of Sand City and a "city wide" habitat

conservation plan has been prepared for these projects. The City of Sand City has yet to present a complete draft of their habitat conservation plan to the Ventura Fish and Wildlife Office for review. Formerly, the City of Marina was also proposing several coastal developments that were expected to have adverse effects on western snowy plovers, but these projects are no longer planned due to changes in land ownership and other factors. The City of Marina has halted the drafting of a habitat conservation plan for lands within their jurisdiction. We have expressed concerns about projects being presented in a piecemeal fashion, which does not allow an adequate assessment of their cumulative effects, and have recommended a regional approach through preparation of a regional habitat conservation plan. This plan would provide greater conservation benefits to the western snowy plover. In addition to the adverse effects of development on western snowy plovers and their habitat, recreation on the extensive public lands along Monterey Bay is also adversely affecting western snowy plovers. Therefore, public land managers, including our Refuges Division, the California Department of Parks and Recreation, the California Department of Fish and Game, and the Monterey Peninsula Regional Park District, need to be involved in planning efforts along Monterey Bay.

Through the consultation process, our Ventura Fish and Wildlife Office determined that a draft biological opinion on Vandenberg Air Force Base's initial proposed beach management plan for the western snowy plover, concluding that the plan would "likely jeopardize the continued existence of the western snowy plover and adversely modify its critical habitat." Our draft biological opinion of January 2001 pointed out that the Air Force's beach plan would have allowed twice as much nesting habitat to be open to public recreation as was allowed during the 2000 breeding season, and it would have reduced the time the Air Force spends patrolling the beaches by about 80 percent. Based on this feedback, the Air Force subsequently reinitiated consultation on a modified version of the beach management plan, including commitments to signage, information kiosk, and enforcement patrols. The Ventura Fish and Wildlife Office issued a non-jeopardy biological opinion on the modified action in March 2001. Beach opening and full implementation of conservation measures was implemented on May 25, 2001, with hours and days of open beach limited due to limited availability of enforcement personnel. For the next three breeding seasons (2002, 2003, 2004), the Service issued biological opinions on annual beach management plans proposed by the Air Force. In 2004, we had a series of meetings

with the Air Force to discuss their beach management strategy and its effects on the western snowy plover. Through a cooperative effort, the Service and the Air Force came to agreement on a 5-year beach management plan that includes many of the same protective measures that had been in place the last several years, yet allows the Air Force to provide recreational access seven days a week. On March 1, 2005, the Ventura Fish and Wildlife Office issued a new non-jeopardy biological opinion on the Air Force's proposed 5-year beach management plan (2005-2009).

Our Ventura Fish and Wildlife Office is also involved with the development of a habitat conservation plan being funded by the Off-Road Vehicle Division of the California Department of Parks and Recreation for the Pismo/Oceano Dunes State Vehicular Recreation Area and other State parks within the San Luis Obispo District of the California Department of Parks and Recreation. The Ventura Fish and Wildlife Office is also involved in the development of a HCP for the Rancho Guadalupe County Park, Santa Barbara, California. These habitat conservation plans will evaluate and mitigate for effects that recreation and park management activities are having on the covered species, including the western snowy plover.

Recent consultations handled by our Newport Field Office include those in response to the New Carissa Oil Spill, a consultation on BLM management actions at the New River Area of Critical Environmental Concern (ACEC), and a consultation on the Integrated Predator Damage Management Program 2002 to 2007. The Oregon Parks and Recreation Department is currently developing a Habitat Conservation Plan that proposes restrictions on some Oregon beaches to help the plover population recover.

The New Carissa oil spill was a long and complicated incident involving a variety of Federal, State, local and private participants. On February 4, 1999, the *New Carissa,*carrying 359,000 gallons of bunker oil and 37,400 gallons of diesel, grounded on the north spit of Coos Bay and began leaking oil shortly thereafter. Subsequently, oil and oiled wildlife were observed on the beach. Attempts were made to burn off the oil. The vessel broke into two pieces during the second attempt. There were three formal consultations associated with the *New Carissa* between 1999 and 2000. The first consultation addressed the effects of issuing permits for salvage of the *New Carissa* stern section, the second the effects of restoring recreational access to the Coos Bay north spit, and the third the response efforts led by the Coast Guard. In all

three consultations, it was concluded that the proposed actions would not jeopardize the western snowy plover if protective measures required to limit take were implemented.

A consultation on the New River ACEC was completed in 2005. The purpose of the biological opinion was to address a variety of issues: recreation management at Floras Lake where measures were not adequately protecting nesting plovers; the periodic construction of a breach on the New River spit to improve fish and wildlife habitat and alleviate flooding; increased habitat restoration; and the development of a primitive beach camping area.

A consultation on Oregon's Integrated Predator Damage Management Program was completed in 2001. The objective of this program is to assist in recovery of the western snowy plover in Oregon by improving western snowy plover nesting and fledging success, through 1) expanding assessment efforts to all western snowy plover breeding and nesting locations to determine predator species responsible for nest, chick and adult predation; and 2) reducing the local predator populations where feasible and where the predator species or individual is known. The consultation calls for a variety of lethal and non-lethal methods to be used by APHIS-WS personnel to control the predator population.

The Oregon Parks and Recreation Department has been working with various cooperating agencies to develop a Habitat Conservation Plan for Oregon beaches. The Oregon Parks and Recreation Department is responsible for various management activities for most of Oregon's coast, including recreation management, general beach management, and the management of natural resources. In addition, the Oregon Parks and Recreation Department is responsible for issuing various permits along the Oregon coast. Some of these activities may result in "take" of or harm to the snowy plover. A draft version of the Habitat Conservation Plan was distributed to the public in January 2004. The Oregon Parks and Recreation Department conducted public meetings in seven coastal communities to solicit public comment. The area covered under the HCP includes the portions of the ocean shore along the Oregon coast that extend between the mouth of the Columbia River South Jetty on the north and the California/Oregon border on the south (approximately 230 miles of beach). In addition, specific portions of six key state parks, state natural areas, and state

recreation areas are included in the covered lands to be managed for snowy plover recovery. Implementation of the plan will begin after approval and completion of the Habitat Conservation Plan and its associated documents.

In southern California, we, through our Carlsbad Fish and Wildlife Office, have worked with local jurisdictions to develop regional habitat conservation plans under section 10 of the Endangered Species Act. The Multiple Species Conservation Program addresses southwestern San Diego County, including, for example, western snowy plover breeding habitat in south San Diego Bay through the City of San Diego. The Multiple Habitat Conservation Program addresses northwestern San Diego County. This plan provides for the conservation of western snowy plover breeding habitat and will potentially result in more management in association with a proposed preserve.

Also in San Diego County, we have been working with the Navy and the Marine Corps to avoid and minimize impacts to western snowy plovers. For example, with the assistance of our programmatic biological opinion in 1995, the Marine Corps has addressed training-related impacts on western snowy plovers and other species on approximately 17 miles of coastline on Camp Pendleton. We have likewise worked with the Navy at Naval Base Coronado to develop a program to conserve western snowy plover nesting and breeding habitat and allow necessary military training. As a result of successful management on these San Diego County military installations, they support a majority of the western snowy plover population in Recovery Unit 6 (*e.g.*, roughly 65 percent in 2006 from window survey data) while the military installations accomplish their respective training missions.

In the past, several instances were documented of western snowy plover nests being trampled by cattle belonging to the Vail and Vickers Company on Santa Rosa Island within the Channel Islands National Park, owned and managed by the National Park Service. In 1996, a lawsuit to remove cattle from Santa Rosa Island was initiated by the Environmental Defense Center, Santa Barbara, on behalf of the National Park Conservation Association. It was initiated under the authority of the Clean Water Act and the Endangered Species Act, based on concerns about management of livestock by the National Park Service and associated impacts to water quality and sensitive

plant and animal species. As a result of a lawsuit settlement, all cattle were removed from Santa Rosa Island in early 1998.

7. Regulatory Protection and Policies of Local Governments

Local governments regulate municipal land uses through development of local land use plans, general plans, comprehensive plans, and zoning policies. On April 21, 1998, we requested that county and coastal city planners within the states of Washington, Oregon, and California complete land-use management surveys regarding the western snowy plover. We sent surveys to 91 State, county, or coastal city planners and received responses from 37 percent of the recipients. Approximately 50 percent of the respondents were aware that western snowy plover habitats occur within their jurisdictions. However, only about one-third knew whether sandy beach and other habitats within their jurisdictions provided breeding and/or wintering habitat for western snowy plovers. Many general plans, coastal zone programs, and comprehensive plans prepared by local governments contain land use designations that are protective of western snowy plover habitats (*e.g.*, parkland, open space, and conservation designations for sandy beach). However, allowable uses in or adjacent to these zones, such as development (*e.g.*, seawalls, recreational facilities, single-family homes), recreation and public access, could cause direct or indirect threats to breeding or wintering western snowy plovers.

Whereas 43 percent of the respondents include regulatory policies that protect western snowy plover habitat (*e.g.*, sandy beach) in their general plans, local coastal programs or comprehensive plans, only 8 percent have developed regulatory policies specifically to protect the western snowy plover. These respondents included the City of Half Moon Bay, California, and Coos and Curry Counties, Oregon. Only 23 percent of the respondents specifically explain the threatened status of the western snowy plover, identify western snowy plover breeding/wintering locations, or specify shorebird nesting/roosting habitats as environmentally sensitive habitat areas in their jurisdictions. About 50 percent of the respondents indicated they either (1) have approved development within or adjacent to sandy beach or other habitats used by the western snowy plover, or (2) did not know whether such development had been approved by their agency. About half of these same respondents could provide some information on the number of permits authorized, area or linear distance affected,

percentage of development types (*e.g.*, housing, recreational) permitted, and permit conditions.

Based on these responses, it seems that specific locations of, and protective measures for, western snowy plover breeding and/or wintering locations are not included in most of the existing general plans, comprehensive plans, local coastal programs, or their implementing ordinances. Also, to better assess cumulative impacts, these responses indicate a need for a better tracking method regarding development projects approved within and adjacent to western snowy plover habitat.

8. Interagency Coordination

Each of the six recovery units for the western snowy plover is represented by a working group which meets at least once a year to coordinate western snowy plover recovery efforts. The working groups have provided a forum for the participation of affected Federal and State agencies and others in discussion, implementation, and adjustment of recovery efforts. Items addressed include research and monitoring needs, predator control, recreation management, habitat restoration, public outreach and law enforcement. In addition, a joint meeting of all six working groups is held annually. This group, consisting of beach managers, researchers, and outreach staff, meet to discuss range-wide issues (within the United States), to coordinate recovery actions, to learn from the experience of others, and to share information and research. Attendees have included local, State, and Federal agency staff, non-governmental organizations, consulting firms, private citizens, and volunteers.

The recovery unit working groups vary somewhat in organizational structure depending on major local issues, patterns of land ownership within the area, and specific agencies responsible for management. For example, the Oregon/Washington working group is composed of several subcommittees, including Outreach, Media, Predator Control, Research, Law Enforcement, and Recovery Plan Implementation. They facilitate funding partnerships for monitoring and management programs, thus promoting the best use and leveraging of limited funds. They also act as the main forum for discussing and tracking the status and trends of the snowy plover population. The subcommittees have worked on or supported a variety of cooperative projects, such as monitoring of yearly reproductive success, predator control, and

outreach materials. Products developed by the Outreach subcommittee include an outreach plan for Oregon/Washington and "Share the Beach" bookmarks, table tents, dog leashes, brochures, interpretive signs, and coloring books. The Media subcommittee is producing a media outreach CD for distribution to various media outlets and inter-agency press releases. The Predator Control subcommittee approved a predator management plan for Oregon, which first went into effect in 2002. The purpose of the Research subcommittee is to identify research and monitoring priorities, establish criteria for setting priorities, review proposed projects, and address funding mechanisms. The Law Enforcement subcommittee focuses on improving compliance with rules and regulations in plover nesting areas and the Recovery Plan Implementation subcommittee is working on guidance that would assist in "stepping down" the recovery plan for Oregon and eventually Washington.

In 1998, an interagency effort in Oregon produced a slide show and portable display to educate beach visitors about western snowy plover conservation. Outdoor education specialists and/or western snowy plover biologists from the U.S. Bureau of Land Management, U.S. Forest Service, Oregon Department of Fish and Wildlife, Oregon Parks and Recreation Department, and U.S. Fish and Wildlife Service participated in this effort. The show provides basic information about the western snowy plover, the reasons for its decline, and actions needed for its recovery, emphasizing the contribution that beach visitors can make.

II. RECOVERY

A. RECOVERY STRATEGY

The recovery strategy for the Pacific coast population of the western snowy plover (western snowy plover) includes three major components: 1) increase population numbers distributed across the range of the Pacific coast population of the western snowy plover; 2) ameliorate or eliminate threats by conducting intensive ongoing management for the species and its habitat, and developing mechanisms to ensure management in perpetuity; and 3) monitor western snowy plover populations and threats to determine success of recovery actions and to refine management actions. Developing and implementing intensive adaptive management actions, ensuring that management will continue in perpetuity, and monitoring to refine management actions, are all necessary to achieve the targeted population increases across the range. These three major components of the recovery strategy each include many actions and multiple partners that are described in further detail below.

1. Recovery Strategy Components

The following recovery strategy components will guide future recovery efforts for the U.S. Pacific coast population of the western snowy plover.

a. Population increases should be distributed across the western snowy plover's Pacific coast range.

A key component of recovering western snowy plovers is to ensure that population increases are distributed throughout the species' Pacific coast range. In order to achieve this, management goals (Appendix B) and needed management actions (Appendix C) have been determined for 155 sites distributed along the coasts of southern Washington, Oregon, and California. Additionally, the population's range has been divided into six recovery units (see discussion below) with population goals established for each recovery unit. The six recovery units correspond to regions of the U.S. Pacific coast and to the six subpopulations used in the Population Viability Analysis for the Pacific coast Snowy Plovers (Appendix D). In the population viability analysis, the Pacific coast population of the western snowy plover is treated

as a metapopulation, defined as a set of subpopulations among which there is limited dispersal.

The population viability analysis assumes dispersal among subpopulations is limited; however, even limited dispersal among subpopulations is important to species survival and recovery. Dispersal of the population across its breeding range helps to counterbalance catastrophes, such as extreme climatic events, oil spills, or disease that might depress regional survival and/or productivity. Maintaining robust, well-distributed subpopulations should reduce variance in survival and productivity of the Pacific coast population of the western snowy plover as a whole, facilitate interchange of genetic material between subpopulations, and promote recolonization of any sites that experience declines or local extirpations due to low productivity and/or temporary habitat loss.

This recovery plan and the population viability analysis (Appendix D) consider the U.S. Pacific coast population of the western snowy plover to be a single management entity, and population goals and objectives are based on that premise. No portion of the Pacific coast population of the western snowy plover appears to function as a distinct population segment. The Recovery Team therefore recommends that no State, geographic region, or subpopulation of the Pacific coast population of the western snowy plover be considered for delisting separately from the others.

b. Remove or reduce threats by conducting intensive ongoing management for the species and its habitat, and develop mechanisms to ensure management in perpetuity to prevent a reversal of population increases following delisting under the Endangered Species Act.

Management consists of multiple components, including identifying actions to ameliorate or eliminate threats, developing mechanisms to ensure management in perpetuity, continuing outreach and education to provide information to the public, partners, and stakeholders on recovery needs and opportunities, and developing of partnerships among Federal, State, and local agencies and groups to develop and implement effective management. Management actions for the western snowy plover are described in the recovery action outline and in Appendix C. These management actions are necessary to eliminate or ameliorate threats to the western snowy plover,

including loss, degradation, and alteration of habitat; disease, predation; and other manmade factors including disturbance of breeding and wintering birds, contaminants, and oil spills.

In addition to specific management recommendations to ameliorate or eliminate threats, the recovery action outline and recovery strategy for the western snowy plover include several recovery actions to develop mechanisms to ensure that management actions continue in perpetuity to ensure that threats remain neutralized. These include establishing working groups and developing participation plans for each recovery unit; ensuring sufficient U.S. Fish and Wildlife Service staff to coordinate recovery of the Pacific coast population of the western snowy plover; developing and implementing management plans for publicly owned lands; assisting local governments and private land owners in developing habitat conservation plans, developing land use protection measures, and developing landowner agreements; and acquiring habitat where necessary. A key component of these efforts includes education and outreach to inform partners and the public about recovery needs and opportunities for the western snowy plover. Actions for outreach are included in the recovery action outline, and the Information and Education Plan (Appendix K) provides greater detail on implementing these outreach and education actions.

Participation of many different groups will be essential to achieve both short-term and long-term management for the western snowy plover and its habitat. The roles of various groups, potential conservation tools and funding available, and the Recovery Team's vision for participation and coordination of partners are further described below.

c. Annual monitoring of western snowy plover subpopulations and reproductive success, and monitoring of threats and effects of management actions in reducing threats, is essential for adaptive management and to determine the success of recovery efforts.

The recovery action outline describes monitoring for breeding, wintering, and migration areas both to determine whether population numbers and survival of western snowy plovers is increasing and whether threats continue to limit population increases. Additional research actions are also recommended to study certain threats

and develop management techniques and monitoring methods. Results from research and monitoring efforts will be used to develop, refine, and improve management of western snowy plovers and their habitat. Monitoring of demographic characteristics will be necessary to demonstrate that population goals in the recovery criteria are being achieved. Monitoring of threats and effects of management actions in reducing those threats also is essential in demonstrating progress toward recovery and ultimately will assist in threats analyses necessary to make a delisting determination.

2. Roles of Federal, State, Local, and Private Sectors

a. Role of Federal Lands

Federal lands administered by the U.S. Fish and Wildlife Service, National Park Service, U.S. Forest Service, U.S. Bureau of Land Management, the National Marine Sanctuary Program, U.S. Marine Corps, and the U.S. Departments of the Army (including Corps of Engineers), Navy, and Air Force are extremely important to the conservation of the western snowy plover. In California, breeding occurs on National Wildlife Refuge lands, Department of Defense lands, Bureau of Land Management lands, and National Park Service lands. In Oregon, the major Federal landowners are the U.S. Forest Service and Bureau of Land Management, although the State also has jurisdiction over much of the Federally owned area (from mean high tide to the vegetation line) through a recreational easement (E.Y. Zielinski and R.W. Williams *in litt.* 1999). In Washington, the breeding area at Leadbetter Point is within a National Wildlife Refuge.

Under section 7(a)(1) of the Endangered Species Act, Federal agencies are required to actively promote the conservation of listed species. The western snowy plover cannot be recovered simply through general habitat protection or complying with required section 7(a)(2) consultations. The western snowy plover must be actively monitored and managed for the purpose of recovery or its population size will decline. Federal agencies alone cannot assure recovery of the western snowy plover, but should have a leading role in monitoring and management efforts to assure survival and recovery of this species. Some Federal lands contain large areas of contiguous habitat, including adjacent inland areas that are easier to manage for conservation of natural resources than fragmented, linear strips of land that may be owned by states, counties, cities,

and private landowners. Protection of western snowy plovers and their habitat on Federal lands is important not only because of the direct benefits to plovers that use these areas, but also because plover protection programs on Federal lands frequently utilize state-of-the art management measures and therefore serve as examples to non-Federal landowners. The Federal Government also should take the lead in addressing the sensitive issue of predator control.

b. Role of State Lands

State lands administered by the California Department of Parks and Recreation, California Department of Fish and Game, Oregon Department of Fish and Wildlife, Oregon Parks and Recreation Department, Washington Department of Fish and Wildlife, Washington State Parks and Recreation Commission, and Washington Department of Natural Resources play an important role in conservation of western snowy plovers and their habitats. Intensive management for western snowy plovers occurs at a number of State-owned plover habitat areas. The western snowy plover cannot be preserved simply through general habitat protection. Western snowy plovers must be actively monitored and managed to achieve recovery goals on State lands or their population size will decline.

c. Roles of State and Local Governments

State and local government agencies, including state planning agencies and city and county planning and community resources departments, have the primary responsibility for overseeing land uses within their jurisdictions. Therefore, their involvement in future recovery planning and implementing processes is critical. All Appendix B locations should be identified as environmentally sensitive habitat areas requiring protective measures for the western snowy plover in state and local planning documents and zoning designations. Local coastal programs should be amended to include these areas. To facilitate this effort, Federal and State agencies managing western snowy plover habitat should provide technical assistance and information to local governments (see Actions 3.1.6, 3.1.7 and 5.2). We can provide detailed maps of current western snowy plover breeding and/or wintering locations; these maps will be updated periodically as needed.

d. Role of Municipal Lands

Regional, county, and city lands, including regional and municipal park districts, also serve a role in conserving breeding and wintering habitats for western snowy plovers. Because these areas frequently receive heavy pedestrian and recreational use, local jurisdictions with active public outreach programs can reach a large segment of the coastal community regarding the plover's status and habitat needs.

e. Role of Private Lands

Conservation efforts on private lands are needed for the survival and recovery of many listed and other sensitive species. Private landowners can also make important contributions to western snowy plover conservation through facilitating or allowing the monitoring of western snowy plover populations on their land and implementing protective measures.

3. Conservation Tools and Strategies

There are numerous conservation tools and strategies available to Federal, State, municipal, and private landowners interested in western snowy plover protection and recovery. Appendix H includes a summary of conservation tools and strategies that may be adopted by landowners, nonprofit organizations, and regulatory agencies to protect western snowy plover habitat.

4. Funding Sources

Appendix I includes a summary of some potential sources of funds for implementation of recovery actions for the western snowy plover. This list is not intended to be exhaustive, however, and other funding opportunities may also be available.

An essential mechanism for recovery of the western snowy plover is the development and implementation of participation plans for each of the six recovery units (see Action 3.1.2). A key element of these participation plans is the long-term commitment by participating agencies to seek annual, ongoing funding for western

snowy plover management and monitoring activities so that funding within agency budgets can be secured.

In many areas a significant portion of western snowy plover conservation resources are expended in efforts to minimize the adverse impacts of recreation. Often, the primary objective of signs, ropes, on-site interpretation, and enforcement is to manage the behavior of beach-goers such that impacts to western snowy plovers are reduced as much as possible. In areas that have suffered extensive habitat loss or degradation, such recreation management activities are an extremely high priority in order to protect the western snowy plovers using the limited habitat that remains. For some beach managers, much of the funding and staff time expended on recreation management in and near western snowy plover habitat comes from resources targeted for threatened and endangered species recovery. In absence of the need to coordinate and pay for recreation management activities, more of these limited conservation dollars and staff resources could be directed toward western snowy plover management actions such as biological monitoring, habitat restoration, and predation control.

This situation is unique in the experience of many resource biologists. More typically, avoidance, minimization, and mitigation measures are integral components of projects or programs that entail adverse impacts to sensitive resources, and the costs of these activities are regarded as part of the overall cost of the project or program. Applying this traditional construct to recreation projects and programs could significantly promote western snowy plover recovery in several ways. First, it would require impacts to western snowy plovers to be considered up front when planning beach access or other recreation projects. Second, it would encourage impact avoidance and minimization since such measures are often less expensive than mitigation. Third, it would promote involvement of recreation professionals in designing and implementing recreation management measures. And fourth, it would eliminate or reduce the diversion of biological resource management funds toward recreation management activities, thus enabling more of those dollars to be spent on western snowy plover recovery actions.

5. Coordination, Participation, and Working Groups

We strongly believe that a collaborative stewardship approach to the proactive management of listed species involving government agencies (Federal, State, and local) and the private sector is critical to achieving the ultimate goal of recovery of listed species under the Endangered Species Act. An essential mechanism to achieve recovery of the western snowy plover is the formation and maintenance of working groups for each of the six recovery units (Appendix A), (see Action 3.1.1). Representation from the full range of Federal, State, local, and private landowners and other parties who have a stake in western snowy plover conservation within each of these six recovery units is needed to advance the recovery actions recommended in this recovery plan. Working group membership should include land managers, environmental groups, user groups, and groups involved in conservation projects (including local chapters such as the National Audubon Society, Sierra Club, Native Plant Society, Americorps, California Conservation Corps, Boy Scouts, Surfrider Foundation, and other recreational use groups). These groups can provide large networks of volunteers who can be mobilized to assist public resource agencies in the implementation of management measures for protection and recovery of the western snowy plover.

Working groups for each of the six recovery units currently exist and convene annually for regional and rangewide meetings. Through evaluation, communication, and coordination, members of each of the six working groups should manage the western snowy plover population and monitor progress towards recovery. They should produce annual reports on population monitoring and the effectiveness of management activities for the working group and our Arcata Fish and Wildlife Office. Each of the six working groups should prepare a participation plan, thereby formalizing recovery implementation efforts and the intentions of responsible agencies to seek ongoing, annual funding for recovery implementation. The Recovery Coordinator should coordinate and communicate with each recovery unit to support recovery efforts and assure implementation of the recovery plan (see Actions 3.1 through 3.4, 6, and 7). The Recovery Coordinator also should coordinate with other western snowy plover survey efforts and assessments throughout the west and throughout North America. Coordination with these other efforts may provide valuable information on the status and distribution of the western snowy plover, as

well as valuable information on management actions that may benefit the Pacific coast population of the western snowy plover. A coordinated international conservation program with Mexico also should be established to protect western snowy plover populations and their habitat in that country (see Action 8).

B. RECOVERY UNITS

The Pacific coast population of the western snowy plover has been divided into six recovery units (Appendix A, Figures A-1 through A-7). Establishing recovery units with specific recovery goals for each recovery unit will assist in meeting the objective of ensuring that population increases are distributed throughout the western snowy plover's Pacific coast range. A recovery unit is a special unit of a listed species that is geographically or otherwise identifiable and is necessary to the survival and recovery of the entire listed entity. Recovery units are individually necessary to conserve genetic robustness, demographic robustness, important life history stages, or other features for long-term sustainability of the entire listed species. However, recovery units are not listed as separate entities and cannot be delisted individually. Each recovery unit must be recovered before the species can be delisted.

The resilience to extinction of a widespread species can be negated if the species is subjected to a new stress over a large area (Raup 1991:122, 182). For the western snowy plover the primary stresses that led to the listing of the species were the loss of habitat due to encroachment of European beachgrass and urban development. As a consequence of such widespread habitat loss and the subsequent reduction in the range and vigor of the species, the western snowy plover is now more vulnerable to environmental fluctuations and catastrophes that the species would otherwise be able to tolerate. Chance events such as oil and contaminant spills, windstorms, and continued habitat loss from European beachgrass expansion, described earlier in this plan, could now cause or facilitate the extirpation of the entire listed species or one or more of the breeding populations.

The recovery unit approach in this recovery plan addresses this risk to the long-term survival and recovery of the western snowy plover by employing two widely recognized and scientifically accepted goals for promoting viable populations of listed species: (1) creation or maintenance of multiple populations so that a single or series

of catastrophic events cannot destroy the whole listed species; and (2) increasing the size of each population in the respective recovery unit to a level where the threats of genetic, demographic, and normal environmental uncertainties are diminished (Mangel and Tier 1994; National Research Council 1995:91; Tear *et al.* 1993; Meffe and Carroll 1994:192).

In general, the larger the number of populations and the larger the size of each population, the lower the probability of extinction (Raup 1991:182; Meffe and Carroll 1994:190). This basic principle of redundancy applies to the western snowy plover. By maintaining viable populations at the breeding locations within multiple recovery units, the threats represented by a fluctuating environment are alleviated and the species has a greater likelihood of achieving long-term survival and recovery. Conversely, loss of one or more important breeding locations within a recovery unit could result in an appreciable increase in the risk that the entire listed species may not survive and recover. Because western snowy plovers tend to exhibit site fidelity, migration to new nesting sites could increase stress to breeding birds and reduce nesting success.

Therefore, when evaluating the potential impact of land management actions that may affect the western snowy plover, we will consider whether a significant loss of western snowy plover breeding or wintering habitat in one recovery unit --without adequate compensation alleviating the impacts of that loss-- would adversely affect the viability of the population in that recovery unit as well as the long-term viability of populations in other recovery units.

Several aspects of the biology and life history of the western snowy plover indicate that designation of recovery units is necessary to ensure the long term health and sustainability of the western snowy plover. A portion of the Pacific coast population of western snowy plovers do not migrate up or down the coast and are year round residents. Additionally, the majority of western snowy plovers that do migrate are site-faithful, returning to the same breeding areas in subsequent breeding seasons (Warriner *et al.* 1986, Stenzel *et al.* 1994). Western snowy plovers occasionally nest in exactly the same location as the previous year (Warriner *et al.* 1986). These two features indicate that the Pacific coast population of western snowy plover likely exhibits subpopulation and metapopulation structure (see also Appendix D).

Designation of separate recovery units across the range will ensure that metapopulation dynamics can be maintained for the species.

The area covered by the six recovery units encompasses all the known breeding and wintering sites for the Pacific coast population of the western snowy plover. In addition to exhibiting site fidelity to breeding locations, western snowy plovers also exhibit fidelity to wintering locations. In contrast to many migratory birds, winter migration of the Pacific coast population of western snowy plovers is not uni-directional. Western snowy plovers may move both north and south along the coast from breeding locations. Nesting birds from Oregon have wintered as far south as Monterey Bay, California, while birds from Monterey Bay in central California have wintered north to Bandon, Oregon and south to Laguna Ojo de Liebre in Baja California, Mexico (Page *et al*. 1995*a*). Nesting birds from San Diego County in southern California have wintered north to Vandenberg Air Force Base in Santa Barbara County and south to Baja California (Powell *et al*. 1995, 1996, 1997). Designation of separate recovery units, each essential to the recovery of the western snowy plover, will ensure that wintering and migratory habitat is distributed across the western snowy plover's Pacific coast range and is protected and managed to maximize western snowy plover population survival.

The six recovery units for the Pacific coast population of the western snowy plover are: (1)Washington and Oregon; (2) Del Norte to Mendocino Counties, California; (3) San Francisco Bay, California; (4) Sonoma to Monterey Counties, California; (5) San Luis Obispo to Ventura Counties, California; and (6) Los Angeles to San Diego Counties, California. These recovery units were designated partly based on gaps in distribution of western snowy plover breeding and wintering locations, and on gaps in available habitat along the coast. For example, a significant portion of the coast of Sonoma County and southern Mendocino County is rocky and composed of steep bluffs lacking beach, dune, or estuary habitat suitable for the western snowy plover. This area constitutes a gap in the distribution of breeding and wintering locations between recovery units 2 and 4. This situation is repeated along the coast of Monterey County, where a gap in western snowy plover locations and suitable habitat occurs between recovery units 4 and 5. Smaller gaps also occur between recovery units 1 and 2, and between recovery units 5 and 6. Recovery unit 3 is unique and has

been designated as a separate recovery unit because much of the habitat in the San Francisco Bay area consists of salt ponds and salt pond levees.

The six recovery units designated for the western snowy plover also vary significantly in numbers of breeding western snowy plovers. Recovery unit 5 supports the greatest number of western snowy plovers, approximately half of the U.S. population, and has the greatest amount of available suitable habitat. Recovery units 4 and 6 support, or have the potential to support, a lesser number of western snowy plovers, collectively about a third of the population. The population in Recovery Unit 3 is relatively lower but has potential to increase with intensive management of salt pond habitat. Recovery units 1 and 2 also support relatively low numbers of western snowy plovers, probably due to suitable habitat being lesser in extent and more widely separated, but represent about half of the geographic range of the Pacific coast population of western snowy plovers within the United States and provide essential wintering, migratory, and breeding habitats.

Collectively, recovery of western snowy plovers within each of the six recovery units is necessary to maintain metapopulation dynamics, ensure protection and appropriate management of wintering and migratory habitat, and ensure the long term health and sustainability of the Pacific Coast population of western snowy plovers across its current range.

C. RECOVERY GOALS AND OBJECTIVES

The goal of this recovery plan is to ensure the long-term viability of the Pacific coast western snowy plover population so that this population can be removed from the Federal list of endangered and threatened species. The specific objectives to achieve this goal are the major components of the recovery strategy described above:

1) Increase population numbers distributed across the range of the Pacific coast population of the western snowy plover;

2) Conduct intensive ongoing management for the species and its habitat and develop mechanisms to ensure management in perpetuity; and

3) Monitor western snowy plover populations and threats to determine success of recovery actions and refine management actions.

D. RECOVERY CRITERIA

Recovery criteria for the Pacific coast population of the western snowy plover include numeric subpopulation targets, reproductive productivity targets, and establishment of management actions. Under each of these three major recovery criteria are additional subcriteria that must be achieved in order to progress toward the major criteria or that must be achieved in order to determine whether the major criteria are being met. Subcriteria include completing development and implementation of population, demographic and threat monitoring programs, incorporating specific management actions into participation and management plans, and completing research actions necessary to refine management actions.

Recovery criteria in this recovery plan are necessarily preliminary and will need periodic reassessment because additional data upon which to base decisions about western snowy plover recovery are needed (*i.e.*, effective predator management techniques, effective restoration techniques, improved monitoring techniques, additional demographic information for some subpopulations). Research actions, monitoring programs, and periodic recovery implementation review are included as recovery actions in order to obtain this information. The completion of many of these actions have been incorporated into recovery criteria in order to ensure that new information is incorporated into recovery implementation decisions.

The recovery criteria recommend that the Pacific Coast population of the western snowy plover be maintained at 3,000 breeding birds. This population increase to 3,000 breeding individuals could occur within 25 years with intensive management of breeding and wintering sites (see Appendix D. Population Viability Analysis for Pacific Coast Snowy Plovers). This population level must be maintained for at least ten years. In addition, average annual productivity of at least one (1.0) fledged chick per male in each recovery unit must be maintained in the last 5 years prior to delisting. Forty years may be required to achieve these demographic components of the recovery criteria, assuming that mechanisms to assure long-term protection and

management of breeding, wintering, and migration areas necessary to maintain the subpopulation sizes and average productivity have been developed and are in place.

The Pacific coast population of the western snowy plover will be considered for delisting when the following criteria have been met:

Criterion 1. Monitoring shows that an average of 3,000 breeding adults distributed among 6 recovery units as specified below have been maintained for a minimum of 10 years:

Recovery Unit	*Subpopulation Size*
1. Washington and Oregon	250 breeding adults
2. Del Norte to Mendocino Counties, California	150 breeding adults
3. San Francisco Bay, California	500 breeding adults
4. Sonoma to Monterey Counties, California	400 breeding adults
5. San Luis Obispo to Ventura Counties, California	1,200 breeding adults
6. Los Angeles to San Diego Counties, California	500 breeding adults

Subpopulation sizes represent the best professional judgment of the Western Snowy Plover Recovery Team's technical subteam. Numbers are based on a site-by-site evaluation of historical records, recent surveys, and future potential (assuming dedicated, proactive management at breeding and wintering locations). Collectively, these numbers represent an approximately 70 percent increase in the Pacific coast population size from the time of listing. On a cumulative range-wide basis the recovery criteria are approximately 83 percent of the total of the "Management Goal Breeding Numbers" identified in Appendices B and C, which represent site-specific target populations under an intensive management scheme. The recovery criteria for population size and distribution for the Pacific coast population of the western snowy plover represent only a portion of its historical abundance and distribution.

To reach these subpopulation sizes will require proactive management to attain a level of productivity that will allow the population to grow. The population viability analysis (Appendix D) suggests that reproductive success between 1.2 to 1.3 fledglings per male per year, with adult survival of 76 percent and juvenile survival of 50 percent, provides a 57 to 82 percent probability of reaching a population of 3,000 western snowy plovers within 25 years. Enhancing productivity is critical to population growth. Once the population size criterion is met, a lower rate of productivity can sustain the population.

1a. A program is developed and implemented to monitor the western snowy plover breeding population and wintering locations (see Actions 1.1 and 1.2) to determine whether recovery unit subpopulation criteria are being achieved.

The monitoring program must include monitoring of population size and distribution, survival, and productivity. Monitoring population size and distribution are necessary as a means of measuring whether the recovery criterion is being met. Monitoring demographic characteristics such as survival and productivity also will be necessary to determine population trends and progress toward achieving the recovery criterion. The monitoring program should also assess whether management goals for breeding and wintering sites listed in Appendix B are being achieved. Collectively, the breeding management goal numbers are about 20 percent higher than the recovery criteria subpopulation sizes. Monitoring of individual sites will assist in determining the effectiveness of management actions and whether any refinements are necessary. Monitoring of wintering sites will assist in indicating whether survival of western snowy plovers is sufficient to make progress toward meeting breeding population size criteria.

When the species has recovered sufficiently to be delisted, the ongoing program of monitoring actions should be integrated into a post-delisting monitoring plan to cover a minimum of 5 years after delisting and ensure ongoing recovery and effectiveness of management actions. This monitoring plan should be developed and ready for implementation before delisting.

1b. A program is developed and implemented to monitor the site-specific threats identified in Appendix C (Action 1.3) and monitoring results are used to refine site-specific management actions identified in Appendix C.

In conjunction with monitoring of breeding subpopulation sizes and distribution and demographic characteristics, threats at each breeding and wintering site must be monitored in order to determine whether management actions are effective in increasing western snowy plover survival and reproduction. If threats continue limiting population increases, or additional threats are identified, management actions recommended in Appendix C may require modification.

1c. Management activities identified in Appendix C that are necessary to ameliorate threats and achieve increases in reproductive success, survival, and overall population size are incorporated into participation and management plans developed and implemented under Criterion 3.

Appendix C provides location-specific summaries of current management activities at western snowy plover breeding and wintering sites based on: 1) responses by public land managers and private conservation organizations to a survey prepared by the Recovery Team on western snowy plover management and beach use; and 2) supplemental information from the Recovery Team and from our field office staff. Appendix C also identifies additional management activities needed at each site to ameliorate threats and achieve management goals. These management recommendations are intended to provide preliminary guidance but additional management needs likely will be identified through monitoring, research, and site-specific experience.

1d. Research actions (Action 4) are completed and incorporated into management and participation plans and into monitoring plans.

Several research needs identified under Action 4 are necessary to refine and improve management activities for the western snowy plover and also to improve monitoring of western snowy plover population sizes, demographics, and threats. Improving and refining management actions will increase the effectiveness of management actions in increasing population numbers, survivorship, and productivity. Improved monitoring

techniques are needed to ensure that monitoring efforts are adequate to detemine whether recovery actions are successful and recovery criteria are being met.

Criterion 2. A yearly average productivity of at least one fledged chick per male has been maintained in each recovery unit in the last 5 years prior to delisting.

From currently available data, it is estimated that males must average one fledged young annually for population equilibrium (see Appendix D). Higher rates of productivity will be necessary to reach the target population size of 3,000 breeding adults. After this population size is achieved and maintained for a minimum of 10 years, a lower rate of productivity of one fledged chick per male will be necessary to maintain the population size at an average of 3,000 breeding adults. Monitoring programs developed and implemented under criteria 1a and 1b should continue throughout this period. We also assume that management designed to ameliorate threats (criteria 1c and 3) will continue through this period and after delisting.

Criterion 3. Mechanisms have been developed and are in place to assure long-term protection and management of breeding, wintering, and migration areas listed in Appendix B to maintain the subpopulation sizes and average productivity specified in Criteria 1 and 2.

Development of mechanisms to ensure long-term management and protection of western snowy plovers and their habitat are listed under Action 3, which outlines the recovery actions recommended to meet these recovery criteria. The recovery action outline section describes each action in detail. The recovery action outline lists all subactions necessary to fulfill the main recovery action. It also represents a prioritization of measures to be implemented. Completion of these actions will ensure that threats to western snowy plovers and their habitat are ameliorated and that management will continue after delisting to prevent a reversal of population increases.

3a. Working groups for each of the six recovery units are established.

Action 3.1 recommends the establishment of working groups for each recovery unit. Working groups should be diverse and include representatives from Federal, State, local, and private sectors. At present working groups are in existence for all recovery

units, and should continue to be maintained and meet regularly. The roles of the working groups are to coordinate and facilitate recovery efforts within each recovery unit, assess population trends, and carry out outreach activities.

3b. A participation plan for each recovery unit working group has been developed and implemented.

Each working group is tasked with developing a participation plan that delineates and prioritizes recovery activities within each recovery unit and for each location identified in Appendix B. These plans should identify the roles and responsibilities of each member of the working group and their commitments to carry out identified recovery actions.

3c. Management plans for all Federal and State lands identified in Appendix C have been developed and implemented.

Appendix C identifies the landowners of western snowy plover wintering and breeding sites. Many of the sites are owned or managed by Federal or State agencies. Development and implementation of management plans that incorporate the management goals and recommendations in Appendix C for all these sites are necessary to ensure that population goals are reached, threats ameliorated, and long-term protection and management of western snowy plovers and their habitat are in place.

3d. Mechanisms to protect and manage western snowy plover breeding and wintering sites identified in Appendices B and C are in place for all areas owned or managed by local governments or private landowners.

Appendix C also identifies many western snowy plover breeding and wintering locations that are owned or managed by local governments, private conservation organizations, or private landowners. These lands also require protection and management to ensure that population goals are reached, threats ameliorated, and long-term protection and management of western snowy plovers and their habitat are in place. Because of the diverse ownership and management of these lands, many different mechanisms may be used to ensure protection and management of these

locations. These mechanisms are further described in the recovery action outline and Appendices H and I.

3e. Public information and education programs are developed and implemented.

Outreach is a major component of developing and putting in place mechanisms to assure long-term protection and management of breeding, wintering, and migration areas listed in Appendix B. Outreach efforts will be needed to solicit participation of the many Federal, State, local, and private groups in recovery efforts and notify groups and individuals of recovery opportunities and incentives for the western snowy plover. Outreach efforts also must be used as a component of management of western snowy plovers and their habitats. These efforts will include informing the public and gaining their support for measures intended to protect western snowy plovers.

E. RELATIONSHIP OF RECOVERY ACTIONS AND CRITERIA TO THREATS

The goal of this recovery plan is to ensure the long-term viability of the Pacific coast population of western snowy plovers so that they can be removed from the Federal list of endangered and threatened species. The delisting process requires demonstrating that threats to the western snowy plover have been reduced or eliminated such that the species survival in the wild is assured. Table 8 lists the threats to the western snowy plover that have been identified during and since the listing process and indicates the actions and recovery criteria in the recovery plan that address each threat.

The western snowy plover faces multiple threats throughout its Pacific coast range. Major threats to the western snowy plover include habitat destruction and modification and lack of habitat protection mechanisms (listing factors A and D), disease or predation (listing factor C), and manmade factors that primarily result in disturbance or mortality of breeding birds (listing factor E). Effects of research on western snowy plovers (listing factor B) is also a threat but is comparatively minor and easily addressed through permitting processes. Many of the threats to western snowy plovers are interrelated or have complex interactions with each other. For example, coastal development that destroys or modifies habitat (listing factor A) also

results in increased disturbance from recreational activities (listing factor E) and in increased predator populations (listing factor C). Recovery actions and criteria therefore may address multiple threats.

The majority of threats to the western snowy plover, other than habitat destruction or modification, affect the western snowy plover's productivity (breeding success) and survival within otherwise suitable habitat. Criteria 1 and 2 are directed at determining whether the effects of threats on productivity and survival have been removed and expected population and productivity increases are being achieved. Threats addressed by these recovery criteria primarily fall under listing factors B, C, and E. Reduction and elimination of these threats, and the expected increases in productivity and survival, rely primarily on developing intensive management and monitoring programs for the western snowy plover. Criterion 3 is directed at achieving the management and habitat protections necessary to reduce and eliminate threats that fall primarily under listing factors A and D, but also address threats under listing factors B, C, and E that can be eliminated or ameliorated by ensuring long-term management.

Table 8. Threats to the Pacific coast population of the western snowy plover and steps within the recovery plan to reduce or eliminate threats.

Factor*	Threat	Action	Criterion
A	**The present of threatened destruction, modification, or curtailment of its habitat or range.**		
A*	Encroachment of introduced beachgrass and nonnative vegetation.	1.1-1.3, 2.2.1, 3.1-3.10, 4.1.1, 5.1-5.7	1b-d, 2, 3a-e
A*	Shoreline stabilization	1.1-1.3, 2.1, 3.1-3.10, 5.1-5.7	1b, 1c, 3a-e
A*	Urban development and construction	1.1-1.3, 2.1, 3.1-3.10, 5.1-5.7	1b, 1c, 3a-e
A	Dredging disturbance and tailings deposit	1.1-1.3, 2.1, 3.1-3.10, 5.1-5.7	1b, 1c, 3a-e
A*	Sand mining	1.1-1.3, 2.1, 2.2.2, 3.1-3.10, 5.1-5.7	3a-e
A	Beach nourishment with inappropriate design and/or sand type	1.1-1.3, 2.2.3, 3.1-3.10, 5.1-5.7	3a-e
A	Driftwood removal	1.1-1.3, 2.3.4, 3.1-3.10, 5.1-5.7	1b, 1c, 2 3a-e
A	Beach fires and camping	1.1-1.3, 2.3.3, 3.1-3.10, 5.1-5.7	1b, 1c, 2 3a-e

Factor*	Threat	Action	Criterion
A	Water course diversion, impoundment, or stabilization	1.1-1.3, 3.1-3.10, 5.1-5.7	1b, 1c, 3a-e
A	Habitat conversion for other species	1.1-1.3, 3.1-3.10, 5.1-5.7	1d, 3a-e
A	Operation of salt ponds	1.1-1.3, 3.1-3.10, 5.1-5.7	1b, 1c, 3a-e
B	**Overutilization for commercial, recreational, scientific or educational purposes.**		
B*	Egg collecting	1.1-1.3, 2.3.8	none, 1c
B	Studying and monitoring plovers	1.4, 1.5, 3.1-3.2, 4.3	1a-d 2
B	Banding	4.6	1a-d
C	**Disease or predation.**		
C*	Introduced nonnative predators	1.1-1.3, 2.4, 4.2, 3.1-3.10, 5.1-5.7	1b, 1c, 2 3a-e
C	Increased populations of native predators due to human influences	1.1-1.3, 2.4, 4.2,3.1-3.10, 5.1-5.7	1b, 1c, 1d, 2, 3a-e
C*	Predator attractants	1.1-1.3, 2.4, 4.2, 3.1-3.10, 5.1-5.7	1b, 1c, 1d, 2, 3a-e
C	Predation by domestic and feral cats	1.1-1.3, 2.4, 4.2, 3.1-3.10, 5.1-5.7	1a-d, 2, 3a-e
D	**The inadequacy of existing regulatory mechanisms.**		

Factor*	Threat	Action	Criterion
D*	Limited habitat protection under the Migratory Bird Treaty Act and State laws	2.3.8, 3.1-3.10, 5.1-5.7	3a-e
D	Conflicting beach management methods and mandates	1.1-1.3, 2.3.8, 3.1-3.10, 5.1-5.7	1b, 1c, 3a-e
D*	Sections 404 of Clean Water Act and 10 of Rivers and Harbors Act apply to limited amount of habitat	2.3.8, 3.1-3.10, 5.1-5.7	1b-d 3a-e
D*	Lack of protection in Baja California, Mexico	8	
E	**Other natural or manmade factors affecting its continued existence.**		
E*	Loss of nests and habitat due to natural events	1.1-1.3, 1.6, 2.1, 2.2, 2.3.8, 3.1-3.10, 4.4, 4.5, 4.10	1b, 1c, 3a-e
E*	Disturbance by pedestrians	1.1-1.3, 2.3.1, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2, 3a-e
E*	Disturbance by dogs	1.1-1.3, 2.3.1, 2.3.2, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2, 3a-e
E*	Disturbance by motorized vehicles	1.1-1.3, 2.3.5, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2, 3a-e

Factor*	Threat	Action	Criterion
E*	Disturbance by beach cleaning	1.1-1.3, 2.3.5, 2.4.1, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2, 3a-e
E*	Disturbance from equestrian traffic	1.1-1.3, 2.3.6, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2, 3a-e
E	Disturbance from fishing activities	1.1-1.3, 2.3.3, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2 3a-e
E	Disturbance by fireworks	1.1-1.3, 2.3.3, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2, 3a-e
E	Disturbance by kites and model airplanes	1.1-1.3, 2.3.3, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2, 3a-e
E*	Military exercises and aircraft overflights	1.1-1.3, 2.3.8, 2.3.9, 3.1-3.10, 5.1-5.7	1b, 1c, 2 3a-e
E	Large crowds associated with special events	1.1-1.3, 2.3.3, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2 3a-e
E	Increased coastal access to beaches	1.1-1.3, 2.3.1.2, 2.3.8, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2 3a-e
E	Livestock grazing	1.1-1.3, 2.3.7, 2.3.8, 3.1-3.10, 5.1-5.7	1b, 1c, 3a-e

Factor*	Threat	Action	Criterion
E	Oil spills and disturbance from oil spill clean-ups	1.1-1.3, 2.5, 4.7, 5.6	1b-d 3a-e 1b, 1c, 2 3a-e
E	Environmental contaminants	1.1-1.3, 4.8, 5.6	1b-d, 3a-e
E	Litter, garbage, & debris	1.1-1.3, 2.3.8, 2.4.1, 3.1-3.10, 4.9, 5.1-5.7	1b, 1c, 2 3a-e
E	Urban runoff and impaired water quality	1.1-1.3, 2.1, 2.3.8, 3.1-3.10, 5.1-5.7	3a-e
E	Management for other special status species	1.1-1.3, 1.7, 2.6, 2.7, 2.3.3, 3.1-3.10, 4.2.2, 5.1-5.7	3a-e

* Indicates threats originally identified during the listing process.

III. NARRATIVE OUTLINE OF RECOVERY ACTIONS

1 **Monitor breeding and wintering population and habitats of the Pacific coast population of the western snowy plover to determine effects of recovery actions to maximize survival and productivity.** To assure the long-term viability of western snowy plover populations, their populations and breeding and wintering habitat should be monitored and managed in a systematic, ongoing fashion. Systematic, ongoing monitoring of breeding birds and wintering birds should be undertaken at the recovery-unit level to measure progress towards recovery and identify management and protection efforts that are needed. In addition to the known breeding sites, all known wintering locations (Appendix B) are considered currently important to western snowy plover conservation. These sites include both wintering locations that currently support breeding birds and locations that may potentially support nesting birds in the future. These locations also may support migrating western snowy plovers. There is a need for better information about wintering and migration sites, including spatial and temporal use patterns, feeding areas, habitat trends, and threats. Appendix C, Table C-1 identifies 147 locations where monitoring western snowy plover populations is occurring or recommended to achieve management goals.

1.1. Annually monitor western snowy plover abundance, population size, and distribution at breeding and wintering locations in each recovery unit using window surveys. Comprehensive range-wide window surveys of breeding locations and wintering locations (Appendix B) should be conducted annually to determine population trends and fluctuations, and to determine whether management goal breeding numbers (Appendix B) are being achieved. The window survey described in Appendix J (Monitoring Guidelines) should be employed as the primary index of population size to minimize the probability of double-counting birds nesting at multiple locations during the same season. Window surveys are conducted over a relatively short time period to minimize double-counting of birds that change location during the season, but may not fully account for all breeding or wintering birds. Window survey methodology should be improved and correction factors estimated (Action 4.3.1) to improve the

accuracy and utility of population indices. This correction may require some banding at sites where there are currently no marked birds on which to base correction factors.

1.2 Develop and implement a program to monitor western snowy plover productivity and annual survival in each recovery unit. Development and implementation of a program to monitor western snowy plover productivity and survival, in addition to comprehensive population size and distribution monitoring, is necessary to measure progress toward achieving recovery criteria and to assess the effectiveness of management in removing threats that affect nesting success and survival. Results from this monitoring program also may be used to update the population viability analysis and assess progress toward recovery goals (Actions 4.11 and 6). Monitoring productivity and survival likely will be much more intensive than monitoring population sizes and distribution (Action 1.1), and cannot be implemented at all breeding sites because of insufficient color band combinations to monitor the entire Pacific coast population. Plans for monitoring these demographic characteristics instead should utilize methods to sample demographic characteristics across the breeding range and in each recovery unit. Actions 4.3.2 and 4.3.3 recommend developing methodologies to estimate productivity and survival. The monitoring program should incorporate these methods and should specify the number of sites sampled in each recovery unit, how sites will be selected, and indicate control sites from intensively monitored breeding locations (*i.e.*, the coast of Oregon, extreme northern California, and the shoreline of Monterey Bay).

1.3 Develop and implement a program to monitor at all breeding and wintering sites the habitat conditions, disturbances, predation, and other threats limiting abundance of breeding and wintering birds, clutch hatching success, chick fledging success, and survival. Monitoring of threats to the western snowy plover is necessary to determine effectiveness of recovery actions in ameliorating or eliminating threats, assess progress toward recovery, and refine site-specific managements as necessary. A standardized threats monitoring program

should be developed and applied to all breeding and wintering sites in conjunction with monitoring developed and implemented under actions 1.1 and 1.2. At a minimum, monitoring should include determining substrate characteristics and vegetation composition (level of nonnative species), frequency and levels of disturbance (*e.g.*, recreational activities, pets, vehicles, horses), and presence and abundance of predators. Appendix J (Monitoring Guidelines) provides general guidance on monitoring but may require revision as research actions under action 4 are completed. Opportunities to incorporate monitoring into Federal activities subject to section 7 of the Endangered Species Act, such as dredging and discharges regulated by the U.S. Army Corps of Engineers, should be utilized when possible.

1.4 Develop and implement training and certification programs for western snowy plover survey coordinators and observers, consistent with recommendations in Appendix J (Monitoring Guidelines). Classroom and field training are required for observers who survey for western snowy plovers, and before we can issue a section 10(a)(1)(A) permit. Instruction programs and materials should be developed for comparable training to occur throughout the western snowy plover range to improve consistency of data collection. Classroom topics should include, but not be limited to: (1) biology, ecology, and behavior of breeding western snowy plovers; (2) identification of adult plovers, their young, and their eggs; (3) threats to plovers and their habitats; (4) survey objectives, protocols, and techniques; (5) regulations governing the salvage of carcasses or eggs; (6) special conditions of existing recovery permits; (7) field identification of potential western snowy plover predators; (8) biology and behavior of predator and scavenger species; and (9) other activities (*e.g.*, banding). Field training should include, as appropriate: (1) locating, identifying, and monitoring nests; (2) handling eggs and capturing and handling adults or chicks; (3) specifics on the target activity for which a recovery permit is to be issued, or under which an observer will work; (4) practical field exercises; and (5) field review of appropriate classroom topics.

1.5 Develop a submittal system for monitoring data to ensure consistent reporting among recovery units and sites, and annually review and revise the system as necessary. Initially, range-wide survey data will be limited to results from 2 annual window surveys. As population and demographic monitoring methods are developed and implemented (Actions 1.1, 1.2, 4.3.1, 4.3.2, and 4.3.3), a more sophisticated reporting and compiling system will be necessary. Our lead office should coordinate with researchers involved with monitoring to ensure that data collection, submittal, and entry systems remain current, include correction factors that account for lack of detections during surveys, and are consistent among recovery units and sites. An annual range-wide report should be developed and distributed to all interested parties. Additionally, consistent reporting of sightings of banded western snowy plovers is needed. Sightings of banded birds provide information on the wintering sites of breeding birds, use of multiple sites by breeding and wintering plovers, and survival and dispersal of adults and juveniles. In accordance with procedures of the U.S. Geological Survey, Bird Banding Laboratory, the Point Reyes Bird Observatory should continue to act as the color band coordinator for the Pacific coast population to avoid use of duplicate color banding schemes among researchers.

1.6 Assess and evaluate new breeding, wintering, and migration areas as they are discovered to determine threats and management needs and update lists of areas identified in Appendices B and C as data become available. As new western snowy plover breeding and wintering areas are discovered, data should be collected to assess site boundaries, habitat characteristics, population levels, and any significant threats. The current list of important breeding and wintering locations (Appendix B) should be expanded or refined as appropriate, and any new areas incorporated into management and monitoring plans. Areas determined to be important for migration through action 4.4.4 also should be evaluated and added to the list of areas requiring protection, management, and monitoring. Management goals and needed management to ameliorate or eliminate threats should be developed for all new breeding, wintering, and migration

areas and should be included in periodic revisions of Appendices B and C of this recovery plan.

1.7 Annually coordinate monitoring of western snowy plovers and California least terns to minimize effects of disturbance to both species. Coordination with least tern monitors and managers is needed in all areas where western snowy plovers share breeding sites with California least terns. Coordination should take place at biannual pre-and post-season California least tern monitoring meetings. Protocols for monitoring California least terns should be revised as necessary so that western snowy plovers are not detrimentally affected. Human activities within some least tern colonies in southern California include monitoring by one to four people several days per week; maintenance of tern fences; predator management; site preparation; and banding/observation efforts. Human activities associated with tern monitoring must be recognized as additional disturbance to western snowy plovers. Section 10(a)(1)(A) permits, issued under the authority of the Endangered Species Act for western snowy plovers and least terns, should include both species where applicable. Monitoring efforts for both species should be kept separate because of differences in monitoring techniques and species' behaviors. Monitors of least terns and western snowy plovers should be aware of species' differences in nest spacing, brood-rearing, foraging behavior, time of breeding, vulnerability to disturbance, and monitoring and banding techniques.

Western snowy plovers generally begin nesting at least 1 month before the arrival of breeding least terns; thus, tern management often begins well after western snowy plovers have initiated nests. Site preparation (vegetation removal and fence construction) should be coordinated to minimize disturbance to nesting western snowy plovers, and if possible to enhance breeding success for both species (as well as considering other sensitive species, including plants, that may be present). Predator management also should be coordinated to benefit both species.

1.8 Develop post-delisting monitoring plan. Prior to delisting a five-year monitoring plan should be developed. Methodology and scope of post-delisting monitoring should be appropriately integrated with existing monitoring efforts for continuity and comparability. Monitoring and research results should be used to guide the long-term conservation of the species.

2 Manage breeding and wintering habitat of the Pacific coast population of the western snowy plover to ameliorate or eliminate threats and maximize survival and productivity. The Pacific coast population of the western snowy plover is sensitive to changes in productivity and in adult and juvenile survival rates (see Appendix D). Furthermore, recovery of this species is contingent on intensive management of breeding habitat and availability of wintering habitat for more than the current number of western snowy plovers (see recovery criteria). Appendix C provides a summary of site-specific management needs at 155 breeding and wintering locations (actions 2 and 3). Management efforts may be time-consuming, costly, and sometimes require intensive management. Western snowy plover breeding habitat is extremely dynamic and factors affecting breeding success, such as types and numbers of predators, can change quickly; therefore, managers should be prepared to modify protection as needed. Action 6 recommends annual review of progress toward recovery and revision of site-specific management actions based on monitoring and research results and site-specific experience. Management and protection of western snowy plovers on Federal and State lands are especially important. In addition, protection on Federal and State lands furnishes leadership by example to local land managers. Land managers should recognize that components of breeding habitat include: areas where plovers prospect for nesting sites, make scrapes, lay eggs, feed, rest, and rear broods. Breeding habitat also includes travel corridors between nesting, resting, brood-rearing, and foraging areas. Wintering and migration habitats should also be monitored and managed to maximize survival and recruitment of western snowy plovers into the breeding population.

2.1 Maintain natural coastal processes that perpetuate high quality breeding and wintering habitat by incorporating the following recommendations into development of participation plans, management planning, and habitat protection (action 3) for the sites identified in Appendix C and any additional sites identified through surveys and monitoring. The dynamic nature of beach strand habitats as storm-maintained ecosystems should be recognized and allowed to function. Natural process that contribute to maintaining wide, flat, sparsely-vegetated beach strands preferred by western snowy plovers include: inlet formation, migration, and closure; erosion and deposition of sand dunes; and overwash and blowouts of beach and dune habitat. Coastal development, beach stabilization, construction of rock jetties and seawalls, sand removal and dredging, water diversion and impoundment, and planting of nonnative vegetation interfere with these processes and result in loss and degradation of habitat.

Maintenance of natural coastal processes can be accomplished through establishment of management plans, conservation easements, fee title acquisition, zoning, and other means. Coastal development, beach stabilization, resource extraction, and water diversion and/or impoundment projects should be carefully assessed for impacts to wintering western snowy plovers. Recommendations from U.S. Fish and Wildlife Service offices (under the Endangered Species Act and Clean Water Act) and/or State agencies should focus on avoiding or minimizing adverse impacts to wintering habitat. Where adverse effects cannot be avoided, agencies should document impacts so that cumulative effects on this species' habitat can be assessed and compensated. When beach development cannot be avoided, the following protections should be implemented: (1) construction should take place outside the nesting season, (2) developers and others should be advised during planning stages that stabilization of shorelines will result in additional habitat degradation and that these impacts may affect evaluation and issuance of permits under the jurisdiction of the U.S. Army Corps of Engineers or State coastal management agencies, and of measures to minimize the impacts, (3) property owners (*e.g.*, hotel or resort owners) should tailor recreational

activity on the beach and dunes to prevent disturbance or destruction of nesting western snowy plovers, their eggs, and chicks, (4) lights for parking areas and other facilities should not shine on western snowy plover habitat, (5) sources of noise that would disturb western snowy plovers should be avoided, and (6) the establishment of predator perches and nesting sites should be avoided when designing facilities. Appendix C, Table C-1 identifies 86 locations which currently have development restrictions in place and 16 locations where development should be restricted or avoided to achieve management goals.

2.1.1 Develop a prioritized list of western snowy plover wintering and breeding sites where natural coastal processes need protection, or where impaired natural coastal processes should be enhanced or restored. Recovery Unit working groups should evaluate the sites within their recovery unit and determine where natural processes are likely to be disrupted or are in need of being enhanced or restored, or are of particular importance to maintaining high quality western snowy plover habitat. Sites should be prioritized based on their importance to western snowy plover breeding and the degree of threat to the western snowy plover and its habitat should natural processes be disrupted.

2.1.2 Identify mechanisms necessary to protect, enhance, or restore natural coastal processes for the sites identified in action 2.1.1 and implement through incorporating into actions 3.1 -3.10. Mechanisms to protect, enhance, or restore natural processes may include development of management plans that prohibit or restrict activities that disrupt natural process (*i.e.* dredging or sand removal, recreational activities that contribute to excessive erosion or compaction), acquisition of habitat, landowner agreements, local land use protection measures, or enhancement activities. Identification of these sites and mechanisms should be used to guide implementation of long-term management and protection under action 3.

2.2 Create and enhance existing and potential breeding and wintering habitat. Past and ongoing impacts to western snowy plover breeding habitat from development, artificial beach stabilization, and other projects have resulted in loss and degradation of western snowy plover habitat. Habitat enhancement and creation are needed at multiple sites to offset these losses. Where impacts cannot be avoided, projects should remediate and compensate habitat loss and degradation by maintaining natural long-shore sand budgets and minimizing interference with natural patterns of sand accretion and depletion. When these types of projects are planned, complex natural sand movement patterns should be taken into account. Beach management policies should recognize that many current erosion and sedimentation problems are the result of past property and/or inlet "protection" efforts. Habitat restoration projects in historic or potential breeding sites, where feasible, is encouraged. Creation of habitat should be emphasized in areas not subject to recreational impacts.

2.2.1 Remove nonnative and other invasive vegetation from existing and potential habitat and replace with native dune vegetation. Land managers should implement remedial efforts to remove or reduce vegetation that is encroaching on western snowy plover breeding habitat or obstructing movement of chicks from nesting to feeding areas. Particular attention should be given to the eradication of introduced beachgrass (*Ammophila* spp.) within coastal dunes.

2.2.1.1 Develop and implement prioritized removal and control strategies for introduced beachgrass and other nonnative vegetation for each recovery unit. These strategies should include early intervention to prevent expansion into breeding areas where introduced beachgrass and other nonnative vegetation have not yet spread or are in early stages of spreading. Attention also should be given to the removal of giant reed, Scotch broom, gorse, iceplant, and shore pine. Remove/manage vegetation on salt ponds, including levees.

Schedule/coordinate removal efforts to avoid disturbing nesting western snowy plovers. Appendix C, Table C-1 identifies 86 locations where removal of nonnative and other vegetation is either currently occurring or needs to be initiated to achieve management goals.

2.2.1.2 Replace exotic dune plants with native dune vegetation where it is likely to improve habitat for western snowy plovers. Land managers should make special efforts to reestablish native dune plants in western snowy plover nesting habitat, while concentrating on removal of nonnative vegetation. Native dune vegetation includes American dunegrass (*Leymus mollis*), beach morning glory (*Calystegia soldanella*), pink sand-verbena (*Abronia umbellata*), yellow sand verbena (*Abronia latifolia*), beach bursage (*Ambrosia chamissonis*), grey beach pea (*Lathyrus littoralis*), whiteleaf saltbush (*Atriplex leucophylla*), and California saltbush (*Atriplex californica*). These efforts should be targeted for coastal dune sites that currently support nonnative vegetation species such as introduced beachgrass (*Ammophila* spp), and should be combined with removal of this invasive plant. Seeds of local native dune plants collected within approximately 32 kilometers (20 miles) of the site to be planted should be used as replacement plant stock. Revegetation efforts should be monitored to ensure that the amount of vegetative cover is compatible with suitable breeding habitat for plovers.

2.2.2 Deposit dredged material to enhance or create nesting habitat. Near-shore (littoral drift) and on-shore disposal of dredged material seems to be beneficial for perpetuating high quality western snowy plover nesting habitat in some instances and should be encouraged where appropriate. However, monitoring of habitat characteristics before, during, and after projects is needed, particularly in cases of

large operations occurring on sites where western snowy plovers nest or are deemed likely to nest following the disposal operation. On-shore disposal of dredged material should be scheduled outside the nesting season and, where possible, during seasons when birds are not present. In addition, dredged material must be clean sand or gravel of appropriate grain size and must be graded to a natural slope.

2.2.2.1 Evaluate western snowy plover breeding and wintering sites listed in Appendix C and potential breeding sites to determine whether dredged materials may be used to enhance or create nesting habitat. Recovery Unit working groups should identify sites where dredged material may be used to enhance or create nesting habitat. Evaluation of sites should include impacts (short- and long-term) to existing western snowy plover habitat, likelihood of use by western snowy plovers, whether appropriate sources of clean dredged material exist, and opportunities to utilize material from dredging projects.

2.2.2.2 Develop and implement plans, including pre- and post-project monitoring, to use dredged material to enhance or create nesting habitat at the sites identified in action 2.2.2.1. Plans to implement use of dredged material to enhance or create nesting habitat should be developed for sites identified in action 2.2.2.1. Plans should include measures to minimize impacts to western snowy plovers and existing habitat and should include pre- and post-project monitoring to determine effectiveness of the project in enhancing or creating nesting habitat.

2.2.3. Implement beach nourishment activities if action 4.1.2 indicates beach nourishment activities are effective in enhancing western snowy plover habitat. Beach nourishment activities have the potential to enhance western snowy plover habitat, but should be carefully evaluated to weigh the probable adverse and beneficial effects on plovers and on other sensitive coastal dune species.

2.2.3.1 Evaluate and identify sites where beach nourishment activities may be effective in creating and enhancing western snowy plover habitat. Potential sites include those sites where natural coastal processes have been disrupted (*i.e*. by coastal development, beach stabilization, construction of rock jetties and seawalls, etc.). Evaluation of sites should consider potential for adverse effects to existing western snowy plover habitat, whether appropriate sand sources are available, and whether long-term benefits are likely to occur.

2.2.3.2 Develop and implement beach nourishment plans, including pre- and post-project monitoring for the sites identified in action 2.2.3.1. Plans to implement beach nourishment activities to enhance or create nesting habitat should be developed for sites identified in action 2.2.3.1. Plans should include measures to minimize impacts to western snowy plovers and existing habitat and should include pre- and post-project monitoring to determine effectiveness of the project in enhancing or creating nesting habitat.

2.2.4 Create, manage, and enhance coastal ponds and playas for breeding habitat. Coastal ponds and playas, including salt ponds, should be enhanced and created to improve breeding habitat. Significant opportunities for management of nesting plovers currently exist within San Francisco Bay salt ponds, Moss Landing

Wildlife Area, Bolsa Chica wetlands, and south San Diego Bay salt ponds. However, salt ponds should only be created or enhanced at existing salt pond habitat; they should not be used for mitigation or compensation of coastal beach-dune or other western snowy plover habitats. Creation of habitat should be emphasized in areas that would preclude or reduce recreational impacts. Appendix C, Table C-1 identifies 15 locations where habitat enhancement is either currently in place or needs to be initiated to achieve management goals. Additional sites also may provide opportunities to enhance western snowy plover breeding habitat.

2.3 Prevent disturbance of breeding and wintering western snowy plovers by people and domestic animals. Disturbance by humans and domestic animals causes significant adverse impacts to breeding and wintering western snowy plovers. Because human disturbance is a primary factor affecting western snowy plover reproductive success, land managers should give the highest priority to implementation of management techniques to prevent disturbance of breeding birds. Western snowy plover breeding and wintering sites are highly variable in their amount of recreational activity. Land managers should conduct site-specific evaluations to determine whether recreational activities, domestic animals, and off-road vehicles pose a threat to plovers and implement appropriate measures. As information is gathered, it should be incorporated into conservation efforts. Management plans (Actions 3.3.1, 3.3.2, and 3.4) should include appropriate human/domestic animal access restrictions to prevent disturbance of western snowy plovers. Management techniques described below can reduce impacts of beach recreation on western snowy plovers, but they must be implemented annually as long as the demand for beach recreation continues.

2.3.1 Prevent pedestrian disturbance. Management measures to protect western snowy plovers should be determined on a site-by-site basis; factors to consider include the configuration of habitat as well as types and amounts of on-going pedestrian activity. On national wildlife refuges and State natural preserves within the

California State Parks system, where protection of wildlife is the paramount purpose of Federal and State ownership, western snowy plover habitat should be closed during the breeding season. Other areas also should be closed when necessary to adequately protect breeding western snowy plovers.

2.3.1.1 Restrict access to areas used by breeding western snowy plovers, as appropriate. Unless a beach is closed to public entry, or use is minimal, posting and/or fencing of nesting areas is recommended to discourage pedestrian use of the area and allow for plover courtship and prenest site selection, to prevent obliteration of scrapes, crushing of eggs or chicks, and repeated flushing of incubating adults. Any access restrictions should be accompanied by outreach programs to inform the public of any restrictions and provide educational material on the western snowy plover (see action 5).

2.3.1.1.1 Seasonally close areas used by breeding western snowy plovers. Dates of seasonal closures/restrictions should be based on the best data available, and be coordinated by geographic region for consistency in communicating with the public. Closures may be determined on a year-to-year basis and other options such as fencing may be considered first. To provide broods with access to foraging areas, closures should cover the area down to and including the water line, where practical. Areas where territorial plovers are observed also should be closed to prevent disruption of territorial displays and courtship. Because nests can be difficult to locate, especially during egg-laying, closure of these areas will also prevent accidental

crushing of undetected nests. Appendix C, Table C-1 identifies 81 locations where public access is either currently restricted or it is recommended it be restricted to achieve management goals.

2.3.1.1.2 Fence areas used by breeding western snowy plovers. Fencing to keep people and beach activities out of nesting/brood rearing areas should not hinder chick movements, unless fencing is specifically meant to keep chicks from being harmed. Areas with a pattern of nesting activity in previous year(s) or where territorial plovers are observed should be fenced before plovers begin nest-site selection. Because nests can be difficult to locate, especially during egg-laying, closure of these areas will also prevent accidental crushing of undetected nests. Symbolic fences (one or two strands of 1/4 inch plastic-coated steel cable strung between posts) with signs identifying restricted areas substantially improve compliance of beach-goers and decrease people's confusion about where entry is prohibited. On portions of beaches that receive heavy human use during the breeding season, fencing of prime brood-rearing areas to exclude or reduce numbers of pedestrians also should be implemented to contribute to the survival and well-being of unfledged chicks. Appendix C, Table C-1 identifies 64 locations where nesting areas are fenced or where fencing is recommended to achieve management goals.

2.3.1.1.3 Post signs in areas used by breeding western snowy plovers. Areas with a pattern of nesting activity in previous year(s) should be posted before plovers begin nest-site selection. On portions of beaches that receive heavy human use during the breeding season, posting of prime brood-rearing areas to exclude or reduce numbers of pedestrians also should be implemented to contribute to the survival and well-being of unfledged chicks. Appendix C, Table C-1 identifies 65 locations where exclusionary signs are in place or recommended to achieve management goals.

2.3.1.2 Locate new access points and trails well away from western snowy plover nesting and wintering habitat, and modify existing access and trials as necessary. Recreational users such as campers, clammers, anglers, equestrians, collectors, *etc.*, should be encouraged to consistently use designated access points and avoid restricted areas. Roads, trails, designated routes, and facilities should be located as far away from western snowy plover habitat as possible. Recreationists using boats should be restricted or prohibited from areas being used by the western snowy plover. Appendix C, Table C-1 identifies 67 locations where boat use is currently and/or is recommended to be prohibited or restricted, and 81 locations where access is currently and/or is recommended to be prohibited or restricted to achieve management goals.

2.3.1.2.1 Evaluate existing and planned access at all breeding and wintering locations and determine whether access may adversely affect western snowy plovers and their habitat. Review of access points should include evaluating level of and timing of use by recreational users and level of effects on the western snowy plover.

2.3.1.2.2 For sites where access is determined in action 2.3.1.2.1 to adversely affect western snowy plovers, develop and implement plans to minimize effects. Actions that could minimize effects of access include seasonal restrictions, signs, fencing, or relocation or modification of access points or trails.

2.3.2 Implement and enforce pet restrictions. It is preferable that land managers prohibit pets on beaches and other habitats where western snowy plovers are present or traditionally nest or winter because any noncompliance with leash laws can cause serious adverse impacts to western snowy plovers. If pets are not prohibited, they should be leashed and under manual control of their owners at all times. Pets should be prohibited on beaches and other western snowy plover habitats if, based on observations and experience, pet owners fail to keep pets leashed and under full control.

Land managers should document the type and frequency of infractions of rules and regulations requiring pets on leash. This information, including the number of verbal warnings, written warnings, and notices to appear (citations), should be documented so that comparisons can be made between locations. This documentation could help ensure that adequate effort is being

made to enforce pet regulations. Appendix C, Table C-1 identifies 120 locations where pets are currently prohibited or restricted and where they are recommended to be prohibited or restricted to achieve management goals.

2.3.3 Annually review existing recreational activities at breeding and wintering sites listed in Appendix C and develop and implement plans to prevent disturbance from disruptive recreational activities where western snowy plovers are present. Some recreational activities may disrupt western snowy plover breeding and foraging, attract predators, destroy nests, or degrade habitat. Management of a variety of recreational activities is needed to minimize these effects. Special events, including sporting events, media events, fireworks displays, and beach clean-ups, attract large crowds and require special attention. Special events planned in western snowy plover nesting areas should not be held during the plover nesting season. Early planning and coordination with local resource agencies should be emphasized. Fireworks should be prohibited on beaches where plovers nest. When fireworks displays are situated to avoid disturbance to western snowy plovers, careful planning also should be conducted to assure that spectators will not walk through and throw objects into plover nesting and brood-rearing areas. Sufficient personnel also must be on-site during these events to enforce plover protection measures and prevent use of illegal fireworks in the vicinity of the birds.

Flying of kites and model airplanes should be managed to avoid adverse impacts in areas where nesting plovers are present. Sports such as ball- and frisbee-throwing should be managed within hitting and throwing distance of western snowy plover nesting areas because of tendencies for stray balls and frisbees to land in closed areas where they can smash nests and where efforts to remove them can disturb territorial or incubating birds. Camping and beach fires should be prohibited in western snowy plover

nesting areas during the nesting season. Appendix C, Table C-1 identifies 11 locations where kites are and/or should be prohibited and/or restricted to achieve management goals, but additional recreational activities also should be reviewed for potential adverse effects to western snowy plovers.

2.3.4 Inform beach users of restrictions on driftwood removal through posting of signs. Driftwood removal should not be allowed unless needed to create sufficient open habitat to induce nesting activities. In such cases, driftwood removal should occur outside of the breeding season. Appendix C, Table C-1 identifies 26 locations where driftwood collection restrictions currently occur and/or are recommended for restriction to achieve management goals. Driftwood removal should also be minimized through enforcement as identified in Action 2.3.8.

2.3.5 Prevent disturbance, mortality, and habitat degradation by prohibiting or restricting off-road vehicles, including beach-raking machines. Recreational off-road vehicles should be prohibited or restricted at western snowy plover breeding areas, as appropriate. Violations associated with unauthorized entry of recreational off-road vehicles into closed or fenced nesting areas should be strictly enforced. During the nonbreeding season, enforcement of violations regarding recreational off-road vehicle use should continue where western snowy plover use of beaches occurs year-round. Because of potential habitat degradation caused by mechanized beach cleaning, alternatives to this type of beach cleaning are recommended, including manual beach cleaning by agency staff and volunteers knowledgeable about the need to maintain coastal dune habitat characteristics and to protect western snowy plovers. Appendix C, Table C-1 identifies 101 locations where off-highway vehicles are currently and/or recommended for prohibition or restriction to achieve management goals.

Essential vehicles within western snowy plover nesting areas should: (1) travel on sections of beaches where unfledged chicks are present only if absolutely necessary; (2) when possible, travel through chick habitats only during daylight hours; (3) travel at less than 8 kilometers (5 miles) per hour; (4) use a guide familiar with western snowy plovers; (5) use open four-wheel motorized off-highway vehicles or nonmotorized all-terrain bicycles to improve visibility; (6) avoid driving on the wrack (marine vegetation) line and during high-tide periods; (7) travel below the high tide mark and as close to the water line as is feasible and safe; and (8) avoid previous tracks on the return trip.

2.3.6 Implement restrictions on horseback riding in nesting areas through annual coordination with commercial and private equestrian operations and groups. Strategies to reduce adverse impacts to nests from commercial and private equestrian use of western snowy plover habitat should include: (1) use of designated trail systems or, when absent, use of the wet sand area in areas not closed to the water line; (2) advance coordination with local resource agencies regarding locations of nests and broods; (3) compliance with closed or restricted areas; and (4) informing riders of the need for restrictions to protect habitats used by western snowy plovers and other sensitive coastal dune species. Avoid high-tide periods. Violations regarding unauthorized entry into closed or restricted breeding areas by equestrians should be strictly enforced. Appendix C, Table C-1 identifies 72 locations where restriction or prohibition of horses currently exists or is recommended to achieve management goals.

2.3.7 Implement and enforce restrictions on livestock in nesting areas through annual coordination with land managers, landowners, and grazing lessees. Strategies to reduce adverse impacts to nests from livestock grazing in western snowy plover habitat should include: (1) advance coordination with local resource agencies regarding locations of nests and broods; (2)

compliance with closed or restricted areas; and (3) informing landowners of the need for restrictions to protect habitats used by western snowy plovers and other sensitive coastal dune species. Violations regarding unauthorized entry into closed or restricted breeding areas by livestock should be strictly enforced. Appendix C, Table C-1 identifies 18 locations where restriction or prohibition of livestock currently exists or is recommended to achieve management goals.

2.3.8 Enforce regulations in areas used by breeding western snowy plovers. Land managers should monitor violations and enforce regulations within all closed and restricted areas, with particular attention to areas where nests or broods are present.

2.3.8.1 Determine enforcement needs for western snowy plover breeding and wintering sites and provide sufficient wardens, agents, or officers to enforce protective measures in breeding and wintering habitat. Wardens are especially needed on heavily-used beaches during the peak recreational season, which coincides with the western snowy plover breeding season in many locations. Federal, State, and local authorities should provide a coordinated law enforcement effort to eliminate activities that may adversely impact western snowy plovers, such as illegally-parked vehicles, trespassing off-road vehicles, pedestrians, pets in restricted areas, illegal or unauthorized activities (*e.g.*, fireworks, beach fires, driftwood removal), pets off leash, and littering. Patrols and enforcement are needed to ensure compliance and to make sure restrictive measures are successful. Specific actions to be implemented include patrols in protected areas (see action 2.3.8.2) and car patrols to prevent illegal driving and parking. Appendix C, Table C-1 identifies 105 locations where

enforcement of regulations currently occurs or is recommended to occur to achieve management goals.

2.3.8.2 Develop and implement annual training programs for enforcement personnel and others who work in western snowy plover breeding habitat to improve enforcement of regulations and minimize effects of enforcement actions on western snowy plovers and their habitat. Federal, State, and local enforcement personnel and others who work in western snowy plover habitat should be trained to be familiar with the Endangered Species Act and other wildlife conservation statutes, and with the measures recommended in this recovery plan. Training, especially specific training for professional law enforcement agents regarding investigation of potential wildlife and Endangered Species Act violations, should be coordinated with local U.S. Fish and Wildlife Service Law Enforcement offices. It is essential that wardens, whether professional or volunteers, (1) be thoroughly trained in procedures for conducting patrols in a manner that minimizes risk to plovers; (2) have at least basic knowledge of western snowy plovers for public education purposes; and (3) be trained to handle potentially confrontational situations. *In cases involving take of listed species, it is essential that investigations be conducted only by trained, certified, and professional law enforcement agents.* Our local Law Enforcement office should be informed *immediately* whenever evidence of suspected take of western snowy plovers is encountered.

Enforcement personnel should be instructed in measures that can minimize effects of enforcement actions on western snowy plovers. Where the extent of habitat to be protected is large, making foot patrols infeasible, horses,

four-wheel all-terrain vehicles/off-road vehicles, or nonmotorized all-terrain bicycles, are preferred over trucks, automobiles, *etc*., because they afford improved visibility for operators. Except during emergencies, vehicle speed should not exceed 8 kilometers (5 miles) per hour and horses should be ridden at a walk only. In addition to providing maximum visibility for operators, horse and foot patrols by uniformed personnel have the added advantage of providing informational/educational interactions with beach visitors to promote compliance with plover protection measures.

Enforcement and emergency response personnel (such as search and rescue, and fire) should be well aware of potential western snowy plover locations. These locations should be named as avoidance areas as a part of their plans and training exercises. Enforcement patrols should use the same access trails as beach visitors; if additional access points are needed, they should be the minimum necessary and as far away from nesting plovers as possible.

2.3.9 Develop and implement a program to annually coordinate with local airports, aircraft operations, and agency aircraft facilities to facilitate compliance with aviation regulations regarding minimum altitude requirements. Each recovery unit working group should develop a list of local airports, aircraft operations, and agency aircraft facilities within each recovery unit. Working groups, land managers, and the U.S. Fish and Wildlife Service should annually inform them of western snowy plover breeding areas that should be avoided by aircraft operations or where minimum altitude requirements should be enforced to minimize disturbance of western snowy plovers. Aircraft operations within western snowy plover habitat should require a minimum altitude of 152 meters (500 feet) for aircraft and a possibly higher altitude for

helicopters. Aircraft operations that have already established guidelines allowing aircraft to fly under the 152-meter (500-foot) threshold should raise the limits to this minimum threshold or higher as needed. Exceptions such as use for low-altitude military training should be addressed in coordination with the appropriate Fish and Wildlife Office through section 7 consultation.

Ultralight aircraft are a new potential source for negative effects to the snowy plover. Ultralight aircraft landed on nesting plover beaches at Point Reyes National Seashore in 2003. These aircraft are sometimes associated with an airport but often are kept on ranches or other private lands (S. Allen *in litt.* 2004).

In addition, land managers should report suspected violations of aviation regulations in western snowy plover nesting areas during the breeding season. Suspected violations and the aircraft's registration number should be reported to law enforcement officers and, if appropriate, the Federal Aviation Administration. If not in violation of aviation regulations (*e.g.*, helicopters), a description of the helicopter should be reported to law enforcement officers so they can notify the operator of the presence of, and potential for take of, western snowy plovers in nesting areas.

