U.S. Fish & Wildlife Service

Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary

Draft Environmental Impact Statement

Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary

Draft Environmental Impact Statement

by

U.S. Fish and Wildlife Service
Migratory Birds and Habitat Programs
911 NE 11th Avenue
Portland, Oregon 97232

U.S. Army Corps of Engineers
Portland District
333 SW 1st Avenue
Portland, Oregon 97204-3495

NOAA Fisheries
525 NE Oregon
Suite 500
Portland, Oregon 97232

July 2004

TABLE OF CONTENTS

Title Page
Table of Contents TOC-1
Executive Summary ES-1

CHAPTER 1: PURPOSE AND NEED FOR ACTION

1.1 Introduction 1- 1
1.2 Purpose of and Need for Action 1- 2
1.2.1 Guiding Principles 1- 4
1.2.2 Context of Purpose and Need 1- 2
1.3 Authority and Responsibility 1- 5
1.3.1 US Fish and Wildlife Service 1- 5
1.3.2 US Army Corps of Engineers 1- 5
1.3.3 National Marine Fisheries Service (NOAA Fisheries) 1- 6
1.4 Policy, Legal Compliance, Consultation, an Coordination with Others 1- 6
1.4.1 Policy and Legal Compliance 1- 6
1.4.2 Consultation and Coordination with Others 1- 6
Public Outreach 1- 7
Coordination with Other Agencies 1- 7
Coordination with Tribal Governments 1- 7
1.5 Scoping 1- 8
1.5.1 Issues and Concern Identified During Scoping 1- 8
1.5.2 Issues Raised, but Eliminated from Detailed Study 1- 9

CHAPTER 2: ALTERNATIVES

2.1 Alternative Development 2- 1
2.1.1 Rationale for Alternative Design 2- 1
2.2 Similarities Among Alternatives 2- 2
2.3 Detailed Description of Alternatives 2- 2
2.3.1 Alternative A – No Action (Current Management Plan) 2- 2
2.3.2 Alternative B – No Management 2- 3
2.3.3 Alternative C – Redistribution of East Sand Island Tern Colony – Preferred Alternative 2- 3
2.3.4 Alternative D – Redistribution and Lethal Control of East Sand Island Tern Colony 2- 6
2.4 Monitoring and Adaptive Management Plan 2- 7
2.5 Alternatives Considered but Eliminated From Detailed Study 2- 7
2.5.1 Elimination of Caspian Terns from East Sand Island 2- 7
2.5.2 Maximum Redistribution of Terns throughout the Region 2- 7
2.5.3 Lethal Control of East Sand Island Tern Colony 2- 9
2.5.4 Reduction of Caspian tern Nesting Habitat on East Sand Island and No Active Facilitation to Other Sites within the Region 2- 9
2.6 Comparison of Alternatives 2- 7

CHAPTER 3: AFFECTED ENVIRONMENT

3.1 Physical Environment 3- 1
3.2 Biological Environment 3- 4
3.2.1 Caspian Terns 3- 4
3.2.2 Fish 3- 10
3.2.3 Federally Endangered and Threatened Fish 3- 11
3.2.4 Other birds 3- 14
3.2.5 Mammals 3- 15
3.2.6 Federally Endangered and Threatened Wildlife 3- 15
3.3 Socioeconomic Environment 3- 15
3.3.1 Commercial and Recreational Fisheries 3- 15
3.4 Tribal Fisheries 3- 17
3.5 Cultural Resources 3- 17

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES

4.1 Effects to Physical Environment 4- 1
4.1.1 Alternative A 4- 1
4.1.2 Alternative B 4- 1
4.1.3 Alternative C 4- 2
4.1.4 Alternative D 4- 3
4.2 Effects to Biological Environment 4- 3
4.2.1 Effects to Caspian Terns 4- 3
4.2.1.1 Alternative A 4- 3
4.2.1.2 Alternative B 4- 6
4.2.1.3 Alternative C 4- 7
4.2.1.4 Alternative D 4- 10
4.2.2 Effects to Fishes 4- 11
4.2.2.1 Alternative A 4- 11
4.2.2.2 Alternative B 4- 12
4.2.2.3 Alternative C 4- 13
4.2.2.4 Alternative D 4- 13
4.2.3 Effects to Federally Endangered and Threatened Fish 4- 13
4.2.3.1 Alternative A 4- 13
4.2.3.2 Alternative B 4- 14
4.2.3.3 Alternative C 4- 15
4.2.3.4 Alternative D 4- 16
4.2.4 Effects to Other Birds 4- 16
4.2.4.1 Alternative A 4- 16
4.2.4.2 Alternative B 4- 17
4.2.4.3 Alternative C 4- 17
4.2.4.4 Alternative D 4- 18

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES (CONTINUED)

4.2.5 Effects to Mammals....4- 18
4.2.5.1 Alternative A.... 4- 18
4.2.5.2 Alternative B.... 4- 18
4.2.5.3 Alternative C.... 4- 18
4.2.5.4 Alternative D 4- 18
4.2.6 Effects to Federally Endangered and Threatened Wildlife 4- 18
4.2.6.1 Alternative A.... 4- 18
4.2.6.2 Alternative B.... 4- 18
4.2.6.3 Alternative C.... 4- 19
4.2.6.4 Alternative D 4- 19
4.3 Effects to Socioeconomic Environment 4- 19
4.3.1 Effects to Commercial and Recreational Fisheries 4- 19
4.3.1.1 Alternative A.... 4- 19
4.3.1.2 Alternative B.... 4- 20
4.3.1.3 Alternative C.... 4- 20
4.3.1.4 Alternative D 4- 20
4.4. Effects to Tribal Fisheries 4- 21
4.4.1 Alternative A.... 4- 21
4.4.2 Alternative B.... 4- 21
4.4.3 Alternative C.... 4- 21
4.4.4 Alternative D 4- 21
4.5 Effects to Cultural Resources 4- 21
4.5.1 Alternative A.... 4- 21
4.5.2 Alternative B.... 4- 21
4.5.3 Alternative C.... 4- 21
4.5.4 Alternative D 4- 22
4.6 Summary of Effects....4- 22
4.7 Cumulative Effects....4- 24

CHAPTER 5: RELATIONSHIPS TO FEDERAL, STATE, AND LOCAL POLICIES AND PLANS

5.1 Fish and Wildlife Service Plans, Policies, and Programs 5- 1
5.2 Other Federal Agency Plans.... 5- 1
5.3 State, Local and Tribal Plans.... 5- 2

APPENDICES

A. Glossary of Terms….A- 1
A.1 Acronyms and Abbreviations….A- 1
A.2 Glossary of Terms….A- 2
B. References….B- 1
B.1 Literature Citations….B- 1
B.2 Federal Register Notices….B- 9

APPENDICES (CONTINUED)

C. NOAA Fisheries Report: Caspian Tern Predation on Juvenile Salmonid Outmigrants in the Columbia River Estuary……C- 1
D. Applicable Laws and Executive Orders……D- 1
E. Distribution List……E- 1
F. Caspian Tern Regional Population Nesting Site Locations and Colony Sizes……F- 1
G. Potential Caspian Tern Nesting Sites in the Pacific Coast Region: Selection Process and Proposed Management Actions……G- 1
H. Scientific Names for Fish, Wildlife, and Plants……H- 1
I. List of Preparers……I- 1

FIGURES

Figure 1.1 Columbia River Estuary……1- 1
Figure 2.1 Columbia River Estuary (mouth to RM 46)……2- 1
Figure 2.2 Illustration of Increasing, Stable, or Declining Population Growth Rates (λ)……2- 5
Figure 3.1 Map of Affected Environment……3- 2
Figure 3.2 Caspian Tern Nesting Habitat on East Sand Island……3- 3
Figure 3.3 Caspian Tern Breeding Regions in North America……3- 5
Figure 3.4 Pacific Region Caspian Tern Population Trend……3- 7
Figure 3.5 Arrival Times of Juvenile Salmonids and Nesting Period of Caspian Terns in the Affected Environment……3- 12

TABLES

Table 2.1 Potential Caspian Tern Nesting Sites and Proposed Management Actions Associated with Alternative C and D. Sites are Listed in Geographical Order from North to South……2- 4
Table 2.2 Population Growth Rate (λ) and Estimated Percent Increase in Four Listed Steelhead ESUs in the Columbia River Basin given a Range of Caspian Tern Nesting Pairs on East Sand Island……2- 5
Table 2.3 Comparison of Caspian Tern Management EIS Alternatives by Component and Associated Anticipated Effects……2- 10
Table 3.1 Estimates of the Caspian Tern Breeding Population in the United States, by Region, from 1976 to 1982 and 1997 to 1998 (from Shuford and Craig 2002), including Current Pacific Coast Regional Population Estimate……3- 6
Table 3.2 Federally Listed ESUs/DPSs that Occur in the Affected Environment……3- 12
Table 4.1 Summary of Alternatives……4- 1
Table 4.2 Actual and Projected Caspian tern colony size in the Columbia River estuary 1997 to 2010……4- 4
Table 4.3 Productivity of Caspian Terns at Various Sites in Pacific Coast Region……4- 7
Table 4.4 Estimated Colony Size and Number of Birds Killed in the Columbia River Estuary with the Implementation of a Lethal Control Program……4- 10
Table 4.5 Range of Salmonid Composition (Percent) of Caspian Tern Diets Observed at Coastal Sites……4- 13
Table 4.6 Summary and Comparison of Potential Effects of Alternatives to Caspian Terns and ESA-Listed Salmonids in the Pacific Coast Region……4- 23

Executive Summary

Recent increases in the number of Caspian terns nesting in the Columbia River estuary has led to concerns over their potential impact on the recovery of threatened and endangered Columbia River salmonids. In 1999, National Marine Fisheries Service (NOAA Fisheries) called for the U.S. Army Corps of Engineers (Corps) to eliminate tern nesting from Rice Island (located in the upper estuary) in an attempt to decrease the number of juvenile salmonids eaten by terns. In 1999, the Corps initiated a pilot project to attract the Rice Island tern colony to East Sand Island, near the mouth of the estuary, where marine fish (i.e., non-salmon) were abundantly available to foraging terns. In 2000, the Corps proposed to complete the project to prevent all tern nesting on Rice Island while attracting terns to nest on East Sand Island. As a result of the proposed actions in 2000, Seattle Audubon, National Audubon, American Bird Conservancy, and Defenders of Wildlife filed a lawsuit against the Corps alleging that compliance with the National Environmental Policy Act for the proposed action of attracting the large colony of Caspian terns from Rice Island to East Sand Island was insufficient, and against the Service in objection to the potential take of eggs as a means to prevent nesting on Rice Island. In 2002, all parties reached a settlement agreement. The settlement agreement stipulates that the Service, Corps, and NOAA Fisheries prepare an EIS to address Caspian tern management in the Columbia River estuary and juvenile salmonid predation.

The purpose of the proposed action is to comply with the 2002 Settlement Agreement by identifying a management plan for Caspian terns in the Columbia River estuary that reduces resource management conflicts with ESA-listed salmonids while ensuring the conservation of Caspian terns in the Pacific Coast/Western region. Although the relocation of terns from Rice Island to East Sand Island resulted in a decreased percentage of salmonids in the tern diet, the Caspian tern colony on East Sand Island is anticipated to continue to increase in size. Thus, predation of juvenile salmonids by terns may increase in the future, maintaining a concern for salmon recovery by NOAA Fisheries.

Alternatives

The four alternatives considered in the Draft EIS are summarized below, followed by features common to all alternatives.

Alternative A – No Action (Current Management Program)

The "No Action" alternative assumes no change from the current management program on East Sand Island and is the baseline from which to compare the other alternatives. Under this alternative, 6 acres of nesting habitat would be prepared annually for Caspian terns on East Sand Island. This requires annual maintenance to provide proper nesting habitat conditions: a bare sand substrate free of vegetative cover. To attain the proper habitat, heavy equipment is used to till and smooth the site in late May or early April (prior to the arrival of terns). Herbicide (Rodeo) may also be applied to the vegetation in the fall (September or October) to control their presence on the tern nesting site.

Alternative B – No Management

The Settlement Agreement requires analysis of this alternative in the EIS. Under this alternative, no management actions would occur on East Sand Island. The current tern nesting habitat on East Sand Island would most likely become fully vegetated within three years. This would result in the loss of the tern nesting site. Thus, abandonment of this colony on East Sand Island would most likely occur.

Alternative C – Redistribution of East Sand Island Tern Colony - PREFERRED ALTERNATIVE

Alternative C, the Preferred Alternative, would reduce tern predation on juvenile salmonids in the Columbia River estuary by managing habitat to redistribute the tern colony on East Sand Island throughout the Pacific Coast/Western region. This redistribution would be achieved by creating new or enhanced tern nesting habitat throughout the region and reducing the tern nesting site on East Sand Island to 1 to 1.5 acres. To ensure a suitable network of sites is available for terns on a regional scale, we propose to manage nesting habitat for terns in the region to replace twice the amount of nesting habitat that would be lost on East Sand Island. Since terns nested on an average of 4.3 acres on East Sand Island from 2001 to 2003, approximately 6 to 7 acres would need to be replaced when the site on East Sand Island is reduced to 1 to 1.5 acres.

The proposed reduction in habitat on East Sand Island would occur only after nesting habitat is enhanced elsewhere in the region. Thus, habitat enhancement in the region and reduction in habitat on East Sand Island would be phased in at a 2:1 ratio. Approximately 8 acres of managed habitat would be enhanced in Washington, Oregon, and California. Seven proposed management sites considered in this alternative include Dungeness National Wildlife Refuge, Washington; Summer, Crump, and Fern Ridge lakes, Oregon; and San Francisco Bay (3 sites), California. See Table 2.1, Chapter 2 and Appendix G for more detail on these sites and proposed management actions.

The proposed habitat acreage (approximately 1 to 1.5 acres) on East Sand Island is expected to be reached in 3 to 5 years, depending upon available funding for habitat enhancement elsewhere in the region. The size of the tern nesting site at East Sand Island (acreage) would be determined annually, and would be dependent upon how much acreage of alternate habitat has been created to date elsewhere in the region. Habitat reduction on East Sand Island would be attained by allowing vegetation to grow in the current nesting area and the remaining tern nesting site would be cleared via the methods described above in Alternative A.

This proposed habitat acreage on East Sand Island (1 to 1.5 acres) was selected for this alternative to reduce tern predation in the estuary on juvenile salmonids to a level that would increase salmonid population growth rates (lambda). In determining an acceptable predation level by terns, NOAA Fisheries conducted an analysis using a life cycle model and tern predation rates to estimate the impact of tern predation on the population growth rate of various Evolutionary Significant Units (ESUs) of Columbia River Basin steelhead. Steelhead were the focus of this analysis because they are the ESUs most affected by tern predation in the Columbia River estuary. Thus, estimates of the potential benefits to reducing tern predation are the greatest for steelhead but other Columbia River salmonid ESUs subject to tern predation would also benefit.

The NOAA Fisheries analysis estimated that a reduction in the tern colony to approximately 3,125 nesting pairs would result in the one percent or greater increase in population growth rate for all Columbia River Basin steelhead ESUs. Because of uncertainties in the model, we propose to manage for a more conservative range of nesting pairs (approximately 2,500 to 3,125) on East Sand Island to ensure an increase in population growth rate for all Columbia River Basin steelhead ESUs. Based on average nesting densities observed on East Sand (0.55 nesting pairs per square meter) and Rice islands (0.78 nesting pairs per square meter), this proposed range of nesting terns would be able to nest on the proposed habitat acreage (approximately one to 1.5 acres). Based upon the average number of nesting pairs (approximately 9,070) in the Columbia River estuary for 2000 through 2003, approximately 5,945 to 6,570 breeding pairs of Caspian terns would be displaced from nesting on East Sand Island with implementation of this alternative.

Alternative D – Redistribution and Lethal Control of East Sand Island Tern Colony

Similar to Alternative C, tern nesting habitat and colony size on East Sand Island proposed in this alternative would be reduced to decrease tern predation on juvenile salmonids and encourage redistribution of the large concentrated tern colony to other nesting sites within the Pacific Coast region. Similar to Alternative C, approximately 8 acres from sites within the Pacific Coast region would be managed as potential Caspian tern nesting sites to replace the habitat lost on East Sand Island to ensure a network of suitable nesting habitat is available to displaced terns. As with Alternative C, the proposed habitat acreage (approximately 1 to 1.5 acres) and anticipated number of nesting terns was selected to increase the population growth rate for Columbia River Basin steelhead by at least 1 percent. Also sites would be selected from the same seven sites identified in Alternative C. Reduction in tern nesting habitat on East Sand Island would be phased in as habitat at alternate sites is developed at a 2:1 ratio (see description in Alternative C). Also similar to Alternative C, we expect the tern nesting area would be reduced to 1 to 1.5 acres within 3 to 5 years, depending upon available funding for habitat enhancement elsewhere in the region.

Unlike Alternative C, if development of potential nesting habitat elsewhere in the region and subsequent habitat reduction on East Sand Island is not sufficient to reduce the colony size by 2008, a lethal control program would be used in conjunction with these measures to achieve the proposed range of nesting terns (approximately 2,500 to 3,125 pairs in the estuary). The lethal control program would kill up to 50 percent of breeding adult terns each year beginning in 2008. Methods for killing adults could consist of euthanasia of terns after capturing them with a rocket net and use of shotguns to remove individual terns. The actual number of terns that would be killed under this alternative would depend on the success of redistributing a majority of the colony to other sites in the region. If the entire colony nested in the smaller acreage that would remain on East Sand Island, a substantial number of terns would need to be killed. If the colony was partially reduced through habitat reduction, a lower number of terns would be killed (see Chapter 4, section 4.2.1.4 for projections of number of terns that would need to be killed under a lethal control program).

Features Common to All Alternatives

The following components are proposed to be implemented under all alternatives (A through D):

1. The Corps would continue non-lethal efforts, such as hazing, to prevent Caspian tern nesting on upper estuary islands (e.g., Rice Island, Miller Sands Spit, Pillar Rock Island) of the Columbia

River estuary to prevent high tern predation rates of juvenile salmonids in compliance with the 1999 Corps Columbia River Channel Operation and Maintenance Program Biological Opinion;

2. The Service would issue an egg take permit to the Corps for upper estuary islands (not including East Sand Island) if the non-lethal efforts to prevent tern nesting at these sites fail; and

3. The Corps would resume dredged material(e.g., sand) disposal on the downstream end of Rice Island, on the former Caspian tern nesting site.

Affected Environment

The EIS study area encompassed ESA-listed salmonid habitat in the Columbia River Basin and Caspian tern nesting habitat in the States of Washington, Oregon, California, Idaho, and Nevada. This study area falls within the breeding range of the Pacific Coast regional population of Caspian terns and the management jurisdiction of the three cooperating agencies (U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, NOAA Fisheries).

During the planning process, the affected environment for this DEIS was more specifically identified as those Caspian tern nesting areas within Washington, Oregon, and California that are most likely to be affected by proposed management alternatives under consideration in this DEIS. The affected environment extends from the Columbia River estuary, the area of primary management concern, into those sites proposed for Caspian tern management for displaced terns from East Sand Island. Although we anticipate that the boundaries of the affected environment extends to all areas potentially affected by proposed management alternatives, Caspian terns may pioneer into locations not discussed in this DEIS on their own volition. Thus, since this species takes advantage of ephemeral habitat and forage conditions over a wide geographical range, we cannot predict with complete certainty where colonies would establish themselves in the future.

The following summary of the affected environment focuses on Caspian terns and ESA-listed salmonids. See Chapter 3 for the full description of the affected environment.

Caspian Terns

Caspian terns breeding in the Columbia River estuary are in the Pacific Coast/Western breeding region of the North American population. In recent years, terns were documented to have nested on about 60 sites scattered throughout the Pacific Coast region, including Alaska. The tern breeding population in the Pacific Coast region is the largest within the United States. This regional population has increased exponentially since the early 1960s. The overall regional population increase, beginning in the early 1980s, largely represents the great increase observed in the Columbia River estuary from 1984 to 2002. The initial colonization and growth of the Rice Island tern colony appears to have occurred because of the immigration of terns from large colonies in Washington (e.g., Grays Harbor and Willapa Bay). The continued growth and success of this colony at Rice Island, and now East Sand Island, are attributed to the stability of the human-created and/or maintained nesting habitat, reliable food supply of outmigrating juvenile salmonids (primarily hatchery smolts), and the apparent immigration of terns that have lost nesting habitat or were hazed from other colonies (e.g., Everett Naval Base, Washington). In 2003, the East Sand Island colony comprised 71 percent of the regional population (approximately 11,756 nesting pairs). Numbers of terns nesting on East Sand Island has been relatively stable since 1997 following the earlier period of exponential growth.

Breeding Caspian terns eat almost exclusively fish, catching a diverse array of species with shallow plunge dives, usually completely submerging themselves underwater. In the Columbia River estuary, diet studies of the Caspian tern colonies on Rice and East Sand islands documented that terns nesting on Rice Island (1999 to 2000) had an average of 83 (77 to 90) percent juvenile salmonids in their diet, while on East Sand Island (1999 to 2003), terns had an average of 36 (24 to 47) percent juvenile salmonids in their diet. From 1999 to 2003, the tern diet on East Sand Island, closer to the mouth of the Columbia River than Rice Island, was primarily non-salmonids, including northern anchovy, herring, shiner perch, sand lance, sculpins, smelt, and flatfish As ocean conditions improved (e.g., increasing productivity of marine fish), and therefore, productivity, the percentage of juvenile salmonids in the diet of terns in the estuary has declined. In all other areas that have been studied, except Commencement Bay, salmonids were found to be uncommon diet items.

Washington. The distribution and abundance of Caspian terns in Washington has fluctuated dramatically since they were first reported in 1929. Breeding activity was first recorded in the 1950s with small coastal colonies in Grays Harbor. Coastal Washington once supported the largest colonies of breeding terns in the region (e.g., colonies in Grays Harbor). Currently, nesting Caspian terns are only documented to nest at Dungeness NWR, Potholes Reservoir, Banks Lake, and Crescent Island and all of these were small colonies consisting of less than 1,000 nesting pairs. A new colony at Dungeness NWR colony was established in 2003 and now constitutes the only current coastal nesting site in Washington. A peak count of 300 adults was observed in 2003. Although the terns nested on less than 0.25 acre in 2003, more nesting habitat is available in the immediate area.

Oregon. Historically, breeding terns were restricted to shallow lakes and reservoirs of the Klamath Basin and Great Basin. In 1940, less than 1,000 pairs nested throughout Oregon. In recent years, tern numbers in Oregon averaged around 9,000 pairs. Currently, what has been considered the world's largest colony is found near the mouth of the Columbia River on East Sand Island, and small colonies still occur in interior Oregon. Nesting activity in the Columbia River estuary was first documented in 1984. Terns used habitat created by deposition of dredged material on the eastern tip of East Sand Island. By 1985, terns moved to nest on Rice Island. The number of terns peaked on Rice Island at 8,700 pairs in 1998. In 1999, a pilot study was implemented to attract the breeding colony of Caspian terns on Rice Island to East Sand Island. This effort included the removal of vegetation to create bare sand nesting habitat and social attraction techniques (i.e., decoys and audio playback systems) on East Sand Island. The project was successful and since 2001, all terns nesting in the estuary occur on East Sand Island. In 2002 and 2003, an average of 9143 breeding pairs nested on East Sand Island.

Caspian terns also nest in interior sites in Oregon (e.g., Summer, Crump, and Malheur lakes). The number of terns nesting at each site varies dependent on water levels and prey availability. Nesting activity in recent years have been absent because of drought conditions. In 2003, 49 pairs of terns nested at Crump Lake, while only 5 pairs nested at Summer Lake. Caspian terns are a casual visitor at Fern Ridge Lake during spring migration and in late summer during the post-breeding season dispersal and/or migration. Fern Ridge Lake does not contain a suitable nesting site for this species at present.

California. The Statewide breeding population appears to have been relatively stable in the last 30 years. Throughout this period, numbers and location of breeding sites in California fluctuated and shifted, typical of a species reliant on ephemeral habitat for nesting. In San Francisco Bay, Caspian terns initially nested in salt ponds but later expanded or relocated to new sites, typically in response to disturbance from routine maintenance of salt pond levees or predation. Numbers of nesting terns in the bay have remained relatively stable during the past 20 years, but considerable annual movement among colony sites is common. During this period, annual breeding Caspian tern numbers ranged from approximately 1,000 to 2,600 pairs.

ESA-listed Salmonids

Washington. ESA-Listed Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, and bull trout occur in Dungeness Bay. Juvenile Chinook may be present in nearshore areas from May through mid-September and may reside up to 189 days in estuarine habitats. Overall, the abundance of Chinook salmon in the Puget Sound ESU has declined substantially, and both long and short-term abundance trends are predominantly downward. Increasing harvest, coupled with generally increasing trends in spawning escapement, provides evidence that chum salmon, while still ESA-listed, have been increasing in recent years within the Hood Canal ESU. Bull trout are char native to the Pacific Northwest and western Canada. Bull trout within the Coastal/Puget Sound DPS were listed as threatened under the ESA in 1999. Bull trout generally spawn from August through November in small tributaries and headwater streams.

Oregon. Seven salmon and steelhead runs have population segments that are ESA-listed and spend a portion of their lives in the lower Columbia River. The species include 12 ESUs identified by NOAA Fisheries. See Table 3.3, Chapter 3 for a complete list of ESA-listed salmonids in the Columbia River. The first outbound migrants of the lower Columbia River fall Chinook and chum may arrive in the lower Columbia River as early as late February. The majority of these fish are present from March through June. Outbound Snake River fall Chinook begin their migration much farther upstream. They arrive in the lower Columbia River approximately a month later.

Bull trout are relatively dispersed throughout the tributaries of the Columbia River Basin, including its headwaters in Montana and Canada. The Columbia River DPS includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin and currently occur in 45 percent of the estimated historical range. A small number of bull trout has been reported from the area below Bonneville Dam.

California. ESA-listed salmonid ESUs that occur in the San Francisco Bay estuary include the Sacramento River winter-run Chinook; Central Valley spring, fall, and late-fall run Chinook; Central Valley steelhead; Central California Coast steelhead; and Central California Coast coho. Most Sacramento River winter-run Chinook salmon juveniles rear in the Sacramento River through the fall and winter months. Some juveniles move downstream to rear in the lower Sacramento River and delta during the late fall and winter and may begin migrating downstream from December through March. Most yearling Central Valley spring-run Chinook salmon move downstream in the first high flows of the winter from November through January, while some remain throughout the summer and exit the following fall as yearlings. Juvenile Central Valley steelhead live in freshwater from one to four years (usually two years in California), then smolt, and migrate to the sea from February through April. Central California Coast steelhead in most tributaries to San Francisco and San Pablo bays have been virtually extirpated. Fair to good runs of steelhead occur in coastal Marin County tributaries. Based on a 1994 to 1997 survey of 30 San Francisco Bay watersheds, NOAA Fisheries believes that there is a relatively broad distribution of steelhead in smaller streams throughout the watershed.

Environmental Consequences

Alternative A

Effects to Caspian Terns

Washington. Under this No Action alternative, available nesting sites and the number of Caspian terns nesting in Washington are not expected to substantially change. The number of nesting terns could increase at Dungeness NWR or eastern Washington if habitat is maximized (see below) on East Sand Island (projected in 2009). However, we do not expect the colony sizes at these sites to increase substantially in numbers because these sites are limited by size of available nesting area, disturbances to the colony, or prey availability.

Oregon. Based on a simple deterministic model developed by D. Roby (USGS), we project the tern colony on East Sand Island would increase to approximately 18,000 breeding pairs by 2009. This projected increase is attributed to the recruitment of a high number of juvenile terns that were produced between 2001 and 2003. This projected breeding concentration would leave a large percentage of the regional tern population more vulnerable to stochastic events (e.g., storms, human disturbance, predation, and disease) as compared to smaller, more traditionally sized tern colonies dispersed throughout the region.

If the colony increases as projected in 2009, terns would need to look for habitat elsewhere and would likely seek new nesting sites in the estuary (e.g., Rice Island, Miller Sands Spit, or Pillar Rock Island). Aggressive hazing early in the nesting season would be implemented to prevent terns from nesting on these islands. If the hazing is unsuccessful in preventing nesting, egg removal would be initiated immediately. Since egg removal would be conducted with the earliest nesting attempts, we expect a small number of eggs would be collected, thus, effects to the breeding birds would be minimal. In addition, since egg removal would be conducted early in the breeding season, nesting terns would have the opportunity to renest at other sites.

We expect existing conditions at Summer and Crump lakes to continue (nesting tern numbers would change every year depending on fluctuating water levels, exposure of nesting islands, and available prey). Nesting habitat does not currently exist at Fern Ridge Lake, thus, we do not expect terns to nest in this area under this alternative.

California. As in Washington, available nesting sites and the number of Caspian terns nesting in California is not expected to change substantially under this alternative. The stable population trend that has been observed in the last 30 years would most likely continue, with shifts in the number and location of breeding sites, characteristic of tern breeding ecology.

Region. *Regional Population:* Under this alternative, the overall Caspian tern Pacific Coast regional population is expected to maintain its' current trend until nesting habitat is fully occupied on East Sand Island. We expect the regional population trend to stabilize once the East Sand Island colony growth stabilizes. Specific colony locations and sizes throughout the region are anticipated to change from year to year, typical for this species. Although in recent years (1997 to present) the East Sand Island colony size has remained relatively stable, we anticipate a growth in the next decade attributed to recruitment of a high number of juvenile terns that fledged between 2001 and 2003.

Regional habitat. Current nesting sites throughout the region would most likely continue to provide a suite of locations for terns on a regional scale. However, we expect East Sand Island would continue to support the majority of breeding terns in the region because of the stable nesting habitat and abundant prey resources. Many of the other sites in the region vary in suitability every year (e.g., fluctuating water levels, prey resources, and predators).

Effects to ESA-listed Salmonids

Washington. Current effects at Dungeness NWR of this No Action alternative, to Puget Sound Chinook and Hood Canal summer-run chum salmon, steelhead, and bull trout have not been quantified. Based on diet studies of terns nesting in similar habitats (i.e., highly marine coastal sites) and the small colony size (less than 200 breeding pairs), we expect juvenile salmonids to comprise a small percent of their diet. Thus, we expect effects to ESA-listed salmonids at Dungeness NWR to not be substantial. The number of nesting terns could increase in Washington if habitat is maximized on East Sand Island (projected in 2009). However, we do not expect the colony sizes at existing sites (Dungeness NWR and eastern Washington) to increase substantially in numbers because these sites are limited by size of available nesting area, disturbances to the colony, or prey availability. Effects to six ESA-listed stocks that originate in part in Washington would continue to be affected by tern consumption in the Columbia River estuary.

Oregon. Continued effects to ESA-listed salmonids, traveling through and/or rearing in the Columbia River estuary are expected under this alternative. There would be a continued and projected increase in predation of ESA-listed juvenile salmonids by Caspian terns as the colony continues to increase in size. The number of juvenile salmonids annually consumed by terns is expected to increase as the tern colony size increases. The benefits gained from the relocation of terns from Rice Island to East Sand Island would be substantially lost as the tern colony continues to grow. More importantly, Alternative A would not result in any appreciable improvement in population growth rate for ESA-listed steelhead. The larger tern colony size and/or predation levels could suppress the population growth rate for ESA-listed salmonids. Since salmonids do not occur in Summer and Crump lakes, no effects are expected.

California. In San Francisco Bay, outmigration periods for ESA-listed salmonids overlaps with the tern breeding season. Despite this overlap in salmonid outmigration and the tern nesting season, a study in 2003 demonstrated that juvenile salmonids comprise a small portion of the diet of terns in San Francisco Bay. Thus, we expect the effects to ESA-listed salmonids to be limited.

Alternative B

Effects to Caspian Terns

Washington. Under this alternative, the potential for new colonies to become established or the growth of existing colonies in Washington is expected to be high after tern nesting habitat is lost on East Sand Island. At that time, terns would need to seek nesting habitat outside the Columbia River estuary. Thus, existing colonies on Dungeness NWR and in eastern Washington could grow in size. However, as described in Alternative A, we do not expect tern colonies at Dungeness NWR and eastern Washington to increase substantially in numbers because these sites are limited by size of available nesting area, disturbances to the colony, or prey availability. This would limit potential increases in consumption of ESA-listed juvenile salmonids. If nesting tern numbers increase substantially at the eastern Washington sites, where terns are known to forage on ESA-listed salmonids in the mid-Columbia River, Federal, Tribal, and State partners would initiate discussions to ensure that impacts to Columbia River salmonids are minimized.

Oregon. With no management of nesting habitat on East Sand Island, the tern nesting area would become vegetated within 3 years, making the site unusable by nesting terns. Terns would need to look for nesting habitat elsewhere in the region or estuary. This would increase the possibility that terns would return to nest on Rice Island or other islands in the estuary, however, active measures would be implemented to prevent terns from nesting on these islands. Effects would be similar to that described in Alternative A, except that the potential take of eggs could be higher since the entire East Sand Island tern colony would be displaced and probably attempt to nest on upper estuary islands. Similar to Alternative A, we expect existing conditions at Summer and Crump lakes to continue (nesting tern numbers would change every year depending on fluctuating water levels, exposure of nesting islands, and available prey). Thus, although displaced terns from East Sand Island would be actively searching for new nesting sites, we do not expect the number of nesting terns at Crump and Summer lakes to increase substantially because of these limiting conditions. No nesting habitat is currently available at Fern Ridge Lake, thus tern nesting is not expected at this location.

California. As in Washington, existing tern colonies in California may see an influx of displaced terns from the Columbia River estuary, resulting in growth of colony sizes or establishment of new colonies. However, displaced terns would need to select from existing nesting sites currently available, as this alternative does not propose any habitat management actions. Sites within San Francisco Bay appear to have available nesting habitat that is most similar to that found in the Columbia River estuary. However, as described in Alternative A, increases in the number of nesting terns at individual colonies are expected to be within the range observed in the past (e.g., 22 to 2,100 nesting pairs).

Region. *Regional Population.* The overall Pacific Coast regional population is expected to stop its increasing trend once the highly successful colony on East Sand Island is lost. We expect an initial decrease in reproductive success because displaced terns from East Sand Island may not be able to breed for a year or two before they find new nesting sites or breed successfully. However, we expect most of the displaced terns to eventually find alternative nesting sites elsewhere within the Pacific Coast region, and potentially in other regions within their continental distribution. Although terns displaced from East Sand Island may find nesting sites elsewhere in the region, those sites may not be as productive as observed in the Columbia River estuary. Thus, even though displaced terns are able to find alternative nesting sites, this expected lower productivity could still result in an overall decrease in productivity of terns in the region. Ultimately, we expect the regional population trend would stabilize, but possibly at a lower number than currently observed, but remain above those documented in the late 1970s and early 1980s (approximately 6,200 breeding pairs).

Regional habitat. Similar to Alternative A, current nesting sites throughout the region would most likely continue to provide a suite of locations for terns on a regional scale. The majority of the sites that do not require habitat enhancement and are currently available to terns are located in California. Other sites in Washington or Oregon require management and/or enhancement and would most likely not be used by displaced terns.

Effects to ESA-listed Salmonids

Washington. If Dungeness NWR is colonized by higher numbers of Caspian terns as a result of the loss of habitat in the Columbia River estuary, it is probable that an increase in consumption of ESA-listed salmonids (Puget Sound Chinook and Hood Canal summer-run chum) could occur. However because this colony would likely remain small (range somewhere between 100 to 1,000 nesting pairs) and alternative prey are abundant, effects are expected to remain limited. Displaced terns from the Columbia River estuary could potentially nest at existing sites in eastern Washington, provided site conditions are suitable. However, we do not expect these colonies to increase substantially in numbers because most of these sites are limited by size of available nesting area, disturbances to the colony, or prey availability. These characteristics, thus, would limit potential increases in consumption of juvenile salmonids.

Oregon. The loss of tern nesting habitat on East Sand Island in conjunction with implementation measures common to all alternatives (prevention of tern nesting at upper estuary islands), Caspian terns would be eliminated from the estuary. This would result in a substantial reduction and eventual elimination of tern predation on ESA-listed salmonids in the estuary. Implementation of this alternative would result in a positive change in steelhead population growth rates that would be realized within 6 to 7 years after implementation of this alternative.

California. In San Francisco Bay, a probable increase of predation on ESA-listed salmonids would occur if terns displaced from the Columbia River estuary select to nest in the bay. However, as described in Alternative A, effects to ESA-listed salmonids are expected to be limited as tern numbers are not expected to grow substantially and salmonids were not observed to be primary prey for terns in San Francisco Bay in 2003.

Alternative C – PREFERRED ALTERNATIVE

Effects to Caspian Terns

Washington. Similar to Alternative B, the colony on Dungeness NWR could increase in size from the immigration of displaced terns from East Sand Island under this alternative. Management actions may be taken to protect this colony from possible disturbance from humans and/or predators. If management efforts are implemented, we expect the size of this colony could grow to range somewhere within the historic colony sizes observed in the Washington coast (100 to 3,500 breeding pairs). Similar to Alternatives A and B, there is also a potential for establishment of new colonies or enlargement of existing sites in eastern Washington. The likelihood of this occurring however, would be lower than in Alternatives A and B because proposed management at alternate sites in the region is expected to attract the majority of displaced terns. Additionally, as described in Alternatives A and B, most of these sites are limited by size of available nesting area, disturbances to the colony, fluctuating water levels, or prey availability. Thus, even if some displaced terns nest at these sites, we do not expect the size of these colonies to increase substantially, limiting potential increases in consumption of Columbia River juvenile salmonids. As with Alternatives A and B, if nesting tern numbers increase substantially in these upper Columbia River sites, Federal, Tribal, and State partners, including appropriate land owners and managers, would initiate discussions as part of the adaptive management approach proposed in this DEIS, to ensure that impacts to Columbia River salmonids are minimized.

Oregon. Based on the range of known nesting densities in the estuary, we expect that the tern colony on East Sand Island would decrease to approximately 2,500 to 3,125 breeding pairs when nesting habitat is restricted to approximately one to 1.5 acres. This would be a 60 to 70 percent decrease from the 2003 colony size, a substantial decrease in this colony. We expect that terns displaced from East Sand Island to find nesting sites elsewhere in the region, especially since this alternative proposes to manage approximately 8 acres of habitat specifically for Caspian terns. However, other tern nesting sites in the region have not been observed to be as productive as in the Columbia River estuary (except for Solstice Island, Washington). Thus, displaced terns may incur an overall decrease in productivity to levels more similar to those typically observed in the region. The active measures (e.g., hazing, egg take, etc.) that would be implemented to prevent terns from nesting on the upper estuary islands would result in effects similar to that described in Alternative A.

Some of these displaced terns could be attracted to nest at Summer, Crump, and/or Fern Ridge lakes as management actions are proposed for these sites in this Alternative. At Summer Lake, we expect that nesting tern numbers could range between 5 to 300 breeding pairs. At Crump Lake, the newly created 1-acre island could also support numbers of terns similar to that expected at Summer Lake. Prey base may be limiting at these two sites, and thus, the actual number of terns that can successfully nest at Summer and Crump lakes may not be as high as the nesting habitat could accommodate. At Fern Ridge Lake, we expect the number of nesting terns at this site to be similar to that of Summer and Crump lakes (5 to 300 breeding pairs). However, since this is not a historic nesting site, social attraction efforts may need to extend over a number of years before terns initiate nesting at this site.

California. The number of terns nesting in California would most likely increase substantially from the immigration of terns displaced from the Columbia River estuary. In San Francisco Bay, the current colony on Brooks Island could grow from an average of approximately 900 pairs to at least 1,500 breeding pairs after habitat is enhanced, but could grow larger if conditions (e.g. prey abundance or predators) are suitable. At the two remaining sites in San Francisco Bay (Hayward Regional Shoreline and Ponds N1-N9), colony sizes are expected to range between 100 to 1,500 breeding pairs (at each site), depending on the success in attracting terns to these new nesting sites.

Region. *Regional population.* We expect a substantial effect to the distribution and initial reproductive success of the Caspian tern regional population under this alternative. An estimated 6,000 to 6,600 breeding pairs of Caspian terns would be displaced from East Sand Island as tern nesting habitat is reduced. The dispersal of this large concentrated colony would be a benefit to the regional population because the potential risk of this large segment of the population to catastrophic events (e.g., disease, predators, storms,) would be removed. Additionally, increasing the network of nesting sites in both coastal and interior locations with varying conditions offers a better potential for maintaining a stable regional population over time in comparison to a network comprised of fewer sites and with larger concentrations of nesting terns. Although we attempt to project the response of displaced birds, Caspian terns may pioneer into locations not discussed in this DEIS on their own volition. Thus, since this species takes advantage of ephemeral habitat and forage conditions over a wide geographical range, we cannot predict with complete certainty where colonies would establish themselves in the future.

We expect that the managed sites would provide suitable habitat to accommodate displaced terns, particularly when combined with existing sites. However, we still would expect an initial decrease in reproductive success because displaced terns from East Sand Island may not breed for a year or two before they find new nesting sites or breed successfully. In the long-term, we expect the regional population to stabilize, possibly at a lower number than currently observed, but remain well above those documented in late 1970s and early 1980s (approximately 6,200 nesting pairs). If the regional population declines to fifty percent of the current size (the number observed in the late 1970s and early 1980s), management of Caspian tern nesting sites in the region would be reevaluated as part of the adaptive management approach proposed in this DEIS.

Regional habitat. Similar to Alternatives A and B, current nesting sites throughout the region would most likely continue to provide a suite of locations suitable for supporting terns on a regional scale. However, unlike Alternatives A and B, the development of approximately 8 acres of nesting habitat proposed under this alternative would ensure that an enhanced network of nesting sites, dispersed throughout the Pacific Coast region, would be available for terns displaced from East Sand Island. Displaced terns would be able to select from these managed sites as well as underutilized existing habitat throughout the region. Even though habitat would be developed for nesting Caspian terns, terns are expected to nest opportunistically throughout the region based on various factors (e.g., food resources, proper nesting substrate, competition, or predation). Thus, specific colony locations and sizes throughout the region would change from year to year as is currently observed. This alternative provides a more enhanced suite of locations suitable for supporting terns on a regional scale (as compared to Alternatives A and B).

Effects to ESA-listed Salmonids

Washington. Effects to Puget Sound Chinook and Hood Canal summer-run chum would be similar to that described in Alternative B with the exception that management actions that may be implemented to further protect the nesting site on Dungeness NWR for terns could result in an increased number of terns. As described in Alternative B, the potential increase in Caspian terns would probably result in an increase in consumption of ESA-listed juvenile salmonids. Effects, however, are expected to remain limited. Similar to Alternative B, there is a potential for displaced terns from the Columbia River estuary to nest in eastern Washington. The likelihood of this occurring, however, would be lower than in Alternatives A and B because proposed management at alternate sites in Oregon and California is expected to attract majority of displaced terns.

Oregon. Based on the NOAA Fisheries analysis, population growth rate for Columbia River steelhead ESUs increases would occur within one generation (4 to 5 years). We expect the reduction in size of the tern colony on East Sand Island to 2,500 to 3,125 breeding pairs is expected to occur within 3 to 5 years after implementation of this alternative. Thus, initial benefits for ESA-listed salmonids could be realized within 6 to 7 years after program implementation. The projected improvement in steelhead population growth rate is similar in magnitude to that of increases in steelhead population growth rates that would result from hydropower improvements (0 to 4 percent increase), but well below improvements that could be achieved by harvest reductions (4 to 8 percent increase). Ultimately, long-term benefits to ESA-listed salmonids in the Columbia River estuary would depend on the ability to maintain available nesting habitat to a level that continues to maintain a range of nesting terns of 2,500 to 3,125 pairs identified in this DEIS. However, long-term success of efforts intended to increase population growth rates of ESA-listed salmonids must be placed in context with other sources of mortality subject to human intervention. Cumulatively, the variety of salmon recovery actions have the potential to influence population growth rate to a substantially greater degree than would be realized from solely reducing predation from avian predators in the Columbia River estuary.

At Fern Ridge Lake, Caspian terns could forage many miles away from the nesting site. A 15 mile radius around Fern Ridge Lake includes portions of the Willlamette and McKenzie rivers. If Caspian terns successfully nested at Fern Ridge Lake, terns would occur in the general area during the mid- to latter stages of the outmigration period for ESA-listed salmonids. Thus, terns could potentially consume juvenile salmonids if they forage in the Willamette and McKenzie rivers. However, effects to these ESA-listed salmonids are expected to be limited because the number of nesting terns are expected to be small (5 to 300 pairs).

California. Effects to ESA-listed salmonids have the potential to increase under this alternative because specific sites in San Francisco Bay may be managed to attract displaced terns from the Columbia River estuary. However, as described in Alternatives A and B, although there is some overlap with the outmigration periods of these salmonid species during the tern breeding season, effects are expected to remain limited. In particular, the diet study conducted in 2003 indicated that salmonids comprise a small portion of the tern diet and individual colony sizes (100 to 1,500 pairs) are predicted to remain small in comparison to that observed in the Columbia River estuary. Additionally, alternative prey (e.g. marine fishes) are most likely abundant and available to nesting terns, reducing the potential for terns to prey on salmonids.

Alternative D

Effects to Caspian Terns

Washington. Effects of habitat management actions proposed in this alternative in Washington would be similar to that described in Alternative C. Since specific habitat would be managed at alternate sites for terns, the likelihood that displaced terns would increase in numbers or establish new colonies in Washington is lower than that expected in Alternative B. However, if a lethal control program is implemented and causes the entire colony on East Sand Island to abandon the site, the pressure of finding alternative nesting habitat would be greater than anticipated in Alternative C. On the other hand, if lethal control is implemented and is successful in reducing the number of breeding terns on East Sand Island by fifty percent, then the actual number of displaced terns would be less than Alternative C and few terns would be expected to breed in Washington.

Oregon. Effects to Caspian tern numbers in Oregon would be the same as that described in Alternative C, except if a lethal control program is implemented. The decreased number of breeding terns in the Columbia River estuary would be a result of both the redistribution of terns due to habitat loss on East Sand Island and the direct loss of breeding birds through a lethal control program. The lethal control program would kill approximately 50 percent of the breeding birds (2,500 to 3,000 annually) for several years until the proposed range of nesting pairs is attained. Although the intention would be to kill a specific number of terns every year to maintain a colony within the target range, the control methods and associated activities (e.g., rocket nets, human activity in the colony) themselves may be disturbing to the entire colony. This may result in complete abandonment of the site and dispersal of these birds back to upper estuary islands or other locations in the region. Thus, effects to the tern colony on East Sand Island under this alternative are expected to be substantial. Similar to Alternative C, we expect small colonies (5 to 300 breeding pairs) at Summer, Crump, and Fern Ridge lakes as a result of habitat enhancement activities at these sites.

California. Since management actions at specific sites in California are the same as proposed in Alternative C, effects to Caspian tern colonies in California would be similar to that described in

Alternative C. However, if a lethal control program is implemented and causes the entire colony on East Sand Island to abandon the site, the pressure of finding alternative nesting habitat would be greater than anticipated in Alternative C. On the other hand, if lethal control is implemented and is successful in reducing the number of breeding terns on East Sand Island, then the actual number of displaced terns would be less than Alternative C and fewer terns would be expected to breed in California.

Region. *Regional population.* If habitat reduction is successful in redistributing displaced terns from East Sand Island to elsewhere in the region, effects to the regional tern population would be similar to that described in Alternative C, resulting in a regional population that could initially decline but eventually stabilize at levels higher than documented in the late 1970s and early 1980s. However, if a lethal control program is implemented, this alternative, unlike all remaining alternatives, would result in a population control program for Caspian terns. If the proposed number of terns is removed from the population, we would expect to see a reduction of the regional tern population by approximately fifty percent. This is a substantial decrease to the regional tern population.

Regional habitat. Similar to Alternative C, the development of approximately 8 acres of nesting habitat, in addition to current nesting sites would provide an enhanced suite of locations suitable for supporting terns on a regional scale (as compared to Alternatives A and B). Displaced terns would be able to select from sites managed specifically for nesting terns as well as underutilized existing habitat throughout the region. Specific colony locations and sizes throughout the region are expected to change from year to year as is currently observed.

Effects to ESA-listed Salmonids

Effects to ESA-listed salmonids in Washington, Oregon, and California are similar to that described in Alternative C, with the exception that if lethal control is implemented to reduce the colony size on East Sand Island, the overall number of birds that may be displaced from the Columbia River estuary may be lower than expected in Alternative C. Thus, fewer salmon would be lost due to tern predation in Washington, Oregon, and California.

Cumulative Effects

This section addresses the potential cumulative effects for all of the alternatives and is intended to consider the proposed action in the context of other actions on a larger temporal and spatial scale. The large breeding concentration of terns in the Columbia River estuary is more vulnerable to stochastic events (e.g., storms, predators) and disease as compared to a similar population that is dispersed among many smaller colonies. Thus, dispersal of the large and concentrated tern colony on East Sand Island would result in a benefit to the regional population because the potential risk of this large segment (approximately 70 percent) of the population to catastrophic events would be removed. Additionally, increasing the network of nesting sites in both coastal and interior locations with varying conditions offers a better potential for maintaining a stable regional population over time in comparison to a netowork comprised of fewer sites and concentrations of larger individual colonies. The proposed enhanced suite of nesting locations would provide more suitable habitat for supporting terns on a regional scale as well as help support other management actions to decrease the loss of juvenile salmonids in the Columbia River estuary.

Reducing tern predation in the estuary is one additional mechanism that can be used to improve juvenile salmonid survival, thereby increasing population growth rates of ESA-listed salmonids in the Columbia River Basin. Many of the measures taken to restore salmonids in the Columbia River Basin have focused on improving survival of juvenile salmonids through the mainstem dams. The reduction in tern predation on juvenile salmonids would complement and protect benefits associated with upstream efforts to increase the number of juvenile salmonids reaching the ocean.

Ultimately, long-term benefits to ESA-listed salmonids in the Columbia River estuary would depend on maintaining nesting habitat on East Sand Island to support the proposed range of terns (2,500 to 3,125 pairs). However, long-term success of efforts intended to increase population growth rates of ESA-listed salmonids must be placed in context with other sources of mortality subject to human intervention. Hydropower operations, harvest impacts, habitat conditions, hatchery operations, and introduced species all have the potential to affect population growth rates of ESA-listed salmonids, and are subject in various degrees to management efforts to alleviate detrimental effects. Actions to address these impacts have been implemented or proposed, and others may be developed in the future. Cumulatively, these actions have the potential to influence population growth rate to a substantially greater degree than would be realized from solely reducing predation from avian predators in the Columbia River estuary.

Chapter 1. Purpose of and Need for Action

1.1 Introduction

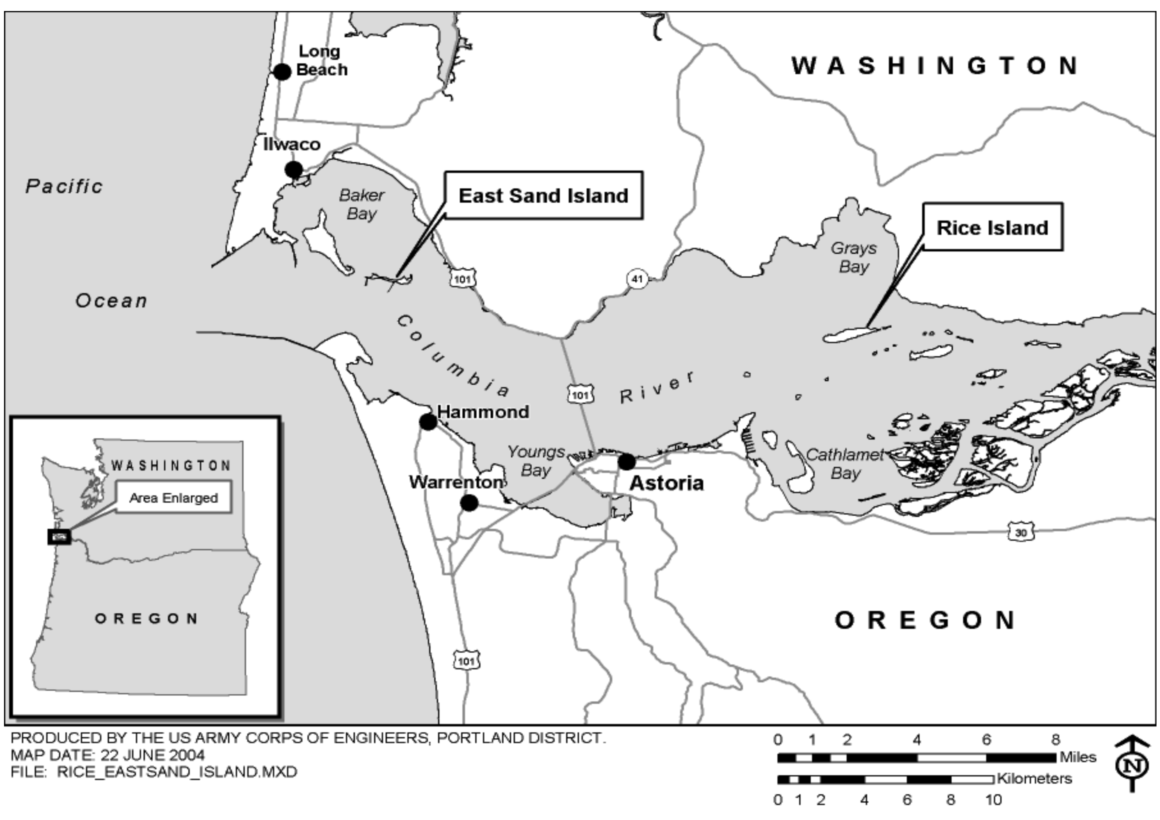
This section of the Draft Environmental Impact Statement (DEIS) discusses the purpose of and need for the Federal action, the legal and policy context of the action, and stakeholder involvement in developing the DEIS.

Recent increases in the number of Caspian terns (*Sterna caspia*, hereafter, tern used alone refers to Caspian tern) nesting in the Columbia River estuary has led to concerns over their potential impact on the recovery of threatened and endangered Columbia River salmonids (salmon and steelhead).

In 1999, National Marine Fisheries Service (NOAA Fisheries) called for the U.S. Army Corps of Engineers (Corps) to eliminate tern nesting from Rice Island (located in the upper estuary) in an attempt to decrease the number of juvenile salmonids eaten by terns (NOAA Fisheries 1999). In 1999, the Corps initiated a pilot project to relocate the Rice Island tern colony to East Sand Island, near the mouth of the estuary (see Figure 1.1 for location of islands), where marine fish (i.e., non-salmon) were abundantly available to foraging terns (U.S. Army Corps of Engineers 1999b). In 2000, the Corps proposed to complete the relocation effort to prevent all tern nesting on Rice Island while attracting terns to nest on East Sand Island (U.S. Army Corps of Engineers 2000).

As a result of the proposed actions in 2000, Seattle Audubon, National Audubon, American Bird Conservancy, and Defenders of Wildlife filed a lawsuit against the Corps and U.S. Fish and Wildlife Service (Service). The four groups alleged in the suit that compliance with the National Environmental Policy Act (NEPA) was not sufficient for the proposed action of relocating Caspian terns from Rice Island to East Sand Island. Furthermore, the groups objected to the Service's issuance of a Migratory Bird Treaty Act (MBTA) permit authorizing the potential take of tern eggs as a means to prevent tern nesting on Rice Island.

FIGURE 1.1 Columbia River Estuary



Caspian tern with salmon smolt. Photo credit: Dan Roby

In 2002, all parties reached a Settlement Agreement. Terms of the agreement required the Service (lead agency), Corps, and NOAA Fisheries to prepare an Environmental Impact Statement (this DEIS) to address long-term management of Caspian terns in the Columbia River estuary. The 2002 Settlement Agreement also required the Service and NOAA Fisheries to develop and publish three technical reports: (1) *Status Assessment and Conservation Recommendations for the Caspian Tern in North America* (Shuford and Craig 2002), (2) *Caspian Tern Predation on Salmon and Steelhead Smolts in the Columbia River Estuary* (NOAA Fisheries 2002), and (3) *A Review of Caspian Tern Nesting Habitat: A Feasibility Assessment of Management Opportunities in the U.S. Fish and Wildlife Service Pacific Region* (Seto et al. 2003).

Although the relocation of terns from Rice Island to East Sand Island resulted in a decreased percentage of salmonids in the tern diet, NOAA Fisheries continues to be concerned about tern predation on juvenile salmonids because of a projected increase in the tern colony size on East Sand Island.

1.2 Purpose of and Need for Action

The purpose of the proposed action is to comply with the 2002 Settlement Agreement by identifying a management plan for Caspian terns in the Columbia River estuary that reduces resource management conflicts with ESA-listed salmonids while ensuring the conservation of Caspian terns in the Pacific Coast/Western region (hereafter Pacific Coast region, see Chapter 3 for description). ESA-listed salmonids (Table 3.2) are those listed as threatened or endangered under the Federal Endangered Species Act (ESA) of 1973. The ESA provides for the conservation of species which are in danger of extinction throughout all or a significant portion of their range and the conservation of the ecosystems on which they depend. Managing Caspian terns to address salmonid predation would add to larger recovery efforts (described below), contributing to the overall recovery of ESA-listed salmonids in the Columbia River Basin.

Caspian tern colony on East Sand Island, Columbia River estuary. Photo credit: Nanette Seto

The need for action has been driven by the recent increase of Caspian terns nesting in the Columbia River estuary and their associated predation on ESA-listed salmonids. Caspian terns were first documented to nest in the Columbia River estuary in 1984. Since then, their numbers have increased from approximately 1,000 breeding pairs to a peak of nearly 10,000 pairs in 2002, the largest recorded tern colony in the world (Shuford and Craig 2002, Collis et al. 2002a). This great increase has resulted in an exponential increase of the regional tern population since the 1960s. From 2000 to 2003, Caspian terns on East Sand Island ate an average 5.9 million juvenile salmonids a year (the annual average ranged from 4.2 to 8.2 million), including ESA-listed salmonids (Collis et al. 2002a, 2002b, 2003a, and 2003b).

NOAA Fisheries assessed the impact of Caspian tern predation on the population growth rate of Columbia River Basin steelhead using a life cycle model and estimated predation rates from available research and monitoring data (NOAA Fisheries 2004, Appendix C). Steelhead were the focus of this analysis because they are consumed in the highest numbers (by terns) and thus, are most affected by tern predation in the Columbia River estuary. Thus, potential benefits from reducing tern predation are the greatest for steelhead but benefits to other salmonids consumed by terns would also occur.

The NOAA Fisheries model estimated that if the number of breeding terns in the estuary was reduced by 50 percent, then steelhead population growth rates were projected to increase by 0.67 to 0.97 percent over a period of about 4 to 5 years (equal to one generation of salmon). If all else were equal, this projected improvement in steelhead population growth rates is equivalent to projected changes in growth rates that would result from improvements in the hydropower system (e.g., increased spill, improved passage facilities, increased fish transportation) required by NOAA Fisheries (NOAA Fisheries 2000), but is well below improvements that could be gained through harvest reductions (e.g., timing, placement of nets, catch limits, McClure et al. 2003, NOAA Fisheries 2004, Appendix C). The cumulative benefits from a reduction in tern predation, hydropower improvements, and other Columbia River Basin regional and local salmon recovery efforts is expected to result in improvement in the status of ESA-listed stocks.

An additional need for action stems from the concentration of Caspian terns on East Sand Island in the Columbia River estuary. Approximately 70 percent of the Pacific Coast regional population of Caspian terns nest in the Columbia River estuary in a single colony (Shuford and Craig

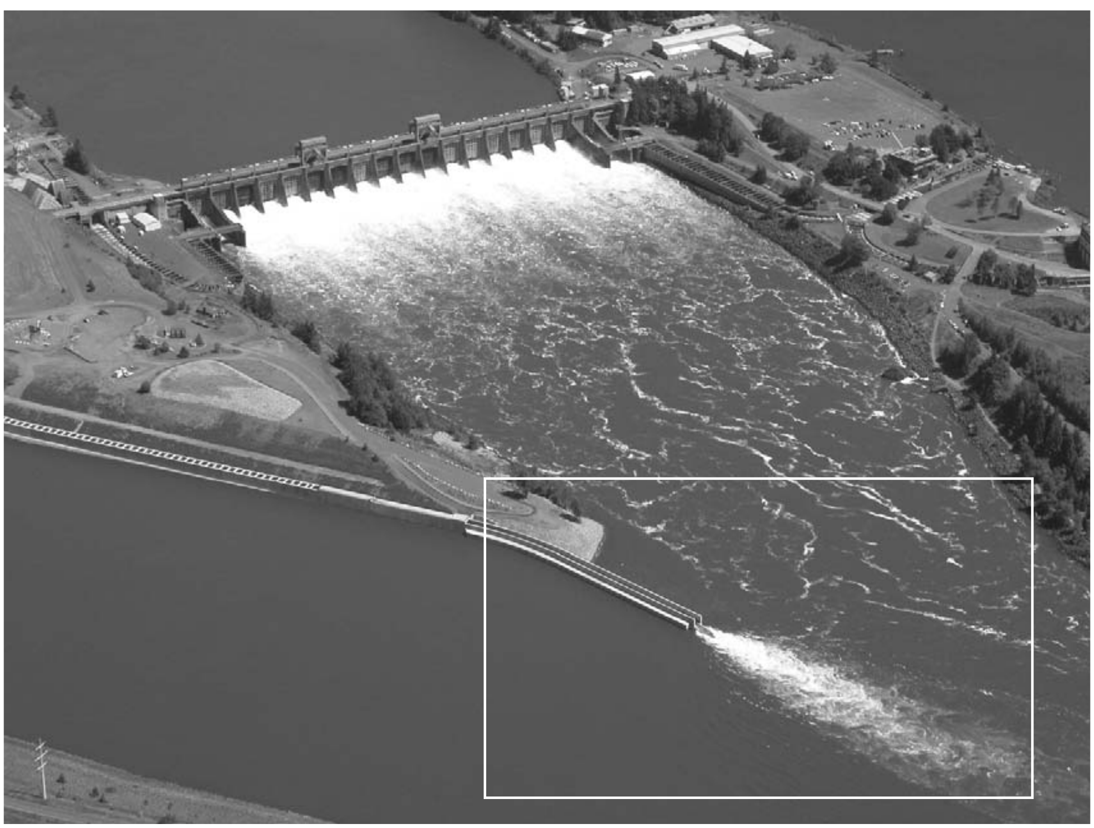


Photo inset: Second Powerhouse Corner Collector at Bonneville Dam which diverts juvenile salmonids away from dam turbines and safely back into the Columbia River.
Photo credit: U.S. Army Corps of Engineers

2002). This breeding concentration leaves birds more vulnerable to stochastic events, (e.g., storms, human disturbance, predation, and disease) as compared to a similar population that is dispersed among many smaller colonies (Roby et al. 2002, Shuford and Craig 2002). Management of this concentrated tern colony would help ensure the long-term conservation of the Pacific Coast regional population.

1.2.1 Guiding Principles

In 1998, an interagency Caspian Tern Working Group (CTWG) was formed that was comprised of representatives from Federal and State agencies, Tribes, and researchers. Their purpose was to address the role of tern predation in the estuary in the recovery of ESA-listed Columbia River salmonids. Agencies participating in the CTWG agreed to the following set of Guiding Principles in developing options for managing salmon recovery and tern resource conflicts:

1. Caspian terns and salmonids are native species of the Pacific Northwest and the Columbia River estuary (defined as the Columbia River from its terminus to River Mile 46).

