STATUS AND TRENDS REPORT

on

WILDLIFE

OF THE

SAN FRANCISCO ESTUARY

Prepared by the

United States Department of Interior
Fish and Wildlife Service
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2800 Cottage Way, Room E-1803
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January 1992

San Francisco Estuary Project

Prepared under EPA Cooperative Agreement
CE-009519-01-0 by the
U.S. Fish and Wildlife Service

"Andy Burnett reached California in the autumn of 1832...Andy had never seen so many waterfowl; had never imagined there could be so many, anywhere. They covered the surface of the small lakes so thickly that....Andy could discern but a gleam of water here and there. On a sudden impulse he extended the long rifle and fired it into the air. A blank instant silence followed....broken a half second later by the crash as of a mighty waterfall as the birds took wing. It seemed as if the dark earth were lifting to expose the hidden silver of the lake. The air was full of hurtling bodies. The very sky was darkened. And another great roar, and a third, like successive peals of thunder, rolled across to the man's astonishment; and then a smooth high silence made up of the thin whistlings of thousands upon thousands of wings."

White, S.E. 1947. The saga of Andy Burnett, with an introduction by Joseph Henry Jackson. Doubleday and Co., Garden City, N.Y.

"On Mare Island I often saw in the year from 1840 to '43 as many as two or three thousand elk, it being their habit to cross and recross by swimming between the island and the mainland, and I remember one occasion, when on the schooner Isabella, of sailing through a band of these elk, probably not less than a thousand, which were then crossing from Mare Island to the mainland. It was a grand and exciting scene."

Davis, W.H. 1929. Seventy-five years in California. Howell Books, San Francisco. (in Vincent 1990).

"In 1833 - Benicia was visited and has been thus described. It was nothing more than a wide and extended lawn, exuberant in wild oats and 'a place for wild beasts to lie down in' - the deer, antelope and noble elk held quiet and undisturbed possession of all that wide domain, from San Pablo Bay to Sutter's Fort ... The above named animals were numerous beyond all parallel - In herds of many hundreds, they might be met, so tame that they would hardly move to open the way for the traveller to pass - They were seen lying, grazing, in immense herds, on the sunny side of every hill, and their young, like lambs were frolicking in all directions - The wild geese, and every species of waterfowl darkened the surface of every bay, and firth, and upon the land, in flocks of millions, they wandered in quest of insects, and cropping the wild oats which grew there in richest abundance - When disturbed, they arose to fly, the sound of their wings was like that of distant thunder - The Rivers were literally crowded with salmon, which ... no one disturbed - It was literally a land of plenty, and such a climate as no other land can boast of "...

Chronicles of George C. Yount, recorded by Rev. Orange Clark. Calif. 1923. Historical Soc. Quarterly 2(1):52.

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ACKNOWLEDGEMENTS

Valuable unpublished information and technical advice were provided by Louise Accurso and Harry Carter of Dixon Wildlife Research Field Station, staff of the San Francisco Bay National Wildlife Refuge, San Francisco Bay Bird Observatory, Larry Spear of the Point Reyes Bird Observatory, Ted Beedy of Jones and Stokes Associates, and Frank Wernette, Gordon Gould, and Fred Botti of California Department of Fish and Game. Much-appreciated reviews of earlier drafts of this report were provided by Louise Accurso, Steven Bailey, Randy Brown, Harry Carter, Howard Cogswell, Kent Dedrick, Phil Detrich, Sandy Wyllie Echeverria, Dick Erickson, Arthur Feinstein, Mark Jennings, Paul Jones, Ron Jurek, Paul Kelly, Trish Mulvey, Joyce Nuttall, Harry Ohlendorf, Doug Pomeroy, Mike Rigney, Barbara Salzman, Peter Sorensen, Jean Takekawa, Frank Wernette, and Leo Winternitz.

We also thank Jini Scammell-Tinling, U.S. Fish and Wildlife Service, and Dean Fearn, Department of Statistics, California State University Hayward, for technical assistance. Special thanks to Lee Neher and Nancy Tosta of the Teal Data Center, California Business, Transportation and Housing Agency; Mike Sebhat and Chuck Johnson of the U.S. Bureau of Reclamation, Geographic Information Systems Office; and Dennis Peters of the U.S. Fish and Wildlife Service, National Wetland Inventory, for preparation of wildlife habitat maps. For cover design and preparation, we thank Linda Knoll and John Steiner, San Francisco Bay Wildlife Society. The cover photographs were graciously provided by Ken Gardiner and B. "Moose" Peterson, who provided the photograph of the salt marsh harvest mouse.

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EXECUTIVE SUMMARY

Beginning in the early nineteenth century, numerous human-related activities resulted in the irretrievable loss and alteration of the abundant wildlife and diverse natural habitats which existed in the San Francisco Estuary. Today, the Estuary still supports a variety of both natural and man-made habitats as well as major populations of resident and migratory wildlife, comprising a valuable resource for protection and enhancement.

From a human perspective, the importance of wildlife includes their recreational, commercial, ecological, scientific, educational, and aesthetic values. Within the Estuary, recreational values consist of both consumptive uses, such as the hunting of waterfowl and other game, and non-consumptive uses such as wildlife observation. The commercial importance of wildlife is best shown by the harvest and sale of furbearers and some amphibians and reptiles. Ecological functions of wildlife populations are demonstrated by their roles both as biological indicators and in controlling populations of undesirable species such as agricultural pests. Opportunities which wildlife provide for scientific research in the region and for environmental education programs act to increase knowledge and public awareness of the value and need to preserve these resources. Finally, wildlife are important solely for the enrichment they provide our lives and for their own inherent value as a significant component of the genetic diversity of nature.

<u>Wildlife Communities and their Habitats</u>

Within the Estuary, a total of seven wetland and deepwater and seven upland habitats were described in this report. Habitat and community distinctions were determined by applying accepted habitat classification systems and by considering similarities in the characteristic plants and wildlife use of each habitat. Wildlife communities most directly associated with the Estuary received the greatest emphasis in this discussion.

The wetland and deepwater habitats include: (1) open water, (2) intertidal mudflat and rocky shores, (3) tidal salt, brackish, and freshwater marshes, (4) seasonal wetlands, (5) riparian woodland, (6) salt ponds, and (7) lakes and ponds. Seasonal wetlands also consist of farmed wetlands, salt and brackish diked marsh, vernal pools, and abandoned salt ponds. These habitat groupings were based on the U.S. Fish and Wildlife Service classification system. Farmed wetlands and open water are the most abundant wetland habitats in the Estuary.

Upland habitats discussed include: (1) grassland, (2) coastal scrub, (3) mixed chaparral, (4) oak woodland, (5) broad-leaved evergreen, (6) agriculture, and (7) urban. The most common upland habitats types are urban, broad-leaved evergreen, oak woodland, and grassland.

Historic Wildlife Populations

When Spanish explorers first arrived in the Region, the 4,600 square mile San Francisco Estuary contained a diverse array of marine, estuarine, freshwater, and upland habitats, supporting an abundance of birds, mammals, reptiles, and amphibians. Large populations of waterfowl, fur-bearers such as sea otter and beaver, and several big game mammals supported commercial harvest during the last half of the nineteenth century. Beginning in the mid-nineteenth century, overharvest, habitat loss, human disturbance, and pollutants brought about dramatic population declines and extirpations of many furbearing and big game mammals, migratory waterfowl and other waterbirds, and raptors. Habitats most severely impacted during the next 70 years, primarily by agricultural conversion, were the tidal freshwater marshes and riparian forests of the Delta, and the tidal salt and brackish marshes of San Francisco, San Pablo, and Suisun bays.

Following the turn of the century, destruction or conversion of habitats both within and outside the Estuary began to accelerate. Expanding agriculture and, ultimately, urban development enveloped permanent and seasonal wetlands, riparian forest, vernal pools, native grasslands, coastal scrub, and oak savannah of the Estuary and the entire State (Figure EXE-1). Other causes of past and ongoing declines in wildlife populations included overharvesting, competition with the livestock industry, expansion of natural or introduced competitors, use of organochlorines, and human disturbance.

Current Trends in Wildlife Populations

Today, habitat fragments remaining within the Estuary continue to steadily deteriorate under an increasing array of negative human effects. Urban encroachment and intensifying agriculture continue to destroy and fragment permanent and seasonal freshwater wetlands, riparian woodlands, vernal pools, grasslands, and oak woodlands of the Estuary.

Declines in habitat quantity and quality are most apparent when considering the tidal salt and brackish marsh habitats of San Francisco, San Pablo, and Suisun bays. Loss of tidal marshlands to filling or conversion to agriculture or saltponds has contributed to major depletions of Estuary wildlife. The continued survival of the unique community of birds and mammals dependent on these remnant marshes is clearly uncertain. Current threats to these marsh inhabitants, including continued habitat degradation as discussed in Chapters 4 and 5, portray a wildlife community under siege. For example, the California clapper rail is nearly extirpated from many of the few remaining tidal marshes within its range by predation by the introduced red fox. Moreover, the many years required for newly-restored tidal marshes to support rails, inconsistent success in designing and implementing such projects, and a shortage of available restoration sites, make extinction of the California clapper rail a real possibility.

Primarily as a result of habitat loss, at least seven insects, one reptile, three birds, and five mammals have been completely extirpated from the Estuary. A total of 90 taxa of insects, amphibians, reptiles, birds, and

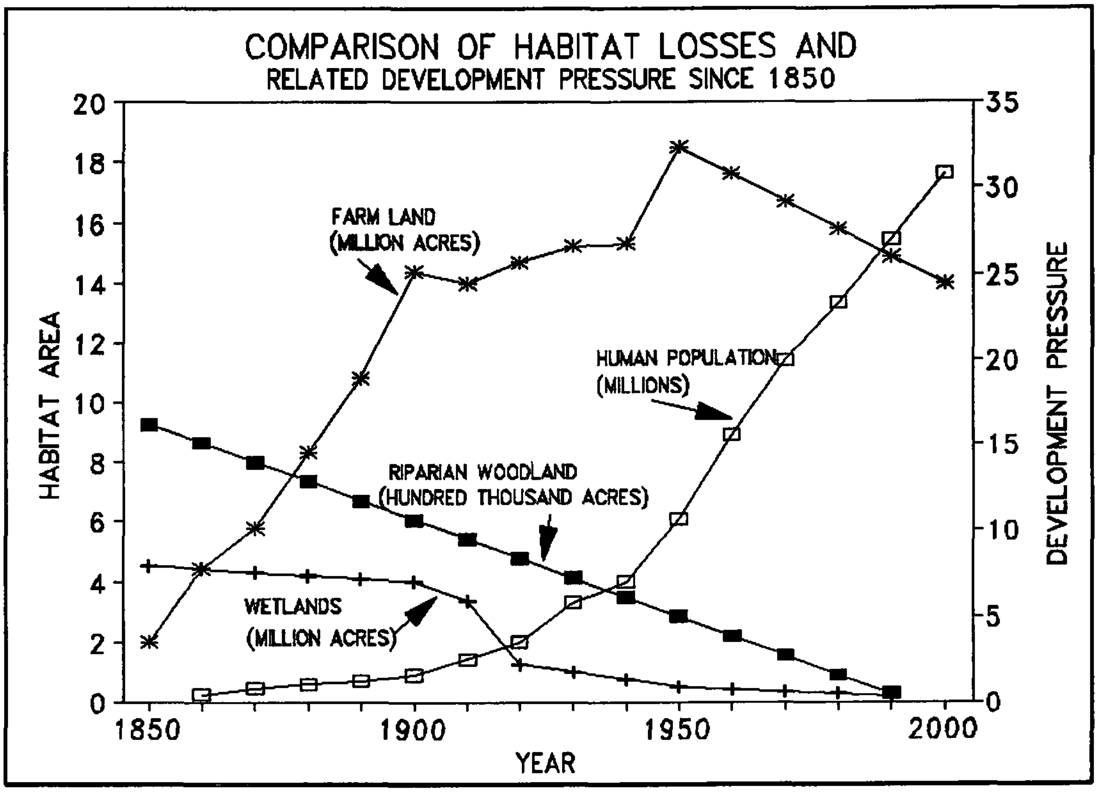

Figure EXE-1. Comparison of Habitat Losses and Population Growth in California Since 1850 (From Jones and Stokes Associates 1987).

mammals within the Estuary, are currently designated by Federal and State governments as having sufficiently declined in numbers to deserve special protection or monitoring (Appendix B). Included in this total are about 15 percent and 16 percent of all the bird and mammal species, respectively, occurring within the study area. Of these 90 taxa, 61 (68 percent) have been depleted through loss of wetland and riparian habitats. Seven species of insects unique to the study area are classified as extinct. Thirty-six special status taxa were identified in this report as declining at the greatest rate within the Estuary study area (Table 7-1).

Throughout California, all bird species are generally at lower population levels than existed historically. However, within the Estuary, use by some waterbirds may have increased in response to creation of artificial habitats and feeding opportunities, such as in salt evaporation ponds.

Within the Estuary, San Francisco and San Pablo bays remain major coastal wintering and migrational areas for a variety of Pacific Flyway ducks such as scaup, scoter, canvasback, ruddy duck, and northern shoveler. Suisun Marsh and the Sacramento-San Joaquin Delta continue to provide valuable habitat for significant numbers of dabbling ducks, geese, tundra swan, and cranes. Total numbers of ducks within the Estuary during the period 1969-1990, have ranged from as high as 1.3 million in 1977 to about 109,000 in 1982; with a mean population during 1981-1990 of 390,532. During the previous 10 years of monitoring, nearly 60 percent of the total diving ducks observed in California have been recorded within the Estuary. Except for some recent signs of recovery, statewide waterfowl populations for many species of dabbling ducks and geese generally remain at all-time low levels, since monitoring began in the 1950s. This has been attributed primarily to the combined effects of drought, habitat loss, and predation both on their wintering and nesting grounds. The degree to which these populations will recover is uncertain and hinges on the extent of habitat recovery in the Canadian Prairies and California and on long-term weather trends. Contaminants, in the form of trace elements, also occur in Bay diving ducks at levels known to impair reproduction in waterfowl.

Even though the San Francisco Estuary has long been cited as and continues to be a major wintering and migrational site for shorebirds, comprehensive population monitoring has only occurred during the last four years. These efforts indicate that more shorebirds are found in the Estuary during migration than in any other wetland in California; up to 1 million in spring and 375,000 in autumn. Counts during 1988-1990, revealed the most abundant species to include western and least sandpipers, dunlin, dowitchers, marbled godwit, willet, and American avocet. Species such as the snowy plover, black-necked stilt, American avocet, and Wilson's phalarope have either become breeding residents within the Estuary or increased their migratory use in response to conversion of tidal marshes into salt ponds. However, an expanding population of introduced red foxes along the bayshore is reducing the value of the Estuary as a nesting area for shorebirds. Other wintering species that nest in the interior of western North America, such as the long-billed curlew, are declining due to conversion and loss of habitat and drought affecting the quality of both their nesting and wintering grounds.

Efforts to monitor populations of nesting colonial waterbirds and seabirds such as cormorants, herons, gulls, and terns have been attempted only within the last 10-15 years and are not conducted consistently throughout the Estuary. The first comprehensive census effort of seabirds in the Estuary, conducted during 1989-1990, showed the most numerous species in decreasing order to be California gull, Forster's tern, western gull, Caspian tern, and double-crested cormorant. There is little information on how current nesting populations compare with historic levels or how to precisely characterize population trends. California gulls, Forster's, Caspian, and California least terns only became established as nesting species following the creation of artificial habitats such as the salt ponds. Species which have shown population increases resulting from a similar ability to exploit other man-made features, include the double-crested cormorant and western gull. California least and Caspian terns and herons and egrets have recently been documented as experiencing major nesting failure within the Estuary due to predation by introduced red foxes. The combined effects of introduced predators, human disturbance, intensive land uses, and contaminants are probably reducing breeding heron and egret populations.

Raptor populations in the Estuary are continuing to experience general declines or at best, only limited recovery from past depletions. For example, more peregrine falcons occur and attempt to nest within the Estuary, but all these nesting pairs are unsuccessful, probably due to contaminant effects. Other species such as burrowing, short-eared, and long-eared owls, Cooper's, sharp-shinned, Swainson's, and red-shouldered hawk, northern harrier, and golden eagle are probably experiencing population declines. This is attributable to continued loss of seasonal wetlands, grasslands, oak woodlands, alfalfa fields, and riparian woodlands to urban expansion and intensifying agriculture as well as expansion of the wind energy industry.

Intensified agricultural practices and increasing urban expansion have also negatively affected numerous passerine birds dependent on grasslands, oak savanna, riparian forests, and seasonal and tidal wetlands. Many of these species are vulnerable to possible extirpation or extinction due to the depleted condition and ongoing degradation of their remaining habitats, combined with introduced predators and competitors.

Numerous native mammalian carnivores, rodents, rabbits, bats, as well as amphibians and reptiles are experiencing declining populations due to intensifying agriculture, urban encroachment, ongoing habitat degradation, and human disturbance. In contrast, many introduced mammals including several rodents, the red fox, and Virginia opossum, which readily adapt to urban settings, are generally increasing their populations often to the detriment of depleted native species. California sea lions, which are evidently still recovering from past exploitation, are increasing their use of San Francisco Bay. Harbor seal numbers in the Estuary are generally stable, but concerns exist about the possible effects of pollutants. Loss of vernal pools, freshwater marshes, riparian woodlands, and grasslands within the Estuary, has caused dramatic depletions of several amphibians and reptiles, some of which are facing possible extirpation. Examples are the California tiger salamander, red-legged frog, giant garter snake, and western pond turtle.

Future Projections on Wildlife Populations

Generally, projections on the future status of wildlife populations within the Estuary do not portray an encouraging scenario. Few would disagree with a future scenario consisting of intensifying threats to seasonal wetlands and upland habitats from urban encroachment and agricultural conversion, increasing contaminant effects, and increasing impacts to wildlife from human disturbance and introduced predators, such as the red fox. Other factors which require further monitoring and may result in alterations or losses of habitat include expansion of the introduced Asian clam and cordgrass, salt marsh conversion from the discharge of sewage effluent, and tidal marsh erosion. The effects of possible global warming and rising sea level need only be considered in a long-term scenario. This may cause dramatic losses and alterations of tidal mudflats and marshes, salt ponds, and farmed wetlands, resulting in losses of critical habitat for many species with some possible long-term benefits for wintering waterfowl.

Roles of Government Agencies in Managing Wildlife

The U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Navy, California Department of Fish and Game, the State Department of Parks and Recreation, and the East Bay Regional Park District have significant management and conservation responsibilities for wildlife populations within the study area. This is due to their management of a significant amount of land within national wildlife refuges, wildlife areas, preserves, parks, and installations.

If adequately implemented, several recent State and Federal planning and habitat acquisition efforts may help to offset many of the projected losses, primarily for wetlands. These include State Senate Resolution 28, the Central Valley Habitat Joint Venture of the North American Waterfowl Management Plan, the Central Valley and San Francisco Bay Concept Plans for Waterfowl Habitat Protection, and the habitat acquisition programs for the San Francisco Bay National Wildlife Refuge and the proposed Stone Lakes National Wildlife Refuge. As summarized in Chapter 6, the primary agencies responsible for management of wildlife are authorized under numerous laws to carry out the protection, conservation, and improvement of these resources. Nevertheless, ongoing declines in the quantity and quality of habitats and the wildlife they support clearly demonstrate the critical shortage of funding, economic incentives, and public resolve to adequately implement these needed protections and restorations.

Gaps in Information and Knowledge

There are numerous gaps in knowledge which need to be addressed to better define the complex relationships of wildlife in the Estuary with their environment. Additional research is needed to characterize population status, trends, and limiting factors, habitat requirements, life history, migration and local movements, and contaminant effects. Additional information on these topics is needed for numerous special status species, waterfowl, shorebirds, colonial waterbirds, seabirds, and other wildlife. In particular, the special status species which were concluded to be currently experiencing populations declines within the Estuary and were identified in Table 7-1 are in need of the most immediate study.

PREFACE

The San Francisco Estuary Project is part of the National Estuary Program (of the U.S. Environmental Protection Agency), which was established in response to requirements of the Clean Water Act. The stated Project goals are as follows:

- * Develop a comprehensive understanding of environmental and public health values attributable to the Bay and Delta and how these values interact with social and economic factors.

- * Achieve effective, united, and ongoing management of the Bay and Delta.

- * Develop a Comprehensive Conservation and Management Plan to restore and maintain the chemical, physical, and biological integrity of the Bay and Delta, including restoration and maintenance of water quality, balanced indigenous populations of shellfish, fish, and wildlife, and recreation activities in the Bay and Delta, and assure that the beneficial uses of the Bay and Delta are protected.

- * Recommend priority corrective actions and compliance schedules addressing point and non-point sources of pollution. These recommendations will include short- and long-term components based on the best scientific information available.

The Estuary Project has set up a five-year schedule to achieve these goals--beginning with "Characterization of the Estuary" and culminating in preparation of a Comprehensive Conservation and Management Plan (CCMP) to be implemented by November 1992.

The characterization of the Estuary involves the production of several technical reports that lay out the current knowledge on various aspects of the Estuary, summarize management issues and their causes, and identify important gaps in information that may impede the development and/or implementation of the CCMP. The reports seek to develop a technical consensus on the present state of the Bay resources and other matters relevant to the development of the CCMP. Reports that have been produced cover the following topics:

1. Dredging and Waterway Modification
2. Pollutants
3. Wetlands and Related Habitats
4. Aquatic Resources
5. Wildlife
6. Land Use and Population
7. Land Use Change and Intensification
8. Quality Assurance in Environmental Analysis

This Status and Trends Report on Wildlife reviews the significance of wildlife resources within the Estuary and their relationships to other chemical, physical, and biological resources. Wildlife which are addressed in this STR include terrestrial insects, amphibians, reptiles, birds, and mammals. Information on special status upland plant species within the Estuary is also provided in Appendix B.

Wetlands--one important habitat type upon which wildlife depends--are discussed in detail in the Wetlands and Related Habitats Status and Trends Report. Analyses of the relationships among the various environmental parameters of concern presented in the STR's have been provided in a San Francisco Estuary Project characterization document known as the State of the Estuary Report.

CHAPTER 1
INTRODUCTION

1.1 PROJECT STUDY AREA--PAST AND PRESENT

The San Francisco Estuary system covers an area of over 4,600 square miles. It lies at the outlet of the Sacramento and San Joaquin river drainages, which drain 40 percent of the land area of California (Figure 1-1). At the time of Spanish discovery in the late 1700s, approximately 27 million acre-feet of freshwater flowed annually down this drainage system, mixing with saltwater entering through the Golden Gate, to create a natural estuarine system that covered 1,300 square miles (Association of Bay Area Governments in prep.). Tidal marshes covered over 850 square miles, including the expansive freshwater and brackish marshes of the Sacramento-San Joaquin Delta and Suisun Bay and the salt marshes of North and South San Francisco Bay. At the time, the Estuary contained the largest contiguous tidal marsh system on the Pacific Coast of North America.

Spreading inland from tidal wetlands were vast expanses of grassland dotted with seasonal wetlands, oak-woodland savannah, and chaparral. Rivers and creeks, supporting lush stands of riparian vegetation, dissected the land. The coastal ranges west and east of the Bay supported dense stands of broad-leaved evergreen forests, oak woodland, and conifer forests. Historic accounts of the region were replete with references to the abundance of waterfowl, deer, elk, antelope, and other wildlife associated with these habitat types.

Colonization and development of the Estuary, which occurred primarily after 1850, eliminated or greatly altered over half the acreage of natural habitats in the Estuary study area. Wildlife suffering the greatest losses from urban and agricultural development were those species inhabiting wetlands, riparian habitats, grasslands, and oak woodlands. Habitat loss coupled with unchecked exploitation of wildlife resources resulted in tremendous population declines of most native wildlife species.

Today the Estuary study area is home to over 7 million people. Urban areas dominate Central and South San Francisco Bay, whereas agricultural land dominates North San Francisco Bay and the Delta. Despite these extensive modifications, the San Francisco Estuary remains the largest on the Pacific Coast. A diversity of natural as well as man-made habitat types exists in the study area. These habitats support over 380 species of wildlife, including a number of species that were historically absent or uncommon in the Estuary. Wetland and riparian habitat, the two rarest native habitat types in the study area, continue to support the greatest diversity of wildlife species.

Large numbers of wildlife species are resident year-round in the study area, including most mammals, all reptiles and amphibians, and about 117 species of birds. The remainder of the birds are migratory. Some birds utilize the Estuary only during the breeding season and winter further south;

others, such as waterfowl and shorebirds, winter in the study area and breed further north. Some species are transitory, utilizing the study area only briefly during northward or southward migrations.

1.2 THE VALUE OF WILDLIFE

The value of wildlife takes many forms. From a human perspective, wildlife is of recreational, commercial, ecological, scientific, educational, and aesthetic value. These values are discussed further below. In addition to these values that are of benefit to humankind, wildlife also possesses its own inherent or intrinsic value. As a group, the myriad of birds, mammals, reptiles, and amphibians on this planet comprise a significant component of the genetic diversity of nature. The recognition of wildlife's inherent value, and the moral obligation to preserve wildlife for wildlife's sake, had its beginning in this country at the turn of the 20th century. In 1900, the Lacey Act was passed establishing federal regulation over wildlife harvest (see Section 6.2.1). Federal efforts to conserve jeopardized species began shortly thereafter, even though the first legislation dealing specifically with endangered species was not enacted until the late 1960s. In 1903, President Theodore Roosevelt established the first national wildlife refuge to protect the brown pelican. Many other refuges have been established since then solely to protect endangered species. For example, the Antioch Dunes National Wildlife Refuge, which is within the Estuary study area, was established to protect an endangered butterfly, the Lange's metalmark.

1.2.1 Recreational Values

Hunting is an important consumptive use of wildlife in the Estuary, with waterfowl among the most popular game species. In California, the average number of waterfowl hunter days from 1971 to 1980 was over 1,100,000 (U.S. Fish and Wildlife Service, unpubl. data). Over this same time period, nearly one-fourth of the total waterfowl harvest in California occurred in the eleven counties comprising the Estuary study area (Carney et al. 1983). The majority of waterfowl hunting takes place in Suisun Marsh and the Delta on private clubs. Suisun Marsh supports 150 private clubs and the Delta 84 clubs (R. Smith, California Department of Fish and Game, pers. comm. and U.S. Bureau of Reclamation 1986). Few private clubs continue to operate around San Francisco Bay because of expanding urbanization. In 1959, Alameda County alone supported 64 private waterfowl hunting clubs (U.S. Army Corps of Engineers 1967). By 1985, only seven were still operating (California Department of Fish and Game, unpubl. data). A similar number still operate in North San Francisco Bay (J. Swanson, California Department of Fish and Game, pers. comm.) Public hunting occurs on San Francisco Bay National Wildlife Refuge, Grizzly Island Wildlife Area, and other State-owned properties in the Estuary. San Francisco Bay National Wildlife Refuge and Grizzly Island Wildlife Area reported 15,600 and 6,310 hunter days, respectively, in 1989 (J. Steiner, U.S. Fish and Wildlife Service, pers. comm.; R. Smith, pers. comm.).

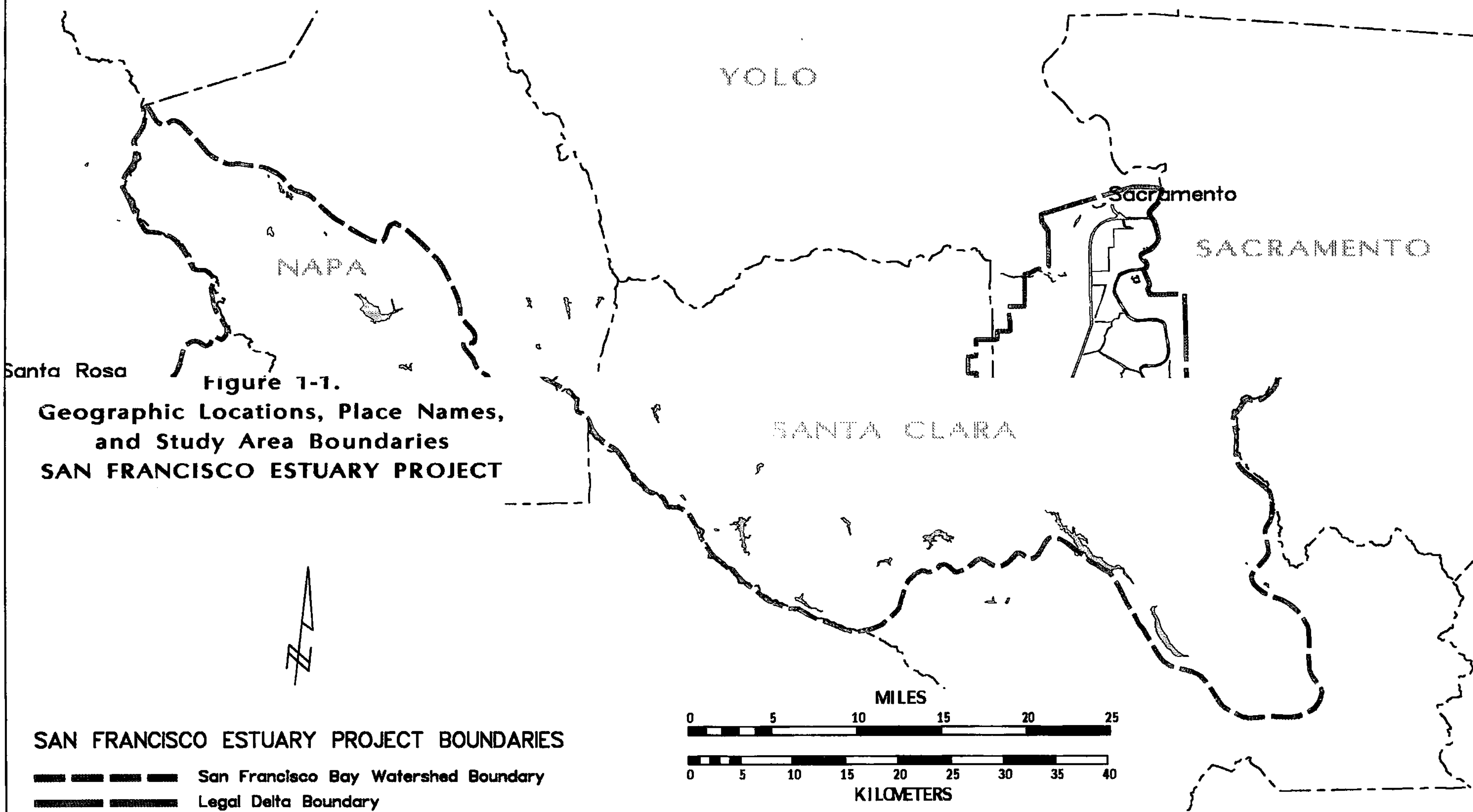

Figure 1-1.
Geographic Locations, Place Names, and Study Area Boundaries
SAN FRANCISCO ESTUARY PROJECT

Expenditures for hunting in California are significant. The U.S. Fish and Wildlife Service (1989a) estimated that $127 million was spent by waterfowl hunters in the state in 1985. Federal duck stamp sales in California have averaged 132,000 stamps per year since 1961. In 1989 over 70,000 stamps were sold, generating over $800,000 for land acquisition purposes. The sale of State duck stamps results in about $600,000 annually (California Department of Fish and Game 1990a).

The deer is another important game species in California. Loomis et al. (1989) estimated that deer hunters spent $134 million in 1987 in pursuit of this sport. From 1985 to 1989 over 11,000 deer, or an average of about 2,300 deer per year, were harvested in the 11 counties comprising the Estuary study area (California Department of Fish and Game, unpubl. data). This amounts to 8 percent of the total state harvest over the same time period.

Non-consumptive recreational uses of wildlife are also important in the Estuary. Popular non-consumptive uses include wildlife observation and photography. In 1988, shoreline parks of the East Bay Regional Park District attracted over 160,000 bird watchers (R. Dawson, East Bay Regional Park District, pers. comm.). An estimated 19,200 hours are spent each year bird watching during field trips organized by the ten National Audubon Society Chapters within the Bay-Delta study area (P. Allen, Marin Audubon Society, pers. comm.). Similarly, at San Francisco Bay National Wildlife Refuge, over 119,000 individuals participated in wildlife observation in 1989-1990 (J. Steiner, U.S. Fish and Wildlife Service, pers. comm.). In 1989, nearly 10,000 individuals engaged in sightseeing and nature study at Grizzly Island Wildlife Area (R. Smith, California Department of Fish and Game, pers. comm.). Recently, non-consumptive wildlife uses exceeded consumptive (hunting) uses at both San Francisco Bay National Wildlife Refuge and Grizzly Island Wildlife Area.

Another indication of increasing non-consumptive uses of wildlife is the sale of duck stamps. Sales of Federal duck stamps to non-hunters have increased in recent years, averaging 15 percent annually of total sales during 1986-1989 (U.S. Fish and Wildlife Service, unpubl. data).

Loomis et al. (1989) estimated that Californians spend approximately $30 per trip to view deer. Applying this figure to the estimated 2.3 million deer-viewing trips results in $69 million spent annually by individuals engaged in this activity (Loomis et al. 1989).

1.2.2 Commercial Values

Furbearers (e.g., bobcat, beaver, muskrat) and certain reptiles and amphibians are the only wildlife species commercially exploited in the state. The pelts of furbearers have generated as much as $5,063,000 (includes fur sales as well as personal use value) as reported in 1978-1979 by the California Department of Fish and Game (1980). Values have generally declined since then, with only $1,140,000 generated in 1988-1989 (Gould and Hom 1990). From 1978 to 1988, trappers took a total of over 107,000 furbearers, an average of about 9,760 per year, from the Estuary study area. The three most commonly harvested species were muskrat (6,962 per year), raccoon (950 per year), and striped skunks (380 per year). The harvest in the Estuary study area represents about 11 percent of the total state furbearer harvest over the same time period (California Department of Fish and Game 1980-82, 1983a, 1984-87a, 1988a, Gould and Escallier 1989, Gould and Hom 1990).

The introduced bullfrog and native reptiles and amphibians, with the exception of protected species, can be sold to scientific and educational institutions by owners of biological and scientific supply houses that have been issued a special permit by the California Department of Fish and Game. Currently there is only one biological supply house in California collecting native species and two scientific supply houses collecting bullfrogs (J. Brode, California Department of Fish and Game, pers. comm.). The economic value of these commercial ventures is not known.

1.2.3 Ecological Values

In recent years, humans have become more aware that they are, along with all other forms of life, integral and inseparable parts of the natural ecosystem. If the ecosystem breaks down because of damage to the environment, humankind is also endangered. Wildlife species can act as indicators of broader problems within the ecosystem; they can serve as "early warning devices," allowing humans an opportunity to solve environmental problems before the damage is irreversible. As an example, the presence of elevated concentrations of contaminants in San Francisco Bay diving ducks indicates a need to look more closely at the overall health of the Bay ecosystem (Ohlendorf and Fleming 1988).

A recent study suggested that people consider harbor seals more valuable if they serve as an indicator species. Meyer (1987) conducted a non-market analysis of the value of harbor seals to residents of the Bay Area and Sacramento. Households were asked to evaluate a 10 percent decline in the local harbor seal population with the decline being the result of 1) an unknown cause or 2) toxins. The non-market cost of a 10 percent decline in the harbor seal population more than doubled when the cause of the decline was known to be toxins.

Another important ecological value of wildlife is that of controlling pest species. Insectivorous bird species consume tremendous quantities of terrestrial insects, many of which are harmful to agricultural or silvicultural crops. Takekawa and Garton (1984) estimated that during the summer birds consumed up to 12,700,000 spruce bud worms on a study area in the Cascade Ranges of north-central Washington. They concluded that passerine birds contributed strongly in the control of outbreaks of this damaging insect. Birds may also indirectly control pest species of insects by consuming vegetation upon which the insect depends for survival. Collins and Resh (1985) conducted a study of the effect of waterfowl on mosquito populations at Coyote Hills Marsh in South San Francisco Bay. They found that waterfowl foraging on sago pondweed (Potamogeton pectinatus) reduced the density of the floating plant's canopy, thereby exposing mosquitos to increased predation by fish.

1.2.4 Scientific and Educational Values

Within the Estuary study area, the large number of wildlife species and the complex interrelationships of wildlife species and their habitats provide ample opportunity for scientific research. Around the Bay there are seven universities, several private colleges, and numerous junior colleges, all of which have had students engaged in wildlife-oriented research over the years. Marshall (1948a,b) did some of the earliest work on the evolution of birds in his studies of the salt marsh song sparrow around San Francisco Bay. Wildlife research has also been conducted over the years by State and Federal agencies. More complete knowledge of the role each wildlife species plays in the ecosystem provides us the tools to properly manage this important natural resource.

The importance of wildlife in education is also a significant value. Within the study area, wildlife-oriented educational programs emphasizing the Estuary are conducted primarily by the U.S. Fish and Wildlife Service at San Francisco Bay National Wildlife Refuge; the U.S. Army Corps of Engineers at the Bay Model in Sausilito, the East Bay Regional Park District; the cities of Hayward, Palo Alto, and Mountain View; the National Audubon Society at Richardson Bay Sanctuary; and by the Coyote Point Museum for Environmental Education in San Mateo. Environmental education programs at San Francisco Bay National Wildlife Refuge attracted over 34,000 individuals in 1989-1990 (J. Steiner, U.S. Fish and Wildlife Service, pers. comm.). In 1989, over 640,000 individuals benefitted from wildlife/habitat-oriented interpretive programs of the East Bay Regional Park District (East Bay Regional Park District 1989). Access to wildlife through educational programs increases public awareness of the value of wildlife and the need to preserve wildlife habitat.

1.2.5 Aesthetic Values

One of the most intangible values of wildlife is its aesthetic worth. The enjoyment people experience from viewing wildlife, either directly or vicariously through artwork or photography, is a value of increasing importance in the Estuary study area. This is evidenced by the large numbers of individuals that annually engage in bird watching and other wildlife observation. The late Dr. H. Thomas Harvey (1966) aptly summarized the importance of wildlife and the natural habitats they live in when he said, "The value of these kinds of contributions to our society are difficult to measure, but that they are of great value is not doubted except by the most deprived and insensitive person."

1.3 PURPOSE AND STRUCTURE OF REPORT

This Status and Trends Report on wildlife provides an overview of the historic and present status of wildlife within the San Francisco Estuary, and based on population trends to this date, predicts the status of wildlife in the future. The goal of this report is to present a clear description for decision-makers of 1) the extent of our knowledge of wildlife resources; 2) the important gaps in our knowledge; and 3) the measures recommended to reverse declines, maintain stability, or increase wildlife populations in the Estuary. The report is divided into the following chapters:

1. Introduction
2. Wildlife Communities and Their Habitats
3. Historic Distribution and Abundance of Wildlife Populations
4. Current Trends in Distribution and Abundance of Wildlife Populations
5. Future Projections on Distribution and Abundance of Wildlife Populations
6. Roles of Government Agencies in Managing Wildlife
7. Gaps in Information and Knowledge

Central to an understanding of the Estuary's wildlife resources is a description of the habitat types that wildlife depend upon. Chapter 2 of this report provides descriptions of 14 major wildlife habitat types and the typical wildlife community supported by each. Information on community dynamics is presented for the various habitat types dependent upon available research findings. Native habitat types, such as wetlands and oak woodlands are included, as well as the highly modified agricultural and urban habitat types.

The past, present, and future distribution and abundance of wildlife populations in the Estuary are discussed in Chapters 3-5. Chapter 3 presents an historical account of the extent of wildlife habitats in the Estuary and the abundance of wildlife associated with them. Historical causes of wildlife population declines are also enumerated.

Chapter 4 describes the current distribution and abundance of wildlife populations in the Estuary, including individual accounts for over 120 species of birds, mammals, reptiles, amphibians, and terrestrial insects including detailed information, where available, on seasonality, abundance, and distribution by habitat types and population trends. Several species groups receive special emphasis in this chapter because of their direct association with scarce estuarine habitat types (e.g., waterfowl, shorebirds, and colonial nesting birds) or special status (i.e., endangered, threatened, or species of special concern). Chapter 4 also discusses the current causes of changes in wildlife populations.

Based on current trends in the Estuary's wildlife populations and human-related factors likely to be affecting wildlife, chapter 5 projects the future distribution and abundance of wildlife. Appendix A of the report includes a complete list of wildlife species for the Estuary study area, including information on relative abundance, seasonality, special status, and habitat types. Appendix B provides a list of special status, extirpated, and extinct wildlife and plant species of the Estuary.

Chapter 6 outlines the authorities and agencies at the Federal, State, regional, local and private levels governing wildlife management in the Estuary. Current plans designed solely to benefit wildlife are also discussed. Chapter 7 enumerates the many gaps in information about the Estuary's wildlife populations.

CHAPTER 2
WILDLIFE COMMUNITIES AND THEIR HABITATS

Within the San Francisco Estuary study area, seven deepwater or wetland habitat types and seven upland habitat types have been identified (Table 2-1). Each wildlife habitat type with its associated wildlife community is described, including the highly modified urban and agricultural types. Wetland, deepwater, and upland habitat types described in this report are grouped based on similarity of wildlife use. Wetland and deepwater habitats that occur within these broader groupings follow the classification system of Cowardin et al. (1979) (Table 2-2) as used in the National Wetlands Inventory by the U.S. Fish and Wildlife Service. Broad upland habitat types are derived from Kuchler (1977), Jones and Stokes Associates, Inc. (1981), and Mayer and Laudenslayer (1988). Habitat types that are directly influenced by or associated with the Estuary receive the greatest emphasis in this report.

Wetland habitat types found in the Estuary study area are shown in Figure 2-1 for San Francisco, San Pablo, and Suisun bays and in Figure 2-2 for the Delta. In South San Francisco Bay, the predominant wetland types, other than open water, are intertidal mudflats and salt ponds. By contrast, San Pablo Bay is characterized by an abundance of intertidal mudflats and farmed wetlands, and the Suisun Bay/Marsh area is dominated by diked salt and brackish marshes. In the Delta, farmed wetlands predominate the landscape.

Upland habitat types for the Estuary study area are shown in Figure 2-3. In the South Bay, the predominant upland habitat types are urban, followed by broad-leaved evergreen forests, which occur along the Peninsula, in the Berkeley Hills, and the Mount Hamilton area, and oak woodlands/savannahs, which occur primarily on the southeastern edge of the study area adjacent to the Diablo Range. In the North Bay, common upland habitat types are urban and a mixture of oak woodland, coastal scrub, and chaparral in the Coast Ranges. In the Suisun Bay/Marsh area, grassland, and urban are the most common upland habitat types. Grassland is the most widespread upland habitat in the Delta.

The approximate areas of each habitat type in the Estuary study area (including the Bay system and the Delta) are listed in Table 2-1. The most abundant wetland habitat type in the study area is farmed seasonal wetlands (385,755 acres), with most of this in the Delta and San Pablo Bay. Open water is the next most common (266,158 acres), followed by other seasonal wetlands (85,134 acres), with Suisun Marsh comprising the largest part of this acreage. Riparian woodland is the most uncommon wetland habitat type in the study area, with the majority (78 percent) of the remaining 12,514 acres occurring in the Delta. Of the upland habitat types, broad-leaved evergreen forest is the most common native habitat type (553,133 acres), followed by oak woodland (287,784 acres) and grassland (213,100 acres). Not surprisingly, urban is the most common non-native upland habitat type in the study area (1,775,277 acres).

Table 2-1. Wildlife Habitats and Their Approximate Areas (Acres) in the San Francisco Estuary Project Study Area.

Habitat Type	South[1] S.F. Bay	Central S.F. Bay San Pablo Bay	Suisun Bay[2]	Delta	Total
Wetland and Deepwater Habitats[3]					
1) Open Water	81,517	110,591	28,247	45,802	266,157
2) Intertidal Mudflat and Rocky Shores	29,780	27,996	5,994	322	64,092
3) Tidal Salt, Brackish, and Freshwater Marshes	8,679	16,787	10,682	8,223	44,371
4) Seasonal Wetlands					
Farmed Wetlands	1,317	26,027	8,064	350,347	385,755
All Others	9,832	11,318	47,482	16,502	85,134
Diked Marsh (Salt and Brackish, Vernal Pools and Other Freshwater Habitat, and Abandoned Saltponds					
5) Riparian Woodland	1,432	890	404	9,788	12,514
6) Salt Ponds	27,544	9,060	27	54	36,685
7) Lakes and Ponds	9,174	4,187	3,526	12,482	29,369
Upland Habitats[4]					
8) Grassland Annual and Perennial Grasslands, and Irrigated Pasture					213,100
9) Coastal Scrub					31,500
10) Mixed Chaparral					32,965
11) Oak Woodland Valley Oak Woodland/Savannah and Blue Oak Woodland					287,784
12) Broad-leaved Evergreen Forest Coast Live Oak/Canyon Live Oak Forest, California Bay Forest, and Mixed Evergreen Forest					553,133
13) Agriculture (upland only) Croplands, Orchards, and Vineyards					234,786
14) Urban					1,775,277
TOTAL AREA					4,081,611

[1] Boundary for South and Central San Francisco bays is latitude 37°45'N.

[2] Suisun Bay extends from Carquinez Straits eastward to Collinsville.

[3] Source for acreages of Wetland and Deepwater Habitats is 1985 National Wetland Inventory data.

[4] Sources for acreages of Upland Habitats are CALVEG Landsat data (1977) and Association of Bay Area Governments (1989).

Table 2-2. National Wetland Inventory (NWI) Classifications Included in the Wetland and Deepwater Wildlife Habitats (Cowardin et al. 1979).

Wildlife Habitat Type	NWI System/Class	NWI Classifications
Open Water	Estuarine, subtidal Riverine, tidal	E1OW,E1UBL,E1UBLx,E1ABL,R1ABV,R1ABVx, R1FL,R1OW,R1OW,R1UBT,R1UBV,R1UBVx,R1USR, R2ABH,R2ABHx,R2OW,R2UBH,R2UBHx,R2UBHrx, R2UBHhx,R2USA,R2USC
Intertidal Mudflat and Rocky Shores	Estuarine, intertidal	E2ABNh,E2ABN/E2USN,E2FL,E2SBN,E2USM, E2USN,E2USP,E2RSN,E2RSP
Tidal Salt, Brackish, and Freshwater Marsh	Estuarine, intertidal, salt, and brackish marsh, Palustrine, tidal, freshwater	E2EM,E2EMF,E2EMFL,E2EMN,E2EMNx, E2EMP,E2EMP/E2USP,E2EM/FL,E2EM/USN, E2EM/USP,E1UBLh,E1UBLhx,E2FLh,E2SB, E2UBhx,E2SBNx,E2UBMhx,E2UBMx,E2USMh, E2USMhx,PABT,PABV,PEMN,PEMR,PEMR/PSSR, PEMRx,PEMS,PEMT,PEMTx,PEMU,PEMV,PEM/USR
Seasonal Wetlands	Palustrine, tidal, and non-tidal, salt, and brackish marsh	PEM,PEMA,PEMAx,PEMA1A,PEMB,PEMB/PSSB, PEMC,PEMCx,PEMC/PSSC,PEMCD,PEMCh/PSSCh, PEMChx,PEMF,PEMFx,PEMFh/PSSFh, PEMFh/PUBFh,PEMFx/PUBFx,PEMH,PEMHx,PEMKx, PEMKCx,PEMKFx,PEM/OW,PEM/UBKx,PEM/UBF,PEM /UBT,PEM/UBV,PEMUSA,PEM/USC,E2EMh,E2EMPh, E2EM/FLh,E2EM/USPh,PABh,PABVh,PEM/ABhx,PE MAh,PEMCh,PEMC3h,PEMFh,PEMFhx,PEMHh, PEMKCh,PEMTh,PEM/FLh,PEM/SSAh,PEM/UBHh, PEM/USAh,PEM/USCh,E1OWh,E2USPh,L2EMAh, L2EMCh,L2USAx,L2USChRx,L2USCx,L2USAh, L2USC,L2USC1h,L2USC3h,L2USCh,L2USChs,PFL, PFLh,PABAh,PUBTh,PUSA,PUSAh,PUSAx,PUSC, PUSC1h,PUSC1x,PUSCh,PUSChs,PUSChx,PUSCrx, PUSCx,PUSCxs,PUSKCx,PUSKx,PUSR,PUSRhPf,Pf /UA,PEMCf,PEMFf,PUBFf
Riparian Woodland	Palustrine, wooded vegetation; perennial and intermittent creeks	E2SSPh,PFO,PFO/EMC,PFO/EMR,PFOA,PFOAh,PFO B,PFOC,PFOCh,PFOCx,PFO/EMA,PFO/EMC,PFO/ EMR,PFOF,PFOFh,PFOR,PFO/SS,PFOS,PSS,PSSA, PSSAh,PSSAhx,PSSAx,PSSB,PSSC,PSSCh,PSSCx, PSSF/PEMF,PSSFh,PSSFh/PUBF4,PSSR,PSSRh, PSSS,PSST,PSS/EM,PSS/EMAh,PSS/EMC,PSS/ EMCh,PSS/EMR,R3USA,R3USC,R4SB,R4SBh, R4SBA,R4SBC,R4SBCx,R4SBF,R4SBFrx,R4SBFx
Salt Ponds	Lacustrine, non-vegetated, diked	L1UBH3hx,L1UBKhx,L2FLh,L2UBh,L2UBK1h, L2UBK3h,L2USC1x,L2USK1hx,PEMK3h,PEM/ UBK3h,PUBK1h
Lakes and Ponds	Lacustrine and palustrine lakes and ponds	L1ABH,L1ABV,L1OW,L1OWh,L1UBh,L1UBHhx, L1UBHx,L1UBKh,L1UBKhx,L1UBKrx, L1UBKx,L1UB,L1UBVx,L1UBVh,L2ABHh, L2EMKhx,L2EM/UBKhx,L2FL,L2O,L2UBF,L2UBFh, L2UBHh,L2UBhx,L2UBKx,L2UBV,PAB,PABF, PABFx,PABHhx,PABFh,PABFhx,PABHh,PABHx, POW,POWh,PUBF,PUBF1h,PUBFh,PUBFhx,PUBFx, PUBH,PUBHh,PUBHhx,PUBHxx,PUBHR,PUBHRx, PUBHx,PUBKh,PUBV,PUBKA,PUBKhx,PUBKrx, PUBKx,PUBT,PUBTx,PUBx,PUBxh,PUB/ABH

Descriptions of the vegetation and characteristic wildlife communities for each of the 14 major wildlife habitat types (Table 2-1) are provided in the following section. Lists of species present are "characteristic" of the habitat types and are not intended to be all inclusive. Species may also be found in other habitat types, because most habitat types are ecologically interconnected. A list of the extant and extirpated wildlife of the Estuary study area, their relative abundance, seasonality, habitat types, and any special status designations is found in Appendix A. Lists of special Federal and State status wildlife and plants within the Estuary study area, are presented in Appendices B and C, respectively.

To illustrate the complexities of community interactions, food webs (from Jones and Stokes, Inc. 1981) are shown for certain habitat types. Abbreviations (e.g., CM, CWB) follow species' names and describe the role of each consumer in the particular food web.

2.1 OPEN WATER

2.1.1 Vegetation

Open water habitat of the Estuary consists of deep water areas of the Bay and the river channels and sloughs of the Delta. The dominant plants of open water habitat (Table 2-3) are phytoplankton, including diatoms, dinoflagellates, green algae, and blue-green algae. In the southern parts of the Delta, in channels with slow moving water, water hyacint), an introduced floating plant, may grow profusely.

Place maps Here

Table 2-3. Characteristic Plan itat Type.

Common Name	
Diatoms	Skeletonema
	Chaetoceros
	Coscinodiscus
	Nitzschia
Dinoflagellates	Ceratium
	Gonyaulax
	Gymnodinium
	Peridinium
Water hyacinth	Eichhornia crassipes
Eelgrass	Zostera marina
Green algae	
Blue-green algae	

The most dominant rooted aquatic plant found in open water habitat of the Estuary is eelgrass (Zostera marina), which is limited to a few sites in San Francisco Bay. Echeverria and Rutten (1989) found a total of 316 acres of eelgrass in 22 different locations in San Francisco and San Pablo bays, ranging from lower San Pablo Bay near Point San Pablo south to Coyote Point. Turbidity and resulting light limitations probably account for the presently patchy and limited distribution of this species considering the overall size of the Estuary (Kitting and Wyllie Echeverria in press).

Eelgrass beds perform valuable functions as a food source for invertebrate grazers and detritivores as well as a nursery ground for a variety of fishes including juvenile salmon (Oncorhynchus spp.), Pacific herring (Clupea harengus pallasi), and rockfish (Sebastes spp.) (Echeverria and Rutten 1989). Eelgrass beds near Bay Farm Island have been cited as providing a critical foraging area for California least terns nesting in nearby colonies at the Oakland International Airport and the Alameda Naval Air Station (LSA Assoc., Inc. 1990).

Ball and Arthur (1979), in their study of San Pablo Bay, Suisun Bay, and the Delta, found that the dominant genera of phytoplankton varied with the time of year and location in the Estuary. Diatoms dominated the algal community during the spring through fall, followed by green algae, which comprised about 20 percent of the total. Dinoflagellates were often concentrated in areas of low water velocity. Algal standing crop is influenced primarily by water and/or phytoplankton residence time, nutrients, temperature, and light (Ball and Arthur 1979). Cloern (1979) hypothesized that spring peaks in diatom abundance in the Central and South bays may be related to diatom blooms in coastal waters during the upwelling season.

2.1.2 Characteristic Wildlife

Wildlife species depicted in the food web (Figure 2-4) and listed in Table 2-4 are characteristic of open water, but they are not necessarily found exclusively in this habitat type (Jones and Stokes Associates, Inc 1981, Madrone Associates et al. 1980).

Wildlife are primarily secondary and tertiary consumers in the open water food web, feeding on fish and invertebrates. Examples are the western grebe, scaup, surf scoter, and double-crested cormorant. As part of a contaminants study in North San Francisco Bay and Suisun Bay, the California Department of Fish and Game made observations of food items in surf scoters, scaup, and canvasbacks. The most important food item for scoters in Suisun Bay was the recently introduced Asian clam, Potamocorbula amurensis. This clam and two other bivalves, a mussel (Musculus senhousia) and the Japanese littleneck clam (Tapes japonica), were common in the diets of scoters and scaup in San Pablo Bay. Scaup were found to feed primarily on the bivalve Corbicula fluminea and the Asian clam in Suisun Bay. Canvasbacks exhibited more specialized food habits than scoters or scaup, feeding almost exclusively on Baltic clam (Macoma balthica) and Mya arenaria.

The open water food web is dominated by primary and secondary consumers including zooplankton, fish, and invertebrates (See Aquatic Resources Status and Trends Report for the Estuary).

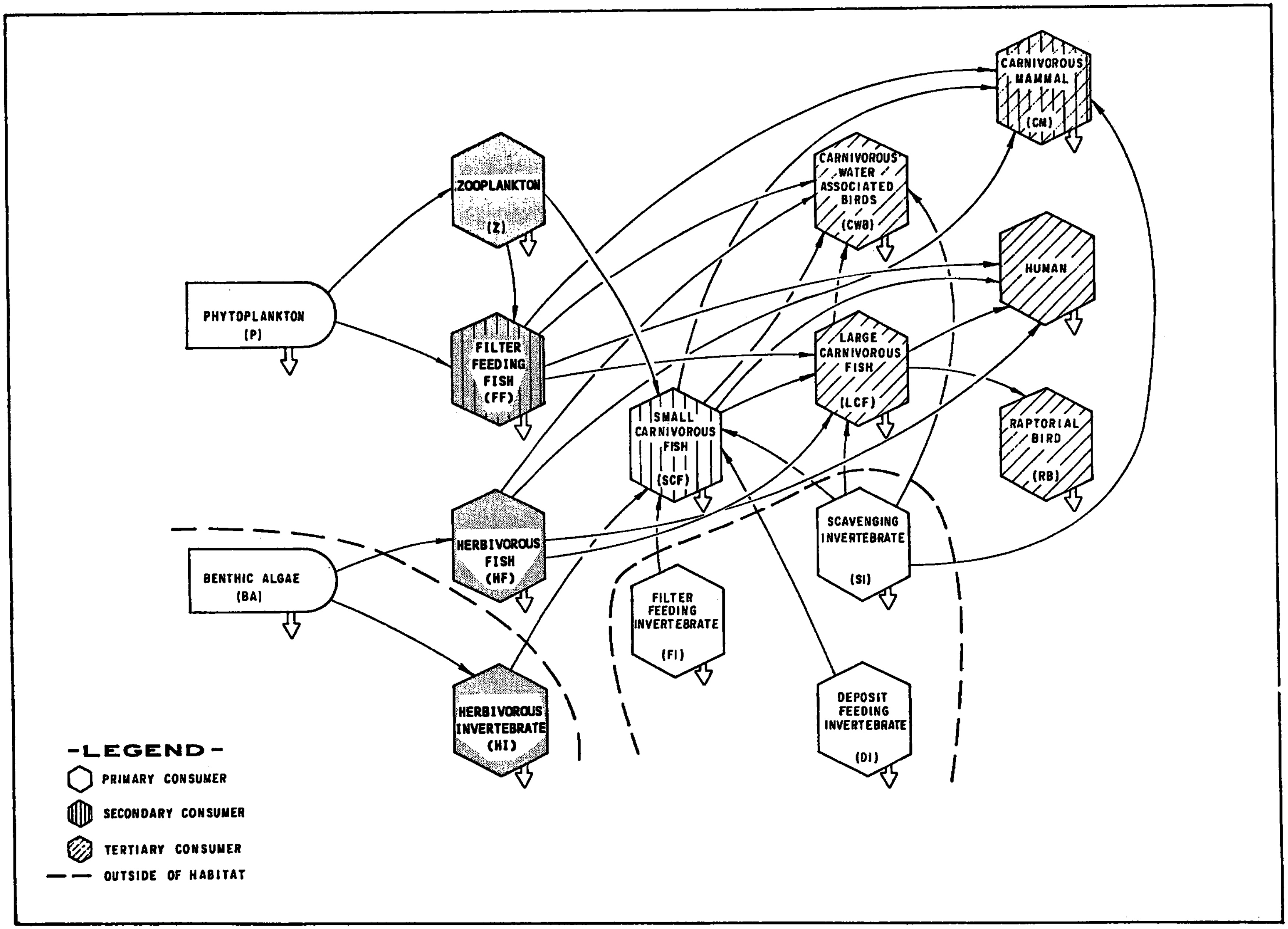

Figure 2-4. General Food Web - Open Water (Jones and Stokes Associates, Inc. 1981).