2.4 Prevent excessive predation for western snowy plovers. Land managers should employ an integrated approach to predator management that considers a full range of management techniques. Managers may need to reevaluate and clarify their policies on the management of predator populations and/or habitat where predation might be limiting local western snowy plover populations. In particular, policies that prohibit management of native predator populations, even when human-abetted factors have caused substantial increases in their abundance, may be counter-productive to the overall goal of protecting "natural" ecosystems.

In addition to predator management activities by on-site biologists, assistance from the U.S. Department of Agriculture (Wildlife Services

Branch) biologists, State wildlife agency furbearer biologists, biologists specializing in avian predators, and professional trappers should be sought and used as needed and appropriate. Federal, State, and local agencies and the general public should be aware of the adverse consequences to listed species if needed predator control measures are prohibited or restricted. Appendix C, Table C-1 identifies 61 locations where predator control currently occurs or is recommended to achieve management goals. Below are specific means of predator control.

2.4.1 Manage litter and garbage and its removal to minimize attracting predators on western snowy plover habitat. Litter and garbage in western snowy plover habitat may increase predation of western snowy plovers by providing food that attracts predators and encourages increased predator populations. Appropriate management of litter and garbage, particularly in areas that receive heavy recreational use, is needed to prevent or minimize excessive predation.

2.4.1.1 Implement and enforce anti-littering regulations. Litter should not be allowed in western snowy plover breeding areas to avoid attracting predators. Littering ordinances should be enforced year-round.

2.4.1.2 Evaluate the effects of current litter and garbage management on predation of western snowy plover at breeding and wintering sites. All sites in Appendix C should be evaluated to determine whether garbage and litter affect predation on western snowy plovers by attracting predators.

2.4.1.3 Develop and implement garbage and litter management plans for all sites identified in action 2.4.1.2 where litter and garbage contribute to predation on western snowy plovers. Plans for managing litter and garbage should be incorporated into

long-term protection and management efforts developed and implemented under action 3. Beachgoers should be discouraged from leaving or burying trash or food scraps on the beach. Trash cans should not be located on the beach unless there is no other recourse to prevent littering. Emptying cans in the evening instead of leaving them overnight is preferable. Fish-cleaning stations should be located well away from plover breeding areas. Land managers should supply covered or scavenger-proof trash receptacles at access points and away from western snowy plover habitat, and receptacles should be routinely emptied. Until predator-proof trash containers can be installed, existing trash cans should be emptied frequently to reduce attractiveness and availability of their contents to scavenging predators. Land managers should also provide toilets at access points and away from western snowy plover habitat to discourage people from using the dunes.

Although removal of trash from the beach reduces predation threats, beach-raking should be avoided year-round to protect breeding and wintering western snowy plovers (see action 2.3.5). Beach-raking of western snowy plover habitat also should be avoided because it removes plover food sources. Trash should be selectively removed from the beach manually, but natural materials, including shells, kelp, and driftwood, should be left intact (see action 2.3.4).

2.4.2 Annually identify predator perches and unnatural habitats attractive to predators and remove where feasible. Planners should not allow unnatural habitats or other predator attractants to be placed near western snowy plover nesting locations. Where feasible, land managers should remove from western snowy plover breeding locations any exotic vegetation, perches, and other

features that attract avian and mammalian predators. Where signs and fences are necessary as part of management to protect plover breeding areas, attempts should be made to design them in a way that will deter their use by predators (*e.g.*, install spikes on fence posts).

2.4.3 Erect predator exclosures to reduce western snowy plover egg predation and improve productivity (number of fledglings per male) where appropriate. Guidelines for the use of predator exclosures to protect nesting western snowy plovers are contained in Appendix F. Exclosures are a valuable tool for countering human-abetted predation threats to western snowy plover eggs, but they are not appropriate for use in all situations, nor do they provide any protection for mobile plover chicks, which generally leave the exclosure within one day of hatching and move extensively along the beach to feed. Exclosures should be used in conjunction with an integrated predator management program. Also, exclosures must be carefully constructed, monitored, and evaluated by qualified persons. In some areas, avian predators have learned over time to associate exclosures with a source of prey (J. Buffa *in litt.* 2004). String (twine) or a more substantial plastic stealth material may be needed on top of exclosures to deter avian predators. Appendix C, Table C-1 identifies 53 locations where exclosures are currently used or recommended for use to achieve management goals.

The use of exclosures (small circular, square, or triangular metal fences that can be quickly assembled) to deter predator and human intrusion is recommended as one of the most effective management tools to protect nests (see Appendix F for exclosure protocols). However, it should be recognized that while exclosures provide nest protection, they do not ensure survival of chicks to fledging age and may contribute to predation on adults, so their use should be evaluated carefully and may not substitute for other measures

that reduce human disturbance (2.3) or control predation (2.4.1, 2.4.2, 2.4.3, 2.4.5).

2.4.4 Evaluate the need for and feasibility of predator removal and implement removal where warranted. Where predators have been identified through monitoring to adversely affect western snowy plover breeding success and/or survival and cannot be adequately controlled through use of exclosures, land managers should evaluate the need for and feasibility of predator removal. Removal of predators should be pursued where it is feasible, warranted, humanely conducted, and useful. Situations that may especially warrant predator removal include those where nonnative predators such as red fox (*Vulpes vulpes regalis*), feral cats, and Norway rats (*Rattus norvegicus*) are present, where predators have been introduced to islands, where predator range extensions have been human-abetted, or where high rates of western snowy plover adult, chick, or egg predation (which cannot be countered with predator exclosures or other aversion methods) are occurring. Nonnative predators should be lethally controlled in plover nesting habitat. Native predators should be removed or controlled by nonlethal means whenever possible. Gulls also should be discouraged from establishing and expanding nesting colonies at western snowy plover nesting areas, and land managers should determine whether existing gull colonies warrant removal. If removal is not warranted, exclosures around plover nests should be used to prevent large flocks of roosting gulls from trampling plover nests.

Federal and State permits must be obtained to legally capture, kill, or hold and release birds protected under the Migratory Bird Treaty Act and State laws. Also, individuals responsible for capturing such birds and the holding facility must have the proper Federal and State permits, and Federal land managers must document that such activities are in compliance with the National Environmental Policy Act. Biological considerations for determining whether

removal of avian predators is appropriate include the time of year (to assess whether the predator is caring for young or is a fledgling itself), whether the predatory bird is a resident or migrating through western snowy plover nesting habitat, and whether the predatory bird is a sensitive species or listed under the Endangered Species Act. Because of the potential for swift and significant losses of plovers by avian predators, land managers should plan in advance to complete the necessary procedures and secure needed permits to effectively deal with cases of high negative impact on western snowy plovers. If feasible, removal of native predators should focus on problem individuals rather than populations. Possible control methods include egg addling, nest removal, translocation of problem individuals, and holding in captivity with later release after plover breeding season. State permits must also be obtained as appropriate for the capture and removal of problem mammals (*e.g.*, raccoons, skunks, and opossums). In 2001, the California Coastal Commission determined that predator management in western snowy plover habitat on Vandenberg Air Force Base was also subject to Coastal Consistency review under the Coastal Zone Management Act.

2.4.5 Remove bird and mammal carcasses in western snowy plover nesting areas. Where practical and not disturbing to western snowy plovers, dead birds and mammals that wash up on the beach in close proximity to plover nests should be removed to reduce the attraction of predators to plover nests. Removal of carcasses of marine mammals and species listed under the Endangered Species Act should be coordinated with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service.

2.5 Protect western snowy plovers and their breeding and wintering habitat from oil or chemical spills. Land managers should develop oil/chemical spill emergency response plans that provide for protection of known western snowy plover breeding areas. The U.S. Coast Guard should update their emergency response measures to include protective

measures for the western snowy plover. In the event of a spill in the vicinity of a western snowy plover nesting or feeding area, efforts should be made to prevent oil/chemicals from reaching these beaches. Clean-up operations should be prompt, but agencies should exercise special care during remediation efforts and coordinate closely with us to prevent accidental destruction of nests and/or excessive disturbance of breeding adults, nests, or chicks. Response plans should include applicable recommendations contained in this recovery plan (*e.g.*, Action 2.3.5 regarding essential vehicles).

Efforts must be made to minimize the likelihood of oil or chemical spills in plover wintering areas. Land managers should develop oil/chemical spill emergency response plans that provide for protection of known plover wintering areas. The U.S. Coast Guard should update their emergency response measures to include protective measures for the western snowy plover. Shorebird or coastal ecosystem protection plans developed by State or local agencies to address oil/chemical spills should also include protection measures for western snowy plovers. In the event of a spill in a known western snowy plover wintering area, efforts should be made to prevent oil/chemicals from impacting plovers and unavoidable impacts should be documented. Restoration efforts should begin expeditiously, but agencies should exercise special care and coordinate closely with us to prevent excessive disturbance to wintering western snowy plovers. Further, habitat restoration efforts must be conducted in compliance with the National Environmental Policy Act and the Coastal Zone Management Act.

If western snowy plovers or their habitat sustain injury due to oil/chemical spills, the responsible parties should restore the areas to their original condition or the Federal Government (U.S. Coast Guard) should lead the clean-up effort; appropriate claims should also be filed under the Natural Resource Damage Assessment regulations to recover damages and undertake relevant restoration work. Assessment of natural resource damages is facilitated by availability of baseline data on pre-spill conditions. Therefore, whenever possible, agencies that own or manage

western snowy plover habitat should collect baseline data on behavior, reproduction, distribution, abundance, and habitat use. The baseline information on plover distribution and habitat use should also be supplied to the Area Committees that develop and update regional spill contingency plans so that this information can be incorporated into pre-spill planning efforts for protection of sensitive environments and species. Oil spill emergency response personnel should be well aware of potential plover locations. These locations should be named as avoidance areas as a part of their training exercises. Appendix C, Table C-1 identifies 4 locations where contaminant removal is occurring or is recommended to achieve management goals.

2.5.1 U.S. Fish and Wildlife Service biologists should participate in Area Committees responsible for maintaining the Area Contingency Plans for the Pacific Coast to facilitate the updating of spill response plans to include protection of western snowy plovers. Active participation in the Area Committees would require funding for staff participation from the six U.S. Fish and Wildlife Service offices responsible for the coastlines of California, Oregon and Washington.

2.5.2 Assign monitors to beaches that are inhabited by western snowy plovers to protect western snowy plovers from injury during spill responses. Monitors would be responsible for identifying areas of beach that are in use by plovers and directing response personnel and vehicles around these sensitive areas. Potential monitors should be identified in advance, and, where necessary, retained under contract so they can begin work immediately in the event of a spill. Spill response may require approximately two weeks of cleanup work that should be monitored, with potentially five incidents of this magnitude per year.

2.6 Reduce adverse impacts of recovery efforts for other sensitive species, including those within the San Francisco Bay Recovery Unit, by compensating for the loss of western snowy plover breeding and wintering habitat. Management and recovery actions for other sensitive species carried out in western snowy plover habitat should be evaluated for adverse effects to western snowy plover habitat. All efforts should be made to conserve western snowy plover habitat and minimize adverse effects. Where this is not possible, any loss of western snowy plover habitat values should be compensated. Within coastal beach-dune habitats in Washington, Oregon, and California, compensation efforts should emphasize the removal of beachgrass (*Ammophila* spp.) for lost western snowy plover breeding habitat resulting from management for other sensitive species.

To compensate for the loss of existing western snowy plover breeding habitat values in San Francisco Bay from planned conversion to tidal marsh, appropriate salt ponds should be designated for protection and enhancement as western snowy plover breeding habitat. Currently, most western snowy plover breeding habitat occurs on levee roads, margins of active salt ponds, and pond bottoms of inactive salt ponds. Roads and levees provide lower quality habitat because of disturbance and ease of predator access. Any losses of western snowy plover breeding habitat should be replaced with habitat that provides similar or higher values (*i.e.*, salt ponds or salt pans) in concert with recovery actions implemented from the Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (U.S. Fish and Wildlife Service in prep.). Habitat enhancement for western snowy plovers should be phased in with scheduled tidal marsh restoration for other listed species. During this interim period, land managers should make all efforts to achieve the recovery criteria of 500 breeding adults within the San Francisco Bay Recovery Unit by intensively managing existing western snowy plover breeding habitat.

Any replacement of western snowy plover breeding habitat in San Francisco Bay should concentrate on areas where the necessary components of western snowy plover breeding habitat can be created.

These areas include locations where unvegetated salt pans, salt ponds, islets and levees, and tidal mudflats/sandflats can be created or enhanced. Also, attempts should be made to avoid areas that are adjacent to landfills or other high concentrations of potential predators. Unless it is shown to be infeasible, creation and enhancement of western snowy plover breeding habitat should be emphasized in areas that currently support high numbers of breeding plovers and/or are not conducive to salt marsh restoration. The area to be managed for western snowy plovers should be sufficient to support a population of 500 breeding birds, estimated at 809 hectares (2,000 acres) of managed salt ponds. Most of these managed salt ponds should be located in South San Francisco Bay, which supports most of the existing western snowy plover population; however, some should also be located in the North Bay. Created or enhanced salt ponds should be intensively managed, similar to the Moss Landing Wildlife Area salt ponds. Management measures practiced at these salt ponds include maintenance of water control structures to maintain desired water levels, removal of excessive vegetation, and predator control.

2.7 Discourage pinnipeds from usurping western snowy plover nesting areas. Land managers should monitor pinniped colonies adjacent to western snowy plover breeding habitat and seek to keep breeding pinnipeds from occupying western snowy plover nesting areas during the breeding season where possible. Where conflicts occur, breeding pinnipeds should be discouraged from hauling out at western snowy plover breeding areas or be relocated, if feasible. Implementation of this action should be coordinated with the National Marine Fisheries Service to ensure compliance with the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 *et seq.*).

2.7.1 In coordination with National Marine Fisheries Service, investigate feasibility and methods for discouraging pinniped use of western snowy plover nesting areas. Marine mammal populations have increased in many western snowy plover nesting areas. However, methods, effectiveness, and impacts of discouraging pinniped use of beaches are unknown and should be

investigated. Methods considered should be evaluated for their effects on western snowy plovers and their habitat as well as effectiveness in discouraging pinniped use. Workshops, such as those conducted by NMFS, for developing methods to reduce conflicts between pinnipeds and other species and human users should be held.

2.7.2 Identify areas where pinniped use is negatively affecting western snowy plover nesting and implement any appropriate methods identified in action 2.7.1. If effective methods are determined through action 2.7.1, sites where pinniped use negatively affects western snowy plover nesting should be identified and methods to discourage pinniped use implemented. Implementation of any methods to discourage pinniped use should be closely coordinated with the National Marine Fisheries Service to ensure compliance with the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 *et seq.*).

3 Develop mechanisms for long-term management and protection of western snowy plovers and their breeding and wintering habitat. Long-term management and protection will be needed on Federal and non-Federal lands to meet recovery criteria for each recovery unit and to meet management goals for individual breeding and wintering locations. Development of long-term protection mechanisms should include opportunities for participation of various stakeholders in development of management options.

3.1 Establish and maintain western snowy plover working groups for each of the six recovery units to facilitate regional cooperative networks and programs. Development of regional cooperative networks and programs, coordinating local public and private land use planning with State and Federal land use planning, recovery planning, and biodiversity conservation is needed (Figure 12). To facilitate and develop regional cooperative programs, working groups have been established for each of the six recovery units and should be maintained. U.S. Fish and Wildlife

Service field offices should facilitate exchange of information among working groups. The working groups should be composed of representatives from the Federal, State, local, and private sectors; and meet regularly to assess western snowy plover population trends and coordinate plover recovery efforts. Each of the six working groups should use this recovery plan as a guide, but members will prioritize in cooperation with our Arcata Fish and Wildlife Office what management measures need to be implemented in their recovery unit because they have on-the-ground, day-to-day, experience about what is currently being done in these areas. Working groups should assist with updating information contained in Appendices B and C, tracking whether management goals are being met, and recommending changes in management goals and site-specific management actions, if necessary. Public outreach also should be a major focus of the working groups. An interchange of ideas between all six working groups should also occur on an on-going basis.

3.2 Develop and implement regional participation plans for each of the six recovery units that outline strategies to implement recovery actions. The 1994 Interagency Cooperative Policy on Recovery Plan Participation and Implementation Under the Endangered Species Act (U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration 1994) provides for a participation plan process, which involves all appropriate agencies and affected interests in a mutually-developed strategy to implement recovery actions. Participation plans for implementing recovery actions for the western snowy plover that include all partners should be developed by each of the six recovery unit working groups. In addition to outlining a strategy to implement recovery actions, the participation plan should include strategies for evaluation of progress and needs for plan revision. Participation plans may also achieve the policy's goal of providing for timely recovery of species while minimizing social and economic impacts. Plans should identify and prioritize specific recovery activities for each location identified in Appendices B and C,while considering the needs of the entire Pacific coast population. They

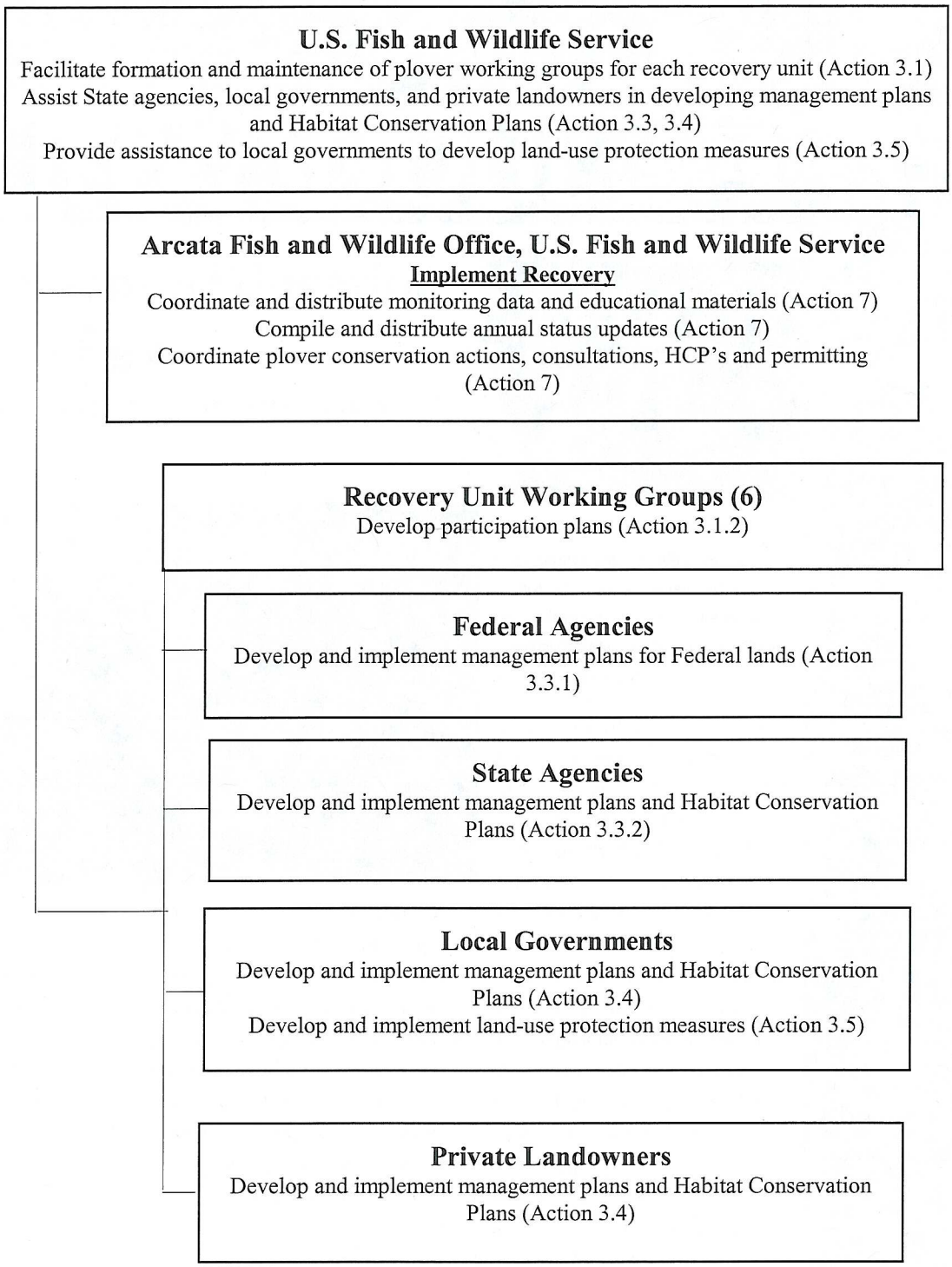

Figure 12. Chart of recovery planning and implementation efforts.

should include, but not be limited to: (1) endorsements by responsible agencies of their intent to seek economic resources for ongoing recovery actions; (2) outreach efforts to enhance the public's understanding of the western snowy plover's habitat needs (including an information and education strategy specific to area demographics and recreational activities); (3) economic incentives for conservation of western snowy plovers on private lands; and (4) all actions necessary to maintain western snowy plover productivity after delisting. Participation plans may also identify ways in which recovery actions for western snowy plovers will be covered as part of coastal ecosystem plans or other conservation measures.

3.3 Develop and implement management plans for all Federal and State lands to provide intensive management and protection of western snowy plovers and their habitat. Federal and State land managers should develop and implement management plans for all breeding and wintering locations (listed in Appendix B) that occur on Federal or State lands. Intensive management programs for western snowy plovers at national wildlife refuges should be implemented and annually evaluated to ensure they provide sufficient plover protection. Intensive management programs also should be implemented and periodically evaluated on lands administered by the National Park Service, U.S. Forest Service, U.S. Bureau of Land Management, U.S. Army Corps of Engineers, and Federal military bases, State wildlife areas, State ecological reserves, and State park lands (including State natural preserves and State seashores).

3.3.1 Develop and implement management plans for Federal lands. Federal agencies should develop or update, as appropriate, site-specific management plans that address threats to western snowy plovers, and adopt management measures for habitat protection and enhancement on Federal lands. Management plans should be implemented on an ongoing basis. Federal agencies also should review their proposed actions under the requirements of sections 7 and 10 of the Endangered Species Act prior to implementing the management plans because they may require authorization under section 7(a)(2) or 10(a)(1)(A).

3.3.2 Develop and implement management plans and habitat conservation plans on State wildlife areas, State ecological reserves, and State beaches. State agencies that manage State beaches, wildlife areas, or ecological reserves should develop and implement site-specific management plans and habitat conservation plans to minimize and mitigate impacts to western snowy plovers, and management measures for habitat protection and enhancement on State lands. State agencies should coordinate the development of habitat conservation plans with us and apply for section 10(a)(1)(B) permits under the Endangered Species Act if their management actions and allowed uses are resulting in incidental take of western snowy plovers.

3.4 Develop and implement habitat conservation plans or other management plans for western snowy plover breeding and wintering sites owned or managed by local governments and private landowners. We should provide assistance in the development of habitat conservation plans or other management plans to: (1) county and city governments that manage western snowy plover habitats; (2) private resource managers; and (3) owners of large amounts of private natural land. Habitat conservation plans are only required if an incidental take permit under section 10(a)(1)(B) of the Endangered Species Act is desired or required.

3.5 Provide technical assistance to local governments in developing and implementing local land use protection measures through periodic workshops. Federal and State agencies should assist local governments with jurisdiction over western snowy plover habitats in developing western snowy plover protection policies as part of new or revised local general plans, zoning policies, implementing measures, land use plans, comprehensive plans, and local coastal programs. For areas where beach closures are necessary, appropriate ordinances, administrative rules, and regulations should be developed by State and local governments to enable law enforcement officers to conduct necessary enforcement actions.

Technical assistance such as maps of western snowy plover habitats, identification of local threats, and recommended site-specific protective measures should be provided to coastal planners. At least two workshops within each recovery unit that provide local governments with basic information on the western snowy plover, its habitats, threats, and recommended protective measures should be conducted during the first 10 years of recovery plan implementation. Additional technical assistance likely will be required but should be provided on an as needed basis as new or revised general plans, policies, ordinances, and other land use protection measures are developed.

3.6 Develop and implement cooperative programs and partnerships with the California State Coastal Commission, the Oregon Department of Land Conservation and Development, the Washington State Parks and Recreation Commission, the Oregon Parks and Recreation Department, the California Department of Parks and Recreation, and the Oregon Department of Fish and Wildlife to ensure that they use their authorities to the fullest extent possible to promote the recovery of the western snowy plover. Federal and State agencies should assist the California State Coastal Commission, Oregon Department of Land Conservation and Development, Washington State Parks and Recreation Commission, Oregon Parks and Recreation Department, California Department of Parks and Recreation, and Oregon Department of Fish and Wildlife in reviewing, updating, and amending local coastal programs and policies for consistency with the western snowy plover recovery plan. This review should include protection of western snowy plover habitats, cumulative impacts to western snowy plovers, and policies or restrictive measures recommended in this recovery plan.

3.7 Obtain long-term agreements with private landowners. Agreements between Federal and State agencies and private landowners interested in western snowy plover conservation should be developed and implemented. Landowners should be informed of the significance of plover populations on their lands and be provided with information about available conservation mechanisms, such as agreements and incentive

programs. For private lands with potential occurrences of western snowy plovers, permission should be sought from landowners to conduct on-site surveys. If surveys identify plover populations, landowners should be informed of their significance and offered incentives to continue current land uses that support species habitat. Appendix C, Table C-1 identifies 69 locations where landowner cooperation/cooperative agreements are occurring or are recommended to achieve management goals.

3.8 Identify and protect western snowy plover habitat available for acquisition. Federal, State, and private conservation organizations should protect western snowy plover habitat as it becomes available, through fee title or conservation easement, *etc*. We and other organizations should identify sites that may become available for acquisition, and we should continue to evaluate excess Federal lands for western snowy plover habitat and apply to acquire them as they become available. Each recovery unit working group should develop a list of priority properties for acquisition, and Federal, State, and nongovernmental organizations should work with land conservancy groups to implement land trades and acquisitions. Management plans for the western snowy plover should be developed during the land acquisition process.

3.9 Ensure that section 10(a)(1)(B) permits contribute to Pacific coast western snowy plover conservation. Recommendations contained in this recovery plan should guide the preparation of habitat conservation plans under section 10(a)(1)(B) of the Endangered Species Act for western snowy plovers on the Pacific coast by providing information to: (1) guide potential applicants in developing plans that minimize and mitigate the impacts of take and (2) assist us in evaluating the impacts of any proposed conservation plans on the recovery of the Pacific coast western snowy plover population. The section 10(a)(1)(B) permit process may be a valuable mechanism for developing the long-term protection agreements called for in Actions 3.3.2 and 3.4, especially where significant population growth has already occurred and productivity exceeds l.0 fledged chick per male.

3.10 Ensure that consultations conducted pursuant to section 7 of the Endangered Species Act contribute to Pacific coast western snowy plover conservation. The recovery plan should also guide the evaluation of impacts to western snowy plovers pursuant to section 7(a)(2) of the Endangered Species Act. In evaluating these impacts, we and other Federal agencies should consider each of the breeding and wintering locations listed in Appendix B as important for recovery, and should also refer to the management goal breeding numbers for applicable locations and determine how the proposed project will affect those goals. Coordination with military bases which have western snowy plover populations is important to ensure that military activities do not affect the western snowy plovers or their habitat. Appendix C, Table C-1 identifies 54 locations where military uses are either restricted or recommended for restriction to achieve management goals.

4 Undertake scientific investigations that facilitate recovery efforts. Major gaps remain in our understanding of useful protection measures and conservation efforts for the western snowy plover. These include effective methods for habitat restoration, predator control, and monitoring population numbers and demographic characteristics.

4.1 Investigate effective methods for habitat restoration.

4.1.1 Evaluate the effectiveness of past and ongoing methods for habitat restoration by removal of introduced beachgrass and identify and carry out additional investigations necessary. Land managers, in coordination with recovery unit working groups, should summarize methods used to date for removal of introduced beachgrass and review their effectiveness. They also should pursue any additional field studies necessary to determine the most effective and cost-efficient methods for habitat restoration through removal of introduced beachgrass. Controlled studies with improved monitoring would provide needed direction for management decisions.

4.1.2 Evaluate the impacts and potential benefits of past and ongoing beach nourishment activities and identify and carry out any additional studies necessary to determine effects of beach nourishment activities on western snowy plover habitat. Beach nourishment activities should be carefully evaluated to weigh the probable adverse and beneficial effects on plovers and on other sensitive coastal dune species. Pre- and post-deposition beach profiles and faunal studies (including invertebrates) should be conducted to determine effects on habitat suitability for western snowy plovers. Consideration should be given to whether the projected long-term benefits are likely to occur.

4.2 Develop and test new predator management techniques to protect western snowy plover nests and chicks. Because many of the techniques currently used to reduce predation have disadvantages or limitations in effectiveness, new predator management techniques should be investigated. Assistance from the U.S. Department of Agriculture, Wildlife Services Branch, from State wildlife agency furbearer biologists, and other predatory bird and mammal specialists should be sought on these matters.

4.2.1 Develop higher-efficiency nest exclosures. Because exclosures must be deployed quickly, and currently-designed exclosures are heavy and labor- and time-intensive to erect, new exclosure designs should be tested. Prototypes should include lightweight materials that are easier to transport and a design that is easy to assemble and install.

4.2.2 Develop California least tern exclosures that prevent harm to western snowy plovers. Resource managers should continue to investigate modified designs for California least tern enclosures to further minimize western snowy plover mortality.

4.2.3 Identify, prioritize, and carry out needed investigations on control of native and nonnative predators. Aspects of the

ecology of problematic avian predators (*e.g.*, ravens and shrikes) and native mammals (*e.g.*, coyotes and gray foxes) that could be used to gain an understanding of how to control their impact on western snowy plover nesting areas during the plover breeding season should be investigated. Information also is needed on the applicability and usefulness of other control methods, including aversive techniques for conditioning predators to avoid foraging in western snowy plover nesting areas or preying on western snowy plover eggs, chicks, or adults. Investigation is also needed to develop methods to discourage gull colonies. Aversive techniques may include taste aversions, displaying predator carcasses, or installing electric fences. Effective modifications of signs and fencing to prevent their use as predator perches also requires investigation. While in many cases there appear to be practical obstacles to development of effective aversion techniques that can be efficiently applied in the field, the goal of reducing predation with minimum disruption to native predator populations that are important to overall ecosystem balance is desirable and any methods that appear potentially practical and useful should be evaluated for success and cost-effectiveness. Initial study trials might be done at sites or seasons where western snowy plovers are not present in order to minimize unplanned adverse impacts. Recovery unit working groups should identify and prioritize studies needed and inform us of their recommendations.

4.2.4 Identify, prioritize, and carry out needed investigations on predator management at the landscape level. Resource managers should investigate landscape-level management of predators that inhabit western snowy plover nesting areas. This management could include removal of predator nest sites and other predator attractants or habitat on lands surrounding western snowy plover breeding areas. Recovery unit working groups should identify and prioritize studies needed and inform us of their recommendations.

4.2.5 Investigate techniques for identifying predators responsible for individual nest predation events. Techniques should be developed to identify predators responsible for nest predation events so that appropriate management measures can be applied. Such techniques could include installation of a remote video camera to monitor western snowy plover nests and exclosures and identify problematical predators.

4.3 Improve methods of monitoring population size and reproductive success of western snowy plovers. Methods used to monitor western snowy plover populations have differed over time and from site to site. To measure progress toward recovery reliably, standard monitoring guidelines have been developed (Appendix J). Logistical and financial constraints likely will preclude complete coverage of all areas, so sampling methods should be developed.

4.3.1 Improve methods of monitoring western snowy plover population size. Not all western snowy plovers at a given location are detected during a single survey, such as the annual breeding-season window survey. Consequently, correction factors are necessary to extrapolate population size from window surveys. Correction factors are determined on a site-specific basis. Intensive monitoring and/or color banding make it possible to know the number of western snowy plovers present at a site. When a window survey is completed, the ratio of the total number of western snowy plovers to the number of western snowy plovers counted provides a correction factor that may be used for future window surveys of the site and for other sites with window surveys but without intensive monitoring. Site-specific correction factors should be obtained for all major nesting locations. When correction factors have been determined for many sites, patterns may emerge that allow correction factors to be applied more broadly.

4.3.2 Develop sampling methods for annually estimating reproductive success within each recovery unit. While it is extremely valuable to monitor clutch hatching success and chick fledging success at each site as a measure of habitat quality, it is critical to determine the number of young fledged per male for each recovery unit to measure the potential for population stability and growth. Measuring the number of young fledged per male requires intensive monitoring, and at sites with large numbers of birds, some method of identifying individual males. Extensive color banding of adults and their young, enabling determination of young fledged per male, has been undertaken in large portions of coastal Oregon, the shoreline of Monterey Bay, and coastal San Diego County for the past several years. These efforts should continue. Since there are insufficient color band combinations to monitor all individuals in every recovery unit, sampling procedures should be developed to color band adequate samples of males, and if necessary their chicks, in the other recovery units to obtain estimates of the number of young fledged per male. Color banding for measuring reproductive success should be integrated with banding for estimating population size.

4.3.3 Develop methods to monitor western snowy plover survival rates within each recovery unit. Extensive color banding of adult plovers and their young in coastal Oregon, the shoreline of Monterey Bay, and coastal San Diego County has enabled survival rates of adults and young to be calculated for several years (see Population Status and Trends and Survival sections). These efforts should continue. Information on survival rates of birds from other recovery units can be derived from birds banded for monitoring reproductive success or estimating population size.

4.4 Conduct studies on western snowy plover habitat use and availability.

4.4.1 Identify western snowy plover brood habitat and map brood home ranges. Brood movements should be mapped and distances

quantified to identify how large an area must be protected for broods. Determine home ranges of western snowy plovers through radio telemetry studies. Traditionally used brood habitat should be identified and protected through actions 2 and 3.

4.4.2 Identify components of high-quality western snowy plover brood rearing habitat. The elements of high-quality brood habitat should be determined to facilitate creation and enhancement of suitable characteristics at other breeding locations.

4.4.3 Quantify wintering habitat needs of western snowy plovers along the Pacific coast. The amount of habitat needed to support wintering western snowy plovers along the Pacific coast should be determined. This effort should include estimating the numbers of western snowy plovers that can be supported at wintering locations listed in Appendix B and identifying important site characteristics. This action will require consideration of wintering habitat quality along the Pacific coast of the United States and Mexico, and quantifying the combined interior and coastal populations.

4.4.4 Identify any important migration stop-over areas used by migrating but not by breeding or wintering western snowy plovers. Additional information on western snowy plover migration patterns is needed because migration involves expenditure of energy that may affect survival or productivity. Although monitoring and protection of breeding and wintering locations are currently higher priorities than protection of migration sites, further investigations of, and protective measures for, migration sites should be undertaken when feasible. Threats and management needs of identified migration stop-over habitat should be evaluated and included in management monitoring, and protection tasks (see action 1.6).

4.5 Develop and implement a research program to determine causes of adult western snowy plover mortality, including investigation of possible causes, magnitude, and frequency of catastrophic mortality. Determine causes of mortality and the stage in the annual cycle (*e.g.*, post-breeding, migration, winter, pre-breeding, breeding) at which mortality occurs for each sex and age class. This assessment can be done through intensive, bi-weekly monitoring to determine relative health and potential for disease. Monitoring could include fat content and weight related to the season.

4.6 Improve techniques for banding western snowy plovers. Improve the technique for banding birds to reduce injuries. Because western snowy plover injuries are usually associated with Federal metal bands but not with plastic bands, removal of U.S. Fish and Wildlife Service lettering from the inside of the metal band should be investigated. Eliminating use of the U.S. Fish and Wildlife Service metal band also should be considered. Experimentation with new techniques must be conducted cautiously and may need to include pre-testing on nonlisted surrogate species.

4.6.1 Compile information regarding number and types of banding injuries to western snowy plovers to determine extent and causes of banding injuries. Several banding injuries to western snowy plovers have been reported. However, there is currently no consistent reporting of injuries to determine the extent or types of injuries. Working groups should compile information on banding injuries to use in determining the type and extent of the problem and in developing a course of action. Information collected should include number of injuries, type of injury (abrasion, foot loss, broken leg, *etc.*), probable cause of injuries (foreign object lodged between band and leg, wearing of band, *etc.*), effect of injuries on behavior (breeding, foraging, predator avoidance), type of bands (plastic or metal) associated with injuries, whether metal bands had writing on the inside or other rough areas likely to cause abrasion or lodging of foreign object.

4.6.2 Review compiled information and determine and implement a appropriate course of action to minimize banding injuries. The information complied in step 4.6.1 should be reviewed to determine the appropriate course of action to minimize banding injuries. Review may reveal that banding injuries are rare or have little impact on breeding success or survival, in which case no changes to banding procedures may be necessary. However, extensive numbers of injuries or impacts on breeding success and survival may require actions such as changing the location of metal bands from the tarsus to tibiotarsus, discontinuing use of metal bands, or using different band types. All decisions regarding changes to banding procedures should consider effects of such changes to the type, quantity, and quality of data that may be gathered from banding efforts, and whether such changes will affect the ability to determine population trends, monitor success of management actions, or otherwise affect recovery efforts. For example, discontinuing use of metal bands may affect the ability to gather information on survival, longevity, and dispersal useful in analyzing population viability.

4.7 Identify effects of oil spills on western snowy plovers. Research should be conducted on the direct and indirect effects of oil spills on western snowy plovers, including, but not limited to: (1) how oil spills affect the plover's prey base; (2) chronic effects of oiling; (3) transmission of oil on partially-oiled birds from the breast to the egg; (4) at what stage oiled plovers need to be captured or re-captured; (5) preferable methods to remove oil from soiled birds; and (6) impacts to plovers during oil clean-up and remediation activities.

4.8 Monitor levels of environmental contaminants in western snowy plovers. When abandoned eggs and/or dead chicks that are not needed for law enforcement investigations become available, they should be collected for potential contaminants assessment. Egg removal and salvage of dead chicks should only be done by individuals possessing proper Federal and State authorizations. Chemical analysis of salvaged specimens should be

coordinated through our Division of Environmental Contaminants. All salvaged eggs should be analyzed for organochlorine pesticides, total polychlorinated biphenyls (PCB's), selenium, mercury, and boron.

All sampling should be opportunistic, based on availability of eggs that are known to be abandoned. Eggs should never be removed from the beach as long as there is any realistic chance that they might hatch. In the case of unhatched eggs from a partially hatched clutch, eggs should not be collected until at least 36 hours after the known hatch date of the other eggs. Full clutches should not be collected unless it is known that 35 or more days have elapsed since the last egg was laid. When this opportunistic sampling of failed eggs indicates potential problems with contaminants, follow up studies should be carried out (see action 4.9).

4.9 Design and conduct contaminants studies if monitoring of contaminants in action 4.8 indicates potential contaminants effects. When opportunistic sampling of failed eggs (action 4.8) indicates potential problems with contaminants, additional studies should be carried out to evaluate the extent of contamination in western snowy plover diets, its effects on nest success and egg hatchability, and its effects on various life stages of snowy plovers (eggs vs. adults). Thresholds when management action is required should be identified. When the target threshold is exceeded research should be conducted to identify the source.

4.10 Identify, prioritize, and carry out needed investigations of the effects of human recreation on western snowy plovers. Many studies on the effects of recreational activities on western snowy plovers have already been conducted. To avoid duplicating previous or ongoing efforts, recovery unit working groups should evaluate and prioritize additional study needs to determine the effects of human recreation on western snowy plover. Western snowy plover should be monitored for effects from recreational activities such as off-road vehicle riding, horseback riding, walking, jogging, fishing, aircraft, ultralight aircraft, and kite-flying.

4.11 Revise the population viability analysis (Appendix D), if needed, when sufficient additional information on demographic characteristics (survival rates, reproductive success) is available from each recovery unit and information is obtained on the probability and magnitude of catastrophic mortality events. As new information on population numbers, survival rates, and reproductive success are acquired from monitoring (actions 1.1 and 1.2), monitoring techniques are improved (action 4.3), and mortality sources and rates of mortality are determined (action 4.5), the population viability analysis should be reviewed and revised if additional information differs significantly from that used to construct the original analysis.

5 Undertake public information and education programs. Expanded efforts are needed to increase public awareness of the needs of western snowy plovers, other rare beach species, and the beach and dune ecosystem. Public outreach efforts should be a major focus of each of the working groups for the six recovery units. Appendix C, Table C-1 identifies 84 locations where public information and education is either currently occurring or is recommended to achieve management goals.

5.1 Develop and implement public information and education programs. Millions of beach recreationists come in contact with western snowy plover nesting and wintering areas each year. Disregard to signs, symbolic fencing, and leash laws by beach users can directly affect the productivity and health of western snowy plovers on those beaches. Public information and education efforts play a key role in obtaining compliance of beach recreationists with plover protection measures that, in turn, affect the birds' recovery. Central messages to the beach-going public include: (1) respect areas fenced or posted for protection of plovers and other rare beach species; (2) do not approach or linger near western snowy plovers or their nests; (3) if pets are permitted on beaches used by plovers, keep the pets leashed; (4) don't leave or bury trash or food scraps on beaches, as garbage attracts predators that may prey upon plover eggs or chicks; and (5) do not build wood structures that can be used as predator perches.

Because of the importance of information and education for the western snowy plover recovery effort, as part of this recovery plan, we developed an Information and Education Plan for the Western Snowy Plover, Pacific coast population (Appendix K).

5.2 Inform Federal, State, and local resource/regulatory agencies and local planning departments of threats to breeding and wintering western snowy plovers and their habitats. Periodic meetings and/or workshops should be held to inform Federal, State, and local resource management and regulatory agencies, and city and county planning departments about threats, research, and management needs for plovers. A network of public agency staff from each of the six recovery unit working groups should develop a coordinated approach to present this information to these agencies periodically, or as needed.

5.3 Develop and maintain updated information and education materials on western snowy plovers. Members of the six recovery unit working groups should develop new western snowy plover information and education materials for target audiences to stimulate public interest and awareness. In addition, all materials should be kept reasonably current regarding the status of the species and protection efforts. These materials should also explain the need for conservation of the beach and dune ecosystem and the plight of other rare beach-dwelling species. Videos detailing needed western snowy plover recovery actions by location and recovery unit should be developed, and might be efficiently produced in conjunction with updated public service advertisements.

5.4 Alert landowners and beach-goers about access restrictions within western snowy plover habitats. Land managers should begin providing informational and educational outreach at least 2 weeks prior to the onset of the nesting season to provide beach-goers and interested landowners with advance notice of impending restrictions on publicly-owned western snowy plover breeding habitats. This outreach is particularly important for the first year of restrictions. If necessary,

follow-up publicity that includes information on citations issued to violators should be implemented to help reinforce the message.

5.5 Provide trained personnel to facilitate protective measures, provide public education, and respond to emergency situations. Biologists, docents, volunteers, and other personnel should be trained to patrol western snowy plover nesting areas to monitor birds, distribute educational materials, respond to emergency situations, and ensure that beach-goers stay out of fenced areas and adhere to other plover protection measures. Biologists engaged in monitoring, management, or research activities should also advance the public's understanding of plover management needs.

5.6 Develop protocols for handling sick, displaced, injured, oiled, and dead birds or salvaged eggs. Land managers within each recovery unit should develop protocols for all trained personnel identifying who should be contacted when injured, dead, oiled, or displaced birds are found, and who is permitted to handle these birds. Federal and State salvage permits are necessary for the disposal of dead birds and the transportation of injured birds. Federal and State endangered species permits are necessary for wildlife rehabilitators to accept and care for injured and sick birds. Coordination with biologists that are monitoring and banding western snowy plovers is essential for capture and release of injured/rehabilitated birds. Live chicks that are found should not be moved or taken for rehabilitation as these chicks are often not abandoned, even though plover adults may not be obvious at the time the chicks are seen. Protocols should also be developed on how to collect and preserve salvaged eggs used for contaminants analysis.

5.7 Establish a distribution system and repository for information and education materials. Land managers must distribute information and education materials to target audiences. To reach the large population of potential beach-goers within a few hours' drive of many major metropolitan areas, broad-scale information and education mechanisms should be implemented, including distribution by mass media such as

newspapers, radio and television announcements, and internet web sites. Land managers should also focus their information and education efforts on user groups at beach parking lot entry stations and kiosks, visitor centers, marinas, beach-front housing developments, equestrian and angler access points, and locations providing off-road vehicle permits. Public outreach efforts should be directed to groups within the geographical location of the managed beaches (*e.g.*, to private and commercial equestrian users) and to groups outside of the area who use the beaches on a regular or seasonal basis (*e.g.*, to off-road vehicle associations from out-of-state or inland locations). Land managers, with the help of docents and volunteers, should coordinate with local school teachers to develop and present environmental education lesson plans and participatory activities for elementary and middle school groups.

We will act as a central repository for current and new information and education materials received; upon request, we will make these materials available to recovery unit working groups and the general public. We will also maintain information on western snowy plovers at our website (http://www.fws.gov/arcata). Major distributional efforts should also continue by Federal, State, and local agencies, and private conservation organizations.

5.8 Establish a reporting and distribution system for annual monitoring data and management techniques. Our Arcata Fish and Wildlife Office should coordinate and produce an annual report of submitted breeding and wintering monitoring data and distribute it to recovery unit working groups. This report should describe results of monitoring throughout the western snowy plover population's range. A distribution system should also be established for sharing information on predator management techniques, nest protection, etc. among working groups.

6 Review progress towards recovery and revise recovery efforts as appropriate. Communication, evaluation, and coordination play a major role in western snowy plover recovery efforts. Land managers within each of the six recovery unit working groups should review the effectiveness of their

management activities in coordination with other members of their working group, and revise management measures as appropriate. They should also provide results of annual population monitoring and the effectiveness of management activities to their working group and to our Arcata Fish and Wildlife Office.

6.1 Develop and implement a tracking process for the completion of recovery actions and the achievement of delisting criteria. A tracking process should be developed to track the completion of recovery actions and progress toward delisting. Utilizing information from specific actions, the recovery criteria such as the implementation of management activities can be tracked. Information from the tracking process can be used in outreach and in helping identify when the western snowy plover can be delisted.

6.2 Review progress toward recovery annually within each recovery unit working group and revise site-specific recovery efforts as appropriate to meet recovery goals. Communication, evaluation, and coordination play a major role in western snowy plover recovery efforts. Land managers within each of the six recovery unit working groups should review the effectiveness of their management activities in coordination with other members of their working group, and revise management measures as appropriate. They should also provide results of annual population monitoring and the effectiveness of management activities to their working group and to our Arcata Fish and Wildlife Office.

Additionally, the working groups in conjunction with land managers should review success in meeting management goal breeding numbers recommended in Appendix B, and develop recommendations for any necessary revisions to those numbers based on site-specific conditions. Ongoing and needed management activities recommended in Appendix C also should be evaluated and revised according to site specific conditions. Revisions to management goals and management activities should be provided to our Arcata Fish and Wildlife Office.

6.3 Assess the applicability, value, and success of this recovery plan to the recovery of the western snowy plover every 5 years until the recovery criteria are achieved. Rather than revising the entire recovery plan, it is proposed that minor revisions, clarifications, and prioritization changes be made through an addendum, to be produced and distributed every 5 years. This addendum would address data gaps identified in this version of the recovery plan including recommended management prescriptions, specific habitat management recommendations, management goal breeding numbers, directed surveys; and necessary changes discussed in previous recovery actions. It would provide a summary of the recovery actions implemented to date, and it would be a forum to solicit comments from the Recovery Team, stakeholders, and others interested parties on any proposed major changes. Major changes, elimination, or addition of recovery actions may initiate a revision.

6.4 Prepare a delisting package for the Pacific coast population of the western snowy plover. If actions 6.1 through 6.3 indicate recovery criteria have been met, actions to ameliorate or eliminate threats have been implemented and determined to be effective, and analyses of threats demonstrate that threats identified during and since the listing process have been ameliorated or eliminated, prepare a delisting package.

6.5 Prepare and implement a post-delisting monitoring plan. If delisting is warranted, prepare a post-delisting monitoring plan. Section 4 of the Endangered Species Act requires, in cooperation with the States, monitoring for a minimum of five years all species that have been recovered (*i.e.*, delisted).

7 Dedicate sufficient U.S. Fish and Wildlife Service staff for coordination of western snowy plover recovery implementation. Our Arcata Fish and Wildlife Office holds lead responsibility for coordinating implementation of western snowy plover recovery. We should assure that the Arcata Fish and Wildlife Office has sufficient staff to handle the primary responsibility of implementing the western snowy plover recovery plan. Duties should include

coordination and distribution of monitoring information and educational materials; transmission of copies of annual population monitoring results to our field offices that are responsible for western snowy plover issues; compilation and distribution of annual population status updates to all working groups; coordination with our other field offices in CNO and Region 1 regarding western snowy plover conservation actions, consultations, habitat conservation plans, and permits; facilitating coordination among the working groups created for the six recovery units; and fund raising to support recovery implementation actions.

8 Establish an international conservation program with the government of Mexico to protect western snowy plovers and their breeding and wintering locations in Mexico. Meeting the recovery goals outlined in this recovery plan is dependent only on actions recommended for implementation along the Pacific coast of the United States. However, other actions are identified for Mexico to complement conservation efforts in the United States. Efforts should be made to establish an international conservation program between the U.S. Fish and Wildlife Service and Mexico's National Institute of Ecology, Ministry of Environment, Natural Resources and Fisheries. Programs to facilitate implementation of this conservation program should include Partners in Flight, North American Waterfowl Management Plan, and the Borderlands Initiative.

8.1 Develop a joint effort between the United States and Mexico to protect western snowy plover populations and their habitat. Joint efforts should be implemented to determine important habitat in Mexico and protect these breeding and wintering locations from human disturbance.

8.2 Encourage research and monitoring of breeding and wintering western snowy plovers in Baja California, Mexico, by universities and authorities of Mexico. Joint efforts should be made to develop and implement a long-term monitoring program for western snowy plover populations of Mexico. They should include developing methods for consistent monitoring, coordination of banding and color-marking with

banders from the United States, assessment of the population status of breeding and wintering birds, and assessment of environmental impacts that may adversely affect plover populations.

8.3 Encourage development and implementation of public information and conservation education in Mexico for western snowy plovers. Public information and educational efforts should be coordinated and implemented by the United States and Mexico. They should include development of bilingual pamphlets for distribution to anglers, tourists, and local communities, and construction and placement of bilingual signs alerting them of the presence of nesting western snowy plovers.

9 Coordinate with other survey, assessment, and recovery efforts for the western snowy plover throughout North America. Western snowy plovers range through much of North America, and many individuals of the Pacific Coast population of western snowy plovers may overwinter in areas that overlap with other populations. Participation and coordination with other groups working on survey, assessment, and recovery efforts may yield valuable information on the distribution, status, and management needs for the Pacific Coast population of the western snowy plover. This coordination effort should be included in establishment of an international conservation program with Mexico.

IV. IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions needed, responsible parties, and estimated costs to recover the United States portion of the Pacific coast population of the western snowy plover. Considering the recovery criteria, results of the population viability analysis (Appendix D), and fulfillment of the recommendations contained in the recovery plan, recovery of the western snowy plover could occur in approximately 40 years. This time estimate assumes dedicated, proactive efforts toward improvements in western snowy plover management in the near-term, and subsequent management at a maintenance level commensurate with fulfillment of the recovery criteria.

The total cost of implementing actions outlined in this recovery plan over 40 years is $149,946,000. However, this figure represents only a portion of the overall costs because the cost of many actions cannot be estimated at this time. For example, costs associated with intensive protection and management on Federal and State lands (Action 3.3) should be determined by members of each of the six recovery unit working groups because they are most familiar with their site-specific needs and constraints. Costs of many actions were estimated based on current management recommendations provided in Appendix C. However, coastal ecosystems are dynamic and necessary management actions may vary with time, as site conditions change. Improvements over time in methods for predator control, control of nonnative vegetation, and monitoring are also expected and may affect actual costs.

It should be recognized that expenditure of funds for recovery of the western snowy plover will provide far-reaching benefits beyond those gained for a single species. Allocation of these funds will also benefit many other sensitive fish and wildlife species, the coastal beach-dune ecosystem, public appreciation for natural habitats, and aesthetics. These estimated costs do not reflect a cost/benefit analysis that incorporates other values or economic effects with implementation of the recommendations contained in this recovery plan.

We believe that protection and management costs could be substantially reduced by selecting protection strategies that are more restrictive of other beach uses.

While we believe that it is neither feasible nor desirable to completely eliminate beach recreation in most western snowy plover habitat, we also recognize that management strategies that protect western snowy plovers on beaches where public use is also maintained require a continuing commitment of person-power, and are inherently expensive.

The Implementation Schedule lists and ranks actions that should be undertaken within the next 5 years. This schedule will be reviewed routinely until the recovery objective is met, and priorities and actions will be subject to revision.

Key to Acronyms used in the Implementation Schedule

Definition of action priorities:

Priority 1 - An action that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Definition of action durations and costs:

Annual - An action that will be implemented each year.

Continual - An action that will be implemented on a routine basis once begun.

Ongoing - An action that is currently being implemented and will continue until action is no longer necessary.

As needed - An action that will be implemented on an "as needed" basis.

Unknown - Either action duration or associated costs are not known at this time.

To Be Determined (TBD) - Costs to be determined at a later date.

Responsible parties*:

ARMY	U.S. Army
BLM	U.S. Bureau of Land Management
CCC	California State Coastal Commission
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CE	U.S. Army Corps of Engineers
CI	Cities
CO	Counties
CON	California Coastal Conservancy
EBRPD	East Bay Regional Park District
ES	U.S. Fish and Wildlife Service, Division of Ecological Services (includes Endangered Species and Contaminants)
FAA	U.S. Department of Transportation, Federal Aviation Administration
HARD	Hayward Area Recreation and Park District
IA	U.S. Fish and Wildlife Service, Office of International Affairs
LE	U.S. Fish and Wildlife Service, Division of Law Enforcement
LMAO	Land Management Agencies and Organizations and other Cooperators. (This category includes Federal and local land management agencies listed above, private organizations and individuals that own and manage snowy plover breeding and wintering habitat, and private conservation groups that provide on-site protection of lands owned by others.)
MPOSD	Mid-Peninsula Open Space District
MPRPD	Monterey Peninsula Regional Park District
NASA	National Aeronautics and Space Administration-Ames Research Center
NAVY	U.S. Navy
NMFS	National Marine Fisheries Service
NPS	National Park Service
ODFW	Oregon Department of Fish and Wildlife
ODLCD	Oregon Department of Land Conservation and Development
OPRD	Oregon Parks and Recreation Department

P	Private landowners (except HARD, MPOSD, and TNC)
PA	U.S. Fish and Wildlife Service, Public Affairs
PGH	Port of Grays Harbor
PO	Port of Oakland
PRBO	Point Reyes Bird Observatory Conservation Science
PSL	Port of San Luis Harbor District
RSCH	Research institutions and agencies
RW	U.S. Fish and Wildlife Service, Division of Refuges and Wildlife (includes Realty)
SDRPJPA	San Dieguito River Park Joint Powers Authority
TNC	The Nature Conservancy
TPL	Trust for Public Land
USAF	U.S. Air Force
USCG	U.S. Coast Guard
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
BBL	U.S. Geological Survey, Bird Banding Laboratory
BRD	U.S. Geological Survey, Biological Resources Division
USMC	U.S. Marine Corps
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WS	U.S. Department of Agriculture, Wildlife Services Branch
WSPRC	Washington State Parks and Recreation Commission

* All responsible parties listed for actions in Implementation Schedule are considered lead agencies for those actions.

IMPLEMENTATION SCHEDULE

Western Snowy Plover Pacific Coast Population Recovery Plan

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
1	Annually monitor abundance, population size and distribution at breeding and wintering locations.	1.1	annual	LMAO, CO, CI, RSCH	2,194	54.9	54.9	54.9	54.9	54.9	Assumes 157 window survey days, with 2 biologists per location at. Action needed to determine fulfillment of recovery criteria.
1	Develop and implement a program to monitor productivity and annual survival.	1.2	annual	LMAO, CO, CI. RSCH	TBD						Action needed to determine fulfillment of recovery criteria. Depends partly on completion of 4.3.2 and 4.3.3.
1	Develop and implement a program to monitor habitat condition and threats at all breeding and wintering sites.	1.3	annual	LMAO, RSCH	1,125	60	27	27	27	27	Assumes initial cost for development of standardized monitoring program and subsequent monitoring for 155 sites.
3	Develop and implement training and certification programs for western snowy plover survey coordinators and observers.	1.4	continual	ES, LMAO, RSCH	363.5	32	8.5	8.5	8.5	8.5	Assumes initial cost to develop program and subsequent implementation.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Improve submittal system for monitoring data to ensure consistent reporting.	1.5	continual	ES, LMAO, BBL, PRBO	346	32	8	8	8	8	Assumes initial cost to develop submittal and reporting system and subsequent annual review.
3	Assess and evaluate new breeding wintering and migration areas for threats and management needs and update lists as data become available.	1.6	continual	ES, LMAO, PRBO	TBD						Depends on results of annual surveys and monitoring.
3	Coordinate monitoring of snowy plovers and California least terns to minimize disturbances.	1.7	annual	ES, RW, NAVY, USMC, USAF, CDFG, CDPR, WS, BRD	1,020	25.5	25.5	25.5	25.5	25.5	Coordinate at biannual pre- and post-season California least tern monitoring meeting. Assumes 2 meetings at 2 days per meeting with 9 agency staff attending.
3	Develop a post-delisting monitoring plan.	1.8	TBD	ES, LMAO, CO, CI, RSCH	TBD						

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
1	Develop a prioritized list of wintering and breeding sites where natural coastal processes need protection and/or enhancement.	2.1.1	2 yrs	ES, LMAO, CO, CI, RSCH	59.65	59.65					Assumes time to evaluate sites and development of the prioritized list.
1	Identify and implement mechanisms to protect, enhance or restore natural coastal processes.	2.1.2	continual	ES, LMAO, CO, CI, RSCH	TBD						Incorporate into ongoing management in action 3. Costs will depend on mechanisms identified and carried out.
1	Develop and implement prioritized removal and control for introduced beachgrass and other non-native vegetation.	2.2.1.1	continual	CE, LMAO, CO, CI	TBD						App C identifies 86 sites. Costs range for mechanical, manual and/or chemical control: $1,000 to $87,000/hectare ($400 to $35,000 per acre).
2	Replace exotic dune plants with native dune vegetation where it is likely to improve habitat.	2.2.1.2	continual	CE, LMAO, CO, CI	TBD						Estimated cost of planting native vegetation: $30,000 per hectare ($12,000 per acre). Number of sites to be determined.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Evaluate breeding and wintering sites to determine whether dredged materials may be used to enhance or create nesting habitat.	2.2.2.1	2 yrs	CE, ES, LMAO, CO, CI	110	55	55				Assumes cost to evaluate each site.
3	Develop and implement plans to use dredged materials may be used to enhance or create nesting habitat.	2.2.2.2	ongoing	CE, ES, LMAO, CO, CI	TBD						Costs will depend on completion of acts on 2.2.2.1.
3	Identify sites where beach nourishment may be effective in creating and enhancing habitat.	2.2.3.1	2yrs	CE, ES, LMAO, CO, CI	110	55	55				Assumes cost to evaluate each site.
3	Develop and implement beach nourishment plans for site identified in action 2.2.3.1.	2.2.3.2	ongoing	CE, ES, LMAO, CO, CI	TBD						Cost dependent on number of sites identified in 2.2.3.1 and outcome of 4.1.1.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
1	Create, manage, and enhance coastal ponds and playas for breeding habitat.	2.2.4	ongoing	ES, RW, CE, CDFG, NASA, HARD, LMAO	TBD						App C identifies 15 sites. Costs dependent on type and area of restoration.
1	Seasonally close areas used by breeding snowy plovers.	2.3.1.1.1	annual	LMAO, CO, CON, CI	559.2	13.98	13.98	13.98	13.98	13.98	App C identifies 81 sites. Assumes cost to close these sites.
1	Fence areas used by breeding snowy plovers	2.3.1.1.2	annual	LMAO, CO, CON, CI	14,840	371	371	371	371	371	App C identifies 64 sites. Cost assumes 1 kilometer fencing required per site at a cost of $5,900 per kilometer.
1	Post signs in areas used by breeding snowy plovers	2.3.1.1.3	annual	LMAO, CO, CON, CI	202	5	5	5	5	5	App C identifies 65 sites. Cost dependent on number of signs needed at each site, but assumes cost for installation and a minimum of 4 signs at $20 per sign.
1	Evaluate effects of existing and planned access at all breeding and wintering locations and any new locations identified.	2.3.1.2.1	1 year	LMAO, CO, CI	455	455					Appendix C identifies 81 sites. Assumes cost to conduct use survey for the identified sites.
1	Develop and implement plans to minimize adverse access effects.	2.3.1.2.2	continual	LMAO, CO, CI	TBD						Costs depend on outcome of 2.3.1.2.1.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Implement and enforce pet restrictions.	2.3.2	continual	LMAO, CO, CI	39,406	985	985	985	985	985	Appendix C identifies 120 sites Assumes staff time to implement and enforce restrictions at the identified sites.
1	Annually review recreational activities and develop and implement plans to prevent disturbance from disruptive recreational activities at breeding and wintering sites	2.3.3	annual	LMAO, CO, CI	21,948	549	549	549	549	549	Assumes staff cost to develop and implement plans at each site annually.
3	Prevent driftwood removal through posting of signs	2.3.4	continual	LMAO, CO, CI	1,805	50	45	45	45	45	Appendix C identifies 26 sites. Cost dependent on number of signs needed at each site, but assumes cost for installation and a minimum of 4 signs at $20 per sign.
1	Prevent disturbance, mortality, and habitat degradation by prohibiting or restricting off-road vehicles and beach-raking machines.	2.3.5	continual	LMAO, CO, CI	18,760	469	469	469	469	469	Appendix C identifies 101 sites. Assumes staff time for monitoring on weekends.
3	Implement restrictions on horseback riding through annual coordination.	2.3.6	annual	LMAO, CO, CI	1,033.7	25.8	25.8	25.8	25.8	25.8	Appendix C identifies 72 sites. Assumes staff time to implement restrictions.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Implement and enforce restrictions on livestock through annual coordination.	2.3.7	annual	LMAO, CO, CI	255	6.3	6.3	6.3	6.3	6.3	Appendix C identifies 18 sites. Assumes staff time to implement restrictions.
1	Determine enforcement needs and provide sufficient wardens, agents or officers to enforce protective measures in breeding and wintering habitat.	2.3.8.1	continual	LE, LMAO, CO, CI	TBD						Cost will depend on identified enforcement needs.
3	Develop and implement training programs for enforcement personnel to improve enforcement of regulations and minimize effects of enforcement.	2.3.8.2	continual	LE, LMAO, CO, CI	320	8	8	8	8	8	Annual training cost estimate $8,000 per year.
2	Develop and implement a program to annually coordinate with local airports, aircraft operations regarding minimum altitude requirementss.	2.3.9	annual	LMAO, CO, CI, FAA, LE	339.8	8.5	8.5	8.5	8.5	8.5	Assumes staff costs per recovery unit to compile list and notify aircraft operations and facilities.
3	Implement and enforce anti-littering regulations.	2.4.1.1	annual	LMAO, CO, CI	TBD						Incorporate into ongoing management and Action 3.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Evaluate the effects of current litter and garbage management on predation at breeding and wintering sites.	2.4.1.2	2 yrs	LMAO, CO, CI	110	55	55				Assumes evaluation time per site.
3	Develop and implement garbage and litter management plans where litter and garbage contribute to predation.	2.4.1.3	continual	LMAO, CO, CI	TBD						Costs will depend on 2.4.1.2 and plans developed.
3	Annually identify and remove predator perches and unnatural habitats attractive to predators.	2.4.2	continual	LMAO, CO, CI	375.2	9.4	9.4	9.4	9.4	9.4	Assumes staff time to complete action each year.
1	Erect predator exclosures to reduce egg predation and improve productivity.	2.4.3	annual	LMAO, CO, CI	18,266	456	456	456	456	456	App C identifies 53 sites. Assumes cost per unit installation.
1	Evaluate the need for predator removal and implement where warranted and feasible.	2.4.4	as needed	LMAO, CO, CI, WS, CDFG	TBD						App C identifies 61 sites for additional predator control. Costs dependent on assessment of needs and feasability.
3	Remove bird and mammal carcasses in nesting areas.	2.4.5	as needed	LMAO, CO, CI	TBD						

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
1	U.S. Fish and Wildlife Service biologists should participate in Area Committees responsible for maintaining the Area Contingency Plans for the Pacific Coast to facilitate the updating of spill response plans to include protection of western snowy plovers.	2.5.1	annual	ES	5,154	128.9	128.9	128.9	128.9	128.9	Assumes staff time from the six ES office responsible for coastlines of CA, OR, and WA.
1	Assign monitors to beaches that are inhabited by western snowy plovers to protect western snowy plovers from injury during spill responses.	2.5.2	as needed	ES, USCG, LMAO, CO, CI	1,984	49.6	49.6	49.6	49.6	49.6	Assumes cost of two weeks of monitoring for five incidents per year.
2	Compensate the loss of plover breeding and wintering habitat associated with recovery efforts for other sensitive species.	2.6	ongoing	ES, RW, CE, LMAO	TBD						Costs dependent on effectiveness of minimizing habitat loss.
3	Investigate feasibility and methods for discouraging pinniped use of nesting areas.	2.7.1	5 yrs	ES, NMFS, NAVY, LMAO	320	64	64	64	64	64	Assumes staff time to investigate.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Identify areas where pinniped use is negatively affecting nesting and implement any appropriate methods.	2.7.2	TBD	ES, NMFS, NAVY, LMAO	TBD						Costs dependent on number of sites identified and methods determined in 2.7.1.
1	Establish and maintain snowy plover working groups for each of the six recovery units.	3.1	continual	ES, LMAO, CO, C I, P	3,650	96	96	91	91	91	Essential mechanism to advance plover recovery. Includes biannual meeting costs and staff costs to establish new working groups.
2	Develop and implement regional participation plans for each of the six recovery units.	3.2	1 yr for develop-ment, continual thereafter	ES, LMAO	193		193				Assumes staff cost to develop and implement participation plans.
3	Develop and implement management plans for Federal lands.	3.3.1	ongoing	RW, ARMY, BLM, CE, NASA, NAVY, NPS, USAF, USMC, USFS	TBD						Implementation cost dependent on content of plans developed.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Develop and implement management plans and Habitat Conservation Plans on State wildlife areas, State ecological reserves, and State beaches.	3.3.2	5 years	CDFG, CDPR, ODFW, OPRD, WDFW, WDNR, WSPRC	966	193	193	193	193	193	Assumes cost for each recovery unit to assist in development. Implementation cost to be determined.
3	Develop and implement Habitat Conservation Plans or other management plans for sites owned by local governments or private landowners.	3.4	5 years	ES, LMAO, CO, CI, P, EBRPD, HARD, MPOSD, MPRPD, PGH, PO, SL, TNC, SDRPJPA	966	193	193	193	193	193	Assumes cost for each recovery unit to assist in development. Implementation cost to be determined.
2	Provide technical assistance to local governments in developing and implementing local land use protection measures through periodic workshops.	3.5	10 years	ES, CCC, CDFG, CDPR, CON, ODFW, ODLCD, OPRD, WDNR, WDFW, WSPRC, CO, CI	TBD						Estimated at 2 workshops per recovery unit at a cost of $ (Patty Carol in RO)

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Develop and implement cooperative programs and partnerships with the California State Coastal Commission, the Oregon Department of Land Conservation and Development, the Washington State Parks and Recreation Commission, the Oregon Parks and Recreation Department, the California Department of Parks and Recreation, and the Oregon Department of Fish and Wildlife.	3.6	continual	ES, CCC, ODLCD, ODFW, OPRD, CDPR, WSPRC	TBD						Costs may vary from year to year based on identified program needs.
3	Obtain long-term agreements with private landowners.	3.7	12 years	ES, CDFG, P CDPR, ODFW, WDFW, WSPRC, LMAO	2,319	193	193	193	193	193	Assumes staff time to facilitate 6 agreements per year per recovery unit. Appendix C identifies 72 sites.
3	Identify and protect habitat available for acquisition.	3.8	ongoing	CON, ES, RW, LMAO	TBD						

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Ensure that any section 10(a)(1)(B) and section 7(a)(2) permits contribute to Pacific coast western snowy plover conservation.	3.9	ongoing	ES, Federal agencies	1,288	32`32	32	32	32	32	Assumes staff time for annual evaluation.
3	Ensure that section 7 consultations contribute to Pacific coast western snowy plover conservation.	3.10	ongoing	ES, Federal agencies	1,288	32`32	32	32	32	32	Assumes staff time for annual evaluation.
2	Evaluate effectiveness of habitat restoration by removal of introduced beachgrass and identify additional studies necessary.	4.1.1	continual	CON, ES, LMAO, RSCH	TBD						Depends on the number and location of sites as well as the temporal duration of the restoration project.
3	Evaluate the impacts and potential benefits of past and ongoing beach nourishment activities and identify and carry out any additional studies necessary.	4.1.2	ongoing	ES, LMAO, RSCH, CE, CI, CO	TBD						
2	Develop higher-efficiency nest enclosures.	4.2.1	ongoing	ES, LMAO, RSCH	20	10	5	3	2	0	Compare new exclosures with current ones to determine effects on snowy plovers.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
2	Develop California least tern enclosures that prevent harm to snowy plovers.	4.2.2	as needed	ES, USMC, CDFG, CDPR, LMAO, RSCH	TBD						Costs specific to sites with California least tern enclosures. Estimated cost for materials (fencing/posts): $7 per linear foot ($23 per meter).
3	Identify, prioritize and carry out investigations on control of predators.	4.2.3	as needed	ES, RW, LMAO, WS, CDFG, RSCH, CO, CI, P	TBD						Cost dependent on number and types of studies identified.
3	Investigate predator management at the landscape level.	4.2.4	as needed	ES, RW, LMAO, WS, RSCH, CO, CI, P	TBD						Costs dependent on number and types of studies identified.
3	Investigate techniques for identifying nest predators.	4.2.5	continual	LMAO, RSCH	TBD						
2	Improve methods of monitoring population size.	4.3.1	ongoing	ES, LMAO, RSCH	TBD						Dependent on costs of intensive monitoring of some sites.
2	Develop sampling methods for annually estimating reproductive success.	4.3.2	2 years	ES, RSCH	64	64					Assumes time to compile and review data and develop methodology.
3	Develop methods to monitor plover survival rates.	4.3.3	ongoing	ES, LMAO, RSCH	TBD						

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Identify brood habitat and map brood home ranges.	4.4.1	ongoing continual	ES, LMAO, RSCH, CO, CI, P	TBD						Costs dependent on study design. May include radio telemetry.
3	Identify components of high-quality brood rearing habitat	4.4.2	1 year	ES, LMAO, RSCH, CO, CI, P	131	131					Assumes study at 6 geographically representative sites for duration of breeding season.
3	Quantify wintering habitat needs along the Pacific coast.	4.4.3	5 years	ES, RSCH, BRD, PRBO	75	75					Assumes study at 6 geographically representative sites during winter months.
3	Identify important migration stop-over habitat.	4.4.4	ongoing	ES, LMAO	TBD						
3	Develop and implement a research program to determine causes of adult mortality.	4.5	ongoing	LMAO, RSCH	TBD						Costs dependent on study design.
3	Compile information regarding number and types of banding injuries to plovers.	4.6.1	1 year	ES, RSCH, PRBO, BRD, BBL	32	32					Assumes staff time to develop, distribute and compile information requests.
3	Review compiled information (see 4.6.1) and determine and implement an appropriate course of action.	4.6.2	1 year	ES, RSCH, PRBO, BRD, BBL	32						Assumes staff time to review compiled information, distribution and coordination with other responsible parties.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Identify effects of oil spills on snowy plovers.	4.7	as needed	ES, RSCH, BRD, LMAO	TBD						Typical range of cost for study is estimated between $25,000 - $100,000.
3	Monitor levels of environmental contaminants in snowy plovers.	4.8	as needed	ES, RSCH, BRD, LMAO	TBD						Depends on number and type of samples. Cost estimate $700 per sample, but may vary depending on type of contaminant.
3	Design and conduct contaminants studies if monitoring of contaminants in action 4.8 indicates potential contaminants effects.	4.9	as needed	LMAO, ES, RSCH, BRD	TBD						Depends on number of sites and samples analyzed. Cost estimates for studies range from $25,000 to $50,000 per site.
3	Identify, prioritize and carry out studies on the effects of human recreation on western snowy plovers.	4.10	ongoing	LMAO, ES, RSCH, PRBO, BRD	TBD						Costs dependent on research needs identified.
3	Revise the population viability analysis when sufficient additional information is available	4.11	1 year	ES, RSCH, PRBO, BRD	25						Assumes cost to conduct modeling.
2	Develop and implement public information and education programs.	5.1	ongoing	ES, PA, LMAO	TBD	TBD	TBD	TBD	TBD	TBD	Depends on individual recovery unit strategies. See Appendix K (Information & Education Plan) for estimates of component expenses.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Inform Federal, State and local planning agencies and local planning departments of threats to breeding and wintering snowy plovers and their habitats.	5.2	continual	ES, LMAO, CCC, CDFG, CDPR, ODFW, ODLCD, OPRD, WDFW, WDNR, WSPRC, CO/CI	TBD						
3	Develop and maintain updated information and education materials on snowy plovers.	5.3	ongoing	ES, PA, LMAO, CO, CI	TBD						Incorporate into ongoing management and Action 3.1 through 3.10. See Appendix K
3	Alert landowners and beach-goers about access restrictions within snowy plover habitats.	5.4	ongoing	ES, PA, LMAO, CO, CI	TBD						Incorporate into ongoing management and Action 3.1 through 3.10. See Appendix K
3	Provide trained personnel to facilitate protective measures, provide public education, and respond to emergency situations.	5.5	continual	LMAO, CO, CI	TBD						Need to secure funds for volunteer coordinator and staff to train volunteers. Incorporate into Action 3.1 through 3.10. See Appendix K.
3	Develop protocols for handling sick, displaced, injured, oiled, and dead birds or salvaged eggs.	5.6	1 with periodic review	LMAO, CO, CI	32.2	32.2					Assumes staff time to develop protocol.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Establish a distribution system and repository for information and education materials.	5.7	continual	ES, LMAO, CO, CI	TBD						Incorporate into ongoing management and Action 3.1 through 3.10 and 7. See Appendix K.
3	Establish a reporting and distribution system for annual monitoring data.	5.8	annual	ES	644	16	16	16	16	16	Assumes time spent collecting and compiling data.
2	Develop and implement a tracking process for the completion of recovery actions and the achievement of delisting criteria.	6.1	continual	ES, RW, ARMY, BLM, CE, NASA, NAVY, NPS, USAF, USFS, USMC, CDFG, CDPR, ODFW, OPRD, WDFW, WDNR, WSPRC, LMAO	688	64	16	16	16	16	Assumes staff time to develop and implement tracking process.
3	Review progress toward recovery annually.	6.2	annual	ES, LMAO	566	14	14	14	14	14	Assumes staff time to compile and review data.
3	Assess the applicability, value and success of this plan to the recovery of the western snowy plover every 5 years.	6.3	every 5 years		258					32.2	Assumes staff time to review every 5 years.
3	Prepare a delisting package for the Pacific coast population of the western snowy plover.	6.4	6 months	ES	64	64					Assumes staff time to prepare delisting package.

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Prepare and implement a post-delisting monitoring plan.	6.5	6 months	ES	64	64					Assumes staff time to prepare and implement post-delisting monitoring plan.
1	Dedicate sufficient U.S. Fish and Wildlife Service staff for coordination of western snowy plover recovery implementation.	7	continual	ES	5,152	128.8	128.8	128.8	128.8	128.8	Assumes staff time to coordinate recovery implementation
3	Develop a joint United States and Mexico effort to protect snowy plover populations and their habitat.	8.1	continual	ES, IA	TBD						
3	Encourage research and monitoring of breeding and wintering snowy plovers in Baja California, Mexico by universities and authorities of Mexico.	8.2	continual	ES, IA, RSCH, BRD	TBD						
3	Encourage development and implementation of public information and conservation education in Mexico.	8.3	continual	ES, IA, PA	TBD						

Priority No.	Action Description	Action Number	Action Duration	Responsible Parties	Total Costs	Cost Estimate (in $1,000 units) FY1	FY2	FY3	FY4	FY5	Comments/Notes
3	Coordinate with other survey, assessment, and recovery efforts for the western snowy plover throughout North America.	9	continual	ES, IA, RSCH, BRD	TBD						

Total Cost of Recovery through 2046: $149,946,000 plus additional costs that cannot be estimated at this time.

V. REFERENCES

A. Literature Cited

Albers, P.H. 1977. Effects of external applications of fuel oil on hatchability of mallard eggs. Pages 158-163 *in* D. A. Wolfe, editor. Fate and effects of petroleum hydrocarbons in marine organisms and ecosystems. Pergamon Press, New York, N.Y.

Albers, P.H. and R.C. Szaro. 1978. Effects of No. 2 fuel oil on common eider eggs. Marine Pollution Bulletin 9:138-139.

Ainley, D.G., C.R. Grau, T.E. Roudybush, S.H. Morrell and J.M. Utts. 1981. Petroleum ingestion reduces reproduction in Cassin's auklets. Marine Pollution Bulletin 12:314-317.

American Ornithologists' Union. 1957. The A.O.U. checklist of North American birds. Fifth edition. 168 pp.

Anthony, J.L. 1985. A report on the distribution, numbers and human disturbance of snowy plovers at Damon Point, Washington. Report to the Washington Dept. of Game. Evergreen State College, WA. 24 pp.

Anthony, J.L. 1987. The snowy plover and biopolitics at Damon Point, Washington. M.E.S. Thesis, The Evergreen State College, Olympia, WA. 106 pp.

Applegate, T.E. 1998. Vandenberg Air Force Base snowy plover monitoring, Torch/Platform Irene Pipeline Oil Spill. Pp C1-C5 In: Preliminary Bird Injury Assessment for the Torch/Platform Irene Pipeline Oil Spill, R.G. Ford, editor. Unpublished report to California Department of Fish and Game, Office of Spill Prevention and Response.

Avery, M.L., M. A. Pavelka, D. L. Bergman, D. G. Decker, C. E. Knittle, and G. M. Linz. 1995. Aversive conditioning to reduce raven predation on California least tern eggs. Colonial Waterbirds 18(2):131-138.

Barbour, M.G. and J. Major. 1990. Terrestrial vegetation of California. California Native Plant Society. Special Publication Number 9, University of Davis, CA. 1028 pp.

Binford, L.C. 1989. A distributional survey of the birds of the Mexican State of Oaxaca. Ornithological Monographs 43. 418 pp.

Blus, L.J. 1982. Further interpretation of the relation of organochlorine residues in brown pelican eggs to reproductive success. Environmental Pollution (Series A) 28:15-33.

Brennan, K. 2003. Snowy plovers at Leadbetter Point, Washington, 2002 Annual Report. U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge. 14 pp.

Brennan, K. and M. Fernandez. 2004*a*. Snowy Plovers at Leadbetter Point, Washington, 2003 Annual Report. U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge. 16 pp.

Brennan, K and M. Fernandez. 2004*b*. Snowy Plovers at Leadbetter Point, Washington, 2004 Annual Report. U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge.

Brennan, K., and M. Fernandez. 2006. Snowy plovers at Leadbetter Point, Washington, 2005 Annual Report. U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge. 14 pp.

Brennan, K. and D. Jaques. 2002. Snowy Plovers at Leadbetter Point, Washington, 2001 Annual Report. U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge.

Brittell, J.D., J.M. Brown, and R.L. Eaton. 1976. Marine shoreline fauna of Washington, Vol. II. Washington Dept. of Game and Ecology, Olympia. 341 pp.

Buick, A.M. and D.C. Paton. 1989. Impact of off-road vehicles on the nesting success of hooded plovers (*Charadrius rubricollis*) in the Coorong region of South Australia. Emu 89:159-172.

Burger, J. 1986. The effect of human activity on shorebirds in two coastal bays in the northeastern United States. Environmental Conservation 13:123-130.

Burger, J. 1993. Shorebird squeeze. Natural History 102(5):8-14.

Burger, J. 1997. Effects of oiling on feeding behavior of sanderlings and semipalmated plovers in New Jersey. Condor 99:290-298.

Burger, A.E. and D.M. Fry. 1993. Effects of oil pollution on seabirds in the northeast Pacific. Pages 254-263 *in* K. Vermeer, K.T. Briggs, K.H. Morgan, and D. Siegel-Causey, eds. The status, ecology, and conservation of marine birds of the North Pacific. Canadian Wildlife Service Special Publication, Ottawa.

Caffrey, C. 1993. California least tern breeding survey, 1992 season. California Department of Fish and Game, Wildlife Management Division, Nongame Bird and Mammal Section Report 93-11, Sacramento, California. Unpublished final report.

Cairns, W.E. and I.A. MacLaren. 1980. Status of the piping plover on the east coast of North America. American Birds 34(2):206-208.

California Coastal Commission. 1995. Regional cumulative assessment project. ReCAP pilot project, findings and recommendations: Monterey Bay Region. 162 pp. plus appendices.

California Department of Fish and Game. Undated [1994]. Managing non-native species in Califomia: The red fox. The Resources Agency, California Department of Fish and Game, Sacramento, CA. 8 pp.

California Department of Parks and Recreation, Off-Road Vehicle Division. 2005. Nesting season management plan for 2005. San Luis Obispo County, California.

California Native Plant Society. 1996. Policy on invasive exotic plants. http://www.cnps.org/cnps/archive/exotics.php

California Natural Diversity Database. 2001. Special Animals. California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch. January 2001. 52 pp.

Cape Mohican Trustee Council. 2002. SS Cape Mohican Oil Spill Restoration Plan and Environmental Assessment. Unpublished report, National Park Service, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, California Dept. of Fish and Game, California Dept. of Parks and Recreation. 99 pp.

Carter, R.W.G. 1988. Coastal environments, an introduction to the physical, ecological and cultural systems of coastlines. 617 pp.

Carter, H.R. and R.T. Golightly, editors. 2003. Seabird injury from the 1997-98 Point Reyes Tarball Spill Incidents. Unpublished draft report, Humboldt State University, Dept. of Wildlife, Arcata, California.

Casler, B.R., C.E. Hallett, M.A. Stern, and G.A. Rosenberg. 1993. Unpublished report submitted to Oregon Department of Fish and Wildlife; Coos Bay District, Bureau of Land Management; and Oregon Dunes National Recreation Area, Suislaw National Forest. 26 pp.

Castelein, K.A., D.J. Lauten, S.R. Pixley, L.N. Renan, M.A. Stern, and C. Grinnell. 2002. The distribution and reproductive success of the western snowy plover along the Oregon coast- 2002. Page 54. The Oregon Natural Heritage Program, Portland.

Center for Disease Control. 2004. West Nile Virus. Retrieved from: http://www.cdc.gov/ncidod/dvbid/westnile/birdspecies.htm/ 9-20-04

Center for Marine Conservation. 1995. National Marine Debris Monitoring Program. Volunteer Handbook. 12 pp.

Chestnut, J. 1997. The distribution of rare species and the distribution and trend of invasive weeds on the Mobil Coastal preserve, Guadalupe-Nipomo Dunes, California. Unpublished document, The Nature Conservancy, San Francisco, CA. 135 pp.

Colwell, M.A., J. Hall, C.B. Millett, J.J. Meyer, R.R. LeValley, S.E. McAllister, A.N. Transou, D. LeValley. 2002. Final Report: 2002 Snowy Plover breeding in northern California, with emphasis on Humboldt County. Unpublished Report, Mad River Biologists, Inc., McKinleyville, CA and Humboldt State University Wildlife Department, Arcata, CA. 14 pp.