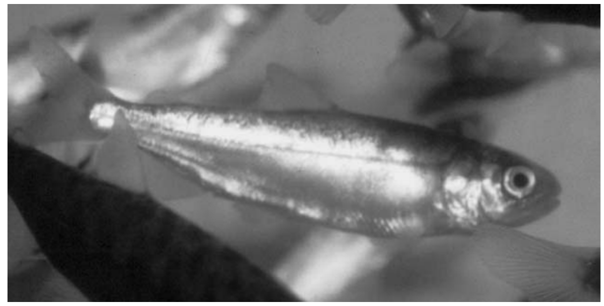
2. Caspian terns and ESA-listed salmonids are protected under International Treaties and Federal and State laws.

3. Management actions will be implemented to ensure Caspian terns remain a viable and integral part of the estuarine, coastal, and interior ecosystems of the Pacific Coast region, including the Columbia River estuary, in a manner consistent with salmon recovery.

4. Tools are available to manage terns as one component of a comprehensive program to recover salmonids.

5. Management actions will be implemented to ensure the recovery of ESA-listed salmonids is not impeded by tern predation.

Guiding Principles 1 through 3 were included in the stipulations of the 2002 Settlement Agreement and, in combination with principles 4 and 5, served to guide the development of management alternatives presented in this DEIS.



Salmon smolt. Photo credit: Bonneville Power Administration

1.2.2 Context of Purpose and Need

Nearly every population of naturally producing anadromous salmonids in the Columbia River Basin is now listed (or is a candidate for listing) under the ESA (NOAA Fisheries 2004). Overall salmon recovery efforts are primarily focused on in-stream improvements in both juvenile and adult survival (e.g., predator control, hydropower improvements, and habitat restoration) since management opportunities for enhancing open ocean survival are limited.

We now know that estuaries help contribute to the viability of salmon populations by providing support for the various life history stages (Fresh et al. 2004). Thus, NOAA Fisheries recommends strategies to improve juvenile salmonid survival [e.g., predator control (birds and other fish), increased spill, etc.] with the expectation that this will contribute to an improvement in adult returns and thereby overall recovery of ESA-listed salmonids. Reducing tern predation in the estuary would be one of several additional mechanisms that can be used to improve juvenile salmonid survival.

The Caspian tern colony in the Columbia River estuary, recently relocated to East Sand Island, continues to annually consume large numbers of juvenile salmonids (average annual consumption for terns during 2000 to 2003 was 5.9 million juvenile salmonids, Collis et al. 2002a, 2002b, 2003a, 2003b). This high consumption level can be attributed to the large tern colony size in the estuary that is made possible due to modifications that have occurred in the Columbia River system.

For example, the creation of dredged material islands provide stable habitat every year, circumstances that are atypical. In addition, barging and release of hatchery-reared and wild salmonids have affected the timing of outmigrating juvenile salmonids, resulting in a concentration of their presence in the estuary during the tern nesting season. With the Caspian tern colony in the estuary anticipated to increase in size due to the high production of fledglings in 2001, 2002, and 2003 (Collis et al. 2002a, 2003a, 2003b), predation of juvenile salmonids by terns may increase in the future as birds produced in those years are recruited into the adult breeding population.

Caspian tern predation should also be considered in context with upstream investments that are implemented to improve juvenile salmonid survival. Many of the measures taken to restore salmonids in the Columbia River Basin have focused on improving survival of juvenile salmonids through the mainstem dams. These measures are associated with the operation and management of the Federal Columbia River Power System (FCRPS) and include research, development, and construction of measures under the Columbia River Fish Mitigation (CRFM) program of the Corps.

Costs associated with the implementation of the FCRPS Biological Opinion (e.g., aggressive hydropower measures, increased spill, improved passage facilities, increased fish transportation, NOAA Fisheries 2000), CRFM, and other salmon recovery efforts are substantial and reported in the Endangered Species Act 2003 Check-In Report (U.S. Bureau of Reclamation et al. 2003). Caspian tern predation on juvenile salmonids should be reduced to complement and protect benefits resulting from upstream efforts (as described above) to increase the number of juvenile salmonids reaching the ocean.

Reducing tern predation in the estuary in combination with other mechanisms that aim to improve juvenile salmonid survival is anticipated to increase population growth rates of ESA-listed salmonids in the Columbia River Basin (NOAA Fisheries 2004, Appendix C). Long-term success of efforts intended to increase population growth rates of ESA-listed salmonids must be placed in context with other sources of mortality subject to human intervention. Hydropower operations, harvest impacts, habitat conditions, hatchery operations, and introduced species all have the potential to affect population growth rates of ESA-listed salmonids, and are subject in various degrees to management efforts that are designed to alleviate detrimental effects. Actions to address these impacts have been implemented or proposed, and others may be developed in the future.

1.3 Authority and Responsibility

1.3.1 U.S. Fish and Wildlife Service

The primary responsibility of the Service is conserving and enhancing the nation's fish and wildlife populations and their habitats. The Service's mission is: "working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people." While the Service's responsibilities are shared with other Federal, State, Tribal, local, and private entities, the Service has specific trust responsibilities for migratory birds; threatened and endangered species; certain anadromous fish and marine mammals; and enforcing Federal wildlife laws. The Service's responsibilities for management of Caspian terns are authorized under the Migratory Bird Treaty Act. Consistent with the Settlement Agreement, the Service is the lead agency for preparation of this EIS.

The Service also has similar responsibilities for the lands and waters it administers in the National Wildlife Refuge System to support the conservation and enhancement of fish and wildlife.

1.3.2 U.S. Army Corps of Engineers

The Corps, in its mission to serve the nation, is responsible for the terms and conditions of the Biological Opinions that pertain to implementation, operation and/or maintenance of the Corps civil works projects. The Corps (referred to as COE in excerpt below) authority and responsibility regarding management of Caspian terns in the Columbia River estuary arises from implementation of mandatory terms and conditions of the September 15, 1999 NOAA Fisheries Biological Opinion (BO) on the Corps' Columbia River Channel Operation and Maintenance Program (NOAA Fisheries 1999).

The BO addressed both Caspian tern and cormorant concerns, and included in sub-section C, the following Terms and Conditions (T&C):
"1a. The COE shall modify the habitat on Rice Island by April 1, 2000, so that it is no longer suitable as a nesting site for Caspian terns or provide for the hazing of terns off the island in a manner that will preclude their nesting. The COE shall ensure that any terns hazed off the island do not nest on any dredge spoil islands in the action area (other than East Sand Island). The COE shall continue to prevent nesting of Caspian terns on disposal islands within the action area for the life of the project."

Caspian tern colony on Rice Island, before relocation to East Sand Island. Photo credit: Columbia Bird Research (OSU/RTR)

In accordance with the stipulations of this T&C, the Corps relocated the Caspian tern colony from Rice Island to East Sand Island in 1999 and 2000 and has annually maintained approximately 6 acres of habitat on East Sand Island for nesting by terns. Hazing operations (see section 2.2 for description) at Rice Island, Miller Sands Spit and/or Pillar Rock Island in the upper estuary (Columbia River mile 21 to 28) have been implemented annually as necessary to discourage terns from attempting to nest at these locations.

Corps responsibilities for tern management are also identified under Public Law 106-53, Section 582c "(1) NESTING AVIAN PREDATORS - In conjunction with the Secretary of Commerce and the Secretary of the Interior, and consistent with a management plan to be developed by the United States Fish and Wildlife Service, the Secretary (Army) shall carry out methods to reduce nesting populations of avian predators on dredge spoil islands in the Columbia River under the jurisdiction of the Secretary."

The Corps is also responsible for implementation of many of the reasonable and prudent alternatives identified in the 2000 FCRPS BO for protection and improvement of juvenile salmon survival at their four mainstem Columbia River and four Snake River dams.

1.3.3 National Marine Fisheries Service

NOAA Fisheries is dedicated to the stewardship of living marine resources (i.e., Pacific salmonids, groundfish, halibut, marine mammals and their habitats) through science-based conservation and management and the promotion of healthy ecosystems. As a steward, NOAA Fisheries conserves, protects, and manages living marine resources in a manner to ensure their continuation as functioning components of marine ecosystems, to afford economic opportunities, and to enhance the quality of life for the American public.

NOAA Fisheries is responsible for overseeing ESA implementation for salmonids. Under Section 7 of the ESA, Federal agencies must consult with NOAA Fisheries on any action they permit, fund, or manage that is likely to adversely affect a threatened on endangered species. NOAA Fisheries must issue a "biological opinion" that explains how the Federal action affects the species and lays out what actions the agency should take to protect the species.

NOAA Fisheries also implements the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended by the Sustainable Fisheries Act of 1996. The MSA establishes a national program to manage and conserve the coastal fisheries of the United States through the development of Federal Fishery Management Plans (FMP) and Federal regulation of domestic fisheries under those FMPs within a 200-mile Exclusive Economic Zone.

Under the MSA, Congress also mandated the identification of habitats essential to managed species and measures to conserve and enhance this habitat. NOAA Fisheries, in coordination with Fishery Management Councils and Federal agencies, is required to protect, conserve, and enhance designated essential fish habitat (EFH). Congress defined essential fish habitat for federally managed species as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

1.4 Policy, Legal Compliance, Consultation, and Coordination with Others

1.4.1 Policy and Legal Compliance

In undertaking the Proposed Action, the cooperating action agencies must comply with a number of Federal laws, Executive Orders, regulations, and other guidance pertinent to a Federal action. These are listed and summarized in Appendix D.

1.4.2 Consultation and Coordination with Others

This section describes consultation and coordination efforts with the public, interested groups, other agencies, and Tribes.

Public Outreach. On April 7, 2003, the Service, in cooperation with NOAA Fisheries and Corps, published a Notice of Intent (68 FR 16826) in the Federal Register to prepare an EIS for Caspian tern management in the Columbia River estuary. The notice also solicited public participation in the scoping process (see Section 1.5 below).

The Service mailed Dear Interested Party letters to 668 organizations and individuals as additional notification of the public meetings. These names were drawn from the three participating agencies' interested-party databases and additional names were provided by the States of California, Oregon, and Washington. Public scoping meetings were in these three States (see Table 1.1 for a list of locations).

The public meeting format was in the style of an open house with information on table-top board displays. Representatives from the three agencies were available to answer questions.

Additionally, the Service created a website to provide the public with information about the project, access to the technical reports mentioned in Section 1.1, and various background documents. This website is located at: http://migratorybirds.pacific.fws.gov/CATE.htm. It will be maintained throughout the EIS development process to keep the public updated on the project.

In addition to the above public outreach, a planning update was distributed in September 2003. This was sent to people or groups who attended public meetings or sent in comments, to anyone who requested to be on our mailing list, and to other interested parties (see Appendix E for our project distribution list).

Coordination with Other Agencies. Staff from the three cooperating agencies met with representatives from the wildlife agencies of the States of Washington and Oregon on May 30, 2003. The objectives of the meeting were to provide a summary report of Columbia River estuary management and research projects, an update on the status of the Caspian Tern EIS, and discuss future plans, expectations, roles, and interagency coordination regarding tern management in the estuary and the Pacific Coast region. Meeting attendees also visited the tern colony on East Sand Island.

State agencies from Washington, Oregon, California, Idaho, and Nevada and the Bonneville Power Administration were given the opportunity to comment on an Administrative Review Draft of the DEIS.

Coordination with Tribal Governments. Tribal governments that fell within the scope of this DEIS were contacted during our scoping period and given the opportunity to submit comments or attend our public scoping meetings. Tribes were also given the opportunity to comment on an Administrative Review Draft of the DEIS.

Federal and State agency representatives and Caspian tern researchers visit East Sand Island as part of an EIS coordination meeting, May 2003.

1.5 Scoping

Scoping is the initial stage of the EIS process used to identify issues, alternatives, and impacts to be addressed in the NEPA analysis. Public comments were accepted from the date of publication of the Notice of Intent on April 7, 2003 until May 22, 2003.

Public meetings (Table 1.1) were held in California, Oregon, and Washington (see section 1.4.2.1 above). Sixty people attended the public scoping meetings. Attendees were asked to submit written comments at the meeting or through the mail. Thirty-seven comment letters were submitted from public meeting attendees and 79 comment letters were submitted outside of public meetings, either electronically (to cateeis@fws.gov) or by mail. Internal scoping meetings were also conducted during the scoping period. A full description of the scoping period can be found in the EIS Scoping Report prepared by the Service. Key issues identified during public and internal scoping are summarized below.

1.5.1 Issues of Concern Identified During Scoping

The majority of comments we received from the public and the coordinating agencies varied from concerns for local salmonid populations to potential impacts of future management to the Caspian tern colony. Some comment letters expressed the need for justification to manage the tern population and the use of sound science in development of the EIS and management plan. Others expressed strong concern for declining salmon runs in the northwest.

Issue 1: Tern Predation Analysis. Many of the comments received expressed concern that the existing analysis of tern predation (NOAA Fisheries 2002) does not demonstrate "that Caspian terns are limiting the recovery of ESA-listed wild salmon in the Columbia River." Comments also expressed a concern that no evidence exists to suggest that there is a direct relationship between smolt and adult numbers, suggesting that "smolts saved from tern predation" will not result in a direct increase in adult salmonid numbers.

Comments called for a "rigorous" analysis of the impact of tern predation using peer-reviewed science. Additionally, some comments stressed that the EIS must discuss all factors limiting salmon recovery and put tern predation in that context. Some comments specifically stated, "Until the cost-effectiveness of hazing, relocating, and otherwise controlling terns has been firmly established in relationship to the four H's (hydropower, habitat loss, hatcheries, and harvest), the terns and other fish-eating birds should not be disturbed." Some also commented that the analyses should distinguish between tern consumption of hatchery salmonids and those that are listed under the ESA.

Issue 2: Impacts to Salmonids. Many comment letters expressed the concern for declining salmonids in the Columbia River. Some comment letters supported "relocation efforts to further disperse the massive Caspian tern colony on East Sand Island to areas where predation mortality is sustainable." However, comments received from the State agencies and the public expressed concern for salmon in various local communities. For example, comments received from the Grays Harbor, Washington area expressed concern for impacts to local salmon fisheries if terns were relocated to Grays Harbor. Comments specifically expressed a concern that relocating Caspian terns to sites outside the Columbia River estuary "would shift the impact to other regions." Some stated that communities surrounding Grays Harbor and Willapa Bay "are making significant investments in salmon recovery, in both volunteer time and Federal, State, and local funds." Therefore, relocating terns to those areas "would be counterproductive." The States

TABLE 1.1 Locations of Public Scoping Meetings

Date	Time	Location
April 14, 2003	5:30 – 8:30 pm	Marriott, Oakland, California
April 15, 2003	5:30 – 8:30 pm	Redwood Park Lodge, Arcata, California
April 28, 2003	5:30 – 8:30 pm	Grays Harbor College, Aberdeen, Washington
April 29, 2003	5:30 – 8:30 pm	Washington State Capital Museum, Olympia, Washington
May 5, 2003	5:30 – 8:30 pm	Duncan Law Seafood Center, Astoria, Oregon
May 6, 2003	5:30 – 8:30 pm	Doubletree Hotel, Portland, Oregon

of California and Oregon expressed concerns of introducing terns into non-historic nesting areas and subjecting salmon or other fish populations to tern predation.

Issue 3: Concentration of Caspian Terns at One Site (East Sand Island). There was substantial support for reducing the size of the tern colony on East Sand Island to decrease losses from catastrophic events as well as protecting endangered salmon. However, many of the public comments expressed that no efforts be undertaken to move terns from East Sand Island until suitable alternative sites are located and established. Comments specifically stated that the current management practice of providing 6 acres of habitat should be continued until alternative sites are available.

1.5.2 Issues Raised, but Eliminated from Detailed Study

Four issues were raised during scoping that were outside the scope of this project. These issues, although significant, will not be addressed in this EIS.

Issue 4: Effects of Hydropower, Habitat loss, Hatcheries, and Harvest (Four H's) on Salmon. Many comment letters requested that the EIS include a detailed analysis of the four H's and their effects on salmon recovery. Commenters expressed their concern that the four H's "are the major causes of salmon declines, not avian predation." This EIS is not addressing the issue of overall salmon recovery, and thus, will not thoroughly analyze the effects of the four H's and associated management actions to aid salmon recovery. Instead, the EIS and proposed action is focused specifically on the management of Caspian terns in the estuary to reduce predation on juvenile salmonids as one measure to aid salmon recovery. A discussion placing tern predation in context with hydropower and harvest is presented in the NOAA Fisheries 2004 report, *Caspian Tern Predation on Juvenile Salmonid Outmigrants in the Columbia River Estuary* (Appendix C), and this EIS (see Chapter 4). A detailed analysis of the four H's is currently being addressed in the biological opinion for the Federal Columbia River Power System, which is under negotiation between NOAA Fisheries and the action agencies (Corps, Bureau of Reclamation, Bonneville Power Administration). This analysis is projected to be completed in 2004.

Illustration: Gary Whitley

Issue 5: Ownership and Management of East Sand Island. Many comment letters expressed the desire for East Sand Island to be managed as part of the National Wildlife Refuge System for the protection of "significant wildlife resources" and habitat by the Service. On February 28, 2003, the Service and Corps issued a joint statement regarding the ownership and management of East Sand Island. The statement reiterates that the Corps "will retain ownership and management responsibilities for East Sand Island through the completion of the Environmental Impact Statement (EIS) and Management Plan for Caspian terns in the Columbia River estuary." In the interim, the Corps will continue to provide 6 acres of habitat for Caspian terns. Since ownership status of East Sand Island would not affect implementation of the proposed action, the impact analysis of this factor is not necessary. The future owner and manager of East Sand Island, whether it is a Federal, State, or private entity, would need to adhere to the same regulations with respect to the Endangered Species and Migratory Bird Treaty Act regulations. The final decision regarding ownership and management of East Sand Island will be made when the EIS is completed and a proposed action, including management actions on East Sand Island, is identified.

Issue 6: Economic Value of Smolts Consumed by Caspian Terns. The State of Idaho's Office of Species Conservation comment letter stated "the economic value of smolts consumed by the Caspian tern colony…be a focus of this EIS." They requested that "all costs relative to smolt rearing, marking, and migration facilitation, along with costs associated with forgone power generation, flow augmentation, habitat improvement, and all other efforts undertaken to deliver smolts to the estuary be assimilated to produce a per smolt cost." Their justification for this analysis is to demonstrate the cost of "maintaining the status quo avian predation by this [East Sand Island] Caspian tern colony."

An economic analysis of this sort would not assist in the development of management alternatives aimed at reducing tern predation on salmonids in the Columbia River estuary to assist in salmonid recovery. The economic analysis proposed by the State of Idaho would not demonstrate the cost of maintaining avian predation by the East Sand Island Caspian tern colony. Rather, this analysis would demonstrate the costs of mitigating measures for a variety of activities that impact threatened and endangered salmonids in the Columbia River Basin. For example, devices are required at hydropower dams to provide fish passage; hatcheries are producing smolts to mitigate the effects of hydropower dams; and habitat restoration projects are being conducted throughout the region to restore and enhance salmonid habitat and watershed functions that have been lost or altered.

Numerous documents have already summarized costs of salmonid recovery efforts in the Columbia River Basin. These include a NOAA Fisheries Report to Congress on the Pacific Coastal Salmon Recovery Fund (NOAA Fisheries 2003a), a partial review of cost-effectiveness of artificial production programs published in 2002 by the Independent Economic Analysis Board, (Independent Economic Analysis Board 2002), a Report to the National Marine Fisheries Service on the Economics of Snake River Salmon Recovery (Huppert et al. 1996), and a General Accounting Office report on Federal agencies' recovery responsibilities, expenditures and actions (U.S. General Accounting Office 2002).

Issue 7: Caspian Tern Colony on Crescent Island

During internal scoping meetings, NOAA Fisheries expressed concern regarding predation of juvenile salmonids by Caspian terns nesting on Crescent Island, Washington. Crescent Island, in the mid-Columbia River, was created with dredge material originating from the Boise Cascade Mill channel, Port of Walla Walla. Crescent Island is managed by the Service as part of the Mid-Columbia River National Wildlife Refuge Complex through a cooperative management agreement with the Corps. In 2000, NOAA Fisheries issued a BO to the Corps, requiring the "Action Agencies… continue to conduct studies (including migrational behavior) to evaluate avian predation of juvenile salmon in the FCRPS reservoirs above Bonneville Dam." Researchers have been studying this colony since 1998, gathering the diet composition of nesting Caspian terns, colony size, and nesting success. These data are currently being analyzed and, as stated in the BO, "If warranted and after consultation with NMFS [NOAA Fisheries] and USFWS, the Action Agencies shall develop and implement methods of control that may include reducing the populations of these predators." If management actions are required for the Crescent Island Caspian tern colony, a separate management plan and associated NEPA document, if needed, will be prepared outside of this EIS. The scope of this EIS is focused on management of Caspian terns in the Columbia River estuary and only extends beyond the estuary in Alternatives C and D which discuss the potential to manage alternate sites for Caspian terns outside of the Columbia River.

Chapter 2. Alternatives

This chapter describes the process used to develop alternatives to the Proposed Action, similarities among the alternatives, a detailed description of each alternative, and a summary comparison of the alternatives by each of the primary components.

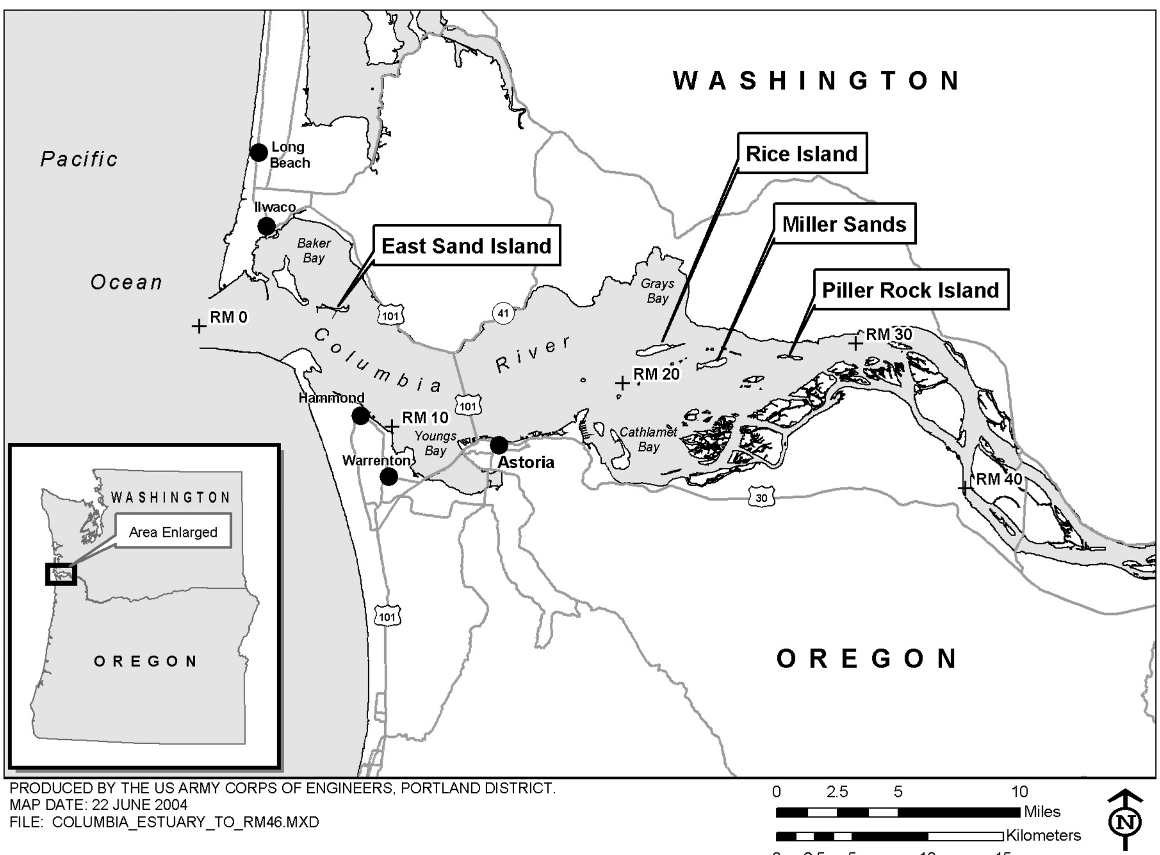
2.1 Alternative Development

The National Environmental Policy Act (NEPA) requires Federal agencies to evaluate a full range of reasonable alternatives to a Proposed Action. The alternatives should meet the purpose and need of the proposal while minimizing or avoiding detrimental environmental effects. The NEPA alternative development process allows the Service, Corps, and NOAA Fisheries to work with the public, stakeholders, interested agencies, and Tribes to formulate alternatives that respond to the issues identified during the scoping process. This DEIS documents the planning and decision-making process.

2.1.1 Rationale for Alternative Design

All alternatives considered were evaluated in relation to their ability to reduce tern predation on ESA-listed Columbia River salmonids while ensuring the conservation of terns in the Pacific Coast region. NEPA regulations require the analysis of a No Action alternative (Alternative A). The settlement agreement also required the analysis of a No Management alternative (Alternative B). The remaining alternatives were developed after evaluating comments received during the public scoping period, holding interagency meetings and internal discussions, and reviewing the best available scientific information. The effects of each alternative described below are analyzed in detail in Chapter 4, Environmental Consequences.

FIGURE 2.1. Columbia River Estuary (mouth to RM 46)]



2.2 Similarities Among Alternatives

Although the alternatives differ in many ways, there are similarities (i.e., shared features or management components) among them as well. These similarities are listed below to reduce the length and redundancy of the individual alternative descriptions. The following is a description of features common to all alternatives (Alternative A through D).

Prevent tern nesting in the upper estuary. The Corps would continue efforts to prevent Caspian tern nesting on upper estuary islands (e.g., Rice Island, Miller Sands Spit, Pillar Rock Island, see Figure 2.1) of the Columbia River estuary to prevent high predation rates of juvenile salmonids and comply with the 1999 Corps Columbia River Channel Operation and Maintenance Program Biological Opinion. Management actions, as appropriate, may include repeated hazing of adult terns on islands from April 1 to June 15 to prevent colony establishment, nesting habitat modification through establishment of vegetation, or other measures (e.g., installation of silt fencing, see photo below). Hazing would consist of personnel or dogs directly disturbing terns that aggregate on upland habitat suitable for nesting purposes. Personnel may use all terrain vehicles for ease of access and to cover distances involved at these upper estuary islands. Eagle silhouette decoys and/or kites may also be employed to preclude nesting terns. Terns that aggregate (e.g., roosting, resting) below the high tide line would not be disturbed. Personnel involved in hazing are restricted in their movements and presence to the tern nesting area, and are to remain out of vegetated areas that support other wildlife resources to the extent practicable.

Permit egg take from upper estuary islands. Should early season hazing activities fail to prevent tern nesting, the Service would issue an egg take permit to the Corps for upper estuary islands (does not include East Sand Island). This permit would assist in preventing the establishment of new tern colonies in the upper Columbia River estuary.

Tern colony on Rice Island (2000) with silt fencing used to prevent terns from nesting on portions of the former colony site. Photo Credit: Tim Jewett

Resumption of dredged material disposal on Rice Island. Since the shift of the Columbia River estuary tern colony from Rice Island to East Sand Island, this former colony location is overgrown with vegetation. Terns no longer attempt to nest at this location. The Corps will resume dredged material disposal on the downstream end of Rice Island, the former location of nesting terns.

The Columbia River estuary, referred to immediately above, pertains to the river downstream of river mile 46 or approximately, the upstream end of Puget Island (Figure 2.1).

2.3 Detailed Description of Alternatives

2.3.1 Alternative A - No Action (Current Management Program)

This alternative assumes no change from the current management program and is considered the baseline from which to compare the other alternatives. Under this alternative, approximately 6 acres of nesting habitat would be maintained annually for terns on East Sand Island. This requires annual maintenance in order to provide proper nesting habitat conditions: a bare sand substrate free of vegetative cover.

To attain the proper habitat conditions on the 6-acre site, equipment is barged to the site during the last week of March or first week of April. Habitat management at this time allows terns to establish nests on the site before the reestablishment of vegetative cover from grasses and forbs. Typically, a tractor and disc are used to till the site, turning under herbaceous vegetation. This is generally followed by running a heavy drag harrow over the site to smooth the surface. Periodically, additional sand is placed on the nesting site to fill erosion channels and low elevation spots as wind and water erosion remove sandy material from the site each year. Sand replenishment in 2003 was accomplished by borrowing sand from the upper beach on the east end of East Sand Island using a tracked excavator and a 25 cubic yard capacity off-road dump truck. This beach is the most likely source for borrowing sand material in the future.

In September or October, herbicide (Rodeo) may be applied to European beachgrass and American dunegrass to control their presence on the tern nesting site. Tillage operations result in the spread of these plants over the nesting site. Herbicide is sprayed in a spot application manner with denser stands receiving a broadcast spray. Equipment and water for herbicide dilution are transported to the site via boat.

Habitat enhancement on East Sand Island. Photo Credit: Columbia Bird Reserch (OSU/RTR)

2.3.2 Alternative B – No Management

The Settlement Agreement requires analysis of this alternative in the EIS. Under this alternative, no management actions would occur on East Sand Island. The current tern nesting area would most likely become vegetated within 3 to 5 years post-implementation of this alternative (similar to that observed in 1985 and 1986 after the last dredged material was deposited), resulting in the loss of the tern nesting site. Thus, abandonment of this colony on East Sand Island would most likely occur. Hazing efforts and possibly egg take would be implemented, as in all alternatives, to prevent tern nesting at upper estuary islands. See section 2.2 for more details on these actions.

2.3.3 Alternative C –Redistribution of East Sand Island Tern Colony - PREFERRED ALTERNATIVE

Under this alternative, tern nesting habitat and colony size on East Sand Island would be reduced to approximately 1 to 1.5 acres and a segment of the concentrated tern colony in the estuary would be redistributed to other nesting sites within the Pacific Coast region. This redistribution would be achieved by ensuring that a network of sites with suitable nesting habitat is available to displaced terns within the region. We propose to manage nesting habitat for terns in the region to replace twice the amount of nesting habitat that would be lost on East Sand Island.

Terns have nested on an average of 4.3 acres (range of 3.9 to 4.5) on East Sand Island from 2001 to 2003 (Collis et al. 2002a, 2003b). Reduction of the nesting area to 1 to 1.5 acres would require a minimum of 6 to 7 acres of replacement habitat in the region. We propose to manage approximately 8 acres at alternate sites for terns (see below). The remaining 1 to 1.5 acres on East Sand Island would be managed to maintain suitable tern nesting habitat in the Columbia River estuary to support approximately 2,500 to 3,125 breeding pairs. This colony size exceeds those typical of the Pacific Coast region as well as the first colony that nested on East Sand Island in 1984 (approximately 1,200 breeding pairs).

The proposed reduction in habitat on East Sand Island would occur only after alternate nesting habitat is enhanced elsewhere in the region and is available to terns displaced from East Sand Island. Thus, habitat enhancement in the region and reduction in habitat on East Sand Island would be phased in at a 2:1 ratio. For example, if 2 acres of nesting habitat is enhanced for terns outside of the Columbia River estuary (i.e., in 2005), the tern nesting area on East Sand Island would be reduced by 1 acre in the following year (i.e., in 2006). The approximately 8 acres of managed habitat that would be enhanced in the region would be selected from the list of sites located in Table 2.1. Habitat alteration and enhancement would occur at most of these sites. Additional proposed management actions include management of predator or human disturbance and social facilitation (e.g., decoys, vocalizations, etc.).

The proposed habitat acreage (approximately 1 to 1.5 acres) on East Sand Island is expected to be reached in 3 to 5 years, depending upon available funding for habitat enhancement elsewhere in the region. The size of the tern nesting site at East Sand Island (acreage) would be determined annually, and would be dependent upon how much acreage of alternate habitat has been created to date elsewhere in the region. Habitat reduction on East Sand Island would be attained by allowing vegetation to grow in the current nesting area and the remaining tern nesting site would be cleared via the methods described above in Alternative A. After the proposed acreage on East Sand Island has been attained, annual maintenance would continue to clear the nesting site on East Sand Island using methods similar to those described in Alternative A, with a management area of 1 to 1.5 acres instead of 6 acres.

This proposed habitat acreage on East Sand Island was selected to reduce tern predation in the estuary on juvenile salmonids to a level that would increase salmonid population growth rates (lambda, λ). Populations with a positive growth rate ($\lambda > 1$)

TABLE 2.1 Potential Caspian tern nesting sites and proposed management actions associated with Alternatives C and D. Sites are listed in geographical order from north to south[a].

Site Name	Proposed Management Action	Projected Available Acreage
WASHINGTON		
Dungeness NWR, Clallam County	Signs for area closure and monitor predator activities	1+ acres
OREGON		
Crump Lake, Lake County	Enlarge and stabilize Crump Island at an elevation to prevent flooding; social facilitation	1 acres
Summer Lake Wildlife Area, Lake County	Create three half acre islands in the East Link impoundment, and near Windbreak and Gold dikes; social facilitation	1.5 acres
Fern Ridge Lake, Lane County	Construct one island north of Royal Avenue near Gibson Island; social facilitation	1 acre
CALIFORNIA		
Brooks Island, Central San Francisco Bay, Contra Costa County	Remove exotic vegetation; predator control; gull harassment or control; protect shoreline; public use management and outreach.	2 acres
Hayward Regional Shoreline, Alameda County	Substrate enhancement; social facilitation; predator control; gull harassment or control	0.5 acre
Ponds N1/N9, Don Edwards, San Francisco Bay NWR, Alameda County	Substrate enhancement; social facilitation; predator control; gull harassment or control	0.5 - 1 acre

[a] See Table G.4 for list of sites elimited from management consideration.

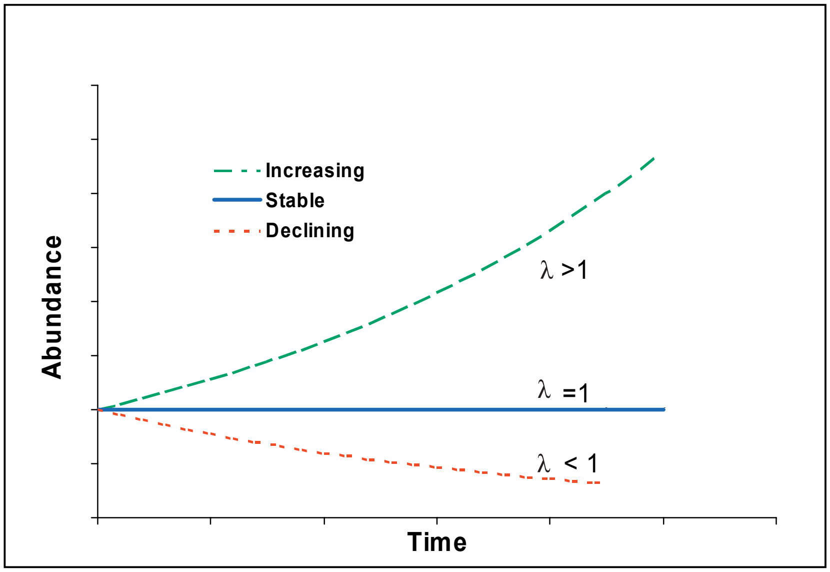
increase in number and thus, would aid salmon recovery (Caughley 1994 and McClure et al. 2003, Figure 2.2).

In determining an acceptable predation level by terns, NOAA Fisheries conducted an analysis using a life cycle model and tern predation rates to estimate the impact of tern predation on the population growth rate of various Evolutionary Significant Units (ESUs, see Chapter 3, section 3.2.3 for definition) of Columbia River Basin steelhead (NOAA Fisheries 2004, Appendix C). Steelhead were the focus of this analysis because they are consumed in the highest numbers by terns, and thus, are most affected by tern predation in the Columbia River estuary. Estimates of the potential benefits of reducing tern predation are the greatest for steelhead but other salmonids consumed by terns would also benefit. Additionally, ESU-specific analysis was conducted because NOAA Fisheries manages Columbia River steelhead at the individual ESU level.

The analysis compared the use of Passive Integrated Transponder (PIT) tag and bioenergetics modeling data sets as sources to calculate an estimated tern predation rate and percent increase in salmon population growth. PIT-tags are small tags inserted into the juvenile fish's body cavity which can be used to determine the location and status (e.g., live or dead) of tagged fish. Identifying PIT-tags on tern colonies can provide a minimum estimate of the proportion of stocks that are consumed by terns at any particular colony. Bioenergetics models are used to estimate consumption levels of piscivorous birds by calculating the amount of prey consumed in biomass or numbers based on diet composition, energy content of prey, energy requirements of individual consumers (i.e., terns), and the number of individual consumers present. Both PIT-tag and bioenergetics modeling analyses demonstrated that the percent increase in population growth rate (λ) is improved as the number of tern pairs are reduced on East Sand Island (NOAA Fisheries 2004, Appendix C). However, the analysis also demonstrated that predation rates are not uniform for all salmon species, thus, analysis of individual ESU-specific predation rates was necessary. Only PIT-tag data was suitable for analyzing benefits to individual steelhead ESUs.

The NOAA Fisheries analysis estimated that a reduction in the tern colony to approximately 3,125 nesting pairs would result in a 1 percent or greater increase in population growth rate (recommended by NOAA Fisheries) for four Columbia River Basin steelhead ESUs (Table 2.2 or Table 5 in Appendix C). However, predation rates based on PIT-tag recovery data are considered minimal because detection efficiency is not 100 percent as not all tags are deposited on nesting islands (e.g., some PIT-tags are most probably excreted over water, removed by wind and water erosion, or damaged and undetectable). Thus, we propose managing a more conservative range of nesting pairs (approximately 2,500 to 3,125) on East Sand Island to ensure an increase in population growth rate for each of the four Columbia River Basin steelhead ESUs. Based on average nesting densities observed on East Sand

FIGURE 2.2. Illustration of increasing, stable, or declining population growth rates (λ)



(average of 0.55 nesting pairs per square meter, Collis et al. 2003b, Roby pers. comm.) and Rice islands (peak of 0.78 nesting pairs per square meter, Roby et al. 2002), this proposed range of nesting terns would be able to nest on the 1 to 1.5 acres, as proposed in this alternative.

Other factors were considered in determining the proposed habitat acreage on East Sand Island, including the average size of coastal tern colonies (e.g. 55 to 1675 nesting pairs) and social behavior necessary for terns to nest successfully. The proposed range of nesting pairs on East Sand Island in this alternative (2,500 to 3,125 pairs) is substantially above the individual average colony sizes typically found along the Pacific Coast (Table F.2). This number also exceeds the size of the tern colony that historically colonized East Sand Island in 1984 (approximately 1,200 pairs). The proposed acreage and anticipated colony size should be suitable to avoid colony abandonment on East Sand Island due to an insufficient number of breeding pairs and encourage the social stimulus to breed.

TABLE 2.2. Population growth rate (λ) and estimated percent increase in four listed steelhead ESUs in the Columbia River Basin given a range of Caspian tern nesting pairs on East Sand Island (taken from NOAA Fisheries 2004, Appendix C).

	Snake River ESU		Upper Columbia River ESU		Middle Columbia River ESU		Lower Columbia River ESU	
No. of Tern Nesting Pairs	**% Δ λ**	**λ**	**% Δ λ**	**λ**	**% Δ λ**	**λ**	**% Δ λ**	**λ**
10000	0.000	1.020	0.000	1.000	0.000	0.970	0.000	0.920
9375	0.124	1.021	0.323	1.003	0.123	0.971	0.100	0.921
8750	0.248	1.023	0.644	1.006	0.245	0.972	0.200	0.922
8125	0.371	1.024	0.962	1.010	0.366	0.974	0.299	0.923
7500	0.494	1.025	1.277	1.013	0.487	0.975	0.398	0.924
6875	0.616	1.026	1.589	1.016	0.608	0.976	0.497	0.925
6250	0.738	1.028	1.898	1.019	0.728	0.977	0.595	0.926
5625	0.859	1.029	2.205	1.022	0.847	0.978	0.693	0.926
5000	0.979	1.030	2.510	1.025	0.966	0.979	0.791	0.927
4375	1.099	1.031	2.812	1.028	1.084	0.981	0.888	0.928
3750	1.219	1.032	3.112	1.031	1.202	0.982	0.985	0.929
3125	**1.337**	1.034	**3.409**	1.034	**1.319**	0.983	**1.082**	0.930
2500	1.456	1.035	3.704	1.037	1.436	0.984	1.178	0.931
1875	1.574	1.036	3.996	1.040	1.552	0.985	1.274	0.932
1250	1.691	1.037	4.287	1.043	1.668	0.986	1.370	0.933
625	1.808	1.038	4.575	1.046	1.783	0.987	1.465	0.934
0	1.924	1.040	4.861	1.049	1.898	0.988	1.560	0.934

% Δ λ = percent change in population growth rate (λ)
λ = population growth rate

Although we have identified a proposed acreage (approximately 1 to 1.5 acres) on East Sand Island, the tern nesting area would be managed based on how terns respond to the reduction in habitat. For example, if a number of terns above the proposed range of nesting pairs continue to attempt nesting on East Sand Island, the proposed habitat acreage would be reduced (potentially to less than 1 acre) in the subsequent year to decrease the number of nesting terns to within the proposed range (2,500 to 3,125 nesting pairs).

Based upon the average number of nesting pairs (approximately 9,070) in the Columbia River estuary from 2000 to 2003 (Collis et al. 2002a, 2003a, and 2003b), approximately 5,945 to 6,570 breeding pairs of Caspian terns would be displaced from nesting on East Sand Island with implementation of this alternative. To minimize any possible negative effect to the Pacific Coast regional tern population by this action and to encourage redistribution of terns within the region, this alternative also identifies habitat that could be enhanced or developed for displaced terns. Although some nesting habitat is currently available for displaced terns at various sites within the Pacific Coast region (Appendix F, Table F.1 and Table F.2), this alternative ensures a network of sites with suitable nesting habitat for terns by managing up to seven sites distributed among both coastal and interior habitats specifically for nesting terns. Approximately 8 acres of nesting habitat would be selected from various sites in Washington, Oregon, and California (Table 2.1). See Appendix G for more detail regarding selection of sites and management actions required at each site for preparation of tern nesting habitat.

2.3.4 Alternative D – Redistribution and Lethal Control of East Sand Island Tern Colony

Similar to Alternative C, tern nesting habitat and colony size on East Sand Island proposed in this alternative would be reduced to decrease tern predation on juvenile salmonids and encourage redistribution of the large concentrated tern colony to other nesting sites within the Pacific Coast region. As with Alternative C, the proposed habitat acreage (approximately 1 to 1.5 acres) and anticipated number of nesting terns was selected to increase the population growth rate (λ) for four Columbia River Basin steelhead ESUs by at least 1 percent (Table 2.2, NOAA Fisheries 2004, Appendix C). Also similar to Alternative C, approximately 8 acres from sites within the Pacific Coast region would be managed as potential Caspian tern nesting sites to replace the habitat lost on East Sand Island and ensure a network of suitable nesting habitat is available to displaced terns. Sites would be selected from the same seven sites identified in Alternative C (Table 2.1). Reduction in tern nesting habitat on East Sand Island would be phased in as habitat at alternate sites are developed at a 2:1 ratio (see description in Alternative C). Similar to Alternative C, we expect the tern nesting area would be reduced to 1 to 1.5 acres within 3 to 5 years, depending upon available funding for habitat enhancement elsewhere in the region.

The East Sand Island tern colony may respond to habitat reduction efforts by compressing into the smaller acreage (at a higher nesting density). Thus, the above management actions could fail to disperse majority of the tern colony. Unlike Alternative C, this alternative proposes to implement a lethal control program if habitat reduction on East Sand Island, combined with development of potential nesting habitat, is not sufficient to reduce the colony size by 2008. The lethal control program would attempt to achieve the proposed range of nesting terns (approximately 2,500 to 3,125 pairs) by killing up to 50 percent of breeding adult terns each year. Methods for killing adults would consist of euthanasia of terns after capturing them with a rocket net or the use of shotguns. Carcasses would be collected and provided to research facilities or museums. Any unused carcasses would be burned or buried off-site.

The actual number of terns that would be killed under this alternative would depend on the success of redistributing majority of the colony to other sites in the region. If the entire colony compressed into the smaller acreage that would remain on East Sand Island, a substantial number of terns would need to be killed. If the colony was partially reduced (e.g., 50 percent) through habitat reduction, we can use a tern population model to project the number of terns that could potentially be killed (e.g., 1,000 to 6,000 terns every year in the first 5 years, see section 4.2.1.4). Lethal control would most likely need to continue annually to keep the number of terns within the proposed range. An egg oiling or removal program was considered in this alternative as a means to decrease the tern colony size. However, population modeling and a literature review demonstrated that an egg oiling or removal program only reduces productivity of the tern colony and thus, would not be effective in reducing the number of adult terns in a reasonable timeframe (Blackwell et al. 2000, Belant 1997, Christens and Blokpoel 1991, Seubert 1990).

2.4 Monitoring and Adaptive Management Plan

A monitoring program for the preferred alternative identified in this DEIS would be three-fold:

1. Long-term monitoring of the regional Caspian tern population and the network of suitable nesting habitat within the region. Monitoring of colony sizes for all colonies in the region would occur immediately following management actions and conclude 3 years after the proposed habitat acreage on ESI has been attained. Following this period, monitoring of the regional population would occur every 10 years (as recommended by Shuford and Craig (2002) in the Caspian Tern Status Assessment). Additionally a selected subset of breeding sites would be regularly surveyed every 2 to 3 years to track more closely the regional population trend;

2. Short-term monitoring of the East Sand Island colony (i.e, colony size and reproductive success) to determine the response of terns to the reduction of habitat (to be completed 3 years after the proposed habitat acreage and number of nesting pairs has been attained); and

3. Short-term monitoring of the presence, absence, and colony size at managed alternate sites. Monitoring efforts would initiate immediately following management actions at each site and conclude 3 years after the proposed habitat acreage is attained on East Sand Island. Monitoring and research of tern diet and reproductive success at managed alternate sites would also be initiated when the colony size at each site reaches an identified minimum threshold (e.g., 500 pairs) that will be identified during the development of the monitoring and adaptive management plan.

The intent of the monitoring program is to determine the level of success and impacts associated with management actions. Monitoring after implementation of the preferred alternative would also allow for an adaptive management approach (e.g., altering management actions if response does not meet specified objectives). Specific details of the monitoring program will be described in a monitoring and adaptive management plan that will be developed upon completion of the EIS and selection of a proposed action.

2.5 Alternatives Considered but Eliminated from Detailed Study

The alternative development process under NEPA is designed to allow consideration of the widest possible range of issues and potential management approaches. During the alternative development process, many different solutions were considered. The following alternatives were considered but not selected for detailed study in this DEIS for the reason(s) described below.

2.5.1 Elimination of Caspian Terns from East Sand Island

This alternative would actively eliminate all nesting habitat for terns on East Sand Island, thus displacing the entire nesting colony. The open and sandy habitat would be eliminated by actively seeding the site and allowing the vegetation to grow into tall and dense cover, thus precluding terns from East Sand Island. In addition, hazing of adult terns would be conducted. This alternative was not acceptable since it would violate Guiding Principle number 3: "…ensure Caspian terns remain a viable and integral part of the estuarine, coastal, and interior ecosystems of the Pacific Coast region, including the Columbia River estuary…"

2.5.2 Maximum Redistribution of Terns throughout the Region

This alternative would reduce habitat on East Sand Island for terns to 1 to 1.5 acres and actively facilitate the redistribution of displaced terns to sites in Washington, Oregon, and California. The initial review (feasibility assessment) of potential tern nesting sites conducted in 2002 and scoping for this DEIS identified six sites in Washington, three sites in Oregon, and three sites in California for Caspian tern management. These sites met all of the criteria used in the feasibility assessment (Seto et al. 2003) and this DEIS (see Appendix G).

Washington sites identified with potential for tern management are located in Grays Harbor, Padilla Bay, and Jetty Island (Puget Sound). Historic colonies in Grays Harbor constituted one of the larger coastal colonies in the region (peak number of 3,590 pairs in 1987, Shuford and Craig 2002) before loss of nesting habitat, gull predation, and bald eagle disturbance apparently caused terns to abandon the site (Shuford and Craig 2002, Seto et al. 2003). Terns last nested in the harbor in 1989. Currently, adults are observed feeding and roosting on the remaining four islands in the harbor throughout the breeding and post-breeding months (Seto et al. 2003). Numbers remain below 50 terns during the breeding months but can increase to over 100 during the post-breeding months, including recently fledged chicks (Seto et al. 2003, Columbia Bird Research 2003). Three of the four islands in Grays Harbor are owned and managed by the Department of Natural Resources, one of which is managed as a Natural Area Preserve. Goose Island, one of the historic tern nesting sites, was designated as a Natural Area Preserve specifically to protect nesting Caspian terns. This island is now under water. The remaining three islands, have limited human and mammalian predator access and would require moderate habitat enhancement to create open nesting habitat for terns. The fourth island, "Cate Island", would also require moderate habitat enhancement. Since this island has mixed private and public ownership and is closer to the mainland, the potential for human disturbance and mammalian predator access is more likely.

Padilla Bay, in northern Puget Sound, contains four dredge spoil islands along the Swinomish channel. Caspian terns (peak number of 126 pairs in 1995) historically nested on a small, privately-owned island in the 1990s but in recent years only a small number of non-breeding adults have been observed (M. Davidson, pers. comm.). This island is small and dynamic, providing little management potential for habitat enhancement. However, the Washington Department of Fish and Wildlife (WDFW) is currently considering creating larger islands in the bay to increase loafing areas for wintering gray-bellied brant (M. Davidson pers. comm.). If this occurs, these islands could be used by nesting terns in the spring and summer months when brant are absent. Jetty Island, an artificial dredge spoil island that parallels the Everett waterfront in northern Puget Sound was used unsuccessfully by a small number (<20) of nesting terns in the mid-1990s (R. Milner, pers. comm.). Extensive, habitat enhancement activities (e.g., removal of Scotch broom, area closures) could be implemented to create habitat for nesting terns.

Although the above sites have potential for tern management, WDFW does not support active management of sites in Washington that could serve as alternate nesting habitat for displaced terns. WDFW supports the goal of reducing tern predation on salmonid stocks in the Columbia River. However, they have concerns regarding possible impacts to salmon from the redistribution of terns to locations in Washington. Thus, although these sites were all historically colonized by terns and are in close proximity to the Columbia River estuary, we did not include these sites in our management alternatives. WDFW also stated that they would not oppose any colonization of terns in Washington if the terns were to recolonize a historic site or establish a new colony of their own accord. Thus, we have included the current nesting site at Dungeness NWR in our management alternatives.

The feasibility assessment identified three sites on the Oregon coast (in Coos Bay and the Umpqua River estuary) because they met all of the criteria described in Seto et al. (2003). These sites are islands that require moderate to extensive habitat enhancement. Fern Ridge Lake, near Eugene, was also identified as a site with potential for Caspian tern management if nesting habitat (island) can be created as proposed by the Corps in 2000. None of these sites are historical Caspian tern nesting sites and Oregon Department of Fish and Wildlife (ODFW) does not want to introduce "predation to other fish stocks that have never historically been subjected to Caspian tern predation (Klumph 2003)." ODFW "is committed to significantly reducing the potential impact of avian predators on Columbia River Basin stocks of salmon and steelhead." They acknowledge that the best way to accomplish this is to "disperse" the East Sand Island colony and manage colonies outside the estuary "at levels in balance with their local ecosystems and species communities." However, ODFW will not support managed relocation of Caspian terns to any site in Oregon other than historic sites (Klumph 2003). Thus, we did not include any sites on the Oregon Coast in our management alternatives. We did include Fern Ridge Lake in our analysis so that we may fully assess potential effects of nesting terns on ESA-listed salmonids found in the Willamette and McKenzie rivers. These rivers are within a 15 mile radius from Fern Ridge and may not serve as a primary food resource for the terns since a variety of resident fish species are present in the lake. Thus, although this is not a historic tern nesting site, relocation of terns to this site may not result in high levels of predation on other salmonid stocks.

California sites identified with potential for tern management are located in Humboldt Bay, San Francisco Bay, and the Sacramento Valley. See Chapter 3 for a description of sites located in San Francisco. Teal Island in the Humboldt Bay National Wildlife Refuge (NWR) was identified as a potential site for Caspian tern habitat management in the feasibility assessment. Since the 1960s, terns have nested on a small dredge spoil island (Sand Island) that was created in the late 1800s in northern Humboldt Bay. From the 1970s to 1990s, no terns were observed to nest in the bay, except for a report of 20 pairs in 1979 (Gill and Mewalt 1983). Terns returned to the site in 2001 and have continued to nest in low numbers through the present. Sand Island is small and limited in size. Teal Island is larger and could provide more nesting habitat for an increased number of terns in the bay. California Department of Fish and Game (CDFG, Morey 2004) and the Service's California/Nevada Operations (CNO) Office have expressed concerns about the impact of tern predation on ESA-listed salmonids and partnership efforts associated with salmon recovery in the Humboldt Bay area. Thus, CDFG and CNO do not support the development of tern nesting habitat in the bay. Teal Island was eliminated from further consideration in this DEIS.

The scoping process and development of alternatives for this DEIS identified development of tern nesting habitat at the Yolo Bypass Wildlife Area and City of Davis Wetlands in the Sacramento Valley. Both of these sites are not historical Caspian tern nesting sites and CDFG expressed concerns for listed salmonids in the Sacramento River (Morey 2004). CDFG "supports Caspian Tern management in California only at historic colonies." Thus, although it appears that habitat could be developed for terns at these two sites in the Sacramento Valley, they were eliminated from further consideration in this DEIS.

2.5.3 Lethal Control of East Sand Island Tern Colony

Under this alternative, a lethal control program on terns would be the only management action implemented to reach and maintain a proposed range of nesting terns (2,500 to 3,125 nesting pairs) on East Sand Island. This proposed range was selected because this reduction was estimated to increase the population growth rate (λ) for Columbia River Basin steelhead by at least 1 percent (Table 2.2, NOAA Fisheries 2004, Appendix C). In order to achieve this proposed range of nesting pairs, up to 50 percent of breeding adult terns each year would be killed beginning in 2005. Based on the same population model used in Alternative A (see Chapter 4), this control program would need to kill a substantial number of terns (up to 10,000 terns in the first year, 5,000 to 8,000 terns in subsequent years) to reach the proposed range. The killing of such a large number of terns would be unacceptable to the Service as it would be contrary to the conservation of this species. In addition, it is anticipated that a lethal control program of this magnitude would not be acceptable to the public.

2.5.4 Reduction of Caspian Tern Nesting Habitat on East Sand Island and No Active Facilitation to Other Sites within the Region

This alternative would reduce the tern nesting habitat on East Sand Island to approximately 1 to 1.5 acres, but there would be no active management of potential nesting sites to redistribute the nesting population of terns within the Pacific Coast region. Displaced terns would need to utilize existing habitat elsewhere in the region (see Appendix F for a list of existing nesting habitat currently available to terns in the Pacific Coast region). Displaced terns would nest at these locations, establish new colonies elsewhere, or continue to nest or feed in the estuary. This alternative was not considered in detail because of the uncertainties with respect to success of achieving the proposed range of nesting pairs, or where displaced terns would go to nest. For example, terns may nest at other Columbia River sites, resulting in no reduction in effects of tern predation on Columbia River salmonids. Additionally, management at alternate sites is expected to influence where displaced terns would nest (e.g, sites that would have minimal conflicts with ESA-listed salmonids). Lastly, plaintiffs of the 2000 lawsuit (see Chapter 1) wanted to ensure that suitable nesting habitat was established in the region prior to reduction in colony size on East Sand Island. This alternative would not ensure suitable habitat was available to terns in the region.

2.6 Comparison of Alternatives

Table 2.3 summarizes and compares the alternative components of the four alternatives described above and associated anticipated effects.

TABLE 2.3. Comparison of Caspian Tern Management EIS Alternatives by component and associated anticipated effects.

ALTERNATIVE COMPONENTS				
	ALTERNATIVE A No Action-Current Management Program	**ALTERNATIVE B** No Management	**ALTERNATIVE C** Redistribution of ESI Tern Colony **PREFERRED ALTERNATIVE**	**ALTERNATIVE D** Redistribution and Lethal Control of ESI Tern Colony
East Sand Island (ESI) Habitat Management	Annually maintain 6 acres of open sand habitat	No preparation of nesting habitat	Reduce nesting habitat on ESI to approximately 1 acre	Same as Alternative C
Habitat Management to Facilitate Redistribution	No	No	Yes; manage potential nesting sites in the region	Same as Alternative C
Tern Control Program	No	No	No	Yes, removal of adults, if necessary, to obtain target colony size of 2,500 to 3,125 breeding pairs
ANTICIPATED EFFECTS				
Regional Tern Population	Maintain current increasing trend	Stabilized or declining trend	Initial decrease but overall stabilization of population	Same as Alternative C, except if lethal control is implemented; then population anticipated to decline
East Sand Island Tern Colony	Maintain current increasing trend until nesting habitat is maximized by 2009	Loss of colony on East Sand Island and entire Columbia River estuary	Colony size range between 2,500 and 3,125 breeding pairs	Same as Alternative C
Columbia River ESA-listed salmonids	Continued/anticipated increase in juvenile smolt consumption; no improvement in population growth rate of ESA-listed salmonids	Elimination of juvenile smolt consumption; anticipate increase in population growth of ESA-listed salmonids	Substantial reduction in juvenile smolt consumption; anticipate increase in population growth of ESA-listed salmonids	Same as Alternative C
ESTIMATED COSTS [a]				
Habitat Management	$ 30,000	$0	$ 2,422,093 (first year costs, includes construction, habitat enhancement, predator management, and social attraction costs at all sites)	$ 2,422,093 (first year costs, includes construction, habitat enhancement, predator management, social attraction costs at all sites); $ 65,400 for lethal control, if implemented
Short- term Monitoring	$ 165,000	$0	$ 269,000/YR	$ 269,000/YR
Long-term Monitoring	$ 5,000	$0	$ 100,000 (baseline regional monitoring – first year and every 10 years) $ 10,000 (annual colony monitoring)	$ 100,000 (baseline regional monitoring – first year and every 10 years) $ 10,000 (annual colony monitoring)

[a] Detailed estimated costs for each proposed alternative site are located in Appendix G.

Chapter 3. Affected Environment

The EIS study area encompasses ESA-listed salmonid habitat in the Columbia River Basin and tern nesting habitat in the States of Washington, Oregon, California, Idaho, and Nevada. This study area falls within the breeding range of the Pacific Coast regional population of terns and the management jurisdiction of the three cooperating agencies (U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, NOAA Fisheries).

During the planning process, the affected environment for this DEIS was more specifically identified as those tern nesting areas within Washington, Oregon, and California that are most likely to be affected by proposed management alternatives under consideration in this DEIS. The affected environment (Figure 3.1) extends from the Columbia River estuary, the area of primary management concern, into those sites proposed for Caspian tern management for displaced terns from East Sand Island (as described in Chapter 2, Table 2.1). Although we anticipate that the boundaries of the affected environment extends to all areas potentially affected by proposed management alternatives, Caspian terns may pioneer into locations not discussed in this DEIS on their own volition. Thus, since this species takes advantage of ephemeral habitat and forage conditions over a wide geographical range, we cannot predict with complete certainty where colonies would establish themselves in the future.

The following description of the affected environment, organized by State, summarizes only those aspects of the environment that could potentially be affected by direct management actions at proposed alternate sites (Table 2.1) identified for proposed management alternatives. Scientific names of the plants and wildlife discussed in this chapter are listed in Appendix H. Specific anticipated effects of the proposed management alternatives will be described in Chapter 4, Environmental Consequences.

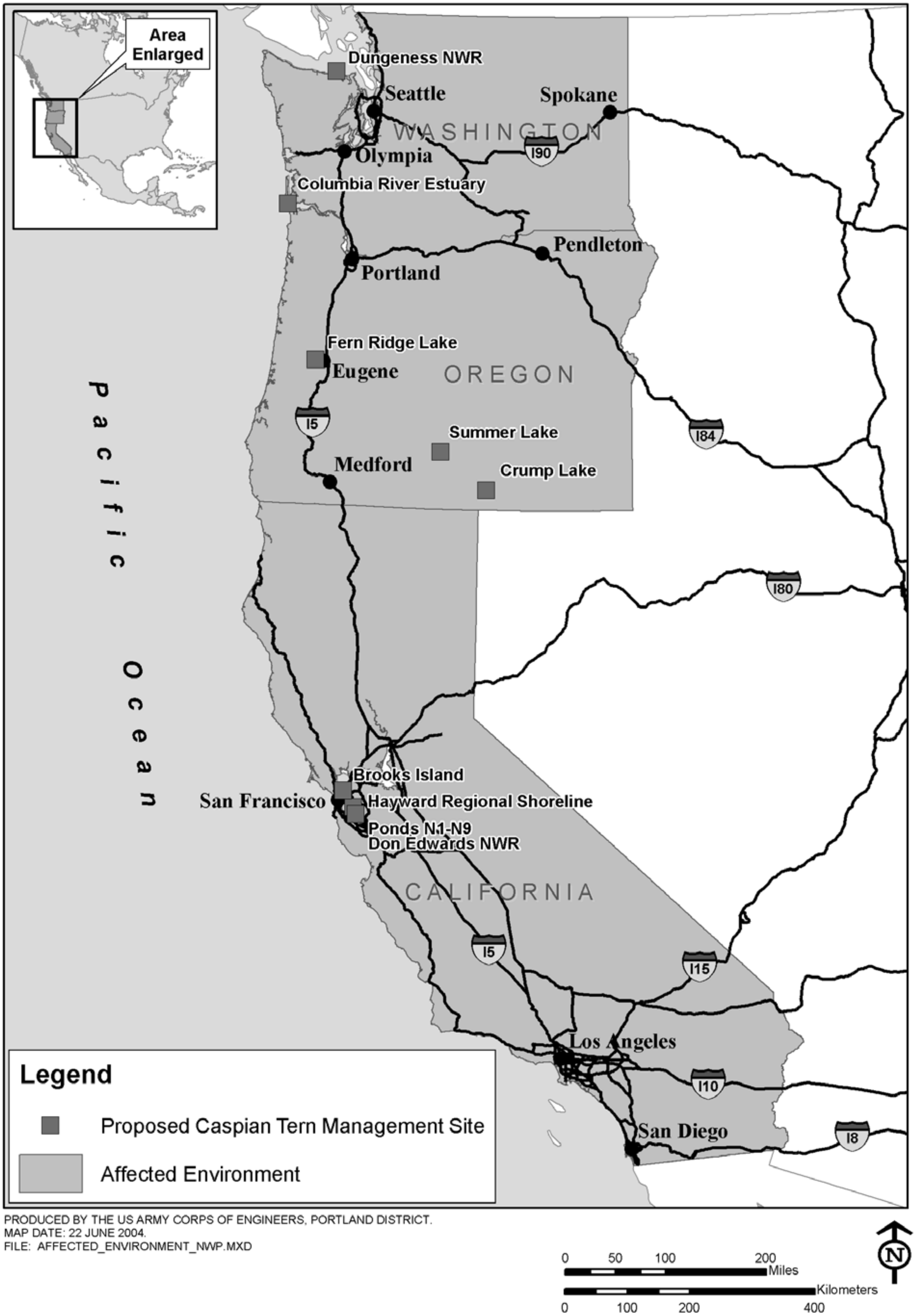
3.1 Physical Environment

Nesting habitat for Caspian terns in the Pacific Coast region includes both coastal and interior sites. Colonies are located in estuarine or marine habitats or freshwater lakes, rivers, marshes, sloughs, reservoirs, irrigation canals, and (low salinity) saline lakes (Cuthbert and Wires 1999). Many sites are ephemeral and their suitability for nesting varies with water levels, vegetation density, and prey availability as affected by droughts, floods, erosion (Shuford and Craig 2002), ocean conditions, or other factors.