Table 2-4. Characteristic Wildlife of the Open Water Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds
California sea lion (LCM)	Red-throated loon (CWB)
Harbor seal (LCM)	Common loon (CWB)
	Horned grebe (CWB)
	Western grebe (CWB)
	Clark's grebe (CWB)
	Brown pelican (CWB)
	Double-crested cormorant (CWB)
	Brandt's cormorant (CWB)
	Pelagic cormorant (CWB)
	Canvasback (CWB)
	Scaup spp. (CWB)
	Surf scoter (CWB)
	American coot (HWB)
	Western gull (CWB)
	Glaucous-winged gull (CWB)
	Caspian tern (CWB)
	Forster's tern (CWB)

Key: CWB--Carnivorous Water Associated Bird; HWB--Herbivorous Water Associated Bird; LCM--Large Carnivorous Mammal

2.2 INTERTIDAL MUDFLAT AND ROCKY SHORES

2.2.1 Vegetation

Intertidal mudflat and rocky shore habitats of the estuary are dominated by algae. On mudflats, the most common micro-algae are the diatoms, which are found on the mud surface, often in dense patches. The macro-algae include green and red algae, which occur both intertidally as well as subtidally. Algal growth occurs primarily during the summer months reaching maximum abundance in late summer and early fall (Jones and Stokes Associates, Inc. 1981). Dominant algae of the mudflat and rocky shore habitat types are listed in Table 2-5.

Table 2-5. Dominant Algae of the Intertidal Mudflat and Rocky Shore Habitat Types.

Common Name	Scientific Name
Intertidal Mudflats	
Sea lettuce	Ulva spp.
Green algae	Enteromorpha spp.
Red algae	Gracilaria sjoestedtii
Diatoms	
Eelgrass	Zostera marina
Rocky Shores	
Sea lettuce	Ulva fenestrata
Gigartina	Gigartina spp.
Green algae	Enteromorpha intestinalis
Red algae	Ralfsia spp.

The intertidal mudflat habitat around San Francisco Bay, Suisun Bay, and the Delta occupies a general zone between 2.5-feet below mean lower low water (MLLW) and mean tide level (MTL), or up to the lower elevational limit of cordgrass or California bulrush (K. Dedrick, California State Lands Commission, pers. comm.). Mudflats are inundated and exposed twice daily by the tides. Mudflat salinities decrease as one moves upstream in the Estuary. The largest areas of intertidal mudflats occur in South San Francisco Bay and San Pablo Bay.

Only a small amount of rocky shore habitat exists in the Estuary. Examples of rocky shore habitat are the shores of Yerba Buena, Angel, Red Rock, and Alcatraz islands and the Brothers, along the shoreline of the Tiburon peninsula, Belvedere, Dumbarton Narrows, San Pablo Point, and both sides of the Golden Gate. Manmade rocky shore habitat consists primarily of breakwaters found at various locations around San Francisco Bay, such as Mare Island and Alameda Naval Air Station breakwaters. There is no rocky shore habitat in Suisun Bay or the Delta.

2.2.2 Characteristic Wildlife

2.2.2.1 Intertidal Mudflats

Probably the most prominent wildlife group associated with intertidal mudflats is the shorebirds. The extensive intertidal mudflats of San Francisco Bay provide key migratory staging areas for overwintering shorebirds of the Pacific Flyway. Although no formal shorebird censuses have been conducted in the Suisun Bay and Sacramento-San Joaquin Delta portions of the study area, San Francisco Bay proper is estimated to support at the peak of migration at least a million shorebirds (Stenzel and Page 1988a, G. Page, Point Reyes Bird Observatory, pers. comm.). Seventy percent of the total shorebirds reported by Stenzel and Page (1988a) were found south of the San Mateo Bridge, 7 percent in central San Francisco Bay, and 23 percent in San Pablo Bay. Fewer shorebirds used the intertidal mudflats of Suisun Bay and the Delta than the Bay proper. This may be related to the smaller amount of intertidal mudflat habitat available in these portions of the study area and the less diverse and rarer benthic fauna inhabiting these mudflats.

The most abundant shorebird species censused in San Francisco Bay by Stenzel and Page (1988a) were western sandpipers, dunlins, dowitchers, marbled godwits, and least sandpipers. Although dunlins, western sandpipers, and dowitchers, as well as most of the numerous species, were found to be fairly widespread in the Bay, some broad differences in species composition were noted. For example, dunlins made up a greater percentage of the total shorebird numbers in the San Pablo Bay region, whereas western and least sandpipers made up a greater percentage of the shorebird population in South San Francisco Bay. The majority of American avocets were found south of the Dumbarton Bridge.

Little quantitative information is available on common shorebirds species utilizing intertidal mudflats of Suisun Bay and the Delta. In a 1971-1973 study of Suisun Marsh, Jurek (1974) found monthly maximum shorebird numbers as high as 5,800 birds. The highest numbers of shorebirds were consistently observed in April. Presumably these same species utilize adjacent intertidal mudflats. A study of intertidal mudflat habitat on dredged material islands in the Delta reported western and least sandpipers, dunlins, and semipalmated plovers as common species foraging and roosting on mudflats. Forster's terns, Caspian terns, and ring-billed gulls were common roosting species (England et al. 1988). (See Chapter 4 for more details on the use of the Bay and Delta by shorebirds.)

The harbor seal is the only mammal that makes significant use of mudflats in the study area, using them for haul-outs during low tides (Fancher and Alcorn 1982). Harbor seals range throughout the South and North San Francisco bays. Raccoons, skunks, and a variety of other mammals traverse exposed mudflats, but they do not make significant use of this habitat (Madrone Associates et al. 1980).

Wildlife species that are characteristic of intertidal mudflat habitat are not necessarily found exclusively in this habitat type (Table 2-6) (Small 1974, Madrone Associates et al. 1980, Jones and Stokes Associates, Inc. 1981, and Mayer and Laudenslayer 1988).

Table 2-6. Characteristic Wildlife of the Intertidal Mudflat Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds
Harbor seal (LCM)	Western grebe (CWB)
	Great blue heron (CWB)
	Great egret (CWB)
	Snowy egret (CWB)
	American wigeon (HWB) (CWB)
	American avocet (CWB)
	Willet (CWB)
	Marbled godwit (CWB)
	Western sandpiper (CWB)
	Dunlin (CWB)
	Dowitcher spp. (CWB)
	Forster's tern (CWB)

Key: CWB--Carnivorous Water Associated Bird; HWB--Herbivorous Water Associated Bird; LCM--Large Carnivorous Mammal.

The food web of the intertidal mudflat habitat is dominated by filter feeding, herbivorous, omnivorous, carnivorous, and scavenging invertebrates and fish (See Wetlands and Aquatic Resources Status and Trends Reports for the Estuary Project). Although the biomass and diversity of invertebrates and fish exceed that of wildlife, wildlife species still play a major role in community dynamics.

Several studies have indicated that shorebirds can be important predators of invertebrates on intertidal mudflats. Evans et al. (1979) calculated that shorebirds could remove 90 percent of the standing crop of some infaunal invertebrates from a study area in England. Goss-Custard (1977), using similar techniques on another wetland in England, found that between 34 and 57 percent of the invertebrate standing crop was removed. Schneider and Harrington (1981), on a Massachusetts wetland, found substantial reductions of invertebrate prey densities (7-90 percent) by early migrating shorebirds. Quammen (1984), in her study of a Southern California wetland, found that shorebirds significantly reduced the densities (26-80 percent) of invertebrates during winter. Quammen (1982) also found that subtle substrate differences in sediment composition affected the ability of shorebirds to detect their prey, with infaunal densities highest in winter on sandier sites.

Shorebirds eat a wide variety of invertebrate prey usually obtained from the top few centimeters of the substrate, or, less often, from the column of water overlaying the substrate. Foraminifera, oligochaetes, polychaetes, ostracods, cumaceans, copepods, tanaidaceans, amphipods, isopods, decapods, insects, gastropods, and bivalves have all been found in the diets of shorebirds at Bolinas Lagoon, about 10 miles north of San Francisco Bay (Stenzel et al. 1983). Fish are also occasional prey of some species (Warnock

1989). Most species prey on small invertebrates that can be swallowed whole, but curlews and willets eat large decapods after breaking them into pieces.

Little research has been done on the food habits of shorebirds on mudflats within the Estuary study area. Recher (1966) examined the stomach contents of plovers, avocets, dowitchers, sandpipers, godwits, knots, and willets at Palo Alto and found considerable overlap in food organisms used by these species. Invertebrates, such as gem clam (Gemma gemma), a polychaete worm (Neanthes succinea), ostracods, and the mud snail (Ilyanassa obsoleta) were commonly taken by American avocets, western sandpipers, least sandpipers, dunlins, and dowitchers, as well as other shorebird species. Nearly all identified prey items consumed were introduced species (Carlton 1979) that did not become established in the Bay until after 1850.

Interspecific competition among shorebird species apparently is avoided through differences in distribution on the mudflat, morphology, and feeding behavior, coupled with an abundant food source (Recher 1966). Recher (1966) also found that larger shorebirds, in general, fed more selectively than the smaller shorebirds.

During high tide periods, shorebirds retreat from the mudflats to roost or forage in alternate wetland habitats, such as dikes, islands, breakwaters, piers, or shallow standing water. Other species, such as canvasbacks and ruddy ducks, then feed on the abundant invertebrates in these shallow water zones. The baltic clam is reported to be one of the most important food items for canvasbacks (California Department of Fish and Game, unpubl. data). Other invertebrates, including Mya arenaria and, in the eastern portions of the Bay, Corbicula sp. are also taken. Fish-eating birds, such as the western grebe and Forster's tern, also utilize this habitat.

2.2.2.2 Rocky Shores

Few wildlife species utilize rocky shore habitat in the study area. Shorebirds, including the ruddy turnstone, black turnstone, surfbird, wandering tattler, and black oystercatcher, feed on the variety of invertebrates that inhabit the rocky intertidal zone. Pacific herring use this habitat for spawning; this attracts feeding cormorants, gulls, and harbor seals during high tides. During low tides, rocky shores provide roosting habitat for cormorants, brown pelicans, black-crowned night-herons, elegant terns, and western gulls. Harbor seals and California sea lions also haul out on exposed rocky shores.

Wildlife species characteristic of the rocky shore habitat type may also be found in other habitat types of the Estuary (Table 2-7) (Jones and Stokes Associates, Inc. 1981, S. Fazio, East Bay Regional Park District, pers. comm., and T. Harvey, U.S. Fish and Wildlife Service, pers. comm.).

Table 2-7. Characteristic Wildlife of the Intertidal Rocky Shore Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds
California sea lion (LCM)	Brown pelican (CWB)
Harbor seal (LCM)	Black oystercatcher (CWB)
	Wandering tattler (CWB)
	Spotted sandpiper (CWB)
	Black turnstone (CWB)
	Surfbird (CWB)
	Elegant tern (CWB)

Key: CWB--Carnivorous Water Associated Bird; LCM--Large Carnivorous Mammal.

The food web of rocky shore habitat is dominated by filter feeding, herbivorous, omnivorous, carnivorous, and scavenging invertebrates and fish. Although the biomass and diversity of invertebrates and fish exceed that of wildlife, wildlife species still play a major role in community dynamics.

2.3 TIDAL SALT, BRACKISH, AND FRESHWATER MARSH

2.3.1 Vegetation

Tidal salt, brackish, and freshwater marshes of the Estuary are dominated by sparse to dense stands of emergent vegetation. Salt and brackish marshes are often interspersed with unvegetated tidal channels and pannes that are exposed at low tide. Plant heights vary from prostrate to nearly three meters. Characteristic plants of the tidal salt, brackish, and freshwater marsh habitat types include grasses, sedges, rushes, and succulent vegetation (Table 2-8).

Salt marsh is found throughout South, Central, and North San Francisco bay. Brackish marshes are common in Suisun and San Pablo bays and in portions of San Francisco Bay with local freshwater influence, such as the Petaluma and Napa rivers, and several South Bay rivers, creeks, or sloughs receiving treated sewage effluent. Islands of freshwater marsh occur in unleveed portions of the Delta.

In salt marsh habitat, cordgrass grows from approximately mean tidal level (MTL) to mean high water (MHW) and pickleweed above MHW (Josselyn 1983). Other salt marsh plants that generally occur at elevations higher than pickleweed include alkali heath (<u>Frankenia grandifolia</u>), gumplant, and saltgrass.

Atwater and Hedel (1976) identified three zones of plant growth in brackish marshes: low marsh (MTL or lower), middle marsh (MTL to mean higher high water [MHHW]), and high marsh (at or above MHHW). The low marsh is dominated by California bulrush (Scirpus californicus); the middle marsh with a mixture of cattails and bulrushes; and a high marsh with a variety of halophytes including saltgrass and baltic rush.

Table 2-8. Characteristic Plants of the Tidal Salt, Brackish, and Freshwater Marsh Habitat Types.

Common Name	Scientific Name
Salt marsh	
Pickleweed	Salicornia spp.
Cordgrass	Spartina foliosa
Saltgrass	Distichlis spicata
Gumplant	Grindelia spp.
Green algae	Enteromorpha spp.
Brackish marsh	
Tule	Scirpus spp.
Cattail	Typha spp.
Alkali bulrush	Scirpus robustus
Baltic rush	Juncus balticus
Freshwater marsh	
Cattail	Typha spp.
Reeds	Phragmites communis

2.3.2 Characteristic Wildlife

2.3.2.1 Tidal Salt and Brackish Marshes

About 92 percent of San Francisco Bay tidal salt and brackish marshes have been filled or converted to other wetland types (Association of Bay Area Governments, in prep.). Many wildlife species that depend on this habitat type are endangered or are candidates for endangered status. Of these, the California clapper rail is a prominent resident species that uses tidal marshes as far upstream in the estuary as Suisun Marsh. The clapper rail uses the cover of cordgrass, pickleweed, and other marsh plants for nesting (Harvey 1988) and forages along tidal sloughs for invertebrates, including ribbed mussels (Ischadium demissum), Baltic clams, yellow shore crabs (Hemigrapsus oregonensis), and spiders (Moffitt 1941). Rails also take salt marsh harvest mice and other small mammals (Josselyn 1983).

Another important resident bird of tidal salt and brackish marshes is the California black rail, listed as a threatened species by the State of California. This species is most abundant in brackish wetlands, such as the Petaluma River, Napa River, and Suisun Slough. In the Corte Madera Ecological

Reserve in North San Francisco Bay, Evens and Page (1982) found that black rails preferred areas containing dense pickleweed, but with a high degree of understory penetrability. Insects and crustaceans are their primary foods (Jones and Stokes Associates, Inc. 1979).

Other birds using tidal salt and brackish marshes include the salt marsh yellowthroat and three races of salt marsh song sparrows: the Alameda race (Melospiza melodia pusillula), which occurs only in San Francisco Bay; the San Pablo race (M. m. samuelis), which occurs only in San Pablo Bay; and the Suisun race (M. m. maxillaris,) which is found in Suisun Bay. All of these subspecies are candidates for endangered or threatened status. Each subspecies is dependent during its entire life cycle on tidal salt or brackish marshes. The three races form small territories along tidal sloughs and channels in the marshes (Marshall 1948a). The Alameda race is the most threatened of the three races because of the greater extent of habitat loss and fragmentation in South San Francisco Bay (Walton 1975). Foods of the three races include seeds of bulrush, pickleweed, and gumplant, mosquito larvae, small nereid worms, snails, and other invertebrates (Marshall 1948a).

The salt marsh yellowthroat nests in a variety of wetland types, including tidal salt and brackish marshes (Hobson et al. 1985) and commonly spreads from other wetland types into tidal marshes in winter (Foster 1977). Insects associated with the various wetlands comprise most of their diet (Hobson et al. 1985).

Other resident bird species that utilize tidal salt and brackish marshes primarily for feeding include the great blue heron, great egret, snowy egret, and black-crowned night-heron. These species frequent tidal marshes at all tide levels where they feed on fish, invertebrates, and small mammals. Nesting occurs in higher elevational portions of the marsh and in adjacent uplands in coyote brush (Baccharis sp.), bulrush, gumplant, and pickleweed (Gill 1977, Rigney and Rigney 1981). Nesting is generally successful in this habitat only where ground predators are rare and human disturbance is low. Other birds reported by Gill (1977) to nest in tidal salt marshes are the black-shouldered kite, northern harrier, marsh wren, red-winged blackbird, and Savannah sparrow. Granholm (1987) reported the American bittern, mallard, cinnamon teal, Virginia rail, sora, marsh wren, and common yellowthroat as typical nesting species of tidal brackish wetlands in Suisun Marsh.

Tidal marshes of San Francisco Bay are also very important to migratory birds of the Pacific Flyway (Josselyn 1983). Actual use, however, of tidal salt and brackish marshes is limited, with most species of migratory waterfowl and shorebirds making substantially greater use of the open Bay, intertidal mudflats, salt ponds (Bollman et al. 1970), and diked wetlands. Within tidal salt marshes, most feeding and roosting activity is restricted to tidal sloughs and high marsh pannes, but some species, such as black rails, penetrate the dense vegetation to hide or forage. Migratory species commonly observed in sloughs and pannes of tidal marshes include shorebirds, such as black-necked stilts, willets, and least sandpipers, and waterfowl, such as the mallard and northern pintail (K. Foerster, U.S. Fish and Wildlife Service, pers. comm.). Bollman et al. (1970) found shorebirds to be the most abundant migratory species group in tidal salt marshes.

Tidal marshes also contribute to the productivity of other intertidal and subtidal habitats of importance to migratory birds. This occurs by release of decomposed plant material (detritus) which is passed through the food chain. Tidal salt marshes of the San Francisco Bay Estuary and elsewhere in California are thought to play a significant role in maintenance of migratory waterfowl populations in the Pacific Flyway, especially during periods of drought when inland wetland habitat is limited (U.S. Fish and Wildlife Service 1979).

Several small mammals are currently resident in tidal salt and brackish marshes of the study area. The most prominent of these are the endangered salt marsh harvest mouse and two candidate species, the salt marsh vagrant shrew and the Suisun ornate shrew. The salt marsh harvest mouse is found in tidal and non-tidal wetlands (Zetterquist 1977, Geissel et al. 1988), while the salt marsh vagrant shrew and Suisun ornate shrew have been reported only from tidal marshes. Both species of shrews are found along the margins of middle elevation tidal marshes containing dense cover, an abundance of invertebrate prey (e.g., crustaceans and amphipods), suitable nesting and resting sites, and fairly continuous ground moisture (Johnston and Rudd 1957; Western Ecological Services Company 1986a,b). The salt marsh vagrant shrew is restricted to salt marshes of South San Francisco Bay, whereas the Suisun ornate shrew utilizes salt and brackish marshes of northern San Pablo Bay and Suisun Bay.

The largest mammal found in association with tidal salt marshes of the Bay is the harbor seal. Harbor seals use tidal salt marshes as high tide haul-outs for loafing as well as giving birth to pups. Since 1928, harbor seals have consistently used a tidal salt marsh haul-out in Mowry Slough (South San Francisco Bay). Populations have ranged from 209 to 266 adults and subadults in censuses conducted between 1972 and 1985 (Fancher and Alcorn 1982, Fancher 1987). Other tidal salt marsh haul-outs in the Bay include Greco Island, Corkscrew Slough, and Guadalupe Slough in the South Bay, and Tubbs Island, Yerba Buena Island, Castro Rocks, Angel Island, and Corte Madera Ecological Reserve in the North Bay. Other mammals reported to utilize salt and brackish marshes in San Francisco Bay include the river otter (brackish only), muskrat (brackish only), mink (brackish only), beaver (eastern part of Suisun Marsh only), black-tailed hare, California vole, Norway rat, and house mouse (Madrone Associates 1977, Jones and Stokes Associates, Inc. 1979, Granholm 1987).

Wildlife species characteristic of tidal salt and brackish marshes are not necessarily found exclusively in this habitat (Table 2-9) (Ingles 1965, Small 1974, Madrone Associates et al. 1980, Jones and Stokes Associates, Inc 1981, Josselyn 1983, and Mayer and Laudenslayer 1988).

Table 2-9. Characteristic Wildlife of the Tidal Salt and Brackish Marsh Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles & Amphibians
Salt marsh vagrant shrew (TI)	Great blue heron (CWB)	Pacific treefrog (AA)
Mink (LCM)	Great egret (CWB)	Red-legged frog (AA)
River otter (LCM)	Snowy egret (CWB)	Western terrestrial garter snake (TR)
Harbor seal (LCM)	Northern pintail (CWB) (HWB)	Central Coast garter snake (TR)
Beaver (HM)	Northern harrier (CB)	
Salt marsh harvest mouse (HM)	Black rail (CWB)	
California vole (HM)	California clapper rail (CWB)	
Muskrat (HM)	Virginia rail (CWB)	
Black-tailed hare (HM)	Sora (CWB)	
	American coot (HWB)	
	Willet (CWB)	
	Short-eared owl (CB)	
	Common yellowthroat (CB)	
	Song sparrow (HLB) (CB)	

Key: AA--Aquatic Amphibian; CB--Carnivorous Bird; CWB--Carnivorous Water Associated Bird; HLB--Herbivorous Land Bird; HM--Herbivorous Mammal; HWB--Herbivorous Water Associated Bird; LCM--Large Carnivorous Mammal; LH--Large Herbivorous Mammal; TI--Terrestrial Insectivorous Mammal; TR--Terrestrial Reptile

Primary consumers in the food web include mammals such as the salt marsh harvest mouse, which feed on the seeds and stems of pickleweed; muskrats and beaver, which consume vegetation in the brackish marshes of the Estuary; and waterbirds, such as the American coot. Other primary consumers in the food chain include zooplankton, amphipods, annelids, bivalves, gastropods, and fish. Predators in the ecosystem include carnivorous insects, spiders, crabs, and fish (See the Wetlands and Aquatic Resources Status and Trends Reports for the San Francisco Estuary). Predators on the large invertebrate population include the California clapper rail, salt marsh vagrant shrew, northern pintail, and salt marsh song sparrow. Fish as well as larger invertebrates are consumed by the snowy egret, mink, and river otter. The northern harrier and introduced red fox and Norway rat prey on small mammals and birds that inhabit the marsh.

2.3.2.2 Tidal Freshwater Marshes

The wildlife values of tidal freshwater marshes in the Sacramento-San Joaquin Delta have been studied by Madrone Associates et al. (1980). Surveys conducted in freshwater marshes of the Delta from January 1979 to February 1980 revealed at least 57 wildlife species associated with this habitat type. Of these, 19 species were found to depend upon some feature of freshwater marshes for breeding, migration, resting or roosting. The majority of the species are year-round residents in freshwater marshes and include American bittern, beaver, western pond turtle, and bullfrog. In a study of dredged material islands in the Delta, England et al. (1988) found common yellow-throats, song sparrows, and marsh wrens to be the predominant species in established tule stands.

Wildlife species characteristic of tidal freshwater marshes (Table 2-10) are not necessarily found exclusively in this habitat (Madrone Associates et al. 1980). Primary consumers in the food web include mammals, such as the muskrat and beaver, which consume emergent and riparian vegetation, and waterbirds, such as the common moorhen. Other primary consumers in the food web include zooplankton, amphipods, annelids, bivalves, gastropods, and fish, which feed on algae, phytoplankton, and detritus. Predators in the ecosystem include carnivorous insects, spiders, and fish (See the Wetlands and Aquatic Resources Status and Trends Reports for the San Francisco Estuary Project). Predators on the invertebrate population include the sora and bullfrog. Fish, as well as larger invertebrates are consumed by the pied-billed grebe, bittern, and mink.

Table 2-10. Characteristic Wildlife of the Tidal Freshwater Marsh Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Mink (LCM)	Pied-billed grebe (CWB)	Pacific treefrog (AA) (TA)
Beaver (HM)	American bittern (CWB)	Red-legged frog (AA)
Muskrat (LH)	Virginia rail (CWB)	Bullfrog (AA)
	Sora (CWB)	Western pond turtle (AR)
	Common moorhen (HWB)	Central Coast garter snake (TR)
	American coot (HWB)	Common garter snake (TR)
	Marsh wren (TIE)	

Key: AA--Aquatic Amphibian; AR--Aquatic Reptile; CWB--Carnivorous Water Associated Bird; HWB--Herbivorous Water Associated Bird; LCM--Large Carnivorous Mammal; HM--Large Herbivorous Mammal; TA--Terrestrial Amphibian; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

2.4 SEASONAL WETLANDS

2.4.1 Vegetation

Seasonal wetlands are shallow depressions characterized by standing water, primarily during the winter rainy season, and soil moisture depletion during summer and fall. In the Estuary, seasonal wetland types include: (1) diked, formerly tidal, farmed wetlands that flood naturally in winter or are managed for hunting; (2) diked, formerly tidal, managed brackish marshes found in Suisun Marsh; (3) diked, formerly tidal, salt marshes adjacent to San Francisco Bay; (4) abandoned salt ponds in South San Francisco Bay; and (5) inland freshwater marshes and vernal pools associated with grasslands. Plants characteristic of seasonal wetlands are listed in Table 2-11.

Table 2-11. Characteristic Plants of Seasonal Wetland Habitats.

Common Name	Scientific Name
Diked Marsh (Salt and Brackish)	
Pickleweed	*Salicornia* spp.
Alkali heath	*Frankenia grandifolia*
Salt grass	*Distichlis spicata*
Alkali bulrush	*Scirpus robustus*
Fat hen	*Atriplex* spp.
Vernal Pools and Other Freshwater Habitat	
Rushes	*Juncus* spp.
Sedges	*Carex* spp.
Downingia	*Downingia* spp.
Meadow foam	*Limnanthes douglasii*
Farmed Wetlands	
Corn	
Hay	
Potatoes	
Abandoned salt ponds	
Wigeon grass	*Ruppia maritima*
Pickleweed	*Salicornia* spp.

2.4.2 Characteristic Wildlife

Although there are no wildlife species restricted to seasonal wetlands, this habitat plays an extremely important role in the maintenance of wildlife populations of the study area. Of all wildlife groups present in the Estuary, migratory birds are most dependent on seasonal wetlands. Seasonal wetlands are important because they provide supplementary feeding habitat at a time of year when California's limited wetland acreage must support a much larger bird population. Seasonal wetlands provide supplemental foraging habitat for both dabbling and diving ducks and play a critical role in support of migratory shorebirds, particularly the smaller species, such as the western sandpiper. When high tides cover intertidal mudflats, seasonal wetlands adjacent to the Bay provide alternate foraging habitat for small shorebirds. Seasonal wetlands provide roosting habitat for larger shorebirds during high tides and shelter for waterfowl and shorebirds during storm events. They also support endangered species, resident waterbirds, small mammals, raptors, upland game birds, and passerine birds.

Extensive surveys of diked and undiked seasonal wetlands in San Francisco Bay have been conducted by the U.S. Fish and Wildlife Service over the last seven years. The Service, through its Diked Baylands Study, has been censusing wildlife use of over 140 seasonal wetland sites around the Bay. Preliminary results indicate that at least 19 species of migratory waterfowl and 20 species of migratory shorebirds utilize San Francisco Bay seasonal wetlands for feeding and roosting in winter. A total of 234 bird species have been observed in seasonal wetlands and surrounding transitional habitat (U.S. Fish and Wildlife Service, unpubl. data).

Friley (1988) observed a total of 63 bird species in censuses conducted at 18 seasonal wetland sites in South San Francisco Bay. Of these, the western meadowlark, western sandpiper, and killdeer were the most commonly observed species. The most abundant species were the western sandpiper, dowitcher, and northern shoveler. Ten species of migratory waterfowl and 12 species of migratory shorebirds were observed. Friley (1988) also found that those seasonal wetland sites exhibiting greater habitat heterogeneity (i.e., moderate ponding, greater vegetative diversity, and moderate vegetation density) supported a greater average number of bird species.

Data collected by the Santa Clara Valley Audubon Society (unpubl. data) attests to the high value of seasonal wetlands to migratory birds. Bird censuses have been conducted by the Audubon Society at Charleston Slough in South San Francisco Bay since 1980. Total birds per census range from 500 to over 5,000 with 25 to 38 species of birds encountered during each census. Species observed in large numbers (over 500 birds per census) have included the northern shoveler, ruddy duck, American coot, western sandpiper, California gull, American avocet, dowitchers, Herring gull, and western gull.

Seasonal wetlands around the Estuary also provide habitat for several endangered species. Seasonal wetlands and adjacent transitional habitat are known to support significant populations of the salt marsh harvest mouse (Zetterquist 1977, Geissel et al. 1988). The endangered San Francisco garter snake is found in seasonal wetlands near drainage canals holding year-round water adjacent to the San Francisco International Airport. The snakes overwinter at the canals, disperse to the seasonal wetlands during spring, and return to the canals as the seasonal wetlands dry up (Wharton et al. 1985). Least terns have been observed foraging in Charleston Slough during the summer months (Santa Clara Valley Audubon Society, unpubl. data).

Seasonal wetlands and ponds of San Francisco Bay have not been surveyed extensively for other wildlife species. However, the Diked Baylands Wildlife Study results show use by mammals and reptiles, including black-tailed hare, California ground squirrel, gray fox, muskrat, black-tailed deer, and gopher snake (U.S. Fish and Wildlife Service, unpubl. data). Seasonal wetlands and adjacent transitional habitat also provide nest sites for waterfowl, such as the mallard and cinnamon teal.

2.4.2.1 Diked Marsh

Reclamation of Bay tidal marshes to create farmed wetlands and salt ponds, basically eliminated historic high marsh habitat, which originally had acted as an important transition zone to adjacent uplands. Today, diked marshes maintain some of these lost habitat values. For example, the endangered salt marsh harvest mouse, a species dependent on high marsh habitat, may occur in significant numbers in some diked marshes.

Suisun Marsh comprises the largest diked seasonal wetland complex in the study area extending over 57,310 acres. These managed marshlands constitute approximately 12 percent of California's remaining wetlands. These seasonal wetlands are of primary importance to migratory waterfowl and shorebirds, particularly in early fall when Central Valley wetlands are not yet flooded or during drought years. Average monthly fall and winter waterfowl populations between 1977 and 1986 have varied between 78,000 and 178,000 birds, representing between 3.3 and 5.6 percent of the State's total migratory waterfowl population (California Department of Fish and Game 1987b).

Of the migratory waterfowl frequenting Suisun Marsh, northern pintails are most numerous, comprising 40 to 96 percent of all waterfowl recorded on the marsh in fall and winter (U.S. Fish and Wildlife Service 1978a). Other important waterfowl species include mallards, American wigeon, northern shovelers, green-winged teal, canvasbacks, cackling Canada geese, and white-fronted geese. The marsh also supports an average annual breeding population of about 2,400 pairs of primarily mallards, gadwall, and cinnamon teal (California Department of Fish and Game 1987b). McLandress and Yarris (1986) found that duck nesting densities in Suisun Marsh averaged 825 nests/mi^2 compared to an average density of 352 nests/mi^2 from other State and Federal wildlife areas in the Sacramento Valley. Mallards were the predominant nesting species, with 44 percent of the nests successful.

Few studies have been conducted on food habits of waterfowl in Suisun Marsh. Based on examination of gizzard contents, Mall (1969) concluded that alkali bulrush seeds were the most important food item in the diets of dabbling ducks in the marsh. Swanson and Bartonek (1970), however, demonstrated that analyses of gizzard contents inflates the importance of seeds in the diet of ducks. Analyses of esophageal contents soon after birds have fed more accurately reflects the diet of waterfowl (Swanson and Bartonek 1970). Batzer (unpubl. data) is currently studying invertebrate food habits of mallards in Suisun Marsh. Preliminary results indicate that blood worms (Chironomus plumosus) and scuds (Gammarus) are commonly taken by mallards.

More recent studies of waterfowl food habits outside the Estuary study area have documented the importance of invertebrates in the diet. Connelly and Chesemore (1980) found that animal matter constituted a much higher percentage of the diet of wintering pintails in the northern San Joaquin Valley than was previously reported. The percentage of animal matter in the diet, primarily chironomid larvae, was highest in winter (November to February), whereas vegetative food items predominated in the fall. Miller

(1987) and Euliss and Harris (1987) found similar results in their studies of waterfowl food habits in the Sacramento Valley and San Joaquin Valley, respectively.

In addition to waterfowl, Suisun Marsh is also important to shorebirds as a migration stop-over area. Of the 21 species of shorebirds that have been observed in Suisun Marsh, the western sandpiper, dunlin, and long-billed dowitcher are most abundant, particularly during spring migration (Jones and Stokes Associates, Inc. and EDAW, Inc. 1975).

Because of its size, location, and abundance of small mammal prey species, Suisun Marsh is also noted as an important raptor wintering area. Jones and Stokes Associates, Inc. and EDAW, Inc. (1975) reported 11 species of hawks, three species of falcons, two species of eagles, and seven species of owls using seasonal wetlands as well as adjacent transitional and upland habitats.

Mammals also abound in Suisun Marsh. The most notable species present in the diked wetlands of the marsh is the salt marsh harvest mouse which is found primarily in areas of dense pickleweed. A complete accounting of species and preferred habitat is presented in Jones and Stokes Associates, Inc. and EDAW, Inc. (1975). They described use of the diked marshes of Suisun Marsh by a total of 14 species of bats, 10 species of carnivores, and 12 species of rodents. The Grizzly Island Wildlife Management Area of Suisun Marsh also supports a herd of tule elk which were reintroduced in the early 1970s and have attained a population of 500-1,000 animals in recent years (R. Helm, U.S. Fish and Wildlife Service, pers. comm.).

2.4.2.2 Vernal Pools

Vernal pools are natural, undiked seasonal wetlands in the study area. Little information is available in the literature on the wildlife use and values of vernal pools in the Estuary project area, but they provide wildlife habitat values similar to other seasonal wetlands. They are used during winter and early spring as loafing and foraging habitat by migratory and wintering waterfowl, and late-drying vernal pool complexes also provide brood habitat for several species of shorebirds and waterfowl (Holland 1988).

Numerous species have been observed in vernal pools of the Central Valley, including: mallard, cinnamon teal, killdeer, American avocet, black-necked stilt, northern pintail, great blue heron, great egret, and willet (Zedler 1987). The following species have been observed using Santa Rosa vernal pools: mallard, cinnamon teal, great egret, snowy egret, killdeer, greater yellowlegs, lesser yellowlegs, and common snipe (M. Long, U.S. Fish and Wildlife Service, pers. comm., Waaland, letter to Corps of Engineers, 3-30-89). Additional information on bird use of vernal pools in the study area comes from censuses conducted by the U.S. Fish and Wildlife Service through its Diked Baylands Wildlife Study. Data from vernal pool habitat in the Fremont area of South San Francisco Bay show significant use by migratory waterfowl and shorebirds in winter for both feeding and roosting. Commonly observed species were the mallard, cinnamon teal, American wigeon, American avocet, and black-necked stilt. Western and least sandpipers were most abundant, with as many as 2,300 individuals observed during spring migration.

Amphibians are also likely inhabitants of vernal pools. Barry (1981) noted that the California tiger salamander breeds in Jepson Prairie vernal pools. According to Zedler (1987), the Pacific treefrog and western spadefoot are common amphibians in Southern California vernal pools. These same species, as well as the western toad, occur in vernal pools of the study area.

No reptiles are limited to vernal pool habitat in the study area. Reptiles of the surrounding grasslands include the western terrestrial garter snake, common garter snake, and southern alligator lizard. These species probably feed on amphibians during winter and spring when the pools are inundated.

Like reptiles, there are no mammals restricted to vernal pools, and most mammals that utilize the vernal pool habitat are grassland-oriented species. In a study of Southern California vernal pools, Winfield et al. (1984) captured a number of small mammal species, including the western harvest mouse, deer mouse, and California vole, all of which could occur in and adjacent to study area vernal pools. The black-tailed hare undoubtedly makes use of vernal pool vegetation in the study area after the pools have dried.

2.4.2.3 Farmed Wetlands

The vast farmed wetlands of the Delta and the Napa Marsh are noted as important migratory bird stop-overs and wintering areas. Of the migratory birds frequenting seasonally flooded agricultural wetlands of the Delta, waterfowl are the most abundant. The Delta supports nearly 10 percent of all waterfowl wintering in California (U.S. Fish and Wildlife Service 1978a) and is the most important wintering area for tundra swans in California, supporting an estimated 73 percent of the wintering Central Valley population. Over one-third of the Central Valley population of white-fronted geese winter in the Delta and feed primarily in flooded and unflooded corn fields (U.S. Fish and Wildlife Service 1978a). Other species of importance include the northern pintail, mallard, and snow goose (California Department of Fish and Game 1987c).

Few waterfowl food habits studies have been conducted in the Delta. Tate and Tate (1966), in a study near Stockton, reported that tundra swans fed on waste corn in both flooded and nonflooded fields as well as potatoes in flooded fields. Flooded agricultural fields in the Delta area are considered to be essential feeding habitat for tundra swans and white-fronted geese (Madrone Associates et al. 1980). Dabbling ducks also prefer flooded fields for feeding (Madrone Associates et al. 1980).

Delta seasonal wetlands also support significant numbers of migratory shorebirds, particularly in late summer or early fall when some farmers flood their fields early to control weeds and centipedes. Shorebirds commonly observed in these wetlands include greater yellowlegs, long-billed dowitchers, long-billed curlews, and western sandpipers (California Department of Fish and

Game 1987c). Later in the fall and into the early spring, shorebirds utilize shallow areas of fields flooded to leach salts, fields flooded to attract waterfowl, and fields flooded by rainwater or unpumped seepage. Farmed wetlands of the Delta, particularly harvested corn and wheat fields, provide valuable foraging habitat for greater sandhill cranes and Swainson's hawks.

2.4.2.4 Abandoned Salt Ponds

Another type of seasonal wetland for which wildlife information exists is recently abandoned salt ponds, which are located primarily in South San Francisco Bay. Abandoned salt ponds near Hayward were found to support 40 species of waterbirds during winter (Cole/Mills Associates 1987). Of these species, the bufflehead was most common during seasons of extensive inundation. When the ponds contained shallow water, western and least sandpipers were predominant, with peaks of from 24,000 to 27,000 birds observed in fall and winter. For shorebirds, the number of individuals observed was highly dependent on tidal sequence and height and time of year. In 1976, members of the Ohlone Chapter, National Audubon Society, counted approximately 332 western snowy plovers on these ponds, which was one of the largest concentrations recorded in the San Francisco Bay Area in recent years (Western Ecological Services Company and Thomas Reid Associates 1989). The western snowy plover was the only nesting species observed in the abandoned salt ponds in this study (Cole/Mills Associates 1987).

Surveys of abandoned salt ponds on Bair Island (Redwood City) also confirm substantial use by shorebirds and nesting by the snowy plover (San Francisco Bay Bird Observatory 1988). Other nesting species include Caspian terns, American avocets, black-necked stilts, and, in some years, Forster's terns. Historically, the least tern nested in these abandoned salt ponds. Few mammals were found in this habitat because of the lack of significant vegetative food and cover. However, H. Cogswell (California State University, Hayward, pers. comm.) observed a red fox on the Baumberg Tract in 1986, and a red fox was observed on Bair Island in April 1991 (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.).

Wildlife species characteristic of seasonal wetlands are not found exclusively in this habitat type (Table 2-12) (Ingles 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, and Mayer and Laudenslayer 1988). Primary consumers of algae, aquatic vegetation and seeds include mammals, such as the salt marsh harvest mouse and California vole, that function in both the terrestrial and aquatic components of the food web, birds, such as the mallard, and small invertebrates, zooplankton, molluscs, crustaceans, and phytophagus insects. Important secondary and tertiary consumers include aquatic invertebrate-eating animals, such as the snowy egret, common snipe, and California tiger salamander, that also function as consumers in the terrestrial environment, and carnivores, such as the striped skunk, the common crow, and carnivorous insects.

Table 2-12. Characteristic Wildlife of the Seasonal Wetland Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
DIKED MARSH		
Striped skunk (SCM)	Snowy egret (CWB)	Gopher snake (TR)
Salt marsh harvest mouse (SH) (SE) (TI)	Northern pintail (HWB) (AIE)	
Black-tailed hare (SH)	Northern shoveler (AIE)	
	American wigeon (HWB) (AIE)	
	Northern harrier (CB)	
	Western sandpiper (TIE)	
	Salt marsh song sparrow (SFE) (TIE)	
VERNAL POOLS AND OTHER FRESHWATER HABITAT		
Striped skunk (SCM)	Snowy egret (CWB)	California tiger salamander (TA) (AA)
Western harvest mouse (SE) (TI)	Mallard (AIE)	Western spadefoot (TA)
California vole (SH)	Killdeer (AIE)	Western toad (TA)
Black-tailed hare (SH)	Common snipe (AIE) (SFE)	Western terrestrial garter snake (TR)
		Common garter snake (TR)
FARMED WETLANDS		
Striped skunk (SCM)	Tundra swan (HWB)	Gopher snake (TR)
Coyote (LC)	White-fronted goose (AIE)	
California ground squirrel (SE) (SH)	Northern pintail (AIE) (HWB)	
California vole (SH)	Greater yellowlegs (AIE)	
	Common crow (CB) (SB) (SFE) (TIE)	
ABANDONED SALT PONDS		
None	Bufflehead (AIE)	None
	Western snowy plover (AIE)	
	Western sandpiper (AIE)	

Key: AA--Aquatic Amphibian; AIE--Aquatic Invertebrate-eating Bird; CB--Carnivorous Bird; CWB--Carnivorous Water Associated Bird; HWB--Herbivorous Water Associated Bird; LCM--Large Carnivorous Mammal; SB--Scavenging Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TA--Terrestrial Amphibian; TIE--Terrestrial Insect-eating Bird; TI--Terrestrial Insectivorous Mammal; TR--Terrestrial Reptile.

2.5 RIPARIAN WOODLAND

2.5.1 Vegetation

The riparian woodland habitat type (Table 2-13) consists primarily of narrow strips of broad-leaved, winter deciduous trees and shrubs that grow adjacent to streams that lead into the Estuary. Trees grow up to 100 feet tall. The understory is sparse to absent when the overstory tree canopy is dense. Soil moisture is more or less permanently available, and flooding events are irregular.

Table 2-13. Characteristic Vegetation of the Riparian Woodland Habitat Type.

Common Name	Scientific Name
Trees	
Boxelder	Acer negundo californicum
Fremont cottonwood	Populus fremontii
Willow	Salix spp.
California sycamore	Platanus racemosa
White alder	Alnus rhombifolia
Shrubs	
Willow	Salix spp.
Elderberry	Sambucus mexicana
Blackberry	Rubus procerus

2.5.2 Characteristic Wildlife

Riparian woodlands are often considered to be the most valuable of habitats available to wildlife. Water, food, and cover, the critical habitat requirements, are all supplied in riparian habitat types. The complexity of microhabitats created by the layering of trees, shrubs, vines, and herbaceous and aquatic vegetation promotes high wildlife species diversity. The shape of riparian zones (i.e., narrow corridors) maximizes the extent of edge habitat, thereby increasing species diversity. A great number of species, such as hole-nesting or bark-gleaning birds, are completely dependent on this habitat type for existence.

Riparian habitat also enhances the value of adjacent fish and wildlife habitats. When adjacent to grasslands or agricultural land, riparian forests provide nest sites for raptors and cover for upland species that use these adjacent habitat for foraging. In addition, riparian zones act as corridors between cover types for species migration. Riparian vegetation that hangs over water shades the aquatic environment, thereby ameliorating water temperatures. Leaf and insect drop provides food and other essential nutrients to the aquatic ecosystem.

Many of the species that frequent riparian habitats also utilize the aquatic habitat for breeding, foraging, or loafing. Examples are the green-backed heron, wood duck, belted kingfisher, western toad, and Pacific treefrog. All of these species require both the stream and adjacent vegetated wetlands to fulfill their life requirements. Other species, such as the Pacific slope and ash-throated flycatchers are dependent on the riparian woodland-stream edge where they feed aerially on terrestrial life stages of aquatic insects.

Riparian habitat is the rarest wetland habitat type in the study area, but has received little attention in the literature. Within the study area, extensive surveys of riparian habitat have occurred only in the Sacramento-San Joaquin Delta, and on Coyote Creek and Guadalupe River in South San Francisco Bay.

Of all the wildlife habitat types surveyed in the Sacramento-San Joaquin Delta, Madrone Associates et al. (1980) found that riparian habitat supported the greatest diversity of wildlife species, including both nesting and wintering species. Of the 107 species observed in riparian woodlands and shrublands, 37 species of birds and one mammal found essential habitat in Delta riparian vegetation (Madrone Associates et al. 1980)

Bird surveys of the Guadalupe River have been conducted over the past year by H.T. Harvey and Associates (unpubl. data). Similar to results of studies in the Delta, over 100 species of birds were found in the study area. Another study of bird life in Santa Clara County (South San Francisco Bay) showed that 60 percent of the 211 species of birds observed in the county occurred in riparian habitat (Harvey and Associates 1988).

An intensive study of existing riparian habitat and riparian revegetation plots is currently being conducted on Lower Coyote Creek by the Coyote Creek Riparian Station (1988). Results of surveys thus far reveal over 60 species of birds in existing mature riparian vegetation. By contrast, riparian revegetation plots in their second year supported 44 species. Previous surveys of Lower Coyote Creek in this vicinity revealed 94 species of birds (Santa Clara Valley Water District 1984). A total of 51 species was found to be resident year-round; 11 species were summer residents; 18 species were winter residents spending six or more months in the study area, but breeding elsewhere; and 16 species were recorded as migrants that stayed a short time (two to five days) in riparian habitat of the study area during migration.

Wildlife species characteristic of riparian woodlands are not necessarily found exclusively in this habitat type (Table 2-14) (Ingles 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Coyote Creek Riparian Station 1988).

Table 2-14. Characteristic Wildlife of the Riparian Woodland Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Opossum (SCM) (SE) (TI)	Wood duck (SFE) (TIE)	Pacific treefrog (TA)
Ornate shrew (TI)	Great horned owl (CB) (TIE)	California newt (TA)
Pallid bat (FI)	Anna's hummingbird (NE) (TIE)	Rubber boa (TR)
Raccoon (SE) (SCM) (TI)	Downy woodpecker (TIE) (SFE)	Ring-necked snake (TR)
Striped skunk (SCM) (TI)	Black phoebe (TIE)	Common garter snake (TR)
Coyote (LCM) (TI)	Tree swallow (TIE)	
Western gray squirrel (SE)	Scrub jay (SFE) (TIE) (CB) (SB)	
Deer mouse (SE) (TI)	Bewick's wren (TIE)	
Audubon cottontail (SH)	Rufous-sided towhee (SFE)	
Black-tailed deer (LH)	Northern oriole (TIE) (SFE)	
	Song sparrow (SFE) (TIE)	

Key: CB--Carnivorous Bird; FI--Flying Insectivorous Mammal; LCM--Large Carnivorous Mammal; LH--Large Herbivorous Mammal; NE--Nectar-eating Bird; SB--Scavenging Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TA--Terrestrial Amphibian; TI--Terrestrial Insectivorous Mammal; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

Primary consumers of vegetation in this habitat type are mammals, such as the black-tailed deer and Audubon cottontail, and phytophagous insects. Seed and fruit production is consumed by mammals, such as the deer mouse and western gray squirrel, and birds, such as the rufous-sided towhee. Secondary and tertiary consumers include insectivores, such as the black phoebe, Anna's hummingbird (also a nectivore), ornate shrew, pallid bat, and Pacific treefrog, and carnivores, such as the coyote, opossum, and great horned owl. The scrub jay is a common scavenging bird. The raccoon is an excellent example of an omnivore, feeding on seeds, fruits, insects, bird eggs, and carrion.

2.6 SALT PONDS

2.6.1 Vegetation

With the exception of wigeon grass, the dominant plants of the salt pond habitat type are algae. Green algae are most common. Plant distribution is related to pond salinities, with species distribution and abundance decreasing as salinity increases (Carpelan 1964) (Table 2-15). Salt ponds, consisting of salt evaporators, crystallizers, and bittern ponds, are located around San Francisco Bay, with over 27,000 acres in the South Bay and over 9,000 acres in the North Bay (U.S. Fish and Wildlife Service 1989b).

Table 2-15. Characteristic Plants of the Salt Pond Habitat Type.

Common Name	Scientific Name
Blue-green algae	Oscillatoria spp.
Diatoms	Melosira moniliformis
Green algae	Enteromorpha spp.
	Dunaliella salina
	Stichococcus bacillaris
Wigeon grass	Ruppia maritima

2.6.2 Characteristic Wildlife

Salt ponds, especially those with low to moderate salinities, provide important wetland habitat for wildlife of the study area. Studies, primarily in South San Francisco Bay, attest to the high seasonal diversity and abundance of bird life utilizing this habitat type. Anderson (1970a) reported 55 and Swarth et al. (1982) 70 bird species in their respective studies of South Bay salt ponds. Salt ponds are of primary importance to migratory birds, but they also provide year-round foraging habitat for a number of resident species. Several species nest on salt pond levees and islands. The most common species and the seasonality of their use of salt ponds are shown in Table 2-16. Some of these species were historically uncommon in San Francisco Bay. Creation of the salt pond habitat type, beginning in the 1850s, enhanced breeding and non-breeding populations of several waterbirds, including the eared grebe, white pelican, snowy plover, Caspian tern, Forster's tern, Wilson's phalarope, California gull, American avocet, and black-necked stilt (Harvey et al. 1988).

Salt ponds support an abundance of several waterbird groups, particularly during fall and spring migration and in winter. Harvey et al. (1988) reported wintering waterfowl peaks in South San Francisco Bay salt ponds of 75,000 birds. Peaks in the number of wintering shorebirds exceeded 200,000 individuals, which attests to the importance of this habitat type to shorebird populations wintering in or migrating through San Francisco Bay. Phalaropes, which utilize salt ponds as post-breeding migrational stopover sites, reached peaks as high as 70,000 individuals (Harvey et al. 1988).

While waterfowl and phalaropes utilize salt ponds primarily for feeding, there is some variability among shorebird species in their use of salt ponds. Harvey et al. (1988) reported that marbled godwits, dowitchers, and black-bellied plovers utilized salt ponds primarily for roosting areas. Smaller shorebirds, such as the western sandpiper and least sandpiper, as well as American avocets, willets, and greater yellowlegs used salt ponds as supplemental feeding and roosting habitat when high tides covered intertidal mudflats. The black-necked stilt, red-necked phalarope, and Wilson's phalarope fed and roosted exclusively in salt ponds.

Table 2-16. Seasonal Use of Salt Ponds by Common Bird Species (Rigney and Rigney 1981, Swarth et al. 1982, Harvey et al. 1988, Feeney 1989, U.S. Fish and Wildlife Service, unpubl. data).

Resident	Migrant/Winter Visitor
Double-crested cormorant	Eared grebe
Great blue heron	White pelican
Great egret	Northern pintail
Snowy egret	Northern shoveler
Gadwall	American wigeon
Ruddy duck	Canvasback
Western snowy plover (1,2)	Scaup sp.
Killdeer (1)	Common goldeneye
Black-necked stilt (1,3)	Bufflehead
American avocet (1,3)	Red-breasted merganser
California gull (5)	American coot
Forster's tern (1,2)	Black-bellied plover (4)
	Willet (4)
Summer Visitor	Marbled godwit (4)
	Western sandpiper
Caspian tern (1,3)	Least sandpiper
Least tern	Dunlin
	Dowitcher sp.
	Northern phalarope
	Red-necked phalarope
	Bonaparte's gull
	Ring-billed gull (4)
	Herring gull
	Western gull
	Glaucous-winged gull

1 Nests on salt pond dikes.
2 Fall, spring, and summer resident, rare in winter.
3 Also migrant.
4 Also non-breeding summer visitor.
5 Three nesting colonies in South San Francisco Bay.

Several species occur more frequently in salt ponds than in any other wetland or deep-water habitat of the Bay. Harvey et al. (1988) noted significantly greater use of salt ponds than of the open Bay by many species of migratory waterfowl, with this preference most prominent during spring migration. Swarth et al. (1982) reported that eared grebes, northern shovelers, and Bonaparte's gulls were abundant on salt ponds, but essentially absent in intertidal habitat. Canvasbacks have been observed to congregate on North Bay salt ponds (U.S. Fish and Wildlife Service, unpubl. data).

Pond salinity affects the distribution of some waterbirds found in salt ponds. White pelicans, cormorants, and other fish-eating species occur most commonly in ponds with low salinities (e.g., 20-30 parts per thousand).

Although phalaropes, eared grebes, and black-necked stilts reportedly prefer higher salinity ponds (Anderson 1970a, Harvey et al. 1988), most shorebirds and nesting terns show no marked salinity preference. The presence of shallow water and isolated islands or dikes is generally the most important criteria in pond selection for these species groups.

Food habits of birds using salt ponds have not been thoroughly investigated. Anderson (1970a) reported the consumption of wigeon grass and water boatmen (Trichocorixa reticulata) by waterfowl, brine shrimp (Artemia franciscana) by eared grebes, water boatmen and brine flies (Ephydra sp.) by least sandpipers and American avocets, and polychaete worms by willets. California least terns were reported by Feeney (1989) to consume topsmelt (Atherinops affinis) in ponds of the Baumberg area, Hayward. Howard (1983), in his study of the feeding ecology of ruddy ducks on San Francisco Bay National Wildlife Refuge, found that brine shrimp, water boatmen, wigeon grass, and green algae were the principal food items in the diet of wintering ruddy ducks.

As shown by frequent large feeding aggregations of species such as white pelican, double-crested cormorant, Forster's tern, and great egret, significant fish populations occur in the low salinity ponds. Lonzarich (1989) reported year-round resident populations of top smelt, threespine stickleback (Gasterosteus aculeatus), rainwater killifish (Lucania parva), yellowfin goby (Acanthogobius flavimanus), and Pacific staghorn sculpin (Leptocottus armatus) in ponds near Alviso ranging up to about 80 parts per thousand in salinity. He also described how seasonal reductions in dissolved oxygen in these ponds, due to decomposition of algal mats, force fish to the pond surface where they are readily available to birds. Populations of long-jawed mudsuckers (Gillichthys mirabilis) have also supported occasional commercial harvest in South Bay salt ponds in the past (U.S. Fish and Wildlife Service, unpubl. data).

2.7 LAKES AND PONDS

2.7.1 Vegetation

Lakes and ponds in the Estuary study area are dominated by a variety of aquatic vegetation, including floating, submerged, and emergent aquatic plants (Table 2-17). Perennial supplies of fresh, brackish, or salt water are required to support most aquatic species.

In the study area, the lakes and ponds habitat type is characterized by numerous constructed lakes and ponds within urban areas of the Bay, reservoirs around San Francisco Bay, sewage treatment lagoons found throughout the Bay and Delta, and lakes found in currently or formerly cultivated islands or overflow channels of the Delta.

Table 2-17. Characteristic Plants of the Lakes and Ponds Habitat Type.

Plant Form	Common Name	Scientific Name
Floating	Duckweed	*Lemna* spp.
	Water fern	*Azolla filiculoides*
	Water hyacinth	*Eichhornia crassipes*
	Green algae	
Submerged	Pondweed	*Potamogeton* spp.
	Naiads	*Najas guadalupensis*
	Water milfoil	*Myriophyllum*
Emergent	Cattail	*Typha* spp.
	Smartweed	*Polygonum* spp.
	Pickleweed	*Salicornia* spp.
	Alkali bulrush	*Scirpus robustus*

2.7.2 Characteristic Wildlife

Data from the U.S. Fish and Wildlife Service's Diked Baylands Wildlife Study reveal significant migratory bird use of an artificial lagoon in San Rafael (Spinnaker Lagoon), as well as nesting by mallards, ruddy ducks, pied-billed grebes, black-necked stilts, American avocets, and American coots.

Several reservoirs in the study area attract large flocks of geese in winter. In 1984, the California Department of Fish and Game and U.S. Fish and Wildlife Service's midwinter waterfowl inventory counted 2,950 Canada geese in East Bay reservoirs (Contra Costa and Alameda counties).