Colwell, M.A., Z. Nelson, S. Mullin, C. Wilson, S.E. McAllister, K.G. Ross, and R.R. LeValley. 2005. Final Report: 2005 Snowy Plover breeding in coastal northern California, Recovery Unit 2. Unpublished report, Mad River Biologists, Inc., and Humboldt State University Wildlife Department, Arcata, CA. 11 pp.

Colwell, M.A., S.M. Mullin, Z.J. Nelson, C.A. Wilson, J.M. Muir, W.P. Goldenberg, S.E. McAllister, and K.G. Ross. 2006. Final Report: 2006 Snowy Plover breeding in coastal northern California, Recovery Unit 2. Unpublished report, Mad River Biologists, Inc., and Humboldt State University Wildlife Department, Arcata, CA.

Connors, P.G., V.C. Anderlini, R.W. Risebrough, M. Gilbertson, and H. Hays. 1975. Investigations of heavy metals in common tern populations. The Canadian Field-Naturalist 89:157-162.

Cooch, E., R. Pradel and N. Nur. 1996. A practical guide to capture/recapture analysis using SURGE. CNRS, Montpellier, France. Approx. 130 pages.

Craig, D.P., M.A. Stern, K.A. Mingo, D.M. Craig, and G.A. Rosenberg. 1992. Reproductive ecology of the western snowy plover on the south coast of Oregon. Submitted to Oregon Department of Fish and Wildlife, Roseburg, OR, and Coos Bay District, Bureau of Land Management, North Bend, OR. 13 pp plus tables and maps.

Davis, W.A. and S.M. Russell. 1984. Birds in southeastern Arizona. Tucson Audubon Society, Tucson, AZ. 169 pp.

Dugan, J.E., H.M. Page, and R. Castelli. 1997. Assays of fertilization success, embryonic development and larval viability in a brooding invertebrate as indicators of ecosystem condition, with emphasis on the intertidal sand crab, Emerita analoga. Research abstracts, University of California Toxic Substances Research and Teaching Program Annual Report. 4 pp.

Evans, M.I. and G.O. Keijl. 1993. Impact of Gulf War oil spills on the wader populations of the Saudi Arabian Gulf Coast. Sandgrouse 15:85-105.

Evans, M.I., P. Symens, and C.W.T. Pilcher. 1993. Short-term damage to coastal bird populations in Saudi Arabia and Kuwait following the 1991 Gulf War. Marine Pollution Bulletin 27:157-161.

Fancher, J., R. Zembal, L. Hays, and P. Knapp. 1998. Western snowy plover nesting at Bolsa Chica, Orange County, California, 1998. Fish and Wildlife Service, Carlsbad Office, October 1998.

Fancher, J., L. Hays, and P. Knapp. 2002. Western snowy plover nesting at Bolsa Chica, Orange County, California, 2002. Fish and Wildlife Service, Carlsbad Office, December 2002.

Fahy, K.A. and C.D. Woodhouse. 1995. 1995 snowy plover linear restriction monitoring project, Vandenberg Air Force Base. Prepared for Natural Resources, Vandenberg Air Force Base, CA. 37 pp.

Feeney, L.R. and W.A. Maffei. 1991. Snowy plovers and their habitat at the Baumberg area and Oliver salt ponds, Hayward, California, March 1989 through May 1990. City of Hayward, Hayward, CA. 162 pp.

Flemming, S.P., R.D. Chiasson, P.C. Smith, P.J. Austin-Smith, and R.P. Bancroft. 1988. Piping plover status in Nova Scotia related to its reproductive and behavioral responses to human disturbance. Journal of Field Ornithology 59(4):321-330.

Ford, R.G. 1998. Preliminary bird injury assessment for the Torch/Platform Irene Pipeline Oil Spill. Unpublished report to California Department of Fish and Game, Office of Spill Prevention and Response.

Foster, B. 2005. Breeding status of the western snowy plover at Marine Corps Base, Camp Pendleton, California, 2003. Unpublished report prepared for the Environmental Core, Natural and Cultural Resources Team, Naval Facilities Engineering Command, Southwest, San Diego, California. 106 pp.

Fox, R. 1990. Snowy plover distribution and nesting success and human activity during summer, 1990, on Damon Point, Washington. Unpublished report., Washington Department of Wildlife, Olympia, WA. 9 pp.

Funk, W.C., T.D. Mullins, and S.M. Haig. 2006. Conservation genetics of North American and Caribbean Snowy Plovers (Charadrius alexandrinus): population genetic structure and delineation of subspecies. Final Report. USGS Forest and Rangeland Ecosystem Science Center, Corvallis, Oregon.

Fry, D.M. and L.J. Lowenstine. 1985. Pathology of common murres and Cassin's auklets exposed to oil. Archives of Environmental Contamination and Toxicology 14:725-737.

Fry, D.M., J. Swenson, L.A. Addiego, C.R. Grau, and A. Kang. 1986. Reduced reproduction of wedge-tailed shearwaters exposed to weathered Santa Barbara crude oil. Archives of Environmental Contamination and Toxicology 15:453-463.

George, D.E. 1997. Nesting success of snowy plovers at Wilder, Laguna, Scott Creek and Waddell Beaches, Santa Cruz County, California, in 1997. Report of Point Reyes Bird Observatory, Stinson Beach, CA. 12 pp.

Golightly, R.T., Jr., M.R. Faulhaber, K.L. Sallee, and J.C. Lewis. 1994. Food habits and management of introduced red fox in southern California. Pages 15-20 *in* Halverson, W.S., and A. C. Crabb, Eds. Proceedings of the 16th Vertebrate Pest Conference. Published at University of California, Davis.

Gorman, L. R. 2000. Population differentiation among Snowy Plovers (*Charadrius alexandrinus*) in North America. M.S. thesis. Oregon State University, Corvallis, OR. 23pp.

Grinnell, J., H.D. Bryant, and T.I. Storer. 1918. The game birds of California. University of California Museum of Vertebrate Zoology, Berkeley, CA. pp. 473-478.

Guinon, M. 1988. Dune restoration at Spanish Bay. Fremontia. October 1988. pp. 8-11.

Hallett, C.E., B.R. Casler, M.A. Platt, and M.A. Stern. 1995. Snowy plover distribution and reproductive success along the Oregon coast. Submitted to Oregon Department of Fish and Wildlife, Portland, OR; Coos Bay District, Bureau of Land Management, North Bend, OR; and Oregon Dunes National Recreation Area, Reedsport, OR. 40 pp.

Hamilton, R.A., and D.R. Willick. 1996. The birds of Orange County, California. Sea and Sage Press. Sea and Sage Audubon Society, Irvine, California.

Harding, E.K., D.F. Doak, J. Albertson, and J.E. Takekawa. 1998. Predator management in San Francisco Bay wetlands: past trends and future strategies. Prepared for U.S. Fish and Wildlife Service, Sacramento, CA. 41 pp.

Hatch, D. 1997. Draft snowy plover management plan for Ocean Beach, Golden Gate National Recreation Area. 58 pp. plus tables and appendices.

Hayman, P., J. Marchant, and T. Prater. 1986. Shorebirds: an identification guide to the waders of the world. Houghton Mifflin Co., Boston. 412 pp.

Heintz, G.H., D.J. Hoffman, A.J. Krynitsky, and D.M.G. Weller. 1987. Reproduction in mallards fed selenium. Environmental Toxicology and Chemistry 6:423-433.

Hickey, C.M., G.W. Page, and K. Wilson. 1995. Nesting success of snowy plovers at Point Reyes National Seashore in 1995. Report of Point Reyes Bird Observatory, Stinson Beach, CA. 10 pp.

Hoopes, E.M., C.R. Griffin, and S.M. Melvin. 1992. Relationships between human recreation and piping plover foraging ecology and chick survival. Unpublished report. University of Massachusetts, Amherst, MA. 77 pp.

Hothem, R.L. and A.N. Powell. 2000. Contaminants in western snowy plovers and California least terns: Is there a link to population decline? Bulletin of Environmental Contamination and Toxicology 65:42-50.

Howard, J.M., R.J. Safran, and S.M. Melvin. 1993. Biology and conservation of piping plovers at Breezy Point, New York. Unpublished report. Department of Forestry and Wildlife Management, University of Massachusetts, Amherst. 34 pp.

Hughes, R. 2003. SS Jacob Luckenbach oil removal project completed. The OSPR News 10:1-5.

Hutchinson, E.S., G.W. Page, and P.E. Persons. 1987. The nesting of snowy plovers on Morro Bay sand spit during and after the 1987 maintenance dredging of Morro Bay harbor. Report of Point Reyes Bird Observatory, Stinson Beach, CA. 16 pp.

Jacobs, R.A. 1986. Snowy plover (*Charadrius alexandrinus*). Section 4.4.1, U.S. Army Corps of Engineers Wildlife Resources Management Manual, Technical Report EL-86-54, Portland, OR. 25 pp.

Jaques, D. 2001. Snowy plovers at Leadbetter Point, Washington- 2000 Annual Report. U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge. 19 pp.

Jurek, R.M. 1992. Non-native red foxes in California. California Department of Fish and Game, Wildlife Management Division, Nongame Bird and Mammal Section Report 92-04. Sacramento, CA. 16 pp.

Kelly, P. and J. Rotenberry. 1996/1997. Buffer zones for ecological reserves in California: replacing guesswork with science. Native Species Network. Winter 1996/97.

Khan, R.A. and P. Ryan. 1991. Long-term effects of crude oil on common murres (Uria aalge) following rehabilitation. Bulletin of Environmental Contamination and Toxicology 46:216-222.

Kindinger, M.E. 1981. Impact of the Ixtoc I oil spill on the community structure of intertidal and subtidal infauna along south Texas beaches. M.S. Thesis, Corpus Christi State University, Corpus Christi, TX. 91 pp.

King, K.A. and C.A. Lefever. 1979. Effects of oil transferred from incubating gulls to their eggs. Marine Pollution Bulletin 10:319-321.

Kloempken, D. and S.A. Richardson. 1995. Snowy plovers and human activity at Leadbetter Point in April 1995. 8 pp. plus survey form.

Lafferty, K. 2001. Disturbance to wintering western snowy plovers. Biological Conservation 101:315-325.

Larsen, E.M. and S.A. Richardson. 1990. Some effects of a major oil spill on wintering shorebirds at Grays Harbor, Washington. Northwestern Naturalist 71:88-92.

Lauten, D.J., K. A. Castelein, E. Seckinger, and E. P. Gaines. 2006*a*. The distribution and reproductive success of the western snowy plover along the Oregon coast - 2005. The Oregon Natural Heritage Information Center Institute for Natural Resources, Portland, OR.

Lauten, D.J., K. A. Castelein, S. Weston, K. Eucken, and E. P. Gaines. 2006*b*. The distribution and reproductive success of the western snowy plover along the Oregon coast - 2006. The Oregon Natural Heritage Information Center Institute for Natural Resources, Portland, OR.

Lebreton, J.-D., K.P. Burnham, J. Clobert, and D.R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecological Monographs 62:67-118.

Leibezet, J.R., and T. L. George. 2002. A summary of predation by corvids on threatened and endangered species in California and management recommendations to reduce corvid predation. California Department of Fish and Game, Species Conservation and Recovery Program Report 2002-02, Sacramento, CA. 103 pp.

Leighton, F.A. 1991. The toxicity of petroleum oils to seabirds: an overview. Pages 43-57 *in* White, J. (Ed.). The effects of oil on wildlife. Sheridan Press, Hanover, PA.

LeValley, R., S. McAllister, and A. Transou. 2001. Effects of the Stuyvesant spill on reproductive success of the western snowy plover at Clam Beach, Humboldt County, California, Year 2000 Season. Unpublished draft report to California Dept. of Fish and Game. 19 pp.

Lewis, J.C., R.T. Golightly, and R.M. Jurek. 1995. Introduction of non-native red foxes in California: Implications for the Sierra Nevada red fox. Transactions of the Western Section of the Wildlife Society 31:29-32.

Lewis, J.C., K.L. Sallee, and R.T. Golightly. 1993. Introduced red fox in California. California Department of Fish and Game, Nongame Bird and Mammal Section Report 93-10. Sacramento, CA. 56 pp plus appendices.

Lingle, G.R., J.G. Sidle, A. Hecht, and E.M. Kirsch. 1999. Observations of banding-related leg injuries in the piping plover. Pp. 118-123 *in* Higgins, K.F., M.R. Brashier, and C.D. Kruse (eds). Proceedings, Piping plovers and least terns of the Great Plains and nearby. Brookings: South Dakota State University.

Lockyer, B., R.M. Frank, T. Berger, B. Hembacher, G.R. Overton, T.L. Samsonetti, S. O'Rourke, J.S. Gordon, L.W. Weidman, and M.L.Miller. 2002. Consent Decree, United States of America and State of California v. Torch Energy Services, Inc., CV-02-3977. U.S. District Court, Central District of California, Western Division.

Mabee, T.J. and V.B. Estelle. 2000. Assessing the effectiveness of predator exclosures for plovers. Wilson Bulletin 112(1):14-20.

Mangel, M., and C. Tier. 1994. Four facts every conservation biologist should know about persistence. Ecology 75:607-614.

Marshall, D.B., M.G. Hunter, and A.L. Contreras, Eds. 2003. Birds of Oregon: a general reference. Oregon State University Press, Corvallis, OR. 768pp.

Marriott, M. 2001. Pacific coast western snowy plover monitoring program at the Don Edwards San Francisco Bay NWR and Eden Landing Ecological Reserve and selected Cargill Salt Division properties. Unpublished report to San Francisco Bay NWR Complex; Fremont, CA.

McCaskie, G., and K.L. Garrett. 2005. Southern California summary. North American Birds 59:493-497.

McGrath Oil Spill Restoration Scoping Document (Berry Petroleum). 1995. 6 pp.

McIvor, L.H. 1991. Research proposal: Conditioned taste aversion: A technique to reduce red fox predation at piping plover nests on Assateague Island National Seashore. Maryland Department of Natural Resources, Annapolis, MD. 8 pp.

Meffe, G., and C. Carroll. 1994. Principles of conservation biology. Sinauer Associates, New York.

Mills, L.S., and F.W. Allendorf. 1996. The one-migrant-per-generation rule in conservation and management. Conservation Biology 10:1509-1518.

Molina, K.C., and M. Erwin. 2006. The distribution and conservation status of the gull-billed tern (*Gelochelidon nilotica*) in North America. Waterbirds 29:271-295.

Monson, G. and A.R. Phillips. 1981. Annotated checklist of the birds of Arizona, 2d ed. University of Arizona Press, Tucson. 240 pp.

National Audubon Society. 2006. West Nile virus. Retrieved from: http://www.audubon.org/bird/wnv/ Accessed July 25, 2006.

National Research Council. 1985. Oil in the sea: inputs, fates and effects. National Academy Press, Washington, D.C. 601 pp.

National Research Council. 1995. Science and the Endangered Species Act. National Academy Press; Washington, DC. 271 pages.

Neuman, K.K., G.W. Page, L.E. Stenzel, J.C. Warriner, and J.S. Warriner. 2004. Effect of mammalian predator management on snowy plover breeding success. Waterbirds 27:257-263.

Ohlendorf, H.M., R.L. Hothem, C.M. Bunck, T.W. Aldrich, and J.F. Moore. 1986. Relationships between selenium concentrations and avian reproduction. Transactions of the Fifty-first North American Wildlife and Natural Resources Conference 51:330-342.

Oregon Department of Fish and Wildlife. 1994. Final Draft. Oregon conservation program for the western snowy plover (*Charadrius alexandrinus nivosus*). Portland, OR. 56 pp.

Oregon Department of Fish and Wildlife. 1996. Snowy plover habitat restoration on the Coos Bay North Spit using inmate labor. 21 pp.

Page, G.W. 1988. Nesting success of snowy plovers in central coastal California in 1988. Report of the Point Reyes Bird Observatory, Stinson Beach, CA. 7 pp.

Page, G.W. 1990. Nesting success of snowy plovers in central coastal California in 1989 and 1990. Report of the Point Reyes Bird Observatory, Stinson Beach, CA. 13 pp.

Page, G.W. and P.E. Persons. 1995. The snowy plover at Vandenberg Air Force Base: population size, reproductive success, and management. Point Reyes Bird Observatory, Stinson Beach, CA. 24 pp. plus appendices.

Page, G.W. and L.E. Stenzel (eds.). 1981. The breeding status of the snowy plover in California. Western Birds 12(1):1-40.

Page, G.W., J.S. Warriner, and L.E. Stenzel. 1997. Nesting success of snowy plovers on Monterey Bay in 1997. Unpublished report of Point Reyes Bird Observatory, Stinson Beach, CA. 10 pp.

Page, G.W., F.C. Bidstrup, R.J. Ramer, and L.E. Stenzel. 1986. Distribution of wintering snowy plovers in California and adjacent states. Western Birds 17(4):145-170.

Page, G.W., L.E. Stenzel, W.D. Shuford, and C.R. Bruce. 1991. Distribution and abundance of the snowy plover on its western North American breeding grounds. Journal of Field Ornithology 62(2):245-255.

Page, G.W., L.E. Stenzel, D.W. Winkler, and C.W. Swarth. 1983. Spacing out at Mono Lake: breeding success, nest density, and predation in the snowy plover. The Auk 100:13-24.

Page, G.W., J.S. Warriner, J.C. Warriner, and R.M. Halbeisen. 1977. Status of the snowy plover on the northern California coast. Part I: Reproductive timing and success. California Department of Fish and Game Nongame Wildlife Investigations, Sacramento, CA. 6 pp.

Page, G.W., J.S. Warriner, J.C. Warriner, and P.W.C. Paton. 1995*a*. Snowy plover (*Charadrius alexandrinus*). *In* The Birds of North America, No. 154 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C. 24 pp.

Page, G.W., M.A. Stern, and P.W. Paton. 1995*b*. Differences in wintering areas of snowy plovers from inland breeding sites in western North America. The Condor 97:258-262.

Page, G.W., J.S. Warriner, J.C. Warriner, D.E. George, and L.E. Stenzel. 1997. Nesting success of snowy plovers at Monterey Bay and northern Santa Cruz County pocket beaches in 1996. Report of Point Reyes Bird Observatory, Stinson Beach, CA. 12 pp.

Page, G.W., D. Dixon, C. Eyster, D.E. George, K. Neuman, L.E. Stenzel, J.C. Warriner, and J.S. Warriner. 1998. Reproduction of snowy plovers at Monterey Bay and pocket beaches of northern Santa Cruz County in 1998. Unpubl. report of Point Reyes Bird Observatory, Stinson Beach, CA. 12 pp.

Palacios, E.P., L. Alfaro, and G.W. Page. 1994. Distribution and abundance of breeding snowy plovers on the Pacific coast of Baja California. Journal of Field Ornithology 65(4):490-497.

Patton, R. 2006a. The status of western gull-billed terns at South San Diego Bay National Wildlife Refuge. Unpublished draft report for the U.S. Fish and Wildlife Service, San Diego National Wildlife Refuge Complex, Carlsbad, California. November 2006. 16 pp. plus tables and figures.

Patton, R. 2006b. Foraging by western gull-billed terns at Tijuana Slough National Wildlife Refuge and Borderfield State Park in 2006. Unpublished final report for the U.S. Fish and Wildlife Service, San Diego National Wildlife Refuge Complex, Carlsbad, California. November 2006. 10 pp. plus tables and figures.

Pearson, S.F, C. Sundstrom, K. Brennan, and M. Fernandez. 2006. Snowy plover distribution, abundance, and reproductive success: 2006 research progress report. Washington Department of Fish and Wildlife, Olympia, WA.

Persons, P.E. 1994. Western snowy plover monitoring in 1993 at Vandenberg Air Force Base, California. Unpublished report of U.S. Fish and Wildlife Service, Ventura, CA. 22 pp.

Persons, P.E. 1995. Western snowy plover population size and nesting success in 1994 at Vandenberg Air Force Base, California. A monitoring report prepared for U.S. Fish and Wildlife Service, Ventura, CA. 21 pp.

Persons, P.E. and T.E. Applegate. 1996. Western snowy plover population size and reproductive success in 1996 at Vandenberg Air Force Base, California. Point Reyes Bird Observatory, Stinson Beach, CA. 35 pp. plus maps.

Persons, P.E. and T.E. Applegate. 1997. Monitoring of the western snowy plover at Vandenberg Air Force Base in 1997: population size, reproductive success, and management. Point Reyes Bird Observatory, Stinson Beach, CA. 30 pp. plus map.

Persons, P.E. and J.A. Ellison. 2001. Nesting of the Western Snowy Plover at Morro Bay Sandspit in San Luis Obispo County, California in 2000.

Peterlein, C., and D. Roth. 2003. Distribution, protection and reproductive success of snowy plovers at Point Reyes National Seashore in 2003. Report to the National Park Service. PRBO contribution number 1071.

Pethick, J. 1984. An introduction to coastal geomorphology. 260 pp.

Pfister, C., B. Harington, and M. Lavine. 1992. The impact of human disturbance on shorebirds at a migration staging area. Biological Conservation 60:115-126.

Philip Williams & Associates, EDAW, H.T. Harvey & Associates, and Brown & Caldwell. 2006. South Bay Salt Pond Restoration Project: Final Alternatives Report. Report submitted to California State Coastal Conservancy, U.S. Fish and Wildlife Service, and California Department of Fish and Game. 122 pp.

Pickart, A.J. 1997. Control of European beachgrass (*Ammophila arenaria*) on the west coast of the United States. Proceedings, 1997, California Exotic Plant Council Annual Meeting, Concord, CA. 13 pp.

Pickart, A.J. and J.O. Sawyer. 1998. Ecology and restoration of northern California coastal dunes. California Native Plant Society, Sacramento, CA. 172 pp.

Powell, A.N. 1996. Western snowy plover use of state-managed lands in southern California, 1995. California Department of Fish and Game, Wildlife Management Division, Bird and Mammal Conservation Program Report 96-103, Sacramento, CA. 14 pp.

Powell, A.N. 2001. Habitat characteristics and nest success of snowy plovers associated with California least tern colonies. The Condor 103:785-792.

Powell, J.A. 1981. Endangered habitats for insects: California coastal sand dunes. Atala 6:41-55.

Powell, A.N. and C.L. Collier. 1994. The status of western snowy plovers (*Charadrius alexandrinus nivosus*) in San Diego County, 1994. Report to California Department of Fish and Game, Sacramento, CA, and U.S. Fish and Wildlife Service, Portland, OR. 28 pp.

Powell, A.N. and C.L. Collier. 1995. The status of western snowy plovers (*Charadrius alexandrinus nivosus*) at Camp Pendleton, 1995. Annual breeding season interim summary report to the Assistant Chief of Staff, Environmental Security, Marine Corps Base, Camp Pendleton, CA. 32 pp.

Powell, A.N., B.L. Peterson, and J.M. Terp. 1996. The status of western snowy plovers (*Charadrius alexandrinus nivosus*) in San Diego County, 1996. Report to the California Department of Fish and Game, Sacramento, CA, and U.S. Fish and Wildlife Service, Carlsbad, CA, and Portland, OR. 25 pp.

Powell, A.N., J.M. Terp, C.L. Collier, and B.L. Peterson. 1995. The status of western snowy plovers (*Charadrius alexandrinus nivosus*) in San Diego County, 1995. Report to the California Department of Fish and Game, Sacramento, CA, and U.S. Fish and Wildlife Service, Carlsbad, CA, and Portland, OR. 24 pp.

Powell, A.N., J.M. Terp, C.L. Collier, and B.L. Peterson. 1997. The status of western snowy plovers (*Charadrius alexandrinus nivosus*) in San Diego County, 1997. Report to the California Department of Fish and Game, Sacramento, CA, and U.S. Fish and Wildlife Service, Carlsbad, CA, and Portland, OR. 34 pp.

Powell, A.N., C.L. Fritz, B.L. Peterson, J.M. Terp. 2002. Status of breeding and wintering Snowy Plovers in San Diego County, California, 1994-1999. Journal of Field Ornithology 73(2):156-165.

Raup, D.M. 1991. Extinction: bad genes or bad luck? W. W. Norton & Company, New York.

Remsen, J.V., Jr. 1978. Bird species of special concem in California. California Department of Fish and Game, Sacramento, CA. 54 pp.

Richardson, S.A., P.J. Doran, W.A. Michaelis, C.S. Sundstrom-Bagley, J.L. Anthony and H.M. Bahn. 2000. A new snowy plover nesting area in Washington: Midway Beach, Pacific County. Washington Birds 7:25-35.

Roletto, J., J. Martinson, L. Grella, and L. Culp. 2000. Beach Watch Annual Report: 2000. Unpublished report, Gulf of the Farallones National Marine Sanctuary, San Francisco, California. 61 pp.

Ruhlen, T.D., S. Abbott, L.E. Stenzel, G.W. Page. 2003. Evidence that human disturbance reduces snowy plover chick survival. Journal of Field Ornithology 74(3):300-304.

Ryan, T.P. and J.L. Parkin. 1998. The western snowy plover (*Charadrius alexandrinus nivosus*) in southern San Francisco Bay. Summary of detections made during colonial waterbird monitoring surveys from 1981 to 1997. Prepared for Santa Clara Valley Water District, San Jose, CA. 19 pp.

Saul, S.M. 1982. Clam diggers and snowy plovers. Washington Wildlife 32(1):28-30.

Schultz, R. and M. Stock. 1993. Kentish plovers and tourists: competitors on sandy coasts? Wader Study Group Bulletin 68:83-91.

Schwarzbach, S.E., M. Stephenson, T. Adelsbach, T. Ruhlen, S. Abbott, L.E. Stenzel, and G.W. Page. 2003. Elevated mercury concentrations in failed eggs of snowy plovers at Point Reyes National Seashore. Unpublished manuscript. 17 pp.

Schwendiman, J. L. 1975. Coastal dune stabilization in the Pacific Northwest. International Journal of Biometeorology 21:281-289.

Seabloom, E.W. and A.M. Wiedemann. 1994. Distribution and effects of *Ammophila breviligulata* Fern. (American beachgrass) on the foredunes of the Washington coast. Journal of Coastal Research 10(2):178-188.

Shuford, W.D., G.W. Page, and C.M. Hickey. 1995. Distribution and abundance of snowy plovers wintering in the interior of California and adjacent states. Western Birds 26:82-98.

Sibley, C.G. and B. L. Monroe, Jr. 1990. Distribution and taxonomy of birds of the world. Yale University Press, New Haven and London. 1111 pp.

Slobodchikoff, C.N. and J.T. Doyen. 1977. Effects of *Ammophila arenaria* on sand dune arthropod communities. Ecology 58:1171-1175.

Smith, G.J. and V.P. Anders. 1989. Toxic effects of boron on mallard reproduction. Environmental Toxicology and Chemistry 8:943-950.

Stanley, T.R., Jr., J.W. Spann, G.J. Smith, and R. Roscoe. 1994. Main and interactive effects of arsenic and selenium on mallard reproduction and duckling growth and survival. Archives of Environmental Contamination and Toxicology 26:444-451.

Stein, R. 1993. Population size and reproductive success of snowy plovers at Skunk Point, Santa Rosa Island. Point Reyes Bird Observatory, Stinson Beach, CA. 38 pp.

Stenzel, L.E., S.C. Peaslee, and G.W. Page. 1981. II. Mainland Coast. Pages 6-16 in Page, G.W. and L.E. Stenzel, (eds.). The breeding status of the snowy plover in California. Western Birds 12(1):1-40.

Stenzel, L.E., J.C. Warriner, J.S. Warriner, K.S. Wilson, F.C. Bidstrup, and G.W. Page. 1994. Long-distance breeding dispersal of snowy plovers in western North America. Journal of Animal Ecology 63:887-902.

Stern, M.A., J.S. McIver, and G.A. Rosenberg. 1990. Investigations of the western snowy plover at the Coos Bay North Spit and adjacent sites in Coos and Curry Counties, Oregon, 1990. Report to Oregon Department of Fish and Wildlife Nongame Program. 33 pp.

Stern, M.A., J.S. McIver, and G.A. Rosenberg. 1991. Nesting and reproductive success of snowy plovers along the south Oregon coast, 1991. Report to Oregon Department of Fish and Wildlife-Nongame, Roseburg, OR, and Coos Bay District, Bureau of Land Management, North Bend, OR. 18 pp.

Stern, M.A., D.J. Lauten, K.A. Castelein, K.J. Popper, and J.A. Fukuda. 2000. Impact assessment of oil spilled from the New Carissa on the Western Snowy Plover along the Oregon Coast. Unpublished report by the Oregon Natural Heritage Program and The Nature Conservancy to TMM Co, Ltd; Coos Bay District Bureau of Land Management; Oregon Dept. of Fish and Wildlife; Dunes National Recreation Area; U.S. Fish and Wildlife Service. 32 pp.

Strong, C., and R. Dakin. 2004. Western snowy plover breeding season surveys for 2003. San Francisco Bird Observatory, Alviso, CA. 28 pp.

Strong, C., N. R. Wilson, and J. D. Albertson. 2004. Western snowy plover numbers, nesting success, and avian predator surveys in the San Francisco Bay, 2004. San Francisco Bay Bird Observatory, Alviso, CA, and Don Edwards San Francisco Bay National Wildlife Refuge, Newark, CA. 41 pp.

Sundstrom, C. 2001. 2000 Snowy plover surveys in coastal Washington (Moclips-Tokeland). Washington Department of Fish and Wildlife, Region 6, Montesano, WA. 8 pp.

Sundstrom, C. 2002*a*. 2001 Snowy plover surveys in coastal Washington. Washington Department of Fish and Wildlife, Region 6, Montesano, WA. 8 pp.

Sundstrom, C. 2002*b*. 2002 Snowy plover surveys in coastal Washington. Washington Department of Fish and Wildlife, Region 6, Montesano, WA. 13 pp.

Sundstrom, C. 2003. 2003 Snowy plover surveys in coastal Washington. Washington Department of Fish and Wildlife, Region 6, Montesano, WA. 11 pp.

Sundstrom, C. 2004. 2004 Snowy plover surveys in coastal Washington. Washington Department of Fish and Wildlife, Region 6, Montesano, WA. 14 pp.

Sundstrom, C. 2005. 2005 snowy plover surveys in coastal Washington. Washington Department of Fish and Wildlife, Region 6, Montesano, WA.

Sundstrom-Bagley, C., W. Michaelis, J. Anthony, M. Bahn. 2000. Snowy plover distribution and nesting success in coastal Washington (1999). Washington Department of Fish and Wildlife, Region 6, Montesano, WA. 27 pp.

Tear, T.H., J.M. Scott, P.H. Hayward, and B. Griffith. 1993. Status and prospects for success of the Endangered Species Act: A look at recovery plans. Science 262:976-977.

Trivelpiece, W.Z., R.G. Butler, D.S. Miller, and D.P. Peakall. 1984. Reduced survival of chicks of oil-dosed adult Leach's storm-petrels. Condor 86:81-82.

Tucker, M.A. and A.N. Powell. 1999. Snowy plover diets in 1995 at a coastal southern California breeding site. Western Birds 30:44-48.

Tucci, L., C. Strong, and J. Albertson. 2006. Western snowy plover numbers, nesting success, and predator surveys in the San Francisco Bay - 2005 breeding season. San Francisco Bay Bird Observatory, Alviso, CA, and Don Edwards San Francisco Bay National Wildlife Refuge, Newark, CA. 33 pp.

Tuttle, D.C., R. Stein, and G. Lester. 1997. Snowy plover nesting on Eel River gravel bars, Humboldt County. Western Birds 28:174-176.

U.S. Bureau of Land Management. 1995*a*. Coos Bay Shorelands, Final Management Plan. 25 pp. plus map.

U.S. Bureau of Land Management. 1995*b*. The New River Area of Critical Concern Management Plan. 149 pp

U.S. Bureau of Land Management. 2001. Notice of Intent to Conduct Restoration Planning, M/V New Carissa Natural Resource Damage Assessment. Federal Register 66:56339-56340.

U.S. Coast Guard. 2001. Marine Casualty Investigation Report, Case Number MC99011413. 13 pp.

U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 1994. Management Plan, Oregon Dunes National Recreation Area, Siuslaw National Forest. 157 pp.

U.S. Department of Agriculture. 2002. Environmental Assessment: Predator damage management to protect the federally threatened Pacific coast population of the western snowy plover in Lane, Douglas, Coos, Curry, Clatsop, Tillamook, and Lincoln Counties, Oregon. Prepared by APHIS-WS Program, Western Region, for USFWS, BLM, USFS, in cooperation with ODFW, OPRD.

U.S. Department of Transportation, Federal Aviation Administration. 1997. Federal Aviation Regulations, Part 91, General Operating and Flight Rules.

U.S. District Court, Central District of California. 1995. Order. Environmental Defense Center, Plaintiff, v. Bruce Babbitt, Secretary of the Interior, *et al.*, Defendants. No. CV 94-5561 ER (Shx). 2 pp.

U.S. District Court, Central District of California. 1998. Order and Judgment. Environmental Defense Center *et al.*, Plaintiffs, v. Babbitt, *et al.*, Defendants. Case No. CV 94-5561 ER (Shx). 4 pp.

U.S. District Court, District of Massachusetts. 1998. Memorandum and Order. United States of America, plaintiff, v. Town of Plymouth, Massachusetts, defendant. Civil Action No. 98-10566-PBS. 29 pp.

U.S. Fish and Wildlife Service. 1983. Endangered and threatened species listing and recovery priority guidelines. Federal Register 48:43098-43105. September 21, 1983.

U.S. Fish and Wildlife Service. 1985. Light-footed clapper rail recovery plan, Portland, OR. 121 pp.

U.S. Fish and Wildlife Service. 1992. Status and trends report on wildlife of the San Francisco Estuary. San Francisco Estuary Project. 315 pp.

U.S. Fish and Wildlife Service. 1993*a*. Endangered and threatened wildlife and plants; determination of threatened status for the Pacific coast population of the western snowy plover; final rule. Federal Register 58(42):12864-12874.

U.S. Fish and Wildlife Service. 1993*b*. Intra-Service Formal Consultation on take of the threatened Pacific coast population of the western snowy plover for scientific purposes and/or enhancement of propagation or survival. Portland, Oregon. 9 pp.

U.S. Fish and Wildlife Service. 1993*c*. Endangered Species Technical Bulletin, Vol. XVIII, No. 2, pp. 7-9.

U.S. Fish and Wildlife Service. 1995*a*. Endangered Species Bulletin, Vol. XX, No. 5. 28 pp.

U.S. Fish and Wildlife Service. 1995*b*. Endangered and threatened wildlife and plants; proposed designation of critical habitat for the Pacific coast population of the western snowy plover; proposed rule. Federal Register 60(41):11768-11809.

U.S. Fish and Wildlife Service. 1996*a*. Piping Plover (*Charadrius melodus*), Atlantic Coast Population, Revised Recovery Plan. Hadley, Massachusetts. 258 pp.

U.S. Fish and Wildlife Service. 1996*b*. Endangered and threatened wildlife and plants; final listing priority guidance for fiscal year 1997; final rule. Federal Register 61:64475-64481.

U.S. Fish and Wildlife Service. 1998. Endangered and threatened wildlife and plants; proposed listing priority guidance for fiscal years 1998 and 1999; proposed rule. Federal Register 63:10931-10935.

U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and plants; Designation of critical habitat for the Pacific coast population of the western snowy plover; final rule. Federal Register 64:68508-68544. December 7, 1999.

U.S. Fish and Wildlife Service. 2002. Draft Recovery Plan for the Great Lakes Piping Plover (*Charadrius melodus*). Fort Snelling, Minnesota. 121 pp.

U.S. Fish and Wildlife Service. 2004*a*. Endangered and threatened wildlife and plants; 90-day finding on a petition to delist the Pacific coast population of the western snowy plover and initiation of a 5-year review. Federal Register 69:13326-13329. March 22, 2004.

U.S. Fish and Wildlife Service. 2004*b*. Endangered and threatened wildlife and plants; Proposed designation of critical habitat for the Pacific coast population of the western snowy plover. Federal Register 69:75608-75771. December 17, 2004.

U.S. Fish and Wildlife Service. 2005. Endangered and threatened wildlife and plants; Designation of critical habitat for the Pacific coast population of the western snowy plover. Federal Register 70:56970-57018. September 29, 2005.

U.S. Fish and Wildlife Service. 2006*a*. Endangered and threatened wildlife and plants; 12-month finding on a petition to delist the Pacific coast population of the western snowy plover. Federal Register 71:20607-20624. April 21, 2006.

U.S. Fish and Wildlife Service. 2006*b*. Endangered and threatened wildlife and plants; Proposed special rule pursuant to section 4(d) of the Endangered Species Act for the Pacific coast distinct population segment of the western snowy plover. Federal Register 71:20625-20636. April 21, 2006.

U.S. Fish and Wildlife Service. 2006*c*. San Diego Bay National Wildlife Refuge Sweetwater Marsh and South San Diego Bay Units Final Comprehensive Conservation Plan and Environmental Impact Statement – August 2006.

U.S. Fish and Wildlife Service. In preparation. Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California.

U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration. 1994. Endangered and threatened wildlife and plants: Notice of interagency cooperative policy on recovery plan participation and implementation under the Endangered Species Act. Federal Register 59(126):34272-34273.

U.S. Geological Survey. 2006. West Nile virus maps. Retrieved from: http://diseasemaps.usgs.gov/wnv_us_bird.html Accessed December 27, 2006.

U.S. Navy. 2001. Integrated Natural Resources Management Plan, Naval Base Coronado.

U.S. Marine Corps. 2006. Integrated Natural Resources Management Plan, Marine Corps Base Camp Pendleton. August 2006 draft revision.

Unitt, P. 2004. San Diego County Bird Atlas. San Diego Natural History Museum and Ibis Publishing Company. San Diego, California.

Warriner, J.S., J.C. Warriner, G.W. Page, and L.E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous snowy plovers. Wilson Bulletin 98(1):15-37.

Washington Department of Fish and Wildlife. 1995. Washington State recovery plan for the snowy plover. Olympia, WA. 87 pp.

White, J.D., and S.G. Allen. 1999. Western snowy plover management plan. Report to the National Park Service, Point Reyes National Seashore, Point Reyes, CA.

White, J.D., and C.M. Hickey. 1997. Distribution, protection and nest success of snowy plovers at Point Reyes National Seashore. A report of Point Reyes Bird Observatory, Stinson Beach, CA. 11 pp.

Widrig, R.S. 1980. Snowy plovers at Leadbetter Point: An opportunity for wildlife management? Prepared for the U.S. Fish and Wildlife Service, Willapa NWR, Ilwaco, WA. 14 pp.

Widrig, R.S. 1981. Snowy plovers at Leadbetter Point. Prepared for the U.S. Fish and Wildlife Service, Willapa NWR, Ilwaco, WA. 13 pp.

Wiedemann, A.M. 1987. The ecology of European beachgrass (*Ammophila arenaria* (L.) Link). A review of the literature. Oregon Department of Fish and Wildlife Nongame Wildlife Program Technical Report #87-1-01. 18 pp.

Wiedemann, A.M., L.J. Dennis, and F.H. Smith. 1969. Plants of the Oregon coastal dunes. Department of Botany, Oregon State University. Oregon State University Book Stores, Inc., Corvallis, OR. 117 pp.

Willapa National Wildlife Refuge. 1988. Willapa National Wildlife Refuge, 1988 annual narrative report. Ilwaco, WA. 46 pp.

Williamson, D.A. 1995. Snowy plovers at Willapa Bay, Washington, 1995. Willapa National Wildlife Refuge Complex, Ilwaco, WA. 13pp.

Williamson, D.A. 1996. Snowy plovers at Willapa Bay, Washington, 1996. Willapa National Wildlife Refuge Complex, Ilwaco, WA. 13 pp.

Williamson, D.A. 1997. Snowy plovers at Willapa Bay, Washington, 1997. Willapa National Wildlife Refuge Complex, Ilwaco, WA. 15 pp.

Wilson, R.A. 1980. Snowy plover nesting ecology on the Oregon coast. MS Thesis, Oregon State University, Corvallis. 41 pp.

Wilson-Jacobs, R., and G.L. Dorsey. 1985. Snowy plover use of Coos Bay north spit, Oregon. Murrelet 66(3):75-81.

Wilson-Jacobs, R., and E.C. Meslow. 1984. Distribution, abundance, and nesting characteristics of snowy plovers on the Oregon coast. Northwest Science 58(1):40-48.

Woolington, M.C. 1985. A preliminary investigation of the effect of recreational use on nesting snowy plovers at Sutton and Siltcoos beach areas, Oregon. Oregon Department of Fish and Wildlife Nongame program. 37 pp.

B. Personal Communications

Albertson, J. 2005. Don Edwards - San Francisco Bay National Wildlife Refuge, U.S. Fish and Wildlife Service, Newark, CA.

Applegate, T. 1996, 1999. Bioresources, Los Osos, CA.

Baye, P. 1997. Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service, Sacramento, CA.

Burns, C. U.S. Forest Service, Siuslaw National Forest, Mapleton Ranger District, Florence, OR.

Dorsey, G. 1997. U.S. Army Corps of Engineers, Portland, OR.

Fernandez, E. 1998. Don Edwards-San Francisco Bay National Wildlife Refuge, U.S. Fish and Wildlife Service, Newark, CA.

George, D. 1998. Point Reyes Bird Observatory, Stinson Beach, CA.

Grettenberger, J. 2004. Western Washington Fish and Wildlife Office, U.S. Fish and Wildlife Service, Lacey, WA.

Heaney, J. 2003. Bureau of Land Management, Coos Bay District, North Bend, OR. June 27, 2003.

Hecht, A. 1996. U.S. Fish and Wildlife Service, Hadbury, MA.

Klinger, R. 1998. The Nature Conservancy, Santa Barbara, CA.

Kolar, M. 2004. Manager, San Francisco Bay National Wildlife Refuge Complex, U.S. Fish and Wildlife Service, Newark, CA.

Mangan, L. 2003. Bureau of Land Management, Coos Bay District, North Bend, OR.

Neuman, K. 1997. California Department of Parks and Recreation, Monterey, CA.

Page, G. 1997, 1998. Point Reyes Bird Observatory, Stinson Beach, CA.

Palermo, K. 1998. U.S. Forest Service, Oregon Dunes National Recreation Area, Siuslaw National Forest, Reedsport, OR.

Pearson, D. 1996. Southern California Edison, Rosemead, CA.

Pickart, A. 1997. The Nature Conservancy, Arcata, CA.

Powell, A.N. 1998. U.S. Geological Survey, Biological Resources Division, Fayetteville, AR.

Read, N. 1998. U.S. Department of the Air Force, Vandenberg Air Force Base, California.

Sandoval, C. 2005. University of California, Santa Barbara, CA.

Stadtlander, D. 1999. Carlsbad Fish and Wildlife Office, U.S. Fish and Wildlife Service, Carlsbad, CA.

Richardson, S. 1998. Washington Department of Fish and Wildlife, Olympia, WA.

Stern, M. 1999. The Nature Conservancy, Oregon Natural Heritage Program, Portland, OR.

VanderHeyden, M. Bureau of Land Management, Coos Bay District, North Bend, OR.

Vissman, S. 2007. U.S. Fish and Wildlife Service, Carlsbad, CA.

Walton, B. 1998. Predatory Bird Research Group, University of California at Santa Cruz, Santa Cruz, CA.

Watkins, J. 2001, 2006. Arcata Fish and Wildlife Office, U.S. Fish and Wildlife Service, Arcata, California.

C. *In Litt.* References

Albertson, J. 1999. Don Edwards-San Francisco Bay National Wildlife Refuge, U.S. Fish and Wildlife Service, Newark, California. Electronic message to U.S. Fish and Wildlife Service, Sacramento, CA, on working draft of the Western Snowy Plover Recovery Plan. 4 pp.

Allen, S. 2004. Point Reyes National Seashore, Point Reyes, CA. Electronic message to Valary Bloom, U.S. Fish and Wildlife Service, Sacramento, CA, providing comments on the Western Snowy Plover Draft Recovery Plan. 3 pp.

Bloom, V. 2005. U.S. Fish and Wildlife Service, Sacramento, CA. Electronic message to Cay Goude, U.S. Fish and Wildlife Service, Sacramento, CA, regarding snowy plover management in San Francisco Bay. 1 p.

Buffa, J. 2004. Don Edwards-San Francisco Bay National Wildlife Refuge, U.S. Fish and Wildlife Service, Newark, California. Electronic message to Valary Bloom, U.S. Fish and Wildlife Service, Sacramento, CA, providing comments on the Western Snowy Plover Draft Recovery Plan. 4 pp.

Copper, E., and B. Foster. 2001. Letter to U.S. Fish and Wildlife Service, Sacramento, CA, providing comments and additional information on the Western Snowy Plover Pacific Coast Population Draft Recovery Plan.

Didion, J. 1999. California Department of Parks and Recreation, Sacramento, CA. Letter to U.S. Fish and Wildlife Service, Sacramento, CA, on working draft of the Western Snowy Plover Recovery Plan. 6 pp.

Dixon, D. 1998. California Department of Parks and Recreation, Monterey, CA. Information provided to U.S. Fish and Wildlife Service, Sacramento, CA, regarding European beachgrass control and snowy plover guardian program. 5 pp.

Dyste, R. 2004. Comprehensive Planning Division, County of Santa Barbara, Santa Barbara, CA. Electronic message to Valary Bloom, U.S. Fish and Wildlife Service, Sacramento, CA, providing comments on the Western Snowy Plover Draft Recovery Plan. 3 pp.

George, D. 2001. Letter to U.S. Fish and Wildlife Service, Sacramento, CA, on working draft of the Western Snowy Plover Recovery Plan. 1 pp.+ attachment.

Goldsmith, G. 2004. U.S. Fish and Wildlife Service, Arcata, CA. Electronic message to Jim Watkins, U.S. Fish and Wildlife Service, Arcata, CA.

Henry, S. 1998. U.S. Fish and Wildlife Service, Ventura, CA. Electronic message to U.S. Fish and Wildlife Service, Sacramento, CA. 2 pp.

Jensen, M. 2006a. U.S. Fish and Wildlife Service, Lacey, WA. Table of window survey data. 1 p.

Jensen, M. 2006b. U.S. Fish and Wildlife Service, Lacey, WA. Electronic message to Grant Canterbury, U.S. Fish and Wildlife Service, Portland OR. 1 p.

Kelly, L. 2005. U.S. Fish and Wildlife Service, Newport, OR. Comparison of the 2005 winter and 2005 summer Snowy Plover surveys of the Oregon/Washington coast. (Recovery Unit 1). 2 pp.

Long, M. 2006. U.S. Fish and Wildlife Service, Arcata, CA. Botulism antitoxin treatment for federally threatened Pacific coast population of western snowy plover in southern California. Memo to Rex Sohn, U.S.G.S. National Wildlife Health Center, Madison, WI. 2 pp.

Mesta, R. 1998. U.S. Fish and Wildlife Service, Ventura, CA. Comments provided to U.S. Fish and Wildlife Service, Sacramento, CA, on the working draft of the Western Snowy Plover Recovery Plan. 3 pp.

Moulton, C. 1997. Manager, Eureka Fisheries, Inc., Fields Landing, CA. Letter to Field Supervisor, U.S. Fish and Wildlife Service, Sacramento, CA. 2 pp.

Myers, J.P. 1988. Senior Vice President, Science and Sanctuaries, National Audubon Society, New York, N.Y. Letter to Director, U.S. Fish and Wildlife Service, Washington, D.C. 19 pp.

Page, G.W. 1988. Point Reyes Bird Observatory, Stinson Beach, CA. Letter to U.S. Fish and Wildlife Service, Portland, OR. 1 p.

Page, G.W. 2004*a*. Point Reyes Bird Observatory, Stinson Beach, CA. Letter to Field Supervisor, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service, Sacramento, CA, providing comments on reassessment of snowy plover listing status. 20 pp.

Page, G.W. 2004*b*. Point Reyes Bird Observatory, Stinson Beach, CA. Letter to Glen Tarr, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service, Sacramento, CA, providing comments on western snowy plover management in Monterey Bay area. 3 pp.

Page, G.W. 2005*a*. Point Reyes Bird Observatory, Stinson Beach, CA. Year 2005 breeding season snowy plover survey of California coast. Electronic file sent to U.S. Fish and Wildlife Service. 3 pp.

Page, G.W. 2005*b*. Point Reyes Bird Observatory, Stinson Beach, CA. Snowy plover banding study proposal. Electronic message to U.S. Fish and Wildlife Service, Arcata, CA. 6 pp.

Page, G. W. 2006. Point Reyes Bird Observatory, Stinson Beach, CA. Comparison of the 2005 and 2006 snowy plover surveys of the Pacific coast. Electronic file sent to U.S. Fish and Wildlife Service. 8 pp.

Palermo, K. 1998*a*. U.S. Forest Service, Oregon Dunes National Recreation Area, Siuslaw National Forest, Reedsport, OR. Letter to U.S. Fish and Wildlife Service, Sacramento, CA, on the working draft of the Western Snowy Plover Recovery Plan. 2 pp.

Pearson, S. 2006. Washington Department of Fish and Wildlife, Olympia, WA. Electronic message to Martha Jensen, U.S. Fish and Wildlife Service, Lacey, WA. 2 pp.

Palermo, K. 1998*b*. U.S. Forest Service, Oregon Dunes National Recreation Area, Siuslaw National Forest, Reedsport, OR. Electronic message to U.S. Fish and Wildlife Service, Sacramento, CA, on European beachgrass control. 1 p.

Pickart, A. 1996. The Nature Conservancy, Arcata, CA. Information provided to U.S. Fish and Wildlife Service, Sacramento, CA, regarding the status of European beachgrass in California. 2 pp.

Price, J.B. 1992. Chief Ranger, Department of Parks and Recreation, Ventura, CA. Memorandum to Oxnard Police Department *et al.* 1 p.

Read, N. 1998. Vandenberg Air Force Base, CA. Electronic message to U.S. Fish and Wildlife Service, Sacramento, CA, on the working draft of the Western Snowy Plover Recovery Plan. 2 pp.

Read Francine, N. 2001. Department of the Air Force, Vandenberg Air Force Base, CA. Letter to U.S. Fish and Wildlife Service, Sacramento, CA, providing comments and additional information on the Western Snowy Plover Pacific Coast Population Draft Recovery Plan. 8 pp.

Richardson, S. 2001. Bureau of Reclamation. Letter to U.S. Fish and Wildlife Service, Sacramento, CA, providing comments and additional information on the Western Snowy Plover Pacific Coast Population Draft Recovery Plan.

Trulio, L. 2007. Electronic message to Valary Bloom, U.S. Fish and Wildlife Service, Sacramento, CA, on snowy plover habitat in San Francisco Bay.

U.S. Department of the Navy. 2001. Letter from U.S. Department of the Navy, China Lake, CA, to the U.S. Fish and Wildlife Service, Sacramento, CA, on increasing pinniped populations on San Nicholas Island.

U.S. Department of the Navy. 2007. Letter to U.S. Fish and Wildlife Service, Carlsbad, CA, requesting re-initiation of consultation at Naval Base Coronado. 13 pp.

U.S. Fish and Wildlife Service. 1995. Memorandum from Acting Field Supervisor, Ventura Field Office, Ecological Services, Ventura, CA, to Superintendent, Channel Islands National Park, National Park Service, Ventura, CA. 26 pp.

Watkins, J. 1999. U.S. Fish and Wildlife Service, Arcata, CA. Electronic message to U.S. Fish and Wildlife Service, Sacramento, CA, on the working draft of the Western Snowy Plover Recovery Plan. 11 pp.

Zielinski, E.Y. 1999. U.S. Bureau of Land Management, Portland, OR, and R.W. Williams, U.S. Forest Service, Portland, OR. Letter to U.S. Fish and Wildlife Service, Sacramento, CA, on the working draft of the Western Snowy Plover Recovery Plan. 15 pp. plus enclosures.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825

April 8, 2013

Document Number: 130408113454

Michelle Giolli
Environmental Science Associates
350 Frank H. Ogawa Plaza Suite 300
Oakland, CA 94612

Subject: Species List for Monterey Desal

Dear: Ms. Giolli

We are sending this official species list in response to your April 8, 2013 request for information about endangered and threatened species. The list covers the California counties and/or U.S. Geological Survey 7½ minute quad or quads you requested.

Our database was developed primarily to assist Federal agencies that are consulting with us. Therefore, our lists include all of the sensitive species that have been found in a certain area *and also ones that may be affected by projects in the area*. For example, a fish may be on the list for a quad if it lives somewhere downstream from that quad. Birds are included even if they only migrate through an area. In other words, we include all of the species we want people to consider when they do something that affects the environment.

Please read Important Information About Your Species List (below). It explains how we made the list and describes your responsibilities under the Endangered Species Act.

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be July 07, 2013.

Please contact us if your project may affect endangered or threatened species or if you have any questions about the attached list or your responsibilities under the Endangered Species Act. A list of Endangered Species Program contacts can be found here.

Endangered Species Division

TAKE PRIDE IN AMERICA

U.S. Fish & Wildlife Service
Sacramento Fish & Wildlife Office
Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 130408113454

Database Last Updated: September 18, 2011

No quad species lists requested.

County Lists

Monterey County

Listed Species

Invertebrates

Branchinecta conservatio
Conservancy fairy shrimp (E)

Branchinecta lynchi
Critical habitat, vernal pool fairy shrimp (X)
vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
valley elderberry longhorn beetle (T)

Euphydryas editha bayensis
bay checkerspot butterfly (T)

Fish

Eucyclogobius newberryi
critical habitat, tidewater goby (X)

Hypomesus transpacificus
delta smelt (T)

Oncorhynchus kisutch
coho salmon - central CA coast (E) (NMFS)

Oncorhynchus mykiss
Central Valley steelhead (T) (NMFS)
Critical habitat, Central California coastal steelhead (X) (NMFS)
South Central California steelhead (T) (NMFS)

Amphibians

Ambystoma californiense
California tiger salamander, central population (T)
Critical habitat, CA tiger salamander, central population (X)

Rana draytonii
California red-legged frog (T)
Critical habitat, California red-legged frog (X)

Reptiles

Gambelia (=Crotaphytus) sila
blunt-nosed leopard lizard (E)

Birds

Brachyramphus marmoratus
marbled murrelet (T)

Charadrius alexandrinus nivosus
Critical habitat, western snowy plover (X)

Gymnogyps californianus
California condor (E)

Rallus longirostris obsoletus
California clapper rail (E)

Sternula antillarum (=Sterna, =albifrons) browni
California least tern (E)

Vireo bellii pusillus
Least Bell's vireo (E)

Mammals

Dipodomys ingens
giant kangaroo rat (E)

Vulpes macrotis mutica
San Joaquin kit fox (E)

Plants

Camissonia benitensis
San Benito evening-primrose (T)

Caulanthus californicus
California jewelflower (E)

Chorizanthe robusta var. robusta
robust spineflower (E)

Erysimum menziesii (includes ssp. yadonii)
Menzies's wallflower (E)

Holocarpha macradenia
Critical habitat, Santa Cruz tarplant (X)
Santa Cruz tarplant (T)

Lasthenia conjugens
Contra Costa goldfields (E)

Layia carnosa
beach layia (E)

Lupinus tidestromii
clover lupine [Tidestrom's lupine] (E)

Monolopia congdonii (=Lembertia congdonii)
San Joaquin woolly-threads (E)

Potentilla hickmanii
Hickman's potentilla (=cinquefoil) (E)

Key:

(E) *Endangered* - Listed as being in danger of extinction.

(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.

(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.

(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.

Critical Habitat - Area essential to the conservation of a species.

(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.

(C) *Candidate* - Candidate to become a proposed species.

(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.

(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

> Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.

- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compensates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our Map Room page.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6520.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be July 07, 2013.

BW-1787

Installation-Wide Multispecies Habitat Management Plan for Former Fort Ord, California

U.S. Army Corps of Engineers
Sacramento District

April 1997

BW-1787
signature pages

Habitat Management Plan
for Former Fort Ord, California

The Habitat Management Plan for former Fort Ord, California, will be completed and in effect once signed by the Army and the U.S. Fish and Wildlife Service. Other agencies will be asked to sign Memoranda of Agreement for implementation of portions of the Habitat Management Plan designated for each agency.

Daniel D. Devlin
Colonel, U.S. Army
Commanding, Presidio of Monterey

The U.S. Fish and Wildlife Service finds that the Habitat Management Plan for the former Fort Ord fulfills reasonable and prudent measure 1 in its October 19, 1993 Biological Opinion for the disposal and reuse of Fort Ord. Additionally, the U.S. Fish and Wildlife Service issued an amended Biological/Conference Opinion in April 1997 that analyzed the effects of the Habitat Management Plan on the federally listed Smith's blue butterfly, western snowy plover, California red-legged frog, sand gilia, Monterey spineflower, and robust spineflower and the proposed black legless lizard and Yadon's piperia. The Habitat Management Plan does not authorize incidental take by entities acquiring land at the former Fort Ord of any species listed as threatened or endangered under the federal Endangered Species Act of 1973, as amended. Entities would submit the Habitat Management Plan in combination with additional documentation, including an implementation agreement signed by all parties receiving lands that are to be managed for wildlife values, to the U.S. Fish and Wildlife Service to receive authorization for incidental take through Section 10(a)(1)(B) permits.

Diane K. Noda
Field Supervisor
U.S. Fish and Wildlife Service

Concurring Agencies

The following agency signs to indicate its concurrence with the Habitat Management Plan.

The Fort Ord Reuse Authority concurs with the Habitat Management Plan and agrees to comply with the conditions in the Habitat Management Plan in implementation of the Base Reuse Plan for former Fort Ord.

Fort Ord Reuse Authority

Michael A. Houlemard, Jr.
Executive Officer

Concurrence with Management Requirements for Habitat Reserve, Habitat Corridor, Borderland Development Areas Along NRMA Interface, and Development with Reserve Areas or Development with Restrictions

The following agencies will receive lands designated in the Habitat Management Plan as Habitat Reserve. Habitat Corridor, Borderland Development Areas Along NRMA Interface. and/or Development with Reserve Areas or Development with Restrictions and concur with the management requirements stated in the Habitat Management Plan for their respective parcels.

U.S. Bureau of Land Management	California Department of Parks and Recreation
California Department of Transportation	Regents of the University of California (Santa Cruz Campus)
Monterey County	Regents of the University of California (Division of Agriculture and Natural Resources)
Monterey Peninsula Regional Parks District	City of Marina
York School	

Concurrence with Provisions for Land Transfers of Parcels with Habitat Management Plan Requirements

These agencies are agencies who, in addition to those above, may receive land having Habitat Management Plan requirements. However. the agency plans to execute the Habitat Management Plan requirements via one of the above agencies or another Habitat Management Plan managing agency acceptable to the U.S. Fish and Wildlife Service.

Fort Ord Reuse Authority	Monterey Peninsula College

Michael A. Houlemard, Jr.
Executive Officer

Concurrence with Management Requirements for Habitat Reserve, Habitat Corridor, Borderland Development Areas Along NRMA Interface, and Development with Reserve Areas or Development with Restrictions

The following agencies will receive lands designated in the Habitat Management Plan as Habitat Reserve, Habitat Corridor, Borderland Development Areas Along NRMA Interface, and/or Development with Reserve Areas or Development with Restrictions and concur with the management requirements stated in the Habitat Management Plan for their respective parcels.

Ed Harley

U.S. Bureau of Land Management

California Department of Parks and Recreation

California Department of Transportation

Regents of the University of California (Santa Cruz Campus)

Monterey County

Regents of the University of California (Division of Agriculture and Natural Resources)

Monterey Peninsula Regional Parks District

City of Marina

Concurrence with Provisions for Land Transfers of Parcels with Habitat Management Plan Requirements

These agencies are agencies who, in addition to those above, may receive land having Habitat Management Plan requirements. However, the agency plans to execute the Habitat Management Plan requirements via one of the above agencies or another Habitat Management Plan managing agency acceptable to the U.S. Fish and Wildlife Service.

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Fort Ord Reuse Authority

Monterey Peninsula College

Habitat Management Plan for Former Fort Ord, California

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Executive Summary

INTRODUCTION

The Installation-Wide Multispecies Habitat Management Plan (HMP) for former Fort Ord complies with the U.S. Fish and Wildlife Service (USFWS) final Biological/Conference Opinion for disposal and reuse of former Fort Ord lands and establishes the guidelines for the conservation and management of wildlife and plant species and habitats that largely depend on former Fort Ord land for survival. The HMP was developed with input from federal, state, local, and private agencies and organizations concerned with the natural resources and reuse of former Fort Ord. Implementation of this HMP will assist in the orderly disposal and reuse of former Fort Ord.

PURPOSE AND NEED FOR THE MULTISPECIES HABITAT MANAGEMENT PLAN

The Department of the Army in 1991 was directed to close and dispose of Fort Ord, California. The Army's action is considered a major federal action that could affect eight species proposed for listing or listed as threatened or endangered under the federal Endangered Species Act (ESA). A Biological Assessment (BA) was prepared that identifies the potential loss of populations and habitat of federally listed species, species proposed for listing, and species that are candidates for listing, resulting from caretaker actions, disposal actions, and six reuse alternatives (U.S. Army Corps of Engineers 1993a). A supplement to the draft BA was prepared that describes the loss of populations and habitat of these same species resulting from an additional reuse alternative (Alternative 6R) (U.S. Army Corps of Engineers 1993b). The USFWS's October 19, 1993, Final Biological Opinion on the disposal and reuse of former Fort Ord required that an HMP be developed and implemented to reduce the incidental take of listed species and loss of habitat that supports these species.

The 1993 Final Environmental Impact Statement (FEIS) for the disposal and reuse of former Fort Ord identified the need to develop and implement a multispecies Habitat Management Plan (HMP) as a mitigation measure for impacts on vegetation and wildlife resources. An HMP was published, initially, in February 1994 in response to both the biological opinion and mitigation measures identified in the FEIS and the December 1993 National Environmental Policy Act Record of Decision (1993 NEPA ROD). The February 1994 HMP (1994 HMP) addressed impacts resulting from predisposal, disposal, and reuse actions. Reuse actions addressed were those proposed under Alternative 6R Modified as included in the 1993 NEPA ROD.

Since publication of the FEIS and 1994 HMP, the U.S. Army (Army) has prepared a Final Supplemental Environmental Impact Statement (FSEIS) (U.S. Army Corps of Engineers 1996) to include additional data and an analysis of the following:

- disposal of additional land excess to the Army needs resulting from changes in the Army's Presidio of Monterey (POM) Annex boundary;
- those reuse areas that, as agreed to by the Army in the 1993 NEPA ROD associated with the FEIS, require additional analysis to cover disposal for new land uses;
- uses contained in the Fort Ord Reuse Authority (FORA) Final Base Reuse Plan (December 1994) that were not covered fully in the FEIS and ROD; and

- three additional reuse alternatives:

  - Alternative 7, which represents the December 12, 1994 FORA Final Base Reuse Plan;

  - Revised Alternative 7 is not significantly different from Alternative 7 and includes land uses established through property transfers or memoranda of agreement (MOA) for property transfers already completed by the Army; land uses proposed through federal, state, local, and McKinney Act screening completed in April 1996 for recently excessed lands; land uses required in the draft Revised HMP; land uses for remaining areas as proposed in the Draft FORA Fort Ord Reuse Plan (March 1996) that do not conflict with laws and other federal regulations, policies, and requirements or the draft Revised HMP (April 1996 Concept Agreement); relocation of a resort hotel; and utility easements needed for transfer of utility systems; and

  - Alternative 8, a land use scenario very similar to Alternative 7, contains most of the land use proposals of the FORA Final Base Reuse Plan (December 1994), but it also includes uses for specific parcels that were received through the scoping process for the Supplemental EIS.

During development of the FSEIS and through an agreement between the Army, USFWS, U.S. Bureau of Land Management (BLM), University of California (UC), and Fort Ord Reuse Authority (FORA) related to minimizing impacts on biological resources, it was determined that a revised HMP would be developed to replace the 1994 HMP. This document (this HMP) serves as a revised HMP. It follows a format similar to that presented in the 1994 HMP and has the same goals and objectives as the original document. The primary differences are modification of the HMP reuse scenario to reflect the planned methods for remediation of the beach trainfire ranges to the health-based level of concern, revisions in development and reserve areas, replacing parcel-specific land use descriptors from a specific reuse alternative with a generic development designation that would include a potential range of reuses considered in the FEIS and the June 1996 FSEIS, and inclusion of the mitigation measures agreed to by the Army, USFWS, and other agencies included in the agreement mentioned above.

A general goal of this HMP is to promote preservation, enhancement, and restoration of habitat and populations of HMP species while allowing development on selected properties that promotes economic recovery after closure of Fort Ord. (Specific HMP goals are described in Chapter 1.) As an installation-wide plan, all parcels to be disposed of by the Army are addressed in this HMP and are considered in achieving HMP goals. However, management guidelines and specifications for reuse may vary from parcel to parcel based on future plans for the parcel associated with this HMP and overall reuse planning.

Some parcels to be disposed of by the Army are intended to promote economic recovery after disposal and will be designated for development with no restrictions or guidelines described in this HMP. Other parcels will have development designated as the primary use, but recipients of disposed land will be obligated to implement certain guidelines and/or preserve specific areas through this HMP and deed covenants. Other parcels are designated as habitat reserves or corridors and have specific management guidelines and restrictions on development and uses. This HMP also includes consideration of specific transportation corridors planned by the local community. (Refer to the "HMP Analysis of Road Corridors" section in Chapter 4.)

Attachment A shows each parcel proposed for reuse and indicates the HMP management categories planned for the parcel: Habitat Reserve, Habitat Corridor, Development with Reserve Areas or Development with Restrictions, Borderland Development Areas Along NRMA Interface, Development, and Future Road Corridors. Figure S-1 shows the areas where these categories apply.

Each parcel is also numbered in Attachment A. The letter before each parcel number identifies the type of agency expected to receive the parcel and/or the anticipated method of transfer. The letter F before a parcel number indicates a Federal Transfer Parcel; an S indicates a State Transfer Parcel; an L indicates a Local Transfer Parcel under a public benefit conveyance (PBC); and an E indicates a parcel available for

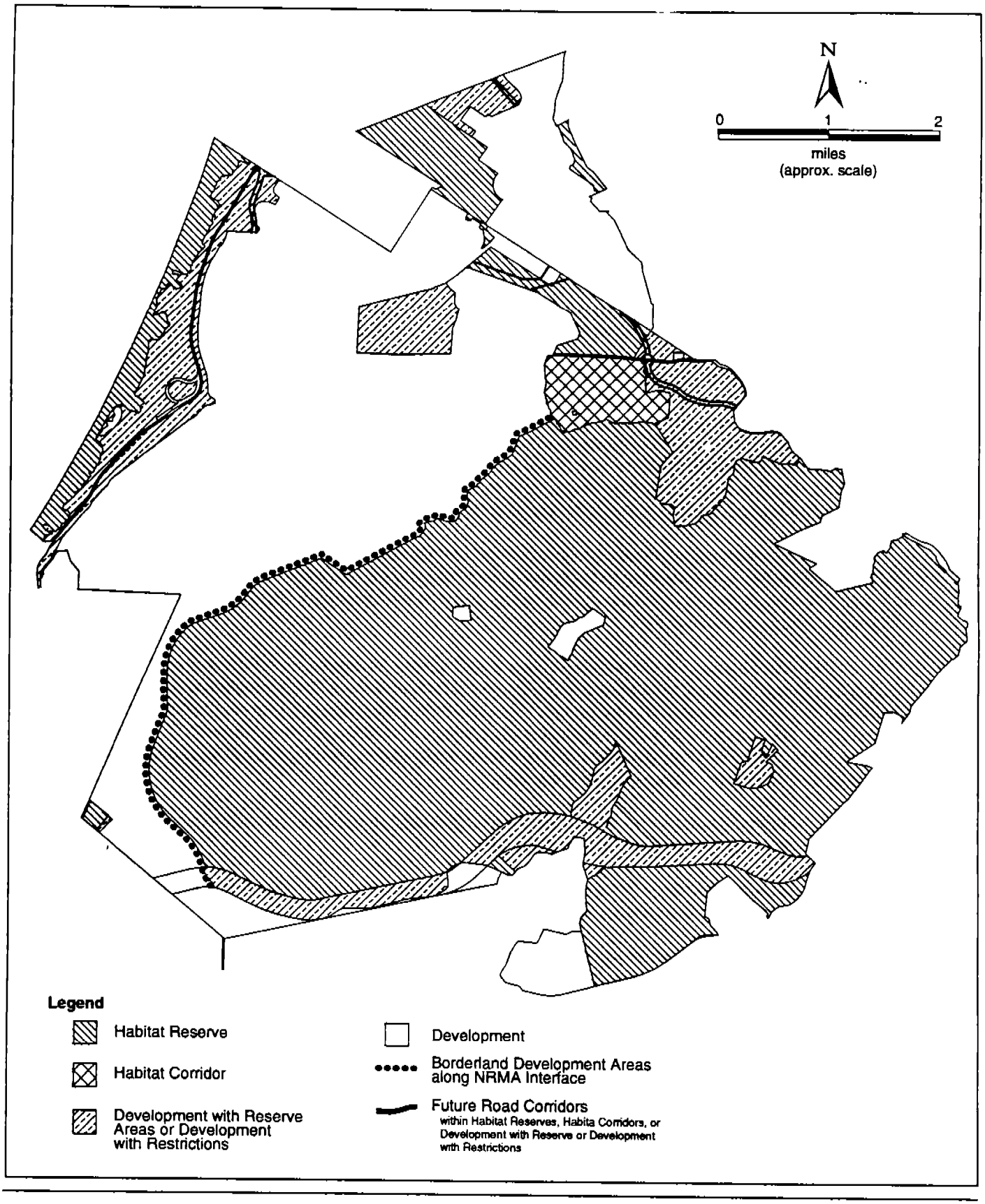

Figure S-1
Habitat Management Plan Map for Former Fort Ord (April 1997)

an Economic Development Conveyance (EDC) or other method of transfer. Parcel numbers beginning with an E correspond to polygon numbers included in the Draft FORA Fort Ord Reuse Plan (March 1996).

ARMY DISPOSAL PROCESS

Upon completion of this HMP and the FSEIS ROD, the Army intends to continue with property disposal at the former Fort Ord. The Army does not intend to adopt a specific reuse plan or alternative. The Army intends for the disposal process to be consistent with FORA's Final Base Reuse Plan where it is not in conflict with laws and other federal regulations, policies, and requirements. As stated in the 1993 NEPA ROD, "The disposal process will consider federal requests received in the screening process for transfer of federal land that is required under the Federal Property and Administrative Services Act of 1949, as well as all McKinney Act requests. The Army will honor, where possible and appropriate, all state and local requests for conveyance from separately authorized federal programs for transportation, education, recreation and open space, public health and safety, and airports." In addition, the Army will proceed with transfers for which memoranda of agreement (MOA) have been completed, e.g., California State University Monterey Bay and University of California Santa Cruz. Lands that are not transferred through these processes will be available for FORA to include in its economic development conveyance (EDC) application. Any remaining property will be available for negotiated sale to public bodies and for private sale.

Key disposal actions have been initiated or committed to by the Army based on the 1993 FEIS and ROD, the 1994 HMP, and the then-existing reuse plan, to federally sponsored PBC recipients, to Health and Human Services sponsored McKinney Act providers, and to the University of California and California State University Monterey Bay via EDC .

The 1993 Biological Opinion describes the concepts for disposal and habitat preservation within portions of Fort Ord (based on Alternative 6R) with habitat reserve lands to be transferred with binding habitat management and conservation requirements. The 1993 Biological Opinion provides for other parcels to be transferred that contain habitat for special-status species as development parcels. The management requirements of the 1993 Biological Opinion have been consolidated into six principal management categories for parcels in this HMP. These include the following:

- **Habitat Reserve** - no development allowed; management goal is conservation and enhancement of threatened and endangered species;
- **Habitat Corridor** - lands between major reserve areas; to be managed to promote connections between conservation areas;
- **Development with Reserve Areas or Development with Restrictions** - lands slated for development that contain inholdings of reserve or require specific restrictions to protect biological resource values; management of reserve inholdings must match that for habitat reserves, while management in developable areas must proceed with certain specific restrictions identified in this HMP;
- **Borderland Development Areas Along NRMA Interface** - areas abutting the Natural Resources Management Area that are slated for development; management of these lands includes no restrictions except along the development/reserve interface;
- **Development**- no management restrictions are contained in this HMP; some plans for salvage of biological resources from these lands may be specified; and
- **Future Road Corridors** - lands within habitat reserve set aside for future road development; to be managed as habitat reserve until road development occurs.

The Development areas, Development with Reserve Areas or Development with Restrictions areas, and Borderland Development Areas Along NRMA Interface (described in this HMP) will be available for disposal and development for reuse. For the 1993 Biological Opinion, it is assumed that a complete loss of biological resources would occur in the development parcels. The development parcels could be transferred with no covenants, deed restrictions, or conservation easements required. Lands designated as Development have no management restrictions placed on them as a result of this HMP.

Several reuse alternatives have been analyzed in the Army FEIS and FSEIS and these include the 1993 NEPA ROD land use map (Alternative 6RM), the December 1994 FORA Final Base Reuse Plan (Alternative 7) and elements of the March 1996 Draft FORA Fort Ord Reuse Plan (Revised Alternative 7). The 1994 HMP supports reuse within development areas based on Alternative 6RM. The FSEIS concluded that Alternative 7 would result in the removal of approximately 6,180 acres of habitat, approximately 240 acres more habitat removed from reserve areas than provided for in the February 1994 HMP. Alternative 7 would have adverse effects on biological resources and while the land uses proposed in the December 1994 FORA Plan could be accommodated within the development areas of the 1994 HMP, avoidance and mitigation measures are needed to avoid significant impacts to HMP target species. These measures have been included in this HMP and in Revised Alternative 7 and Alternative 8 of the FSEIS. The land uses described in these alternatives can be accommodated within the Development, Development with Reserve Areas or Development with Restrictions Areas, Borderland Development Areas Along NRMA Interface, and Habitat Corridor lands in this HMP. Other development land uses may also be accommodated within this HMP's development areas.

ORGANIZATION OF THE HMP

This HMP is organized in the same manner as the 1994 HMP. It is presented in six chapters. Chapter 1, "Purpose of and Need for the Habitat Management Plan", describes the purpose and need, goals and objectives, and procedure followed in developing this HMP. Chapter 2, "Minimum Conservation Area and Corridor System", describes methods used to develop a minimum conservation area and corridor system for former Fort Ord. Chapter 3, "Habitat Management for Predisposal Actions", presents habitat management procedures to accompany Army actions taken before disposal of former Fort Ord land. Chapter 4, "Habitat Management for Disposal and Reuse", describes the habitat management procedures to be taken by recipients of disposed land. Chapter 5, "Citations", lists the sources cited in this HMP. Chapter 6, "List of Preparers and Acknowledgments", describes the contributions of key staff and agency representatives.

GOALS AND OBJECTIVES

The goals and objectives of this HMP are the same as those for the 1994 HMP.

- Preserve, protect, and enhance populations and habitat of federally listed threatened and endangered wildlife and plant species.
- Avoid reducing populations or habitat of federal proposed and candidate wildlife and plant species to levels that may result in one or more of these species becoming listed as threatened or endangered.
- Preserve and protect populations and habitat of state-listed threatened and endangered wildlife and plant species.

- Avoid reducing populations or habitat of species listed as rare, threatened, and endangered by the California Native Plant Society (CNPS) (List 1B), or with large portions of their range at former Fort Ord, to levels that may result in one or more of these species becoming listed as threatened or endangered.

- Conduct the disposal of land to public and private entities in a manner that is compatible with the preservation of federally listed threatened and endangered wildlife and plants within the HMP conservation area.

- Inform potential recipients of former Fort Ord land and the general public of methods that provide a suitable mechanism for protecting natural resources while allowing implementation of a community-based reuse plan that promotes economic recovery after closure of former Fort Ord.

- Provide the basis for recipients of former Fort Ord lands to seek Section 10(a) permits pursuant to the federal ESA and achieve compliance for conservation of state-listed threatened and endangered species and other special-status species recognized by California Department of Fish and Game (DFG) under the California ESA and the California Environmental Quality Act (CEQA).

- Provide a foundation for a prelisting agreement between USFWS and recipient landowners.

The overall goal of this HMP is to provide for, at a minimum, no net loss of populations or important habitat for any of the subject species of this HMP. This goal can be met through the careful selection of areas designated as reserves and corridors. The beneficial enhancement of habitat by the selected management agencies is essential to the achievement of this goal.

FLEXIBILITY OF THE HMP

Pre-Transfer Modifications to the HMP

This HMP has adjusted the development and reserve areas to reflect changes proposed in the community reuse plan and information relating to the Army environmental remediation actions. The specific land use designations for individual development parcels have been replaced with a generic development designation, allowing for broad flexibility in reuse of specific development parcels. Changes in specific use of development parcels within the range of uses described in the FEIS and the FSEIS would not require revision to this HMP. During disposal by the Army, it may be necessary to alter management agencies for reserve areas or portions of reserve areas because of changes in anticipated land recipients. Any such change would be coordinated with USFWS and agreed to by both parties. Any further revision to habitat reserves or corridors before transfer would necessitate revisions in this HMP.

The Army will remain responsible for any changes to this HMP in areas that have not been transferred (pre-transfer). The Army will also remain responsible for revisions to this HMP relating to hazardous, toxic, and radiological waste and ordnance and explosives response actions. Changes undertaken in parcels after they are transferred are the responsibility of the land recipient.

Polygon boundaries in development areas may be modified, and development polygons may be subdivided or aggregated before transfer. These types of changes in development polygons will not require modifications to this HMP.

Post-Transfer Modifications to the HMP

All recipients of former Fort Ord lands will be required to abide by management guidelines and procedures addressed in this HMP. However, situations may arise during the life of this HMP that make changes in the plan's guidelines after lands have been transferred (post-transfer) appropriate. Several types of changes may occur. Land recipients may wish to change the boundaries of their parcels or land uses within their parcels. Actions such as additional infrastructure development in reserve areas may be necessary. Changes in management guidelines within a land use may be required to better preserve or enhance a resource. These kinds of changes may be made if the affected landowners and USFWS can agree that the overall goals and objectives of this HMP will not be compromised.

Such post-transfer revisions do not involve the Army and would be the responsibility of future landowners, subject to the terms of the reservation placed on the lands in the MOAs and/or deeds at the time the lands are transferred from the Army. Such revisions will be funded by the responsible agency/land recipient. The agency or land recipient will also be responsible for any necessary documentation and any coordination with USFWS, BLM, or other agencies.

Polygon boundaries in development areas may be modified, and development polygons may be subdivided or aggregated after transfer. These types of changes in development polygons will not require modifications to this HMP.

HABITAT MANAGEMENT PLAN SPECIES AND HABITATS

Species Addressed in the HMP

Wildlife and plant species and habitats addressed in this HMP are the same as those included in the 1994 HMP (Tables S-1 and S-2). These species are a subset of the species analyzed in the FEIS. Species addressed in the 1994 HMP were included based on their legal protection, listing status at the time of publication, and the relative importance of populations and habitats at former Fort Ord to the continued survival of the species.

Since publication of the 1994 HMP, the legal status of several species has changed. On February 28, 1996, the Department of the Interior published in the Federal Register (FR) the Department of the Interior Endangered and Threatened Species, Plant and Animal Taxa; Proposed Rule (61 FR 7596 February 28, 1996). Under the rule, the Category 1 and 2 classifications for federal candidate species are removed. Species either are identified as Candidate species with a listing priority classification or are no longer given any federal status. Many species previously considered Category 1 or 2 candidates are retained under the new Candidate status. Other species that were previously considered candidate species are identified as no longer having status under the federal ESA.

Although several species included in the 1994 HMP are no longer considered federal candidates, they are still retained in this HMP because they may be listed under the California ESA, they have a significant portion of their range at former Fort Ord, or they are associated with a habitat that is important to a suite of many other sensitive species.

Maritime Chaparral

Maritime chaparral is a coastal form of chaparral associated with specific soil conditions. Two forms are recognized at former Fort Ord based on the substrate that supports them: sand hill maritime chaparral occurs on relict dunes of the late Pleistocene epoch, and Aromas formation maritime chaparral occurs on weakly consolidated red sandstone that is a relict of mid-Pleistocene epoch dunes.

Periodic disturbance or removal of vegetation caused by unstable substrate and fire are important factors in maintaining and rejuvenating the maritime chaparral community. Early successional sites appear to support the highest diversity of shrubs, including the largest number of HMP shrub species.

HMP species occurring in maritime chaparral are black legless lizard, Toro manzanita, sandmat manzanita, Hooker's manzanita, Monterey ceanothus, Eastwood's ericameria, Seaside bird's-beak, sand gilia, Monterey spineflower, coast wallflower, and Yadon's piperia.

Healthy maritime chaparral occurs as a patchwork of stands that have burned at different times and that support vegetation of various ages and structures. This habitat mosaic allows for high species and habitat diversity and provides sources of propagules for dispersal between patches.

Successful conservation of maritime chaparral is dependent on proper management of the habitat by using fire as a management tool and allowing or encouraging some forms of substrate disturbance. The goal of management is to achieve high species and habitat diversity through a program of controlled burning that creates and maintains a mosaic pattern of maritime chaparral of various aged stands. However, sand gilia, Monterey spineflower, and coast wallflower may be dependent on open habitat created by blowing sand rather than by fire. Promoting a dynamic system of moving sand by selective vegetation removal may encourage the formation of habitat for these HMP species.

Coastal Dunes

Coastal strand and dune scrub habitats of the coastal dunes are dynamic plant communities that respond to a moving sand substrate and changing dune configuration. Blowing sand undermines and buries plants, but most dune plants are adapted to shallow burial and blasting by sand. Large areas of destabilized sand, called "blowouts", result in large-scale removal of vegetation and change in dune structure. As plants reinvade the bare sand they stabilize the dune.

The highest diversity of dune habitat and species is best maintained in dunes with conditions ranging from active to stabilized and a variety of topography with foredunes and rear dunes, dune crests, interdune valleys, and north- and south-facing slopes.

HMP species occurring in coastal strand and dune scrub are Smith's blue butterfly, sand gilia, Monterey spineflower, robust spineflower, black legless lizard, and coast wallflower. Yadon's piperia may occur in these habitats.

HABITAT CONSERVATION AND MANAGEMENT FOR PREDISPOSAL ACTIONS

Predisposal actions include placing former Fort Ord into a caretaker status, remediating contaminated sites, and supporting interim uses. As the 7th Infantry Division (Light) (IDL) realigned from Fort Ord, the Army placed structures, utilities, and operation and maintenance systems into a caretaker status until property disposal decisions are implemented. Caretaker status is defined by Army regulation as "the minimum required staffing to maintain an installation in a state of repair that maintains safety, security, and health standards".

Cleanup of contaminated sites is required in preparing lands for disposal and proposed future uses. The entire former Fort Ord installation is listed on the National Priorities List as a Superfund site. A Federal Facilities Agreement, negotiated under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), requires the Army to perform the Superfund cleanup process described in the Other Physical Attributes Baseline Study of Fort Ord, California (U.S. Army Corps of Engineers, Sacramento District 1992c). Cleanup activities that have potential to affect biological resources include excavation of contaminated soils, landfill remediation, removal of lead and other heavy metals, and ordnance and explosives removal. Impacts resulting from each of these actions are discussed separately in this chapter.

HMP guidelines for the cleanup of contaminated sites have been developed based on the best available information. Mitigation for cleanup activities may be modified in the future based on findings and conclusions in the Fort Ord Basewide Record of Decision for the Remedial Investigation/Feasibility Study, which is currently in preparation. Other mitigation measures may be considered based on site-specific information, results of human health and ecological risk assessments, and the development and screening of remedial alternatives. Any modifications to this HMP based on new information must be reviewed and approved by USFWS.