Washington. Interior nesting sites consist of rock or silt islands in natural lakes or human-created reservoirs, the majority of which are relatively flat with little to no vegetation. Coastal nesting sites have varied considerably through the years, occurring both in Puget Sound and the coastal bays (e.g., Willapa Bay and Grays Harbor). Nesting habitat has primarily been sandy, flat islands with little to no vegetation but also includes sites on the mainland that are sandy or bare, but typically near the shoreline (e.g., Dungeness Spit, Everett Naval Base). The only documented coastal tern

Caspian terns nesting among driftwood on Dungeness Spit, Dungeness NWR, Washington

FIGURE 3.1 Map of Affected Environment

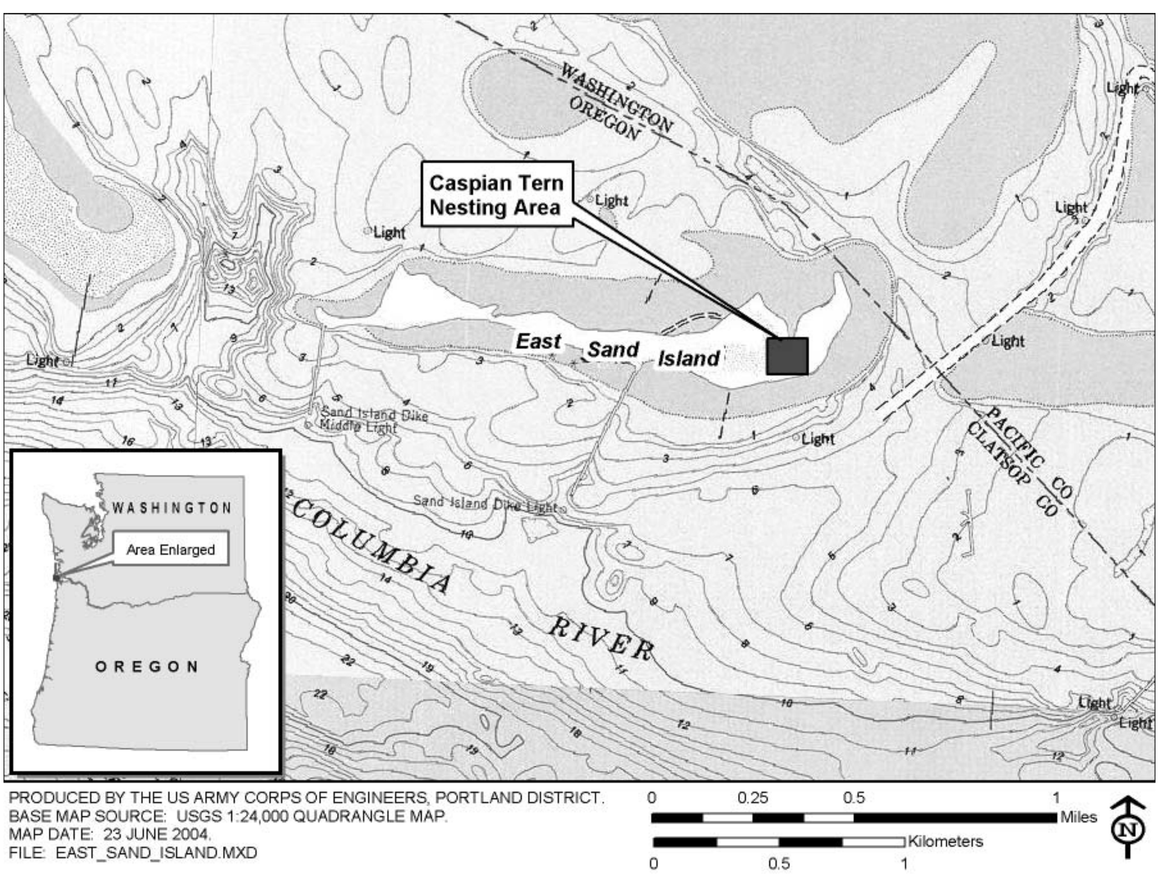


colony in 2003 nests at Dungeness NWR, located on Dungeness Spit near Sequim in Clallam County, Washington, on the southern side of the Strait of Juan de Fuca. The 6-mile long Dungeness Spit is characterized on its north (Strait) side by sand and cobble beaches. The bay side is more sandy, resembling the character of the shoreline on the Strait side, but driftwood and a variety of grass are also present (U.S. Fish and Wildlife Service 1996).

Oregon. The only coastal tern nesting activity in Oregon has been restricted to islands (natural and/or artificial) in the Columbia River. The colony on East Sand Island (Figure 3.2), located in the Columbia River estuary, is the primary management focus of this DEIS. The Columbia River estuary is 4 to 5 miles wide, and, for the purposes of this DEIS, extends upriver to around river mile (RM) 46 (Figure 2.1, although tidal influence extends up to Bonneville Dam, RM 146). The main navigation channel is dredged annually by the Corps to maintain the presently authorized 40-foot-deep, 600-foot-wide navigation project. Miller Sands Spit and Rice and Pillar Rock islands are active disposal sites for operations and maintenance dredging actions. Active disposal areas/islands typically have little vegetation on the upland portion of the site. The high tide lines at these islands contain lush vegetation communities because of accumulated organic material (debris) and availability of water. East Sand Island is located near the mouth of the Columbia River and is a naturally occurring island. Stone fill was placed on the western end of East Sand Island in 1950 and persists to date. Dredged material was placed in a diked containment area on the eastern end of the island in 1983. Caspian terns initiated nesting on the dredged material disposal site in 1984. Alders and willows form the dominant vegetative cover beginning at the western boundary of the disposal site and extending eastward to the area managed for Caspian tern nesting habitat (bare ground). A wet, hummocky, driftwood strewn flat occurs northeast of the tern nesting habitat with a sandy spit extending towards the water at this location. The southern shore is beaten by ocean swells, waves and tidal currents, and is rocky from the western end to approximately the mid-point of the island, thereafter, the shoreline is a sandy beach.

Two of three proposed sites in Oregon (Summer and Crump lakes) are located in natural lakes, with terns primarily nesting on silt islands with little vegetation. Exposure of islands, and thus availability of nesting habitat, varies considerably from year to year based on lake water levels. The Summer Lake Wildlife Area, managed by the Oregon Department

FIGURE 3.2 Caspian Tern Nesting Habitat on East Sand Island



of Fish and Wildlife (ODFW), is located at the north end of Summer Lake and was established in 1944 (St. Louis 1993). The lake and marsh are primarily fed by the Ana River that arises from a series of springs located 5 miles to the north in the Ana Reservoir. The majority of the area is a very shallow, primarily man-made alkaline and freshwater marsh. Crump Lake is located in the southern end of the Warner Basin. Crump Island is a barren, flat island in the central part of the lake, north of the peninsula that nearly bisects the lake. In the 1990s, ODFW attempted to restore the island; the island was not rebuilt to an elevation above highest water levels in the lake, thus, is regularly underwater during high water levels (C. Foster pers. comm.).

Although terns do not currently nest in Fern Ridge Lake, the site represents potential nesting habitat. Fern Ridge Lake is a reservoir located on the Long Tom River approximately 6 miles west of Eugene, Oregon in the southern Willamette Valley. The primary purpose of the lake is for flood control. More than 5,000 acres are licensed to ODFW for wildlife management. Currently, there is no suitable habitat for nesting terns in the lake, but habitat can be easily created adjacent to a sub-impoundment project constructed by the Corps (U.S. Army Corps of Engineers 1988).

California. Tern nesting sites in California have been numerous in both interior and coastal areas. Interior sites consist of natural and artificial wetlands, lakes, or reservoirs and coastal sites can be found in almost all the coastal bays and estuaries in the State. Sites of management concern in this DEIS are located in San Francisco Bay. San Francisco Bay and estuary contain a variety of habitats, ranging from deep bays, channels, and tidal marshes to artificial salt ponds. The Sacramento and San Joaquin rivers enter the bay in the northeastern portion, forming a delta. These rivers drain California's Central Valley, including parts of the Sierra Nevada and Cascade mountains, forming the largest estuary on the west coast of North America. The freshwater runoff in the delta flows seaward, mixing with ocean water through Suisun Bay, San Pablo Bay, and lastly, San Francisco Bay. Caspian tern nesting in the bay has usually been associated with artificial salt ponds. Commercial salt production has been discontinued in many of the salt ponds throughout the bay. Inactive salt ponds have been transferred to Federal, State, or local governments and are managed primarily as wildlife habitat. Some have been or will be restored to tidal influence. Ponds N1-N9 are active salt ponds included within the Don Edwards San Francisco Bay NWR. Although active salt harvest is occurring, internal levees are free from disturbance and have provided habitat for nesting terns in the past. Also of management concern in San Francisco Bay is Brooks Island, a 373-acre island, located in the east-central part of the bay just off the Richmond Inner Harbor near Point Potrero. It is managed as a natural preserve by East Bay Regional Parks District and contains salt marshes, tidal flats, sandy shoreline and an upland portion that rises 163 feet. Caspian terns and gulls nest on the flat sandy shoreline that is mostly vegetated with a non-native ice plant and a Mediterranean aster.

3.2 Biological Environment

3.2.1 Caspian Terns

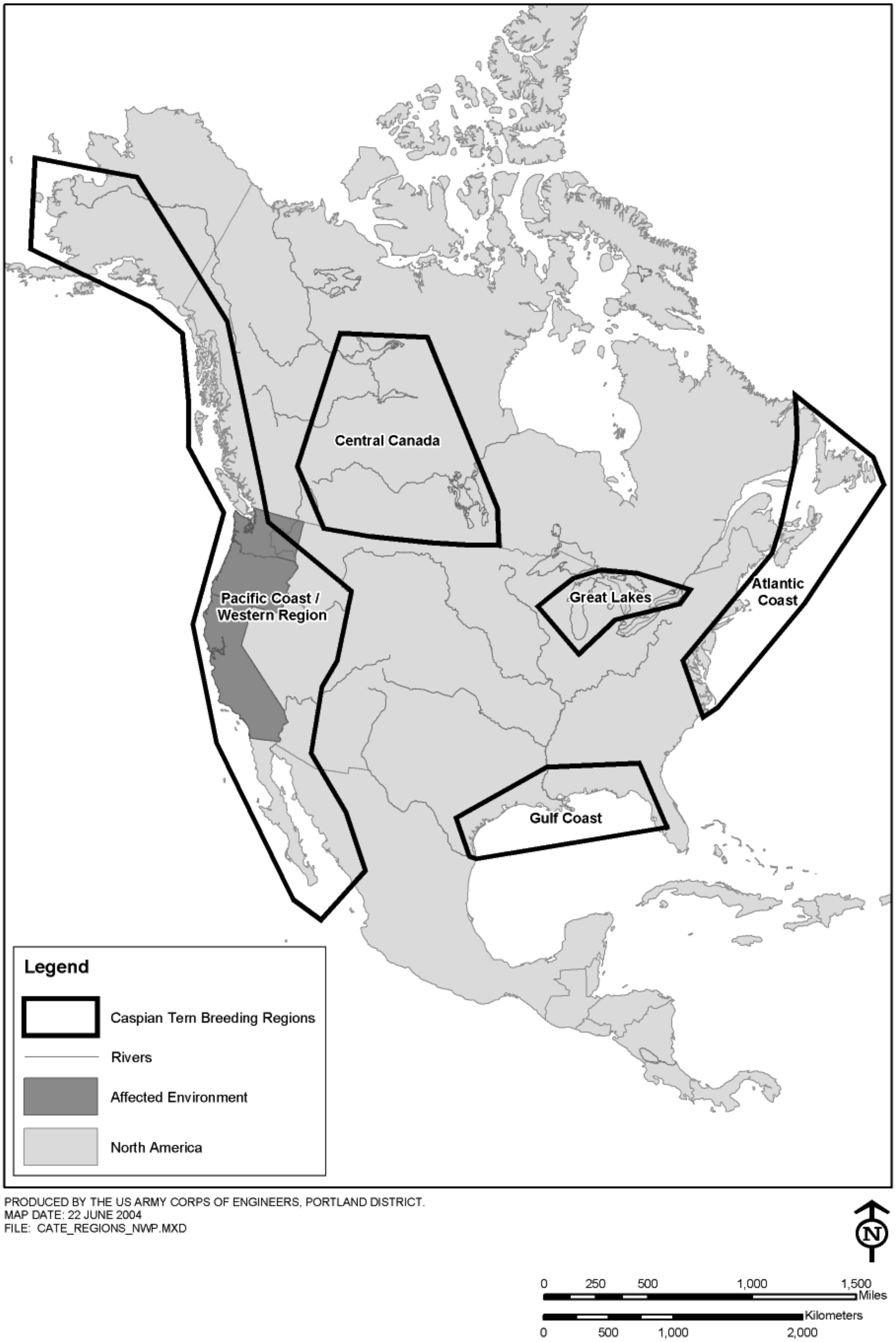
The 2002 Settlement Agreement required the Service to prepare a technical report summarizing the distribution, abundance, and conservation needs of Caspian terns in North America. Much of the information presented below is derived from this report, entitled: *Status Assessment and Conservation Recommendations for the Caspian Tern (Sterna caspia) in North America* (Shuford and Craig 2002).

Species Range. Caspian terns breed at widely scattered sites across North America. Wires and Cuthbert (2000) described five disjunct breeding regions in North America (Figure 3.3). Caspian terns breeding in the Columbia River estuary are in the Pacific Coast region. This region includes coastal Alaska, southwestern British Columbia, Washington, Oregon, California, Baja California, and Sinaloa, Mexico; and interior Washington, Oregon, California, southern Idaho, Montana, Wyoming, western Nevada, and northern Utah. See Appendix F (Table F.1) for a complete list of current and historic tern nesting sites within the Pacific Coast region.

Pacific Coast Region Overview. Since the beginning of the 20th Century, the Pacific Coast regional population has shifted from nesting in numerous small colonies associated with freshwater marshes in interior California and southern Oregon, to primarily larger colonies along the coast extending into the State of Washington (Gill and Mewaldt 1983). Caspian terns adapt to spatial and temporal variability of breeding habitat and prey, leading to highly variable colony locations and sizes within the region.

In recent years, terns were documented to have nested on about 60 sites scattered throughout the Pacific Coast region, including Alaska (Table F.2). This habitat base serves as a network of sites, which individually may vary in suitability from one year to the next but collectively provide a suite of locations for terns on a regional scale. Colonies in the interior are characteristically small in size (few to hundreds of birds, Table F.2) and are subject to substantial shifts in location, quantity, and quality corresponding to cycles of flood and drought. Interior sites may

FIGURE 3.3 Caspian Tern Breeding Regions in North America



also be subject to intensive management such as the control of reservoir and irrigation water. Larger colonies (e.g., many hundreds to thousands of terns) have been documented primarily along the Pacific Coast.

Coastal nesting habitat can be managed or natural and is typically subject to erosion and vegetation changes over time. Although ocean conditions may affect prey availability, coastal prey resources are typically more diverse, abundant, and stable in comparison to prey resources at interior sites which are highly variable from year to year. For a detailed review of current, historic, and potential tern nesting habitat throughout the Pacific Region see: *A Review of Caspian Tern Nesting Habitat: A Feasibility Assessment of Management Opportunities in the U.S. Fish and Wildlife Service Pacific Region* (Seto et al. 2003).

Regional Population Trends. The tern breeding population in the Pacific Coast region is the largest within the United States (see Table 3.1 for a breakdown of regional populations). This regional population has increased exponentially since the early 1960s (Figure 3.4, Gill and Mewaldt 1983, Shuford and Craig 2002). Although actual numbers were not reported for the early 1960s, Gill and Mewaldt (1983) described a regional population estimate of approximately 6,000 pairs in the late 1970s and early 1980s (a 74 percent increase from the 1960s numbers). Thus, the regional population in the 1960s would have been around 3,500 pairs. Shuford and Craig (2002) reported that this increase may have represented a rebound to, or below, the levels before the great loss of wetland habitat at interior portions of the region. A second increase occurred in the late 1990s with an estimated 14,500 breeding pairs reported in the region.

The overall regional population increase (Figure 3.4), beginning in the early 1980s, mainly represents the large increase observed in the Columbia River estuary (see section below) from 1984 to 2002. Numerous anthropogenic and natural factors are thought to have contributed to this increase in tern numbers but the interactions among them are not well understood. The initial colonization and growth of the Rice Island tern colony appears to have occurred because of the immigration of terns from large colonies in Washington (e.g., Grays Harbor and Willapa Bay). A number of factors such as habitat loss, decreased prey availability, erosion of islands, vegetation of nesting sites, and increased predators (gulls, eagles) may have contributed to the shift of nesting terns from coastal Washington to the Columbia River estuary. The continued growth and success of this colony at Rice Island, and now East Sand Island, are attributed to the stability of the human-created and/or maintained nesting habitat, reliable food supply, vulnerability of some hatchery smolts to tern predation, and the apparent immigration of terns that have lost nesting habitat or were hazed from other colonies (e.g., Everett Naval Base, Shuford and Craig 2002). Highly productive ocean conditions which supported an abundance of marine prey species most likely also contributed to the high tern reproductive success observed on East Sand Island from 1999 to 2003. In 2003, the East Sand Island colony comprised 71 percent of the regional population (approximately 11,756 nesting pairs, Table F.2) which has declined slightly since the 1996-1998 estimate.

Colony Sizes and Growth Rates. Colony size varies widely among locations and years, but typically ranges from tens to hundreds of pairs (Shuford and Craig 2002). Terns rarely breed in colonies greater than 1,000 nesting pairs (Cuthbert and Wires 1999, Wires and Cuthbert 2000). Development of

TABLE 3.1 Estimates of the Caspian tern breeding population in the United States, by region, from 1976 to 1982 and 1997 to 1998, including current Pacific Coast regional population estimate.

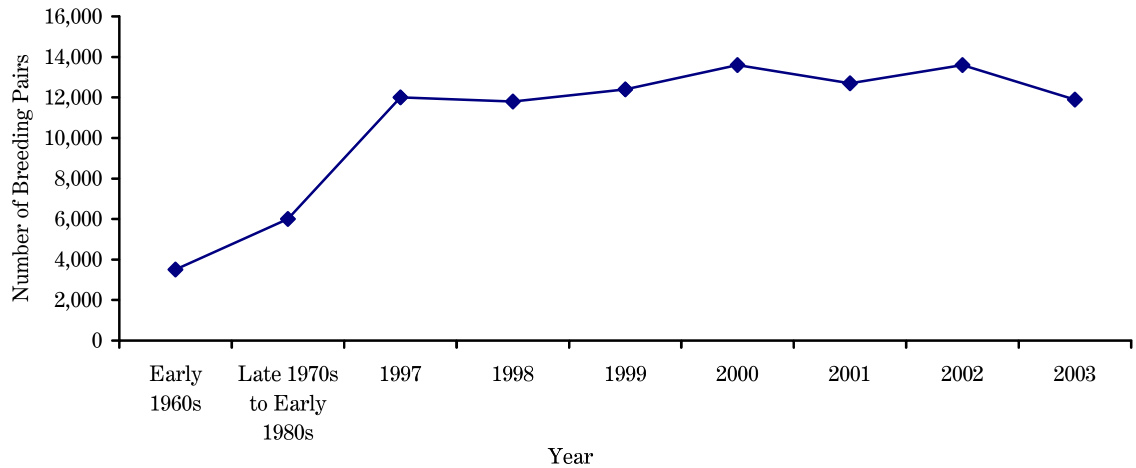
	1976-1982[a]		1997-1998[b]		2003[c]
	Estimated Pairs	% U.S. Population	Estimated Pairs	% U.S. Population	Estimated Pairs
Pacific Coast	6,218	66.4	14,534	69.4	11,756
Great Lakes	1,682	18.0	3,979	19.0	-
Gulf Coast	1,456	15.5	2,303	11.0	-
Atlantic Coast	10	0.12	122	0.6	-
TOTAL	9,366	100.00	20,938	100.00	-

[a] Spendelow and Patton 1988. Numbers of adults divided by two to estimate nesting pairs. Some of the original data were raw counts of adults, thus, these numbers are likely underestimated given some adults are usually away from the colony at any given time.

[b] Shuford and Craig 2002.

[c] U.S. Fish and Wildlife Service, unpublished data.

FIGURE 3.4 Pacific Region Caspian Tern Population Trend



References:

Early 1960s – Spendelow and Patton 1988. Estimated population was calculated based on a 74% decrease from the estimated population reported during the late 1970s – early 1980s.
Late 1970s to Early 1980s – Spendelow and Patton 1988.
1997 to 2001 - Shuford and Craig 2002. Data for 1997 and 1998 consists of data for individual sites in the region for each year and differs slightly from that reported in Wires and Cuthbert 2000 for the two years combined.
2002 to 2003 - U.S. Fish and Wildlife Service, unpublished data.

dredge material islands and salmonid production (hatchery reared and barged salmonids) have provided an abundance of stable and predictable nesting and foraging resources for breeding terns in the Columbia River estuary. These unique characteristics enabled the unprecedented growth rate and size of the tern colony in the estuary. These characteristics are not representative of tern habitat elsewhere in the Pacific Coast region and North America.

In contrast to the colony in the Columbia River estuary (average size of 7,248), the average sizes of other individual tern colonies in the Pacific Coast region since 1997 ranges from 8 to 681 nesting pairs (Table F.2), often fluctuating from year to year (Shuford and Craig 2002, D. Shuford and U.S. Fish and Wildlife Service unpublished data). In California, colonies fluctuated in growth rates and size but the overall breeding population remained stable for over 30 years (Shuford and Craig 2002). The trends observed in California are characteristic of the region overall, excluding the Columbia River estuary. Colony sizes from East Sand Island in the estuary, north along the Washington coastline averaged about 1,000 pairs between 1957 to 1991. In 1987, the colony at Grays Harbor, Washington peaked at 3,590 pairs, representing the second largest colony historically in the Pacific Coast region. By 1989 terns abandoned this site and Grays Harbor has since been used only intermittently as a foraging area (no nesting activity) by a small number of terns (e.g., 50 to 100 adults, Seto et al., Columbia Bird Research 2003).

HABITAT REQUIREMENTS. Caspian terns nest in single-species colonies or in multi-species assemblages with other ground nesting waterbirds (gulls, skimmers, other terns, and cormorants). Caspian terns breed in a variety of habitats ranging from coastal estuarine, salt marsh, and islands. Terns typically nest in open, barren to sparsely vegetated areas, but also among or adjacent to driftwood, partly buried logs, rocks, or tall annual weeds (Shuford and Craig 2002). Nest substrates vary from sand, gravel, spongy marshy soil, or dead or decaying vegetation to hard soil, shell banks, limestone, or bedrock (Shuford and Craig 2002). Nests range from simple depressions in a bare substrate to nests lined with debris, such as shells, crayfish chelipeds, dried grasses and weed stems, wood, or pebbles (Shuford and Craig 2002).

DIET. Breeding Caspian terns eat almost exclusively fish, catching a diverse array of species with shallow plunge dives, usually completely submerging themselves underwater (Shuford and Craig 2002, Cuthbert and Wires 1999). The sizes of fish caught and diet composition are largely determined by geography and annual and seasonal prey availability, but most fish are between 5 to 25 cm and occur near the surface of the water (Shuford and Craig 2002). In the Columbia River estuary, diet studies of the Caspian tern colonies on Rice and East Sand islands documented that terns nesting on Rice Island (1999 to 2000) had an average of 83 (77 to 90) percent juvenile salmonids in their diet (Roby et al. 2002), while on East Sand Island (1999 to 2003), terns had an average of 36 (24 to 47) percent juvenile salmonids in their diet (Collis et al. 2002a, 2002b, 2003a, 2003b). From 1999 to 2003, the tern diet on East Sand Island, closer to the mouth of the Columbia River than Rice Island, was primarily non-salmonids, including northern anchovy, herring, shiner perch, sand lance, sculpins, smelt, and flatfish (Roby et al. 2002, Collis et al. 2002b and 2003a). As ocean conditions improved, and therefore, productivity, the percentage of juvenile salmonids in the diet of terns in the estuary has continued to decline.

In all other areas that have been studied, except Commencement Bay, salmonids were found to be uncommon diet items. For example, in Grays Harbor, coastal Washington, chum and coho salmon were found in the tern diet in low numbers (14 to 21 percent), while primary prey taken were shiner perch and northern anchovy (Penland 1976). This is in contrast to that observed in Commencement Bay (Puget Sound), Washington. In 2000, terns here were observed to have an average of 52 percent salmonids in their diet (Thompson et al. 2002). A possibility for these observed differences in diet composition could be that Grays Harbor contains a larger diversity and/or abundance of marine prey species than Commencement Bay in Puget Sound. In addition, Commencement Bay is located at the mouth of the Puyallup River, with outmigrating salmonids coinciding with the tern breeding season. In San Francisco Bay, a diet study conducted in 2003 found that the Caspian tern diet varied among the various nesting locations found in the bay, but primary prey species included anchovy, surf perch, silversides, herring, sunfish, gobies, and toadfish (Roby et al. 2003a). Salmonids (not including trout from reservoirs) were found in the diets of four out of five nesting colonies, ranging from 0.1 (Agua Vista Park and Baumberg Pond) to 8.7 (Knight Island) percent of prey items (Roby et al. 2003a). Some tern colonies do not have salmonids available as prey items. In interior Oregon (Summer and Crump lakes), a study conducted in 2003 found tui chubs to be the primary prey of nesting Caspian terns (Roby et al. 2003a). In San Diego, food habits of terns were studied in 1995, 1997, and 1998. These studies consistently found terns to feed primarily on sardines, anchovies, and topsmelt (Horn et al. 1996, Horn and Dahdul 1998 and 1999).

Migration. Caspian terns migrate singly or in groups that can be as large as thousands (Shuford and Craig 2002). Most terns congregate for migration at traditional foraging locations along marine coasts and major rivers or freshwater lakes about a month after young have fledged (Shuford and Craig 2002). Timing of migration varies with region; fall movement typically occurs between mid-July and mid-September along the Pacific Coast (Shuford and Craig 2002).

Adult Caspian tern with chick. Photo credit: Dan Roby

Colony Descriptions. Two documents describe and summarize Caspian tern colony information: (1) *Status Assessment and Conservation Recommendations for the Caspian Tern in North America* (Shuford and Craig 2002), and (2) *A Review of Caspian Tern Nesting Habitat: A Feasibility Assessment of Management Opportunities in the U.S. Fish and Wildlife Service Pacific Region* (Seto et al. 2003). Full descriptions of Caspian tern colonies found in the Pacific Coast region can be found in these documents. The following section summarizes tern nesting activity within the affected environment. See Table F.2 for a summary of all current nesting sites within the Pacific Coast region and estimated nesting tern numbers for 1997 to 2003.

Washington. The distribution and abundance of Caspian terns in the State has fluctuated dramatically since they were first reported along the coast of Westport in 1929 (Shuford and Craig 2002). Breeding activity was first recorded in the 1950s with small coastal colonies in Grays Harbor. The Washington breeding population peaked in 1982 with nesting colonies in Grays Harbor, Willapa Bay (coast), and the Potholes Reservoir (eastern Washington). By 1995, several tern nesting islands were lost in Grays Harbor and Willapa Bay from erosion, typical at naturally occurring ephemeral habitats. The one remaining tern nesting island in Grays Harbor, Sand Island, is now vegetated. Some terns moved to nest in Puget Sound (Padilla Bay, Everett Naval Base, and Commencement Bay), but urban development, active hazing, and habitat loss ultimately precluded nesting terns from using those sites. In 2003, nesting Caspian terns were only documented on the Washington coast at Dungeness NWR, and at the Potholes Reservoir, Banks Lake, and Crescent Island in the interior and all of these were small colonies consisting of less than 1,000 nesting pairs.

The newly colonized Dungeness NWR colony constitutes the only current coastal nesting site in Washington. Caspian terns have been observed in small numbers in Dungeness Bay since the late 1990s but nesting activity was never documented until 2003 (P. Sanguinetti pers. comm.). About 200 adult terns were observed in late July with at least 50 young chicks (P. Sanguinetti pers. comm.). A complete count of nesting terns was not possible due to visual obstructions (driftwood) and colony sensitivity. The peak count of adults (300) was converted to an estimate of breeding pairs (186) by multiplying the number of adults by a 0.62 correction factor based on the average ratio of nests to adults at sites on the California coast (Shuford and Craig 2002). The area used by terns is sandy and open, with pieces of driftwood and very little vegetation. Although the terns nested on less than 0.25 acre in 2003, more nesting habitat is available in the immediate area. Adults and chicks were observed through the end of September (P. Sanguinetti pers. comm.). Although specific prey species have not been identified, terns were observed feeding in Dungeness Bay and the Strait of Juan de Fuca (P. Sanguinetti pers. comm.).

Oregon. Local summer residents and migrants occur along Oregon's coast, major rivers, and inland water bodies (Shuford and Craig 2002). In 1940, less than 1,000 pairs nested throughout Oregon. Historically, breeding terns were restricted to shallow lakes and reservoirs of the Klamath Basin and Great Basin (Shuford and Craig 2002). In recent years, tern numbers in Oregon averaged around 9,000 pairs. Currently, what has been considered the world's largest colony is found near the mouth of the Columbia River on East Sand Island, and small colonies still occur in interior Oregon. Recent trends in Oregon reflect the population trend observed in the Pacific Coast regional population (see section 3.2.1, Shuford and Craig 2002).

Although terns were observed near East Sand Island in 1975 (Tabor 1976), nesting activity in the Columbia River estuary was first documented in 1984 (1,164 nesting pairs, Shuford and Craig 2002). Terns used habitat created by deposition of dredged material on the eastern tip of East Sand Island. By 1985, vegetation covered the East Sand Island nesting site and by 1986, most of the colony shifted to Rice Island, a large sandy dredge disposal island 21 km farther upriver. From 1987 to 1998, no terns attempted to breed on East Sand Island. The tern colony on Rice Island increased rapidly from the initial estimate of 1,000 pairs in 1986 to about 6,200 pairs in 1991 (Shuford and Craig 2002). Growth of this colony slowed after 1991, but it again increased substantially in size in 1995 and 1996, coincident with loss of a colony at the U.S. Naval Base at Everett, Washington (Shuford and Craig 2002). The number of terns peaked on Rice Island at 8,700 pairs in 1998. In 1999, a pilot study to attract the breeding colony of terns on Rice Island to East Sand Island resulted in approximately 547 pairs nesting at the eastern end of East Sand Island (Roby et al. 2002) while approximately 8,300 pairs remained on Rice Island. This relocation effort included the removal of vegetation to create bare sand nesting habitat and social attraction techniques (i.e., decoys and audio playback systems) on East Sand Island. Terns that nested on East Sand Island were presumably from the nearby Rice Island colony (Roby et al. 2002). In 2000, colony relocation efforts continued, resulting in only about 590 nesting terns on Rice Island and approximately 8,500 on East Sand Island (Roby et al. 2002). Thereafter, all Caspian terns in the Columbia River estuary have nested on East Sand Island and terns attempting to nest elsewhere in the estuary have been hazed. In 2002 and 2003, 9,933 and 8,352 nesting pairs, respectively nested on East Sand Island (Collis et al. 2003a and 2003b).

Caspian terns were described as "usually breeding" at Summer Lake in 1940 (Shuford and Craig 2002) but in recent years observations of terns have been less than 50 pairs. At Crump Lake, tern numbers are slightly higher. In 2000, approximately 150 pairs were observed in Crump Lake (Shuford and Craig 2002). Since then, water levels have been high and the island used for nesting has been underwater and unavailable to terns. In 2003, 49 active tern nests were monitored on an artificial platform constructed by a research group in Crump Lake (Roby et al. 2003a). Currently, Caspian terns are a casual visitor at Fern Ridge Lake during spring migration and in late summer during the post-breeding season dispersal and/or migration. Fern Ridge Lake does not contain a suitable nesting site for this species at present.

California. There is very little historical information on tern nesting activity in California. Prior to 1945, only six breeding sites were known for the State, five in the interior and one in San Francisco Bay (Shuford and Craig 2002). In the late 1970s, approximately 2,586 pairs nested at 10 sites (78 percent on coastal sites and 22 percent on interior sites). By 1997, a colony at the Salton Sea increased, bringing the State population to 4,350 pairs; but by 2000, the California breeding population declined to about 2,583 pairs at 12 sites. Other than for the very brief period when peak numbers were reached at the Salton Sea in the mid-1990s, the Statewide breeding population appears to have been relatively stable in the last 30 years despite shifts in the number and location of breeding sites (Shuford and Craig 2002).

In San Francisco Bay, Caspian terns initially nested in salt ponds but later expanded or relocated to new sites, typically in response to disturbance from routine maintenance of salt pond levees or predation. A study which monitored nesting tern colonies in

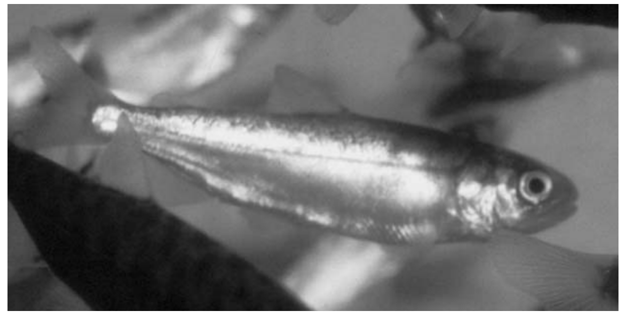
San Francisco Bay between the years of 1982 to 2003 found that the numbers of nesting terns in the bay have remained relatively stable during the past 20 years, but considerable annual movement among colony sites was observed (Strong et al. 2003). During this same period, tern numbers in the entire bay ranged from approximately 1,000 to 2,600 pairs (Strong et al. 2003), with approximately 1,190 pairs nesting in 2003 (Roby et al. 2003a).

3.2.2 Fish

A variety of fish are found within the affected environment. These vary greatly based on their location (coastal vs. interior waterbodies). Generally, coastal areas contain a larger diversity of fish including marine and anadromous fish (e.g., salmon). Abundance of these fish is heavily dependent upon ocean conditions. In contrast, interior sites contain fish such as trout, tui chub, bass, crappie, or suckers. Abundance and availability of these fish are heavily dependent upon drought conditions and water levels. The section below describes an overview of fish that could be affected by proposed management alternatives of this DEIS.

Salmonids. Salmonids discussed in this DEIS refer to anadromous species only. Salmon and steelhead are similar in their ecological requirements. They spend most of their lives in the ocean where they grow to relatively large size, and then return to freshwater to spawn. Steelhead are the anadromous form of rainbow trout (a salmonid native to western North America and the Pacific Coast of Asia) and do not necessarily migrate to sea at a specific age or die after spawning. Even though repeat spawning is common, post-spawning survival rates are quite low (10 to 20 percent, California Department of Fish and Game 2001).

Salmon and steelhead exhibit two principle life history types. The first is stream-type, in which fish rear in fresh water, usually remaining in the stream where they hatched for a year or more before beginning their downstream migration to the ocean. Stream-type salmonids include some of the Chinook, sockeye, and coho salmon and steelhead. The second is ocean-type, in which fish migrate downstream to and through the estuary as sub-yearlings (less than one year old), generally leaving the spawning area where they hatched within days to months following their emergence from the gravel. Ocean-type salmonids include Chinook and chum salmon. Ocean-type subyearlings arrive in estuaries at a small size (generally 3 to 7 cm) and can remain in the estuary for weeks to months until they reach the transitional size necessary to migrate to the ocean (U.S. Army Corps of Engineers 2001, California Department of Fish and Game 2001).



Salmon smolt. Photo credit: Bonneville Power Administration

Washington. Dungeness NWR and Harbor are important nursery habitats for salmonids. Large numbers of ESA-listed (see section 3.2.3) and unlisted juvenile salmonids transit and are presumed to rear along the shore in this vicinity. Non-listed salmonids include Puget Sound pink salmon, coho, Puget Sound sockeye, Puget Sound steelhead, cutthroat, and possibly Fraser River (Canadian) sockeye. The nearshore Strait (shorelines stretching from Neah Bay to Admirality Inlet including Port Angeles, Dungeness, Sequim, and Discovery bays, Kilsut, and Port Townsend Harbors) provide a critical feeding, refuge, and migration corridor for many species, including three federally ESA-listed salmonids (see section 3.2.3), as well as sockeye, pink, and chum salmon. Washington coastal waters also include designated Essential Fish Habitat (EFH) for salmonids.

Oregon. All Columbia River Basin salmonids pass through the Columbia River estuary during their migration out to the sea and back upstream to their natal spawning grounds. The Columbia River estuary is also an important nursery area for some stocks of salmon, in particular, chum and fall Chinook (Fresh et al. 2003). Many of the salmonids found in the river are ESA-listed species (see section 3.2.3). The Columbia River estuary also includes designated EFH for salmonids.

Salmonids do not occur within Summer and Crump lakes. At Fern Ridge Lake, salmonids do not occur within the lake proper, however, they do occur in the Willamette and McKenzie rivers which are greater than six miles from Fern Ridge Lake, within foraging range of Caspian terns (if terns were to nest at Fern Ridge Lake). These include spring and fall Chinook and winter and summer steelhead.

California. California coastal waters also include designated EFHs for salmonids. Native salmonids found in San Francisco Bay include Chinook salmon and steelhead, both of which are listed under the ESA (see section 3.2.3 for description). Coho salmon were historically found in the estuary but are now believed to be extirpated (Brown et al. 1994).

Other Fish. A variety of marine and freshwater fish that are not part of the salmonid family also occur within the affected environment. Abundance and diversity varies greatly among locations.

Washington. Several species of cod and sole rear in the shallow nearshore marine and estuarine habitats of Dungeness Bay. Surf smelt, sand lance, herring, anchovies, and a variety of rockfish are also found in the area. Juvenile surf smelt reside in nearshore waters and may use estuaries for feeding and rearing (Emmett et al. 1991, Lemberg et al. 1997). Surf smelt are a widespread and important member of the nearshore fish community throughout Puget Sound. Although surf smelt movements within Puget Sound are unstudied, a number of genetically distinct stocks are thought to occur. Because no stock assessment studies have been done, the status of Puget Sound surf smelt populations is currently unknown (Lemberg et al. 1997). EFH has been designated for certain groundfish and coastal pelagic species in Washington coastal waters.

Oregon. Other fish that occur in the Columbia River estuary include some anadromous species such as green and white sturgeon, Columbia River smelt, stickleback, shiner perch, and shad. Marine species such as anchovies, Pacific herring, sardines, surf smelt, surf perch, rockfish, and flounder are also present. EFH has been designated for certain groundfish (Pacific Fishery Management Council. 1998a and 1998b) and coastal pelagic species in Oregon coastal waters. At Summer, Crump, and Fern Ridge lakes, primary fish species include tui chub, rainbow trout, carp, bass, crappie, bullhead catfish, and suckers.

California. Northern anchovy and Pacific herring are the most abundant fish species in San Francisco Bay. Other fish found in the bay include smelt, flounder, sole, sturgeon, Sacramento splittail, and shad. In addition, the introduced striped bass range throughout San Francisco, San Pablo, and Suisun bays (Herbold et al. 1992).

3.2.3 Federally Endangered and Threatened Fish

Federally endangered and threatened (ESA-listed) fish that occur in the affected environment are either anadromous or non-anadromous. The discussion of anadromous fish species involves species within Evolutionary Significant Units (ESU) or Distinct Population Segments (DPS). An ESU includes “any distinct population segment of any species of vertebrate fish or wildlife that interbreeds when mature” (Waples 1991). This population segment must be reproductively isolated from other nonspecific population units. It also must represent an important component in the evolutionary legacy of the species. All ESU designations used by NOAA Fisheries, including steelhead trout, are associated with salmonids. Although steelhead trout are commonly called trout, they are closely related to other salmon scientifically grouped with them in the *Oncorhynchus* genus. The definition of DPS used by the Service is essentially the same as that for an ESU but is a designation for non-salmonid anadromous fish. The Service and NOAA Fisheries issued a joint policy describing DPSs in *Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act* (61 CFR 4722).

A description of the species and available historical and most recently published abundance information for ESA-listed salmonids, as well as life history and biological requirements, are summarized in *Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California* (Myers et al. 1998), *Status Review of Coho Salmon from Washington, Idaho, Oregon, and California* (Weitcamp et al. 1995), *Status Review of Chum Salmon from Washington, Oregon, and California* (Johnson et al. 1997) and *Status Review Update for Chum Salmon for Hood Canal Summer-Run and Columbia River ESUs* (Grant et al. 1999), and *Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California* (Busby et al. 1996). Table 3.2 lists all threatened and endangered anadromous fish and associated ESUs or DPSs protected under the ESA that occur in the affected environment. Figure 3.5 illustrates known occurrence times for the various salmonids in comparison to the Caspian tern nesting season.

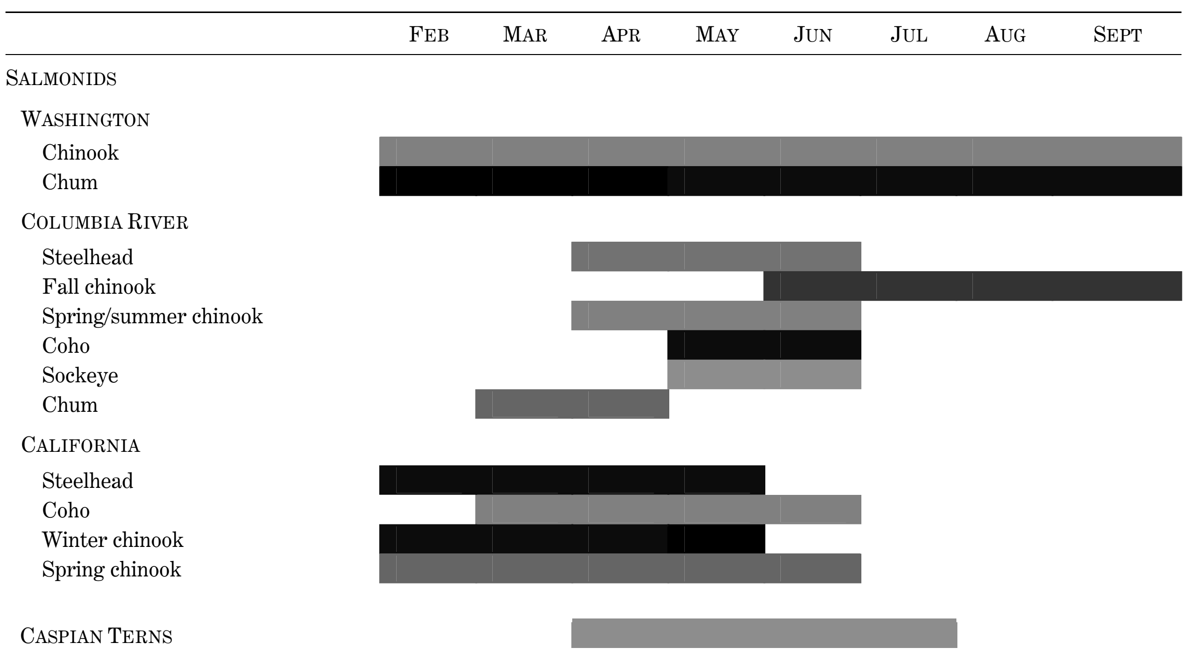
Washington. ESA-Listed Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, and bull trout occur in Dungeness Bay. The Puget Sound Chinook ESU includes all naturally spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca to the Elwha River. Chinook salmon from the following hatchery stocks are considered part of the ESA-listed ESU: Kendall Creek (spring run); North Fork Stillaguamish River (summer run); White River (spring run); Dungeness River (spring run); and Elwha River (fall run, NOAA Fisheries 2003c). The bay’s location at the southeastern end of the Strait of Juan de Fuca indicates that Chinook juveniles that emigrate annually from Puget Sound travel along the nearshore of Dungeness Spit (M. Longenbaugh pers. comm.).

Ocean-type Chinook salmon predominately occur in coastal regions, including Puget Sound, and use estuaries and coastal areas more extensively for juvenile rearing (Levy and Northcote 1982, Pearce et al. 1982). Juvenile Chinook may be present in nearshore areas from May through mid-September (NOAA Fisheries 2004, Marlowe et al. 2001) and may reside up to 189 days in estuarine habitats (Wallace and Collins 1997, Levy and Northcote

TABLE 3.2 Federally Listed ESUs/DPSs that Occur in the Affected Environment.

Evolutionarily Significant Unit (ESU) or Distinct Population Segments (DPS)	Status	Life History Type
CHINOOK		
Puget Sound	Threatened	Stream/Ocean
Snake River spring/summer	Threatened	Stream
Snake River fall	Threatened	Ocean
Lower Columbia River	Threatened	Ocean
Upper Columbia River spring	Endangered	Stream
Upper Willamette River	Threatened	Ocean
California Coastal	Threatened	Ocean
Sacramento winter-run	Endangered	Stream
Central Valley spring-run	Threatened	Stream
COHO		
Lower Columbia River/Southwest Washington	Candidate	Stream
Central California Coast	Threatened	Stream
Southern Oregon/Northern California Coasts	Threatened	Stream
CHUM		
Hood Canal summer-run	Threatened	Ocean
Columbia River	Threatened	Ocean
SOCKEYE		
Snake River	Endangered	Stream
STEELHEAD TROUT		
Snake River	Threatened	Stream
Lower Columbia River	Threatened	Stream
Middle Columbia River	Threatened	Stream
Upper Columbia River	Endangered	Stream
Upper Willamette River	Threatened	Stream
Central Valley	Threatened	Stream
Central California Coast	Threatened	Stream
Northern California	Threatened	Stream
BULL TROUT		
Puget Sound	Threatened	Trout
Columbia River	Threatened	Trout

FIGURE 3.5 Arrival Times of Juvenile Salmonids and Nesting Period of Caspian Terns in the Affected Environment



1982). Overall, the abundance of Chinook salmon in the Puget Sound ESU has declined substantially, and both long and short term abundance trends are predominantly downward (Myers et al. 1998).

Increasing harvest, coupled with generally increasing trends in spawning escapement, provides evidence that chum salmon, while still ESA-listed, have been increasing in recent years within the Hood Canal ESU (Johnson et al. 1997). Juvenile chum salmon depend on estuarine and nearshore habitats for rearing, and usually have longer residence times (from days to three months) in estuaries than other anadromous salmonids besides Chinook (Pearce et al. 1982, Johnson et al. 1997).

Bull trout are char native to the Pacific Northwest and western Canada. Bull trout within the Coastal/Puget Sound DPS were listed as threatened under the ESA in 1999. Bull trout generally spawn from August through November in small tributaries and headwater streams. Anadromous bull trout juveniles typically spend 2 to 3 years rearing in tributary streams before migrating to sea.

Oregon. Seven salmon and steelhead runs have population segments that are ESA-listed and spend a portion of their lives in the lower Columbia River (Figure 3.5). The species include 12 ESUs identified by NOAA Fisheries (Table 3.2).

The first outbound migrants of the lower Columbia River fall Chinook and chum (ocean-type) may arrive in the lower Columbia River as early as late February (Herrmann 1970, Craddock et al. 1976, Healey 1980, Congleton et al. 1981, Healey 1982, Dawley et al. 1986, and Levings et al. 1986). The majority of these fish are present from March through June. Outbound Snake River fall Chinook begin their migration much farther upstream. They arrive in the lower Columbia River approximately a month later. As Chinook fry migrate to the estuary, they may remain in the low salinity or even freshwater areas for some time until they have grown somewhat larger (Kjelson et al. 1982, Levings 1982, Levy and Northcote 1982, MacDonald et al. 1986, Shreffler et al. 1992, and Hayman et al. 1996). However, some Chinook fry appear to move immediately to the outer edges and higher salinity portions of the estuary (Stober et al. 1971, Kask and Parker 1972, Sibert 1975, Healey 1980, Johnson et al. 1992, and Beamer et al. 2000).

Stream-type or yearling steelhead and Chinook migrate to the ocean in their second year of life or later as relatively large smolts [generally 10 to 30 cm (4 to 12 inches)] and move through the lower Columbia River and estuary within days to weeks (U.S. Army Corps of Engineers 2001).

The bull trout information in this paragraph is excerpted from the Service's 2002 Biological Opinion on the Columbia River Channel Improvements Project (U.S. Fish and Wildlife Service 2002a). Bull trout are relatively dispersed throughout the tributaries of the Columbia River Basin, including its headwaters in Montana and Canada. The Columbia River DPS includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin and currently occur in 45 percent of the estimated historical range (Quigley and Arbelbide 1997). The Columbia River DPS comprises 141 bull trout sub-populations in four geographic areas of the Columbia River Basin. The current distribution of bull trout in the lower Columbia River Basin is less than the historical range (Buchanan et al. 1997).

Incidental catches of bull trout in the Bonneville Pool (Wachtel 2000) indicate that bull trout are using the mainstem reach of the lower Columbia River. Bull trout have been reported from the lower reaches of the Kalama and Lewis rivers (J. Byrne pers. comm.) and Sandy River (PGE *in litt.*). One bull trout was reportedly caught and released in the Columbia River downstream from Bonneville Dam between the dam and Reed Island in 1994. Another was harvested from the area below Bonneville Dam in 1998 (Wachtel 2000). Three other bull trout have been reported as having been caught in Bonneville Pool during 1998 by anglers participating in the northern pikeminnow Sport-Reward fishery (Wachtel 2000). There have been two reports of bull trout caught by anglers in the White Salmon River downstream from Condit Dam in recent years.

The endangered Oregon chub was formerly distributed throughout the lower elevation backwaters of the Willamette River drainage. Decline of the Oregon chub is attributed to loss of its backwater habitats. Habitat at the remaining population sites typically consists of low- or zero-velocity water flow conditions, depositional substrates, and abundant aquatic or overhanging riparian vegetation. Currently, known populations are restricted to an 18.6 mile stretch of the Middle Fork Willamette River in the vicinity of Dexter and Lookout Point Reservoirs in Lane County (58 FR 53800).

Threatened Warner suckers are endemic to the Warner Valley (Crump Lake). Warner suckers are bottom dwellers and comprise less than five percent of the total fish population in the Warner Valley (C. Allen pers. comm.). There are no ESA-listed fish species in Fern Ridge Lake. However, ESA-listed salmonids occur in the Willamette and McKenzie rivers, approximately 6 miles east of the lake. These include Upper Willamette River Chinook, and Upper Willamette winter steelhead ESUs.

California. ESA-listed salmonid ESUs that occur in the San Francisco Bay estuary include the

Sacramento River winter-run Chinook; Central Valley spring, fall, and late-fall run Chinook; Central Valley steelhead; Central California Coast steelhead; and Central California Coast coho.

Adult Sacramento River winter-run Chinook salmon leave the ocean and migrate through the Sacramento-San Joaquin delta to the upper Sacramento River from December through June. Most juveniles distribute themselves to rear in the Sacramento River through the fall and winter months. Some Sacramento River winter-run Chinook salmon juveniles move downstream to rear in the lower Sacramento River and delta during the late fall and winter and may begin migrating downstream from December through March (Moyle et al. 1989, Vogel and Marine 1991).

Most yearling Central Valley spring-run Chinook salmon move downstream in the first high flows of the winter from November through January (U.S. Fish and Wildlife Service 1995, California Department of Fish and Game 1998), while some remain throughout the summer and exit the following fall as yearlings. At present, all Central Valley steelhead are considered winter-run steelhead (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento River system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program Steelhead Project Work Team 1999). Juveniles live in freshwater from one to four years (usually two years in California, Barnhart 1986), then smolt, and migrate to the sea from February through April. However, some steelhead smolts may outmigrate during the fall and early winter months.

Central California Coast steelhead have been virtually extirpated in most tributaries to San Francisco and San Pablo bays (McEwan and Jackson 1996). Fair to good runs of steelhead occur in coastal Marin County tributaries. Based on a 1994 to 1997 survey of 30 San Francisco Bay watersheds, NOAA Fisheries believes that there is a relatively broad distribution of steelhead in smaller streams throughout the watershed (Busby et al. 1996).

Central Valley fall and late fall-run Chinook is a candidate species. This ESU includes all naturally spawned populations of fall-run Chinook in the Sacramento and San Joaquin River basins and their tributaries. Fall-run Chinook juveniles emigrate during their first winter (January to March).

The delta smelt, which is endemic to the upper Sacramento-San Joaquin estuary, is federally ESA-listed as threatened. Delta smelt inhabit open surface waters where they school. The green sturgeon is a candidate species and is comprised of two DPSs (68 FR 4433). The green sturgeon is anadromous but is the most marine oriented sturgeon species (Adams et al. 2002). Green sturgeon adults and juveniles occur throughout the upper Sacramento River.

3.2.4 Other Birds

Bird species other than Caspian terns that could potentially be affected by proposed management alternatives of this DEIS are described below, except for those species listed under the ESA. Descriptions of ESA-listed bird species are located in section 3.2.6 with other ESA-listed wildlife.

Washington. A variety of shorebirds and waterbirds use Dungeness Bay throughout the year. The bay is one of Washington's major wintering and spring staging areas for the brant (U.S. Fish and Wildlife Service 1996). A pair of black oystercatchers nest on the site at Dungeness NWR used by Caspian terns in 2003. Numerous glaucous-winged gulls and double-crested cormorants also use this area.

Oregon. Two species of cormorants nest on East Sand Island. East Sand Island supports the largest known colony of double-crested cormorants on the Pacific Coast (Roby pers. comm.). These cormorants nest on the western end of the island, separated from the tern nesting site by dense upland shrub habitat. The nesting colony has increased nearly 100-fold since it was first recorded in 1989 (Anderson 2002). In 2003, about 10,600 pairs of cormorants nested on East Sand island (Roby pers. comm.). Brandt's cormorants nest on a pile dike offshore of East Sand Island. A large gull colony is also located on East Sand Island both at the eastern end near the Caspian tern colony and at the western end near the cormorant colony site. Nesting gulls consist mostly of glaucous-winged/western gull hybrids but several hundred pairs of ring-billed gulls also nest on the island. The endangered California brown pelican roosts on East Sand Island (see section 3.2.6 for more details on pelican use of the island). Bald eagles also have a substantial breeding and wintering/transient population in the Columbia River estuary (see section 3.2.6 for more details). Mallards and western Canada geese are probably the most abundant breeding waterfowl on the island. Songbirds also use the vegetated habitat on the upland portion of the island.

Several species of colonial waterbirds and shorebirds use Summer and Crump lakes. These include American avocet, black-necked stilt, willet, common snipe, California gull, ring-billed gull, double-crested cormorant, Forster's tern, and American white pelican. Some of these species may compete for nesting habitat with Caspian terns. Gulls are common in Fern Ridge Lake but no nesting occurs since habitat is currently unavailable.

California. Double-crested cormorant, California gull, and Forster's tern are commonly found in

San Francisco Bay. These bird species use habitat similar to terns and may nest adjacent to or near tern colonies. The numbers of Forster's terns in the bay have declined significantly between 1984 and 2003 (Strong et al. 2003). Much of this decline is attributed to fluctuating water levels, encroachment by gulls, predation, human disturbance, and contaminants.

3.2.5 Mammals

Washington. Coyote, skunk, river otter, red fox, weasel, and raccoon all occur on Dungeness NWR in low numbers (P. Sanguinetti pers. comm.). All of these species could be potential predators of Caspian terns. Up to 600 harbor seals have been observed on Dungeness NWR (U.S. Fish and Wildlife Service 1996). Dungeness Spit is a traditional haul-out and pupping site. In recent years, pupping activity here occurred near the tern nesting site used in 2003.

Oregon. Nutria, vole, mice, and rat are residents on East Sand Island. Occasionally, visitors such as deer can be found on the island. None of these species are predators of terns. Mammals found in the Summer Lake Wildlife Area include coyote, skunk, mink, raccoon, and feral cat (St. Louis 1993). Coyote and raccoons are in the area around Crump Lake but do not have access to the tern nesting island. Beaver, nutria, raccoon, and muskrat are common species at Fern Ridge Lake. River otter and mink are likely present and could be potential predator species. More terrestrial species such as red fox, coyote, and black-tailed deer are also present at Fern Ridge Lake.

California. Mammals commonly found in San Francisco Bay include river and sea otters, coyote, and the non-native red fox. The red fox has been implicated in the population declines of the endangered California clapper rail, Caspian tern, and other colonial nesting species, such as the great blue heron and great egrets (Goals Project 2000). The Service began a Predator Management Program in 1991 which focused on removing red fox and other targeted predators on refuge lands(Goals Project 2000).

3.2.6 Federally Endangered and Threatened Wildlife

A complete list of federally endangered and threatened (ESA-listed) wildlife that occur in the affected environment is located in Appendix H. The description below focuses only on those species that may be affected by proposed management actions presented in this DEIS.

Washington. The threatened western snowy plover is found at Dungeness NWR with peak numbers of four to six birds observed in 1995 (U.S. Fish and Wildlife Service 1996). The current breeding status of western snowy plovers at Dungeness NWR remains uncertain. The threatened bald eagle also occurs here, with as many as 24 birds seen feeding or roosting on the Refuge at one time. Marbled murrelets also occur in the Dungeness Bay area.

Oregon. The endangered California brown pelican typically occurs from late spring to mid-fall along the Oregon Coast. Concentrations of this species form at the mouth of the Columbia River at the South Jetty and at East Sand Island-Baker Bay. This species forages in nearshore waters of the Pacific Ocean and estuarine waters of the Columbia River. Up to 10,800 birds were observed roosting on East Sand Island in 2002, primarily, on the western end of the island (Fischer 2004). In 2003, a peak of 6,700 pelicans was observed on East Sand Island (Fischer 2004). In recent years, nest building behavior by a few pelicans has been observed, however, egg-laying has never been documented. The Columbia River estuary supports a healthy bald eagle population with approximately 46 nesting territories. In Summer Lake, bald eagles occur in large numbers, especially in the spring when 50 to 100 birds may be found using the lake. An active nesting territory is found two miles west of the area (St. Louis 1993). One bald eagle territory is located on Fern Ridge Lake (Issacs and Anthony 2003). Resident, transient, and wintering bald eagles occur at Fern Ridge Lake.

California. Western snowy plovers are present in San Francisco Bay. Salt ponds, their levees, and pond edges, which may mimic historic salt pan habitat, provide almost all known western snowy plover nesting habitat in the bay. The endangered California least tern also nests in the bay. California least terns were first recorded in the San Francisco Bay Area in 1927, in Alameda, where the current largest northern California colony breeds (Goals Project 2000). The proposed Alameda NWR is the only known nesting location in San Francisco Bay. The Bay Area colony is considered a critical population, vital to the Statewide species recovery effort (Goals Project 2000). California least terns also occur in coastal sites in southern California (e.g., Bolsa Chica Ecological Reserve and South San Diego NWR).

3.3 Socioeconomic Environment

3.3.1 Commercial and Recreational Fisheries

Because fish are exposed to harvest from commercial and recreational fisheries across large geographic regions of the West Coast, Pacific salmon and steelhead management is governed by numerous regional organizations. The Pacific Salmon Commission (PSC) implements the Pacific Salmon Treaty between Canada and the U.S. to achieve optimum production and divide the harvests so that each country reaps the benefits of its investment in salmon management. The Pacific Fishery Management Council (PFMC), established by the U.S. Magnuson Act, regulates commercial fisheries off the coasts of California, Oregon, and Washington, including groundfish, shellfish, and salmon.

Coastal ocean fisheries in Washington and Oregon became important in the late 1950s as more restrictions were imposed on freshwater and coastal estuary fisheries. Ocean harvest of salmonids peaked in the 1970s and 1980s. In recent years, commercial and recreational ocean harvest of salmonids have generally been reduced as a result of international treaties, fisheries conservation acts, regional conservation goals, and State and Tribal management agreements.

Washington. Commercial fisheries that occur in Dungeness Bay include Dungeness crab, clams (including geoduck), octopus, coho and steelhead trout. In addition, many marine species for which EFH is designated are likely to spend part of their life history in the vicinity of Dungeness Bay. Recreational fishing and crabbing are also intensive uses in Dungeness Bay. In 1997, the Washington State Department of Health reported increasing levels of fecal coliform bacteria in Dungeness Bay. Since then, bacteria levels have continued to increase. As a result of this, 300 acres near the mouth of the Dungeness River has been closed to shellfish harvest. There are increasing concerns that marine sources, including wildlife, are contributing to this decrease in water quality.

At least 18 Pacific herring stocks, defined by spawning grounds, occur inside Puget Sound (Lemberg et al. 1997). Currently, there are two commercial herring fisheries in Washington; the principal one is in south-central Puget Sound and has an annual average catch (1992 to 1996) of 510 tons (Lemberg et al. 1997). Currently, Puget Sound herring are fished at a conservative level (Puget Sound Water Quality Action Team 2002). Although Puget Sound herring stocks have declined over the past 20 years, NOAA Fisheries decided they did not warrant listing under the ESA in 2001. It is probable that Pacific herring of all ages pass through nearshore habitats, including Dungeness Bay, especially as juveniles rearing in the summer months and as adults migrating to holding areas near natal spawning grounds.

Oregon. Before 1975, lower Columbia River recreational fisheries focused primarily on salmonid and steelhead harvest. Season closures to protect declining salmonids transitioned much of the recreational fisheries to sturgeon. Salmonid fishing efforts have rebounded with recent improvements in fish returns and selective fishery opportunities. Recreational fisheries for salmonids, white sturgeon, and steelhead can be quite extensive in the Columbia River estuary depending on stock populations and associated regulations. Recreational crabbing is also pursued extensively in the lower estuary. The lower Columbia River mainstem below Bonneville Dam is separated into two main areas for recreational harvest management: Buoy 10 (ocean/in-river boundary) to the Astoria-Megler Bridge, and the Astoria-Megler Bridge to Bonneville Dam. Columbia River tributary recreational fisheries occur throughout the lower Columbia. Depending on the time of year, different salmonids are targeted, including spring Chinook, summer steelhead, fall Chinook, coho, and winter steelhead.

Columbia River commercial fisheries became important in the 1860s. Since the early 1940s, Columbia River commercial catches of salmon and steelhead have steadily declined, reflecting changes in fisheries in response to declines in salmonid abundance. Lower Columbia River non-Indian commercial fisheries occur below Bonneville Dam in the mainstem or in select off-channel fishing areas. The Columbia River above Bonneville Dam to McNary Dam (Zone 6) was open to non-Indian commercial fishing until 1956. Commercial fishing for salmonids (gillnet and tanglenet) occurs in the estuary and lower Columbia River although it is heavily restricted in time and space. Groundfisheries and trolling occur offshore. Commercial crabbing occurs to a limited extent in the estuary with the primary focus occurring offshore.

Washington and Oregon establish season dates and gear restrictions for mainstem commercial fisheries according to the Columbia River Compact (organization charged by congressional and statutory authority to adopt seasons and rules for Columbia River commercial fisheries). Columbia River fisheries are also regulated according to the Columbia River Fish Management Plan adopted by the U.S. District Court order in 1988 and agreed to by the parties of US v. Oregon: the United States; the States of Oregon, Washington, and Idaho; and the four treaty Indian Tribes (the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe). Finally, because of the ESA status of many Columbia River salmonids, harvest managers must consult annually with NOAA Fisheries to ensure fishers are regulated to meet no-jeopardy standards established for ESA-listed salmonids.

There are no commercial fisheries at Crump and Summer lakes. Recreational fishing occurs primarily along the upper four miles of the Ana River but no fishing occurs within the Summer Lake Wildlife Area. Largemouth bass, white and black crappie, and brown bullhead primarily make up the recreational fisheries at Crump Lake. The fisheries are highly dependent upon water levels and crappie fishing is the primary fishery (C. Edwards pers. comm.). No commercial fishery occurs at Fern Ridge Lake. Recreational fishing for introduced warmwater species is a common recreational pursuit at Fern Ridge Lake and on the Long Tom River. The Willamette and Mackenzie rivers, approximately 6 miles east of Fern Ridge Lake, support recreational fisheries for salmon, steelhead, and trout, plus some warmwater fish species.