Of the artificial wetland habitats within the study area, waste treatment ponds possess some of the greatest existing and potential wildlife values. Such ponds in Hayward, Sunnyvale, San Jose, San Rafael, Stockton, Petaluma, Novato, and Lodi are known to provide feeding and resting habitat for significant numbers of migratory and resident birds, but bird use has been quantified in only a few cases. However, Madrone Associates et al. (1980) conducted bird surveys of oxidation ponds associated with the Stockton and Lodi sewage treatment plants. A total of 63 bird species were observed, including 11 species of waterfowl, 19 species of shorebirds, and 5 gull species. These ponds were used most heavily during migration periods and in winter.

Aerial surveys of the sewage treatment ponds in Sunnyvale by the California Department of Fish and Game and the U.S. Fish and Wildlife Service from 1981 to 1986 revealed a total of 26 species of birds utilizing these ponds. Waterfowl species were most common, with the northern shoveler and ruddy duck most numerous. In November 1984, over 38,000 shovelers and 7,500 ruddy ducks were observed during one survey (California Department of Fish and Game and U.S. Fish and Wildlife Service, unpubl. data).

Bird-use information is currently being gathered by the East Bay Regional Park District for the sewage effluent treatment ponds in Hayward. Information on species use and total numbers of birds has been collected on a monthly basis since May 1988 when the ponds were initially established. More recently, information has been gathered on bird activity patterns. These data, however, have not yet been summarized (M. Taylor, East Bay Regional Park District, pers. comm.).

Although waste treatment ponds possess high wildlife potential, creation and management of this artificial wetland habitat type should be approached with caution. Depending on nutrient and other pollutant loads in these ponds, avian botulism outbreaks as well as bioaccumulation of toxic elements or compounds may occur.

Natural lakes and ponds of the Delta support nesting birds, such as mallard, American coot, and pied-billed grebe. In winter, migratory waterfowl utilize this habitat type for feeding and resting. Wildlife species characteristic of the lakes and ponds habitat type, but not found exclusively in this habitat type, are listed in Table 2-18.

Table 2-18. Characteristic Wildlife of the Lakes and Ponds Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Amphibians and Reptiles
Beaver (HM)	Pied-billed grebe (CWB)	Western toad (TA)
Muskrat (HM)	Great egret (CWB)	Pacific treefrog (TA)
	Mallard (AIE)	Bullfrog (AA)
	Canvasback (CWB)	Western pond turtle (AR)
	Scaup sp. (CWB)	Giant garter snake (TR)
	American coot (HWB)	

Key: AA-Aquatic Amphibian; AIE--Aquatic Invertebrate-eating Bird; AR--Aquatic Reptile; CWB--Carnivorous Water Associated Bird; HM--Large Herbivorous Mammal; HWB--Herbivorous Water Associated Bird; TA--Terrestrial Amphibian; TR--Terrestrial Reptile.

2.8 GRASSLAND

2.8.1 Vegetation

The grassland habitat type is dominated by annual and perennial grasses and forbs (Table 2-19). Herbaceous cover ranges from sparse to dense, and plant heights range up to 6 feet in years of moist, warm spring seasons. Plant species composition varies with annual rainfall, soil type, irrigation, and grazing practices. Common species include both natives and exotics introduced from other Mediterranean-type climates (e.g., southern Europe, Australia). Many of the natives are perennial bunchgrasses which were more abundant and widespread prior to European settlement of California (Heady 1977). The grassland habitat type intergrades with and forms the herbaceous ground cover in the oak woodland habitat type. It also intergrades with mixed chaparral and coastal scrub on soils of coarser texture or where range burning has been practiced.

Table 2-19. Characteristic Plants of the Grassland Habitat Type.

Cover Type	Common Name	Scientific Name
Annual Grassland	Wild oats	Avena fatua
	Soft chess	Bromus mollis
	Filaree	Erodium spp.
Perennial Grassland	California oatgrass	Danthonia californica
	Red fescue	Festuca rubra
	California needlegrass	Stipa lepida and S. pulchra
Irrigated Pasture	Ryegrass	Lolium spp.
	Ladino clover	Tifolium repens

The grassland habitat type occurs on coastal terraces, inland valleys, foothills, ridges, and south-facing slopes at elevations ranging from sea level to 3,000 feet. Perennial grassland typical of the moist, coastal prairie extends up to 60 miles inland; there it grades into the drier, annual grassland cover type near the inland margin of the coast live oak forest and broad-leaved evergreen forest habitat types. Irrigated pasture can occur wherever an ample water supply exists, and the terrain is generally level.

2.8.2 Characteristic Wildlife

Over 100 species of wildlife occur in the grassland habitat type, but only a few nesting bird species occur. The western meadowlark, Savannah sparrow, horned lark, and grasshopper sparrow conceal their nests in the vegetation, and the burrowing owl utilizes abandoned ground squirrel holes as nest sites. Some waterfowl, such as the mallard and cinnamon teal, nest in grasslands, where this habitat type interfaces with seasonal and permanent wetlands. In winter, grasslands provide important foraging habitat for sandhill cranes and migratory shorebirds and geese, particularly in the Delta.

Wildlife species characteristic of grasslands are not necessarily found exclusively in this habitat type (Table 2-20) (Ingles 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Mayer and Laudenslayer 1988).

Table 2-20. Characteristic Wildlife of the Grassland Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Ornate shrew (TI)	Turkey vulture (SB)	Western toad (TA)
Broad-footed mole (TI)	Black-shouldered kite (CB)	Western skink (TR)
Badger (SC)	Red-tailed hawk (CB) (SB)	Racer (TR)
Striped skunk (SC) (TI)	Northern harrier (CB)	Gopher snake (TR)
Coyote (LCM) (TI)	American kestrel (CB) (TIE)	
Calif. ground squirrel (SE) (SH)	Ring-necked pheasant (SFE) (TIE)	
Botta pocket gopher (SH)	Burrowing owl (CB) (TIE)	
Western harvest mouse (SE) (TI)	Horned lark (SFE) (TIE)	
California vole (SH)	Western meadowlark (TIE) (SFE)	
Black-tailed hare (SH)	Savannah sparrow (SFE) (TIE)	
	Grasshopper sparrow (SFE) (TIE)	

Key: CB--Carnivorous Bird; LCM--Large Carnivorous Mammal; SB--Scavenging Bird; SC--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TA--Terrestrial Amphibian; TIE--Terrestrial Insect-eating Bird; TI--Terrestrial Insectivorous Mammal; TR--Terrestrial Reptile.

In the food web of the grassland habitat, primary consumers of herbaceous vegetation include mammals, such as the black-tailed hare, Botta's pocket gopher, and California vole and phytophagus insects, such as the field cricket (Figure 2-5). Seeds are consumed by mammals, such as the California ground squirrel and western harvest mouse, and birds, such as the horned lark and Savannah sparrow. Important secondary consumers include insectivores, such as the broad-footed mole, western skink, western toad, and western meadowlark, and carnivores, such as the badger, red-tailed hawk, and gopher snake. The turkey vulture is a common scavenging bird. These, as well as other secondary consumers, also function as tertiary consumers, feeding on primary as well as secondary consumers (Jones and Stokes and Associates, Inc. 1981).

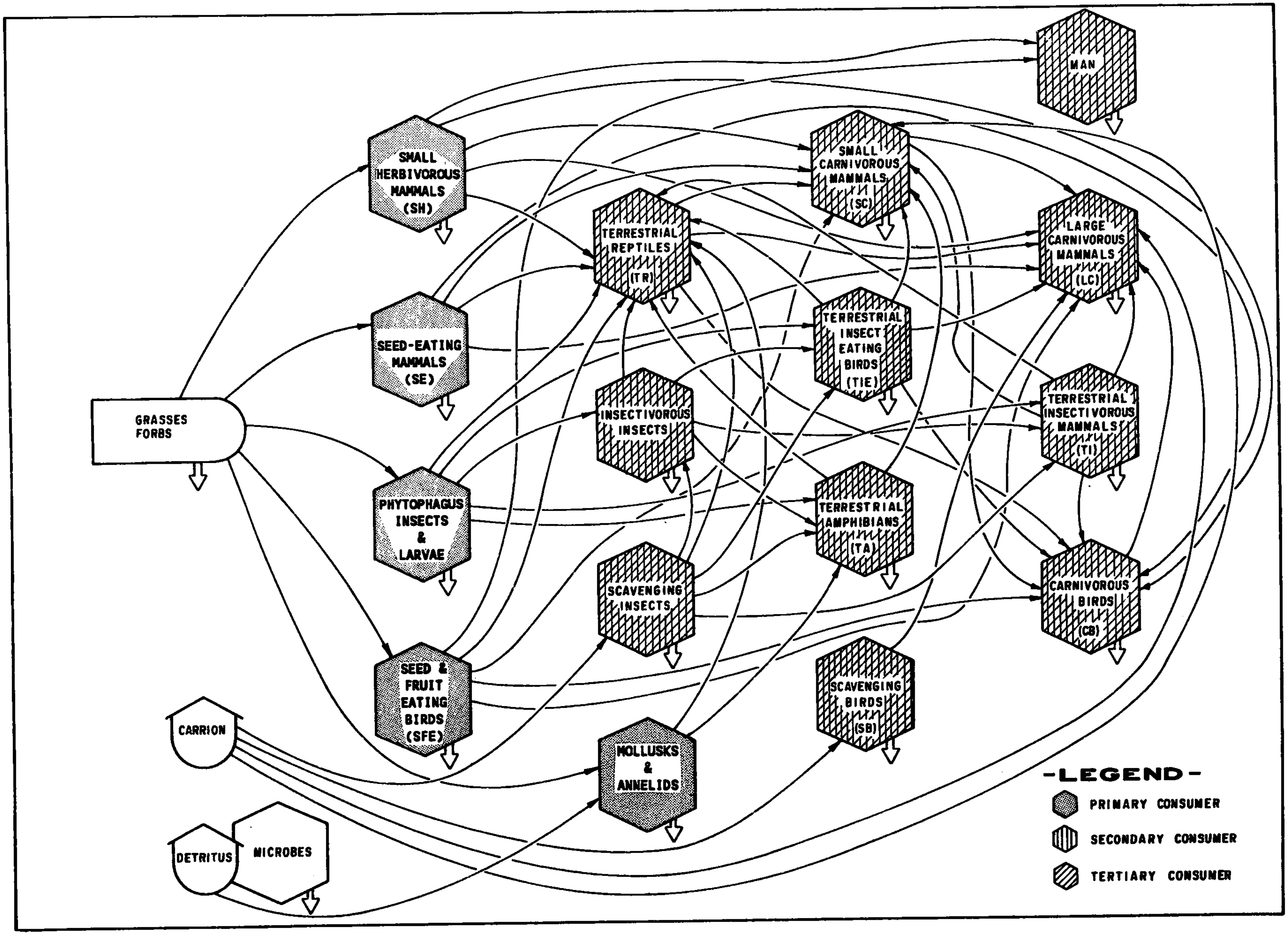

Figure 2-5. General Food Web - Grassland (Jones and Stokes Associates, Inc. 1981).

2.9 COASTAL SCRUB

2.9.1 Vegetation

Coastal scrub habitat is dominated by dense stands of low evergreen and drought-deciduous shrubs (Table 2-21), ranging in height from 2 to 6 feet. These species comprise 70-100 percent of the vegetative cover (Jones and Stokes Associates, Inc. 1981). Shrub cover is typically comprised of two layers, an upper partially open canopy of primarily coyote brush and a lower closed canopy of low shrubs, herbs, and ferns. Patches of perennial grassland habitat often occur within the coastal scrub habitat type. It also intergrades into the broad-leaved evergreen forest habitat type.

Table 2-21. Characteristic Plants of the Coastal Scrub Habitat Type.

Plant Type	Common Name	Scientific Name
Shrubs	Coyote brush	Baccharis pilularis
	Poison oak	Rhus diversiloba
	Blackberry	Rubus vitifolius
Herbs and Ferns	Sword fern	Polystichum munitum
	Cow-parsnip	Heracleum lanatum

The coastal scrub habitat type occupies coastal terraces and slopes. This habitat type typically occurs on shallow, rocky soils below 500 feet elevation, and within several miles of the coast. Fire, grazing, and landslides are important factors affecting the coastal scrub ecosystem. Although characteristic shrubs will sprout from their roots after burning, repeated burning and grazing will convert this habitat type to perennial grassland.

2.9.2 Characteristic Wildlife

Wildlife species (Table 2-22) characteristic of the coastal scrub food web are not necessarily found exclusively in this habitat type (Ingles, 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Mayer and Laudenslayer 1988). Primary consumers of shrub and herbaceous vegetation are mammals, such as the black-tailed deer, brush rabbit, and Botta's pocket gopher, and phytophagus insects, such as swift moth larvae. Seeds are consumed primarily by small mammals, such as the deer mouse, and birds, such as the white-crowned sparrow and rufous-sided towhee. Important secondary consumers in the food web include insectivores, such as the Bewick's wren, coast horned lizard, tiger salamander, vagrant shrew, and California bat, and carnivores, such as the gray fox and long-tailed weasel. These carnivores also act as scavengers. All of these secondary consumers also function as tertiary consumers, feeding on secondary as well as primary consumers.

Table 2-22. Characteristic Wildlife of the Coastal Scrub Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Vagrant shrew (TI)	American kestrel (CB) (TIE)	Western fence lizard (TR)
California bat (FI)	California quail (SFE)	Alligator lizard (TR)
Long-tailed weasel (SCM)	Allen's hummingbird (NE)	Striped racer (TR)
Coyote (LCM) (TI)	Wrentit (TIE) (SFE)	Gopher snake (TR)
Gray fox (LCM)	Bewick's wren (TIE)	
Botta's pocket gopher (SH)	Orange-crowned warbler (TIE)	
Deer mouse (SE) (TI)	Rufous-sided towhee (SFE) (TIE)	
Dusky-footed woodrat (SE) (SH)	California towhee (SFE) (TIE)	
Brush rabbit (SH)	White-crowned sparrow (SFE) (TIE)	
Black-tailed deer (LH)	Song sparrow (SFE) (TIE)	

Key: CB--Carnivorous Bird; FI--Flying Insectivorous Mammal; LCM--Large Carnivorous Mammal; LH--Large Herbivorous Mammal; NE--Nectar-eating Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed- and Fruit-eating Bird; SH--Small Herbivorous Mammal; TI--Terrestrial Insectivorous Mammal; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

2.10 MIXED CHAPARRAL

2.10.1 Vegetation

The mixed chaparral habitat type is characterized by open to dense shrubland, ranging from 30 to 100 percent shrub cover (Table 2-23). Primarily evergreen shrub species are dominant, with heights ranging from 3 to 15 feet. Vegetation of this habitat type is typically dense and impenetrable, with little or no understory of herbaceous plants or shrub seedlings.

This habitat type occurs on hills and lower mountain slopes of the Coast Range portion of the study area up to 3,000 feet in elevation, typically on steep, rocky slopes. It is also found inland and on south-facing slopes.

Table 2-23. Characteristic Plants of the Mixed Chaparral Habitat Type.

Common Name	Scientific Name
Chamise	Adenostoma fasciculatum
Wild lilacs	Ceanothus spp.
Manzanitas	Arctostaphylos spp.
Oaks	Quercus spp.
Poison oak	Rhus diversiloba)

2.10.2 Characteristic Wildlife

Wildlife species characteristic of mixed chaparral are not necessarily found exclusively in this habitat type (Table 2-24) (Sibley 1952, Ingles 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Mayer and Laudenslayer 1988).

Table 2-24. Characteristic Wildlife of the Mixed Chaparral Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Vagrant shrew (TI)	Turkey vulture (SB)	Western fence lizard (TR)
California bat (FI)	Red-tailed hawk (CB) (SB)	Coast horned lizard (TR)
Long-tailed weasel (SCM)	California quail (SFE) (TIE)	Alligator lizard (TR)
Coyote (LCM) (TI)	Anna's hummingbird (NE) (TIE)	Striped racer (TR)
Gray fox (LCM)	Wrentit (SFE)	Common kingsnake (TR)
Bobcat (LCM)	Bewick's wren (TIE)	Western rattlesnake (TR)
Sonoma chipmunk (SE)	California thrasher (SFE) (TIE)	
California pocket mouse (SE)	Rufous-sided towhee (SFE) (TIE)	
Dusky-footed woodrat (SE) (SH)	Sage sparrow (TIE) (SFE)	
Brush rabbit (SE) (SH)	White-crowned sparrow (SFE) (TIE)	
Black-tailed deer (LH)		

Key: CB--Carnivorous Bird; FI--Flying Insectivorous Mammal; LCM--Large Carnivorous Mammal; LH--Large Herbivorous Mammal; NE--Nectar-eating Bird; SB--Scavenging Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TI--Terrestrial Insectivorous Mammal; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

In the mixed chaparral food web, the primary consumers of herbaceous vegetation are mammals, such as the black-tailed deer and brush rabbit, and phytophagus insects, such as the gray hairstreak butterfly larvae. Mast (i.e., acorns, nuts, and fruits) and seed production is consumed primarily by seed gathering beetles and ants; mammals, such as the black-tailed deer and dusky-footed woodrat; and birds, such as the California quail, band-tailed pigeon, and California thrasher. Secondary and tertiary consumers in the food web include insectivores, such as the wrentit, Anna's hummingbird (also a nectivore), vagrant shrew, and California bat, and carnivores, such as the striped racer, coyote, long-tailed weasel,and red-tailed hawk. The turkey vulture is a common scavenger where chaparral habitat is more open.

2.11 OAK WOODLAND

2.11.1 Vegetation

The oak woodland habitat type (Table 2-25) is characterized by a fairly open (20-70 percent cover) tree canopy of various oak species from 25 to 75 feet tall. There is little or no understory shrub layer. The herbaceous layer is characteristic of the annual grassland habitat type.

Table 2-25. Characteristic Plants of the Oak Woodland Habitat Type.

Cover Type	Common Name	Scientific Name
Valley oak woodland/ Savannah	Valley oak	Quercus lobata
	Interior live oak	Quercus wislizenii
	Poison oak	Rhus diversiloba
	Wild oats	Avena fatua
	Ripgut brome	Bromus rigidus
	California poppy	Eschscholzia californica
	Filaree	Erodium cicutarium
Blue oak woodland	Blue oak	Quercus douglasii
	Digger pine	Pinus sabiniana
	California buckeye	Aesculus californica
	Poison oak	Rhus diversiloba
	Toyon	Heteromeles arbutifolia
	Wild oats	Avena fatua

Valley oak woodlands occur in valleys or on gentle slopes with deep alluvium. Occasionally this habitat type is found on ridgetops in the coast ranges, generally below 2,000 feet elevation. Blue oak woodlands also occur in valleys and on lower slopes of the Coast Ranges where the environment is more xeric, generally below 3,000 feet elevation. Blue oak woodland often intergrades with mixed chaparral on deeper, rocky soils.

2.11.2 Characteristic Wildlife

Wildlife species (Table 2-26) characteristic of oak woodlands are not necessarily found exclusively in this habitat type (Sibley 1952, Ingles 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Mayer and Laudenslayer 1988). In this habitat's food web the primary consumers of tree, shrub, and herbaceous vegetation include black-tailed deer; small mammals, such as Botta's pocket gopher and Audubon's cottontail; and phytophagus insects, such as the California oak moth and California sister larvae. Mast and seed production provides food for black-tailed deer; rodents, such as the western gray squirrel and California mouse; and birds, such as the acorn woodpecker and scrub jay. Important secondary and tertiary consumers include insectivores, such as the western kingbird, white-breasted nuthatch, western toad, and ornate shrew; and carnivores, such as the red-tailed hawk, gopher snake, coyote, and striped skunk. The turkey vulture is a common scavenger in the more open oak woodland savannahs.

Table 2-26. Characteristic Wildlife of the Oak Woodland Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Ornate shrew (TI)	**VALLEY OAK WOODLAND/SAVANNAH**	California tiger salamander (TA)
Hoary bat (FI)		Ensatina (TA)
Striped skunk (SCM) (TI)	Turkey vulture (SB)	California slender salamander (TA)
Coyote (LCM) (TI)	Red-tailed hawk (CB) (SB)	Arboreal salamander (TA)
Calif. ground squirrel (SE) (SH) (TI) (SCM)	American kestrel (CB) (TIE)	Western toad (TA)
	Mourning dove (SFE)	Western fence lizard (TR)
Western gray squirrel (SE)	Barn owl (CB) (TIE)	Southern alligator lizard (TR)
Botta's pocket gopher (SH)	Acorn woodpecker (SFE) (TIE)	Racer (TR)
California mouse (SE) (TI)	Western kingbird (TIE) (SFE)	Gopher snake (TR)
Audubon's cottontail (SH)	Scrub jay (SFE) (TIE) (CB) (SB)	Common kingsnake (TR)
Black-tailed deer (LH)	Loggerhead shrike (CB) (TIE) (SB)	Western rattlesnake (TR)
	BLUE OAK WOODLAND	
	Red-tailed hawk (CB) (SB)	
	California quail (SFE) (TIE)	
	Band-tailed pigeon (SFE)	
	Acorn woodpecker (SFE) (TIE)	
	Ash-throated flycatcher (TIE)	
	Yellow-billed magpie (SFE) (TIE) (CB)	
	White-breasted nuthatch (TIE) (SFE) (SB)	
	House wren (TIE)	
	Lark sparrow (SFE) (TIE)	

Key: CB--Carnivorous Bird; FI--Flying Insectivorous Mammal; LCM--Large Carnivorous Mammal; LH--Large Herbivorous Mammal; SB--Scavenging Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TA--Terrestrial Amphibian; TI--Terrestrial Insectivorous Mammal; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

2.12 BROAD-LEAVED EVERGREEN FOREST

2.12.1 Vegetation

The broad-leaved evergreen forest habitat type is typically a closed-canopy forest with a 70-100 percent overstory cover of predominantly broad-leaved evergreen trees, ranging from 30 to 120 feet tall (Table 2-27). The shrub layer is dense to absent, and the herbaceous layer ranges from sparse to absent depending upon available light and soil moisture. This habitat type often forms mosaics with the grassland, oak woodland, coastal scrub, and mixed chaparral habitat types.

Table 2-27. Characteristic Plants of the Three Vegetative Cover Types within the Broad-leaved Evergreen Forest Habitat Type.

Cover Type	Common Name	Scientific Name
Coast live oak/ canyon live oak forest	Coast live oak	Quercus agrifolia
	Canyon live oak	Quercus chrysolepsis
	Interior live oak	Quercus wislizenii
	Tanoak	Lithocarpus densiflorus
	California bay	Umbellularia californica
	Madrone	Arbutus menziesii
	Toyon	Heteromeles arbutifolia
	Poison oak	Rhus diversiloba
California bay forest	California bay	Umbellularia californica
	Poison oak	Rhus diversiloba
	Star flower	Trientalis latifolia
Mixed evergreen forest	Tanoak	Lithocarpus densiflorus
	Douglas-fir	Pseudotsuga menziesii
	Madrone	Arbutus menziesii
	Bigleaf maple	Acer macrophyllum
	Coast redwood	Sequoia sempervirens
	Hazelnut	Corylus cornuta
	Wild rose	Rosa gymnocarpa

This habitat type typically occurs on steep to very steep (25-80 percent) slopes, canyon sides, and ridges throughout the Coast Range to an elevation of 4,000 feet. Where environmental conditions are more xeric, this habitat type is found predominantly on north-facing slopes.

2.12.2 Characteristic Wildlife

Wildlife species characteristic of broad-leaved evergreen forests are not necessarily found exclusively in this habitat type (Table 2-28) (Sibley 1952, Ingles 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Mayer and Laudenslayer 1988).

Table 2-28. Characteristic Wildlife of the Broad-leaved Evergreen Forest Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Ornate shrew (TI)	**COAST LIVE OAK/CANYON LIVE OAK/**	Ensatina (TA)
Western pipistrelle (FI)	**CALIFORNIA BAY FOREST**	Ca. slender salamander (TA)
Spotted skunk (SCM) (TI)		Western toad (TA)
Coyote (LCM) (TI)	Cooper's hawk (CB)	Western fence lizard (TR)
Gray fox (LCM)	California quail (SFE) (TIE)	Western skink (TR)
Western gray squirrel (SE)	Band-tailed pigeon (SFE) (TIE)	Common king snake (TR)
Dusky-footed woodrat (SE) (SH)	Anna's hummingbird (NE) (TIE)	Common garter snake (TR)
Brush rabbit (SH)	Acorn woodpecker (SFE) (TIE)	
Black-tailed deer (LH)	Nuttall's woodpecker (TIE) (SFE)	
	Scrub jay (SFE) (TIE) (CB) (SB)	
	Common bushtit (TIE) (SFE)	
	Wrentit (SFE) (TIE)	
	Bewick's wren (SFE) (TIE)	
	Rufous-sided towhee (SFE) (TIE)	
	California towhee (SFE) (TIE)	
	Dark-eyed junco (SFE) (TIE)	
	MIXED EVERGREEN FOREST	
	Cooper's hawk (CB)	
	Pygmy owl (CB) (TIE)	
	Western flycatcher (TIE)	
	Chestnut-backed chickadee (TIE) (SFE)	
	Hermit thrush (TIE) (SFE)	
	Hutton's vireo (TIE)	
	Yellow-rumped warbler (TIE)	
	Purple finch (SFE) (TIE)	
	Black-headed grosbeak (SFE) (TIE)	

Key: CB--Carnivorous Bird; FI--Flying Insectivorous Mammal; LCM--Large Carnivorous Mammal; LH--Large Herbivorous Mammal; NE--Nectar-eating Bird; SB--Scavenging Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TA--Terrestrial Amphibian; TI--Terrestrial Insectivorous Mammal; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

In the broad-leaved evergreen forest food web, mast production of oaks, tanoaks, madrone, and California bay is utilized by a number of primary consumers. These include mammals, such as the black-tailed deer, California mouse, and dusky-footed woodrat, and birds, such as the California towhee and California quail. Tree, shrub, and herbaceous foliage provides food for herbivores, such as the black-tailed deer and brush rabbit, and phytophagus insects, such as the California laurel borer. Important secondary consumers in the food web include insectivores, such as Nuttall's woodpecker, western fence lizard, ensatina, ornate shrew, and hoary bat, and carnivores, such as the gray fox, spotted skunk, and Cooper's hawk. These secondary consumers may also function as tertiary consumers, feeding on secondary as well as primary consumers.

2.13 AGRICULTURAL LAND

2.13.1 Vegetation

The agricultural land habitat type is dominated by a wide variety of crop types including wheat, corn, hay, potatoes, and asparagus. Tree and vine crops include pears, almonds, and grapes. Plant species diversity is low as a result of herbicide usage and tillage to control unwanted vegetation.

This habitat type occurs on flat to gently rolling terrain, much of which was formerly tidal wetland. In the South San Francisco Bay area, former agricultural land has been replaced to a large extent by urban development. Large expanses of intensively farmed agricultural land still exist, however, in the San Pablo Bay area and in the Delta. In the study area as a whole, approximately three-fifths of the increase in urban land between 1975 and 1985 was due to the conversion of agricultural land (Association of Bay Area Governments 1989).

2.13.2 Characteristic Wildlife

Some species of wildlife, including ring-necked pheasants, many rodent species, and several species of migratory waterfowl, benefit from cropland. Seasonally flooded agricultural lands, primarily in the Delta, provide important wintering habitat for migratory waterfowl including white-fronted geese, mallards, and tundra swans. Unflooded fields, particularly cornfields, are also heavily utilized in winter by white-fronted geese, snow geese, and Ross' geese (Madrone Associates et al. 1980). For most other species, however, the agricultural land habitat type generally supports low wildlife diversity when compared to other wildlife habitats. Habitat value is limited by frequent disturbance, application of pesticides, and clean farming techniques. Where agricultural land lies adjacent to more valuable wildlife habitat types, such as riparian forests or seasonal wetlands, values may be increased.

Wildlife species characteristic of agricultural land (Table 2-29) are not necessarily found exclusively in this habitat type (Ingles 1965, Small

1974, Madrone Associates et al. 1980, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Mayer and Laudenslayer 1988).

Table 2-29. Characteristic Wildlife of the Agricultural Land Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Opossum (SCM) (SE) (TI)	Great egret (CWB)	Western toad (TA)
Broad-footed mole (TI)	Tundra swan (HWB)	Western fence lizard (TR)
Raccoon (SE) (SCM) (TI)	Mallard (AIE)	Gopher snake (TR)
Coyote (LCM)	Black-shouldered kite (CB)	
Calif. ground squirrel (SE) (SH) (TI) (SCM)	Swainson's hawk (CB)	
	American kestrel (CB) (TIE)	
Botta's pocket gopher (SH)	Ring-necked pheasant (SFE) (TIE)	
House mouse (SE) (TI)	Greater sandhill crane (SFE) (CB)	
Black-tailed hare (SH)	Western sandpiper (TIE)	
Black-tailed deer (LH)	Mourning dove (SFE)	
	American crow (SFE) (TIE) (SB) (CB)	
	American robin (SFE) (TIE)	
	European starling (SFE) (TIE)	
	Western meadowlark (TIE)	
	Red-winged blackbird (SFE) (TIE)	
	Brewer's blackbird (SFE) (TIE)	

Key: AIE--Aquatic Invertebrate-eating Bird; CB--Carnivorous Bird; CWB--Carnivorous Water Associated Bird; HWB--Herbivorous Water Associated Bird; LCM--Large Carnivorous Mammal; LH--Large Herbivorous Mammal; SB--Scavenging Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TA--Terrestrial Amphibian; TI--Terrestrial Insectivorous Mammal; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

In the agricultural food web, primary consumers of tree, vine, and herbaceous vegetation include mammals, such as the black-tailed deer and Botta's pocket gopher, and numerous phytophagus insects, such as the grasshopper and cabbage butterfly. Seeds and fruits are consumed by mammals, such as the California ground squirrel and house mouse, and birds, such as the ring-necked pheasant and mourning dove. Important secondary and tertiary consumers include insectivores, such as the broad-footed mole, western toad, and Brewer's blackbird, and carnivores, such as the coyote and gopher snake. The common crow is an example of a scavenging bird. The raccoon is an omnivore, consuming seeds, fruits, insects, small mammals, reptiles, and amphibians.

2.14 URBAN

2.14.1 Vegetation

The urban habitat type is dominated by a wide variety of annual and perennial grasses, forbs, shrubs, and trees, both exotic and native. Plant species composition varies with planting design, climate, and maintenance practices. This habitat type is found adjacent to all other terrestrial habitat types in the estuary study area. It is the most common habitat type in the study area and is projected to increase in the future, primarily at the expense of agricultural land (Association of Bay Area Governments 1989).

2.14.2 Characteristic Wildlife

Mayer and Laudenslayer (1988) distinguish three categories of urban habitat for wildlife: downtown, urban residential, and suburbia. Species diversity and richness are extremely low in downtown urban areas because of high density development and minimal vegetation. Rock doves, house sparrows, and European starlings are often the only bird species present. As vegetative cover increases and development decreases in urban residential areas and suburbia, species diversity increases. Where urban habitat lies adjacent to other wildlife habitat, both species diversity and the number of native species increase.

Wildlife species characteristic of the urban environment are not necessarily found exclusively in this habitat type (Table 2-30) (Ingles 1965, Small 1974, Jones and Stokes Associates, Inc. 1981, Stebbins 1985, Mayer and Laudenslayer 1988).

Table 2-30. Characteristic Wildlife of the Urban Habitat Type (Key to trophic level abbreviations given below).

Mammals	Birds	Reptiles and Amphibians
Raccoon (SE) (SCM) (TI)	Rock dove (SFE)	California slender salamander (TA)
Striped skunk (SCM) (TI)	Mourning dove (SFE)	Western toad (TA)
Botta's pocket gopher (SH)	Anna's hummingbird (NE) (TIE)	Pacific treefrog (TA)
Norway rat (SE) (SCM) (TI)	Scrub jay (SFE) (TIE) (CB) (SB)	Western fence lizard (TR)
House mouse (SE)	Mockingbird (SFE) (TIE)	Alligator lizard (TR)
	American robin (SFE) (TIE)	Gopher snake (TR)
	European Starling (SFE) (TIE)	
	House sparrow (SFE) (TIE)	
	House finch (SFE) (TIE)	
	White-crowned sparrow (SFE)	

Key: CB--Carnivorous Bird; NE--Nectar-eating Bird; SB--Scavenging Bird; SCM--Small Carnivorous Mammal; SE--Seed-eating Mammal; SFE--Seed and Fruit-eating Bird; SH--Small Herbivorous Mammal; TA--Terrestrial Amphibian; TI--Terrestrial Insectivorous Mammal; TIE--Terrestrial Insect-eating Bird; TR--Terrestrial Reptile.

In the urban environment, where native vegetation has often been replaced by ornamental, exotic plants, the resulting food web is less complex and is dominated by species that have adapted to the human environment (Figure 2-6).

Primary consumers of tree, shrub, and herbaceous vegetation are mostly phytophagus insects and their larvae. Seeds and fruits are consumed by mammals, such as the raccoon and house mouse, and birds, such as the house finch, house sparrow, and rock dove. Important secondary and tertiary consumers include the Norway rat, western toad, Anna's hummingbird (also a primary consumer), and mockingbird, which consume insects as all or part of their diet, and species, such as the gopher snake and striped skunk, which are primarily carnivores. The scrub jay is a common scavenging bird and also a good example of an omnivorous species.

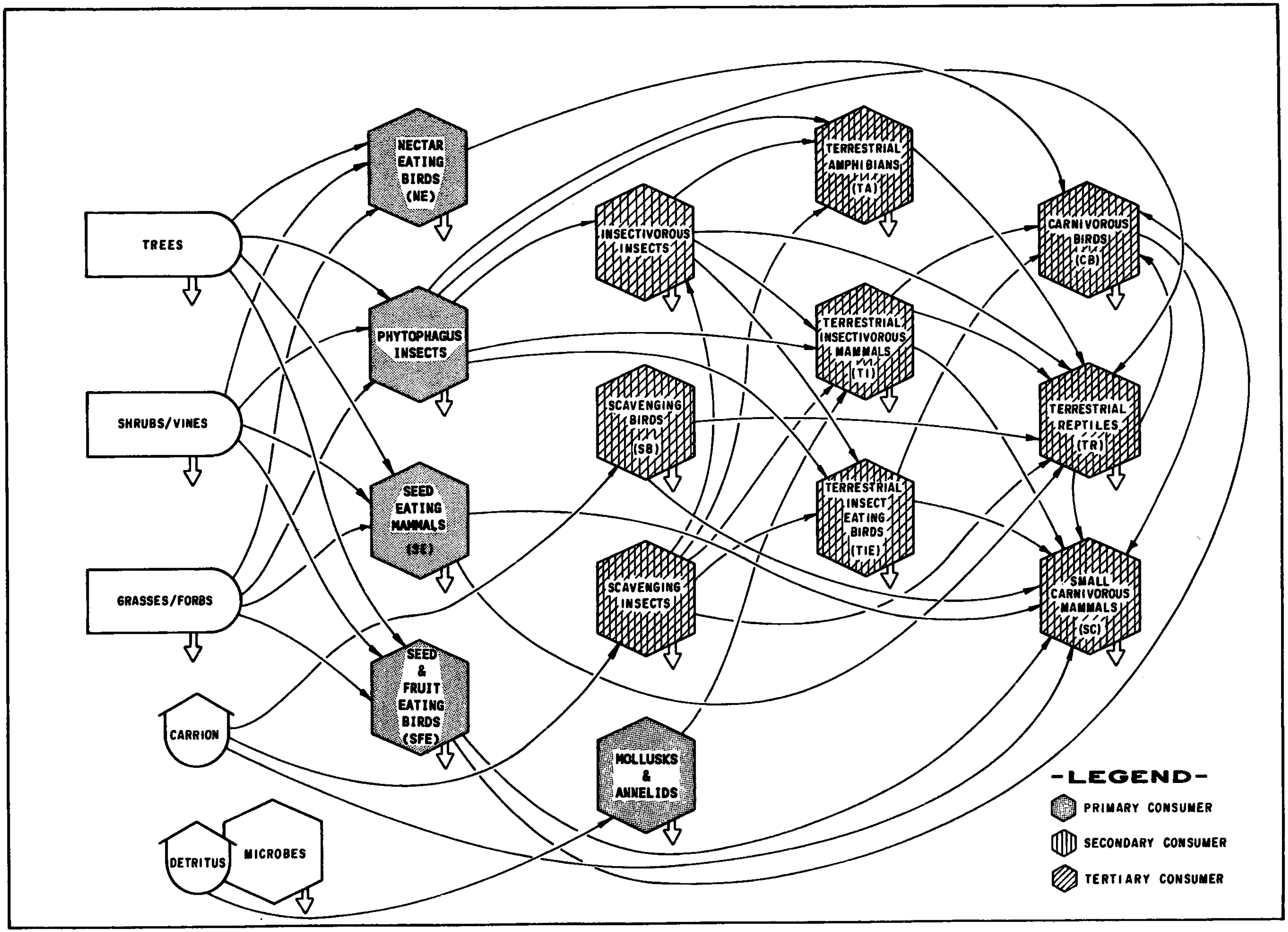

Figure 2-6. General Food Web - Urban (Jones and Stokes Associates, Inc. 1981).

CHAPTER 3
HISTORIC DISTRIBUTION AND ABUNDANCE OF WILDLIFE POPULATIONS

3.1 HISTORIC HABITATS AND THEIR DISTRIBUTION

3.1.1 Wetlands

Historical observations of habitat conditions and wildlife in the San Francisco Bay Area and Sacramento-San Joaquin Delta were initially recorded by Spanish explorers and missionaries when they arrived in 1769 and later by trappers, naturalists, and cartographers during the first half of the nineteenth century. Surveys beginning in the 1850s described the Estuary as supporting a vast complex of tidal salt, brackish, and freshwater marshes and riparian woodlands. An estimated 313 square miles of tidal marsh was believed to border San Francisco, San Pablo, and Suisun bays (Nichols and Wright 1971), with the Delta supporting an additional 540 square miles of tidally influenced freshwater emergent marsh (Atwater et al. 1979). The open water areas of the Bay encompassed a total area of approximately 476 square miles (Nichols and Wright 1971).

Within the South Bay region, these marshes formed a nearly continuous corridor from the vicinity of San Mateo on the west to San Leandro on the east, ranging from 0.25 to over 4.0 miles in width. High marsh transition zones graded into adjacent upland habitats around the margins of the Bay. In these high marsh zones, hypersaline conditions supported unique communities in some areas. For example, low berms at the bayward margin of the marsh near Hayward formed natural salt ponds which received Bay waters only during particularly high tides and precipitated salt in the summer.

Moving upstream on the major creeks and numerous small streams draining into the Bay, salt marsh gave way to brackish vegetation and then corridors of riparian shrub and woodlands comprised of willows and cottonwoods. Significant flows from many of these creeks probably occurred only seasonally. Moreover, some creeks had no clearly recognizable mouths but rather meandered onto the plains adjacent to the Bay forming perennial and intermittent watercourses supporting freshwater and brackish seasonal wetlands.

Brackish tidal marshes were more predominant in San Pablo and Suisun bays due to the freshwater influences of the Delta, local rivers, and creeks. In the Napa Marsh on the north shore of San Pablo Bay, about 94 square miles of tidal marsh existed historically, extending several miles northward up the Sonoma and Napa valleys (Dedrick 1989). Tidal wetlands also extended about 13 miles upstream along the Petaluma River. The brackish tidal marshes of Suisun Marsh encompassed about 111 square miles from Benicia eastward to Collinsville (Dedrick 1989).

The estimated 500-540 square miles of tidal marshes found in the historic Sacramento-San Joaquin Delta, translated into about three-fifths of the total Delta area being awash during ordinary tides (Atwater et al. 1979, Thompson 1957). The majority of this marsh occurred in the western and southern Delta. In the southern Delta, the natural alluvial levees, which were formed by deposition of sediments along river and slough channels, attained relatively lower elevations (Atwater et al. 1979). This accounted for the more extensive, regularly inundated tidal marsh in that region. Flooding in the north Delta probably occurred only as high river flows inundated adjacent lowlands by overtopping these levied channels. The lower San Joaquin Delta probably supported large scattered tracts of tules interspersed with perennial grassland and valley oak savannah. Flooding of the Delta was frequent. In the spring, virtually all the area became a vast inland lake, covered by river runoff which was often impeded by high tides from San Francisco Bay (Madrone Associates et al. 1980).

Historical accounts of early Delta explorers are replete with references to the luxuriant, dense stands of riparian forest supporting trees of immense size. An estimated 1,200 to 1,500 square miles of riparian forest was believed to have existed in the region. The forest was most extensive on the higher alluvial mineral soils of the Sacramento, Cosumnes, Mokelumne, and San Joaquin rivers historic floodplains, around the periphery of the Delta (Madrone Associates et al. 1980). Along channels of the western and central Delta, the monotypic tules were occasionally interrupted by channel or pond surfaces and intermittent strips of higher alluvial soil supporting woody shrubs and trees. Continuous stands of large valley oaks, cottonwoods, sycamores, white alders, and willows did not occur until upstream of upper Brannan Island in the north and upper Union and Roberts islands towards Stockton (Thompson 1957).

3.1.2 Uplands

Compared to wetland habitats, historic descriptions of upland habitats in the Estuary study area are less well documented. Upland habitats immediately adjacent to the tidal marshes of San Francisco, San Pablo, and Suisun bays probably consisted originally of perennial bunchgrass prairies, coastal scrub, and valley oak woodland/savannah. Cooper (1926) described the alluvial fans in the Palo Alto area as originally supporting "a continuous belt of oak forest." Captain George Vancouver likened this same area in 1798 to a well kept park planted with huge oaks (Vancouver 1798 in Rossi 1979). Broeck (1932 in Rossi 1979) described the Santa Clara Valley as "a grassland dotted with evergreen oaks...". In the Delta at about the 100-year flood line, riparian forest graded into valley oak savannah and broad reaches of perennial grasslands interspersed with vernal pools (Warner and Hendrix 1985).

The northwest/southeast-oriented valleys and hills, in the San Francisco Bay watershed, historically supported a mixture of coastal scrub, chaparral, oak woodland, and broad-leaved evergreen forest. In the hills east of Central San Francisco Bay, a seven-square mile coastal redwood forest supported a thriving timber harvest from about 1840 to 1860. Trees with diameters approaching 30 feet and of such heights as to serve as navigational landmarks to mariners were recorded in historical accounts of this area (Monteagle 1976).

3.2 HISTORIC WILDLIFE POPULATIONS

3.2.1 Introduction

In general, numerous anecdotes and little quantitative information was provided in historical accounts by explorers, trappers, and naturalists describing wildlife in the San Francisco Estuary. They frequently referred to the impressive diversity and abundance of fish and wildlife. Vast multitudes of waterfowl "darkening the surfaces of bays" and white geese giving the ground the appearance of being covered with snow are recounted. Heerman in the 1850s described how native Americans sometimes hunted geese on horseback by clubbing and trampling while charging flocks. Dawson (1923) described how native Americans hunted diving ducks on San Francisco Bay at night by lighting a fire on the bows of their canoes, allowing clubbing and spearing of birds. A chronicle written by George C. Yount describes deer, elk, and antelope in herds of hundreds near Benicia. Similar accounts by Richard H. Dana and Joseph W. Revere in the 1830s and 1840s refer to elk and deer herds numbering as many as 400 animals in Marin and Sonoma counties (Skinner 1962, Harper et al. 1967). Descriptions also exist of the abundance of grizzly bear, furbearers, and other mammals, as well as impressive runs of salmon through the Carquinez Straits. The 30,000 native Americans believed to have originally inhabited the Delta attest to the abundance of animal food sources occurring in the region (Madrone Associates et al. 1980). Clearly the rich diversity of marine, estuarine, freshwater, and upland habitats of the Estuary created an ideal setting for a host of fish and wildlife species.

3.2.2 Birds

The hundreds of thousands of acres of tidal and freshwater marshes, overflow lands, and waterways historically existing in the Central Valley and San Francisco Bay had long served as a wintering and migratory haven for the major share of the waterfowl of the Pacific Flyway. Dawson (1923) believed the Central Valley may have historically supported tens of millions of white and white-fronted geese in winter. Moreover, he estimated that duck populations, in general, were probably 40 times more abundant historically than numbers encountered during the 1920s. Undoubtedly, the Delta and the more brackish marshes of the Bay also supported tens of thousands of nesting dabbling ducks. Skinner (1962) cited the vast tidal and freshwater marshlands of San Pablo and Suisun bays and the west and east shores of South San Francisco Bay, such as near Alvarado in Hayward, as heavily used by historic duck and goose populations. The Santa Clara Valley also supported valuable waterfowl habitat prior to conversion to agriculture. Excellent waterfowl hunting led to the growth of "Drawbridge," a town along the Southern Pacific Railroad line in the South Bay. Drawbridge became a resort solely for duck hunters arriving from San Francisco by regular trains in the 1880s.

Changes in the occurrence of several waterfowl species which are now less widely distributed in the Estuary, attest to the contrast between past and present conditions. For example, brant were considered an abundant visitor to San Francisco Bay in winter, and trumpeter swans were seen regularly throughout the Central Valley (Grinnell et al. 1918). Tundra swans were also considered regular winter visitors in Suisun Marsh and in Sonoma, San Francisco, and San Mateo counties (Grinnell et al. 1918, Grinnell and Wythe 1927, Sibley 1952). Canada geese were common winter visitors to the tidal marshes of San Pablo Bay, San Francisco and San Mateo counties (Grinnell and Wythe 1927). As a reflection of the original extent of riparian habitat, wood ducks were considered abundant prior to 1870. They nested on creeks in Sonoma, Marin, Napa, San Mateo, and Alameda counties (Grinnell and Wythe 1927).

In contrast to their current less common status, numerous other species associated with permanent lakes and ponds, freshwater and tidal marshes, riparian woodlands, and grasslands around the Estuary Region, were abundant during historic times. These included white pelican, American bittern, white-faced ibis, black tern, long-eared owl, short-eared owl, and tricolored blackbird. Many of these species presumably were common breeders. Dawson (1923) also mentions California gulls as formerly breeding in the Sacramento River. Long-billed curlews, mountain plovers, and sandhill cranes wintered in seasonally flooded areas and grasslands adjacent to the Estuary. Lesser sandhill cranes evidently wintered commonly near San Rafael and San Francisco in the 1840s (Grinnell and Miller 1944) and near San Bruno in the 1820s (California Historical Society 1929). Mountain plovers were reported as rare winter visitants in the vicinity of Oakland during the late 1800s (Grinnell et al. 1918). Gill (1979) inferred from historic newspaper accounts of hunting results in the late 1800s that thousands of clapper rails probably inhabited the South Bay tidal marshes alone.

In Central San Francisco Bay, rocky islands such as Alcatraz, Angel Island, Yerba Buena, Brooks Island, and Red Rock probably supported significant numbers of an array of nesting seabird species. These may have included double-crested, Brandt's, and pelagic cormorants, western gull, pigeon guillemot, and black oystercatcher. Beechey (1831) noted in 1826 that Alcatraz was covered with the guano of pelicans which roosted upon the island. Grinnell and Wythe (1927) described the marbled murrelet as occasionally seen in limited numbers on San Francisco Bay. This leads to speculation that murrelets may have historically nested within the study area, given the extensive coniferous stands occurring originally in Contra Costa, Alameda, Marin, San Mateo, and Santa Clara counties.

The historical distribution of several raptor species also contrasts greatly with current conditions. For example, early naturalists encountered osprey nesting along both the Sacramento and San Joaquin rivers (Grinnell and Miller 1944). Bald eagles were common both along the coast and throughout the Central Valley and were reported nesting in the vicinity of Sacramento in 1849 (Detrich 1986). In the 1860s, they nested in Santa Clara County and in the 1900s near La Honda (San Mateo County). They were also commonly observed foraging along the Bay shore of those counties (Grinnell and Wythe 1927, Detrich 1986). In addition, Detrich (1986) suspected the species may have historically nested at other sites adjacent to the Bay in San Mateo or Marin counties and at Clear Lake (Lake County). Peregrine falcons were reported nesting in San Mateo and Santa Clara counties and on the cliffs of Mt. Diablo (Grinnell and Wythe 1927). California condors were commonly observed on the San Francisco Peninsula and in the South Bay Area, often in association with turkey vultures. In San Mateo County, it was estimated that condors occurred at a ratio of 1:20 with turkey vultures around 1870 (Sibley 1952). An amateur ornithologist, J.P. Lamson, who lived among the East Bay redwood forests during 1853-1855, reported seeing condors commonly. He mentioned seeing more than 50 individuals during a single hour (Monteagle 1976).

3.2.3 Mammals

In terms of the historic distribution and abundance of mammals in the San Francisco Estuary, several fur-bearing and big game species deserve special discussion. At the time of European discovery, sea otters were particularly abundant in the Bay and around the Farallon Islands (Skinner 1962). In the Bay, they typically occurred at the numerous creek and river mouths in Napa, Sonoma, San Mateo, Santa Clara and Alameda counties (Ogden 1941 <u>in</u> Association of Bay Area Governments 1989). As a result, San Francisco Bay was one of the areas most frequented by Spanish, French, Russian, and American otter hunters. Skinner (1962) cites a perhaps exaggerated manuscript from General Vallejo reporting that otters in the Bay "were so abundant in 1812, they were killed by boatmen with their oars in passing through the kelp." Based on excavations of midden sites adjacent to the South Bay, the sea otter was the most common mammal hunted by local native Americans (Bickel 1981, Leventhal 1991).

Accounts of early fur trappers described a large population of golden beavers occurring throughout the lower drainages of the Central Valley and Delta. The mouths of the Sacramento and San Joaquin rivers were cited in particular by Farnham in 1840 as supporting a concentration of beaver with "no spot of equal in all North America." Trappers reported that, in the tule-dominated lower Delta, beaver houses were frequently constructed completely of emergent vegetation. Animals were also described as being larger than other beaver the trappers had previously encountered. Weights typically ranged from 50 to 60 pounds, with the largest individual on record being 82 pounds. The latter was taken from the Merced River in 1895 (Grinnell et al. 1937). The Delta also supported large numbers of other furbearers such as river otter, bobcat, raccoon, mink, and skunk.

Due to its abundance, size, and lack of fear, the California grizzly bear was one of the most frequently mentioned large mammals in historic accounts. Early settlers reported viewing anywhere from 9 to 40 individuals at once from the same observation point and commonly encountering groups of up to 20. Viewing grizzlies near present day Antioch was described by early settlers as a daily, almost hourly, experience (Thompson 1957). Bears were also described as common in the Woodside area (San Mateo County) where they were roped, taken to the docks at Redwood City and butchered for their meat (Grinnell et al. 1937). They were most abundant in the Central Valley in tule marshes and dense stands of willows and cottonwoods, and in coast range chaparral (Jameson and Peeters 1988).

Grinnell et al (1937) described two subspecies of grizzly that reportedly occurred in the Bay Area and Delta. These were the coastal grizzly, which ranged from the Bay south to San Luis Obispo, and the Sacramento grizzly, found in the Central Valley west to the inner coast range. In the 1850s, Xantu described the bear as generally nocturnal, frequenting dense stands of brush during the day. He said they would excavate large areas (several acres in a night) to "remarkable depths" searching for rodents, badgers, roots and grubs as well as traveling significant distances for berries and beehives (Grinnell et al. 1937). Grizzlies in the Bay and Delta region probably excluded black bears from the area.

Herds of thousands of elk, pronghorn and deer once roamed the grasslands, marshes, and other habitats of the San Francisco Estuary. The tule elk (Cervus canadensis nannodes) ranged throughout much of the Central Valley and west to the coast. The Portola expedition in 1769 reported elk as abundant in the Santa Cruz Mountains, around the Bay on the San Francisco Peninsula, on the East Bay "flats", and on some Bay islands (Harper et al. 1967). Prior to European settlement, the historic tule elk population in the entire state may have numbered 500,000 individuals (McCullough 1971 in Jones and Stokes Associates, Inc. 1987). Mingling and intergrading with tule elk were Roosevelt elk (C. c. roosevelti) which originally ranged from Marin, Sonoma, Napa and Solano counties north through the coast range to the Oregon border (Harper et al. 1967). Herds of up to a thousand individuals were reported adjacent to the Bay and Delta in early accounts (Davis 1929 in Vincent 1990, Thompson 1957). Black-tailed deer were mentioned by early Spanish explorers as common in the San Francisco Bay Area and an important source of food and clothing to the original inhabitants (Skinner 1962).

The pronghorn antelope was historically present in the northeastern part of the State and in the Central Valley south through the Mojave Desert to the Mexican border. Antelope densities in the San Joaquin Valley were reported to be greater than in any area elsewhere in North America (California Department of Fish and Game 1990b). Accounts from early explorers indicate that they inhabited much of the grasslands, oak, and riparian woodlands and chaparral vegetation of Santa Clara, Alameda, Contra Costa, Sonoma, Napa, and Solano counties. The historic pronghorn population for the entire state has been estimated at perhaps 500,000 individuals (Pyshora 1981 in Jones and Stokes Associates, Inc. 1987).

The historic status of the gray wolf in the study area is unclear, due to the inability of early observers to distinguish between this species and coyotes. Also, there are no specimens from the study area in collections. Grinnell et al. (1937) believed the original distribution of the subspecies Canis lupus fuscus, which has been verified for northeastern and north central California, may have coincided with that of the Roosevelt elk.

Aside from the sea otter, the historical distribution of marine mammals in San Francisco Bay is less well documented. Two pinnipeds, the harbor seal and California sea lion, were described as extremely numerous in the Bay. Harbor seals hauled out and pupped in extensive rookeries in the South Bay (Skinner 1962). The harbor porpoise was common and frequently observed in the vicinity of Pt. San Pablo and Alcatraz Island; the Dall's porpoise (Phocoenoides dalli) was also an occasional to regular visitor to the Central Bay (Benson and Goody 1942, Yocum 1946). Skinner (1962) also reported a killer whale being taken as far inland as Benicia. Use of beached gray whale remains by native Americans adjacent to the Bay has been documented; however, the historic status of this species in the Bay is unclear. The obvious similarities between gray whale calving grounds in Baja California and the shallow, sheltered tributaries of the Bay has led to speculation that calving may have occurred at one time.

An additional impression of historic wildlife communities found in the San Francisco Bay Region is available from excavations of native American middens located adjacent to the Bay. Excavations of sites at Coyote Hills Regional Park in Fremont, representing the period 400 BC to 400 AD, have revealed an array of mammal, bird, and fish remains (Bickel 1981, Leventhal 1991). Considering their size and frequency of occurrence in the excavations, mammals furnished most of the meat for the inhabitants of the midden sites. Some of the most frequently encountered mammals, in decreasing order of abundance were sea otter, mule deer, canines, elk, pronghorn antelope, harbor seal, rabbit, raccoon, skunk, squirrel, and badger. Sea otter and mule deer comprised 62 percent of the total animals identified, attesting to their proximity, abundance, and ease of killing by local residents. Mule deer were probably the most important food species (A. Leventhal, San Jose State University, pers. comm.).

The most numerous birds identified from these excavations, in descending order included snow goose and Ross'goose, canvasback, green-winged teal, Canada goose, northern pintail, American wigeon, northern shoveler, ring-necked duck, marbled godwit, mallard, wood duck, surf scoter, Brandt's cormorant, and western gull. Geese and wintering ducks comprised 90 percent of the total birds identified, indicating waterfowl were most relied upon from September through April. The high occurrence of geese and dabbling ducks attest to the rich diversity of brackish and freshwater marshes, which must have originally existed in the Fremont area adjacent to the Bay. Wing bones of several larger species such as great blue heron, brown pelican, and tundra swan that had been fashioned into whistles were also recorded. California condor bones have been found in ceremonial associations (shaman kit) from these midden sites (Davis and Treganza 1959).

3.3 EARLY CAUSES OF CHANGES IN HISTORIC WILDLIFE POPULATIONS

3.3.1 Fur Trade

The first significant human impact on wildlife in the Estuary Region began with the harvesting of fur-bearing mammals. Commercial hunting of sea otters began in California in 1786 under the Spanish and soon expanded to include traders of many nationalities. Aleutian Islanders hunted otters with spears and clubs from canoes, and later Americans and Europeans hunted with guns. Otters were so numerous in the Bay that as many as 1,200 animals were taken during "some months" by Russian trappers in 1811 (Grinnell et al. 1937). One source states that Russians took 700 to 800 pelts in a single week in 1812. In a period of five years, 50,000 otters were taken from the Bay; thereafter, 5,000 a year were taken until 1831 (California Department of Fish and Game 1971). By 1820, over-hunting had caused a noticeable decline in otter abundance. Nevertheless, during a day-long hunting expedition in 1830 at a haul-out site at Point San Quentin, 30 out of a total of 100 otters were captured with lassos and killed. One day's shooting at the mouth of Sonoma Creek in 1846 yielded 42 otter pelts (Grinnell et al. 1937). After 1850, otters were extremely rare in the Bay Area.

Hunting of sea lions and harbor seals for oil and hides also occurred in the Bay and along the outer coast. Harvest of sea lions in the Bay probably continued until the 1870s after their numbers declined along the California coast. Harbor seals were hunted until about 1890 (Skinner 1962).