FUTURE REGULATORY COMPLIANCE

This HMP does not exempt future landowners from complying with environmental regulations enforced by federal, state, or local agencies. These regulations could include obtaining Section 7 or Section 10(a) permits from USFWS pursuant to the federal ESA, complying with federal ESA Section 9 prohibitions against take of listed species, complying with measures for conservation of state-listed threatened and endangered species and other special-status species recognized by DFG under the California ESA, CEQA compliance, and complying with local land use regulations and restrictions. This HMP is intended to form a basis for binding agreements between receiving jurisdictions, the Army and USFWS to establish detailed plans for natural resource conservation, and specific management goals for each land parcel with habitat management requirements.

The HMP does not authorize incidental take by entities acquiring land at former Fort Ord of any species listed as threatened or endangered under the ESA, as amended. Entities would submit the HMP in combination with additional documentation, including an Implementation Agreement signed by all parties receiving lands that are to be managed for wildlife values, to the USFWS to receive authorization for incidental take.

In addition, the HMP is intended to be the basis for a habitat conservation plan (HCP) that will support the issuance of incidental take permits under Section 10(a)(1)(B) of the ESA to the land recipients identified above. The provisions of the HCP(s) are expected to closely mirror the provisions of this HMP, and the implementing agreement developed to implement the HCP(s) is expected to establish detailed provisions for monitoring of the habitat conservation areas by the affected land recipients and reporting of habitat conditions to BLM, USFWS, and DFG consistent with the procedure outlined below.

Section 9 of the ESA prohibits any taking of a threatened or endangered animal species. The definition of "take" includes to harass, harm, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Exemptions to Section 9 can be obtained through Sections 7 and 10 of the ESA. The USFWS has recommended that all nonfederal entities acquiring land at former Fort Ord apply for Section 10(a)(1)(B) incidental take permits for the species covered in the HMP. Although the USFWS will not require further mitigation from entities that are in conformance with the HMP, those entities without incidental take authorization would be in violation of the ESA if any of their actions resulted in the take of a listed animal species.

To apply for a Section 10(a)(1)(B) incidental take permit, an entity must submit an application form (Form 3-200), a complete description of the activity sought to be authorized, the common and scientific names of the species sought to be covered by the permit, and a conservation plan (50 CFR 17.22[b]). Pursuant to 50 CFR 17.22(b)(1)(iii), the Habitat Conservation Plan (HCP) must specify (a) the impacts that will likely result from such takings; (b) what steps the applicant will take to monitor, minimize, and mitigate such impacts, the funding that will be available to implement such steps, and the procedures to be used to deal with unforeseen circumstances; (c) what alternative actions to such taking the applicant considered and the reasons why such alternative are not proposed to be utilized; and (d) such other measures that the director of the USFWS may require as being necessary or appropriate for purposes of the plan. For the USFWS to issue incidental take permits to any entities acquiring land at former Fort Ord, that entity will have to provide the above information.

Because this HMP addresses several unlisted species, the HMP provides a foundation for prelisting agreements between USFWS and recipient landowners.

To coordinate this HMP with CEQA compliance, DFG may take into account the conservation measures set forth in this HMP when considering CEQA requirements for sensitive species and habitat types. DFG would consider the conservation program for HMP species and their habitats included in this HMP as adequate mitigation for CEQA compliance for those natural resources during the implementation of land reuse and development planning at former Fort Ord. There may be issues, such as oak woodland mitigation, outside the scope of this HMP that would need to be considered under CEQA.

IMPACTS ON LISTED AND PROPOSED HMP SPECIES

The following sections summarize the impacts on federally and state-listed HMP target species and HMP species proposed for federal listing, if all development areas identified in this HMP were developed. Plant and animal species considered in this HMP are listed in Tables S-1 and S-2, respectively, at the end of this Executive Summary.

Appendix B identifies which species occur in each parcel at former Fort Ord. Table B-1 indicates the presence or absence of each target species based on the latest available information. Table B-2 describes acreage of low-, medium-, and high-density habitat suitable for each target species within each of the HMP reserves, HMP corridors, and the development areas based on 1992 survey information. Maps indicating the distribution of each HMP plant species at former Fort Ord and potential and occupied habitats for each HMP wildlife species are also included in Appendix B. Maps are based on data collected during preparation of the 1992 Flora and Fauna Baseline Study (U.S. Army Corps of Engineers, Sacramento District 1992a). Information in Appendix B has been updated where available; however, analysis of impacts in this HMP is based on the 1992 data. The tables, combined with the distribution maps, provide further understanding of impacts to HMP species associated with development in development areas. The losses of habitat within development areas, as well as acres of habitat to be protected and enhanced within the HMP reserves and corridors, are described in Chapter 4 in the "Analysis of Impacts to HMP Target Species from the HMP" section.

Robust Spineflower (Federal Endangered)

Robust spineflower occurs on sandy soils in coastal dune and coastal scrub habitat. Several plants were observed at one site on the dunes west of Highway 1 during the 1992 field surveys. No other occurrences of robust spineflower were observed. Under this HMP, the group of plants would be preserved.

Sand Gilia (Federal Endangered)

Sand gilia inhabits openings in maritime chaparral and coastal scrub communities. It also prefers disturbed sites, such as the borders of old roads and firebreaks. Based on 1992 survey results for all of former Fort Ord, approximately 5 acres of maritime chaparral and coastal scrub supporting sand gilia at high densities, 120 acres at medium density, and approximately 680 acres at low density will be removed under this HMP. Annually from 1993 to 1996, portions of former Fort Ord have been resurveyed to provided more site-specific data on sand gilia distribution and abundance. Results of the 1993 surveys for the northern portion of former Fort Ord are shown in Figure B-1b in Appendix B. These surveys have typically shown a greater abundance of sand gilia than indicated by the 1992 survey results. However, none of these surveys has covered the entire installation as was done in 1992.

Smith's Blue Butterfly (Federal Endangered)

Smith's blue butterfly is completely dependent on seacliff and coast buckwheat for oviposition and as food sources for larvae and adults. Distribution and density of seacliff and coast buckwheat were recorded during the 1992 botanical surveys. Analysis of impacts to Smith's blue butterfly habitat is based on this data. Areas supporting medium or high densities of either buckwheat species are considered potential habitat for Smith's blue butterfly based on models included in the Flora and Fauna Baseline study. The 1994 HMP states that under that plan approximately 15 acres of potential Smith's blue butterfly habitat (areas supporting medium- and high-density populations of buckwheat) would be removed in the dunes west of SR1. In addition, an area of approximately 35 acres of dune habitat supporting buckwheat at low density would be removed and could potentially affect populations of Smith's blue butterfly. Habitat conservation and management requirements and land uses on the dunes west of Highway 1 under this HMP are consistent with those described for the 1994 HMP. Therefore, impacts to Smith's blue butterfly under this HMP are expected to be no greater than those described for the 1994 HMP.

Western Snowy Plover (Federal Threatened)

Western snowy plovers are known to nest on the beaches at former Fort Ord from the northern installation boundary to Stilwell Hall. They may also nest south of Stilwell Hall. The USFWS has proposed critical habitat for the Western snowy plover (60 FR 11768, March 2, 1995). The beaches at former Fort Ord are among the areas proposed as critical habitat. The HMP will not directly remove any western snowy plover nesting habitat. However, increased human presence on the beaches associated with the alternative could negatively affect snowy plover breeding success.

Monterey Spineflower (Federal Threatened)

Implementation of this HMP would result in the loss of approximately 3,910 acres of maritime chaparral, coastal dunes, coastal scrub, and grassland habitats occupied by Monterey spineflower. These habitat areas support Monterey spineflower at high densities on approximately 310 acres, medium densities on about 1,200 acres, and low densities on approximately 2,400 acres. Sand hill maritime chaparral, all coastal dune habitats, and grassland and coastal scrub habitats on sandy soils are potentially suitable habitat for Monterey spineflower. Monterey spineflower occurs in natural and artificial disturbance patches in these habitats.

Seaside Bird's-Beak (Species of Concern)

Seaside bird's-beak occurs in openings on sandy soils in maritime chaparral and oak woodland habitats. Implementation of this HMP would result in the removal of roughly 45 acres of maritime chaparral and oak woodlands supporting Seaside bird's-beak at low densities.

California Red-Legged Frog (Federal Threatened)

The California red-legged frog typically occupies cold water ponds with both emergent and submergent vegetation. No red-legged frogs have been observed on former Fort Ord; although potential habitat is available. Approximately 2 acres of potential California red-legged frog habitat would be removed under this HMP. However, part of this two acres consists of an artificial pond in parcel L20.2.2 (Attachment A) associated with the former Army Family Camp. The pond is filled from artificial sources and has been stocked with fish to provide recreational fishing for campers. Due to the presence of predatory game fish, it is unlikely that red-legged frogs would occur in this water body.

Almost all other potential red-legged frog habitat at former Fort Ord would be preserved within the Natural Resource Management Area (NRMA). The Salinas River is also considered potential red-legged frog habitat. One portion of former Fort Ord is within the river channel. This area is identified as a habitat reserve.

Yadon's Piperia (Federal Proposed Endangered)

The species occurs near established shrubs in maritime chaparral habitat. One population is known to occur on former Fort Ord in parcel E2a. This population would be preserved under this HMP. USFWS has proposed Yadon's piperia for federal listing as endangered.

Black Legless Lizard (Federal Proposed Endangered)

The California black legless lizard is found on dune habitats supporting native vegetation and where maritime chaparral and coastal scrub occur on loose sandy soils. Figure B-16 in Appendix B shows the occurrence of potential black legless lizard habitat at former Fort Ord based on habitat models developed during preparation of the 1992 Flora and Fauna Baseline study. Areas where potential habitat will be most affected include the western boundary of the multirange area (MRA) and where the former Fort Ord boundary abuts the City of Marina. USFWS has proposed the black legless lizard for federal listing as endangered.

ANALYSIS OF REUSE ALTERNATIVES FROM THE FEIS AND FSEIS

This HMP assumes, as described in the previous "Impacts on Listed and Proposed HMP Species" section, that development can occur through all development areas with the resultant loss of habitat. The following description provides a similar analysis of the full buildout of areas identified for development within Alternative 6R of the FEIS; Alternative 6RM of the 1993 NEPA ROD; and Alternative 7, Revised Alternative 7, and Alternative 8 of the FSEIS. These alternatives give an indication of the range of specific land uses that may occur within various development areas within this HMP.

This section summarizes impacts to biological resources associated with Alternative 6R from the 1993 FEIS; 6RM of the 1993 NEPA ROD; and Alternative 7, Revised Alternative 7, and Alternative 8 as described in the 1996 FSEIS. The 1993 FEIS, 1993 Biological Assessment, and the USFWS final Biological Opinion (October 19, 1993) describe Alternative 6R. Alternative 6RM is a modification of Alternative 6R that was contained in the 1993 NEPA ROD; it incorporated likely land uses in NPU areas based on an early version of the community reuse plan. Alternative 7 represents the December 12, 1994 FORA Final Base Reuse Plan. Revised Alternative 7 incorporates the Draft FORA Fort Ord Reuse Plan (March 1996) where it does not conflict with Army policies or agreements. Alternative 8, a land use scenario similar to Alternative 7, includes uses for specific parcels received during scoping processes. The full discussion of impacts to biological resources associated with Alternative 6R appears on pages 6-100 through 6-130 of Volume I of the FEIS. The full discussion of impacts to biological resources associated with Alternative 7 appears on pages 5-67

through 5-74 of the FSEIS. The full discussion of impacts to biological resources associated with Revised Alternative 7 appears on pages 5-112 through 5-121 of the FSEIS. The full discussion of impacts to biological resources associated with Alternative 8 appears on pages 5-125 through 5-127 of the FSEIS.

Alternative 6R was analyzed using a Geographic Information System (GIS) database of the 1992 biological survey data overlaid with a map of the alternative. For impact calculations, development-related land uses were assumed to remove all biological resources within the land use footprint and habitat conservation related land uses were assumed to preserve all biological resources in the land use footprint. Alternative 6R also included several areas with no proposed use (identified as NPU areas). NPU areas were assumed to have no effect on biological resources. However, it was acknowledged in the FEIS that lands designated as NPU could be subject to reuse in the future and would require future, separate environmental documentation.

The total effect of Alternative 6R would be the removal of approximately 2,507 acres of common and special native biological communities. Within this area of removed habitat, approximately 130 acres supporting low-density populations of sand gilia, 5 acres supporting medium-density populations, and 15 acres supporting high-density populations of sand gilia would be removed. The only other listed plant species that would be affected would be Monterey spineflower. This species would lose approximately 355 acres, 515 acres, and 70 acres respectively of areas supporting low-, medium-, and high-density populations. Alternative 6RM was analyzed using the same methodology described above for Alternative 6R, except that land uses were inserted into NPU areas based on the local reuse planning assumptions available at the time the 1993 NEPA ROD was completed.

The total effect of Alternative 6RM would be the removal of 5,941 acres of common and special native biological communities. Within this area of removed habitat, approximately 555 acres supporting low-density populations of sand gilia, 125 acres supporting medium-density populations of sand gilia, and 13 acres supporting high-density populations of sand gilia would be removed. The only other federally listed plant species that would be affected would be Monterey spineflower. This species would lose approximately 1,970 acres, 985 acres, and 260 acres, respectively, of areas supporting low-, medium-, and high-density populations.

Alternative 7 was analyzed using both a GIS database and manual overlaying of a proposed road network map with resource maps. The GIS analysis for Alternative 7 used the same methods as used for the Alternative 6R analysis. However, impact assumptions for some parcels were modified based on more recent information. Impact calculations using the GIS did not include impacts associated with a proposed road network because the digital mapping data for the road network was not compatible with the GIS biological resource data. Impacts from the road network were quantified by overlaying by hand road network maps with resource maps and planimetering the acres of effect.

The total effect of Alternative 7 would be the removal of approximately 6,180 acres of common and special native biological communities. Within this area of removed habitat, approximately 595 acres supporting low-density populations of sand gilia, 120 acres supporting medium-density populations of sand gilia, and 6 acres supporting high-density populations of sand gilia would be removed. The only other federally listed plant species that would be affected would be Monterey spineflower. This species would lose approximately 1,965 acres, 1,065 acres, and 250 acres, respectively, of areas supporting low-, medium-, and high-density populations.

Revised Alternative 7 was analyzed through a comparison against the reuse scenario described in the 1994 HMP. Areas where the alternative differed from the 1994 HMP relative to locations of development and habitat reserved were identified. Locations where portions of the proposed transportation network conflicted with habitat reserve areas in the February 1994 HMP were included in this analysis. Acreages of loss or gain of areas identified as habitat reserve were calculated for each location where Revised Alternative 7 and the 1994 HMP differed. Losses and gains were also calculated for key HMP resources. For the analysis, key HMP resources include areas supporting sand gilia, Monterey spineflower, and Seaside bird's beak.

The total effect of Revised Alternative 7 on habitat reserve areas is the conversion of approximately 370 acres of area considered habitat reserve in the 1994 HMP to developed area or another use. The total effect on key HMP resources under Revised Alternative 7 would be a loss of approximately 114 acres of habitat supporting low-density sand gilia populations; a loss of approximately 3 acres of area supporting medium-density sand gilia populations; a gain of approximately 8 acres of area supporting high-density sand gilia populations; a loss of approximately 183 acres and 62 acres, respectively, of area supporting low- and medium-density Monterey spineflower populations; a gain of approximately 7 acres of area supporting high-density Monterey spineflower populations; and a loss of approximately 25 acres of habitat supporting low-density populations of Seaside bird's beak.

Alternative 8 is very similar to Alternative 7, with differences primarily associated with proposed changes in land uses in specific areas. Alternative 8 was analyzed by examining these specific areas. Differences between Alternatives 7 and 8 that could affect impacts to biological resources included expansion of a community park, removal of small areas from the NRMA (at the request of BLM due to the separation of these areas from the main body of the NRMA by existing roads), and construction of a golf course on the landfill parcel. The total effect of Alternative 8 would be the removal of approximately 6,230 acres of common and special native biological communities and removal of approximately 793 acres of area supporting sand gilia and 3,423 acres of area supporting Monterey spineflower at various densities.

ANALYSIS OF IMPACTS TO HMP TARGET SPECIES FROM THIS HMP

This section summarizes the habitat areas within each HMP reserve or corridor area that are going to be preserved for each HMP target species. In some cases, the HMP reserve area is actually a combination of Habitat Reserve parcels and parcels that are classified Development with Reserve or Development with Restrictions but contain primarily lands to be managed as reserve. The section also indicates the habitat acreage contained within the total development area allowed by this HMP. This Development Areas category includes parcels that are classified as Development and others that are classified as Development with Reserve or Development with Restrictions but have no reserve component, only restrictions.

Acreage totals for HMP target species were calculated by overlaying the current reserve, corridor and development area boundaries with the 1992 habitat data contained in the planning-level Geographic Information System (GIS) developed by the Army to support the disposal and reuse of Fort Ord. The totals have been summarized for low-, medium-, and high-density habitats for each species. For the detailed breakdown of low-, medium-, and high-density habitat for each species in each reserve, refer to Table B-2 in Appendix B.

State Parks Reserve

The State Parks reserve is located along the coast, west of SR 1. It includes both Reserve and Development with Reserve Areas or Development with Restrictions parcels, as mapped in Figure 4-1. This reserve occupies approximately 970 acres. Table S-3 indicates which target species are supported by habitat on this reserve area.

Landfill Development with Reserve

The Landfill reserve is located northeast of the Main Garrison, just south of Imjin Road. It is composed of two Development with Reserve or Development with Restrictions parcels. This reserve occupies approximately 308 acres. Refer to Table S-3 for target species supported within the Landfill reserve.

UC/NRS Fort Ord Natural Reserve

The UC/NRS Fort Ord Natural Reserve is located in the southwestern corner of the former Fritzsche Army Airfield and south of Reservation Road; it has already been transferred to UC. It is being managed as part of the UC Natural Reserve System. This reserve includes approximately 590 acres. Table S-3 lists target species supported by this natural reserve.

Marina Reserve

The Marina reserve is located in the Fritzsche Army Airfield area, north and west of the developed portion of the airfield. It includes both Reserve and Development with Reserve or Development with Restrictions parcels. The reserve has approximately 175 acres. This reserve area has already been transferred to the City of Marina. Refer to Table S-3 for a list of species supported in this reserve area.

East Garrison Reserve

The East Garrison reserve is located in the easternmost portion of former Fort Ord, south of Reservation Road. The reserve includes both Reserve and Development with Reserve or Development with Restrictions parcels. The reserve totals approximately 855 acres. Refer to Table S-3 for a list of species supported in this reserve area.

Habitat Corridor

The Habitat Corridor, located immediately west of the East Garrison portion of former Fort Ord, includes both Reserve and Development with Reserve or Development with Restrictions parcels. The reserve totals approximately 400 acres. Table S-3 lists the target species supported within the Habitat Corridor.

BLM Natural Resource Management Area

The BLM NRMA is located in the southern and eastern portions of former Fort Ord. This reserve is largest natural area being retained in the HMP area. It totals approximately 15,000 acres. Some portions of the area have already been transferred to BLM and are being managed as reserve. This transfer includes most of the land east of Barloy Canyon Road. Refer to Table S-3 for a list of target species supported within the BLM NRMA.

Caltrans State Route 68 Easement

The Caltrans State Route (SR) 68 easement overlays the NRMA in the southern portion of former Fort Ord (Figure 4-1). A total of approximately 660 acres are contained within the corridor. Of this total, approximately 180 acres could be lost to development of a highway, assuming a 300-foot-wide construction corridor. Refer to Table S-3 for a list of species supported by habitat in this corridor.

MPRPD Reserve

The MPRPD Reserve is located in the extreme southwestern portion of former Fort Ord. It is a Reserve parcel containing approximately 20 acres. Refer to Table S-3 for a list of species supported by habitat in this reserve.

Caltrans State Route 1 Area

The SR 1 corridor passes through the western portion of former Fort Ord, separating the beach areas from the Main Garrison area. It is considered a Development with Reserve or Development with Restrictions area. The corridor totals approximately 225 acres. Refer to Table S-3 for a list of target species supported within the SR 1 corridor.

Development Areas

The Development Areas of former Fort Ord include the remaining parcels outside of reserve areas and corridors. Some of these parcels are developable with no restrictions, while several others are classified as Development with Restrictions. The Development Areas total approximately 10,500 acres. The developable areas are located primarily between the SR 1 corridor and the NRMA (Figure 4-1). Habitat supporting nearly all of the HMP target species is found within the Development Areas (Table S-3).

There are no resource conservation requirements in the HMP for most of the Development Areas. The habitat resources contained in the parcels are not considered critical to the long-term survival of the species. However, habitat may be preserved within and around the development areas within these parcels.

MANAGEMENT GUIDELINES FOR RECIPIENTS AND/OR HABITAT MANAGERS OF DISPOSED LAND

This section describes key resources, expected impacts on resources, and land management responsibilities for each recipient of disposed land in the HMP area. Land management responsibilities are divided into the following categories: Habitat Reserve, Habitat Corridor, Development with Reserve Areas or Development with Restrictions, Borderland Development Areas Along NRMA Interface, Development, and Future Road Corridors. The Army will include deed covenants in transfer of lands and may, as appropriate, enter into separate MOAs with recipients or habitat managers of disposed land to ensure implementation of HMP requirements. Land recipients may also agree to take part in a Coordinated Resource and Management Planning (CRMP) process. The CRMP is described in detail at the end of Chapter 4. Methods for updating or modifying this HMP after agencies or private parties have received Fort Ord lands are described in the "Flexibility of HMP" section in Chapter 1.

Habitat conservation and management responsibilities by recipients or habitat managers of disposed lands at former Fort Ord are discussed individually with each land use parcel in Chapter 4.

Implementation Strategies

Memoranda of Agreement and Deed Covenants

Before disposal of land, the Army will place appropriate deed covenants (restrictions and/or management requirements) on lands to be transferred and/or enter into MOAs with recipients and/or habitat managers of disposed lands identified in this HMP as Habitat Reserve, Habitat Corridor, Borderland Development Area Along NRMA Interface, or Development with Reserve Areas or Development with Restrictions. Appropriate HMP guidelines will be included in each document. A sample deed is included in Appendix D. USFWS will enforce the requirements of the federal ESA.

Monitoring Procedures and Responsibilities

Monitoring of habitat reserves and habitat corridors would be the responsibility of BLM, California Department of Parks and Recreation, UC, Monterey County, City of Marina, Monterey Peninsula Regional Park District, California Department of Transportation (Caltrans), FORA, and any other organization with management responsibilities for areas designated as Habitat Reserve, Habitat Corridor, or Development with Reserve Areas or Development with Restrictions in this HMP. These agencies would be responsible for ensuring that the HMP guidelines are implemented on parcels under their jurisdictions.

FORA or other organizations receiving Borderland Development Areas Along NRMA Interface will provide status reports for parcels adjacent to the NRMA on interim habitat management and/or firebreak construction and maintenance (according to Item c. in the agreement) and compliance with other management requirements associated with these parcels (see the "Borderland Development Areas Along NRMA Interface" section in Chapter 4).

Monitoring results for CRMP participants will be coordinated by BLM, and BLM will consolidate the results into a single monitoring report. Annual monitoring reports will be filed with USFWS and DFG, as well as with each of the participating agencies.

Program Costs and Funding

Funding to develop this HMP has been provided by the Army. Funding to implement the HMP prescribed habitat restoration, management, and monitoring for reuse will be provided by entities receiving properties or having management responsibilities for areas designated as Habitat Reserve, Habitat Corridor, Borderland Development Area Along NRMA Interface, or Development with Reserve Areas or Development with Restrictions in this HMP. These agencies will fund implementation of this HMP and implement conservation and/or management guidelines specific to parcels they receive. This HMP does not preclude other sources of funding for HMP implementation or preclude these agencies from securing funding from other sources to support their implementation of HMP guidelines. Requirements for each agency's minimal participation and accomplishments toward implementation of this HMP will be specified in covenants in the deed that will be completed at the time of land transfer or in a MOA with the Army.

ANALYSIS OF ROAD CORRIDORS

The analysis of impacts to biological resources in the FSEIS considered the effects of a proposed transportation network. The transportation network considered was based on the FORA December 12, 1994 Final Fort Ord Base Reuse Plan with mitigations and modifications agreed on with USFWS, UC, and FORA on March 15 and 28, 1996. Several road segments included in the proposed network pass through areas identified as Habitat Reserve, Habitat Corridor, or Development with Reserve Areas or Development with Restrictions in this HMP (Figure 4-2). These road corridors are accommodated within this HMP. Descriptions of individual parcels affected by these road segments each contain a reference to the road segment and how it may affect HMP habitat conservation or management requirements. The SR68 transportation easement is treated separately and is considered in the category of "Development with Reserve Areas or Development with Restrictions".

Table S-1. Plant Species Considered in This Habitat Management Plan (HMP Plants)

Plant Species	Listing Status[a] Federal/State/CNPS	CNPS RED Code[b]	Approximate Percent of Range at Former Fort Ord	Habitat	Distribution	Importance of Populations at Former Fort Ord
Robust spineflower *Chorizanthe robusta* var. *robusta*	E/--/4	1-1-3	<1	Found on sandy soils in coastal dune and coastal scrub habitats	Historically from Alameda and San Mateo Counties south to Santa Cruz County and near the coast from southern Santa Cruz County to northern Monterey County, much of which is now developed (4, 5, 8)[c]	Several plants of robust spineflower were found at one site on former Fort Ord; former Fort Ord does not provide important habitat for this species (7)
Sand gilia *Gilia tenuiflora* ssp. *arenaria*	E/T/1B	3-3-3	50-70	Sandy openings in coastal dunes and scrub and maritime chaparral	Occurs around Monterey Bay, Salinas River Beach, Asilomar State Beach, from Point Pinos to Point Joe, and Fort Ord (1, 2, 9)	Former Fort Ord provides extensive suitable habitat for sand gilia and constitutes a substantial portion of its range (at least half)
Yadon's piperia *Piperia yadoni*	PE/--/1B	N/A	<1	Occurs on sandy soils in maritime chaparral, coastal scrub, and closed-cone coniferous forest	Occurs in Monterey County from the Pajaro Hills to the Monterey Peninsula	Less than 1% of the individuals of Yadon's piperia are found on former Fort Ord; it is noteworthy that its habitat on former Ford Ord is intermediate between that of its occurrence in chaparral and pine forest habitats (7)
Monterey spineflower *Chorizanthe pungens* var. *pungens*	T/--/1B	3-3-3	75-95	Colonizes recently disturbed sandy sites in coastal dune, coastal scrub, grassland, and maritime chaparral habitats	Along the coast of southern Santa Cruz and northern Monterey Counties and inland to the coastal plain of the Salinas Valley (1, 4, 8)	Former Fort Ord supports the largest populations of Monterey spineflower known (7, 8)
Coast wallflower *Erysimum ammophilum*	SC/--/1B	2-2-3	10-30	Occurs scattered on stabilized coastal dunes	Coastal dunes of Monterey Bay and Santa Rosa Island, and coastal scrub on former Fort Ord (10, 11)	Former Fort Ord provides a moderate amount of suitable habitat for coast wallflower and may constitute an important portion of its range because of the limited extent and high degree of disturbance to its habitat in California
Eastwood's ericameria *Ericameria fasciculata*	SC/--/1B	3-3-3	70-90	Inhabits coastal dune and scrub, maritime chaparral, and closed-cone coniferous forest communities	Found in Monterey County, including Del Monte Forest, Monterey Airport, Toro Regional Park, near Prunedale, and former Fort Ord (1)	Former Fort Ord supports most of the remaining individuals of Eastwood's ericameria (3)
Monterey ceanothus *Ceanothus cuneatus* var. *rigidus*	SC/--/4	1-2-3	50-70	Sandy hills and flats of maritime chaparral, closed-cone coniferous forests, and coastal scrub	Monterey County along the coast and former Fort Ord, Toro Regional Park, Monterey Airport, and near Prunedale (1, 6)	The most abundant and probably most vigorous population of Monterey ceanothus is found on former Fort Ord (3)

Plant Species	Listing Status[a] Federal/State/CNPS	CNPS RED Code[b]	Approximate Percent of Range at Former Fort Ord	Habitat	Distribution	Importance of Populations at Former Fort Ord
Sandmat manzanita *Arctostaphylos pumila*	SC/--/1B	3-2-3	70-90	Sand hills of maritime chaparral and coast live oak woodland	Scattered locations around Monterey Peninsula and an extensive area on former Fort Ord (1, 3)	A large and important part of the range of sandmat manzanita is found on former Fort Ord
Seaside bird's-beak *Cordylanthus rigidus* var. *littoralis*	SC/E/1B	2-3-3	30-50[d]	Inhabits sandy soils of stabilized dunes, maritime chaparral, coastal scrub, and closed-cone coniferous forests	Monterey and Santa Barbara Counties, including former Fort Ord, Monterey Airport, and between Carmel and Elkhorn Slough in Monterey County, and on Burton Mesa in Santa Barbara County (1, 2)	A substantial portion of the range of Seaside bird's-beak is found at former Fort Ord
Toro manzanita *Arctostaphylos montereyensis*	SC/--/1B	3-2-3	70-90	Occurs on stabilized sandy soils and badlands in maritime chaparral	Restricted to several sites in Monterey County, including former Fort Ord, Toro Regional Park, and Monterey Airport (1, 3)	Former Fort Ord supports the largest expanse of Toro manzanita in existence
Hooker's manzanita *Arctostaphylos hookeri*	--/--/1B	2-2-3	15-35	Sand hill and Aromas formation maritime chaparral and closed-cone coniferous forest	Del Monte Forest, Monterey Peninsula, Prunedale Hills, former Fort Ord, and sand hills in the Larkin Valley	Former Fort Ord supports large populations of Hooker's manzanita; although it is more common on the Monterey Peninsula and near Prunedale than at former Fort Ord, former Fort Ord provides important and extensive habitat (3,6)

[a] Status explanations (see the "Definitions of Special-Status Species" section above for citations):

Federal

- E = listed as endangered under the federal Endangered Species Act.
- T = listed as threatened under the federal Endangered Species Act.
- PE = proposed for federal listing as endangered under the federal Endangered Species Act.
- SC = Species of Concern are all former Category 1 and 2 candidate species that without additional conservation action are likely to become candidates for listing by the U.S. Fish and Wildlife Service under the federal Endangered Species Act.
- -- = no designation.

State

- E = listed as endangered under the California Endangered Species Act.
- T = listed as threatened under the California Endangered Species Act.
- -- = no designation.

California Native Plant Society

1B = List 1B species: rare, threatened, or endangered in California and elsewhere.
4 = List 4 species: plants of limited distribution.
– = no designation.

[b] **CNPS RED Code:**

Rarity (R)

1 = Rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time.
2 = Occurrence confined to several populations or to one extended population.
3 = Occurrence limited to one or a few highly restricted populations, or present in such small numbers that it is seldom reported.

Endangerment (E)

1 = Not endangered.
2 = Endangered in a portion of its range.
3 = Endangered throughout its range.

Distribution (D)

1 = More or less widespread outside California.
2 = Rare outside California.
3 = Endemic to California.

[c] Data sources:

1 = Natural Diversity Data Base 1992.
2 = Hillyard 1992.
3 = Griffin 1976.
4 = Reveal and Hardham 1989.
5 = Thomas 1961.
6 = Griffin 1978.
7 = Morgan 1992.
8 = U.S. Fish and Wildlife Service 1991.
9 = U.S. Fish and Wildlife Service 1992.
10 = Munz and Keck 1968.
11 = Abrams 1940.

[d] This estimate incorporates locations of Seaside bird's-beak in Santa Barbara County, which may have formed as a result of hybridization. The estimate based only on Monterey County occurrences would increase the percent of range at former Fort Ord to 60-80%.

Table S-2. Wildlife Species Considered in This Habitat Management Plan (HMP Species)

Wildlife Species	Listing Status[a] Federal/State	Approximate Percent of Range at Former Fort Ord	Habitat	Distribution	Occurrence at Former Fort Ord	Importance of Former Fort Ord Population
Smith's blue butterfly *Euphilotes enoptes smithi*	E/–	5-10	Uses coastal dunes and hillsides that support seacliff buckwheat (*Eriogonum parvifolium*) or coast buckwheat (*Eriogonum latifolium*); these plants are used as a nectar source for adults and host plant for larvae	Restricted to localized populations along the coast of Monterey County; single populations reported in Santa Cruz and San Mateo Counties	Known to occur near the northern boundary of former Fort Ord and from Giggling Siding to the southern base boundary (5)[b]	Former Fort Ord has been identified as important to the recovery of Smith's blue butterfly
California black legless lizard *Anniella pulchra nigra*	PE/SSC	10-20	Requires moist, warm habitats with loose soil for burrowing and prostrate plant cover; may be found on beaches, in chaparral, pine oak woodland, or riparian areas	Restricted to small populations along the coast in Monterey and northern San Luis Obispo Counties; one population in Contra Costa County	Found in stabilized dunes, oak woodland, and oak savanna, and maritime chaparral with sandy soils at former Fort Ord (2, 4, 7)	Former Fort Ord supports one of the larger expanses of black legless lizard habitat within the species' range
California red-legged frog *Rana aurora draytoni*	T/SSC	<1	Requires coldwater ponds with emergent and submergent vegetation and riparian vegetation at the edges	Found along the coast and coastal mountain ranges from Humboldt to San Diego Counties, and in the Sierra Nevada from Butte to Fresno Counties	May occur at Ford Ord (1)	Former Fort Ord composes little of the species' total range; however, former Fort Ord provides potential habitat for California red-legged frog, which is relatively rare within the Monterey Bay region
Western snowy plover *Charadrius alexandrinus nivosus*	T/SSC	5-10	Found along beach above the high tide limit; also uses shores of salt ponds and alkali or brackish inland lakes	Intermittent nesting sites along the Pacific Coast from Washington to Baja California	Nests along the beaches at former Fort Ord north of Stillwell Hall (3)	Former Fort Ord supports one of 20 coastal breeding populations of western snowy plovers in California; Monterey Bay as a whole is considered one of eight primary coastal nesting areas; former Fort Ord beaches are one of the areas proposed by USFWS as critical habitat for this species (60FR 11768 March 2, 1995)

Wildlife Species	Listing Status[a] Federal/State	Approximate Percent of Range at Former Fort Ord	Habitat	Distribution	Occurrence at Former Fort Ord	Importance of Former Fort Ord Population
California tiger salamander *Ambystoma tigrinum californiense*	C/SSC	<1	Favors open woodlands and grasslands; requires water for breeding and burrows or cracks in the soil for summer dormancy	Occurs only in California from the coastline to the Sierra Nevada crest and from Sonoma to Santa Barbara Counties	Occurs in ponds and vernal pools throughout former Fort Ord (2, 6)	Former Fort Ord comprises little of the total range of California tiger salamander; however, vernal pool habitat is relatively rare in the Monterey Bay region
Monterey ornate shrew *Sorex ornatus salarius*	SC/--	15-25	Found in a variety of riparian, woodland, and upland communities where there is thick duff or downed logs	Restricted to the Monterey Bay region; historical occurrences at the mouth of the Salinas River and Moss Landing in Monterey County	May occur at former Fort Ord (1)	Former Fort Ord provides abundant potential habitat for Monterey ornate shrew within the species' limited range
California linderiella *Linderiella occidentalis*	--/--	<1	Ephemeral freshwater habitats such as vernal pools, rock outcrop pools, swales, and ponds	Found in the Central Valley from Tehama to Madera Counties, and the central and south Coast Ranges from Lake to Riverside County	Known from eight water bodies at former Fort Ord (2)	Former Fort Ord composes little of the total range of California linderiella; however, vernal pool habitat is relatively rare in the Monterey Bay region

[a] Status definitions:

Federal

E = listed as endangered under the federal Endangered Species Act.
T = listed as threatened under the federal Endangered Species Act.
PE = federally proposed for listing as endangered.
C = species for which USFWS has on file sufficient information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened.
SC = Species of Concern are former Category 1 and 2 species that without additional conservation action are likely to become candidates for listing by the U.S. Fish and Wildlife Service under the federal Endangered Species Act.
-- = no status.

State

SSC = considered a State Species of Special Concern by California Department of Fish and Game.
-- = no status.

[b] Data sources.

(1) Not found during field surveys.
(2) Encountered during field surveys.
(3) Source: George pers. comm.
(4) Source: Bury 1985.
(5) Source: Arnold 1983.
(6) Source: Stanley pers. comm.
(7) Source: Installation UXO surveys.

Table S-3. HMP Target Species Supported by Habitat Within HMP Reserve Areas, Corridors, and Development Areas

	Plants											Animals						
Parcel	Sand Gilia	Eastwood's Ericameria	Coast Wallflower	Seaside Bird's Beak	Robust Spineflower	Monterey Spineflower	Monterey Ceanothus	Sandmat Manzanita	Toro Manzanita	Hooker's manzanita	Yadon's Piperia	California Linderiella	California Tiger Salamander	Western Snowy Plover	California Red-Legged Frog	Monterey Ornate Shrew	California Black Legless Lizard	Smith's Blue Butterfly
State Parks Reserve			X		X	X		X						X			X	X
Landfill Development with Reserve	X		X			X	X	X								X	X	
UC/NRS Fort Ord Natural Reserve	X	X	X			X	X	X	X							X	X	
Marina Reserve	X					X		X							X	X	X	
East Garrison Reserve	X	X	X	X		X	X	X	X	X						X	X	
Habitat Corridor	X					X		X				X	X		X	X		
BLM Natural Resource Management Area	X	X	X	X		X	X	X	X	X		X	X		X	X	X	
Caltrans State Route 68 Easement	X					X	X	X	X	X		X	X			X		
MPRPD Reserve		X		X		X	X	X									X	
Caltrans State Route 1 Area	X	X	X			X	X	X			X						X	
Development Areas	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	X

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prbo

NESTING OF THE SNOWY PLOVER IN THE MONTEREY BAY AREA, CALIFORNIA IN 2012

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SYNOPSIS

Researchers and associates of PRBO Conservation Science (PRBO), the U.S. Fish and Wildlife Service (USFWS), and the California Department of Parks and Recreation (CDPR) monitored nesting Snowy Plovers at Monterey Bay in Monterey and Santa Cruz counties, and on pocket beaches in northern Santa Cruz County in 2012. The objective was to assess the plover's response to management efforts by the government agencies to enhance the species' breeding success and increase its population size. Management actions undertaken by federal and state agencies included:

- Roping-off upper beach and riverine spit breeding habitat to minimize disturbance to nesting birds by the public (Table 1).
- Exclosures to protect individual nests from predators when needed (Table 1).
- Predator removal by the Wildlife Services Division of the U.S. Department of Agriculture (USDA).
- Water management to provide nesting and feeding habitat in the managed ponds of the Moss Landing Wildlife Management Area.

The estimated 386 plovers that nested in 2012 was a 10% decrease from the previous year (Fig. 1) but still a higher number than the target of 338 breeders recommended for the Monterey Bay area in the USFWS Recovery Plan. No plovers were detected nesting on northern Santa Cruz County pocket beaches for the third consecutive year (Table 2). The 2012 nesters consisted of 213 males and 173 females. All but 9 unbanded males and 12 unbanded females were uniquely color banded. Among the color marked breeders were 25 males and 29 females raised in the Monterey Bay area in 2011.

Return rates of 2012 nesters were above average for males and about average for females. Overall, 74.8% of the banded males and 63.2% of the banded females documented nesting in the study area in 2011 also bred there in 2012 (Fig. 2). Return rates exceeded the prior 13-year-average of 67.5% for males and 63.1% for females by 10.7% and 0.2%, respectively.

There were 413 nests and 11 broods from undetected nests indicating at least 424 nesting attempts in the Monterey Bay area in 2012 (Table 2).

The plovers experienced subpar breeding success in 2012. Their clutch-hatching rate was 51.0 % on Monterey Bay beaches and 58.8% in the Salt Ponds. These rates were well below their respective averages from 1999-2011. The hatching rate on the beaches was 21% below the 64% average of the previous 13 years and the Salt Pond rate was 17% below the prior 13-year average of 71% (Fig. 3).

Overall, 56% of the 197 nest losses in 2012 were attributed to predators (Tables 3 and 4). Of nest losses to predators 71.6% were attributed to birds, 2.8% to mammals and 25.7% to unknown predators. A one-legged Western Gull, captured on camera taking one nest and an abandoned egg at Monterey Dunes and seen taking a nest at North Salinas, was collected by Wildlife Service personnel and found to have plover egg shells in its alimentary canal. We believe it was responsible for most of the nest losses attributed to unidentified avian predators in the Monterey Dunes and at Molera/Potrero areas.

Eight losses were attributed to humans, including 3 nests that were deliberately removed from mini exclosures on the Pajaro River spit (Table 4). Ironically two of the exclosures had just been placed around nests to protect them from being trampled by roosting gulls.

Chick fledging rate was well below average on the beaches and about average in the Salt Ponds. From 28-30% of the chicks fledged on the beaches in 2012. This rate was about 32% below the average of 42.4% from 1999-2011. Fledging rates were below 10% in the Reservation Road and Monterey Dunes areas and below 20% at the Pajaro Spit and Martin areas. The 39-42% fledging at the Salt Ponds was about 4% greater than the 39.1% Salt Pond average over the previous 13 years (Table 2, Fig. 4).

The total of 180 fledglings in 2012 was also below the 1999-2011 average (Fig. 5); 137 were from the beaches and 43 from the Salt Ponds. The total was 25% below the 241-bird average; the number from the beaches was 27% below the 188-bird average; and the number from the salt ponds was 12% below the 49-bird average.

The 2012 fledging rate of 0.8 young per male was 42% lower than the 1.45 bird average of the past 13 years (Fig. 6) and was well below the level of one young per male needed to prevent the population from declining (USFWS Recovery Plan).

The consequence of the low number of fledglings in 2012 will likely be a smaller breeding population in the Monterey Bay area in 2013.

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INTRODUCTION

Staff and research associates of PRBO Conservation Science, with assistance of staff and/or interns of the U.S. Fish and Wildlife Service and the California Department of Parks and Recreation, have monitored nesting Snowy Plovers annually on the shores of Monterey Bay since 1984, and on small pocket beaches in northern Santa Cruz County since 1988, to assess the number of breeding plovers, number of nests, clutch hatching rate, chick fledging rate, and causes of egg and chick loss. Here we summarize the results of the monitoring effort in 2012.

STUDY AREA

The study area includes the beaches of Monterey Bay, former salt ponds in Elkhorn Slough (hereafter Salt Ponds), and pocket beaches in northern Santa Cruz County. For reporting purposes we divide up the study area as follows:

Monterey Bay Area

South Beach Subregion

Del Monte: Beach between the City of Monterey and Tioga Road, Sand City. Most of it is adjacent to Sand City. The beach is managed by CDPR.

Sand City: Beach between Tioga Road, Sand City and the south boundary of Fort Ord.

South Fort Ord: Beach between the south boundary of Fort Ord and the site of former Stilwell Hall. It is managed by CDPR.

North Fort Ord: Beach between Stilwell Hall site and the Lake Court beach access to Marina State Beach. It is managed by CDPR.

Reservation Road: From the Lake Court beach access for Marina State Beach to Reservation Road. It is managed by CDPR.

Marina: The entire beach from Reservation Road to the Salinas River National Wildlife Refuge. It is managed by CDPR and the Monterey Peninsula Regional Park District. It is subdivided into four segments, all of which are completely or partly bordered by private property (Table 1).

Salinas River National Wildlife Refuge: The entire beach on the Salinas River National Wildlife Refuge (NWR), which is owned and managed by USFWS.

Salinas River North: The entire beach from the Salinas River NWR (or north of the Salinas River mouth) to the mouth of Elkhorn Slough. It is owned and managed by CDPR. It is further divided into three segments – the north spit of the Salinas River, Monterey Dunes, and Molera/Potrero road segments (Table 1). The Monterey Dunes segment is backed by a beach front housing development. The northernmost section of the Molera/Potrero segment is backed by commercial development.

North Beach Subregion

Jetty Road to Beach Road: All the beach between Jetty Road (mouth of Elkhorn Slough) and Beach Road. It is divided into 3 segments all managed by CDPR (Table 1). The north end of the Pajaro spit is bounded by a beach front development.

Sunset/Manresa: The entire beach from Beach Road to the north boundary of Manresa State Beach. The south end of this subregion is backed by a beach front development. The beach is managed by CDPR.

Salt Pond Region

It includes approximately half of the former salt ponds in Elkhorn Slough that have been converted to managed, diked wetlands and are now encompassed within the California Department of Fish and Game's (DFG) Moss Landing Wildlife Management Area.

Northern Santa Cruz County Pocket Beach Region

We sporadically covered the four beaches known to have formerly supported nesting Snowy Plovers in northern Santa Cruz County. ***Wilder Creek Beach*** and ***Laguna Creek Beach*** are owned and managed by CDPR. ***Scott Creek Beach*** is owned and managed by the County of Santa Cruz and ***Waddell Creek Beach*** is owned by the CDPR and by a private party.

MONITORING

We attempt to find all plover nests initiated in the study area. Unique color band combinations are used to individually mark plover adults and chicks. For color banding, adults are usually trapped on the nest. Chicks are captured in or near the nest at the time of hatching. Clutch hatching dates are estimated from egg laying dates, when known, or from egg flotation. They are further refined by examination of eggs for cracked shells, tapping chicks, or peeping chicks just before the estimated hatching date. Chicks are considered fledged if they survive 28 or more days after hatching. Monitors look for fledglings when they have reached 28 days of age by watching banded males known to have broods and by monitoring flocks of roosting plovers during the latter part of the nesting season. Fledging success for specific sites is always categorized by nest location, even in cases where broods move to adjacent areas before fledging. In 2012, we recorded the longitude and latitude of all nests with Global Positioning Units. These locations are depicted in Appendices 1-12. Monitoring is conducted under U. S. Fish and Wildlife Service Permit PRT 807078-14.1.

MANAGEMENT

A variety of techniques are used to improve the breeding success of the Snowy Plover in the study area. The upper beach at Salinas River NWR and the salt ponds are closed to the public to protect nesting plovers from human disturbance. On California state beaches symbolic fencing, consisting of signed, roped-off upper beach areas, are used to protect most nests (Table 1) and limit human disturbance of brood rearing birds.

While 10 foot by 10 foot single nest exclosures, made of 2-inch-wide by 4-inch-tall wire mesh fencing, standing 5-feet-high and 10 feet-long on each side have been used extensively in the past to protect nests from predators, their widespread use in the Monterey Bay area has been limited in recent years because of the effectiveness of a mammalian predator removal program conducted by USDA. No exclosures of this

type were used in 2012 (Table 1). However, 28 circular mini exclosures 24-36 inches in diameter and 24 inches high were used to protect nests from predators in the North Bay (Table 1) after some areas had experienced a large number of nest losses. We also sometimes use gull exclosures – a symbolic fenced exclosure with a few lengths of cord stretched over the top that surrounds individual nests. Four gull-specific exclosures were used at the Pajaro spit in 2012 (Table 1).

Table 1. Nest protection measures for Snowy Plovers at Monterey Bay in 2012.

Location	Total Nests	Nest Protection Measures						
		10 X 10 Excl. Only	Min Excl. Only	Symb. Fence Only	Fence & Mini Excl.	Fence & 10 X 10 Excl.	Fence & Gull Excl.	Sign Only
Del Monte	**1**			1				
Sand City	**2**			2				
Fort Ord	**13**			12				
Reservation Road	**13**			13				
Marina								
Marina South	**9**			9				
Marina Middle	**22**			19				
Marina North	**7**			7				
Martin	**9**			9				
Salinas River NWR	**50**			50				
Salinas River North								
Salinas River N. Spit	**19**			19				
Monterey Dunes	**23**			23				
Molera/Potrero	**28**			26				
Jetty to Beach Roads								
Moss Landing	**45**			42	2			
Zmudowski Beach	**30**			20	10			
N. Pajaro R.M.	**60**			41	14		4	1
Sunset/Manresa	**14**			12	2			
Salt Ponds	**68**			68				
Total	**413**	0	0	373	28	0	4	1

We continued to manage water levels at the Salt Ponds to create dry nesting substrate and associated wet foraging areas for Snowy Plovers. Water is drawn down rapidly from some ponds at the beginning of the season to provide dry nest sites. Thereafter, flooding of remnant-wet areas is undertaken several times per month throughout the nesting season to maintain foraging habitat for adults and chicks.

RESULTS

The 2012 Nesting Season

Number of Breeders

The estimated 386 plovers that nested in 2012 was a 10% decrease from the previous year (Fig. 1) but still a greater number than the target of 338 breeders recommended for the Monterey Bay area in the USFWS Recovery Plan. The 2012 nesters consisted of 213 males and 173 females. All but 9 unbanded males and 12 unbanded females were uniquely color banded. Among the color marked breeders were 25 males and 29 females that were produced from nesting attempts in the Monterey Bay area in 2011. No plovers were detected nesting on the northern Santa Cruz County pocket beaches in 2012 (Table 2).

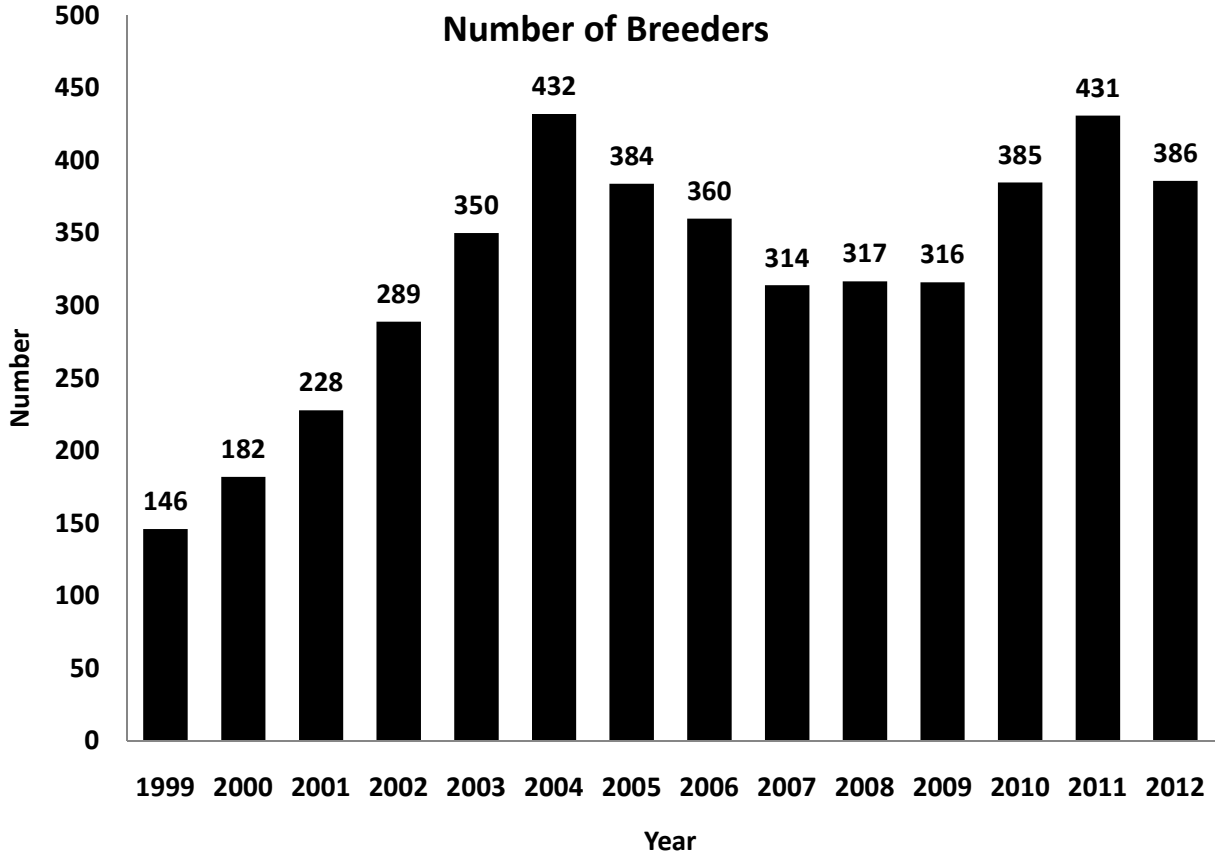


Figure1. Number of nesting Snowy Plovers at Monterey Bay, 1999-2012.

Return Rates

Male return rates were above average and female rates about average in 2012. Overall, 74.8% of the banded males and 63.2% of the banded females documented nesting in the study area in 2011 also bred there in 2012 (Fig. 2). The 2012 return rates exceeded the prior 13-year-average of 67.5% for males and 63.1% for females by 10.7% and 0.2%, respectively. As is in most years, male return rate exceeded that of females (Fig 2).

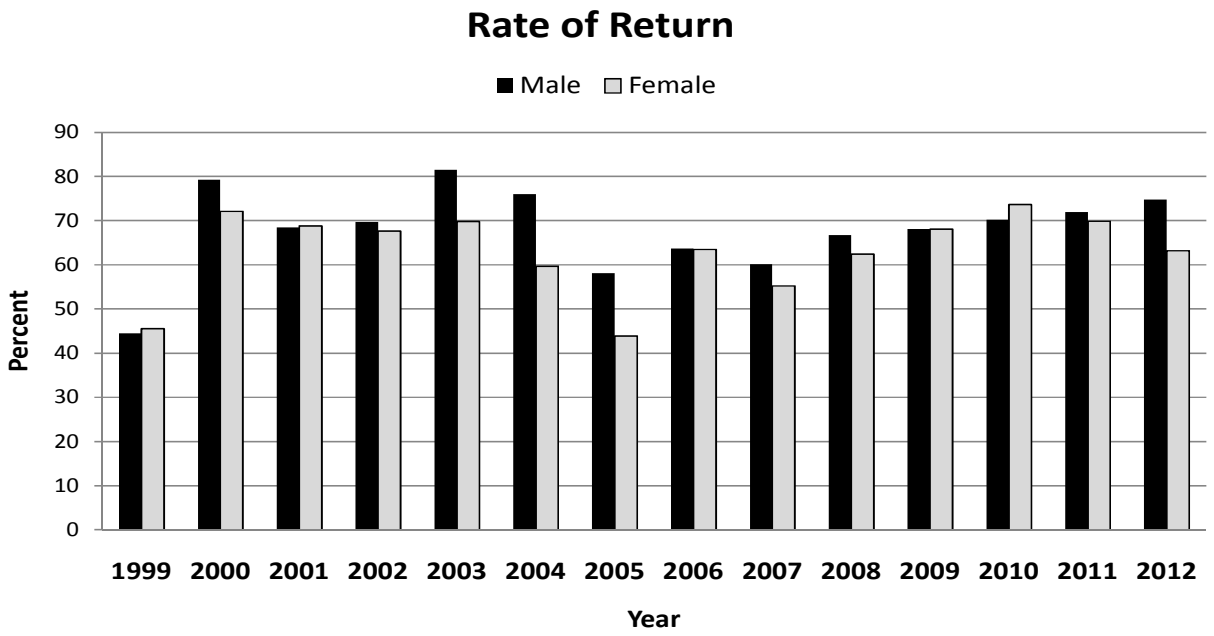


Figure 2. Return rates of nesting Snowy Plovers at Monterey Bay.

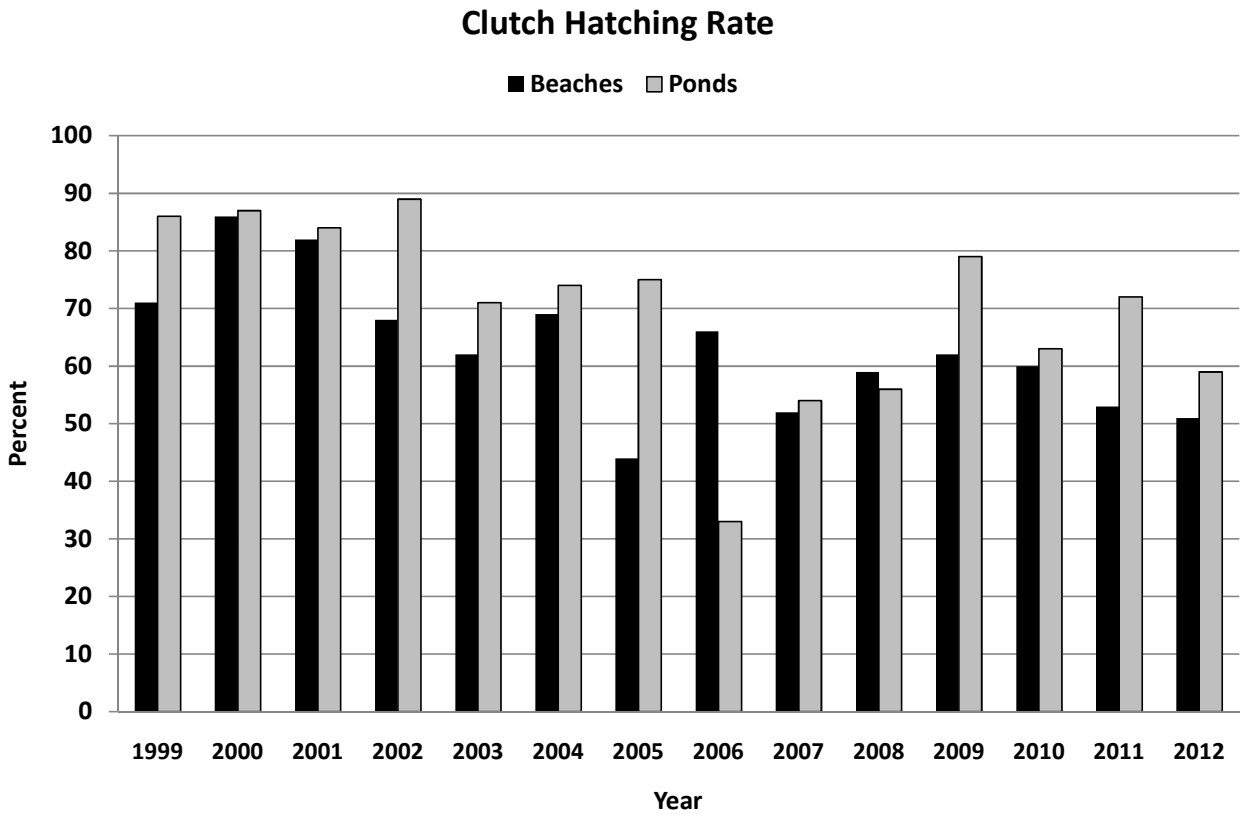


Figure 3. Clutch hatching rates of Snowy Plovers at Monterey Bay.

Table 2. Breeding success of Snowy Plovers at Monterey Bay in 2012. Juv. is Juvenile and Att. is Attempt.

	Nest Attempts		Chicks			% Nests	% Chicks Fledge		Juv. Per
Regions	**Nests**	**Broods**	**Low**	**High**	**Juv.**	**Hatch**	**High**	**Low**	**Nest Att.**
Del Monte-Reserv. Rd.									
Del Monte	1	0	0	0	0	**0.0**	**0.0**	**0.0**	**0.00**
Sand City	2	0	5	5	1	**100.0**	**20.0**	**20.0**	**0.50**
Fort Ord	13	0	32	35	9	**100.0**	**28.1**	**25.7**	**0.69**
Reservation Road	13	0	31	31	2	**84.6**	**6.5**	**6.5**	**0.15**
Marina									
Marina South	9	1	13	14	7	**55.6**	**53.8**	**50.0**	**0.70**
Marina Middle	22	1	35	37	13	**54.5**	**37.1**	**35.1**	**0.57**
Marina North	7	0	16	16	5	**85.7**	**31.3**	**31.3**	**0.71**
Martin	9	1	15	17	2	**55.6**	**13.3**	**11.8**	**0.20**
Salinas NWR	50	4	96	104	44	**70.0**	**45.8**	**42.3**	**0.81**
Salinas River N									
N. Salinas River	19	0	27	30	7	**63.2**	**25.9**	**23.3**	**0.37**
Monterey Dunes	23	2	23	27	2	**30.4**	**8.7**	**7.4**	**0.08**
Molera/Potrero	28	1	19	21	9	**25.0**	**47.4**	**42.9**	**0.31**
Jetty-Beach Rds.									
Moss Landing	45	0	23	23	5	**20.0**	**21.7**	**21.7**	**0.11**
Zmudowski Beach	30	0	48	48	13	**66.7**	**27.1**	**27.1**	**0.43**
Pajaro Spit	60	0	71	71	12	**46.7**	**16.9**	**16.9**	**0.20**
Sunset/Manresa	14	0	9	10	6	**28.6**	**66.7**	**60.0**	**0.43**
TOTAL BEACHES	**345**	**10**	**463**	**489**	**137**	**51.0**	**29.6**	**28.0**	**0.39**
SALT PONDS	**68**	**1**	**102**	**110**	**43**	**58.8**	**42.2**	**39.1**	**0.62**
Wilder Creek	0	0	0	0	0	**0.0**	**0.0**	**0.0**	**0.00**
Laguna Creek	0	0	0	0	0	**0.0**	**0.0**	**0.0**	**0.00**
Scott Creek	0	0	0	0	0	**0.0**	**0.0**	**0.0**	**0.00**
Waddell Creek	0	0	0	0	0	**0.0**	**0.0**	**0.0**	**0.00**
TOTAL S. CRUZ	**0**	**0**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**0.00**
GRAND TOTAL	**413**	**11**	**565**	**599**	**180**	**52.3**	**31.9**	**30.1**	**0.42**

Clutch Hatching Rates

There were 413 nests and 11 broods from undetected nests indicating at least 424 nesting attempts in the Monterey Bay area in 2012 (Table 2). The clutch-hatching rates (percent of nests documented hatching at least one egg) were 51.0 % on Monterey Bay beaches and 58.8% in the Salt Ponds. These rates excluded all nesting attempts documented only from the detection of broods.

The 2012 clutch hatching rates on the beaches and at the Salt Ponds were below their respective averages from 1999-2011. The 51.0% hatching rate on the beaches was 21% below the 64.2% average of the previous 13 years and the Salt Pond rate of 58.8% was 17% below the 71% average of the previous 13 years (Fig. 3). The < 33% clutch hatching rates at Monterey Dunes, Molera/Potrero, Moss Landing, and Sunset/Manresa areas dragged down the overall beach rate in 2012 (Table 2).

Table 3. Total Snowy Plover clutches lost and percent attributed different causes. Unk. is unknown.

Year	Total Nest Losses	Mammal Predator	Avian Predator	Unknown Predator	Human	Wind Tide Rain	Desertion	Non-Viable	Unk. Cause	Lost at Hatch
1999	**31**	13	3	13	6	23	29	13	0	0
2000	**27**	0	19	26	0	15	30	11	0	0
2001	**51**	2	45	6	4	2	22	8	12	0
2002	**87**	13	39	2	3	17	17	1	7	0
2003	**91**	10	25	4	1	9	13	3	34	0
2004	**129**	6	23	12	8	20	11	2	19	0
2005	**216**	16	47	5	3	9	6	1	14	0
2006	**123**	33	12	25	0	10	9	2	9	0
2007	**162**	12	37	14	2	10	10	5	9	0
2008	**138**	11	37	20	1	17	1	4	7	2
2009	**113**	11	33	9	2	19	4	11	12	0
2010	**153**	8	18	22	3	20	9	3	16	1
2011	**193**	8	33	16	1	11	11	1	20	0
2012	**197**	2	40	14	4	9	6	0	25	0
Mean	**122**	**10**	**29**	**13**	**3**	**14**	**13**	**5**	**13**	**0**

At least 55% of the 197 nest losses in 2012 were likely caused by predators (Tables 3 and 4). Of the 109 losses attributed to predators, 71.6% were taken by birds, 2.8% to mammals and 25.7% to unknown predators. Skunks and a canine took a total of 3 nests (Table 4). Gulls, ravens, and Whimbrels, were the avian species identified (by their tracks) depredating nests (Table 4). A one-legged Western Gull, captured on camera taking one nest and an abandoned egg at Monterey Dunes, and seen taking one nest at North Salinas, was collected by Wildlife Service personnel and found to have plover egg shells in its alimentary canal. We believe it was responsible for most of the nest losses attributed to unidentified avian predators in the Monterey Dunes and Molera/Potrero areas. Eight losses were attributed to humans, including 3 nests that were deliberately removed from mini exclosures on the Pajaro River spit and 1 nest vandalized by humans in a mini-exclosure at north Sunset. Ironically two of the exclosures at Pajaro had just been placed around nests to protect them from being trampled by roosting gulls. Clutch desertion was responsible for 6% of the nest failures; and high tides, strong winds and rain together were responsible for at least 9% of the failed nests (Table 3). No nests had non-viable eggs and the fate of one nest was not determined (Table 4).

Table 4. Causes of Snowy Plover nest loss at Monterey Bay in 2012. Unk. is Unknown, and Pred. is Predator.

	Avian Predator					Mammalian Predator			Unk.					Non-		Cause	Lost at		Fate
Locations	**CORA**	**WHIM**	**Gull**	**NOHA**	**Unk.**	**Canine**	**Skunk**	**Unk.**	**Pred.**	**Human**	**Tide**	**Wind**	**Rain**	**Viable**	**Desert.**	**Unk.**	**Hatch**	**Total**	**Unk.**
Del Monte					1													1	
Sand City																		0	
Fort Ord																		0	1
Reservation Road													1		1			2	
Marina South					3											1		4	
Marina Middle					5							1			3	1		10	
Marina North					1													1	
Martin												1				3		4	
Salinas NWR		1				1				1		1			2	9		15	
N. Salinas River			1													6		7	
Monterey Dunes			2		12											2		16	
Molera/Potrero					13					3						5		21	
Moss Landing			2		14				7		6	2			1	4		36	
Zmudowski Beach	2	2			1		2					2				1		10	
Pajaro River Spit	3		4		4					3	1	3			2	12		32	
Sunset/Manresa	2									1					1	6		10	
Salt Ponds					5				21						2			28	
Wilder Creek																		0	
Laguna Creek																		0	
Scott Creek																		0	
Waddell Creek																		0	
Total	**7**	**3**	**9**	**0**	**59**	**1**	**2**	**0**	**28**	**8**	**7**	**10**	**1**	**0**	**12**	**50**	**0**	197	**1**

Chick Fledging Rates

From 28-30% of the chicks that hatched on the beaches fledged in 2012 (Table 3). This rate was about 32% below the average of 42.4% from 1999-2011 (Fig. 4). Fledging rates were below 10% in the Reservation Road and Monterey Dunes areas and below 20% at the Pajaro Spit and Martin areas. The 39-42% fledging rate at the Salt Ponds was about 4% greater than the 39.1% average there over the previous 13 years (Fig. 4).

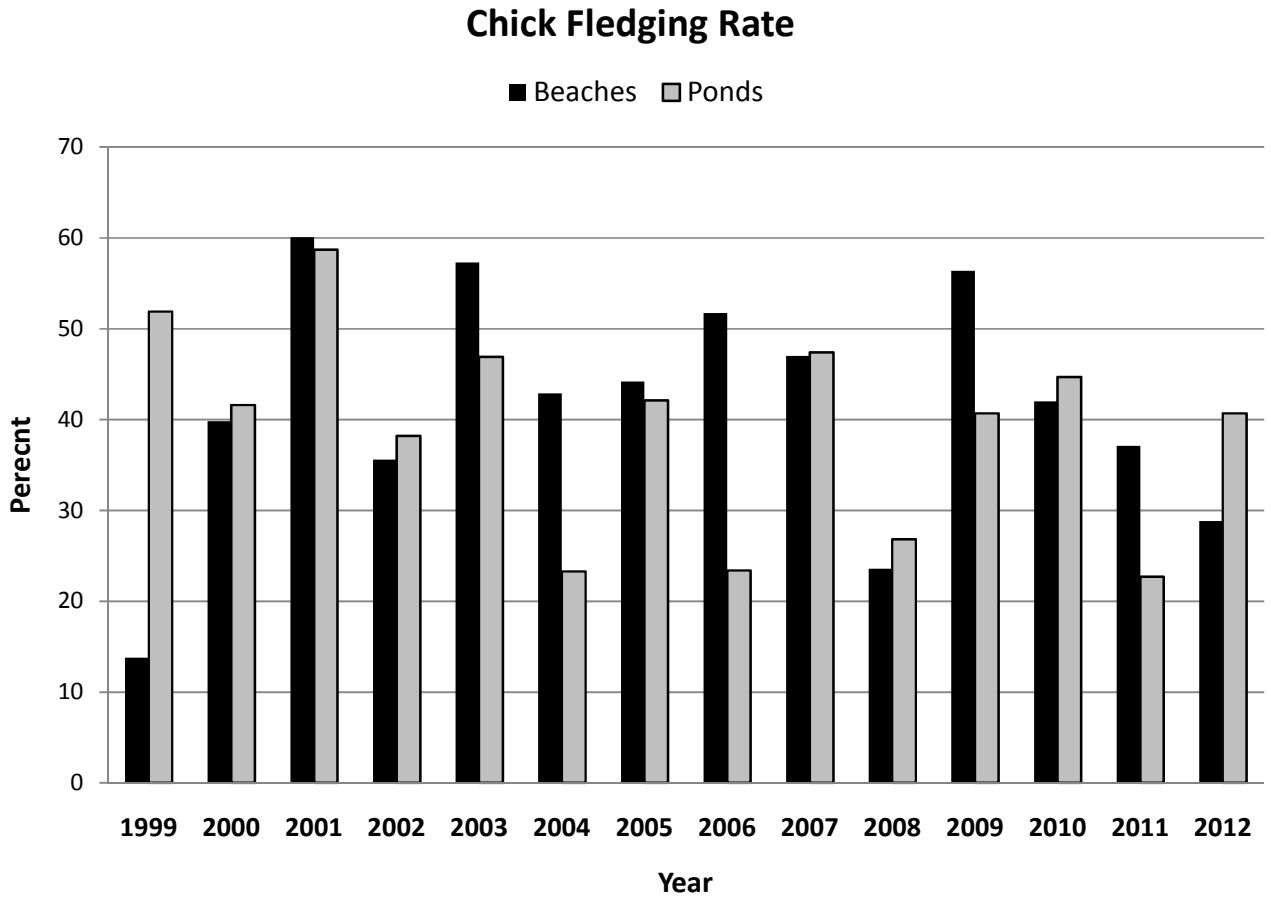


Figure 4. Chick fledging rates of Snowy Plovers at Monterey Bay.

Number of chicks fledged

Of the 180 young that fledged in 2012, 137 were from the beaches and 43 from the Salt Ponds. The total number of fledged young in 2012 was 25% below the 241-bird average from 1999-2011 (Fig.5). The number of fledglings from the beaches was 27% below the prior 13-year 188-bird average and the 43 fledglings from the salt ponds 12% below the prior 49-bird average.

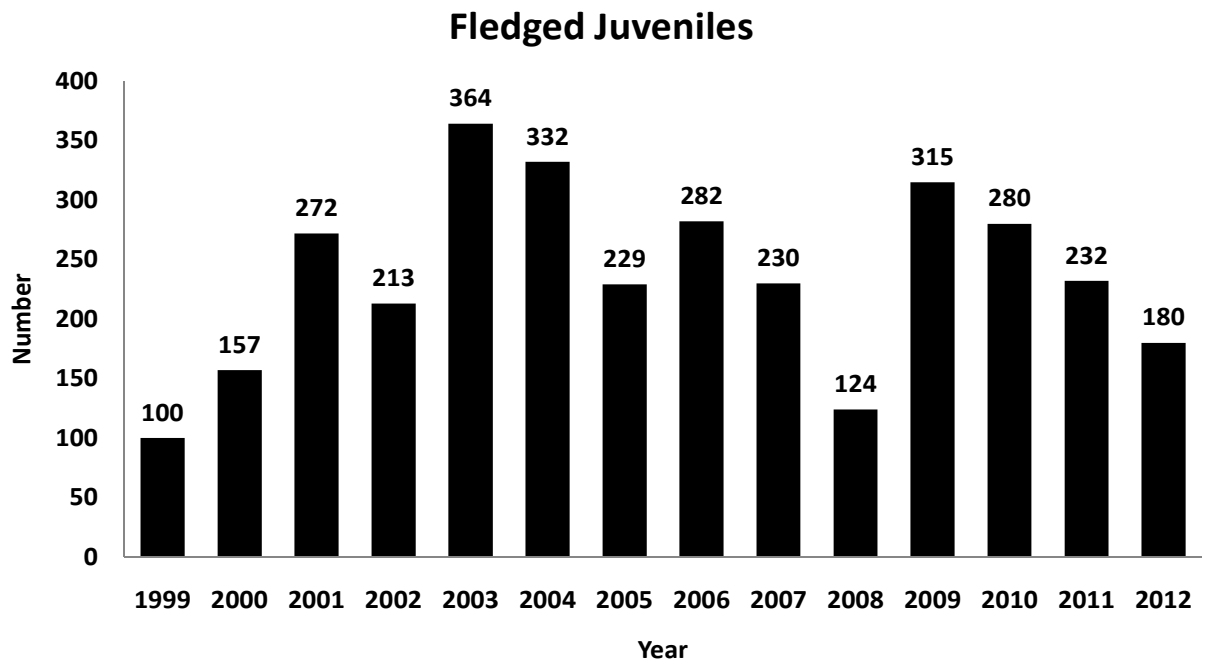


Figure 5. Number of fledged juveniles at Monterey Bay.

Young Fledged Per Male

The 2012 fledging rate of 0.8 young per male was 42% lower than the 1.45 bird average of the past 13 years (Fig. 6) and was well below the level of one young per male needed to prevent the population from declining (USFWS Recovery Plan).

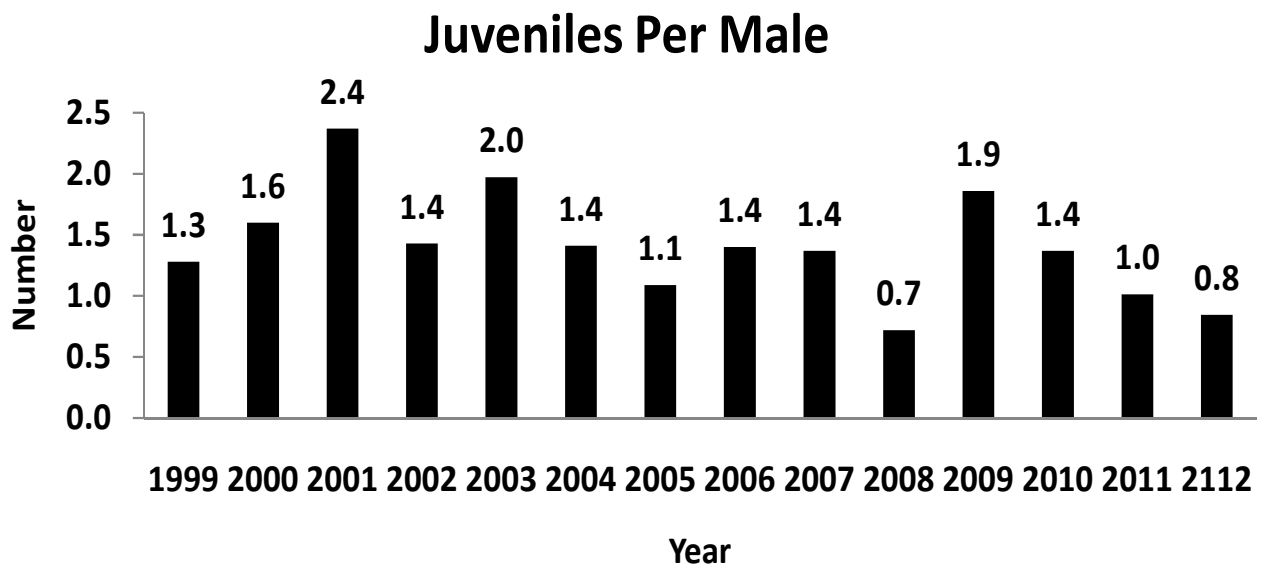


Figure 6. Mean number of juveniles reared per male at Monterey Bay.

DISCUSSION

Despite a 10% decline in the number of breeding Snowy Plovers from 2011, the 386 Snowy Plovers in 2012 was 14% larger than the target of 338 adults for the Monterey Bay region recommended by the USFWS. This target has been exceeded in the Monterey Bay area in 7 of the 10 years since it was first attained in 2003. Although the number of breeders in the Monterey Bay area dipped slightly below the 400-bird target for all of USFWS Recovery Unit 4 – all coastal nesting areas from Sonoma through Monterey counties – when breeders from other areas within unit 4 are accounted for it is likely that the population for the entire recovery unit will approximate the 400-bird target.

The USFWS window survey in late May is the underlying method of estimating the relative size of the U.S. Pacific coast population from year to year. Our data continue to suggest that it underestimates the number of breeders in the Monterey Bay region. In 2012, 305 adults were recorded in the study area on the window survey. This represents only 79% of the estimated 386 adults (mainly color banded birds) known to have nested in the study area.

Plovers experienced subpar breeding success in the Monterey Bay area in 2012. Clutch hatching rates were below the 13-year average on both the beaches (- 21%) and the Salt Ponds (- 17%). The chick fledging rate was about average in the Salt Ponds (+ 4%) but well below average on the beaches (- 32%). The number of fledglings was below average on both the beaches and in the Salt Ponds. The total of 180 fledges, for both areas combined, was 25% lower than the average of the prior 13 years. The consequence of the low number of fledglings produced in 2012 will likely be a smaller breeding population in the Monterey Bay area in 2013. One fledged young per male is necessary to sustain a population experiencing average mortality levels but only 0.8 chicks per male fledged in 2012.

Depredation of clutches by avian predators was the prominent identified cause of nest failure. Avian predators were responsible for at least 39.6% of the 197 nest losses. Many of 28 additional losses attributed to unknown predators and 50 nesting failures for which no cause of loss could be assigned were likely caused by avian predation as well. Only 3 nest losses were attributed to mammalian predators in 2012.

Gulls and ravens were the main avian predators identified taking nests (Table 4). Gulls and ravens were responsible for at least 7 nests lost at Pajaro spit and probably some of 12 additional nests for which no cause of loss could be assigned. Although we only were able to positively identify gulls as responsible for 2 nest losses in the Molera/Potrero and Monterey Dunes areas combined, many of the 25 nests categorized as lost to unidentified avian predators and some of the 7 for which no cause could be assigned were likely taken by a one-legged Western Gull which we confirmed taking one nest and an abandoned egg at Monterey Dunes. It was observed actively searching for plover nests and also was seen taking a nest at North Salinas. The gull was collected by personnel from Wildlife Services on 2 July and found to have a gut full of plover egg shells. It may have been responsible for losses over the broad area from Marina to Jetty Road.

Most nest loss at the Salt Ponds (93%, n = 28) was attributed to predators which could not be positively identified because they do not leave tracks on the dry, hard, pond bottoms. In the recent past we obtained indisputable evidence of ravens and Red-tailed Hawks depredating plover nests in the ponds. Since two pairs of these hawks nested in eucalyptus trees overlooking the ponds, we are suspicious that

they were responsible for some, if not the majority, of the losses attributed to unknown predators in 2012. Most nest losses in the ponds were in the cells closest to the nesting hawks. In cell one (southwest cell in Appendix 6), which was farthest from the trees, 100% of 24 nests hatched. Moving clockwise toward the area where the Red-tailed Hawks nested, only 50% (n = 14) of the nests hatched chicks in cell two, 33% (n = 12) in cell three, and 24% (n = 17) in cell four.

Five areas exhibited very low chick fledging rates. They were Reservation Road (6.5%), Monterey Dunes (7-9%), Martin (12-13%), Pajaro Spit (17%), and Moss Landing (22%). It is rare to observe actual chick depredation but we speculate that avian predators were largely responsible for the high levels of chick loss in these areas. Red-tailed Hawks and Peregrine Falcons, seen on several occasions hunting at Reservation Road, may have been important contributors to the high rate of chick loss noted there. At Pajaro spit, the regular presence of Great Horned Owl tracks on the beach points to owls as one possibility. Also contributing to chick mortality at Pajaro spit may have been gulls which formed large restless roosting flocks within the fenced-off breeding area. Predators that may have been taking chicks in the Salt Ponds were Red-tailed Hawk, Northern Harrier, Peregrine Falcon, Barn Owl, Great Horned Owl and Coyote.

The Snowy Plover is a management-dependent species requiring provision of undisturbed nesting areas and protection from predators to be a successful breeder on the Pacific coast. Monitoring plover nests and broods is an important component of a management program because it identifies where and when plovers are experiencing breeding problems so that management actions can be directed to where they are most needed. This year it took weeks to identify the cause of high levels of nest loss in the Molera/Potrero and Monterey Dunes areas because the predator(s) didn't leave distinctive tracks or other signs and the monitors did not suspect a gull that deliberately targeted nests. Also, in the Salt Ponds the predators, which took 21 nests, could not be identified to species as they didn't leave tracks on the hard pond bottoms. To counter these problems in 2013, we plan to deploy several nest cameras to speed up the identification of the predators which are taking nests.

Cameras are not a practical method of identifying the predators of chicks because of the mobility of chicks. We checked a Barn Owl nesting box near the Salt Ponds after the end of this breeding season and turned up the bands of one Snowy Plover that disappeared as a chick in the ponds several years ago. Limited dissection of both hawk and owl pellets has not turned up any additional plover bands, but many pellets and nest box debris remain unexamined. In the past there have been up to three active Barn Owl nest boxes near the ponds and this year at least one brood of Great Horned Owls fledged in the adjacent eucalyptus trees. We will continue to check hawk and owl pellets in 2013 to see if we can learn more about what avian predators are responsible for chick loss, especially in the Salt Ponds.

ACKNOWLEDGEMENTS

Lynne Stenzel and Bernadette Ramer of PRBO Conservation Science greatly assisted with the fieldwork at Pajaro Dunes, Laird Henkel in the South Bay, and Jacob Martin in the North Bay. Amy Palkovic deserves special thanks for preparing the nest maps. This project was conducted collaboratively by PRBO Conservation Science, the Salinas River National Wildlife Refuge Unit of the Don Edwards San Francisco Bay National Wildlife Refuge of the U. S. Fish Wildlife Service, the California Department of Parks and Recreation, the California Department of Fish and Game, the Wildlife Services Unit of the U. S. Department of Agriculture, and the Monterey Bay Aquarium.

Appendix 1. Overview of Snowy Plover nest locations in the Monterey Bay area in 2012.

Appendix 2. Snowy Plover nest locations at the northern section of Sunset State Beach in 2012.

Appendix 3. Snowy Plover nest locations at the Pajaro Spit at Sunset and Zmudowski State Beaches in 2012.