California. In San Francisco Bay, special status fisheries of the San Francisco Bay estuary include anadromous and resident species, crab, and shrimp. All portions of the bay/delta support commercially and/or recreationally important fisheries. Important sportfish that forage and/or rear young in intertidal mudflat and rocky shore habitats include native species such as Chinook salmon, white sturgeon, diamond turbot, and a variety of sharks in addition to the introduced striped bass. Pacific herring support a large fishery in the estuary as bait and human food, but more importantly as the roe and roe-on-kelp fishery for export to Japan. The roe fishery is closely regulated by CDFG (California Department of Fish and Game 2001). Depressed herring populations were observed in San Francisco resulting from the 1977/1978 El Nino event (California Department of Fish and Game 2001). Anchovies support a commercial bait fishery. As juveniles in the near shore areas, anchovies are vulnerable to a variety of predators, including birds and some recreationally and commercially important species of fish. Total anchovy harvests and exploitation rates since 1983 have been below the theoretical levels for maximum sustained yield, and stock biomass estimates are unavailable for recent years. Based on abundance index data, the stock is thought to be stable at a modest biomass level (California Department of Fish and Game 2001). Introduced species that have commercial and recreational value in the estuary include American shad and striped bass. American shad supported a large commercial fishery soon after its introduction. Commercial fishing was later banned in 1957 due to declining populations. Today a sport fishery exists in the estuary. Despite a ban on commercial fishing of the striped bass, its population continues to decline.

The white sturgeon is also an important fishery resource. White sturgeon are particularly vulnerable to the effects of over-harvesting because they mature slowly. Commercial fishing of sturgeon dates back to the mid-1800s, but declined by the early 1900s. In 1954, the Fish and Game Commission abolished the commercial fishery and established a sport fishery that continues today. Populations have continued to decline in recent years. The major factor affecting sturgeon populations is believed to be decreased river outflow into the bay (CDFG 2001). Adult English sole and starry flounder support a small commercial ocean fishery. While English sole shows no signs of decline, the starry flounder has declined specifically in San Pablo and Suisun bays. The starry flounder appears to be more sensitive to hydrologic and environmental changes (SFEP 1992a). Dungeness crab has provided a valuable commercial fishery for San Francisco for over a century.

3.4 Tribal Fisheries

Washington. Jamestown S'Klallam, Lower Elwah Klallam, and Port Gamble Klallam have Tribal treaty rights for fisheries associated with the Point No Point Treaty. Dungeness Bay is the main fishing area for the Jamestown S'Klallam Tribe. The Tribe operates a commercial fishery for coho (of hatchery origin), primarily from September through October (S. Chitwood pers. comm.). The Jamestown S'Klallam Tribe also operates a small commercial net fishery for steelhead (December to February), commercial oyster operation (in the bay), commercial and recreational crab fishery (in the bay), and a commercial geoduck harvest (outside the bay, S. Chitwood pers. comm.).

Oregon. Tribal (treaty) fisheries on the Columbia River occur upstream of Bonneville Dam. Treaty Indian harvest includes commercial, ceremonial, and subsistence (C&S) fisheries. The four Columbia River treaty Indian Tribes include the Bands of the Yakama Nation, Confederated Tribes of the Warm Springs Reservation of Oregon, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe. Treaty Indian commercial catches became a larger portion of the total Columbia River commercial catches following the 1968 Federal court ruling regarding equitable Indian and non-Indian harvest sharing. Since 1968, commercial fishing in the area between Bonneville and McNary dams (Zone 6) has been the exclusive province of the Treaty Indian Tribes. No Tribal fisheries occur at Summer, Crump, and Fern Ridge Lakes.

California. No Tribal fisheries occur in San Francisco Bay.

3.5 Cultural Resources

Washington. The New Dungeness Lighthouse on Dungeness NWR is located approximately 0.5 mile from the tern colony. The lighthouse was established in 1857 and was placed on the National Register of Historic Places in 1993. The concrete foundations and rubble remains of a small WWII naval station is on Graveyard Spit about three-quarters of a mile southwest of the colony.

The S'Klallam Indian Tribe inhabited the Dungeness area when the first European settlers arrived. Their use of Dungeness and Graveyard spits probably included temporary camping and food gathering. The Tribe lived on Dungeness Spit from 1872 to 1873 after being asked to move off land which had been homesteaded in the Dungeness community. Dungeness and Graveyard spits are known S'Klallam burial grounds. In 1980, a burial canoe was collected from Graveyard Spit by the Service.

Oregon. The Columbia River has a rich history of cultural resources associated with Native Americans and European exploration and settlement. Shipwrecks are particularly abundant in the area. East Sand Island was formerly a part of a mid-estuary shoal that migrated north and west to its present location apparently due to various navigation improvements. Cultural resources on the island are primarily associated with the early commercial fishing industry and military blockade of the mouth of the Columbia River during the World Wars.

Cultural resources associated with Native Americans are abundant in southeastern Oregon. Artifacts are especially prevalent around waterbodies such as Summer and Crump lakes. Human occupation at these locations goes back at least 11,500 years. Sites found in both areas range from large village sites located on the shores of each lake to small camp sites in the adjacent uplands or on playas. Depending upon water levels, sites may be inundated on both lakes, may appear as islands within the lakes or may be located high above the present shoreline. Native Americans with interests in Summer and Crump lakes include the Fort Bidwell Tribe, the Burns Paiute Tribe, Paiutes from the Confederated Tribes of Warm Springs, and the Yahuskin Band of the Klamath-Modoc Tribe.

Fern Ridge Lake has high value as an archaeological and historical resource. Native Americans used the area heavily. The Indian bands that ceded this area are documented under a treaty by the Confederated Bands of the Willamette Valley, January 22, 1855. Their descendants are included in the modern Confederated Tribes of Grand Ronde. A travel route for early settlers passed through the now inundated portions of Fern Ridge Lake, including the historic Applegate Trail (U.S. Army Corps of Engineers 1988). Native Americans were also a substantial presence in the Long Tom River channel, Coyote Creek, and areas adjacent to Orchard Point Park, which represent major archaeological areas. A Cultural Resources Management Plan has been prepared for known cultural resource sites at Fern Ridge Lake.

California. There are no cultural resources located in the areas proposed for management actions in San Francisco Bays with the exception of Brooks Island. Brooks Island was home to local natives for two or three thousand years. The Ohlone Indians originally settled the island. Their shell mounds and burial sites, up to 2,500 years old, are an archaeological treasure being preserved and protected on Brooks Island.

Chapter 4. Environmental Consequences

This chapter identifies the effects of the four alternatives (summarized in Table 4.1, above) described in Chapter 2 on the affected environment (Chapter 3). The effects of each alternative on the affected environment are described in the same order as presented in Chapter 3.

4.1 Effects to Physical Environment

4.1.1 Alternative A

Washington. No habitat modification would occur at Dungeness NWR or other sites in Washington under this alternative. Thus, no effects to the physical environment in Washington are expected and existing nesting sites in the State would remain available to terns.

Oregon. Current habitat management practices (see section 2.3.1), to maintain 6 acres of nesting habitat on East Sand Island, would remain in place. Thus, no change to the current physical environment is expected. However, we expect limited effects to the physical environment at the upper estuary islands (Miller Sands Spit, Rice and Pillar Rock islands) that would result from proposed management actions under Alternative A and all other remaining alternatives. These actions may entail development of vegetative cover to preclude tern nesting. Hazing (e.g., personnel disturbing birds) and/or egg take operations on upper estuary islands would not affect the physical environment. Dredged material placement at the downstream end of Rice Island, where the estuary tern colony was present from 1986 through 2000 would resume. This area is approximately 28 acres in size and vegetation development has precluded tern use.

No habitat modification would occur at Summer, Crump, and Fern Ridge lakes under Alternative A. Thus, no effects to the physical environment at these locations are expected. Existing habitat at Summer and Crump lakes would continue to be available to terns in years with appropriate conditions (e.g., adequate water levels).

California. No habitat modification would occur in California under Alternative A. Thus, no effects to the physical environment are expected and existing nesting sites would remain available to terns.

Region. Under this alternative, we do not expect effects to the physical environment within the region. Existing habitat management actions would continue on East Sand Island and current nesting sites (Table F.1 and F.2) throughout the region would most likely continue to be available to nesting terns on a regional scale.

4.1.2 Alternative B

Washington. Similar to Alternative A, no habitat modifications are proposed in this alternative. Thus, we expect no effects to the physical environment at Dungeness NWR or other sites in Washington. Existing nesting sites in the State would most likely remain available to terns.

Oregon. Current habitat management practices (see section 2.3.1) for maintenance of tern nesting habitat on East Sand Island would be discontinued with implementation of Alternative B, resulting in a substantial change in the physical environment of the tern nesting area. Based upon current annual maintenance requirements, we expect natural

Table 4.1 Summary of Alternatives

Alternative	Habitat Management Program on East Sand Island (ESI)	Redistribution of ESI Tern Colony	Lethal Control of ESI Tern Colony
A	Annually maintain 6 acres of open sand habitat	No	No
B	No preparation of nesting habitat	Yes; indirectly in response to loss of habitat on ESI	No
C	Reduce nesting habitat on ESI to approximately 1 - 1.5 acres	Yes; actively develop and attract birds to potential nesting sites throughout region	No
D	Same as Alternative C	Same as Alternative C	Yes, if necessary, beginning in 2008

revegetation of the site used by nesting terns to occur immediately. European beachgrass and American dunegrass would achieve sufficient coverage and density to preclude nesting by terns within 3 years after implementation of this alternative.

Similar to Alternative A, actions (e.g., development of vegetative cover and hazing) to preclude Caspian terns nesting at upper estuary islands (Miller Sands Spit, Rice and Pillar Rock islands) would continue. However, we expect that hazing operations would be substantially more intense and prolonged (e.g., frequent disturbance to birds with personnel and/or dogs from April 1 through June 15 or longer) under this alternative because the entire tern colony would be displaced from East Sand Island. No habitat modification would occur at Crump, Summer, and Fern Ridge lakes under this alternative, thus, no effects to the physical environment are expected.

California. Similar to Alternative A, no effects to the physical environment are expected because habitat modification actions are not proposed in California under this alternative. Existing nesting sites in the State would most likely remain available to terns.

Region. Effects to the physical environment includes the loss of tern nesting habitat on East Sand Island, an important nesting site in the region. Current nesting sites (Table F.1 and F.2) throughout the region outside the Columbia River estuary would continue to provide nesting habitat for terns on a regional scale.

4.1.3 Alternative C

Washington. Similar to Alternatives A and B, habitat modification actions at sites in Washington are not proposed in this alternative. Thus, we expect no effects to the physical environment at Dungeness NWR or other sites in Washington. Existing nesting sites in the State would most likely remain available to terns.

Oregon. Under this alternative, effects to the physical environment on East Sand Island would occur in association with the reduction in size of the tern nesting area. Current habitat management practices (see section 2.3.1) would be reduced to provide approximately 1 to 1.5 acres of tern nesting habitat. The timeframe for this to occur would be dependent on the creation of tern nesting habitat at alternate sites in the region (projected to occur within 3 to 5 years after implementation of this alternative). Natural revegetation of the current nesting area would be allowed to attain the reduced nesting area. Effects to upper estuary islands (Miller Sands Spit, Rice and Pillar Rock islands) would be similar to that described in Alternatives A and B. However, similar to Alternative B, we expect that hazing operations would be intensified and prolonged to prevent new colonies from forming in the upper estuary as the tern nesting area on East Sand Island is reduced and more terns seek nesting habitat elsewhere.

Nesting islands would be created at the Summer Lake Wildlife Management Area in wetland impoundments (three, half acre islands) and Crump Lake (1 acre island). See Appendix G for a full description of construction of islands. Construction of the islands is expected to have a negligible effect on the water storage capacity at both sites given the small size of the proposed islands relative to the impoundment or lake area. A short-term increase in sedimentation or siltation would occur in the wetland impoundment and lake as a result of the construction activities. These effects, however, are expected to subside once construction activities are completed.

On Fern Ridge Lake, a 1-acre island near the intersection of Royal Avenue and Gibson Island Road within the pool, would be constructed under Alternative C. See Appendix G for a full description of construction of the island. Construction would occur in the winter when this portion of the lake is exposed due to drawdown for winter flood control storage. Construction access would be on the portions of Royal Avenue and Gibson Island roadbeds within the boundaries of Fern Ridge Lake. Flood control is one of the primary purposes for Fern Ridge Lake. The proposed island would reduce flood control storage by approximately 3 to 5 acre-feet. Fern Ridge Lake provides approximately 110,000 acre-feet of flood control storage. Similar to Summer and Crump lakes, a short-term increase in sedimentation or siltation would occur around the construction area within the lake as a result of the construction activities. These effects, however, would subside once construction activities are completed.

California. Under this alternative, management actions that would affect the physical environment are proposed at San Francisco Bay.

Habitat management to provide tern nesting habitat would occur at three locations in San Francisco Bay under Alternative C: Brooks Island, Hayward Regional Shoreline, and Ponds N1-N9. Brooks Island and Hayward Regional Shoreline are managed by East Bay Regional Parks. Habitat management efforts at Brooks Island would focus on hand removal of non-native plants and other vegetation from 1 to 2 acres on the island at or adjacent to the location currently used by nesting terns. Removal of vegetation would cause minimal disturbance to the area and is not expected to affect the soils and substrate of the nesting area. Vegetation removal may be required annually to maintain the tern nesting area. In addition, efforts would be made to evaluate erosion of the spit and long-term protection options.

Hayward Regional Shoreline contains numerous islands in former salt ponds. Management actions at this site would focus on Islands 2, 6, and 7 and include removing existing vegetation, installing a weed barrier fabric, saturating the site with salt to prevent revegetation, and improving the substrate with sand or oyster shells. A small amount of siltation may occur during the vegetation removal process, but would subside immediately following completion of the project. Ponds N1–N9 are located within the Don Edwards San Francisco Bay NWR. Management actions proposed at these sites include the utilization of social facilitation, predator control measures, and improvement of nesting substrate (e.g., deposition of sand or gravel material). The dike surface may also require some leveling or flattening to make the site suitable for nesting terns. Since no other actions are proposed that may disturb the levee substrate, negligible effects to the physical environment at these two locations are expected.

Region. Under this alternative, we expect negligible effects to the physical environment at the sites described above. Proposed habitat management actions would add to current nesting sites (Table F.1 and F.2) to ensure a network of suitable habitat is available for terns throughout the region.

4.1.4 Alternative D

Since proposed management actions that could affect the physical environment in Washington, Oregon, and California are the same as Alternative C, expected effects at specific sites and within the region would be similar to that described above in Alternative C.

4.2 Effects to Biological Environment

4.2.1 Effects to Caspian Terns

4.2.1.1 Alternative A

Washington. Under this No Action alternative, available nesting sites and the number of terns nesting in Washington are not expected to substantially change. The newly established nesting site on Dungeness NWR may grow in subsequent years as birds are able to nest successfully and through immigration. Although nesting substrate is not limiting at this site, we do not expect this colony to grow substantially because of other potentially limiting factors, such as predators. Mammalian predators (e.g., fox, coyote, mink) have access to the tern colony site on Dungeness NWR and may reduce or preclude successful nesting in some years. Other predators may include eagles or a small colony of gulls which nest nearby.

Food resources at Dungeness NWR are most likely not as concentrated during the tern nesting season as those in the Columbia River estuary. Thus, we do not expect this site to support a substantially large number of terns. The barging and release of large numbers of hatchery reared and wild juvenile salmonids into the Columbia River estuary coinciding with the tern breeding season does not occur in the Dungeness River and Bay. The East Sand Island tern colony in the Columbia River estuary is atypical of all other colonies observed in the region and is unlikely to occur elsewhere because of the unique conditions described in Chapter 3, section 3.3.1 (also see Table F.2 for a comparison of average colony sizes in the region). Historically, the colony sizes of terns nesting on the Washington coast ranged from 100 to 3,500 nesting pairs (Shuford and Craig 2002). However, we expect the tern colony at Dungeness NWR to remain below 1,000 nesting pairs because predators may likely limit the growth of this colony.

Terns would most likely continue to nest in the Columbia River estuary since nesting habitat and abundant food resources are predictable and available every year. If nesting habitat in the estuary becomes fully occupied (projected in 2009, see Table 4.2 below), the likelihood of terns immigrating into Washington could increase. Sites in coastal Washington may be limited by lack of suitable habitat, as documented in the feasibility assessment (Seto et al. 2003), and evidenced by the use of atypical nesting sites (e.g., soil waste piles, barges, warehouse rooftops) in recent years. Terns may instead attempt to nest in eastern

Washington (e.g., Potholes Reservoir, Sprague Lake, etc.). Although terns from some of these sites are believed to consume juvenile salmonids from the Columbia River (Glabek et al. 2003), most of these sites are limited by size of available nesting area (e.g., Crescent Island), disturbances to the colony (e.g. human access to the nesting islands in Potholes Reservoir, fluctuating water levels, etc.), or prey availability (e.g. at Sprague Lake, Seto et al. 2003). Thus, we do not expect the size of these colonies to increase substantially, which limits potential increases in consumption of Columbia River juvenile salmonids. However, if nesting tern numbers do increase substantially at these sites, Federal, Tribal, and State partners, including appropriate land owners and managers, would initiate discussions as part of an adaptive management approach proposed in this DEIS to ensure that impacts to Columbia River salmonids are minimized.

Oregon. Under this alternative, available nesting sites in Oregon are not expected to change. Although the tern colony in the Columbia River estuary has remained relatively stable in recent years (Figure 3.4), we expect the Caspian tern colony on East Sand Island to grow in size because of the expected recruitment from the high number of fledglings produced from 2001 to 2003 (since terns have been observed to have a high natal site fidelity). We used a simple deterministic model developed by D. Roby (*in litt.*) to calculate projected tern colony sizes on East Sand Island from 2004 to 2009 (Table 4.2 and inset box). This model was based on data collected from the Columbia River Avian Predation Project from 1997 through 2003 and other currently available data on tern breeding biology (Cuthbert and Wires 1999, Suryan et al. *In review*).

Simple Deterministic Population Model for Caspian Terns (D. Roby *in litt.*):

Model Assumptions:

- All Caspian terns nesting in the Columbia River estuary nest on East Sand Island
- 6 acres of usable nesting habitat are available for terns each year on East Sand Island
- Each tern nesting pair raises 1.0 young per year (the average productivity observed on East Sand Island in the last 5 years)
- Annual adult survival is 0.91, based on band recoveries during 1981 to 2000 (Suryan et al. *In review*)
- Survival of fledglings to average age of first reproduction (4 years) is 0.59, based on band recoveries during 1981 to 2000 (Suryan et al. *In review*)
- Emigration of terns raised on East Sand Island to other locations is balanced by immigration to East Sand Island (nesting site philopatry subsequently is 100%)
- Frequency of severe storm events during the breeding season remains comparable to the 1999 - 2003 period (as it affects tern production on East Sand Island)

The resulting formula used in the model is:

Projected number of terns =

0.91(prior year breeding bird estimate) + 0.59 (number of chicks fledged 4 years prior)

TABLE 4.2 Actual and Projected Caspian tern colony size in the Columbia River estuary, 1997 to 2010.

Year	Island	Estimated No. of Terns[a] (breeding pairs)	Projected No. of Terns (breeding pairs)
1997	Rice Island	7,134	-
1998	Rice Island	8,766	-
1999	Rice and East Sand Islands	8,875	-
2000	East Sand Island	9,101	-
2001	East Sand Island	8,982	-
2002	East Sand Island	9,933	-
2003	East Sand Island	8,325	-
2004	East Sand Island	-	~9,000
2005	East Sand Island	-	~12,000
2006	East Sand Island	-	~14,000
2007	East Sand Island	-	~15,000
2008	East Sand Island	-	~16,500
2009	East Sand Island	-	~18,500

[a] Colony counts based on data from the Columbia River Avian Predation Project (Roby et al. 2002, Collis et al. 2001, Roby et al. 2003b, Collis et al. 2003b).

Projections from this model may change based on changes in available data, violations of assumptions, or changes in conditions in the estuary. For example, in 2003, the model projected that approximately 10,500 breeding pairs would nest on East Sand Island. Instead, only approximately 8,300 pairs actually nested on the island. Clearly, one of the assumptions in the model did not apply over the last year. Nonetheless, this model can be used to project a reasonable population trend (rather than an accurate estimate of tern numbers) for the East Sand Island colony, which is a projected increase. If all of the assumptions in the model are met, the colony on East Sand Island would increase to fully occupy the available nesting area (6 acres) on the island by 2009 (based on the highest nesting density that has been observed in the estuary, 0.78 pair/sq. m., Roby et al. 2002). This breeding concentration would leave a larger number of terns (and percentage of the regional population) more vulnerable to stochastic events (e.g., storms, human disturbance, oil spills, predation, and disease) as compared to similar populations dispersed among many smaller colonies (Roby et al. 2002, Shuford and Craig 2002).

If the colony increases as projected in 2009, terns would need to look for habitat elsewhere in the estuary (e.g., Rice Island, Miller Sands Spit, or Pillar Rock Island) or the Pacific Coast region. Aggressive hazing early in the nesting season would be implemented to prevent terns from nesting on other islands in the estuary (as it would in all alternatives). These islands would be monitored regularly to detect nesting behavior immediately after initiation. If the hazing is unsuccessful in preventing nesting, egg removal would be initiated immediately. Since egg removal would be conducted with the earliest nesting attempts, we expect a small number of eggs would be collected, thus, effects to the breeding birds would be minimal. In addition, since egg removal would be conducted early in the breeding season, nesting terns would have the opportunity to renest at other sites.

Although this alternative proposes to maintain nesting habitat for terns on East Sand Island, terns may not choose to nest there every year. Fidelity of terns to breeding sites in successive years varies due to habitat stability, predator disturbance, and prey availability. Thus, even though nesting habitat may be available in the estuary, other factors (e.g., prey abundance based on ocean conditions and availability of nesting habitat elsewhere) may affect whether and to what extent terns nest in the estuary.

Existing colonies at Summer and Crump lakes would most likely not be substantially affected under this alternative because terns would still be attracted to nest in the Columbia River estuary. Even if nesting habitat in the estuary is saturated by the growing tern colony, these sites are limited in nesting habitat, and thus, would not be able to accommodate large numbers of terns. Thus, we expect nesting tern numbers at Summer and Crump lakes to continue to change every year depending on fluctuating water levels, exposure of nesting islands, and available prey. Nesting habitat does not currently exist at Fern Ridge Lake, thus, we do not expect terns to nest in this area under this alternative.

California. As in Washington, available nesting sites and the number of Caspian terns nesting in California is not expected to change substantially under this alternative. The stable population trend that has been observed in the last 30 years would most likely continue, with shifts in the number and location of breeding sites, characteristic of tern breeding ecology. Existing colonies are expected to continue fluctuating in numbers from year to year. Establishment of new nesting sites may occur if current sites are lost or others become available. The likelihood of terns immigrating into California from the Columbia River estuary could increase as nesting habitat on East Sand Island becomes saturated. Colony sizes are expected to be similar to that observed historically on the coast (22 to 2,100 breeding pairs) or in the interior (four to 500 breeding pairs, Table F.2).

Region. *Regional Population.* Under this alternative, the overall Pacific Coast regional tern population is expected to maintain its' current trend (increasing since the early 1980s) until nesting habitat is fully occupied on East Sand Island. Since the regional population is primarily influenced by the growth of the colony in the Columbia River estuary, we expect the regional population trend to stabilize once the East Sand Island colony growth stabilizes. Specific colony locations and sizes throughout the region are anticipated to change from year to year, typical for this species.

Regional habitat. Current nesting sites (Table F.1 and F.2) throughout the region would most likely continue to provide a suite of locations for terns on a regional scale. Many of these sites vary in suitability every year based on fluctuating water levels, exposure of nesting islands, prey resources, and predators, contributing to the changes in colony locations and sizes throughout the region. terns are well adapted to responding to these changes both within and between years. An exception to these conditions is East Sand Island, because 6 acres of nesting habitat would be maintained annually and prey resources are expected to remain abundant in the Columbia River.

4.2.1.2 Alternative B

Washington. Under this alternative, the potential for new colonies to become established or the growth of existing colonies in Washington is expected to be high after tern nesting habitat is lost on East Sand Island (due to vegetation encroachment on the nest site). At that time, terns would need to seek nesting habitat outside the Columbia River estuary. Thus, existing colonies on Dungeness NWR and in eastern Washington could grow in size. However, as described in Alternative A, we do not expect these colonies to increase substantially in numbers, limiting potential increases in consumption of juvenile salmonids. If nesting tern numbers increase substantially at the eastern Washington sites, Federal, Tribal, and State partners would initiate discussions to ensure that impacts to Columbia River salmonids are minimized.

Terns would probably continue to try to colonize new areas along the Washington Coast and Puget Sound as seen in previous years (e.g., Commencement and Padilla bays, and Dungeness NWR). However, as described in Alternative A, establishment of new and growth of existing colonies are expected to be limited. If new colonies are established (on their own accord), we expect individual colony sizes could range from 100 to 3,500 nesting pairs, based on historic colony sizes observed on the Washington Coast.

Oregon. With no management of nesting habitat on East Sand Island, the tern nesting area would become vegetated within 3 years, making the site unusable for nesting terns. Terns would need to look for nesting habitat elsewhere in the region or estuary. This would increase the possibility that terns would return to nest on Rice Island or other islands in the upper estuary. However, similar to Alternative A and all other alternatives, active measures would be implemented to prevent terns from nesting on these islands. Effects would be similar to that described in Alternative A, except that the potential take of eggs could be higher since the entire East Sand Island tern colony would be displaced and probably attempt to nest on upper estuary islands.

The number of terns nesting in Oregon are expected to decrease substantially once the colony on East Sand Island is lost. Remaining habitat in Oregon is limited and restricted to sites in interior Oregon (e.g., Summer, Malheur, and Crump lakes) which are heavily dependent on annual water levels. As described in Alternative A, we do not expect the number of nesting terns at Crump and Summer lakes to increase substantially because of limited nesting habitat and prey resources. No nesting habitat is currently available at Fern Ridge Lake, thus tern nesting is not expected at this location.

California. As in Washington, existing tern colonies in California may see an influx of displaced terns from the Columbia River estuary, resulting in growth of colony sizes or establishment of new colonies. Displaced terns, however, would need to select from existing nesting sites currently available, as this alternative does not propose any habitat management actions. Sites within San Francisco Bay appear to have available nesting habitat that is most similar to that found in the Columbia River estuary. However, as described in Alternative A, increases in the number of nesting terns at individual colonies are expected to be within the range observed in the past (e.g., 22 to 2,100 nesting pairs).

Region. *Regional Population.* The increasing trend in the overall Pacific Coast regional tern population is expected to stop once the highly successful colony on East Sand Island is lost. We expect an initial decrease in reproductive success because displaced terns from East Sand Island may not be able to breed for a year or two before they find new nesting sites or breed successfully. However, since Caspian terns are long-lived birds, opportunistic and very mobile, they adapt well to habitat loss and gain (due to natural events such as drought, vegetation succession and high water which provide or take away nesting habitat or prey resources). These factors have contributed to their ability to move great distances, adapt to different situations, increase in numbers, and maintain a viable breeding population over time even as breeding site conditions, availability, and locations change from year to year. Thus, we expect most of the displaced terns to eventually find alternate nesting sites elsewhere within the Pacific Coast region and potentially in other regions within their continental distribution.

Based on the feasibility assessment conducted by the Service in 2002 (Seto et al. 2003), there appears to be nesting habitat elsewhere in the region that could be used by some of these displaced terns. Whether these sites are sufficient to accommodate all of the displaced terns from East Sand Island is unclear. If displaced terns are not able to find sufficient nesting habitat elsewhere in the region, the regional population trend could decline. In addition, although terns displaced from East Sand Island may find nesting sites elsewhere in the region, those sites may not be as productive as sites in the Columbia River estuary (see Table 4.3 for documented productivity at sites outside the estuary). Thus, even though displaced terns are able to find alternate nesting sites, the expected lower productivity could still result in an overall decrease in productivity of terns in the region. Caspian tern life history is well suited to fluctuating levels of reproductive success that occurs at various sites. Ultimately, we expect the regional population trend would stabilize, possibly at a lower number than currently observed, but above numbers documented in the late 1970s and early 1980s (approximately 6,200 breeding pairs).

Regional habitat. After the loss of nesting habitat on East Sand Island, existing sites (Table F.1 and F.2) throughout the region would need to provide nesting locations for terns on a regional scale. As described above, whether these sites are sufficient to accomodate all of the displaced terns remains unclear. The majority of the sites that do not require habitat enhancement and are currently available to terns are located in California. Other sites in Washington or Oregon require management and/or enhancement and would most likely not be used by displaced terns.

4.2.1.3 Alternative C

Washington. Similar to Alternative B, the colony on Dungeness NWR could increase in size from the immigration of displaced terns from East Sand Island under this alternative. However, factors that could limit reproductive success and size of the tern colony (e.g., predators and human disturbance) would still be present. Management actions would be considered to protect this colony from possible disturbance from humans and/or predators. If management efforts are implemented, we expect the size of this colony could grow to range somewhere within the historic colony sizes observed on the Washington Coast (100 to 3,500 breeding pairs).

Similar to Alternatives A and B, there is a potential for establishment of new colonies or enlargement of existing sites in eastern Washington (e.g., Potholes Reservoir). The likelihood of this occurring however, would be lower than in Alternatives A and B because proposed management at alternate sites (Table 2.1) is expected to attract the majority of displaced terns. Additionally, as described in Alternative A, most of these sites are limited by size of available nesting area (e.g., Crescent Island), disturbances to the colony (e.g. human access to the nesting islands in Potholes Reservoir, fluctuating water levels), or prey availability (e.g. at Sprague Lake, Seto et al. 2003). Thus, even if some displaced terns nest at these sites, we do not expect the size of these colonies to increase substantially, limiting potential increases in consumption of Columbia River juvenile salmonids. As with Alternatives A and B, if nesting tern numbers increase substantially in these upper Columbia River sites, Federal, Tribal, and State partners, including appropriate land owners and managers, would initiate discussions as part of an

Table 4.3 Productivity of Caspian terns at various sites in Pacific Coast Region.

Site	Year (s)	Average Productivity (fledglings/pair)
Crescent Island, WA[a]	2000 – 2003	0.49 – 1.07
Solstice Island, WA[b]	2001	1.04 – 1.88
Rice Island, OR[c]	1997 – 2000	0.06 – 0.55
East Sand Island, OR[c]	1999 – 2003	0.57 – 1.39
Crump Lake, OR[d]	2003	0.63
Summer Lake, OR[d]	2003	0.40
Brooks Island, CA[d]	2003	0.62
Knight Island, CA[d]	2003	0.62
Baumberg Pond, CA[d]	2003	0.43
A-7 Pond, CA[d]	2003	0.08
Agua Vista, CA[d]	2003	0.42

[a] data from Antolos 2002 and Collis et al. 2003a, b
[b] data from Antolos 2002
[c] data from Collis et al. 2003a and b; Roby et al. 1998 and 2002
[d] data from Roby et al. 2003a

adaptive management approach proposed in this DEIS, to ensure that impacts to Columbia River salmonids are minimized.

Oregon. Based on the range of known nesting densities in the estuary, we expect that the tern colony on East Sand Island would decrease to approximately 2,500 to 3,125 breeding pairs when nesting habitat is reduced to approximately 1 to 1.5 acres. This would be a 60 to 70 percent decrease from the 2003 colony size, a substantial decrease for this colony. Terns displaced from East Sand Island would most likely find nesting sites elsewhere in the region, especially since this alternative proposes to manage approximately 8 acres of habitat specifically for terns. However, other nesting sites in the region have not been observed to be as productive as in the Columbia River estuary (except for Solstice Island, see Table 4.3). Thus, displaced terns may experience an overall decrease in productivity to levels more similar to those typically observed in the region (e.g., 0.08 to 1.88 fledgling/pair). See *Regional Population* section below for description of anticipated effects to the regional population.

The active measures (e.g., hazing, egg take, etc.) that would be implemented to prevent terns from nesting on the upper estuary islands would result in effects similar to that described in Alternative A and B. Similar to Alternative A, although this alternative proposes to provide suitable tern nesting habitat on East Sand Island, Caspian terns may choose to nest elsewhere on their own accord.

Some of the displaced terns could be attracted to nest at Summer, Crump, and Fern Ridge lakes. The expected colony sizes at each of these sites would depend on the size of the islands created at each site, the success of the social attraction techniques and available prey resources. Social attractants (e.g., decoys and sound recordings) have proven successful in attracting terns to nest at targeted locations (Kress 1983, Collis et al. 2002c, Roby et al. 2002). At Summer Lake, since other colonial nesting birds occur at this site, we expect that majority of the three, half acre nesting islands could be used by Caspian terns. We expect that nesting tern numbers at Summer Lake could range between 5 to 300 breeding pairs if displaced terns are successfully attracted to this site (based on historical numbers observed in interior Oregon). The number of nesting terns could be larger since a large number of terns would be displaced from East Sand Island, but would remain dependent upon annual availability of nesting habitat and prey resources. Human and/or predator disturbance at this site should be minimal, but would be managed, if necessary, to protect nesting terns.

At Crump Lake, the newly created 1-acre island would likely be shared with other colonial nesting birds resulting in anticipated numbers of terns to be similar to that expected at Summer Lake (5 to 300 breeding pairs). Since this island would be located far from the shoreline, and public use in the lake is limited, we expect minimal human or predator disturbance. Similar to Summer Lake, the number of nesting terns could be larger because of the large number of displaced terns from East Sand Island. On the other hand, since prey base may be limiting at these two sites, the actual number of terns that can successfully nest at Summer and Crump lakes may not be as high as the nesting habitat could accommodate. Prey availability in both Summer and Crump lakes will vary annually, based on water levels, and thus would affect tern nesting success in these locations.

At Fern Ridge Lake, since there are not many other colonial nesting birds at this site, it is expected that majority of the newly created island would be available for nesting terns. We expect the number of nesting terns at this site would also be similar to that of Summer and Crump lakes (5 to 300 breeding pairs). However, since this is not a historic nesting site, social attraction efforts may need to extend over a number of years before terns initiate nesting at this site. Since the nesting island would be located in shallow waters, human disturbance from the extensive boat use that occurs in the lake is expected to be minimal. Other historically used nesting locations in Oregon (e.g., Malheur Lake) may also receive additional tern use under this alternative when conditions allow for tern nesting; however, since terns would be actively attracted to sites specifically managed for terns (Table 2.1), the likelihood that displaced terns would select other sites would be lower than that expected in Alternative B.

California. The number of terns nesting in California would most likely increase substantially from the immigration of terns displaced from the Columbia River estuary. Although these sites are some distance from East Sand Island, we expect displaced terns to nest at these sites because only a small number of sites would be managed for terns in Washington and Oregon. Active development or enhancement of nesting habitat at San Francisco Bay would most likely attract the majority of the displaced terns because these coastal sites are similar to habitat found in the

Columbia River estuary and terns already nest in the bay. Additionally, terns probably follow a coastal migration route to and from wintering grounds. Thus, it would be more likely that terns would discover these alternate sites on the coast, in contrast to interior sites.

In San Francisco Bay, the tern nesting site on Brooks Island could be enlarged to at least 2 acres through hand-pulling of vegetation (e.g., non-native ice plant and aster). If adjacent gulls do not encroach into the tern nesting area, the current colony could grow to at least 1,500 breeding pairs (average colony size of terns in coastal California) but could grow larger if conditions (e.g., prey abundance or predators) are suitable. At the two remaining sites in San Francisco Bay (Hayward Regional Shoreline and Ponds N1-N9), colony sizes are expected to range between 100 to 1,500 breeding pairs (at each site), depending on the success in attracting terns to these new nesting sites.

Success of San Francisco Bay sites would be dependent on management of human and predator disturbances. Human activities are restricted at all three sites but a variety of avian or mammalian predators are present. Thus, predator management would be necessary to protect nesting terns.

Terns nesting in San Francisco Bay are exposed to contaminants and this may be an issue of concern. Some preliminary work has shown that mercury, selenium, and brominated fire retardant (PBDE) concentrations have been found in Caspian tern eggs (T. Adelsbach pers. comm., Schwarzbach and Adelsbach *In review*). Mercury concentrations in the eggs of Caspian terns were above 0.5 parts per million and within the range found to affect reproduction in common terns (T. Adelsbach pers. comm.). However, current monitoring efforts in San Francisco Bay have shown that tern reproductive success (range from 0.42 to 0.62 fledglings/pair), with the exception of one site, is within the range of that observed in the region (see Table 4.3).

Region. *Regional population.* We expect a substantial effect to the distribution and initial reproductive success of the tern regional population under this alternative. An estimated 5,000 to 6,500 breeding pairs of terns would be displaced from East Sand Island as tern nesting habitat is reduced to one to 1.5 acres under this alternative. The dispersal of this large concentrated colony would be a benefit to the regional population because the potential risk of this large segment of the population to catastrophic events (e.g., predators, storms, and disease, see section 3.2.1) would be removed. Additionally, increasing the network of nesting sites in both coastal and interior locations with varying conditions offers a better potential for maintaining a stable regional population over time in comparison to a network comprised of fewer sites and larger concentrations of individual colonies.

We expect that the managed sites would be able to provide suitable habitat to accommodate displaced terns, particularly when combined with existing sites. However, we still would expect an initial decrease in reproductive success because displaced terns from East Sand Island may not be able to breed for a year or two before they find new nesting sites or breed successfully. In addition, this alternative could also result in a decrease in the overall regional population since adult birds could be lost if they cannot find new sites in the region or because displaced terns are expected to have lower productivity (see section 4.2.1.2). In the long-term, we expect the regional population to stabilize, possibly at a lower number than currently observed, but well above numbers documented in late 1970s and early 1980s (approximately 6,200 nesting pairs, Figure 3.3). The exponential growth that this regional population incurred since the 1960s is not expected to continue indefinitely. The variety of factors that influence population growth (e.g., prey resources, stable nesting habitat, and conflicts with other resources) vary considerably over time and would most likely preclude a long-term exponential growth trend. If the regional population declines to 50 percent of the current size, management of tern nesting sites in the region would be reevaluated as part of the adaptive management approach proposed in this DEIS.

Regional habitat. Similar to Alternatives A and B, current nesting sites (Table F.1 and F.2) throughout the region would most likely continue to provide a suite of locations suitable for supporting terns on a regional scale. However, unlike Alternatives A and B, the development of approximately 8 acres of nesting habitat (Table 2.1) proposed under this alternative would ensure that an enhanced network of nesting sites, dispersed throughout the Pacific Coast region, would be available for terns displaced from East Sand Island. Displaced terns would be able to select from these managed sites as well as underutilized existing habitat throughout the region (Table F.1). Based on observed colony sizes in the region (Table F.2), we expect colony sizes at these locations may increase but would not grow to the level observed in the Columbia River estuary. Predictable nesting habitat (managed dredged material islands) and concentrated food resources (e.g., barged and released hatchery-reared salmonids) in the Columbia River estuary represent a unique combination that facilitated the rapid growth and atypical size of the estuary colony. This same combination of factors is not characteristic of any other site within the region.

Even though habitat would be developed for nesting terns, they are expected to nest opportunistically throughout the region based on various factors (e.g., food resources, proper nesting substrate, competition, or predation). Thus, specific colony locations and sizes throughout the region would change from year to year as is currently observed (Table F.2). Although nesting habitat in the Columbia River estuary and at alternate sites would be specifically managed for nesting terns, they may chose to nest elsewhere on their own accord.

4.2.1.4 Alternative D

Washington. If habitat reduction is successful in reducing the number of terns on East Sand Island, effects in Washington would be similar to that described in Alternative C. Unlike Alternative C, if lethal control is implemented, the number of displaced terns would be lower, reducing the potential increase in numbers of terns that could nest in Washington. However, if lethal control efforts result in the dispersal of the entire colony on East Sand Island, effects would be similar to that described for Alternative B.

Oregon. If habitat reduction is successful in reducing the number of terns on East Sand Island, effects in Oregon would be the same as that described in Alternative C. If a lethal control program is implemented, the decreased number of breeding terns in the Columbia River estuary would be a result of both the redistribution of terns due to habitat loss on East Sand Island and the direct loss of breeding birds through a lethal control program. The lethal control program would attempt to achieve the proposed range of nesting terns by killing up to 50 percent of breeding adult terns each year. The actual number of terns that would be killed under this alternative would depend on the success of redistributing majority of the colony to other sites in the region. If the entire colony continued to nest on the smaller acreage that would remain on East Sand Island, a substantial number of terns would need to be killed. If the colony was partially reduced (e.g., by 50 percent) through habitat reduction, we can use a population model to estimate the number of terns that could potentially be killed (e.g., 1,000 to 6,000 terns very year in the first 5 years, see Table 4.4). This model, however, may not be accurate after a control program has been implemented, as population parameters have been observed to change (e.g., reduction in nesting density, decreased age of recruitment, etc.) in response to population control programs (Coulson et al. 1982). Killing of adults rather than juveniles or the take of eggs, has proven to be the most effective in reducing populations (Smith and Carlile 1993, Bedard et al. 1995). Table 4.4 summarizes the estimated number of terns that would need to be killed each year if a lethal control program was implemented in 2008.

Although the intention would be to kill a specific number of terns every year to maintain a colony within the target range, the control methods and associated activities (e.g., rocket nets, shot guns, human activity in the colony) themselves may be disturbing to the entire colony. This may result in complete abandonment of the site and dispersal of these birds back to upper estuary islands or other locations in the region.

Table 4.4 Estimated colony size and number of birds killed in the Columbia River estuary with the implementation of a lethal control program.

Year	Pre-Implementation Estimated Colony Size (no. of breeding pairs)	Approximate No. of Terns Killed (individual no. of terns, not no. of pairs)	Post–Implementation Projected Colony Size (no. of breeding pairs)
2008	3,200	3,000	2,700
2009	-	5,900	3,000
2010	-	3,000	2,500
2011	-	2,000	2,600
2012	-	1,000	2,700
2013	-	1,000	2,800
2014	-	1,000	2,800

Similar to Alternative C, we expect small colonies (5 to 300 breeding pairs) at Summer, Crump, and Fern Ridge lakes as a result of habitat enhancement activities at these sites.

California. If habitat reduction is successful in reducing the number of terns on East Sand Island, effects in California would be similar to that described in Alternative C. However, if lethal control is implemented and is successful in killing terns, then the actual number of displaced terns would be less than Alternative C, decreasing the possible increase of terns in California. On the other hand, if a lethal control program is implemented but causes the entire colony on East Sand Island to abandon the site, a higher number of terns would be looking for alternate nesting sites, similar to that anticipated in Alternative C.

Region. *Regional population.* If habitat reduction is successful in redistributing terns from East Sand Island to elsewhere in the region, effects to the regional tern population would be similar to that described in Alternative C. It would result in a regional population that could initially decline but eventually stabilize, most likely at levels higher than documented in the late 1970s and early 1980s. However, if a lethal control program is implemented, this alternative, unlike all remaining alternatives, would result in a population control program for terns. The level of lethal take, however, cannot be specifically estimated because it would be dependent upon the level of dispersal of terns to sites elsewhere in the region. If habitat reduction on East Sand Island is successful in dispersing birds outside of the estuary, lethal take would be minimal. Should terns persist in attempting to nest on East Sand Island in excess of the proposed range of breeding pairs, then lethal take could be substantial (as described in Table 4.4) because as many as 50 percent of the current breeding population would be removed. This would result in a substantial decline in the regional tern population.

Regional habitat. Similar to Alternative C, the development of approximately 8 acres of nesting habitat, in addition to current nesting sites (Table F.1 and F.2) would provide an enhanced suite of locations suitable for supporting terns on a regional scale (as compared to Alternatives A and B). Displaced terns would be able to select from sites managed specifically for nesting terns as well as underutilized existing habitat throughout the region (Table F.1 and F.2). Even though habitat would be developed for nesting terns, they are expected to nest opportunistically throughout the region based on various factors (e.g., food resources, proper nesting substrate, competition, or predation). Thus, specific colony locations and sizes throughout the region are expected to change from year to year as is currently observed (Table F.2).

4.2.2 Effects to Fish

4.2.2.1 Alternative A

Washington. Effects to non-ESA-listed salmonids and other fish populations are not expected to change from current conditions (see section 4.2.3 below for description of effects to ESA-listed salmonids). Terns from Dungeness NWR consume these fish, however, effects are not considered substantial given that the tern nesting colony at Dungeness NWR is estimated to be less than 200 breeding pairs. Terns in eastern Washington also consume non-ESA-listed salmonids and other fish, but similar to Dungeness NWR, effects are not considered to be substantial because these colonies are all relatively small (average size of 18 to 545 breeding pairs). The number of terns may increase if nesting habitat in the estuary becomes fully occupied (projected in 2009). However, most of these sites are limited by size of available nesting area (e.g., Crescent Island), disturbances to the colony (e.g., human access to the nesting islands and fluctuating water levels in Potholes Reservoir), or prey availability (e.g., at Sprague Lake, Seto et al. 2003). Thus, these colonies are not expected to increase substantially, limiting effects to non-ESA-listed salmonids.

Some non-ESA-listed salmonids that originate in part in Washington are consumed by terns as they outmigrate through the Columbia River system (see section below). A continued increase in tern numbers at East Sand Island would result in increased consumption of those juvenile salmonids.

Oregon. Non-ESA-listed juvenile salmonids and other fish would continue to comprise a portion of the tern diet in the Columbia River estuary. If the tern colony continues to increase, then consumption of these fish in the Columbia River by terns would also increase under this alternative, but there has been no demonstrated effect on the populations of these species. Fluctuations in fish consumption levels by terns would be expected to vary across fish species as research efforts to date have documented. For example, in recent years, the number of juvenile salmonids in the tern diet has declined and the percent of marine/estuarine fish species (e.g., herring, anchovies) has increased through time (both annually and within years, Collis et al. 2003b). These fluctuations in fish consumption are influenced by a variety of factors such as good ocean conditions (e.g., ocean upwelling resulting in high marine fish productivity).

Herbicides would be used in upland areas on East Sand Island to control vegetation growth in the tern nesting area. These herbicides have a limited likelihood of negatively affecting, directly or indirectly, salmonids and other fish species. Rodeo, an EPA-registered chemical approved for over-water application, would be used in conjunction with mechanical control measures. The Rodeo formulation is comprised of glyphosate and water as the carrier agent. Glyphosate is slightly toxic to fish and practically non-toxic to aquatic invertebrates. The glyphosate formulation proposed for use under this action was selected for its low relative toxicity compared to other available formulations.

Currently, tern colonies at Summer and Crump lakes are small (less than 50 pairs). Salmonids are not found in these lakes, thus, no effects to non-listed salmonids are expected. Terns were observed to primarily eat non-native tui chubs in 2003 (Roby et al. 2003a) and since tui chubs are abundant, effects on local fish populations are considered to be negligible. Increases in fish consumption could occur at these two sites if the tern nesting site on East Sand Island is maximized and breeding terns seek new nesting sites at these locations. However, given the fact that these sites have limited nesting habitat, the increase in number of terns would be small. Thus, effects to fish are expected to remain at negligible levels. No effects to fish at Fern Ridge Lake are expected as there currently is no nesting tern colony at this site.

California. Similar to Washington, effects to non-ESA-listed salmonids and other fish are not expected to change from current conditions and are not considered to be substantial since tern colonies are relatively small (range between 50 to less than 1000 pairs) and distributed throughout the State. In particular, a study in San Francisco Bay demonstrated that salmonids were a small component (0.17 to 8.7 percent, Roby et al. 2003a) of the tern diet. Effects may increase if terns from the Columbia River estuary are displaced when nesting habitat is maximized (anticipated in 2009). Since this alternative does not propose to implement management actions that would increase suitable nesting habitat for terns, effects are expected to remain the same.

4.2.2.2 Alternative B

Washington. Tern numbers at existing colony locations in Washington (Table F.2) may increase with implementation of this alternative. Loss of nesting habitat at East Sand Island would result in approximately 8,000 nesting pairs moving to alternative locations, possibly in Washington. Pioneering of terns onto new locations, including former coastal nesting locations, may occur but specific location and future size of colonies cannot be predicted. Terns would more likely attempt to nest at existing sites (e.g., Dungeness NWR, Banks Lake, Potholes Reservoir and Sprague Lake), provided site conditions are suitable. However, as described in Alternative A, although consumption might increase, tern colony sizes are expected to remain small, thus, effects to non-ESA listed salmonids and other fish are not considered to be substantial.

Unlike Alternative A, effects to non-ESA-listed salmonids that originate in part in Washington would be eliminated in the Columbia River estuary as the tern habitat would be lost (see section below).

Oregon. We expect the lack of management on East Sand Island would result in an elimination of tern nesting habitat within 3 years, causing Caspian terns to seek new nesting habitat elsewhere. The initial location where Caspian terns can be expected to seek new nesting sites would be at the upper estuary islands – Miller Sands, Rice and Pillar Rock islands. However, implementation of the measures (i.e., hazing, egg take) common to all alternatives in this DEIS is intended to preclude their use of these islands. Since there are no other locations in the estuary suitable for nesting terns, the loss of the tern colony in the Columbia River estuary would substantially reduce juvenile salmonid consumption levels from that observed from 2000 to 2003 (average of 5.9 million juvenile salmonids, Collis et al. 2002a, 2002b, 2003a, 2003b). Consumption of various marine fishes in the estuary (e.g., northern anchovy, sardines, herring, smelt) would also be substantially reduced with implementation of this alternative.

As no management actions would occur at Summer and Crump lakes, effects to fish would be negligible, similar to that described in Alternative A. Also similar to Alternative A, no effects would occur in Fern Ridge lake as no habitat currently exists for nesting terns.

California. Effects would be similar to that described in Alternative A. Effects to non-ESA-listed salmonids and other fish are not considered to be substantial since tern colonies in California are relatively small (50 to less than 1000 breeding pairs).

4.2.2.3 Alternative C

Washington. Effects to fish (non-ESA-listed salmonids and other fish) would be similar to that described in Alternative B, except that effects would most likely not change from current conditions at eastern Washington sites (e.g., Banks Lake, Potholes Reservoir and Sprague Lake) because managed alternate sites at Dungeness NWR and in Oregon and California are expected to provide habitat for displaced terns from the Columbia River estuary. Effects to non-ESA listed Columbia River salmonids that originate in Washington would continue to occur, although less than that described in Alternative A.

Oregon. Effects in the Columbia River estuary would be similar to that described for Alternative B, except that some consumption of non-ESA-listed fishes would still occur since some terns (2,500 to 3,125 breeding pairs) would remain in the estuary. However, since the tern colony would be reduced by 60 to 70 percent on East Sand Island, the consumption of juvenile non-ESA-listed Columbia River salmonids and other fish would also reduce substantially (compared to current conditions).

Although habitat would be created for terns at Summer, Crump, and Fern Ridge lakes, we expect effects to the local fish populations to be negligible because expected tern colonies at these sites would be relatively small (e.g., 5 to 300 breeding pairs) and resident fish species are abundant. However, terns nesting at Fern Ridge Lake may travel to feed on salmonids in the nearby Willamette and McKenzie rivers. If this occurs, effects are not expected to be substantial because the anticipated size of this new colony would remain relatively small (5 to 300 breeding pairs).

Short-term effects to fish may occur at all three of these sites associated with an increase in sedimentation or siltation caused by island construction activities. These effects are expected to be temporary, subsiding once construction activities have ceased.

California. Effects to non-ESA-listed fish in California are expected to be similar to that described in Alternative B, except that if nesting habitat is managed for terns at identified sites (Table 2.1), effects to fish would primarily occur in San Francisco Bay. We expect tern colonies in the bay to grow but individual colony sizes are expected to remain substantially smaller (100 to 1,500 pairs) than that observed in the Columbia River estuary. Thus, effects to non-ESA-listed fish in San Francisco Bay are not considered to be substantial.

4.2.2.4 Alternative D

Since Caspian tern numbers in Washington, Oregon, and California are expected to be similar to Alternative C, effects to non-ESA-listed fishes are similar to that described in Alternative C. However, if lethal control is implemented to reduce the tern colony size on East Sand Island, the potential increase in tern numbers at alternate sites would decrease because a number of terns would be removed from the regional population. Thus, effects to non-ESA-listed fish populations would be lower than that expected in Alternative C.

4.2.3 Effects to Federally Endangered and Threatened Fish

4.2.3.1. Alternative A

Washington. Current effects of this No Action alternative, to Puget Sound Chinook and Hood Canal summer-run chum salmon, steelhead, and bull trout have not been quantified. The primary outmigration periods for ESA-listed salmonids in the Puget Sound area occur between February and July (Tynan 1997), coinciding with the tern breeding season (April to July). Based on diet studies of terns nesting in similar habitats (i.e., highly marine coastal sites), we expect juvenile salmonids to comprise a small percent of their diet (Table 4.5). This colony is also relatively small (less than 200 breeding

Table 4.5 Range of Salmonid Composition (percent) of Caspian Tern Diets observed at Coastal Sites.

Site	Salmonid Composition (percent)
Grays Harbor (WA) (1975-1976) [a]	3.5 – 21 %
Commencement Bay (WA) (2000) [b]	52%
East Sand Island (OR) (2000-2003) [c]	24 – 47 %
San Francisco (CA) (2003) [d]	0.17 – 8.7 %

[a] Penland. 1976
[b] Thompson et al. 2002
[c] Collis et al. 2002b. and Roby et al. 2002.
[d] Roby et al. 2003a

pairs), resulting in a low number of total salmonids consumed. Thus, we expect effects to ESA-listed salmonids to be limited.

Six ESA-listed stocks that originate at least in part in Washington would continue to be affected by tern consumption in the Columbia River estuary under this alternative since the tern colony on East Sand Island would continue to increase. These include Lower Columbia River Chinook, Upper Columbia River Chinook, Columbia River chum, Upper Columbia River steelhead, Mid-Columbia River steelhead and Snake River Basin steelhead. A more detailed description of effects to ESA-listed Columbia River Basin stocks is presented below, under the Oregon section.

Effects to other ESA-listed ESUs in Washington could occur if nesting habitat on East Sand Island is maximized in 2009, causing breeding terns to seek nesting habitat elsewhere. However, we expect effects at new or enlarged nesting sites in Washington to be limited since habitat is currently limited in the State (see section 4.2.1.1).

Oregon. Continued effects to ESA-listed salmonids, traveling through and/or rearing in the Columbia River estuary are expected under this alternative. There would be a continued and projected increase in predation of ESA-listed juvenile salmonids by terns as the colony continues to increase in size. Under this alternative, terns would continue to consume approximately 5.9 million (or higher as the number of terns increase) juvenile salmonids annually (the average number of juvenile salmonids consumed by terns from 2000 to 2003 when nesting on East Sand Island, Collis et al. 2002a, 2002b, 2003a, and 2003b). Although juvenile salmonids comprise a smaller portion of the diet of terns nesting on East Sand Island, overall consumption of juvenile salmonids may be comparable to what was observed of the Rice Island colony in 1998 (approximately 12. 4 million smolts consumed by terns, Roby et al. 2002) if numbers increase to nearly 20,000 tern pairs. The benefits gained from the relocation of terns from Rice Island to East Sand Island would be substantially lost as the tern colony continues to grow.

More importantly, Alternative A would not result in any appreciable improvement in population growth rate (λ) for ESA-listed salmonids (Table 2.2 or see Table 5 in NOAA Fisheries 2004, Appendix C). The larger tern colony size and/or predation levels could suppress the population growth rate for ESA-listed salmonids. In addition, if present good ocean upwelling conditions reverse, alternative marine prey resources would diminish, potentially increasing the consumption of ESA-listed juvenile salmonids.

No substantial effects to Warner suckers are anticipated at Crump Lake as terns here were observed to feed primarily on tui chubs in 2003 (Roby et al. 2003a). No nesting habitat exists at Fern Ridge Lake, thus effects to ESA-listed fish species are not anticipated.

California. In San Francisco Bay, outmigration periods for juvenile Sacramento River winter-run Chinook (January to May), Central California Coast coho (mid-April or earlier to mid-June or later), Central Valley spring-run Chinook (March to mid-June or November to April), and Central Valley and Central California Coast steelhead (February through mid-May) overlaps with the tern breeding season (early April through early August, G. Stern pers. comm.). Despite this overlap, a study in 2003 demonstrated that juvenile salmonids comprise a small portion of the tern diet in San Francisco Bay (Table 4.5, Roby et al. 2003a). Salmonids were found in the diets of three out of five nesting colonies, ranging from 0.17 (Pond A7) to 8.7 (Knight Island). Thus, effects to ESA-listed salmonids are considered to be limited. As in Washington, if nesting habitat on East Sand Island is maximized in 2009 and breeding terns seek nesting habitat elsewhere in the region, the number of nesting terns in San Francisco Bay may increase. However, we expect effects to remain limited since tern colonies are not predicted to increase substantially and their diets would remain comprised primarily of non-salmonids.

4.2.3.2 Alternative B

Washington. If Dungeness NWR is colonized by higher numbers of Caspian terns as a result of the loss of habitat in the Columbia River estuary, it is probable that an increase in consumption of ESA-listed salmonids (Puget Sound Chinook and Hood Canal summer-run chum) could occur. Timing of juvenile salmonid outmigration (from late February to late July, peaking from May to June, Bax et al. 1980, Bax 1983a, b, Tynan 1997) generally coincides with the tern's nesting season. However because this colony would likely range somewhere between 100 to 1,000 nesting pairs and alternative prey are abundant, effects are expected to remain limited.

Oregon. Within the Columbia River estuary, implementation of Alternative B would initially reduce and ultimately eliminate Caspian tern nesting on East Sand Island in approximately

3 years. In conjunction with implementation measures common to all alternatives (prevention of tern nesting at upper estuary islands), terns would be eliminated from the estuary, seeking alternate nesting habitat elsewhere in the region. This would result in a substantial reduction and eventual elimination in the total number of ESA-listed salmonids consumed by terns in the estuary. However, although nesting habitat would be unavailable within 3 years, displaced terns from East Sand Island may still attempt to nest in the estuary for several years. Terns displaced from East Sand Island are also likely to roost, loaf, and continue to forage in the estuary even if breeding does not occur. Thus, there would still be some consumption of ESA-listed salmonids in the Columbia River estuary during the initial breeding seasons following implementation of this alternative.

Implementation of this alternative would result in a positive change in population growth rate (1.560 to 4.861 percent for steelhead) that would be realized within 6 to 7 years after implementation of this alternative (NOAA Fisheries 2004). It is important to note that population growth rate calculations presented in NOAA Fisheries 2004 are based on tern predation of juvenile steelhead because they are the most impacted of outmigrating juvenile salmonids (because they are consumed by terns in the highest numbers, Ryan et al. 2003 and Roby et al. 2003b). Therefore, estimates of the potential benefit of reducing tern predation are the greatest for steelhead and serve as a surrogate for potential benefits to other salmonid species. The use of steelhead data in this analysis is especially important for Upper Columbia River steelhead because this ESU is among the most endangered of all ESA-listed stocks.

Similar to Alternative A, terns nesting at Crump Lake have not been documented to consume large numbers of Warner suckers (Roby et al. 2003a). Thus, although tern numbers may increase slightly under this alternative, effects to this ESA-listed species are expected to be negligible. No effects are expected in the Fern Ridge Lake area because nesting habitat for terns does not currently exist.

California. The loss of nesting habitat at East Sand Island would most likely result in terns seeking alternative nesting locations elsewhere in the region. However, specific location and future size of colonies of pioneering of Caspian terns cannot be predicted. In San Francisco Bay, a probable increase of predation on ESA-listed salmonids would occur if terns displaced from the Columbia River estuary select to nest in the bay. However, as described in Alternative A, effects to ESA-listed salmonids are expected to be limited as tern numbers are not expected to grow substantially and salmonids were not observed to be primary prey for terns in San Francisco Bay in 2003 (Roby et al. 2003a).

4.2.3.3 Alternative C

Effects to ESA-listed salmonids at alternate nesting sites analyzed as part of this DEIS will depend on the number of birds and/or nesting pairs at each location.

Washington. Effects to Puget Sound Chinook and Hood Canal summer-run chum would be similar to that described in Alternative B with the exception that management actions that may be implemented to further protect the nesting site on Dungeness NWR for terns could result in an increased number of terns. As described in Alternative B, the potential increase in terns would probably result in an increase in consumption of ESA-listed juvenile salmonids. The primary outmigration period for these salmonids coincide with the tern nesting season, the predicted colony size would most likely remain relatively small (100 to 3,500 nesting pairs, based on historic colony sizes on the Washington coast) as compared to the colony in the Columbia River estuary. In addition, consumption of juvenile salmonids is not expected to be high if the terns' diet composition at Dungeness NWR is similar to terns nesting in highly marine areas (e.g., Grays Harbor, San Francisco Bay, and East Sand Island) in which salmonids have not been observed to be a primary component of their diets (Table 4.5). Thus, effects to ESA-listed salmonids are anticipated to remain limited. We do not expect large numbers of displaced terns to nest in eastern Washington sites because alternate sites would be managed to attract these terns. Thus, we expect effects to ESA-listed salmonids in these locations to remain limited.

Oregon. Based on the NOAA Fisheries (2004) report (Appendix C), population growth rate increases would occur within one generation (4 to 5 years). We expect the reduction in size of the tern colony on East Sand Island (2,500 to 3,125 breeding pairs) would occur within 3 to 5 years after implementation of this alternative. Thus, initial benefits for ESA-listed salmonids could be realized within 6 to 7 years after implementation of this alternative. The NOAA Fisheries report also indicated that a potential for a positive population growth rate change (1.082 to 3.704 percent) can be achieved for the Snake River, Upper Columbia River, Middle Columbia River, and Lower Columbia River steelhead (see Table 2.2 or Table 5, NOAA Fisheries 2004). This improvement in population growth rate is similar in magnitude to that of increases in population growth rate that would result from hydropower improvements (0 to 4 percent increase), but well below improvements that could be achieved by harvest reductions (4 to 8 percent increase, see Table 6, NOAA Fisheries 2004, Appendix C).

Ultimately, long-term benefits to ESA-listed salmonids in the Columbia River estuary from proposed management actions would depend on maintaining a range of nesting terns of 2,500 to 3,125 pairs in the estuary. However, long-term success of efforts intended to increase population growth rates of ESA-listed salmonids must be placed in context with other sources of mortality subject to human intervention. Hydropower operations, harvest impacts, habitat conditions, hatchery operations, and introduced species all have the potential to affect population growth rates of ESA-listed salmonids, and are subject in various degrees to management efforts to alleviate detrimental effects. Actions to address these impacts have been implemented or proposed, and others may be developed in the future. Cumulatively, these actions have the potential to influence population growth rate to a substantially greater degree than would be realized from solely reducing predation from avian predators in the Columbia River estuary (Kareiva et al. 2000, Wilson 2003).

An increase in nesting terns at Crump Lake is not expected to affect the threatened Warner sucker since they were not observed to be a primary prey species for terns in 2003 (Roby et al. 2003a). However, proposed activities to build up the existing island could result in temporary effects to Warner suckers through siltation or increase in sedimentation, with effects subsiding once construction activities are completed. Efforts would be made to minimize potential effects. No ESA-listed salmonids occur at Summer and Crump lakes, thus no effects are expected.

If terns initiated nesting at Fern Ridge Lake, there is a possibility that terns could forage in the nearby Willamette and McKenzie rivers. Studies on terns in the Columbia River estuary indicate (East Sand Island in 2000) that about 65 percent of the terns foraged up to 6 miles away, while about 30 percent foraged as far as 15 miles (Collis et al. 2000). A 15 mile radius around Fern Ridge Lake includes the mainstem Willlamette River downstream to Harrisburg, Middle Fork and Coast Fork Willamette River to Mt. Pisgah, and the McKenzie River to its confluence with the Mohawk. If terns successfully nested at Fern Ridge Lake, they would occur in the general area during the mid- to latter stages of the outmigration period for ESA-listed salmonids. Thus, terns could potentially consume juvenile salmonids if they forage in the Willamette and McKenzie rivers. However, effects to these ESA-listed salmonids are expected to be limited because the number of nesting terns are expected to be small (5 to 300 pairs).