About the time of the first declines in the coastal fur trade, harvest of inland furbearers began with the arrival in the Central Valley, of American and British beaver trappers. Profitable trapping of beavers lasted about 20 years until 1845. During this period, Hudson Bay Company trappers took 4,000 beaver skins near the mouths of the Sacramento and San Joaquin rivers. In 1828, trappers with Jedediah Smith reported catching 20 beavers using 28 traps at the confluence of the Sacramento and Feather rivers (Grinnell et al. 1937). As numbers of beaver were reduced and with the discovery of gold, trappers soon turned to other pursuits.

3.3.2 Market Hunting and Other Activities

Following the gold rush, an expanding human population required meat in the form of wild game, which was an important staple. With large bore guns and animal blinds, waterfowl and other waterbirds were literally shot by the millions for sport and market. Market hunters shooting ducks rafting on the Bay, utilized 2 or 3-inch bore diameter, muzzle-loading swivel guns mounted on small boats. Ducks and geese feeding in fields were taken by "bull hunters" who used a trained cow or horse as a blind to bunch birds together until they could be slaughtered with large bore guns (Monteagle 1978). Using a horse as a blind, a single hunter killed 200 snow geese in 1910 near Los Banos (Miller and Hanson 1989). Grinnell et al. (1918) reported that three hunters killed 400 ducks from animal blinds with six shots from four-gauge guns; also, a single hunter in the "Sonoma marshes" killed 268 drake canvasbacks in one day. Cuneo (1987) cites a report of a South Bay landowner personally shooting 6,500 geese and 1,700 ducks during the winter of 1855. As late as 1913-1914, about 1,000 ducks a week were being taken at the Alvarado marshes (Skinner 1962).

As a result, waterfowl became the major trade commodity of the five game transfer companies in San Francisco which sold birds primarily to restaurants and hotels (Skinner 1962). In 1900, the San Francisco markets were handling a minimum of 250,000 ducks per year. Monteagle (1978) described a 1912 editorial in Western Field which estimated that of 15,000 ducks shipped to San Francisco markets in the first week of the season, more than half spoiled.

As shown in Table 3-1, a variety of species were impacted by market hunting in California. Skinner (1962) believed the kill for small local markets and by private individuals for sport and table use far exceeded the numbers reaching the San Francisco and Los Angeles markets. As early as 1883, declines in waterfowl numbers attributable to overhunting were reported (Grinnell et al. 1918). Public concern regarding market hunting activities and the plight of waterfowl finally resulted in a legislative ban on the sale of waterfowl in 1915.

Table 3-1. Waterbirds Sold in California Markets in the 1895-1896 Season (Source: Grinnell et al. 1918).

Species	Number Sold	Market
Mallard	47,565	San Francisco
Gadwall	671	San Francisco
American Wigeon	>52,000	San Francisco
Green-winged Teal	>182,000	San Francisco
Sandhill Crane	38	San Francisco
Whistling Swan	518	Los Angeles
Canada Goose	2,411	Los Angeles
White-fronted Goose	19,419	Los Angeles
Snow Goose	10,251	Los Angeles

Grinnell et al. (1918) estimated that both waterfowl and upland game birds had on the average decreased by about one-half during the forty-year period prior to 1918. They cited excessive hunting and sale of game, as well as wetland reclamation (discussed later in this chapter) as major factors in this precipitous decline. Dawson (1923) believed that numbers of ducks present at that time generally represented only about 3 percent of "former numbers."

Shorebirds were also shot and sold commercially during the period of market hunting from 1850 to 1914, and several species were clearly affected (Grinnell et al. 1918). Species sought most heavily and commonly offered in the San Francisco and Stockton markets were American avocets, willets, marbled godwits, curlews, black-bellied plovers, dowitchers, and snipe, but stilts and sandpipers were also taken (Grinnell et al. 1918). By 1900-1910, hunting is believed to have severely reduced numbers of curlew and to have moderately reduced avocet, godwit, and dowitcher numbers in California (Grinnell et al. 1918). Willets and black-bellied plovers were less affected, and stilts and small sandpipers very little affected by the hunting. Annual numbers of shorebirds taken from the San Francisco Bay Estuary were likely in the tens of thousands. Skinner (1962) reported over 12,000 shorebirds sold in the San Francisco market during the 1895-96 season. According to Grinnell and Miller (1944), the godwit returned to its former numbers after the cessation of hunting, but the curlew did not. Whether there was a lasting effect on other species is not known.

Other species impacted by commercial hunting included: bittern, rails, quail, dove, and pigeon. In the 1895-96 season, Bay Area counties accounted for 15,326 quail offered in California game markets (Skinner 1962). Gill (1979) cited a report from a San Mateo newspaper in which at least 5,000 "rails" were reported as being killed during a single week in 1897 in the South Bay. It was not uncommon for hunters to take 200 clapper rails, a highly prized table bird, in one day's hunting (Grinnell et al. 1918). By the early 1900s, market hunting was believed responsible for a reduction in numbers and distribution of clapper rails in the Bay. In 1903, the San Mateo County Board of Supervisors passed an ordinance prohibiting the hunting of rails from boats from one hour before to one hour after high tide (Redwood City Times Gazette 1903).

Shooting by plume hunters of great and snowy egrets, both of which were historically abundant nesting species prior to 1880, decimated their numbers in California. Most of this hunting pressure occurred during the early 1900s (Dawson 1923). Due to this unregulated harvest, snowy egrets were believed extirpated from California by 1900, and not a single great egret was reported in the South Bay Area between 1880 and 1928 (Sibley 1952). By 1908, snowy egrets began to be observed again, primarily in the Central Valley. Great egrets were still considered scarce and irregular in the Bay in the early 1920s but then steadily increased in numbers.

Market hunting, human encroachment and agriculture contributed to the depletion or extirpation of many big game species such as elk, pronghorn antelope, mule deer, and grizzly bear. Roosevelt elk were hunted heavily during the Gold Rush for their meat and hides and extirpated from Marin and Sonoma counties during the 1870s (Harper et al. 1967). Tule elk and pronghorn supported a flourishing trade for meat, hides, and tallow in Stockton until populations were greatly reduced by about 1850 (Skinner 1962). By 1870, tule elk numbered as few as two individuals and only remnant bands of antelope remained in the Central Valley (Jones and Stokes Associates, Inc. 1987, Thompson 1957). A few elk were still believed to occupy unreclaimed islands in the Delta as late as 1874 (Thompson 1957). A statewide census of pronghorn antelope in 1924 revealed a total population of 1,007 animals (Ferrel and Leach 1952).

Market hunting and unrestricted subsistence hunting reduced deer populations during the second half of the nineteenth century (Fowler 1989). Between 1850 and 1903, one of the largest meat and hide camps in California, primarily for deer, was operated in Gilroy (Schauss 1984).

Early market hunters, ranchers, miners, and other pioneers slaughtered grizzlies at every opportunity for sport and to prevent livestock depredation; one account reported a single grizzly killing 200 sheep in one night. A perpetual bounty of 500 dollars was placed on the species (Grinnell et al. 1937). Unrestricted hunting of their prey species and degradation of fisheries habitat also impacted the bear's food sources. The population declined dramatically in the late 1800s and was extremely reduced by 1900. The last bear on the San Francisco Peninsula was killed in 1886 west of Ben Lomond (Santa Cruz County) (Grinnell et al. 1937).

Prior to the turn of the century, there was extensive commercial exploitation for food of native frogs, particularly the California red-legged frog. Between 1880 and 1900, 50,000-125,000 frogs per year were harvested from the San Francisco Bay Region and the San Joaquin Valley. By 1900, populations were tremendously reduced (Jennings and Hayes 1985).

3.3.3 Habitat Loss and Alteration

The Gold Rush of 1849 and subsequent statehood in 1850 marked the beginning of the alteration and loss of wildlife habitats in the Bay Area and Delta. Major changes resulted from factors such as hydraulic mining, reclamation of tidal habitats, agricultural and urban development, introduced plants and animals, and pesticide use.

Between 1853 and 1884 gold miners washed vast quantities of sediment into Sierran streams through hydraulic mining. Gilbert (1917) estimated the amount of mining sediment deposited in the Bay and Delta through 1909 totalled 1.15 billion cubic yards or nearly eight times the volume moved in making the Panama Canal. Bottom elevations of Delta waterways were raised by as much as 15 feet. By smothering anadromous fish spawning streams, this material reduced food availability for many wildlife species. Hydraulic mining sediment also caused a reduction in open water areas, the shoaling of subtidal areas in San Pablo and Suisun bays, and the rapid horizontal expansion of marshlands across mudflats of northern Suisun Bay, western San Pablo Bay, and possibly South San Francisco Bay (Atwater et al. 1979, Nichols et al. 1986). Gilbert (1917) estimated that during a 41-year period the average deposition on shoals in Suisun and San Pablo bays, was 3.3 feet and 2.5 feet, respectively. The effect these sediments may have had on the invertebrate populations utilized by intertidal or subtidal benthic-feeding shorebirds and waterfowl is unknown. However, since the acreage of tidal flats that were invaded by marsh vegetation, and thereby made less attractive to shorebirds, was likely offset by flats newly created through shoaling, little overall long-term effect on the quantity of shorebird habitat probably occurred.

Reclamation of tidal marshes in the Bay and Delta first began in the early 1850s and occurred most intensively between 1860 and 1910. Frustrated gold miners soon realized that fortunes could be made more readily by satisfying the rising demand of the human population for food. Tidal marshes in the Delta, Suisun Bay and San Pablo Bay were diked primarily for agriculture while those in the South Bay and in some parts of San Pablo Bay were reclaimed for commercial salt harvesting. By 1900, one-half of the Delta had been diked, and, by 1930, Delta reclamation was complete with the creation of 450,000 acres of farmed, formerly tidal wetlands (Madrone Associates et al. 1980). Diking of tidal marshes in the Bay for salt evaporation ponds was initiated about 1860 and, by the 1930s, about 30,000 acres or 63 percent of the historic tidal marshes in the South Bay had been diked for salt production

(K. Dedrick, California State Lands Commission, pers. comm.). Atwater et al. (1979) estimated that of the 846 square miles of tidal marshes found in the Estuary prior to 1850, only 48 square miles exist currently, a decline of 95 percent. There has also been a reduction by about 12 percent in the amount of open water habitat since the gold rush (Atwater et al. 1979).

Conversion of San Francisco, San Pablo, and Suisun bay tidal marshes to agricultural land and salt ponds reduced available habitat for species such as rails, song sparrows, harvest mice, and shrews, leading to their current special Federal or State status. Diking of marshes left narrow strips of tidal habitat remaining outboard of the levees and eliminated high marsh transition zones which originally graded into surrounding upland habitats. Diking also eventually facilitated intensive industrial and residential development immediately bordering remnants of these tidal marshes. In contrast to these marsh-dependent species, the diking and filling of tidal wetlands probably had far less effect on shorebirds due to their primary reliance on mudflats.

Conversion of tidal marshes into salt evaporation ponds increased use of the Bay by waterbirds able to exploit the rich food resources and remote nesting/roosting sites provided by this new artificial habitat (Harvey et al. 1988). Such species include eared grebe, American white pelican, black-necked stilt, American avocet, western snowy plover, Wilson's phalarope, California gull, and Caspian and Forster's terns. In the early 1900s, most of the above shorebird species were reported as rare to uncommon and probably did not historically nest within the Bay Region (Grinnell et al. 1918, Grinnell and Wythe 1927). By 1918, the snowy plover was apparently a fairly common nester on the South Bay salt ponds (Page and Stenzel 1981). Caspian and Foster's terns, which were historically winter visitors and migrants, became common nesting species by 1916 and 1948, respectively (Grinnell and Miller 1944, Sibley 1952).

Even with conversion of most marsh to salt ponds, numerous private duck clubs still existed in the South Bay as of 1959. At that time, the U.S. Army Corps of Engineers (1967) reported a total of 64 clubs in Alameda County, 15 in Santa Clara County, and 16 in San Mateo County. Factors cited as contributing to the decline of hunting in the Bay Area then were high costs of land and water, high membership fees, competition with farming, and restrictive bag limits.

Diking of tidal marshes in the Delta for conversion to intensive agricultural use greatly reduced the value of this prime area for wintering and nesting waterfowl. As a result, birds were concentrated on remaining wetlands where they were more vulnerable to hunting pressure, disease, predation, and human disturbance.

Loss of the seasonally flooded overflow areas in the interior of Delta islands reduced or extirpated nesting populations of waterbirds such as shorebirds, rails, herons, ibis, and terns. By 1944, Grinnell and Miller (1944) described black-necked stilts and American avocets as less abundant than formerly in California because of the loss of wetlands.

(1944) described black-necked stilts and American avocets as less abundant than formerly in California because of the loss of wetlands.

Adjacent to the Bay and Delta, there was extensive conversion of grassland, seasonal wetlands, and vernal pools to agricultural land and later to commercial and residential development. This reduced the values of these areas or eliminated them for both wintering and nesting waterbirds. For example, extensive seasonal wetlands and overflow lands, which existed in Fremont (Stivvers Lagoon) and in Santa Clara Valley, supported high numbers of wintering waterfowl (Skinner 1962). Loss of these habitats was probably also detrimental to shorebirds, since they use seasonal wetlands and grasslands adjacent to the tidal marshes as foraging and roosting areas when mudflats are inundated by tides. Loss to development of these upland roosting sites close to the Bay may have affected shorebird numbers particularly in the central regions of San Francisco Bay where there are no salt pond levees or other roosting areas during high tide. Snipe populations around the Bay have likely decreased as seasonal wetlands have disappeared, but this has not been documented. Widespread conversion to agriculture of valley grasslands adjacent to the Delta also contributed to the extirpation of the tule elk (Bakker 1971), mountain plover, and blunt-nosed leopard lizard from the study area (M. Jennings, California Academy of Sciences, pers. comm.).

Through grazing and the exclusion of fires in the Bay Area, some invasion of former grasslands by brush also occurred (Fowler 1989). For example, much of the east Bay hills above Berkeley and Oakland historically provided suitable chaparral and grassland habitat for coast horned lizards (M. Jennings, California Academy of Sciences, pers. comm.) and mountain plovers (R. Jurek, California Department of Fish and Game, pers. comm., Grinnell et al. 1918). Following the turn of the century, invading brushy species, such as coyote brush, became increasingly established causing conversion of this habitat.

Levee construction and agricultural development in the Delta resulted in the elimination and fragmentation of much of the original riparian woodland habitat. Once levees were constructed, ongoing maintenance and bank protection through rip-rapping further reduced the continuity of these forest corridors. Concurrently with loss of riparian woodlands in the Delta, similar streambank habitat was being eliminated adjacent to major creeks draining into San Francisco Bay. This resulted in major reductions in many land birds, waterbirds, raptors, reptiles, amphibians, and mammals that depended on these forests. For example, extirpation from the Estuary study area of the purple martin, bank swallow, willow flycatcher, yellow-billed cuckoo, and the least Bell's vireo (last seen in the Sacramento Valley in 1958) was largely due to this habitat conversion (Gaines 1974). More recent declines of some of the above species may also be related to the spread of the nest parasite, the brown-headed cowbird (Laymon 1987). The extent of riparian wood duck habitat was reduced to where the species was considered on the "verge of extinction" in 1913 (Dawson 1923) and "rare" by 1915 (Grinnell and Miller 1944). Only four wood duck nesting records for the Estuary were documented in 1918 (Grinnell et al. 1918). Grinnell and Wythe (1927) believed the species to be absent from any part of the Bay Region, excluding the Delta.

Clearing land for agriculture, draining of wetlands, stream alterations, and hydraulic mining greatly reduced the abundance of riparian nesting sites and foraging habitat for raptors such as the bald eagle, osprey, and Swainson's hawk. By 1929, less than ten percent remained of the original salmon spawning habitat in the Sacramento and San Joaquin river systems (Netboy 1974 in Detrich 1986). Clearing of aquatic vegetation and bank stabilization in Delta channels and adjacent Estuary tributaries also caused increased ambient water temperatures and loss of underwater streambed habitats, all negatively affecting populations of fish, amphibians, and reptiles (Jennings 1988).

Starting in the 1850s, extensive oak woodland habitat along with its wildlife community was lost as a result of wood cutting and clearing for orchards, cropland, and range. During the 19th century, oak wood was the primary source of fuel. Oak wood fueled the quicksilver (mercury) retorts at New Almaden in Santa Clara County and was also cut extensively around San Francisco Bay for production of charcoal. Sonoma County was the top producer in the early 1900s, producing about 1,000 tons of charcoal per year (Rossi 1979).

The earliest agricultural clearing of oaks in the Estuary study area was primarily for orchards. Orchards were planted as far north as Rio Vista on the Sacramento River and south to Santa Clara Valley. Extensive conversion of oak woodlands to croplands also occurred in the Napa Valley (Rossi 1979). Eventually much of this agricultural land in the study area was converted to urban development.

Oak woodlands remaining during the late 19th and early 20th century were subjected to additional pressures that severely limited their reproduction including: 1) grazing on oak seedlings by livestock; 2) greater competition for oak seedlings in the thick annual cover resulting from the widespread introduction of exotic annual plants (Holland 1976); 3) trampling of the soil by livestock, making germination more difficult; 4) consumption of acorns by livestock, wild pigs, and increasing populations of introduced and native seed-eating rodents and birds (Holland 1976, Rossi 1979); and 5) girdling and chewing of oak roots by increased gopher populations (Holland 1976). Bird species most affected by reduction in oak woodlands would have included insect-gleaning canopy species, woodpeckers, and other cavity nesters.

The widespread historic losses and alterations of native upland wildlife habitats did not adversely affect populations of all wildlife species. The conversion of forested uplands to grasslands or agricultural land initially may have benefitted such species as the California vole, California ground squirrel, mule deer, horned lark, mourning dove, western meadowlark, American kestrel, burrowing owl, brown-headed cowbird, and Brewer's blackbird. The California condor may also have experienced a short-lived population increase in northern California, in response to the conversion of woodlands for grazing, and the expansion of the whaling industry (Gordon 1977). Conversion of forests to brushlands may have benefitted such species as the California thrasher, cottontail, and California quail because of their preference for ecotone or edge habitats. Urbanization resulted in increased populations of some species able to adapt to the urban environment, including the raccoon, coyote, American robin, house finch, California towhee, mockingbird, and several species of gull that are attracted to garbage dumps.

3.3.4 Other Causes of Population Changes

In addition to habitat loss and conversion, indiscriminate shooting and poisoning of predators contributed to early declines in numbers of certain raptor species and the complete extirpation of others. Species most affected included the peregrine falcon, bald eagle, osprey, California condor, and black-shouldered kite. According to Heermann (1857), heavy boat traffic and shooting led to abandonment of a bald eagle eyrie four miles from Sacramento. During the latter nineteenth and early twentieth centuries, shooting by stockmen and bounties greatly reduced eagle numbers in the Central Valley. Kites were considered abundant in the 1860s but rare or reduced to "the point of extinction" or rarity by shooting and loss of nesting habitat by the 1930s (Dawson 1923, Grinnell and Wythe 1927, Sibley 1952).

Following the introduction and extensive application of chlorinated hydrocarbons, such as DDT, in the late 1940s, complete elimination of several high trophic level birds from the study area and large portions of the state were documented. Species most affected included the bald eagle, osprey, peregrine falcon, and brown pelican.

Brant, historically abundant winter visitors in the Estuary (Grinnell et al. 1918), were largely eliminated from the Bay by the effects of human disturbance and unregulated hunting. Only scattered accounts of a few brant per year have been reported since the early 1900s (H. Cogswell, California State University Hayward, pers. comm.)

During the 1930s through the 1960s, massive withdrawals of groundwater for agriculture had a negative effect on some wildlife groups. For example, lowering of groundwater in the Palo Alto area caused the dewatering of some freshwater wetlands thus reducing the distribution of native amphibians and reptiles (M. Jennings, California Academy of Sciences, pers. comm.). Another effect was significant land subsidence such as occurred adjacent to the South Bay where lands have sunk 3 to 9 feet since 1916 (Poland and Ireland 1988). This subsidence lowered the elevations of tidal marshes, affecting their value for species dependent on high marsh habitats. Groundwater removal and lowered water elevations adjacent to the Delta also contributed to the elimination of riparian corridors.

Either through deliberate efforts or incidental to other activities many exotic species of plants, invertebrates, fish, and wildlife have been introduced in the Bay and Delta Region beginning from about 1850. Although there is little quantitative evidence, introductions of exotic plants must have affected wildlife populations through elimination or alteration of native habitats. The most extensive conversion of native habitat occurred in the grassland habitat type. Historically, grasslands in California were dominated by perennial bunchgrasses. In the late 1800s, native perennial species were rapidly replaced by exotic annual grasses whose seeds were introduced from the wool or hair of livestock (Bakker 1971), or from weed seeds mixed with crop seeds (Frenkel 1970). Heavy grazing between 1850 and 1863 on native bunchgrasses, which were not adapted to this pressure, coupled with severe drought and deficient rainfall from 1851 to 1864, contributed to the success of alien annual plants (Frenkel 1970, Bakker 1971).

Presumably, some native wildlife species were adversely affected by this conversion, although many seed-eating species probably benefitted from the increased seed production of the exotic annual plants. Grazing pressure combined with this habitat conversion produced more favorable habitat for the pocket gopher, California ground squirrel, and the burrowing owl, which uses ground squirrel holes for nesting.

Eucalyptus trees, which were planted in the Bay area as early as 1850, were widely cultivated for their hardwood and medicinal qualities (Gordon 1977). These groves, however, proved to be poor wildlife habitat compared to the natural uplands they replaced. Other exotic plants which provided minimal or no wildlife value and flourished at the expense of more valuable native plants, were tamarisk (Tamarix spp.) and false bamboo (Arundo spp.) in riparian areas, pampas grass (Cortaderia selloana) in grasslands and ruderal areas, and scotch broom (Cytisus scoparius) in disturbed areas of coastal scrub and broad-leaved evergreen forest. Scotch broom was additionally detrimental to wildlife because of its highly flammable nature (Ornduff 1974).

Since 1850 at least 96 species of invertebrates have been introduced into San Francisco Bay primarily from ship hulls, ship ballast, and transplanted oysters (Carlton 1979). These invertebrates have become prominent components of the Bay's benthic fauna and today are important shorebird prey. The ecological interactions between native and introduced species have been little studied. No native marine invertebrates are known to have become extinct in the Bay from competition with introduced species; however, portions of once broader niches of some native species may have been acquired by introduced species (Carlton 1979). In terms of number of species, the relatively young San Francisco Bay supported a sparse native aboriginal fauna, and many introduced species did not have to compete with a native counterpart to become established (Carlton 1979). Overall, shorebirds probably have benefited from the increase in the number of introduced prey species.

Introduced mammals such as Norway rats, black rats, house mice, feral cats, and Virginia opossums became established and quickly expanded to occupy many habitats in the Region. Ground nesting waterbirds, upland game, and native rodent and reptile populations were affected by these introduced mammals. Introductions of predatory fish (60 species over the last 120 years) and the bullfrog were also factors in the reduction of native species of amphibians and reptiles (Hayes and Jennings 1986, 1988).

CHAPTER 4
CURRENT TRENDS IN DISTRIBUTION AND ABUNDANCE OF WILDLIFE POPULATIONS

4.1 INTRODUCTION

The following accounts discuss species whose current status is considered representative of major wildlife groups within the San Francisco Estuary. The wildlife groups discussed include birds, mammals, amphibians, reptiles, and Federal or State-listed insects. Each account discusses historic distribution and abundance, causes for population declines, current status (distribution, seasonality, relative abundance) within the study area, any critical habitat requirements, population trends if known, and current threats to the species. The species accounts for insects only include the Federally listed species, due to the large number of Federal candidates.

Specific conclusions regarding population status and trends are possible for only a limited number of wildlife species within the Estuary. For example, migratory waterfowl have been monitored most consistently and over the greatest period, while colonial birds, shorebirds, pinnipeds, and special status species have generally received intermittent attention during the last 25 years.

Scientific names are used in the accounts when discussing particular wildlife subspecies or when referring to plants, invertebrates, and fish. A comprehensive list, including common and scientific names, of all wildlife species historically or currently known from the Estuary study area is found in Appendix A. A listing of all Federal and State special status birds, mammals, amphibians, reptiles, insects, and plants is presented in Appendix B. The plant species contained in Appendix B include only those found within the upland habitats of the Estuary study area. Special status plants found within wetland habitats are presented in the **Status and Trends Report on Wetlands and Related Habitats in the San Francisco Estuary** (Association of Bay Area Governments 1991).

The accounts are presented generally in taxonomic sequence and address the following major groups:

a) Federal- and State-listed endangered and/or threatened species as presented by the U.S. Fish and Wildlife Service (1990a) and California Department of Fish and Game (1989b, 1990c).
b) Federal and State candidate species as listed by the United States Fish and Wildlife Service (1989b).
c) Federal species of special management concern including:
   - Sensitive Bird Species (U.S. Fish and Wildlife Service 1985a)
   - Migratory Nongame Birds of Management Concern in the United States (U.S. Fish and Wildlife Service 1987a)
d) State Species of Special Concern (Remsen 1978, Williams 1986, Jennings 1987a).

e) National Audubon Society Blue List (Tate 1986) of birds that are experiencing population declines.
f) Selected native species that have significantly declined or increased in numbers and distribution.
g) Selected introduced species that have expanded their distribution.
h) Selected Federally and/or State-regulated harvested species.
i) Species groups such as waterfowl, shorebirds, and colonial-nesting birds for which quantitative population information has been collected over a significant portion of their distribution within the Estuary.
j) Other selected waterbird species, in general, due to their close dependence on the Estuary, degree of public interest concerning their status, and/or availability of quantitative population information.

4.2 BIRDS

4.2.1 Loons and Grebes

4.2.1.1 Red-throated and Pacific Loons

These species are fairly common in winter (mid-October through April), occurring chiefly on the deep open water of Central San Francisco Bay. They are often observed in the vicinity of Richardson Bay, Berkeley, and Alameda. They nest in the arctic regions of Canada and Alaska, and migrate and winter along the outer Pacific Coast from the Aleutians south to Baja California. Both species are strongly associated with saltwater coastal areas and are only rarely observed inland. Red-throated loons generally winter closer inshore in enclosed bays and are more common in the study area than the Pacific loon (Grinnell and Miller 1944).

Comprehensive censuses of loons have not been conducted in the Bay, and overall population estimates are not available. Cogswell (1977) reported the red-throated loon had apparently declined in numbers since 1968; however, it is still more common on San Francisco Bay than the Pacific loon (D. Erickson, LSA Associates, pers. comm.). From 16 to 84 red-throated loons were observed per count on portions of the Central Bay in Alameda County during 1984 through 1989 on the Oakland Christmas Bird Count. In the South Marin Christmas Count during 1978-89, total numbers observed per count along the Marin County bayshore ranged from fewer than five to as many as 300 individuals. During both the South Marin and Oakland Christmas Counts, numbers of Pacific loons have been sporadic. Frequently fewer than 10 individuals were counted. However, one high count of 220 Pacific loons was reported at Tiburon in 1983.

4.2.1.2 Common Loon

The common loon is a fairly frequent winter visitor (early September through late May) on deeper openwater areas of Central San Francisco Bay; they also winter on large, deep, inland lakes and reservoirs. The species nests throughout Canada and Alaska and winters along the Pacific coast from the Aleutians south to northern Mexico.

Numbers of common loons observed during the Christmas Bird Counts in the Bay have generally exceeded those of both other species, except for occasionally high numbers of red-throated loons seen during the South Marin Christmas Count. Numbers of common loons seen during the Oakland count in 1984-89 ranged from 21 to 83 individuals, while 10 to 40 birds were counted in the Marin count (1975-1989).

Common loons historically nested above 5,000 feet on lakes east of Lassen Peak, in Shasta and Lassen counties (Grinnell and Miller 1944). Human disturbance at these sites by boaters most likely led to eventual abandonment of these areas (Remsen 1978). Except for Idaho, the common loon has also been extirpated as a nesting species throughout the western states (U.S. Fish and Wildlife Service 1985a). According to Christmas Bird Counts between 1965-69 and 1975-79, there was an 11 percent decline in the number of wintering individuals on the west coast, excluding Washington (Trapp 1981 in U.S. Fish and Wildlife Service 1985a). As a result, the species was designated a Highest Priority State Species of Special Concern by the California Department of Fish and Game (Remsen 1978) and a Sensitive Species by the U.S. Fish and Wildlife Service (1985a). Human disturbance during the breeding season, pollution (oil spills) in their wintering (marine) environments, and lake acidification have been cited as present and potential problems for common loons in the western states. All three species of loons were killed in the 1986 Apex Houston oil spill from outside the Golden Gate to Monterey Bay (Page et al. 1990). Large numbers were also killed in gill nets along the outer coast of Central California in 1979-1987 (California Department of Fish and Game 1987d).

4.2.1.3 Pied-billed Grebe

No Estuary-wide surveys have been conducted of any of the five grebe species discussed in this report. The pied-billed grebe is a fairly common but solitary resident throughout the Estuary, in sheltered, freshwater areas supporting substantial stands of emergent vegetation. They typically nest on marshy ponds, large ditches, or sheltered portions of larger lakes throughout North America from Central Canada south. They winter in the western states north to British Columbia. In California, the species typically nests from April into August (Cogswell 1977). During migration and winter, the local population is supplemented by additional individuals from the northern interior, and increased use occurs of tidal channels, sheltered portions of San Francisco Bay, as well as larger lakes and rivers. In the South Bay, small numbers (<15) were observed during winter and early spring on salt evaporation ponds (California Department of Fish and Game/U.S. Fish and Wildlife Service, unpubl. data) in 1982-84. As many as about 300 individuals have been observed during the Oakland Christmas Counts from 1984 through 1989.

4.2.1.4 Horned Grebe

Horned grebes are fairly common winter visitors throughout open, saltwater tidal areas of San Francisco, San Pablo, and Suisun bays, but they are nearly absent from March through August. Cogswell (1977) cited this species as increasing in abundance along the California coast since the 1930s. This species breeds throughout the northern United States, Central Canada, and Alaska and winters south along the Pacific Coast to Mexico (Palmer 1978). The species occurs in fewer numbers along the coast south of Monterey and in the southern one-third of California (Small 1974). The National Audubon Society included this species on their Blue List, based on their reported decline in numbers in the northeastern states (Tate 1986).

4.2.1.5 Eared Grebe

The eared grebe is an abundant winter visitor (September - April) throughout the study area, most often on salt evaporation ponds in South San Francisco Bay and the Napa Marsh. The winter distribution encompasses the Pacific Coast from Canada south and throughout Mexico. Generally, eared grebes breed colonially on freshwater lakes in the western half of the United States, north to central Canada. In California, nesting has traditionally occurred on marshy lakes in the eastern Sierra Nevada, southern California mountains, and northeastern portion of the state. However, the presence of birds during summer at Lake Merced (San Francisco County) suggests that nesting may have occurred (Grinnell and Wythe 1927).

The first confirmed nesting by eared grebes within the study area occurred in 1983 when about 30 pairs nested at Krittenden Marsh, a diked seasonal wetland adjacent to the South Bay in Santa Clara County. Even though nearly surrounded by salt evaporation ponds, the site received freshwater runoff from the Moffett Field Naval Air Station and the National Aeronautics and Space Administration Ames Research Center. Since the Navy's dewatering pumps were not functioning properly at the time, as much as four to five feet of water ponded at the site. Eared grebes and at least five pairs of pied-billed grebes utilized dense wigeon grass for nest-building (T. Roundtree, Santa Clara County Planning Department, pers. comm.). Following the successful nesting in 1983, the site has received less water, due to dewatering by the Navy and low rainfall. As a result, only minimal nesting occurred by 1986. Since 1987, ponding has not occurred at Krittenden Marsh, and eared grebes have not nested there. A second colony of eared grebes nested in 1983 on an unused sewage pond in Pleasanton, Alameda County; however, the pond was subsequently destroyed (H. Cogswell, California State University Hayward, pers. comm.).

Eared grebes represent one of the most abundant species on the salt ponds of the Bay (Swarth et al. 1982). Monthly aerial waterbird surveys in the South Bay during 1981-1984 of salt ponds, open bay, and a variety of nontidal wetland habitats (diked seasonal wetlands, duck clubs, sewage ponds, freshwater flood basins) revealed that eared grebes occurred nearly exclusively on the salt ponds (Swarth et al. 1982, California Department of Fish and Game/U.S. Fish and Wildlife Service, unpubl. data). Highest numbers were generally observed during December through April, with a spring peak migration count of 43,381 individuals on 13 April 1984 (Figure 4-1). Eared grebe numbers on both the North and South Bay salt ponds were recorded during October through April from 1988 to 1990 (L. Accurso, U.S. Fish and Wildlife Service, unpubl. data). These counts also revealed peaks from mid-January

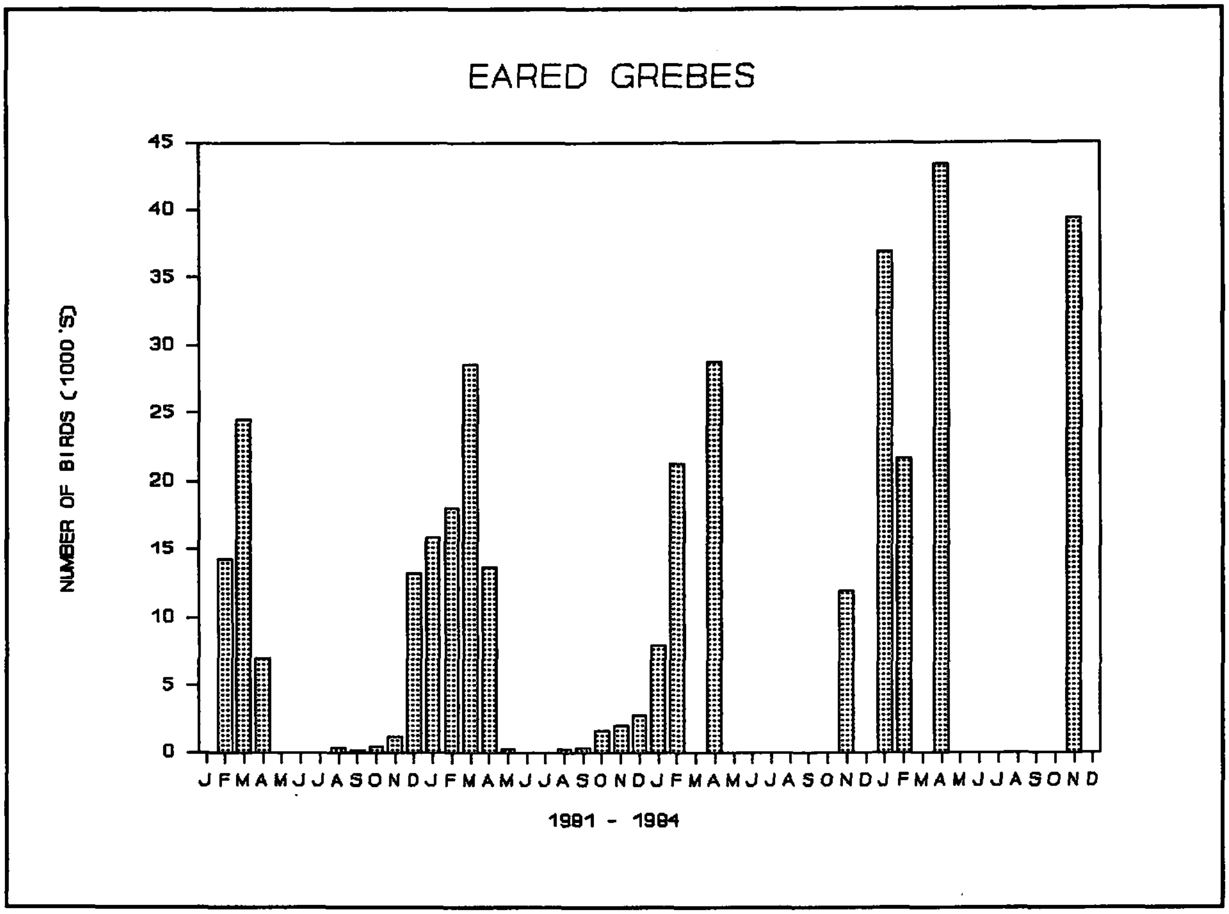

Figure 4-1. Results of Monthly Aerial Surveys of South San Francisco Bay Salt Ponds. No Surveys Were Conducted on 1/81;3,5,6,8-10,12/83 and 3,5-7,9,10,12/84. Source: California Department of Fish and Game/U.S. Fish and Wildlife Service (unpubl. data).

into March with a high count of 40,767 on 3 April 1990. These data indicate that (1) the majority of eared grebe use occurs in the South Bay salt ponds; (2) the current Bay population is comparable to levels reported in the mid-1980s; and (3) more than 40,000 eared grebes currently use the Estuary annually.

Eared grebes have been recorded in salt ponds with salinities ranging from about 50 to 200 parts per thousand where they rely on abundant brine shrimp and brine flies (Anderson 1970a, Swarth et al. 1982). Aerial surveys revealed a peak median grebe density of 4 birds/acre in ponds ranging from 150 to 179 parts per thousand (California Department of Fish and Game/U.S. Fish and Wildlife Service, unpubl. data).

Grinnell (1915) and Grinnell and Wythe (1927) described the eared grebe as wintering abundantly along the outer coast and common on fresh and salt water throughout the Bay Region. Given the clear preference shown by this species for salt ponds and the absence of this habitat prior to 1860, it is reasonable to assume their use of the Bay Area has increased from historic times, in response to creation of this habitat.

4.2.1.6 Western and Clark's Grebes

These grebes winter generally from northwestern California south through Baja California and throughout the western portion of California, including the outer seacoast, large bays and lagoons, and the Central Valley. They are abundant in winter (October - May) throughout the study area, most frequently on open Bay waters, large lakes, and salt ponds (Figure 4-2). In the open Bay, largest numbers are encountered in the Central Bay where they are frequently found near narrows or islands where currents may facilitate successful diving for fish.

Western and Clark's grebes breed primarily east of the Sierra Nevada, in the northeastern portion of California, extending into the northern Rockies and Great Plains. They currently nest at Clear Lake where past pesticide use led to nesting failure and abandonment in the 1950s. The species also historically nested commonly on lakes in the San Joaquin Valley prior to their conversion to agriculture (Grinnell 1915). Nesting still occurs locally in this region such as in eastern Stanislaus County (D. Erickson, LSA Associates, pers. comm.). Grinnell and Wythe (1927) reported nesting at Lake Merced (San Francisco County) in 1885 and 1926.

Of the various Christmas Bird Counts that encompass portions of the open Bay, the highest western grebe numbers have been recorded during the South Marin Count. During the period 1975 through 1983, 6,000-18,000 birds per count were encountered within the Bay, while, more recently, numbers have ranged from 2,000 to 3,000. Aerial wintering waterfowl surveys during October through April (1988-1990) of nearly the entire Bay revealed populations ranging from as few as 30 birds in early October 1988 to a peak of 3,052 in mid-January 1989 (Figure 4-2) (L. Accurso, U. S. Fish and Wildlife Service, unpubl. data).

Smaller numbers occur in the Estuary during summer. In June 1990, U.S. Fish and Wildlife Service personnel observed these grebes between Horseshoe Bay and Point San Quentin (200-300), Richmond Harbor to the Bay Bridge (200), Hunter's Point to the San Francisco Airport (450-500), midbay between the Bay and San Mateo bridges (400-450), mid San Pablo Bay (18), Carquinez Straits (16), Suisun Bay (1), and the Napa River (6) (H. Carter, U.S. Fish and Wildlife Service, pers. comm.).

During aerial surveys of the salt ponds of South San Francisco Bay in the early 1980s (California Department of Fish and Game/U.S. Fish and Wildlife Service, unpubl. data), more western and Clark's grebes were observed on the open bay than on the salt ponds. However, occasional peaks in low salinity ponds occurred in response to seasonal booms in fish populations.

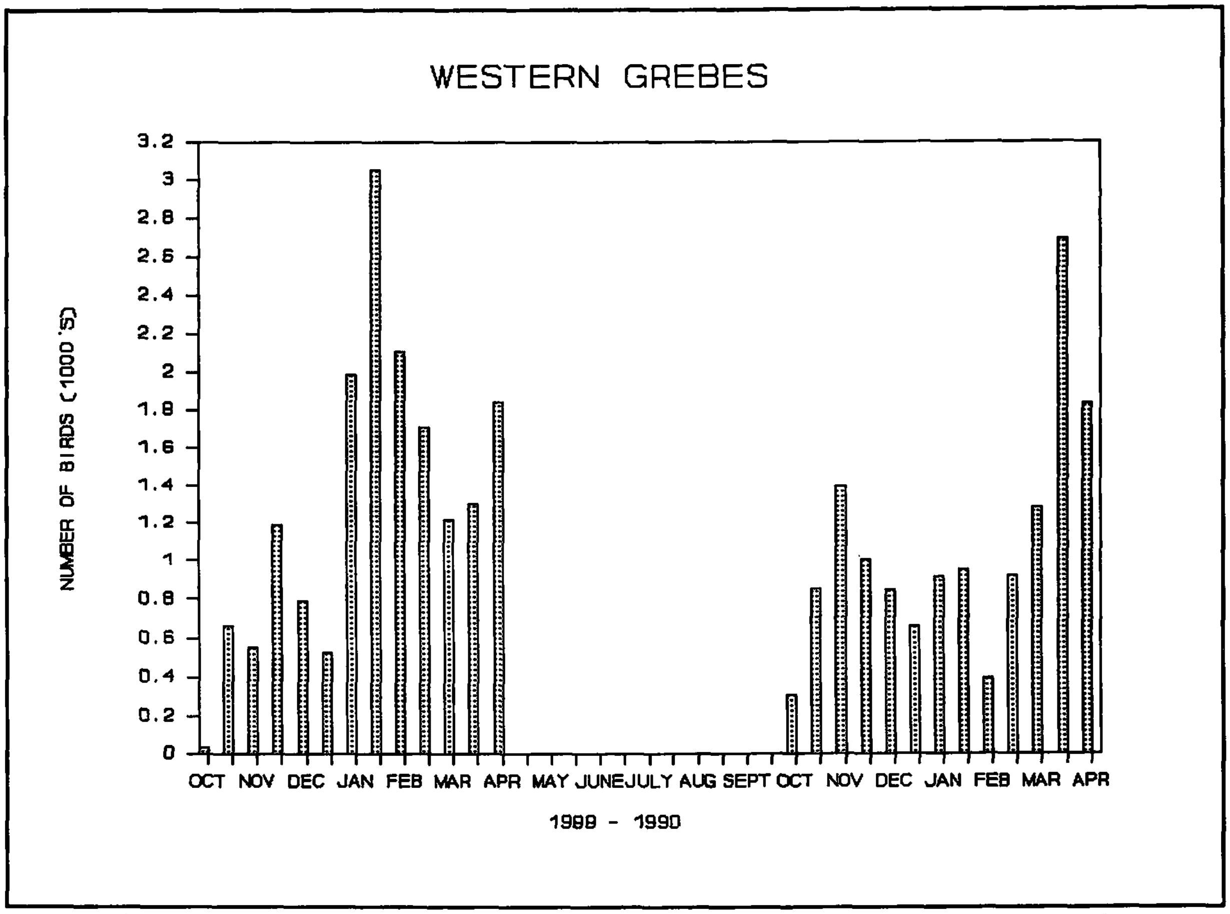

Figure 4-2. Results of Monthly Aerial Surveys of San Francisco Bay Open Water and Salt Ponds (L. Accurso, U.S. Fish and Wildlife Service, unpubl. data). No Surveys Were Conducted During May through September.

The National Audubon Society added western grebes to their Blue List due to observed declines in the 1970s, and they currently consider the western grebe a species of Special Concern (Tate 1986).

Although less frequently identified, the Clark's grebe is a common species that winters sympatrically in central California with the western grebe. During the 1984-1989 South Marin Christmas Bird Counts, the ratio of grebes identified as Clark's grebes to western grebes was 1-7:100. Bailey (unpubl.) found that Clark's grebes near the Alameda Naval Air Station comprised 10-20 percent of the observed individuals. Of 157 western grebes observed in Moss Landing (Santa Cruz County), 35 percent were identified as Clark's (Erickson et al. 1986). Western and Clark's grebes were killed in the 1986 Apex Houston oil spill from outside the Golden Gate to Monterey (Page et al. 1990). Large numbers were also killed in gill nets along the outer coast of Central California in 1979-1987 (California Department of Fish and Game 1987d).

4.2.2 Pelicans

4.2.2.1 American White Pelican

The American white pelican is a late summer/fall migrant and winter visitor (July - December) in the San Francisco Estuary, locally common on large open water areas such as bays, lakes, salt ponds, and diked habitats (Figure 4-3). White pelicans also migrate through and winter in the Central Valley and along the Pacific coast from Point Reyes south into Mexico. In the Western states and central Canada, the species breeds on isolated, large lakes (Palmer 1978). At the turn of the century and prior to conversion of many shallow lakes to agriculture, white pelicans commonly nested in the Central Valley and nearly the entire breadth of the state (Grinnell 1915). In California, remnant colonies currently exist only in the Klamath Basin and Honey Lake Area (Remsen 1978, Sidle et al. 1985).

During fall and winter, large flocks of white pelicans are commonly observed flying between the salt ponds of the Napa Marsh and the South Bay, which they prefer for roosting or feeding, and the farmed wetlands and large waterbodies of the Delta and Suisun Marsh. During mid-June 1990 surveys of breeding seabirds in Suisun Bay, scattered flocks of 3-72 birds were observed roosting at several sites along the shoreline of Suisun Bay including Benicia, the mouth of Pacheco Creek, Middle Ground Island, and Pittsburg Point (H. Carter, U.S. Fish and Wildlife Service, pers. comm.). During these same surveys, a flock of 100 pelicans was seen circling over Honker Bay.

During aerial surveys of the South Bay salt ponds, a peak of 3,147 birds was recorded on 6 August 1984 (California Department of Fish and Game/U.S. Fish and Wildlife Service unpubl. data) (Figure 4-3). White pelicans in the South Bay were recorded only in ponds with salinities ranging from about 25 to 90 parts per thousand, and the highest densities (0.4-0.8 birds/acre) were recorded in ponds with salinities from 25 to 30 parts per thousand. A gular pouch of a pelican killed by collision with a powerline on San Francisco Bay National Wildlife Refuge (Refuge files), contained rainwater killifish, which Lonzarich (1988) found to be permanent residents of low-salinity (22-40 parts per thousand) salt ponds. Given the tendency of white pelicans to congregate during the nonbreeding season and their preference for salt ponds, Figure 4-3 may show a fair estimate of the total numbers utilizing the Estuary during the early 1980s.

Grinnell and Wythe (1927) described the white pelican as a casual visitor to the Estuary that was sometimes seen during migration in flocks overhead. Records of flocks in the South Bay during September and December were considered noteworthy. Compared with these accounts, the relatively large numbers of white pelicans observed now during fall and winter suggest that their nonbreeding use of the Estuary may have increased since the early 1900s. The creation of salt ponds with their abundant prey populations and isolated, undisturbed dikes for roosting may have contributed to this increase.

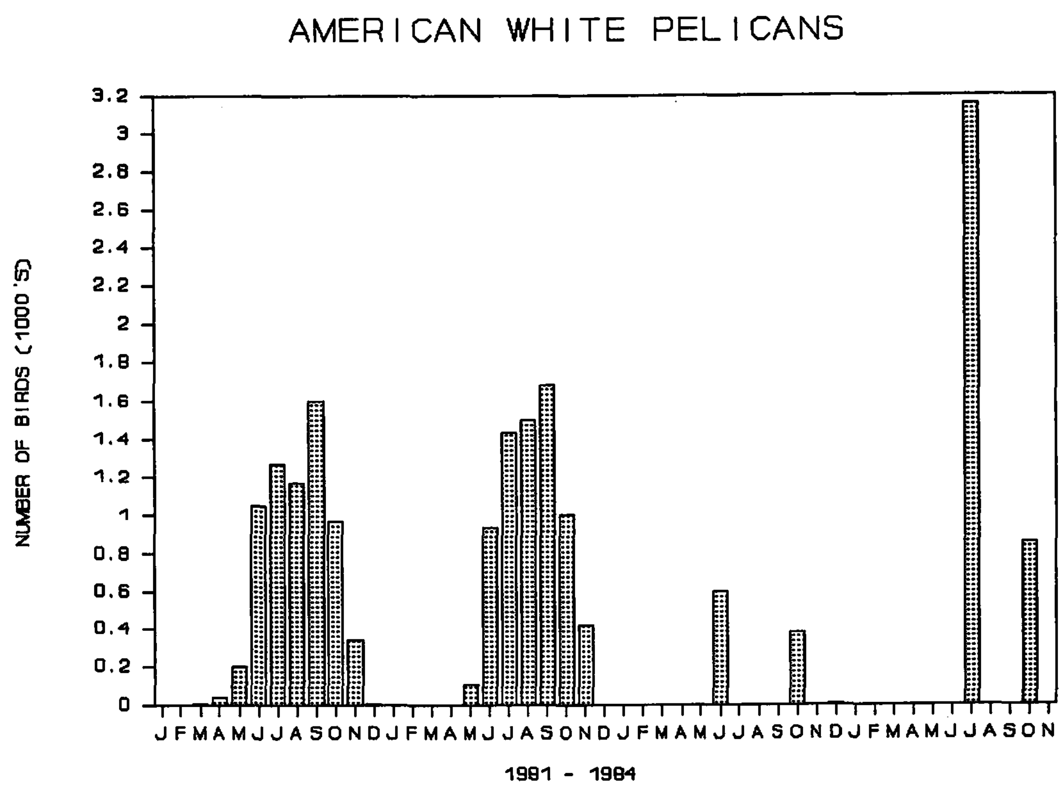

Figure 4-3. Results of monthly aerial surveys of South San Francisco Bay salt ponds. No surveys were conducted on: 1/81;3,5,6,8-10,12/83 and 3,5-7,9,10,12/84. Source: California Department of Fish and Game/U.S. Fish and Wildlife Service (unpubl. data).

Historically, white pelicans have experienced a long-term reduction in overall population and in the number of colony sites throughout much of their range in the western United States. Currently, the only two breeding colonies left in California are within the Klamath National Wildlife Refuge Complex. Factors contributing to this decline include conversion of habitat, drought, inundation of nesting colonies, predation, deliberate destruction of nests, the effects of pesticides, and human disturbance (Lies and Behle 1966, Sidle et al. 1985).

Since 1972, the species has been on the Audubon Society's Blue List and has also been designated a Highest Priority Species of Special Concern by the California Department of Fish and Game (Remsen 1978). Although the U.S. Fish and Wildlife Service has designated the white pelican a Sensitive Bird Species due to the reduced number of active breeding sites in the western states, Sidle et al. (1985) concluded that pelican numbers were stable or increasing throughout the remainder of their North American range.

4.2.2.2 California Brown Pelican

This subspecies of brown pelican (Pelecanus occidentalis californicus) is a fairly common post-breeding resident (May-November) throughout the open waters of Central San Francisco and San Pablo Bays. On the Pacific Coast, they breed from the Southern California Channel Islands south into Mexico; after breeding, they disperse along the coast south to Central America and north to Vancouver Island (Cogswell 1977, Palmer 1978). Peak numbers occur along the northern California coast during August - September (Briggs et al. 1983). In the Bay, these pelicans forage over deep open water and roost on sites relatively free from human disturbance such as breakwaters, pilings, and, to a lesser extent, salt-pond dikes. During the early 1980s, U.S. Fish and Wildlife Service personnel also documented brown pelicans surface feeding in low-salinity salt ponds in the South Bay (San Francisco Bay National Wildlife Refuge files).

In response to a major population decline during the 1950s through late 1970s in California brown pelicans breeding from the Channel Islands south to northern Baja California, the species was Federally-listed as endangered in 1970 (Gress and Lewis 1988). Factors contributing to this decline included pesticide-induced eggshell thinning, oil spills, human disturbance of breeding colonies, over-harvest of its prey, loss of post-breeding roost sites, and fishing gear entanglement (California Department of Fish and Game 1989b). In general, numbers of nesting pairs and reproductive success have increased in Southern California since 1978. In addition, colony sites in Southern California and Mexico have been designated as preserves and now receive protection during the nesting season.

No systematic survey has been attempted to monitor brown pelican abundance in the San Francisco Estuary. A breakwater at the Alameda Naval Air Station, which is known to be a major roost for the species, supported a peak of 401 individuals in June 1984 (Campbell and LeValley 1984). During surveys for nesting seabirds in 1988-90, U.S. Fish and Wildlife Service and Point Reyes Bird Observatory personnel observed as many as 130 birds at several Central San Francisco Bay and San Pablo Bay roost sites, including Hunter's Point, Angel Island, East Sister Island, West Brother Island, north of Point San Pablo, the Brooks Island breakwater, and the Mare Island breakwater (H. Carter, U.S. Fish and Wildlife Service, pers. comm.). On a small-boat survey on 14 June 1990, this team recorded a total of 240 brown pelicans from the San Francisco International Airport to Alameda, with 219 roosting at the Alameda Naval Air Station breakwater. The Farallon Islands National Wildlife Refuge, 30 miles west of San Francisco, supports a major nonbreeding pelican roost of as many as several thousand birds in late summer and fall.

Year-to-year variations in the numbers of post-breeding pelicans in California and San Francisco Bay may be related to the timing and success of nesting in Gulf of California colonies, the availability of their main prey, the northern anchovy (Engraulis mordax), and sea surface temperatures along the coast (Briggs et al. 1983). Considering the major historic use which Alcatraz Island received by roosting pelicans (Grinnell and Wythe 1927) and the nesting that occurred as far north as Point Lobos (Monterey County) as late as 1959 (Baldridge 1973), brown pelican numbers in the Bay may have been higher in the past. However, given the natural population fluctuations expected at the northern periphery of its range and the current limited use of the Bay, compared to the overall abundance of the subspecies, the local population of brown pelicans was probably never very significant.

4.2.3 Colonial Waterbirds and Seabirds

Nesting colonial waterbirds and seabirds occur in a variety of Estuary habitats and comprise several species groups. These include cormorants, herons, egrets, gulls, terns, and alcids (Table 4-1). They may nest on isolated islands, in shrubs or trees, on salt-pond levees, or at any site relatively free of predators. Predators that threaten eggs, young, and occasionally adults include rats, cats, dogs, foxes, skunks, raccoons, and a variety of avian species. However, human disturbance and habitat loss have often been the primary threats to breeding populations of these species. With expanding human populations and resulting development, sites where colonial waterbirds and seabirds can nest free from encroachment are becoming rare. Because they are primarily fish eaters, they are also sensitive to bioaccumulation of pollutants through the food web.

Colonial waterbird and seabird breeding colonies may exhibit great plasticity in site selection. For example, gulls and terns nest on salt-pond levees, and cormorants nest on towers and bridges. Herons and egrets may nest at sites near aquatic feeding areas in trees that are inaccessible to ground predators (Pratt 1983). Cormorants and gulls tend to be very site-faithful unless the habitat is removed or birds are continuously disturbed, but individuals of other species are more likely to move among colonies, depending on food availability and human disturbance. This may complicate estimates of annual nesting success unless all colonies are surveyed at the same time each year. Because of differing survey techniques, the remoteness of colonies, and the secretive behavior of some species, the best use of census data may be to describe colony trends and not absolute population size. The most consistent and comprehensive census of colonial waterbirds has been that of heron, tern, and gull populations in South San Francisco Bay, conducted for the last ten years by the staff of the San Francisco Bay Bird Observatory, San Jose State University, and the San Francisco Bay National Wildlife Refuge. Coverage of the North Bay Region, Suisun Marsh, and the Delta has generally been less consistent, but, in 1990, Audubon Canyon Ranch began a comprehensive annual inventory of heron and egret breeding colonies in the North Bay (Marin, Sonoma, Napa, Solano, and Contra Costa counties).

Table 4-1. Estimates of Numbers of Nesting Colonial Waterbirds and Seabirds in the San Francisco Estuary as of the 1990 Breeding Season (Sources: Carter et al. 1990, Stenzel et al. 1990, San Francisco Bay Bird Observatory unpubl. data, U.S. Fish and Wildlife Service unpubl. data).

Species	Nesting Pairs
Double-crested cormorant	1,185
Brandt's cormorant	63
Pelagic cormorant	58
Great blue heron	160
Great egret	350
Snowy egret	950
Black-crowned night-heron	1,000
Western gull	1,623
California gull	2,221
Caspian tern	1,409
Forster's tern	1,775
California least tern	89
Pigeon guillemot	46

4.2.3.1 Double-crested Cormorant

Double-crested cormorants nest in fresh, brackish, and saltwater areas across North America. This species is a good example of an indigenous species that has successfully adapted to drastic human alteration of the Bay Region. Cormorants nest on artificial structures such as the San Francisco-Oakland Bridge, the Richmond-San Rafael Bridge, transmission towers adjacent to the San Mateo Bridge and near Antioch, and towers and duck blinds in the Napa salt ponds area (Carter et al. 1990). A few also nest on trees in Napa and Sacramento counties. Low-salinity salt ponds, particularly in the South Bay, receive significant use for both foraging and roosting, especially during the fall months (Figure 4-4).