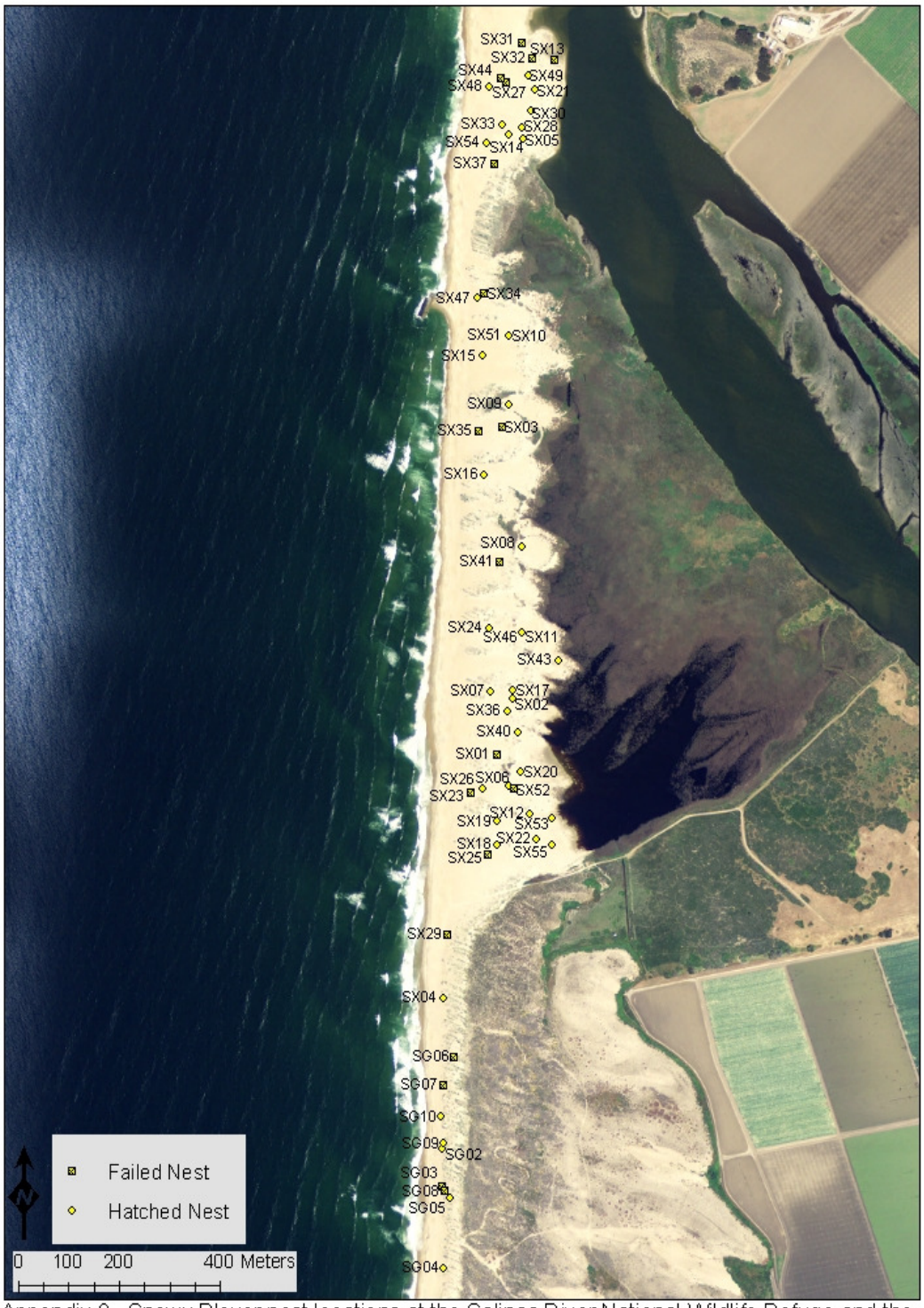
Appendix 4. Snowy Plover nest locations at Zmudowski State Beach in 2012.

Appendix 5. Snowy Plover nest locations near Jetty Road at Zmudowski and Moss Landing State Beaches in 2012.

Appendix 6. Snowy Plover nest locations at the Moss Landing Wildlife Management Area in 2012. This map does not include 1 additional nest that was found as a brood.

Appendix 7. Snowy Plover nest locations at the northern portion of Salinas River State Beach in 2012. This map does not include 1 additional nest that was found as a brood.

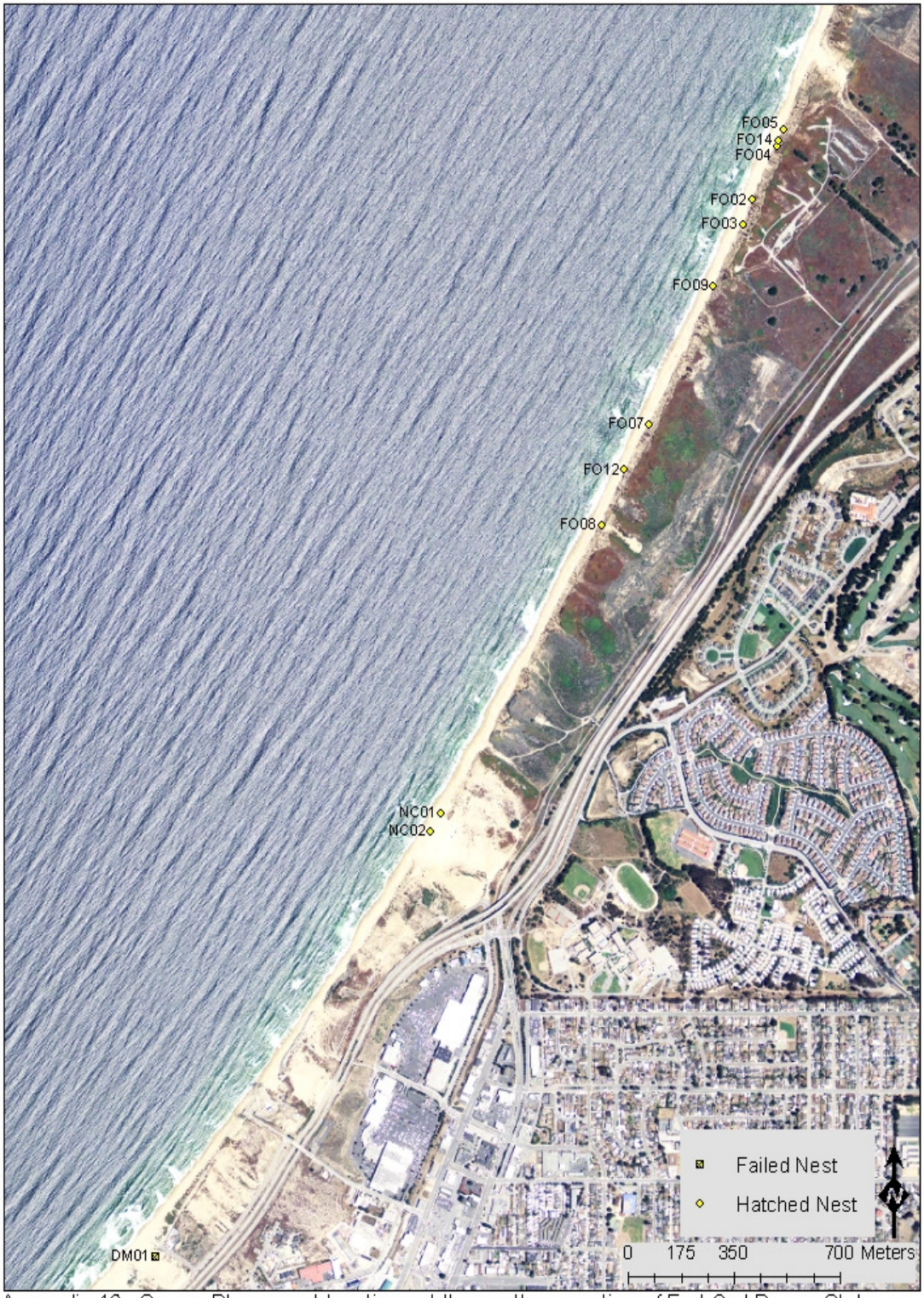
Appendix 8. Snowy Plover nest locations at the southern portion of Salinas River State Beach in 2012. This map does not include 3 additional nests that were found as broods.



Appendix 9. Snowy Plover nest locations at the Salinas River National Wildlife Refuge and the Martin dunes in 2012. This map does not include 7 additional nests that were found as broods.

Appendix 10. Snowy Plover nest locations at Marina beach in 2012. This map does not include 2 additional nests that were found as broods.

Appendix 11. Snowy Plover nest locations at Marina State Beach and the northern portion of Fort Ord Dunes State Park in 2012.



Appendix 12. Snowy Plover nest locations at the southern portion of Fort Ord Dunes State Park, Sand City, and Monterey State Beach in 2012.

NESTING OF THE SNOWY PLOVER IN THE MONTEREY BAY AREA, CALIFORNIA IN 2014

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SYNOPSIS

Researchers and associates of Point Blue Conservation Science (Point Blue), the U.S. Fish and Wildlife Service (USFWS), and the California Department of Parks and Recreation (CDPR) monitored nesting Snowy Plovers at Monterey Bay in Monterey and Santa Cruz counties in 2014 to assess the plover's response to management efforts by the government agencies to enhance the species' breeding success and increase its population size. Management actions undertaken by federal and state agencies included:

- Roping-off upper beach and riverine spit habitat to minimize disturbance of nesting birds by the public.
- Exclosures to protect individual nests from predators when needed (Table 1).
- Predator removal by the Wildlife Services Division of the U.S. Department of Agriculture (USDA) and the Ventana Wildlife Society.
- Water management to provide nesting and feeding habitat in the managed ponds of the Moss Landing Wildlife Area (MLWA).

The estimated 419 plovers that nested in 2014 exceeded the estimate of 382 breeders the previous year (Fig. 1) and significantly exceeded the target of 338 breeders recommended for the Monterey Bay area in the USFWS Recovery Plan. No plovers were detected nesting on northern Santa Cruz County pocket beaches for the fifth consecutive year. The 2014 nesters consisted of 224 males and 195 females, all of which were uniquely color banded except for 19 males and 20 females which were unbanded. Among the uniquely color marked breeders were 20 males and 12 females produced from nesting attempts in the Monterey Bay area in 2013. Among the female nesters were 2 banded as chicks at Vandenberg, 3 at Oceano Dunes and 1 in Oregon.

Return rates of breeders of both sexes were approximately 20% above average in 2014. Of color banded adults that nested in 2013, 81% of males and 75% of females returned and bred in 2014. This compares with average return rates of 68% for males and 64% for females in the prior 15 years (Fig. 2).

We found 463 nests and 34 broods from undetected nests indicating at least 497 nesting attempts in the Monterey Bay area in 2014 (Table 2). In 2014 both the beach and pond clutch hatching rates were below their respective averages from 1999-2013. The 51% hatching rate of nests on the beaches was 16% below the 61% average of the previous 15 years and the salt pond rate of 50% was 24% below the 66% average of the previous 15 years (Fig. 3).

Predators were likely responsible for at least 58% of the 226 nest losses in 2014 (Tables 3 and 4). Of the 131 losses attributed to predators, 55.0% were attributed to avian predators, 32.1% to mammalian predators and 13.0% to unknown predators. Ravens, gulls and raven were the avian species identified depredating nests (Table 4). Skunks, canines, and raccoons were deemed responsible for 41 of the 42 nest losses attributed to mammalian predators (Table 4). One nest categorized as lost at hatch was undoubtedly also destroyed by avian or mammalian predators but we could not be sure if the loss occurred in the egg or chick phase.

Among nest losses attributed to other causes were 5 nests destroyed by humans and 23 by natural elements such as wind, tide and rain (Table 4). Nineteen nests were deserted and 4 had non-viable eggs.

No cause of loss could be attributed for 18.6% of the 226 nests categorized as failed but most of these were probably taken by predators rather than other causes listed in Table 4.

This year the chick fledging rate of 34.2% on beaches was 16% below the 1999-2013 average of 40.6% whereas the salt pond fledging rate of 52.3% was 43% above the 1999-2013 average of 36.6% (Fig. 4).

The total of 241 fledged young for the Monterey Bay area in 2014 was slightly above the 228-bird average from 1999-2013 and ended the steady decline from 2009 to 2013 (Fig. 5). The number of fledglings from the beaches was 24% above the prior 15-year 180-bird average whereas the 17 fledges from the salt ponds was 62% below the 45-bird average.

The 2014 fledging rate of 1.1 young per male was 21% lower than the 1.4 bird average of the past 15 years (Fig. 6) but sufficient to maintain population stability (USFWS Recovery Plan). The consequence of the 1.1 fledglings per male in 2014 should be a stable breeding population in the Monterey Bay area in 2015.

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INTRODUCTION

Staff and research associates of Point Blue Conservation Science (formerly PRBO), with the assistance of staff and/or interns of the U.S. Fish and Wildlife Service and the California Department of Parks and Recreation, have monitored nesting Snowy Plovers annually on the shores of Monterey Bay since 1984, and on small pocket beaches in northern Santa Cruz County since 1988, to assess the number of breeding plovers, number of nests, clutch hatching rate, chick fledging rate, and causes of egg and chick loss. Here we summarize the results of the monitoring effort in 2014.

STUDY AREA

The study area includes the beaches of Monterey Bay, former salt ponds in Elkhorn Slough (hereafter Salt Ponds), and pocket beaches in northern Santa Cruz County. For reporting purposes we divide up the study area as follows:

Monterey Bay Area

South Beach Subregion

Del Monte: Beach between the City of Monterey and Tioga Road, Sand City. Most of it is adjacent to Sand City. The beach is managed by CDPR.

Sand City: Beach between Tioga Road, Sand City and the south boundary of Fort Ord.

South Fort Ord: Beach between the south boundary of Fort Ord and the site of former Stilwell Hall. It is managed by CDPR.

North Fort Ord: Beach between the Stilwell Hall site and the Lake Court beach access to Marina State Beach. It is managed by CDPR.

Reservation Road: From the Lake Court beach access for Marina State Beach to Reservation Road. It is managed by CDPR.

Marina: The entire beach from Reservation Road to the north border of the Salinas River National Wildlife Refuge. It is managed by CDPR and the Monterey Peninsula Regional Park District. It is subdivided into four segments, all of which are completely or partly bordered by private property (Table 1).

Salinas River National Wildlife Refuge: The entire beach on the Salinas River National Wildlife Refuge (NWR), which is owned and managed by USFWS.

Salinas River North: The entire beach from the south border of the Salinas River NWR to the mouth of Elkhorn Slough. It is owned and managed by CDPR. It is further divided into three segments – the north spit of the Salinas River, Monterey Dunes, and Molera/Potrero road segments (Table 1). The Monterey Dunes segment is backed by a beach front housing development. The Molera/Potrero segment is backed by dunes, the Old Salinas River channel, salt marsh, and, east of the river channel, by agricultural fields south of and by development north of Potrero Road.

North Beach Subregion

Jetty Road to Beach Road: All the beach between Jetty Road (mouth of Elkhorn Slough) and Beach Road. It is divided into 3 segments all managed by CDPR (Table 1). The north end of the Pajaro Spit is bounded by a beach front development.

Sunset/Manresa: The entire beach from Beach Road to the north boundary of Manresa State Beach. The south end of this subregion is backed by a beach front development. The beach is managed by CDPR.

Salt Pond Region

It includes approximately half of the former salt ponds in Elkhorn Slough that have been converted to managed, diked wetlands and are now encompassed within the California Department of Fish and Wildlife's (DFW) Moss Landing Wildlife Area.

Northern Santa Cruz County Pocket Beach Region

We sporadically covered the four beaches known to have formerly supported nesting Snowy Plovers in northern Santa Cruz County. ***Wilder Creek Beach*** and ***Laguna Creek Beach*** are owned and managed by CDPR. ***Scott Creek Beach*** is owned and managed by the County of Santa Cruz and ***Waddell Creek Beach*** is owned by the CDPR and by a private party.

MONITORING

We attempt to find all plover nests initiated in the study area. Unique color band combinations are used to individually mark plover adults and chicks. For color banding, adults are usually trapped on the nest. Chicks are captured in or near the nest at the time of hatching. Clutch hatching dates are estimated from egg laying dates, when known, or from egg flotation. They are further refined by examination of eggs for cracked shells, tapping chicks, or peeping chicks just before the estimated hatching date. Chicks are considered fledged if they survive 28 or more days after hatching. Monitors look for fledglings when they have reached 28 days of age by watching banded males known to have broods and by monitoring flocks of roosting plovers during the latter part of the nesting season. Fledging success for specific sites is always categorized by nest location, even in cases where broods move to adjacent areas before fledging. In 2014, we recorded the longitude and latitude of all nests with Global Positioning Units. These locations are depicted in Appendices 1-13. Monitoring is conducted under U. S. Fish and Wildlife Service Permit TE 807078-15.

MANAGEMENT

A variety of techniques are used to improve the breeding success of the Snowy Plover in the study area. The upper beach at Salinas River NWR and the salt ponds are closed to the public to protect nesting plovers from human disturbance. On California state beaches symbolic fencing, consisting of signed, roped-off upper beach areas, is used to protect most nests (Table 1) and limit human disturbance of brood-rearing birds during the nesting season.

Mini exclosures, 24-36 inches in diameter and 24 inches high, were used to protect 16 nests from predators at Pajaro Dunes 2014. Fourteen were deployed at Pajaro nests a few days from hatching to protect them from skunks and ravens. Two nests that were exclosed early in the incubation period were deserted. One of the two deserted nests was possibly a dumped egg. Selective removal of problem mammalian and avian predators by Wildlife Service biologists also was conducted in 2014.

Biologists from the Ventana Wildlife Society captured a second-year female Peregrine Falcon at Salinas River NWR on June 9, 2014 and it was released at the Sacramento NWR by USFWS staff. It had been observed hunting in Snowy Plover habitat from Marina to the Salinas River from late March to June. It was observed taking a shorebird chick at Salinas River NWR and suspected of taking multiple adult and young Snowy Plovers during this timeframe. Fledgling production was extremely low during its presence. An adult Great Horned Owl was trapped at Ford Ord Dunes State Park by a Ventana Wildlife Society biologist and moved and released at Antioch NWR by USFWS staff on June 26, 2014. Owls were suspected to be responsible for low chick fledging rates at Fort Ord.

We continued to manage water levels at the Salt Ponds to create dry nesting substrate and associated wet foraging areas for Snowy Plovers. Water is drawn down rapidly from some ponds at the beginning of the season to provide dry nest sites. Thereafter, flooding of remnant-wet areas is undertaken several times per month throughout the nesting season to maintain foraging habitat for adults and chicks.

Table 1. Nest protection measures for Snowy Plovers at Monterey Bay in 2014.

Location	Total Nests	Large Excl. Only	Min Excl. Only	Symb. Fence Only	Fence & Mini Excl.	Fence & Large Excl.	Fence & Gull Excl.	Sign Only	None	Found Broods Only
Sand City	1	0	0	1	0	0	0	0	0	0
Fort Ord	33	0	0	33	0	0	0	0	0	0
Reservation Road	17	0	0	17	0	0	0	0	0	1
Marina										
Marina South	15	0	0	15	0	0	0	0	0	1
Marina Middle	38	0	0	38	0	0	0	0	0	2
Marina North	11	0	0	10	0	0	0	0	1	2
Martin	11	0	0	11	0	0	0	0	0	1
Salinas River NWR	57	0	0	57	0	0	0	0	0	7
Salinas River North										
Salinas River N. Spit	38	0	0	38	0	0	0	0	0	1
Monterey Dunes	20	0	0	20	0	0	0	0	0	4
Molera/Potrero	23	0	0	22	0	0	0	0	1	3
Jetty to Beach Roads										
Moss Landing	48	0	0	48	0	0	0	0	0	5
Zmudowski Beach	32	0	0	32	0	0	0	0	0	1
N. Pajaro R.M.	86	0	0	70	16	0	0	0	0	3
Sunset/Manresa	12	0	0	12	0	0	0	0	0	1
Seascape	1	0	0	1	0	0	0	0	0	0
Salt Ponds	20	0	0	19	0	0	0	0	1	2
Total	463	0	0	444	16	0	0	0	3	34

RESULTS

The 2014 Nesting Season

Number of Breeders

The estimated 419 plovers that nested in 2014 exceeded the estimate of 382 breeders of the previous year (Fig. 1) and substantially exceeded the target of 338 breeders recommended for the Monterey Bay area in the USFWS Recovery Plan. Again, no plovers were detected nesting on the northern Santa Cruz County pocket beaches in 2014 (Table 2).

The 2014 nesters consisted of 224 males and 195 females. Nineteen of the males and 20 of the females were unbanded. Among the remaining 205 uniquely color marked male breeders were 20 birds produced from nesting attempts in the Monterey Bay area in 2013. Among the 175 uniquely marked female nesters were 12 produced from nesting attempts in the Monterey Bay area in 2013. In addition to the recruitment of locally-hatched plovers into the Monterey Bay area were 2 females fledged from Vandenberg, 3 from Oceano, and 1 from Oregon

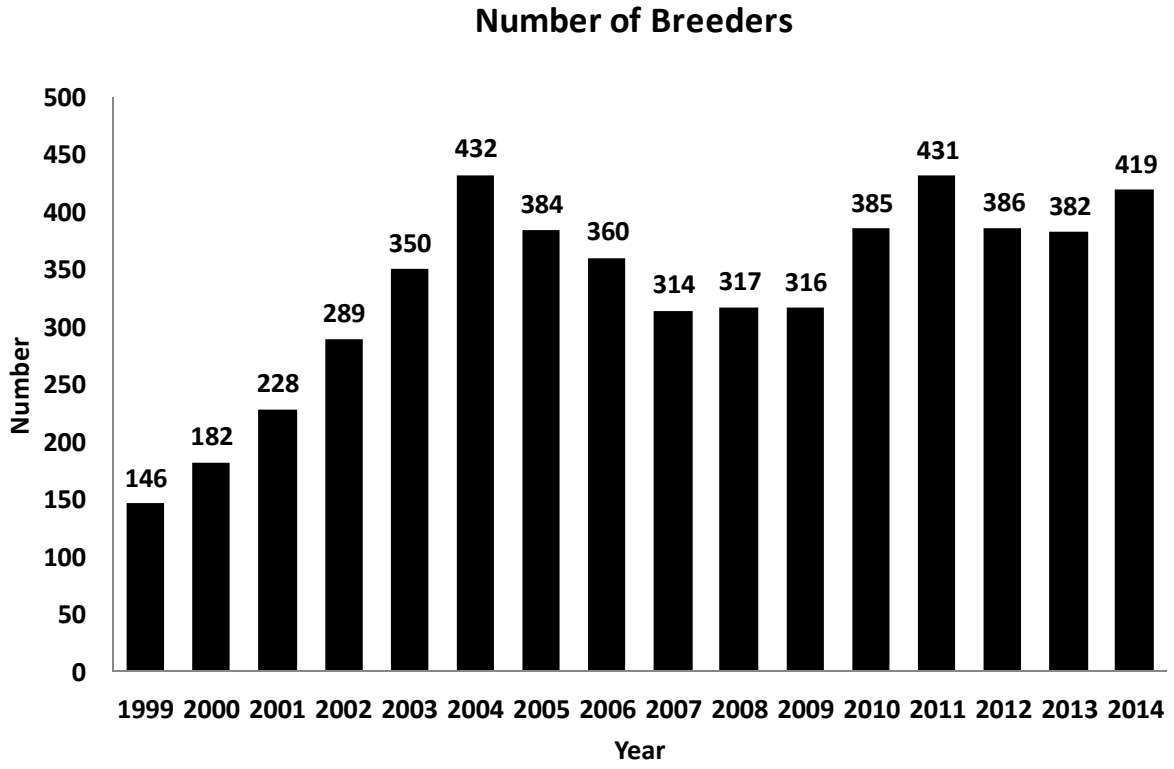


Figure1. Number of nesting Snowy Plovers at Monterey Bay, 1999-2014.

Return Rates

Return rates of breeders of both sexes were approximately 20% above average in 2014. Of color banded adults that nested in 2013, 81% of males and 75% of females returned and bred in 2014. This compares with average return rates of 68% for males and 64% for females in the prior 15 years (Fig. 2).

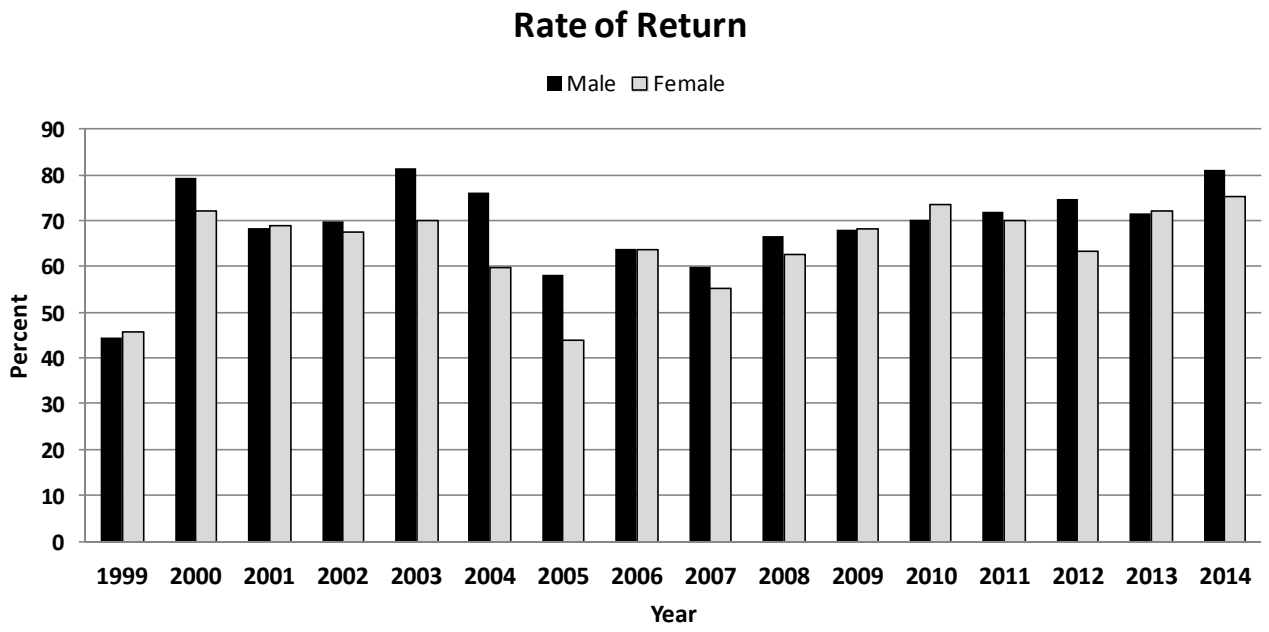


Figure 2. Return rates of nesting Snowy Plovers at Monterey Bay.

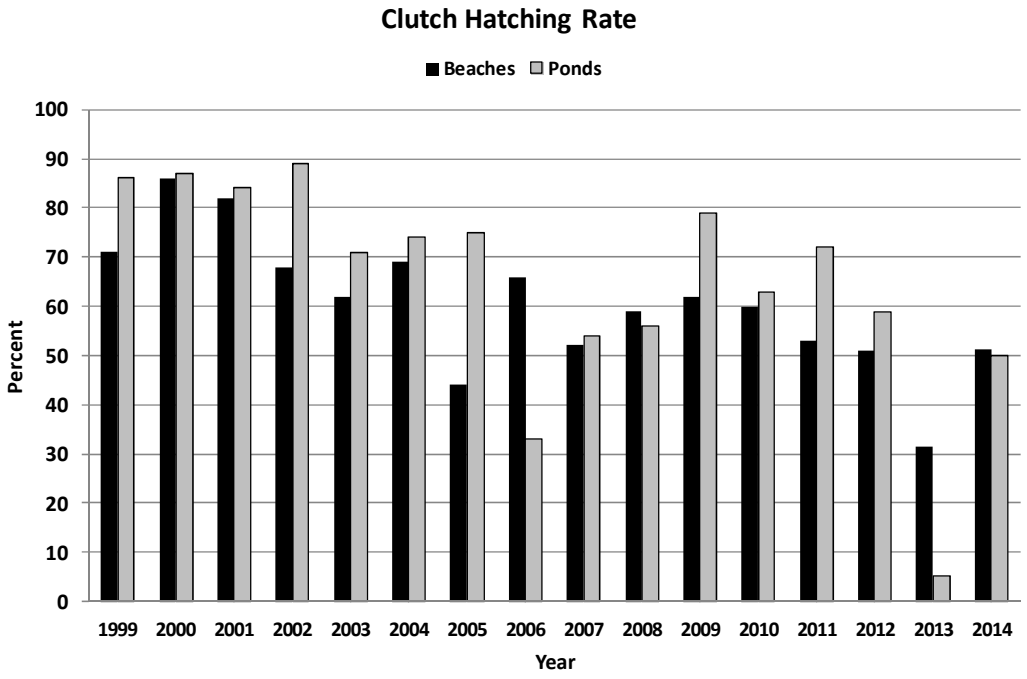


Figure 3. Clutch hatching rates of Snowy Plovers at Monterey Bay.

Clutch Hatching Rates

We found 463 nests and 34 broods from undetected nests indicating at least 497 nesting attempts in the Monterey Bay area in 2014 (Table 2). Our calculations of the clutch hatching rates of these nests exclude all nesting attempts documented only from the detection of broods.

The 2014 hatching rate of clutches on the beaches and the salt ponds was below their respective averages from 1999-2013. The 51% hatching rate on the beaches was 16% below the 61% average of the previous 15 years and the salt pond rate of 50% was 24% below the 66% average of the previous 15 years (Fig. 3).

Table 2. Snowy Plover nesting success at Monterey Bay in 2014. Juv. is Juvenile and Att. is Attempt.

	Nest Attempts		Chicks			% Nests	% Chicks Fledge		Juv. Per	Hatch	Failed
Regions	**Nests**	**Broods**	**Low**	**High**	**Juv.**	**Hatch**	**High**	**Low**	**Nest Att.**	**Nests**	**Nests**
Del Monte-Res. Rd.											
Sand City	1	0	0	0	0	**0.0**	**0.0**	**0.0**	**0.00**	0	1
Fort Ord	33	0	62	63	24	**66.7**	**38.7**	**38.1**	**0.73**	22	11
Reservation Road	17	1	28	34	10	**70.6**	**35.7**	**29.4**	**0.56**	12	5
Marina											
Marina South	15	1	15	17	4	**40.0**	**26.7**	**23.5**	**0.25**	6	9
Marina Middle	38	2	55	67	15	**63.2**	**27.3**	**22.4**	**0.38**	24	14
Marina North	11	2	23	27	8	**72.7**	**34.8**	**29.6**	**0.62**	8	3
Martin	11	1	22	24	6	**72.7**	**27.3**	**25.0**	**0.50**	8	3
Salinas NWR	57	7	86	99	29	**49.1**	**33.7**	**29.3**	**0.45**	28	29
Salinas River N											
N. Salinas River	38	1	52	54	9	**50.0**	**17.3**	**16.7**	**0.23**	19	19
Monterey Dunes	20	4	45	47	16	**65.0**	**35.6**	**34.0**	**0.67**	13	7
Molera/Potrero	23	3	50	52	21	**78.3**	**42.0**	**40.4**	**0.81**	18	5
Jetty-Beach Rds.											
Moss Landing	48	5	67	72	18	**45.8**	**26.9**	**25.0**	**0.34**	22	26
Zmudowski Beach	32	1	36	38	10	**43.8**	**27.8**	**26.3**	**0.30**	14	18
Pajaro Spit	86	3	78	83	53	**34.9**	**67.9**	**63.9**	**0.60**	30	56
Sunset/Manresa	12	1	6	9	1	**16.7**	**16.7**	**11.1**	**0.08**	2	10
Seascape	1	0	2	2	0	**100.0**	**0.0**	**0.0**	**0.00**	1	0
TOTAL BEACHES	**443**	**32**	**627**	**688**	**224**	**51.24**	**35.7**	**32.6**	**0.47**	**227**	**216**
SALT PONDS	**20**	**2**	**32**	**33**	**17**	**50.0**	**53.1**	**51.5**	**0.77**	**10**	10
GRAND TOTAL	**463**	**34**	**659**	**721**	**241**	**51.2**	**36.6**	**33.4**	**0.48**	**237**	**226**

Note: One Reservation Road nest of unknown fate is treated as a failed nest for these calculations.

Table 3. Total Snowy Plover clutches lost and percent attributed to different causes from 1999 to 2014. Unk. is unknown.

Year	Total Nest Losses	Mammal Predator	Avian Predator	Unknown Predator	Human	Wind Tide Rain	Desertion	Non-Viable	Unk. Cause	Lost at Hatch	Unk Fate
1999	**31**	13	3	13	6	23	29	13	0	0	0
2000	**27**	0	19	26	0	15	30	11	0	0	0
2001	**51**	2	45	6	4	2	22	8	12	0	0
2002	**87**	13	39	2	3	17	17	1	7	0	0
2003	**91**	10	25	4	1	9	13	3	34	0	0
2004	**129**	6	23	12	8	20	11	2	19	0	0
2005	**216**	16	47	5	3	9	6	1	14	0	0
2006	**123**	33	12	25	0	10	9	2	9	0	0
2007	**162**	12	37	14	2	10	10	5	9	0	0
2008	**138**	11	37	20	1	17	1	4	7	2	0
2009	**113**	11	33	9	2	19	4	11	12	0	0
2010	**153**	8	18	22	3	20	9	3	16	1	0
2011	**193**	8	33	16	1	11	11	1	20	0	0
2012	**197**	2	40	14	4	9	6	0	25	0	0
2013	**340**	7	36	20	0	4	3	0	28	1	0
2014	**226**	19	32	8	2	10	8	2	19	0	0
Mean	**142**	**11**	**30**	**13**	**3**	**13**	**12**	**4**	**14**	**0**	**0**

At least 58% of the 226 nest losses in 2014 were caused by predators (Tables 3 and 4). Of the 131 losses attributed to predators, 55.0 % were attributed to avian predators, 32.1% to mammalian predators and 13.0% to unknown predators. Ravens, gulls and a Whimbrel were the avian species identified depredating nests (Table 4). Nest depredation by ravens was documented at 5 sites and gull depredation at 6 sites (Table 4). Overall, 25 nest losses were attributed to ravens.

Skunks, canines, and raccoons were responsible for 42 of the 43 nest losses attributed to mammalian predators (Table 4). One nest categorized as lost at hatch was undoubtedly also destroyed by avian or mammalian predators but we could not be sure if the losses occurred in the egg or chick phase.

Among nest losses attributed to other causes were 5 nests destroyed by humans and 23 by natural elements such as wind, tide and rain (Table 4). Nineteen nests were deserted and 4 had non-viable eggs.

No cause of loss could be attributed 18.6% of the 226 nests that failed but most of these were probably taken by predators rather than other causes listed in table 4.

Table 4. Causes of Snowy Plover nest loss at Monterey Bay in 2014. Unk. is Unknown, and Pred. is Predator.

	Avian Predator					Mammalian Predator					Unk.				Non-		Cause	Lost at	Fate	
Locations	**CORA**	**WHIM**	**Gull**	**Corvid**	**Unk.**	**Coyote**	**Canine**	**Skunk**	**Racoon**	**Unk.**	**Pred.**	**Human**	**Tide**	**Wind**	**Viable**	**Des.**	**Unk.**	**Hatch**	**Unk**	**Total**
Sand City												**1**								1
Fort Ord							1	6								2	1			10
Reservation Road					1			1								2	1		1	6
Marina South					2						2			2		2	1			9
Marina Middle			1		2			1			3			1	1	2	3			14
Marina North																	3			3
Martin			3																	3
Salinas NWR					2		1	10			2	1	2	2	1	1	6	1		29
N. Salinas River			3		4		2	2					4			2	2			19
Monterey Dunes			1		1							1	1	3						7
Molera/Potrero	1				3											1				5
Moss Landing	7	1			5	1	1					1		3		1	6			26
Zmudowski Beach	8		4		2		1										3			18
Pajaro River Spit	7		7	1	3			8	1	1	4			5	1	4	14			56
Sunset/Manresa	2				1			3	2								2			10
Seascape																				
Salt Ponds											6	1			1	2				10
Total	**25**	**1**	**19**	**1**	**26**	**1**	**6**	**31**	**3**	**1**	**17**	**5**	**7**	**16**	**4**	**19**	**42**	**1**	**1**	**226**

Note: The Reservation Road nest of unknown fate is treated as a failed nest.

Chick Fledging Rates

Chick fledging rate was also below average on the beaches and above average at the ponds in 2014. On the beaches, only 33-36% of the chicks fledged in 2014 (Table 2). This rate was about 16% below the average of 40.6% from 1999-2013 (Fig. 4). In contrast, the 52-53% chick fledge rate at the ponds exceeded the 1999-2013 average of 36.6% by 43%.

Fledging success pooled for the areas that the peregrine hunted – from North Salinas to Marina-- was 14% for all nests that hatched prior to the falcon's removal compared with 34% for all nests that hatched afterwards, including nests that had chicks on the ground after the falcon returned to the area. The fledging rate of chicks from plover nests that hatched prior to the removal of the Great Horned Owl was 31% and 43% subsequent to its removal.

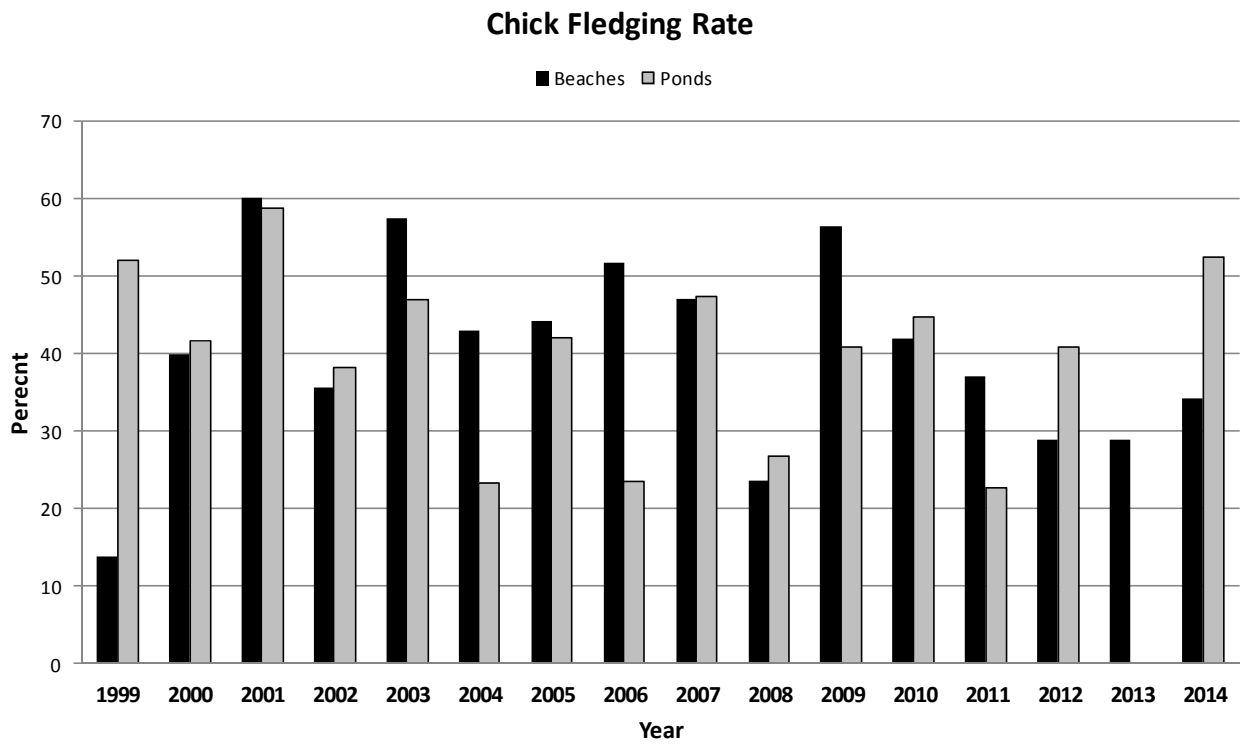


Figure 4. Chick fledging rates of Snowy Plovers at Monterey Bay.

Number of chicks fledged

The total of 241 fledged young for the Monterey Bay area in 2014 was slightly above the 228-bird average from 1999-2013 and ended the steady decline from 2009 to 2013 (Fig. 5). The number of fledglings from the beaches was 24% above the prior 15-year 180-bird average whereas the 17 fledges from the Salt Ponds was 62% below the 45-bird average.

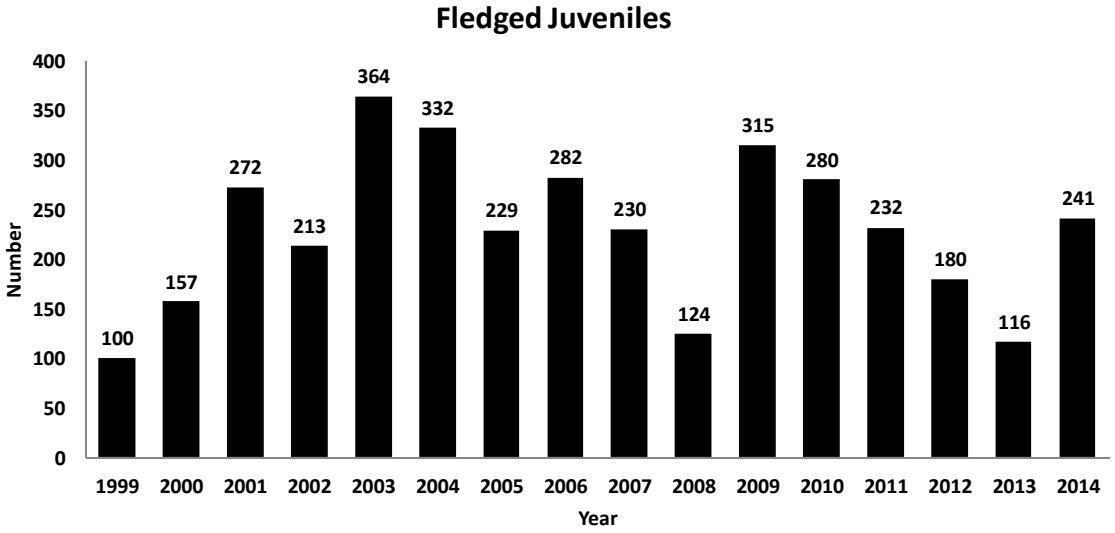


Figure 5. Number of fledged juveniles at Monterey Bay.

Young Fledged Per Male

The 2014 fledging rate of 1.1 young per male was 21% lower than the 1.4 bird average of the past 15 years (Fig. 6) but sufficient to maintain population stability (USFWS Recovery Plan).

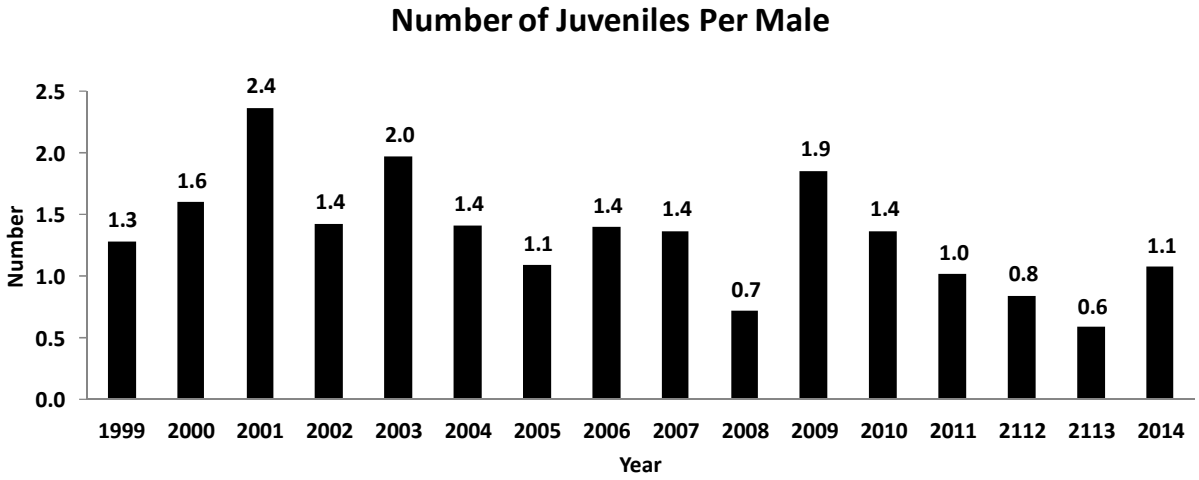


Figure 6. Mean number of juveniles reared per male at Monterey Bay.

DISCUSSION

Our estimate of 419 breeding Snowy Plovers in the Monterey Bay region again in 2014 exceeded the USFWS recovery plan target of 338 adults for the region for the 9th time in the 12 years since it was first attained in 2003. Moreover, the number of breeders in the Monterey Bay area also exceeded the 400-bird target for USFWS Recovery Unit 4 which encompasses all coastal nesting areas from Sonoma through Monterey counties.

The USFWS window survey in late May is currently the primary method of estimating the relative size of the entire U.S. Pacific coast population annually. Our data continue to suggest that the window survey underestimates the number of breeders in the Monterey Bay region. In 2014, 337 adults were detected in the study area on the window survey. This represents only 80% of the estimated 419 adults (mainly color banded birds) known to have nested there over the season. Over the 10-years from 2005-2014 the percent of plovers detected on the Monterey Bay area window survey averaged 75.1% (SE= 2.4%) of known nesters.

The 241 chicks fledged in the Monterey Bay area in 2014 slightly exceeded the previous 15 year average of 228 fledglings for Monterey Bay and the USFWS target of 1 fledgling per male for population stability. Despite the above average fledgling production plovers experienced below average hatching and fledgling rates in 2014 relative to the prior 15 years in the area. The overall clutch hatching rate was 51% compared with the 62% average and the overall chick fledging rate was 35% compared to the 41% average for the prior 15 years

Pajaro Spit experienced exceptionally high fledging success compared with recent years. Fifty-three chicks fledged there in 2014, a great increase over the average of 11 fledglings during the previous 5 years. Several factors may have contributed to this increase including the absence of Northern Harriers, the presence of a large Caspian Tern colony (not typical at this site), and an abundance of vegetation, which provided food and cover for a high density of broods. Many plover broods favored the southern half of the spit, which the highly territorial terns defended against predators. The chicks may also have benefitted from the dense vegetative cover in the closed area of the beach. Flightless chicks were rarely observed on the beach west of the protected area and consequently not subjected to human disturbance as much as observed in previous years when broods frequented the unfenced area. Great Horned Owl tracks were consistently observed throughout the 2014 season (as in previous years) and several depredated adult tern carcasses were found The owls may have been preying on the terns and ignoring the plover chicks in contrast to prior years. The use of 14 single nest exclosures late in pairs' incubation periods also had a positive effect on hatching success at Pajaro Spit. As in recent years, hatching rates improved with control of Common Ravens and Striped Skunks.

Bay-wide, improved control of Common Ravens in or adjacent to plover habitat probably also led to improved plover productivity. Nest losses attributed to ravens were distributed over a small geographic area in 2014 with only 5 sites documented having losses to ravens in 2014 compared with 11 sites in 2013.

Capture and translocation of two avian predators this year appeared to have a positive effect on plover productivity. A second-year Peregrine Falcon observed hunting in Snowy Plover habitat from Marina to the Salinas River from late March to June was seen taking a shorebird chick at Salinas River NWR and suspected of taking multiple adult and young Snowy Plovers during the same timeframe. This bird was captured at Salinas River NWR on June 9 and transported to the Sacramento NWR where it was released. Fledging success pooled for the areas that the peregrine hunted – from North Salinas to Marina -- was 14% for hatchlings from all nests that hatched prior to the falcon's removal compared with 34% for those that hatched afterwards, including in nests that had chicks on the ground after the falcon returned. This same falcon was identified (marked with a VID band) depredating what appeared to be a 2-week old Snowy Plover chick near the Marina dredge pond on Aug 12, 2014. Nevertheless, productivity dramatically improved for all beach segments during the two month interim when this falcon was not observed and presumably absent from the area.

Owls were suspected to be responsible for low chick fledging rates at Fort Ord. Consequently an adult Great Horned Owl was trapped at Ford Ord Dunes State Park and released at Antioch NWR on June 26. The fledging rate of chicks from plover nests that hatched prior to the removal of the Great Horned Owl was 31% and 43% subsequent to its removal.

The population of Snowy Plovers increased in the Monterey Bay in spite of falling below one fledged chick per male in the previous 2 years. Potential contributors to the higher than expected numbers were the very high return rates of breeding males and females between 2013 and 2014 and the recruitment of birds from other areas such as Oceano Dunes and Vandenberg AFB into the Monterey Bay population. The high rate of return of Monterey Bay breeders from 2013 to 2014 may be a reflection of relatively mild winter in 2013-14.

On the Pacific coast, the Snowy Plover has become a management-dependent species requiring provision of undisturbed nesting areas and protection from predators to be a successful breeder. Monitoring plover nests and broods continues to be an important component of the management program because it identifies where and when plovers are experiencing breeding problems so that management actions can be directed to where they are most needed.

RECOMMENDATIONS

The following summarizes suggested management actions for Monterey Bay nesting areas.

Wilder, Laguna, Scott Creek, and Waddell Creek Beaches -- While no nests have been found on these beaches since 2009, Snowy Plovers are regularly seen during the breeding season, particularly in spring. More frequent surveys of northern Santa Cruz County beaches are needed to properly assess nesting activity.

Management and monitoring actions:

1) Symbolic fence maintenance (Scott Creek).
2) Enforcement of dog prohibition (Scott Creek).
3) Twice weekly plover nesting and predator surveys, particularly from March through May.

Sunset State Beach – Raccoon, Common Raven and Striped Skunk depredation of nests continues to overwhelm plover nesting efforts at Sunset.

Management actions:

1. Initiate skunk and raccoon trapping early in the nesting season.
2. Explore the possibility of Common Raven management at north Sunset early in the season by State Parks rangers using methods similar to those used at Big Basin State Park.

Pajaro River mouth (northern river spit north to Palm Beach) – Common Ravens, Striped Skunks and gulls were the primary nest predators north of the Pajaro River. Great-horned Owls were present in the nesting area for most of the season; however, moderate vegetative cover and the presence of a large Caspian Tern colony may have lessened the negative impacts owls have been suspected of causing at the Pajaro River mouth in past years.

Management actions:

1) Initiate skunk removal at the north end of Pajaro Spit in March.
2) Promote a joint State Parks/ Pajaro Dunes integrated skunk management strategy.
3) Consider installation of predator exclusion fence at north end of Pajaro Spit nesting area to prevent skunks from crossing into nesting area from under the condominiums.
4) Increase State Park ranger patrols to improve compliance with the leash law in front of Pajaro Dunes houses and compliance with the dog prohibition on Pajaro River spit.
5) Symbolically fence and install signs on the eastward side of fenced areas in front of the Pajaro Dunes houses to prevent trespass into nest area. Alternatively, consider leaving these areas unfenced in order to discourage nesting in this area.

Zmudowski and Moss Landing State Beaches – Common Ravens were documented taking 8 nests, nearly half of all nest losses at Zmudowski. Horseback riders continue to ride in the fenced area.

Management actions:

1) Increase enforcement to improve equestrian compliance with horse regulations.
2) Devote more State Park staff time to maintenance of cable fencing.

Salt Ponds (Moss Landing Wildlife Area) – Productivity was improved over 2013, with a lower density of nesting plovers in the ponds. However, the lack of vegetative cover is likely still a limiting factor for chick survival.

Management actions:

1) Increase monitoring of diurnal predator activity.
2) Initiate limited, experimental planting of vegetative cover.

Molera through Potrero Road (Salinas River State Beach) – Equestrian use in this area continues to heavily impact nesting habitat. In 2014 one nest was abandoned after equestrians heavily disturbed the area around an unfenced nest. Pedestrian trespass into fenced areas is especially problematic in the 300 meters just south of the Potrero access.

Management actions:

1) Increase enforcement to improve equestrian compliance with horse regulations.
2) Increase ranger foot patrols of the Potrero beach area to prevent trespass into fenced habitat areas.

Monterey Dunes Colony – There was a high level of trespass within fenced habitat areas, a lot of which came from the east (house) side. A nest was deliberately destroyed by humans and a symbolic fence vandalized. Residents persist in taking dogs onto the beach from houses in violation of the dog prohibition.

Management actions:

1) Increase enforcement to improve equestrian compliance with horse regulations.

North Salinas (Salinas River State Beach) The area just north of and adjacent to the Salinas River mouth is a natural preserve that, except for the outer beach area, is closed to pedestrian access during the Snowy Plover nesting season. Fisherman and beach-goers accessing the outer beach and lagoon area via the Scatini farm property continue to disturb birds as they pass through the closed nesting area. Nests and chicks are at risk of being stepped on. The river mouth was not breached this year and it provided good foraging habitat and cover for broods.

Management actions:

1) Repair the back gate on the levee at the corridor entrance to prevent pedestrian and vehicle trespass into the closed nesting area.
2) Ensure that the symbolic fencing and closed nesting area signs are up on the boundary of the Scatini farm and State Park property.
3) Install new signs at the end of the symbolic fence line when the river mouth is open to the ocean to alert the public of the river mouth closure. Suggested wording would be: "Attention: Do not go past this point. Area between river and cable fencing is closed to protect Snowy Plover nesting habitat. Entering this area may result in citation."
4) Increase patrols of the Salinas River levee by State Parks rangers to improve compliance with the closure of the nesting area.
5) Coordinate with all of the agencies to have river breaching occur at the earliest possible date.

Salinas River National Wildlife Refuge – Striped skunks were identified taking 10 nests, over a third of all nest losses at Salinas River NWR. A second year Peregrine Falcon suspected of depredating adult and chick plovers was captured and released at Sacramento National Wildlife Refuge in June but returned by August. Therefore, vigilant monitoring for this individual will be needed prior to and during the 2015 breeding season.

Management actions:

1) Initiate skunk trapping in the early nesting season.

2) Monitor Peregrine Falcon activity and determine appropriate management actions.

3) Monitor Northern Harrier hunting and nesting activity and determine management actions with consideration of overall bay-wide harrier management.

4) Maintain the "no dog" signs at the kiosk and on the entrance gate as they get vandalized throughout the season.

5) Install new signage at the end of the symbolic fence line when the river mouth is open to the ocean to alert the public of the river mouth closure. Suggested wording is "Attention: Do not go past this point. Area between river and cable fencing is closed to protect Snowy Plover nesting habitat. Entering this area may result in citation."

6) Increase patrols by Refuge law enforcement officers to improve compliance with the closure of the nesting area.

Martin Dunes and Marina (Cemex) – There were a variety of causes of nest loss on these beaches. The transported Peregrine Falcon was likely responsible for depressed early season fledge rates on these beach segments.

Management Actions

1) Monitor Peregrine Falcon activity and determine appropriate management action.

Reservation Road and Fort Ord– Excellent hatch rates indicate productivity is limited by chick survival at these beaches. The translocation of a Great Horned Owl may have had a positive impact on fledge rates at both sites this year.

Management Actions

1) Consider trapping and relocating up to two Great Horned Owls.
2) Increase enforcement of the dog prohibition on beaches and entry into closed nesting areas.

Sand City and Monterey State Beach

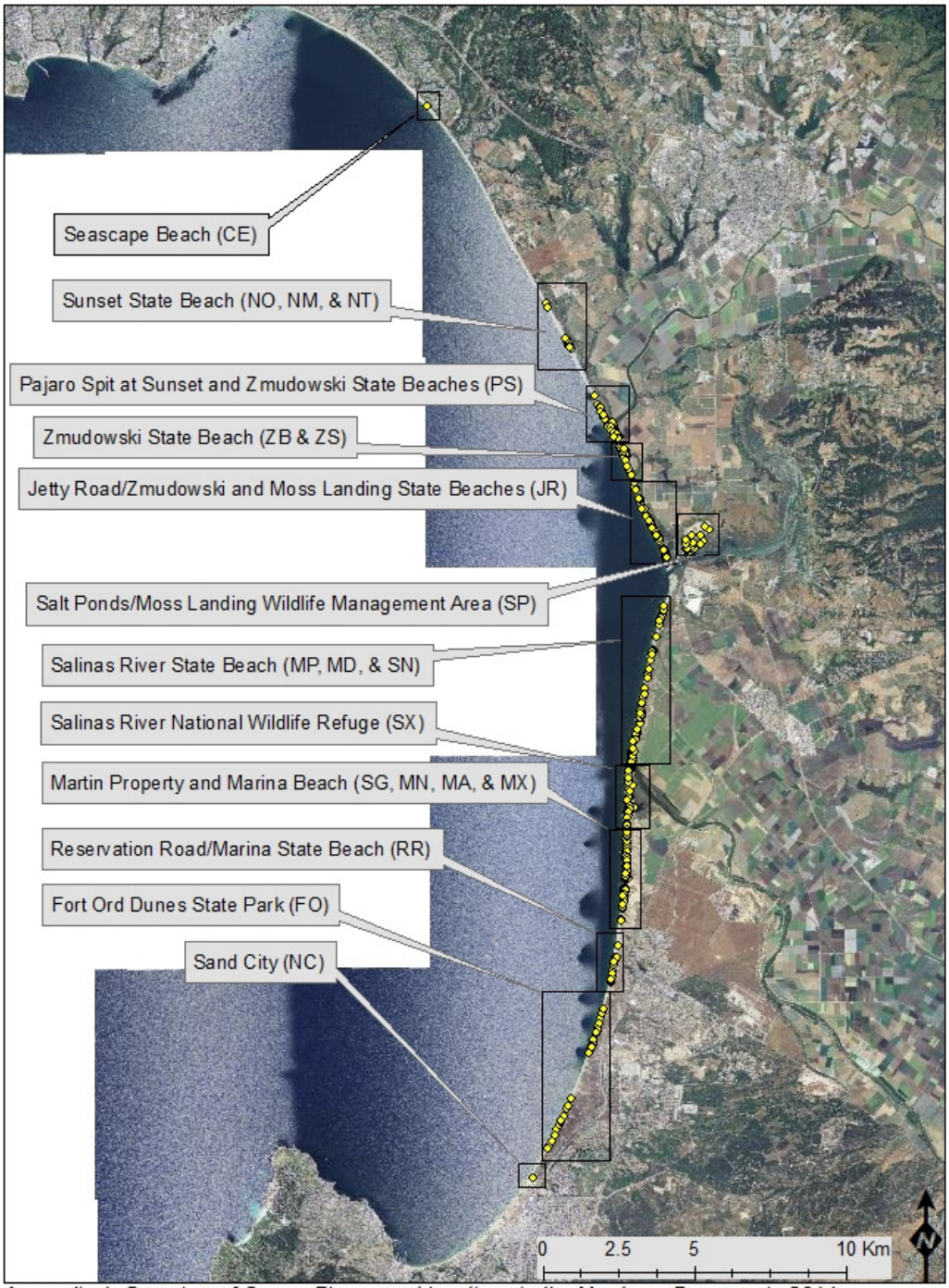
Management Actions

1) Increase enforcement of the dog prohibition on beaches and closed nesting areas.

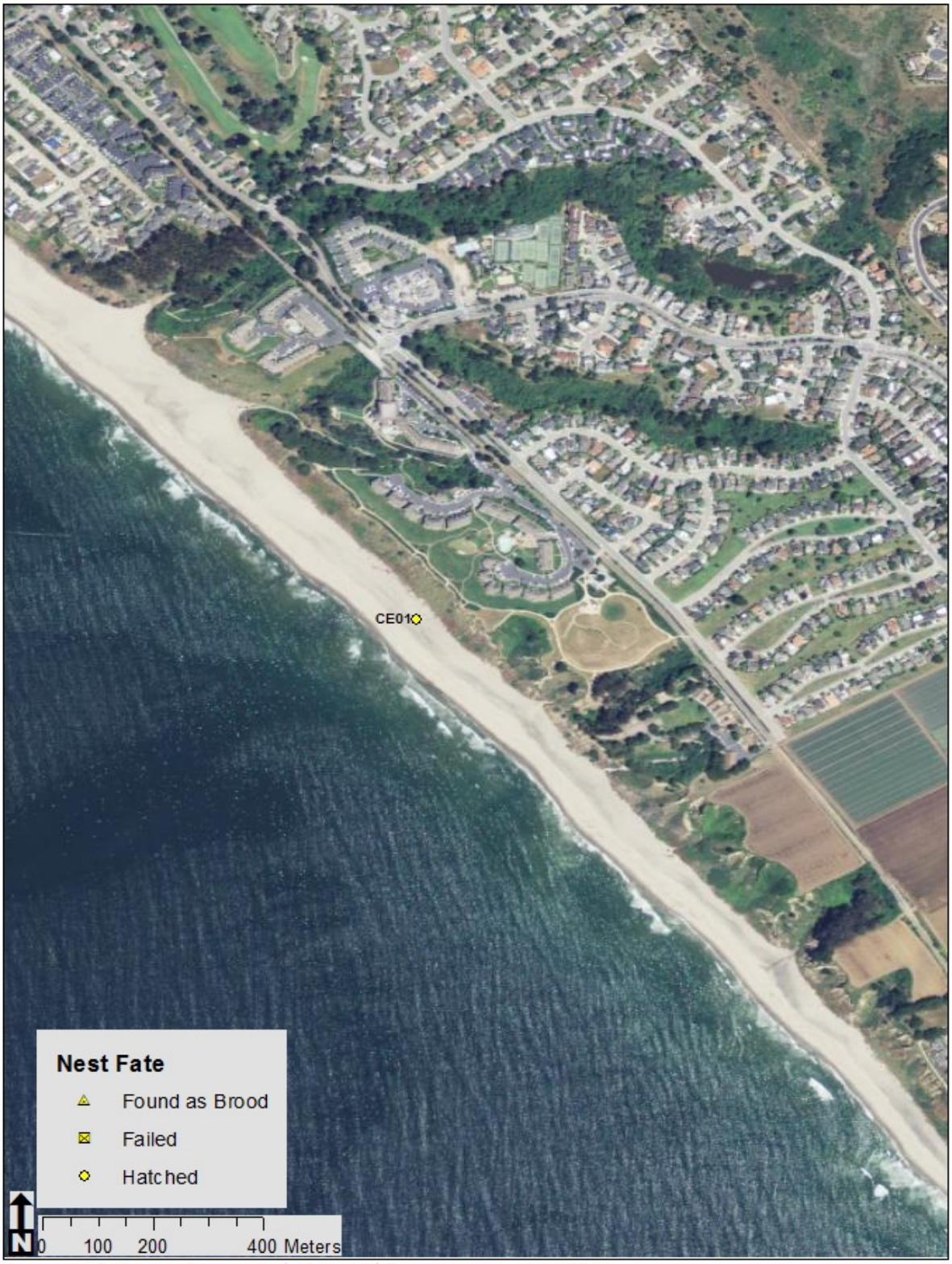
ACKNOWLEDGEMENTS

Jacob Martin greatly assisted with the fieldwork at Sunset Beach and Amy Palkovic at Reservation Road and Fort Ord. Allie Patrick, Esther Haile, and Chris Caris also contributed significantly to the field work in the south bay. Amy Palkovic deserves special thanks for preparing the nest maps. Nick Todd and the Ventana Wildlife Society conducted raptor management work. Personal of USDA Wildlife Services were responsible for control of skunks and ravens. This project was conducted collaboratively by Point Blue (formerly PRBO) Conservation Science, the Salinas River National Wildlife Refuge Unit of the Don Edwards San Francisco Bay National Wildlife Refuge of the U. S. Fish

Wildlife Service, the California Department of Parks and Recreation, the California Department of Fish and Wildlife, the Wildlife Services Unit of the U. S. Department of Agriculture, and the Monterey Bay Aquarium.

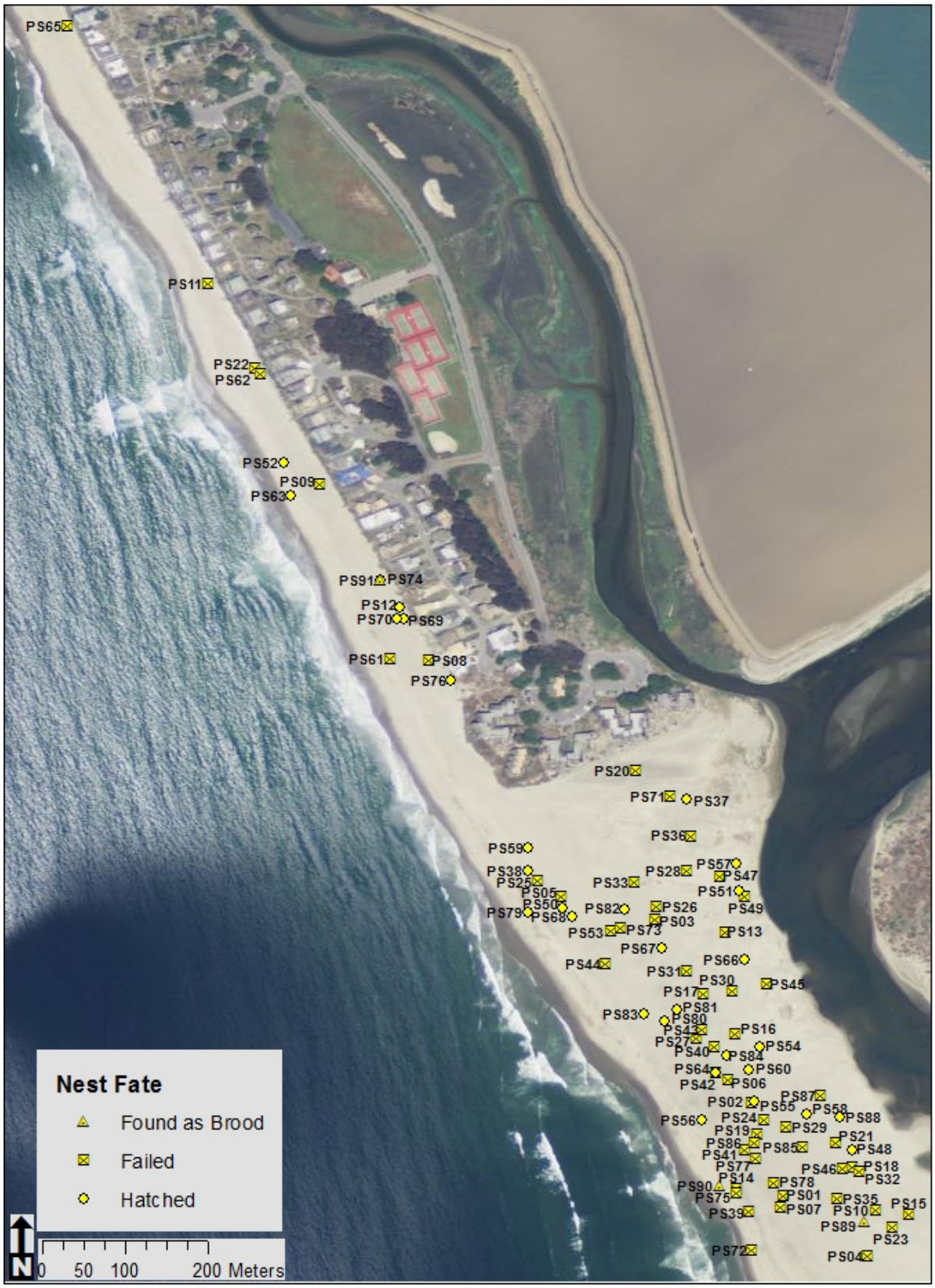


Appendix 1. Overview of Snowy Plover nest locations in the Monterey Bay area in 2014.



Appendix 2. Snowy Plover nests found at Seascape beach in 2014.

Appendix 3. Snowy Plover nest locations at the northern section of Sunset State Beach in 2014.



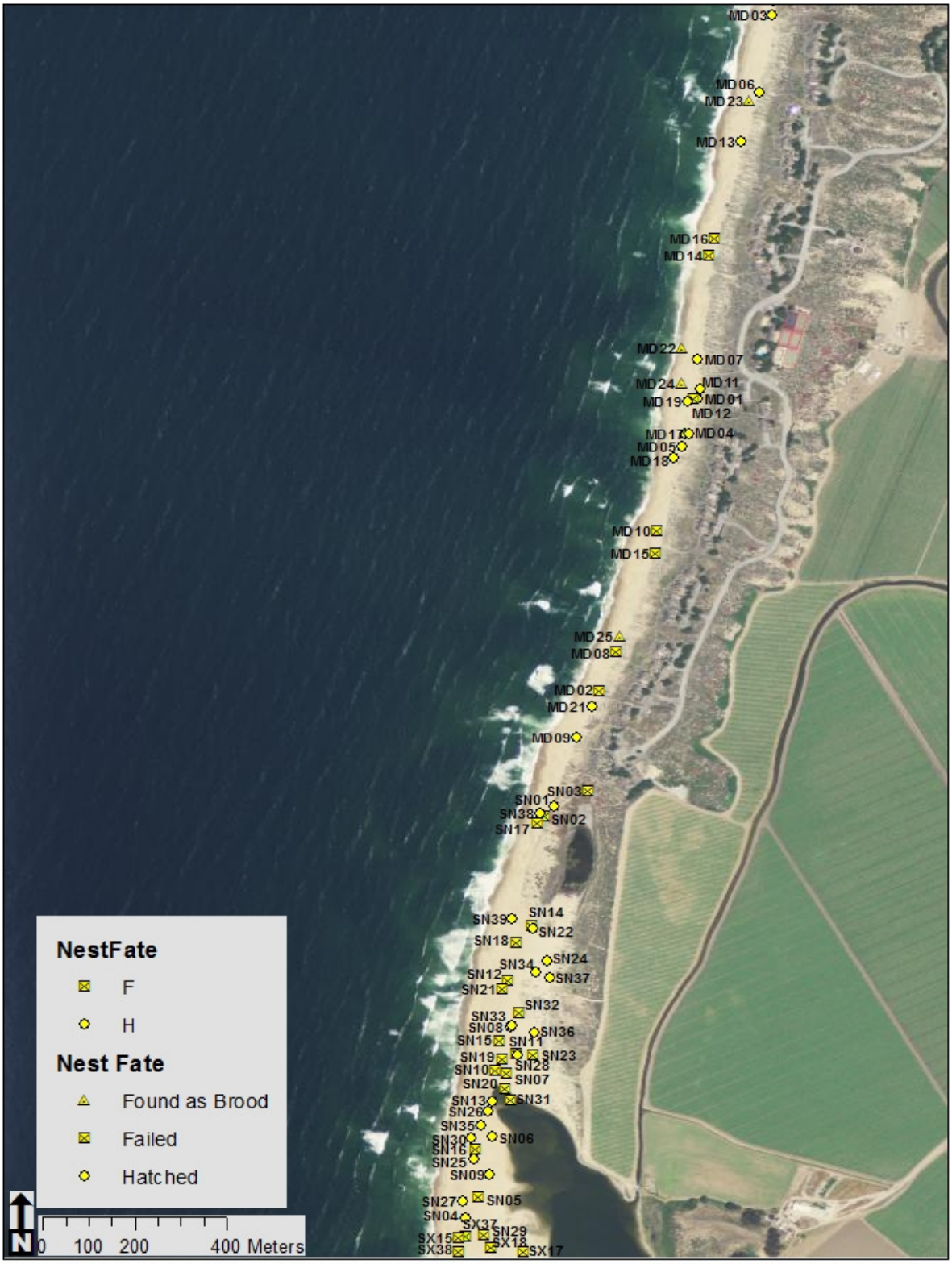
Appendix 4. Snowy Plover nest locations at the Pajaro Spit at Sunset and Zmudowski State Beaches in 2014.

Appendix 5. Snowy Plover nest locations at Zmudowski State Beach in 2014.

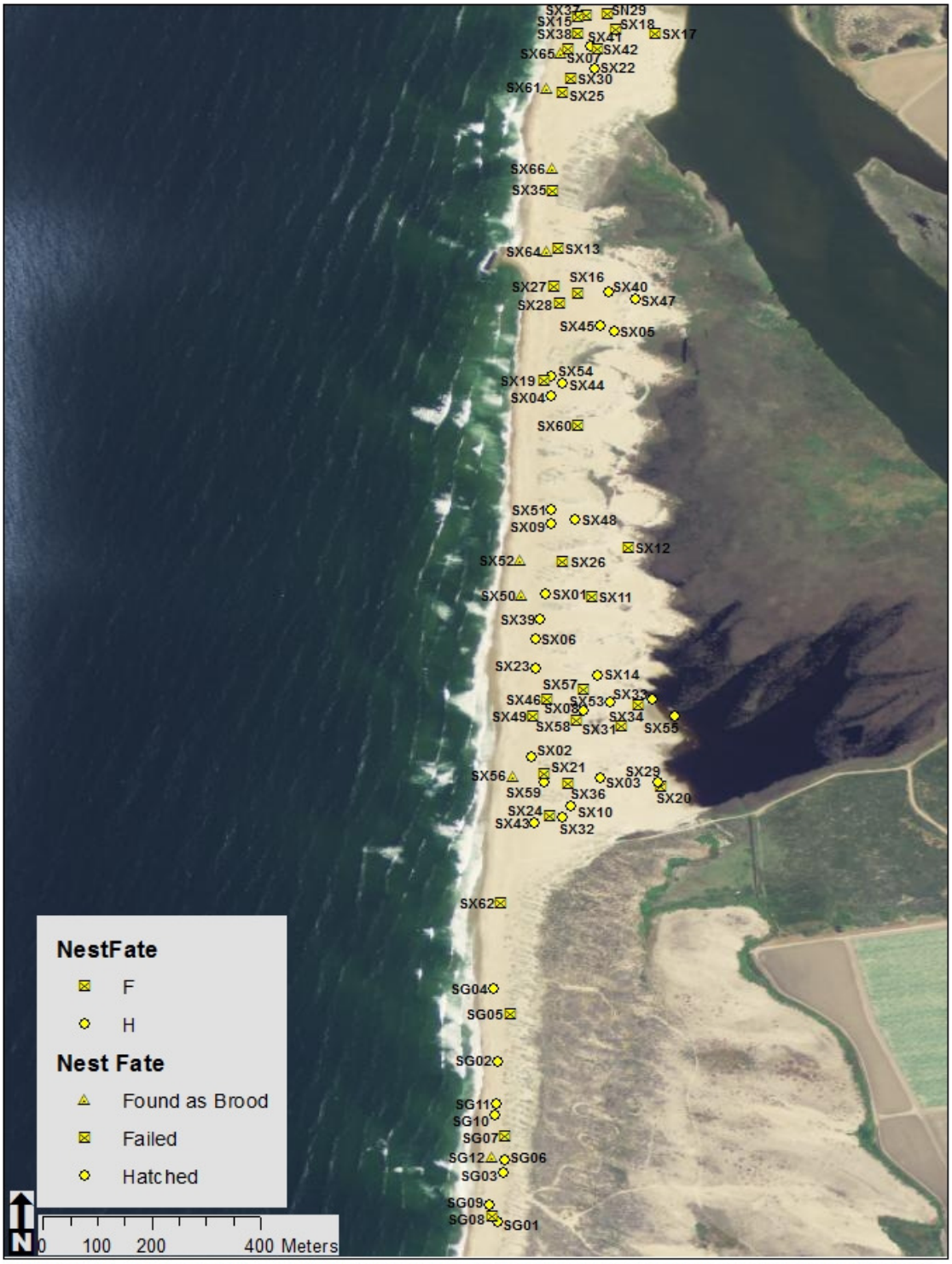
Appendix 6. Snowy Plover nest locations at Jetty Road at Zmudowski and Moss Landing State Beaches in 2014.

Appendix 7. Snowy Plover nest locations at Moss Landing Wildlife Management Area in 2014.

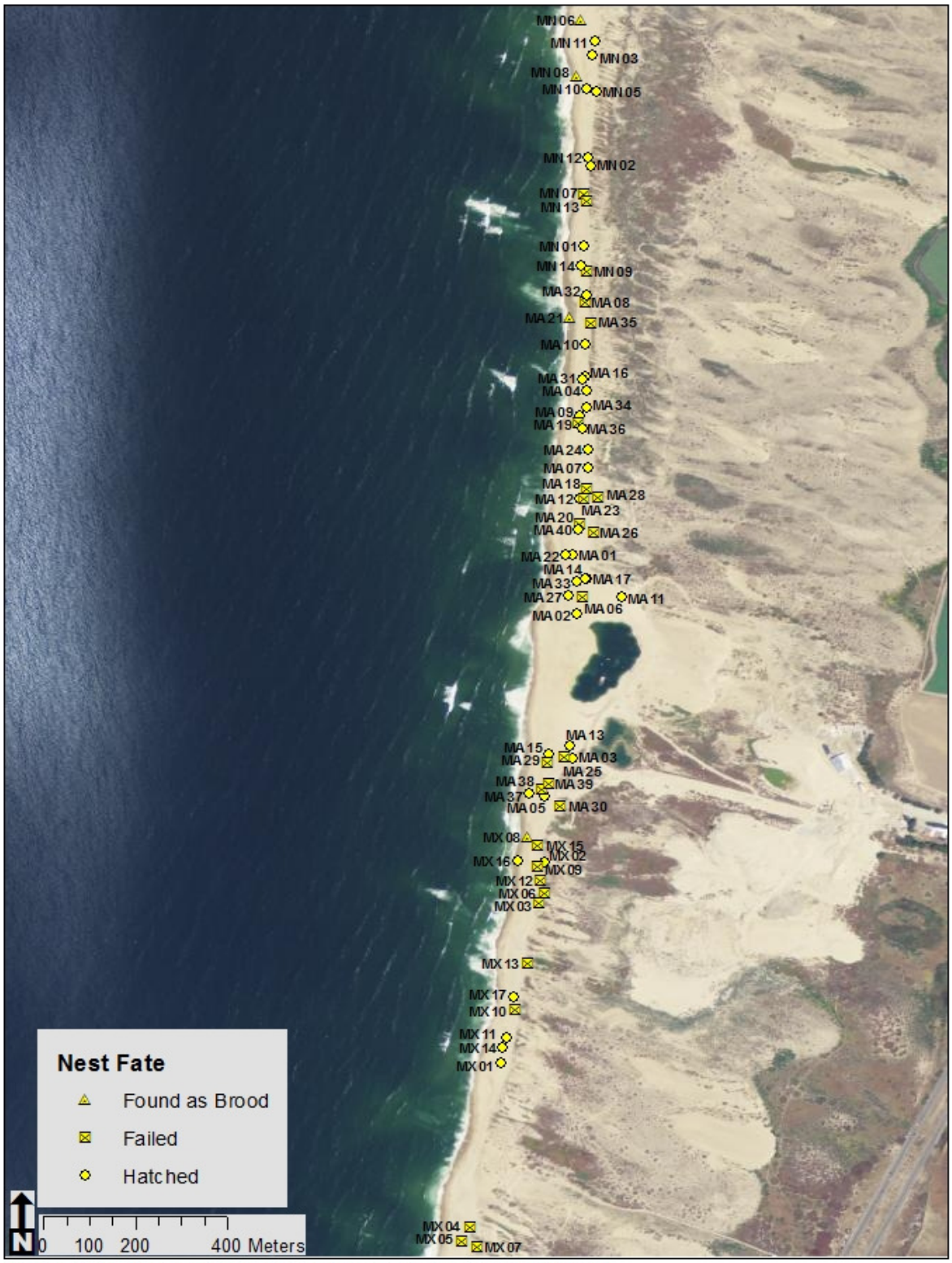
Appendix 8. Snowy Plover nest locations at the northern portion of Salinas River State Beach in 2014.



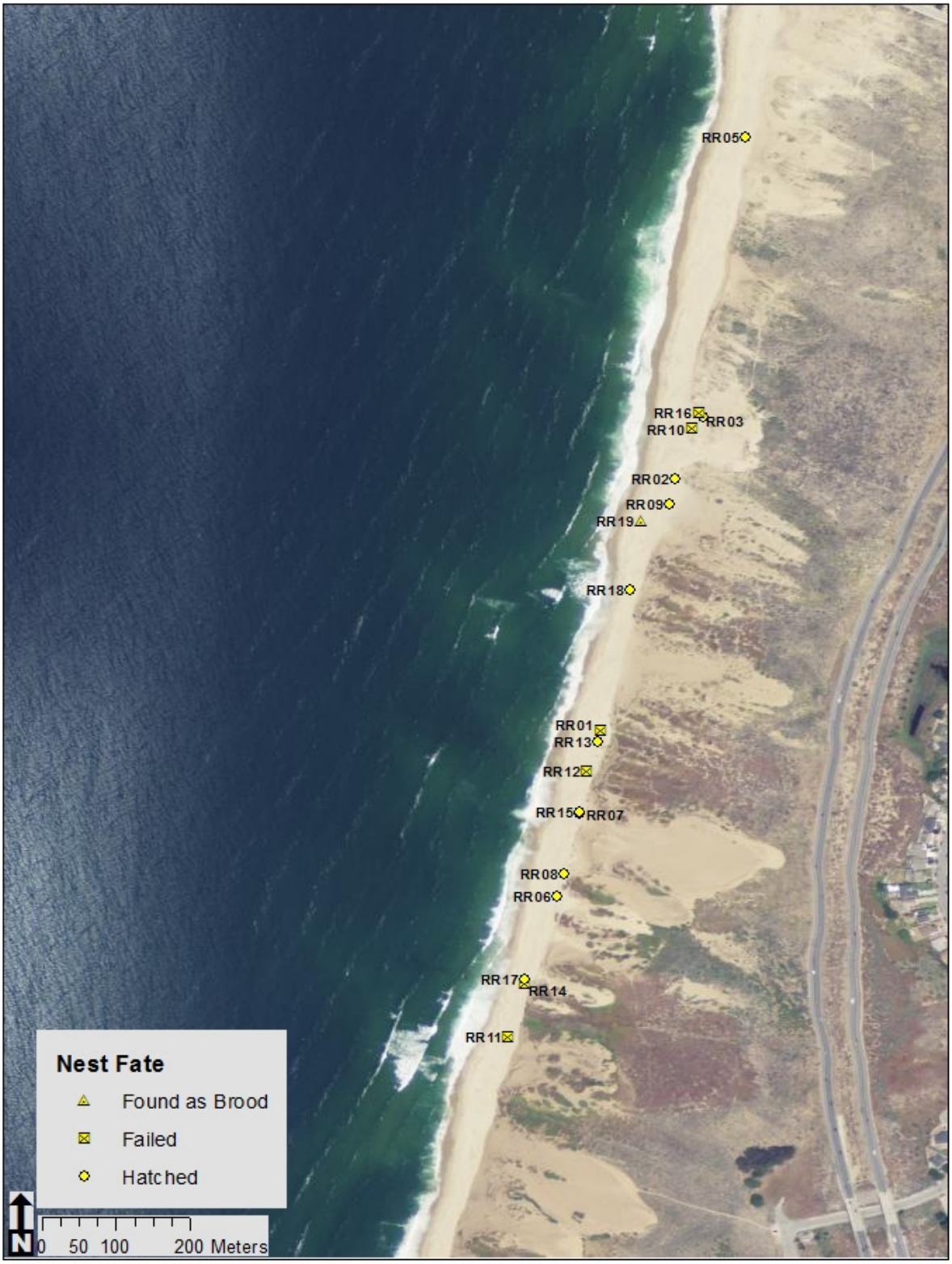
Appendix 9. Snowy plover nest locations at the southern portion of Salinas River State Beach in 2014.