California. Effects to ESA-listed salmonids have the potential to increase under this alternative because specific sites in San Francisco Bay would be managed to attract displaced terns from the Columbia River estuary. Increased numbers of terns could increase consumption of ESA-listed salmonids in San Francisco Bay. However, as described in Alternatives A and B, although there is some overlap with the outmigration periods of these salmonid species during the tern breeding season, effects are expected to remain limited. In particular, a diet study conducted in 2003 indicated that salmonids comprise a small portion of the tern diet (Roby et al. 2003a) and individual colony sizes (100 to 1,500 pairs) are predicted to remain small in comparison to that observed in the Columbia River estuary. Additionally, alternative prey (e.g. marine fishes) are most likely abundant and available to nesting terns, reducing the potential for terns to prey on salmonids.

4.2.3.4 Alternative D

Effects to ESA-listed fish in Washington, Oregon, and California are similar to that described in Alternative C, with the exception that if lethal control is implemented to reduce the colony size on East Sand Island, the overall number of birds that may be displaced from the Columbia River estuary may be lower than expected in Alternative C. Thus, effects from displaced birds would be lower than anticipated in Alternative C.

4.2.4 Effects to Other Birds

4.2.4.1 Alternative A

Washington. Under this alternative, effects to other bird species at Dungeness NWR are expected to be absent or negligible because nesting terns currently use an area not used by many other bird species. The black oystercatcher is on the Service's Birds of Conservation Concern list (U.S. Fish and Wildlife Service 2002b). The one to three pairs of oystercatchers currently nesting on Dungeness NWR, use the same location as the terns but no negative interactions were observed. A larger tern colony may potentially cause the black oystercatchers to move their nest site away from nesting terns. It is also possible that a larger tern colony may attract mammalian predators onto the spit, potentially increasing predation risks to the black oystercatchers. Despite the potential for effects to these nesting oystercatchers, we do not expect effects to the overall regional population of black oystercatchers. No specific effects to other colonial nesting bird species have been identified for known tern colony sites in eastern Washington. Thus, effects to other birds are expected to be absent or negligible in Washington.

Oregon. Effects to gulls nesting on East Sand Island are not expected since the amount of nesting habitat available to terns would not change from the current situation. Double-crested cormorants would probably not be affected by an increased number of nesting terns on East Sand Island since the cormorants nest on the opposite end of the island. Activities associated with the small colonies of terns on Summer and Crump lakes are not expected to affect other bird species found in these locations.

California. As no management actions would be implemented in California and the number of nesting terns is not expected to increase, no effects are anticipated on other bird species in California under this alternative.

4.2.4.2 Alternative B

We expect approximately 12,000 breeding pairs of terns (based on estimated colony size in 2005) would be displaced from the Columbia River estuary. These terns may potentially affect other colonial nesting waterbirds that also prefer to nest in similar habitats as they seek new nesting habitat in the region. However, we expect that these effects would be dispersed throughout the region and thus, would be limited.

Washington. Similar to Alternative A, effects to other bird species in Washington are expected to be negligible, even with potentially increased tern numbers.

Oregon. Nesting gulls may benefit from the vegetation growth in the tern nesting area on East Sand Island because gulls prefer to nest in vegetated areas. However, as this area continues to become vegetated, it would most likely be covered with dense, thick vegetation and could potentially displace nesting gulls as well. Effects to other colonial nesting bird species found on East Sand Island are not expected. Song birds and some waterfowl species that nest on East Sand Island would benefit from the additional acres of vegetated habitat.

Effects to other bird species at Summer and Crump lakes are expected to be negligible because existing nesting habitat, without management efforts, cannot accommodate a large number of displaced terns from the Columbia River estuary. There is no suitable nesting habitat at Fern Ridge Lake, thus, effects to other bird species are not expected under this alternative.

California. Displaced terns may nest at sites within San Francisco Bay, northeastern California, and southern California and thus, could compete with other colonial nesting birds. Effects are expected to be negligible since nesting habitat is usually not limited, except in southern California. In southern California, nesting habitat is very limited and there is a potential that the larger Caspian tern could displace smaller Forster's or California least terns. However, effects are expected to be limited since Caspian tern colony sizes are not anticipated to be similar to those observed in the Columbia River estuary.

4.2.4.3 Alternative C

Washington. Effects to other bird species at Dungeness NWR are similar to that described for Alternative A and B, except that the management actions to protect the tern colony from human disturbance and/or predators would most likely also benefit other birds nesting near the terns.

Oregon. Adverse effects to other bird species found on East Sand Island are not expected. Nesting gulls would benefit from decreased competition with nesting terns and the increased vegetated nesting area. Songbirds would also benefit from the development of densely vegetated habitat. Canada geese and mallards would also be expected to nest in the newly created habitat.

Since this alternative would create more island nesting habitat at Summer and Crump lakes, other colonial nesting birds, such as American white pelicans, Forester's terns and double-crested cormorants would benefit by having more nesting habitat available. The creation of a nesting island at Fern Ridge Lake could also benefit colonial nesting birds that may select to nest at that site if habitat was available.

California. In San Francisco Bay, increased tern numbers are not expected to affect other bird species because habitat is not limiting at these sites. Displaced terns may choose to nest on their own accord in southern California and could compete with other colonial nesting birds since habitat is very limited here. However, since habitat would be created in San Francisco Bay, it is unlikely that a large number of terns would select nest sites in southern California.

4.2.4.4 Alternative D
Effects to other birds would be similar to that described in Alternative C for Washington, Oregon, and California with the exception that if a lethal control program was implemented, it would most likely disturb nesting gulls, cormorants, and other bird species on East Sand Island, potentially causing colony abandonment.

4.2.5 Effects to Mammals

4.2.5.1 Alternative A
No effects to mammals are expected in Washington, Oregon, and California under this alternative as no management actions are proposed.

4.2.5.2 Alternative B
No effects are expected to mammals in Washington, Oregon, and California under this alternative beyond habitat improvement for small mammals on East Sand Island.

4.2.5.3 Alternative C
Washington. If mammalian predators become an issue on Dungeness NWR, a predator management program may be necessary. It is unlikely that large numbers of mammals would wander onto the spit to become a problem. Thus, if a predator management program was implemented, we expect that it could potentially affect a small number of individuals. Effects to mammal populations near Dungeness NWR are expected to be negligible. The expected larger tern colony should have no effects to harbor seals that frequently haul out on the spit.

Oregon. No effects to mammals are expected on East Sand Island. If predation from mammals on nesting terns occurs in Summer and Crump lakes, a predator management program may be necessary. Similar to that described for Dungeness NWR, effects to mammals are expected to be negligible. No mammalian predators are expected to access the tern nesting island in Fern Ridge Lake. Thus, no affects are expected.

California. The red fox is a known predator on nesting terns in San Francisco Bay. Predator management would be necessary at all three sites in San Francisco Bay. Similar to that described in Washington and Oregon, effects to the red fox population are expected to be negligible.

4.2.5.4 Alternative D
As management programs would be the same as proposed in Alternative C, effects to mammals would be similar to that described in Alternative C for Washington, Oregon, and California.

4.2.6. Effects to Federally Endangered and Threatened Wildlife

4.2.6.1 Alternative A
Washington. Implementation of Alternative A would have no effect to bald eagles, western snowy plovers, and marbled murrelets, which occur in Dungeness Bay because they do not compete with Caspian terns for nest sites or prey.

Oregon. Under this alternative we expect no effects to roosting brown pelicans that primarily occur on the western half of East Sand Island, along the shoreline or on the upstream beaches. These areas are outside the tern nesting site. Bald eagle use of the island would continue under this alternative and no effect for this species is expected. The current tern nesting colonies at Summer and Crump lakes are extremely small, resulting in no effects to bald eagles in the area.

California. Under this alternative, we expect no effects to bald eagles, western snowy plovers, brown pelicans, and California least terns in California because no change in existing tern colony sizes are expected and competition with these species for nest sites or prey is absent.

4.2.6.2 Alternative B
Washington. Although there is a potential for the Caspian tern colony to increase at Dungeness NWR under this alternative, expected effects are similar to that described in Alternative A because terns do

not compete with the various ESA-listed species for nest sites or prey.

Oregon. The loss of the current tern colony on East Sand Island is not expected to affect roosting brown pelicans which primarily occur along the shorelines or on the beaches of the island. These areas are not associated with the tern nesting site. Although bald eagles would lose a potential food resource, there are no indications that the tern colony is an important food resource for bald eagles. As with Alternative A, bald eagles at Summer and Crump lakes would not be affected.

California. The potential growth of existing tern colonies in San Francisco Bay are not expected to affect bald eagles, western snowy plovers, and brown pelicans for the same reasons described in Alternative A. Effects to California least terns nesting in San Francisco Bay are not expected because competition for nest sites at the proposed Alameda NWR is unlikely. Caspian terns currently nest at sites that are at least 8 miles away. In addition, foraging competition is not expected because there is only a slight overlap in prey size preference for both species (California least terns feed on prey that are 2.0 to 9.0 cm long (Thompson et al. 1997) while Caspian terns feed on prey that is at least 5 cm long (Cuthbert and Wires 1999). However, if Caspian tern colonies increase in size in southern California, the larger Caspian tern could compete for nesting habitat with the smaller California least tern since nesting habitat is already limiting for colonial nesting waterbirds in this highly urbanized coastline. However, effects are expected to be limited under this alternative because colony sizes are not expected to be similar to those observed in the Columbia River estuary.

4.2.6.3 Alternative C

Washington. Although there is a potential for the tern colony to increase at Dungeness NWR under this alternative, expected effects are similar to that described in Alternatives A and B.

Oregon. Similar to Alternatives A and B, the smaller tern colony on East Sand Island is not expected to affect roosting brown pelicans which primarily occur along the shorelines or on the beaches of the island. Increased numbers of nesting terns may benefit bald eagles at Summer, Crump, and/or Fern Ridge lakes by providing an additional food resource.

California. The potential growth of existing and the establishment of new tern colonies in San Francisco Bay are not expected to affect bald eagles, western snowy plovers, and brown pelicans. Western snowy plovers primarily use dry salt pond beds, whereas, terns use nesting islands or abandoned levees. Thus, with the exception of the levees, terns would not be competing for nesting habitat with western snowy plovers. As in Alternative B, larger nesting colonies of terns are not expected to affect the California least tern colony nesting at the proposed Alameda NWR because nest site and foraging competition is unlikely. Although displaced terns may nest in southern California under their own accord, we do not expect large numbers of terns selecting these sites since other sites in California would be actively managed to attract displaced terns. Thus, unlike Alternative B, we expect effects to California least terns to be negligible.

4.2.6.4 Alternative D

Effects to threatened and endangered wildlife would be similar to that described in Alternative C for Washington, Oregon, and California. The only difference is if a lethal control program is implemented on East Sand Island, removal of an undetermined number of terns would occur on an annual basis until the target colony size is attained. This program may disturb to roosting brown pelicans and bald eagles on the island.

4.3 Effects to Socioeconomic Environment

4.3.1 Effects to Commercial and Recreational Fisheries

4.3.1.1 Alternative A

Washington. Terns consume commercially and recreationally harvested fish species (e.g., salmonids, herring) that occur in Dungeness Bay (see section 4.2.2 and 4.2.3). However, effects are not considered to be substantial because the current colony at Dungeness NWR is less than 200 breeding pairs, resulting in low consumption levels. In addition, as described in section 4.2.2 and 4.2.3, we expect the diet of terns nesting in Dungeness NWR would primarily consist of non-salmonids. Salmonid stocks that originate in Washington and associated with the Columbia River Basin would al be consumed by terns nesting in the Columbia River (see Oregon section below).

Effects to herring fisheries in Washington are not expected because these stocks are not depressed and should not be affected by the small tern colony. The current tern colony probably does not contribute to fecal coliform levels that have been observed in Dungeness Bay (causing shellfish harvest closures) because the number of nesting terns is small and their nesting area is located on an upland site, reducing the possible contamination of bay waters.

Oregon. Consumption of juvenile salmonids and pelagic fisheries species by terns in the Columbia River would increase under this alternative. This increased consumption could potentially affect commercial and recreational salmonid fisheries if increased tern predation continues to affect depressed or ESA-listed stocks. Failure to attain management objectives for survival and recovery of ESA-listed stocks would most likely continue to result in restricted commercial and recreational fisheries for salmon stocks.

Since no commercial fisheries occur at Summer, Crump, or Fern Ridge lakes, no effects to commercial and recreational fisheries are expected.

California. In San Francisco Bay, tern colonies are predicted to remain similar to current numbers. Thus, effects to fisheries in the bay are not considered to be substantial. In particular, salmonids comprise a small portion of the tern diet in the bay (Roby et al. 2003a, Table 4.4).

4.3.1.2 Alternative B

Washington. Effects would be similar as described in Alternative A, except that there would be an increased likelihood that tern numbers could increase in Washington as tern nesting habitat is lost on East Sand Island. However, colonies are not expected to grow to the sizes observed in the Columbia River estuary, thus, effects to are expected to be similar to current conditions.

Oregon. Consumption of juvenile salmonids by terns would decrease subtantially and eventually be eliminated under this alternative, potentially resulting in beneficial effects to commercial and recreational salmonid fisheries if reduction of tern predation aids salmon recovery in the Columbia River Basin.

Since no commercial fisheries occur at Summer, Crump, and Fern Ridge lakes, no effects are expected. Since there is a potential for the number of nesting terns to increase, predation on recreational fish may also increase at Crump Lake. However, since nesting habitat is limiting, this increase is expected to be negligible.

California. Effects would be similar as described in Alternative A, except that the likelihood that tern numbers could increase in California would be greater as habitat is lost on East Sand Island. Effects are expected to be similar to current conditions (see above).

4.3.1.3 Alternative C

Washington. Effects would be similar as described in Alternatives A and B. We expect effects to not be substantial because the colony size is expected to remail small, resulting in low consumption levels. In addition, as described in section 4.2.2 and 4.2.3, we expect the diet of terns nesting in Dungeness NWR would primarily consist of non-salmonids. Effects to herring fisheries in Washington are not expected and tern colony would not contribute to fecal coliform levels that have been observed in Dungeness Bay because their nesting area is located in an upland site, reducing the possible contamination of bay waters.

Oregon. Effects would be similar to Alternative B, except that there would still be some amount of predation on commercially harvested salmonids in the Columbia River. However, consumption of juvenile salmonids by terns would substantially decrease under this alternative, potentially resulting in beneficial effects to commercial and recreational salmonid fisheries if reduction of tern predation aids salmon recovery in the Columbia River Basin. We expect a possible increase in tern predation on recreational fish at Summer and Crump lakes if Caspian terns eventually relocate to these sites. These colonies would be small (5 to 300 pairs) and resident fish populations are healthy and abundant. Thus, effects are expected to be negligible.

California. Similar to Alternative B, we expect possible increases in tern predation on commercially important species if terns relocate from the Columbia River estuary to San Francisco Bay. Effects in San Francisco Bay are similar to that described in Alternative B.

4.3.1.4 Alternative D

Effects to commercial and recreational fisheries in Washington, Oregon, and California are similar to that described in Alternative C.

4.4 Effects to Tribal Fisheries

4.4.1 Alternative A

Washington. The current effect on Tribal harvested salmonids at Dungeness NWR is unknown since terns have been nesting at this site for just one year. Effects are expected to be similar to that described above in the Effects to Commercial and Recreational Fisheries section. Terns most likely do consume some Tribal harvested salmonids that occur in Dungeness Bay. However, effects are not considered to be substantial because the current colony is less than 200 breeding pairs, resulting in low consumption levels. Consumption could increase if the number of terns nesting at Dungeness NWR increases when the nesting habitat on East Sand Island is maximized in 2009. However, we expect this increase would not be substantial since tern numbers are not anticipated to be similar to that observed in the Columbia River estuary. In addition, as described in section 4.2.2 and 4.2.3, we expect the diet of terns nesting in Dungeness NWR would primarily consist of non-salmonids. Tribal fisheries associated with salmonid stocks that originate in Washington in the Columbia River Basin would be affected by continued tern predation occurring in the Columbia River (see Oregon section below).

Oregon. Similar to the description of effects to commercial and recreational fisheries, consumption of juvenile salmonids by terns in the Columbia River would increase under this alternative. This increased consumption could potentially affect Tribal salmonid fisheries if increased tern predation continues to affect depressed or ESA-listed stocks. Failure to attain management objectives for survival and recovery of ESA-listed stocks would most likely continue to result in restricted Tribal fisheries for salmon stocks.

California. No Tribal fisheries occur within the affected environment. Thus, no affects are expected.

4.4.2 Alternative B

Washington. Effects would be similar to those described in Alternative A, except that the likelihood that tern numbers could increase in Washington would be greater. However, effects to salmonid fisheries are expected to similar to current conditions.

Oregon. Consumption of juvenile salmonids by terns would decrease under this alternative, potentially resulting in beneficial effects to Tribal fisheries if reduction of tern predation aids salmon recovery in the Columbia River Basin.

California. No Tribal fisheries occur within the affected environment. Thus, no affects are expected.

4.4.3 Alternative C

Washington. Effects would be similar to those described in Alternatives A and B.

Oregon. Effects would be similar to Alternative B, except that there would still be some amount of predation on Tribal harvested salmonids in the Columbia River. However, consumption of juvenile salmonids by terns would substantially decrease under this alternative, potentially resulting in beneficial effects to commercial and recreational salmonid fisheries if reduction of tern predation aids salmon recovery in the Columbia River Basin.

California. No Tribal fisheries occur within the affected environment. Thus, no affects are expected.

4.4.4 Alternative D

Effects to Tribal fisheries in Washington, Oregon, and California are similar to that described in Alternative C.

4.5 Effects to Cultural Resources

4.5.1 Alternative A

Since this alternative does not propose any habitat manipulations and actions, other than ongoing actions on East Sand Island, no effects to cultural resources are expected under this alternative in Washington, Oregon, and California.

4.5.2 Alternative B

Similar to Alternative A, since this alternative does not propose any habitat manipulations and actions, there are no anticipated effects to cultural resources under this alternative in Washington, Oregon, and California.

4.5.3 Alternative C

Washington. There are no anticipated effects to cultural resources under this alternative in Washington.

Oregon. There are no anticipated effects to cultural resources under this alternative on East Sand Island. However, since cultural resources are present in Summer, Crump, and Fern Ridge lakes, activities associated with the creation of the proposed islands in each lake could potentially affect cultural resources. Coordination with associated Tribes and archeologists would be required.

California. There are no anticipated effects to cultural resources under this alternative in San Francisco Bay. Hand-pulling of vegetation on Brooks Island would be the management measure to develop additional nesting habitat for Caspian terns. This low impact method would preclude effects to cultural resources at this site.

4.5.4 Alternative D

Effects to cultural resources are similar to that described in Alternative C for Washington, Oregon, and California.

4.6 Summary of Effects

Table 4.6 summarizes potential effects to Caspian terns and ESA-listed salmonids for each of the four alternatives.

TABLE 4.6 Summary and comparison of potential effects of Alternatives to Caspian Terns and ESA-listed Salmonids in the Pacific Coast region.

RESOURCE	ALTERNATIVE A No Action-Current Management Program	ALTERNATIVE B No Management	ALTERNATIVE C Redistribution of ESI Tern Colony	ALTERNATIVE D Redistribution and Lethal Control of ESI Tern Colony
CASPIAN TERNS				
Nesting Habitat on East Sand Island (ESI)	6 acres	Anticipate nesting area completely vegetated within 3 years	1 - 1.5 acres	Same as Alternative C
Nesting Habitat in Region	Existing network of nesting sites throughout the region	Existing network of nesting sites throughout the region, except for the loss of ESI	Enhanced network of nesting sites throughout the region with approximately 8 acres of managed nesting habitat	Same as Alternative C
East Sand Island Colony Size	Would continue to increase until habitat is maximized	Anticipate colony elimination	2,500 and 3,125 pairs	Same as Alternative C
Regional Tern Population	Continue current increasing trend	Stabilize (possibly lower than current numbers) or potential decline if terns unable to find alternative nesting sites	Stabilize (possibly lower than current numbers)	Stabilize (possibly lower than current numbers) or potential decline if lethal control is implemented
ESA-LISTED SALMONIDS				
Columbia River Estuary (CRE)	Increase in consumption of ESA-listed salmonids no improvement in lambda	Substantial decrease or eventual elimination of consumption of ESA-listed salmonids, improvement in lambda	Substantial decrease in consumption of ESA-listed salmonids, improvement in lambda	Same as Alternative C
Alternate Sites	No effects	Possible increase in consumption of local ESA-listed salmonid populations	Increase in consumption of local ESA-listed salmonid populations at managed alternate sites	Same as Alternative C, except if lethal control is implemented, lesser increase in consumption of ESA-listed salmonids
Region	No effects	Overall decrease in consumption of ESA-listed salmonids	Overall decrease in consumption of ESA-listed salmonids	Same as Alternative C, except if lethal control is implemented, less terns would be displaced, resulting in greater effects than Alternative C

4.7 Cumulative Effects

This section addresses the potential cumulative effects for all of the alternatives and is intended to consider the proposed action in the context of other actions on a larger temporal and spatial scale.

Natural and human-caused events have reduced or eliminated tern nesting habitat throughout the region. This has apparently led to the concentration of terns on the few remaining suitable sites or the colonizing of new sites in conflict with human interests (Shuford and Craig 2002). The large breeding concentration in the Columbia River estuary is more vulnerable to stochastic events (e.g., storms, predators) and disease as compared to a similar population that is dispersed among many smaller colonies (Roby et al. 2002, Shuford and Craig 2002). Thus, dispersal of the large and concentrated tern colony on East Sand Island would result in a benefit to the regional population because the potential risk of this large segment (approximately 70 percent) of the population to catastrophic events would be removed.

Additionally, increasing the network of nesting sites in both coastal and interior locations with varying conditions offers a better potential for maintaining a stable regional population over time in comparison to a network comprised of fewer sites and concentrations of larger individual colonies. The proposed enhanced suite of nesting locations would provide more suitable habitat for supporting terns on a regional scale as well as help support other management actions to decrease the loss of juvenile salmonids in the Columbia River estuary.

Tern predation should be considered in context with other efforts to improve juvenile salmonid survival. Many of the measures taken to restore salmonids in the Columbia River Basin have focused on improving survival of juvenile salmonids through the mainstem dams. These measures are associated with the operation and management of the Federal Columbia River Power System (FCRPS) and include research, development, and construction of measures under the Columbia River Fish Mitigation (CRFM) program of the Corps. Costs associated with the implementation of the FCRPS Biological Opinion (aggressive hydropower measures, NOAA Fisheries 2000), CRFM, and other salmon recovery efforts are substantial and reported in the Endangered Species Act 2003 Check-In Report (U.S. Bureau of Reclamation et al. 2003). Thus, the reduction in Caspian tern predation on juvenile salmonids would complement and protect benefits associated with upstream efforts to increase the number of juvenile salmonids reaching the ocean.

Reducing tern predation in the estuary is one additional mechanism that can be used to improve juvenile salmonid survival, thereby increasing population growth rates of ESA-listed salmonids in the Columbia River Basin (NOAA Fisheries 2004, Appendix C). Ultimately, long-term benefits to ESA-listed salmonids in the Columbia River estuary would depend on the ability to maintain nesting habitat to support the proposed range of terns (2,500 to 3,125 pairs). If a more stable, dispersed regional tern population resulted in less predation of juvenile salmonids then conditions may improve for some Columbia River estuary ESUs.

However, long-term success of efforts intended to increase population growth rates of ESA-listed salmonids must be placed in context with other sources of mortality subject to human intervention. Hydropower operations, harvest impacts, habitat conditions, hatchery operations, and introduced species all have the potential to affect population growth rates of ESA-listed salmonids, and are subject in various degrees to management efforts to alleviate detrimental effects. Actions to address these impacts have been implemented or proposed, and others may be developed in the future. Cumulatively, these actions have the potential to influence population growth rate to a substantially greater degree than would be realized from solely reducing predation from avian predators in the Columbia River estuary (e.g., Kareiva et al. 2000, Wilson 2003).

Chapter 5. Relationships to Federal, State, and Local Policies and Plans

This chapter contains an overview of the policies and plans used by public agencies within the jurisdiction of the affected environment of this EIS. A summary is included for each relevant policy and plan, as well as a brief discussion of its relevancy to the proposed action. Land use plans associated with specific sites (e.g., National Wildlife Refuges, Wildlife Management Areas), have been considered in the development of the proposed action and will not be discussed in detail here.

5.1 Fish and Wildlife Service Plans, Policies, and Programs

Management of Caspian terns is included in a Draft Regional Seabird Conservation Plan. The purpose of this plan is to identify the Service's goals and priorities for seabird conservation in the Pacific Region, including specific objectives and strategies to achieve these goals. The plan will serve to direct and coordinate Service activities towards seabird conservation in the future.

Service policies relevant to the development of a management plan for the Caspian tern are summarized in Appendix D.

5.2 Other Federal Agency Plans

The Corps Columbia River Channel Operation and Maintenance Program (O&M Program) would be supported by implementation of a selected alternative associated with this EIS. The NOAA Fisheries 1999 BO for the O&M Program, under Terms and Conditions 1a, states: " The COE shall modify the habitat on Rice Island by April 1, 2000, so that it is no longer suitable as a nesting site for Caspian terns or provide for the hazing of terns off the island in a manner that will preclude their nesting. The COE shall ensure that any terns hazed off the island do not nest on any dredge spoil islands in the action area (other than East Sand Island). The COE shall continue to prevent nesting of Caspian terns on disposal islands within the action area for the life of the project." Thus, implementation of a measure to reduce the Caspian tern population in the Columbia River estuary would assist in achieving the prescribed Terms and Conditions.

Reconsultation is underway for the O&M Program. It is anticipated that the forthcoming BO will address Caspian tern management in the Columbia River estuary in a manner comparable to the existing Terms and Conditions. The future BO for the O&M Program will be merged with the Columbia River Channel Improvement Project (CRCIP) BO to ensure a continuity of management practices relative to Caspian terns in the estuary. The CRCIP would entail a deepening of the existing 40-foot navigation channel to a 43-foot project depth plus implementation of a number of ecosystem restoration features.

The Corps has a number of environmental restoration programs in place authorized by Section 1135 of the 1986 Water Resources Development Act (WRDA), Section 206 of WRDA 1996 and Section 536 of WRDA 2000. Various projects are underway or have been completed under these authorities in the lower Columbia River and estuary. Restoration projects associated with these authorities and the CRCIP are principally intended to restore fish and wildlife habitat, to include tidal marshes and riparian forest, and to reconnect the Columbia River to floodplain and/or diked habitats.

The Northwest Power Act of 1980 directs the Northwest Power and Conservation Council (formerly known as the Northwest Power Planning Council) to develop a program for the protection, mitigation, and enhancement of fish and wildlife of the Columbia River Basin and make annual funding recommendations to the Bonneville Power Administration for projects to implement the program. Sub-basin plans are being developed and contain strategies that will drive the implementation of the Council's Fish and Wildlife Program at the sub-basin level. The sub-basin plan for the lower Columbia River and Willamette River includes a discussion of management of Caspian terns.

The Columbia River Fish Mitigation (CRFM) program is funding research efforts on salmon use of Columbia River estuarine habitats. The Lower Columbia River General Investigation Study has been established to investigate and recommend appropriate solutions to accomplish ecosystem restoration in the lower Columbia River and estuary, including wetland/riparian habitat restoration, stream and fisheries improvement, water quality, and water-related infrastructure improvements. The study area includes all areas west of Bonneville Dam on the Columbia River, including tidally influenced tributaries.

The U.S. Army Corps of Engineers 2002 Draft interim environmental assessment titled: Caspian Tern Interim Management Plan Fiscal Year 2003-2004 and Pile Dike Excluder Maintenance to Discourage Cormorant use Lower Columbia River, Oregon (U.S. Army Corps of Engineers 2002) describes management of terns in the Columbia River estuary and presents a plan (see description in Chapter 2, Alternative A) for managing Caspian terns in the Columbia River estuary until a proposed action resulting from this EIS is implemented.

5.3 State, Local, and Tribal Plans

5.3.1 Washington

The State of Washington has various strategies and programs designed to improve the habitat of ESA-listed salmonids and assist in recovery planning. Washington's 1998 Salmon Recovery Planning Act provided the framework for developing watershed restoration projects and established a funding mechanism for local habitat restoration projects. It also created the Governor's Salmon Recovery Office to coordinate and assist in the development of salmon recovery plans. Washington's Department of Fish and Wildlife and Tribal co-managers have been implementing the Wild Stock Recovery Initiative since 1992. The co-managers are currently completing comprehensive species management plans that examine limiting factors and identify needed habitat activities. The plans also concentrate on actions in the harvest and hatchery areas, including comprehensive hatchery planning. The Department and some western Washington treaty Tribes have adopted a wild salmon policy to provide general policy guidance to managers on fish harvest, hatchery operations, and habitat protection and restoration measures to better protect wild salmon runs.

Washington State's Forest and Fish Plan were promulgated as administrative rules. The rules were designed to establish criteria for non-Federal and private forest activities that will improve environmental conditions for ESA listed salmonids. The State of Washington also established the Lower Columbia Fish Recovery Board to begin drafting recovery plans for the lower Columbia region.

The Washington Shoreline Management Act (RCW 90.58), administered by the Washington Department of Ecology through Shoreline Master Programs adopted by each local jurisdiction, regulates the development of Washington shorelines.

5.3.2 Oregon

The Oregon Plan is designed to restore the healthy function of Oregon's natural aquatic systems. It represents commitments on behalf of governments, interest groups, and private citizens from all sectors of the State. While the plan originated as an effort to address declining populations of coho salmon, in the two years since its initiation, the plan has engaged new participants, addressed new fish species, attained regional significance and promoted unique approaches to natural resource issues on a State-wide basis (The Oregon Plan for Salmon and Watersheds 2004).

5.3.3 California

The Goals Project was undertaken in June 1995 to establish a long-term vision for a healthy and sustainable baylands ecosystem. The Goals Project used available scientific knowledge to identify the types, amounts, and distribution of wetlands and related habitats needed to sustain diverse and healthy communities of fish and wildlife resources in the San Francisco Bay Area. The Project provides a biological basis to guide regional wetlands planning processes for public and private interests seeking to preserve, enhance, and restore the ecological integrity of wetland communities (Goals Project 1999).

5.3.4 Local Governments

As identified in the FCRPS Hydropower biological opinion, the Lower Columbia River Estuary Partnership (LCREP) works with private environmental groups, Federal, State, and local governments on ecosystem protection of the Lower Columbia River. LCREP encompasses a watershed wide perspective through their Comprehensive Conservation and Management Plan (CCMP), cross cutting political boundaries to address land use, water quality, and species protection. LCREP coordinates and implements a program for conservation of the Lower Columbia River. LCREP is also actively working with NMFS on recovery planning for salmonids. By involving local governments and private organizations in planning efforts, there is potential for a comprehensive, cohesive, and sustained program for species recovery in the Lower Columbia River.

5.3.5 Tribal Governments

The Wy-Kan-Ush-Mi Wa-Kish-Wit, or "Spirit of the Salmon" plan is a joint restoration plan for anadromous fish in the Columbia River basin prepared by the Nez Perce, Umatilla, Warm Springs and Yakama Tribes. It provides a framework for restoring anadromous fish stocks, specifically salmonids, Pacific lamprey (eels), and white sturgeon in upriver areas above Bonneville Dam. Overall, future implementation of the Spirit of the Salmon plan should have positive cumulative effects on

ESA-listed salmonids and their habitats. The Nez Perce, Warm Spring, Umatilla, and Yakama Tribal governments are now seeking to implement this plan and salmon restoration in conjunction with the States, other Tribes, and the Federal government, as well as in cooperation with their neighbors throughout the basin's local watersheds and with other citizens of the Northwest.

Appendix A - Appendix I

Appendix A: Acryonyms, Abbreviations, and Glossary of Terms

1. Acronyms & Abbreviations

BO	Biological Opinion
BPA	Bonneville Power Administration
C & S	Commercial, Ceremonial, and Subsistence Fisheries
CCMP	Comprehensive Conservation and Management Plan
CDFG	California Department of Fish and Game
COE	U.S. Army Corps of Engineers
Corps	U.S. Army Corps of Engineers
CRCIP	Columbia River Channel Improvement Project
CRFM	Columbia River Fish Mitigation
CTWG	Caspian Tern Working Group
DEIS	Draft Environmental Impact Statement
DPS	Distinct Population Segment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESI	East Sand Island
ESU	Evolutionary Significant Units
FCRPS BO	Federal Columbia River Power System Biological Opinion
FCRPS	Federal Columbia River Power System
FMP	Federal Fishery Management Plans
FOUR H'S	Hydropower, habitat loss, hatcheries, and harvest
LCREP	Lower Columbia River Estuary Project
MBTA	Migratory Bird Treaty Act
MSA	Magnuson – Stevens Fishery Conservation and Management Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service
NWR	National Wildlife Refuge
O & M Program	Corps Columbia River Channel Operation and Maintenance Program

1. Acronyms & Abbreviations (Continued)

ODFW	Oregon Department of Fish and Wildlife
PFMC	Pacific Fishery Management Council
PSC	Pacific Salmon Commission
RM	River Mile
RM 146	River Mile 146 (Bonneville Dam)
Service	U.S. Fish and Wildlife Service
T & C	Terms and Conditions
UKL	Upper Kalamath Lake
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WRDA	Water Resource Development Act

2. Glossary of Terms

Anadromous. Describes fis that migrate from the sea to fresh water to spawn (breed).

Arid. Lacking moisture, insufficient rainfall to support trees or woody plants.

Bioenergetics Modeling. Used to estimate consumption levels of piscivorous waterbirds. They calculate the amount of prey consumed in either biomass or numbers, based on diet composition, energy content of prey, energy requirements of individual consumers, and the number of individual consumers present (adults and juveniles).

Cyprinid. A soft-finned mainly freshwater fish typically having toothless jaws and cycloid scales

Delta. Area where a river divides before entering a larger body of water.

Demersal. Fish that live on or near the ocean bottom. They are often called benthic fish, groundfish, or bottom fish.

Dredge material. Any excavated material from waterways.

Ephemeral. Lasting a very short time; short-lived; transitory.

Estuary. The wide part of a river where it nears the sea; fresh and salt water mix.

Exclusive Economic Zone. Consists of those areas adjoining the territorial sea of the U.S. and extends up to 200 nautical miles from the U.S. coastline. Within its Exclusive Economic Zone, the U.S. has sovereign rights over all living and nonliving resources. (This also includes the territorial sea of the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and U.S. overseas territories and possessions).

Fledglings. Young birds that have recently acquired their flight feathers.

Foraging habitat. The area where an animal searches for food and provisions.

Fry. The young of any fish.

Generation time. The average amount of time between the appearances of two successive generations (parent and offspring).

Habitat. The type of environment in which an organism or group normally lives or occurs.

Hazing. Disturbance to Caspian terns early in the nesting season through the use of repeated walk through of the nesting area by people or dogs.

Herbaceous. Relating to or characteristic of an herb as distinguished from a woody plant. Green and leaflike in appearance or texture.

Mudflats. Flat un-vegetated wetlands subject to periodic flooding and minor wave action.

Outmigrant. Juvenile salmonids (smolts) that are migrating out of their native rivers or streams on their way to ocean waters.

Pelagic. Of or pertaining to the ocean; applied especially to animals that live at the surface of the ocean, away from the coast.

2. Glossary of Terms (Continued)

Pile dike. Dike with pilings.

Piscivorous. Fish-eating.

Pit-tags. Passive Integrated Transponder or PIT tag. Very small (12 mm by 2.1 mm) glass tube containing an antenna and an integrated circuit chip inserted into the juvenile fish's body cavity that remains inactive until activated at a PIT-tag monitoring facility.

Rodeo-herbicide. A herbicide (chemical) used to control a variety of emergent (any of various plants [such as a cattail] rooted in shallow water and having most of the vegetative growth above the water) aquatic weeds.

Salmonid. Of, belonging to, or characteristic of the family Salmonidae, which includes the salmon, trout, and whitefish. Includes steelhead.

Salt ponds. Persistent hypersaline ponds that are intermittently flooded with sea water. Artificial salt ponds are surrounded by levees or dikes (manmade embankments) were created for salt harvest and have completely replaced natural salt ponds in San Francisco Bay.

Scarify. Make superficial incisions in.

Shoal. An area of shallow water; submerged sandbank visible at low water.

Smolts. A young salmon two or three years old, when it has acquired its silvery color.

Subtidal zone. Zone includes from ten meters depth to the low tide line.

Subyearling. A juvenile fish less than 1 year old.

Thermocline. A layer of water in an ocean or certain lakes, where the temperature gradient is greater than that of the warmer layer above and the colder layer below.

Trolling. To fish for by running a baited line behind a slowly moving boat.

Upwelling. An oceanographic phenomenon that occurs when strong, usually seasonal, winds push water away from the coast, bringing cold, nutrient-rich deep waters up to the surface.

Yearling. A fish that is one year old or has not completed its second year.

Appendix B: References

B.1 Literature Citations

Adams, P.B., C. B. Grimes, J. E. Hightower, S. T. Lindley, and M.L. Moser. 2002. Status Review for North American Green Sturgeon, *Acipenser medirostris.* National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA, 49 pages.

Anderson, C. D. 2002. Factors affecting colony size, reproductive success, and foraging patterns of double-crested cormorants nesting on East Sand Island in the Columbia River estuary. Masters thesis, Oregon State University, Corvallis, OR, 127 pages.

Antolos, M. 2002. Breeding and foraging ecology of Caspian terns (*Sterna caspia*) in the Mid-Columbia River: predation on juvenile salmonids and management implications. Masters thesis, Oregon State University, Corvallis, OR, 152 pages.

Barnhart, R.A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) – steelhead. U.S. Fish and Wildlife Service, Biological Report 82(11.60). U.S. Army Corps of Engineers, TR EL-82-4, 21 pages.

Bax, N.J., E.O. Salo, and B.P. Snyder. 1980. Salmonid outmigration studies in Hood Canal. Final report, Phase V, January to July 1979. FRI-UW-8010, Fisheries Research Institute, University of Washington, Seattle, WA, 55 pages.

Bax, N.J. 1983. The early marine migration of juvenile chum salmon (*Oncorhynchus keta)* through Hood Canal – its Variability and Consequences. Ph.d. Dissertation, University of Washington, Seattle, WA.

Beamer, E.M., J.C. Sartori, and K.A Larsen. 2000. Skagit Chinook life history study progress report, Number 3. Federal Energy Regulatory Commission Project Number 553, unpublished report, 20 pages.

Bedard, J., A. Nadeau, and M. Lepage. 1995. Double-crested cormorant culling in the St. Lawrence River estuary. Colonial Waterbirds 18 (Special Publication 1): 78-85.

Belant, J.L. 1997. Gulls in urban environments: landscape-level management to reduce conflict. Landscape and Urban Planning 38 (1997): 245-258.

Blackwell, B.F., T.W. Seamans, D.A. Helon, and R.A. Dolbeer. 2000. Early Loss of herring gull clutches after egg oiling. Wildlife Society Bulletin 28(1): 70-75.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyma. 1994. Historical decline and current status of coho salmon in California. N. Am. J. Fish. Management 14: 237-261.

Buchanan, D., M. Hanson, and R.M. Hooten. 1997. Status of Oregon's bull trout, distribution, life history, limiting factors, management considerations and status. Oregon Department of Fish and Wildlife, Portland, OR.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-27, 261 pages.

California Department of Fish and Game. 1998. Report to the Fish and Game Commission: A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage.

California Department of Fish and Game. 2001. California's Living Marine Resources: A Status Report (ANR Publication #SG01-11).

Caswell, H. 2001. Matrix population models. Sinauer, Sunderland. Massachusetts, USA.

Christens, E. and H. Blokpoel. 1991. Operational spraying of white mineral oil to prevent hatching of gull eggs. Wildlife Society Bulletin. 19:423-430.

Collis, K., S. Adamany, D. D. Roby, D. P. Craig, and D. E. Lyons. 2000. Avian predation on juvenile salmonids in the Lower Columbia River, 1998 Annual Report. Unpublished report prepared for Bonneville Power Administration and U.S. Army Corps of Engineers, 98 pages.

Collis, K., D.D. Roby, D.P. Craig, B.A. Ryan, R.D. Ledgerwood. 2001. Colonial waterbird predation on juvenile salmonids tagged with passive integrated transponders in the Columbia River estuary: vulnerability of different salmonid species, stocks, and rearing types. Transactions of the American Fisheries Society 130: 385-396.

Collis, K. D., D. Roby, D. E. Lyons, R. M. Suryan, M. Antolos, S. K. Anderson, A. M. Myers and M. Hawbecker. 2002a. Caspian tern research on the Lower Columbia River, Final 2001 Summary. Prepared for Bonneville Power Administration and the Interagency Caspian Tern Working Group, 35 pages.

Collis, K. D., D. Roby, D. E. Lyons, M. Antolos, S. K. Anderson, A. M. Myers, and M. Hawbecker. 2002b. Caspian tern research on the Lower Columbia River, Final 2000 Season Summary. Prepared for Bonneville Power Administration and the Interagency Caspian Tern Working Group, 26 pages.

Collis, K., D. D. Roby, C.W. Thompson, D.E. Lyons, and M. Tirhi. 2002c. Barges as temporary breeding sites for Caspian terns: assessing potential sites for colony restoration. Wildlife Society Bulletin 30(4): 1140-1149.

Collis, K. , D. D. Roby, D. E. Lyons, R. M. Suryan, M. Antolos, S. K. Anderson, A. M. Myers and M. Hawbecker. 2003a. Caspian tern research on the Lower Columbia River, Final 2002 Season Summary. Prepared for Bonneville Power Administration and the Interagency Caspian Tern Working Group, 16 pages.

Collis, K. ,D. D. Roby, C. Couch, G. Dorsey, K. Fischer, D. E. Lyons, A. M. Myers, S. K. Nelson, R. M. Suryan, A. Evans, and M. Hawbecker. 2003b. Caspian tern research on the Lower Columbia River, Draft 2003 Season Summary. Prepared for Bonneville Power Administration and the Interagency Caspian Tern Working Group, 38 pages.

Columbia Bird Research. 2003. Weekly reports from April 28 to July 27, 2003. Internet: www.columbiabirdresearch.org.

Congleton, J.L., S.K. Davis, and S.R. Foley. 1981. Distribution, abundance and outmigration timing of chum and Chinook salmon fry in the Skagit salt marsh, pages 153-163 *in* E.L. Brannon and E.O., editors, Salmon and Trout Migratory Behavior Symposium. University of Washington, Seattle, WA.

Coulson, J.C., N. Duncan, and C. Thomas. 1982. Changes in the breeding biology of the Herring gull (*Larus argentus*) induced by reduction in the size and density of the colony. Journal of Animal Ecology 51: 739-756.

Craddock, D.R., T.H. Blahm, and W.D. Parente. 1976. Occurrence and utilization of zooplankton by juvenile Chinook salmon in the Lower Columbia River. Transactions of the American Fisheries Society 1:72-76.

Cuthbert, F.J. and L.R. Wires. 1999. Caspian tern *(Sterna caspia) in* The Birds of North America, No. 403 (A. Poole and F. Gill, eds). The Birds of North America, Inc. Philadelphia, PA.

Dawley, E. M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kirn, A.E. Rankis, G.E. Monan, and F.J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. Final Report to the Bonneville Power Administration, Portland, OR and Northwest and Alaska Fisheries Center, Seattle, WA. 256 pp.

Emmett, R.L., S.L., Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: Species life history summaries. ELMR Rep. No. 8. NOAA/NOS SEA Division, Rockville, MD 329 pages.

Fischer, K.N. 2004. California Brown pelicans on East Sand Island, Columbia River estuary, 2003. U.S. Geological Survey-Oregon Cooperative Fish and Wildlife Research Unit unpublished report, Corvallis, OR, 13 pages.

Fresh, K.L., E. Casillas, L. Johnson, and D.L. Bottom. 2003. Role of the estuary in the recovery of Columbia River Basin salmon and steelhead: An evaluation of limiting factors. NOAA Technical Memorandum (Draft), Northwest Fisheries Science Center, Seattle, WA, 116 pages.

Gill, R.E., Jr., and L.R. Mewaldt. 1983. Pacific Coast Caspian terns: Dynamics of an expanding population. The Auk 100: 369-381.

Glabek, J.H., B.A. Ryan, E.P. Nunnallee, and J.W. Ferguson. 2003. Detection of passive integrated transponder (PIT) tags on piscivorous bird colonies in the Columbia River Basin, 2001. U.S. Army Corps of Engineers unpublished report, Walla Walla, WA, 65 pages.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. First Reprint. U.S. Environmental Protection Agency, San Francisco, California/ San Francisco Bay Regional Water Quality Control Board, Oakland, CA, 209 pages.

Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project, P.R. Olofson, editor. San Francisco Bay Regional Water Quality Control Board, Oakland, CA, 408 pages.

Grant, S., J. Hard, R. Iwamoto, O. Johnson, R. Kope, C. Mahnken, M. Schiewe, W. Waknitz, R. Waples, J. Williams, and J. Helle. 1999. Status review update for chum salmon from Hood Canal summer-run and Columbia River ESUs. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA, 27 pages.

Hayman, R.A., E.M. Beamer, and R.E. McClure. 1996. FY 1995 Skagit River Chinook restoration research. Chinook Restoration Research Progress Report No. 1. Skagit System Cooperative, LaConner, WA, 54 pages.

Healey, M.C. 1980. Utilization of the Nanaimo River estuary by juvenile Chinook salmon, *Oncorhynchus Tshawytscha*. Fishery Bulletin 77(3):653-668.

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: The life support system, pages 315-341 *in Estuarine Comparisons*, V.S. Kennedy, editor, Academic Press, New York, NY.

Herbold, B., A.D. Jassby, and P.B. Moyle. 1992. Status and trends report of aquatic resources in the San Francisco estuary. San Francisco Estuary Project, USEPA, Oakland, CA.

Herrmann, R.B. 1970. Food of juvenile Chinook and chum salmon in the Lower Chehalis River and Upper Grays Harbor, pp. 59-82 *in* Grays Harbor Cooperative Water Quality Study 1964-1966. Washington Department of Fisheries, Technical Report 7.

Horn, M.H., P.A. Cole, and W. E. Loeffler. 1996. Prey resource base of the tern and skimmer colonies at the Bolsa Chica Ecological Reserve, Orange County, and the Western Salt Works, south San Diego Bay. U.S. Fish and Wildlife Service unpublished report (Final report on Grant# 14-48-001-95586), Carlsbad, CA, 54 pages.

Horn, M.H. and W.M. Dahdul. 1998. Prey resource base of the tern and skimmer colony at the Western Salt Works, south San Diego Bay, during the 1997 breeding season. U.S. Fish and Wildlife Service unpublished report (Final report on Grant# 3 14-48-0001-95586), Carlsbad, CA, 27 pages.

Horn, M.H. and W.M. Dahdul. 1999. Prey resource base of the tern and skimmer colony at the Western Salt Works, south San Diego Bay, during the 1998 breeding season. U.S. Fish and Wildlife Service unpublished report (Final report on Grant# 14-48-0001-95586), Carlsbad, CA, 36 pages.

Huppert, D.D., D.L. Fluharty, E.E. Doyle, and A. Benyounes. 1996. Economics of Snake River salmon recovery: A report to the National Marine Fisheries Service, Seattle, WA.

Interagency Ecological Program Steelhead Project Work Team. 1999. Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review Existing Programs, and Assessment Needs. In Comprehensive Assessment, and Research Program Plan, Tech. App. VII. www.iep.water.ca.gov

Independent Economic Analysis Board. 2002. Artificial production review – economics analysis, phase I. Independent Economic Analysis Board Task 56. July 9, 2002.

Issacs, F.B. and R.G. Anthony. 2003. Bald eagle nest locations and history of use in Oregon and Washington portion of the Columbia River Recovery Zone, 1971 through 2003. Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, OR, 36 pages.

Johnson, S.W., J.F. Thedinga, and K. V. Koski. 1992. Life history of juvenile ccean-type Chinook salmon (*Oncorhynchus tshawytscha*) in the Situk River, Alaska. Canadian Journal of Fisheries and Aquatic Science 49: 2621-2629.

Johnson, O.W., W.S. Grant, R.G. Cope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-32, 280 pages.

Kask, B.A., and R.R. Parker. 1972. Observations on juvenile Chinook salmon in the Somass River estuary, Port Alberni, B.C. Fisheries Research Board of Canada, Technical Report No. 308, Nanaimo, B.C., 15 pages.

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer Chinook salmon in the Columbia River Basin. Science 290: 977-979.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary, California, pages 393-411 *in* Estuarine Comparisons, V.S. Kennedy, editor, Academic Press, New York, NY.

Klumph, R. 2003. Letter to Nanette Seto, USFWS regarding comments to *Caspian Tern Site Feasibility Study*, Oregon Department of Fish and Wildlife, Office of Director, Portland, OR.

Kress, S.W. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. Colonial Waterbirds 6: 185-196.

Lemberg, N.A., M.F. O'toole, D.E. Penttila, and K.C. Stick. 1997. 1996 forage fish stock status report. Wash. Dep. Fish. Wildl. Fish Manag. Program. Stock status Report Number 98-1.

Levings, C.D. 1982. Short-term use of a low tide refuge in a sandflat by juvenile Chinook, *(Oncorhynchus tshawytscha)*, Fraser River Estuary. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1111. Department of Fisheries and Oceans, Fisheries Research Branch, West Vancouver, British Columbia.

Levings, C.D., C.D. McAllister, and B.D. Chang. 1986. Differential use of the Campbell River estuary, British Columbia, by wild and hatchery-reared juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 43 (7):1386-1397.

Levy, D.A., T.G. Northcote, and G.J. Birch. 1979. Juvenile salmon utilization of tidal channels in the Fraser River Estuary. Technical Report No. 23. Westwater Research Centre, University of British Columbia, Vancouver, B.C., 70 pages.

Levy, D.A., and T.G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Canadian Journal of Fisheries and Aquatic Sciences 39 (2):270-276.

Marlowe, C., B. Freymond, R.W. Rogers, and G. Volkhardt. 2001. Dungeness River Chinook salmon rebuilding project, Progress Report 1993-1998. Washington Department of Fish and Wildlife, Fish Program Science Division, Report #FPA 00-24, 96 pages.

MacDonald, J.S., I.K. Birtwell, and G.M. Kruzynski. 1986. Food and habitat utilization by juvenile salmonids in the Campbell River Estuary. Canadian Journal of Fisheries and Aquatic Sciences 45:1366-1377.

McClure. M.M, E.E. Holmes, B.L. Sanderson, and C.E. Jordan. 2003. A large-scale, multispecies status assessment: Anadromous salmonids in the Columbia River Basin. Ecological Applications 13(4):964-989.

McEwan D., and T.A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game, 234 pages.

Morey, S.C. 2004. Letter to Nanette Seto, U.S. Fish and Wildlife Service regarding comments to Administrative Review copy of Draft Environmental Impact Statement (EIS) for Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Department of Fish and Game, Sacramento, CA.

Moyle P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern in California. Final Report submitted to State of California Resources Agency.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neeley, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35, Seattle, WA, 443 pages.

NOAA Fisheries [National Marine Fisheries Service]. 1999. Biological Opinion on Corps of Engineers' Columbia River Channel Operation and Maintenance Program. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Northwest Region, Seattle, WA, 29 pages.

NOAA Fisheries [National Marine Fisheries Service]. 2000. Biological Opinion: Federal Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. National Marine Fisheries Service, Northwest Region, Portland, OR.

NOAA Fisheries. 2002. Caspian tern predation on salmon and steelhead smolts in the Columbia River estuary. NOAA Fisheries. Portland, OR, 14 pages.

NOAA Fisheries. 2003a. Report to Congress: Pacific Coastal Salmon Recovery Fund, FY 2000 through FY 2002. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Northwest Region, Seattle, WA, 43 pages.

NOAA Fisheries [National Marine Fisheries Service]. 2003b. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat for the Hood Canal Bridge Retrofit and East Half Replacement Project (WRIAs 15, 17 and 18)(2002-00546). National Marine Fisheries Service, Northwest Region, Seattle, WA.

NOAA Fisheries [National Marine Fisheries Service]. 2003c. NOAA Fisheries, National Marine Fisheries Service, Northwest Regional Office website, www.nwr.noaa.gov.

NOAA Fisheries [Northwest Fisheries Science Center, NMFS/NOAA]. 2004. Caspian tern predation on juvenile salmonid out migrants in the Columbia River estuary. Northwest Fisheries Science Center, NMFS/NOAA, Seattle, WA, 31 pages.

The Oregon Plan for Salmon & Watersheds. 2004. The Oregon plan for salmon and watersheds. Governor's Natural Resources Office. Salem, Oregon. Internet: www.oregon-plan.org

Pacific Fishery Management Council. 1998a. Final environmental assessment/regulatory impact review for Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan (NOAA Award Number NA87FC0008). Pacific Fishery Management Council, Portland, OR, 53 pages.

Pacific Fishery Management Council. 1998b. Coastal Pelagic Species Fishery Management Plan: Amendment 8 to the Northern Anchovy Fishery Management Plan (NOAA Award Number NA87FC0008). Pacific Fishery Management Council, Portland, OR.

Puget Sound Water Quality Action Team. 2002. Puget Sound Update 2002: Eighth Report of the Puget Sound Ambient Monitoring Program. Puget Sound Water Quality Action Team, Olympia WA , 144 pages.

Pearce, T. A., J. H. Meyer, and R. S. Boomer. 1982. Distribution and food habits of juvenile salmon in the Nisqually Estuary, Washington, 1979-1980. U.S. Fish Wildl. Serv., Fish. Assist. Off., Olympia, WA, 77 p. (Available from U.S. Fish and Wildlife Service, Western Washington Fishery Resource Office, 2625 Parkmount Lane, Bldg. A, Olympia, WA 98502-5751.)

Penland, S.T. 1976. The natural history and current status of the Caspian tern *(Hydroprogne caspia)* in Washington State. Masters thesis, University of Puget Sound, WA, 101 pages.

Quigley, T.M., and S.J. Arbelbide. Editors. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins: Volume I. Portland, OR: US Department of Agriculture, Forest Service. General Technical Report. PNW-GTR-405.

Roby, D.D., D.P. Craig, K. Collis, and S.L. Adamany. 1998. Avian predation on juvenile salmonids in the Lower Columbia River, 1997 Annual Report. Prepared for Bonneville Power Administration and U.S. Army Corps of Engineers, 63 pages.

Roby, D.D., K. Collis, D.E. Lyons, D.P. Craig, J.Y. Adkins, A.M. Myers, and R.M. Suryan. 2002. Effects of colony relocation on diet and productivity of Caspian terns. Journal of Wildlife Management 66(3): 662-673.

Roby, D.D., K. Collis, S.K. Nelson, K. Larsen, C. Couch, and P.J. Klavon. 2003a. Caspian tern nesting ecology and diet in San Francisco Bay and Interior Oregon, Final 2003 Annual Report. U.S. Fish and Wildlife Service unpublished report, Portland, OR, 50 pages.

Roby, D.D., D.E. Lyons, D.P. Craig, K. Collis, and G. H. Visser. 2003b. Quantifying the effect of predators on endangered species using a bioenergetics approach: Caspian terns and juvenile salmonids in the Columbia River estuary. Canadian Journal of Zoology 81(2): 250-265.

Ryan B.A., S.G. Smith, J.M. Butzerin, and J.W. Ferguson. 2003. Relative vulnerability to avian predation of juvenile salmonids tagged with passive integrated transponders in the Columbia River estuary, 1998-2000. Transactions of the American Fisheries Society 132: 275-288.

Schwarzbach, S. and T. Adelsbach. *In review*. Assessment of ecological and human health impacts of mercury in the Bay-Delta Watershed. Draft Final Report to Department of Fish and Game, Moss Landing Marine Labs, Moss Landing, CA, 30 pages.

Seto, N., J. Dillon, W.D. Shuford, and T. Zimmerman. 2003. A review of Caspian tern (*Sterna caspia*) nesting habitat: A feasibility assessment of management opportunities in the U.S. Fish and Wildlife Service Pacific Region. U.S. Department of Interior, Fish and Wildlife Service, Portland, OR.

Seubert, J.L. 1990. Reducing gull hazards to aviation by controlling nesting populations. Denver Wildlife Research Center, Denver, CO, 30 pages.

Shreffler, D.K., C.A. Simenstad, and R.M. Thom. 1992. Temporary Residence by Juvenile Salmon in a Restored Estuarine Wetland. Canadian Journal of Fisheries and Aquatic Sciences 47:2079-2084.

Shuford, W.D. and D.P. Craig. 2002. Status assessment and conservation recommendations for the Caspian tern (*Sterna caspia*) in North America. U.S. Department of Interior, Fish and Wildlife Service, Portland, OR, 152 pages.

Sibert, J. 1975. Residence of Juvenile Salmonids in the Nanaimo River Estuary. Environment Canada, Fisheries and Marine Service. Technical Report No. 537, 23 pages.

Smith, G.C. and N. Carlile. 1993. Methods for population control within a silver gull colony. Wildlife Research 20: 219-226.

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: Evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2): 325-333.

Spendelow, J.A. and S.R. Patton. 1988. National atlas of coastal waterbird colonies in the contiguous United States: 1976-82 [Biological Report 88(5)]. Prepared for U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C.

St. Louis, Marty. 1993. Summer Lake Wildlife Area, Long Range Management Plan. Oregon Department of Fish and Wildlife, Portland, OR, 34 pages.

Stober, Q.J., S.J. Walden, and D.T. Griggs. 1971. Juvenile Salmonid Migration Through North Skagit Bay, pages 35-69, *In* Biological Studies of Kiket Island Nuclear Power Site, Q.J. Stober and E.O. Salo, editors. Second Annual Report by Fisheries Research Institute, University of Washington, Seattle, WA.

Strong, C., L. Spear, T. Ryan, and R. Dakin. 2003. Forster's and Caspian tern colonies in the San Francisco Bay: Population sizes and trends, 1982 - 2003. Prepared for U.S. Department of Interior, Fish and Wildlife Service, Portland, OR, 18 pages.

Suryan, R.M., D.P. Craig, D.D. Roby, N.D. Chelgren, K. Collis, W.D. Shuford, and D.E. Lyons. *In review*. Redistribution and growth of the Caspian tern population in the Pacific Coast region of North America, 1981-2000. Submitted to The Condor.

Tabor, J.E. 1976. Inventory of riparian habitats and associated wildlife along the Columbia River. Presented to U.S. Army Corps of Engineers, Wildlife Work Group, OR.

Thompson, B.C., J.A. Jackson, J. Burger, L.A. Hill, E.M. Kirsch, and J.L. Atwood. 1997. Least Tern (*Sterna antillarum*). *In* The Birds of North America, No. 290 (A. Poole and F. Gill eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Thompson, C.W., E.R. Donelan, M.M. Lance, and A.E. Edwards. 2002. Diet of Caspian terns in Commencement Bay, Washington. Waterbirds 25(1): 78-85.

Tynan, T. 1997. Life history characterization of summer chum salmon populations in the Hood Canal and Eastern Strait of Juan de Fuca Regions. Technical Report #H97-06, Washington Department of Fish and Wildlife.

U.S. Army Corps of Engineers. 1988. Fern Ridge Lake, Plan of Management and Development *in* Upper Willamette Valley Projects, Master Plan for Resource Use. U.S. Army Corps of Engineers, Portland District, Portland, OR.

U.S. Army Corps of Engineers. 1999. Caspian tern relocation pilot study Lower Columbia River Clatsop County, Oregon. Finding of No Significant Impact and Environmental Assessment, U.S. Army Corps of Engineers, Portland District, Portland, OR, 34 pages.

U.S. Army Corps of Engineers. 2000. Caspian tern relocation FY 2000 management plan and pile dike modification to discourage cormorant use, Lower Columbia River, Oregon and Washington. Finding of No Significant Impact and Environmental Assessment, U.S. Army Corps of Engineers, Portland District, Portland, OR, 59 pages.

U.S. Army Corps of Engineers. 2001. Columbia River Channel Improvements Project, Biological Assessment. U.S. Army Corps of Engineers, Portland District, Portland, OR.

U.S. Army Corps of Engineers. 2002. Caspian tern interim management plan FY 2003-2004 and pile dike modification to discourage Cormorant use, Lower Columbia River, Oregon. Finding of No Significant Impact and Environmental Assessment, U.S. Army Corps of Engineers, Portland District, Portland, OR, 46 pages.

U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and Bonneville Power Administration. 2003. Endangered Species Act 2003 Check-In Report for the Federal Columbia River Power System.

U.S. Fish and Wildlife Service. 1995. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 1996. Management of public use for Dungeness National Wildlife Refuge. Finding of No Significant Impact and Environmental Assessment. U.S. Fish and Wildlife Service, Olympia, WA.

U.S. Fish and Wildlife Service. 2002a. Biological Conference Opinions for the Columbia River Channel Improvements Project. U.S. Department of the Interior, Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service. 2002b. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, VA, 99 pages.

U.S. General Accounting Office. 2002. Columbia River salmon and steelhead. Federal agencies recovery responsibilities, expenditures, and actions. GAO-02-612.

Vogel, D.A. and K.R., Marine. 1991. Guide to the Upper Sacramento River Chinook salmon life history. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. 55p. With references.

Wachtel, M. 2000. Dolly varden/bull trout reported catch by northern pikeminnow sport-reward fishery project. State of Washington, Department of Fish and Wildlife, Fish Management Program, Native Resident Fish Division. Memo from Mark Wachtel, Fish and Wildlife Biologist to Jim Byrne, Fish and Wildlife Biologist. Dated March 10, 2000.

Wallace M., and B.W. Collins. 1997. Variation in the use of the Klamath River estuary by juvenile chinook salmon. California Fish and Game 83(4): 132-143.

Waples, R.S., R.P. Jones, Jr., B.R. Beckman, and G.A. Swan. 1991. Status review for Snake River fall Chinook salmon. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS F/NWC-201, 73 pages.

Weitkamp, L.A., T.C. Wainwright, G.W. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status Review of Coho Salmon from Washington, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Science Center. NOAA Technical Memorandum NMFS-NWFSC-24.

Wilson, P.H. 2003. Using population projection matrices to evaluate recovery strategies for Snake River spring and summer Chinook salmon. Conservation Biology 17 (3):782-794.

Wires, L. R. and F.J. Cuthbert. 2000. Trends in Caspian tern numbers and distribution in North America: A review. Waterbirds 23(3): 388-404.

B.2 Federal Register Notices

68 FR 16826. Notice of Intent to prepare an Environmental Impact Statement for Caspian tern management in the Columbia River estuary and notification of six public scoping meetings, April 7, 2003.

58 FR 53800. Endangered and Threatened Wildlife and Plants: Determination of endangered status for the Oregon chub, October 18, 1993.

68 FR 4433. Endangered and Threatened Wildlife and Plants; 12 month finding on a petition to list North American green sturgeon as a threatened or endangered species, January 29, 2003.

Appendix C.