In the late 1800s, double-crested cormorants nested on Seal Rocks near Lands End (Grinnell and Wythe 1927). By the early 1900s, the colony size was reduced to fewer than 50 pairs, due in part to human disturbance, and it eventually disappeared. The next most recent record was nesting in dead Eucalyptus trees in the Napa salt ponds in 1978 (Varoujean 1979).

Nesting on the San Francisco-Oakland and Richmond-San Rafael bridges was not documented until 1984. In recent years, the Richmond-San Rafael Bridge has become an important breeding site for these cormorants. In 1984, fewer than 20 nests were counted in the first bridge survey (S. Bailey and L. Feeney, pers.comm.). In 1988, the first year of accurate monitoring, 296 nests were documented, and, even though 1988 was a relatively poor reproductive year for cormorants overall, about 290 young fledged from this site (Carter et al. 1989). In 1989, the colony increased by 31.4 percent to 389 active nests, and

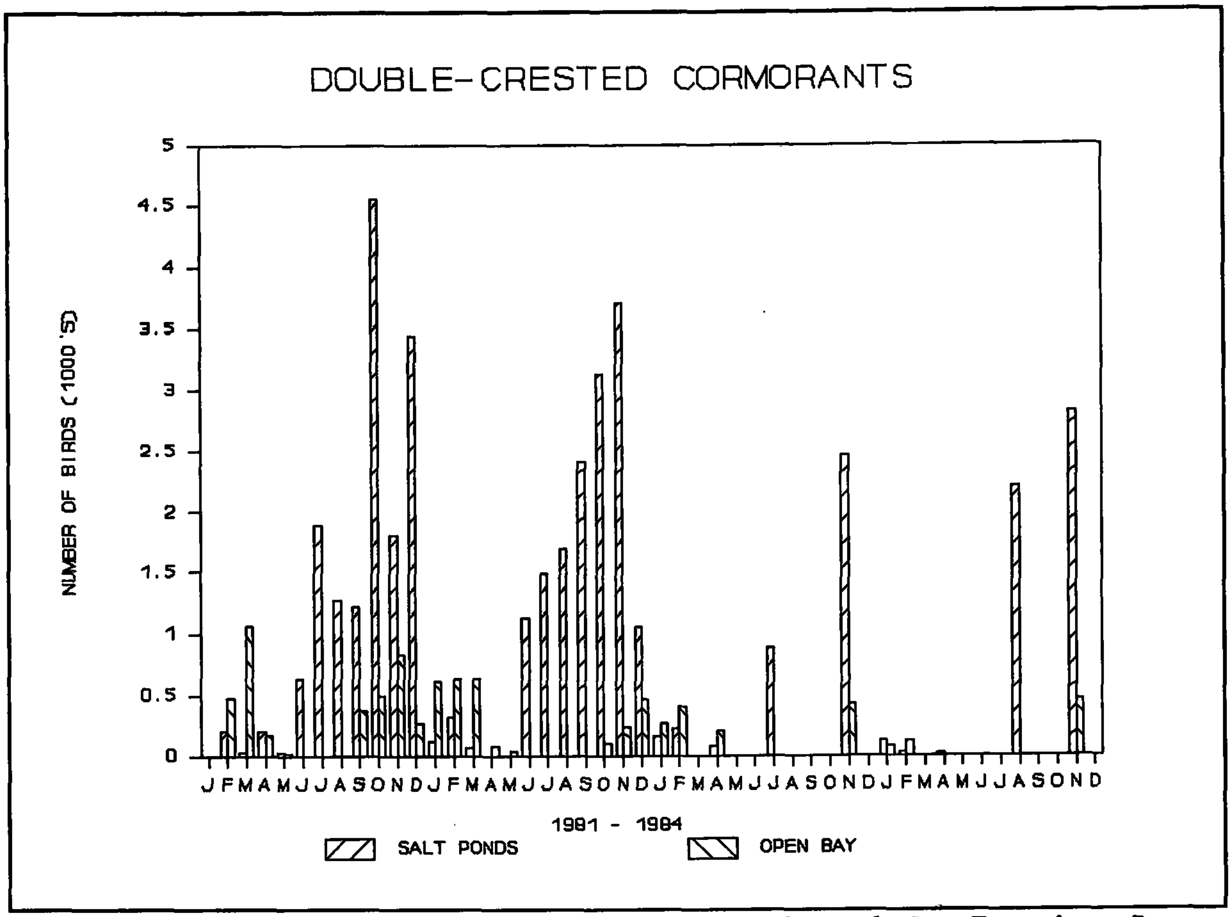

Figure 4-4. Results of Monthly Aerial Surveys of South San Francisco Bay Salt Ponds. No Surveys Were Conducted on: 1/81;3,5,6,8-10,12/83 and 3,5-7,9,10,12/84. Source: California Department of Fish and Game/U.S. Fish and Wildlife Service (unpubl. data).

fledging success improved to where approximately 690 chicks fledged (Rauzon et al. 1989). In 1990, 422 nesting pairs used the bridge, almost 10 percent more than in 1989, making it the fourth largest colony in the state (Carter et al. 1990, Stenzel et al. 1991). One source of breeding cormorants on the Richmond-San Rafael Bridge is the Farallon Islands National Wildlife Refuge; birds banded as young on the Farallon Islands have been observed nesting on the bridge (Carter et al. 1989).

In 1990, 465 pairs nested on the San Francisco-Oakland Bridge (P. Henderson, Point Reyes Bird Observatory, pers. comm.), making it the second largest colony on the northern and central California coasts (Carter et al. 1990). During other surveys by Point Reyes Bird Observatory and the U.S. Fish and Wildlife Service in 1990 (Carter et al. 1990), 76 nests were found on utility towers along the San Mateo Bridge, 153 nests were found in dead trees and on duck blinds on the Russ Island salt ponds of Napa County, 20 nests were found on San Pablo Bay radar targets, 4 nests were found on a San Pablo Bay beacon nearby, and 28 nests were found on a transmission tower at Donlon Island, near Antioch. Seventeen nests were documented at a traditional colony site in cottonwood trees in North Stone Lake, about 10 miles south of Sacramento. In 1990, the approximately 1,185 nesting pairs (Table 4-1) of double-crested cormorants in the Estuary comprised about 36 percent of the entire population occurring in the coastal region of northern and central California (Carter et al. 1990). In 1991, an additional colony of 26 nests was observed on Wheeler Island in Suisun Bay (J. Kelly, Audubon Canyon Ranch, pers. comm.).

The local increase in the nesting population of double-crested cormorants coincides with the observed trend currently occurring throughout California and North America (Sowls et al. 1980, Hobson et al. 1989, Carter et al. 1990). Possible factors contributing to these increases include the decline in use of organochlorine pesticides and local reductions in populations of large fish such as striped bass and salmon, thus contributing to increased availability of small fish for foraging cormorants. In addition, colonization of anthropogenic structures was crucial to the introduction of large numbers of breeding double-crested cormorants into the Estuary.

4.2.3.2 Other Cormorant Species

The Brandt's cormorant is principally found along the outer Pacific coast from Baja California to British Columbia. Within San Francisco Bay, these birds are primarily transients and winter residents (Grinnell and Miller 1944). Roosting birds have been observed at the Brothers Islands and Red Rock. However, during a bay-wide seabird survey, a colony of four nests was discovered in 1990 at Yerba Buena Island, marking the first record of their breeding in the Bay (Carter et al. 1990). Also at this site, two pelagic cormorant nests were found. The only other pelagic cormorant colony within the Bay is at the Needles, a rock just inside the Golden Gate Bridge near the north approach, where seven nests were found in 1989 (Carter et al. 1990). Outside the Golden Gate Bridge, in the Golden Gate National Recreation Area, pelagic cormorants nest at Point Bonita, Bonita Cove, and Point Diablo Bluffs (totalling 51 nests in 1989); 53 Brandt's cormorant nests were also documented at Lobos Rock at Lands End, along the south shore to the Bay entrance (Carter et al. 1990). Totals of 63 and 58 pairs of Brandt's and pelagic cormorants, respectively, were estimated to have nested within the study area during 1989-1990 (Carter et al. 1990).

4.2.3.3 Great Blue Heron

Great blue herons are found in fresh and salt water habitats from southern Canada and Southeast Alaska to Florida and Mexico (Palmer 1978). This species is a permanent resident of California and breeds in the study area (Grinnell and Miller 1944). During July through October, they are common in low-salinity salt ponds (Cogswell 1977). Great blue herons are sensitive to human disturbance near colony sites and have also probably been negatively affected by pesticide use (Jackman and Scott 1975). Although no comprehensive Estuary-wide surveys of great blue heron colonies have been attempted, approximately 160 nesting pairs are currently believed to utilize the area (Table 4-1).

State-wide periodic surveys during the late 1960s through the early 1980s revealed a general increase in numbers. However, wide fluctuations in colony size, as individuals move from one colony to another, and the presence of widely scattered colony sites throughout the study area make it difficult to monitor overall trends in the great blue heron breeding population. Numerous historic colonies have been destroyed or abandoned as land has been developed and rookery trees felled. For example, at Grizzly Island Ranch (Solano County), a colony with an estimated 43 pairs of great blue herons in 1977 was eliminated in 1982, when the nesting trees were removed as part of the development of a new duck club (California Department of Fish and Game, unpubl. data).

The status of this species has been of concern to the California Department of Fish and Game since the early 1970s (Gould 1973). For example, during the 1970s and early 1980s, the rate of abandonment of rookeries within the Estuary exceeded the rate at which new colonies had been discovered by about a two to one margin (Schlorff 1982).

In the South Bay, the most active and well-monitored colony has been at Bair Island near Redwood City (San Mateo County), where birds nested on coyote brush growing on dredge spoil deposits (Carriger and Pemberton 1908). Between 1967 and 1969, 30 pairs nested on this island (Gill 1977). In 1971, the population peaked at 49 pairs, but it declined to only 7 pairs by 1984 (Stone and Rigney 1978). In 1989, there were 17 nests with 48 chicks (P. Woodin, San Francisco Bay Bird Observatory, pers. comm.).

Trends in this colony have been influenced by the ongoing degeneration of the coyote brush which supports the nest sites. To offset this loss of nest sites, artificial platforms have been erected over the last few years. Great blue herons have used these structures, with use peaking in 1990 when 21 of 22 observed nests were located on these sites (San Francisco Bay Bird Observatory, unpubl. data). The arrival of introduced red foxes to outer Bair Island was first documented during April 1991 (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.). Subsequent visits to the island have revealed complete abandonment of this traditional colony site by nesting populations of herons, egrets, and terns.

Great blue herons have used a variety of nesting substrates in the Estuary, including seven pairs that nested on old windmills and duck blinds in salt ponds in the Baumberg Tract (San Francisco Bay Bird Observatory 1988) and small numbers on transmission towers at Bair Island (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.). Great blue herons nesting in the Delta, near reservoirs and in other woodland sites within the study area generally use trees, such as oaks, cottonwoods, redwoods, Eucalyptus, and California buckeye.

Population trends for great blue herons are difficult to characterize. Surveys of rookeries in the study area are inconsistent and reflect the scattered nesting distribution of the species, as shown by the following records. Known nesting sites in recent years include San Pablo Reservoir, which supported 11 nests in 1991, and Lake Chabot Reservoir in San Leandro, which had 11 nests in 1978 and 35 nests in 1990. There were nine nests in the Alameda Creek quarries in Fremont in 1990 and, in 1988, there were 20 nests in Calaveras Reservoir (J. DiDonato, East Bay Regional Park District, pers, comm.). In the Napa Marsh salt ponds only two nests were found in 1990 (H. Carter, U.S. Fish and Wildlife Service, pers. comm.), perhaps because double-crested cormorants had taken over the nest trees (Rauzon and Carter 1988, Carter et al. 1990). In 1979, 10-20 pairs of herons were observed nesting in eucalyptus trees near Hastings Slough east of Grizzly Island (T. Harvey, U.S. Fish and Wildlife Service, unpubl. data). A colony existed on Brown's Island (Contra Costa County) in 1962, but no birds were observed at the site in 1989 (H. Cogswell, pers. comm.). In Sacramento County, a colony on North Stone Lake supported 49 nests in 1990.

Several locations have been reported in Marin County to support nesting great blue herons. During 1990, the largest great blue heron colony found in the North Bay (32 nests), was at Stafford Lake (Marin County) near Novato (J. Kelly, Audubon Canyon Ranch, pers. comm.). In 1991, the entire colony failed due to predation. In 1990, one nest was located on West Marin Island (H. Pratt, Audubon Canyon Ranch, unpubl. data), and eight were found on DeSilva Island at the north end of Richardson Bay (Marin County). In 1990, 22 pairs nested at North San Pedro Road (Marin County), but the entire colony failed due to predation. At least seven pairs renested on a nearby ridge in 1990, and 17 nested there in 1991 (J. Kelly, Audubon Canyon Ranch, pers. comm.). Other miscellaneous North Bay nesting reports during 1991 include 13 nests from Napa County, four from Marin County, one from Solano County (Joice Island) and 16 from Sonoma County (J. Kelly, pers. comm.).

4.2.3.4 Great Egret

Great egrets breed from southern Oregon south through the Central Valley and into the San Francisco Estuary. The California population is isolated from other populations, breeding at scattered locations across the United States (Palmer 1978). In the Estuary, breeding great egrets outnumber great blue herons. Approximately 350 breeding pairs nested within the Estuary in 1990 (Table 4-1).

Beginning in the 1880s, great egrets were virtually extirpated in the Bay Area by plume hunters; the lowest population level was estimated to occur in 1902-03. Population recovery was first noted in the Bay Area in 1924 (Stoner 1934), and with continued protection, the numbers of nesting egrets continued to build.

In the South San Francisco Bay Area, nesting may have occurred historically, but it was first verified in 1977. At that time, a breeding population of 10 great egrets was located nesting within tules in a tidal marsh along Mallard Slough in Alviso. A 1990 census revealed an estimated 30 pairs nesting at this site (San Francisco Bay National Wildlife Refuge, unpubl. data). They have also nested in low numbers at Bair Island where they were first observed in 1987, and where 10 nests were recorded in 1990 (San Francisco Bay Bird Observatory, unpubl. data). As previously described, this species has abandoned Bair Island for nesting, following the arrival of red foxes.

As with other species, colony size may vary as individuals move among sites. In Suisun Marsh, Grizzly Island Ranch had increasing numbers of great egrets in the early 1980s, with 76 pairs nesting there in 1981, until the rookery was destroyed in 1982 (California Department of Fish and Game, unpubl. data). In 1990, approximately 42 nesting pairs were observed near the mouth of Volanti Slough on western Joice Island where nesting has occurred at least since the late 1970s (B. Grewell, California Department of Water Resources, pers. comm.). The species was also observed nesting in 1979 near Tree Slough on Grizzly Island (T. Harvey, U.S. Fish and Wildlife Service, pers. comm.). In a 1991 survey, J. Kelly (Audubon Canyon Ranch, pers. comm.) found 197 great egret nests in Suisun Marsh at five sites including Tree Slough (8), Volanti Slough (10), Joice Island (87), Bohannan (6), and Simmons Island (86).

Great egrets first began breeding at Oakland's Lake Merritt in 1971, possibly as birds were displaced from other rookeries. An estimated 33 pairs nested at this urban location during 1990 (S. Alavarez, City of Oakland, pers. comm.). Great egrets nest in the tops of buckeye trees at West Marin Island; ground surveys found 155 nests on the island in 1990 (R. Hothem, U.S. Fish and Wildlife Service, unpubl. data). The North Stone Lake colony (Sacramento County) had 52 great egret nests in 1990. In 1989, 35 adults were observed on nests on Sherman Island (Sacramento County) (H. Cogswell, pers. comm.), but none were found there in 1991 (J. Kelly, pers. comm.). In 1990 and 1991, there was a colony of about 30 pairs of great egrets in Solano County, near Jepson Prairie (J. Kelly, pers. comm.).

Results of past contaminant analyses at the Audubon Canyon Ranch colony (Marin County) demonstrated that eggshell thinning had occurred among great egrets and great blue herons. In the early 1970s, egret eggshells averaged 15.2 percent thinner than pre-1947 museum specimens. This effect was attributed to the use of chlorinated hydrocarbons which may have contributed to a decline in the mean number of young fledged from 1.4 per nest in 1967 to 1.0 in 1970 at this location (Pratt 1972).

4.2.3.5 Snowy Egret

Prior to the 1880s, snowy egrets were locally common, but overharvest by plume hunters led to the species being considered extirpated from California by the early 1900s. By 1908, snowy egrets were recorded again in the state but Grinnell and Wythe (1927) considered them to be rare stragglers in the Bay Region. By 1943 they were considered fairly common in the San Joaquin and Sacramento Valley and from Marin County south to Mexico (Grinnell and Miller 1944). Today, snowy egrets are considered numerous within the Estuary where about 950 nests were recorded in 1990 (Table 4-1).

Numbers of snowy egrets nesting in the South Bay colonies at Bair Island and Mallard Slough have ranged from more than 2,000 individuals in 1981 to an average 763 birds during 1984-1990 (Figure 4-5). Since, dense emergent vegetation at the Mallard Slough colony in the South Bay prevents counts of individual nests, estimates at this site are derived only from visual counts of total adults flushed. In 1990, 532 adults (about 266 nests) were counted at Mallard Slough, while at Bair Island, 185 nests were found (P. Woodin, San Francisco Bay Bird Observatory, pers. comm.). The future breeding status of this species in the South Bay remains doubtful given the recent abandonment of Bair Island and the threat posed by the red fox to the remaining Mallard Slough colony.

West Marin Island has been a snowy egret stronghold for many years. The highest count of nests recorded by boat surveys was 500 in 1982; the lowest was 126 in 1986 (H. Pratt, unpubl. data). In 1990, 463 nests were found during a ground survey (R. Hothem, U.S. Fish and Wildlife Service, unpubl. data). Lake Merritt in Oakland supports a site which reportedly has been relatively stable, and where 43 nests were counted in 1990 (S. Alvarez, City of Oakland, pers. comm.). In 1991, snowy egrets were observed to breed for the first time in recent years at Brooks Island, where two nests were found (R. Hothem, U.S. Fish and Wildlife Service, unpubl. data). They also are suspected of breeding in small numbers on Red Rock; they were first noted there in 1988 (H. Carter and M. Rauzon, pers. comm.). In the Delta, the Brown's Island heronry contained about 150 adult snowy egrets in 1962, with about 100 nests present. No birds were present at this site in 1989 or in 1991 (H. Cogswell, California State University Hayward, and J. Kelly, Audubon Canyon Ranch, pers. comm.).

4.2.3.6 Black-crowned Night-Heron

The black-crowned night-heron is common throughout the study area (Grinnell and Miller 1944). Censusing of breeding colonies is difficult because night-herons often nest in dense vegetation, including tules, coyote brush, and poison oak, and disturbance during surveys may adversely affect reproduction. Historic, but now abandoned, colonies occurred on Belvedere Island (Marin County), in Alameda, and near Alvarado (Alameda County). During 1969-82, monitoring of active rookeries in the Estuary revealed a high of 623 nests in 1971 and a low in 1982 of only 80 (Schlorff 1982); however, the 1982 figure may also reflect incomplete coverage of the survey area. State-wide, there is concern for the night-heron population because of loss of nesting habitat (Gould 1973).

Bair Island has been traditionally the largest South Bay colony for this species, and it is where most nest monitoring has occurred. At this location, the first nests of night-herons were recorded during 1970 in low-lying areas supporting pickleweed (Gill 1977), and, by 1977, an estimated 515 pairs nested in coyote brush. As with other species, significant fluctuations in nest numbers have been noted at this site. For example, numbers of nests ranged from 380 in 1978, (Stone and Rigney 1978) to 229 in 1990 (San Francisco Bay Bird Observatory unpubl. data). As already described, the recent arrival of introduced red foxes to Bair Island had caused the abandonment of this

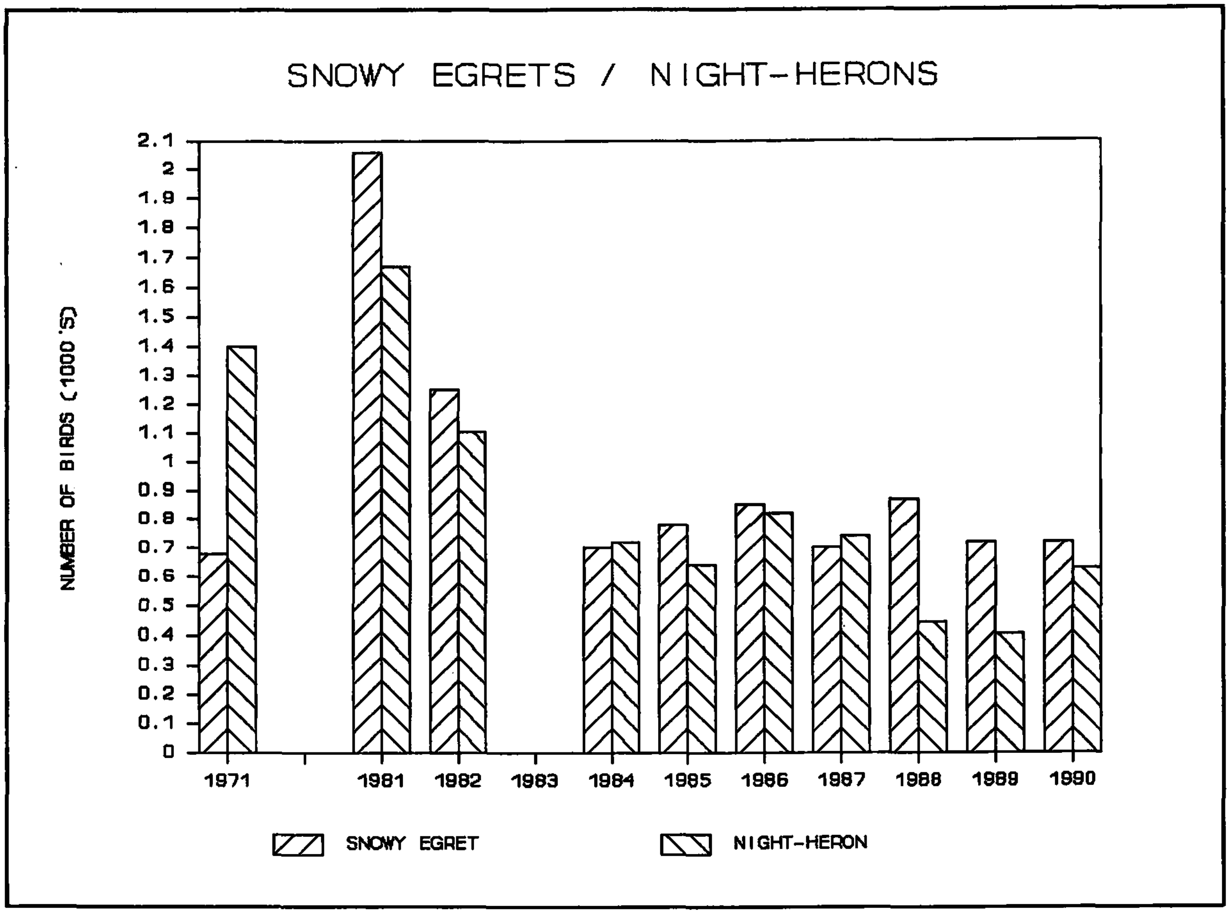

Figure 4-5. Individual Nesting Egrets and Herons in South San Francisco Bay; No Data Available for 1983. Source: Gill (1973), Rigney and Rigney (1981), San Francisco Bay National Wildlife Refuge/San Francisco Bay Bird Observatory (unpubl. data).

traditional colony site by herons in 1991.

The second major breeding site in the South Bay is at Mallard Slough. This site was first identified in the mid 1970s and has steadily increased in size since then (San Francisco Bay Bird Observatory, unpubl. data). Numbers have ranged from 42 adults in 1978 to at least 229 in 1990. During 1990, the total estimated number of nesting black-crowned night-herons in the South Bay was about 343 pairs (Figure 4-5), which is a downward trend from ten years ago when about 835 nested (P. Woodin, San Francisco Bay Bird Observatory, pers. comm.).

In the North Bay, the major black-crowned night-heron colony is at West Marin Island. Based on counts from boats during the 1980s, total numbers of night-heron nests at West Marin Island have declined from 109 nests in 1981 to only 37 nests in 1990 (Pratt, unpubl. data). However, boat counts of night-herons at this location significantly underestimated nest numbers in 1990, since a ground survey in late April revealed a total of 306 nests (R. Hothem, U.S. Fish and Wildlife Service unpubl. data), nearly 10 times more than were reported from the June boat survey. In general, boat surveys provide a useful population index for some easily detectable species, such as snowy and great egrets, but they are less reliable for estimating night-heron abundance.

Night-herons have nested on Alcatraz Island since about 1981. In 1986, 37 nests were located in mirror bush (Coprosma repens) (Alvarez and Thomas 1989). During an extensive search in 1990, 169 nests were found (R. Hothem, U.S. Fish and Wildlife Service, unpubl. data). In 1990, 60-90 night-heron nests were located on Brooks Island, and 40-90 were estimated to occur on Red Rock (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.). Herons had been first noted nesting on Red Rock in 1988 by Point Reyes Bird Observatory personnel (Rauzon and Carter 1988). In 1989, Robert Crown Memorial State Beach in Alameda supported three nests, and there were 56 nests in Lake Merritt in Oakland (Alvarez and Thomas 1989). In 1990, there were 40 nests at Napa State Hospital and 3 at the Oak Street site in Penngrove (Solano County) (J. Kelly, Audubon Canyon Ranch, pers. comm.). In 1990, about 70 percent of the Estuary's nesting night-herons were located in the North Bay. Overall, more than 1,000 night-heron nests were located within the study area in 1990, making this species the most abundant breeding wading bird (Table 4-1).

Nesting night-herons are vulnerable to predation by northern harriers, ravens, turkey vultures, and other night-herons (H. Ohlendorf, CH2M Hill, pers. comm.). In addition, during monitoring of nesting activities in San Francisco Bay, abnormal embryos and crushed eggshells have been discovered, suggesting that contaminant-related reproductive problems exist (U.S. Fish and Wildlife Service, unpubl. data). Brooks Island, a colony newly established in 1988, is near the Levin Richmond Terminal, a U.S. Environmental Protection Agency Superfund clean-up site containing high concentrations of DDT and related compounds. If night-herons feed on contaminated prey in this area, adverse effects on their reproduction may occur.

4.2.3.7 Other Wading Birds

White-faced ibis are locally common summer residents, which are increasing in numbers in the study area. Ibis prefer to nest in dense tules in permanent freshwater emergent marshes (Grinnell and Miller 1944), but they use rice fields for feeding. During recent years, a colony near Colusa (Sacramento National Wildlife Refuge) has exhibited a near annual doubling of numbers (S. Berendzen, U.S. Fish and Wildlife Service, pers. comm). Another colony, also expanding outside of the study area, is located in the Spreckels Sugar Company ponds in Woodland (Yolo County). Within the area, individuals have been observed at Coyote Hills Regional Park (Alameda County) and at Mallard Slough in 1989 (J.E. Takekawa, U.S. Fish and Wildlife Service, pers. comm.), but breeding has not been documented. Contaminant studies at Carson Lake Wildlife Management Area in Nevada have revealed thin eggshells and lower production of young to be correlated with elevated levels of DDE (Henny and Herron 1989). The species is currently designated as a category 2 Federal candidate (U.S. Fish and Wildlife Service 1990a).

The cattle egret is among the most abundant breeding wading birds in California, especially around the Salton Sea (Schlorff 1982). This is an Old World species which has spread throughout southern North America, and the occurrence of cattle egrets in the study area is expected to increase. The species was first detected breeding within the Mallard Slough heron colony in 1986 when two nests were discovered (P. Woodin, San Francisco Bay Bird Observatory, pers. comm.). The number of adults observed at the colony increased to a high of 18 in 1989. Perhaps as many as four pairs attempted to nest in 1990 (P. Woodin, San Francisco Bay Bird Observatory, pers. comm.). Unconfirmed reports from Lake Merritt in Oakland of an adult with a young may indicate breeding at that location (S. Alvarez, City of Oakland, pers. comm.).

Little blue herons nest in small numbers at Mallard Slough. In 1987, only four adults were counted at that site; in 1990, one pair nested. Since the late 1960s, individual birds have been seen almost annually within the study area.

American bitterns are primarily fresh or brackish marsh birds which nest in dense tules and other emergent vegetation. They are residents of the study area but are not commonly observed, and due to their secretive nature, their nests are seldom located. Elimination of permanent freshwater marsh throughout the study area has undoubtedly led to a major decline in abundance and distribution of this species.

4.2.3.8 Large Gull Species

The expansion of sanitary landfills in the 1970s served to increase gull populations in all parts of the study area (Drury 1979 in Sowls et al. 1980). Gull numbers in the region have generally increased and appear stable despite the closing of the main dumps in the study area during the early 1980s. One of the first nearly Bay-wide gull population surveys was conducted prior to the dump closures by L. Spear (Point Reyes Bird Observatory, unpubl. data). Landfills surveyed included Richmond and three that have since closed: Alameda (closed 1980), San Leandro (1980), and Berkeley (1983). Alviso, Palo Alto, and Novato were also occasionally surveyed. It was estimated that 87-95 percent of the larger gulls (western, glaucous-winged, western x glaucous-winged hybrids, herring, Thayer's, and glaucous gulls) foraging at San Francisco Bay Area landfills were recorded during these surveys (Figures 4-6 and 4-7). It was also estimated that approximately 30 percent of the total large gull population occurring within the San Francisco Bay Region foraged at the landfills.

The western gull was the major species using landfills in the early 1980s with populations peaking in the winter months (Figure 4-6). Glaucous-winged gulls, winter visitors, were second in abundance at dump sites. Generally, glaucous-winged gulls were more likely to forage at inland dumps than western gulls. Several other species were also common at landfill sites (Figure 4-7). Thayer's gulls were prevalent at pig farms in the Delta until they closed in the early 1980s. About 750 Thayer's gulls also traditionally foraged in the Brentwood area; and 500 utilized the Belevedere/Tiburon area, feeding opportunistically on algae and schooling fish (S. Moorhouse, Woodward-Clyde Assoc., pers. comm.)

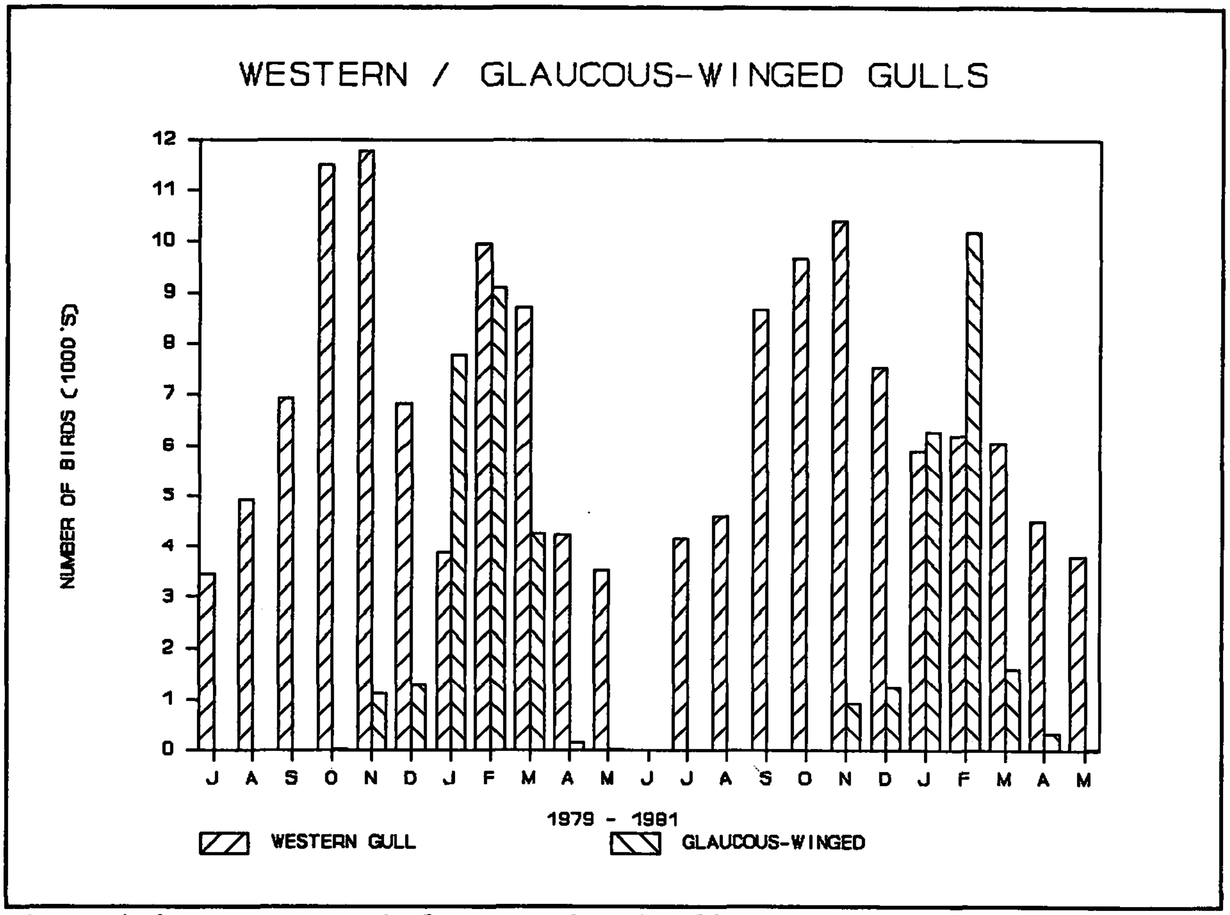

Figure 4-6. Western and Glaucous-winged Gulls Counted During Monthly Visits to the Richmond, Berkeley, Alameda and San Leandro Dumps. No Census Conducted in June 1980. Source: L. Spear, Point Reyes Bird Observatory, unpubl. data.

4.2.3.9 Western Gull

The western gull nests from the most southern coast of British Columbia to the Mexican border (Grinnell and Miller 1944) and is the most numerous breeding gull in California. In 1979-1980, Sowls et al. (1980) identified 170 gull colonies along the California coast totaling 50,930 breeding birds; 39,180 of these birds were in northern and central California, with the vast majority (32,000) reported nesting at the Farallon Islands, and a few reported nesting in San Francisco Bay. Population estimates for the current number of breeding western gulls in northern and central California are similar (33,760 breeding birds), but only 22,000 were nesting on the Farallon Islands in 1989 (Carter et al. 1990). U.S. Fish and Wildlife Service surveys found 3,264 birds nesting in the Estuary in 1990, making the Estuary the second most important nesting area in northern and central California, accounting for 10 percent of all nesting western gulls in the region (Carter et al. 1990). The

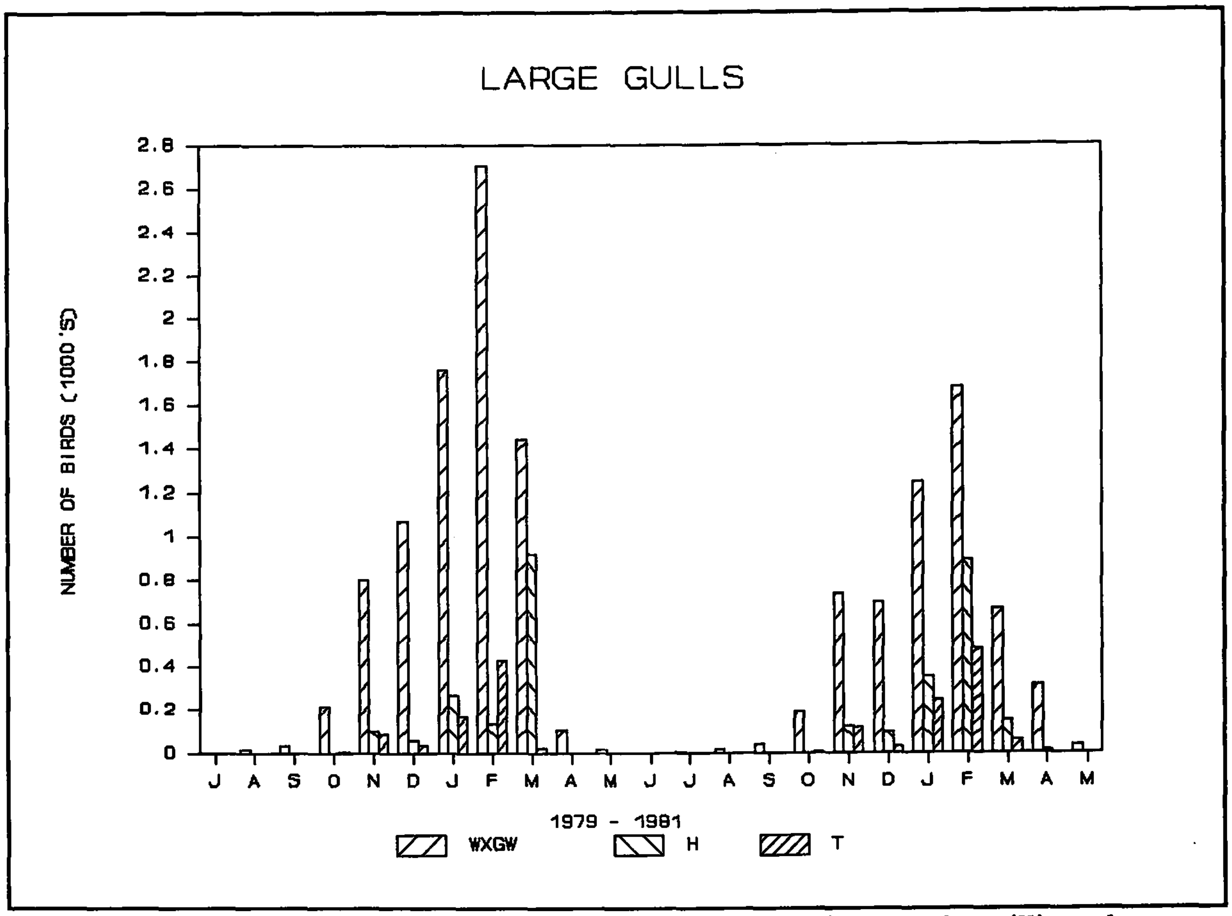

Figure 4-7. Western x Glaucous-winged Hybrid (WxGW), Herring (H) and Thayer's (T) Gulls Counted During Monthly Visits to Richmond, Berkeley, Alameda and San Leandro Dumps; No Census in June 1980. Source: L. Spear, Pt. Reyes Bird Observ. (unpubl. data).

number of breeding pairs at the South Farallon Islands has remained stable since 1959 at between 22,000 and 26,000 (Ainley and Lewis 1974, Carter et al. 1990).

Grinnell and Wythe (1927) listed only the colonies on the Farallon Islands and cliffs at Point Reyes as active Bay Area sites. No doubt, individual scattered nests missed detection, but major colonies such as are now found on Alcatraz Island, Bay breakwaters, and San Francisco piers, had not yet formed. Grinnell and Miller (1944) reported nests on Oakland Bay Bridge piers and as far north as the Carquinez Straits. Although they questioned the report of a colony "100 miles up the Sacramento River". In 1990, western gulls were reported nesting as far inland as the "Mothball Fleet," east of the Benicia Bridge in 1990 (Carter et al. 1990).

During 1990, 1,623 breeding pairs were estimated to occur within the study area, including San Francisco and San Pablo bays and the outer coast from Point Bonita to Seal Rocks (Carter et al. 1990). This is about 10 percent of the entire northern and central California population (Carter et al. 1990). The largest colonies within the Bay are located on Alcatraz Island (450 nests) and Alameda Naval Air Station breakwater (244). Other major colonies are Red Rock (192), Brooks Island (49), West Marin Island (48), East and West Brothers Islands (89), San Francisco-Oakland Bridge (21), Yerba Buena Island (31), and the San Francisco piers (180). Numerous pilings, piers, and channel markers support the remaining nesting pairs (Rauzon and Carter 1988, Carter el al. 1990).

Within the study area, western gull numbers have been observed to increase during the last ten years. Sowls et al. (1980) included estimates for some existing main colonies but did not report other sites that are currently significant. Either they were absent, less conspicuous, or new sites have been colonized and overall numbers have therefore increased. A colony at breakwater island at the Alameda Naval Air Station became established around 1982 when perhaps as many as 30 pairs first bred. This colony has grown from over 160 pairs in 1984 to 244 in 1990 (S. Bailey, California Academy of Science, unpubl. data, Carter et al. 1990).

As shown by monthly counts at Central San Francisco Bay Area landfill sites (Figure 4-6), western gulls were the major species present, with winter populations peaking in November (L. Spear, Point Reyes Bird Observatory, unpubl. data). During 1979-1981, populations feeding at San Francisco Bay Area dumps peaked in 1979 at 11,759. Populations then declined in December and January to lows of about 4,000 during April through August when birds congregate at major breeding areas such as the Farallon Islands National Wildlife Refuge. In spite of the closures of landfills at Alameda, San Leandro, and Berkeley, gull numbers remain high as evidenced by stable numbers on the Farallon Island National Wildlife Refuge and increased nesting activity within the Bay.

4.2.3.10 California Gull

Exhibiting a great range of habitat use, California gulls are found foraging over the ocean, open bays, tidal mudflats, freshwater and saltwater marshes, lakes, ponds, agricultural lands, lawns, and schoolyards (Grinnell and Miller 1944). They range from California throughout the northern, inter-mountain states, and into central Canada where they commonly nest on shores and islands of alkaline and freshwater lakes and salt ponds.

In California, the species previously nested only on lakes in the northeastern plateau (Grinnell and Miller 1944). However, Dawson (1923) reported California gulls breeding at an unspecified site on the Sacramento River. The largest colony in the State is on Negit Island in Mono Lake with 44,000-49,000 birds breeding per year during the 1983-89 seasons; 60,000 breeding birds were reported in 1990.

Since the 1930s, diversions of water from four tributaries to Mono Lake by the City of Los Angeles Department of Water and Power have caused fluctuations and declines in lake water levels. This, in turn, has exposed the nesting colony to substantial predation by coyotes and resulted in the current State designation of the California gull as a Species of Special Concern. The 1989 Third Appellate Court of Appeal decision, which commands Los Angeles to reduce their diversions to where the tributary fish populations can be restored and maintained, should stabilize lake levels and benefit this species.

In 1981, a foundling colony of thirty pairs of California gulls was discovered in South San Francisco Bay nesting on dredge-spoil islands on the Knapp property salt pond. Gulls banded as fledglings at Mono Lake have since been observed at this colony. In 1982, approximately 103 pairs nested at this site, and by 1989, it had expanded to approximately 2,382 nesting pairs at three South Bay sites (Figure 4-8). The colony was roughly the same in 1990, with 2,221 nesting pairs counted (P. Woodin, San Francisco Bay Bird Observatory, pers. comm.). As a result of this dramatic nesting explosion, the California gull is now the most abundant seabird breeding in the Estuary study area (Carter et al. 1990) (Table 4-1). The two main colonies; the Knapp

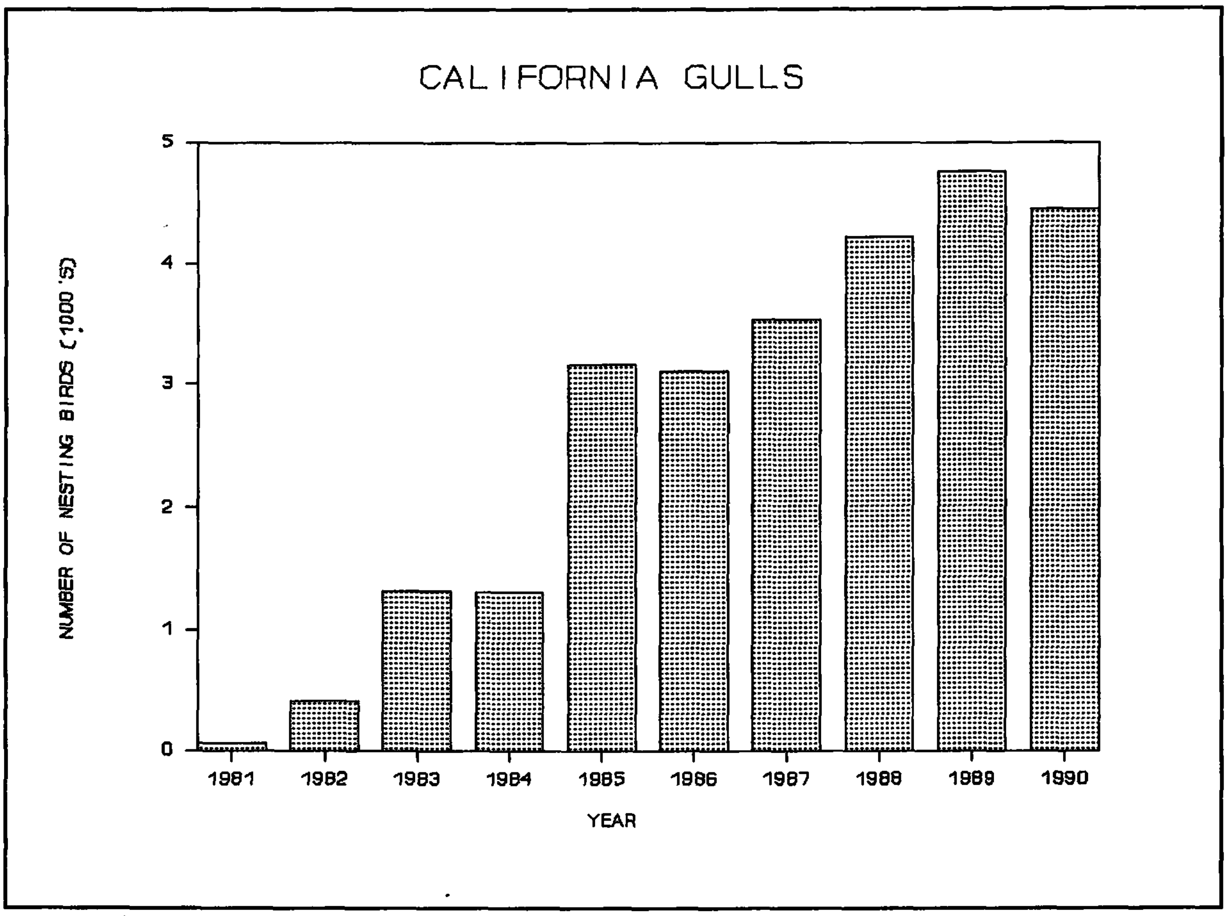

Figure 4-8. Total Numbers of Individual California Gulls Observed Nesting in the South San Francisco Bay Salt Ponds. Sources: Rigney and Rigney (1981), San Francisco Bay National Wildlife Refuge/San Francisco Bay Bird Observatory (unpubl. data).

property and the A-9 salt pond, are both within the San Francisco Bay National Wildlife Refuge northwest of Alviso (Santa Clara County). The combination of relatively predator-free islands for nesting and the abundant food available in nearby landfills in Alviso, Newby Island, Mountain View, and Palo Alto as well as the salt ponds, provide suitable conditions for this opportunistic species (Rigney and Rigney 1981). California gulls also use salt ponds extensively in the Napa Marsh, in particular Knight Island, for foraging and roosting, and they may eventually breed in that area (H. Carter, U.S. Fish and Wildlife Service, pers. comm.).

In addition to nesting in large numbers, the species is also an abundant winter visitor within the study area. They return in early spring and begin nesting in April in the South Bay colonies. Throughout their range, opportunistic foraging on grasshoppers and crickets has been well documented. It was vast flocks of California gulls that saved a struggling Mormon colony besieged by long-horned grasshoppers (Mormon crickets) at Salt Lake, Utah, in the late 1880s.

4.2.3.11 Bonaparte's Gull

The Bonaparte's gull is a common winter migrant in the study area. At times, especially in spring, it is locally abundant, typically feeding or roosting in salt ponds (Grinnell and Wythe 1927). Their use of tidal habitats within the Bay is very low. However, at night many birds fly out to the Bay apparently to roost until daylight (H. Cogswell, California State University Hayward, pers. comm.).

These gulls primarily occur within the study area from October through April in dense flocks on high salinity (75-200 parts per thousand) salt ponds where they actively feed on invertebrates such as brine shrimp and brine flies (Ephydra spp.), and small fish (Figure 4-9). Densities as high as 0.9 gulls per acre on South Bay salt ponds of 120-149 parts per thousand, were observed during California Department of Fish and Game/U.S. Fish and Wildlife Service aerial surveys during 1981-1985. Swarth et al. (1982) reported 0.8 birds per acre on salt ponds in Fremont.

In counts conducted between 1981 and 1984, peak numbers occurred in November and December, with a peak count of 11,757 in November 1984 (Figure 4-9). During the rest of the year, their numbers declined to about 3,000 by the spring, and these gulls were absent except for a few individuals during the mid-summer months (California Department of Fish and Game/U.S. Fish and Wildlife Service, unpubl. data). By the end of April, most have left the study area for their nesting grounds in the interiors of Alaska and Canada.

4.2.3.12 Caspian Tern

Caspian terns, common summer residents throughout the study area, breed at many locations in North America and winter in Mexico and Central America. Prior to large-scale conversion of tidal marsh to salt ponds, both Caspian and Forster's terns had only been migrants in the Bay Region. With the availability of isolated, relatively predator-free dikes and islands,

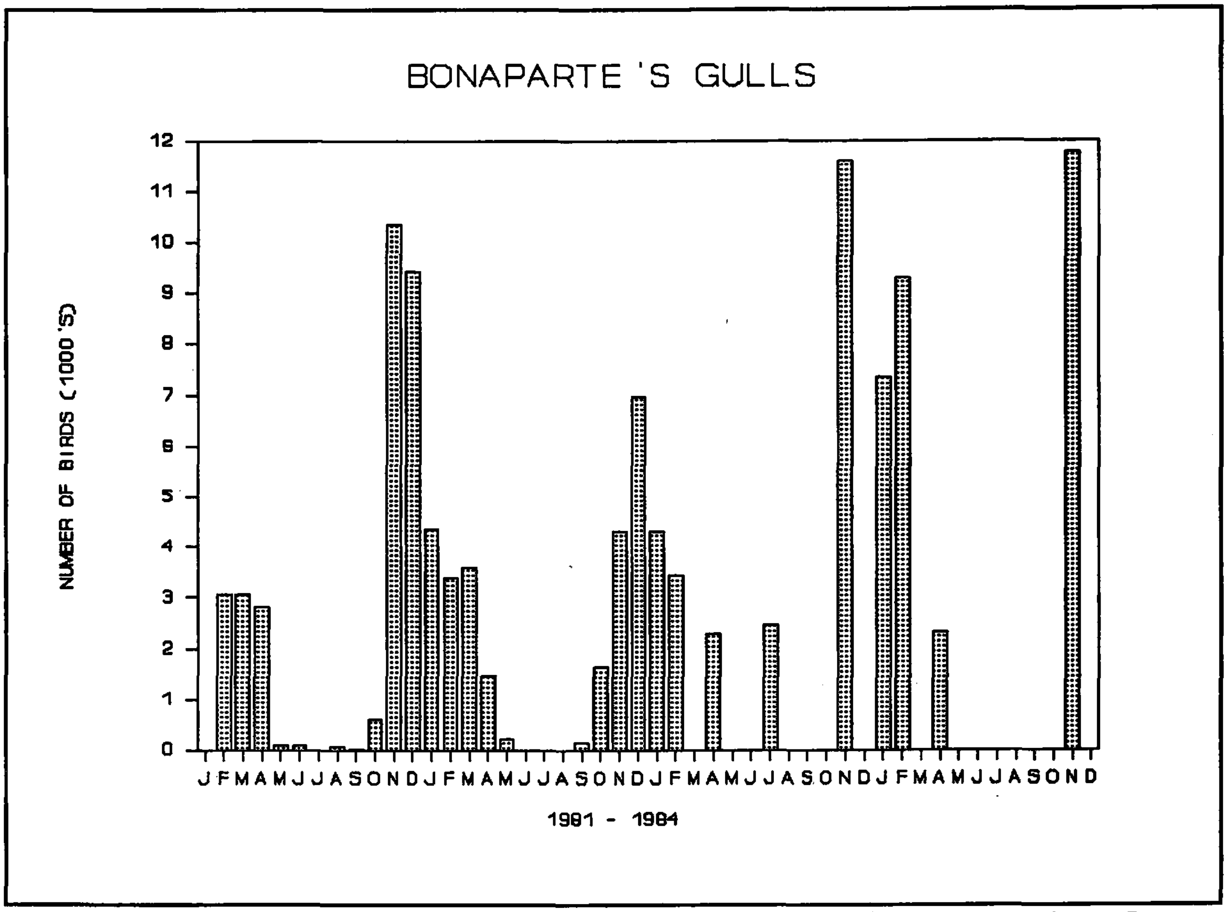

Figure 4-9. Results of Monthly Aerial Surveys of South San Francisco Bay Salt Ponds. No Surveys Were Conducted on: 1/81;3,5,6,8-10/83 and 3,5-7,9,10,12/84. Source: California Department of Fish and Game/U.S. Fish and Wildlife Service (unpubl. data).

following creation of the salt ponds, Caspian terns were soon documented nesting in the South Bay in 1916 (Grinnell and Miller 1944).

In 1971, the total South Bay breeding population was estimated to be 1,000-1,200 nesting individuals (Figure 4-10) (Gill 1973); in 1981, 2,350 birds nested (Rigney and Rigney 1981). Nesting in the South Bay has occurred at a number of traditional salt pond sites, including west of Coyote Hills, Bair Island, Mowry Slough, Turk Island, and the Baumberg area. Breeding activity has shifted among these sites, typically in response to human disruption from routine salt pond dike maintenance. From 1981 to 1989, the South Bay population has fluctuated annually, averaging 1,620 birds counted at colonies (Figure 4-10). Unfortunately, the South Bay population experienced near complete breeding failure in 1990, with only about 100 nest sites (at Bair Island) reported (P. Woodin, San Francisco Bay Bird Observatory, unpubl. data). Following surveys of both the South and North Bays in 1989-1990, the total breeding population for the Estuary was estimated to be 2,818 birds

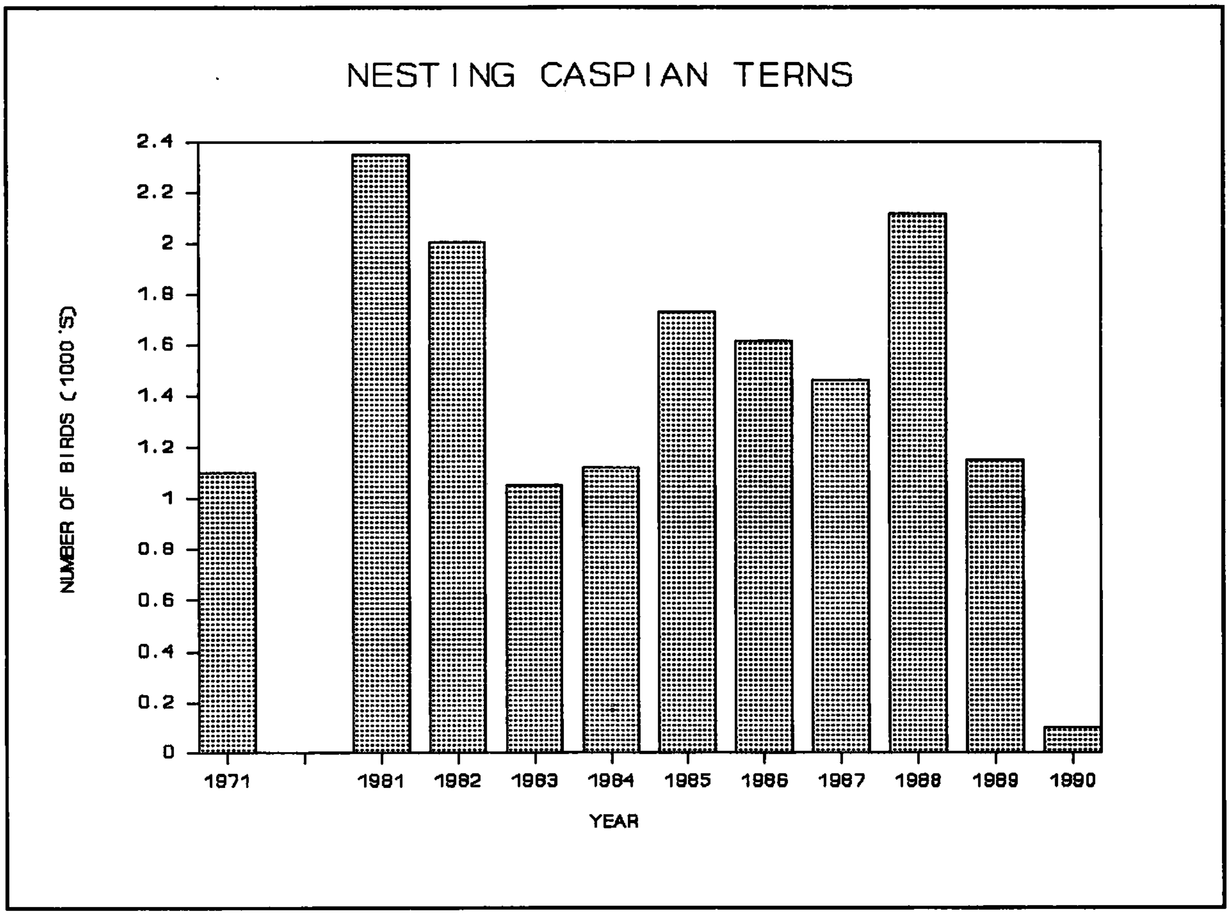

Figure 4-10. Numbers of Caspian Terns Counted at Nesting Colonies in the South San Francisco Bay Salt Ponds. Sources: Gill (1973), Rigney and Rigney (1981), San Francisco Bay National Wildlife Refuge/San Francisco Bay Bird Observatory (unpubl. data).