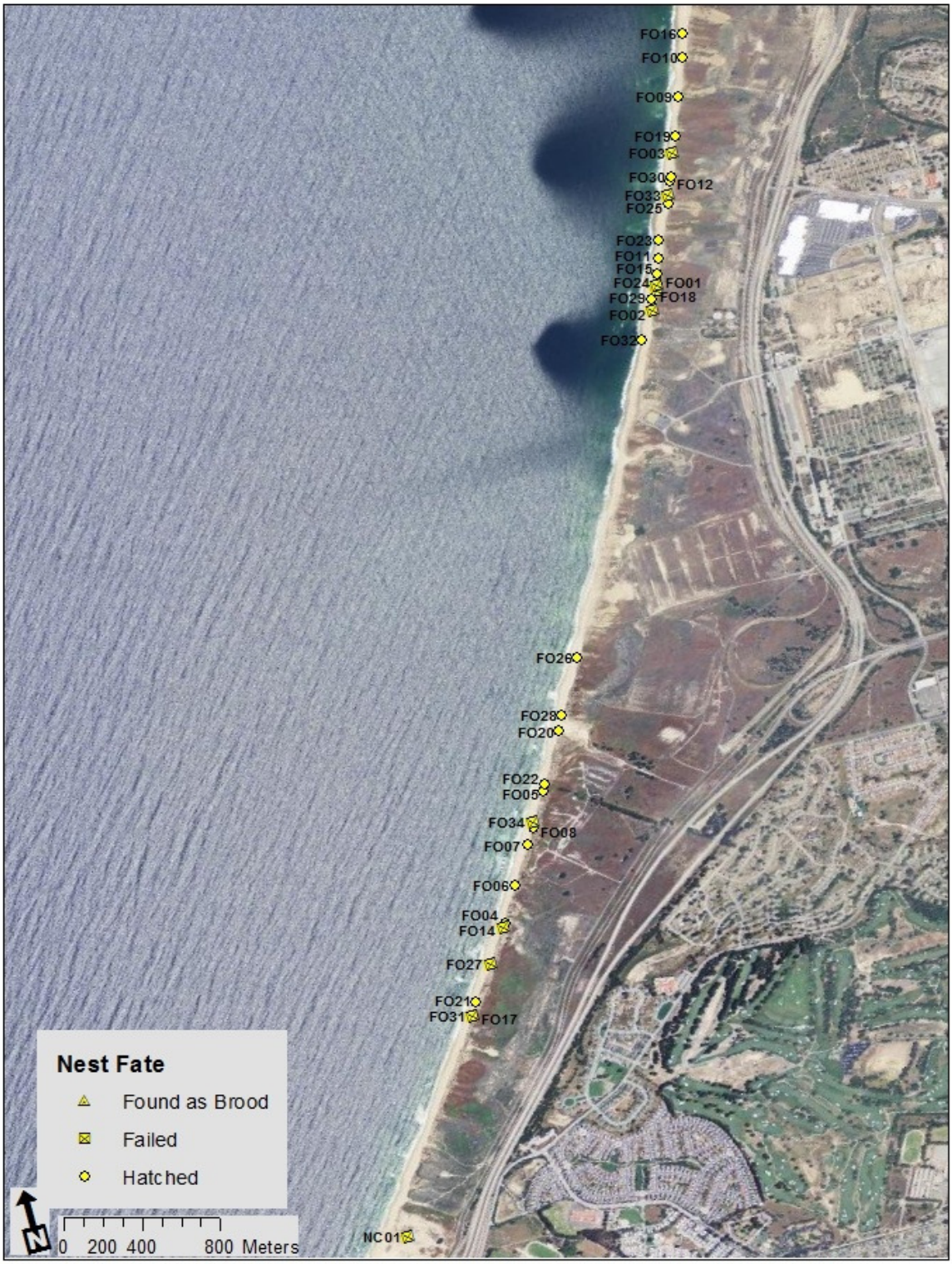
Appendix 10. Snowy plover nest locations at the Salinas River National Wildlife Refuge and the Martin dunes in 2014.



Appendix 11. Snowy Plover nest locations at Marina beach in 2014.



Appendix 12. Snowy Plover nest locations at Marina State Beach in 2014.



Appendix 13. Snowy Plover nest locations at Fort Ord Dunes State Park and Sand City in 2014.

Appendix 13. Monterey Bay, 2014, Injured and Dead Snowy Plovers

Disposition	Band Combination	Point Blue Specimen Number	MWVCRC (DFW/OSPR) No.[1]	UCD Path No.[2]	Date Collected/ Captured	Disposition Date (carcass)	Disposition Location (carcass)	Location Collected/ Captured	Collector/ Observer	Age	Sex
INJURED/ DEAD	Yb og	14346	14-0363	14s0387/ 14s0529	5/18/2014	5/19/2014	MWVCRC (DFW/OSPR)	Moss Landing	Carleton Eyster	Adult	Female
DEAD	Rb ww	14868	14-0381	14s0373	5/23/2014	5/23/2014	MWVCRC (DFW/OSPR)	Marina (CEMEX dredge pond)	Allie Patrick	Adult	Male
DEAD	pr ol	13967	14-0382	NA	5/23/2014	5/23/2014	MWVCRC (DFW/OSPR)	Moss Landing State Beach	Dave Dixon	Adult	Female
DEAD	wy ba	12914	14-0404	14s0528	6/30/2014	6/30/2014	MWVCRC (DFW/OSPR)	Moss Landing State Beach	Dave Dixon	Adult	Male
DEAD	bo ra	15328	14-0446	14s0777	8/11/2014	8/11/2014	MWVCRC (DFW/OSPR)	Pajaro Spit	Jenny Erbes	Chick	Female
DEAD	ra yy	15284	14-0575	NA	9/9/2014	10/1/2014	MWVCRC (DFW/OSPR)	Moss Landing	General Public/ Kriss Neuman	2014 Fledged Juvenile	Female
DEAD	pv bg	19520	NA	NA	7/17/2014	7/17/2014	discarded	Pajaro Spit	Carleton Eyster	Adult	Male
INJURED/ DEAD	unbanded	NA	NA	NA	5/21/2014	5/22/2014	Monterey Bay Aquarium (alive)	Marina (CEMEX dredge pond)	Carleton Eyster	UNKNOWN	Male
INJURED	aa ya	15320	NA	NA	9/24/2014			Pajaro Spit	Carleton Eyster	2014 Fledged Juvenile	UNKNOWN
INJURED	oa bb	13396	NA	NA	3/12/2014			Pajaro Spit	Carleton Eyster	Adult	Female
INJURED	yy ol	12030	NA	NA	9/16/2014			Salinas River NWR	Jenny Erbes	Adult	Male

[1] MWVCRC is Marine Wildlife Veterinary Care and Research Center, CA Dept Fish and Wildlife/Office of Spill Prevention and Response

[2] UCD is University of California Davis (birds with these numbers had tissue samples archived at MWVCRC or sent to UCD)

Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities

State of California
CALIFORNIA NATURAL RESOURCES AGENCY
Department of Fish and Game
November 24, 2009[1]

INTRODUCTION AND PURPOSE

The conservation of special status native plants and their habitats, as well as natural communities, is integral to maintaining biological diversity. The purpose of these protocols is to facilitate a consistent and systematic approach to the survey and assessment of special status native plants and natural communities so that reliable information is produced and the potential of locating a special status plant species or natural community is maximized. They may also help those who prepare and review environmental documents determine when a botanical survey is needed, how field surveys may be conducted, what information to include in a survey report, and what qualifications to consider for surveyors. The protocols may help avoid delays caused when inadequate biological information is provided during the environmental review process; assist lead, trustee and responsible reviewing agencies to make an informed decision regarding the direct, indirect, and cumulative effects of a proposed development, activity, or action on special status native plants and natural communities; meet California Environmental Quality Act (CEQA)[2] requirements for adequate disclosure of potential impacts; and conserve public trust resources.

DEPARTMENT OF FISH AND GAME TRUSTEE AND RESPONSIBLE AGENCY MISSION

The mission of the Department of Fish and Game (DFG) is to manage California's diverse wildlife and native plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. DFG has jurisdiction over the conservation, protection, and management of wildlife, native plants, and habitat necessary to maintain biologically sustainable populations (Fish and Game Code §1802). DFG, as trustee agency under CEQA §15386, provides expertise in reviewing and commenting on environmental documents and makes protocols regarding potential negative impacts to those resources held in trust for the people of California.

Certain species are in danger of extinction because their habitats have been severely reduced in acreage, are threatened with destruction or adverse modification, or because of a combination of these and other factors. The California Endangered Species Act (CESA) provides additional protections for such species, including take prohibitions (Fish and Game Code §2050 *et seq.*). As a responsible agency, DFG has the authority to issue permits for the take of species listed under CESA if the take is incidental to an otherwise lawful activity; DFG has determined that the impacts of the take have been minimized and fully mitigated; and, the take would not jeopardize the continued existence of the species (Fish and Game Code §2081). Surveys are one of the preliminary steps to detect a listed or special status plant species or natural community that may be impacted significantly by a project.

DEFINITIONS

Botanical surveys provide information used to determine the potential environmental effects of proposed projects on all special status plants and natural communities as required by law (i.e., CEQA, CESA, and Federal Endangered Species Act (ESA)). Some key terms in this document appear in **bold font** for assistance in use of the document.

For the purposes of this document, **special status plants** include all plant species that meet one or more of the following criteria[3]:

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1 This document replaces the DFG document entitled "Guidelines for Assessing the Effects of Proposed Projects on Rare, Threatened and Endangered Plants and Natural Communities."

2 http://ceres.ca.gov/ceqa/

3 Adapted from the East Alameda County Conservation Strategy available at http://www.fws.gov/sacramento/EACCS/Documents/080228_Species_Evaluation_EACCS.pdf

- Listed or proposed for listing as threatened or endangered under ESA or candidates for possible future listing as threatened or endangered under the ESA (50 CFR §17.12).

- Listed[4] or candidates for listing by the State of California as threatened or endangered under CESA (Fish and Game Code §2050 *et seq.*). A species, subspecies, or variety of plant is **endangered** when the prospects of its survival and reproduction in the wild are in immediate jeopardy from one or more causes, including loss of habitat, change in habitat, over-exploitation, predation, competition, disease, or other factors (Fish and Game Code §2062). A plant is **threatened** when it is likely to become endangered in the foreseeable future in the absence of special protection and management measures (Fish and Game Code §2067).

- Listed as rare under the California Native Plant Protection Act (Fish and Game Code §1900 *et seq.*). A plant is **rare** when, although not presently threatened with extinction, the species, subspecies, or variety is found in such small numbers throughout its range that it may be endangered if its environment worsens (Fish and Game Code §1901).

- Meet the definition of rare or endangered under CEQA §15380(b) and (d). Species that may meet the definition of rare or endangered include the following:

  - Species considered by the California Native Plant Society (CNPS) to be "rare, threatened or endangered in California" (Lists 1A, 1B and 2);

  - Species that may warrant consideration on the basis of local significance or recent biological information[5];

  - Some species included on the California Natural Diversity Database's (CNDDB) *Special Plants, Bryophytes, and Lichens List* (California Department of Fish and Game 2008)[6].

- Considered a **locally significant species,** that is, a species that is not rare from a statewide perspective but is rare or uncommon in a local context such as within a county or region (CEQA §15125 (c)) or is so designated in local or regional plans, policies, or ordinances (CEQA Guidelines, Appendix G). Examples include a species at the outer limits of its known range or a species occurring on an uncommon soil type.

Special status natural communities are communities that are of limited distribution statewide or within a county or region and are often vulnerable to environmental effects of projects. These communities may or may not contain special status species or their habitat. The most current version of the Department's *List of California Terrestrial Natural Communities*[7] indicates which natural communities are of special status given the current state of the California classification.

Most types of wetlands and riparian communities are considered special status natural communities due to their limited distribution in California. These natural communities often contain special status plants such as those described above. These protocols may be used in conjunction with protocols formulated by other agencies, for example, those developed by the U.S. Army Corps of Engineers to delineate jurisdictional wetlands[8] or by the U.S. Fish and Wildlife Service to survey for the presence of special status plants[9].

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4 Refer to current online published lists available at: http://www.dfg.ca.gov/biogeodata.

5 In general, CNPS List 3 plants (plants about which more information is needed) and List 4 plants (plants of limited distribution) may not warrant consideration under CEQA §15380. These plants may be included on special status plant lists such as those developed by counties where they would be addressed under CEQA §15380. List 3 plants may be analyzed under CEQA §15380 if sufficient information is available to assess potential impacts to such plants. Factors such as regional rarity vs. statewide rarity should be considered in determining whether cumulative impacts to a List 4 plant are significant even if individual project impacts are not. List 3 and 4 plants are also included in the California Natural Diversity Database's (CNDDB) *Special Plants, Bryophytes, and Lichens List.* [Refer to the current online published list available at: http://www.dfg.ca.gov/biogeodata.] Data on Lists 3 and 4 plants should be submitted to CNDDB. Such data aids in determining or revising priority ranking.

6 Refer to current online published lists available at: http://www.dfg.ca.gov/biogeodata.

7 http://www.dfg.ca.gov/biogeodata/vegcamp/pdfs/natcomlist.pdf. The rare natural communities are asterisked on this list.

8 http://www.wetlands.com/regs/tlpge02e.htm

9 U.S. Fish and Wildlife Service Survey Guidelines available at http://www.fws.gov/sacramento/es/protocol.htm

BOTANICAL SURVEYS

Conduct botanical surveys prior to the commencement of any activities that may modify vegetation, such as clearing, mowing, or ground-breaking activities. It is appropriate to conduct a botanical field survey when:

- Natural (or naturalized) vegetation occurs on the site, and it is unknown if special status plant species or natural communities occur on the site, and the project has the potential for direct or indirect effects on vegetation; or
- Special status plants or natural communities have historically been identified on the project site; or
- Special status plants or natural communities occur on sites with similar physical and biological properties as the project site.

SURVEY OBJECTIVES

Conduct field surveys in a manner which maximizes the likelihood of locating special status plant species or special status natural communities that may be present. Surveys should be **floristic in nature**, meaning that every plant taxon that occurs on site is identified to the taxonomic level necessary to determine rarity and listing status. "Focused surveys" that are limited to habitats known to support special status species or are restricted to lists of likely potential species are not considered floristic in nature and are not adequate to identify all plant taxa on site to the level necessary to determine rarity and listing status. Include a list of plants and natural communities detected on the site for each botanical survey conducted. More than one field visit may be necessary to adequately capture the floristic diversity of a site. An indication of the prevalence (estimated total numbers, percent cover, density, etc.) of the species and communities on the site is also useful to assess the significance of a particular population.

SURVEY PREPARATION

Before field surveys are conducted, compile relevant botanical information in the general project area to provide a regional context for the investigators. Consult the CNDDB[10] and BIOS[11] for known occurrences of special status plants and natural communities in the project area prior to field surveys. Generally, identify vegetation and habitat types potentially occurring in the project area based on biological and physical properties of the site and surrounding ecoregion[12], unless a larger assessment area is appropriate. Then, develop a list of special status plants with the potential to occur within these vegetation types. This list can serve as a tool for the investigators and facilitate the use of reference sites; however, special status plants on site might not be limited to those on the list. Field surveys and subsequent reporting should be comprehensive and floristic in nature and not restricted to or focused only on this list. Include in the survey report the list of potential special status species and natural communities, and the list of references used to compile the background botanical information for the site.

SURVEY EXTENT

Surveys should be comprehensive over the entire site, including areas that will be directly or indirectly impacted by the project. Adjoining properties should also be surveyed where direct or indirect project effects, such as those from fuel modification or herbicide application, could potentially extend offsite. Pre-project surveys restricted to known CNDDB rare plant locations may not identify all special status plants and communities present and do not provide a sufficient level of information to determine potential impacts.

FIELD SURVEY METHOD

Conduct surveys using **systematic field techniques** in all habitats of the site to ensure thorough coverage of potential impact areas. The level of effort required per given area and habitat is dependent upon the vegetation and its overall diversity and structural complexity, which determines the distance at which plants can be identified. Conduct surveys by walking over the entire site to ensure thorough coverage, noting all plant taxa

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10 Available at http://www.dfg.ca.gov/biogeodata/cnddb

11 http://www.bios.dfg.ca.gov/

12 Ecological Subregions of California, available at http://www.fs.fed.us/r5/projects/ecoregions/toc.htm

observed. The level of effort should be sufficient to provide comprehensive reporting. For example, one person-hour per eight acres per survey date is needed for a comprehensive field survey in grassland with medium diversity and moderate terrain[13], with additional time allocated for species identification.

TIMING AND NUMBER OF VISITS

Conduct surveys in the field at the time of year when species are both evident and identifiable. Usually this is during flowering or fruiting. Space visits throughout the growing season to accurately determine what plants exist on site. Many times this may involve multiple visits to the same site (e.g. in early, mid, and late-season for flowering plants) to capture the floristic diversity at a level necessary to determine if special status plants are present[14]. The timing and number of visits are determined by geographic location, the natural communities present, and the weather patterns of the year(s) in which the surveys are conducted.

REFERENCE SITES

When special status plants are known to occur in the type(s) of habitat present in the project area, observe reference sites (nearby accessible occurrences of the plants) to determine whether those species are identifiable at the time of the survey and to obtain a visual image of the target species, associated habitat, and associated natural community.

USE OF EXISTING SURVEYS

For some sites, floristic inventories or special status plant surveys may already exist. Additional surveys may be necessary for the following reasons:

- Surveys are not current[15]; or
- Surveys were conducted in natural systems that commonly experience year to year fluctuations such as periods of drought or flooding (e.g. vernal pool habitats or riverine systems); or
- Surveys are not comprehensive in nature; or fire history, land use, physical conditions of the site, or climatic conditions have changed since the last survey was conducted[16]; or
- Surveys were conducted in natural systems where special status plants may not be observed if an annual above ground phase is not visible (e.g. flowers from a bulb); or
- Changes in vegetation or species distribution may have occurred since the last survey was conducted, due to habitat alteration, fluctuations in species abundance and/or seed bank dynamics.

NEGATIVE SURVEYS

Adverse conditions may prevent investigators from determining the presence of, or accurately identifying, some species in potential habitat of target species. Disease, drought, predation, or herbivory may preclude the presence or identification of target species in any given year. Discuss such conditions in the report.

The failure to locate a known special status plant occurrence during one field season does not constitute evidence that this plant occurrence no longer exists at this location, particularly if adverse conditions are present. For example, surveys over a number of years may be necessary if the species is an annual plant having a persistent, long-lived seed bank and is known not to germinate every year. Visits to the site in more

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13 Adapted from U.S. Fish and Wildlife Service kit fox survey guidelines available at www.fws.gov/sacramento/es/documents/kitfox_no_protocol.pdf

14 U.S. Fish and Wildlife Service Survey Guidelines available at http://www.fws.gov/sacramento/es/protocol.htm

15 Habitats, such as grasslands or desert plant communities that have annual and short-lived perennial plants as major floristic components may require yearly surveys to accurately document baseline conditions for purposes of impact assessment. In forested areas, however, surveys at intervals of five years may adequately represent current conditions. For forested areas, refer to "Guidelines for Conservation of Sensitive Plant Resources Within the Timber Harvest Review Process and During Timber Harvesting Operations", available at https://r1.dfg.ca.gov/portal/Portals/12/THPBotanicalGuidelinesJuly2005.pdf

16 U.S. Fish and Wildlife Service Survey Guidelines available at http://www.fws.gov/ventura/speciesinfo/protocols_guidelines/docs/botanicalinventories.pdf

than one year increase the likelihood of detection of a special status plant especially if conditions change. To further substantiate negative findings for a known occurrence, a visit to a nearby reference site may ensure that the timing of the survey was appropriate.

REPORTING AND DATA COLLECTION

Adequate information about special status plants and natural communities present in a project area will enable reviewing agencies and the public to effectively assess potential impacts to special status plants or natural communities[17] and will guide the development of minimization and mitigation measures. The next section describes necessary information to assess impacts. For comprehensive, systematic surveys where no special status species or natural communities were found, reporting and data collection responsibilities for investigators remain as described below, excluding specific occurrence information.

SPECIAL STATUS PLANT OR NATURAL COMMUNITY OBSERVATIONS

Record the following information for locations of each special status plant or natural community detected during a field survey of a project site.

- A detailed map (1:24,000 or larger) showing locations and boundaries of each special status species occurrence or natural community found as related to the proposed project. Mark occurrences and boundaries as accurately as possible. Locations documented by use of global positioning system (GPS) coordinates must include the datum[18] in which they were collected;
- The site-specific characteristics of occurrences, such as associated species, habitat and microhabitat, structure of vegetation, topographic features, soil type, texture, and soil parent material. If the species is associated with a wetland, provide a description of the direction of flow and integrity of surface or subsurface hydrology and adjacent off-site hydrological influences as appropriate;
- The number of individuals in each special status plant population as counted (if population is small) or estimated (if population is large);
- If applicable, information about the percentage of individuals in each life stage such as seedlings vs. reproductive individuals;
- The number of individuals of the species per unit area, identifying areas of relatively high, medium and low density of the species over the project site; and
- Digital images of the target species and representative habitats to support information and descriptions.

FIELD SURVEY FORMS

When a special status plant or natural community is located, complete and submit to the CNDDB a California Native Species (or Community) Field Survey Form[19] or equivalent written report, accompanied by a copy of the relevant portion of a 7.5 minute topographic map with the occurrence mapped. Present locations documented by use of GPS coordinates in map and digital form. Data submitted in digital form must include the datum[20] in which it was collected. If a potentially undescribed special status natural community is found on the site, document it with a Rapid Assessment or Relevé form[21] and submit it with the CNDDB form.

VOUCHER COLLECTION

Voucher specimens provide verifiable documentation of species presence and identification as well as a public record of conditions. This information is vital to all conservation efforts. Collection of voucher specimens should

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17 Refer to current online published lists available at: http://www.dfg.ca.gov/biogeodata. For Timber Harvest Plans (THPs) please refer to the "Guidelines for Conservation of Sensitive Plant Resources Within the Timber Harvest Review Process and During Timber Harvesting Operations", available at https://r1.dfg.ca.gov/portal/Portals/12/THPBotanicalGuidelinesJuly2005.pdf

18 NAD83, NAD27 or WGS84

19 http://www.dfg.ca.gov/biogeodata

20 NAD83, NAD27 or WGS84

21 http://www.dfg.ca.gov/biogeodata/vegcamp/veg_publications_protocols.asp

be conducted in a manner that is consistent with conservation ethics, and is in accordance with applicable state and federal permit requirements (e.g. incidental take permit, scientific collection permit). Voucher collections of special status species (or suspected special status species) should be made only when such actions would not jeopardize the continued existence of the population or species.

Deposit voucher specimens with an indexed regional herbarium[22] no later than 60 days after the collections have been made. Digital imagery can be used to supplement plant identification and document habitat. Record all relevant permittee names and permit numbers on specimen labels. A collecting permit is required prior to the collection of State-listed plant species[23].

BOTANICAL SURVEY REPORTS

Include reports of botanical field surveys containing the following information with project environmental documents:

- **Project and site description**
  - A description of the proposed project;
  - A detailed map of the project location and study area that identifies topographic and landscape features and includes a north arrow and bar scale; and,
  - A written description of the biological setting, including vegetation[24] and structure of the vegetation; geological and hydrological characteristics; and land use or management history.
- **Detailed description of survey methodology and results**
  - Dates of field surveys (indicating which areas were surveyed on which dates), name of field investigator(s), and total person-hours spent on field surveys;
  - A discussion of how the timing of the surveys affects the comprehensiveness of the survey;
  - A list of potential special status species or natural communities;
  - A description of the area surveyed relative to the project area;
  - References cited, persons contacted, and herbaria visited;
  - Description of reference site(s), if visited, and phenological development of special status plant(s);
  - A list of all taxa occurring on the project site. Identify plants to the taxonomic level necessary to determine whether or not they are a special status species;
  - Any use of existing surveys and a discussion of applicability to this project;
  - A discussion of the potential for a false negative survey;
  - Provide detailed data and maps for all special plants detected. Information specified above under the headings “Special Status Plant or Natural Community Observations,” and “Field Survey Forms,” should be provided for locations of each special status plant detected;
  - Copies of all California Native Species Field Survey Forms or Natural Community Field Survey Forms should be sent to the CNDDB and included in the environmental document as an Appendix. It is not necessary to submit entire environmental documents to the CNDDB; and,
  - The location of voucher specimens, if collected.

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22 For a complete list of indexed herbaria, see: Holmgren, P., N. Holmgren and L. Barnett. 1990. Index Herbariorum, Part 1: Herbaria of the World. New York Botanic Garden, Bronx, New York. 693 pp. Or: http://www.nybg.org/bsci/ih/ih.html

23 Refer to current online published lists available at: http://www.dfg.ca.gov/biogeodata.

24 A vegetation map that uses the National Vegetation Classification System (http://biology.usgs.gov/npsveg/nvcs.html), for example *A Manual of California Vegetation*, and highlights any special status natural communities. If another vegetation classification system is used, the report should reference the system, provide the reason for its use, and provide a crosswalk to the National Vegetation Classification System.

- **Assessment of potential impacts**
  - A discussion of the significance of special status plant populations in the project area considering nearby populations and total species distribution;
  - A discussion of the significance of special status natural communities in the project area considering nearby occurrences and natural community distribution;
  - A discussion of direct, indirect, and cumulative impacts to the plants and natural communities;
  - A discussion of threats, including those from invasive species, to the plants and natural communities;
  - A discussion of the degree of impact, if any, of the proposed project on unoccupied, potential habitat of the species;
  - A discussion of the immediacy of potential impacts; and,
  - Recommended measures to avoid, minimize, or mitigate impacts.

QUALIFICATIONS

Botanical consultants should possess the following qualifications:

- Knowledge of plant taxonomy and natural community ecology;
- Familiarity with the plants of the area, including special status species;
- Familiarity with natural communities of the area, including special status natural communities;
- Experience conducting floristic field surveys or experience with floristic surveys conducted under the direction of an experienced surveyor;
- Familiarity with the appropriate state and federal statutes related to plants and plant collecting; and,
- Experience with analyzing impacts of development on native plant species and natural communities.

SUGGESTED REFERENCES

Barbour, M., T. Keeler-Wolf, and A. A. Schoenherr (eds.). 2007. Terrestrial vegetation of California (3rd Edition). University of California Press.

Bonham, C.D. 1988. Measurements for terrestrial vegetation. John Wiley and Sons, Inc., New York, NY.

California Native Plant Society. Most recent version. Inventory of rare and endangered plants (online edition). California Native Plant Society, Sacramento, CA. Online URL http://www.cnps.org/inventory.

California Natural Diversity Database. Most recent version. Special vascular plants, bryophytes and lichens list. Updated quarterly. Available at www.dfg.ca.gov.

Elzinga, C.L., D.W. Salzer, and J. Willoughby. 1998. Measuring and monitoring plant populations. BLM Technical Reference 1730-1. U.S. Dept. of the Interior, Bureau of Land Management, Denver, Colorado.

Leppig, G. and J.W. White. 2006. Conservation of peripheral plant populations in California. Madroño 53:264-274.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, Inc., New York, NY.

U.S. Fish and Wildlife Service. 1996. Guidelines for conducting and reporting botanical inventories for federally listed plants on the Santa Rosa Plain. Sacramento, CA.

U.S. Fish and Wildlife Service. 1996. Guidelines for conducting and reporting botanical inventories for federally listed, proposed and candidate plants. Sacramento, CA.

Van der Maarel, E. 2005. Vegetation Ecology. Blackwell Science Ltd., Malden, MA.

Section 6
Other CEQA Required Sections

6.1 Significant Environmental Effects That Cannot Be Avoided

According to Section 15126.2(a) (b) of the State CEQA Guidelines, an EIR shall identify and focus on the significant environmental effects of the proposed project, including effects that cannot be avoided if the proposed project were implemented. Each of the preceding impact sections has identified those significant impacts that cannot be reduced below a level of significance. The significant, unavoidable impacts are summarized in Table 6-2 at the end of this chapter.

The reader is directed to the various impact sections of this EIR for a more detailed discussion of each of these significant, unavoidable impacts.

6.2 Significant Irreversible Environmental Effects

The environmental effects of the 2007 General Plan are summarized in Section 1.0 (Executive Summary) and are analyzed in detail in Section 4.0 (Impacts and Mitigation Measures) of this EIR.

As mandated by the State CEQA Guidelines Section 15127, an EIR for a general plan must address any significant irreversible environmental change that would result from implementation of that plan. Specifically, per the Guidelines (Section 15126.2[c]), such an impact would occur if:

- the project would involve a large commitment of nonrenewable resources;
- irreversible damage can result from environmental accidents associated with the project; and
- The proposed consumption of resources is not justified (e.g., the project results in the wasteful use of energy.)

Approval and implementation of actions related to the 2007 General Plan would result in an irretrievable commitment of nonrenewable resources such as energy supplies and construction-related materials. The energy resource demands would be used for construction, heating and cooling of buildings, transportation of

people and goods, heating and refrigeration, lighting, and other associated energy needs.

Environmental changes with implementation of the 2007 General Plan would occur as the physical environment is altered through continued commitments of land and construction materials to urban and rural development. There would be an irretrievable commitment of labor, capital, and materials used in construction and a permanent loss of open space. Nonrenewable resources would be committed primarily in the form of fossil fuels and would include oil, natural gas, and gasoline used to support the additional development associated with implementation of the 2007 General Plan.

The consumption of other nonrenewable or slowly renewable resources would result from the development of the 2007 General Plan. These resources would include, but not be limited to, lumber and other forest products, sand and gravel, asphalt, steel, copper, lead, and water. Because alternative energy sources such as solar, geothermal, or wind energy are not currently in widespread local use, it is unlikely that real savings in nonrenewable energy supplies (e.g., oil and gas) could be realized in the immediate future.

Development in unincorporated Monterey County as envisioned by the 2007 General Plan would result in the construction of structures, facilities, or infrastructure on lands that are currently undeveloped. Development of lands generally would result in their future and permanent commitment to urban uses.

6.3 Growth Inducement

CEQA requires a discussion of the ways in which the 2007 General Plan could be growth-inducing. State CEQA Guidelines Section 15126.2(d) identifies a project as growth-inducing if it fosters economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. New employees from commercial and industrial development and new population from residential development represent direct forms of growth. These direct forms of growth have a secondary effect of expanding the size of local markets and inducing additional economic activity in the area. Examples of development that would indirectly facilitate growth are the installation of new roadways and the construction or expansion of water delivery or treatment facilities.

A project could indirectly induce growth by removing barriers to growth, by creating a condition that attracts additional population or new economic activity, or by providing a catalyst for future unrelated growth in the area. While a project may have a potential to induce growth, it does not automatically result in growth. Growth can happen only through capital investment in new economic opportunities by the public or private sectors.

Typically, the growth-inducing potential of a project is considered significant if it fosters growth or a concentration of population in excess of the existing setting or

baseline. Growth may be induced through the provision of infrastructure or service capacity that would accommodate new development.

By law, Monterey County is required to adopt "a comprehensive, long-term general plan for the physical development of the county" (Government Code Section 65300). The general plan's housing element is required to include

> An identification and analysis of existing and projected housing needs and a statement of goals, policies, quantified objectives, financial resources, and scheduled programs for the preservation, improvement, and development of housing. The housing element shall identify adequate sites for housing, including rental housing, factory-built housing, mobile homes, and emergency shelters, and shall make adequate provision for the existing and projected needs of all economic segments of the community. (Government Code Section 65583)

On a regular basis (generally every 5 to 7 years), the Association of Monterey Bay Area Governments (AMBAG) is responsible for adopting the Regional Housing Needs Assessment or RHNA that establishes the share of projected future housing growth that the County must accommodate in its general plan. Unincorporated Monterey County's current RHNA housing share is 1,554 dwelling units for the current 2007 - 2014 housing element cycle. The current housing element is based on the prior 2000-2007 share and will be amended as necessary to account for the new allocations. A county that does not amend its housing element to reflect the RHNA share is subject to litigation (Government Code Section 65587).

6.3.1 Conclusion

In order to comply with state general plan law, in particular the housing element statute, the 2007 General Plan must provide sufficient opportunities for new residential growth to accommodate its RHNA share. Based on the definition of growth inducement, a general plan is inherently growth-inducing because it must accommodate at least projected housing demand. The 2007 General Plan and related comprehensive land use plans will provide the framework by which public officials will be guided in making decisions relative to development in Monterey County. However, it is the implementation of land use policies that will incrementally increase demands for public services, utilities, and infrastructure.

6.4 Cumulative Impacts

6.4.1 In General

Cumulative impacts result from individually minor, but collectively significant, impacts occurring over a period of time. State CEQA Guidelines Section 15130 requires that an EIR include a discussion of the potential cumulative impacts of a proposed project. Cumulative impacts are defined as two or more individual effects that, when considered together, are significant. The cumulative impact

from several projects is the change in the environment that results from the incremental impact of the development when added to other closely related past, present, and reasonably foreseeable or probable future developments.

As defined in State CEQA Guidelines Section 15355,

> …a cumulative impact consists of an impact which is created as a result of the combination of the project evaluated in the EIR together with other projects causing related impacts. An EIR may determine that a project's contribution to a significant cumulative impact will be rendered less than cumulatively considerable and thus is not significant. A project's contribution is less than cumulatively considerable if the project is required to implement or fund its fair share of a mitigation measure or measures designed to alleviate the cumulative impact.
>
> The following elements are necessary to an adequate discussion of significant cumulative impacts:
>
> Either:
>
> 1. A list of past, present, and probable future projects producing related or cumulative impacts, including, if necessary, those projects outside the control of the agency, or
> 2. A summary of projections contained in an adopted general plan or related planning document, or in a prior environmental document, which has been adopted or certified, which described or evaluated regional or area wide conditions contributing to the cumulative impact. Any such planning document shall be referenced and made available to the public at a location specified by the lead agency.

The determination of a project's cumulative effects involves the identification of the following:

- direct and indirect effects of the proposed action and other projects causing related impacts;
- which resources, ecosystems, and human communities are affected; and
- Whether these effects are cumulatively significant.

State CEQA Guidelines Section 15065(c) states that a mandatory finding of significance is required if the project will make a cumulatively considerable contribution to a cumulative impact. The importance of a project's contribution must be viewed in the context of the cumulative effect. Case law has held that even a small contribution may be cumulatively considerable if the cumulative effect is particularly acute (*Communities for a Better Environment* v. *California Resources Agency* (2002) 103 Cal.App.4th 98)

Because of the broad project objectives associated with the implementation of the 2007 General Plan, the cumulative analysis presented in this EIR does not

evaluate the site-specific impacts of individual projects. Project-level analyses will be prepared by implementing agencies on a project-by-project basis.

6.4.2 Approach to this Analysis

The cumulative impact analysis in this EIR relies upon the projections approach. Unless so stated, it considers the potential for cumulative contributions at both the horizon year of the general plan in 2030 and buildout of the 2007 General Plan estimated to be in 2092. There are numerous uncertainties about the state of the environment in 2030 and 2092, as well as the protective laws and regulations that may be in effect at that time. Accordingly, the following assessment of cumulative impacts is strictly qualitative because of the infeasibility of predicting the timing, design features, and density of future projects. Many future projects will be the subject of separate environmental studies.

For the most part, the area addressed in the cumulative impact analysis is Monterey County, including its incorporated cities. There are a few notable exceptions to this general statement. The air quality analysis is based on the Monterey Bay air basin. The three-county AMBAG region is the area of analysis for transportation and population/housing since those issues have regional effects. Because biological resources analysis in general assesses cumulative impacts that naturally occur over a larger area than a single county, it is also based on a larger geographic area.

The cumulative impact analysis is based on population growth figures published by AMBAG in its 2004 regional forecast of population, housing, and employment (refer to Chapter 3, Project Description). The 2004 forecast is somewhat higher than AMBAG's recently released 2008 regional forecast. Using the 2004 forecast offers a more conservative view of growth potential. Therefore, using the 2004 AMBAG figures in this analysis would not result in understating the 2007 General Plan's potential for cumulatively considerable contributions.

Population growth and the development associated with it are the major factors contributing to direct impacts on land use, agriculture resources, water resources, transportation, air quality, noise, public services and utilities, and population and housing. In addition, growth can cause secondary impacts on these and other areas, such as biological resources. Therefore, using forecast population growth as a basis for analyzing cumulative impacts is the preferred approach when examining a large project area such as a county general plan.

The interpretation of cumulative impacts is such that, in the presence of a severe cumulative impact, a project's contribution may be considerable even if it is only more than one molecule (*Communities for a Better Environment* v. *California Resources Agency* (2002) 103 Cal.App.4th 98). This analysis errs on the side of considerable contributions. Where there is a severe cumulative impact, the conclusion is that the 2007 General Plan would make a considerable contribution if it contributes at all.

The magnitude of the 2007 General Plan's contributions to cumulative impacts is different in 2030 than at buildout in 2092. However, the 2007 General Plan would contribute to the same cumulative effects under the both the 2030 planning horizon and 2092 buildout. The following discussion notes any situations where this general rule is not the case.

6.4.2.1 Non-cumulative Impacts

In each of the following instances the 2007 General Plan's contribution does not rise to the level of being considerable.

Geology, Soils, and Seismicity

This is a site specific impact that affects individual development projects and that is adequately mitigated on an individual basis. As discussed in Chapter 4.4, Geology, Soils, and Seismicity, there are numerous state and local regulations that act to reduce geologic and seismic risks to acceptable levels. Project design and building standards avoid the aggregation of individual effects into a significant combined impact. Therefore, there would be no cumulative impact. Soil erosion is the exception to this and is discussed under water quality.

Mineral Resources

By virtue of their location along rivers and in lightly settled portions of the county, the county's mineral resources are not being impacted by overall development and will not have an impact on development.

Cultural Resources

These resources are site-specific and generally of individual value. The exception is where the resource is part of a designated historic district or landscape. In that situation, the cumulative loss of key or contributing resources would lead to eventual loss of the district's or landscape's defining characteristics. There is only one historic districts or landscapes within the lands under county jurisdiction – the town of Spreckles. Otherwise, where such districts exist within Monterey County, they are within cities. City, not county, actions would be the driving force of any potential erosion of those districts.

Spreckles is subject to the county's HR (Historic Review) overlay zone (Monterey County Code Section 21.54.010). This zoning ordinance requires a discretionary conditional use permit prior to structural alterations within the district. The conditional use permit is subject to review by the County's Historic Resources Review Board, as well as the approving authority, in order to ensure that historic integrity is preserved. Therefore, implementation of the 2007 General Plan would not contribute to the loss of those resources.

In addition, the 2007 General Plan has a number of specific policies that will avoid the loss of individual cultural resources. They include the following:

- Policy OS-6.1 provides that important representative and unique archaeological sites and features shall be identified and protected for all parcels with undisturbed natural conditions (i.e., ungraded properties) consistent with State Historic Preservation Office guidelines and definitions employed on a state-wide basis including Phase I, II, and III studies.
- Policy OS-6.2 requires that information on the location and significance of the County's archaeological resources shall be compiled and used in the environment and development review process. The County shall rely on and participate in the state-wide inventory work of the Native American Heritage Commission and the State Office of Historic Preservation. All Phase I, II, and III studies and records of Native Californian consultation shall be filed with appropriate state agencies and local tribes as well as local data source compilations maintained by the County. The County shall work with local tribes to update County GIS maps showing high, moderate and low archaeological sensitivity areas.
- Policy OS-6.3 provides that mew development proposed within moderate or high sensitivity zones, or within 150 feet of a known recorded archaeological and/or cultural site, shall complete a Phase I survey including use of the regional State Office of Historic Preservation Clearinghouse or the Native American Heritage Commission's list of sacred and traditional sites.
- Policy OS-6.5 requires the county to establish policies and procedures that encourage development to avoid impacts to sensitive archaeological sites including:
  - designing or clustering development to avoid archaeological site deposits, historic sites and resources, and Native Californian cultural sites;
  - dedicating permanent conservation easements shall be required where subdivisions and other developments can be planned to provide for such protective easements.
- Policy OS-6.6 requires the county to adopt a uniform set of guidelines to define Phase I, II, and III significance assessment and data recovery programs. Similar guidelines will be created to set standards for requirements for consultation with Native Californian descendents to determine procedures for determining the presence or absence of sacred or traditional sites. These guidelines will address monitoring requirements and participation in cultural resource data recovery programs.

In addition, Monterey County Code Section 21.66.050 establishes Standards for Archeological Resource Areas that require preparation of an archeological resource report prior to development, avoidance of known resources when feasible, and implementation of a mitigation plan when avoidance is not feasible. The mitigation plan must include preservation measures. Further, the existing provisions of CEQA protect sites from adverse impacts.

Public Services and Utilities

With the exception of solid waste capacity, these facilities serve particular areas and impacts to one are individual, not cumulative. The provisions of the 2007 General Plan requiring concurrent provision of services to new development (Policies PS-1.1 [Adequate Public Facility and Services (APFS) requirements] through PS-1.6 [Only those developments that have or can provide adequate concurrent public services and facilities shall be approved]) avoid the potential for cumulative impacts. As discussed in Chapter 4.11, Public Services and Utilities, these facilities will have individual construction and operational impacts. They are not, however, expected to be significant. School impacts are not considered significant provided that school impact fees are paid in accordance with Government Code Section 65995. Solid waste is discussed in the following section.

Parks and Recreation

As discussed in Chapter 4.12, Parks and Recreation, the county's supply of parks and recreation facilities far exceeds its target ratio of 3 acres per 1,000 residents. Development under the 2007 General Plan would not exceed that ratio and therefore, would not result in a cumulative effect on parks and recreation.

Hazards and Hazardous Materials

These impacts, with the exception of wildfire hazard, are project- and site-specific and generally of individual concern. The existing provisions of CEQA protect developments from adverse impacts. In addition, as discussed in Chapter 4.13, Hazards and Hazardous Materials, federal, state, and local laws and regulations protect against accidental exposure. Where exposure occasionally occurs, it is individual, not cumulative. Wildfire hazard is discussed in the following section,

6.4.3 2007 General Plan Cumulative Impacts

6.4.3.1 Land Use

There is no cumulative impact on land use, based on the thresholds identified in Chapter 4.1, Land Use. The 2007 General Plan is written to accommodate existing development trends and would not physically divide communities. As discussed in Chapter 4.1, Land Use, instead the 2007 General Plan would center future urban development in existing cities and in Community Areas, Rural Centers, and AHOs where some level of urbanization already exists. Nor would the 2007 General Plan conflict with land use plans. The 2007 General Plan accommodates the existing HCPs in the county. HCPs and NCCPs operate separately from the general plan and future resource conservation plans would be project specific and not conflict with the 2007 General Plan's land uses. Policies BIO-1.2 (Salinas Valley Conservation Plan for kit fox) and BIO-1.5 (Prepare Comprehensive County Natural Communities Conservation Plan by 2030) will

ensure that HCP and NCCP activities are coordinated with land use planning in the future.

Therefore, the project would not make a considerable contribution to a cumulative land use impact.

6.4.3.2 Agriculture Resources

Impact CUM-1 Agricultural Resources.
As discussed in Section 4.2, Agricultural Resources, the Department of Conservation's Farmland Mapping and Monitoring Program has documented a steady trend of loss of prime farmland to other uses statewide. Therefore, loss of farmland is a significant cumulative impact in California. In Monterey County, farmland will be converted to urban uses over time, particularly with the expansion of cities in the Salinas Valley. County land use regulations will limit the loss of farmland on the coastal plain, with the exception of lands within the Castroville Community Area. Development and land use activities under the 2007 General Plan would contribute to the cumulative conversion of Important Farmland to nonagricultural uses illustrated by the Farmland Mapping and Monitoring Program's data.

Implementation of 2007 General Plan goals and policies would partially reduce the impacts resulting from conversion of agricultural lands to urban uses by fostering continued agricultural production through policies such as the AWCP, and through specific policies including the following:

- Policy AG-1.1: prohibits activities that would conflict with on-going agricultural activities.
- Policy AG-1.2: requires buffers adjoining new non-agricultural uses.
- Policy AG-1.3: limits subdivisions in agricultural areas to those that would not conflict with agricultural uses.
- Policy AG-1.12: requires the county to develop a mitigation program with the cities.
- Policies AG-3.1- 3.3: authorize the partial exemption of routine and ongoing agricultural use from county regulations.

Further, the identified Community Areas and Rural Centers to which growth is channeled are mostly located on less productive lands. As discussed under the GPI Alternative in Chapter 5, Alternatives, the housing element mandates under California Planning Law require cities and counties to accommodate future housing need based on growth projections and make infeasible any mitigation or alternative that would prohibit all farmland conversion.

Past trends in Monterey County agriculture indicate that agricultural acreage will remain the same as current conditions or decrease slightly over time. Nonetheless, future conversion of Important Farmland, particularly in the Salinas Valley as its cities grow onto adjoining farmland, remains a significant

unavoidable cumulative impact. While the policies of the 2007 General Plan reduce the potential for additional contributions to this impact from county actions, they will not eliminate losses. Accordingly, the 2007 General Plan will make a considerable contribution to this impact.

6.4.3.3 Water Resources

Water Quality

Impact CUM-2. Surface Water Quality
Activities within the county and cities can affect surface water quality by releasing contaminants through point sources or through stormwater runoff. As discussed in the Project Description, AMBAG has projected continued growth throughout the region, including Monterey County, its cities, and those parts of Santa Cruz County that drain into the Pajaro River and its groundwater basin. The growth of the cities and those county areas identified for urbanization would increase the potential for new point sources, expanded point sources (such as wastewater treatment plants), and urban runoff. Rural and agricultural activities can similarly contribute contaminants from runoff. As discussed in Section 4.3, Water Resources, the SWRCB has listed numerous waterways within the county as "impaired waterways" under Section 303(d) of the Clean Water Act. Discharges to impaired waterways are regulated under the Central Coast RWQCB's Basin Plan, which includes TMDLs for the impaired waterways. Over time, the Central Coast RWQCB will adopt TMDLs for all impaired waterways in the County. In turn, county and city regulations will be required to limit discharges to the limits set by the TMDLs.

The RWQCB's conditional agricultural waiver program is preventing sediment-laced runoff from agricultural lands. These regulations are or will be in addition to the County's existing grading, slope development, and erosion control ordinances. Further, the 2007 General Plan will impose additional requirements on development that will reduce the release of contaminants to surface waters, including the following:

- Policies OS-3.5 and -3.6: require slope development regulations to be adopted.
- Policy S-3.8: requires the county to provide public education/outreach and technical assistance programs on erosion and sediment control.
- Policy OS-3.9: will establish a program that will address the potential cumulative hydrologic impacts of the conversion of hillside rangeland areas to cultivated croplands.
- Policy OS-5.7, as well as state and County regulation of timber harvesting will also limit potential discharges to streams from forestry activities.

These state and local regulations will mitigate the 2007 General Plan's impact to surface water quality and therefore, the 2007 General Plan's contribution will not be cumulatively considerable.

Impact CUM-3. Groundwater Quality

Most groundwater supplies and demand originate and exist within the county. The major exception is the Pajaro groundwater basin, which Santa Cruz County and the city of Watsonville share with portions of northern Monterey County. The analysis in Chapter 4.3, Water Resources, considers groundwater supplies in each of the county's groundwater basins (including the Pajaro basin, taking into account the influence of the Santa Cruz county jurisdictions) taking into account the demands of incorporated areas as well as the unincorporated county. Accordingly, this cumulative analysis reflects the entire groundwater basin.

As discussed in Chapter 4.3, Water Resources, a number of Monterey County's groundwater basins have high levels of salt (from seawater intrusion into the aquifer) and other contaminants. Chapter 4.3, Water Resources, describes the numerous projects currently underway or planned (i.e., SVWP, CSIP, Watsonville Water Recycling Project, etc.) that are addressing the issue of seawater intrusion. In addition, the following 2007 General Plan policies would limit groundwater overdraft and minimize resultant seawater intrusion:

- Policy PS-2.6: would establish a Hydrologic Resources Constraints and Hazards Database that would help the county track problem areas.
- Policy PS-3.3: will require the county to develop and apply specific criteria for proof of a long term sustainable water supply for new residential or commercial subdivisions, including water quality, effects on wells in the immediate vicinity, existing groundwater conditions, cumulative impacts and planned growth in the area, and other factors.
- Policy PS-3.6: would restrict the drilling or operation of any new wells in known areas of saltwater intrusion as identified by Monterey County Water Resource Agency until such time as a program has been approved and funded which will minimize or avoid expansion of salt water intrusion into useable groundwater supplies in that area.

Nitrates and other groundwater contaminants enter the aquifers from septic systems, municipal wastewater treatment systems, urban runoff, and routine agricultural practices. Regulations promulgated by the Central Coast RWQCB under the NPDES program limit contamination from the first three sources. The RWQCB's conditional agricultural waiver program limits agricultural runoff as a source. Routine fertilizer use, however, remains a contributor. As discussed earlier, agricultural use is expected to remain the same or decline slightly from existing conditions. As a result, routine fertilizer use is not expected to increase with implementation of the 2007 General Plan. The 2007 General Plan does not contain any explicit policies on the topic of groundwater contaminants other than those identified above for water quality.

While existing regulations and the implementation of the 2007 General Plan policies would reduce impacts to groundwater quality, they would not completely eliminate contributions from new development under the Plan. Therefore, implementation of the 2007 General Plan would result in a cumulatively considerable contribution to the existing cumulative impact of groundwater quality.

The following proposed mitigation measures will also reduce impacts on groundwater quality:

> **Mitigation Measure WR-1: Support a Regional Solution for the Monterey Peninsula in addition to the Coastal Water Project. This will require cooperation on a long-term, regional solution to groundwater overdraft and other issues. That, in turn, will reduce seawater intrusion.**
>
> **Mitigation Measure WR-2: Initiate Planning for additional Supplies to the Salinas Valley. This will begin the task of bringing long-term water supplies to the Salinas Valley over the buildout 2092 time frame. This would have reducing seawater intrusion and groundwater overdraft among its objectives.**

Mitigation Measures WR-1 and WR-2 hold promise for a long-term solution to the related problems of overdraft and seawater intrusion. Their implementation would reduce, but not eliminate the contribution of 2007 General Plan implementation.

Water Supply

Impact CUM-4. Water Supply
This examines the impacts of the 2007 General Plan on water demand and supply, and the potential to adversely affect groundwater levels. Chapter 4.3, Water Resources, describes the various agency plans that lay out the available water storage, ongoing and future water demand, and existing overdraft conditions within Monterey County, its cities, and the adjoining jurisdictions in the Pajaro Valley. The discussion in Chapter 4.3 considers water supplies by groundwater basin and sub-basin, thereby including affected contributing cities and counties. In the Pajaro basin, this includes Watsonville and a portion of Santa Cruz County.

Cumulative impacts would occur through the existing and projected gaps between water supplies and demand. As discussed in Chapter 4.3, a number of projects are underway or planned that would expand water supplies and reduce overdraft (i.e., Coastal Water Project, CSIP, Watsonville Water Recycling Project, SVWP, etc.). Nonetheless, there will be insufficient supply to support development to the 2030 planning horizon and beyond on the Monterey Peninsula and in the Pajaro Valley. Long term supply in the Salinas Valley will depend upon a future phase of the SVWP to secure additional water from the Salinas River. Mitigation measures WR-1 and WR-2 described above would bring the county together with other agencies to pursue long-term solutions to water supply and maintenance of groundwater levels.

In addition, the 2007 General Plan contains the following policies that would help match water demand to supply and reduce overdraft.

- Policy OS-10.10 would require consideration of sustainable land use strategies (including water conservation and greywater reuse) in the design of future development within Community Areas and Rural Centers.
- Policy PS-2.6 would establish a Hydrologic Resources Constraints and Hazards Database that would help the county to track problem areas.
- Policies PS-3.1 to -3.3 would require proof of availability of a sustainable water supply before new development is allowed. This would slow the growth of demand in the county.
- Policy PS-3.9 would require a program to eliminate overdraft of water basins be developed as part of the Capital Implementation and Financing Plan (CIFP).
- Policies PS-3.13 and -3.14 would establish an ordinance identifying conservation measures to reduce potable water demand and would maximize the use of recycled water as a potable water offset and in agricultural areas where allowed by state regulations.

Nonetheless, future growth planned in the cities (including Watsonville in Santa Cruz County), Community Areas, Rural Centers, Affordable Housing Overlay zones, and wineries will exacerbate the existing water supply and overdraft problems. By 2092 and full buildout, the constraints on the water supply will be even more acute. These policies and mitigation measures WR-1 and WR-2 described above will reduce, but cannot be certain of solving the long-term water supply shortage. Buildout of the 2007 General Plan would make a cumulatively considerable contribution to this cumulative impact.

Impact CUM-5. Indirect Impacts of Water Supply Projects
There are a number of existing and planned projects that are intended to increase water supplies and/or reduce overdraft conditions. These projects would reasonably be expected to have significant environmental impacts. Reasonably foreseeable water supply projects include the desalination plants of the Coastal Water Project and Pajaro/Sunny Mesa Community Services District proposed at Moss Landing. Both of these projects are in the planning stage and no draft EIR has been released for either of them. The SVWP is partially in operation and its impacts are disclosed in and being mitigated under the EIR/EIS prepared for that project by the MCWRA. The CSIP is in operation, as is the Watsonville Water Recycling Plant. Water distribution systems are being installed for both the SVWP and the water from the Watsonville plant. The water distribution pipelines will be installed in agricultural areas and are not expected to have significant effects.

Project impacts would include construction-related air quality emissions, traffic increases, and sediment release; brine disposal during operation (desalination plants); biological impacts (desalination plants); and increased electrical demand (desalination plants). A number of safeguards exist that will act to reduce most of these indirect impacts below the level of significance. For example:

- The Monterey Bay Unified APCD requires construction to follow BMPs to reduce dust. If the construction would exceed the APCD's threshold,

additional measures will be required to ensure that dust does not exceed the threshold. This will avoid contributing to the cumulative impact.

- The EIRs prepared for the desalination plants are expected to require that construction equipment use alternative fuels or other means to reduce their emissions of ozone precursors. Although, depending upon the intensity of construction, there is the potential for a significant impact on air quality from ozone precursors.
- County erosion control regulations and the requirements of the Central Coast RWQCB will prohibit the release of sediment beyond project boundaries. This would avoid contributing to surface water quality impacts.
- Brine from the desalination process is expected to be diluted with cooling water from the Moss Landing power plant and discharged into Monterey Bay. The Central Coast RWQCB will require that brine disposal meet regulatory limits to avoid conflict with the CWA. Therefore, this is not expected to make a considerable contribution to water quality impacts.

Biological impacts, particularly from the release of brine into the Monterey Bay National Marine Sanctuary, are unknown at this point, but would potentially be cumulatively considerable. The effectiveness of any future mitigation measures developed in the EIRs to be prepared for the desalination projects is unknown.

Desalination plants typically are large consumers of electrical energy. The power consumption of the proposed plants would potentially result in a significant effect on electrical supply. This would be analyzed in the EIRs to be prepared for the plants.

Taking a conservative view, the indirect impacts of the water supply projects to be built would potentially make considerable contributions to air quality, biological, and electrical energy use.

6.4.3.4 Transportation

Impact CUM-6. Transportation
Development anticipated by the 2007 General Plan and city growth cumulatively would generate additional traffic volumes that would worsen existing deficient performance conditions on Monterey County roadways. The cumulative contribution of the 2007 General Plan to traffic conditions is analyzed and disclosed in Chapter 4.6, Transportation, and therefore is not repeated here.

6.4.3.5 Air Quality

Impact CUM-7. Air Quality
The Monterey Bay Unified APCD's Air Quality Management Plan (AQMP) establishes the projections of air quality that would result from development within this air basin. The North Central Coast Air Basin is in attainment for all criteria pollutants except ozone (state standard). The significance thresholds set out in the Monterey Bay Unified APCD's CEQA guide are based on the AQMP

and what would be the limits of allowable emissions that would stay within state and federal attainment requirements. The thresholds are essentially indicators of a project's individual and cumulative impacts.

The 2007 General Plan is generally consistent with the objectives of the North Central Coast Air Basin 2008 AQMP. However, vehicle traffic associated with growth under the 2007 General Plan and winery development under the General Plan's AWCP would exceed thresholds for ozone precursors. Policy C-1.2 of the 2007 General Plan requires adoption of a comprehensive Capital Improvement and Facilities Plan that will identify road improvements needed to reduce congestion and supports use of County traffic impact fee to fund related transportation projects. This ultimately would reduce idling and have a corresponding reduction in mobile-source air quality emissions. However, this will not avoid contributions of ozone precursors along roads that will suffer increased congestion as a result of the 2007 General Plan and city growth, nor would it reduce vehicle miles travelled. Further mitigation is infeasible, as discussed in Chapter 4.6, Transportation.

The 50 wineries proposed under the AWCP component of the 2007 General Plan would together emit VOCs in excess of the individual daily limit of 137 pounds established by the AQMP. As discussed in Chapter 4.7, Air Quality, there is no feasible mitigation for winery VOCs.

Therefore, implementation to the 2030 horizon and buildout of the 2007 General Plan in 2092 would make a considerable contribution to the cumulative impact on air quality.

There is also the reasonable possibility that, at the project level, there may be future individual developments whose construction emissions will exceed the APCD's standards. Such cases are rare in that large projects are practically always subject to discretionary permits that require CEQA review. As part of the CEQA process, future mitigation measures would be developed in cooperation with the Monterey Bay Unified APCD to bring construction emissions below the APCD's standards. This is unlikely to contribute to the cumulative effect on air quality.

Further, odiferous future projects such as composting yards or confined animal facilities that are not proposed as part of the 2007 General Plan, but that would be allowable under its provisions, could be installed. If these are clustered in one or more areas of the county, they will have cumulative effects on local air quality. That these uses might occur under the General Plan establish the possibility of additional considerable contributions at buildout of the 2007 General Plan.

6.4.3.6 Noise

Impact CUM-8. Noise
The EIR does not identify any significant direct noise impacts that would result from implementation of the 2007 General Plan at either the 2030 planning horizon or 2092 buildout. A cumulative noise impact exists when the applicable

noise standard is exceeded by 1 dbA or more. Although a 1 dbA change is unnoticeable, it contributes measurably to a significant effect.

Overall traffic volumes across the county are forecast to be about 45% greater than volumes under 2030 conditions. This generally corresponds to a 1 to 2 dB increase in traffic noise. Table 4.8-3 (Traffic Noise Modeling Results) in Chapter 4.8, Noise, illustrates that there will be cumulative significant noise impacts along a number of road segments. The column entitled "2030 Cumulative with Project minus No Project" and "Buildout minus 2030 Cumulative with Project"reflect those places where the county noise standard is forecast to be exceeded by 1 dbA or more. Keep in mind that because traffic is not limited to residents of the unincorporated county, not all of the cumulative impacts along these roads are attributable to the 2007 General Plan. These results are summarized in Table 6-1 below.

Table 6-1. Cumulative Noise Impacts

Segment	Existing Ldn	2030 Cumulative (with Project) Ldn	2030 Cumulative with Project minus No Project	Buildout minus 2030 Cumulative with Project
Espinosa Rd to E Boronda Rd	74	76	1	0
Chualar Rd to Old Stage Rd	72	75	0	2
SR-183 to SR-156	69	71	2	0
Del Monte Blvd to Imjin Pkwy	75	75	0	2
17 Mile Dr to Skyline Forest Dr	67	67	0	1
Canyon del Rey Blvd to Bit Rd	63	64	0	1
Spreckels Blvd to E Blanco Rd	67	68	-1	3
County Road G-15 to Stonewall Canyon Rd	53	54	0	3
Castroville Blvd to US-101	70	70	0	1
Cooper Rd to S Davis Rd	67	70	0	1
US-101 to Cattlemen Rd	45	48	-1	2
Carlton Dr to SR-68	61	62	0	1
Salinas Rd to San Miguel Canyon Rd	54	58	0	1
Strawberry Rd to Castroville Blvd	63	67	2	0
US-101 to San Lucas Rd	52	55	0	2
Carmel Rancho Blvd to Rio Rd	64	65	0	1
Robinson Canyon Rd to Miramonte Rd	61	62	0	2
Las Palmas Rd to Las Palmas Pkwy	60	61	1	3
Drake Ave to Lighthouse Ave	62	65	0	2
Pacific Ave to Forest Ave	56	57	0	2
Forest Ave to David Ave	56	54	0	1
Washington St to Camino Aguajito	66	67	0	2
Abrego St to Camino Aguajito	64	65	0	1
Soledad Dr to Via Zaragoza	64	65	1	2
Playa Ave to Fremont Blvd	61	62	-1	3
N Del Monte Blvd to SR-1	59	59	-1	3
Reindollar Ave to Reservation Rd	67	68	0	2
Casa Verde Wy to SR-218	65	66	0	3
US-101 to Abbott St	65	65	0	2
San Juan Grade Rd to W Laurel Dr	65	66	0	2

Segment	Existing Ldn	2030 Cumulative (with Project) Ldn	2030 Cumulative with Project minus No Project	Buildout minus 2030 Cumulative with Project
US-101 to N Main St	60	63	0	2
Romie Ln to E Blanco Rd	62	62	0	2
Abbott St to US-101	65	65	-1	2
Davis Rd to N Main St	62	62	0	2
W Laurel Dr to SR-183	62	62	0	1
W Alisal St to SR-68	57	57	0	3
SH 101 to Salinas City Line	67	68	0	2
SR-183 to Commercial Pkwy E	60	61	0	0
Reservation Rd to Cooper Rd	68	69	0	1
Carmel Rancho Ln to Rio Rd	53	53	-1	2
Serra Ave to SR-1	58	58	0	3
Blanco Rd to Reservation Rd	65	68	-1	0
Spreckels Blvd to Abbott St	61	63	0	2
Carmel City Line to SR-1	57	57	0	2
San Juan Rd to Santa Cruz County Line	65	67	0	1
Carmel City Line to SR-1	57	58	0	2
SR-1 to Fruitland Ave	60	63	1	1
Salinas City Line to Russell Rd	57	62	0	3
SR-68 to Harkins Rd	57	60	0	1

As discussed in Chapter 4.8, Noise, there are a number of measures that can be taken to attenuate noise impacts to meet county standards. These measures would be equally useful in attenuating cumulative impacts. Noise attenuation is very specific to the circumstances of the area where noise levels are being exceeded, so identifying specific measures to avoid cumulative impacts is neither practical nor effective. The 2007 General Plan includes a number of policies that will act to reduce these increases when applied to individual projects and avoid contribution to the impact. They include, but are not limited to, the following:

- Policy S-7.1: New noise-sensitive land uses may only be allowed in areas where existing and projected noise levels (*Figures 22 A-H and 23 A-E*) are "acceptable" according to *Table S-2* ("Land Use Compatibility for Community Noise"). A Community Noise Ordinance shall be established that addresses, but is not limited to the following: (1) capacity-related roadway improvement projects; (2) construction-related noise impacts on adjacent land uses; (3) new residential land uses exposed to aircraft

operations at any airport or air base; (4) site planning and project design techniques to achieve acceptable noise levels such as: building orientation, setbacks, earthen berms, and building construction practices; (5) design elements necessary to mitigate significant adverse noise impacts on surrounding land uses; and (6) impulse noise. The use of masonry sound walls for noise control in rural areas shall be discouraged.

- S-7.2: Proposed development shall incorporate design elements necessary to minimize noise impacts on surrounding land uses and to reduce noise in indoor spaces to an acceptable level.
- S-7.4: New noise generators may be allowed in areas where projected noise levels (*Figures 22 and 23*) are "conditionally acceptable" only after a detailed analysis of the noise reduction requirements is made and needed noise mitigation features are included in project design.
- S-7.5: New noise generators should generally be discouraged in areas identified as "normally unacceptable." Where such new noise generators are permitted, mitigation to reduce both the indoor and outdoor noise levels will be required.
- S-7.6: Acoustical analysis shall be part of the environmental review process for projects when: (a) Noise sensitive receptors are proposed in areas exposed to existing or projected noise levels that are "normally unacceptable" or higher according to *Table S-2* ("Land Use Compatibility for Community Noise") or (b) Proposed noise generators are likely to produce noise levels exceeding the levels shown in the adopted Community Noise Ordinance when received at existing or planned noise-sensitive receptors.
- S-7.7: All discretionary projects which propose to use heavy construction equipment that has the potential to create vibrations that could cause structural damage to adjacent structures within 100 feet would be required to submit a pre-construction vibration study prior to the approval of a building permit. Specified measures and monitoring identified to reduce impacts would be incorporated into construction contracts. Pile driving or blasting are illustrative of the type of equipment that could be subject to this policy.

With implementation of these policies at the project level, the 2007 General Plan will not make a cumulatively considerable contribution to cumulative noise impacts.

6.4.3.7 Biological Resources

Impact CUM-9. Biological Resources
Development of natural lands, whether by urbanization, construction of single-family residences in sensitive habitats, or conversion of woodlands or grazing land to intensive agricultural use results in the loss of natural habitats and associated biological resources. Seawater intrusion may also affect special status species through change in habitat. Implementation of the 2007 General Plan will be one of the factors affecting biological resources. In addition, development of

the cities will impact these resources directly through loss of habitat, and indirectly through increased water demand and its relationship to seawater intrusion.

The state and federal Endangered Species Acts (ESAs), as well as related listings of special status species by the Department of Fish and Game and its federal counterparts, provide a projection of those species that are adversely affected by loss of habitat and other impacts resulting from development throughout their local, state or federal range. These species are identified in Chapter 4.9, Biological Resources. Resources subject to cumulative impact are: special status species; sensitive natural communities, riparian habitat and wetlands; wildlife movement corridors; and potential loss or disturbance of nesting migratory birds and raptors. The 2007 General Plan provides a projection of the cumulative impact of future development on these species, habitats, and resources.

There are a number of current laws and regulations that reduce the impacts of development on biological resources. These include the state and federal ESAs, additional regulations such as streambed alteration agreements (DFG) and wetland permitting (Corps of Engineers, Central Coast RWQCB), the county tree protection ordinance, and CEQA as it applies to individual discretionary projects. The 2007 General Plan proposes a number of policies that would reduce the impact of its implementation. These include the following:

- Policy PS-3.6 provides that the County and all applicable water management agencies will not allow the drilling or operation of any new wells in known areas of saltwater intrusion as identified by Monterey County Water Resource Agency until such time as a program has been approved and funded which will minimize or avoid expansion of salt water intrusion into useable groundwater supplies in that area.
- Policy OS-4.3 requires the protection of estuaries, salt and fresh water marshes, tide pools, wetlands, sloughs, river and stream mouth areas in accordance with state and federal laws. This would avoid impacts to special status species dependent on those habitats.
- Policy OS-5.1 promotes the conservation of critical habitat. This would reduce impacts to special status species (as otherwise defined in Section 15380 of the CEQA Guidelines) to the extent that they are covered under the Federal Endangered Species Act and critical habitat has been identified.
- Policies OS-5.3 and 5.4 encourage careful design of new development and the avoidance of State and federally listed plant and animal species and designated critical habitat for federally listed species. This would similarly reduce impacts to state and federally listed species, but not those special status species (as otherwise defined in Section 15380 of the CEQA Guidelines) that are not included on the state or federal endangered species lists.
- Policy OS-5.16 requires biological surveys and mitigation as part of project consideration. These would implement the above policies.

- Policy OS-5.17 requires the county to mitigate los of critical habitat in consultation with state and federal agencies. This would reduce impacts to special status species (as otherwise defined in Section 15380 of the CEQA Guidelines) to the extent that they are covered under the state and federal Endangered Species Acts and critical habitat has been identified.

As discussed in Chapter 4.9, Biological Resources these policies would not avoid significant effects and, by implication, cumulatively considerable contributions.

In addition, this EIR recommends the adoption of a number of mitigation measures to address the impacts of the 2007 General Plan. These include:

- BIO-1.1: Baseline Inventory of Landcover, CEQA-Defined Special Status Species Habitat, Sensitive Natural Communities, Riparian Habitat, and Wetlands in Monterey County. This would identify areas of concern so that they could be avoided in project design. That would reduce the potential for significant effects.
- BIO-1.2: Salinas Valley Conservation Plan to preserve habitat for the San Joaquin kit fox in the Salinas Valley. This would provide long-term protection for the species while authorizing development in particular areas. It would avoid cumulative contributions to impacts on this species before the 2030 planning horizon.
- BIO-1.3: Project Level Biological Survey and Avoidance, Minimization, and Compensation for Impacts to CEQA-defined Special-Status Species and Sensitive Natural communities. This would expand considerations of species beyond those formally listed under the state and federal Endangered Species Acts to approximate the list in Section 15380 of the CEQA Guidelines. This would minimize impacts, including cumulative contributions, before the 2030 planning horizon.
- BIO-1.4: By 2030, prepare an Update to the General Plan to identify expansion of existing focused growth areas and/or to identify new focused growth areas to reduce loss of natural habitat in Monterey County. This would provide similar protections to those of mitigation measure BIO-1.4.
- BIO-1.5: By 2030, prepare a Comprehensive County Natural Communities Conservation Plan (NCCP). This would provide similar protections to those of mitigation measure BIO-1.2, but for multiple species. Depending on the species included in the NCCP, this has the potential to avoid cumulative contributions for all special status species (as otherwise defined in Section 15380 of the CEQA Guidelines) in the county.
- BIO-2.1: Stream Setback Ordinance. This will protect riparian habitats and the species that depend on them.
- BIO-2.2 – Oak Woodlands Mitigation Program. This will protect this habitat and the species that depend upon it.
- BIO-2.3 – Add Considerations Regarding Riparian Habitat and Stream Flows to Criteria for Long-Term Water Supply and Well Assessment. This would

expand the types of permits requiring consideration of habitat and stream flows. This would benefit riparian-dependent and fish species.

- BIO-3.1: Project-Level Wildlife Movement Considerations. This would expand protections to species that are not listed, such as deer, but that would otherwise be affected by development by loss of movement corridors.
- BIO-3.2: Remove Vegetation During the Nonbreeding Season and Avoid Disturbance of Nesting Migratory Birds, Including Raptors, as Appropriate (generally September 16 to January 31). This would expand protections for non-listed, special status birds in keeping with the definition in Section 15380 of the CEQA Guidelines. That would avoid a cumulative contribution.

Together, these would reduce the 2007 General Plan's contribution to cumulative impacts, but in some cases these impacts would still remain considerable. As development continues toward buildout, particularly development of existing lots of record, low-intensity development will cover larger expanses of the county's jurisdiction (federal lands such as Fort Hunter Liggett and Los Padres National Forest and state parks, which provide substantial areas of habitat within the county would not be affected). Similarly, expansion of the cities, which is outside the control of Monterey County, will impact habitats adjoining urban areas. Non-discretionary activities, such as the conversion of grassland to intensive agriculture, will also continue to contribute to the larger impact on these resources. Because the extent and species coverage of the future NCCP is unknown, there is a potential for cumulative impacts on special status species not covered by the NCCP. As a result, there would be a considerable contribution to cumulatively significant biological impacts.

6.4.3.8 Public Services and Utilities

Impact Cum-10. Solid Waste
As discussed in Section 4.11, Public Services and Utilities, future growth anticipated with build out of the 2007 General Plan would exceed landfill capacity, as tracked by the California Integrated Waste Management Board, by buildout in 2092. Landfills serve both city and county dwellers and businesses.

The Integrated Waste Management Act will continue to require reduction, recycling, and reuse to reduce the amount of waste sent to landfills. Future efforts to reduce greenhouse gas emissions are likely to include regulations requiring the further reduction and recycling of solid waste, including building materials. This should reduce the wastestream requiring disposal in landfills. Nonetheless, existing landfill capacity will be exceeded by 2092. To be conservative, the long-term contribution of 2007 General Plan buildout is expected to be considerable.

Assuming that landfills will be constructed between 2008 and buildout, development of a new or expanded landfill typically results in numerous environmental impacts. Construction impacts typically include air quality emissions from dust and machinery, temporary increases in traffic, and effect on

surrounding biological resources. Landfills are typically located away from sensitive receptors, so noise impacts would be minimal during construction and operations. Operational impacts can include air quality impacts resulting from odors and the release of landfill gases, biological impacts on the area of the expansion or location, traffic impacts from trucks going to and from the landfill, water quality impacts from storm runoff or leaching, and aesthetics impacts resulting from removal of existing vegetation and landfill cover.

Existing air quality regulations and standard traffic control measures would reduce construction impacts. However, depending upon the intensity of construction, there is the potential for significant effects. Similarly, existing regulations of the Monterey Bay Unified APCD would regulate odors and the release of landfill gas such that air quality standards would not be exceeded. Similarly, the Central Coast RWQCB and the California Integrated Waste Management Board would regulate landfill operations so that no runoff escapes the site and landfill design and monitoring wells ensure that no leachate is released to either surface or groundwater. These sets of regulations would reasonably be expected to avoid a contribution to cumulative air and water quality impacts.

Biological impacts, although dependent upon the sensitivity of the area chosen for the expansion or new landfill would potentially be significant and would contribute to cumulative impacts on biological resources. Aesthetics impacts, again dependent upon the visibility of the landfill site, would potentially be significant and contributors to visual impacts.

6.4.3.9 Wildfire Hazard

Impact CUM-11. Wildfire Hazard
Portions of Monterey County, particularly west of the Salinas Valley, are highly susceptible to wildfire. The risk of wildfires is acute in areas of high fuel loading; somewhat less so in moderate fuel loaded areas. As described in Chapter 4.13, Hazards and Hazardous Materials, the 2007 General Plan and the Fort Ord Master Plan contain detailed requirements for and limitations on future development to avoid contributing to fire risk, limiting damage through provision of defensible space, and funding fire suppression services.

In the recent past, the Basin Fire and Indian Fire devastated areas around Big Sur and inland southern portions of the Salinas Valley. These are only the latest of many catastrophic wildfires originating in rugged terrain along the coast. The state parks and National Forest have suffered the brunt of the damage from these fires, primarily because populations are low and communities in the area are small. The 2007 General Plan would encourage development within several Rural Centers that would place additional residents in areas that have the potential for wildfires. In addition, development to 2092 buildout would include existing rural lots of record, some in areas of high or moderate fire hazard; placing new residents in the literal line of fire.

Chapter 4.13, Hazards and Hazardous Materials, describes the voluminous policies and requirements that will be applied to new development under the 2007 General Plan. In the interest of space, the reader is referred to that chapter. These policies, implemented well before 2030 and in place long before 2092, would greatly reduce the potential contribution of the 2007 General Plan to the risk of wildfires. However, the 2007 General Plan cannot eliminate the risk of catastrophic wildfires originating on public lands sweeping across Rural Communities and, more particularly, individual lots of record, despite the best efforts of fire fighters to slow or halt their approach. The 2007 General Plan would make a cumulatively considerable contribution to this risk.

6.4.3.10 Aesthetics, Light and Glare

Impact CUM-12. Aesthetics, Light, and Glare
Future growth in Monterey County and development in surrounding areas would result in the intensification of existing urban uses as well as conversion of open space into urban land uses and the introduction of new sources of light and glare. City growth also would have a cumulatively considerable contribution in this regard. Aesthetics impacts occur as a result of substantial changes in pleasant views. Light and glare are impacts where undeveloped or rural lands adjoin urbanized development or where new sources of light and glare are introduced into a dark environment. The county General Plan and city general plans essentially describe the factors that will change the existing landscape and result in aesthetics, light, and glare impacts. Individual projects under these county and city plans that result in the urbanization of open lands, development on ridgelines, and expansion of urban areas all contribute to the incremental loss of aesthetically pleasing views or the introduction of incompatible light and glare.

Development under the 2007 General Plan would be primarily centered on the existing cities, and the county's designated Community Areas, Rural Centers, and AHOs. For the most part, these would minimize aesthetics impacts caused by the conversion of open lands to urban development by building adjacent to existing development. Nonetheless, particularly in cities in the Salinas Valley where the surrounding land use is agricultural fields, there will be an incremental change in the visual character of the area. Also, buildout of the county's individual lots of record will result in a more expansive distribution of low-intensity development than exists today.

The 2007 General Plan has a number of policies to reduce its contribution to visual impacts. They include the following:

- Policy LU-1.10 will discourage new off-site advertising to enhance public safety and to avoid visual clutter and scenic intrusion. Off site advertising may only be considered in heavy commercial and industrial zoning districts and not abutting residential districts.
- Policy LU-1.13 provides that all exterior lighting is to be unobtrusive and constructed or located so that only the intended area is illuminated, long

range visibility is reduced of the lighting source, and off-site glare is fully controlled (based on design criteria to be developed by the county).

- Policy OS-1.3 restricts new development on ridgelines.
- Policy OS-1.7 will lead to a transfer of development rights program to direct development away from areas with unique visual or natural features.
- Policies OS-1.9 and -1.11 require the establishment of an inventory of viewsheds and encourage project design that protects those views.

Nonetheless, the slow transition of areas away from agriculture and open lands, and the expansion of the urban edge, where light and glare intrude on nearby less-developed lands; will result in a considerable contribution to the cumulative loss of landscape aesthetic quality. Because of California Planning Law requires counties and cities to provide for projected housing needs and the associated urban growth, this contribution cannot be fully avoided.

6.4.3.11 Population and Housing

Impact CUM-13. Population and Housing
The cumulative contribution of population and housing growth in Monterey County will be examined to the year 2030 planning horizon since "buildout" numbers are not available for Santa Cruz and San Benito Counties, the other counties in the AMBAG region. However, the type of contribution at buildout is not expected to differ greatly from the type of contribution in 2030 because these contributions are common to long-term growth, whether the term is 20 years or 80 years.

The AMBAG 2004 regional forecast estimates that by 2030 the total population of Monterey County (including the cities) will total 602,731 persons residing in 187,001 dwelling units. Of this, the unincorporated county would accommodate 135,375 persons (about 22% of the total) and the cities would accommodate 467,356 persons (about 78% of the total). Region-wide (Santa Cruz, Monterey, and San Benito Counties), the population is expected to grow to 991,370 persons by 2030. This would represent a 39% increase between 2000 and 2030, for an annual growth rate of 1.3 %, By comparison, the California Department of Finance currently projects that the State's annual growth rate between 2000 and 2030 will be about 1.5% (State of California, Department of Finance 2007). Growth in Monterey County and its neighboring counties is cumulatively significant. Although the 30-year annual rate of growth is projected to be less than the statewide average, the adverse changes inherent in growth here (e.g., aesthetics, water supply, traffic congestion) and the controversy over Monterey County growth indicate that it is a significant cumulative impact.

As discussed previously in Chapter 4.15, Population and Housing, the 2007 General Plan is growth-inducing by nature of its role in accommodating new housing opportunities under California Planning Law. Because California Planning Law mandates that each city and county plan for its fair share of the regional housing need and that need is based on projections of population growth, there is no feasible mitigation for the resultant increase in population and

dwelling units. Therefore, the 2007 General Plan would make a considerable contribution to this cumulative effect.

There is no cumulative impact with regard to residential displacement or housing replacement. As discussed in Chapter 4.15, Population and Housing, the 2007 General Plan would not result in substantial displacement, nor would it require substantial replacement housing as a result of displacement.

6.4.3.12 Climate Change

Impact CUM-14. Climate Change
Climate change is a global phenomenon driven by myriad individual actions, large and small, in every country. As explained in Chapter 4.16, Climate Change, no individual project within Monterey County is large enough in itself to trigger global climate change. However, most individual projects contribute to the greenhouse gas emissions that fuel climate change. Climate change is a cumulative impact. Accordingly, the climate change analysis in Chapter 4.16 is an analysis of the project's contribution to this cumulative impact. The reader is directed to that chapter and no additional discussion is needed here.

Table 6-2. Significant and Unavoidable Impact Table

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
4.2 Agriculture Resources		
Impact AG-1: Implementation of the 2007 General Plan would result in the conversion of Important Farmland to non-agricultural use. **[Also cumulative impact]**	No feasible mitigation beyond the 2007 General Plan goals and policies is available.	2030 - Significant Unavoidable Impact. Buildout – Significant Unavoidable Impact.
Implementation of the 2007 General Plan would involve other changes in the existing environment which, due to their location or nature, would result in conversion of farmland to non-agricultural use. **[Also cumulative impact]**	No feasible mitigation beyond the 2007 General Plan goals and policies is available.	2030 - Significant Unavoidable Impact. Buildout – Significant Unavoidable Impact.
4.3 Water Resources		
Impact WR-4: Land uses and development consistent with the 2007 General Plan would exceed the capacity of existing water supplies and necessitate the acquisition of new supplies to meet expected demands. **[Also cumulative impact]**	**2030 Mitigation** **WR-1:** Support a Regional Solution for the Monterey Peninsula In Addition to the Coastal Water Project **2092 Mitigation** **WR-1:** Support a Regional Solution for the Monterey Peninsula In Addition to the Coastal Water Project **WR-2:** Initiate Planning for Additional Supplies to the Salinas Valley **BIO-2.3:** Add Considerations Regarding Riparian Habitat and Stream Flows to Criteria for Long-Term Water Supply and Well Assessment. (see Section 4.9 Biological Resources, below).	2030 - Significant Unavoidable Impact (In some portions of the County). Buildout – Significant Unavoidable Impact (In some portions of the County).
Impact WR-5: Land uses and development consistent with the 2007 General Plan would increase the demand for water storage, treatment, and conveyance facilities that could have significant secondary impacts on the environment.	The General Plan and Area Plan goals and policies will apply. Future projects will be subject to CEQA and have specific mitigation measures. As the experience with existing large-scale water supply projects shows, impacts cannot always be mitigated to a less than significant level.	2030 –Significant Unavoidable Impact. Buildout – Significant Unavoidable Impact.

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
Impact WR-6: Land uses and development consistent with the 2007 General Plan would increase demand on groundwater supplies in some areas; the associated increased well pumping would result in the continued decline of groundwater levels and accelerated overdraft in portions of the county. **[Also cumulative impact]**	**2030 Mitigation** **WR-1:** Support a Regional Solution for the Monterey Peninsula In Addition to the Coastal Water Project **2092 Mitigation** **WR-1:** Support a Regional Solution for the Monterey Peninsula In Addition to the Coastal Water Project **WR-2:** Initiate Planning for Additional Supplies to the Salinas Valley	2030 - Significant Unavoidable Impact (In some portions of the County). Buildout – Significant Unavoidable Impact.
Impact WR-7: Land uses and development consistent with the 2007 General Plan would increase demand on groundwater supplies in areas currently experiencing or susceptible to saltwater intrusion. Increased groundwater pumping in certain coastal areas would result in increased saltwater intrusion in some areas of the county. **[Also cumulative impact]**	**2030 Mitigation** **WR-1:** Support a Regional Solution for the Monterey Peninsula In Addition to the Coastal Water Project **2092 Mitigation** **WR-1:** Support a Regional Solution for the Monterey Peninsula In Addition to the Coastal Water Project **WR-2:** Initiate Planning for Additional Supplies to the Salinas Valley	2030 - Significant Unavoidable Impact (In some portions of the County). Buildout – Significant Unavoidable Impact (In all of the County).
Impact WR-12: Land uses and development consistent with the 2007 General Plan would allow continued development in 100-year flood hazard areas.	**2092** Extent and locations of future impact are unknown; no mitigation is feasible.	Buildout – Significant Unavoidable Impact.
Impact WR-13: The placement of land uses and structures within Special Flood Hazard Areas would impede or redirect flood flows, resulting in secondary downstream flood damage, including bank failure.	**2092** Extent and locations of future impact are unknown; no mitigation is feasible.	Buildout – Significant Unavoidable Impact.
Impact WR-14: Potential failure of levees or dams would expose people and structures to inundation and result in the loss of property, increased risk, injury, or death.	**2092** Extent and locations of future impact are unknown; no mitigation is feasible.	Buildout – Significant Unavoidable Impact.
4.6 Transportation		
Impact TRAN-1B: Development of the land uses allowed under the 2007 General Plan would create traffic increases on County and Regional roadways which would cause the LOS to exceed the LOS		Less Than Significant Impact.