Caspian Tern Predation on Juvenile Salmonid Outmigrants in the Columbia River Estuary

Northwest Fisheries Science Center
NMFS/NOAA
Seattle, Washington

June 1, 2004

Contributors: Thomas P. Good, Katherine Barnas, Douglas M. Marsh, Michelle M. McClure, Brad A. Ryan, Benjamin P. Sandford and Edmundo Casillas

TABLE OF CONTENTS

EXECUTIVE SUMMARY 4

BACKGROUND 4

CASPIAN TERNS..6

ESTIMATING PREDATION IMPACTS 7

RELOCATION EFFORTS..9

PREDATION IMPACT OF CASPIAN TERNS ON EAST SAND ISLAND.............................10

ADDITIONAL AVIAN PREDATION IMPACTS..15

AVIAN PREDATION IMPACTS UPRIVER OF THE COLUMBIA RIVER ESTUARY 16

CONCLUSIONS..16

REFERENCES 17

LIST OF TABLES

Table 1 - Estimates of the number of the available juvenile salmonids reaching the estuary and being consumed by Caspian terns in the Columbia River estuary 1997 – 2002……….7

Table 2 - Ratio of PIT tags detected per Caspian tern nesting pair on East Sand Island in 1999 and 2002……………………………………………………………………….....9

Table 3 - Estimates of nesting population, the number of steelhead consumed, the number of steelhead available, and predation rates of Caspian terns nesting on East Sand Island..10

Table 4 - Estimated predation rate and percent increase in the population growth rate (λ) of all steelhead in the Columbia River basin given a range of population sizes of Caspian Terns breeding on East Sand Island and assuming a linear relationship between Caspian Tern breeding population size and predation rates using (a) recovery of PIT-tags and (b) bioenergetics modeling……………………………………………………………...12

Table 5 - Estimated predation rates, % increase in λ predicted from predation rates at those levels, and population growth rate(λ) of four of the five listed steelhead ESUs in the Columbia River basin given a range of population sizes of Caspian Terns breeding on East Sand Island and assuming a linear relationship between Caspian Tern breeding population size and predation rates from ESU-specific PIT-tag recoveries…………...14

Table 6 - Potential increases in population growth rate of Columbia River basin steelhead ESUs corresponding to passage improvements in the Federal Columbia River Hydropower System and elimination of harvest……………………………………………………..15
Table 7 - Comparison of estimated predation rates for Double-crested cormorants and Caspian terns breeding on East Sand Island on all steelhead in the Columbia River basin using PIT-tag recoveries……………………………………………………………………...15
Table 8 - Estimated predation rates for Caspian terns and Double-crested cormorants breeding on East Sand Island on four of the five ESA-listed steelhead ESUs in the Columbia River basin..……………………..…………………………………………………………16
Table 9. Estimated predation rates for Caspian terns and all birds breeding on Crescent Island on all steelhead ESUs in the Columbia River basin.…………………….………………..16

LIST OF FIGURES

Figure 1 - Map of the Columbia River estuary showing the locations of the East Sand Island and Rice Island Caspian tern nesting colonies……………………………………………..21
Figure 2 - Map of Columbia River Basin showing the ESA-listed ESUs……………………….22
Figure 3 - Numbers of Caspian terns utilizing islands in the Columbia River estuary for nesting 1984 – 2002…………………………………………………………………………23
Figure 4 - Arrival times of juvenile salmonids and nesting period of Caspian terns in the Columbia River estuary……………………………………………………………..24
Figure 5 - Estimated predation rates on all steelhead in the Columbia River estuary by Caspian Terns (1999-2002) using bioenergetics modeling and recovery of PIT tags…………..25
Figure 6 - Linear regression of predation rates on all steelhead in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using bioenergetics modeling……………………………………………………………………………26
Figure 7 - Linear regression of predation rates on all steelhead in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using recovery of PIT tags……………………………………………………………………………...27
Figure 8 - Linear regression of predation rates on the Snake River steelhead ESU in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using recovery of PIT tags………………………………………………….28
Figure 9 - Linear regression of predation rates on the Upper Columbia River steelhead ESU in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using recovery of PIT tags…………………………………………...29
Figure 10 - Linear regression of predation rates on the Middle Columbia River steelhead ESU in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using recovery of PIT tags…………………………………………...30
Figure 11 - Linear regression of predation rates on the Lower Columbia River steelhead ESU in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using recovery of PIT tags…………………………………………...31

EXECUTIVE SUMMARY

- Relatively new human-constructed islands in the Columbia River estuary have provided breeding habitat for Caspian terns, where they have been able to successfully exploit juvenile salmonids as a food resource.
- The effect of Caspian tern predation: varies between years, varies among salmonid species, is greatest on steelhead, and is lowest on wild yearling chinook.
- Caspian tern predation on juvenile salmonids reduces salmon population growth rate and thus recovery, however, removing all tern predation will not-- by itself--lead to full recovery of any listed salmon and steelhead stock.
- The effect of Caspian tern predation on recovery may be comparable to fish passage improvements at Columbia River dams and harvest reductions for some Evolutionarily Significant Units.
- Relocating Caspian terns to habitat closer to the mouth of the Columbia River significantly reduced predation impact on juvenile salmon.
- Additional PIT tag data needs to be collected and evaluated to validate initial predation rates at East Sand Island.

BACKGROUND

The ecosystems inhabited by anadromous salmonids are extensive and complex. In the case of upper Columbia River and Snake River salmon and steelhead, their range extends inland as far as 1500 km and rise to elevations of 2500 m above mean sea level. Their oceanic range extends through the North Pacific Ocean to the Bering Sea and the Sea of Japan. Climate conditions and human activities have had adverse affects on water flows, river conditions, spawning and rearing habitat, ocean productivity, and eventually, salmonid survival and productivity. Wild and naturally reproducing stocks of steelhead have declined dramatically in the interior Columbia River Basin (McClure *et al.* 2003). Wild and naturally reproducing spring- and summer-run chinook stocks also have declined dramatically throughout the Pacific Northwest. As a result, nearly every population of naturally producing anadromous salmonids in the Columbia River Basin is now listed (or is a candidate for listing) under the Endangered Species Act (ESA).

Salmonids experience high mortality rates as juveniles in freshwater, the estuary and early ocean, leading researchers to suggest that reducing mortality during the juvenile stage has the potential to increase population growth rates (Kareiva *et al.* 2000). Although significant mortality of juvenile salmonids occurs in the ocean, our ability to influence ocean survival is limited. Therefore, improvements in freshwater survival and production are imperative and can directly affect the number of returning adult salmonids (Raymond 1988, Beamesderfer *et al.* 1996).

Many of the measures taken to restore anadromous salmonid production in the Columbia River Basin have focused on improving the survival of juvenile migrants through the mainstem dams. Various life-cycle models indicate that mortality of juveniles during migration in freshwater constrains anadromous salmonid production in the Columbia River Basin, thereby reducing the benefits of enhancement measures upstream (Beamesderfer *et al.* 1996, Kareiva *et al.* 2000). Increasing populations of piscivorous birds (primarily Caspian terns) nesting on islands in the Columbia River estuary annually consume large numbers of migrating juvenile salmonids (Roby *et al.* 1998) and thus constitute one of the factors that currently limit salmonid stock recovery (Roby *et al.* 1998; Independent Multidisciplinary Science Team 1998; Johnson *et al.* 1999). Therefore, reducing Caspian tern predation in the estuary, is one potential mechanism to reduce mortality, thereby increasing population growth rates of Endangered Species Act (ESA) listed salmonid Evolutionarily Significant Units (ESUs)[1] in the Columbia River Basin.

Anthropogenic changes in the Columbia River Basin appear to have facilitated increases in populations of colonial waterbirds. The largest recorded colony of Caspian terns in the world now occupies East Sand Island—a natural island that has been augmented by depositing upon it dredge material from maintaining a navigation channel in the Columbia River estuary (Roby *et al.* 1998). There, the terns feed on large numbers of migrating juvenile salmon and steelhead, and basin-wide losses to avian predators now constitute a substantial proportion of individual salmonid runs (Roby *et al.* 1998).

In the early 1990s, National Marine Fisheries Service (NOAA Fisheries) staff at the Point Adams Field Station noted substantial increases in the size of newly established Caspian tern nesting colonies on Rice Island in the Columbia River estuary. Several estuary islands on which piscivorous birds nest (Fig. 1) were created from or augmented by materials dredged to maintain the Columbia River Federal Navigation Channel. Before 1984, there were no recorded observations of terns nesting in the Columbia River estuary, when approximately 1000 pairs apparently moved from Willapa Bay to nest on newly deposited dredge material on East Sand Island. In 1986, those birds moved to Rice Island, an island created by the Army Corps of Engineers for the purpose of dredge disposal. The Caspian tern colonies in the estuary have since expanded to 9,000-10,000 pairs, the largest ever reported. In 1999, the colony was encouraged to relocate to East Sand Island. In 2001, the majority of the West Coast population nested on just four acres on East Sand Island; in 2002, the terns nested on six acres.

Because of the growing concern over the increasing impacts of avian predation on salmonid smolts, NOAA Fisheries required the Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers (USACE) to study avian predation in the Columbia River estuary and, if necessary, develop potential measures for managing the predator populations. These requirements were part of the 1995 Formal Consultation on the Operation of the Federal Columbia River Power System and Juvenile Transport Program (NMFS 1995). Oregon State University (OSU) and the Columbia River Inter-Tribal Fish Commission (CRITFC) began the research in 1996. The losses of salmonid smolts to newly established and expanding numbers of avian predators is of concern as currently 12 ESUs of anadromous salmonids native to the Columbia River Basin are listed as threatened or endangered under the ESA (Fig. 2).

As avian predation on salmonids is a multi-jurisdictional issue, NOAA Fisheries, the U. S. Army Corps of Engineers, U.S. Fish and Wildlife Service, the Bonneville Power Administration, the

---

[1] Under the Endangered Species Act, the National Marine Fisheries Service (NOAA Fisheries) lists species, subspecies and distinct population segments of vertebrates. NOAA Fisheries policy stipulates that a salmon population will be considered distinct if it represents an "evolutionary significant unit" (ESU) of the biological species (Waples 1991). For the purposes of conservation under the ESA, an Evolutionarily Significant Unit (ESU) is a distinct population segment that is substantially reproductively isolated from other conspecific population units and represents an important component in the evolutionary legacy of the species (Waples 1991).

Columbia River Inter-Tribal Fish Commission, and resource agencies of the states of Washington, Idaho and Oregon formed the Caspian Tern Working Group (CTWG) to develop a long-term management plan for reducing tern predation in the estuary. As part of this effort, NOAA Fisheries is evaluating the overall risk that tern predation presents to listed salmonid populations.

The intent of this document is to summarize what is known about Caspian tern predation impacts to salmonids in the Columbia River estuary. We have included a summary of Caspian tern populations in the Columbia River basin and estimates of predation rates gained from recovery of PIT tags and bioenergetics modeling. We have also included analyses of predation impacts on ESA-listed steelhead through the use of a life-cycle model that focuses on Caspian terns nesting on East Sand Island since their relocation from Rice Island. This information will be useful to resource managers to develop management options to reduce predation impacts.

CASPIAN TERNS (*Sterna caspia*)

Caspian terns are highly migratory and are nearly cosmopolitan in distribution (Harrison 1983; Harrison 1984). In North America, nesting has been reported on the west coast from Baja, California to the Bering Sea, in the interior from the Gulf Coast of Texas to Lake Athabasca, Saskatchewan, and on the east coast from the Florida panhandle to Labrador. Outside of North America, nesting has been reported in Australia, New Zealand, South Africa, Asia, and Europe.

Caspian Terns winter primarily on the Pacific coast from southern California south through west Mexico and Central America (Shuford and Craig 2002). Early estimates of the Pacific Northwest population were as many as 500 pairs nesting with gulls and cormorants as far north as Klamath Lakes in Oregon (Harrison 1984). Nesting colonies were first discovered in Washington near Moses Lake and Pasco in the 1930s, but coastal colonies were not recorded until the late 1950s, when one was found in Grays Harbor (Alcorn 1958, Penland 1976, 1981). Since the early 1960s, the population has shifted from small colonies in interior California and southern Oregon to large colonies nesting on human-created habitats along the coast (Gill and Mewaldt 1983). The current population in the Columbia River basin is part of a dramatic northward and coastward expansion in range and an overall increase in Caspian tern numbers in western North America.

The numbers of Caspian terns in western North America more than doubled between 1980 and 1999 (Cuthbert and Wires 1999). One reason for the increase is that human-created habitat provides high quality nest sites and is associated with population increases in many parts of North America (Cuthbert and Wires 1999). In the Columbia River estuary, Caspian terns have increased from a few scattered individuals before 1984 to nearly 10,000 pairs in 2002 (Fig. 3).

Caspian terns arrive in the Columbia River estuary in April and begin nesting at the end of the month (Roby *et al.* 1998). To avoid mammal and avian predators, terns construct their nests on islands (Harrison 1984) and show a preference for barren sand. They are piscivorous in nature (Harrison 1984), requiring about 220 grams (roughly one-third of their body weight) of fish per day during the nesting season. The timing of courtship, nesting and chick rearing corresponds with the outmigration of many of the salmonid stocks in the basin (Collis *et al.* 2002) (Fig. 4).

ESTIMATING PREDATION IMPACTS

One approach to evaluating the extent of Caspian tern predation and resultant salmonid mortality uses bioenergetics modeling. Since 1997, biologists with the Bonneville Power Administration-funded research project ("Avian Predation on Juvenile Salmonids in the Lower Columbia River," - a joint project of Oregon State University, the U. S. Geological Survey, the Columbia River Inter-Tribal Fish Commission, and Real Time Research Consultants) have used observed salmonid consumption at tern colonies in a bioenergetics model (Roby *et al.* 1998) to estimate the consumption of salmonids in the Columbia River estuary.

This analytical approach indicates that salmon and steelhead constituted a major portion of tern diets, particularly when the birds nested on Rice Island. Diet analyses indicated that juvenile salmonids constituted 77.1% of prey items in 1997 and 72.7% of prey items in 1998 of Caspian terns nesting on Rice Island (Collis *et al.* 2002). During the peak of smolt out-migration of steelhead, yearling chinook salmon, and coho salmon through the estuary, when Caspian terns are in their incubation period in May, the diet of Caspian terns was consistently over 90% juvenile salmonids (Collis *et al.* 2002). This concentration on smolts as a food source translates into substantial juvenile mortality during the outmigration period.

Smolt consumption and the number of smolts estimated to reach the estuary from 1999 to 2002 is given in Table 1. The smolt consumption data is estimated from bioenergetics modeling, while the latter is estimated from data on fish passing through the hydropower system or transported around the system and released below Bonneville Dam. Smolt estimates are comprised only of steelhead, yearling chinook and hatchery coho, and should not be thought of as absolute totals. Estimates for subyearling chinook are not included, as their expansions are based on few data and thus not reliable, and they outmigrate later in the season and are subject to less predation pressure from terns. Estimates for chum are also not included as their outmigration is earlier in the season and they are thus subject to less predation pressure from terns.

Table 1. Estimates of outmigrating steelhead, yearling chinook and hatchery coho smolts reaching the estuary[a] and of juvenile salmonids consumed by Caspian terns in the Columbia River estuary 1997-2002.

Year	Number of smolts reaching estuary in millions	Number of smolts consumed in millions (95% C.I.)
1999	63.1	11.7 (9.4 - 14.0) [b]
2000	65.6	7.3 (6.1 - 8.6) [b]
2001	60.6	5.9 (4.8 - 7.0) [b]
2002	55.5	6.5 (5.5 – 7.6) [c]

[a] Data from NOAA Fisheries Fish Ecology Division, Sustainable Fisheries Division and Fish Passage Center. Includes estimated numbers of hatchery coho salmon only, no estimates are available for wild coho. Since no values for coho survival through the power system are available, estimates of survival of hatchery coho through the system were developed through the use of SIMPAS (NMFS 2000a) values for yearling chinook.
[b] Collis *et al.* 2001a [c] Collis *et al.* 2002

Another approach uses detections of passive integrated transponders (PIT) tags on Caspian tern colonies to estimate salmonid predation rates overall as well as by ESU (Collis *et al.* 2001b, Ryan *et al.* 2001). In 1997 and 1998, 1 - 2 million ESA-listed salmonid smolts entered the Columbia River estuary, representing 1 - 2 % of all salmonid smolts migrating to the estuary. However, in 1999, seven additional ESUs of anadromous salmonids in the Columbia River Basin were listed, and roughly 6 million ESA-listed salmonid smolts entered the estuary along with over 80 million unlisted smolts, which were primarily of hatchery origin. The majority of juvenile salmonids in the estuary are of hatchery origin and the majority being consumed by Caspian terns are hatchery fish (Independent Multidisciplinary Science Team 1998). Overall, Caspian terns consumed approximately 6% to 14% of the estimated outmigrating population of juvenile salmonids originating from the Columbia River basin.

Since 1987, researchers in the Columbia River basin have placed over five million PIT tags in juvenile salmonids for a variety of studies (Ryan *et al.* 2001). Identifying PIT tags on bird colonies can provide a minimum estimate of proportion of the stocks that were consumed by terns in these colonies. In recent years, approximately one million juvenile salmonids have been PIT-tagged annually (Collis *et al.* 2001b), the vast majority of which are steelhead and chinook from the Snake River basin. Using PIT tag detection equipment, over 115,000 PIT tags were detected on Rice Island in 1998 and 1999 (Ryan *et al.* 2001). Collis *et al.* (2001b) indicate that the majority of these PIT tags detected were from steelhead and chinook, coho and sockeye salmon. Of the PIT tags placed in steelhead smolts in 1997 that were detected at Bonneville dam, 2.8% of wild smolts and 5.4% of hatchery-raised smolts were subsequently detected on the Rice Island tern colony (Collis *et al.* 2001b). For steelhead PIT-tagged in 1998 and detected at Bonneville Dam, 11.7% of wild smolts and 13.4% of hatchery-raised smolts were subsequently detected on the Rice Island tern colony (Collis *et al.* 2001b). For yearling chinook salmon PIT-tagged in 1998 and detected at Bonneville Dam, 0.5% of wild smolts and 1.6% of hatchery-raised smolts were subsequently detected on the Rice Island tern colony (Collis *et al.* 2001b). PIT tag data also determined that steelhead experienced higher predation rates (0.6% to 8.1% on East Sand Island and 1.3% to 9.4% on Rice Island) than chinook salmon (0.2% to 2.0% on East Sand Island and 0.6% to 1.6% on Rice Island).

There are some important uncertainties from estimating predation rates for Caspian terns. Predation impacts derived from PIT tags, while more direct than those derived from bioenergetics models, represent minimum estimates of the proportion of stocks consumed--an unknown number of tags are regurgitated/defecated off-colony or removed by wind and water erosion, tags may be damaged and undetectable, and not all tags are detected (Ryan *et al.* 2001, Collis *et al.* 2001b, Collis *et al.* 2002). Also, predation rates vary annually and by the methodology used to make the estimate, making it difficult to derive a single predation rate. Although there is good correspondence of predation rates between methodological estimates, utilizing the upper and lower bounds of the predation rates to bracket potential recovery improvements represent the most reliable approach that currently should be used to assess potential impacts of smolt predation by Caspian terns. Finally, it is clear that predation rates are not uniform for all salmon species, thus evaluation of the impact of Caspian tern predation should be species or ESU-specific, to the extent possible.

RELOCATION EFFORTS

Efforts to relocate the terns to East Sand Island began in 1999, and these efforts have apparently succeeded in reducing consumption of smolts without affecting tern productivity. The Caspian Tern Working Group relocated the Caspian tern colony from Rice Island to East Sand Island--a site lower in the estuary with abundant alternate prey sources--in an attempt to decrease losses of juvenile salmonids. Over the last few years, consumption of salmonids in the estuary has been lower than previously, while consumption of alternative prey species has increased. Relocating the colony to East Sand Island, which is lower in the estuary and closer to periodically abundant Pacific herring [Clupeidae] and anchovies [Engraulidae] has contributed to the reduction. In 2000, salmonid consumption for both islands combined was estimated at 7.3 million smolts, which is 4.4 million less than in 1999--the last time a substantial number of terns nested on Rice Island (Collis *et al.* 2001a, USFWS 2001). In 2001, salmonid consumption was estimated at 5.9 million smolts, which is 5.9 million less than in 1999 (Collis *et al.* 2001a).

Caspian tern diets also shifted following relocation from Rice Island. Observed diets, which consisted of almost exclusively salmonids at Rice Island (77% in 1999 and 90% in 2000), shifted to 46%, 47% and 33% salmonids at East Sand Island in 1999, 2000 and 2001 respectively (Collis *et al.* 2001a, Roby *et al.* 2003). These data represent substantial declines in juvenile salmonid mortalities from Caspian tern predation. These observational data were substantiated by PIT tag detections on the two islands in 1999 and 2002. Significantly fewer PIT tags detected per nest on East Sand Island in 1999 and 2000 than were detected on Rice Island in 1999 and 2000 (Table 2).

Table 2. Ratio of PIT tags detected per Caspian tern nesting pair on East Sand Island and Rice Island in 1999 and 2000.

	1999	**2000**
Rice Island	0.59	1.25
East Sand Island	0.32	0.35

In addition to reductions in Caspian tern predation on juvenile salmonids, relocation efforts have not significantly impaired Caspian tern reproductive performance. Nesting success has been substantially higher for Caspian terns nesting on East Sand Island as compared to Rice Island (Roby *et al.* 2003), and productivity at East Sand Island in 2001 was the highest recorded for terns nesting in the estuary (Collis *et al.* 2001a). It appears that relocating terns to East Sand Island accomplished the goal of reducing consumption of juvenile salmon without adversely affecting tern population growth rates.

PREDATION IMPACT OF CASPIAN TERNS ON EAST SAND ISLAND

Data and Analyses

In this report, we focus on predation on steelhead by Caspian terns nesting on East Sand Island from 1999-2002. We focus on steelhead because they are the most heavily affected of the outmigrating juvenile salmonids (Ryan *et al.* 2003, Roby *et al.* 2003); estimates of the potential benefit of reducing Caspian tern predation are thus the greatest for steelhead and would encompass potential benefits afforded to other salmonid species. We focus on the Caspian tern colonies on East Sand Island in the lower estuary of the Columbia River, because the colony represents the majority of the West Coast Caspian tern population, and we focus on 1999-2002 because this represents the time period, after relocation from Rice Island, during which this colony has persisted in the Columbia River estuary. In general, both analytical techniques (PIT tag detections; bioenergetics modeling) found a positive relationship between the number of Caspian terns on East Sand Island and the predation rate on juvenile salmonids*, i.e.* the proportion of available juvenile salmonids consumed (Fig. 5).

Bioenergetics modeling, which has been used to estimate the effect of Caspian tern predators on juvenile salmonids on Rice Island (Roby *et al.* 2003), was used to calculate predation rates (%) (estimated # of steelhead consumed/estimated # of steelhead available in the estuary x 100) using updated and refined estimates of the number of outmigrating steelhead that run the river or are transported to below Bonneville Dam (Table 3; Fig. 6).

Table 3. Estimates of nesting population, the number of steelhead consumed, the number of steelhead available, and predation rates of Caspian terns nesting on East Sand Island using bioenergetics modeling (D. Lyons and D. Marsh, unpublished data).

Year	# tern pairs	# of steelhead consumed	# of steelhead available	Predation Rate % (95% C.I.)
1999	547	72,844	13,501,917	0.5 (0.3 - 0.8)
2000	8513	842,433	13,359,935	6.3 (4.4 - 8.3)
2001	8982	571,441	13,560,423	4.2 (3.2 - 5.2)
2002	9933	741,772	12,124,528	6.1 (4.8 - 7.4)

Although the relationship between tern abundance and predation rate is not known with certainty, possibilities include linear, exponential, asymptotic, and logistic. A simple linear response of the predation rate on all steelhead to the number of Caspian terns nesting on East Sand Island during the breeding seasons of 1999-2002 appears to describe the relationship.[2] Further support for a linear relationship between estimates of predation rate and the number of terns nesting on East Sand Island comes from per capita consumption rates (# of smolts consumed/adult tern), which have been relatively constant throughout the range of colony sizes

[2] Analyses of influence statistics on linear regressions of PIT tag recoveries on Caspian Tern numbers demonstrated that the 1999 data point exacted little leverage on the regression analyses (P. Wilson, USFWS, unpublished data). He concluded that regressions including the 1999 data resulted in reasonable representations of the data, provided they were modeled through the origin.

on East Sand Island from 1999-2003. The per capita consumption rate in 1999 (mean = 437.5 salmonids) was virtually the same as that in 2000 (mean = 431.1 salmonids), despite a ten-fold difference in Caspian Tern numbers (1094 in 1999 vs 17,026 in 2000) (D. Roby and D. Lyons, unpublished data). A relatively constant per capita consumption rates for salmonids has also been seen on Rice Island over a range of tern population numbers from 1997-2000. The per capita consumption rate on Rice Island in 1999 (mean = 784.1 salmonids) was virtually the same as in 2000 (mean = 739.7 salmonids) despite a ten-fold difference in colony size (8328 nesting pairs in 1999 vs. 588 nesting pairs in 2000) D. Roby and D. Lyons, unpublished data). This suggests that the Caspian Tern predation rate is not affected by prey availability, at least over the range of values experienced from 1999-2003. While non-linear relationships described the data just as well as the linear one, per capita consumption rates associated with an exponential relationship (increasing with an increase in terns), logistic relationship (parabolic over the range of tern numbers), or asymptotic relationship (decreasing with an increase in tern numbers) were not observed.

As both analytical techniques produced similar results, we focus on the PIT tag detection analytical technique--which has also been used to estimate the effect of Caspian tern predators on juvenile salmonid outmigrants (Ryan *et al.* 2003)--to calculate estimates of predation rates on steelhead. Moreover, as the PIT tag detection approach makes possible ESU-specific predation rate estimates, subsequent analyses presented use PIT tag predation rates. Estimates of predation rates (%) from this approach (# PIT tags detected on East Sand Island/# PIT tags detected at Bonneville Dam x 100) also showed a linear response to the number of Caspian terns nesting on East Sand Island during the breeding seasons of 1999-2002 (Figure 7).

We then used these estimates of predation rate (derived from the number of terns) to derive the likely impact on the overall population trajectory for steelhead in the Columbia River. We first calculated the median population growth rate lambda (λ) using the methods in Holmes (2001) and McClure *et al.* (2003). These methods have been: developed for data sets with high sampling error and age-structure cycles (Holmes 2001), extensively tested using simulations for threatened/endangered populations as well as for low-risk stocks (Holmes 2004), and have been cross-validated with time series data (Holmes and Fagan 2002). We chose this parameter for two reasons. First, population growth rate is an essential parameter in viability assessments and a primary predictor of extinction risk. Second, calculating population growth rate in this manner (annualized), provides a standard metric for comparison between species (or ESUs) with different generation times.

We next calculated the deterministic change in population growth rates given standard reductions in mortality. Because the vast majority of steelhead in the interior Columbia are semelparous, the percent increase in λ attributable to an increase in survival at a particular life history stage can be approximated as:

$$\Delta\lambda = = \left[\left(\frac{S_{new}}{S_{old}} \right)^{1/G} - 1 \right] \times 100$$

where S_{old} is the initial survival rate before recovery action, S_{new} is the survival rate following the recovery action, and G is the average generation time (McClure *et al*. 2003). This calculation assumes that the change in survival due to tern predation is independent of density and of changes in survival elsewhere in the salmonid life history. We did not use a formal Leslie matrix analysis to estimate changes in population growth rates because data to parameterize a detailed model for steelhead were not available.

We estimated the impact of Caspian tern predation on the population growth rate (λ) of all steelhead in the Columbia River basin to compare predation rate estimates from bioenergetics modeling and PIT tag detection approaches. Because of the similarity in the results between the two approaches, we present both for comparative purposes (Table 4).

Table 4. Estimated predation rate (PR) and percent increase in the population growth rate (λ) of all steelhead in the Columbia River basin if populations of Caspian Terns breeding on East Sand Island are reduced to that number, assuming a linear relationship between predation rates and Caspian Tern breeding population size (see Figs. 7-8). Calculations used the predation rate estimated for 20,000 terns from linear regressions of (a) ***recovery of PIT-tags*** and (b) ***bioenergetics modeling***, and the generation time for the Snake River basin*.

(a)

Number of tern pairs	PR	Increase in λ (%)
10000	8.7	0.0
9375	8.1	0.1
8750	7.6	0.2
8125	7.0	0.4
7500	6.5	0.5
6875	6.0	0.6
6250	5.4	0.7
5625	4.9	0.9
5000	4.3	1.0
4375	3.8	1.1
3750	3.2	1.2
3125	2.7	1.3
2500	2.2	1.4
1875	1.6	1.6
1250	1.1	1.7
625	0.5	1.8
0	0.0	1.9
	4.79*	

(b)

Number of tern pairs	PR	Increase in λ (%)
10000	6.1	0.0
9375	5.7	0.1
8750	5.3	0.2
8125	4.9	0.3
7500	4.6	0.3
6875	4.2	0.4
6250	3.8	0.5
5625	3.4	0.6
5000	3.0	0.7
4375	2.6	0.7
3750	2.3	0.8
3125	1.9	0.9
2500	1.5	1.0
1875	1.1	1.1
1250	0.8	1.2
625	0.4	1.2
0	0.0	1.3
	4.79*	

The predation rate for 10,000 Caspian tern pairs on all steelhead was estimated using the regression equations generated using both approaches. Reductions in predation rate corresponding to lowered tern population sizes were used to model the potential increase in λ, assuming all steelhead mortality attributable to terns is not compensated for by mortality due to other sources. The maximum proportional increase in λ corresponding to complete elimination of mortality due to tern predation was 1.9% using the PIT-tag estimate of predation rate and 1.3% using the bioenergetics modeling estimate of predation rate; the proportional increase in λ corresponding to a 50% reduction of mortality due to tern predation was 0.97% using the PIT-tag estimate of predation rate and 0.67% using the bioenergetics modeling estimate of predation rate.

To investigate how variation in generation times in Columbia River basin steelhead influenced model output, we also estimated the potential increase in λ using the recovery of PIT tags for all steelhead using the range of generation times (4.27 – 4.85) that have been estimated for steelhead ESUs in the Columbia River basin. This resulted in maximum increases in λ (corresponding to a minimum breeding population size of 0 tern pairs) that ranged from a low of 1.88% to a high of 2.44%.

As the PIT tag detection approach enables ESU-specific estimates of predation rate (and hence proportion increase in λ), we used the life-cycle model to estimate impact of Caspian tern predation on the population growth rate (λ) of steelhead ESUs using predation rates estimated from PIT tag detections (Table 5). Predation rates for 10,000 Caspian tern pairs on four of the five ESA-listed steelhead ESUs were estimated using linear regression (Figs. 8-11). Reductions in predation rate corresponding to lowered tern population sizes were used to model the potential increase in λ, again assuming all steelhead mortality attributable to terns is additive, *i.e.* not compensated for by mortality due to other sources. The maximum proportional increase in λ corresponding to complete elimination of mortality due to tern predation ranged from 1.6% to 4.9% under the most optimistic assumptions (hatchery fish do not reproduce) and 0.7% to 1.0% under the most pessimistic assumptions (hatchery fish reproduce at the same rate as wild-born fish).

Although this analysis was restricted to assessing the potential effects of reducing Caspian tern predation, McClure *et al*. (2003) estimated the effects of other potential conservation actions, including changes to the hydropower system and reductions in harvest. Because these estimates were calculated using similar methods, they are comparable to our results, and we present them here to provide context.

Table 5. Estimated predation rates (PR), % increase in λ predicted from predation rates at those levels, and population growth rate λ) of four of the five listed steelhead ESUs in the Columbia River basin given a range of pairs of Caspian Terns breeding on East Sand Island. Calculations used the predation rate estimated from the linear regression of ESU-specific PIT-tag recoveries (see Figs. 7-10). Generation times* and lambda values (1980-2000) for each ESU are taken from McClure *et al.* (2003), where λ has been estimated under different assumptions about hatchery fish reproduction (λ = hatchery fish on the spawning grounds do not reproduce and λ_h = hatchery fish reproduce at the same rate as wild-born fish).

	Snake River				Upper Columbia River				Middle Columbia River				Lower Columbia River			
# Pairs	PR	% Δ λ	λ	λ_h	PR	% Δ λ	λ	λ_h	PR	% Δ λ	λ	λ_h	PR	% Δ λ	λ	λ_h
10000	8.7	0.0	1.02	0.96	16.4	0.0	1.00	0.63	8.7	0.0	0.97	0.95	6.9	0.0	0.92	0.81
9375	8.2	0.1	1.02	0.96	15.3	0.3	1.00	0.63	8.2	0.1	0.97	0.95	6.5	0.1	0.92	0.81
8750	7.6	0.2	1.02	0.96	14.3	0.6	1.01	0.63	7.6	0.2	0.97	0.95	6.1	0.2	0.92	0.81
8125	7.1	0.4	1.02	0.96	13.3	1.0	1.01	0.64	7.1	0.4	0.97	0.95	5.6	0.3	0.92	0.81
7500	6.5	0.5	1.02	0.96	12.3	1.3	1.01	0.64	6.5	0.5	0.98	0.96	5.2	0.4	0.92	0.81
6875	6.0	0.6	1.03	0.97	11.2	1.6	1.02	0.64	6.0	0.6	0.98	0.96	4.8	0.5	0.92	0.81
6250	5.4	0.7	1.03	0.97	10.2	1.9	1.02	0.64	5.4	0.7	0.98	0.96	4.3	0.6	0.93	0.82
5625	4.9	0.9	1.03	0.97	9.2	2.2	1.02	0.64	4.9	0.8	0.98	0.96	3.9	0.7	0.93	0.82
5000	4.4	1.0	1.03	0.97	8.2	2.5	1.02	0.65	4.4	1.0	0.98	0.96	3.5	0.8	0.93	0.82
4375	3.8	1.1	1.03	0.97	7.2	2.8	1.03	0.65	3.8	1.1	0.98	0.96	3.0	0.9	0.93	0.82
3750	3.3	1.2	1.03	0.97	6.1	3.1	1.03	0.65	3.3	1.2	0.98	0.96	2.6	1.0	0.93	0.82
3125	2.7	1.3	1.03	0.97	5.1	3.4	1.03	0.65	2.7	1.3	0.98	0.96	2.2	1.1	0.93	0.82
2500	2.2	1.5	1.04	0.97	4.1	3.7	1.04	0.65	2.2	1.4	0.98	0.96	1.7	1.2	0.93	0.82
1875	1.6	1.6	1.04	0.98	3.1	4.0	1.04	0.66	1.6	1.6	0.98	0.96	1.3	1.3	0.93	0.82
1250	1.1	1.7	1.04	0.98	2.0	4.3	1.04	0.66	1.1	1.7	0.99	0.97	0.9	1.4	0.93	0.82
625	0.6	1.8	1.04	0.98	1.0	4.6	1.05	0.66	0.5	1.8	0.99	0.97	0.4	1.5	0.93	0.82
0	0.0	1.9	1.04	0.98	0.0	4.9	1.05	0.66	0.0	1.9	0.99	0.97	0.0	1.6	0.93	0.82
	4.79*				4.27*				4.85*				4.63*			

For comparison, we include the results of similar modeling exercises conducted to estimate increases in population growth rates anticipated from changes to hydropower or harvest operations (Table 6). The estimates for hydropower improvement come from changes to improve passage for both adults and juveniles called for in NOAA Fisheries' FY 2000 Biological Opinion on operation of the Federal Columbia River Hydropower System (FCRPS) (NMFS 2000b, McClure *et al.* 2003). The estimates for harvest elimination come from McClure *et al.* (2003) and have been largely realized already. Thus, the potential increase in λ that may be realized from eliminating Caspian tern predation (1.6 - 4.9%) is equivalent to that of hydropower improvements but well below that of elimination of harvest reductions, all else being equal.

Table 6. Potential increases (%) in population growth rate of Columbia River basin steelhead ESUs corresponding to passage improvements in the Federal Columbia River Hydropower System and elimination of harvest.

	Snake River	Upper Columbia River	Middle Columbia River	Lower Columbia River
Caspian Tern predation (eliminated)	1.9	4.9	1.9	1.6
Caspian Tern predation (halved)	1.0	2.5	1.0	0.8
Hydropower improvements	1-2	2.0-4.0	2.0-3.0	0.0-1.0
Harvest elimination	4.0-7.0	8.0	4.0	6.0-8.0

ADDITIONAL AVIAN PREDATION IMPACTS

Other avian predators of juvenile salmonids in the Columbia River estuary include Double-crested Cormorants *(Phalacrocorax auriti*s), California Gulls (*Larus californicu*s), Ring-billed Gulls (*L. delawarensi*s), and members of the Glaucous-winged/Western Gull hybrid complex (*L. glaucescens/L. occidentali*s) (Roby *et al.* 1998, Collis *et al.* 2001a). Calculations of predation rates based upon the PIT tag detection approach for cormorants nesting on East Sand Island are provided for purposes of comparison and to place Caspian tern predation in context with other avian predation in the Columbia River basin (Table 7).

Table 7. Comparison of estimated predation rates (%) for Double-crested cormorants and Caspian terns breeding on East Sand Island on all steelhead in the Columbia River basin. Predation rates were calculated as the percent of PIT tags detected at Bonneville Dam that were later detected on cormorant colonies on East Sand Island.

	1999	**2000**	**2001**	**2002**
Caspian terns	0.8	6.7	7.7	9.2
Double-crested cormorants	0.6	2.5	1.2	0.7

Analyses of PIT tag detections on East Sand Island cormorant colonies made it possible to compare these sources of mortality by ESU; these methods found not insubstantial predation rate estimates from double-crested cormorants as compared to Caspian terns (Table 8).

Table 8. Estimated predation rates (%) for Caspian terns and Double-crested cormorants breeding on East Sand Island on four of the five ESA-listed steelhead ESUs in the Columbia River basin. Predation rates were calculated as the percent of PIT tags detected at Bonneville Dam that were later detected on cormorant colonies on East Sand Island.

	Caspian terns				Double-crested cormorants			
	1999	2000	2001	2002	1999	2000	2001	2002
Snake River	0.7	5.8	7.2	10.6	0.6	2.7	1.3	0.7
Upper Columbia River	0.6	10.9	25.2	9.3	0.6	2.0	0.8	0.9
Middle Columbia River	0.4	6.8	10.0	7.2	0.4	1.9	0.8	0.3
Lower Columbia River	0.4	6.1	6.7	6.3	0.3	0.8	1.1	0.2

AVIAN PREDATION UPRIVER OF THE COLUMBIA RIVER ESTUARY

Substantial numbers of salmonid smolts are also lost to avian predators--terns, cormorants, and gulls--upriver of East Sand Island. In particular, a significant number of Caspian terns nest on Crescent Island in the mid-Columbia River. The proportion of their diet represented by salmonid smolts is greater than for terns nesting on East Sand Island (Collis *et al.* 2001a), and comparisons of the potential impact of this predation remains an important consideration in any analysis of avian predation impacts in the Columbia River basin (Table 9).

Table 9. Estimated predation rates (%) for Caspian terns and all birds breeding on Crescent Island on all steelhead ESUs in the Columbia River basin. Predation rates were calculated as the percent of PIT tags detected at Lower Monumental Dam that were later detected on cormorant colonies on Crescent Island (B. Ryan, unpubl. data).

	1999	2000	2001	2002
Caspian terns	4.1	1.7	13.2	7.2
Other birds	0.4	2.0	7.9	2.9

CONCLUSIONS

Many evaluations of salmonid predation by Caspian terns in the Columbia River estuary have indicated that substantial numbers of juvenile salmonids are being consumed (Roby *et al.* 1998, Collis *et al.* 2001a, 2001b, Ryan *et al.* 2001, Ryan *et al.* 2003, Roby *et al.* 2003). The two approaches that have been used to evaluate the extent of that impact yield similar results and appear to provide reasonable estimates of predation rates. The PIT tag recovery approach has also revealed species-specific vulnerability to Caspian tern predation--steelhead are substantially more susceptible to tern predation than yearling chinook. Efforts to reduce predation by moving the colony from Rice Island (more central to the Columbia River estuary) to East Sand Island (located towards the mouth of the Columbia River) have successfully decreased overall predation as fewer salmon are consumed per nest on East Sand Island. The decrease in consumption has been substantial. However, PIT tag data on predation rates needs to be further collected at East Sand to confirm initial observations and to document that the relocation efforts have been successful in reducing impacts for all ESUs (particularly for steelhead).

Several factors must be considered when interpreting the results of these calculations. Perhaps the most important factor is that this type of calculation assumes that there is no compensatory mortality later in the life cycle, and that the benefits from any reduction in tern predation are fully realized. In their assessment of predation impact by Rice Island terns on salmonids in 1997-1998, Roby et al (2003) hypothesized that tern predation was 50% additive. Given these limitations and uncertainties, the estimates of percent change in population growth rates should be viewed as maximum potential improvements. Realized improvements in population growth would likely be lower from any management action that reduces Caspian tern predation impacts on salmonid ESUs. These results may not be as easy to achieve as they are to calculate. It is also important to recognize that other factors such as ocean conditions may also influence population growth rate to a greater degree than the potential gains that may be realized from reducing predation by one species of avian predator on one island located in the lower estuary of the Columbia River basin.

Not all listed salmonid populations have declined because of the same factors or combination of factors, and not all populations could be expected to respond positively to any particular management measure or combination of measures. In the case of the avian predator populations discussed here, artificial islands (such as Rice Island) have promoted the development of unprecedented large colonies of piscivorous birds with subsequent increases in losses of juvenile salmonids from predation.

Finally, additional factors may influence the gains in population growth rate that may be realized from reducing predation rates on outmigrating juvenile salmonids. These include, but are not limited to: hydropower operations, harvest rates, habitat conditions, the influence of hatchery fish and exotic species, ocean conditions, and climate change.

REFERENCES

Alcorn, G. D. 1958. Nesting of the Caspian tern in Gray's Harbor, Washington. The Murrelet 39(2):19-20.

Beamesderfer, R. C. P., D. L. Ward and A. A. Nigro, 1996. Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia and Snake Rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Caswell, H. 2000. Matrix Population Models. Sinauer Associates, Inc., Sunderland, MA, USA.

Collis, K., S. L. Adamany, D. D. Roby, D. P. Craig, and D. E. Lyons 1999. Avian predation on juvenile salmonids in the lower Columbia River. Secondary Avian predation on juvenile salmonids in the lower Columbia River. 1998 Annual Report to the Bonneville Power Adminstration and U. S. Army Corps of Engineers.

Collis, K., D. D. Roby, D. E. Lyons, R. M. Suryan, M. Antolos, S. K. Anderson, A. M. Meyers, and M. Hawbecker. 2001a. Caspian Tern Research on the Lower Columbia River, Final 2001 Summary. Columbia Bird Research, www.columbiabirdresearch.org.

Collis, K., D. D. Roby, D. E. Lyons, R. M. Suryan, M. Antolos, S. K. Anderson, A. M. Meyers, and M. Hawbecker. 2002. Caspian Tern Research on the Lower Columbia River, Draft 2002 Summary. Columbia Bird Research, www.columbiabirdresearch.org.

Collis, K., D. D. Roby, D. P. Craig, B. A. Ryan, and R. D. Ledgerwood. 2001b. Colonial waterbird predation on juvenile salmonids tagged with passive integrated transponders in the columbia River estuary: vulnerability of different salmonid species, stocks and rearing types. Transactions of the American Fisheries Society 130:385-396.

Collis, K., D. D. Roby, D. P. Craig, S. L. Adamany, J. Y. Adkins, and D. E. Lyons. 2002. Colony size and diet composition of piscivorous waterbirds on the lower Columbia River: Implications for losses of juvenile salmonids to avian predation. Transactions of the American Fisheries Society 131:537-550.

Cuthbert, F. J. and L. R. Wires. 1999. Caspian Tern (*Sterna caspia*). *In*: The Birds of North America, No. 403 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Gill, R. E. Jr., and L. R. Mewaldt. 1983. Pacific Coast Caspian Terns: Dynamics of an Expanding Population. The Auk 100:369-381.

Harrison, C. S. 1984. Terns: Family Laridae. *In:* Seabirds of Eastern North Pacific and Arctic Waters (D. Haley, ed.), pp. 146-160. Pacific Search Press, Seattle. WA. 214 p.

Harrison, P. 1983. Seabirds: an Identification Guide. Houghton Mifflin Company. Boston, MA. 448 p.

Holmes, E. E. 2001. Estimating risks in declining populations with poor data. Proceedings of the National Academy of Sciences: 98(9): 5072-5077.

Holmes, E. E. 2004. Beyond theory to application and evaluation: diffusion approximations for population viability analysis. Ecological Applications (*in press*).

Holmes, E. E. and W. F. Fagan. 2002. Validating population viability analysis for corrupted data sets. Ecology 83: 2379-2386.

IMST (Independent Multidisciplinary Science Team). 1998. Pinniped and seabird predation: Implications for recovery of threatened stocks of salmonids in Oregon under the Oregon Plan for Salmon and Watersheds. Technical Report 1998-2 to the Oregon Plan for Salmon and Watersheds. Governor's Natural Resources Office. Salem, OR.

Johnson, O. W., M. H. Ruckelshaus, W. S. Grant, F. W. Waknitz, A. M. Garrett, G. J. Bryant, K. Neely, and J. J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon and California. NOAA Technical Memorandum NMFS-NWFSC-37. Seattle, WA. 292 p.

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinook salmon in the Columbia River Basin. Science 290:977-979.

McClure, M. M., E. E. Holmes, B. L. Sanderson, and C. E. Jordan. 2003. A large-scale, multispecies status assessment: anadromous salmonids in the Columbia River Basin. Ecological Applications 13:964–989.

NMFS (National Marine Fisheries Service). 1995. Biological Opinion for Reinitiation of Consultation on 1994-1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years. Northwest Region National Marine Fisheries Service. Portland, OR. 166 p.

NMFS (National Marine Fisheries Service). 2000a. Appendix D: Biological effects analysis and SIMPAS model documentation. *In*: Biological Opinion for reinitiation of consultation on operation of the Federal Columbia River Power System, including the juvenile fish transportation program and 19 Bureau of Reclamation projects in the Columbia Basin. U. S. Department of Commerce, NOAA, NMFS, NW Region, Seattle, WA.

NMFS (National Marine Fisheries Service). 2000b. Operation of the Federal Columbia River Power System Including the juvenile fish transportation program and the Bureau of Reclamation's 31 projects, including the entire Columbia Basin Project. Secondary Operation of the Federal Columbia River Power System Including the juvenile fish transportation program and the Bureau of Reclamation's 31 projects, including the entire Columbia Basin Project. U. S. Department of Commerce, NOAA, NMFS, NW Region, Seattle, WA.

Penland, S. 1976. The Caspian tern: a natural history. Washington Wildlife 28(4):16-19.

Penland, S. 1981. Natural History of the Caspian tern in Grays Harbor, Washington. The Murrelet 62:66-72.

Raymond, H. L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer chinook salmon and steelhead in the Columbia River Basin. North

American Journal of Fisheries Management 8:1-24.

Roby, D. D., D. P. Craig, K. Collis, and S. L. Adamany. 1998. Avian predation on juvenile salmonids in the lower Columbia River 1997 Annual Report. Bonneville Power Administration Contract 97BI33475 and U. S. Army Corps of Engineers Contract E96970049. 70 p.

Roby, D. D., K. Collis, D. E. Lyons, D. P. Craig, J. Y. Adkins, A. M. Myers, and R. M. Suryan. 2002. Effects of colony relocation on diet and productivity of Caspian terns. Journal of Wildlife Management 66: 662-673.

Roby, D. D., D. E. Lyons, D. P. Craig, K. Collis, and G. H. Visser. 2003. Quantifying the effects of predators on endangered species using a bioenergetics approach: Caspian terns and juvenile salmonids in the Columbia River estuary. Canadian Journal of Zoology 81: 250-265.

Ryan, B. A., J. A. Ferguson, R. D. Ledgerwood, and E. P. Nunnallee. 2001. Detection of passive integrated transponder tags from juvenile salmonids on piscivorous bird colonies in the Columbia River Basin. North American Journal of Fisheries Management 21:417-421.

Ryan, B. A., S. G. Smith, J. M. Butzerin, and J. W. Ferguson. 2003. Relative vulnerability to avian predation of juvenile salmonids tagged with passive integrated transponders in the Columbia River estuary, 1998-2000. Transactions of the American Fisheries Society 132: 275-288.

Schiewe, M. H. 1998. Estimation of listed steelhead smolts outmigrating from the lower Columbia River ESU in 1998. Memo to Nancy Chu, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA. April 2, 1998.

Shuford, W. D. and D. P. Craig. 2002. Status assessment and conservation recommendations for the Caspian tern (Sterna caspia) in North America. U.S. Department of the Interior, Fish and Wildlife Service. Portland, Oregon.

USACE (U. S. Army Corps of Engineers). 2000. Caspian tern relocation FY 2000 Management Plan and pile dike relocation, Clatsop County, Oregon and Grays Harbor County, Washington. Environmental Assessment and Finding of No Significant Impact. USACE, Portland District, Portland, OR.

USFWS (U. S. Fish and Wildlife Service). 2001. Seabird predation and salmon recovery in the Columbia River estuary. U.S. Fish and Wildlife Service. Portland, OR. 10 p.

Waples, R. 1991. Definition of a “species” under the Endangered Species Act: application to Pacific salmon. NOAA Tech. Memo. NMFS F/NWC-194. National Marine Fisheries Service, 525 NE Oregon St./Suite 500, Portland, OR. 29 p.

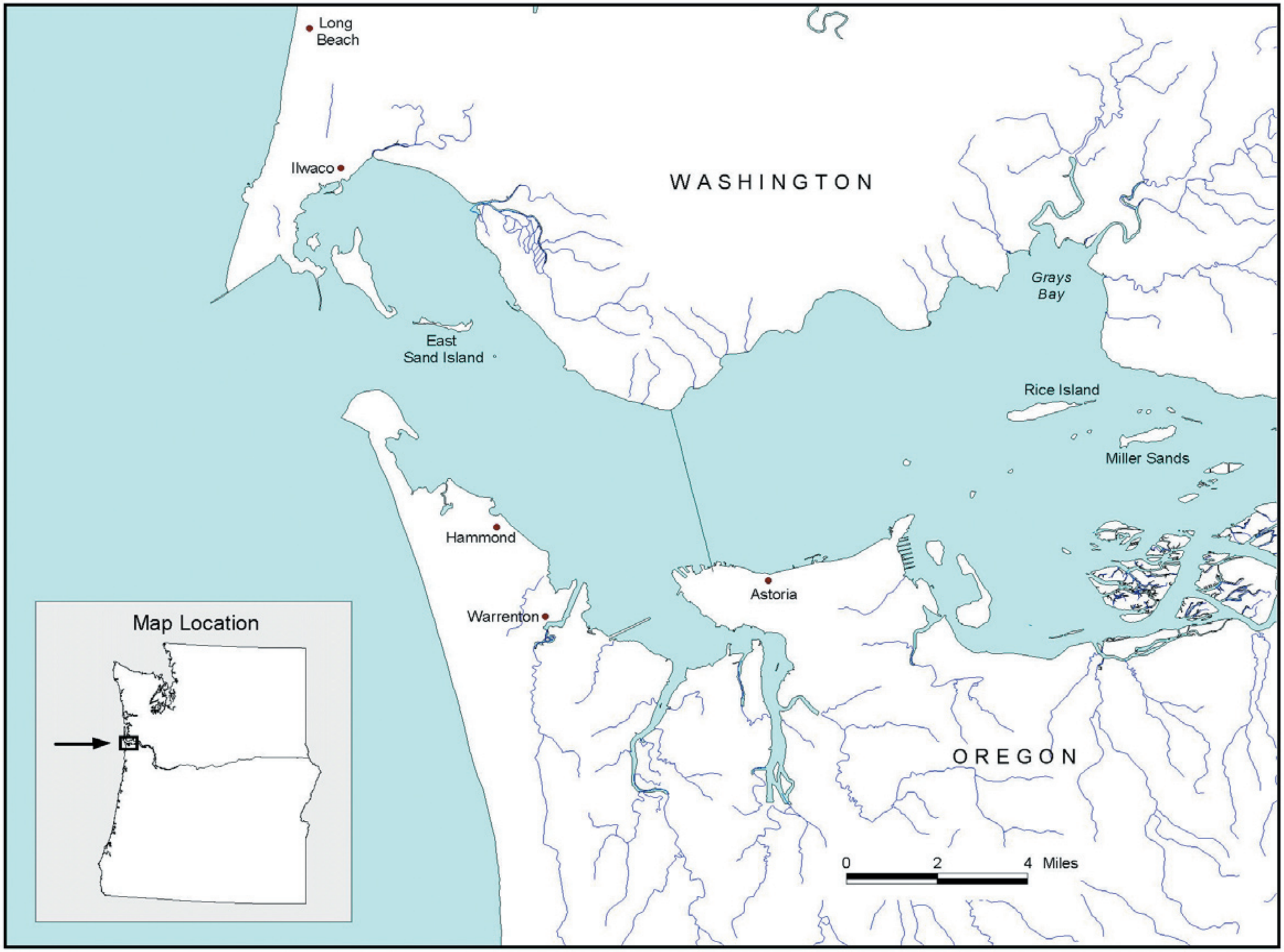


Figure 1. Map of the Columbia River estuary showing the relative locations of East Sand and Rice Islands, sites of Caspian tern nesting colonies.

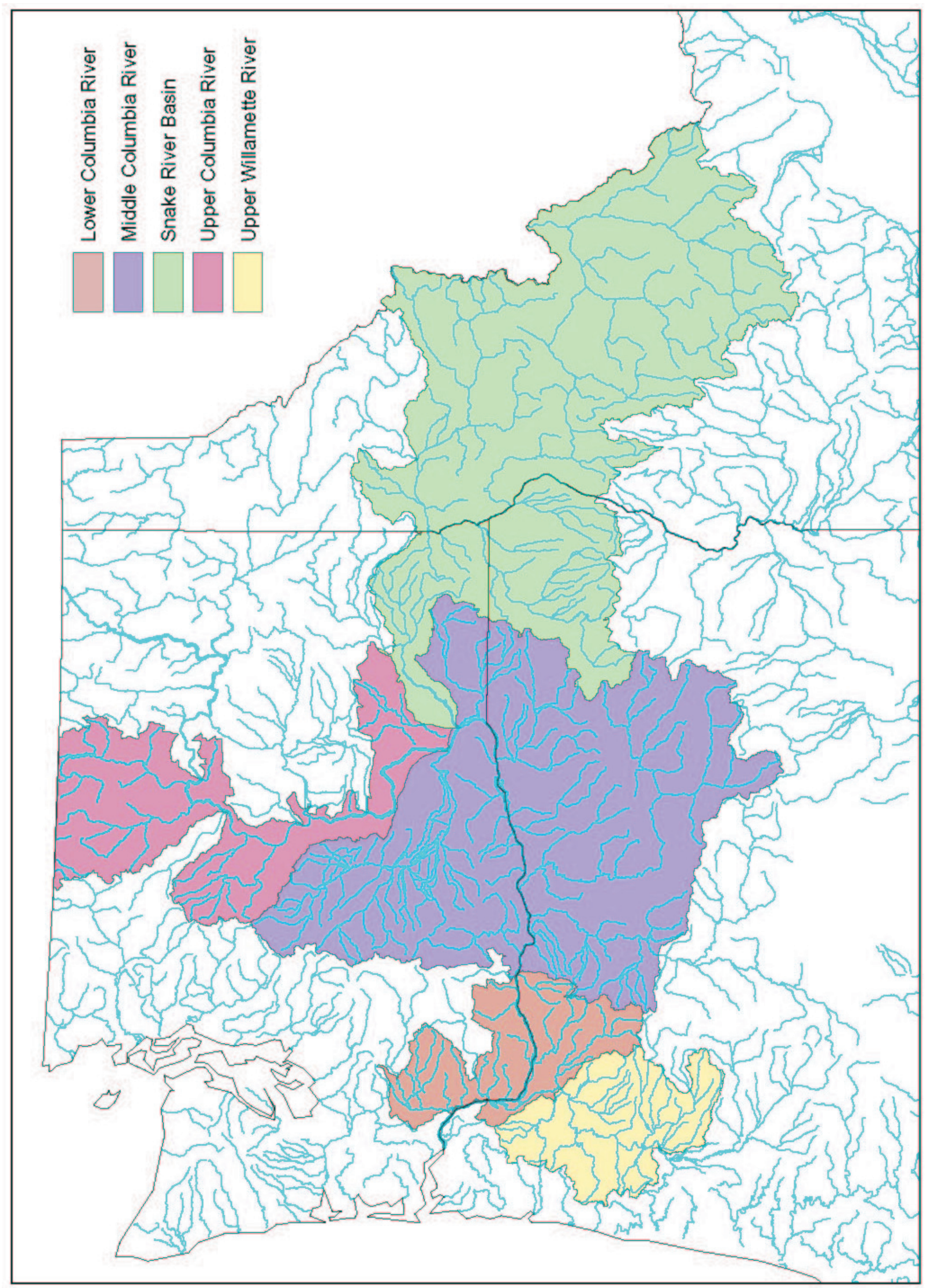


Figure 2. Map of Columbia River Basin showing the locations of the ESA-listed Lower Columbia River, Upper Willamette River, Middle Columbia River, Upper Columbia River and Snake River steelhead ESUs.

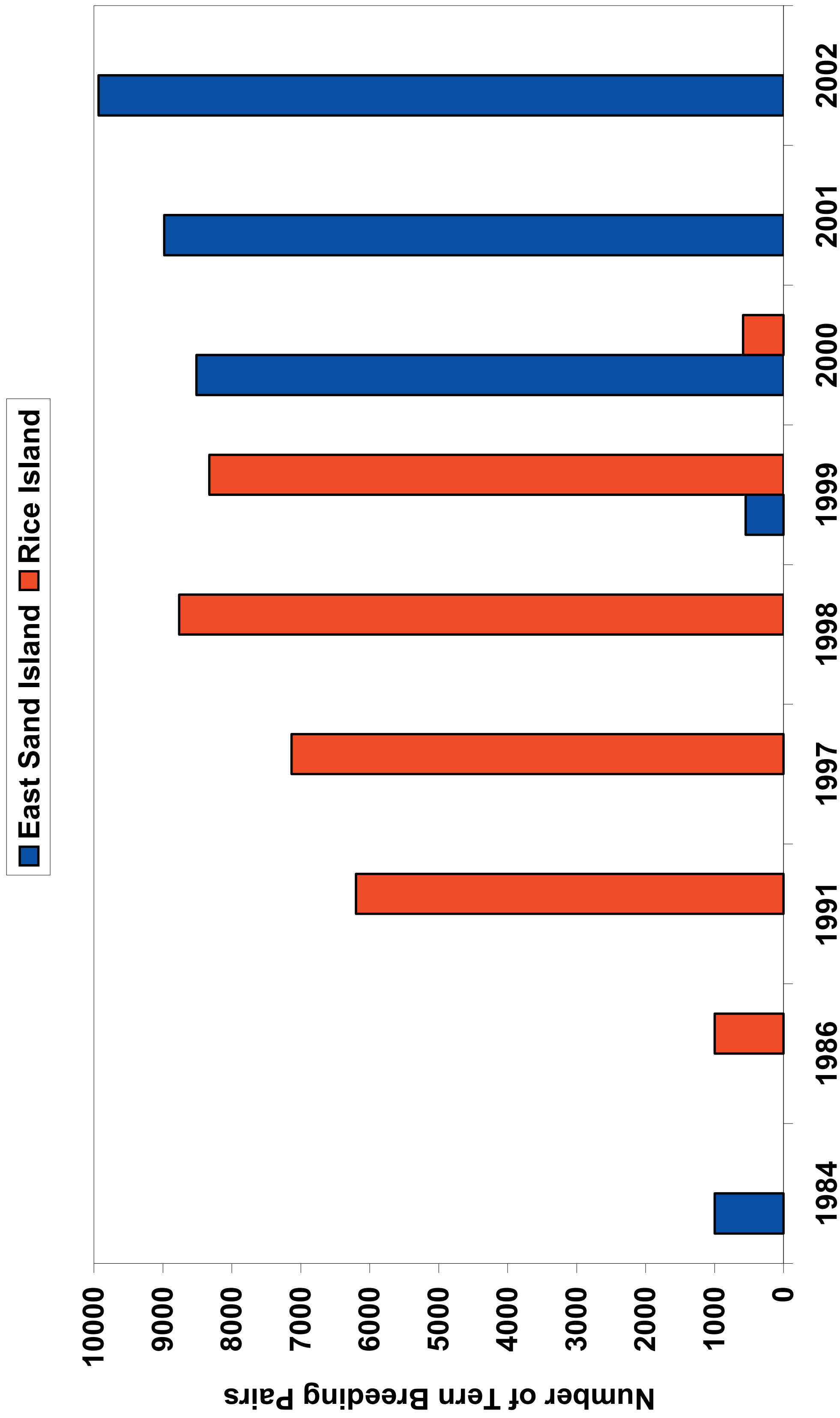


Figure 3. Numbers of Caspian terns nesting on islands in the Columbia River estuary since 1984.

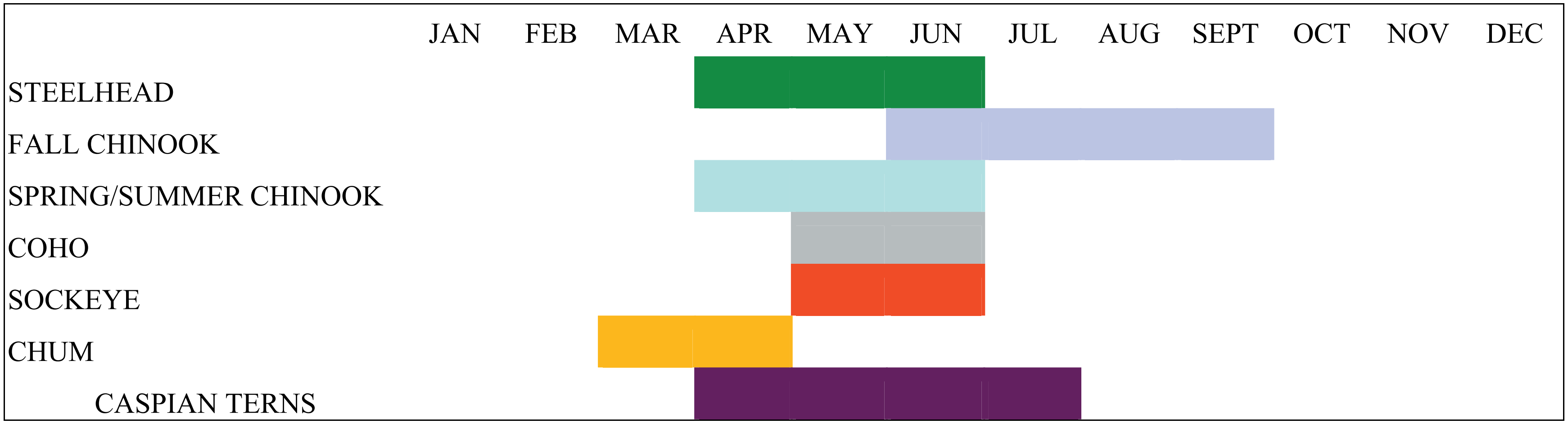


Figure 4. Arrival times of juvenile salmonids and nesting period of Caspian terns in the Columbia River estuary.