(Carter et al. 1990) (Table 4-1). These authors multiplied counts of birds at colonies with a rough correction factor of 1.25 to account for birds that were away from the colony at the time of the count.

Major factors currently affecting colonies of both Caspian and Forster's terns primarily in the South Bay and, to a limited extent, elsewhere in the study area, include disruptions due to levee maintenance forcing colonies to relocate, predation, and erosion of levees leading to tidal inundation of the Bair Island colony. The threat from predation was demonstrated in 1990, when the introduced red fox caused the complete failure of the Mowry Slough colony (P. Woodin, San Francisco Bay Bird Observatory, pers comm.). The recent arrival of red foxes on Bair Island has also accelerated abandonment by Caspian terns of the only other colony site used by this species in the South Bay.

Other Caspian tern colonies in the North and Central Bay, such as the Alameda Naval Air Station which recently had about 600 breeding pairs, may be less vulnerable to some of these disruptions. However, other potential conflicts and threats exist. The relatively new colony that started in the early 1980s at predator-free Brooks Island, supported about 60 nests with up to 400 adults counted in June 1990 (Carter el al. 1990). Both these colonies may increase in importance as birds relocate from displaced South Bay colonies. However, potential conflicts with air traffic at the Alameda Naval Air Station may occur if that colony continues to expand. At Brooks Island, increased public access may adversely affect the growth of this foundling colony. Finally, if Caspian terns nesting at Brooks Island feed on contaminated prey from the nearby Levin Richmond Terminal Superfund Site, adverse effects on their reproduction may occur.

4.2.3.13 Forster's Tern

Historically, the Forster's tern was a common spring and fall migrant in the study area (Grinnell and Wythe 1927). With the creation of nest sites in the salt ponds, the species is now a common resident in summer, migrant in spring and fall, and a less common resident in winter (Figure 4-11). This

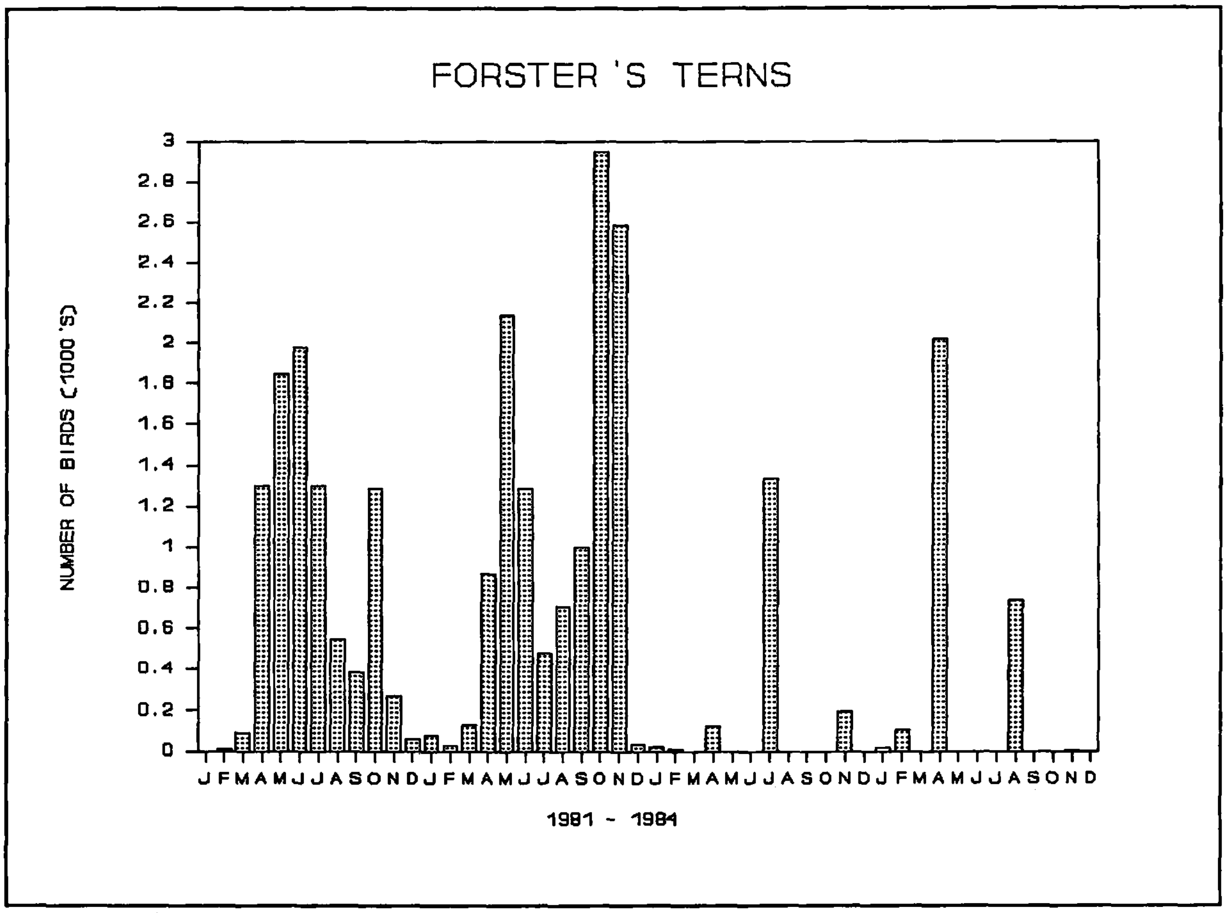

Figure 4-11. Results of Monthly Aerial Surveys of South San Francisco Bay Salt Ponds. No Surveys Were Conducted on: 1/81;3,5,6,8-10,12/83 and 3,5-7,9,10,12/84. Source: California Dept. of Fish and Game/U.S. Fish and Wildlife Service (unpubl. data).

species nests in several western North American states, southwestern Canada and the Atlantic and Gulf Coasts; it winters in the southern United States through Central and South America (Cogswell 1977, Peterson 1990). Forster's terns forage over both the open water and the low-salinity salt ponds of the Estuary. The species was first recorded breeding in South San Francisco Bay in 1948, and, by 1953, three colonies were established in that portion of the Bay (Sibley 1953). Traditionally, the largest colony in the study area has been located on small islands in salt pond B-2 near Mountain View on the San Francisco Bay National Wildlife Refuge. Other sites have been established at salt ponds near Alviso, the Baumberg area, and Redwood City. Additional nesting also occurs in the Napa Marsh salt ponds, but survey efforts for colonial birds in that area have been sporadic and poorly documented.

Gill (1973) estimated that 2,400 and 4,000 individuals nested in the South Bay in 1971 and 1972, respectively; Rigney and Rigney (1981) reported approximately 2,500 breeding birds in that region in 1981 (Figure 4-12). In 1989-1990, surveys of both the South Bay and the Napa Marsh provided an

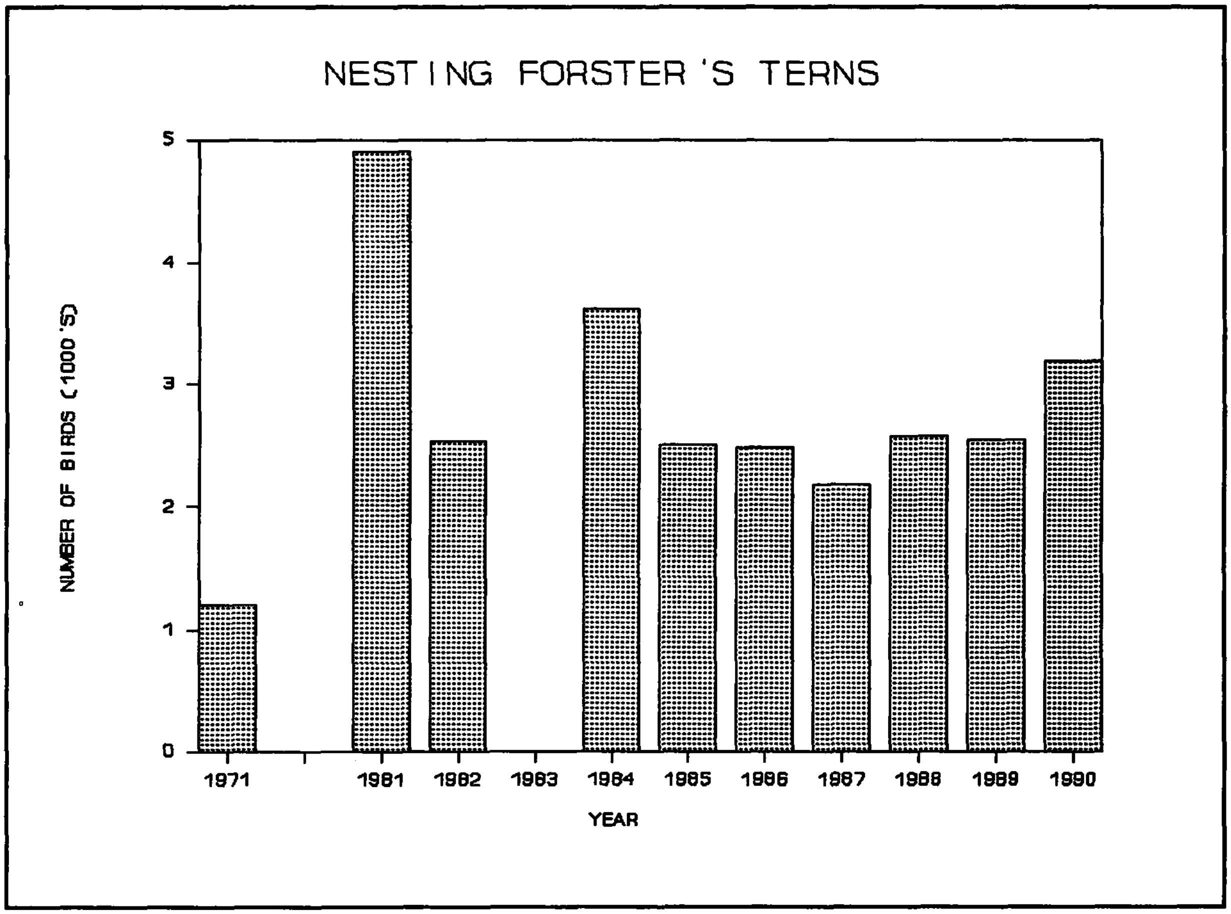

Figure 4-12. Numbers of Forster's Terns Counted at Nesting Colonies in the South San Francisco Bay Salt Ponds; No Survey in 1983. Sources: Gill (1973), Rigney and Rigney (1981), S.F. Bay National Wildlife Refuge/S.F. Bay Bird Observatory (unpubl. data).

estimate of the breeding population for the Estuary of 3,550 individuals (Carter et al. 1990) (Table 4-1).

Both Forster's and Caspian terns that nest in salt ponds are vulnerable to disruption caused by periodic dike maintenance and extreme water level fluctuation as well as predation by species such as the Norway rat and red fox. Of the two species, Forster's tern is more opportunistic and better able to rapidly exploit suitable nesting conditions (Harvey 1982).

4.2.3.14 California Least Tern

The California least tern (Sterna antillarum browni) historically nested on coastal sandy beaches from the Pajaro River mouth and Moss Landing (Santa Cruz and Monterey counties), where it occurred as recently as 1956, southward into northern Baja, Mexico (Grinnell and Miller 1944, Atwood et al. 1979, Carter et al. 1990). During the last 40 years, the estimated thousands of birds which originally nested in the state have been reduced to a little over 1000 nesting pairs. Factors causing this population reduction include displacement of colonies by coastal development, introduced predators, and recreational disturbance. As a result, the California least tern was listed as an endangered species by the State and Federal governments in 1970 (U.S. Fish and Wildlife Service 1990a).

Even though they were considered rare fall stragglers in the Bay Area in the early 1900s (Grinnell and Wythe 1927), large flocks of postbreeding least terns were often observed dispersing from coastal colonies (Wilbur 1977). The first verified Bay Area nesting occurred on an Alameda sandy bayfill (Ballena Bay) in 1967, probably following displacement from the coast (Anderson 1970b). However, the subspecies may have been nesting undetected at other Alameda locations since the mid-1960s (R. Erickson, LSA Associates, pers. comm.). The Ballena Bay site was soon eliminated by residential development as was a second site colonized about 1969 at Bay Farm Island (Alameda County) (Anderson 1970b).

The least tern currently nests at scattered locations, including the Alameda Naval Air Station and the Oakland International Airport (Alameda County), where major nesting efforts occur. Other nesting sites are Port Chicago and the Pittsburg Pacific Gas and Electric power plant (Contra Costa County) (Collins 1987). In previous years, additional nesting colonies were located at Bair Island, the Redwood City salt ponds (San Mateo County), salt ponds in the Baumberg area, and west of Coyote Hills (Alameda County) (Atwood et al. 1979, Feeney and Collins 1985, Carter et al. 1990).

The total numbers of least terns nesting in the Bay Area have fluctuated significantly over the years, averaging 74 pairs a year during 1973-1989. Nesting estimates for before 1980 resulted from inconsistent monitoring efforts. Carter et al. (1990) reported that about 89 pairs of birds attempted to nest within the Estuary during 1990 (Table 4-1).

Within the study area, least terns nest on open, flat, artificial terrain with a smooth sandy or hardpan surface such as bayfill sites, abandoned salt ponds, and aircraft runways. During the 1990 nesting season, predation by introduced red foxes on least terns in Northern California was first documented at the Oakland International Airport where complete nesting failure occurred (L. Feeney, pers. comm.). In Southern California tern colonies, red foxes have caused nesting failure or abandonment at some locations. Some of these sites have shown recovery through the use of electrified or chain-link fences and the re-establishment of local coyote populations which eliminate the red fox (Massey 1988).

Current threats to successful breeding by least terns in the Bay Area include predation by species such as red foxes, feral cats, rats, opossums, northern harriers, American kestrels, and common crows, as well as human disturbance. Successful nesting at the Alameda Naval Air Station is dependent on a predator control program that includes an electric fence surrounding the colony to keep out mammalian predators and an intensive predator trapping program. Predator removal is also necessary at the Oakland Airport. Other more long-term threats include invasion of colony sites by exotic vegetation and increasing boat traffic leading to deterioration of foraging habitat in adjacent eelgrass beds.

Generally, least terns forage for small fish in the open water adjacent to their colonies. In addition, two sites supporting low-salinity salt ponds in Hayward (Alameda County) and Palo Alto (Santa Clara County) provide undisturbed pre-migratory staging sites that are important to foraging terns during the post-nesting dispersal period (July-August). In these areas, young-of-the-year birds develop fishing skills prior to their southward migration to Central and South America (Massey and Atwood 1982). In Hayward (Alameda County), one of these post-nesting salt pond sites is currently indirectly threatened by a proposed development that could increase predation or human disturbance.

4.2.3.15 Elegant Tern

Following dispersal from breeding colonies primarily in the Gulf of California, mainland Baja and also in southern California (Cogswell 1977), this species is a fairly common to abundant fall (mid-July through mid-October) visitor north to the central coast of California. Prior to the onset of nesting in Southern California, the species was considered an irregular, rare straggler in the Bay Region (Grinnell and Wythe 1927, Grinnell and Miller 1944).

This tern is most commonly observed foraging or roosting near breakwaters and marinas in the Central Bay. However, peaks of 358 to 753 birds have been observed over the open bay and salt ponds south of the San Mateo Bridge during August-October (California Department of Fish and Game/U.S. Fish and Wildlife Service, unpubl. data). Ongoing threats of human disturbance to Mexican and Southern California colonies render the species vulnerable to possible extirpation in the State and account for its status as a category 2 Federal candidate (U.S. Fish and Wildlife Service 1990a). The elegant tern is also considered as a third priority State Species of Special Concern (Remsen 1978).

4.2.3.16 Common Murre

In 1989, common murres nested at eight colonies along the Central California coast, mainly at the Farallon Islands and along the Marin County coast south of Point Reyes to the Golden Gate (Carter et al. 1990). This population declined 52.6 percent between 1980-1982 to 1986 (including the loss of the Devil's Slide Rock colony south of the Golden Gate) due to high mortality from gill-net fishing and oil spills plus poor reproduction during the severe 1982-1983 El Niño event (Takekawa et al. 1990; also see Ainley and Boekelheide 1990, Page et al. 1990). An additional 7 percent decline has occurred from 1986 to 1989 (Carter et al. 1990).

Murres regularly forage in the waters just inside the Golden Gate, as far as Treasure island (H. Carter, U.S. Fish and Wildlife Service, pers. comm.). In summer, they are found inside Alcatraz Island more rarely. In June 1990, U.S. Fish and Wildlife Service personnel observed murres off Horseshoe Bay (50), Yerba Buena Island (38), Hunter's Point (2), Oakland Inner Harbor mouth (1), and Candlestick Park (1) (H. Carter, U.S. Fish and Wildlife Service, pers. comm.).

4.2.3.17 Pigeon Guillemot

Pigeon guillemots were confirmed breeding in San Francisco Bay on Alcatraz Island in 1982. This is apparently the first record for inside the Golden Gate Bridge (Sowls et al. 1980). Perhaps as many as 10 pairs of guillemots were breeding on Alcatraz Island during 1983 through 1989 (Boarman 1989, Carter et al. 1990). Outside the Golden Gate Bridge, 86 pigeon guillemots were reported breeding at Point Bonita and Lobos Rock (Carter et al. 1990). Approximately 46 pairs were estimated by Carter et al. (1990) to have nested within the Estuary during 1989-1990 (Table 4-1).

4.2.3.18 Marbled Murrelet

Although they are occasionally reported in winter and rarely in summer in the waters off Lands End at the entrance to the Golden Gate, marbled murrelets (Brachyramphus marmoratus) have been recorded only rarely within San Francisco Bay (Carter and Erickson 1988). None currently nest or have ever been known to nest in the Estuary area, although a small population exists on the outer coast of southern San Mateo and northern Santa Cruz counties (Sowls et al. 1980, Carter and Erickson 1988, Paton and Ralph 1988). Marbled murrelets may have bred in the vicinity of the Golden Gate (Marin County) or the Oakland Hills in the late 1800s (Carter and Erickson 1988).

Loss of old-growth forest nesting habitat and mortality from gill-net fishing and oil spills probably has caused large declines in their numbers since the 1800s, especially in California, Oregon, and Washington. Several were reported killed in a 1937 oil spill in the Golden Gate (Aldrich 1938, Moffitt and Orr 1938). The species has been proposed for designation as a threatened species at the Federal level and has been classified as an endangered species at the State level.

4.2.4 Waterfowl

4.2.4.1 Introduction

The San Francisco Estuary is one of the most important staging and wintering areas for migratory waterfowl populations in the Pacific Flyway. More ducks winter in the Estuary than in the much larger Chesapeake Bay (Perry 1987).

Waterfowl present in San Francisco Bay and the Sacramento-San Joaquin Delta during all or part of the year may be divided into dabbling ducks, diving ducks, mergansers, geese, and swans. Dabbling ducks commonly found in the Bay Area during all or part of the year include mallard, northern pintail, gadwall, American wigeon, green-winged teal, cinnamon teal, and northern shoveler.

Diving ducks found in the Bay include redhead, canvasback, ring-necked duck, greater scaup, lesser scaup, common goldeneye, Barrow's goldeneye, bufflehead, and ruddy duck. The surf scoter is the most abundant diving duck found in San Francisco Bay; fewer numbers of white-winged scoters occur, and the black scoter is occasionally found. Mergansers include the common, hooded, and red-breasted merganser, but because an average of only 73 were recorded in the San Francisco Bay Estuary during the 1985-1989 midwinter waterfowl surveys, they are not considered a major species group (J. Bartonek, U.S. Fish and Wildlife Service, unpubl. data).

Geese found in the Bay Area include "white geese" (snow goose and Ross' goose), greater white-fronted geese (tule and Pacific), and Canada geese, including the cackling Canada goose and the Federally-threatened Aleutian Canada goose.

Even though the San Francisco Estuary is particularly vital as a wintering and migrational area for waterfowl, some reproduction also occurs in the region, primarily limited to relatively small numbers of mallards, gadwalls, northern pintails, cinnamon teal, and ruddy ducks. Within the study area, tidal marshes, diked wetlands, and seasonal wetlands are of primary importance to nesting waterfowl (Houghten et al. 1989).

Recent improvements in management of upland nesting cover at the Grizzly Island Wildlife Area in Suisun Marsh have encouraged mallards and pintail to nest in increasing numbers (McLandress and Yarris 1986). In 1988, 677 duck nests (593 mallard, 47 gadwall, 25 pintail, 6 cinnamon teal, and 6 northern shoveler) were found in the upland habitat of the Suisun Marsh (McLandress et al. 1988). In 1988, the total nests found and the nesting success (23 percent) in Suisun Marsh was lower than in the previous three years; mammalian predation was the primary factor reducing nesting success.

Gill (1973) estimated that 50-100 pairs of northern pintail, 100-150 pairs of gadwall, 100-150 pairs of mallard, 25-50 pairs of ruddy ducks, 75-100 pairs of cinnamon teal, and 2-5 pairs of northern shovelers nested in the South Bay. In recent years, primarily introduced populations of Canada geese have begun nesting within the Bay Area in small numbers.

Breeding waterfowl in the Delta have not been studied closely. However, the breeding population is probably comprised of species known to breed in Suisun Marsh. The relatively few breeding ducks in the Delta are associated with either freshwater marsh habitats or with riparian woodland habitats that are essential to the breeding population of wood ducks.

4.2.4.2 Waterfowl Censuses

The midwinter waterfowl survey, the oldest of the continental surveys, is a cooperative effort of the U.S. Fish and Wildlife Service and the individual States. Conducted annually, generally during the first week of January, the midwinter attempts to count all species of waterfowl in major concentration areas. Once the major means of monitoring waterfowl populations, it now supplements better data acquired from various breeding and other special surveys. The midwinter survey provides an index to population trends, rather than an estimate of total numbers. Variations in survey coverage, weather, observers, and distributional patterns of waterfowl in the flyway markedly influence annual indices for a particular state. Within the Estuary, separate counts are made for waterfowl in the Delta, Suisun Marsh, and San Francisco Bay.

In 1987, a study was initiated by the U.S. Fish and Wildlife Service to better document and describe the abundance and distribution of waterfowl within San Francisco Bay. To accomplish this goal, aerial surveys were used to census waterfowl in six subregions of the Bay: (1) South Bay salt ponds (including sewage ponds, sloughs, marshes, and river mouths); (2) South Bay (open water south of San Mateo Bridge); (3) Central Bay (open water between San Mateo Bridge and Richmond-San Rafael Bridge); (3) North Bay (open water of San Pablo Bay north of Richmond-San Rafael Bridge and west to Carquinez Straits); (5) North Bay salt ponds (including sewage ponds, sloughs, marshes, and river mouths); and (6) Suisun Bay (open water east of Carquinez Straits, including Suisun, Grizzly, and Honker bays; but not including Suisun Marsh or the Delta).

4.2.4.3 Waterfowl Distribution and Abundance in the Estuary

The San Francisco Bay Area provides wintering grounds for many species of California waterfowl. San Francisco Bay has consistently wintered nearly one-half (47 percent during 1981-1990) of the total birds of the entire Estuary. It is an especially important site for wintering diving ducks. On average, more than 57 percent of the total diving ducks observed during the previous 10 years of midwinter waterfowl surveys in California were counted in

San Francisco Bay. This may, however, underestimate the populations. Midwinter surveys are conducted during early January, which may not always coincide with the period when diving duck populations peak in the Bay Region (U.S. Fish and Wildlife Service, unpubl. data). During the past three years, for example, numbers peaked in December in two years, and two weeks after the midwinter survey the other year (L. Accurso, U.S. Fish and Wildlife Service, unpubl. data).

Midwinter surveys during 1981-1990 indicated that an average of about 193,000 waterfowl were present on the open water and salt ponds of San Francisco Bay. During the last ten years, scaup made up the greatest proportion of all waterfowl (34.9 percent), followed by scoters (13.7 percent), northern shovelers (12.0 percent), ruddy ducks (10.7 percent), and canvasbacks (8.5 percent) (Figure 4-13). The most abundant diving duck species observed in the Bay during midwinter surveys over the past ten years, in descending order of abundance, have been scaup, surf scoter, ruddy duck, canvasback, and bufflehead.

During the 1987-1990 study, more waterfowl were observed in the North Bay (30 percent) and in South Bay salt ponds (23.6 percent) than in the other four areas (Figure 4-14). Within the salt ponds, dabbling duck use was highest in low-to mid-salinity ponds (Takekawa et al. 1988). Northern shovelers, wigeon, northern pintail, and other dabbling ducks comprised about 70 percent of the waterfowl on the South Bay salt ponds. Scaup and scoters made up the majority of ducks in the open water areas of South, Central, and North bay. Together, these two species comprised 96, 92, and 96 percent of the waterfowl found in the Central, North, and South bays, respectively. Ruddy ducks were the most common on the salt ponds in both the north and south ends of the Bay, while canvasbacks preferred the North Bay salt ponds and Suisun Bay (Figure 4-14) (L. Accurso, U.S. Fish and Wildlife Service, unpubl. data).

The Sacramento-San Joaquin Delta is a waterfowl wintering area of national and international significance (California Department of Fish and Game and California Department of Water Resources 1962), generally supporting about 10 percent of California's wintering waterfowl. During 1981-1990, about 24 percent of the waterfowl counted in the Estuary in winter were counted in the Delta. Together, the Delta and Suisun Marsh to the west, the grasslands to the south, and other Sacramento and San Joaquin Valley habitats provide wintering grounds for nearly two-thirds of the waterfowl in the Pacific Flyway. At least 25 waterfowl species are found in the Delta, mostly in winter, including one swan species, four goose species, and 20 duck species. The most abundant waterfowl species in the Delta, as shown by the annual midwinter waterfowl survey data for the past ten years, have been northern pintails (an average of 37 percent of the total), geese (27 percent), and tundra swans (17 percent).

In the Delta, use by wintering waterfowl is limited early in the season and generally peaks later in the fall and winter (U.S. Fish and Wildlife Service 1978a). For example, Delta band recoveries from white-fronted geese begin in October and peak in early January (Timm and Dau 1979), before the end

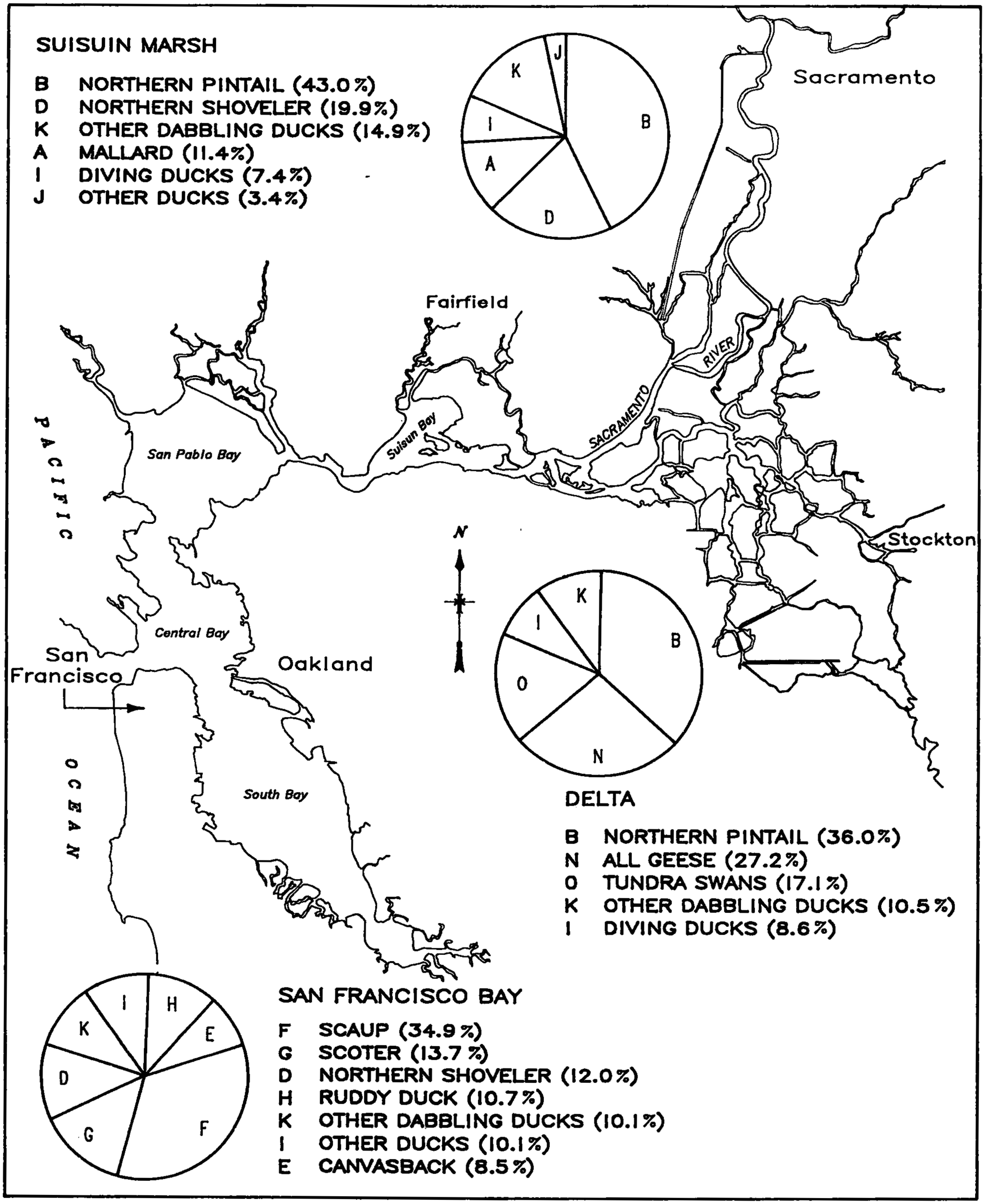

Figure 4-13. Average Relative Composition of Waterfowl Species in the San Francisco Estuary, Including San Francisco and San Pablo Bays, Suisun Marsh, and the Sacramento-San Joaquin Delta, 1981-1990.

of the hunting season. White-fronted geese remain in the Central Valley through April (McCaskie et al. 1979). Tundra swans arrive in the Delta relatively late in the winter, peaking during December through February (Bellrose 1980). McCaskie et al. (1979) gave the peak season as November through March.

The wintering waterfowl of the Delta may be considered part of the overall Central Valley population, because predictable and regular movement occurs between the two areas. These patterns are influenced by, and are dependent on, weather changes, water conditions, food availability, and season. The patterns do not apply during unusually wet years when flooded habitat in the Central Valley increases dramatically, as when the Yolo Bypass floods (U.S. Fish and Wildlife Service 1978a). Waterfowl tend to leave Suisun Marsh, Napa Marsh, and San Pablo Bay and move to the Delta and other areas when winter rains begin. However, relatively large numbers of waterfowl remain in Suisun Marsh when winter rains are late. Similarly, large numbers of birds move from Suisun Marsh to the Delta when farmers begin to flood their agricultural fields (U.S. Fish and Wildlife Service 1978a). Corn and other cereal grains grown in the Delta have been found in the crops of Suisun Marsh ducks late in the season, indicating that these birds forage in the Delta (Michny 1979).

Although many of the tidal wetlands of the Delta have been converted to agricultural lands, they are still valuable habitat for wintering waterfowl. In the past 25 years, major crops have shifted from potatoes, asparagus, and tomatoes to corn, sorghum, alfalfa, and pasture grasses (U.S. Fish and Wildlife Service 1978a). These new crops favor waterfowl and are supporting larger concentrations of waterfowl in the Delta than earlier in the century (Michny 1979). Much of the value of agricultural lands in the Delta results from the practice of flooding fields in the winter to leach out salts and to control weeds or insects (Rollins 1977 in Herbold and Moyle 1989, U.S. Fish and Wildlife Service 1978a, Michny 1979). Because corn, probably the most valuable crop to waterfowl, is among the most salt-sensitive crops (Madrone Associates et al. 1980), corn fields require regular leaching (Rollins 1977). The amount of habitat created by agricultural flooding varies yearly, depending on the crops grown and on weather, but, generally, about 25 percent of Delta islands are flooded by mid-December (F. Wernette, California Department of Fish and Game, pers. comm.). This generally coincides with normal peaks in waterfowl use.

Within the Delta, waterfowl have grown dependent on crop wastes for food (Madrone Associates et al. 1980). For example, the Delta corn crop increased five-fold from 1962 to 1976-77 (Michny 1979), but since the mid-1970s, the percentage in corn production has remained relatively stable (F. Wernette, California Department of Fish and Game, pers. comm.). In general, geese and swans make the most use of flooded agricultural fields (Madrone Associates et al. 1980), but dabbling ducks also utilize flooded fields for feeding and roosting. Nonflooded agricultural fields are secondary in importance. In the Delta, both white-fronted and snow geese prefer to feed in open, nonflooded corn fields (Bauer 1979). For Ross' geese, both flooded and nonflooded corn fields provide essential feeding habitat. Northern pintails feed extensively

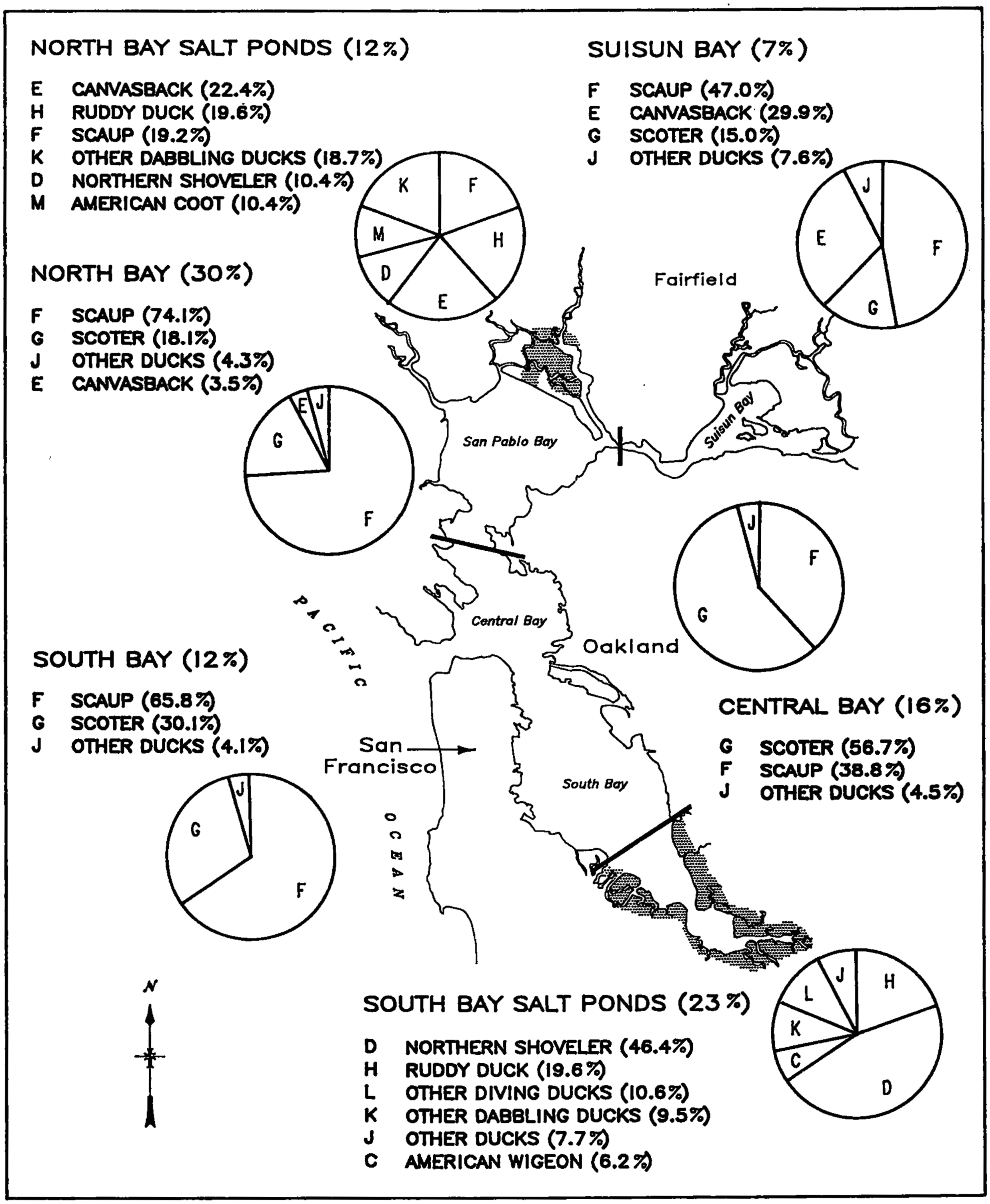

Figure 4-14. Average relative composition of waterfowl species in the San Francisco Estuary during 1987-1990, for six subregions including Suisun Bay, North Bay Salt Ponds, North Bay, Central Bay, South Bay, and South Bay Salt Ponds. Percentages indicate percent of the average number of birds counted per survey by subregion (Source: L. Accurso, U.S. Fish and Wildlife Service, unpubl. data).

on barley, rice (Bellrose 1980), corn, and other cereal grains in the Delta (Michny 1979).

Overall, during 1981-1990, Suisun Marsh wintered an average of about 30 percent of the total waterfowl counted in the San Francisco Bay Estuary. During that same period, the northern pintail was by far the most numerous species, comprising an average of 43 percent of the waterfowl present, followed by northern shovelers (20 percent), mallards (11 percent), and green-winged teal (8 percent). Percentages of geese, swans, and diving ducks have been consistently low over the years (Figure 4-13).

4.2.4.4 Species Accounts

4.2.4.4.1 Swans

The **tundra swan** is common during fall and winter, especially in the Delta. It prefers lake-like habitats, wet croplands, pastures, grasslands, and the borders of emergent wetlands; it is found less commonly on estuarine and slow-moving riverine waters. This species feeds in shallow water, dipping its head or neck in the water or, rarely, tipping up to reach the bottom. These birds also feed on land, grubbing in mud for food, and sometimes feeding in dry agricultural land; they rest, roost, and feed in similar habitats. The California wintering population migrates to breeding grounds in northern Canada and Alaska and is absent from April to September. In most states, including California, the swan is not a legal game bird. Harvesting of eggs and flightless, molting birds by native North Americans is a significant mortality factor in some areas, as are illegal shooting and lead poisoning in the lower 48 states (Palmer 1976).

About 25 percent of the continental population of tundra swans is found in the Pacific Flyway during the winter, and about 75 percent of those counted in the Pacific Flyway in 1990 were counted in California (Table 4-2). Within the Pacific Flyway, the Delta is the most important wintering area for tundra swans (U.S. Fish and Wildlife Service 1978a), ranking second in numbers only to Chesapeake Bay in the United States. In 1990, about 42 percent of the 30,000 tundra swans counted in California were found in the San Francisco Bay Estuary, with 99.7 percent of those counted in the Delta. However, the mid-winter data do not accurately describe the population status, since recent breeding population indices reveal a long-term increasing trend (J. Bartonek, U.S. Fish and Wildlife Service, unpubl. data).

The **trumpeter swan**, which is believed to have historically occurred regularly in small numbers throughout the Central Valley (Grinnell and Miller 1944), is now considered very rare throughout the State (McCaskie et al. 1979).

4.2.4.4.2 Geese

The two subspecies of greater white-fronted goose occurring in the area, are the **tule** and the **Pacific greater white-fronted goose**, the latter of which is far more numerous. These two subspecies have been differentiated by size and color, with the tule goose being the larger and darker of the two.

Table 4-2. Population Trends for Waterfowl in the San Francisco Estuary, California, and the Pacific Flyway as Measured by the Midwinter Waterfowl Survey[1].

	San Francisco Estuary[2]		California		Pacific Flyway	
Species	1990 Index	% Change[3] 1981-1990	1990 Index	% Change 1981-1990	1990 Index	% Change 1981-1990
Mallard	31,407	+58	342,848	-19	1,515,684	+7
Gadwall	1,882	-34	112,623	+10	123,926	+125
American Wigeon	20,681	+4	312,536	-24	507,867	-14
Gr-winged Teal	30,044	+156	243,002	+2	295,823	+5
N. Shoveler	58,005	+17	397,656	+21	403,868	+7
N. Pintail	97,273	+1	758,871	-39	888,876	-47
Subtotal Dabblers	239,331	+20	2,184,280	-19	3,753,445	-15
Canvasback	35,448	+54	44,667	+26	54,861	+5
Scaup	122,709	+71	141,325	+55	196,652	+47
Goldeneye	909	+87	1,173	-10	32,134	-12
Bufflehead	4,300	+14	26,978	+63	49,261	+27
Ruddy Duck	12,586	-52	85,524	-10	93,167	-13
Scoter	48,281	+77	84,664	+85	125,597	+39
Subtotal Divers	224,248	+20	419,581	+40	334,917	+25
All Ducks	464,607	+27	2,609,953	-14	4,456,431	-10
All Geese	23,189	-21	754,888	+33	1,145,845	+38
Tundra Swan	12,684	-24	30,008	-39	40,052	-41

1 Totals do not reflect sum of the presented indices because waterfowl rarely seen or unidentified in the Estuary are also included in the totals.
2 San Francisco Estuary = San Francisco Bay, San Pablo Bay, Suisun Bay, Suisun Marsh, Grizzly Island, and the Sacramento-San Joaquin Delta.
3 Percent change is a comparison of the 1990 index with the mean of the indices from 1981-1990 surveys.

Pacific greater white-fronted geese are common in winter in California's Central Valley. They are found in moist and wet grasslands, pastures, croplands, meadows, fresh emergent wetlands, small lakes, and, less commonly, in estuarine and saline (brackish) emergent habitats. In the Delta, these geese are abundant October to March and fairly common September, April, and early May. They roost and loaf mainly in secluded ponds and marshes (Grinnell and Miller 1944), but also in fields used for feeding and in lakes. These geese nest on coastal areas of southwestern Alaska, primarily on the Yukon-Kuskokwim Delta (Timm and Dau 1979). From the 1960s to about 1982, the peak numbers of these geese at their major autumn concentration area in California's Klamath Basin declined by about 80 percent (Raveling 1984). The primary cause for this decline was apparently excessive harvest of the geese on the breeding grounds. In the past 10 years, numbers at the Klamath Basin have remained fairly stable at this reduced level (J. Bartonek, U.S. Fish and Wildlife Service, unpubl. data). Midwinter waterfowl surveys in 1990, however, recorded 138,222 white-fronted geese in California, about 99 percent of the Pacific Flyway population. This total represents an increase of 83 percent over the state-wide average for the previous 10 years. Another index of white-fronted goose populations, the fall survey, produced an index of 219,000 geese in California in 1989. This also is evidence of a trend toward increasing numbers from the record lows of 70,000-90,000 in 1979-1980. Based on midwinter counts, the 1990 population in the Delta, which comprised about 9 percent of the total in California, declined from an average of about 18,000 during 1980-1989 to 12,000 in 1990.

Tule greater white-fronted geese nest only at Redoubt Bay, in Cook Inlet, Alaska. Following their fall migration, these birds make significant use of Suisun Marsh by late November. The major wintering areas include the Sacramento Valley, Suisun Marsh, and, to a lesser degree, Napa Marsh. Greatest habitat use occurs in seasonally flooded alkali and tuberous bulrush marshes. Winter population estimates have ranged from 2,100 to 5,000 birds in 1978-79 and 1981-82, respectively (Wege 1984), to more recent counts in 1988-89 and 1989-90 of 6,600 and 6,900 birds, respectively (G. Mensik, U.S. Fish and Wildlife Service, unpubl. data). Most of the tule goose hunting mortality takes place on the California migration/wintering grounds. Threats to this subspecies include continued wetland degradation and loss and some agricultural land use practices that may affect the amount of suitable migration and wintering habitat. This subspecies was previously considered a Federal candidate for listing as an endangered species, but recent information has indicated it is more abundant than previously thought.

In 1990, about 97 percent of the **white geese** (snow and Ross' geese) counted in the Pacific Flyway during the midwinter waterfowl survey were counted in California (572,000 birds). During 1985-1989, an average of 5.4 percent of the white geese counted in California were counted in the Bay Estuary, and, in 1990, all 8,300 of these geese were counted in the Delta. Despite some declines among breeding subpopulations in Alaska, the total population wintering in the Delta has remained relatively stable (U.S. Fish and Wildlife Service 1978a). The midwinter index for total white geese in California in 1990 (556,400) was about one-third higher than both the 1955-1990 and the 1981-1990 averages for the state, but no clear long-term trends are evident (J. Bartonek, U.S. Fish and Wildlife Service, unpubl. data).

Snow geese are winter residents found primarily in the Delta. Their preferred habitats are fresh emergent wetlands, adjacent lakes and nearby pastures, wet croplands, meadows, and grasslands. However, snow geese are occasionally found in saline (brackish) emergent wetlands and adjacent estuarine waters. They are abundant in California from November to early March and fairly common in October and April. These geese usually rest and roost in large flocks on open water of marshes or lakes and occasionally on coastal bays (Grinnell and Miller 1944); they also rest in fields and marshes used for feeding.

The California wintering population of snow geese migrates to breeding grounds in northern Canada and eastern Siberia (Bellrose 1980) and is mostly absent from May to September. The major cause of death for adults is hunting, but other important factors are disease and lead-shot poisoning (Bellrose 1980).

A special Ross' goose survey was conducted in 1989-1990, and this species was found to comprise 44 percent of the white geese wintering in the Central Valley (Silveria 1989). It is likely that white geese in the Delta contain a similar percentage of Ross' geese. The population of Ross' geese appears to have increased, possibly doubling since 1965. However, much of the increase may reflect more complete surveys, because the Sacramento Valley is now included in post-season surveys (McLandress 1979).

Most Ross' geese winter in the Central Valley and are locally common fall and winter residents (November to March) of the Delta. Preferred habitats include fresh emergent wetlands, adjacent lacustrine waters, and nearby wet croplands, pastures, meadows, and grasslands. In California, Ross' geese prefer to forage in wet open fields near lakes or ponds used for resting. The wintering population in California migrates to breeding grounds in central arctic Canada and is absent April to October (Palmer 1976). Hunting is a major source of adult mortality.

Canada geese (Branta canadensis) are widespread migrants and are common to abundant residents of the Delta and Suisun Marsh in the winter (October or November to March or April). A scattered number of introduced birds also breed within the Estuary. Preferred habitats include lakes, fresh emergent wetlands, grasslands, croplands, pastures, and meadows.

During the past five years, Canada geese in the San Francisco Bay Estuary have comprised about 3.4 percent of the total counted in California during the midwinter waterfowl surveys (J. Bartonek, U.S. Fish and Wildlife Service, unpubl. data). Most of these geese are found in the Delta and Suisun Marsh, with only small numbers recorded from San Francisco Bay. A complete survey of the East Bay reservoirs (Alameda and Contra Costa counties) during the 1984 mid-winter count revealed a total of nearly 3,000 Canada geese. In 1990, only seven percent of the Canada geese counted in the Estuary were found in San Francisco Bay itself.

The **Aleutian Canada goose** (B.c. leucopareia) is a small race of Canada goose that is a localized winter (November - March) resident in managed pasture, corn, grain, and rice fields, as well as farm ponds and small lakes primarily in the San Joaquin Valley. During late October-mid-November, these geese migrate south along the Oregon coast, the northern California coast, and through the Sacramento Valley (Colusa and Sutter counties). A small portion of the population spends November and December in the Grizzly Island Wildlife Management Area (Suisun Marsh) and on farmed wetlands of the Delta, including Staten, Wheeler, Bouldin, Venice, and Mandeville islands. Small numbers are also regularly recorded during November through January on San Pablo Reservoir (Contra Costa County), Calaveras Reservoir (Alameda and Santa Clara counties), and adjoining stock ponds. Other reservoirs and ponds within the Estuary also may be used by the subspecies. During January through March and April, the population moves north through the Sacramento Valley, passes through northern coastal California, returning to their Aleutian Islands breeding grounds by May. Historically, the Aleutian Canada goose nested throughout the outer two-thirds of the Aleutians, as well as in the Commanders and some of the Kuril Islands (Bellrose 1980).

No estimate has been made of the historic abundance of this subspecies in the Estuary. Their decline in numbers has been attributed to predation on their nesting islands from introduced Arctic foxes (Alopex lagopus) and possibly rats (U.S. Fish and Wildlife Service 1982a). Other factors adversely affecting the existing population include hunting during migration in Alaska and on the California wintering grounds, as well as disease outbreaks and conversion or loss of wintering habitat. Recovery efforts have included eradication of foxes from suitable nesting islands, followed by transplanting of potential breeding birds and closures on hunting of small Canada geese in California. As a result, the population has increased an average of 16 percent per year from 790 individuals in 1975 to an estimated spring count of 6,200 in 1988-1989 (Gregg et al. 1987, U.S. Fish and Wildlife Service 1990b). As a result, the U.S. Fish and Wildlife Service has recently reclassified this subspecies from endangered to threatened.

The **cackling goose** (B. c. minima) is the smallest subspecies of Canada goose. It is found only in the Pacific Flyway and has been the most abundant of the Canada geese that winter in California's Central Valley (Pacific Flyway Study Committee 1986). During the 1970s, about 10 percent of the cackling geese in California wintered in the Delta (U.S. Fish and Wildlife Service 1978a). Recently, cackling geese have been counted during special surveys in October and November, and, as of 1984, the overall abundance of these geese in the Pacific Flyway had declined to only 23,000 birds (O'Neill 1979, Raveling 1984, Raveling et al. 1986). There was a significant decline in the total numbers of cackling geese counted from 1956 to 1983 on the breeding grounds of the Yukon-Kuskokwim Delta. Causes of this decline were probably related to a number of factors, including overharvest on their breeding grounds and in California and poor production due to weather and predation, especially by arctic foxes (Stehn 1986). In the 1989 special fall survey, however, the total was 77,000, about a three-fold increase over the record low indices of 1983-84, but still far less than the estimated 400,000 cackling geese present in the late 1960s (Pacific Flyway Study Committee 1986).

Nearly the entire population of cackling geese nests on the Yukon-Kuskokwim Delta of Alaska and winters exclusively in the Central Valley of California. From Alaska, cackling geese migrate to the Willamette Valley and the Klamath Basin, with the first arrivals occurring in mid- to late October and peak numbers arriving in late October to early November. By December, the majority of these geese leave the Klamath Basin for the Central Valley. Cackling geese readily use grains such as barley and rice in the fall, but they rely on grazing to provide food during much of the wintering period (Raveling 1979). Grass is especially important in March and April for fattening the geese prior to their northward migration (Raveling 1979), which begins in late February and continues through April.

4.2.4.4.3 Northern Pintail

Typically, northern pintails occur in lakes and estuarine habitats, fresh and saline emergent wetlands, and wet croplands, pastures, grasslands, and meadows. They are common to abundant in the San Francisco Bay Estuary from August to March. Some pintails remain in the Estuary to breed, but they are rare to uncommon in the Bay Area during the spring and summer (Cogswell 1977).

Northern pintails prefer to rest on exposed muddy or sandy shores or on shallow water. During wing molt, July to August, pintails hide in dense stands of emergent vegetation (Palmer 1976). The bulk of the wintering population migrates north to breeding grounds in the northern continental United States, Canada, and Alaska, departing mostly in March to April and returning in July to August. In California, northern pintails nest from May to July (Cogswell 1977). Because they nest early and in open sites, pintails may suffer more nest failures from avian predators than other ducks (Bellrose 1980), but mammalian predators are also important, especially in Suisun Marsh (McLandress et al. 1988). Nests in agricultural fields are often destroyed by farming operations, including burning.

The northern pintail is by far the most abundant wintering waterfowl species in California, comprising about 50 percent of the total population counted during the midwinter surveys during 1955-1990, but declining to about 29 percent of the total in 1990. About 85 percent of the Pacific Flyway population (889,000) spent the winter in California in 1990. The pintail index for the Estuary in 1990 was 97,273 birds, which comprised about 13 percent of the California population. Pintails concentrate in the Delta during November through January in response to the food provided by flooded agricultural fields (Michny 1979).

In the San Francisco Bay Estuary, pintails comprised an average of 23.3 percent of the total waterfowl counted during the midwinter surveys during 1981-1990, but they comprised 43 percent of the Suisun Marsh total and 37 percent of the total in the Delta; pintails only made up about 4 percent of the waterfowl in San Francisco Bay (Figure 4-13). During 1987-1990, pintails were most numerous in the salt ponds of the North and South bays, with few counted in the open water areas (Figure 4-14).

Ducks, in general, suffered a significant decline in midwinter populations from 1980 to 1983 (Figure 4-15). Pintail populations in California crashed during that period, declining by 71 percent from 3.75 million to 1.08 million birds (Figure 14-16). In the Delta, the pintail index dropped from about 509,000 in January 1980 to 3,385 in 1983, a decline of 99.3

percent in only 3 years. Since then, numbers have steadily increased, and, by 1990, the estimated number of wintering pintails in the Delta had climbed to over 43,000, with 54,000 more in Suisun and San Francisco bays. Still, the most recent Bay area total of 97,000 pintails is less than 10 percent of the maximum total counted in the region in 1977 (Figure 4-16), and the total in 1990 is only 1 percent over the average for the previous 10 years (Table 4-2). Pintails have declined by 47 percent in the Pacific Flyway compared with the average for the past 10 years, and they have declined by 39 percent in California over that same period.

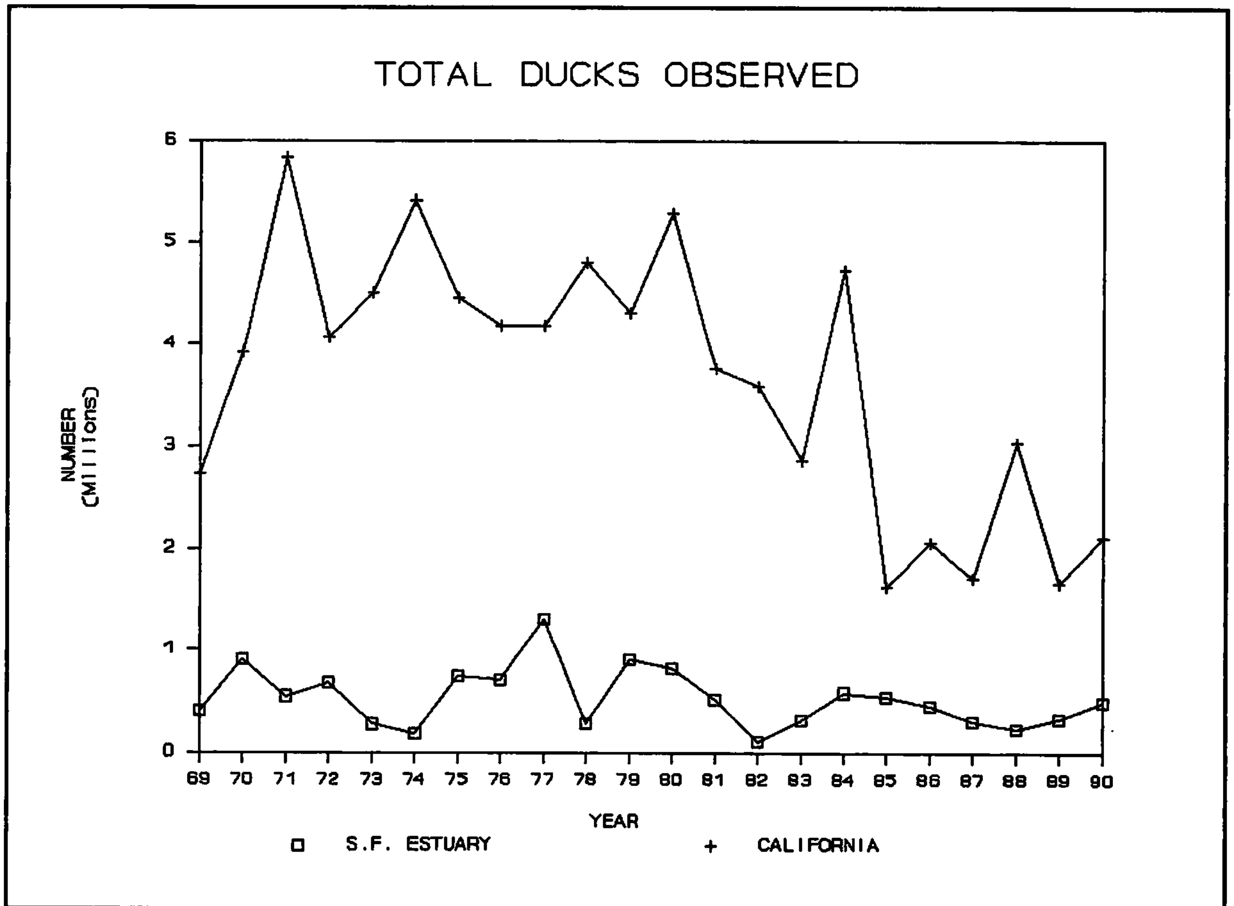

Figure 4-15. Population Indices for Total Ducks in California and the San Francisco Estuary as Measured by the Midwinter Waterfowl Survey, 1969-1990.