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
standard, or contribute traffic to County and Regional roads that exceed the LOS standard without development.		
	TRAN-1B-a: Circulation Element Policy C-1.2 shall be amended to state: C-1.2 The standard for the acceptable level of service (LOS) is to be achieved by 2026. That LOS standard is to be achieved through the development and adoption of Capital Improvement and Financing Plans (CIFP) and implementing ordinances that: a. Define benefit areas to be included in the CIFP. Benefit areas could include Planning Areas, Community Areas, or the County as a whole. b. Identify and prioritize the improvements to be completed in the benefit areas over the life of the General Plan. c. Estimate the cost of the improvements over the life of the General Plan. d. Identify the funding sources and mechanisms for the CIFP to include, but not limited to, a Traffic Impact Fee (TIF). e. Provide an anticipated schedule for completion of the improvements. f. Coordinate with TAMC regional fee program. g. A TIF shall be implemented to ensure a funding mechanism for transportation improvements to county facilities. The TIF shall be imposed on development in cities for the improvement of major County roads in accordance with the Monterey County 2007 General Plan. The CIFP shall be reviewed every five (5) years in order to evaluate the effectiveness of meeting the LOS standard for County roads. Road segments or intersections identified to be approaching or below LOS D shall be a high priority for	Significant Unavoidable Impact.

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	funding. **TRAN-1B-b:** Circulation Element Policy C-1.8 shall be amended to state: C-1.8 "Development proposed in cities and surrounding jurisdictions shall be carefully reviewed to assess the proposed development's impact on the County's circulation system. The County, in consultation with TAMC and Monterey County cities, shall develop a Traffic Impact Fee that addresses impacts of development in cities and unincorporated areas on major County roads."	
Impact TRAN-1B: Development of the land uses allowed under the 2007 General Plan would create traffic increases on County and Regional roadways which would cause the LOS to exceed the LOS standard, or contribute traffic to County and Regional roads that exceed the LOS standard without development.	No mitigation is feasible.	2030 -- Significant Unavoidable Impact.
Impact TRAN 1-E: Growth in land uses allowed under the 2007 General Plan would result in inadequate emergency access.	**TRAN-1E:** Revise Safety Element S-4.27 on increasing roadway connectivity to enhance emergency access. S-4.27 The County shall continue to review the procedure for proposed development, including minor and major subdivisions, and provide for an optional pre-submittal meeting between the project applicant, planning staff, and fire officials. In addition, the County shall review Community Area and Rural Center Plans, and new development proposals for roadway connectivity that provides multiple routes for emergency response vehicles. At the time of their update, Community Area and Rural Center Plans shall identify primary and secondary response routes. Secondary response routes shall be required to accommodate through traffic and may be existing roads, or may be new roads required as part of development proposals. The emergency route and connectivity plans shall be coordinated with the appropriate Fire District.	2030 – Significant Unavoidable Impact.
Impact TRAN-2B: Development of the land uses allowed under the 2007 General Plan cumulatively with development in incorporated	No mitigation is feasible for County and Regional roadways	2030 – Cumulatively

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
cities and in adjacent counties would create traffic increases on County and Regional roadways which would cause the LOS to exceed the LOS D standard, or contribute traffic to County and Regional roads that exceed the LOS standard without development.	outside of the CVMP. **TRAN-2B:** Revise policies in the Carmel Valley Master Plan as follows: Policy CV-2.10. The following are policies regarding improvements to specific portions of Carmel Valley Road: a) Via Petra to Robinson Canyon Road. Every effort should be made to preserve its rural character by maintaining it as a 2-lane road with paved shoulders, passing lanes and left turn channelizations at intersections where warranted. b) Robinson Canyon Road to Laureles Grade. Every effort should be made to preserve its rural character by maintaining it as a 2-lane road with paved shoulders, passing lanes and left turn channelizations at intersections where warranted. c) Carmel Valley Road/Laureles Grade. A grade separation should be constructed at this location instead of a traffic signal. The grade separation needs to be constructed in a manner that minimizes impacts to the rural character of the road. An interim improvement of an all-way stop or stop signal is allowable during the period necessary to secure funding for the grade separation. d) Laureles Grade to Ford Road. Shoulder improvements and widening should be undertaken here and extended to Pilot Road, and include left turn channelization at intersections as warranted. e) East of Esquiline Road. Shoulder improvements should be undertaken at the sharper curves. Curves should be examined for spot realignment needs. f) Laureles Grade improvements. Improvements to Laureles Grade should consist of the construction of shoulder widening, spot realignments, passing lanes and/or paved turn-outs. Heavy vehicles should be	Considerable Impact (most of county).

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	discouraged from using this route. Policy CV-2.12: To accommodate existing and future traffic, the following road improvements are recommended: a) Add a northbound climbing lane between Rio Road and Carmel Valley Road; b) Laureles Grade - undertake shoulder improvements, widening and spot realignment; c) Carmel Valley Road, Robinson Canyon Road to Ford Road - add left turn channelization at all intersections. Shoulder improvements should be undertaken. Policy CV-2.18 : To implement traffic standards to provide adequate streets and highways in Carmel Valley, the County shall conduct and implement the following: a) Twice yearly monitoring by Public Works (in June and October) of peak hour traffic at the following 12 locations: ▪ Carmel Valley Road - ▪ East of Holman Road ▪ Holman Road to Esquiline Road ▪ Esquiline Road to Ford Road ▪ Ford Road to Laureles Grade ▪ Laureles Grade to Robinson Canyon Road ▪ Robinson Canyon Road to Schulte Road ▪ Schulte Road to Rancho San Carlos Road ▪ Rancho San Carlos Road to Rio Road ▪ Rio Road to Carmel Rancho Boulevard ▪ Carmel Rancho Boulevard to SR1 Other Locations - ▪ Carmel Rancho Boulevard between Carmel Valley Road and Rio Road	

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	▪ Rio Road between its eastern terminus and SR1 b) A yearly evaluation report (December) shall be prepared jointly by the Public Works and Planning Departments and shall evaluate the peak-hour level of service (LOS) for these 12 locations to indicate segments approaching a traffic volume which would lower levels of service below the LOS standards established below under CV 2-18(d). c) Public hearings shall be held in January immediately following a December report in (b) above in which only 100 or less peak hour trips remain before an unacceptable level of service (as defined by CV 2-18(d)) would be reached for any of the 12 segments described above. d) The traffic LOS standards (measured for peak hour conditions) for the CVMP Area shall be as follows: ▪ Signalized Intersections – LOS of “C” is the acceptable condition. ▪ Unsignalized Intersections – LOS of “F” or meeting of any traffic signal warrant are defined as unacceptable conditions ▪ Carmel Valley Road Segment Operations: ❑ LOS of “C” for Segments 1, 2, 8, 9, and 10 is an acceptable condition; ❑ LOS of “D” for Segments 3, 4, 5, 6, and 7 is an acceptable condition. During review of development applications which require a discretionary permit, if traffic analysis of the proposed project indicates that the project would result in traffic conditions that would exceed the standards described above in CV 2-18(d) after the analysis takes into consideration the Carmel Valley Traffic Improvement Program to be funded by the Carmel Valley Road Traffic Mitigation Fee, then approval of the	

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	project shall be conditioned on the prior (e.g. prior to project-generated traffic) construction of additional roadway improvements OR an Environmental Impact Report shall be prepared for the project. Such additional roadway improvements must be sufficient, when combined with the projects programmed in the Carmel Valley Traffic Improvement Program, to allow County to find that the affected roadway segments or intersections would meet the acceptable standard upon completion of the programmed plus additional improvements. This policy does not apply to the first single-family residence on a legal lot of record. Policy CV-2.19: Carmel Valley Traffic Improvement Program (CVTIP) a) The CVTIP shall include the following projects (unless a subsequent traffic analysis identifies that different projects are necessary to maintain the LOS standards in Policy CV-2.18(d): ▪ Left-turn channelization on Carmel Valley Road west of Ford Road; ▪ Shoulder widening on Carmel Valley Road between Laureles Grade and Ford Road; ▪ Paved turnouts, new signage, shoulder improvements, and spot realignments on Laureles Grade; ▪ Grade separation at Laureles Grade and Carmel Valley Road (an interim improvement of an all-way stop or stop signal is allowable during the period necessary to secure funding for the grade separation); ▪ Sight Distance Improvement at Dorris Road; ▪ Passing lanes in front of the proposed September Ranch development; ▪ Passing lanes opposite Garland Park;	

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	▪ Climbing Lane on Laureles Grade; ▪ Upgrade all new road improvements within Carmel Valley Road Corridor to Class 2 bike lanes; ▪ Passing lane (1/4 mile) between Schulte Road and Robinson Canyon Road; and ▪ Passing lane (1/4 mile) between Rancho San Carlos Rd and Schulte Road. b) The County shall adopt an updated fee program to fund the CVTIP. c) All projects within the CVMP area and within the "Expanded Area" that contribute to traffic within the CVMP area shall contribute fair-share traffic impact fees to fund necessary improvements identified in the CVTIP, as updated at the time of building permit issuance. d) Where conditions are projected to approach unacceptable conditions (as defined by the monitoring and standards described above under CV 2-18(d)), the CVTIP shall be updated to plan for and fund adequate improvements to maintain acceptable conditions.	
Impact TRAN-2E: Growth in land uses allowed under the 2007 General Plan, cumulatively with development in incorporated cities and adjacent counties, would result in inadequate emergency access.	No additional mitigation beyond 2007 General Plan policies and Mitigation Measure TRAN-1E (described above) is available.	2030 – Cumulatively Considerable Impact
Impact TRAN-3B: Buildout of the 2007 General Plan would increase traffic on County and Regional roadways which would cause the LOS to exceed the LOS D standard, or contribute traffic to County and Regional roads that exceed the LOS standard without development.	No additional mitigation beyond 2007 General Plan policies and Mitigation Measure TRAN-2B (described above) is feasible.	Buildout – Significant Unavoidable Impact.
Impact TRAN-3E: Buildout of the 2007 General Plan would result in inadequate emergency access.	No additional mitigation beyond 2007 General Plan policies and Mitigation Measure TRAN-1E (described above) is available.	Buildout – Significant Unavoidable Impact.

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
Impact TRAN-4B: Buildout of the 2007 General Plan cumulatively with development in incorporated cities and in adjacent counties would create traffic increases on County and Regional roadways which would cause the LOS to exceed the LOS D standard, or contribute traffic to County and Regional roads that exceed the LOS standard without development.	No additional mitigation beyond 2007 General Plan policies and Mitigation Measure TRAN-2B (described above) is feasible.	Buildout – Significant Unavoidable Impact.
Impact TRAN-4E: Buildout of the 2007 General Plan, cumulatively with development in incorporated cities and adjacent counties, would result in inadequate emergency access.	No additional mitigation beyond 2007 General Plan policies and Mitigation Measure TRAN-1E (described above) is available.	Buildout – Significant Unavoidable Impact.
4.7 Air Quality		
Impact AQ-1: Buildout of the 2007 General Plan would conflict with applicable Air Quality Management Plans and Standards.		
Impact AQ-3: Net Change in Ozone Precursor (ROG and NOx) and Particulate Matter.	**2030 and 2092 Mitigation** **CC-2 and CC-3.** See these measures under Climate Change, below. **AQ-3:** Implement MBUAPCD Mitigation Measures for Commercial, Industrial, and Institutional Land Uses **AQ-4:** Implement MBUAPCD Mitigation Measures for Residential Land Uses **AQ-5:** Implement MBUAPCD Mitigation Measures for Alternative Fuels	2030 –Significant Unavoidable Impact. Buildout – Significant Unavoidable Impact.
4.8 Noise		
	N-1: A new policy shall be added to the Noise Hazards section of the Safety Element that states the following: S-7.x All proposed discretionary residential projects that are within roadway noise contours of 60 CNEL or greater shall include a finding of consistency with the provisions of the Noise Hazards section of the Safety Element and, where appropriate, a project-specific noise impact analysis conducted before final approval. If impacts are identified, a "reasonable and	Less Than Significant Impact.

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	feasible" mitigation analysis shall be conducted using published Caltrans/Federal Highway Administration guidelines. Any mitigation measures meeting these tests shall be concurrently funded and constructed as part of the roadway improvement.	
	N-2: A new policy shall be added to the Noise Hazards section of the Safety Element that states the following: S-7.x All discretionary projects which propose to use heavy construction equipment within 50 feet of a residence, or pile drivers or blasting within 100 feet of a residence (or similar sensitive use) shall be required to submit a pre-construction vibration study prior to project approval. Any specified mitigation and monitoring shall be incorporated into construction contracts.	Less Than Significant Impact.
	N-3A: A new policy shall be added to the Noise Hazards section of the Safety Element that states the following: S-7.x No construction activities 500 feet of a noise sensitive land use during the evening hours of Monday through Saturday, or anytime on Sunday or holidays shall be allowed prior to completion of a noise mitigation study. Noise protection measures, in the event of any identified impact, may include: ▪ Constructing temporary barriers, ▪ Using quieter equipment than normal, or, ▪ Temporarily relocating affected persons (hotel vouchers).	Less Than Significant Impact.
	N-3B: A new policy shall be added to the Noise Hazards section of the Safety Element that states the following: S-7.x Standard noise protection measures shall be incorporated into all construction contracts. These measures shall include: ▪ Construction shall occur only during times allowed	

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	by ordinance/code unless such limits are waived for public convenience; ▪ All equipment shall have properly operating mufflers; and ▪ Lay-down yards and semi-stationary equipment such as pumps or generators shall be located as far from noise-sensitive land uses as practical.	
	No mitigation beyond the 2007 General Plan policies is required.	Less Than Significant Impact.
4.9 Biological Resources		
Impact BIO-1: Potential Adverse Impact on Special-Status Species. **[Also Cumulative Impact]**	*All Special Status Species – Program Level* **Mitigation Measure BIO-1.1:** Baseline Inventory of Landcover, Special Status Species Habitat, Sensitive Natural Communities, Riparian Habitat, and Wetlands in Monterey County **Mitigation Measure BIO-1.2:** Salinas Valley Conservation Plan to preserve habitat for the San Joaquin kit fox in the Salinas Valley *All Special Status Species – Project Level* **Mitigation Measure BIO-1.3:** Project Level Biological Survey and Avoidance, Minimization, and Compensation for Impacts to Non-Listed Special-Status Species and Sensitive Natural Communities. **Mitigation Measure BIO-1.4:** By 2030, prepare an Update to the General Plan to identify expansion of existing focused growth areas and/or to identify new focused growth areas to reduce loss of natural habitat in Monterey County. **Mitigation Measure BIO-1.5**: By 2030, prepare a Comprehensive County Natural Communities Conservation Plan.	2092 -- Significant Unavoidable Impact.
Impact BIO-2: Potential Adverse Effects on Sensitive Riparian Habitat, Other Sensitive Natural Communities and on Federal and State	**Mitigation Measure BIO-1.1, 1.2, 1.3, 1.4, and 1.5** as described above under Impacts to Special Status Species.	2092 - Significant

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
Jurisdictional Waters and Wetlands **[Also Cumulative Impact]**	**Mitigation Measures BIO-2.1, 2.2 and 2.3** as described above.	Unavoidable Impact.
4.11 Public Services and Utilities		
Impact PSU-8: Development and land use activities contemplated in the 2007 General Plan may result in a need for new solid waste facilities or non-compliance with waste diversion requirements. Future solid waste facilities would have a significant effect on the environment.	**2092** The County will add the following policy to the 2007 General Plan: Policy PS-5.5 The County will review its Solid Waste Management Plan on a 5-year basis and institute policies and programs as necessary to exceed the wastestream reduction requirements of the California Integrated Waste Management Act. The County will adopt requirements for wineries to undertake individual or joint composting programs to reduce the volume of their wastestream. Specific mitigation measures to reduce the impacts of future solid waste facilities are infeasible because the characteristics of those future facilities are unknown.	Buildout - Significant Unavoidable Impact.
4.12 Parks and Recreation		
	No mitigation beyond the 2007 General Plan policies is necessary.	Less Than Significant Impact.
	No mitigation beyond the 2007 General Plan policies is necessary.	Less Than Significant Impact.
4.13 Hazards and Hazardous Materials		
	No mitigation beyond the 2007 General Plan policies is necessary.	Less Than Significant Impact.
	No mitigation beyond the 2007 General Plan policies is necessary.	Less Than Significant Impact.
	No mitigation beyond the 2007 General Plan policies is necessary.	Less Than Significant Impact.
.	No mitigation beyond the 2007 General Plan policies is	Less Than

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	necessary.	Significant Impact.
4.14 Aesthetics, Light, and Glare		
Impact AES-1: Implementation of the 2007 General Plan would result in a substantial adverse effects on scenic vistas. **[Significant Cumulative Impact]**	No mitigation beyond the 2007 General Plan policies is available.	Significant Unavoidable Impact.
Impact AES-2: Implementation of the 2007 General Plan could result in the degradation of scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway. **[Significant Cumulative Impact]**	No mitigation beyond the 2007 General Plan policies is available.	Significant Unavoidable Impact.
Impact AES-3: Implementation of the 2007 General Plan would substantially degrade the existing visual character or quality of Monterey County. **[Also Cumulative Impact]**	No mitigation beyond the 2007 General Plan policies is available.	2030 - Significant Unavoidable Impact. Buildout - Significant Unavoidable Impact.
Impact AES-4: Implementation of the 2007 General Plan could create substantial new sources of light and glare that would adversely affect day or nighttime views in the area.	No mitigation beyond the 2007 General Plan policies is available.	2030 - Significant Unavoidable Impact. Buildout - Significant Unavoidable Impact.
4.15 Population and Housing		
Impact POP-1: Implementation of the 2007 General Plan would induce population growth in unincorporated Monterey County.	No feasible mitigation beyond the 2007 General Plan goals and policies is available.	2030 - Significant Unavoidable Impact. Buildout - Significant Unavoidable Impact.
4.16 Climate Change		
Impact CC-1: Development of the 2007 General Plan would contribute considerably to cumulative GHG emissions and global climate change as the County in 2020 would have GHG emissions greater than 72 percent of business as usual conditions. **(Cumulative Impact in 2092)**	**CC-11 (Same as BIO-1.9):** By 2030, prepare an Update to the General Plan to identify expansion of existing focused growth areas and/or to identify new focused growth areas to reduce loss of natural habitat in Monterey County and vehicle miles	Buildout - Cumulatively Considerable Impact.

Issues/Impacts	Mitigation Measures	Level of Significant after Mitigation
	traveled The County shall update the County General Plan by no later than January 1, 2030 and shall consider the potential to expand focused growth areas established by the 2007 General Plan and/or the designation of new focused growth areas. The purpose of such expanded/new focused growth areas would be to reduce the loss of natural habitat due to continued urban growth after 2030. The new/expanded growth areas shall be designed to accommodate at least 80% of the projected residential and commercial growth in the unincorporated County from 2030 to buildout. **CC-12**: Greenhouse Gas Reduction Plan Requirements Beyond 2030 In parallel with the development and adoption **of** the 2030 General Plan, Monterey County will develop and adopt a Greenhouse Gas Reduction Plan with a target to reduce 2050 GHG emissions by 80 percent relative to 1990 emissions. At a minimum, the Plan shall establish an inventory of current (2030) GHG emissions in the County of Monterey; forecast GHG emissions for 2050 for County operations and areas within the jurisdictional control of the County; identify methods to reduce GHG emissions; quantify the reductions in GHG emissions from the identified methods; identify requirements for monitoring and reporting of GHG emissions; establish a schedule of actions for implementation; and identify funding sources for implementation.	

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The California Hotspots Project: identifying regions of rapid diversification of mammals

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Abstract

The high rate of anthropogenic impact on natural systems mandates protection of the evolutionary processes that generate and sustain biological diversity. Environmental drivers of diversification include spatial heterogeneity of abiotic and biotic agents of divergent selection, features that suppress gene flow, and climatic or geological processes that open new niche space. To explore how well such proxies perform as surrogates for conservation planning, we need first to map areas with rapid diversification — 'evolutionary hotspots'. Here we combine estimates of range size and divergence time to map spatial patterns of neo-endemism for mammals of California, a global biodiversity hotspot. Neo-endemism is explored at two scales: (i) endemic species, weighted by the inverse of range size and mtDNA sequence divergence from sisters; and (ii) as a surrogate for spatial patterns of phenotypic divergence, endemic subspecies, again using inverse-weighting of range size. The species-level analysis revealed foci of narrowly endemic, young taxa in the central Sierra Nevada, northern and central coast, and Tehachapi and Peninsular Ranges. The subspecies endemism-richness analysis supported the last four areas as hotspots for diversification, but also highlighted additional coastal areas (Monterey to north of San Francisco Bay) and the Inyo Valley to the east. We suggest these hotspots reflect the major processes shaping mammal neo-endemism: steep environmental gradients, biotic admixture areas, and areas with recent geological/climate change. Anthropogenic changes to both environment and land use will have direct impacts on regions of rapid divergence. However, despite widespread changes to land cover in California, the majority of the hotspots identified here occur in areas with relatively intact ecological landscapes. The geographical scope of conserving evolutionary process is beyond the scale of any single agency or nongovernmental organization. Choosing which land to closely protect and/or purchase will always require close coordination between agencies.

Keywords: California, conservation, evolutionary hotspot, Mammalia, origination, speciation

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Introduction

The assessment of biodiversity pattern in order to prioritize areas for conservation has become an increasingly sophisticated science (Margules & Pressey 2000; Sarkar *et al*. 2006). However, given the rate of anthropogenic change in environments at all scales, it is clear that to sustain biological diversity we also need to protect the ecological and evolutionary *processes* that sustain and generate diversity (Frankel 1974; Smith *et al*. 1996; Cowling & Pressey 2001; Moritz 2002). This is a substantial challenge, as we ultimately need to identify the key processes for the system in question, and then the landscape and environmental surrogates with which to represent them spatially. In relation to evolutionary processes, emphasis has been placed on identifying regions that maintain rapid adaptive evolution, concentrations of historically isolated populations (i.e. phylogeographical lineages), or both. Mapping spatial patterns of phylogenetic diversity (PD; Faith 1992) has been the subject of much recent effort, the assumption being that areas that capture the maximum

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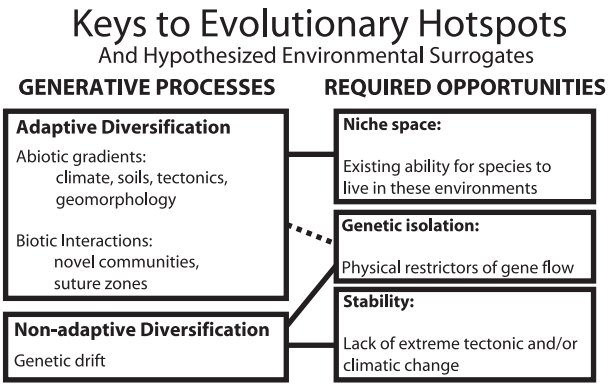

Fig. 1 Hypothesized relationship between physical environment and evolutionary landscape.

branch length for a given taxonomic group will also have the greatest trait diversity, and thus potential to respond evolutionarily to future environmental change (e.g. Forest *et al*. 2007). As a complement to the PD approach, we suggest that emphasis should be placed on protecting landscape features that promote rapid diversification, i.e. diversity potential (DP). Others (e.g. Erwin 1991) have argued for the protection of rapidly speciating clades; the difference here is the emphasis on environmental features rather than on specific taxonomic lineages. The best developed case to date concerns the diverse and rapidly evolving flora of the Cape Floristic Region of South Africa. For this biome, major environmental surrogates included edaphic, topographic, and macroclimate gradients, and emphasis was placed on identifying habitat corridors that will maintain capacity for migration and gene flow across such gradients (Cowling & Pressey 2001; Rouget *et al*. 2003, 2006). In another context, ecologically stable montane areas were identified as foci of recent speciation in African birds (Fjeldsa & Lovett 1997).

More generally, we can look to the large body of empirical and theoretical studies in evolutionary biology to identify the processes that promote rapid diversification (Fig. 1). Put simply, the key generative process is spatially heterogeneous, divergent selection. This can arise from heterogeneity in the abiotic environment (e.g. soils, climate), biotic interactions (e.g. sexual selection, Price 1998; co-evolutionary hotspots, Thompson 1999; suture zones, Remington 1968; Stebbins 1972; Rieseberg *et al*. 1999), or both. Nonadaptive divergence, through genetic drift in isolates, can also contribute to diversification, but is typically a more gradual process (Gavrilets 2003). Whether these generative processes translate into speciation depends on a number of factors. Genetic isolation, achieved through some form of assortative mating (Kirkpatrick & Ravigne 2002), most often geographical separation, facilitates adaptive modes of speciation and is essential for non-adaptive (i.e. drift) mechanisms. Nascent species also depend on available niche space if they are to persist, and this is most prevalent in novel environments as generated through geological or climatic change. Conversely, as nonadaptive diversification is typically a slow process, we expect to see concentrations of historically isolated populations in areas of environmental stability — especially Quaternary refugia (Moritz 2002). This schematic model (Fig. 1) provides a framework for interpreting observed patterns of endemism and for identifying environmental surrogates for evolutionary processes. Of course, the current geographical distributions of taxa are likely to differ from their distributions at the time of origination, but by focusing on young taxa with inferred recent divergence, we can begin to isolate the environmental conditions conducive to diversification. Observing coincident distributions of young taxa across several independently evolving lineages would add weight to this argument.

Our central aim here is to identify 'evolutionary hotspots' — geographical areas representing rapid diversification — within California, itself recognized as a globally significant hotspot of biological diversity (Myers *et al*. 2000). In this way, we can begin to prioritize areas of higher DP for conservation. California is well known for its high richness and endemism of species (e.g. 30% of 4839 plant species are endemic, as are 8% of the 804 vertebrate species; Stein *et al*. 2000). This, no doubt, reflects the extraordinary environmental heterogeneity of the region, combined with its dynamic geological and climatic history (Raven & Axelrod 1974; Jacobs *et al*. 2004). Previous studies on geographical patterns of endemism have focused on plants and identified divergent concentrations of palaeo- vs. neo-endemism (Stebbins & Major 1965; Raven & Axelrod 1978). Palaeo-endemic plants, identified as taxonomically remote lineages, tended to be concentrated in areas with moderate to high summer rainfall (i.e. the Siskiyou–Trinity Mountains of northern California, and the northern and eastern margin of the Colorado Desert in the south). Conversely, neo-endemic species — inferred as polyploid derivatives — were concentrated in areas with low summer rainfall and ecotones, e.g. the inner Coast Ranges. Thus, it was proposed that recent diversification of plants in California has been driven by the relatively recent (Plio–Pleistocene) development of a Mediterranean-type climate in the region. By contrast, for the fauna of California, scant attention has been given to patterns of species endemism *within* the state, although there have been prominent analyses of individual taxa (e.g. gophers, Patton & Smith 1990; salamanders, Wake 2006). However, state-wide analyses of comparative phylogeography have revealed congruent patterns in the distribution of historically isolated populations (Calsbeek *et al*. 2003; Lapointe & Rissler 2005), and highlighted areas of the state with high concentrations of narrowly endemic phylogeographical lineages (Rissler *et al*. 2006).

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Here, we focus on spatial patterns of endemism in the mammals of California. The state has a rich mammal fauna and also has the largest number of fully endemic species of any state within the USA (185 species, of which 18 are fully endemic; Stein *et al*. 2000). The fauna includes some taxa, such as pocket gophers (*Thomomys*, Patton & Smith 1990) that exhibit spectacular levels of geographical diversity and others with multiple narrowly distributed species (e.g. *Dipodomys* kangaroo rats, *Tamias* chipmunks).

In particular, and following Stebbins & Major (1965), our aim is to identify geographical areas with concentrations of neo-endemic taxa. We do this at two taxonomic scales. First, for species that are endemic or near-endemic (> 75% of range in California), we use molecular (mtDNA) phylogenies with dense sampling of congeners to estimate relative divergence times. Combined with fine-scale (1 km^2) estimates of distributions, we then map inverse range- and divergence-weighted endemism to locate geographical hotspots of recently diverged taxa. Second, for endemic or near-endemic subspecies, we use distributional information alone to estimate geographical patterns of inverse range-weighted richness. Subspecies, identified as morphologically differentiated yet intergrading sets of populations, have long attracted the attention of students of speciation because they often represent a stage of phenotypic diversification preceding full speciation (Grinnell 1928; Lidicker 1960; Mayr 1982; Patton & Smith 1990). Some have argued that such morphologically defined subspecies have limited utility for diversity analyses because they often do not correspond with historical subdivisions within species (Zink 2004; but see Phillimore & Owens 2006). However, in the context of our present study, which seeks to identify geographical foci of rapid diversification, it is exactly this emphasis on spatially bounded phenotypic differentiation that we wish to capture as a surrogate for adaptive divergence. Indeed, cases where strong morphological discontinuities are evident but genetic divergence is minimal are of particular interest as they attest to recent phenotypic evolution or to divergence in the face of ongoing gene flow.

Materials and methods

Molecular data for species-level analysis

Twenty-five species have > 75% of their geographical range in California (Hall 1981), and for all of these but one (*Ammospermopholis nelsoni*), there are published or unpublished mtDNA phylogenetic hypotheses with taxon sampling sufficient to allow estimation of sequence divergence from their respective sister group (Table 1). We obtained relevant sequence data — mostly cytochrome *b*, but also cytochrome subunits 1 or 3 in some cases — from GenBank and/or unpublished studies. Using MEGA version 3.1 (Kumar *et al*. 2004), sequences were aligned within each genus (using the CLUSTAL W plugin with default parameters and subsequent visual inspection). For taxa with multiple individuals sequenced, we estimated net Tamura–Nei (1993) (TN) distances to the sister taxon; otherwise, simple pairwise distance was calculated. Although there is likely to be some variation among lineages in mtDNA substitution rates, this will have little effect at low divergence levels (which receive the highest weight) and we have not attempted to correct for this here. For species sister to a larger clade, we recorded the average of the distances from the endemic to the members of its sister clade. Because one cannot generally identify which is the derived species, we included both sister taxa if they meet our criterion for endemism. The inverse of these TN distances were used as weights for the construction of maps of neoendemism; that is, all gridcells for a species' range were multiplied by 1/TN for that species. In this way, the ratios of genetic distances between species were preserved, but weights were applied so that shorter distances between sisters produced higher values.

Distribution data for species- and subspecies-level analyses

For each of the focal species (N = 25; Table 1) and subspecies (N = 133; Appendix I), we extracted point distribution data from the Museum of Vertebrate Zoology (MVZ) database. Much of the georeferencing of MVZ mammal data took place as a result of the Mammal Networked Information System (MaNIS) project (http://manisnet.org). We did not include the one species (*Urocyon littoralis*) and 13 subspecies endemic to one or more of the Channel Islands because their necessarily small ranges would have disrupted the range-weighted analyses of endemism across the continental area. This should not be taken to suggest that island taxa are not important for either the endemism of an area or for conservation of evolutionary processes.

Our analysis rests upon voucher-backed museum records. For both species and subspecies, occurrence data from the MVZ database (http://mvzarctos.berkeley.edu/) were downloaded after mapping (using BERKELEYMAPPER http://berkeleymapper.berkeley.edu/) to restrict records to those for which latitude and longitude coordinates were available. Prior to analysis, we used multiple approaches to detect and remove unreliable records. Geographical outliers, detected using BERKELEYMAPPER, were checked and either corrected (if obviously entry errors) or omitted. Records with maximum uncertainty estimates greater than 13.6 km (the 90th percentile for all localities) were removed from our data set. As a final test for our occurrence data, taxon records were checked for environmental outliers using DIVA-GIS (http://www.diva-gis.org/; annual temperature, annual precipitation, extreme quarters for temperature and

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Table 1 List of included mammal species, their Tamura–Nei distances to sisters, relevant publications, and model statistics

Scientific name	Tamura–Nei	Gene(s) used	Reference	Sister taxon/taxa	AUC	Kappa	Area	*n* for modelling
Sorex lyelli	0.017*	Cyt *b*	J.L.P. unpublished data	*S. preblei*	1.00	1.00	4498	30
Sorex ornatus	0.077	Cyt *b*	Demboski & Cook (2001)	*S. vagrans*	0.81	0.52	25521	52
Thomomys monticola	0.083	Cyt *b*	J.L.P. unpublished data; Spradling *et al*. (2004)	*T. talpoides*, *T. mazama*	0.96	0.86	72960	263
Chaetodipus californicus	0.098	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*C. arenarius*	0.79	0.48	150309	161
Dipodomys agilis	0.012	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*D. simulans*	0.95	0.78	74610	106
Dipodomys californicus	0.138	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*D. agilis*, *D. gravipes*, *D. heermanni*, *D. ingens*, *D. microps*, *D. panamintus*, *D. simulans*, *D. stephensi*, *D.venustus*	0.94	0.79	74610	176
Dipodomys heermanni	0.034	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*D. panamintus*	0.90	0.70	91403	12
Dipodomys ingens	0.145†	Cyt *b*	Alexander & Riddle (2005)	*D. microps*	0.95	0.89	9379	59
Dipodomys nitratoides	0.070	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*D. insularis*, *D. margaritae*, *D. merriami*	0.98	0.91	18516	87
Dipodomys panamintus	0.034	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*D. heermanni*	0.98	0.95	77665	10
Dipodomys stephensi	0.085‡	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*D. panamintus*, *D. heermanni*	0.92	0.81	4498.3	46
Dipodomys venustus	0.097	Cyt *b*	J.L.P. unpublished data; Alexander & Riddle (2005)	*D. agilis*, *D.simulans*	0.93	0.86	23786	318
Perognathus alticola	0.026[b]	Cyt *b* and CO3	Alexander & Riddle (2005)	*P. pavus* -Utah	0.97	0.96	2154	155
Perognathus inornatus	0.050	Cyt *b*	J.L.P. unpublished data	*P. longimemberis*	0.90	0.77	194450	7
Arborimus pomo	0.030	Cyt *b*	Bellinger *et al*. (2005)	*A. albipes*	0.98	0.93	29215	270
Microtus californicus	0.123[b]	Cyt *b*	Conroy & Cook (2000)	*M. mexicanus*	0.75	0.37	392395	75
Neotoma fuscipes	0.063	Cyt *b*	Matocq *et al*. (2007)	*N. macrotis*	0.80	0.54	230434	47
Peromyscus californicus	0.140§	CO3	Riddle *et al*. (2000)	*P. eremicus*, *P. eva*, *P. merriami*	0.84	0.56	97096	10
Reithrodontomys raviventris	0.149[b]	Cyt *b*	Arellano *et al*. (2005)	*R. montanus*	0.98	0.96	4325	138
Ammospermophilus nelsoni	N/A				0.97	0.86	12692	7
Spermophilus mojavensis	0.042[a]	Cyt *b*	Harrison *et al*. (2003)	*S. tereticaudus*	0.99	0.95	25521	56
Tamias alpinus	0.014	Cyt *b*	Rubidge personal communication; Piaggio & Spicer (2001)	*T. minimus*	0.99	0.97	9256	152
Tamias merriami	0.044	Cyt *b*	Rubidge personal communication; Piaggio & Spicer (2001)	*T. obscurus*	0.86	0.60	82497	55

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Table 1 *Continued*

Scientific name	Tamura–Nei	Gene(s) used	Reference	Sister taxon/taxa	AUC	Kappa	Area	*n* for modelling
Tamias ochrogenys	0.035	Cyt *b*	Rubidge personal communication; Piaggio & Spicer (2001)	*T. townsendii*	0.98	0.94	11193	46
Tamias quadrimaculatus	0.056	Cyt *b*	Rubidge personal communication; Piaggio & Spicer (2001)	*T. speciosus*	0.97	0.94	35419	22
Tamias senex	0.033¶	Cyt *b*	Rubidge personal communication; Piaggio & Spicer (2001)	*T. ochrogenys*, *T. sonomae*, *T. townsendi*	1.00	0.98	89644	119
Tamias sonomae	0.025	Cyt *b*	Rubidge personal communication; Piaggio & Spicer (2001)	*T. senex*	0.97	0.87	52384	219
Tamias speciosus	0.049	Cyt *b*	Rubidge personal communication; Piaggio & Spicer (2001)	*T. aplinus*, *T. minimus*, *T. panamintinus*	0.95	0.84	50387	178

*Two individuals for each species.
†Pairwise distances between individuals.
‡One individual of *D. stephensi*, but net distance to other spp.
§One individual of *P. merriami*, but net distance to other spp.
¶Paraphyly of *T. senex* suggests it is actually a palaeoendemic ancestor of *T. townsendi*, *T. ochrogenys*, and *T. sonomae*.

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precipitation) and cut at the 25th percentile. For the remaining data, all duplicate localities were deleted. Taxa with fewer than five records were not included in our species level analysis and were not modelled for subspecies (see section on niche modelling for their treatment).

Environmental data, niche modelling and range inference

To generate the fine-scale (1 km^2) estimates of species distribution necessary for subsequent analyses, we used a hybrid approach, combining species distribution models generated from presence records with estimates of range boundaries inferred from expert range maps and/or buffered points (Graham & Hijmans 2006). Given its strong performance in tests using presence-only records (Elith *et al*. 2006), we used maximum entropy distribution modelling (MaxEnt; Phillips *et al*. 2006) to estimate geographical ranges from the occurrence data. Twenty environmental variables were used in the initial modelling, all at 1 km resolution and clipped to a bounding box for our analysis (53.70001N and 19.23334S latitudes; –137.87076W and –94.92090E longitudes). Standard bioclimatic variables for temperature and precipitation were used, derived from the global data set Worldclim (Hijmans *et al*. 2005) with the addition of altitude (SRTM 30 arc second, *c*. 1 km resolution).

To model species distributions for each species and subspecies, we used MaxEnt 2.3 (Phillips *et al*. 2006) with the following options: jackknife, 25% testing, remove duplicates. Receiver operating characteristic (ROC) curves, area under curve (AUC) and Kappa values were calculated to evaluate model performance. To minimize overprediction, we cut predicted species ranges using a combination of established range maps from NatureServe (Patterson *et al*. 2005) and 10 km buffers around the MVZ point data. We kept all probability information from MaxEnt, to provide additional precision to our maps of endemism. For the subspecies data, we cut the predictions using a combination of 100 km buffers around minimum convex polygons built on the original point data and a probability threshold for each taxon that maximized Kappa; the latter preventing range estimates from overpredicting within the 100-km buffer. Eight of the 133 subspecies with $n < 7$ geographically unique records had environmental outliers included to increase sample size (Appendix I). Seven subspecies had ranges too small to provide the geographical sampling required for this method of range estimation. For these taxa (Appendix I), we estimated presence–absence distributions based on both the confirmed location of MVZ specimens and the field experience of J.L.P.

Compilation of endemism maps

We were able to construct four types of endemism maps from species ranges and two from subspecies ranges. All included the MaxEnt probability surface to put more weight on cells with high levels of predicted occurrence. The first is simple richness, i.e. the number of species or subspecies in each 1 km grid cell. The second is richness weighted by the inverse of range size in km^2, normalized by the taxon with the smallest area (cf. Williams *et al*. 1993). Normalizing by the smallest area restricts the weight values to the range [0–1] and removes the effect of units on the values of map cells. These 'richness endemism' maps emphasize areas with concentrations of geographically restricted endemic taxa and have a direct relationship to complementary — a key driver in systematic conservation planning (Kier & Barthlott 2001). For species only, we then produced two additional types of endemism maps, richness weighted by the inverse of sequence divergence (neo-endemism) and richness weighted by both the inverse of sequence divergence and the inverse of taxon area (neo-endemism richness). The inverse sequence divergence values are normalized to the shortest distance, again confining the values to the range [0–1].

Results

Estimation of geographical ranges

In general, we were able to obtain robust estimates of distribution from the filtered point occurrence data (Table 1). For the species models, AUC averages 0.93 ± 0.07 (± SD) and kappa values average 0.81 ± 0.18. *Microtus californicus* has the lowest AUC (0.75) and kappa (0.37). *Sorex lyelli* has the highest AUC (1.00) and kappa (1.00). For MaxEnt models of subspecies, the AUC averages 0.95 ± 0.055 and kappa values average 0.86 ± 0.131. Several subspecies have AUC and kappa values at or near 1, as a consequence of the small number of training and testing points available. These subspecies have known attenuated ranges, so we have included them in our analysis despite their artificially high statistics. *Lepus californicus bennettii* has the lowest AUC (0.69) and kappa (0.32) of the subspecies. Of course, the seven restricted-range subspecies based on expert-opinion maps have no AUC or kappa values.

The estimated geographical areas for California endemic species (Table 1) are log-normally distributed, with a mean of 78 928 km^2 and a standard deviation of 91 615 km^2. The species with the largest distribution is *M californicus* (392 394 km^2) and the species with the smallest distribution is *Perognathus alticolus* (2154 km^2). The geographical areas for subspecies (Appendix I) are log-normally distributed, with a mean of 34 274 km^2 and a standard deviation of 36 342. The subspecies with the largest distribution is *Canis latrans ochropus* (172 493 km^2) and the MaxEnt-modelled subspecies with the smallest distribution is *Microtus californicus halophilus* (317 km^2). The seven subspecies with so few records that we used expert maps rather than

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modelling had estimated ranges of between 6 km² (*Perognathus alticolus alticolus*) and 856 km² (*Sorex ornatus relictus*) (Appendix I).

Sequence divergence of endemic species

We were able to estimate mtDNA sequence divergence for 27 of the 28 mammal species endemic or near-endemic to California, the exception being *Ammospermophilus nelsoni*. Using net sequence divergence for 23 taxa and simple pairwise divergence for the four taxa for which only single individuals have been sequenced (Table 1), divergence values between the endemic species and their sister taxa are log-normally distributed, with a mean of 0.066 and a standard deviation of 0.043. *Dipodomys agilis* has the shortest TN distance, 0.012, and *Reithrodontomys raviventris* has the longest distance, 0.149. The two most speciose genera in our analysis, *Dipodomys* and *Tamias*, show contrasting evolutionary histories of diversification; *Dipodomys* has consistently longer branch lengths (mean = 0.08), whereas the Californian endemic species of *Tamias* have much lower sequence divergence to their sister groups (mean = 0.04), and thus contribute much more strongly to patterns of neo-endemism (see below). There is no relationship between TN distance and geographical area ($r = 0.20$, $P = 0.30$) or log area ($r = 0.08$, $P = 0.69$).

Mapping of species level diversity

Species richness. Geographical richness for the 28 species of mammals regarded as endemic or near-endemic to California (Fig. 2A) is highest across the central and southern Coast Ranges and adjacent montane regions — the Tehachapi, Transverse and Peninsular Ranges. To a large extent, this pattern of higher richness to the west of the study area is to be expected given the selection of endemic and near-endemic species. Five widely ranging endemic species occur across most of this high richness area (*M. californicus*, *S. ornatus*, *Tamias merriami*, *Chaetodipus californicus*, *Peromyscus californicus*). Individual subsets of this area of high richness are each supported by at least one taxon restricted to that area (Appendix II). *R. raviventris* contributes only to the San Francisco (SF) Bay Area subregion; *A. nelsoni*, *Dipodomys ingens*, and *Dipodomys nitratoides* only to the intersection of the San Joaquin Valley (southern Central Valley in Fig. 2A) and the southern Coast Range; *P. alticolus* only to the Tehachapi and Transverse Ranges; and *Dipodomys stephensi* only to the Peninsular Range.

Endemism richness. Weighting of the selected species by the inverse of range size (Table 1) highlights six hotspots with concentrations of narrowly distributed taxa: the SF Bay Area, the southwestern San Joaquin Valley, a narrow montane band connecting the Tehachapi and Inner Coast Ranges, the Peninsular Ranges, the central Sierra Nevada, and the North Coast (Fig. 2B, Appendix II). For each of these areas, there are particular species that dominate the endemism-richness analysis. The SF Bay Area is highlighted because of *R. raviventris*, which is restricted to the salt marshes around the bay. For the southwestern San Joaquin Valley, *D. ingens* dominates the signal, but *A. nelsoni* and *D. nitratoides* reinforce it. The Tehachapi and San Bernardino Ranges are highlighted by *P. alticolus* alone, the species with the smallest geographical range in our analysis. The Peninsular Range hotspot, centred on the San Jacinto Valley, is driven by *D. stephensi*. The central Sierra Nevada hotspot, which was not evident from patterns of species richness alone (cf. Fig. 2A, B), is driven by two restricted range species — *S. lyelli* and *Tamias alpinus*. The northern Coast Ranges, unlike the other hotspots, depend on the co-occurrence of several medium-ranged species rather than one or two very restricted species, these being *Tamias ochrogenys*, *Arborimus pomo* and *Tamias sonomae* and, to a lesser extent, *Dipodomys californicus*.

Neo-endemism. Weighting of species occurrences by the inverse of sequence divergence (Fig. 2C) accentuated the Central Coast, Tehachapi, Transverse, and Peninsular Ranges, along with the central and southern Sierra Nevada. This reflects the presence of relatively recently evolved species in each area; these are *D. agilis*, *D. panamintus*, *P. alticolus*, *T. merriami*, and *Tamias speciosus* for the Tehachapi, Transverse, and Peninsular Ranges; and *S. lyelli* and *T. alpinus* for the central Sierra Nevada (Table 1, Appendix II). When species are weighted by the inverse of both sequence divergence and geographical range (i.e. neo-endemism richness), five hotspots are apparent: the Tehachapis, the San Bernardino Mountains in the Transverse Ranges, San Jacinto Valley within the Peninsular Ranges, the central Sierra Nevada, and the northern Coast Ranges (Fig. 2D). As for the endemism-richness analyses, the Tehachapi, San Bernadino, San Jacinto Valley, and central Sierra Nevada hotspots are driven by a small number of species. The Tehachapi hotspot is driven by *P. alticolus*, but *D. agilis, T. merriami,* and *T. speciosus*, all species ranging into the Tehachapis from other regions, add support. The hotspot in the San Bernardino Mountains reflects the southernmost disjunct population of *P. alticolus*, which may be already extirpated (Williams 1986). The San Jacinto Valley hotspot reflects the distribution of *D. stephensi*. The central Sierra Nevada hotspot is dominated by *S. lyelli* and *T. alpinus*, both species with restricted ranges and short branch lengths, and is reinforced by the wide-ranging, but recently evolved *T. speciosus.* The contrast between the central Coast Ranges and the adjacent western San Joaquin Valley is instructive. The latter was strongly represented in the endemism-richness analysis because of the presence of

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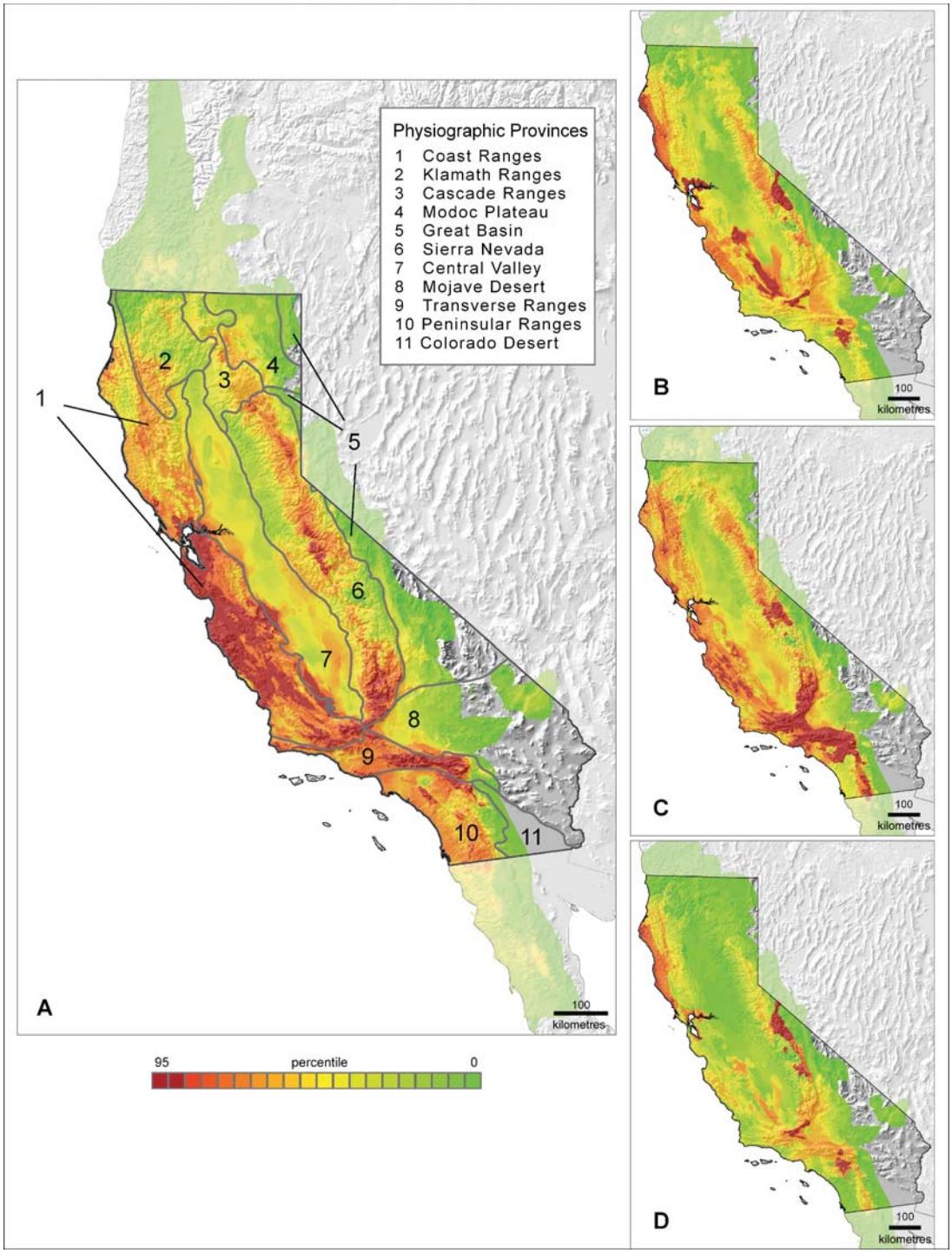

Fig. 2 Species-level maps of mammalian endemism. (A) Unweighted richness with physiographic provinces. (B) Endemism-richness (weighted by area^{-1}). (C) Neo-endemism (weighted by TN depth^{-1}). (D) Neo-endemism richness (weighted by area^{-1} and TN depth^{-1}).

narrowly distributed species of *Dipodomys* (*D. ingens* and *D. nitratoides*), but these show large to moderate sequence divergence from their sister taxa (genetic data are lacking for the third species relevant to this area — *A. nelsoni*). By contrast, the central Coast Ranges have higher values than the San Joaquin Valley in the neo-endemism analysis, supported by the overlap of several wide-ranging, recently diverged species: *Dipodomys heermani*, *Perognathus inornatus* and *T. merriami*. These two contrasting patterns cancel out in the neo-endemism richness analysis, leaving

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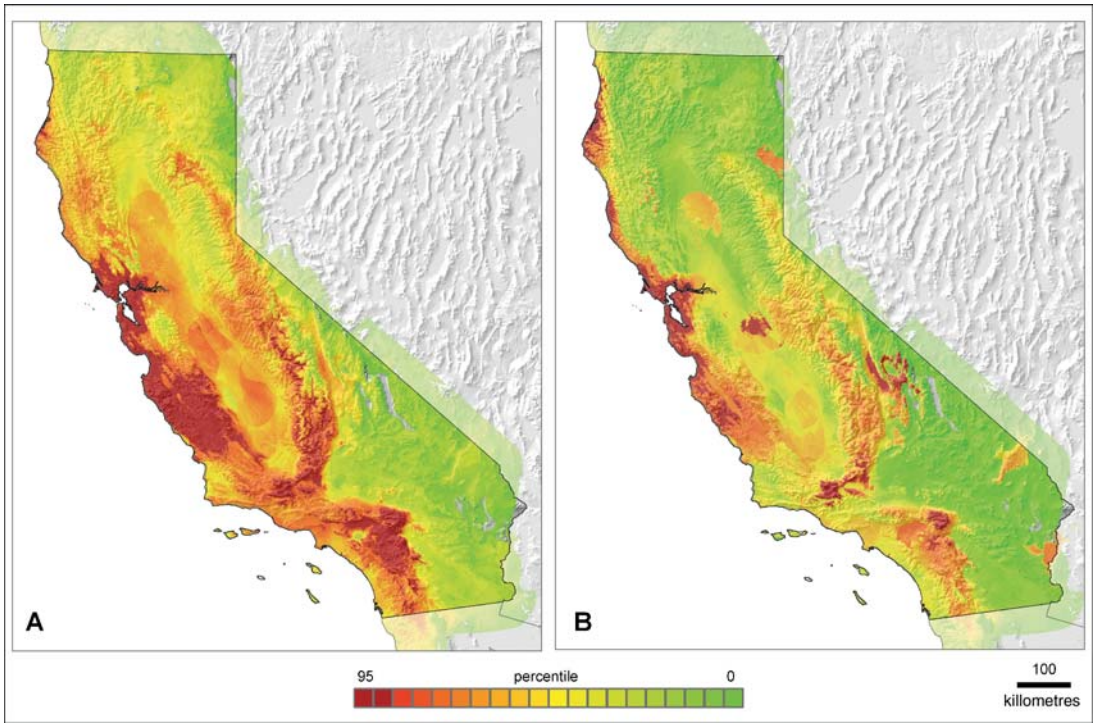

Fig. 3 Subspecies-level maps of mammalian endemism. (A) Unweighted richness. (B) Endemism richness (weighted by area^{-1}).

no hotspots in the central coast and San Joaquin Valley. The neo-endemism richness hotspot of the northern coast is dominated by *T. ochrogenys* and *A. pomo*. As with the endemism-richness analysis, this hotspot is created by several medium-value taxa co-occurring and not a single, small-ranged short-branched species. *R. raviventris*, important to making the SF Bay Area a hotspot in the richness and endemism-richness analyses, is deemphasized in the neo-endemism and neo-endemism richness analyses because of its relatively long branch length.

Mapping of subspecies endemism

As for species, the maximum richness of subspecies endemic to California is along the central coast from the San Francisco Bay Area, south through the Santa Lucias and inner Coast Ranges, the Tehachapi, Transverse, and Peninsular Ranges, and the central to southern Sierra Nevada (Fig. 3A). When subspecies are weighted the inverse of geographical range size (i.e. subspecies endemism-richness; Fig. 3B), several hotspots of phenotypic differentiation emerge. There are multiple hotspots along the Coast Ranges; two in the northern Coast Range, one in the SF Bay Area, and one in the central Coast. As for the species-level analyses, hotspots are evident in the Tehachapi and San Bernardino Ranges. Unique to the subspecies analysis are additional foci of differentiation in the Owens Valley area (east of the southern Sierra Nevada), and in the Central Valley on the San Joaquin River. These hotspots break down into those dominated by a single, small-ranging taxon, those driven by multiple small-ranging taxa, and those supported by a large number of medium-ranged taxa (Appendix I). The two hotspots dominated by a single subspecies are those in the Central Valley and the more southerly region of the northern Coast Range. The remaining hotspots, save one, are driven by several smaller-ranging taxa, ranging between 13% and 36% of the subspecies present (Appendix I). The last hotspot is the one in the central Coast Ranges area, running along the Santa Lucia Range; this hotspot is supported by 14 of the 28 subspecies present, a very different pattern from all of the others.

Discussion

Limitations of analysis

Our primary goal here was to identify geographical regions that represent foci of recent divergent evolution of mammals in California, and so inform future identification of environmental surrogates for evolutionary hotspots (e.g. Fig. 1) and planning for conservation initiatives. Before discussing the results themselves, we highlight some limitations inherent to such analyses. One potential limitation is with the quality of range information for individual taxa. All records used were backed by voucher

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specimens (in the MVZ), so that we can have confidence in their taxonomic identification, and georeferencing has been done to modern standards (Wieczorek *et al*. 2004). Nonetheless, some potential errors were detected by outlier analysis and these records were omitted. Following Graham & Hijmans (2006), we used a hybrid approach that intersects modelled ranges with range maps to provide the best possible, high-resolution estimates of distribution.

The use of mtDNA sequence divergence as a surrogate for relative divergence time is a second limitation of this study. Even allowing for the assumption of uniform rates of sequence divergence, any such single gene estimates of divergence time are prone to error because of unquantified differences between times of gene-coalescence and lineage-divergence (Edwards & Beerli 2000). Typically, we estimated net sequence divergence which should, to some extent, correct for the differences between the two (Wilson *et al*. 1985), but we acknowledge that in many cases we may be overestimating true divergence time. On the other hand, if there has been introgression of mtDNA among species, as proposed for some of these genera (e.g. Rocky Mountain *Tamias*, Good *et al*. 2003), then lineage divergence time will be underestimated. Collectively, we expect that the combined sources of error will add noise, rather than bias. More precise estimates of divergence time could, of course, be obtained using multilocus estimates and coalescent methods (e.g. Hey & Nielsen 2004), but those are beyond the scope of the present analysis.

The final area of potential concern is whether subspecies have been delineated using consistent criteria. While this might be a problem in general, much of the present taxonomy for Californian mammals has common roots in the work of Grinnell and his intellectual descendents, and so is reasonably consistent in approach. For example, of the taxa with the largest numbers of described subspecies, the current subspecies of chipmunks ($N = 12$ Californian taxa) were reviewed systematically by Johnson (1943), *Dipodomys* ($N = 20$) by Grinnell (1922) and Lidicker (1960) and *Chaetodipus* ($N = 10$ taxa) by Benson (1933). By far, the most problematic group, gophers of the *Thomomys bottae* group, were examined in detail by Patton & Smith (1990) using a philosophy similar to that of Grinnell, but with much richer data and improved analytical methods, resulting in a reduction of the number of recognized subspecies within California from 46 to 15.

Identification and implications of hotspots

Although there is some disagreement in the details, all of the analyses (Figs 2–4) indicate that California contains several hotspots of endemism. The concentration of richness of Californian endemic or near-endemic species along coastal areas and associated mountain ranges likely reflects the geographical criteria for taxon-selection, and we do not ascribe any special significance to it. Within this area, five hotspots are supported by both the neo-endemism analysis of species and endemism-richness of subspecies: the Tehachapi Ranges, the San Bernardino Range, at Bodega Bay on the north coast, parts of the Santa Cruz Mountains and the Santa Lucia Range of the central coast, northeastern Transverse and Tehachapi Ranges east to the Piute Mountains, and the San Bernardino Range into the San Jacinto Valley (Fig. 4). Beyond these, the analyses of species and subspecies reveal geographically distinct foci of recent diversification. The former exhibit a unique concentration of neo-endemism in the central Sierra Nevada, whereas the latter show hotpots of endemism in the north coast, San Francisco Bay Area and the Owens Valley to the east (Fig. 4).

The observed hotspots are generated by two patterns. The first of these patterns is a hotspot created by high species richness in an area where many taxa of medium range size or divergence intersect. In particular, the patterns across most of the California coast, except for the SF Bay Area, fit this profile, since the coastal and Coast Range hotspots are never dominated by a single species or subspecies.

The area of the Central Coast and southern Coast Ranges are of particular interest to scholars of California endemism, since they were highlighted by the seminal work of Stebbins & Major (1965) as containing hotspots of neo-endemism in vascular plants. On the whole, our results agree with theirs, but ours suggest more of a concentration of neo-endemic species and a concentration of narrow-range subspecies on the western, coastal side of the region. By contrast, plant neo-endemism was concentrated in the inner Coast Range, approaching the Central Valley, leading Stebbins & Major (1965) to suggest that the change to the summer-dry Mediterranean climate through the Pleistocene had triggered this evolution. The mammal species of the inner Coast Range to Central Valley area tend to have longer branch lengths and smaller ranges than those on the western side, which creates a reversal from the endemism-richness to the neo-endemism maps. These species on the eastern edge of the region, several *Dipodomys* and *Ammospermophilus nelsoni*, are adapted for the arid conditions Stebbins & Major (1965) suggest are the driver of plant neo-endemism, and the substantial molecular divergence of the *Dipodomys* species suggest relatively old (perhaps Pliocene) diversification, which would link them to the Late Miocene change to summer-dry conditions. The concentration of recent speciation and phenotypic diversification in the southern Coast Range occurs in a region that, while tectonically active, may have been more environmentally stable than the interior, which contained expanded wetlands and riparian corridors in the Central Valley and permanent glaciers in the Sierra Nevada as recently as 10 000 years ago (Jacobs *et al*. 2004). This correlation of neo-endemism and stability fits with the observations of

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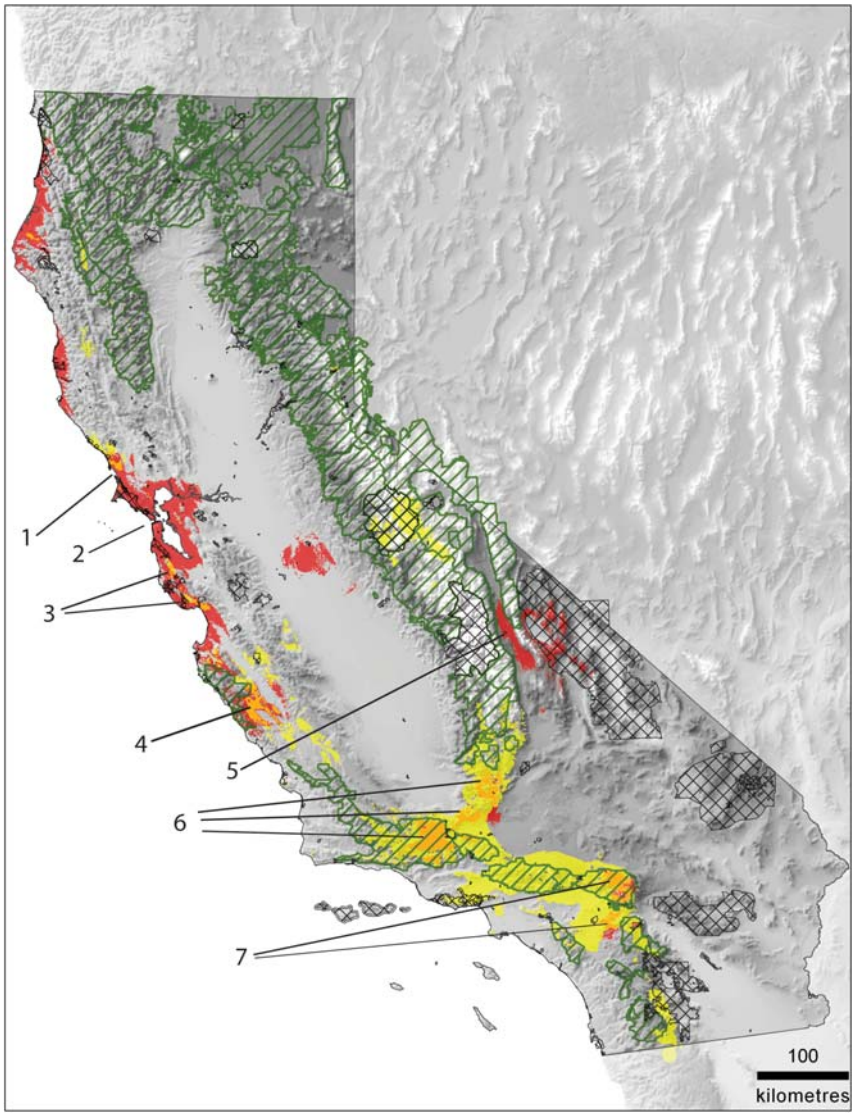

Fig. 4 Mammalian evolutionary hotspots shown in relationship with protected areas. Red areas are above the 90th percentile for subspecies endemism richness; yellow are above the 90th percentile for species neo-endemism richness; orange are areas of overlap between species and subspecies hotspots. Black cross-hatches indicate State and National Parks; green hatches show National Forests. Numbered geographical features are: 1, Bodega Bay; 2, San Francisco Bay; 3, Santa Cruz Mountains; 4, Santa Lucia Range; 5, Owens Valley; 6, northeastern Transverse, Tehachapi Ranges, and Piute Mountains; 7, San Bernardino Range and San Jacinto Valley.

Fjeldsa & Lovett (1997), who found a similar pattern in species of birds and plants in tropical Africa. Stability and steep environmental gradients are two of our suggested drivers of evolutionary process (Fig. 1), and the coincidence of these two factors in this area of elevated neo-endemism provides qualitative support to use them as environmental proxies for evolutionary hotspots.

The north coast and northern Coast Ranges show a high degree of neo-endemism, as measured using subspecies endemism-richness (Fig. 4). Species level neo-endemism is consistently elevated across these northern ranges from coast to Central Valley (although most often at less than the 90th percentile illustrated in Fig. 4), but the subspecies endemism-richness is much more localized on the coast, again suggesting the importance of steep environmental gradients towards the equitable coastal climate.

The other major pattern revealed by our analyses is that of a hotspot dominated by one or two small-ranged and/or short-branched taxa. The best example is the SF Bay Area, which is dominant in both the species- and subspecies-level endemism-richness analyses. The SF Bay Area has already been implicated as a contributor to evolutionary change because of its central location as an aquatic barrier to dispersal (Hooper 1940, 1944). The area is home to a large number of endemic subspecies, such as the salt marsh endemic of *Microtus californicus* described by Thaeler (1961), and one very prominent endemic species, *Reithrodontomys raviventris*, which has two subspecies around the bay, documented by Dixon (1909). In the maps of both species and subspecies endemism-richness, *R. raviventris* contributes most of the weight that makes the SF Bay Area a hotspot, but its long branch-length down-weights it in the neo-endemism analyses to the point that the SF Bay Area is

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no longer highlighted. The long branch of *R. raviventris* illustrates the complementarity between analyses of species-level neo-endemism and endemism-richness of subspecies; its highly divergent sister taxon, *Reithrodontomys montanus*, is only found in the Great Plains, yet *R. raviventris* does have two subspecies in the SF Bay Area, which suggests that local differentiation may be recent and/or ongoing. The subspecies endemism-richness data show that the SF Bay Area hotspot is supported by a variety of small-ranging subspecies, two of which belong to species that are not considered California endemics in our species-level analysis (Appendix I).

By contrast, the Tehachapi hotspot of the endemism-richness and neo-endemism seems at first to rely almost exclusively on the small, recently diverged *Perognathus alticolus*, but this is something of an illusion. Examination of the subspecies data indicates that this area is still important, even when the relative size of the range of *P. alticolus* is tempered by the many other small-ranged subspecies included in the analysis. In fact, the coincidence of so many endemic subspecies in the Transverse and Tehachapi Ranges and immediately adjacent Coast Range was noted long ago by Kellogg (1918) in his revision of *M. californicus*. The reason why this region continues to be highlighted is because it represents a crossroads of sorts between the other major regions of California: the Sierra Nevada, the Coast Ranges, the Central Valley, and the deserts of the southeast. Many species have ranges that extend from these areas into the Transverse Ranges, and it is the conjunction of these ranges (as can be seen even in the unweighted species richness map, Fig. 2A) that makes the area important. Evolutionary processes in the Transverse/Tehachapi Ranges are probably dominated by both the environmental gradients in this transitional area and by the complex biotic interactions among the populations there; as outlined in the Introduction (Fig. 1), interactions with other species can be as important for origination as interactions with the physical environment.

The hotspots in the central Sierra Nevada and the Owens Valley and adjacent ranges to the east are also created by a small number of dominant taxa. The central Sierra Nevada hotspot stems from a few recently diverged small mammals that are adapted to alpine habitats, most prominently *Tamias alpinus* and *Sorex lyelli*. It may be that the neo-endemism here is related to steep environmental gradients and open niche space concomitant with postglacial colonization (Fig. 1). The Owens Valley hotspot may reflect analogous evolutionary processes. The subspecies involved in this hotspot are extreme southern members of cool- and dry-climate adapted species from the Great Basin. The ongoing topographic evolution of Owens Valley (Pinter & Keller 1995) and the surrounding areas, coupled with the environmental gradient from the cooler northern Great Basin desert through this area to the much warmer Mojave Desert to the south, may have produced the concentration of small-ranged subspecies here.

The last small-range dominated hotspot, the hotspot of the Central Valley, is evident only from the subspecies data, since the species distributed in the Central Valley are all too widely ranging and too old to be regarded as neo-endemics. This hotspot may be associated with Pleistocene climate change, but it more likely reflects human-mediated habitat change, since the Central Valley was already highly impacted before the beginning of MVZ specimen collecting in the early 20th century. Note that many of these subspecies are riparian — a habitat type that has been highly impacted by land-cover change.

Implications for conservation in human-altered environments

Conservation priorities should be set with respect to diverse kinds of organisms, so our results for mammals alone (Fig. 4) should not be considered as representative of neo-endemism patterns for the California biota. We are currently pursuing a broader perspective, collaborating with others to analyse information concerning amphibians, reptiles and vascular plants endemic to California. Further, given that vertebrates and plants can be poor surrogates for invertebrates (e.g. Moritz *et al*. 2001), the analyses should be extended to the latter as information on species distributions and evolutionary processes accumulates (e.g. Caterino 2006; Gompert *et al*. 2006; Starrett & Hedin 2007; Vandergast *et al*. 2007). All of these kinds of organisms can be expected to respond to evolutionary processes with distinct geographical scales and environmental drivers. The ultimate goal is to synthesize across these groups to better understand how and where to protect evolutionary processes that can benefit the biological landscape as a whole.

Human modifications of ecological systems, whether through introduced species, land-cover change, or climate change, are likely to alter spatial patterns of natural selection and gene flow. Substantial areas of California have been impacted by a combination of urbanization and agriculture (FRAP 2003) and effects on biological systems of global warming are already evident (e.g. Inouye *et al*. 2000; Epps *et al*. 2004; Millar *et al*. 2004). Yet, many of the hotspots of recent evolution identified for mammals (Fig. 4) occur in relatively intact ecological landscapes. To protect interplay of selection and attenuated gene flow that promotes diversification (Endler 1977; Gavrilets 2003) will require protection of ecologically heterogeneous landscapes, with patch sizes that are at least an order of magnitude larger than per-generation dispersal distances of the taxa in question. The spatial scale of our results agrees with those of previous workers, emphasizing the large geographical scale needed to protect both isolated populations and especially to protect the sorts of environmental

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gradients we invoke as drivers of evolutionary processes (cf. Rouget *et al*. 2003). The geographical scope of this sort of conservation is beyond the scale any single agency or nongovernmental organization can administer. Already some 50% of California lands are federally managed (Fig. 4), but choosing which of those lands to closely protect and which new lands to protect requires careful coordination in conservation planning between agencies and a unified set of conservation priorities. To judge from these results for mammals, important areas in need of coordinated conservation effort include the Tehachapi Range, the Santa Lucia Range of the central coast, and areas along the northern coast of California (Fig. 4). The San Francisco Bay Area is similarly important, but the large urban population there serves to both prevent additional acquisition of natural land for conservation and an intense interest in conservation efforts in currently protected lands.

Another important aim for evolutionary conservation is to produce a quantitative model for evolutionary rates at the landscape scale, building on both the theoretical framework developed over 150 years of evolutionary thought and empirical observations of centres of rapid evolution (Fig. 1). Further development and validation of this model would allow conservation planners to translate geographical data about important environmental conditions (e.g. temperature or precipitation gradients, topographic or edaphic complexity, major boundaries between ecoregions, environmental stability) into maps that highlight areas with high diversity potential. Applying a model of DP to a range of scenarios of future climate and land use changes would allow policy makers to judge which areas could be relied upon to be consistently important for future biodiversity. In such a way, it will be possible to make evolutionary process part of the conservation policy toolkit, adding it as a complement to the existing approaches that prioritize protecting existing taxa and ecological communities.

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References

Alexander LF, Riddle BR (2005) Phylogenetics of the new world rodent family heteromyidae. *Journal of Mammalogy*, **86**, 366–379.

Arellano E, González-Cozátl FX, Rogers DS (2005) Molecular systematics of middle American harvest mice *Reithrodontomys* (Muridae), estimated from mitochondrial cytochrome *b* gene sequences. *Molecular Phylogenetics and Evolution*, **37**, 529–540.

Bellinger MR, Haig SM, Forsman ED, Mullins TD (2005) Taxonomic relationships among *Phenacomys* voles as inferred by cytochrome *b*. *Journal of Mammalogy*, **86**, 201–210.

Benson SB (1933) *Concealing coloration among some desert rodents of the southwestern United States*. Dissertation, University of California, Berkeley, California.

Calsbeek R, Thompson JN, Richardson JE (2003) Patterns of molecular evolution and diversification in a biodiversity hotspot: the California Floristic Province. *Molecular Ecology*, **12**, 1021–1029.

Caterino MS (2006) California beetle faunistics: 100 years after Fall. *Coleopterists Bulletin*, **60**, 177–191.

Conroy CJ, Cook JA (2000) Molecular systematic of a Holarctic rodent (*Microtus*: Muridae). *Journal of Mammalogy*, **81**, 344–359.

Cowling RM, Pressey RL (2001) Rapid plant diversification: planning for an evolutionary future. *Proceedings of the National Academy of Sciences, USA*, **98**, 5452–5457.

Demboski JR, Cook JA (2001) Phylogeography of the dusky shrew, *Sorex monticolus* (Insectivora, Soricidae): insight into deep and shallow history in northwestern North America. *Molecular Ecology*, **10**, 1227–1240.

Dixon (1909) A new harvest mouse from Petaluma, California. *University of California Publications in Zoology*, **5**, 271–273.

Edwards SV, Beerli S (2000) Perspective: gene divergence, population divergence, and the variance in coalescence time in phylogeographic studies. *Evolution*, **54**, 1839–1854.

Elith J, Graham CH, Anderson RP *et al*. (2006) Novel methods improve prediction of species' distributions from occurrence data. *Ecography*, **29**, 129–151.

Endler JA (1977) *Geographic Variation, Speciation, and Clines*. Princeton University Press, Princeton, New Jersey.

Epps CW, McCullough DR, Wehausen JD, Bleich VC, Rechel JL (2004) Effects of climate change on population persistence of desert-dwelling mountain sheep in California. *Conservation Biology*, **18**, 102–113.

Erwin TL (1991) An evolutionary basis for conservation strategies. *Science*, **253**, 750–752.

Faith DP (1992) Conservation evaluation and phylogenetic diversity. *Biological Conservation*, **61**, 1–10.

Fire and Resource Assessment Program (FRAP) (2003) *The Changing California: Forest and Range 2003 Assessment Summary*. Sacramento, California. http://www.frap.cdf.ca.gov/assessment2003/index.html.

Fjeldsa J, Lovett JC (1997) Geographical patterns of old and young species in African forest biota: the significance of specific montane areas as evolutionary centres. *Biodiversity and Conservation*, **6**, 325–346.

Forest F, Grenyer R, Rouget M *et al*. (2007) Preserving the evolutionary potential of floras in biodiversity hotspots. *Nature*, **445**, 757–760.

Frankel OH (1974) Genetic conservation: our evolutionary responsibility. *Genetics*, **78**, 53–65.

Gavrilets S (2003) Perspective: models of speciation: what have we learned in 40 years? *Evolution*, **57**, 2197–2215.

Gompert Z, Fordyce JA, Forister ML, Shapiro AM, Nice CC (2006) Homoploid hybrid speciation in an extreme habitat. *Science*, **314**, 1923–1925.

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Good JM, Demboski JR, Nagorsen DW, Sullivan J (2003) Phylogeography and introgressive hybridization: chipmunks (genus *Tamias*) in the northern Rocky Mountains. *Evolution*, **57**, 1900–1916.

Graham C, Hijmans R (2006) A comparison of methods for mapping species ranges and species richness. *Journal of Biogeography*, **15**, 578–587.

Grinnell J (1922) *A Geographical Study of the Kangaroo Rats of California*. University of California Press, Berkeley, California.

Grinnell J (1928) A distributional summation of the ornithology of Lower California. *University of California Publications in Zoology*, **32**, 1–300.

Hall ER (1981) *The Mammals of North America*, 2nd edn. John Wiley and Sons, New York.

Harrison RG, Bogdanowicz SM, Hoffman RS, Yensen E, Sherman PW (2003) Phylogeny and evolutionary history of the ground squirrels (Rodentia: Marmotinae). *Journal of Mammalian Evolution*, **10**, 249–276.

Hey J, Nielsen R (2004) Multilocus methods for estimating population sizes, migration rates and divergence time, with applications to the divergence of *Drosophila pseudoobscura* and *D. persimilis*. *Genetics*, **167**, 747–760.

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, **25**, 1965–1978.

Hooper ET (1940) Geographic variations in bushy-tailed wood rats. *University of California Publications in Zoology*, **42**, 407–424.

Hooper ET (1944) *San Francisco Bay as a Factor Influencing Speciation in Rodents*. University of Michigan Press, Ann Arbor, Michigan.

Inouye DW, Barr B, Armitage KB, Inouye BD (2000) Climate change is affecting altitudinal migrants and hibernating species. *Proceedings of the National Academy of Sciences, USA*, **97**, 1630–1633.

Jacobs DK, Haney TA, Louie KD (2004) Genes, diversity and geologic process on the Pacific coast. *Annual Review of Earth and Planetary Sciences*, **32**, 601–652.

Johnson DH (1943) Systematic review of the chipmunks (genus *Eutamias*) of California. *University California Publications in Zoology*, **48**, 63–143.

Kellogg R (1918) A revision of the *Microtus californicus* group of meadow mice. *University of California Publications in Zoology*, **21**, 1–42.

Kier G, Barthlott W (2001) Measuring and mapping endemism and species richness: a new methodological approach and its application on the flora of Africa. *Biodiversity and Conservation*, **10**, 1513–1529.

Kirkpatrick M, Ravigne V (2002) Speciation by natural and sexual selection: models and experiments. *American Naturalist*, **159**, S22–S35.

Kumar S, Tamura K, Nei M (2004) MEGA3: integrated software for molecular evolutionary genetics analysis and sequence alignment. *Briefings in Bioinformatics*, **5**, 150–163.

Lapointe F-J, Rissler LJ (2005) Notes and comments — congruence, consensus, and the comparative phylogeography of codistributed species in California. *American Naturalist*, **166**, 290–299.

Lidicker WZ Jr (1960) An analysis of intraspecific variation in the kangaroo rat *Dipodomys merriami*. *University of California Publications in Zoology*, **67**, 125–218.

Margules CR, Pressey RL (2000) Systematic conservation planning. *Nature*, **405**, 243–253.

Matocq MD, Shurtliff QR, Feldman CR (2007) Phylogenetics of the woodrat genus *Neotoma* (Rodentia: Muridae): implications for the evolution of phenotypic variation in male external genitalia. *Molecular Phylogenetics and Evolution*, **42**, 637–652.

Mayr E (1982) of what use are subspecies? *Auk*, **99**, 593–595.

Millar CI, Westfall RD, Delaney DL, King JC, Graumlich L (2004) Response of subalpine conifers in the Sierra Nevada, California, USA, to 20th-century warming and decadal climate variability. *Arctic, Antarctic, and Alpine Research*, **36**, 181–200.

Moritz C (2002) Strategies to protect biological diversity and the evolutionary processes that sustain it. *Systematic Biology*, **51**, 238–254.

Moritz C, Richardson KS, Ferrier S *et al*. (2001) Biogeographical concordance and efficiency of taxon indicators for establishing conservation priority in a tropical rainforest biota. *Proceedings of the Royal Society of London. Series B, Biological Sciences*, **268**, 1875–1881.

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853–858.

Patterson BD, Ceballos G, Sechrest W *et al*. (2005) *Digital Distribution Maps of the Mammals of the Western Hemisphere*, Version 2.0. NatureServe, Arlington, Virginia. http://www.natureserve.org/getData/mammalMaps.jsp.

Patton JL, Smith MF (1990) The evolutionary dynamics of the pocket gopher *Thomomys bottae*, with emphasis on Californian populations. *University of California Publications in Zoology*, **123**, 1–161.

Phillimore AB, Owens IPF (2006) Are subspecies useful in evolutionary and conservation biology? *Proceedings of the Royal Society of London, Series B, Biological Sciences*, **273**, 1049–1053.

Phillips SJ, Anderson RP, Schapire RE (2006) Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, **190**, 231–259.

Piaggio AJ, Spicer GS (2001) Molecular Phylogeny of the Chipmunks Inferred from Mitochondrial Cytochrome *b* and Cytochrome Oxidase II Gene Sequences. *Molecular Phylogenetics and Evolution*, **20**, 335–350.

Pinter N, Keller EA (1995) Geomorphological analysis of neotectonic deformation, northern Owens Valley, California. *International Journal of Earth Sciences*, **84**, 200–212.

Price T (1998) Sexual selection and natural selection in bird speciation. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, **353**, 251–260.

Raven PH, Axelrod DI (1974) Angiosperm biogeography and past continental movements. *Annals of the Missouri Botanical Garden*, **61**, 539–673.

Raven PH, Axelrod DI (1978) *Origin and Relationships of the California Flora*. University of California Press, Berkeley, California.

Remington CL (1968) Suture–zones of hybrid interaction between recently joined biotas. *Evolutionary Biology*, **2**, 321–428.

Riddle BR, Hafner DJ, Alexander LF (2000) Phylogeography and systematic of the *Peromyscus eremicus* species group and the historical biogeography of North American warm regional deserts. *Molecular Phylogenetics and Evolution*, **17**, 145–160.

Rieseberg LH, Archer MA, Wayne RK (1999) Transgressive segregation, adaptation and speciation. *Heredity*, **83**, 363–372.

Rissler LJ, Hijmans RJ, Graham CH, Moritz C, Wake DB (2006) Phylogeographic lineages and species comparisons in conservation analyses: a case study of California herpetofauna. *American Naturalist*, **167**, 655–666.

Rouget M, Cowling RM, Lombard AT, Knight AT, Kerley GIH (2006) Designing large-scale conservation corridors for pattern and process. *Conservation Biology*, **20**, 549–561.

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Rouget M, Cowling RM, Pressey RL, Richardson DM (2003) Identifying spatial components of ecological and evolutionary processes for regional conservation planning in the Cape Floristic Region, South Africa. *Diversity and Distributions*, **9**, 191–210.

Sarkar S, Pressey RL, Faith DP *et al*. (2006) Biodiversity conservation planning tools: present status and challenges for the future. *Annual Reviews in Environmental Research*, **31**, 123–159.

Smith TB, Bruford MW, Wayne RK (1996) The preservation of process: the missing element of conservation programs. (Reprinted from Biodiversity Letters, Vol. 1, pp 164–167, 1993) *Ecosystem Management: Selected Readings*, 71–75.

Spradling TA, Brant SV, Hafner MS, Dickerson CJ (2004) DNA data support a rapid radiation of pocket gopher genera (Rodentia: Geomyidae). *Journal of Mammalian Evolution*, **11**, 105–125.

Starrett J, Hedin MC (2007) Multilocus genealogies reveal multiple cryptic species and biogeographical complexity in the California turret spider *Antrodiaetus riversi* (Mygalomorphae, Antrodiaetidae). *Molecular Ecology*, **16**, 583–604.

Stebbins RC (1972) *Amphibians and Reptiles of California*. University of California Press, Berkeley, California.

Stebbins GL, Major J (1965) Endemism and speciation in the California flora. *Ecological Monographs*, **35**, 1–35.

Stein BA, Kutner LS, Adams JS (2000) *Precious Heritage: The Status of Biodiversity in the United States*. Oxford University Press, New York.

Tamura K, Nei M (1993) Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. *Molecular Biology and Evolution*, **10**, 512–526.

Thaeler CS (1961) Variation in some salt-marsh populations of *Microtus californicus*. *University of California Publications in Zoology*, **60**, 67–94.

Thompson JN (1999) The evolution of species interactions. *Science*, **284**, 2116–2118.

Vandergast AG, Bohonak AJ, Weissman DB, Fisher RN (2007) Understanding the genetic effects of recent habitat fragmentation in the context of evolutionary history: phylogeography and landscape genetics of a southern California endemic Jerusalem cricket (Orthoptera: Stenopelmatidae: *Stenopelmatus*). *Molecular Ecology*, **16**, 977–992.

Wake DB (2006) Problems with species: patterns and processes of species formation in salamanders. *Annals of the Missouri Botanical Garden*, **93**, 8–23.

Wieczorek J, Guo Q, Hijmans R (2004) The point-radius method for georeferencing locality descriptions and calculating associated uncertainty. *International Journal of Geographical Information Science*, **18**, 745–767.