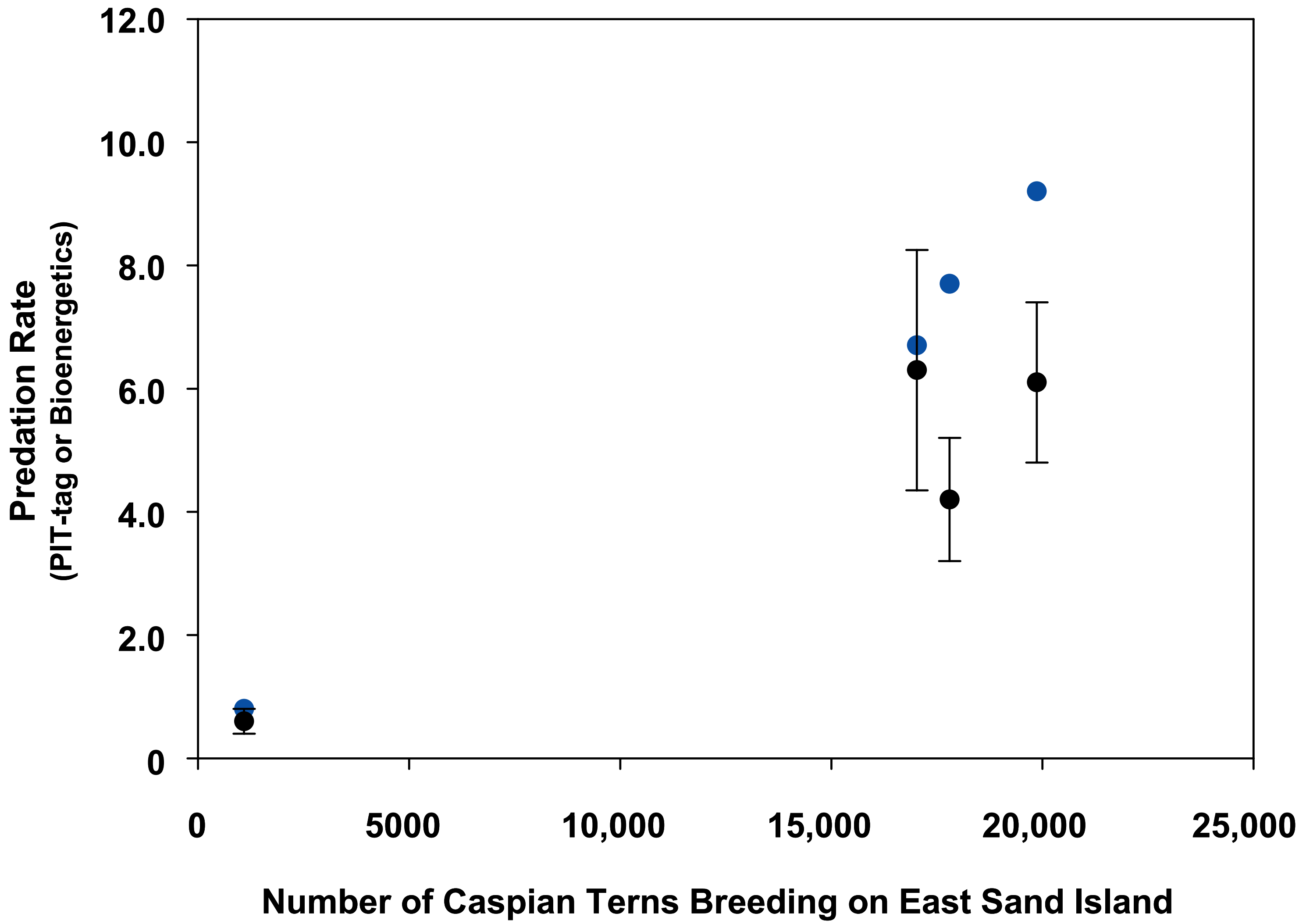


Figure 5. Estimated predation rates on ***all Columbia River basin steelhead*** in the Columbia River estuary by Caspian Terns (1999-2002) using bioenergetics modeling (black symbols) and recovery of PIT tags (blue symbols). Error bars on bioenergetics estimates represent 95% confidence limits.

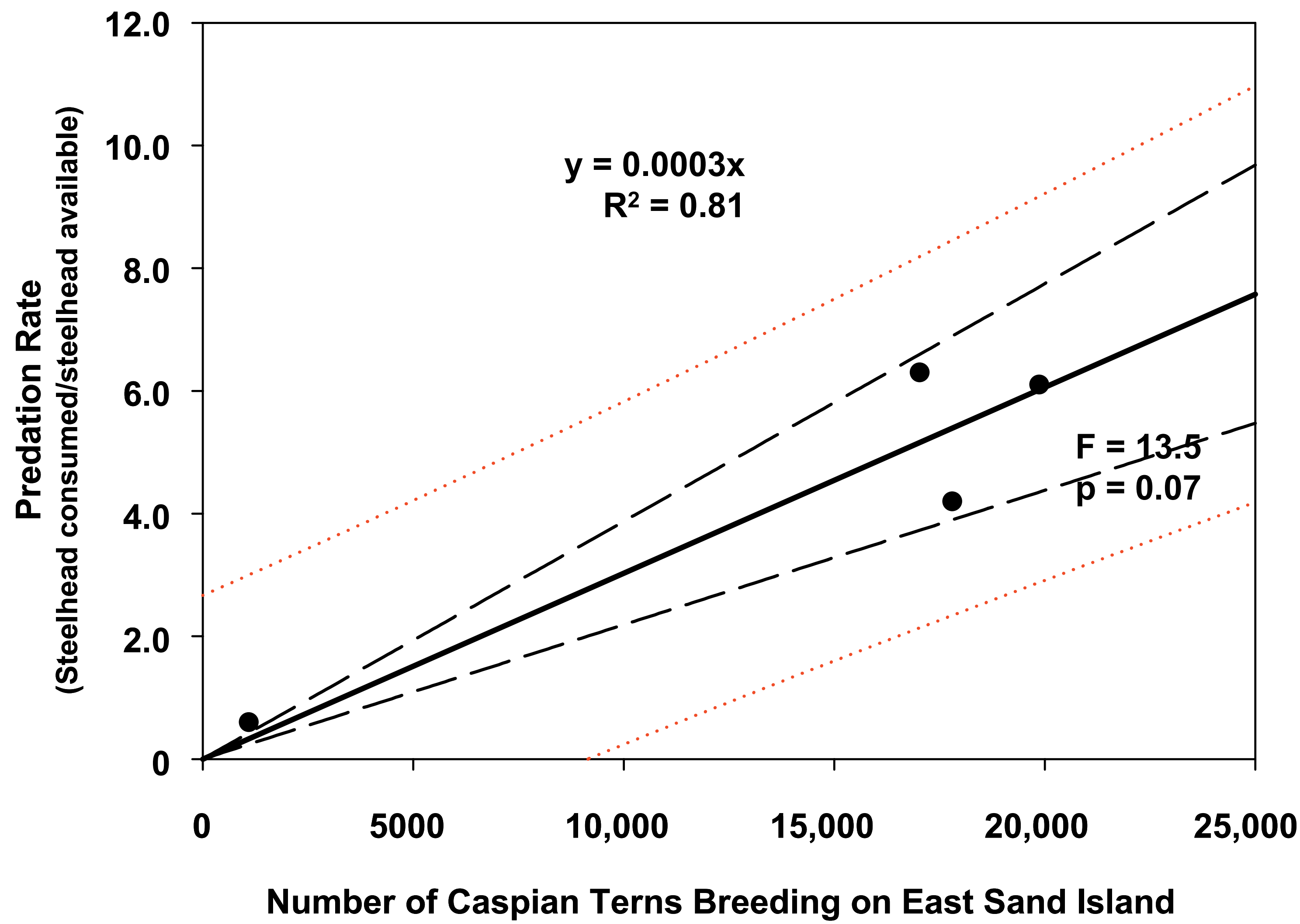


Figure 6. Linear regression of predation rates on ***all Columbia River basin steelhead*** in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using ***bioenergetics modeling***. Dashed black lines represent 95% confidence limits; dotted red lines represent 95% prediction limits.

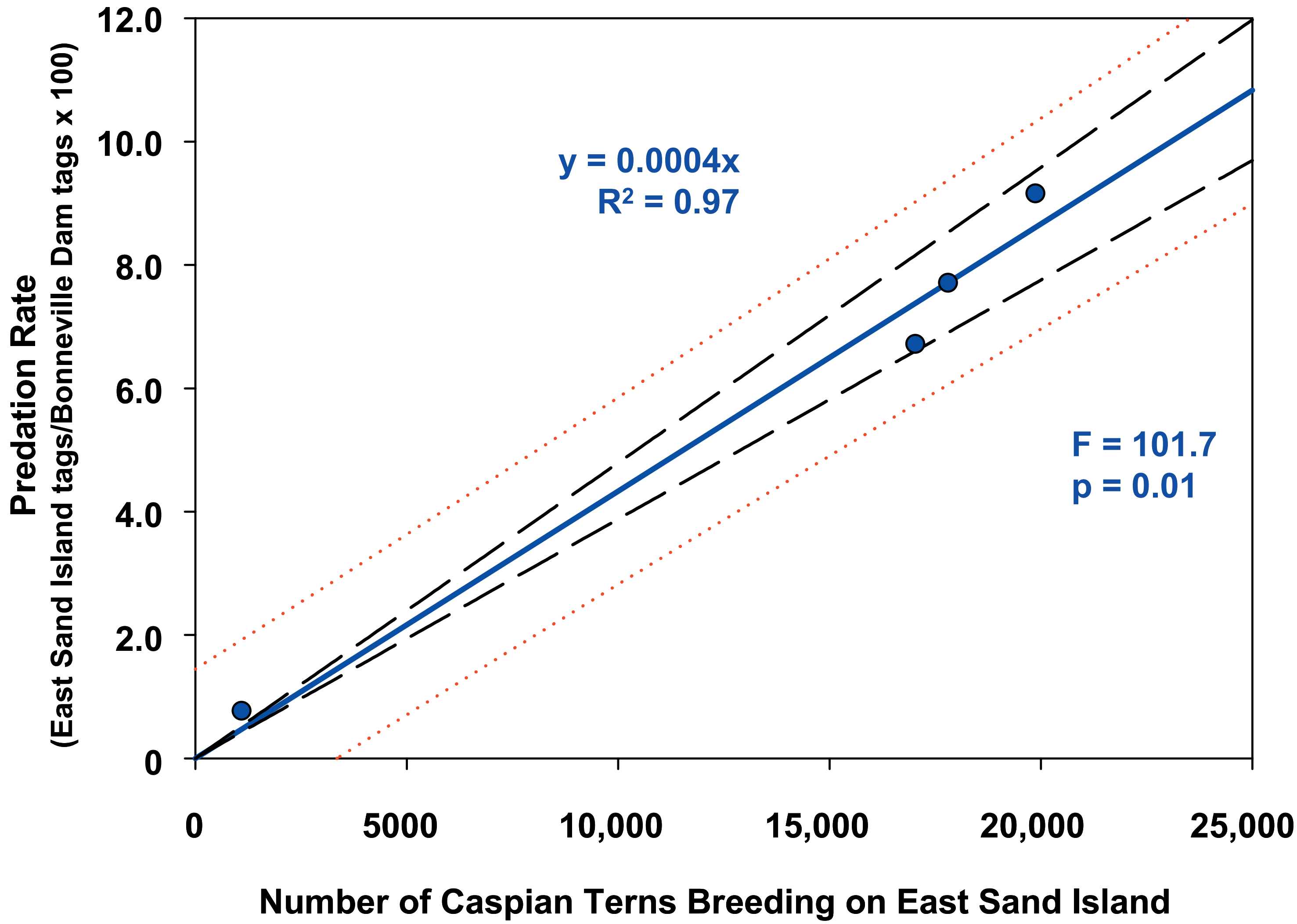


Figure 7. Linear regression of predation rates on ***all Columbia River basin steelhead*** in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using ***recovery of PIT tags***. Dashed black lines represent 95% confidence limits; dotted red lines represent 95% prediction limits.

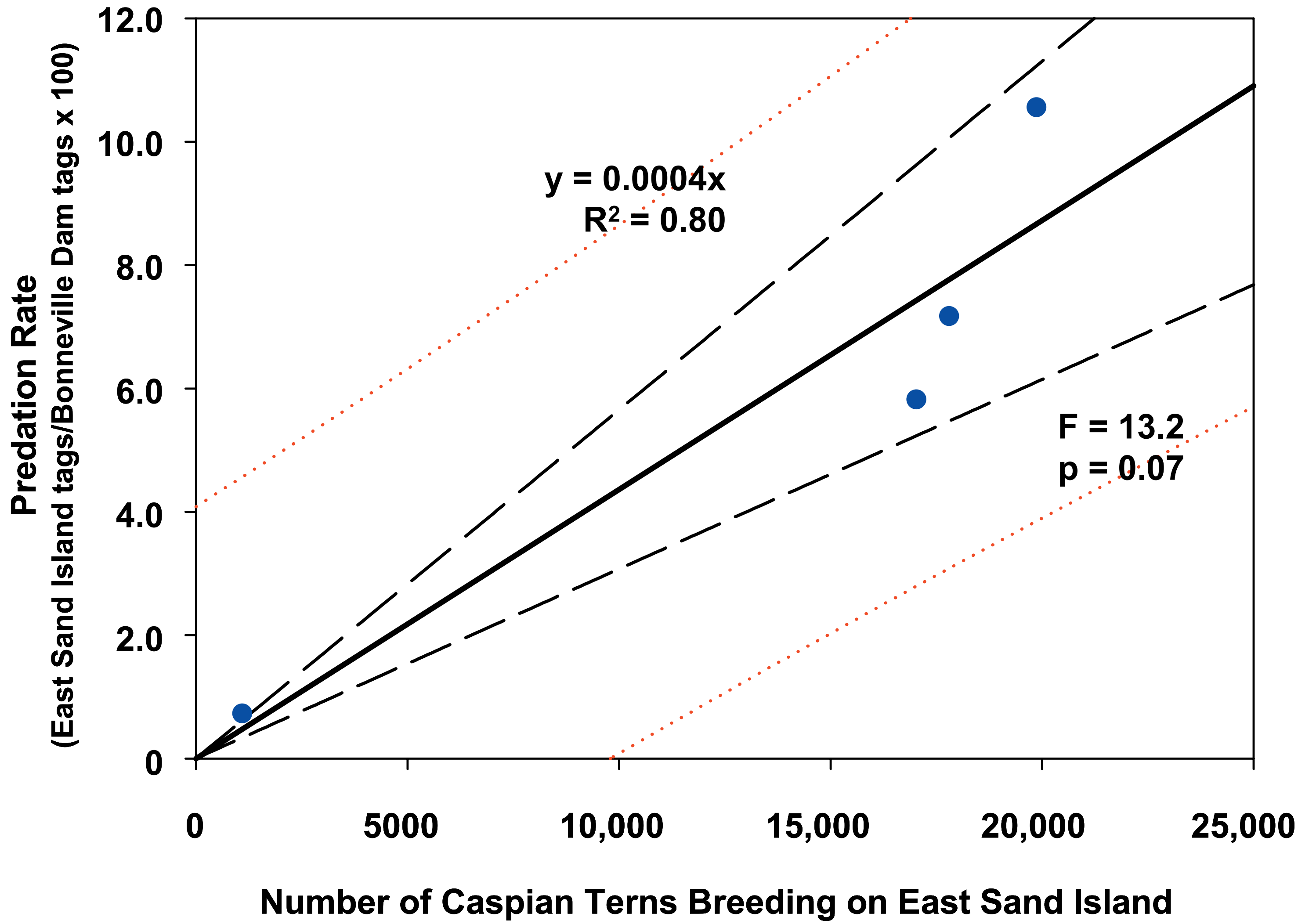


Figure 8. Linear regression of predation rates on the ***Snake River steelhead ESU*** in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using ***recovery of PIT tags***. Dashed black lines represent 95% confidence limits; dotted red lines represent 95% prediction limits.

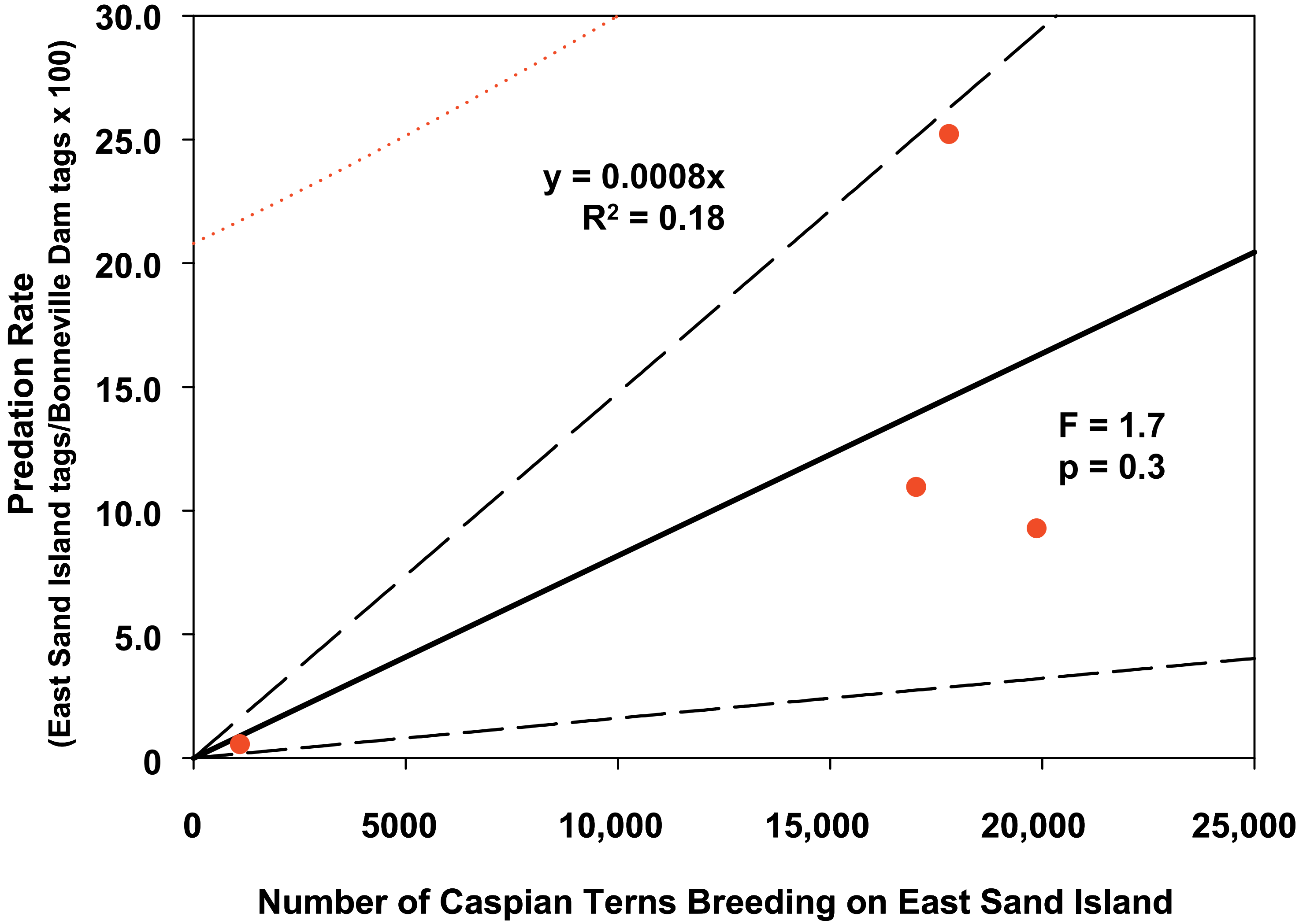


Figure 9. Linear regression of predation rates on the ***Upper Columbia River steelhead ESU*** in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using ***recovery of PIT tags***. Dashed black lines represent 95% confidence limits; dotted red lines represent 95% prediction limits.

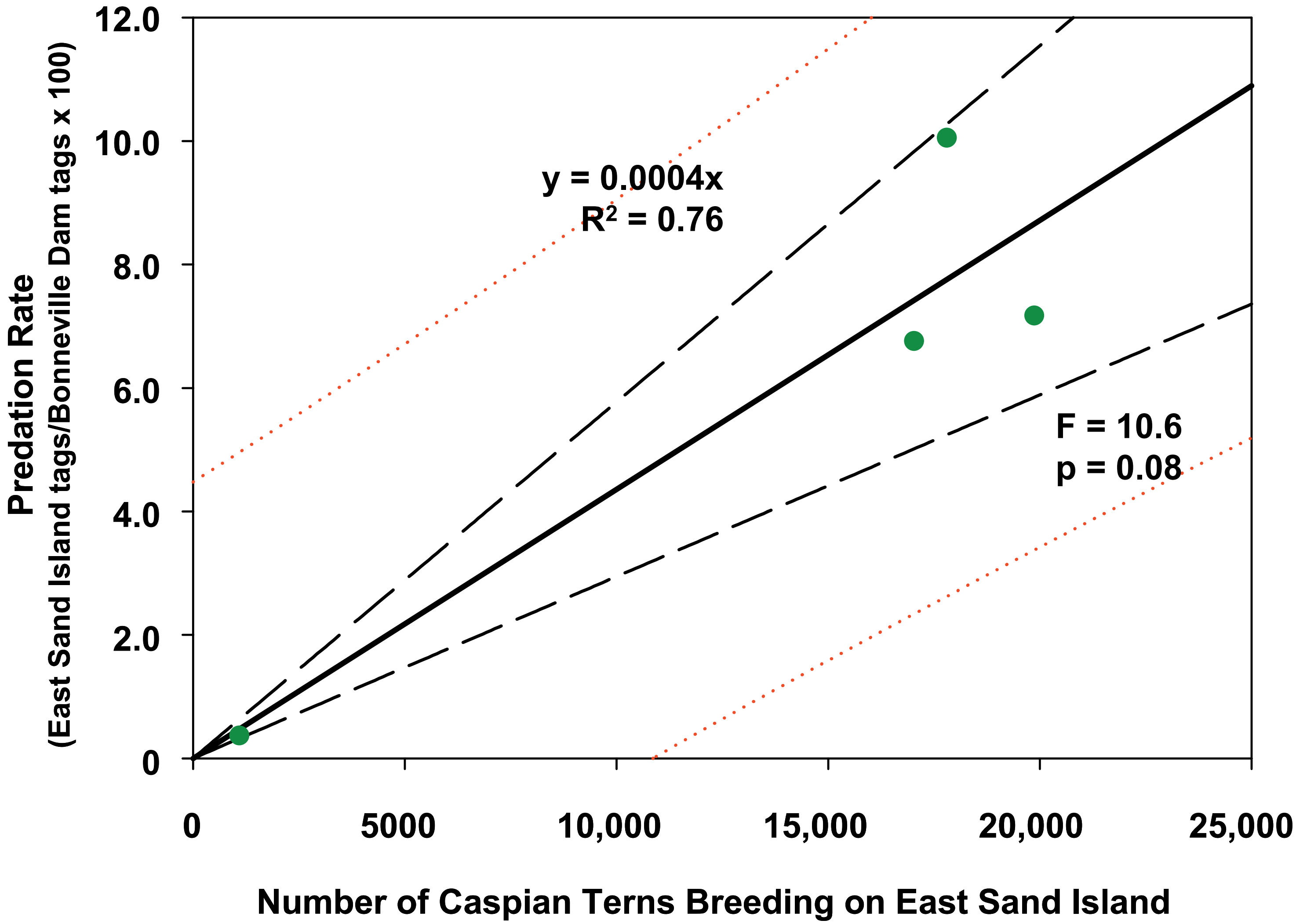


Figure 10. Linear regression of predation rates on the ***Middle Columbia River steelhead ESU*** in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using ***recovery of PIT tags***. Dashed black lines represent 95% confidence limits; dotted red lines represent 95% prediction limits.

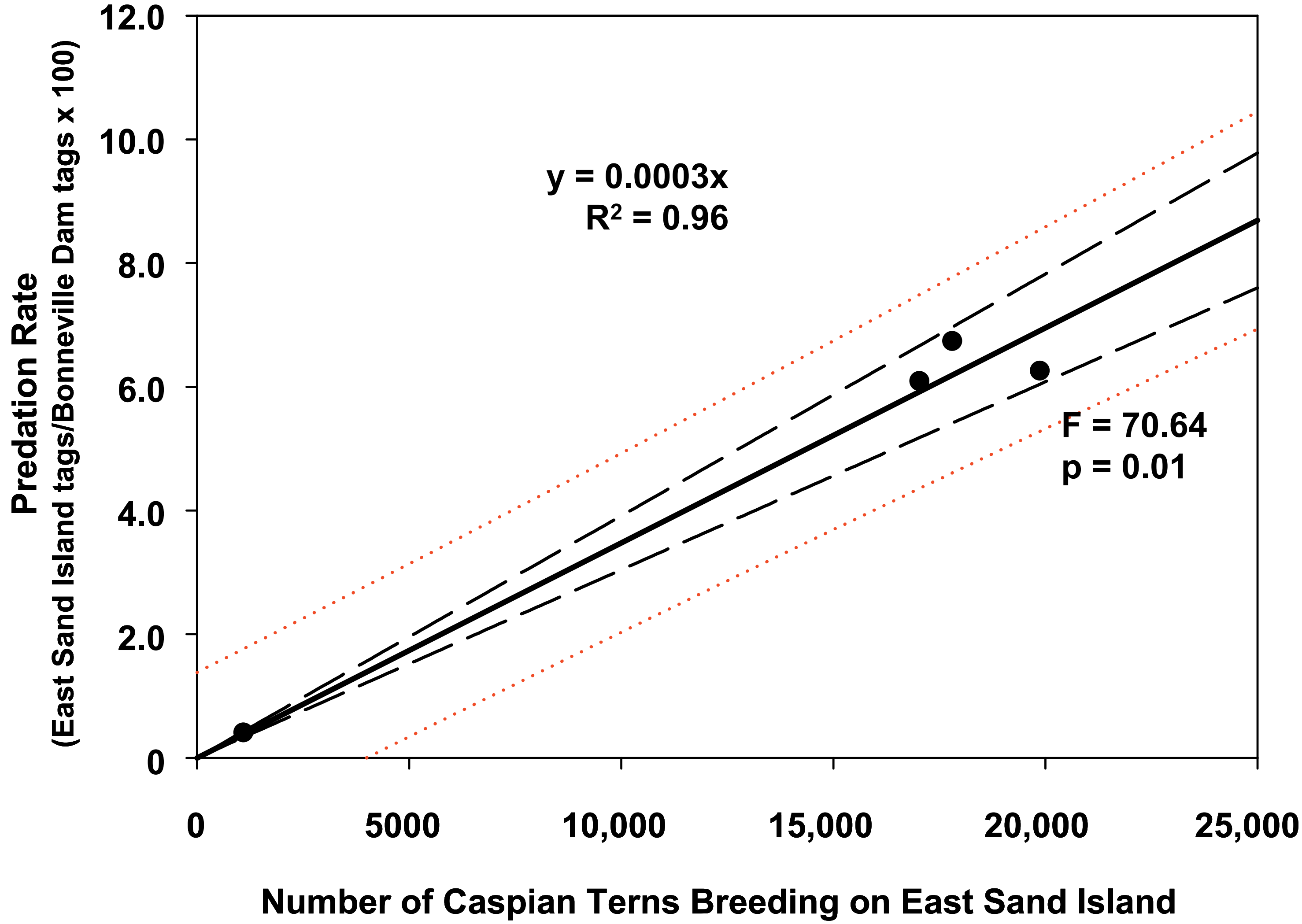


Figure 11. Linear regression of predation rates on the ***Lower Columbia River steelhead ESU*** in the Columbia River estuary by Caspian Terns breeding on East Sand Island (1999-2002) estimated using ***recovery of PIT tags***. Dashed black lines represent 95% confidence limits; dotted red lines represent 95% prediction limits.

Appendix D. Applicable Laws and Executive Orders

Law, Regulation, or Guideline	Description
Migratory Bird Treaty Act of 1918 (MBTA), as amended, (16 U.S.C. 703-711)	The Service has the primary statutory authority to manage migratory bird populations in the United States. The MBTA implements treaties with Great Britain (for Canada in 1916 as amended in 1999), the United Mexican States (1936 as amended in 1972 and 1999), Japan (1972 as amended in 1974), and the former Soviet Union (1978) and imposed certain obligations on the U.S. for the conservation of migratory birds, including the responsibilities to: conserve and manage migratory birds internationally; sustain healthy migratory bird populations for consumptive and non-consumptive uses; and restore depleted populations of migratory birds. Conventions are also held with Mexico, Japan, and Russia.
Endangered Species Act of 1973 (ESA), as amended (7 U.S.C. 136; 16 U.S.C. 460 et seq.)	It is Federal policy, under the ESA, that all Federal agencies seek to conserve threatened and endangered species and utilize their authorities in furtherance of the purposes of the Act (Sec. 2(c)).
National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321-4347)	NEPA is our national charter for protection of the environment; it requires Federal agencies to evaluate the potential environmental impacts when planning a major Federal action and ensures that environmental information is available to public officials and citizens before decisions are made and before actions are taken. It mandates a process for thoroughly considering what an action may do to the human environment and how any adverse impacts can be mitigated (http://npi.org/nepa/process.html).
Sustainable Fisheries Act (Public Law 104-297) (re-named from the Magnuson-Stevens Act) (MSA)	Amended the habitat provisions of the MSA. It calls for direct action to stop or reverse the continued loss of fish habitats. The Act requires Federal agencies to protect, conserve, and enhance "essential fish habitat" (EFH) for federally managed fish species; "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."
Public Law 106-53, Section 582c	Requires the U.S. Army Corps of Engineers to "carry out methods to reduce nesting populations of avian predators on dredge spoil islands in the Columbia River under the jurisdiction of the Secretary" in conjunction with the Departments of Interior and Commerce.

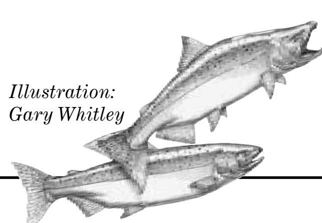
Appendix D. Applicable Laws and Executive Orders Continued

Law, Regulation, or Guideline	Description
Fishery Conservation and Management Act (FCMA) of 1976 (16 U.S.C. 1801-83)	Law 99-659, Section 104, amended Section 302 of the 1976 act requires all Federal agencies to respond within 45 days to comments and recommendations made by the Regional Fishery Management Council relative to the impacts a Federal activity have on fishery resources under the Council's jurisdiction.
Fish and Wildlife Coordination Act (FWCA) of 1958	Requires equal consideration and coordination of wildlife conservation with other water resource development programs.
Fish and Wildlife Conservation Act (16 USC 661-667e), as amended	Requires the Service to monitor non-gamebird species, identify species of management concern, and implement conservation measures to preclude the need for listing under ESA.
Fish and Wildlife Act of 1956 (16 USC 742a-743j)	Provides Secretary of Interior with authority to protect and manage fish and wildlife resources.
Executive Order 13186 (EO), Responsibilities of Federal Agencies to Protect Migratory Birds	Directs any Federal agency whose actions have a measurable negative impact on migratory bird populations to develop a Memorandum of Understanding (MOU) with the Service to promote conservation of migratory birds. The MOUs would establish protocols to guide future agency regulatory actions and policy decisions; renewal of permits, contracts or other agreements; and the creation of or revisions to land management plans.
Federal Water Pollution Control Act of 1948, as amended ("Clean Water Act")	The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. Provides for protection of water quality.
Coastal Zone Management Act (CZMA) of 1972, as amended (16 U.S.C. 1451-1464)	Protects environmental quality of coastal areas.
Estuary Protection Act (16 U.S.C. 1221-1226)	The purpose of the Estuary Protection Act is to establish a program to protect, conserve and restore estuaries. The act does not affect an agency's authority for existing programs within an estuary.
Executive Order 11593 (EO), Protection and Enhancement of the Cultural Environment	States that if the Service proposes any development activities that may affect archeological or historical sites, the Service will consult with Federal and State Historic Preservation Officers to comply with Section 106 of the National Historic Preservation Act of 1966, as amended.

Appendix D. Applicable Laws and Executive Orders Continued

Law, Regulation, or Guideline	Description
Executive Order 12898 (EO), Federal Actions to Address Environmental Justice in Minority and Low-Income Populations, 11 February 1994	The overall purpose of the order is to avoid disproportionately high imposition of any adverse environmental or economic impacts on minority or low-income populations. All NEPA environmental analyses must include an evaluation of effects on minority and low income communities.
Executive Order 13175, Consultation and Coordination with Indian Tribal Governments	Provides a mechanism for establishing regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications.
Section 10, Rivers and Harbors Act of 1899 (30 Stat 1151: 33 USC 401 Section 10)	Provides for the protection of waters associated with work in or affecting Navigable Waters of the United States. Requires U.S. Army Corps of Engineers review for structures or work.

Illustration:
Gary Whitley



Appendix E: Distribution List

INDIVIDUALS

Ainley, David
Alderson, George & Francis
Babb, Evelyn
Boeholt, Dan
Boerner, Stephen
Bradford, Debby
Brookman, Gerald
Colter, Carolee
Conroy, Edward
Corriere, Caryn
Daigneault, Steve
Davis, Shannon
DeNiro, Liz
Durr, Greg & Becky
Emde, Richard
Fatta, Louis
Fields, Gary
Fisher, Bruce
Fisk, Bill
Grant, Catherine
Groves, Desiree
Hamilton, Dave
Hearn, Jim
Hendricks, Brenda
Hill, Brandon
Honican, Albert
Huhtala, Peter
Ishiyama, D.
Jacus, Anna
Julius, Theressa
Knutson, Peter
Kocsis, Amy
Krajewski, Dan
Laier, Charles
Lamb, Alexandra J.
Larsen, Adolph
Long, Meredith
Malek, Robert
Marett, Robert & Susan
Marinkovich, Fred
Martinson, Kahler
Mayo, John
McGuire, Matthew
Miller, Bonnie
Moon, Melanie
Morse, Melissa
Muller, Gretchen
Murray, Shannon
Norman, Donald
O'Brien, Kim
Parameswaran, G.
Powers, Denise
Richards, Loretta
Ruud, Mary Catherine
Sandall, Marilyn
Skumanich, Marina
Smith, Deborah
Smith, Kerry
Swanson, Michael
Thomas-Blake, Debra
Williams, George
Winstead, Robert

NAME	ORGANIZATION
ACADEMIC INSTITUTIONS	
Colwell, Mark	Humboldt State University
Fischer, Karen	OSU-Columbia River Avian Predation Project
Larson, Keith	Oregon State University
Roby, Dan	Oregon State University
Schiller, Anja	Oregon State University
Shugart, Gary	Slater Museum of Natural History
Wells, Adam	OSU-Columbia River Aviation Predation Program
NON GOVERNMENT ORGANIZATIONS	
(no contact name)	North Cascades Audubon Society
(no contact name)	Olympic Pennisula Audubon
(no contact name)	Humboldt Fish Action Council
(no contact name)	San Francisco Bay Chapter, Sierra Club
(no contact name)	Oregon Chapter, Sierra Club
(no contact name)	Cascade Chapter, Sierra Club
(no contact name)	Oregon Environmental Council
(no contact name)	Audubon Society - Redwood Region
(no contact name)	National Audubon Society
(no contact name)	NW Steelhead/Salmon Council of Trout Unlimited
(no contact name)	
(no contact name)	Westport Charter Fisherman's Association
(no contact name)	Washington Trout
(no contact name)	Northwest Sportfishing Industry & Association
(no contact name)	Sea and Sage Audubon
(no contact name)	The Nature Conservancy
(no contact name)	California Sportfishing Coalition
(no contact name)	California Sportfishing Protection Alliance
(no contact name)	American Rivers Society
(no contact name)	Golden Gate Audubon
(no contact name)	Santa Clara Audubon
(no contact name)	Napa Solano Audubon
(no contact name)	Trout Unlimited
(no contact name)	Columbia River Keeper
(no contact name)	Marin Conservation League
(no contact name)	National Audubon
(no contact name)	Sequoia Audubon
(no contact name)	Fisherman's Marketing Association
Allen, Brian	Columbia Basin Fish & Wildlife Authority
Ambroge, Christina	EPIC
Bakke, Bill	Native Fish Society
Barber, Harry	Lower Columbia Fish Enhancement Group
Beaty, Roy	Fish Commission
Berggren, Steve	Resource Coalition and Commercial
Burns, Keith	Gray Harbor Poggie Club
Cedergreen, Mark	Westport Charterboat Association
Clark, Tom	Lower Columbia Basin Audubon
Cochlin, Clyde	E. Washington Steelhead Foundation
Cohen, Ellie	PRBO Conservation Science
Croonquist, David	Puget Sound Anglers

NAME	ORGANIZATION
NON GOVERNMENT ORGANIZATIONS (CONTINUED)	
Curl, Jr, Herbert	Seattle Audubon Society
Eaton, Bob	Salmon for All
Englemeyer, Paul	National Audubon Society
Eversen, John	Steelhead Trout Club of Washington
Fee, Sharnelle	Wildlife Rehab Center of the North Coast
Feinstein, Arthur	Golden Gate Audubon/CCCR
Fricke, Doug	Chehalis Basin Fisheries Task Force
Grunbaum, Arthur (R.D)	Friends of Grays Harbor
Hanson, Janet	San Francisco Bay Bird Observatory
Harrison, Craig	Pacific Seabird Group
Heiken, Doug	Oregon Natural Resources Council
Hoppler, Wes	Steelhead Trout Club of Washington
Jacobsen, Jim	USACE-Seattle
Jones, Tod	CEDC Fisheries
Kennedy, Caroline	Defenders of Wildlife
Ketcham, Paul	Audubon Society of Portland
Kress, Stephen	Seabird Restoration Program
LePage, Al	National Coast Trail Associations
LeValley, Ron	Mad River Biologists
Mantua, Nathan	Wild Steelhead Coalition
McRoberts, James	Federation of Fly Fishers
Mills, Kyra	PRBO Conservation Science
Morgan, Alex	Seattle Audubon
Mueller, Dana	Eastern Washington Steelhead Foundation
Nelson, Ray	Lahontan Audubon Society
Packard, Heath	Audubon Washington and Black Hills Audubon
Perciasepe, Bob	National Audubon Society
Puddicombe, Steve	Willapa Hills Audubon
Rolfe, Allison	San Diego Audubon Society
Schoyen, Kris	Washington State Audubon
Schwickerath, Dean and Dianne	Grays Harbor Audubon Society
Senatore, Mike	Defenders of Wildlife
Shaffner, Owen	SW WA County Farm Bureau
Sikes, Ron	Admirality Audubon Chapter
Soverel, Peter	Wild Salmon Center
Spain, Glen	Pacific Coast Federation of Fishermen's Assoc.
Strake, Gretchen	Vancouver Audubon Society
Strong, Cheryl	San Francisco Bay Bird Observatory
Tingley, Ron	Wildcat Steelhead Club
Turner, Terry	Washington Council of Trout Unlimited
Twitchell, Marlyn	National Audubon Society
Wahl, Leslie	Yakima Valley Audubon Society
Whitworth, Joe	Oregon Trout
Winegrad, Gerald	American Bird Conservation
BUSINESS	
	Columbia River Fisherman's Protective Union
Blanchard, Cecil	SafeHarbor Technology Corporation
Brewer, Rone	Landau Associates Inc.
Collis, Ken	Real Time Research
Cook, Bill	Port of Astoria

NAME	ORGANIZATION
BUSINESS (CONTINUED)	
Meier, Robert	Rayonier Technical Services
Mitby, Eric	
Nelson Crab Inc	
Rauzon, Mark	Marine Endeavors
MEDIA	
Crampton, Bill	Columbia Basin Bulletin
Espenson, Barry	Columbia Basin Bulletin
Loney, Terry	The Daily World
CITY AGENCIES & GROUPS	
(no contact name)	Port of Chinook
(no contact name)	City of Arcata
(no contact name)	City of Eureka
Andrews, Ryan	City of Westport
Kavanaugh-Lynch, Maragret	City of Alameda Planning and Building
McNerney, John T.	City of Davis, Public Works
COUNTY AGENCIES & GROUPS	
	Pacific County Commissioners Courthouse
Beerbower, Bob	Grays Harbor County Board of Commisioners
Bobzien, Steve	East Bay Regional Park District
Carter, Albert	District #3
Cervelli, Ann	Contra Costa County Board of Supervisors
Chapman, Michael	Clallam County Commisioner
Conlon, Thomas	Humboldt County Planning Department
Doherty, Mike	Clallam County Comissioner
Hishida, Crystal	Alameda County Board of Supervisors
Huntingford, Glen	Jefferson County Commissioner
Leong, Eugene	Association of Bay Governments
Maltbie, John	San Mateo County Board of Supervisors
McGoldrick, Jake	San Francisco Board of Supervisors District 1
Morrisette, Dennis	Grays Harbor County Board of Commisioners
Palmer, Andy	Jefferson County Marine Resource Company
Perez-Sorensen, Phyllis	Santa Clara County Board of Supervisors
Pock, Darrel	Grant County PUD
Schmitt, Joe	Clallam County Marine Resource Company
Tharinger, Stephen	Clallam County Commissioner
STATE AGENCIES & GROUPS	
	Washington Environmental Council
Ball, Lindsay	Oregon Department of Fish and Wildlife
Beach, Rocky	Washington Department of Fish and Wildlife
Bean, Dave	Washington Department of Natural Resources
Burkett, Esther	California Department of Fish and Game
Caswell, James	State of Idaho Office of Species Conservation

NAME	ORGANIZATION
STATE AGENCIES & GROUPS CONTINUED	
Crawforth, Terry	Nevada Department of Wildlife
Dobler, Fred	Washington Department of Fish & Wildlife
Frey, Vicki	California Department of Fish and Game
Hampton, Steve	Office of Spill Prevention and Response CDFG
Huffaker, Steve	Idaho Department of Fish and Game
Koenings, Jeff	Washington Dept. of Fish and Wildlife
Neel, Larry	Nevada Department of Wildlife
Nichols, Mary	CA Resources Agency
Pustis, Nancy	Oregon Division of State Lands
Rea, Maria	CA Resource Agency - Salmon & Watershed
Sallabanks, Rex	Idaho Fish and Game Department
Schnebly, Shan	WSFB
Smith, Jack	Washington Department of Fish and Wildlife
Stone, Richard	Washington Department of Fish and Wildlife
Warren, Ron	Washington Department of Fish and Wildlife
Wood, Dan	Farm Bureau
Zora, Craig	Washington Department of Natural Resources
TRIBAL GOVERNMENTS & STAFFS	
	Northwest Indian Fisheries Commision
Allen, W. Ron	Jamestown S'Klallam Tribal Council
Anderson, Jim	Northwest Indian Fisheries Commission
Brunoe, Garland	Conf. Tribes of the Warm Springs Reservation
Burke, Gary	Confederated Tribes of the Umatilla Indian Resv.
Capoeman-Baller, Pearl	Quinault Indian Nation-Business Committee
Charles, Ronald	Port Gamble S'Klallam Tribe
Crombie, Howard	Conf. Tribes of Coos, Lower Umpqua & Siuslaw
Hapner, Nina	Table Bluff Reservation Wiyot Tribe
James, Gordon	Skokomish Tribal Council
Jim, Russell	Conf. Tribes & Bands of the Yakama Indian Nation
Johnson, Anthony	NPTEC, Nez Perce Tribe
Kennedy, Cheryle	Confederated Tribes of the Grande Ronde
McCullough, Dale	Columbia River Inter-Tribal Fish Commission
Meninick, Jerry	Conf. Tribes & Bands of the Yakama Indian
Nation	
Nelson, Charlene	Shoalwater Bay Tribal Council
Pigsley, Delores	Confederated Tribes of Siletz Indians
Sullivan, Dennis	Lower Elwha Klallam Tribe
FEDERAL AGENCIES & OFFICES	
(no contact name)	Klamath Basin NWRC
(no contact name)	Sacramento/San Joaquin Estuary FRO
(no contact name)	San Diego NWR
(no contact name)	Upper Columbia River Basin Fisheries Office
(no contact name)	Cultural Resource Team, Sherwood, Oregon
(no contact name)	San Pablo Bay NWR
(no contact name)	California/Nevada Operations Office
(no contact name)	Oregon Coast NWRC

NAME	ORGANIZATION
FEDERAL AGENCIES & OFFICES (CONTINUED)	
(no contact name)	Sonny Bono Salton Sea NWRC
(no contact name)	Modoc NWRC
(no contact name)	United States Fish and Wildlife Service
(no contact name)	Malhuer NWRC
(no contact name)	Malhuer NWRC
(no contact name)	Mid Columbia NWRC
(no contact name)	Southeast Idaho NWRC
(no contact name)	Minidoka NWRC
(no contact name)	Stillwater National Wildlife Refuge Complex
(no contact name)	Oregon State Office
(no contact name)	Columbia Basin Ecoregion
Adelsbach, Terry	Sacramento Fish and Wildlife Office
Berg, Ken	Western Washington Fish and Wildlife Office
Bohan, Carolyn	National Wildlife Refuge System
Cameron, Forrest	National Wildlife Refuge System
Concannon, Julie	U.S. Fish and Wildlife Service, Regional One
Diggs, Daniel	U.S. Fish and Wildlife Service, Region One
Dunmire, Scott	USCOE, Walla Walla District Office
Gibbons, Jason	USDA-APHIS Wildlife Services
Kolar, Margaret	San Francisco Bay NWRC
Marker, Doug	Northwest Power Planning Council
Maslen, Bill	Bonneville Power Administration
McChesney, Gerry	San Francisco Bay National Wildlife Refuge
McQuillen, Harry	Sacramento Fish and Wildlife Office
Nelson, Eric	Humboldt Wildlife Refuge
Olney, Fred	U.S. Fish and Wildlife Service, Region One
Paulin, Dave	Klamath and Central Valley/San Francisco Bay
Roush, Linda	Arcata Resource Area, BLM
Ryan, Kevin	Washington Maritime NWRC
Schlafmann, Deb	Habitat Conservation and Partners
Selvaggio, Sharon	U.S. Fish and Wildlife Service
Shake, Bill	U.S. Fish and Wildlife Service, Regional One
Stenvall, Charlie	Willapa NWRC
Swan, Ron	U.S. Fish and Wildlife Service, Regional One
Takekawa, Jean	Nisqually NWR
Thompson, Steve	California/Nevada Operations Office
Wagne, Kim	USDA/APHIS/COS
Walsworth, Dan	Nevada/Southern California-CNO Sacramento
Waters, Linda	North Pacific Coast/Pacific Islands Ecoregion
Welch, Dorie W.	Bonneville Power Administration
Wesley, Dave	United States Fish and Wildlife Service
Wills, David	R1 Columbia River Fisheries Program Office
Wilson, Paul	Columbia River Fisheries Program Office
STATE LEGISLATURE	
Dukes, Joan	Member of Congress
Blake, Brian	Member of Congress
Butler, Tom	Member of Congress
Canciamilla, Joesph	Member of Congress
Doumit, Mark	Member of Congress

NAME	ORGANIZATION
STATE LEGISLATURE (CONTINUED)	
Figueroa, Liz	Member of Congress
Guinn, Kenny	Governor of Nevada
Hatfield, Brian	Member of Congress
Kempthorne, Dick	Governor of Idaho
Kulongoski, Ted	Governor of Oregon
Locke, Gary	Governor of Washington
McPherson, Ruce	Member of Congress
Merkle, Jeff	Member of Congress
Perata, Don	Member of Congress
Schwarzenegger, Arnold	Governor of California
Sher, Byron	Member of Congress
Speier, Jackie	Member of Congress
Stark, Fortney “Pete”	Member of Congress
Tauscher, Ellen	Member of Congress
Vasconcellos, John	Member of Congress
Yee, Ph.D., Leland	Member of Congress
US CONGRESS	
Baird, Brian	Member of Congress
Boxer, Barbara	Member of Congress
Cantwell, Maria	Member of Congress
Craig, Larry E.	Member of Congress
Crapo, Mike	Member of Congress
Dicks, Norm	Member of Congress
Eshoo, Anna	Member of Congress
Feinstein, Dianne	Member of Congress
Ferrioli, Ted	Member of Congress
Gibbons, James	Member of Congress
Honda, Michael	Member of Congress
Kitts, Derrick	Member of Congress
Lantos, Tom	Member of Congress
Lee, Barbara	Member of Congress
Lofgren, Zoe	Member of Congress
Miller, George	Member of Congress
Murray, Patty	Member of Congress
Pelosi, Nancy	Member of Congress
Reid, Harry	Member of Congress
Rusigh, John	Member of Congress
Simpson, Mike	Member of Congress
Smith, Gordon	Member of Congress
Walden, Greg	Member of Congress
Wu, David	Member of Congress
Wyden, Ron	Member of Congress

Appendix F: Caspian Tern Regional Population Nesting Site Locations and Colony Sizes

TABLE F.1 Current and Historic Caspian Tern Nesting Locations in the Pacific Coast Region

Site Location	Current [a]	Historic [b]
WASHINGTON		
Dungeness Spit NWR, Cllalam County	x	
Padilla Bay, Skagit County		x
Commencement Bay, Pierce County	x [c]	
Grays Harbor, Grays Harbor County		x
Willapa Bay, Pacific County		x
Miller Rocks, Klickitat County		x
Crescent Island, Walla Walla County	x	
Banks Lake, Grant County	x	
Potholes Reservoir, Grant County	x	
Sprague Lake, Adams County	x	
OREGON		
East Sand Island, Clatsop County	x	
Rice Island, Clatsop County	x [d]	
Miller Sands Spit, Clatsop County		x [d]
Threemile Canyon Island, Morrow County	x [e]	
Malheur Lake, Harney County	x	
Crump Lake, Lake County	x	
Summer Lake, Lake County	x	
CALIFORNIA		
Humboldt Bay, Humboldt County	x	
Knights Island, Solano County	x	
Brooks Island, Contra Costa County	x	
Agua Vista, San Francisco County	x	
Hayward Regional Shoreline, Alameda County	x	
Bair Island, San Mateo County	x	
Ravenswood, San Mateo County	x	
Proposed Alameda NWR, Alameda County	x [f]	
Baumberg Tract, Alameda County	x	
Ponds M4/M5, Alameda County		x
Ponds N1-N9, Alameda County		x
Alviso (Pond A7), Santa Clara County	x	
Elkhorn Slough, Monterey County	x	
Salinas River NWR, Monterey County	x	
Bolsa Chica Ecological Reserve, Orange County	x	
Pier 400, Terminal Island, Los Angeles County	x	
South San Diego Bay NWR, San Diego County	x	
Meiss Lake, Butte Valley WA, Siskiyou County	x	
Clear Lake NWR, Modoc County	x	
Goose Lake, Modoc County	x	
Big Sage Reservoir, Modoc County	x	
Honey Lake WA, Lassen County	x	
Mono Lake, Mono County	x	
Lemoore NAS sewer ponds, Kings County	x	
Westlake Farms North Evaporation Ponds, Kings County	x	
Westlake Farms South Evaporation Basin, Kings County	x	
Tulare lakebed, Kings County	x	
South Wilbur Flood Area, Kings County	x	
Tulare Lake Drainage District, North Evaporation Basin, Kings County	x	
Tulare Lake Drainage District, South Evaporation Basin, Kings and Kern County	x	
Lake Elsinore, Riverside County	x	
Salton Sea, Imperial County	x	

Appendix F: Caspian Tern Regional Population Nesting Site Locations and Colony Sizes Continued

TABLE F.1 Current and Historic Caspian Tern Nesting Locations in the Pacific Coast Region (continued)

Site Location	Current [a]	Historic [b]
MEXICO		
Cerro Prieto, Mexicali Valley	x	
Isla Montague	x	
Isla Concha	x	
Isla Vaso 8	x	
IDAHO		
Mormon Reservoir, Camas County	x	
Magic Reservoir, Blaine County		x
Minidoka NWR, Cassia County	x	
American Falls Reservoir, Bingham County	x	
Blackfoot Reservoir, Caribou County	x	
Bear Lake NWR, Franklin County		x
NEVADA		
Stillwater Point Reservoir, Churchill County		x
Lahontan Reservoir, Lyon County		x
Carson Sink, Churchill County	x	
Anaho Island NWR, Washoe County	x	
UTAH		
Great Salt Lake, Tooek County		x
Bear River Migratory Bird Refuge, Box Elder County		x
Farmington Bay Waterfowl Management Area, Davis County		x
Utah Lake, Utah County		x
MONTANA		
Canyon Lake Ferry Reservoir, Lewis and Clark Counties	x	
Fort Peck Reservoir, Charles M. Russell NWR, Valley County	x	
WYOMING		
Molly Island, Yellowstone National Park	x	
Pathfinder Reservoir, Natrona and Carbon Counties		x
Soda Lake Islands, Natrona County	x	
Gray Reef Reservoir, Natrona County		x
Bamforth Lake, Albany County		x
Caldwell Lake, Albany County		x

[a] Active nesting occurred at these sites in the last 5 years. Nesting may or may not have occurred in 2003.

[b] Nesting activity has not occurred for the last 5 consecutive years.

[c] Colony last nested in 2002 but site is no longer available because of environmental clean-up.

[d] Terns could potentially nest at these locations, but active management actions are being implemented to prevent terns from nesting.

[e] Mink predation occurred at this site in 2001 and most likely will inhibit any future nesting activity .

[f] Nesting habitat was lost to heavy vegetation in 1999; restoration needs to occur before terns are able to nest again.

Appendix F: Caspian Tern Regional Population Nesting Site Locations and Colony Sizes Continued

TABLE F.2 Caspian Tern Pacific Coast Regional Population, 1997 to 2003 and Average Colony Size[a]

Site Location	1997	1998	1999	2000	2001	2002	2003	Average[b] Colony Size
	Number of Nesting Pairs							
WASHINGTON								
Dungeness NWR							186[c]	-
Padilla Bay	0	0	-	-	-	-	0	104[d]
Commencement Bay	-	-	423	620[e]	388	215[e]	0	412
Grays Harbor	0	0	0	0	0	0	0	1675[f]
Willapa Bay	0	0	0	0	0	0	0	820[g]
Miller Rocks	-	-	-	-	15	0	0	-
Crescent Island	614[c]	357[c]	552[c]	548	657	578	509	545
Banks Lake	-	-	-	10	23	-	21	18
Potholes Reservoir	259	-	-	150	~250	~250	205	223
Sprague Lake	-	-	~50	20	20	-	-	30
OREGON								
East Sand Island	0	0	547	8,513	8,896	9,933[h]	8,352[h]	7,248
Rice Island	7,151	8,691	8,328	588	0	0	0	6,190
Miller Sands Spit	0	17	0	0	0	0	0	-
Threemile Canyon Island	354[c]	210[c]	238[c]	260	2	0	0	266[i]
Malheur Lake	65	25	30	192[c]	51[c]	0	0	73
Crump Lake	-	-	-	155[c]	-	0	49	102
Summer Lake	-	-	38	16	0	~5	5	16
CALIFORNIA								
Humboldt Bay	-	-	-	-	~17[c]	~6[c]	60[c]	28
Knights Island	400	~200	-	121[c]	43[c]	153	203	187
Brooks Island	~500	582	Active	806[c]	512[c]	825	859	681
Agua Vista	-	-	-	-	-	86[c]	43[c]	65
Hayward Regional Shoreline	1	1	1	1	1	1	0	1
Ravenswood	0	4	0	1	1	1	0	1
Alameda	285	267	1	0	0	0	0	184
Baumberg Tract	0	33	26	79	116	80	35	62
Alviso (Pond A7)	104	30	122	118	155	73	50	93
Elkhorn Slough	0	0	~30	~80	~65	~50	~50	~55
Salinas River NWR	-	-	-	-	2	93[c]	167	87
Bolsa Chica[j]	175	40	58	51	92	192	5	613
Pier 400, Terminal Island	25	146	250	336	160	151	170	177
South San Diego Bay NWR	320	198	261	380	350	379	311	314
Meiss Lake, Butte Valley WA	25[c]	16	27	19	0	0	0	22
Clear Lake NWR	180[c]	68[c]	118	242[c]	201	0	29	120
Goose Lake	143[c]	-	310[c]	4	~240	133	282	185
Big Sage Reservoir	62[c]	-	0	48	0	0	0	55
Honey Lake WA	152	-	87	82	92	46	13	79
Mono Lake	0	0	0	8	6	11	8	8
Lemoore NAS sewer ponds	-	20[c]	0	-	-	0	-	-
Westlake Farms, South Evaporation Basin	0	3	0	0	0	0	-	-
Tulare lakebed	0	20[c]	0	0	0	0	-	-
South Wilbur Flood Area	0	70	27	0	0	0	-	49
Tulare Lake Drainage District, North Evaporation Basin	0	0	0	0	1	0	-	-
Tulare Lake Drainage District, South Evaporation Basin	0	40	0	0	0	0	-	-
Lake Elsinore	-	-	14	-	-	0	-	-
Salton Sea	1,200	800	211	207	327	29	88	409

Appendix F: Caspian Tern Regional Population Nesting Site Locations and Colony Sizes Continued

TABLE F.2 Caspian Tern Pacific Coast Regional Population, 1997 to 2003 and Average Colony Size[a]

Site Location	Number of Nesting Pairs							
	1997	1998	1999	2000	2001	2002	2003	Average[b] Colony Size
MEXICO								
Cerro Prieto	30	-	-	0	0	4	37	-
Isla Montague	-	-	-	-	-	83	-	-
Isla Concha	-	-	-	-	-	21	23	22
Isla Vaso 8	-	-	-	-	-	32	90	61
IDAHO								
Mormon Reservoir	-	-	-	-	~2	25	0	14
Minidoka NWR	-	-	-	1	0	4	0	1
American Falls Reservoir	-	-	-	-	-	5	0	-
Blackfoot Reservoir	-	-	-	-	0	50	40	45
NEVADA								
Carson Sink	0	-	685	0	0	0	0	-
Anaho Island NWR, Pyramid Lake	1	5	0	0	0	0	5	4
MONTANA								
Canyon Lake Ferry Reservoir	5	0	2	7	35	43	11	15
Fort Peck Reservoir, Charles M. Russell NWR	?	?	?	?	~25	~25	-	25
WYOMING								
Molly Island, Yellowstone Lake	4	5	4	0	3	5	-	4
Soda Lake islands	0	0	0	7	12	19	-	13
PACIFIC REGION TOTALS[k]	**12,115**	**11,848**	**12,440**	**13,669**	**12,760**	**13,606**	**11,906**	**-**

[a] Data from Shuford and Craig 2002 with additional data for 2002 and 2003 from USFWS and D. Shuford. To enable estimation of the total numbers of breeding pairs in the entire region, we adjusted some raw counts or estimates. When a range was given for numbers of nests or pairs we report the mid-point (e.g., 800-850 pairs reported as 825 pairs) and for breeding adults we use the mid-point as the basis for estimating numbers of pairs. Counts or estimates of breeding adults were multiplied by 0.62 to approximately estimate numbers of breeding pairs based on the average ratio of nests to adults at sites on the California coast (0.625, Carter et al. 1992, p. I-45) and the California interior (0.61, D. Shuford unpubl. data). Dashes (–) indicate that no survey was conducted or no data available, zeroes (0) that a survey was conducted but no evidence of nesting observed, and question marks (?) that nesting strongly suspected but no solid data available.

[b] Average colony size was based on years with nest counts only.

[c] Counts of adults were converted to an estimate of breeding pairs by multiplying raw adults by the 0.62 correction factor described above.

[d] Average colony size for Padilla Bay was calculated based on data collected in 1991 and 1995 (M. Davison pers. comm)

[e] Counts of adults were converted to an estimate of breeding pairs by multiplying raw adults by the 0.62 correction factor described above. Terns at Commencement Bay in 2002 were nesting on the rooftop of a Port of Tacoma building (# 407); the count of adults on which the estimate of pairs was made was taken late in the nesting season (9 July).

[f] Average colony size calculated from data in Shuford and Craig (2002). Range = 9 - 3950 breeding pairs

[g] Average colony size calculated from data in Shuford and Craig (2002). Range = 175 - 1500 breeding pairs

[h] Data from Collis et al. 2003a and 2003b

[i] Average colony size does not include 2001 nest count because the colony was affected by a predator that year.

[j] All counts from Bolsa Chica are of total nest attempts (on the basis of marked nests), which likely overestimates nesting pairs because of pairs that renest after initial failures.

[k] Totals are likely underestimates because of a lack of surveys at some sites in particular years or during the whole time period (e.g., most sites in Mexico).

Appendix G: Potential Caspian Tern Nesting Sites in the Pacific Coast Region: Selection Process and Proposed Management Actions

The process used to identify the seven sites in this DEIS consisted of an initial review (feasibility assessment) of Caspian tern nesting habitat that was conducted by the Service in 2002 (see Seto et al. 2003 for full report). A total of 77 individual historic, current, and potential nesting sites (sites with appropriate habitat) in Washington, Oregon, California, Idaho, and Nevada were evaluated in this study (including site visits) to determine their management potential for Caspian terns (Seto et al. 2003). Sites in or near the Columbia River, such as Crescent Island, were eliminated from consideration because specific activities to enhance Caspian tern colonies in these locations would not contribute to the goal of reducing impacts to ESA-listed Columbia River salmonids. During the feasibility assessment, a site was determined to have management potential for Caspian terns if the following conditions were met (Seto et al. 2003, Table G.1):

1. Suitable nesting habitat is present or habitat enhancement requirements are minimal,
2. Site is available or could be managed for nesting terns every year,
3. Site can support a substantial number of breeding terns (350 to 2,000 nesting pairs),
4. Prey is available in most or all years,
5. Potential predators (mammalian and avian) are absent or controllable, and
6. Levels of natural or human disturbance are absent, minimal, or controllable.

Sites determined to have management potential for Caspian terns were also ranked to identify those sites which had the best potential to serve as alternate nesting habitat for terns displaced from East Sand Island (Tables G.2 and G.3). Based on this initial review, further investigation of sites, public scoping, and comments received by the states of Washington, Oregon, and California, the list of potential nesting sites for displaced Caspian terns was refined for analysis in this DEIS. A few sites not discussed in the feasibility assessment (e.g. Dungeness National Wildlife Refuge (NWR), Yolo Bypass Wildlife Area, and City of Davis Wetlands) were identified during scoping.

Although these sites were identified as having potential for Caspian tern management, some sites were eliminated from further consideration in this EIS (See Table G.4 for a summary of nesting sites that were not selected and the reason for elimination). These included socio-political and biological concerns expressed by Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), California Fish and Game (CDFG), and the Service's California/Nevada Operations office. For example, several sites in coastal Washington (e.g., Grays Harbor and Padilla Bay) were identified in the feasibility assessment (Seto et al. 2003, Table G.1) as having high management potential for development of tern nesting habitat, but have been eliminated from further consideration because WDFW does not support or would not facilitate the managed relocation of Caspian terns within Washington. Since Caspian terns established a colony at Dungeness NWR in 2003 on their own accord, this site remained in our analysis.

ODFW will not support managed relocation of Caspian terns to non-historic nesting sites in Oregon. Since terns have not been documented to nest on the Oregon Coast, sites on the coast that were identified in the feasibility assessment were eliminated from further consideration (Seto et al. 2003, Table G.1). Crump and Summer lakes, although identified as having no management potential in the feasibility assessment, are included in the DEIS at the request of ODFW because they are historic or current nesting sites. Although Fern Ridge Lake is not a historic tern nesting site in Oregon, we included Fern Ridge Lake in our analysis. The Willamette and McKenzie rivers are about 15 miles from the area and since a variety of resident fish species are present in the lake, we do not expect ESA-listed salmonids to serve as a primary food resource for the terns. Thus, although this is not a historic tern nesting site, relocation of terns to this site may not result in high levels of predation on other salmonid stocks.

Similarly, CDFG will support Caspian tern management in California only at historic colonies. Therefore, although the scoping process of this EIS identified development of tern nesting habitat at the Yolo Bypass Wildlife Area and City of Davis Wetlands in the Sacramento Valley, these sites were removed from further analysis because they are not historical Caspian tern nesting sites. Additionally, although Humboldt Bay is a historic tern nesting site, Teal Island in the Humboldt Bay National Wildlife Refuge (NWR) was eliminated from further consideration in this EIS because of concerns expressed by CDFG and the Service's California/Nevada Operations office about the potential impact of tern predation on ESA-listed salmonids and partnership efforts associated with salmon recovery. Although management actions associated with this EIS are not proposed for these sites, displaced Caspian terns may select to nest on these sites or any other sites in the region by their own accord.