Intensified agricultural land use on the major breeding grounds in the Prairie Potholes, including continued conversion of wetlands to farmlands, has combined with a drought that began in 1980 to depress reproduction by nesting waterfowl in that area. The pintail breeding population had declined in the Prairie Pothole region of the United States and Canada from an average of 6.3 million in the 1970s to 2.9 million in 1985 (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986). Apparently, the drought in the primary

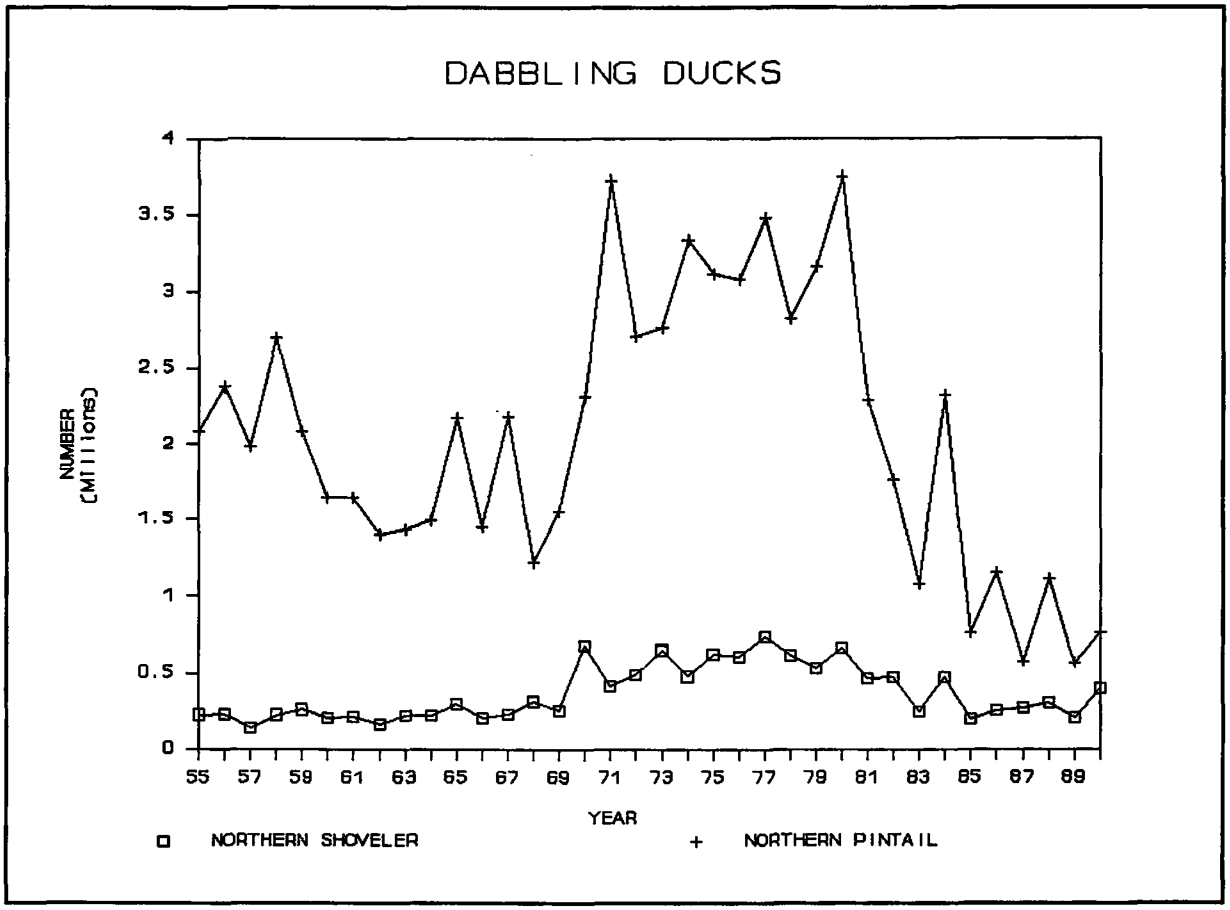

Figure 4-16. Population Indices for Total Northern Pintails and Northern Shovelers in California as Measured by the Midwinter Waterfowl Survey, 1955-1990.

breeding area has now eased. Habitat conditions, in terms of numbers of ponds and water levels, were thus much improved in Canada in 1990 over 1989, but they are still below the long-term average (Caswell 1990). Pintail breeding numbers were improved in 1990 over 1989, but they continued to be extremely low compared to the 10-year and long-term averages.

4.2.4.4.4 Mallard

Although the mallard is California's most abundant breeding duck, this species is most numerous in the winter (Kozlik 1974). Mallards are found in fresh emergent wetlands, estuarine, lacustrine, and riverine habitats, ponds, pastures, croplands, and urban parks, and, less commonly, on saline emergent wetlands and mudflats. They are most numerous in the Central Valley, where they comprised an average of 76 percent of the total California midwinter survey population during 1985-1989.

Mallards often use dense marsh vegetation, especially during late summer (drakes) and early fall (hens), when flight feathers are molting (Bent 1923, Madson 1960), but they prefer heavier cover throughout the year compared to most ducks. They will winter wherever food and open water are available (Johnsgard 1975).

Mallards typically nest on fairly dry sites in tall, dense, herbaceous vegetation or low shrubs. While breeding, mallards need shallow-water feeding areas with suitable nest sites nearby. Resident populations are augmented in fall and winter, chiefly October to March, by local migrants from higher mountains and distant migrants from the north (Grinnell and Miller 1944, Cogswell 1977). Nesting is primarily from March to July.

Hunting is probably the greatest source of mortality; waterfowl diseases and poisoning from lead shot are also important in certain local areas. Nest failures are frequent, and in California they are largely due to predation on eggs by mammals (Bellrose 1980, McLandress et al. 1988). Other causes of nest failure are plowing, mowing, burning, flooding of nest sites, and egg predation by birds.

Mallards are the second most numerous duck species in the Delta, but midwinter Flyway surveys during the past 10 years indicate that mallards, on the average, only comprise 5.9 percent of the waterfowl in that area. During the same period, mallards comprised 11.4 percent of the waterfowl in the Suisun Marsh, but they were less abundant than northern pintails (43.0 percent) and northern shovelers (19.9 percent) (Figure 4-13). Few mallards (1.3 percent of the Estuary total during 1981-1990) have been counted in San Francisco Bay, but, overall, almost 5 percent of the waterfowl wintering in the Estuary in the past 10 years have been mallards. In the Pacific Flyway, mallards have increased by about 7 percent while they have declined in California by 19 percent when compared with the average for the previous 10 years. In the San Francisco Bay Estuary, mallards have shown a trend toward increasing numbers, with the 1990 midwinter survey index being 58 percent greater than the 10-year average (Table 4-2).

Like northern pintails, mallards primarily breed in north-central North America, and adverse conditions affecting pintails have also affected mallards. Breeding populations in the Prairie Pothole area decreased significantly from 8.7 million birds in the 1970s to 5.5 million in 1985 (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986). In response to increased rainfall, the breeding population of mallards has increased, but their numbers are still well below the long-term averages (Caswell 1990).

4.2.4.4.5 Northern Shoveler

Over the past 10 years, the northern shoveler has been the second most common dabbling duck (after northern pintail) wintering in the San Francisco Bay Estuary, comprising an average of 12.1 percent of all the waterfowl counted during the midwinter surveys. Shovelers comprised 19.9 percent of the waterfowl in Suisun Marsh, 12.0 percent in San Francisco Bay, and 2.4 percent of the total in the Delta. Shallow, freshwater lacustrine habitats bordered by emergent wetlands are preferred. Shovelers generally arrive in late August and leave in early May, but they rarely nest in the Bay Area. They are common from September to early May on certain salt evaporating ponds, brackish, lacustrine, estuarine, saline emergent habitats, and sewage treatment ponds. During 1987-1990, 46 percent of all the waterfowl counted on the South Bay salt ponds were shovelers. On the North Bay salt ponds during that same period, 10 percent of the total was shovelers (Figure 4-14). Almost 99 percent of all the shovelers were counted on the salt ponds, with 89 percent of those counted in the ponds of the South Bay.

Most of the shovelers that winter in California migrate to breeding grounds in the northern continental United States, Canada, and Alaska; they are generally absent from mid-May to mid-August. The few shovelers that breed in California nest from March to July (Cogswell 1977) and usually nest in low grass, on dry sites near open, shallow water (Palmer 1976). Shovelers also nest in taller grasses, hayfields, meadows, and marshes of bulrushes and salt grass (Bellrose 1980).

Like the pintail population, the shoveler population in California crashed about 10 years ago, declining from 664,000 birds in 1980 to about 249,000 in 1983. Unlike pintails, however, California shoveler populations in 1990 increased by 21 percent over the average for the previous 10 years. Shovelers that wintered in California in 1990 made up almost all (98.5 percent) of the Pacific Flyway population.

The total of 58,005 shovelers counted during the 1990 midwinter survey in the San Francisco Bay Estuary was an increase of 17 percent over the average for the previous 10 years (Table 4-2), and this total represented 14.6 percent of the California population. The recent overall trend appears to be toward an increase in shoveler numbers, but the totals remain far below the levels of the mid-1970s (Figure 4-16).

4.2.4.4.6 Green-winged Teal

The green-winged teal is a common to abundant winter (October to March) resident of the Central Valley of California; it is also fairly common in April. It inhabits lacustrine and slow-moving riverine habitats, often with bordering fresh emergent wetlands, nearby grasslands, wet meadows, or wet croplands and pastures. These teal are rarely found in estuarine and saline emergent habitats. The main breeding grounds for the green-winged teal are in the northern continental United States, Canada, and Alaska (Palmer 1976, Bellrose 1980).

About 94 percent of the 257,400 green-winged teal counted in the Pacific Flyway during the midwinter survey in 1990 were counted in California. The greatest percentage of this species (91 percent during 1985-1989) winter in the Central Valley, but, in 1990, 30,044 (12.4 percent of the California total) were recorded from the San Francisco Bay Estuary. Over the past 10 years, most of these teal (84.1 percent) have been found in the Suisun Marsh, with very few (4.9 percent) counted in San Francisco Bay, and only 11.0 percent counted in the Delta. During the same period, green-winged teal have comprised 8.1 percent of the waterfowl counted in the Suisun Marsh, 1.3 percent of those in the Delta, and 0.3 percent of those in San Francisco Bay. Overall, these teal comprised 2.8 percent of the Estuary's waterfowl.

Both the Pacific Flyway and the California populations of green-winged teal have remained relatively stable over the long term as well as the short term (Table 4-2). There was no population crash in 1983, based on the midwinter survey data, and in 1990, the estuary total was about 2.6 times higher than the average for the previous 10 years (Table 4-2).

4.2.4.4.7 American Wigeon

The American wigeon is very common from October to March and common from September and April in lacustrine and fresh emergent habitats and nearby herbaceous and agricultural field habitats in lowlands throughout California. Wigeon are uncommon to fairly common along the coast in winter, in salt ponds, estuarine waters, and saline emergent wetlands. This species rarely nests in the Central Valley; most nest well to the north of California, wintering in California and migrating to breeding grounds in the northern continental United States, Canada, and Alaska.

In 1990, about 62 percent of the Pacific Flyway population of American wigeon were counted during the midwinter survey in California. Recently, most (76 percent) of these birds have been counted in the Central Valley (J. Bartonek, unpubl. data), with only about 6.4 percent of the California total recorded from the San Francisco Bay Estuary. In 1990, 77.5 percent of the estuary's wigeons were counted in Suisun Marsh, with only 14.5 percent in the Delta, and the remaining 8 percent in San Francisco Bay. Over the past 10 years, however, average numbers in the Suisun Marsh and San Francisco Bay have been fairly similar (Figure 4-13). Within San Francisco Bay, most wigeon (72-82 percent over 1987-1990) were counted in the South Bay salt pond area; and, when combined with the ponds in the North Bay, they accounted for over 88 percent of the wigeon each year.

Wigeon and mallard average populations for 1981-1990 are nearly identical for the Estuary, but their distribution is much different, as mallards tend to concentrate in the Suisun Marsh and the Delta, with only a few in San Francisco Bay. Within the Estuary, 1990 wigeon numbers were only slightly (4 percent) higher than the 10-year average (Table 4-2). However, the California total, as well as the Pacific Flyway population, both showed declines, by 24 and 14 percent, respectively (Table 4-2). American wigeon, like the pintails and shovelers, experienced a significant population decline during 1980-1983. Based solely on the midwinter survey data, it appears that wigeon numbers have recovered better than the pintail but not as well as the shoveler.

4.2.4.4.8 Canvasback

Most years, about 25 percent of the canvasbacks found in North America during January are counted in Pacific Flyway midwinter surveys, with 81 percent of those found in California (J. Bartonek, U.S. Fish and Wildlife

Service, unpubl. data). During 1981-1990, an average of 65 percent of the California wintering canvasbacks were counted in the San Francisco Bay Estuary. Canvasbacks are found in estuarine and lacustrine habitats throughout much of California. They are abundant from November to March and less common in September to October and April to May on bays along the northern and central California coast, especially San Francisco Bay. They are also common in the Central Valley in winter, but in much smaller numbers. Except for a small breeding population in California, the wintering population migrates to breeding grounds in the northern continental United States, Canada, Alaska, and Ruby Lake, Nevada, and is mostly absent from June to August.

Canvasbacks prefer to forage in extensive areas of shallow water. In tidal areas, they feed most actively in shallow water just after it floods the tideflats (Cogswell 1977). In San Francisco Bay, during 1987-1990, 82 percent of the canvasbacks were found in the areas north of the Richmond-San Rafael Bridge, with 42.5 percent of these birds counted in the North Bay salt ponds. Canvasbacks were the most abundant of all waterfowl on these ponds, comprising 22.4 percent of the total (Figure 4-14). They were also present on Suisun Bay, where they averaged 29.9 percent of the total.

As with pintails, midwinter surveys show that canvasback numbers plummeted in California by about 61 percent from 1980 to 1982, to a low of 28,535 birds (Figure 4-17). In 1987 and 1988, however, canvasbacks were present in California at the lowest levels in the past 35 years (21,123 and 20,758 birds, respectively); this trend was observed flyway-wide. In the past two years, numbers of wintering canvasbacks have increased by about 12,000 birds per year to a level in California in 1990 that is 26 percent higher than the average for the previous 10 years (Table 4-2). The Pacific Flyway total for 1990 was only 5 percent above the average for the previous 10 years, but in the Estuary, the increase was 54 percent.

Drought and conversion of wetlands to agricultural lands in the prairie pothole region have adversely impacted reproduction, but population declines may also be related to overharvesting of female and young birds (Palmer 1975).

4.2.4.4.9 Greater and Lesser Scaup

Because the two scaup species are similar in appearance and are difficult to discriminate during aerial surveys, they are combined for this discussion. Scaup inhabit estuarine and lacustrine habitats throughout much of California. They are common winter residents, especially from October to April when they are abundant on San Francisco and San Pablo bays (Bellrose 1980). During winter, the birds utilize large coastal bodies of water with abundant plant and animal life, but normally they avoid mudflats. In addition to large bays and inshore waters, they may also winter regularly on large freshwater bodies in California. They are present in the Estuary in small numbers in summer; however, they are generally absent from California from June through August while breeding occurs in northeastern California, Oregon, Washington, Canada, and Alaska. Greater scaup reproduce principally north of

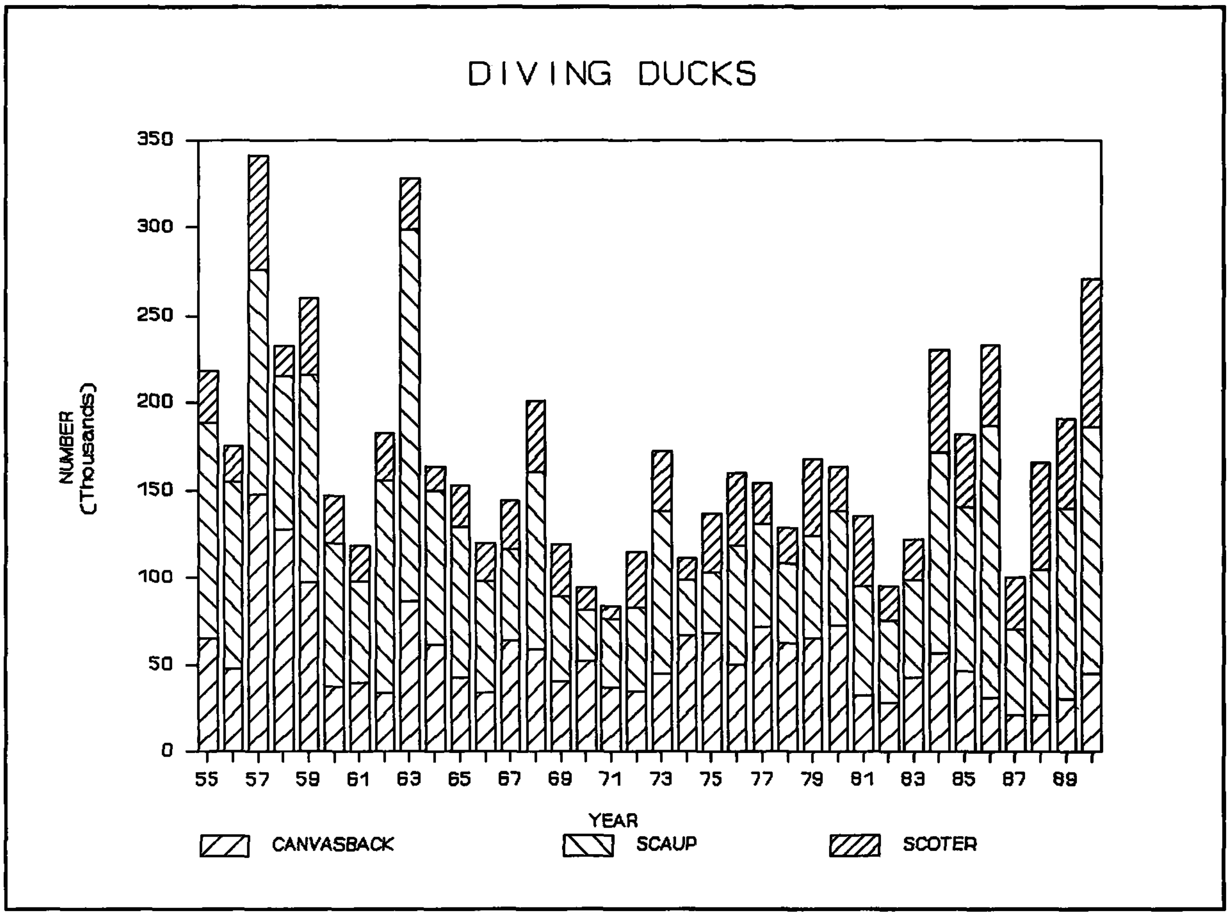

Figure 4-17. Population Indices for Total Canvasback, Scaup and Scoter in California as Measured by the Midwinter Waterfowl Survey, 1955-1990.

60° latitude in Alaska. Scaup were the most abundant of all diving ducks wintering in California in 1990. They were also the most abundant species of diving duck in the San Francisco Bay Estuary; according to the midwinter survey, they comprised over one-half of the diving ducks present in the Estuary.

Scaup numbers declined in the Pacific Flyway during the early 1980s, but California numbers remained relatively stable. In both areas, scaup have had significant increases in numbers for each of the past three years, with 1990 numbers being 55 percent greater than the average for the previous 10 years in California and 47 percent greater in the Pacific Flyway (Table 4-2).

The recent trends in the San Francisco Bay Estuary have been similar to the State and flyway trends, with the 1990 midwinter total being 71 percent higher than the 10-year average (Table 4-2). The overall state-wide trend appears to indicate a gradual increase in the number of scaup (Figure 4-17).

Distribution patterns within the estuary over the past 10 years have remained about the same, with an average of 94 percent of the scaup found in San Francisco Bay, 5 percent in Suisun Marsh, and only about 1 percent in the Delta. Within San Francisco Bay, there were nearly three times more scaup counted than any other species (Figure 4-13). In the entire Estuary, only pintails (23.3 percent) were more abundant than scaup (17.4 percent) during the 1981-1990 period.

During the 1987-1990 surveys, an average of about 50 percent of the scaup counted in San Francisco Bay were using the North Bay, with others present in similar, but lower, numbers, primarily in the open bay areas; few used the salt ponds, which only contained 7.7 percent of the total. Scaup were the most abundant of all species in the North Bay, the South Bay, and Suisun Bay, and they were second only to scoters in the Central Bay (Figure 4-14).

4.2.4.4.10 Ruddy Duck

Ruddy ducks are common to abundant in winter (late September to April), preferring bays, salt ponds, and lacustrine habitats, but occasionally they may be found on marine waters near shore. These ducks are present year-long throughout much of their California range, but much of the wintering population migrates north and east to breed in other western states and in Canada, departing April or May and returning in late August or September. Ruddys nest in fresh emergent wetlands bordering lacustrine habitats, but the species is fairly uncommon through the summer along the coast. About 75 percent of the California breeding population is in the Klamath Basin.

Ruddy ducks have comprised an average of 6.4 percent of the San Francisco Bay Estuary waterfowl population over the past 10 years, with numbers less than scaup but similar to scoters and canvasbacks. Almost 92 percent of the ruddy ducks counted in the Pacific Flyway during the 1990 midwinter survey were located in California. During 1985-1989, about one-third of the ruddy ducks in California were counted in the San Francisco Bay Estuary and one-third in the Central Valley (J. Bartonek, U.S. Fish and Wildlife Service, unpubl. data), but, in 1990, only about 15 percent were located in the San Francisco Bay Estuary. Unlike 1988 and 1989, the winter peak for ruddy ducks in San Francisco Bay did not occur the week of the midwinter survey. Instead it occurred one month earlier, in early December, when nearly twice as many ruddy ducks (24,073) were counted in San Francisco Bay as were recorded for the midwinter survey (12,181) in early January (L. Accurso, U.S. Fish and Wildlife Service, unpubl. data).

Compared with the average populations for the past 10 years, ruddy duck numbers in 1990 were 13, 10, and 52 percent lower for the Pacific Flyway, California, and the San Francisco Bay Estuary, respectively (Table 4-2). However, if the December totals from San Francisco Bay are used for comparison with the previous 10 years instead of those from the midwinter survey, then the decline for the Estuary is only 9.2 percent.

Within the Estuary, 10.7 percent of the waterfowl counted during the midwinter survey in San Francisco Bay were ruddy ducks, with ruddys comprising 3.4 percent of those surveyed in the Delta and 2.1 percent of the Suisun Marsh waterfowl (Figure 4-13).

The distribution pattern for ruddy ducks remained fairly constant during the winters of 1987-1990. The vast majority of the birds were found on the salt ponds, with an average of between 86 and 92 percent of the ruddys found there during that period. Although about twice as many ruddys were present on the South Bay salt ponds, the percentage composition was just under 20 percent at both North and South Bay salt ponds (L. Accurso, U.S. Fish and Wildlife Service, unpubl. data) (Figure 4-14).

Factors limiting reproduction of other species, such as predation, drought, and conversion of wildlife habitat to farmland, are probably also responsible for the overall trend toward fewer ruddy ducks.

4.2.4.4.11 Surf Scoter

Surf scoters are abundant in the San Francisco Bay Area from October to April and common late September and early May on large bays and marine waters near shore along the entire California coast. Scoters are uncommon through the summer when they occur primarily at river mouths and along the outer coast. Except for a small nonbreeding summer population, the California wintering population migrates to breeding grounds in northern Canada and Alaska and is absent from late May to early September.

In 1990, scoters wintering in California comprised about two-thirds of the 125,597 scoters counted during the midwinter survey in the Pacific Flyway. Most scoters (57 percent) were counted in the San Francisco Bay Estuary, where they ranked fourth in total abundance behind scaup, pintail, and shovelers (Table 4-2).

Within the estuary, an average of 97 percent of the scoters counted during midwinter surveys during 1981-1990 were recorded from within San Francisco Bay, with an average of only 3 percent from Suisun Marsh and none from the Delta (Figure 4-13). Scoters, like scaup, primarily used open Bay areas in San Francisco Bay. Only one percent of all the scoters counted during the winters of 1987-1990 were found in the salt pond areas. Open Bay areas used by scoters included: Central Bay (46 percent), North Bay (27 percent), South Bay (18 percent), and Suisun Bay (8 percent).

Scoters were the most abundant of all waterfowl counted in the Central Bay during 1987-1990 (56.7 percent). They ranked second in abundance in the North Bay and South Bay behind scaup, and they were third in Suisun Bay after scaup and canvasbacks (Figure 4-14).

Compared with the previous 10 years, the total number of scoters in 1990 increased in the Pacific Flyway by 39 percent, in California by 85 percent, and in the Estuary by 77 percent (Table 4-2). Part of the reason for this apparent trend is the large increase (by 66 percent in California) in scoters in 1990 compared with 1989, but there also appears to be an overall trend toward larger numbers (Figure 4-17).

Two other species of scoter are also found in the San Francisco Bay Area, but their numbers are far less than those of the surf scoter. The white-winged scoter is an uncommon winter resident in large bays, river mouths, and marine waters near shore along the California coast. They are uncommon through the summer, because they breed in Canada and Alaska. Black scoters are uncommon winter residents on large bays and marine waters near shore, most commonly north of Point Reyes, Marin County. The population wintering in California breeds in Alaska and is almost entirely absent in the Estuary from May to September. All three scoters were killed in the 1986 Apex Houston oil spill, outside the Golden Gate to Monterey Bay (Page et al. 1990). White-winged scoters were also killed in gill nets along the outer coast of Central California in 1979-1987 (California Department of Fish and Game 1987d).

4.2.5 Eagles, Hawks, and Falcons

4.2.5.1 Golden Eagle

The golden eagle is found throughout the western states and in limited numbers in Maine and Canada (Dunne et al. 1988). Golden eagles are uncommon year-round residents and are fairly common migrants in appropriate habitats in the study area and throughout California. They winter throughout the state except at the highest elevations in the Sierras.

Golden eagles use habitats in the coast range of the East Bay region for nesting and feeding. Oaks and eucalyptus are particularly suitable as nesting trees (C. Thelander, Biosystems Analysis, Inc.; B. Walton, Santa Cruz Predatory Bird Research Group, pers. comm), and, currently, at least 60 pairs of nesting birds are known to occur in this area (J. DiDonato, East Bay Regional Park District, pers. comm.). They primarily use open grassy terrain or oak savanna where they prey mostly on small mammals.

Golden eagles no longer breed in the Central Valley, primarily due to habitat loss (Harlow and Bloom 1989). However, a significant wintering population occupies the foothills that surround the Central Valley (C. Thelander, Biosystems Analysis, Inc., pers. comm.). Individuals also winter just north of the Delta and move into the area to hunt in the open flatlands within the farmed islands. In addition, eagles migrate through the Estuary. Historical population estimates for the golden eagle are not available. The most current estimate of the number of breeding pairs in California is 500 for the mid-1970s (Harlow and Bloom, 1989).

Overall, numbers of golden eagles have declined from historic levels in California and are thought to currently be either stable or declining, depending on various local conditions (Remsen 1978, Harlow and Bloom 1989, P. Detrich, U.S. Fish and Wildlife Service, pers. comm.). Numbers in the study area are thought to be at or below carrying capacity. In expanding urban areas such as the San Francisco Bay region and particularly in Southern

California, population levels will likely continue to decline as suitable habitat is eliminated.

Statewide, the most serious threats to the species include habitat destruction, shooting, collisions and electrocution, lead poisoning, and human disturbance at nest sites (Harlow and Bloom 1989, P. Bloom, Western Foundation of Vertebrate Zoology, and P. Detrich, U.S. Fish and Wildlife Service, pers. comm.). The primary threat to the status of the population in and around the study area is habitat loss resulting from continued urban expansion (P. Bloom, Western Foundation of Vertebrate Zoology, and P. Detrich, U.S. Fish and Wildlife Service, pers. comm.). The Alameda County Wind Farm east of Livermore has caused significant mortalities to resident and migratory eagles passing through this area; in 1986, 76 golden eagles were killed in this area. Currently, the U.S. Fish and Wildlife Service, California Department of Fish and Game, Pacific Gas and Electric, the California Energy Commission, and local counties have formed a Technical Advisory committee to formulate ways to reduce these losses.

4.2.5.2 Bald Eagle

The bald eagle is a rare, localized winter resident associated with large lakes, reservoirs, or rivers primarily near the northern and eastern periphery of the Estuary. In northern California, increases in numbers of wintering bald eagles annually coincide with autumn salmon runs and the arrival of migratory waterfowl. Frequently, the occurrence of eagles is associated with concentrations of American coots, a regular prey species (Detrich 1986). The current wintering population for California totals about 800 individuals; 40 percent of these concentrate in the Klamath Basin, with the remainder distributed throughout the state in suitable habitats (Detrich 1986). According to Detrich (1981, 1982), sites within or adjacent to the Estuary where wintering eagles have been observed (and approximate numbers of birds recorded) include: Lake Berryessa (Napa County) (5-10), Crystal Springs Reservoir (San Mateo County) (1-2), the Cosumnes River area (Sacramento County) (3-6), and Calaveras Reservoir (Santa Clara County) (1-2). San Antonio Reservoir (2-6) and Del Valle Lake (1-2) also had wintering eagles in 1986-1987 (J. DiDonato, East Bay Regional Park District, pers. comm.). Annual variations in numbers of wintering birds are likely influenced by food availability to the north of California.

A steady decline in numbers of eagles during the first half of the 20th century, culminating in the pesticide-induced elimination of about 70 percent of their breeding population from about 1945 through 1972, led to the bald eagle being listed as an endangered species by the Federal government in 1968. The species is also listed as endangered by the State of California. A statewide survey of bald eagles revealed 26 active nesting territories in the northern one-third of the state in 1972-1973 (Thelander 1973 in Detrich 1986).

Beginning in the late 1970s, numbers of nesting eagles began to increase, although the population currently remains confined to reservoirs, lakes, and rivers in the northern counties of the state. In 1988, there were 82 known nesting pairs (California Department of Fish and Game 1989b).

Following nesting, juvenile birds are believed to migrate to the Pacific Northwest in late summer.

Current threats to bald eagles in California are primarily human-related and include collisions with towers and powerlines, shooting, poisoning, and electrocution. DDE may still be depressing reproduction.

4.2.5.3 Northern Harrier

The northern harrier is a common year-round resident and, to a lesser extent, winter visitor in the marshes and grasslands of the Estuary study area. In suitable habitats, they may occur in relatively high concentrations in the region, nesting primarily in shoreline areas, fresh and saltwater marshes, agricultural lands, and moist grasslands (J. DiDonato, East Bay Regional Park District, pers. comm.). The species breeds from the mid-latitudes of the United States north to Canada and Alaska, generally moving south to winter in the southern states. Some individuals also winter in Mexico and Central and South America.

Harriers most often nest on the ground, in low, shrubby vegetation and often at the water's edge. As ground nesters, they are highly vulnerable to predation by gulls and various mammals and to trampling by deer and cattle. The tendency to nest in moist areas or by water also makes nests susceptible to flooding (Martin 1989).

Surveys of northern harriers were conducted as part of a study of waterfowl nesting in upland habitats in the Grizzly Island Wildlife Management Area. Harrier densities were found to be relatively high and stable over a six-year study period, with a background population density of approximately 25 birds per square mile (M. MacLandress, California Waterfowl Association, pers. comm.). These high densities are thought to result from upland habitat management for waterfowl in the management area. A boom in populations of California vole and harvest mice in 1987 contributed to a total of 74 nesting pairs of northern harriers within the Management Area (California Department of Fish and Game 1987e). Gill (1977) estimated that from 26 to 32 individuals nested in the 5,524 acres of salt and freshwater marshes and grasslands adjacent to South San Francisco Bay in the early 1970s. Red foxes recently arrived on Bair Island, and evidence of their predation on northern harrier nests was observed in 1991 (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.). The increase in numbers of red foxes presently occurring in the Estuary may jeopardize the reproductive success of this ground-nesting species.

Statewide, a noticeable decline in northern harrier numbers was reported as early as the 1940s, with a slight increase noted in the late 1960s (Brown 1973, Remsen 1978). Overall, population levels appear to have declined over the past three decades (Evans 1982). However, status is difficult to estimate, given the lack of a consistent, comprehensive population survey. Citing a decline in both breeding and wintering densities, the California Department of Fish and Game included the northern harrier as a Species of Special Concern (Remsen 1978). Even though harrier populations will benefit from ongoing efforts to improve habitat conditions for waterfowl, they will also continue to lose habitat to urban expansion.

4.2.5.4 Sharp-shinned and Cooper's Hawks

Sharp-shinned and Coopers hawks are two of the three North American accipiters occurring in the Estuary study area. The sharp-shinned hawk is an uncommon migrant and winter resident in dense forest habitats throughout California, concentrated primarily in the northern part of the state and in the foothills of the Sierra Nevada during its breeding period. This bird is a rare breeder in the Estuary study area, due in large part to the low abundance of avian prey species in the spring and summer. In winter, sharp-shinned hawk population levels within the study area increase in areas of optimal habitat with the influx of migrants and winter visitors and increased numbers of migrant prey species. They are found wintering in relatively high numbers in areas such as Point Reyes and Mount Diablo State Park (B. Walton, Santa Cruz Predatory Bird Research Group, pers. comm.). During the fall and winter, both species are occasionally seen in urbanized areas and in parks (P. Detrich, U.S. Fish and Wildlife Service, pers. comm.). In North America, this species breeds as far north as Alaska and northern Canada south through the midwestern United States to Mexico. Birds winter along the coast of Alaska and Canada, throughout the lower 48 states, south to Central America and the Florida Keys (Clark and Wheeler 1987).

Cooper's hawks are uncommon year-round residents of woodland and forest habitats in many parts of the state. They winter throughout the state except for the higher elevations of the Sierra Nevada. In the Estuary study area they are particularly common to the East Bay coastal hills in such areas as Mount Diablo State Park and Mission Peak (B. Walton, Santa Cruz Predatory Bird Research Group, and J. DiDonato, East Bay Regional Park District, pers. comm.). This bird breeds over most of the United States and southern Canada.

Both species have experienced substantial declines in the past throughout the United States, particularly in the east. Particularly severe losses occurred from the 1940s through the 1960s. The earlier declines resulted mainly from intense shooting along migration routes, spurred by the species' depredation on poultry. By the late 1940s, the effects of organochlorine pesticide contamination caused reproductive failures of both species. Evidence of eggshell thinning was found in the west, but the losses due to organochlorines were most pronounced in the eastern states.

Population numbers of both species are reduced from historic levels. Continued urban expansion and subsequent destruction of woodland and forest habitats makes continued declines in these species likely. The continued use of organochlorine pesticides in Central and South America also poses a significant threat to both species. Both species are on the Audubon Blue List and designated as Species of Special Concern by the California Department of Fish and Game.

4.2.5.5 Swainson's Hawk

Swainson's hawks are a locally common summer resident in portions of the Central Valley and Great Basin Region. Birds nesting in California winter in open pampas areas of South America as far south as Argentina.

Swainson's hawks nest primarily in riparian areas, but they also may use lone trees, or groves of trees in agricultural fields, pastures, and near roads. They prefer large open grasslands with abundant prey in association with suitable nest trees. Suitable foraging areas include: native grasslands, lightly grazed pastures, alfalfa and other hay crops, as well as certain grain crops. Agricultural crops with low prey densities or excessively dense vegetation are unsuitable for foraging.

Historically, Swainson's hawks may have occurred at a population of more than 17,000 pairs, occupying most of the non-forested lowlands and large valleys of the state; they were absent only from the Sierra Nevada, north coast ranges, and the Klamath Mountains (Risebrough et al. 1989, California Department of Fish and Game 1989).

Possible contributors to the decline of the species over the last 80 years include loss of native grassland habitat to exotic vegetation and agricultural and urban development in the California breeding grounds and in South American wintering areas (Estep 1988). Other factors that may have played a role in this decline include: organochlorine pesticide contamination, shooting during migration, and inter-specific interactions (Risebrough et al. 1989).

Swainson's hawks nest in the Central Valley and the Great Basin Region of California. The Central Valley and the Delta support an estimated 78 and 9 percent, respectively, of the total statewide nesting population (550 pairs). More than 85 percent of the Central Valley nesting population is found within the riparian woodlands of Sacramento, Yolo, and San Joaquin counties. Conversion of Delta wetlands into agriculture and loss of adjacent grassland habitat has contributed to the expansion of the species into this portion of the Estuary. Concentrations of nesting pairs in the Delta are found (1) west of Stockton on Middle Roberts, Union, and Coney islands (about 20 pairs); (2) along Steamboat Slough and the Sacramento River from Isleton north to Courtland (about 7 pairs); (3) from Freeport north to Sacramento (about 10 pairs); and (4) at the confluence of Dry Creek, the Mokelumne and Cosumnes rivers and Snodgrass Slough (about 7 pairs) (J. Estep, Jones and Stokes Assoc. and P. Houghten, ECOS, pers. comm.). Small numbers of nesting pairs may also be scattered through the central Delta where suitable habitat exists.

Following recognition that a decline in the breeding population by about 91 percent had occurred, the State of California designated the Swainson's hawk a Species of Special Concern in 1978 and listed it as threatened in 1983. The National Audubon Society has Blue-Listed the species previously and considers it of Special Concern (Tate 1986). The Species was also a candidate for Federal listing, but recent information indicates they are more abundant than previously thought (U.S. Fish and Wildlife Service 1989b).

Loss of nesting and foraging habitat due to Delta bank protection measures, urban and agricultural expansion, and conversion to unsuitable crops such as vineyards, orchards, and rice continue to present major threats to this species in the Central Valley (California Department of Fish and Game 1989b). Statewide, the population is believed to have remained stable during the last 10 years.

4.2.5.6 American Peregrine Falcon

The American peregrine falcon historically nested throughout North America, from the boreal forests south into Mexico wherever suitable nesting and foraging habitat occurred. In California, the peregrine was considered fairly common prior to 1947 (Grinnell and Miller 1944), with a minimum of 100 pairs nesting on coastal and inland cliffs. The gradual decline exhibited by the species with increasing human population accelerated in the early 1950s to where less than five pairs were believed to nest in the State by 1970. The major factor contributing to this decline has been the adverse reproductive effects caused by organochlorine pesticides, which have been most detrimental to coastally nesting falcons. The American peregrine falcon was placed on the Federal endangered species list in 1970.

Today, the American peregrine falcon may be encountered year-round throughout most of the state, especially during migration and in winter when they may be found along the coast, and the population is supplemented by birds from north of the state. The San Francisco Bay Area and Delta are considered an important wintering concentration area for the species because an estimated 10-20 birds range over the entire region. Since 1988, an average of three peregrine falcons have been recorded on the Point Reyes Bird Observatory's spring and fall shorebird counts in San Francisco and San Pablo bays. During the last 20 years, the local falcon population has increased by an estimated tenfold (B. Walton, Santa Cruz Predatory Bird Group, pers. comm.). This is probably due to the continued abundance of avian prey populations and availability of secure nest sites. All wetland types, except riparian habitat, provide potential foraging areas for the peregrine which, in the Bay Area, is an opportunistic predator, taking several bird species including: pigeons, terns, shorebirds, blackbirds, and sparrows. Ongoing telemetry studies have revealed frequent use of transmission line towers, where peregrines have been recorded up to 15 hours per day (B. Walton, Santa Cruz Predatory Bird Group, pers. comm.).

Peregrine falcons typically nest on protected ledges of high cliffs, mainly in woodland, forest, and coastal habitats. Most nesting in the State occurs outside the study area along the central California coast, inland north coastal range, the Klamath and Cascade ranges, Sierra Nevada, and the Channel Islands. However, during the last 2-6 years, four pairs began nesting within the study area at two Central Bay locations and one site in Suisun Bay. Additional sites where pair activity, but no documented nesting, has been observed are in the South Bay and near the western Delta. Outside the study area, an additional two pairs have become reestablished at outer coastal sites in San Mateo and Marin counties. Approximately half of all these birds were released outside of the Estuary during previous falcon breeding enhancement efforts.

At present, none of the above local nesting pairs are successfully reproducing. Threats to falcons statewide include powerline collisions and electrocutions, shooting, falconry, human disturbance, and predation of captive-bred birds by great horned owls and a variety of other avian and mammalian predators. Future studies within the Bay Region will involve continued monitoring of existing populations, opportunistic contaminant analyses, and telemetry (B. Walton, Santa Cruz Predatory Bird Group, pers. comm.).

4.2.6 Rails and Cranes

4.2.6.1 *California Black Rail*

The California black rail is believed to have occurred historically in the tidal salt and brackish marshes of San Francisco Estuary as well as in the freshwater marshes of the Delta (California Department of Fish and Game 1989b). Throughout its range the species is known to inhabit salt, brackish, and freshwater marshes. Loss or conversion of 95 percent of San Francisco Bay's tidal marshes, as well as other wetlands throughout the State, resulted in the black rail being listed by the State of California as a threatened species and as a category 1 candidate for Federal listing. Surveys conducted in 1986-1988 confirmed that the black rail's distribution has been greatly reduced and fragmented. No present breeding has been confirmed for the South and Central bays (Evens et al. in prep.). Highest densities of nesting black rails occur in the larger undiked marshes in the Petaluma River Wildlife Management Area, along Black John and Fagan sloughs and Coon Island in Napa Marsh, and in some bayshore marshes of San Pablo Bay. Elsewhere in San Pablo and Suisun bay marshes and the Delta their distribution is patchy. The subspecies is also present during the breeding season along the Lower Colorado River, at the Salton Sea, and in marshes along the central California coast (Evens et al. in prep.).

Rails are generally found only in tidal marshes containing higher elevational zones. They are present in small numbers in narrow tidal marshes along major sloughs and are absent from nontidal marshes. The black rail is apparently critically dependent on a very narrow high-marsh zone not subject to extreme and frequent tidal action, where insect abundances are greatest and where some freshwater influences may exist (Evens et al. in prep.). The presence of weedy vegetation on dikes adjacent to North Bay marshes provides additional transitional upland cover during extreme high tides. Generally, tidal marshes in the North Bay are at a higher elevation, while South Bay marshes lack any broad remaining high marsh or transition zones and experience a more extreme fluctuation in tidal height. In the nonbreeding season, black rails disperse widely, and greater use of the South Bay has been observed, especially by juvenile rails.

Current causes of black rail mortality include shortage of well-developed high-marsh habitat, contributing to exposure during extreme high tides and subsequent predation by harriers, egrets, herons, short-eared owls, and feral cats (Evens and Page 1986). The recently established population of introduced red foxes in the South Bay may also prey on black rails during high tide events in this region. Predation by Norway rats on rail eggs may also occur during nesting. Contaminants such as mercury were detected in San Francisco Bay clapper rail eggs in 1986-1987 at sufficient levels to affect nesting success (Lonzarich et al. in prep.). Such contaminants could also be adversely affecting the California black rail.

4.2.6.2 California Clapper Rail

This nonmigratory subspecies of clapper rail occurred historically in the tidal salt and brackish marshes of San Francisco and San Pablo bays, as well as sporadically in several coastal marshes from Morro Bay north to Humboldt Bay. In the Estuary, the subspecies was believed to originally occur as far east as Benicia (Solano County). As discussed previously, cessation of heavy turn-of-the-century market hunting led to a short-lived recovery in numbers of these rails, but these gains have been steadily eroded with the destruction of tidal marshes for salt ponds, agricultural land, and bayfill. Finally, in 1970, this subspecies was listed by the Federal government as endangered; it was listed as endangered by the State of California in 1971.

Since historical times, optimal habitat and highest population densities for clapper rails have been in the tidal salt marshes of the South Bay. Gill (1979) estimated that 55 percent of the total population existed in the South Bay during the early 1970s. Present information (K. Foerster, U.S. Fish and Wildlife Service, pers. comm.), however, indicates that the South Bay may support about 90 percent of this total.

Generally, four features characterize preferred habitat for this subspecies: (1) marshes supporting an extensive system of tidal sloughs, providing direct tidal circulation throughout the site; (2) predominant coverage by pickleweed with extensive stands of Pacific cordgrass in the lower elevation marsh zone; (3) high marsh cover consisting of tall stands of pickleweed, gumplant, and wrack; and (4) abundant invertebrate populations, especially Ischadium demissum and Hemigrapsus oregonensis. Lower rail densities in the more brackish marshes of San Pablo Bay and Napa Marsh may be related to variations in freshwater outflow and resulting changes in vegetation. For example, the first recorded nesting by clapper rails in Suisun Marsh (Solano County) occurred in 1979, following the drought years of 1976-1977 (Harvey 1980).

The total clapper rail population was first estimated in the early 1970s by Gill (1979) at 4,200-6,000 individuals. Based on surveys during 1981-87, the population was re-estimated to be about 1,500 individuals (Harvey 1988), with the difference believed to largely represent more accurate survey techniques rather than a population reduction. Reflecting an alarming and ongoing population decline, the subspecies was estimated at about 700 individuals in 1988 and only between 300 and 500 as of 1990-1991. Thus the subspecies is believed to be on the verge of extinction (California Department of Fish and Game and U.S. Fish and Wildlife Service, unpubl. data).

Concurrent with this declining population in rails has been the dramatic population increase of introduced red foxes, particularly along the east shore of the South Bay. Fox predation on rails was documented during 1990-1991, when the remains of several rails and an unhatched egg were found at den sites (J. Takekawa, U.S. Fish and Wildlife Service, pers. comm.). During the mid-1980s, establishment of an introduced red fox population at Seal Beach National Wildlife Refuge in Southern California, led to a severe decline in endangered local light-footed clapper rail (R. l. levipes) and California least tern breeding populations. San Francisco Bay National Wildlife Refuge has prepared a predator management plan and environmental assessment which addresses losses of clapper rails, salt marsh harvest mice, and colonially nesting birds to predators and proposes protection measures (U.S. Fish and Wildlife Service 1991).

Other threats to clapper rails include predation of eggs, young, and adults by Norway rats, raccoons, striped skunks, and feral cats. In addition, extremely high tides and the the lack of high marsh/transition zone habitat has led to predation on adults by northern harriers, barn owls, short-eared owls, and red-tailed hawks. Also, during 1986-1987, mercury was detected in San Francisco Bay clapper rail eggs at levels sufficient to cause embryotoxic effects in mallards (Lonzarich et al. in prep.). Sewage effluent is also reducing salt marsh habitat in the South Bay by its conversion to brackish marsh.

4.2.6.3 Greater Sandhill Crane

Greater sandhill cranes nest in northeastern California in Lassen, Modoc, Plumas, Shasta, Sierra, and Siskiyou counties (California Department of Fish and Game 1988b) and in south-central Oregon. The California population winters entirely within the Central Valley, including the Delta. Surveys by Pogson (1988) estimated that over two-thirds of the Central Valley population used the Delta as a wintering area in December and January of the 1983-1984 season. One of the most significant roosting sites within the Delta for populations of both greater and lesser sandhill cranes is in the vicinity of Thornton. In particular, the Brack Tract and Staten Island have provided roosting habitat for populations numbering over 10,000 birds, including high numbers of greater sandhill cranes (D. Gifford and R. Schlorff, California Department of Fish and Game, pers. comm.). Optimal roosting sites are characterized by shallow water bodies from 5 to 20 acres in size, typically interspersed with or surrounded by low herbaceous or emergent vegetation (U.S. Fish and Wildlife Service 1978b). Feeding within the Delta primarily occurs in harvested cornfields and nearby pastures.

Due to a lack of consistent surveys to assess crane use of the Central Valley, it is difficult to characterize overall population trends. Currently, the population is believed to be relatively stable, although significant threats to their status still exist. On their breeding grounds, the availability of suitable nesting habitat, typically characterized by wet meadow, is largely influenced by agricultural practices and weather conditions. Nesting productivity has been adversely affected by recent drought conditions, which resulted in a 50 percent reduction in nesting attempts in some breeding areas and increased vulnerability to predation (California Department of Fish and Game 1988c).

On the breeding grounds, habitat destruction, human disturbances, predation, and mower-caused mortality have contributed to the threatened status of this subspecies in California. Significant losses have also occurred in the winter due to collisions with powerlines in foggy conditions. Since the Delta wintering areas are vital for sustaining the existing Central Valley population, the potential conversion of these private lands to other uses also poses a significant threat. As a result, nesting habitat in Modoc and Siskiyou counties and wintering grounds in the Delta, such as the Woodbridge Ecological Reserve, have been acquired by the California Department of Fish and Game (R. Schlorff, California Department of Fish and Game, pers. comm.). Efforts by the California Central Valley Habitat Joint Venture to acquire habitat for wintering waterfowl will also benefit the greater sandhill crane in the Central Valley and Delta.

4.2.7 Shorebirds

4.2.7.1 Introduction

Shorebirds comprise plovers, oystercatchers, stilts and avocets, sandpipers (includes willets, curlews, turnstones, small sandpipers, snipe, and dowitchers), and phalaropes. At least 34 species (Table 4-3) occur regularly within the San Francisco Estuary. Only snowy plover, killdeer, black oystercatcher, black-necked stilt, American avocet, and spotted sandpiper (very rarely) nest in the Bay or Delta. Most breed in the tundra, taiga, prairie, or Great Basin regions of North America and pass through the Estuary during their migrations; others spend the winter in the Estuary. These species nest during a two- to three-month period between May and July, thus spending the major part of the year at migratory staging areas and wintering grounds such as the Estuary. The importance of the San Francisco Estuary to shorebirds is apparent, based on the amount of time spent there.

Shorebirds eat a wide variety of invertebrates on tidal mud flats, salt evaporation ponds, shallow ponds, marshes, tidal rocky shores, and agricultural fields in the Bay and Delta. Within San Francisco, San Pablo, and Suisun bays, mudflats are the primary foraging areas for most species at low tide (Table 4-3). Five species feed primarily in salt ponds and five primarily on rocky shores, but the rocky-shore species are not numerous in the Bay (Table 4-4).

Seasonal and farmed wetlands with their associated shallow ponds are a diverse habitat varying in salinity, amount, and type of vegetation, and duration of ponded water. They are likely the most important foraging habitat for at least three species of shorebirds and of secondary importance to at least 12 other species (Table 4-3). When agricultural fields are flooded they provide feeding habitat for several species during the rainy season including black-bellied plover, semipalmated plover, killdeer, greater yellowlegs, long-billed curlew, least sandpiper, dunlin, and common snipe.

Fresh, brackish, and salt marshes are less important feeding areas than other habitats, since shorebirds generally tend to avoid densely vegetated areas. Common snipe and pectoral sandpipers frequently feed in marshes; willets, curlews, and least sandpipers use them to some extent. When using marshes, these species typically forage on tidal mud flats along marsh channels or in shallow ponds.

Tides control the availability of mudflats for foraging shorebirds. Rising tides force birds to abandon the flats both day and night and move to other habitats where they either continue to feed or where they loaf, preen, bathe, or sleep (Recher 1966, Luther 1968, Kelly and Cogswell 1979). Many shorebirds fly to the salt ponds where they roost in tight flocks on islands, levees, or dry pond surfaces. When in salt ponds at high tides, black-bellied plovers and marbled godwits spend almost the entire time roosting, whereas semipalmated plovers, American avocets, willets, dunlins, western sandpipers, least sandpipers, and dowitchers may spend some time foraging (Point Reyes Bird Observatory, unpubl. data). The latter seven species may also move to seasonal wetlands during high tides to forage or roost. Some willets, greater yellowlegs, long-billed curlews, and least sandpipers fly into marshes to forage at high tide, but this habitat is largely avoided by most other species.

4.2.7.2 Shorebird Censuses

There have been five major shorebird censusing efforts in San Francisco Bay. On comparable dates each autumn and spring from 1928 to 1941, Donald McLean made day-long shorebird counts along the same route between Alviso and the Dumbarton Railroad bridge. Data on 14 species from these counts are provided by Skinner (1962). Most species showed no change in numbers over the 14-year period. Red-necked phalarope numbers, however, unexplicably declined. Numbers of godwits increased over the period, perhaps as the population rebounded from losses due to market hunting in the 1800s (Grinnell et al. 1918, Grinnell and Miller 1944). It is not possible to duplicate McLean's counts today because there is no record of the dates, route traveled, or even which side of the Bay was censused.

The next broad-based shorebird counts were conducted by the California Department of Fish and Game between February 1964 and December 1965. Using volunteers, the Department attempted to count all aquatic birds bimonthly in 13 areas scattered around the Bay (Bollman et al. 1970, Gill 1972a). The data from these counts have not been summarized in a manner that allows comparison with other census efforts.

From July 1969 to June 1974, the California Department of Fish and Game undertook a follow-up volunteer effort to conduct censuses of shorebirds throughout California. The study provided valuable information on species' habitat preferences, relative abundance, distribution, and seasonal occurrence patterns (Jurek 1974, 1979). However, the census effort was too limited to be linked with other Bay studies for the purpose of looking at trends in population size over time (Jurek 1974, 1979).

Between February 1981 and January 1985, the California Department of Fish and Game and the U.S. Fish and Wildlife Service jointly conducted a series of aerial surveys to count shorebirds and other birds in the salt ponds south of the San Mateo Bridge. The high counts for species found mainly in the South Bay salt ponds provide insight into the size of some shorebird populations in the Region.

In 1988 the Point Reyes Bird Observatory began a series of spring and fall ground censuses to provide the first Bay-wide estimates of the numbers of all shorebird species. An attempt was made to census all shorebird habitats in San Pablo Bay and northern San Francisco Bay simultaneously on one day and all birds in the remainder of the Bay on the following day (Stenzel and Page 1988b). Since there are only two or three counts per year, they are limited in the degree of annual change that they can detect. Many years of censuses would be required to detect a significant change in the numbers of shorebirds on the Bay. Surveys by the bird observatory revealed that a minimum of 1,125,000 shorebirds currently use San Pablo and San Francisco bays during the year. Numbers for each species at periods of maximum abundance were estimated from U.S. Fish and Wildlife Service aerial counts and Point Reyes Bird Observatory ground counts (Table 4-4).

Since 1989, Point Reyes Bird Observatory has organized broad-based censuses of shorebirds in many of the most important wetlands in California, Nevada, British Columbia, and some wetlands in Utah, Oregon, and Baja California to identify their relative importance to migrating and wintering shorebirds (Page et al. 1990). It is apparent that many more shorebirds are found in the San Francisco Estuary during spring and fall migration than in any other wetland in California. During the height of migration, up to 1,000,000 shorebirds can be counted on San Francisco and San Pablo bays in the spring and up to 375,000 in the autumn. The only other sites on the Pacific Flyway where equivalent or greater numbers have been documented are Grays Harbor in Washington, the Copper River Delta in Alaska, and Great Salt Lake, with its large numbers of migrating Wilson's phalaropes in autumn (Jehl 1988). Information on numbers of wintering birds is somewhat fragmentary. However, it is likely that very few Pacific Flyway wetlands will support 225,000 wintering shorebirds, the number found in the Estuary during 1989.

In April 1990, the San Francisco-San Pablo Bay system was recognized as a site of hemispheric importance by the Western Hemisphere Shorebird Reserve Network, a coalition of public and private agencies dedicated to the conservation of shorebirds. Only three other wetlands in the Pacific Flyway have received the Reserve Network's highest recognition of importance, indicating the Bay's international importance to shorebirds.

Table 4-3. Primary (P) and secondary (S) foraging habitats for regularly-occurring shorebirds in the San Francisco-San Pablo-Suisun Bay system.

Species	Tidal Mud Flat	Salt Ponds	Shallow Ponds	Marshes	Tidal Rocky Shores	Agric. Fields
Black-bellied Plover	P					S
Snowy Plover	S	P				
Semipalmated Plover	P	S				S
Killdeer	P	S	S			P
Black Oystercatcher					P	
Black-necked Stilt		P	S			
American Avocet	P	S	S			
Greater Yellowlegs		S	P			S
Lesser Yellowlegs		P	S			
Willet	P	S		S	S	
Wandering Tattler					P	
Spotted Sandpiper					P	
Whimbrel	P				S	S
Long-billed Curlew	P			S		S
Marbled Godwit	P					
Ruddy Turnstone	P				S	
Black Turnstone	S				P	
Surfbird					P	
Red Knot	P					
Sanderling	P					
Semipalmated Sandpiper	P		S			
Western Sandpiper	P	S	S			
Least Sandpiper	P	S	S	S		S
Baird's Sandpiper	P	S	S			
Pectoral Sandpiper			P	S		
Dunlin	P	S	S			S
Short-billed Dowitcher	P		S			
Long-billed Dowitcher	P		S			S
Common Snipe				P		S
Wilson's Phalarope		P	S			
Red-necked Phalarope		P	S			

Table 4-4. Numbers of shorebirds in the San Francisco-San Pablo Bay system (Point Reyes Bird Observatory, unpubl. data).