Williams DF (1986) *Mammalian Species of Special Concern in California*. State of California, the Resources Agency, Department of Fish and Game, Sacramento, California.

Williams PH, Vane-Wright RI, Humphries CJ (1993) Measuring biodiversity for choosing conservation areas. In: *Hymenoptera and Biodiversity* (eds LaSalle J, Gauld ID), pp. 309–328. Oxford University Press, New York.

Wilson AC, Cann RL, Carr SM *et al*. (1985) Mitochondrial DNA and two perspectives on evolutionary genetics. *Biological Journal of the Linnean Society*, **26**, 375–400.

Zink RM (2004) The role of subspecies in obscuring avian biological diversity and misleading conservation policy. *Proceedings of the Royal Society of London. Series B, Biological Sciences*, **271**, 561–564.

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Appendix I

Subspecies data synopsis table. For each subspecies, the number of points used for modelling, AUC, Kappa, and area, are listed. N/A values for highly restricted ranges estimated by J.L.P. [1]Taxa which include environmental outliers to bolster sample size. In addition, presence and importance in subspecies endemism-richness hotspots are indicated ('–' indicates presence only, '+' indicates an important weighting)

Subspecies	*n*	AUC	Kappa	Area (km²)	North coast (N)	North coast (S)	SF Bay Area	Central coast	Central Valley	Tehachapis	Transverse Ranges	Owens Valley
Aplodontia rufa californica	27	0.92	0.80	26769								
Aplodontia rufa humboltiana	8	0.99	0.93	5682	+							
Aplodontia rufa phaea	11	0.99	0.99	1645			+					
Bassariscus astutus octavus[1]	4	0.81	0.61	20386							–	
Bassariscus astutus raptor	21	0.89	0.75	87826								
Canis latrans ochropus	102	0.75	0.41	172493	–	–	+	–	–	–	+	
Castor canadensis subauratus	17	0.99	0.97	18397					–		+	
Cervus elaphus nannodes	35	0.96	0.85	29814			–	–		–		–
Chaetodipus californicus bensoni	46	0.96	0.90	28532				+				
Chaetodipus californicus bernardinus	21	0.97	0.85	13552								
Chaetodipus californicus californicus	26	0.97	0.92	6546								
Chaetodipus californicus dispar	46	0.94	0.79	46448						+	–	
Chaetodipus californicus femoralis	23	0.97	0.93	22476								
Chaetodipus californicus marinensis	35	0.97	0.89	9793				+				
Chaetodipus californicus ochrus	66	0.97	0.87	36435						–		
Chaetodipus fallax pallidus	58	0.97	0.89	37639								
Chaetodipus penicillatus stephensi[1]	5	1.00	1.00	746								
Chaetodipus spinatus rufescens	25	0.98	0.87	41251							–	
Dipodomys agilis agilis	94	0.96	0.88	32200								
Dipodomys agilis cabezonae	31	0.98	0.89	13730							–	
Dipodomys agilis perplexus	36	0.98	0.87	43231						–	–	
Dipodomys californicus californicus	74	0.93	0.74	118785		–	–				–	
Dipodomys californicus eximius	5	0.99	0.99	5706							–	
Dipodomys californicus saxatilis	27	1.00	0.99	16474								
Dipodomys heermanni arenae	8	0.98	0.92	22327								
Dipodomys heermanni berkeleyensis	8	0.91	0.81	10181								
Dipodomys heermanni dixoni	7	0.99	0.99	1677					+			
Dipodomys heermanni goldmani	25	0.98	0.94	9945				+				
Dipodomys heermanni heermani	12	0.98	0.90	19119					–			
Dipodomys heermanni jolonensis	23	0.99	0.93	20801				+				
Dipodomys heermanni swarthi	24	0.98	0.90	14853								
Dipodomys heermanni tularensis	57	0.96	0.87	53566				+	–			
Dipodomys merriami collinus	13	0.99	0.95	7442								
Dipodomys merriami parvus	14	0.99	0.98	3141								
Dipodomys microps levipes	6	1.00	0.99	5368								+
Dipodomys microps microps	17	0.99	0.97	13578						–		+
Dipodomys nitratoides brevinasus	26	0.97	0.91	31283				+				
Dipodomys nitratoides exilis	N/A	N/A	N/A	314								
Dipodomys nitratoides nitratoides	25	0.99	0.97	12672								
Dipodomys panamintinus caudatus	12	1.00	1.00	3841								
Dipodomys panamintinus mohavensis	72	0.98	0.93	31923						–		–
Dipodomys panamintinus panamintinus	4	1.00	1.00	1076								+
Dipodomys venustus elephantinus	13	0.99	0.93	11549				+				

Appendix I *Continued*

Subspecies	*n*	AUC	Kappa	Area (km²)	North coast (N)	North coast (S)	SF Bay Area	Central coast	Central Valley	Tehachapis	Transverse Ranges	Owens Valley
Dipodomys venustus sanctiluciae	14	0.98	0.95	11405				+				
Dipodomys venustus venustus	18	0.98	0.91	7682				+				
Glaucomys sabrinus californicus[1]	8	0.98	0.88	18270								
Glaucomys sabrinus flaviventris	23	0.93	0.73	60037	–							
Glaucomys sabrinus lascivus	40	0.95	0.85	45417							–	
Glaucomys sabrinus stephensi[1]	5	0.82	0.61	33606	–	–	–					
Lepus americanus tahoensis	13	0.98	0.92	14318								
Lepus californicus bennettii	12	0.69	0.32	17124								
Lepus californicus californicus	89	0.81	0.51	150629	–	–	–	–	–			
Lepus californicus richardsonii	27	0.93	0.79	70648				–		–		
Lynx rufus californicus	149	0.77	0.41	93711		–	–	–		+		
Marmota flaviventris flaviventris	23	0.89	0.76	98433								
Marmota flaviventris sierrae	34	0.95	0.88	32044								
Martes americana humboltensis[1]	5	0.94	0.89	16468	–	–	–					
Martes americana sierrae	34	0.96	0.85	26017							–	
Mephitis mephitis holzneri	31	0.89	0.70	56177						–		
Microdipodops megacephalus polionotus	16	0.99	0.97	12882							+	
Microtus californicus aestuarinus	40	0.94	0.79	71405			–	–	–			
Microtus californicus californicus	113	0.94	0.80	24140				+			–	
Microtus californicus constrictus	15	0.97	0.87	12361	–	–						
Microtus californicus halophilus	10	1.00	0.99	317			+	–				
Microtus californicus kernensis	15	0.96	0.90	23114						+		
Microtus californicus mariposae	30	0.97	0.87	28254					–			
Microtus californicus sanctidiegi	75	0.93	0.78	59870						–		
Microtus californicus sanpabloensis	5	0.98	0.97	1687								
Microtus californicus vallicola	12	0.99	0.95	17058							–	–
Microtus longicaudus bernardinus	4	0.99	0.99	1009								
Microtus longicaudus sierrae	193	0.92	0.76	71806								
Mustela frenata latirostra	25	0.96	0.84	26298								
Mustela frenata munda	16	0.93	0.78	26354		–	–					
Mustela frenata nigriauris	63	0.94	0.79	27365				–			–	
Mustela frenata xanthogenys	17	0.99	0.96	25909					–			
Mustela vison aestuarina	36	0.77	0.46	69624	+	–	–	–	–			
Myotis yumanensis oxalis	9	0.90	0.80	35900					–			
Neotoma fuscipes annectens	44	0.94	0.84	16710				–				
Neotoma fuscipes bullatior	11	0.99	0.96	15514								
Neotoma fuscipes fuscipes	70	0.92	0.68	132141		–	–					
Neotoma fuscipes perplexa	27	0.96	0.83	25092				+				
Neotoma fuscipes riparia	N/A	N/A	N/A	27								
Perognathus alticolus alticolus	N/A	N/A	N/A	6								
Perognathus alticola inexpectatus[1]	5	1.00	1.00	2512						+		
Perognathus inornatus inornatus	54	0.93	0.81	79308			–		–	–		
Perognathus inornatus neglectus	12	0.91	0.74	78705					–	–		
Perognathus inornatus sillimani	N/A	N/A	N/A	829								
Peromyscus californicus benitoensis	21	0.97	0.89	25121			+	+				
Peromyscus californicus californicus	57	0.97	0.85	20598				+				
Peromyscus californicus insignis	110	0.94	0.81	57633						+		

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Appendix I *Continued*

Subspecies	*n*	AUC	Kappa	Area (km²)	North coast (N)	North coast (S)	SF Bay Area	Central coast	Central Valley	Tehachapis	Transverse Ranges	Owens Valley
Peromyscus californicus mariposae	13	0.96	0.87	12670						–		
Peromyscus californicus parasiticus	68	0.95	0.86	10334							–	
Reithrodontomys raviventris halicoetes	29	0.99	0.96	3797			+					
Reithrodontomys raviventris raviventris	22	0.98	0.96	3234								
Sorex ornatus californicus	69	0.91	0.71	50546			–	–	–			
Sorex ornatus ornatus	47	0.81	0.53	126055				–	–	–		–
Sorex ornatus relictus	N/A	N/A	N/A	856								
Sorex ornatus salarius[1]	5	1.00	1.00	16291			+				–	
Sorex ornatus salicornicus	N/A	N/A	N/A	404								
Sorex ornatus sinuosus	N/A	N/A	N/A	160								
Tamias amoenus monoensis	79	0.96	0.85	34393								
Tamias amoenus ochraceus	36	0.98	0.86	25950								
Tamias merriami kernensis	19	0.98	0.96	12449						–		–
Tamias merriami merriami	100	0.92	0.72	80436				–		–		
Tamias merriami pricei	30	0.98	0.90	8080				+				
Tamias panamintinus acrus[1]	5	1.00	1.00	898							–	
Tamias senex pacifica	24	0.99	0.92	16491	–							
Tamias sonomae alleni	25	0.97	0.85	5538		–	+					
Tamias sonomae sonomae	100	0.97	0.82	41933			–					
Tamias speciosus callipeplus	4	1.00	0.99	1637								
Tamias speciosus frater	159	0.95	0.83	26596								
Tamias speciosus sequoiensis	33	0.98	0.94	11208								
Tamias speciosus speciosus	22	0.99	0.92	6559								
Thomomys bottae albatus	46	1.00	0.98	28826								
Thomomys bottae alpinus	30	0.98	0.90	8781							–	
Thomomys bottae awahnee	15	0.98	0.92	10733								
Thomomys bottae bottae	448	0.82	0.54	132842			–	–		–		–
Thomomys bottae canus	7	1.00	1.00	2096								
Thomomys bottae laticeps	41	0.99	0.96	16477	–	–					–	
Thomomys bottae leucodon	18	0.99	0.95	15566								
Thomomys bottae mewa	44	0.98	0.91	27687					–			
Thomomys bottae navus	192	0.94	0.82	87735		–	–					
Thomomys bottae nigricans	79	0.96	0.88	29552								
Thomomys bottae operarius	8	1.00	1.00	1803								+
Thomomys bottae pascalis	40	0.99	0.94	31226							–	
Thomomys bottae perpallidus	173	0.98	0.90	145802						–		–
Thomomys bottae riparius	6	1.00	1.00	2529								
Thomomys bottae saxifragilis	66	0.99	0.98	15311							–	
Urocyon cinereoargenteus californicus	35	0.90	0.70	83378						–		
Vulpes macrotis mutica	201	0.99	0.93	24400								
Zapus princeps pacificus	107	0.91	0.73	106507							–	
Zapus trinotatus eureka	13	0.94	0.82	1280	+	+						
Zapus trinotatus orarius	6	1.00	0.98	1735			+					
Total '+'					3	1	8	14	1	5	3	4
Total taxa					11	14	23	28	16	23	23	11
+/total					0.272727273	0.071428571	0.347826087	0.5	0.0625	0.217391304	0.130434783	0.363636364

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Appendix II

Importance of mammal species to hotspots. '-' indicates presence in the hotspots of that area, but low weighting in endemism-richness and neo-endemism richness analyses. 'ER' indicates a high weighting in the endemism-richness analysis. 'NE' indicates a high weighting in the neo-endemism and neo-endemism richness analyses

Family	Scientific name	North Coast	SF Bay Area	Central Coast/ southern Coast Rages/ SW San Joaquin Valley	Tehachapi Range	Transverse Ranges	Peninsular Ranges	Southern Sierra Nevada	Central Sierra Nevada
Soricidae	*Sorex lyelli*								ER, NE
Soricidae	*Sorex ornatus*		—	—	—	—	—	—	—
Geomyidae	*Thomomys monticola*								—
Heteromyidae	*Chaetodipus californicus*		—	—	—	—	—	—	
Heteromyidae	*Dipodomys agilis*				NE	NE	NE	NE	
Heteromyidae	*Dipodomys californicus*	ER							
Heteromyidae	*Dipodomys heermanni*		NE	NE					
Heteromyidae	*Dipodomys ingens*			ER					
Heteromyidae	*Dipodomys nitratoides*			ER					
Heteromyidae	*Dipodomys panamintus*				NE	NE		NE	
Heteromyidae	*Dipodomys stephensi*						ER, NE		
Heteromyidae	*Dipodomys venustus*		—	—					
Heteromyidae	*Perognathus alticolus*				ER, NE	ER, NE (extirpated)			
Heteromyidae	*Perognathus inornatus*			—				—	
Muridae	*Arborimus pomo*	ER, NE							
Muridae	*Microtus californicus*	—	—	—	—	—	—	—	—
Muridae	*Neotoma fuscipes*	—	—	—					
Muridae	*Peromyscus californicus*		—	—	—	—	—	—	
Muridae	*Reithrodontomys raviventris*		ER						
Sciuridae	*Ammospermophilus nelsoni*			ER					
Sciuridae	*Spermophilus mojavensis*							NE	
Sciuridae	*Tamias alpinus*								ER, NE
Sciuridae	*Tamias merriami*			NE	NE	NE	NE	NE	—
Sciuridae	*Tamias ochrogenys*	ER, NE							
Sciuridae	*Tamias quadrimaculatus*								—
Sciuridae	*Tamias senex*								—
Sciuridae	*Tamias sonomae*	ER	—						
Sciuridae	*Tamias speciosus*					NE			NE

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25 YEARS PACIFIC INSTITUTE

Key Issues in Seawater Desalination in California

Marine Impacts

KEY ISSUES IN SEAWATER DESALINATION IN CALIFORNIA

Marine Impacts

December 2013

Authors: Heather Cooley, Newsha Ajami, and Matthew Heberger

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1 Introduction

In June 2006, the Pacific Institute released Desalination, With a Grain of Salt, an assessment of the advantages and disadvantages of seawater desalination for California. At that time, there were 21 active seawater desalination proposals along the California coast. Since then, only one project, a small plant in Sand City, has been permitted and built. A second, much larger project is now under construction in Carlsbad, 35 miles north of San Diego, and is scheduled to go online in 2016. Interest in seawater desalination remains high in California, and several agencies are conducting technical and environmental studies and constructing pilot projects to determine whether to develop full-scale facilities.

In 2011, the Pacific Institute began a new research initiative on seawater desalination. As part of that effort, we conducted some 25 one-on-one interviews with industry experts, environmental and community groups, and staff of water agencies and regulatory agencies to identify some of the key outstanding issues for seawater desalination projects in California. This is the fourth in a series of research reports that addresses these issues. The first report, released in July 2012, describes the 19 proposed projects along the California coast. The second report, released in November 2012, discusses the costs, financing, and risks related to desalination projects. The third report, released in May 2013, describes the energy requirements of seawater desalination and the associated greenhouse gas emissions and the impact of short-term and long-term energy price variability on the cost of desalinated water.

In this report, we describe the marine impacts of seawater desalination plants. We focus on plants that use reverse osmosis, because that is the technology that would be used for all proposed plants in California. Chapter 1 provides a brief introduction to the study. Chapter 2 describes the impacts of intakes withdrawing large volumes of water from the ocean. This chapter includes a review of our current understanding about these impacts and an overview of some of the technological, operational, and design measures that have been developed to reduce marine impacts, including subsurface intakes. Chapter 3 focuses on the discharge of concentrated brine produced by desalination plants and includes a review of brine studies that have been conducted at recently completed plants and a description of observed impacts, and identifies research gaps. Chapter 4 describes the processes for regulating seawater intakes and brine disposal as it is evolving in California, with an emphasis on those processes controlled by the State Water Resources Control Board. Finally, Chapter 5 provides conclusions and recommendations for minimizing the impacts of seawater desalination plants on the marine environment.

2 Seawater Intakes

Modern seawater reverse-osmosis desalination plants, such as those planned or proposed on the California coast, take in large volumes of seawater, pass it through fine-pored membranes to separate freshwater from salt, and discharge the hyper-saline brine back into the ocean. Seawater intakes generally fall into two categories: direct intakes and indirect intakes. Figure 1 shows the categories and relationships of intakes in use or proposed for desalination plants around the world. Direct intakes – also referred to as open water intakes – extract seawater directly from the ocean. These intakes may be located at the surface, in deep water, or less commonly, on a flotation plant. The vast majority of existing desalination plants uses surface intakes, which typically consist of a set of intake screens to exclude marine life, trash, and debris; a conveyance pipeline; and a wet well or other mechanism for housing the pumps (Mackey et al. 2011). These intakes generally require some sort of pre-treatment system to remove silt, algae, dissolved organic carbon, and other organic material that may clog the membranes.

A small but growing number of desalination plants use indirect intakes, also referred to as subsurface intakes. While not suitable in all locations, they have the advantage of virtually eliminating marine life impacts associated with

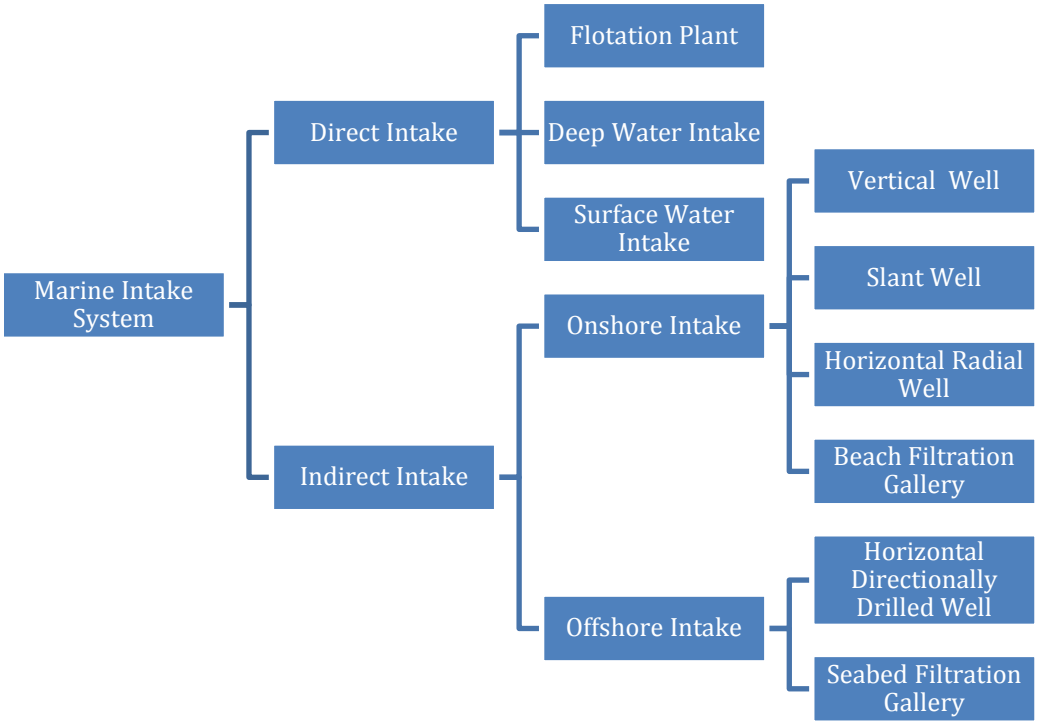

Figure 1. Marine Intake Systems for Seawater Desalination Plants.
Source: Adapted from Pankratz 2008

the intakes and reducing pretreatment requirements. Subsurface intakes extract seawater from beneath the seafloor or a beach and may be located on- or off-shore. They typically consist of buried pipes and/or wells and do not generally require a pre-treatment system because sand acts as a natural filter. Several design configurations of subsurface intakes are available and are described in more detail beginning on page 9 of this report.

Marine Impacts of Seawater Intakes

On average, seawater desalination plants withdraw two gallons of water for every gallon of freshwater produced. As noted in a 2005 California Energy Commission analysis, "seawater… is not just water. It is habitat and contains an entire ecosystem of phytoplankton, fishes, and invertebrates" (York and Foster 2005). As a result, the intake of seawater from the ocean results in the impingement and entrainment of marine organisms. Impingement occurs when fish and other large organisms are trapped on the intake screen, resulting in their injury or death. Entrainment occurs when organisms small enough to pass through the intake screens, such as plankton, fish eggs, and larvae, are killed during processing of the salt water. Entrained organisms are killed by pressure and velocity changes caused by circulating pumps in the plant, chlorine and other chemicals used to prevent corrosion and fouling, and predation by filter feeders like mussels and barnacles that line the intake pipes and themselves are considered a fouling nuisance (Mackey et al. 2011).

The impacts of impingement and entrainment from desalination plants on the marine environment are not well understood. Much of what is known has been drawn from studies on coastal power plants that use once-through cooling (OTC) systems. In an analysis of coastal and estuarine power plants in California, York and Foster (2005) find that "impingement and entrainment impacts equal the loss of biological productivity of thousands of acres of habitat" (York and Foster 2005). But while it is widely acknowledge that these systems damage the marine environment, the full extent of these impacts "may never be fully understood because comprehensive monitoring and evaluation of the surrounding ecosystems was not done" (Kelley 2010).

Further, OTC studies along the California coast have found that impingement and entrainment at coastal power plants vary considerably based on the location, year, and even time of year. For example, the state's two largest nuclear power plants, Diablo Canyon and San Onofre, withdraw similar quantities of water, but their impact on marine life differed dramatically. In an average year, Diablo Canyon entrains 1.8 billion fish and fish larvae and impinges about 400 fish and one large marine animal. San Onofre, by contrast, annually entrains 5.6 billion fish and fish larvae and impinges 3.5 million fish (SWRCB 2008). The differences in impact are not due to a single cause, but "arise from the plants' local marine environments, respective designs, and intake and discharge technologies" (McClary et al. 2013). Even for a single facility, impingement and entrainment rates may be subject to daily, seasonal, annual, and even decadal variation. Because of this variability, site-specific analyses are needed to determine the type and extent of impingement and entrainment (see Box 1 for two analyses conducted in California).

Project developers typically conduct impingement and entrainment studies to inform plant design and to obtain the permits needed for operation. Sampling studies and monitoring at pilot plants can provide useful information, but neither can paint a full picture of the actual impacts a desalination plant will have on marine life over its lifetime of operation. As previously noted, the distribution and abundance of a fish

Box 1: Case Studies

Several desalination project developers in California have recently built and operated small pilot projects to determine the feasibility of the projects and to test various design configurations. In several cases, project developers have conducted impingement and/or entrainment studies. Two of these are described below.

Santa Cruz

The City of Santa Cruz Water Department and Soquel Creek Water District have proposed to build a 2.5 million-gallon-per-day (MGD) desalination plant on California's central coast, at the tip of the Santa Cruz Bight at the northern end of Monterey Bay. The agencies operated a 50 gallon-per-minute (gpm, or 0.07 MGD) pilot desalination plant in Santa Cruz for 13 months from 2008-2009. To estimate impingement and entrainment, scientists collected samples at offshore locations and at a test intake at the end of a downtown pier and used video cameras to monitor intakes for impinged fish and invertebrates. In its 2013 Draft Environmental Impact Report for the project, the agency found that impingement and entrainment impacts were "less than significant" (SCWD2 2013). That is, the agency estimated impacts would occur, but that they do not rise to the level that requires any mitigation under California's environmental laws. One reason for the "less than significant" designation is that no endangered or threatened species were found during sampling. The study, by Tenera Environmental, concluded that intakes would kill some fish and invertebrate species (including gobies, croakers, anchovies, halibut, rockfishes, shrimp, and crabs), but the numbers killed are not likely to exceed "about six-hundredths of one percent of their populations (0.0006%) within the source water at risk of entrainment" (Tenera Environmental 2010a).

San Francisco Bay

In the San Francisco Bay Area, five large water utilities are jointly exploring the development of a regional desalination project. With some funding the from California Department of Water Resources, the project partners built and operated a 50 gpm (0.07 MGD) pilot plant from October 2008 to April 2009 near Pittsburgh, California. The pilot plant was located in an estuary, with widely fluctuating salinity levels and relatively high biological productivity compared to the open ocean. The plant's source water is home to the Delta smelt (*Hypomesus transpacificus*), listed as an endangered species by the state and federal governments, and the longfin smelt (*Spirinchus thaleichthys*), listed as threatened under the California Endangered Species Act (Tenera Environmental, Inc. 2010b). A 2010 study, also performed by Tenera Environmental, found both types of smelt during sampling. An estimated 13 Delta smelt were identified during a 30-minute survey in March 2009 that filtered about 240,000 gallons of water. While Delta smelt eggs adhere to substrate and are not likely to be entrained, the larvae are planktonic and susceptible to entrainment (Tenera Environmental, Inc. 2010c). The presence of an endangered species in the proposed plant's source water means it would likely have a "significant" environmental impact, and mitigation plans would be required.

species may change dramatically from one year to the next, or at different times during the year. This variability may not be adequately captured with short-term studies. For desalination projects in California, ongoing monitoring will likely be required to evaluate impingement.[1] Monitoring will better show how these impacts occur, when these impacts occur, and which species are affected. This information is useful for "adaptive management," allowing us to better manage those projects that are developed. Additionally, it will help us to plan for and design future projects so that they have less impact. As previously noted, marine impact data related to actual desalination operations have rarely been collected in California or elsewhere, and this information will be of use to regulators, policymakers, and the general public.

Minimizing Marine Life Impacts from Intakes

Various technological, design, and operational measures are available to reduce the marine impacts of seawater intakes. These are described in more detail in this section. While several measures are available to reduce impingement, fewer measures are available to minimize entrainment losses. As a result, habitat restoration is often used to mitigate these losses (Strange 2012). Box 2 describes the methodology commonly used in California to estimate the area of habitat needed to produce the organisms lost to entrainment.

Design and Operational Measures

The majority of desalination plants in operation around the world employ surface intakes. For these intakes, there are several design and operational measures that can reduce impingement and entrainment, e.g., locating the intake in areas of low biological productivity, such as in deep waters or outside of bays and estuaries (Ferry-Graham et al. 2008, NRC 2008). Deeper intakes, however, are not a panacea. In particular, they may not be effective in areas where fish spawn in deeper water or strong tidal currents distribute larvae throughout different depths. For example, California's San Onofre Nuclear Generating Station has the longest and deepest intake of any California power plant but also the highest impingement rate. The intake pipeline itself seems to be part of the cause, as "biologists and regulators seem to agree that […] the long intake pipe is attractive to marine animals as a place of refuge, potentially for food, and possibly for other reasons not yet determined" (Ferry-Graham et al. 2008).

Improving the recovery rate of a desalination facility can also reduce impingement and entrainment. Typically seawater desalination plants are designed to recover (turn into freshwater) 45 to 55% of the seawater collected by the intake. Designing the plant to operate closer to the upper limits of recovery (i.e., 50 to 55%) would require withdrawing less water and as a result, would reduce both impingement and entrainment. Other design and operational measures include installing low-velocity intakes that allow some organisms to swim out of the current or temporarily reducing pumping or intake velocity during critical periods for marine organisms, such as during spawning or important larval stages.

Technological Measures

Several technologies are available to reduce impingement and entrainment from surface intakes. These measures generally fall into two broad categories: physical barriers and behavioral deterrents. In the following section, we provide additional detail on some of these measures. We

[1] It is generally believed that entrainment impacts are fairly well understood due to the data available from power plants operating along the California coast.

Box 2: Quantifying and Mitigating Entrainment Losses through Habitat Restoration

In California, entrainment impacts are commonly compensated for or "offset" by creating or restoring fish habitat at a nearby location. The concept of offsets to mitigate the environmental impact of projects has been required by many regulators in the US and Europe since the 1970s. Under this approach, a project aims to achieve a "net neutral" impact on fish populations by creating habitat where fish feed and reproduce to make up for those killed by a project's construction and operations. The size and type of habitat required is estimated by fisheries biologists using a method referred to as the Area Production Foregone, or APF. This method is used by the California Energy Commission, California Coastal Commission, and other state regulatory entities.

The APF provides an estimate of the area of habitat needed to produce the organisms lost to entrainment and is intended to balance entrainment losses with the gains expected from a restoration project (Strange 2012). It is calculated using the area of habitat from which the larvae could be drawn into the intake (referred to as the "source water area") and is based on a determination of the period that the larvae are vulnerable to entrainment and the distance the larvae could have traveled during that period. The source water area is then multiplied by the percentage of larvae that are actually pulled into the intake to obtain the APF.[a] This calculation is repeated for all *meroplankton* – organisms that grow out of the larval stage to larger adult stages – entrained within the intake, and the results are averaged. The restored habitat may be of a different type or quality than the impacted habitat, and thus some conversion factor is typically applied. For example, one acre of highly productive wetlands may be restored to offset losses from 10 acres of open-ocean habitat. In a recent analysis for the California Energy Commission, Strange (2012) provides several cautions about the method. In particular, while the APF method may be reliable for bay and estuary settings, they are not reliable for the open coast. Additionally, monitoring is needed to ensure that the restoration projects provide the benefits expected.

[a] This percentage is based on the number of larvae entrained, larval density and abundance, and the proportion of sampled source water to total source water.

also describe the application of subsurface intakes and some of the advantages and disadvantages of these systems.

Physical barriers

Physical barriers are intended to block fish passage into the desalination plant and, depending on their design, can reduce both impingement and entrainment. Physical barriers have been used on power plant intakes for over a century. The earliest versions were essentially metal bars, or "trash racks," designed to keep large debris out of the intakes. Today, open intakes are typically equipped with primary coarse screens, which have openings of 20 mm to 150 mm, and smaller, secondary screens with openings of 1 mm to 10 mm. The coarse screens are stationary, whereas the secondary screen may be stationary (passive) or move periodically (active).

Barrier nets are suspended from booms or buoys and can exclude some marine organisms from intakes. Barrier nets are relatively inexpensive and easy to employ but are only effective in reducing impingement and do not reduce entrainment because larvae are able to pass through the nets (Ferry-Graham et al. 2008). As with many types of screens with small openings, barrier nets are subject to fouling, and cleaning clogged or fouled nets in the marine environment can be difficult (Hogan 2008). Additionally, barrier nets may impede navigation and eliminate some benthic and open-water habitat (Mackey et al. 2011).[2]

Travelling screens are mesh screens that are in continuous movement. The screens are equipped with mesh panels, and as the panels move out of the flow of water into the desalination plant, a high-pressure spray dislodges the accumulated debris and washes it into a trench for disposal in a landfill or back into the ocean (Figure 2). These screens have been employed on seawater intakes since the 1890s (Pankratz 2004). Originally intended to prevent trash from entering the intake, traveling screens were designed to impinge items, including organisms, on the mesh screens. These screens, however, have been modified to reduce entrainment and impingement, including by using angled or Risotroph screens (Ferry-Graham et al. 2008).

Figure 2. Example of a Travelling Screen Over an Intake

Ristroph screens are simple modifications of conventional traveling screens, by which water-filled buckets collect the impinged organisms and return them to the source water body by a sluiceway or pipeline. Impinged fish, however, may suffer lacerations or other mechanical damage to their gills or fins. Additionally, the locations where fish are returned to the environment often turn into a "fish feeding station for larger fish and birds." According to a recent study, "The effectiveness of such systems…is relatively easy to measure, but the survival and ecological success of the returned organisms is difficult to observe or quantify" (Mackey et al. 2011). In most cases, Ristroph screens and other fish-collection systems are not commonly employed and are often still

[2] Benthic habitat refers to the ecological zone on the sediment surface and in some sub-surface layers.

considered experimental (Ferry-Graham et al. 2008).

Wedgewire screens are passive screens that combine a fine-mesh screen with low-velocity intakes (Figure 3). Although they have been shown to be effective in reducing impingement and entrainment, wedgewire screens are susceptible to clogging and must be cleaned periodically with bursts of compressed air to dislodge material from the screens, where natural currents then remove the dislodged material (Mackey et al. 2011). These currents are commonly found in riverine systems but are less common in the marine environment. As a result, wedgewire screens may have limited application for seawater desalination plants. These screens, however, have been tested at several pilot and demonstration plants in California, including in Santa Cruz, Marin, and Los Angeles. In Santa Cruz, wedgewire screens with 2-millimeter (mm) openings were found to eliminate impingement and reduce entrainment of by 20%. For the pilot study, the natural currents exceeded the intake velocity (0.33 feet per second), which helped to clean the intake screens and reduce impingement (Tenera 2010c). A full-scale plant would operate at a higher intake velocity, suggesting that impingement would be higher.

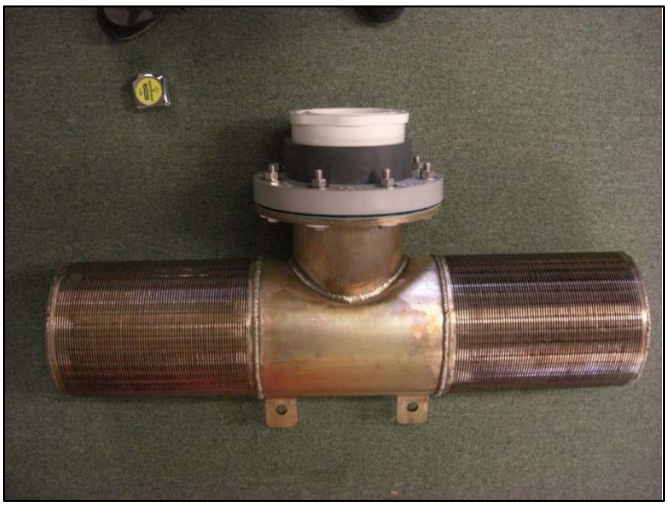

Figure 3. Wedgewire Screen Module Used in Testing During Studies for Santa Cruz and Soquel Creek Water Districts in 2009 and 2010
Source: Tenera 2010c

Behavioral Deterrents

Behavioral deterrents can be installed near intakes to discourage fish from entering the area or to encourage them to enter a bypass. In general, these devices may reduce impingement but have no effect on entrainment (Hogan 2008, Mackey et al. 2011, Foster et al. 2012). Behavioral deterrents include sound generators, strobe lights, air bubble curtains, and velocity caps.

Air bubble curtains are created by pumping air through a diffuser to create a continuous curtain of bubbles. Most studies have found that air bubble curtains are not effective, although a handful of studies suggest they may be effective at some sites and for some species (EPRI 2005).

Strobe lights and sound generators have been used to illicit an avoidance response from power plants and other water intake structures. However, a 2008 study by the Electric Power Research Institute (EPRI) on strobe-light and subsonic sound systems at cooling water intakes found that "there is no evidence that the impinged total fish numbers or impinged individual species numbers were reduced when the deterrent systems were operating." EPA (2001) notes that sound systems may be effective at targeting particular species, such as alewife, but are ineffective for others.

A **velocity cap** is essentially a device placed over an open intake pipe that creates variations in horizontal flow, triggering an avoidance response in fish and signaling it to step away from the intake. Studies have shown that velocity caps reduce impingement but there is some debate about whether they reduce entrainment (EPA 2001, Ferry-Graham et al. 2008). Velocity caps, which are usually combined with other devices,

have been used at many offshore intakes, including at several power plants in California and at the desalination plant in Sydney, Australia (EPA 2001, Ferry-Graham et al. 2008, Pankratz 2008).

The effectiveness of behavioral deterrents is highly varied. The EPA finds that most studies "have either been inconclusive or shown no tangible reduction in impingement or entrainment" (EPA 2001). Indeed, some critics have noted that behavioral deterrents may cause undue stress to marine organisms, with an unknown effect on marine ecosystems. Most behavioral deterrents, with the possible exception of velocity caps, are not widely employed or recommended as a means for reducing impingement and entrainment, although they may be employed in combination with other measures or to target a specific species (Chow et al. 1981, EPA 2001, Pankratz 2004).

Subsurface Intakes

Subsurface intakes extract seawater from beneath the seafloor or a beach. These intakes, which include vertical, slant, and horizontal wells and galleries, may be located onshore or offshore. Here, we provide a short summary of the various subsurface intakes currently in use in desalination plants around the world and some of the advantages and disadvantages of these systems.

Vertical beach wells consist of a series of shallow wells near the shoreline that use beach sand or other geologic deposits to filter water (Figure 4). Each well has a yield of 0.1 to 1.0 MGD (Pankratz 2004), and several wells may be needed at a desalination plant to meet its source water requirements. Beach wells may need to be located sufficiently far from shore so that they are not intercepting fresh groundwater, either because of quality concerns or an obligation not to cause salinization of freshwater aquifers. The largest plant using vertical beach wells is the Sur Desalination Plant in Oman, which has a production capacity of 21.2 MGD (Pankratz 2008).

Slant wells, also sometimes referred to as angle wells, are drilled at an angle such that the wellhead and related infrastructure may be onshore, while the well extends below ocean sediments and draws seawater through the seabed. With this technology, the wellhead can be located some distance from the beach to minimize "loss of shoreline habitat, recreation access, and aesthetic value" (Mackey et al. 2011).

Compared to vertical wells, slant wells have a larger surface area in contact with the aquifer, which allows for higher yields (Williams 2008). While slant wells have been used for some applications, they have not yet been employed at a full-scale desalination plant. They are, however, currently being evaluated in field tests and research studies (Missimer et al. 2013). The Municipal Water District of Orange County (MWDOC), for example, pilot-tested a slant well intake system at Doheny State Beach in Dana Point, California. The 12-inch diameter well

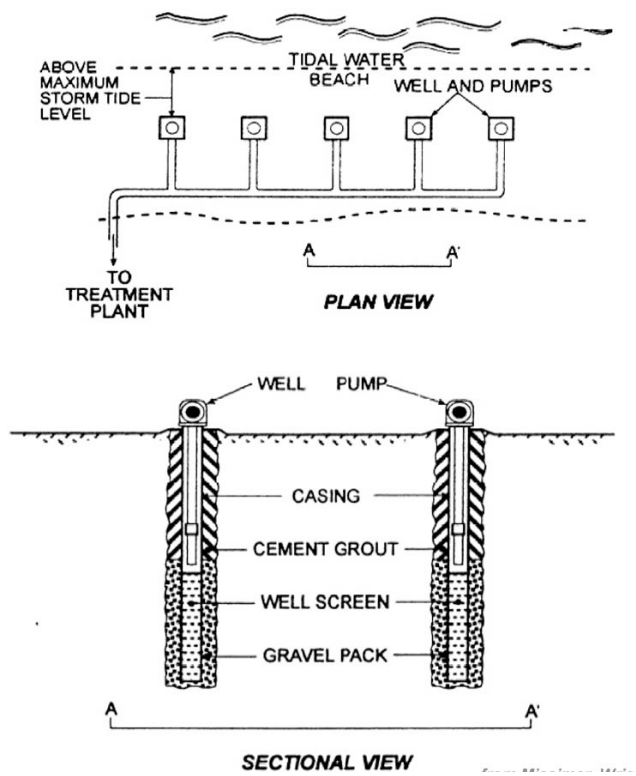

Figure 4 Beach Well Conceptual Design
Source: Wright and Missimer (1997)

withdrew 3 MGD of source water, and the "pump and aquifer performed exceptionally well" (MWDOC 2013). Based on the results from the pilot plant, it is expected that the full-scale plant could withdraw 30 MGD of water through a slant beach well system consisting of nine wells.

Horizontal directionally drilled (HDD) wells are non-linear slant wells. While slant wells are drilled at an angle from the surface, HDD wells typically begin as vertical wells before changing direction. Fluid and pressure are used to drill a pilot hole which is usually reamed to sufficient diameter before installation of the pipeline and screen. HDD wells are more difficult to install in areas with unconsolidated cobbles or boulders, which can drive the drill bit off course (Williams 2008). HDD well technology is used extensively by the oil exploration industry and has been used in desalination plants. The 34 MGD San Pedro del Pinatar (Cartagena) plant in Spain is the largest desalination plant using this technology. The HDD intake system, which has operated successfully for several years, consists of 9 wells that provide about half of the source water requirements for the plant (Mackey et al. 2011). Hydrological constraints necessitated the use of open intakes for the remainder of the source water requirements for the plant (WateReuse Association 2011a).

Horizontal radial wells, also referred to as radial collector wells or Ranney collectors, consist of a central chamber, called a caisson, from which several collector wells extend laterally as much as 300 feet. The collector wells can be oriented radially (like a bicycle wheel) or in some other formation toward the source water. The higher capacity of horizontal radial wells relative to vertical wells results in fewer wellheads and potentially less visual and construction-related impacts on the beach environment. This increases the options for siting the pumping station, something that can be difficult in coastal areas with high populations or sensitive ecosystems. Horizontal radial wells are designed to induce vertical flow, resulting in a greater yield per well (Missimer et al. 2013). Indeed, each horizontal collector well is typically designed to withdraw from 0.5 MGD to 5 MGD of source water (Mackey et al. 2011).

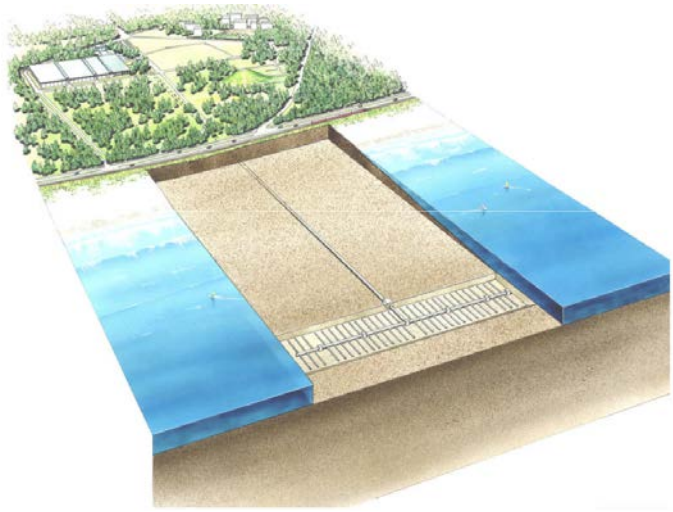

Figure 5. Infiltration Gallery Design at the Fukuoka District Waterworks, Japan.
Source: Reprinted from Pankratz 2008

Infiltration galleries are typically constructed by removing soil or rock, placing a screen or network of screens within the excavated area, and then backfilling the area with a porous media to form an artificial filter around the screens. A pipe then connects the intake screens to an on-shore pump. Infiltration galleries can be located on the beach near or above the high tide line, within the intertidal zone of the beach, or in the seabed. These systems are best suited for sandy areas without significant concentrations of mud (Missimer et al. 2013). Seabed galleries have been used in a limited number of desalination plants, the largest of which is the 13 MGD Fukuoka desalination plant in Japan (Figure 5). The seabed gallery, which has been in operation since 2006, has an intake flow of 27 MGD and covers an area of 5 acres (Pankratz 2008), or slightly less than the size of three football fields. Over the past eight years of operation, the gallery system has not required cleaning, and the filter membranes

have required only minimal maintenance (Missimer et al. 2013). The City of Long Beach, California has also been operating a pilot seabed gallery for several years, and several other systems around the world are in design or have been proposed. Subsurface intakes provide several important advantages. By using sand and sediment as a natural filter, they virtually eliminate impingement and entrainment (Hogan 2008). Subsurface intakes also provide significant water quality improvements, reducing the complexity of the pre-treatment system, lowering the energy requirements of the system, and improving the operational reliability of the plant (e.g., by avoiding production losses that could occur during algal blooms). In a recent review of subsurface intakes, Missimer et al. (2013) find that while the capital costs of subsurface intakes can be slightly to significantly higher than open-ocean intakes, the overall operating costs are 5 to 30% lower, resulting in significant cost saving over operating periods of 10 to 30 years.

Subsurface intakes, however, may not be appropriate in all locations because their installation depends on having the proper geology and sediment characteristics, such as sand and gravel with a sufficiently high porosity and transmissivity. However, with new drilling technologies, e.g., directional drilling, it may be possible to find a pocket with the right conditions surrounded by generally unfavorable ones. A report by the Middle East Desalination Research Center noted that subsurface intakes should be explored even where they are initially assumed to be infeasible because “an adequate geological configuration may be encountered, even within the most precipitous coastal environment, in some deltaic deposits, river outlets, closed harbors and short sandy shores” (Schwarz et al. 2000).

Subsurface intakes have several other disadvantages. Among the concerns are the higher construction costs relative to surface intakes, and the cost and complexity of survey methods to determine site properties and evaluate the feasibility of subsurface intakes (Schwarz et al. 2000). As described above, subsurface intakes tend to have lower treatment costs, which can reduce total project cost over the life of the plant. However, the presence of inorganic minerals, such as iron and manganese, in the source water can necessitate pre-treatment and additional cost (Mackey et al. 2011). Finally, some plant operators and designers argue that the technology is new and untested, although this is changing as subsurface intakes are being used in a growing number of plants around the world.

3 Brine Disposal

The seawater desalination process produces two major waste streams: brine and spent cleaning solutions. The cleaning solution, which is produced intermittently and in relatively small amounts, typically contains chemicals used in the cleaning process and contaminants removed during this process. The brine, also referred to as concentrate, is produced continuously and in relatively large amounts. One of the key features of the concentrate is elevated salinity levels, which depend on the salinity of the source water, the desalination method employed, and the recovery rate of the plant. In addition to elevated salinity levels, brine from a seawater desalination plant has the following characteristics:

Natural Constituents of Seawater: The process of desalting seawater concentrates constituents normally found in seawater, such as magnesium, boron, calcium, and sulfate (Water Consultants International 2006).

Chemical Additives: A variety of chemicals are used throughout the desalination process. For example, coagulants, such as ferrous chloride and aluminum chloride, are used to remove suspended matter from the source water (Lattemann and Höpner 2008, NRC 2008). Antiscalants, including polyphosphates and phosphonates, are added to the feedwater to prevent the formation of scale precipitates and salt deposits on the desalination equipment (NRC 2008). Other chemicals used include biocides, anti-foaming additives, and detergents. The majority of these chemicals are added during the pretreatment process to prevent membrane fouling (Amalfitano and Lam 2005). Some of these chemicals can be toxic to marine organisms, even at low concentrations.

Heavy Metals: Desalination equipment can corrode during operations, resulting in the release of heavy metals, such as copper, zinc, and nickel, into the waste stream. Corrosion chemicals are unlikely to be a major concern for reverse osmosis (RO) plants, although RO plants will discharge minor amounts of iron, chromium, nickel, and molybdenum in their concentrate from stainless steel (Lattemann and Höpner 2008). While these elements may occur in seawater in trace amounts, higher concentrations can be toxic to the aquatic environment and can impair biological communities (Jenkins et al. 2012, NRC 2008, Water Consultants International 2006).

Temperature: Desalination plants may produce brine that is warmer than the receiving waters, although this is of greater concern for plants using thermal desalination technologies than for those using membrane technologies, e.g., reverse osmosis. Typically, brine for reverse osmosis plants are usually within 1°C of the ambient seawater temperature and will not likely have an impact on the marine environment (Water Consultants International 2006). Even for RO plants, however, temperature can be an issue if the brine is mixed with cooling water from a power plant, industrial process water, or effluent from a wastewater treatment plant.

Brine Disposal

There are several options available to dispose of the concentrate produced from a desalination plant. Concentrate from inland desalination plants – which is typically less saline than that from a seawater desalination plant and of lesser volume than for a similar-sized seawater desalination plant – can be disposed via evaporation ponds; deep well injection; land application (e.g. used for lawns, parks, golf courses, or crop land); solar energy ponds; or sewer system (this is also an option for small coastal plants). Disposal options for seawater desalination plants include discharge into evaporation ponds, the ocean, or saline rivers that flow into an estuary, or injection into a confined aquifer (NRC 2008, Cooley et al. 2006). An inland or coastal desalination plant may also be equipped with a zero liquid discharge (ZLD) system that evaporates water from the concentrate, leaving a salt residue for disposal or reuse. Disposal options, and their associated cost, depend on site-specific factors, such as hydrologic conditions, low season flows, permitting requirements, the concentration of chemicals, and the toxicity of the brine (NRC 2008). Disposal options should also be informed by the brine tolerance thresholds of native marine species inhabiting the discharge site, although the scientific information needed to define these thresholds is often limited.

Each disposal method has a unique set of advantages and disadvantages. Large land requirements make evaporation ponds uneconomical for many developed and urban areas. Sites along the California coast, for example, tend to have high land values, and coastal development for non-coastal-dependent industrial processes is discouraged by regulators. Injection of brine into confined groundwater aquifers is technically feasible, but it is both expensive and unless comprehensive and competent groundwater surveys are done, there is a risk of unconfined brine plumes appearing in freshwater wells. Discharges into estuaries and the ocean can disrupt natural salinity balances and cause environmental damage to marine ecosystems, especially sensitive marshes and fisheries. Currently, all seawater desalination plants of significant capacity worldwide discharge brine into oceans and estuaries (NRC 2008), and all of the proposed plants in California, would discharge brine in this manner.

Brine from a seawater desalination plant is typically twice as saline as the ocean. Because of its relatively high salt concentration, brine has a greater density than the waters into which it is discharged, and when released from an outfall, tends to sink and slowly spread along the ocean floor. There is typically little wave energy on the ocean floor to mix the brine, and as a result, dilution occurs more slowly that at the surface. The result is a layer of brine with an elevated salt concentration near the outfall. As has been observed in Perth and in other shallow bays, dissolved oxygen levels can also become depleted near the outfall (Hodges et al. 2011,Spigel 2008), further increasing stress for marine organisms along the seafloor.

There are several proven methods to disperse concentrated brine. For example, multi-port diffusers can be placed on the discharge pipe to promote mixing. Brine can also be diluted with effluent from a wastewater treatment plant or with cooling water from a power plant or other industrial user, although these approaches have their own drawbacks. All of these options are discussed in more detail on page 14 of this report.

Marine Impacts of Brine Disposal

Field-based monitoring as well as field and laboratory experiments can be used to evaluate the marine impacts of brine discharge. Despite the long history of seawater desalination plants operating in some regions, however, data on their ecological impacts are limited (NRC 2008). The majority of studies conducted thus far focus on a limited number of species over short time periods with no baseline data (Roberts et al. 2010, Fernández-Torquemada and Sánchez-Lizaso 2007). In a recent review, Roberts et al. (2010) identified 62 peer-reviewed research articles concerned with brine discharge in marine waters and found that the majority (44%) of articles are discussions or opinion pieces with little quantitative data. Likewise, Jenkins et al. (2012) find that studies on the impacts of brine on California biota in particular are "extremely limited, often not peer-reviewed, not readily available, or have flaws in the study design."

Because of a lack of baseline ecological data, most of the available studies are based on a comparative analysis of environmental conditions at the discharge location and at least two other nearby locations believed to be unaffected by brine discharge. Most of these studies report some sort of environmental degradation due to exposure to desalination discharge (Fernandez-Torquemeda et al. 2005, Gacia et al. 2007,Sanchez-Lizaso et al. 2008, Ruso et al. 2007, 2008). In a recent review, Roberts et al. (2010) conclude that both laboratory and field studies "clearly demonstrate the potential for acute and chronic toxicity and small-scale alterations to community structure in marine environments."

The few studies available indicate that the ecological impacts of brine discharge vary widely and are a function of several factors, including the characteristics of the brine, the discharge method, the rate of dilution and dispersal, and the sensitivity of organisms. For example, brine discharge can cause widespread changes in the benthic community in shallow and/or semi-enclosed bays, whereas impacts can be undetectable in areas with heavy wave activity or significant flushing. Based on a literature review, Jenkins et al. (2012) find that some species are affected by salinity increases of only 2-3 parts per thousand (ppt) above ambient, while others are tolerant of salinity concentrations of up to 10 ppt above ambient. They further note that sub-lethal effects of desalination discharges have not been well studied in the field or in the laboratory.

Minimizing Impacts of Brine Disposal

As noted above, the common practice for large coastal seawater desalination plants is to discharge brine into oceans or estuaries. Over 90% of the large plants in operation today dispose of brine through a new ocean outfall specifically designed and built for the desalination plant (Voutchkov 2011). The addition of *diffusers* can promote mixing and improve dilution of the brine and are commonly used at desalination plants worldwide, including at all of the recently constructed plants in Australia and for many plants in Spain, the Middle East, Africa, South America, and the Caribbean (WateReuse Association 2011b). The diffusers may consist of a single port at the end of the pipe or multiple ports along a section of the pipe and are generally angled upwards to promote mixing. Recent research and modeling efforts suggest that a discharge angle of 30º–45º enhances mixing and dilution in moderate-to-steep coastal waters (Bleninger and Jirka 2008, Jirka 2008, Maugin and Corsin 2005). There is also general consensus among modeling studies that optimal mixing is achieved by discharging the brine in sub-tidal, off-shore environments with persistent turbulent flow (Roberts et al. 2010). However, the length and location of the pipe and the placement of the diffusers are typically determined by modeling for

the conditions at the discharge location (WateReuse Association 2011b).

Brine dilution prior to disposal is also being used by some plants to reduce the potential marine impacts. The Carlsbad desalination plant, for example, will mix the brine with cooling water from the adjacent Encina Power Station prior to discharge into a lagoon leading to the ocean. Recently, the State of California adopted new standards for implementing Section 316(b) of the Clean Water Act that effectively prohibits California power plants from using once-through cooling systems. Thus, cooling water will not be available for dilution in the near future. In order to comply with its discharge permit, the Carlsbad plant will withdraw additional seawater for dilution, a practice referred to as "in-plant dilution." This approach produces a more dilute brine discharge, which may reduce some of the environmental risks associated with brine discharge. However, it requires a larger amount of water to be withdrawn from the ocean, increasing the environmental risks associated with intakes, i.e., impingement and entrainment.

Dilution can also be achieved by mixing brine with treated wastewater effluent. Co-discharge of brine and wastewater effluent is still fairly uncommon but is practiced by several large-scale seawater desalination plants, including a 50 MGD plant in Barcelona and a 30 MGD plant in Japan (WateReuse 2011b). This approach is being considered for nearly a quarter of the proposed plants in California (Cooley and Donnelly 2012). Co-discharge of brine and wastewater effluent raises several concerns. First, if the combined mixture is denser than seawater, it may introduce nutrients to the seafloor, a zone with limited mixing. Second, while brine production is relatively constant, wastewater flows are variable and are especially low at night. To account for this variability, desalination plants may need to adjust operations or construct brine storage facilities (WateReuse Association 2011b).

Moreover, California's goal to increase the use of recycled water by at least one million acre-feet by 2020 and at least two million acre-feet by 2030 (SWRCB 2009) would reduce the availability of wastewater effluent to dilute brine discharges. Finally, there may be synergistic effects associated with combining brine with wastewater effluent that are not yet well understood (Kämpf 2009, Jenkins et al. 2012).

Reducing the amount of chemicals used in the desalination process can decrease the environmental impact of brine discharge. In particular, pretreating the source water with membrane technologies, such as microfiltration or ultrafiltration, can reduce the use of chemicals throughout the desalination process (Elimelech and Phillip 2011, Peters and Pinto 2008). Developing membranes resistant to fouling can reduce the need for anti-fouling chemicals (Elimelech and Phillip 2011). Additionally, as described previously, subsurface intakes use sand as a filter, reducing the complexity of the pre-treatment system and the amount of chemicals required during the pretreatment process (Missimer et al. 2013).

Finally, a coastal desalination plant may be equipped with a zero liquid discharge (ZLD) system that evaporates water from the concentrate, leaving a salt residue for disposal or reuse. Reducing the volume and increasing the salinity of the discharged brine might enable the harvesting of salts and minerals from drying ponds to be feasible. In a modeling and bench-scale experiment, Davis (2006) evaluated a process to use electrodialysis on the brine to further concentrate the waste stream and improve the recovery of the desalination plant.[3] Generally, the process has been shown to be technically feasible, but has not yet proven to be economically feasible.

[3] Electrodialysis is an electrochemical separation process that uses electrical currents to move salt ions selectively through a membrane, leaving fresh water behind.

Case Studies

As described previously, comprehensive monitoring data are not available for the vast majority of desalination plants that have been constructed around the world, in part because many of these plants have been built in places and at times when environmental concerns were not at the fore. This is changing, and several recently constructed plants have monitoring programs in place to evaluate environmental impacts associated with brine discharge. In this section, we provide case studies of the monitoring programs in place at two desalination plants built in Florida and Australia, and the results of these programs. Results from the Tampa Bay desalination plant suggest that some of the short-term impacts of brine discharge can be addressed through dilution. In Australia, however, while diffusers may help to minimize some of the impacts of brine discharge, monitoring and adaptive management are needed to evaluate short- and mid-term impacts. In all cases, additional monitoring is needed to evaluate the long-term impact of discharges on the marine environment.

Tampa Bay Desalination Plant

The 25 MGD Tampa Bay desalination plant is located in the southeastern part of Tampa Bay, Florida. Initial operation of the plant began in 2003, although the facility was taken offline between 2005 and 2007 for remediation. The plant was brought back online in 2007. Seawater for the desalination plant is obtained by diverting cooling water from the adjacent TECO Big Bend Power Station, which discharges an estimated 1.4 billion gallons of cooling water per day. At full capacity, the desalination plant produces 19 MGD of brine, which is mixed with cooling water from the power plant in a ratio of 70:1 prior to discharge into Hillsborough Bay (PBS&J 2010).

The National Pollution Discharge Elimination System (NPDES) permit issued by the State of Florida specifies effluent limits and monitoring requirements for the operation of the plant. Monitoring is conducted by Tampa Bay Water independently of the plant operator, American Water-Acciona Agua, and data are submitted to the Florida Department of Environmental Protection. Tampa Bay Water also conducts supplemental monitoring not required by the permit.

The monitoring program has biological and water quality components (PBS&J 2010). Biological monitoring includes an analysis of seagrass, benthic macroinvertebrates, and fish. Benthic invertebrates are sampled quarterly along three transects near the facility discharge. Data on fish and seagrass communities are collected by other ongoing monitoring programs in the area. The water quality monitoring program includes continuous monitoring of conductivity, salinity, dissolved oxygen, and temperature for a 72-hour period every two months. Grab samples are also collected to measure chloride and pH levels. Three continuous water-quality monitoring stations were established near the intake, discharge, and a nearby embayment (PBS&J 2010). Additional water quality testing occurs near the biological monitoring sites.

Monitoring of the plant commenced in 2002, about a year before the initial operation of the plant (McConnell 2009). The water quality sampling indicates that there were small differences in salinity levels between the intake and discharge canals but that these differences were likely not ecologically significant, even at maximum production (PBS&J 2010). The Shannon Diversity Index was used to determine the biological integrity at each of the sampling locations, and a change in the index in excess of 25% relative to the control site was defined as a change in the biological integrity. The difference in the diversity of benthic, fish, and seagrass communities at the sampling locations was less

than the 25% benchmark during operation and no-operation periods in each of the three designated monitoring zones (PBS&J 2010).

Perth Seawater Desalination Plant, Australia

The 38 MGD Perth desalination plant supplies over 17% of the drinking water for Perth, a city of 1.9 million, and the largest city on Australia's west coast. The plant, which began operating in 2006, is located in Cockburn Sound, a shallow inlet of the Indian Ocean with limited natural mixing. Cockburn Sound is the most intensely used embayment in Western Australia and is the site of a diverse mix of activities, including military operations, commercial industries, commercial and recreational fishing, mussel farming, and recreational diving and swimming (Environmental Protection Authority 2009).

To reduce the impacts of brine discharge, the plant is equipped with a discharge pipe that extends 1,500 feet offshore and includes a 40-port diffuser along the last 600 feet of pipe. The diffusers are located 1.5 feet above the seabed at a 60-degree angle (Water Reuse 2011b). Solids from the sludge that accumulate on the backwash filter are not discharged with the brine; rather, they are disposed of in a landfill. This reduces the turbidity of the brine discharge and minimizes the visible impact of the effluent on the Cockburn Sound.

Environmental permits were required before the plant could begin operations. The plant's operational permit, issued by the Department of Environment and Conservation (DEC), specifies that the brine discharge will meet a dilution factor of 45 at a distance of 50 meters in all directions from the diffuser (the edge of the defined mixing zone). The permits also required implementation of a monitoring program, which includes computer modeling for diffuser design and validation, Rhodamine dye testing, toxicity tests with local species, real-time dissolved oxygen and brine monitoring, and surveys of sediment characteristics and benthic macrofauna. A baseline survey of nearby sites in the Cockburn Sound was conducted six months before the plant went online to map the spatial pattern of the benthic communities.

The monitoring program began in 2006. The impacts of the plant, and the monitoring program put in place to evaluate those impacts, have been subject to significant debate. Dissolved oxygen levels are a key concern. A drop in dissolved oxygen levels has been observed at the ocean bottom, and these levels fell below the limit set in the operating permit twice in 2008. As stipulated in the permit, the plant reduced production during those periods.[4] The Water Corporation has asserted that the plant does not affect oxygen levels in the deep portions of the Sound and poses no significant risk to Cockburn Sound (Water Corporation 2008). In a subsequent review, however, the National Institute of Water & Atmospheric Research (NIWA) concluded that the desalination plant has "an effect on dissolved oxygen concentrations in Cockburn Sound. The effect may be small or even negligible much of the time; it may become significant only infrequently; and it may be so localised geographically that affected areas are recolonised over time. But it undoubtedly adds a further increment to existing stress on the Cockburn Sound ecosystem" (Spigel 2008, 3). The author further finds that the impact of the desalination plant may be masked by natural variability and unable to be resolved through modeling alone; therefore, additional monitoring and measures are required. These findings were supported by the Western Australia Environmental Protection Authority (WA EPA 2009) and monitoring is ongoing.

[4] All other water quality parameters were below the permit requirements.

4 Regulatory Framework

Project developers must obtain several permits from state and federal agencies for the construction and operation of seawater intake and brine disposal facilities. A full analysis of the permitting requirements for these facilities is beyond the scope of this paper. In this section, we focus on the requirements set forth by the State Water Resources Control Board (State Board) covering seawater intake and brine disposal facilities in California.

The State Board, under the federal Clean Water Act and the Porter-Cologne Water Quality Control Act, has regulatory authority for protecting the water quality of California's lakes, bays and estuaries, rivers and streams, and about 1,100 miles of coastline. Porter-Cologne, passed in 1969 and codified in the California Water Code, addresses water quality and waste discharge. In particular, it authorizes the State Board to adopt statewide water quality control plans (including the Ocean Plan to protect the state's ocean waters) and directs each of the nine Regional Boards to adopt regional water quality control plans. Additionally, as required under the federal Clean Water Act, the Water Boards (both state and regional) issue National Pollution Discharge Elimination System (NPDES) permits that have requirements for intakes and discharges to surface waters.

As part of its charge to protect water quality, the State Board has the authority to regulate seawater intakes for industrial facilities, including for desalination plants. Specifically, Section 13142.5(b) of the California Water Code requires each new or expanded coastal power plant or other industrial facility using seawater for cooling, heating, or industrial processing to use "the best available site, design, technology, and mitigation measures feasible…to minimize the intake and mortality of all forms of marine life." In May 2010, amid growing concern about the impacts of power plant intakes on coastal ecosystems, the State Board promulgated new standards to reduce impingement and entrainment from existing power plants. The new policy defines recirculating cooling systems, also referred to as "closed-loop" cooling systems, as the best available technology. As a result, power plants operators will have to reduce impingement and entrainment to a level commensurate with those achieved with recirculating cooling systems. This, in effect, forces operators to shut down OTC systems. While they could have applied this standard to desalination intakes, the State Board decided to address desalination intakes through a separate policy (SWRCB 2010).

Ocean Plan Amendments

The Ocean Plan, first adopted in 1972 and most recently updated in 2009, sets water quality objectives and policies to protect ocean waters. The Plan prohibits diluting brine with seawater prior to discharge, but does not "have an objective for elevated salinity levels in the ocean, nor does it describe how brine discharges are to be regulated and controlled, leading to

permitting uncertainty" (Jenkins et al. 2012). Additionally, the Ocean Plan does not address impacts to marine life from desalination intakes. These issues have been raised during several Ocean Plan reviews but have not yet been resolved due to staff limitations and other priorities, namely the once-through cooling policy. However, the 2011-2013 Ocean Plan Triennial Review determined that an evaluation of desalination intakes and brine disposal regulations was a very high priority.

The State Board is currently developing amendments to the Ocean Plan, as well as the Enclosed Bays and Estuaries Plan, to address the impacts of desalination facilities. These amendments will have five components: (1) best available intake siting and design requirements, including identifying the best available technology; (2) mitigation requirements for surface water intakes; (3) a narrative salinity water quality objective; (4) implementation of the salinity objective; and (5) monitoring requirements. The State Board initiated three studies to gather scientific data and obtain technical input on key issues, including two expert panels (one on intakes and one on brine) and a salinity toxicity study on several test species. It was anticipated that the amendments would be complete by 2013, however, the deadline has been extended into 2014.

5 Conclusions and Recommendations

Desalination, like other major industrial processes, has environmental impacts that must be understood and mitigated. These include effects associated with the construction of the plant and, especially, its long-term operation, including the effects of withdrawing seawater from the ocean and discharging the highly concentrated brine. Environmental impacts are also indirectly associated with the substantial use of energy, which is discussed in more detail in Cooley and Heberger (2013).

Seawater Intakes

One of the key environmental impacts of seawater reverse-osmosis desalination plants is associated with their intakes, which generally withdraw two gallons of water for every gallon of freshwater produced. The majority of desalination plants extract water directly from the ocean through open water intakes which have a direct impact on marine life. Fish and other larger marine organisms are killed on the intake screens (impingement); organisms small enough to pass through the intake screens, such as plankton, fish eggs, and larvae, are killed during processing of the salt water (entrainment). The impacts of impingement and entrainment on the marine environment are not fully understood but are likely to be species- and site-specific. Additionally, impingement and entrainment rates, even for a single desalination plant, may be subject to daily, seasonal, annual, and even decadal variation.

Several operational, design, and technological measures are available to reduce impingement and entrainment from open water intakes. These measures generally fall into two broad categories: physical barriers and behavioral deterrents. Physical barriers, e.g., mesh or wedgewire screens, block fish passage into the desalination plant and may be coupled with some sort of fish collection and return system. Behavioral deterrents, e.g. strobe lights or air bubble curtains, provide a signal to keep fish and other organisms away from the intake area or prevent them from crossing a threshold where they may be impinged. Additionally, subsurface intakes offer an alternative to open water intakes and can virtually eliminate impingement and entrainment.

The choice of intake design will ultimately be site-specific. While some project developers contend that subsurface intakes are infeasible due to their higher construction costs, desalination plants in many other countries have made use of these systems, including beach wells and onshore and offshore infiltration galleries. Subsurface intakes, however, may not be appropriate in all locations because their installation depends on having the proper geology and sediment characteristics, such as sand and gravel, with a sufficiently high porosity and transmissivity. However, with new drilling technologies, e.g., directional drilling, it may be possible to find a pocket with the right conditions surrounded by generally unfavorable ones. When the appropriate site conditions are present, the

advantages are clear. These systems can virtually eliminate impingement and entrainment; they also provide a level of pre-filtration that can reduce plant chemical and energy use and operating costs over the long term.

Brine Disposal

Safe disposal of the concentrated brine produced by desalination plants presents a major environmental challenge. All large coastal seawater desalination plants discharge brine into oceans and estuaries. Brine, by definition, has a high salt concentration, and as a result, it is denser than the waters into which it is discharged. Once discharged, brine tends to sink and slowly spread along the ocean floor. Mixing along the ocean floor is usually much slower than at the surface, thus inhibiting dilution and resulting in elevated salt concentrations near the outfall. Diffusers can be placed on the discharge pipe to promote mixing. Brine can also be diluted with effluent from a wastewater treatment plant or with cooling water from a power plant or other industrial user, although these approaches have their own drawbacks.

The impacts of brine on the marine environment are largely unknown. The majority of studies available focus on a limited number of species over short time periods and lack baseline data which would allow a comparison to pre-operation conditions. The laboratory and field studies that have been conducted to date, however, indicate the potential for acute and chronic toxicity and changes to the community structures in marine environments. The ecological impacts of brine discharge, however, vary widely and are a function of several factors, including the characteristics of the brine, the discharge method, the rate of dilution and dispersal, and the sensitivity of organisms.

Despite the long history of seawater desalination plants operating in some regions, data on their ecological impacts are limited. Several recently constructed plants, including plants built in Tampa Bay, Florida and Perth, Australia, have monitoring programs in place to evaluate impacts associated with brine discharge. These studies suggest that the short-term impacts of brine discharge can be addressed through dilution and use of multi-port diffusers. However, additional monitoring is needed to evaluate mid- and long-term impacts.

Regulatory Framework

There is considerable uncertainty about the regulatory requirements for seawater intakes and brine disposal, especially as it relates to those requirements set forth in the federal Clean Water Act and the Porter-Cologne Water Quality Control Act. The State Water Resources Control Board has the authority to regulate seawater intakes for industrial facilities, including for desalination plants, and to protect the water quality of California's lakes, bays and estuaries, rivers and streams, and about 1,100 miles of coastline. Water quality objectives and implementation policy for the protection of ocean waters are set forth in the state's Ocean Plan. As noted by the State Board, however, this plan "does not currently have an objective for elevated salinity concentrations, nor does it specifically describe how brine is to be regulated and controlled, leading to permitting uncertainty and possible delays."

The State Board is currently developing amendments to the Ocean Plan, as well as the Enclosed Bays and Estuaries Plan, to address the impacts of desalination facilities, including the best available intake technology, siting, and design requirements; mitigation requirements for surface water intakes; a salinity water quality objective; and monitoring requirements. It was anticipated that the amendments would be complete by 2013; however, the deadline has been extended into 2014. Once complete, these

amendments will provide greater clarity on the regulatory requirements and theoretically allow for a more effective and efficient regulatory process.

Recommendations

This report examines the impacts of seawater desalination on the marine environment. We conclude with a series of recommendations.

Surface seawater intakes result in impingement and entrainment of marine organisms, which may pose a serious threat to the marine environment.

- Intake pipes should be located outside of areas with high biological productivity and designed to minimize impingement and entrainment.
- For all desalination projects, proponents should thoroughly investigate the feasibility of subsurface intakes, including the evaluation of alternative siting and reduced design capacity of the project.

Desalination produces highly concentrated salt brines that contain other chemicals used throughout the desalination process. Steps should be taken to ensure its safe disposal.

- Water managers should avoid disposing of brine in close proximity to sensitive habitats, such as wetlands and some benthic areas.
- Water managers should carefully monitor, report, and minimize the impacts of brine disposal on the marine environment.
- More comprehensive studies are needed to determine the impacts of brine on the marine environment and to mitigate these impacts.

More research is needed to fill gaps in our understanding about the impacts of seawater intakes and brine disposal on the marine environment.

- Studies should examine the sub-lethal and chronic effects of brine exposure and the toxicity of brine effluent mixtures, i.e., brine and wastewater effluent.
- Studies should be conducted under a range of climatic conditions to evaluate seasonal and inter-annual differences to species response.
- Given differential response among species, more research is needed on those species found along the California coast.
- To evaluate the accuracy of existing models, comparisons are needed of early modeling efforts with field observations once the plant is in operation.

Monitoring of existing and proposed desalination plants is vital to improving our understanding of the sensitivity of the marine environment and can help to promote more effective operation and design to minimize ecological and biological impacts.

- Regulators should require desalination plant operators to develop adequate monitoring programs that include multiple sites, adequate replication of samples, and baseline data.
- Monitoring should account for natural seasonal and inter-annual variability.
- Monitoring data should be subject to third-party validation and be made easily available at no cost by internet in an accessible format, e.g. data files rather than PDF summaries where appropriate, to all concerned parties, including the general public.

References

Amalfitano, A., and K. Lam. (2005). "Power to Seawater RO in China." *World Water and Environmental Engineering* 28(4): 16-17.

Bleninger, T., and Jirka, G. (2008). "Modelling and Environmentally Sound Management of Brine Discharges from Desalination Plants." *Desalination* 221: 585-597.

Chow, W., I.P. Murarka, and R.W. Brocksen, (1981). "Entrainment and Impingement in Power Plant Cooling Systems." *Journal of the Water Pollution Control Federation* 53(6): 965-973.

Cooley, H., P. Gleick, and G. Wolff (2006). *Desalination with a Grain of Salt: A California Perspective*. Oakland, CA: Pacific Institute.

Cooley and Donnelly. (2012). *Key Issues for Seawater Desalination in California: Proposed Seawater Desalination Facilities*. Oakland, CA: Pacific Institute.

Cooley and Heberger. (2013). *Key Issues for Seawater Desalination in California: Energy and Greenhouse Gas Emissions*. Oakland, CA: Pacific Institute.

Davis, R. (2006). Zero Discharge Seawater Desalination: Integrating the Production of Freshwater, Salt, Magnesium, and Bromine. Desalination and Water Purification Research and Development Program Report No. 111. United States Bureau of Reclamation. Denver, CO.

Electric Power Research Institute (EPRI). (2005). "Air Bubble Curtains - Chapter 14."

Electric Power Research Institute (EPRI). (2008). "Performance Evaluation of Behavioral Deterrents for Reducing Impingement at Cooling Water Intakes." http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001014022.

Elimelech, M., and W.A. Phillip. (2011). "The Future of Seawater Desalination: Energy, Technology, and the Environment." *Science* 333:712-717.

Environmental Protection Agency (EPA). (2001). Chapter 5: Efficiency of Cooling Water Intake Structure Technologies. EPA-821-R1-036.

Fernandez-Torquemeda, Y., Snchez-Lizaso, J., and J. Gonzalez- Correa. (2005). "Preliminary Results of the Monitoring of The Brine Discharge Produced by the SWRO Desalination Plant of Alicante (SE Spain)." *Desalination* 182: 395-402.

Fernández-Torquemada, Y., and J. L. Sánchez-Lizaso. (2007). "Monitoring of brine discharges from seawater desalination plants in the Mediterranean." *International Journal of Environment and Health* 1(3): 449-461.

Ferry-Graham, L., M. Dorin, and P. Lin. (2008). Understanding Entrainment at Coastal Power Plants: Informing a Program to Study Impacts and Their Reduction. CEC-500-2007-120. PIER Energy-Related Environmental Research Program. California Energy Commission. http://65.74.139.74/2005publications/CEC-500-2005-004/CEC-500-2005-004.PDF.

Foster, M.S., G.M. Cailliet, J. Callaway, P. Raimondi, and J. Steinbeck. (2012). Mitigation and Fees for the Intake of Seawater by Desalination and Power Plants. California State Water Resources Control Board.

Gacia, E., O. Invers, M. Manzanera, E. Ballesteros, and J. Romero. (2007). "Impact of the Brine from a Desalination Plant on a Shallow Seagrass (*Posidonia oceanica*) Meadow." *Estuarine, Coastal and Shelf Science* 72(4): 579-590.

Hodges, B.R., J.E. Furnans, and P.S. Kulis. (2011). "Thin-Layer Gravity Current with Implications for Desalination Brine Disposal." *Journal of Hydraulic Engineering* 137: 356-371.

Hogan, T. (2008). "Impingement and Entrainment: Biological Efficacy of Intake Alternatives." presented at the Desalination Intake Solutions Workshop, October 16-17, Alden Research Laboratory, Holden, MA.

Jenkins, S., J. Paduan, P. Roberts, D. Schlenk, and J. Weis (2012). "Management of Brine Discharges to Coastal Waters." Recommendations of a Science Advisory Panel, Prepared for the State Water Resources Control Board, Technical Report 694, Southern California Coastal Water Research Project. Costa Mesa, CA.

Jirka, G. (2008). "Improved Discharge Configurations for Brine Effluents from Desalination Plants." *Journal of Hydraulic Engineering* 134(1):116-120.

Kämpf, J. (2009). "Impacts of Blending on Dilution of Negatively Buoyant Brine Discharge In A Shallow Tidal Sea." *Marine Pollution Bulletin* 58: 1032-1038.

Kelley, A. H. (2010). "A Call for Consistency: Open Seawater Intakes, Desalination, and the California Water Code." *Golden Gate University Environmental Law Journal* 4(2): 277-301.

Lattemann, S., and T. Höpner, T. (2008). "Environmental Impact and Impact Assessment of Seawater Desalination." *Desalination,* 220(1-3): 1-15.

Mackey, E.D., N. Pozos, J. Wendle, T. Seacord, H. Hunt, and D.L. Mayer. (2011). *Assessing Seawater Intake Systems for Desalination Plants*. Denver, Colorado: Water Research Foundation.

Maugin, G., and P. Corsin. (2005). "Concentrate and Other Waste Disposals from SWRO Plants: Characterization and Reduction of Their Environmental Impact." *Desalination* 182(1-3): 355-364.

McClary, S.C., H.L. Mehta, M.E. Fulmer, and L.B. Norin. (2013). AB 1632 Assessment of California's Operating Nuclear Plants. Accessed June 27. http://www.energy.ca.gov/2008publications/CEC-100-2008-005/CEC-100-2008-005-F.PDF.

McConnell, R. (2009). Tampa Bay Seawater Desalination Facility – Environmental Impact Monitoring, Proceedings of 2009 Annual WateReuse Conference, Seattle, September.

Metropolitan Water District of Orange County (MWDOC). (2013). Doheny Ocean Desalination Project Phase 3 Investigation: Final Summary Report. Orange County, California.

Missimer, T. M., N. Ghaffour, A.H.A. Dehwah, R. Rachman, R.G. Maliva, and G. Amy. (2013). "Subsurface Intakes for Seawater Reverse Osmosis Facilities: Capacity Limitation, Water Quality Improvement, and Economics." *Desalination* 322: 37–51.

National Research Council (NRC). (2008). *Desalination: A National Perspective*. Washington, D.C.: National Academies Press, 312 p.

Pankratz, T. (2004). "An Overview of Seawater Intake Facilities for Seawater Desalination." *The Future of Desalination in Texas*. http://earth1.epa.gov/region1/npdes/merrimackstation/pdfs/ar/AR-161.pdf.

Pankratz, T. (2008). "Global Overview of Seawater Desalination Intake Issues." Presented at the Desalination Intake Solutions Workshop, October 16-17, Alden Research Laboratory, Holden, Massachusetts.

Peters, T. and D. Pintó. (2008). "Seawater Intake and Pre-Treatment/Brine Discharge — Environmental Issues." *Desalination* 221(1-3): 576-584.

PBS&J. 2010, Tampa Bay Desalination Facility Hydrobiological Monitoring Data Summary 2002 – 2010, Prepared for Tampa Bay Water.

Roberts, D.A., E.L. Johnston, and N.A. Knott. (2010). "Impacts of Desalination Plant Discharges on the Marine Environment: A Critical Review of Published Studies." *Water Research* 44(18): 5117-5128.

Ruso, Y.P., J.A. Carretero, F.G. Casalduero,, and J.L. Lizaso. (2007). "Spatial and Temporal Changes in Infaunal Communities Inhabiting Soft- Bottoms Affected by Brine Discharge." *Marine Environmental Research* 64(4): 492-503.

Ruso, Y.P., J.A. Carretero, F.G. Casalduero,, and J.L. Lizaso. (2008). "Effects of a Brine Discharge over Soft Bottom Polychaeta Assemblage." *Environmental Pollution* 156(2): 240-250.

Sánchez-Lizasoa, J.L. J. Romero, J. Ruiz, E. Gacia, J.L. Buceta, O. Invers, Y. F. Torquemada, J. Mas, A. Ruiz-Mateo, and Marta Manzanera. (2008). "Salinity Tolerance of the Mediterranean Seagrass Posidonia Oceanica: Recommendations to Minimize the Impact of Brine Discharges from Desalination Plants." *Desalination* 221(1-3): 602-607.

Schwarz, J., I. Zacharias, O.M.S. Awwad, E. Shachnai, S Lumelski, U. Hurvitz, and Y. Maoz. (2000). "Beach Well Intakes for Small Seawater Reverse Osmosis Plants." Muscat, Oman: The Middle East Desalination Research Center. http://seawatergreenhouse.com/Downloads/MEDRC%20Report%20-%20Seawater%20Greenhouse%20Development.pdf.

SCWD2. (2013). *Proposed Regional Seawater Desalination Project Draft Environmental Impact Report*. Santa Cruz, California: Santa Cruz and Soquel Creek Water Districts. http://www.scwd2desal.org/Page-EIR_Docs.php.

Spigel, R. (2008). "Review of Studies Relating to the Discharge from the Perth Seawater Desalination Plant in Cockburn Sound." National Institute of Water & Atmospheric Research Ltd.

State Water Resources Control Board (SWRCB). (2008). "Water Quality Control Policy on the Use of Coastal and Estuarine Waters For Power Plant Cooling". Sacramento: California State Water Resources Control Board. http://www.energy.ca.gov/2008publications/SWRCB-1000-2008-001/SWRCB-1000-2008-001.PDF.

State Water Resources Control Board (SWRCB). (2009). "Water Quality Control Policy for Recycled Water". Sacramento: California State Water Resources Control Board. http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2013/rs2013_0003_a.pdf.

State Water Resources Control Board (SWRCB). (2010). "Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling." Final Substitute Environmental Document.

Strange, E. (2012). Compensation for Cooling Water Intake Entrainment Effects and the Habitat Production Foregone Method. Prepared for the California Energy Commission. Sacramento, CA.

Tenera Environmental, Inc. (2010a). Open Ocean Intake Effects Study. Prepared for the City of Santa Cruz Water Department & Soquel Creek Water District scwd^2 Desalination Program.

Tenera Environmental, Inc. (2010b). Entrainment and Source Water Study. In *Bay Area Regional Desalination Project Entrainment and Source Water Study Report*.

Tenera Environmental, Inc. (2010c). "Bay Area Regional Desalination Project Entrainment and Source Water Study Report."

Voutchkov, N. (2011). "Overview of Seawater Concentrate Disposal Alternatives." *Journal of Desalination* 273: 205-219.

Water Consultants International. (2006). An Environmental Literature Review and Position Paper for Reverse Osmosis Desalination Plant Discharges. Prepared for the Water Corporation of Western Australia. Contract No. CN-05-12269.

Water Corporation (2008). Perth Seawater Desalination Plant Water Quality Management, Section 46, Revision C, with appendices.

WateReuse Association. (2011a). "Overview of Desalination Plant Intake Alternatives."

WateReuse Association, (2011b) "Seawater Concentrate Management", Desalination Committee, Accessed on 30 September 2013 at http://www.watereuse.org/sites/default/files/u8/Seawater_Concentrate_WP.pdf.

Western Australia Environmental Protection Authority (WA EPA). (2009). Perth Metropolitan Desalination Proposal – Water Quality Management, Change to Implementation Conditions. Section 46 report and recommendations of the Environmental Protection Authority.

Williams, D.E. (2008). Research and Development for Horizontal/Angle Well Technology. U.S. Department of the Interior, Bureau of Reclamation, Desalination and Water Purification Research and Development Program Report No. 151.

Wright, R. R., and T. M. Missimer. (1997). "Alternative Intake Systems for Seawater Membrane Water Treatment Plants." In Proceedings of the International Desalination Association Conference, Madrid, 3:407–422.

York, R. and M. Foster. (2005). *Issues and Environmental Impacts Associated with Once-Through Cooling at California's Coastal Power Plants*. California Energy Commission. Sacramento, California.