Final criteria used to identify potential nesting sites listed in Table 2.1 included:

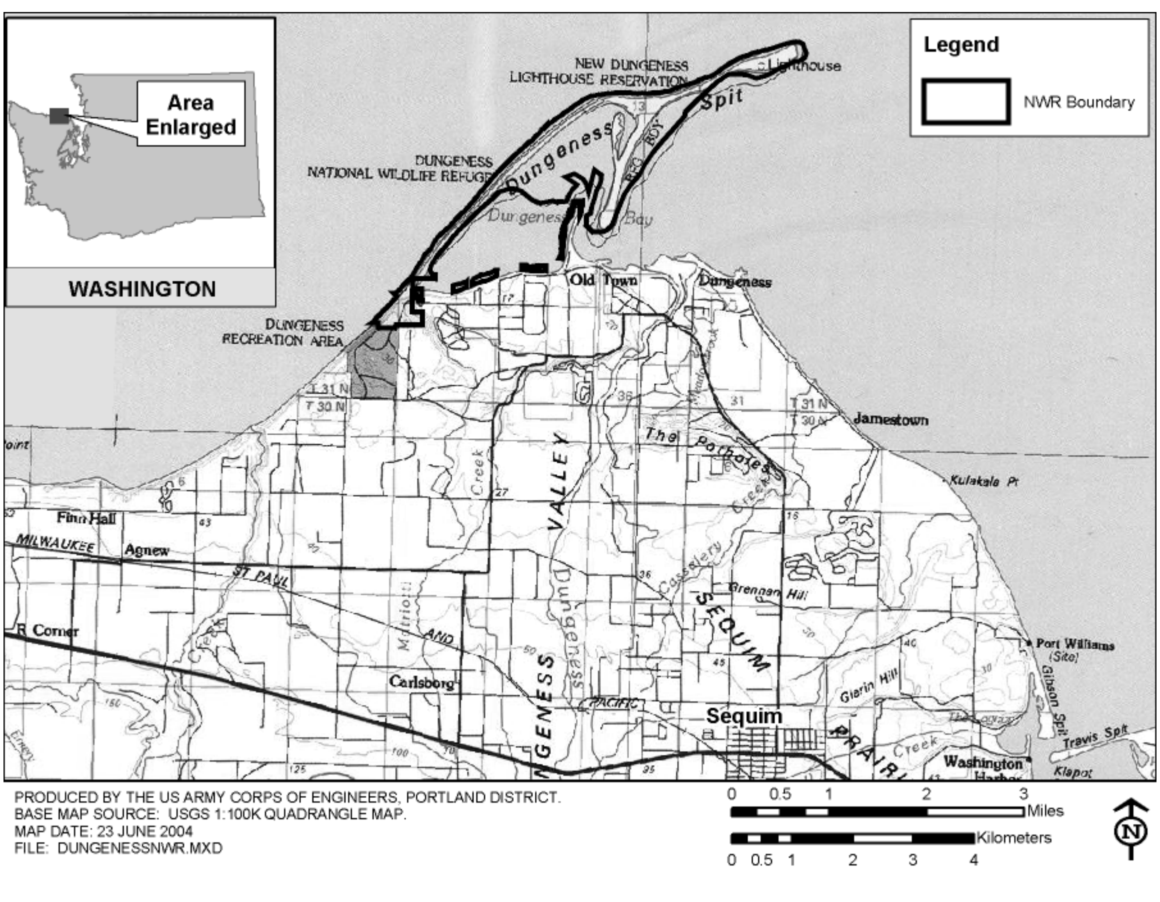
1. Relative stability and abundance of suitable prey (i.e., prey are heavily dependent on annual water levels at interior sites vs. sites with more stable water/prey resources),
2. Availability of or capability to improve/develop Caspian tern nesting habitat in the near future (2005 to 2008),
3. Ability to attract nesting terns from East Sand Island (using distance from East Sand Island as an indicator), and,
4. Minimal conflict with ESA-listed species.

Potential Caspian Tern Nesting Sites and Possible Management Actions

Management actions that would be required at each potential site if selected for implementation are described below and summarized in Table 2.1.

Dungeness NWR. Since the completion of the feasibility assessment report, a new site, Dungeness NWR (Figure G.1), in northwestern Washington, became available for consideration because terns established a new nesting colony there in 2003. The current Caspian tern nesting site at Dungeness NWR could accommodate an increased number of nesting terns and thus, does not require any habitat enhancement. However, protecting this newly established Caspian tern colony to decrease possible human disturbance and predator access would provide a secure nesting site less susceptible to factors that would otherwise lead to site failure or abandonment. This includes adding educational signs to notify visiting public of the existing closed area, enforcing closures, and monitoring predator activity. If predators, primarily mammalian, become

FIGURE G.1 Dungeness National Wildlife Refuge (NWR), Washington



a problem, a predator management program may be considered to ensure successful tern nesting. However, the control or elimination of predators may not be feasible because this site is connected to the mainland, unlike an island site which has limited predator access.

Estimated costs: $ 65,000.00 (first year costs, including monitoring)

Crump Lake. Management actions proposed at Crump Lake (Figure G.2), in south-central Oregon, are extensive. Since the reconstructed nesting island (Crump Island) lies below full lake water levels and is subject to erosion, we propose to build up the island to an elevation that would remain above high water levels. This would be achieved by using a "mudcat" hydraulic dredge to place material from the lakebed to form the island. An interlocking, plastic sheet pile wall would be used around the island to hold the dredged material in place. These activities would occur during the month of June when water levels would be at their highest. To stabilize the surface of the constructed island (1.5 acres) and to reduce the risk of dense vegetation encroachment, the island would be capped with gravel and fines. This material would need to be placed on site via helicopter. Social attraction techniques using decoys and vocalization recordings would be used to attract terns to nest at the new island site.

Estimated costs: $ 1,192,413.00 (first year costs, including construction and monitoring)

Summer Lake. The historic Caspian tern nesting island in Summer Lake (Figure G.3), also in south-central Oregon, is connected to the mainland during low water years, resulting in increased vulnerability to predators. Since it would be difficult to ensure that this island remains isolated during low water level years, we propose to build new islands in wetland impoundments north of Summer Lake within the ODFW Wildlife Management Area. Proposed management actions for the Summer Lake Wildlife Management Area would occur at the East Link impoundment, and adjacent to the Windbreak and Gold Dike locations. ODFW personnel have better control of the water in these impoundments. Thus, they would serve as higher quality and more predictable habitat for Caspian terns. The East Link location is a diked, rectangular impoundment that would need to be allowed to dry in late November-early December to allow for a late July to September construction period. A 0.5 acre island would be constructed at this site, centered in the unit. Material for the island will come from either of two methods. If site conditions are suitable,

FIGURE G.2 Crump Lake, Oregon

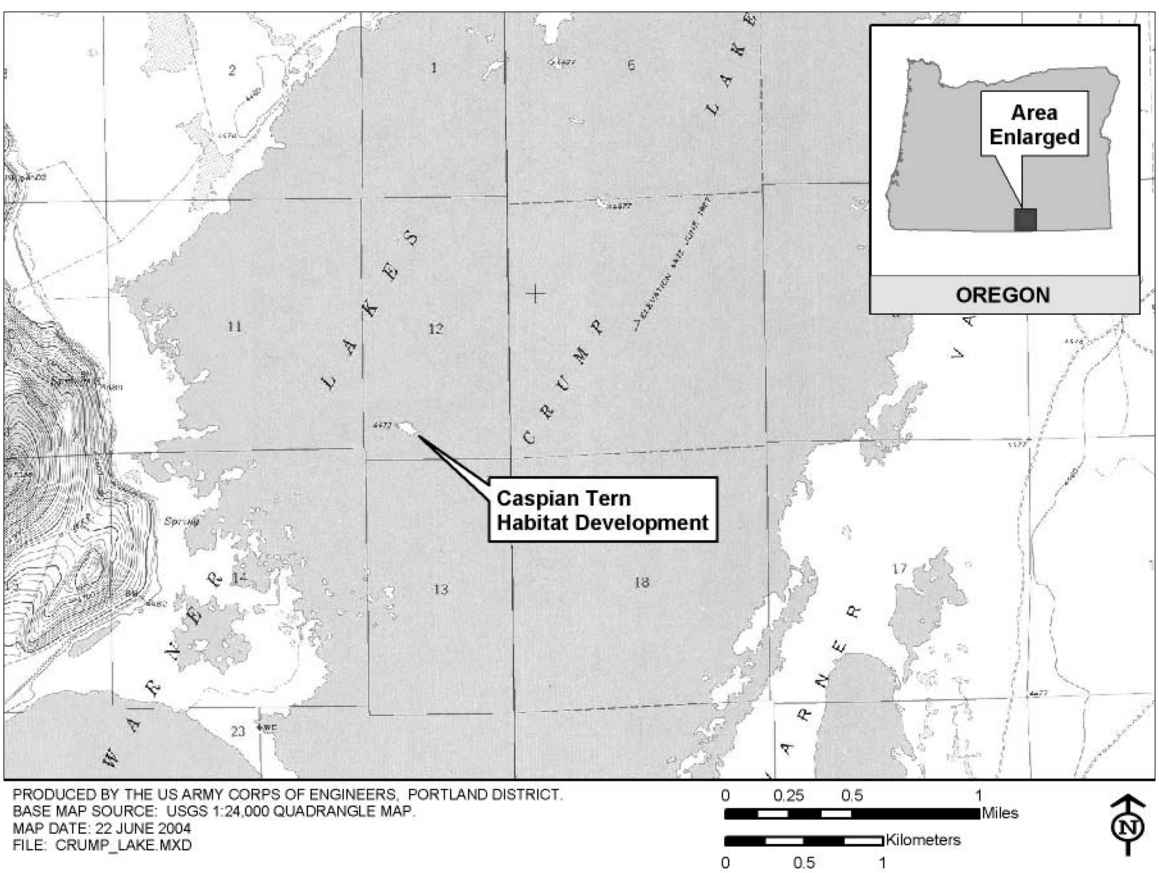


FIGURE G.3 Summer Lake, Oregon

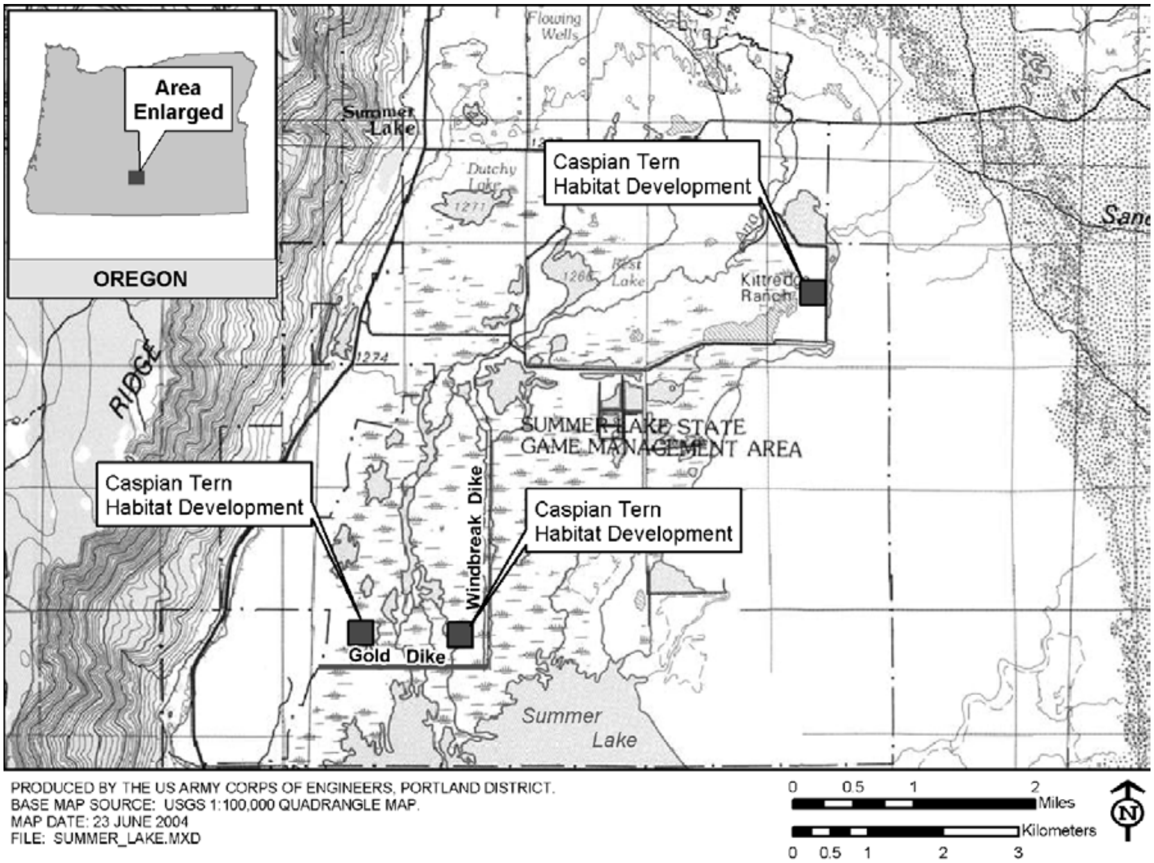
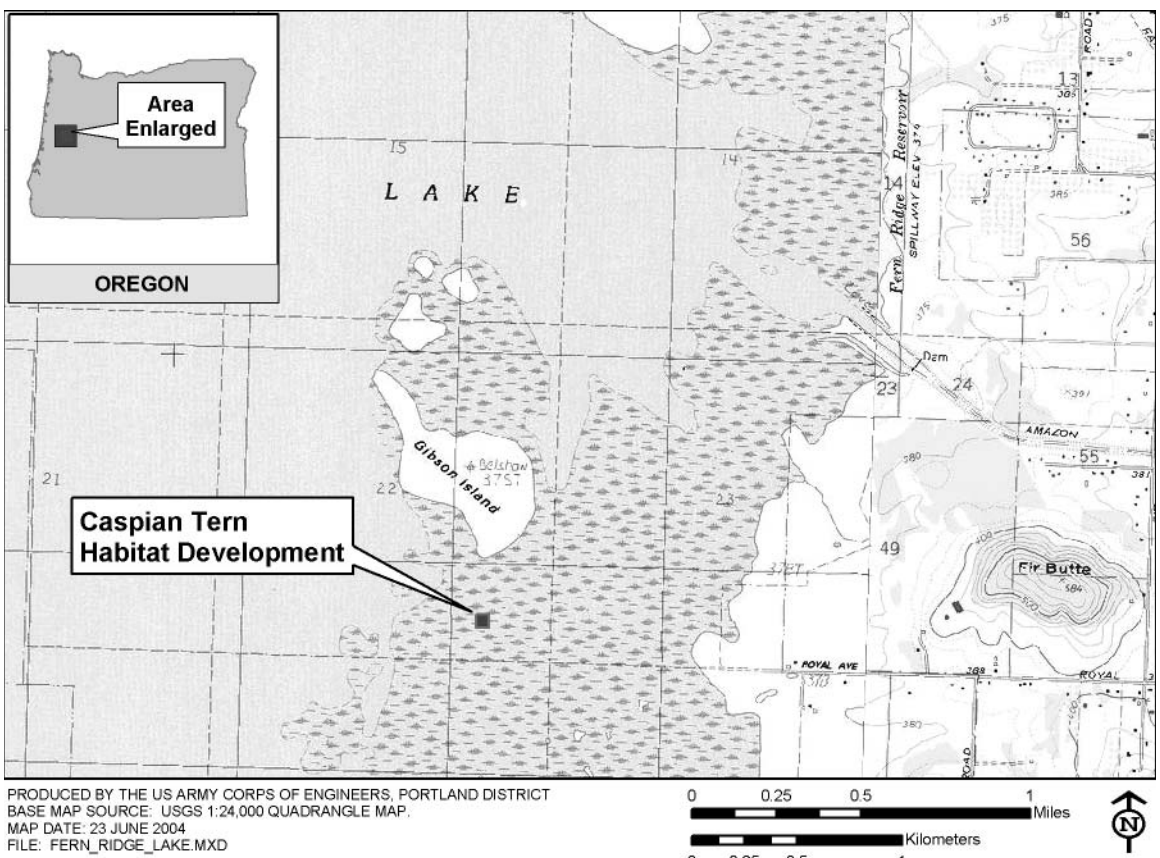


FIGURE G.4 Fern Ridge Lake, Oregon



excavators would be used to push material to the island from adjacent land. The second construction method would obtain the necessary borrow material from dry soil formerly sidecast from the maintenance excavation of the East Link canal. This material would need to be trucked into the site. Once the island is completed, a top dressing of relatively fine gravels (approximately pea-size or smaller) obtained from an ODFW quarry would be placed on the island. This material would provide a suitable nesting substrate for terns. A construction access road would be constructed for gravel trucks to reach the constructed island. Upon completion of the project, the road would be sidecast back into the borrow pits from which it was constructed.

Two additional 0.5 acre-islands would also be constructed off the Windbreak and Gold dikes. Both of these dikes are located within a diked impoundment. As with the East Link location, the impoundment would need to be allowed to dry before construction, again preceded by a drawdown initiated in late November to early December. Construction at these sites would occur as described above for the East Link site. As with Crump Lake, social attraction techniques would also be used to attract terns to all three islands that would be constructed at this site.

Estimated costs: $ 600,873.00 (first year costs, including construction and monitoring)

Fern Ridge Lake. Fern Ridge Lake (Figure G.4), in the southern Willamette Valley of Oregon, currently contains no appropriate nesting habitat for Caspian terns. The Corps has prepared a conceptual draft for the construction of a 1-acre island in the reservoir to serve as nesting habitat for terns (U.S. Army Corps of Engineers 1998). We propose to implement this project and attract terns to the site with social attraction techniques. A 1-acre island would be constructed off Royal Avenue within the full pool boundary.

Estimated costs: $ 428,807.00 (first year costs, including construction and monitoring)

San Francisco Bay. Brooks Island. In San Francisco Bay, California (Figure G.5), there are several sites that could be enhanced for Caspian terns. On Brooks Island (Figure G.6), we propose to assist the East Bay Regional Parks Department in removing vegetation adjacent to the current tern nesting area to create more open habitat for nesting terns. Open habitat at higher elevations would help eliminate the possibility of nest loss due to flooding at high tide. Increased enforcement of area closures would also protect the tern nesting colony. Rats have been documented on the island and may need to be controlled or eliminated to ensure long-term nesting success for the terns. Predator control (avian and mammalian), may also be necessary. In addition, we would explore various methods to prevent erosion of the spit at Brooks Island that is currently occurring. Estimated costs: $ 56,000.00 (first year costs, including habitat management and monitoring)

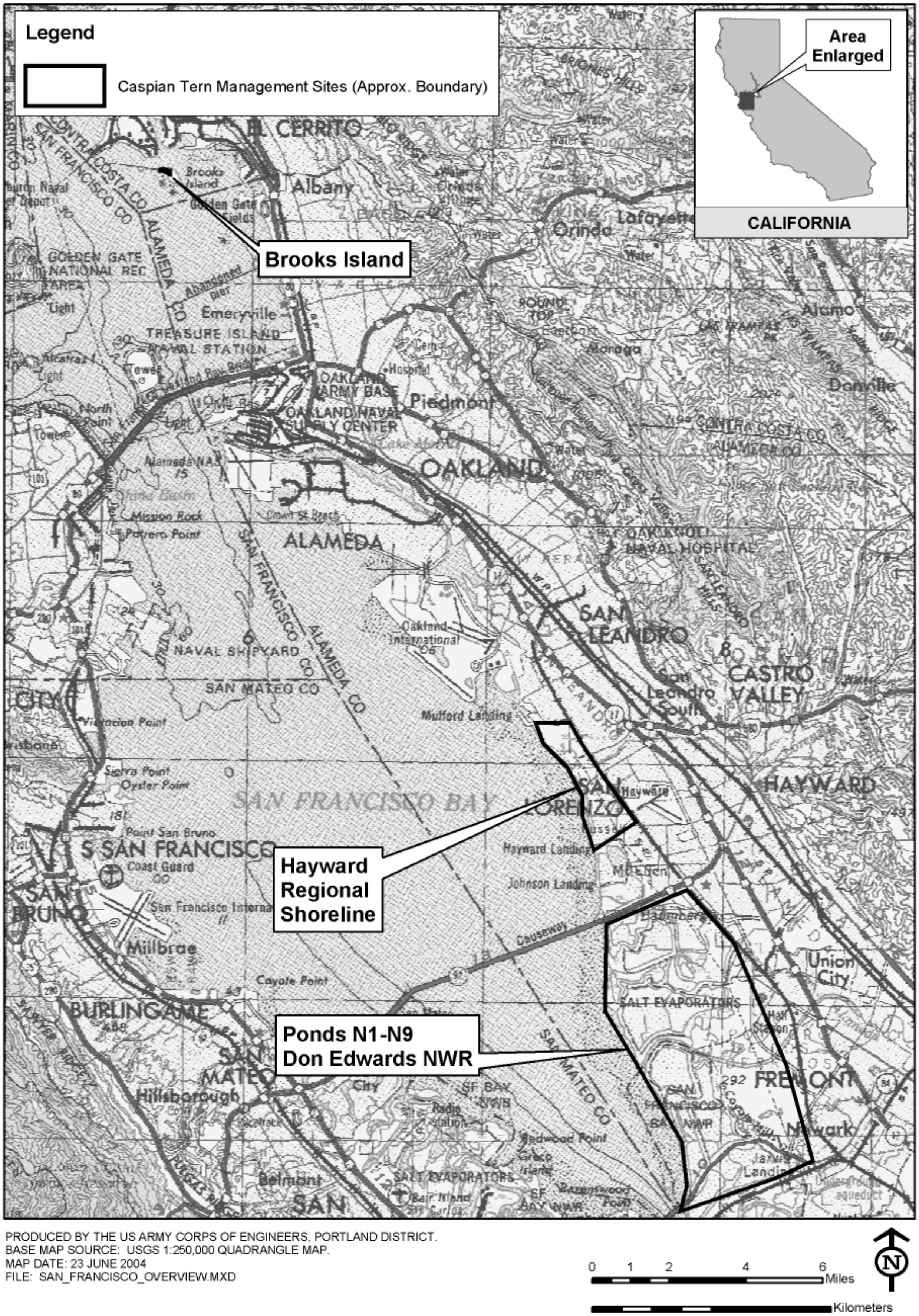
Ponds N1/N9. Ponds N1/N9 in the Don Edwards San Francisco Bay NWR (Figure G.7) are active salt ponds with numerous internal levees that are closed to visiting public. Although nesting terns have used nearby areas, no nesting activity has been documented at this site. Nesting habitat could be created for terns by enhancing nesting substrate and increasing predator control. Gravel or oyster shells would be deposited on the site via helicopter. Social attraction techniques would also be used.

Estimated costs: $ 174,000.00 (first year costs, including construction and monitoring)

Hayward Regional Shoreline. Hayward Regional Shoreline (Figure G.8) is also managed by East Bay Regional Parks. This site contains a number of inactive salt ponds that are now managed for various wildlife species. Numerous islands are found throughout the former salt ponds. A single pair of Caspian terns has nested at this site in recent years. Nesting habitat can be enhanced on Islands 2, 6, and 7 and include removing existing vegetation, installing a weed barrier fabric, saturating the site with salt to prevent vegetation growth, and improving the substrate with sand or oyster shells (via helicopter). Social attraction techniques would also be used.

Estimated costs: $ 174,000.00 (first year costs, including construction and monitoring)

FIGURE G.5 Caspian Tern Management Sites in San Francisco Bay, California



PRODUCED BY THE US ARMY CORPS OF ENGINEERS, PORTLAND DISTRICT.
BASE MAP SOURCE: USGS 1:250,000 QUADRANGLE MAP.
MAP DATE: 23 JUNE 2004
FILE: SAN_FRANCISCO_OVERVIEW.MXD

FIGURE G.6 Brooks Island, San Francisco Bay, California

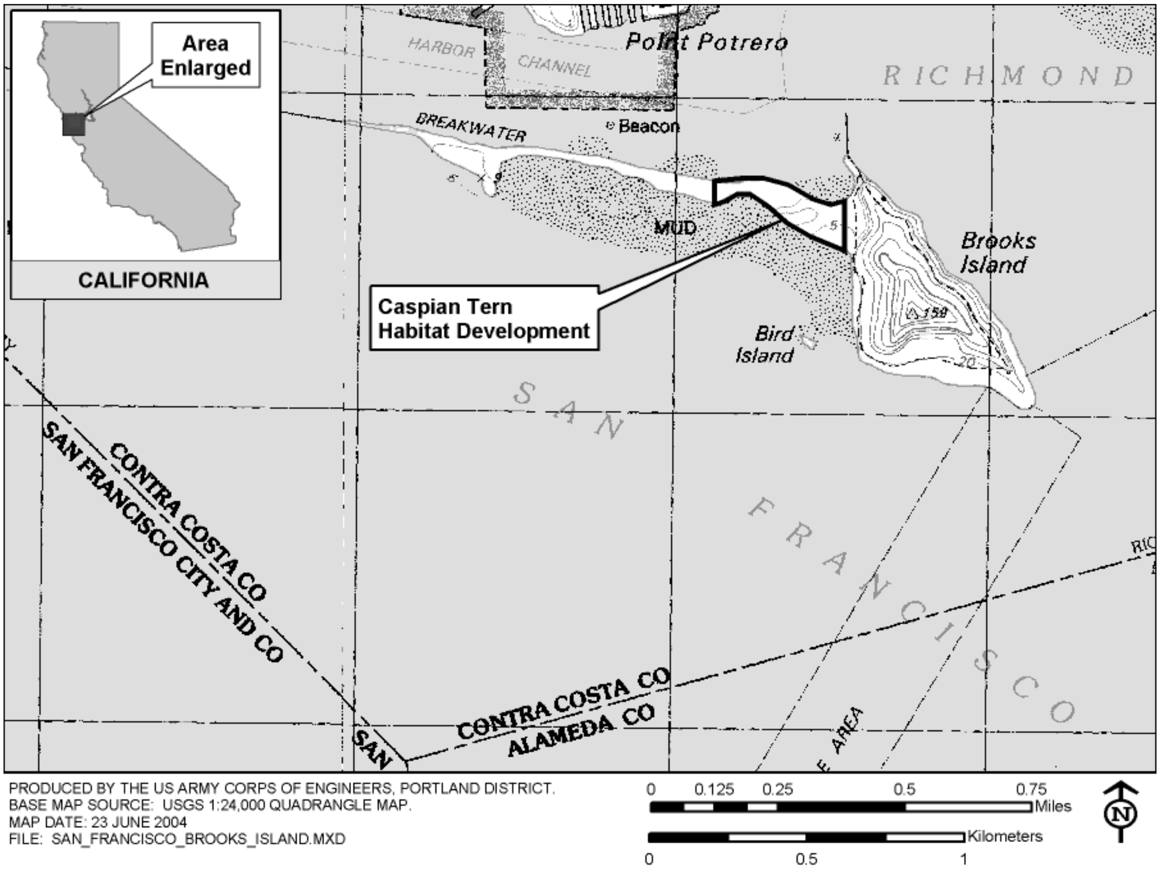


FIGURE G.7 Ponds N1/N9 in the Don Edwards San Francisco Bay NWR, California

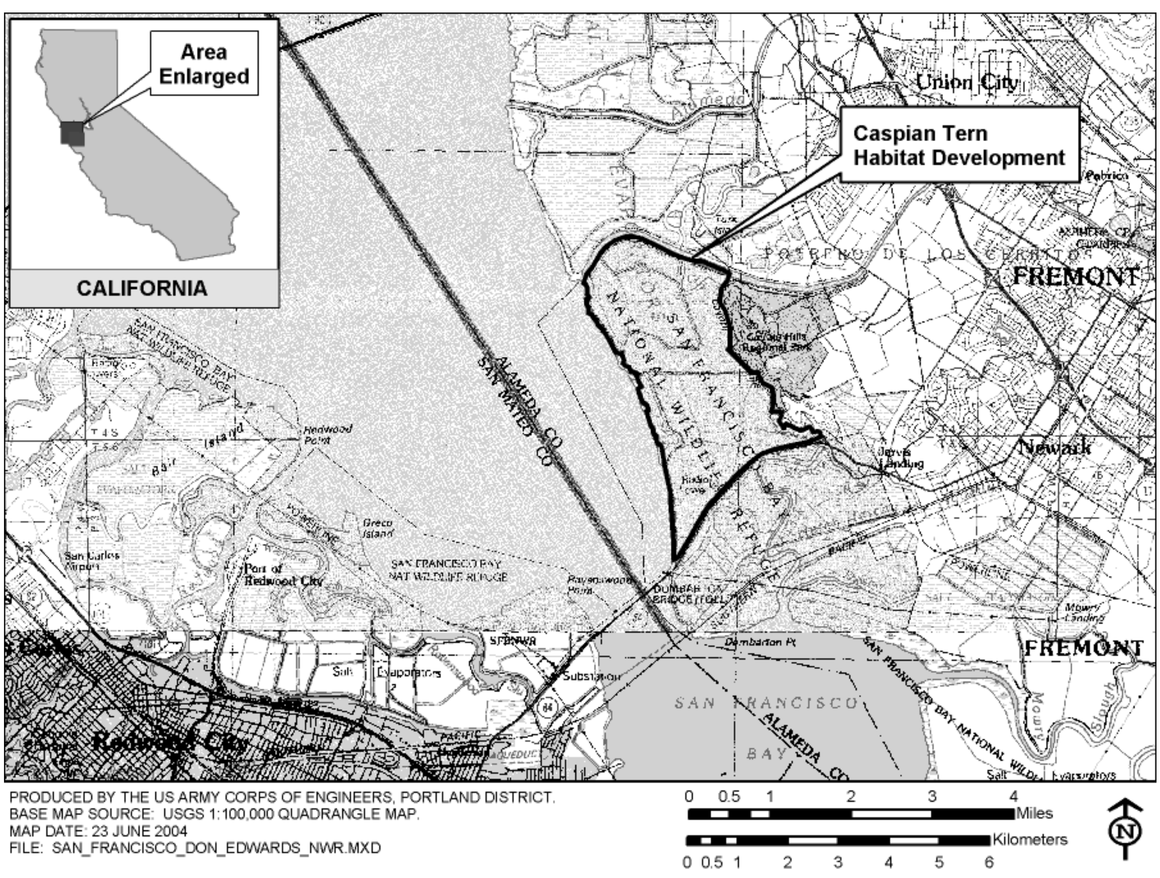


FIGURE G.8 Hayward Regional Shoreline, California

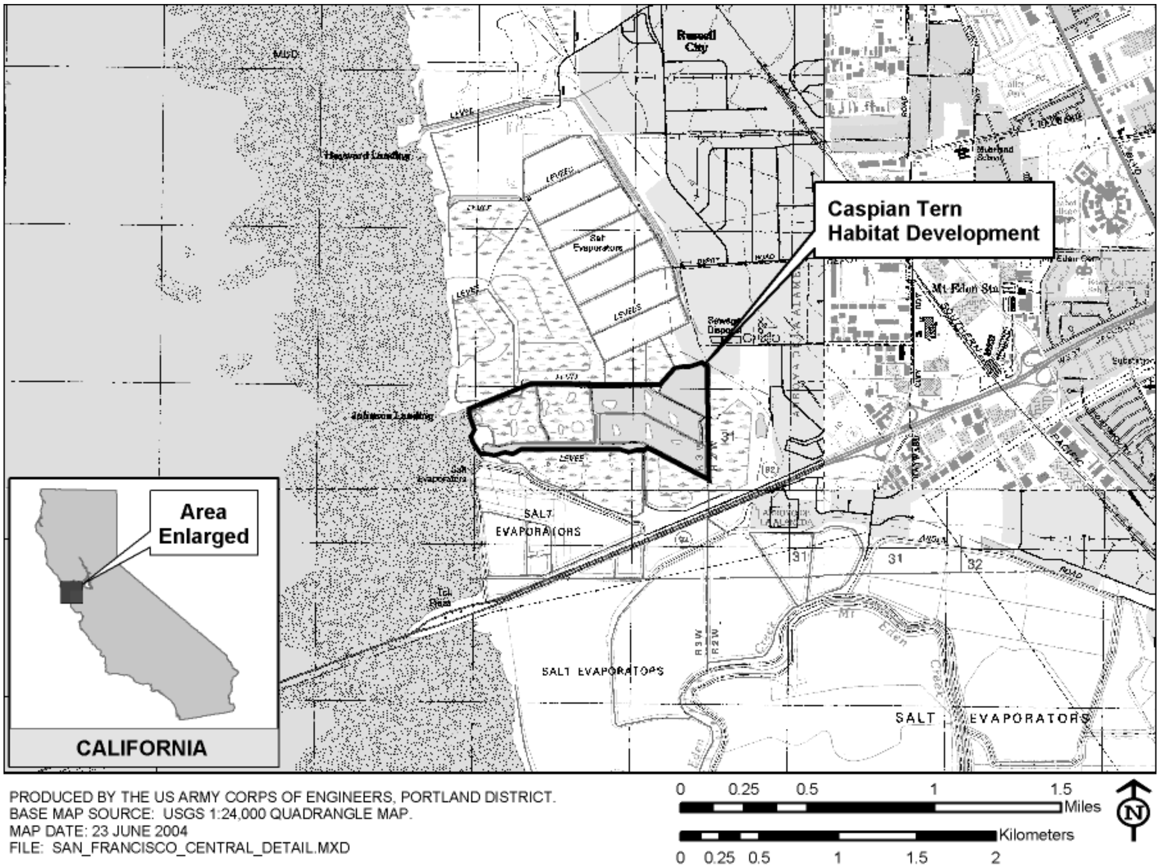


Table G.1 Assessment of Caspian tern habitat management potential at 77 sites in the Pacific Coast/Western Region. [a]

Site Name	Management Potential Yes	No	Factors limiting Management Potential
COASTAL WASHINGTON			
Sand Island, Grays Harbor	x		
No Name Island, Grays Harbor	x		
Unnamed Island, Grays Harbor	x		
Cate Island, Grays Harbor	x		
Bldg 407, Commencement Bay		x	Landowner will discourage birds
McNeil Island, Puget Sound		x	No site available
Snag Islands, Willapa Bay		x	No stable nesting habitat
Unnamed Island, Padilla Bay	x		
Jetty Island, Puget Sound	x		
INTERIOR WASHINGTON			
Solstice Island, Potholes Reservoir		x	Fluctuating reservoir water levels
Unnamed Island, Potholes Reservoir		x	Fluctuating reservoir water levels
Harper Island, Sprague Lake		x	Poor nesting substrate
Unnamed Island # 1, Banks Reservoir		x	Fluctuating reservoir water levels
Unnamed Island #2, Banks Reservoir		x	Fluctuating reservoir water levels
Goose Island, Banks Reservoir		x	Fluctuating reservoir water levels
MID-COLUMBIA RIVER			
Crescent Island		x	Will not reduce Columbia River impacts
Straight Six Island, Umatilla		x	Will not reduce Columbia River impacts
No Name Island #1, Umatilla		x	Will not reduce Columbia River impacts
No Name Island # 2, Umatilla		x	Will not reduce Columbia River impacts
No Name Island #3, Umatilla		x	Will not reduce Columbia River impacts
“Test” Island, Umatilla		x	Will not reduce Columbia River impacts
Miller Rocks		x	No available habitat
Threemile Canyon Island		x	Will not reduce Columbia River impacts
COASTAL OREGON			
Unnamed Island, Coos Bay	x		
“South” Island, Coos Bay		x	Heavily vegetated, heavy boat traffic
“Middle” Island, Coos Bay		x	Heavily vegetated, heavy boat traffic

Table G.1 (Cont.) Assessment of Caspian tern habitat management potential at 77 sites in the Pacific Coast/Western Region. [a]

Site Name	Management Potential Yes	No	Factors limiting Management Potential
"North" Island, Coos Bay		x	Heavily vegetated, heavy boat traffic
Unnamed Island, Umpqua River Estuary	x		
Steamboat Island, Umpqua River Estuary	x		
Fern Ridge Reservoir, Oregon	x		
INTERIOR OREGON/NEVADA			
Pelican/Crump Lake, Oregon		x	Site availability varies annually
Summer Lake, Oregon		x	Site availability varies annually
Tern Island, Malheur Lake		x	Site availability varies annually
Anaho Island, Pyramid Lake		x	Inadequate prey base
Stillwater National Wildlife Refuge		x	Site availability varies annually
Carson Sink, Nevada		x	Site availability varies annually
SOUTHERN IDAHO			
Unnamed Island, Mormon Reservoir		x	Site availability varies annually
Tern Island, Minidoka NWR		x	Site availability varies annually
Gull Island, American Falls Reservoir		x	Site availability varies annually
Gull Island, Blackfoot Reservoir		x	Site availability varies annually
Unnamed Island, Bear Lake NWR		x	Site availability varies annually
NORTHERN COASTAL CALIFORNIA			
Sand Island, Humboldt Bay	x		
Knight Island, San Pablo Bay	x		
Brooks Island, San Francisco Bay	x		
Runway wetland, Alameda NWR	x		
West wetland, Alameda NWR	x		
Pond A7, South San Francisco Bay	x		
Pond A16, South San Francisco Bay	x		
Pond 10, Baumberg Tract, San Francisco Bay	x		
Elkhorn Slough, Monterey Bay	x		
Salinas River, Monterey Bay		x	Incompatible with management for snowy plovers
SOUTHERN COASTAL CALIFORNIA			
Terminal Island, Los Angeles Harbor		x	Limited habitat

Table G.1 (Cont.) Assessment of Caspian tern habitat management potential at 77 sites in the Pacific Coast/Western Region. [a]

Site Name	Management Potential Yes	No	Factors limiting Management Potential
Upper Newport Bay Ecological Reserve, Newport	x		
Bolsa Chica Ecological Reserve, Huntington Beach	x		
South San Diego Bay NWR, Saltworks		x	Limited habitat
NORTHEASTERN CALIFORNIA			
Meiss Lake, Butte Valley Wildlife Area		x	Site availability varies with annual precipitation
Lower Klamath NWR	x		
Tule Lake NWR	x		
Clear Lake NWR		x	Site availability varies with annual precipitation
Goose Lake		x	Site availability varies with annual precipitation Site
Bird Island, Big Sage Reservoir		x	Site availability varies with annual precipitation Site
Honey Lake Wildlife Area		x	Site availability varies with annual precipitation Site
Mono Lake		x	Inadequate prey in close proximity
TULARE BASIN			
Lemoore Naval Air Station		x	Site availability varies with annual precipitation
Westlake Farms North Evaporation Basin		x	Site availability varies with annual precipitation
Tulare Lakebed		x	Site availability varies with annual precipitation
Westlake Mitigation Wetland, section 3		x	Site availability varies with annual precipitation
Westlake Farms South Evaporation Basin		x	Site availability varies with annual precipitation
South Wilbur Flood Area		x	Site availability varies with annual precipitation
Hacienda Ranch Flood Basin		x	Site availability varies with annual precipitation
Tulare Lake Drainage District, South Evaporation Basin		x	Site availability varies with annual precipitation
SOUTHERN INTERIOR CALIFORNIA			
Obsidian Butte, Salton Sea		x	Long-term availability of site uncertain
Morton Bay, Salton Sea		x	Long-term availability of site uncertain
Headquarters Unit "D," Salton Sea		x	Long-term availability of site uncertain
Mullet Island, Salton Sea		x	Long-term availability of site uncertain
Unit 1-B4, Salton Sea NWR		x	Long-term availability of site uncertain
Unit 1-A4, Salton Sea NWR		x	Long-term availability of site uncertain

[a] Table taken from Table 7 in Seto, N., J. Dillon, W.D. Shuford, and T. Zimmerman. 2003. A review of Caspian tern (*Sterna caspia*) nesting habitat: a feasibility assessment of management opportunities in the U.S. Fish and Wildlife Service Pacific Region.

TABLE G.2 Potential Caspian tern management sites ranked by Tier I criteria and Categorical Factor assignments.[a]

Sites with Management Potential	Ranking Criteria						Sum of Tier I Ranks	Categorical Factor
	Site Status [b]	Potential Conflict with Salmon [c]	Proximity to East Sand Island [d]	Site Capacity [e]	Conflicts with other listed species (non-salmonids) [f]	Site Availability [g]		
COASTAL WASHINGTON								
Sand Island, Grays Harbor	3	3	3	5	3	5	22	H
No Name Island, Grays Harbor	0	3	3	5	3	3	17	M
Unnamed Island, Grays Harbor	0	3	3	3	3	5	17	M
Cate Island, Grays Harbor	0	3	3	3	3	3	15	M
Whitcomb Island, Grays Harbor	3	3	3	5	3	0	17	M
Unnamed Island, Padilla Bay	3	3	1	1	5	3	16	M
Jetty Island, Puget Sound	0	3	1	5	5	3	17	M
COASTAL OREGON								
Unnamed Island, Coos Bay	0	3	2	1	3	3	12	L
Unnamed Island, Umpqua River Estuary	0	3	2	1	5	3	14	L
Steamboat Island, Umpqua River Estuary	0	3	2	1	5	3	14	L
Fern Ridge Reservoir	0	3	2	5	5	0	15	M
NORTHERN COASTAL CALIFORNIA								
Sand Island, Humboldt Bay	5	3	1	1	5	5	20	H
Knight Island, San Francisco Bay	5	3	1	3	5	3	20	H
Brooks Island, San Francisco Bay	5	3	1	5	5	5	24	H
Runway wetland, Alameda, San Francisco Bay	3	3	1	3	3	3	16	M
West Wetland, Alameda, San Francisco Bay	3	3	1	3	3	3	16	M

TABLE G.2 (cont.) Potential Caspian tern management sites ranked by Tier I criteria and Categorical Factor assignments.[a]

Sites with Management Potential	Ranking Criteria: Site Status [b]	Potential Conflict with Salmon [c]	Proximity to East Sand Island [d]	Site Capacity [e]	Conflicts with other listed species (non-salmonids) [f]	Site Availability [g]	Sum of Tier I Ranks	Categorical Factor
Salt Pond A7, South San Francisco Bay	5	3	1	3	3	3	18	H
Salt Pond A16, South San Francisco Bay	0	3	1	1	3	5	13	L
Baumberg Pond, San Francisco Bay	5	3	1	1	3	3	16	M
Elkhorn Slough, Monterey Bay	5	5	1	1	3	3	18	H
SOUTHERN COASTAL CALIFORNIA								
Bolsa Chica Ecological Reserve, Huntington Beach	5	5	1	3	3	0	17	M
Upper Newport Bay Ecological Reserve, Newport Beach	0	5	1	3	3	3	15	M
NORTHEASTERN INTERIOR								
Lower Klamath NWR	3	5	1	3	5	0	17	M
Tule Lake NWR	3	5	1	3	5	0	17	M

[b] Site Status: 5 = nesting colony currently active, 3 = historic nesting colony, 0 = no recorded Caspian tern nesting

[c] Conflict with salmonids: 5 = salmon not available as potential prey item, 3 = salmon present as potential prey but good abundance of non-salmonid prey items, 1 = salmon comprises primary prey base

[d] Proximity to East Sand Island: 3 = site less than 200 km from East Sand Island, 2 = site 200-500 km from East Sand Island, 1 = site greater than 500 km from East Sand Island

[e] Site Capacity: 5 = greater than 2000 nesting pairs, 3 = 350-1000 nesting pairs, 1 = less than 350 nesting pairs

[f] Conflicts with other listed species or species of concern (non-salmonids): 5 = no listed species present, 3 = listed species present but low likelihood of conflict, 1 = listed species present and relatively high potential for conflict

[g] Site Availability: 5 = site currently suitable or requires minimal habitat enhancement, 3 = site available after extensive manipulation, 0 = site needs to be constructed

[a] Table taken from Table 8.A in Seto, N., J. Dillon, W.D. Shuford, and T. Zimmerman. 2003. A review of Caspian tern (*Sterna caspia*) nesting habitat: a feasibility assessment of management opportunities in the U.S. Fish and Wildlife Service Pacific Region.

TABLE G.3 Potential Caspian tern management sites ranked by Tier II criteria and Total Site Scores.[a]

Sites	Ranking Criteria			Sum of Tier II Ranks	Total Site Score
	Habitat Management [b]	Human Disturbance [c]	Potential Predators [d]		
High Category (*5)					
Elkhorn Slough, Monterey Bay	2	3	1	6	30
Sand Island, Grays Harbor	2	5	3	10	50
Brooks Island, San Francisco Bay	2	3	5	10	50
Sand Island, Humboldt Bay	3	5	5	13	65
Knight Island, San Francisco Bay	3	5	5	13	39
Salt Pond A7, South San Francisco Bay	3	5	5	13	39
Medium Category (*3)					
Unnamed Island, Grays Harbor	3	5	5	13	39
No Name Island, Grays Harbor	2	5	3	10	30
Whitcomb Island, Grays Harbor	3	5	5	13	39
Cate Island, Grays Harbor	2	3	1	6	18
Unnamed Island, Padilla Bay	2	5	3	10	10
Jetty Island, Puget Sound	1	3	3	7	21
Fern Ridge Reservoir	2	5	5	12	12
Runway wetland Alameda NWR, San Francisco Bay	2	5	1	8	24
West Wetland, Alameda NWR, San Francisco Bay	2	5	1	8	24
Baumberg Pond, San Francisco Bay	3	5	5	13	13
Bolsa Chica Ecological Reserve, Huntington Beach	2	5	5	12	36
Upper Newport Bay Ecological Reserve, Newport Beach	2	5	3	10	30

TABLE G.3 (cont.) Potential Caspian tern management sites ranked by Tier II criteria and Total Site Scores.[a]

Sites	Ranking Criteria			Sum of Tier II Ranks	Total Site Score
	Habitat Management [b]	Human Disturbance [c]	Potential Predators [d]		
Lower Klamath NWR	1	5	5	11	33
Tule Lake NWR	1	5	5	11	33
Low Category (*1)					
Unnamed Island, Coos Bay	1	5	5	11	11
Unnamed Island, Umpqua River Estuary	1	5	5	11	11
Steamboat Island, Umpqua River Estuary	3	5	5	13	13
Salt Pond A16, South San Francisco Bay	3	5	5	13	13

[a] Table taken from Table 8.B in Seto, N., J. Dillon, W.D. Shuford, and T. Zimmerman. 2003. A review of Caspian tern (*Sterna caspia)* nesting habitat: a feasibility assessment of management opportunities in the U.S. Fish and Wildlife Service Pacific Region

[b] Habitat maintenance: 3 = short tern or infrequent management requirements, 2 = annual habitat maintenance but no heavy equipment required, 1 = annual maintenance and heavy equipment required

[c] Human disturbance: 5 = site is relatively inaccessible and no established human use, 3 = site is accessible with a history of human use; disturbance levels are manageable, 1 = site is readily accessible with regular human use and limited opportunities for managing use

[d] Predators: 5 = inaccessible to mammals and no known concentration of avian predators in close proximity, 3 = avian and/or mammalian predators on site, but potential impacts to tern colony are low or manageable, 1 = site accessible to mammals and high concentration of avian predators on-site or nearby

TABLE G.4. Sites eliminated from consideration for Caspian Tern Management under Alternatives C and D. Sites are listed in geographical order from north to south.

SITE NAME	REASON FOR ELIMINATION FROM CONSIDERATION
WASHINGTON	
Commencement Bay	Loss of site due to environmental clean-up activities
Padilla Bay	WDFW does not support site development
Jetty Island	WDFW does not support site development
Grays Harbor (4 islands)	WDFW does not support site development
Willapa Bay	Loss of site due to natural erosion
Banks Reservoir (3 islands)	Some nesting terns from this colony forage in the Columbia River, and thus, management of this site for Caspian terns does not support the reduction of tern predation on Columbia River salmon
Potholes Reservoir (2 islands)	Some nesting terns from this colony forage in the Columbia River, and thus, management of this site for Caspian terns does not support the reduction of tern predation on Columbia River salmon
Sprague Lake	Some nesting terns from this colony forage in the Columbia River, and thus, management of this site for Caspian terns does not support the reduction of tern predation on Columbia River salmon
Crescent Island	Location in the Columbia River, and thus, management of this site for Caspian terns does not support the reduction of tern predation on Columbia River salmon
Threemile Canyon Island	Location in the Columbia River, and thus, management of this site for Caspian terns does not support the reduction of tern predation on Columbia River salmon
Miller Rocks	Location in the Columbia River, and thus, management of this site for Caspian terns does not support the reduction of tern predation on Columbia River salmon
OREGON	
Rice Island	Location in the Columbia River, does not support reduction of tern predation on Columbia River salmon
Miller Sands Spit	Location in the Columbia River, does not support reduction of tern predation on Columbia River salmon
Coos Bay	ODFW does not support site development
Umpqua Estuary	ODFW does not support site development
CALIFORNIA	
Humboldt Bay NWR	CDFG and Service California/Nevada Office does not support site development
Knight Island, San Francisco Bay	Loss of nesting area to tidal restoration project by CDFG
Bair Island, San Francisco Bay	Loss of nesting area and restoration not feasible
Turk Island, San Francisco Bay	Loss of nesting area, restoration not feasible
Baumberg Tract, San Francisco Bay	Nesting habitat currently maximized, habitat enhancement not feasible
Alviso (Pond A7), San Francisco Bay	Nesting habitat currently maximized and concerns associated contaminant issues
Moss Landing salt ponds, Monterey Bay	Loss of site
Elkhorn Slough Ecological Reserve	Nesting habitat is not maximized, no habitat enhancement necessary
Pier 400, Terminal Island	Nesting habitat currently maximized, habitat enhancement not feasible
Clear Lake NWR	Nesting habitat is not lacking

TABLE G.4. Sites eliminated from consideration for Caspian Tern Management under Alternatives C and D. Sites are listed in geographical order from north to south.

SITE NAME	REASON FOR ELIMINATION FROM CONSIDERATION
CALIFORNIA (continued)	
Lower Klamath NWR	Loss of site; extremely small historic nesting colony (15-27 pairs), last nested in 1976
Tule Lake NWR	Loss of site; small historic nesting colony (3-80 pairs), last nested in 1962
Mono Lake	Extremely small nesting colony (6 -8 nesting pairs)
Lemoore NAS sewer ponds	Extremely small nesting colony (0-20 nesting pairs)
Yolo Bypass Wildlife Area	CDFG does not support site development
City of Davis Wetlands	CDFG does not support site development
Westlake Farms South Evaporation Basin	Extremely small nesting colony (0 -3 nesting pairs)
Tulare lakebed	Extremely small nesting colony (0 -20 nesting pairs)
South Wilbur Flood Area	Extremely small nesting colony (0-70 nesting pairs)
Tulare Lake Drainage District	Extremely small nesting colony (0-1 nesting pairs)
Tulare Lake Drainage District	Extremely small nesting colony (0-40 nesting pairs)
Lake Elsinore	Extremely small nesting colony (0 -14 nesting pairs); high potential for human disturbance
Salton Sea	Uncertainty of long term water management and prey availability due to potential water transfer from Imperial Irrigation District to San Diego
IDAHO	
Mormon Reservoir	Availability of nesting habitat varies from year to year because of reservoir water levels; large distance from East Sand Island colony
Magic Reservoir	Availability of nesting habitat varies from year to year because of reservoir water levels; large distance from East Sand Island colony
Blackfoot Reservoir	Availability of nesting habitat varies from year to year because of reservoir water levels; large distance from East Sand Island colony
Minidoka NWR	Lack of nesting habitat; large distance from East Sand Island colony
Deer Flat NWR (Snake River Island)	Lack of nesting habitat; large distance from East Sand Island
Bear Lake NWR	Lack of nesting habitat; large distance from East Sand Island
NEVADA	
Carson Sink	Nesting habitat only available during high water/flood years
Anaho Island NWR	Lack of prey base
Stillwater Point Reservoir	Nesting habitat only available during high water/flood years

Appendix H. Scientific Names for Fish, Wildlife and Plants

Federally Endangered and Threatened Fish and Wildlife

Common Name	Scientific Name	Status
Birds		
California brown pelican	*Pelecanus occidentalis*	E
California clapper rail	*Rallus longirostris obsoletus*	E
California least tern	*Sterna antillarum browni*	E
Marbled murrelet	*Brachyramphus marmoratus*	T
Bald eagle	*Haliaeetus leucocephalus*	T
Western snowy plover	*Charadrius alexandrinus*	T
Yellow-billed cuckoo	*Coccyzus americanus*	C
Streaked horned lark	*Eremophila alpestris strigata*	C
Fish		
Chinook salmon	*Oncorhynchus tshawytscha*	*
Coho salmon	*Oncorhynchus kisutch*	*
Chum salmon	*Oncorhynchus keta*	*
Sockeye salmon	*Oncorhynchus nerka*	*
Steelhead salmon	*Oncorhynchus mykiss*	*
Bull trout	*Salvelinus confluentus*	*
Oregon chub	*Oregonichthys crameri*	E
Tidewater goby	*Eucyclogobius newberryi*	E
Lost River sucker	*Deltistes luxatus*	E
Shortnose sucker	*Chasmistes brevirostris*	E
Delta smelt	*Hypomseus transpacificus*	T
Warner sucker	*Catostomus warnerensis*	T
Green sturgeon	*Acipenser medirostris*	C
Mammals		
Salt marsh harvest mouse	*Reithrodontomys raviventris*	E
Riparian brush rabbit	*Sylvilagus bachmani riparius*	E
San Joaquin kit fox	*Vulpes macrotis mutica*	E
Riparian (San Joaquin Valley) woodrat	*Neotoma fuscipes riparia*	E
Reptiles		
Alameda whipsnake	*Masticophis lateralis euryxanthus*	T
Giant garter snake	*Thamnophis gigas*	T
Amphibians		
California red-legged frog	*Rana aurora draytonii*	T
California tiger salamander	*Ambystoma californiense*	PT
California tiger salamander	*Ambystoma californiense*	PT
Columbia spotted frog	*Rana luteiventris*	C
Oregon spotted frog	*Rana pretiosa*	C
Invertebrates		
Fender's blue butterfly	*Icaricia icarioides fenderi*	E
Lange's metalmark butterfly	*Apodemia mormo langei*	E
Callippe silverspot butterfly	*Speyeria callippe callippe*	E
Conservancy fairy shrimp	*Branchinecta conservatio*	E

Federally Endangered and Threatened Fish and Wildlife Continued

Common Name	Scientific Name	Status
Invertebrates (Continued)		
Vernal pool tadpole shrimp	*Lepidurus packardi*	E
Longhorm fairy shrimp	*Branchinecta longiantenna*	E
Bay checkerspot butterfly	*Euphydrayas editha bayensis*	T
Vernal pool fairy shrimp	*Branchinecta lynchi*	T
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	T
Taylor's checkerspot	*Euphydryas editha taylori*	C
Plants		
Willamette daisy	*Erigeron decumbens* var. *decumbens*	E
Bradshaw's lomatium	*Lomatium bradshawii*	E
Antioch Dunes evening-primrose	*Oenothera deltoides ssp. howellii*	E
Contra Costa goldfields	*Lasthenia conjugens*	E
Contra Costa wallflower	*Erysimum capitatum ssp. angustatum*	E
California sea blight	*Suaeda californica*	E
Presidio clarkia	*Lasthenia conjugens*	E
Large-flowered fiddleneck	*Amsinckia grandiflora*	E
Palmate-bracted bird's beak	*Cordylanthus palmatus*	E
Soft bird's beak	*Cordylanthus mollis ssp. mollis*	E
Robust spineflower	*Chorizanthe robusta var. robusta*	E
Showy Indian clover	*Trifolium amoenum*	E
Gold Indian paintbrush	*Castilleja levisecta*	T
Howellia	*Howellia aquatilis*	T
Kincaid's lupine	*Lupinus sulphureus* var. *kincaidii*	T
Santa Cruz tarplant	*Holocarpha macradenia*	T
Pallid manzanita	*Arctostaphylos pallida*	T

Key:

E = Endangered
T = Threatened
PT = Proposed Threatened
C = Candidate
* = see specific ESU listed-status for salmonids in Chapter 3, Table 3.2

Non-Listed Fish, Wildlife and Plants

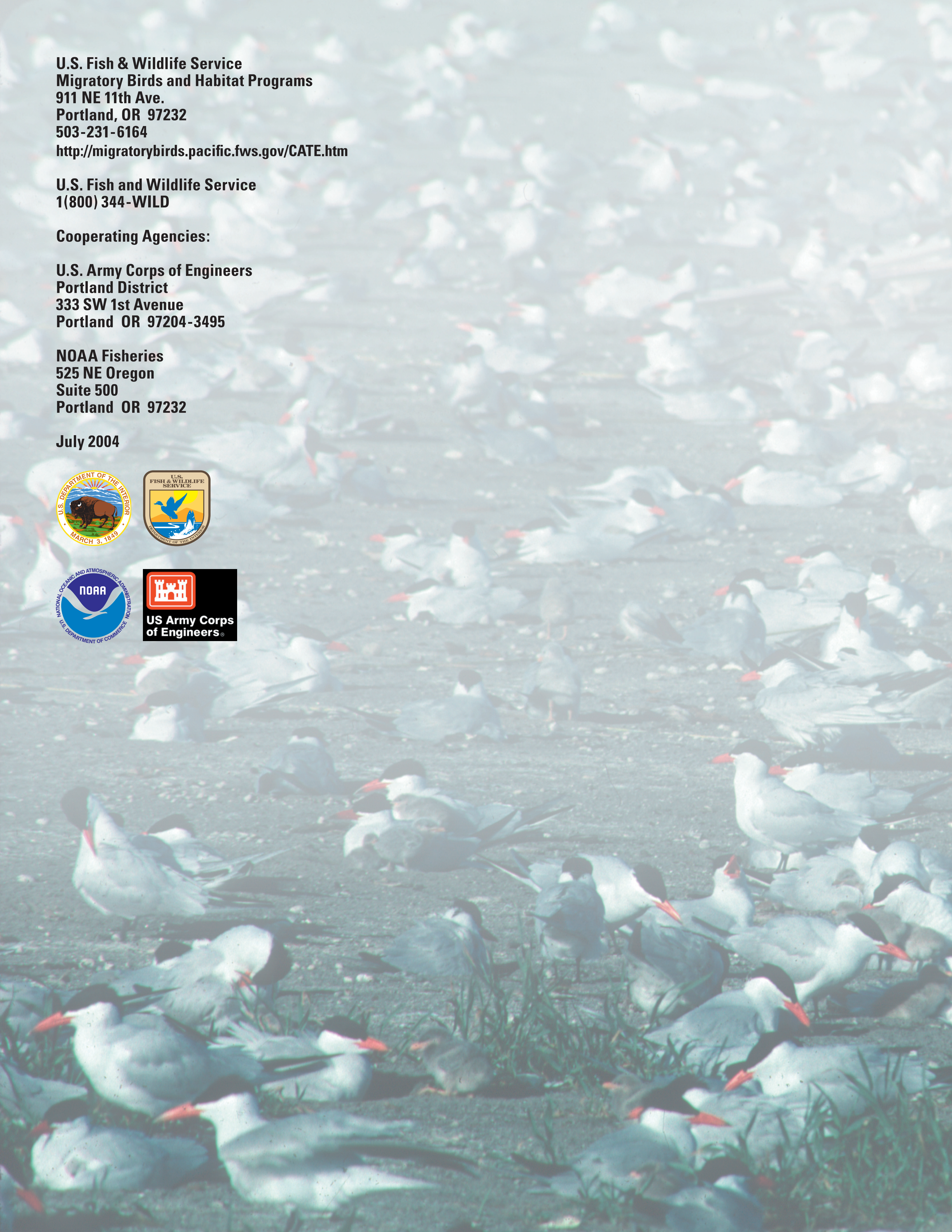
Common Name	Scientific Name
Wildlife	
Birds	
American white pelican	*Pelecanus erythrorhynchos*
Brandt's cormorant	*Phalacrocorax penicillatus*
Double-crested cormorant	*Phalacrocorax auri*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Western Canada goose	*Branta Canadensis*
Brant	*Branta bernicla*
Mallard	*Anas platyrhynchos*
Peregrine falcon	*Falco peregrinus*
Black oystercatcher	*Haematopus bachmani*
Black-necked stilt	*Himantopus mexicanus*
American avocet	*Recurvirostra americana*
Dunlin	*Calidris alpina*
Common snipe	*Gallinago gallinago*
Ring-billed gull	*Larus delawarensis*
California gull	*Larus californicus*
Western gull	*Larus occidentalis*
Glaucous-winged gull	*Larus glaucenscens*
Caspian tern	*Sterna caspia*
Forster's terns	*Sterna forsteri*
Mammals	
Black-tailed deer	*Odocoileus hemionus*
Mule deer	*Odocoileus hemionus*
Coyote	*Canis latrans*
River otter	*Lutra canadensis*
Nutria	*Myocastor Coypus*
Skunk	*Mephitis spp.*
Raccoon	*Procyon lotor*
Mink	*Mustela vison*
Beaver	*Castor Canadensis*
Muskrat	*Ondatra zibethicus*
Red fox	*Vulpes vulpes*
Gray fox	*Urocyon cinereoargenteus californicus*
Cat	*Felis catus*
Weasel	*Mustela spp.*
Black-tailed jackrabbit	*Lepus californicus*
Western harvest mouse	*Reithrodontomys megalotis longicaudus*
Voles	Muridae
Fish	
Pink salmon	*Oncorhynchus gorbuscha*
Cutthroat trout	*Oncorhynchus clarki*
Northern anchovy	*Engraulis mordax*
Herring	*Clupea pallasii*
Shiner perch	*Cymatogaster aggregata*
Pacific sand lance	*Ammodytes hexapterus*
Sculpin spp.	Cottidae
Surf smelt	*Hypomesus pretiosus*

Non-Listed Fish, Wildlife and Plants Continued

Common Name	Scientific Name
Fish (Continued)	
Surf perch	Embiotocidae
Silversides	Atherinidae
Sunfish	Centrarchidae
Gobies	Gobiidae
Toadfish	Batrachoididae
Tui chubs	*Siphateles bicolor*
Rainbow trout	*Salmo gairdneri*
Pacific cod	*Gadus macrocephalus*
English sole	*Parophrys vetulus*
Rockfish	*Sebastes spp.*
White sturgeon	*Acipenser transmontanus*
Starry flounder	*Platichthys stellatus*
American shad	*Alosa sapidissima*
Black Crappie	*Pomoxis nigromaculatus*
Sacramento splittail	*Pogonichthys macrolepidotus*
Striped bass	*Morone saxitilis*
Marine Invertebrates	
Dungeness crab	*Cancer magister*
Plants	
Red alder	*Alnus rubra*
Willow species	*Salix spp.*

Appendix I. List of Preparers

Name	Position	Education	Years of Experience
U.S. Fish and Wildlife Service			
Nanette Seto	Wildlife Biologist	BS, Zoology MS, Wildlife Biology	13
Michelle Whalen	Technical Writer	BA, Language and Literature	10
Tara Zimmerman	Chief, Branch of Bird Conservation	BS, Wildlife Management	25
U.S. Army Corps of Engineers			
Geoff Dorsey	Wildlife Biologist	BS, Wildlife Science MS, Wildlife Science	23
Gregg Bertrand	Geographer	BS, Geography	19
NOAA Fisheries			
Jim Bottom	Technical Editor	BJ, MA Journalism	15
Cathy Tortorici	Chief, Oregon Coast/Lower Columbia River Branch	MA, Biology	15



U.S. Fish & Wildlife Service
Migratory Birds and Habitat Programs
911 NE 11th Ave.
Portland, OR 97232
503-231-6164
http://migratorybirds.pacific.fws.gov/CATE.htm

U.S. Fish and Wildlife Service
1(800) 344-WILD

Cooperating Agencies:

U.S. Army Corps of Engineers
Portland District
333 SW 1st Avenue
Portland OR 97204-3495

NOAA Fisheries
525 NE Oregon
Suite 500
Portland OR 97232

July 2004