Species	Fall 1988	Fall 1989	Winter 1989	Spring 1988	Spring 1989	Spring 1990
Black-bellied Plover	12471	12165	10147	10971	2736	8678
Snowy Plover	159	122	168	103	24	100
Semipalmated Plover	2412	2369	1398	695	1977	1041
Killdeer	544	326	385	281	304	205
Black Oystercatcher	4	0	0	0	4	0
Black-necked Stilt	7622	5589	6956	2541	684	1394
American Avocet	24807	10856	26557	6247	2451	6055
Greater Yellowlegs	641	328	234	602	220	393
Lesser Yellowlegs	69	28	84	105	66	47
Willet	24086	24308	18777	5143	888	4214
Wandering Tattler	15	16	0	2	7	1
Spotted Sandpiper	43	33	9	26	14	11
Whimbrel	325	133	63	135	160	93
Long-billed Curlew	2300	1956	767	293	330	236
Marbled Godwit	28865	24673	19842	32353	16433	24191
Ruddy Turnstone	59	121	34	129	89	47
Black Turnstone	137	53	61	212	115	103
Surfbird	15	17	16	0	77	19
Red Knot	1189	2078	204	1639	1443	260
Sanderling	2234	818	335	922	536	680
Western Sandpiper	121912	107851	26143	555931	717355	474896
Least Sandpiper	34160	27170	3279	16763	21742	28830
Least/Western Sandpiper	84560	72188	-	-	-	-
Baird's Sandpiper	20	20	0	2	1	0
Pectoral Sandpiper	12	2	0	0	1	0
Dunlin	22	4	16941	139713	105599	67775
Least/Western/Dunlin	-	-	77456	-	-	-
dowitchers	20513	23805	15528	62458	50052	43541
Common Snipe	1	1	42	5	3	1
Wilson's Phalarope	8	0	0	213	0	0
Red-necked Phalarope	9387	21408	0	985	8248	977
Total Shorebirds	378612	340083	225427	838470	931561	663790

4.2.7.3 Shorebird Distribution and Abundance in the Estuary

Concentrations of species of shorebirds differ within the Estuary. Overall, more shorebirds are found in the southern than the northern reaches of the system (Table 4-5). On five Bay-wide Point Reyes Bird Observatory censuses (all but the winter census, Table 4-4), 60-70 percent of the total shorebirds found were south of the San Mateo Bridge, compared to 16-26 percent in San Pablo Bay, the next highest region. The northern portion of San Francisco Bay between the Richmond-San Rafael Bridge and the Oakland-San Francisco Bridge held only 2-3 percent of the total, and the portion south to the San Mateo Bridge held 5-19 percent of the total. Red-necked phalaropes, black-necked stilts, greater yellowlegs, lesser yellowlegs, and American avocets were concentrated in the southern portion of San Francisco Bay, red knots in the central portion, and sanderlings in the northern portion. Compared to other species, long-billed curlew and dunlin were relatively abundant in San Pablo Bay.

Greater availability of invertebrate prey on tidal flats and possibly greater availability of high tide foraging habitat are the probable reasons for the larger numbers of shorebirds in the southern reach of the Estuary. Using the Oakland-San Francisco Bridge as a division point, the U.S. Fish and Wildlife Service calculates approximately equal amounts of tidal flat in the north (27,996 acres) and south (29,780 acres) regions of the Bay, and three times more salt pond habitat in the south (27,544 acres) than the north (9,060 acres) reach of the Bay. By contrast there is about twenty times more farmed wetland in the north (26,027 acres) compared to the south (1,317 acres) region of the Bay. If the amount of foraging habitat at high tide is a contributing factor, then the advantages gained from the greater amount of salt pond habitat in the South Bay must more than offset any benefits from the much greater amount of farmed wetland in the north Bay.

Availability of tidal flat invertebrates alone may explain the differing shorebird abundances between the North and South Bay. According to Nichols (1979), the biomass of benthic invertebrates is greater on the tidal flats in the most southern reaches of San Francisco Bay than in San Pablo or Suisun bays. High variability in salinity, due to fluctuating freshwater flow from the Sacramento and San Joaquin rivers, interferes with the establishment of mature populations of estuarine organisms and causes the biomass of benthic intertidal organisms to be lower in the northern than the southern reaches of the Bay. Furthermore, the mean tide level is 8-inches higher and the tidal range is lower in the northern than in the southern reach of the Bay (Conomos 1979). Thus, tidal flats of lower elevation, and presumably of greater invertebrate biomass, are more available to shorebirds in the south than the north reaches of the Bay.

Much less information is available on shorebird use of Suisun Bay. A total of 21 species of shorebirds have been identified in Suisun Bay (Blanchfield 1976), but most are uncommon or occur occasionally. The results of one Point Reyes Bird Observatory census, which included an aerial count of shorebirds in Suisun Bay, indicated that many fewer shorebirds use Suisun Bay

Table 4-5. The percent composition of shorebirds among four regions of the San Francisco-San Pablo Bay system. Min = minimum, med = median, max = maximum. An asterisk indicates a percentage greater than 0% but less than 0.5% (Point Reyes Bird Observatory, unpubl. data).

	San Pablo Bay			North San Francisco Bay			Central San Francisco Bay			South San Francisco Bay		
Species	min	med	max	min	med	max	min	med	max	min	med	max
Black-bellied Plover	20	29	32	1	3	9	6	9	17	46	56	70
Semipalmated Plover	7	22	41	3	6	11	17	21	32	29	53	72
Killdeer	24	29	52	14	14	23	17	20	28	17	25	41
Black-necked Stilt	1	1	6	*	1	4	2	6	15	75	93	96
American Avocet	11	17	27	1	1	4	2	10	22	52	72	86
Greater Yellowlegs	3	12	20	1	5	6	3	6	16	58	76	87
Lesser Yellowlegs	0	1	46	0	0	3	0	3	11	51	86	99
Willet	15	18	55	4	5	7	6	11	19	34	63	70
Long-billed Curlew	40	45	63	2	5	19	4	6	14	23	37	47
Marbled Godwit	31	36	43	1	1	2	13	16	18	40	46	52
Ruddy Turnstone	0	0	6	2	9	17	23	45	75	8	53	65
Black Turnstone	2	13	74	6	39	89	5	17	73	2	4	7
Red Knot	0	9	85	0	0	*	1	65	97	3	14	51
Sanderling	0	11	41	27	65	86	13	17	42	1	5	16
Western Sandpiper	16	18	27	2	2	3	3	9	12	59	70	79
Least Sandpiper	27	39	43	5	7	7	11	14	18	36	38	55
Dunlin	17	45	48	1	2	5	4	9	9	41	47	72
dowitchers	16	20	28	3	3	5	9	24	28	46	50	68
Red-necked Phalarope	0	*	2	0	0	*	0	*	13	87	99	100
Total shorebirds	16	22	26	2	3	3	5	12	19	60	62	70

than San Pablo or San Francisco bays (Stenzel et al. 1989). In early September 1988 a total of 2,646 shorebirds (at least 11 species) were counted on the aerial census of Suisun Bay, compared to 376,000 for San Pablo and San Francisco bays combined. Black-bellied plovers, western sandpipers, least sandpipers, and dowitchers were the only species to exceed 100 individuals on the count.

Estimates of the abundance of regularly occurring species in Suisun Bay are based on information from Grizzly and Joice islands (Jurek 1974), Benicia area Christmas Bird Counts of the Audubon Society, and the Point Reyes Bird Observatory's September 1988 census. The most abundant species were western sandpiper, dunlin, and dowitchers, all of which were present in the hundreds during fall and in the thousands during winter and spring. Those occurring in the hundreds during fall, winter, and spring included the black-bellied plover, killdeer, black-necked stilt, American avocet, greater yellowlegs, long-billed curlew, least sandpiper, and common snipe. Lesser numbers (<100) of semipalmated plover, lesser yellowlegs, willet, spotted sandpiper, marbled godwit, sanderling, and red-necked phalarope were counted during fall, winter, and spring. Killdeer and American avocet were the only species breeding in Suisun Bay in spring and summer.

Shorebird abundance in the Delta has not been determined through censuses. Shorebird numbers are probably greater in the Delta than they are in Suisun Bay, but they are much lower than in San Pablo and San Francisco bays. To a large degree shorebird use of the Delta is dependent on agricultural practices, especially crop patterns and the flooding of fields. Extensive early fall and spring flooding of plowed fields can result in large concentrations of shorebirds (D. Gifford, California Department of Fish and Game, pers. comm.). The relative abundance of shorebirds in the Delta and their foraging habitat preferences are indicated in Tables 4-6 and 4-7, adapted from Manolis and Tangren (1975), Madrone Associates et al. (1980), and England and Naley (1990). At least 27 species occur annually in the Delta. Killdeer, black-necked stilt, American avocet, and rarely snowy plover and spotted sandpiper are the only nesting species. Other species occur only during migration or in winter.

4.2.7.4 Species Accounts

4.2.7.4.1 Black-bellied Plover

Black-bellied plovers breed in arctic regions of Alaska and Canada. In the West they winter primarily along the Pacific coast from southern British Columbia to central Chile (American Ornithologists' Union 1983). The autumn migration extends principally from late July until at least late November (Jurek and Leach 1973, DeSante and Ainley 1980, Shuford et al. 1989). In San Francisco Bay it is unclear whether an annual maximum in abundance is reached by late August and maintained until the spring exodus from mid-April to early May (Shuford et al. 1989), or whether there is a peak in numbers in October followed by a decline to relatively stable winter levels from November through mid-April (Gill 1972a, Point Reyes Bird Observatory, unpubl. data). There is no increase in abundance during spring migration in April and May (Storer

Table 4-6. Relative abundance of species of shorebirds which occur annually in the Sacramento-San Joaquin Delta. Adopted from Manolis (1975). F = Fall, S = Spring, W = Winter, B = Summer Breeder.

	Occurring Every Year Number per day per locality						Irregular Occurrence
Species	201- 1000+	51- 200	21- 50	7- 20	2- 6	>0- 1	
Black-bellied Plover	F	S		W			
Lesser Golden Plover						F	W
Snowy Plover						S	FB
Semipalmated Plover				SF			W
Killdeer	W	S		B			
Mountain Plover			W				
Black-necked Stilt			SB				W
American Avocet			SB			W	
Greater Yellowlegs			F	S	W		
Lesser Yellowlegs				F		W	S
Solitary Sandpiper						F	S
Willet					F	S	W
Spotted Sandpiper					FWS		B
Whimbrel			S			F	W
Long-billed Curlew	FWS						
Marbled Godwit					F	S	W
Ruddy Turnstone						F	
Western Sandpiper	FS				W		
Least Sandpiper		FS			W		
Baird's Sandpiper					F		S
Pectoral Sandpiper				F			S
Dunlin	S	F	W				
Short-billed Dowitcher					F	S	
Long-billed Dowitcher	FS		W				
Common Snipe				F	SW		
Wilson's Phalarope		F			S		
Red-necked Phalarope		F			S		

Table 4-7. Primary (P) and secondary (S) foraging habitats for regularly-occurring shorebirds in the Sacramento-San Joaquin Delta.

Species	Marshes	Tidal Flats	Oxidation Ponds	Riprapped Levees	Agric. Fields
Black-bellied Plover		S	S		P
Lesser Golden Plover			P		P
Snowy Plover			P		
Semipalmated Plover		P	P		S
Killdeer	S	S	S	S	P
Mountain Plover					P
Black-necked Stilt	S		P		S
American Avocet	S	S	P		S
Greater Yellowlegs	S	S	P		P
Lesser Yellowlegs	S	S	P		S
Solitary Sandpiper	P		P		
Willet	S	P	S		
Spotted Sandpiper		S	P	S	
Whimbrel	S	?	S		P
Long-billed Curlew	?	?	S		P
Marbled Godwit			P		S
Ruddy Turnstone		P	P		
Western Sandpiper		P	P		
Least Sandpiper	S	P	S		P
Baird's Sandpiper	S		P		
Pectoral Sandpiper	S		P		
Dunlin		S	S		P
Short-billed Dowitcher		S	P		
Long-billed Dowitcher	S	S	S		P
Common Snipe	P	S	S		P
Wilson's Phalarope	S		P		S
Red-necked Phalarope	S		P		

1951, Gill 1972a, DeSante and Ainley 1980, Shuford et al. 1989). The yearly low in numbers extends from mid-May until late July. Birds in the Bay during this period are non-breeders, primarily one-year-olds.

About 12,000 black-bellied plovers were found in San Francisco Bay during the Point Reyes Bird Observatory's autumn counts in 1988 and 1989 (Table 4-4). A mid-winter count of 10,000 birds in 1989-90, and mid-April counts between 8,700 and 11,000 in 1988 and 1990, suggest that 9,000 to 12,000 plovers may be present in the Bay from at least late August until mid-April. The low of 2,700 black-bellied plovers in late April 1989 resulted from the departure of wintering birds earlier in the month or was an underestimate of actual numbers due to poor census conditions during part of the count. Apparently hundreds of non-breeding black-bellied plovers spend the summer in the Bay. In June 1989, Page and Kjelmyr (unpubl. data) counted 674 black-bellied plovers in the South Bay during snowy plover surveys.

4.2.7.4.2 Snowy Plover

In western North America, snowy plovers nest along the west side of the Great Basin, in California's Mojave and Colorado deserts and San Joaquin Valley, in Arizona and New Mexico, and along the Pacific Coast from southern Washington to Mexico (Page et al. in prep.). Though some New Mexico birds may winter in the Gulf of Mexico, those from other states spend winter primarily on the Pacific Coast from Oregon south to Mexico.

Salt pond levees and islands and the bottoms of dried salt ponds provide the nesting habitat for snowy plovers in San Francisco Bay where breeding extends from mid-March until mid-September (Warriner et al. 1986). Snowy plovers may not have bred in San Francisco Bay prior to the construction of salt evaporators. It is possible that natural salt ponds in the vicinity of San Lorenzo once supported nesting birds, but insufficient data exist to assess this, and the ponds have been destroyed. The snowy plover is known to colonize newly available habitat very quickly (Ivey 1984) and was apparently a fairly common nester on the salt ponds as early as 1918 (Page and Stenzel 1981).

Gill (1977) surveyed some South Bay salt ponds for breeding adults in 1971 and extrapolated 150 pairs (300 birds) for the South Bay. Subsequent surveys based on counts of the entire Bay produced 351 adults in June 1978, 270 in 1984, and 226 in 1989 (Page and Stenzel 1981, Page et al. in prep) and indicated that the number of breeders may be declining. Almost all nesting occurs in the South Bay.

The breeding population is augmented by wintering birds that begin returning in early July and continue arriving until November (J. Warriner, Point Reyes Bird Observatory, pers. comm.). Some breeding birds likely migrate from the Bay to wintering areas on the outer coast of California and Mexico (Warriner et al. 1986). A few breeders may return to the Bay as early as January, but most come back from February through April (Warriner et al. 1986). Page et al. (1986) estimated that 350-500 snowy plovers may winter in the Bay, but, based on more recent information, it appears likely that winter numbers are closer to 350 than 500 birds. The salt evaporators in the Baumberg area hold most of the wintering plovers, with roosts of up to 330 birds found there in recent years (Page et al. 1986).

Snowy plovers have been eliminated from a substantial portion of their former breeding range on the Pacific Coast, and numbers of coastal breeders appear to be on the decline (Page and Stenzel 1981, Page et al. in prep.). Human encroachment of breeding habitat and nest loss to introduced predators (red foxes) are two of the most serious problems currently faced by the plover. As a result, the U.S. Fish and Wildlife Service was petitioned to list the coastal population of snowy plovers, including those that nest in San Francisco Bay, as threatened; a determination on the listing is pending.

4.2.7.4.3 Long-billed Curlew

Up to 2,300 long-billed curlews have been recorded around San Francisco and San Pablo bays in the fall (Table 4-4). Only about 750 curlews were found on the one winter census conducted to date. By mid-April many curlews have left the Bay Area for their breeding grounds (Shuford et al. 1989). Therefore, numbers in Bay-wide censuses in April are consistently lower than those in the fall (Table 4-3). The largest concentrations of curlews occur in the Central Valley during winter when seasonal wetlands are inundated (Cogswell 1977). Curlews also winter along the Pacific Coast from Washington south into Mexico. This species is believed to be on the decline due to agricultural conversion of their inter-mountain prairie breeding habitat. They are currently listed as a Category 2 candidate species by the U.S. Fish and Wildlife Service.

4.2.7.4.4 Willet

In western North America, willets breed in the Great Basin, and in prairie regions of Canada and the United States. They winter along the Pacific Coast from northern Oregon to northern Chile (American Ornithologists Union 1983).

Willets are present on San Francisco Bay year-round. Fall migration lasts from mid-June until early November (Jurek and Leach 1973, Shuford et al. 1989). In the Bay, willet numbers probably reach a peak between early August and mid-October (Storer 1951, Gill 1972a, Shuford et al. 1989) before they stabilize at winter levels from November until mid-April. The spring exodus for the breeding grounds occurs primarily during the latter part of April (Shuford et al. 1989). Numbers are lowest from the beginning of May until mid-June.

The peak numbers of willets recorded for the Bay were 24,000 birds on two autumn Point Reyes Bird Observatory censuses (Table 4-4). A mid-winter count located 18,800 willets (Table 4-4). The highest numbers on U.S. Fish and Wildlife Service aerial counts of the South Bay were 18,500 willets on 27 October 1982 and 17,000 on 29 July 1982. Given the limited data available to date, it would be reasonable to assume that autumn numbers of willets in the Bay reach at least 24,000 and winter numbers approach 20,000 birds. Numbers of willets on three Point Reyes Bird Observatory April counts did not exceed 5,150 birds (Table 4-4) because many had left the Bay for their breeding grounds by the time of the counts. In early June 1989, Page and Kjelmyr (unpubl. data) recorded a minimum of 220 willets in the South Bay during snowy plover counts, indicating that hundreds of non-breeding willets spend the summer on the Bay.

4.2.7.4.5 Western Sandpiper

This species breeds in the northern and western regions of Alaska and in northeastern Siberia. Its western winter range extends primarily along the Pacific Coast from Washington to northern Peru (American Ornithologists Union 1983, Peterson 1990).

The western sandpiper's autumn migration extends from late June until at least late October (Shuford et al. 1989). According to Storer (1951), abundance decreases over the course of the winter, but this pattern is not supported by data collected during the winter of 1989-90 by the Point Reyes Bird Observatory (Page and Kjelmyr, unpubl. data). Spring migration, from late March until late May, is marked by a pronounced influx of western sandpipers into the Bay when numbers of spring migrants peak about the last week of April. After May, only occasional western sandpipers are found in the Bay until fall migrants begin arriving in late June.

Three Point Reyes Bird Observatory counts indicated 475,000 to 700,000 western sandpipers are found in the Bay during the peak of spring migration (Table 4-4). Peak numbers in spring probably regularly exceed 500,000 birds. Estimates of numbers for fall and winter are coarser than spring numbers, because many small sandpipers have not been separated according to species on counts during these periods. On two autumn Bird Observatory counts, 180,000 to 190,000 western sandpipers were estimated for the Bay. One mid-winter count in 1989-1990, on which only 37 percent of the small sandpipers were identified to species, indicated that there were about 70,000 western sandpipers in the Bay, providing unidentified small shorebirds were proportioned similarly to those identified on the census.

4.2.7.4.6 Least Sandpiper

Least sandpipers breed in tundra and taiga regions of Alaska and Canada. Their wintering grounds in the west extend along the coast from Washington to northern Chile and include some inland locations in southern Utah, central Arizona, central New Mexico, and California (American Ornithologists Union 1983, Peterson 1990).

Fall migration of this species in the San Francisco Bay area extends from late June until mid-November. During late August until early October, the number of least sandpipers in the Bay are likely higher than at any other time of the year (Shuford et al. 1989). It is unclear whether winter numbers are relatively stable or whether they decline from mid-November to early April. The spring exodus is from early April to early May. If there is a spring influx of migrants into the Bay area, the numbers are not great enough to cause a discernable peak in abundance (Shuford et al. 1989). From mid-May until late June, only occasional least sandpipers are encountered in the Bay.

Spring shorebird counts by Point Reyes Bird Observatory indicated 16,800 to 28,800 least sandpipers in the Bay in April (Table 4-4). In autumn, Bird Observatory counts indicated that 45,000 to 52,000 least sandpipers can be present on the Bay. The Point Reyes Bird Observatory's only mid-winter count extrapolates to only 8,800 birds, probably a substantial underestimate of typical winter numbers.

4.2.7.4.7 Dunlin

Dunlin that winter in San Francisco Bay belong primarily to the race that breeds in western Alaska and winters along the Pacific Coast from southeastern Alaska to Baja California and Sonora Mexico. Dunlin also winter in California's Central Valley and at the Salton Sea (Maclean and Holmes 1971, Browning 1977, American Ornithologists Union 1983, Greenwood 1984).

In the fall, dunlin migrate into the Bay area much later than other shorebirds. Migration does not begin until the third or fourth week of September. Dunlin numbers at the latitude of San Francisco Bay are greatest between late October and mid-November (Storer 1951, Holmes 1966, Shuford et al. 1989). They appear to decline between late November and late February, after which they are fairly stable until a spring exodus from early April until mid-May. The absence of an influx of spring migrants into the Bay is demonstrated in most studies by the lack of a spring peak in abundance (but see Gill 1972a). Dunlin are only occasionally encountered on the Bay between mid-May and mid-September.

Between 68,000 and 140,000 dunlin have been recorded on the Bay on three April counts (Table 4-4). Numbers recorded on autumn counts have been comparatively very low because most dunlin have not reached the Bay by the time of the August and September counts. Only 45,000 dunlin were extrapolated from one mid-winter count (Table 4-4), a number that seems low, considering April numbers and the suspected seasonal abundance pattern of the species on the Bay.

4.2.7.4.8 Dowitcher Species

Two species of dowitchers, the short-billed dowitcher and long-billed dowitcher, occur in San Francisco Bay but are very difficult to separate, and are therefore combined as dowitcher species on most censuses. Pitelka (1950) found that the short-billed dowitcher occurs mostly in marine and brackish water environments and the long-billed dowitcher mostly in fresh water. It is assumed that the majority of dowitchers in the Bay are the short-billed species. S. Bailey (California Academy of Sciences, pers. comm.) also describes long-billed dowitchers as more common in brackish, non-tidal habitats around the periphery of the Bay.

Dowitchers breed mostly in coastal regions of Alaska, the northern Yukon, the northwest MacKenzie region, and northeastern Siberia. They winter along the Pacific Coast from Washington to central Peru, with long-billed dowitchers distributed more to the north and short-billed dowitchers more to the south. The long-billed dowitcher also winters in California's Central Valley, in southern Arizona, southern New Mexico, and throughout Mexico to Panama (American Ornithologists Union 1983, Peterson 1990).

The conspicuous autumn (late June into November) and spring (mid-March to late May) migrations of dowitchers through the Bay area (Shuford et al. 1989) are characterized by two peaks in species abundance. The fall peak is of lower magnitude and is more protracted than the spring peak (Storer 1951, Recher 1966, Shuford et al. 1989). Dowitchers are probably most abundant in the Bay during the second half of April. Winter numbers, from late November to mid-March, are probably relatively stable (Page and Kjelmyr, unpubl. data). From late May to late June dowitchers are only occasionally seen in the Bay.

More dowitchers have been counted during the three spring counts (43,541-62,458 birds) than during the two fall counts (20,513-23,805) or the one winter count (15,528) of the Bay (Table 4-4).

4.2.7.4.9 Marbled Godwit

Marbled godwits nest primarily on the Canadian prairies south into Montana, North Dakota, South Dakota, and Minnesota. In the West they winter primarily along the coast from southern Washington to northern Chile (American Ornithologists Union 1983, Peterson 1990).

The fall migration of marbled godwits into the Bay Area begins by late June or early July and extends until at least the third week of October (Kelly and Cogswell 1979, Shuford et al. 1989). It is unclear what happens during winter. Gill (1972a) shows numbers dropping sharply between December and January and remaining stable from January to April. Kelly and Cogswell (1979) describe winter numbers as decreasing, possibly as birds move farther south. Other data suggest that numbers of wintering godwits do not decline from late October until late April (Storer 1951, Luther 1968, Page and Kjelmyr, unpubl. data). The spring exodus of godwits extends from the last week of April to the last week of May as birds fly to their breeding grounds (Kelly and Cogswell 1979, Shuford et al. 1989). There may be some migratory movement through the Bay during this time (Luther 1968, Jurek and Leach 1973), but it is not marked by a sharp increase in numbers. Relatively few non-breeding godwits remain on the Bay from late May until late June. In June 1989, Page and Kjelmyr (unpubl. data) recorded at least 230 birds in the South Bay alone.

The highest U.S. Fish and Wildlife Service count for marbled godwits in the South Bay was 16,000 on 27 October 1982. Point Reyes Bird Observatory counts for the entire Bay averaged about 27,000 godwits on two fall counts, almost 20,000 on a mid-winter count, and about 28,000 on two spring counts in mid-April.

Godwits in California were believed to have decreased markedly in number by 1910 due to market hunting and destruction of breeding habitat (Grinnell et al. 1918, Grinnell and Miller 1944). Grinnell and Miller (1944) reported that population recovery began about 1910 and was nearly complete by 1944.

4.2.7.4.10 American Avocet

American avocets breed throughout much of the western United States and into south-central Canada (Peterson 1990). In western North America this species winters mostly in coastal lowlands from northern California to southern Mexico (American Ornithologists Union 1983).

Currently, avocets nest primarily on levees or islands at salt evaporation ponds in San Pablo and South San Francisco bays (Gill 1977, Rigney and Rigney 1981). Nesting in Suisun Bay and the Delta is near ponded water in marshes or on agricultural land. The breeding period lasts from mid-March (Swarth et al. 1982) probably through mid-September.

American avocets have probably become more abundant in the San Francisco Bay Estuary since 1850. Prior to 1850 they likely bred in the Central Valley (Grinnell et al. 1918), but probably not in San Francisco Bay, at least in any numbers. There are records of avocets from Indian middens near Coyote Hills and Emeryville, indicating occurrence in the Bay prior to 1850 (Howard 1931, Leventhal 1991). The species was recorded near Berkeley in December 1884, and several hundred were reported in November 1899 at salt ponds near Hayward (Grinnell et al. 1918). By 1918, Grinnell et al. (1918) described avocets as wintering casually on the coast north to San Francisco Bay. The first verified breeding record for the Bay was in 1926 (Gill 1977). By 1927 Grinnell and Wythe (1927) describe the species as an irregularly common visitor to the Bay chiefly in autumn and winter. Stoner (1937) reported nesting by two pairs in a Suisun Bay marsh in 1934 and described the species as being common there during migrations. By 1944 Grinnell and Miller (1944) considered avocets to be occasional breeders in the Bay. At that time San Francisco Bay was still the northern limit of the winter range. By about 1950, avocets were recognized as common residents in the Bay (Sibley 1952, Gill 1977). In 1981, Rigney and Rigney (1981) described nesting pairs of avocets in the South Bay as increasing steadily since 1950, but Cogswell (California State University Hayward, pers. comm.) feels avocet numbers have not increased in the South Bay since the 1960s.

Avocet numbers increase in San Francisco Bay from July to October or November as fall migrants augment the breeding population (Gill 1972a, U.S. Fish and Wildlife Service unpubl. data). It is unclear whether avocet numbers decline steadily from November through May, or whether they decline from November to December and are then fairly stable until March, after which there is a spring exodus of wintering birds that extends into May (Storer 1951, Gill 1972a, Jurek and Leach 1973, Page and Kjelmyr, unpubl. data).

Estimates of the size of the breeding avocet population in the South Bay are 1,800 pairs in 1971 (Gill 1977), 800 pairs in 1980 (Moss 1980), and 650 pairs in 1981 (Rigney and Rigney 1981). The crude and sometimes differing extrapolation methods used by these authors for their population estimates could lead to such variable results in the absence of real differences in population size. During June, the U.S. Fish and Wildlife Service tallied 1,884 and 218 avocets on aerial surveys of the South Bay in 1981 and 1982, respectively. During a snowy plover survey during June 1989, Page and Kjelmyr (unpubl. data) recorded a minimum of 1,656 avocets (breeders and nonbreeders) in the South Bay. By comparison, relatively few avocets breed in the salt ponds of the North Bay. Gill (in litt.) reported 24 pairs of avocets at the Little Island evaporator in June 1975. In June 1978, Page and Henderson (unpubl. data) surveyed the North Bay evaporators and found only 25 avocets, all at Little Island.

On Point Reyes Bird Observatory's shorebird censuses in San Francisco Bay, avocet numbers ranged from 10,856 in August 1989 to 26,557 during a mid-winter count in 1989-90 (Table 4-4). The highest count of avocets on U.S. Fish and Wildlife Service aerial surveys of the South Bay was 24,450 on 1 December 1982. Overall, these data suggest that about 25,000 avocets may occur in the Bay from late fall into winter. Numbers on three Point Reyes Bird Observatory April counts did not exceed 6,250 birds (Table 4-4), indicating that most avocets have left the Bay by mid-April.

4.2.7.4.11 Black-necked Stilt

Stilts breed in southwestern North America, Central America, and in northern South America (Johnsgard 1981). In western North America, concentrations of breeding stilts are found in the interior of the state of Washington, the Great Basin, the Central Valley of California, and the Pacific Coast from San Francisco Bay south (Peterson 1990). Birds vacate most of the interior for coastal locations in winter; San Francisco Bay is at the northern limit of the coastal wintering range.

Black-necked stilts have apparently increased in abundance in San Francisco Bay since the construction of salt ponds. Stilts have nested in wetlands of the Central Valley since before 1850 (Grinnell et al. 1918, American Ornithologists Union 1983). Within San Francisco Bay, they probably occurred only rarely or sporadically as migrants prior to salt pond construction. Grinnell et al. (1918) described the stilt as occurring only sparingly in the Bay during migration. Grinnell and Wythe (1927) reported limited numbers in the Bay in summer and fall and rare stragglers during winter. Stilts nested in the Bay area by at least 1927. Stoner (1931) described a stilt with young in May 1931 as the "first and only black-necked stilts which I have observed in marshes about Suisun Bay." By 1952, Sibley (1952) described the species as an uncommon summer resident and a rare winter resident in the Bay. According to Gill (in litt.), stilts probably did not move into San Pablo Bay until 1965, and nesting did not begin (in the salt ponds) until the early 1970s. According to H. Cogswell (California State University Hayward, pers. comm.), the number of breeding stilts began to increase substantially in the South Bay in the 1960s and has continued to increase to the present.

Currently, black-necked stilts nest mainly on levees or islands at salt evaporation ponds in South San Francisco Bay. In Suisun Bay and the Delta, nesting is near ponded water in marshes and on agricultural lands. The breeding period is probably similar to the snowy plover's, extending from mid-March through mid-September.

There is an influx of stilts into the Bay during fall migration, which probably extends from July until November; peak numbers likely occur sometime between September and November (Gill 1972a). It is unclear what happens to stilt numbers after November. Aerial survey data from the South Bay between 1982 and 1985 showed that stilt numbers declined steadily from November to May, while data from ground counts in 1964 and 1965 showed a sharp decrease in fall numbers to winter lows by November or December. In any case, there is an exodus of wintering birds from the Bay from the last week of March into May (Jurek and Leach 1973, Shuford et al. 1989).

The South Bay breeding population of stilts was estimated to be 400 to 500 pairs in 1971 (Gill 1977), and 600 to 650 pairs in 1981 (Rigney and Rigney 1981). On California Department of Fish and Game/U.S. Fish and Wildlife Service June aerial surveys of the South Bay, observers recorded 534 and 347 stilts in 1981 and 1982, respectively. In a survey of snowy plovers in June 1989, Page and Kjelmyr (unpubl. data) recorded at least 729 stilts (both breeding and nonbreeding birds) in the South Bay. Fewer stilts nest in the wetlands of the North Bay. On surveys in 1973 and 1974, Gill (1977) never found more than a few nesting pairs there, and in June 1978 Henderson and Page (unpubl. data) observed only 10 stilts during a survey of the ponds.

The Point Reyes Bird Observatory recorded an average of about 6,600 stilts during two fall surveys in San Francisco Bay and nearly 7,000 birds during a mid-winter count in 1989-1990 (Table 4-3). April numbers from 1988 to 1990 were much lower, undoubtedly because many wintering birds had migrated from the Bay by that time. California Department of Fish and Game/U.S. Fish and Wildlife Service aerial counts of stilts from the South Bay found a high of 11,600 birds on 9 November 1981. Since the majority of stilts occurred in the South Bay, it would appear that 8,000 to 12,000 stilts may occur in the Bay in late fall with numbers during the remainder of the year being lower.

4.2.7.4.12 Wilson's Phalarope

This species main breeding areas are the prairie marshes of the northern United States and southwestern Canada. Recently, the breeding range of the Wilson's phalarope has expanded to include small and isolated breeding localities from the southern Yukon and Vancouver Island to central Arizona in the west, and from James Bay, Quebec, and Nova Scotia to Massachusetts in the east. The principal wintering grounds are in South America along the Cordillera, from Cochabamba, Bolivia, to central Cordoba Province, Argentina (Jehl 1988).

Wilson's phalaropes occur almost exclusively on salt ponds during migrational stopovers in San Francisco Bay. Given their strong preference for the ponds and the apparent rarity of the species in San Francisco Bay even as late as 1927 (Grinnell and Wythe 1927), it is likely that this species uses the Bay in greater numbers now than they did before the construction of salt ponds. During fall migration from June to late September, tens of thousands of Wilson's phalaropes congregate on the salt ponds of San Francisco Bay (Swarth et al. 1982, Jehl 1988), with peak numbers probably occurring between early July and early August, but varying considerably among years. Swarth et al. (1982) counted 22,000 phalaropes in the ponds between Highway 84 and the Alameda Flood Control Channel in early July 1981. The highest fall aerial count by the California Department of Fish and Game/U.S. Fish and Wildlife Service of Wilson's phalaropes in the South Bay was 37,462 on 6 August 1984. This count represented about 2.5 percent of the estimated world population of Wilson's phalaropes (1,500,000 birds) (Jehl 1988). There is a small passage of spring migrants through the Bay in April and May, but the peak numbers during this period probably do not exceed a few hundred birds.

4.2.7.4.13 Red-necked Phalarope

Red-necked phalaropes breed in arctic and taiga regions of Alaska and Canada; in the west they winter at sea, primarily off South America (American Ornithologists Union 1983). This species occurs in the Bay during spring and autumn migrations. Red-necked phalaropes prefer salt ponds over other habitats, although to a lesser degree than do Wilson's phalaropes. Grinnell and Wythe (1927) described this phalarope as abundant during both migrations. Fall migrants occur from early July until early October and reach maximum abundance in August (Gill 1972a, Swarth et al. 1982). Lower numbers are present during spring migration (Sibley 1952), which extends from mid-April through late May (Storer 1951, Gill 1972a, Shuford et al. 1989). Small flocks of non-breeding birds may be found in June.

The highest count of red-necked phalaropes on U.S. Fish and Wildlife Service aerial surveys of the south Bay was 19,000 on 18 August 1981. Bay-wide counts in fall by the Point Reyes Bird Observatory ranged from 9,387 in 1988 to 21,408 in 1989 (Table 4-4). Cogswell (California State University Hayward, pers. comm.) observed tens of thousands of red-necked phalaropes in a few salt ponds during late summer in the 1960s. If other ponds in the Bay of comparable salinity held similar numbers, Cogswell estimates that over 100,000 red-necked phalaropes may have been staging in the Bay. Bay-wide spring counts conducted by the Point Reyes Bird Observatory produced from 977 to 8,248 birds, but the species was absent during the one mid-winter count.

4.2.8 Owls

4.2.8.1 Burrowing Owl

The burrowing owl is found throughout the western United States, north to southern Canada and south into South and Central America. This species is a year-around resident throughout central and southern California, including the study area. This owl occupies dry, open upland habitats, such as grassland, uncultivated agricultural fields, and, occasionally, vacant urban areas. Historically, Estuary populations were greater in Alameda, Contra Costa, and Santa Clara counties than in Sonoma, Napa, Solano, and Marin counties (Grinnell and Wythe 1927).

Declining populations were first reported in the 1940s (Grinnell and Miller 1944). Steady declines continued and were described by a number of sources as being severe by the late 1970s (Remsen 1978). Currently, numbers in California continue to decline (Marti and Marks 1989). As a result, the burrowing owl is a State Species of Special Concern in California and in three other western states, a sensitive species in Idaho, and an endangered species in two midwestern states (Marti and Marks 1989).

Habitat destruction due to agricultural conversion and urban expansion is the major factor in population declines of the burrowing owl (Zarn 1974, Remsen 1978, Marti and Marks 1989). Also, since these owls feed on rodents, nest colonially, and are dependent on active mammal burrows for nest sites, small mammal eradication efforts adversely affect populations through direct loss of nest sites, reduction in prey base, and toxic effects from rodenticides. In addition, Remsen (1978) reported, "their propensity for nesting in roadside banks also makes them particularly vulnerable to roadside shooting, being hit by cars, road maintenance operations, and general harassment."

4.2.8.2 Long-eared Owl

The long-eared owl is a year-round resident throughout much of the study area as well as in the northeastern and eastern portions of California. In the Central Valley and the southeastern part of California, this owl is currently an exclusive winter resident (Zeiner et al. 1990a). They forage in open grassland and agricultural areas and occasionally are found feeding in forest habitats. This species was historically common to abundant throughout California (Grinnell and Miller 1944). Within the study area, they were known to occur in Sonoma and Marin counties, with individuals reported in San Francisco, Santa Clara, and Alameda counties. Historic nesting sites were found in Alameda and Marin counties (Grinnell and Wythe 1927). Long-eared owls nest primarily in dense forest and riparian habitat, most often using abandoned crow and hawk nests as nesting sites.

A decline in population numbers and distribution became apparent by the early 1940s (Grinnell and Miller 1944). Remsen (1978) cited severe declines in population numbers, especially in the Sacramento and San Joaquin valleys and the San Diego area, all of which had historically supported abundant numbers of the species. Remsen (1978) also reported no records of nesting in the Bay area for a number of years. However, a recent nesting attempt was reported for the Monte Bello Open Space Reserve in northwestern Santa Clara County (D. Erickson, LSA Associates, pers. comm.).

Loss of riparian habitat is likely the primary factor contributing to declines in the long-eared owl population (Remsen 1978). Other possible factors include corvid eradication, which affects the availability of nesting sites, loss of foraging areas through agricultural conversion, and the effects of pesticides (Marti and Marks 1989). The long-eared owl is currently designated a California Species of Special Concern.

4.2.8.3 Short-eared Owl

This owl is found throughout North America as well as northern Eurasia and the southern portion of South America. In California they are year-around residents in the northern part of the state and winter visitors in the south. Within the Estuary, the species is uncommon in the winter, with even fewer remaining the rest of the year (Grinnell and Wythe 1927). This owl uses saltwater and freshwater marshes, tall grasslands, and agricultural fields as nesting and foraging habitat (Marti and Marks 1989). Conversion of land to agriculture, grazing, trampling, and predation threaten this species. Both the short-eared owl and northern harrier face similar threats due to their ground nesting behavior and reliance on rapidly declining nesting habitat. Because the breeding population levels in California, including portions of the Estuary study area, have been greatly reduced, Remsen (1978) listed this owl as a Species of Special Concern in California.

The present status of this species in California is not clear due to insufficient inventory data. It can be assumed, however, that ongoing losses of marsh and grasslands in the Estuary study area and throughout the species range will continue to cause declines.

Short-eared owls monitored during waterfowl nesting studies on Grizzly Island Wildlife Area appeared to benefit greatly from habitat management for waterfowl (California Department of Fish and Game 1987f). Tall, dense herbaceous vegetation provides increased nesting cover as well as increased habitat for prey species

4.2.8.4 Northern Spotted Owl

The northern spotted owl (Strix occidentalis caurina) is listed as threatened under the U.S. Endangered Species Act. In the San Francisco Bay area its habitat is primarily redwood and mixed evergreen forests. Historically, spotted owls probably occurred in forested areas throughout the margins of the study area. Currently, the species occurs at scattered locations in the Mayacamas Mountains of Napa and Sonoma counties and in the western portion of Marin County.

4.2.9 Other Birds

4.2.9.1 Bank Swallow

Historically, this species was considered locally common to abundant in the scattered lowlands of California wherever fine, sandy-textured vertical earthen banks, bluffs, sand, or gravel pits occurred (Grinnell and Miller 1944). These swallows dig their burrows and nest colonially in California and then winter in South America. Within the study area, historic nesting colonies existed in Contra Costa, Alameda, and Sacramento counties (Grinnell and Wythe 1927, Garrison et al. 1987), but bank swallows have now been extirpated as a nesting species from the study area.

Major factors responsible for reductions in populations and nesting colonies include loss of habitat due to reshaping of vertical riverbanks, riprapping of rivers for bank stabilization, and human disturbance. Since population monitoring began in 1986, five known nesting sites on the Sacramento River have been lost to riprap projects. The range of the species has been reduced in California by an estimated 50 percent since 1900 (California Department of Fish and Game 1989b). A remnant colony exists just west of the study area at Fort Funston, San Francisco County, but approximately 70-80 percent of California's remaining bank swallows nest along the Sacramento River from about the confluence of the Feather River northward (Garrison et al. 1987).

The species has been designated a threatened species by the California Department of Fish and Game (1989). Continued loss of natural stream banks is the most serious threat to the long-term survival of the species in California.

4.2.9.2 Salt Marsh Yellowthroat

The salt marsh yellowthroat, a subspecies of the common yellowthroat, can be found year-round in the Bay Region. This subspecies is believed to winter in coastal salt marshes from the San Francisco Bay Region south to San Diego (Grinnell and Miller 1944). During the breeding season, it inhabits fresh and brackish water marshes on the inland margins of the Bay as well as more remote site such as Tomales Bay (Marin County) and Lake Merced (San Francisco County) (Grinnell and Miller 1944). Foster (1977) believed birds wintering in Bay salt marshes annually dispersed from brackish/freshwater breeding sites when they become unsuitable due to seasonal vegetational die-offs.

Losses of tidal salt, brackish, and freshwater marshes around the Estuary have drastically reduced both breeding and wintering habitats for this bird. The distribution and abundance of its habitat has been so reduced or altered in quality that Foster (1977) estimated a population decrease of 80-95 percent during the previous 100 years. As discussed previously, the continuous corridors of salt marshes grading upstream into adjacent brackish/freshwater wetlands, which historically existed around the Bay, have been fragmented through creation of salt ponds, stream alterations, agricultural conversion, and more recently, urban development. This has made successful dispersion of fledglings and seasonal movements by adults difficult (Hobson et al. 1985). Reductions in freshwater inflow from adjacent creeks and rivers are also believed to negatively affect the population through reduced abundance of marsh vegetation and insects (Foster 1977).

Currently, the salt marsh yellowthroat is a Category 2 candidate for Federal listing and has been considered for designation as a State Species of Special Concern. Foster (1977) encountered subpopulations at 13 sites and a total of 166 breeding pairs. In 1985, Hobson et al. (1985) recorded a total of 569 pairs of salt marsh yellowthroats at 23 locations. He concluded that lower numbers reported in the mid-1970s resulted from drought conditions then in effect.

Current threats to the subspecies include loss of freshwater marshes, and continued degradation of salt marshes by erosion, introduced salt marsh vegetation and predators, loss of breeding areas to flood control practices, urban encroachment, and rising sea level.

4.2.9.3 Alameda, San Pablo, and Suisun Song Sparrows

Three subspecies of song sparrow are year-long residents of tidal salt and brackish marshes of the Bay Region. These are the Alameda (salt marsh) song sparrow, which occurs in the South Bay north to Redwood City on the west and Albany on the east; the San Pablo (Samuel's) song sparrow, a resident of Bay marshes of Marin County and San Pablo Bay; and the Suisun song sparrow, a resident of Suisun Bay from Benicia east to the Delta. These forms of song sparrow are distinct from the Marin song sparrow, which resides in upland riparian habitats surrounding the entire Bay Area (Basham and Mewaldt 1987). Habitats utilized by these sparrows vary with salinity but include pickleweed marshes supporting gumplant in the South and North bays, grading into brackish marshes with tules, sedges, and cattails in Suisun Bay. Territories are typically associated with tidal sloughs, creeks, or the bayshore (Grinnell and Miller 1944, Walton 1975).

Historically, these song sparrows were considered to be abundant permanent residents of marshes surrounding San Francisco Bay. Destruction and conversion of tidal salt and brackish marshes, particularly in the South and Suisun bays, has greatly reduced the numbers of and habitat availability for these subspecies. The total Suisun song sparrow population is believed to be about 10-20 percent of its historic numbers and to be comprised of 6,000 pairs within 13 small, isolated subpopulations (Larsen 1989).

These resident subspecies are highly sedentary; Johnston (1956) reported a median juvenile dispersal distance from hatching to breeding sites of 607 feet for the San Pablo song sparrow. They also do not take extended flights over unfamiliar, unsuitable habitat (Marshall 1948a). Thus, fragmentation of their historic habitat greatly limits breeding among subpopulations. As a result, all three subspecies currently are category 2 candidates for Federal listing. The Suisun song sparrow was recently considered by the California Fish and Game Commission for possible State listing as threatened (Larsen 1989), but no action was taken.

In general, song sparrows occurring along the Bayshore are limited to marshes covered daily by the tides, where flow is unimpeded by dikes, levees, or channels (Larsen 1989). Some irregular use may be made of nontidal managed wetlands such as occur in Suisun Marsh; however, this typically occurs only in those areas immediately adjacent to a tidal marsh supporting the sparrows (J. Collins, University of California, pers. comm.)

Current threats to song sparrows around the Bay include factors which all tidal marsh-dependent species presently face, including genetic isolation of subpopulations due to habitat fragmentation and lack of high marsh nesting cover, resulting in increased vulnerability to high tides and predation by Norway rats and diurnal raptors. In addition, these song sparrows are vulnerable to the effects of contaminants either directly from toxic spills or through the food web. Other threats include ongoing commercial and residential development adjacent to tidal wetlands, which increases the potential for pollution, increased human disturbance, and predation by feral animals. Any further reductions in freshwater outflow from the Delta could also adversely impact the quality of song sparrow habitat (Larsen 1989).

4.2.9.4 Tricolored Blackbird

This species is a locally common, nearly endemic resident of California which has historically nested within the Central Valley and along the coast from Sonoma County south to Mexico. In the interior, sporadic nesting has occurred in the northeastern portion of the state (Grinnell and Miller 1944). During the nonbreeding season, nomadic flocks interspersed with other blackbirds generally converge in the Delta and in the northern San Joaquin Valley and adjacent to Suisun, San Pablo, and San Francisco bays where the species can be fairly common (DeHaven et al. 1975).

Preferred nesting habitat has traditionally been emergent freshwater wetlands with a reliable water source supporting dense stands of cattails, tules, or willows as well as an abundant supply of terrestrial insects (Hosea 1986). Suitable sites are also capable of supporting large numbers of individuals of this highly colonial gregarious species which, unlike the territorial red-winged blackbird, has been known to nest in the tens of thousands. Neff (1937), DeHaven et al. (1975), and Beedy et al. (1991) also reported extensive nesting in other types of wetland and low-lying vegetation such as blackberry, mustard, thistles, and nettles. Use of some of the above plants may be due to the protection which they provide against mammalian predators (E. Beedy, Jones and Stokes Assoc., pers. comm.). Year-to-year variations in the distribution and density of nesting colonies may be related to fluctuations in local insect abundance.

Within the study area, nesting colonies were reported during 1931-1936 in the Stockton-Tracy, Sacramento, and Davis areas, as well as other sites in Sacramento, San Joaquin, Solano, and Yolo counties. Additional sites have been documented for the Petaluma and Napa rivers, Drakes Bay, Hayward, Fremont, Newark, Milpitas, San Jose, and Santa Clara (Neff 1937, Sibley 1952, Beedy et al. 1991). The number of records for the South Bay Area attest to the historic presence of extensive freshwater wetlands in this region. Gill (1972b) noted a colony of 400 pairs at Coyote Hills (Alameda County) in 1971; no nesting has occurred there since the mid-1970s (H. Cogswell, California State University Hayward, pers. comm.). It is not believed that tricolors historically nested in significant numbers in the Delta.

Initial declines in the tricolored blackbird population were attributable to draining and reclamation of freshwater wetlands and riparian habitat as well as market hunting for blackbirds which occurred up through the 1930s. Neff (1937) believed that the expansion of agriculture and irrigation beginning at the turn of the century may have initially increased food supply and habitat for the species. He estimated the total state population at about 375,000 breeding birds.

DeHaven et al. (1975) compared nesting distribution during 1968-1972 with that reported by Neff (1937) and found that the breeding range had changed little during the intervening 30 years. However, the total number of colonies had declined by 64 percent, and DeHaven et al. (1975) estimated that the Central Valley population had declined by more than 50 percent. In addition, tricolors were found to occur in relatively smaller colonies, with an average of only about 133,000 breeding birds per year. During 1981-1982, Hosea (1986) surveyed the four counties in the Sacramento Valley that had traditionally supported the largest numbers of tricolored blackbirds. He found that tricolored blackbird populations had suffered serious declines, by as much as 80-90 percent from previous surveys.

The most recent information on population trends (Beedy et al. 1991) documents a continuing drastic decline in overall population and average colony size. The total average population for the 1980s was estimated at about 51,600 per year, representing a decline of 72 percent between the 1970s and 1980s and an overall decline of 89 percent since the 1930s (Beedy et al. 1991).

Current factors contributing to this decline are loss of wetland habitat, food supplies, and water; human disturbance; predation; competition with red-winged blackbirds; and poisoning (Beedy et al. 1991). As a result, the tricolored blackbird is currently a Category 2 Federal candidate species, and listing of the Central Valley population as a threatened species may be warranted.

4.3 MAMMALS

4.3.1 Introduction

Historical accounts describing wildlife attest to the large and diverse populations of mammals originally occurring in the Estuary. Grizzly bear, sea otter, pronghorn antelope, and elk were numerous. The changes that occurred after the arrival of the early explorers, trappers, and gold miners contributed to the elimination of these species. (Additional historical information concerning mammals is presented in Chapter 3) The current status of some of the mammals within the project area, many of them Federally and State protected species, is discussed below.

4.3.2 Species Accounts

4.3.2.1 Suisun Shrew

The Suisun shrew historically inhabited tidal marshes of northern San Pablo and Suisun bays, ranging as far east as Grizzly Island and as far west as the mouth of Sonoma Creek, Petaluma River, and Tubbs Island (Western Ecological Services Company 1986b). Brown and Rudd (1981) determined that the Suisun shrew was a subspecies of the ornate shrew. According to Williams (1983), Grizzly Island has the only extant population of Suisun shrews.

This species inhabits the middle-to-higher marsh elevations where driftwood and litter provide nesting and foraging sites. Suisun shrews occupy a smaller area and more restricted habitat than the endangered salt marsh harvest mouse. Few remaining tidal marshes in the Estuary have intact adjacent upland areas where shrews can seek shelter during extreme high tides. It appears that shrews prefer tidal over diked wetlands, but recent findings of salt marsh harvest mice in diked wetlands suggests this habitat may also provide some suitable cover for shrews (Western Ecological Services Company 1986b). Physical structure and species composition of the plant community is probably also important for adequate shrew habitat (Williams 1986). The remaining tidal marshes of San Pablo and Suisun bays are broken into small, isolated units which rarely have a complete elevational gradient of marshland vegetation (Williams 1986).

Within the historic distribution of the Suisun shrew, approximately 58,800 acres of diked marshes are present. More extensive habitat currently remains in Suisun Marsh than in San Pablo Marsh. Areas with recorded shrew specimens include the Gentry-Pierce site in Suisun City, Simmons Island, Roe Island, Wildwings Duck Club, the Ehmann site on Marrow Island (U.S. Fish and Wildlife Service, unpubl. data), Pacific Gas and Electric Company's West Pittsburg site, Concord Naval Weapons Station, Peyton Slough, and Point Edith, Hastings Slough.

Based on their restricted distribution and shortage of habitat, this subspecies is considered a Highest Priority Species of Special Concern by the California Department of Fish and Game (Williams 1986) as well as a Category 1 Federal candidate for listing. Management, acquisition, and creation of upland marsh areas appears essential to the continued survival of the Suisun shrew (Williams 1986).

4.3.2.2 Salt Marsh Wandering Shrew

Salt marsh wandering shrews prefer tidal marshes with dense cover, consisting of pickleweed and scattered driftwood where soil moisture is adequate and invertebrates are available for food (Johnston and Rudd 1957). They may prefer the "medium high marsh" at from 6 to 8 feet above sea level.

This shrew, now limited to salt marshes in the south arm of San Francisco Bay (Findley 1955), is probably one of the most endangered animals inhabiting the study area (Western Ecological Services 1986a). Past records of observations and captures around the study area include the marshes of Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara counties (Williams 1986). Paul Kelly (California Department of Fish and Game, pers. comm.) reported many rafting on high tide debris at Greco Island (San Mateo County) in the mid-1980s. Like the Suisun shrew, it is a Species of Special Concern in California with Highest Priority (Williams 1986). It is also a Category 1 Federal candidate and is recommended by Ford (1986) for endangered species status.

4.3.2.3 Alameda Island Mole

The little-known Alameda Island mole (Scapanus latimanus parvus) is a subspecies found only on the island of Alameda (Hall 1981). Although habitat for this species is very limited because most of the island is intensively developed, small populations probably persist at Alameda Memorial State Beach Park (Williams 1986). Although this subspecies is unlisted, Williams (1986) considers it a sensitive species and R. Jurek (California Department of Fish and Game, pers. comm.) suggested that the subspecies may already be extinct. The Angel Island mole (S. l. insularis) is also island-limited, but it is not currently threatened (Williams 1986).

4.3.2.4 Pacific Western Big-eared Bat

The Pacific western big-eared bat is a coastal subspecies of the Townsend's big-eared bat which lives in a variety of habitats throughout California. In the study area, the subspecies inhabits coastal conifer and broad-leaf woodlands and open grasslands (Williams 1986).

This species is colonial, with females aggregating to give birth in spring to a single young (Pearson et al. 1952). Maternity sites have been recorded in the study area in Alameda, Napa, San Mateo, and Marin counties, but there has been a marked population decline in the last 40 years (Pierson 1988). Surveys in 1987 found active maternity sites only in Marin and Napa counties, but they were outside the study area (Pierson 1988). Almost half of the maternity colonies, one third of the roosting sites, and an estimated two-thirds of the individual bats have been lost.

Human disturbance and destruction of natal roost sites is the primary threat to this subspecies. Because individuals remain in the area where they were born and continue to roost near their natal site (Kunz and Martin 1982), subpopulations are highly vulnerable to local population extirpation. These bats rarely seek shelter in cracks and crevices, roosting instead in exposed places, often within reach of humans. They are very sensitive to people entering the roost site; such disturbance can cause them to abandon the site for years. In 1986, the subspecies was designated a Species of Special Concern by California and a Category 2 candidate for Federal listing. In eastern North America, two subspecies are listed as endangered.

4.3.2.5 Greater Western Mastiff Bat

The distribution of the greater western mastiff bat extends from central Mexico, northwestward through southern California to San Francisco (Hall 1981). The northern population may be present in the study area in the San Joaquin Valley, and one old record from Hayward exists (Williams 1986).

This bat roosts colonially in old houses and large cracks in rocky areas. This subspecies has declined in recent years, and it was designated a Species of Special Concern, second priority, by the State of California; it is also a Category 2 Federal candidate (Williams 1986).

4.3.2.6 Riparian Brush Rabbit

Riparian brush rabbits are limited to herbaceous vegetation like willows, blackberries, and dense brush along the San Joaquin River, from Stanislaus County to the Delta Area. Loss of habitat due to agricultural clearing has fragmented, isolated, and limited populations to marginal areas where periodic flooding may completely inundate the species habitat. Hunting, off-road vehicles, and burning may also reduce and could extirpate isolated populations. One moderately sized population (less than 100 animals) exists at Caswell State Park in San Joaquin County (Williams 1988). Riparian brush rabbits appear to be limited to the San Joaquin River where they may also contact another subspecies of brush rabbit (Sylvilagus bachmani macrorhinus) (Orr 1940). Because of the above threats and the possibility that the riparian brush rabbit could interbreed itself out of existence, it is listed as a highest priority Species of Special Concern in the state as well as a Category 1 Federal candidate for threatened status (Williams 1986).

4.3.2.7 Berkeley Kangaroo Rat

This subspecies (Dipodomys heermanni berkeleyensis) occurs in grasslands on hilltops and in open spaces in chaparral and blue oak/digger pine woodlands in the Berkeley Hills, Mount Diablo, and Livermore Valley (Williams 1986). Although extensive land development in these areas has significantly reduced its range, this subspecies is common on the east flank of the Diablo range from Del Puerto Canyon, Stanislaus County, to Corral Hollow, Alameda County (Williams 1986).

4.3.2.8 Salt Marsh Harvest Mouse

Two subspecies of the salt marsh harvest mouse are endemic to the salt and brackish marshes bordering the San Francisco Bay Region. The preferred habitat is the mid-to-higher elevation tidal wetlands and adjacent transition zones which provide essential refugia during extreme high tides. These marshes are typically dominated by pickleweed, but a diverse mixture of annual and perennial herbaceous vegetation often characterizes the transitional habitat frequented by the species (Shellhammer et al. 1982, Shellhammer 1989). Salt marsh harvest mice will also move from tidal and diked marshes into adjacent grasslands in the late spring for limited periods of time (Geissel et al. 1988).

The northern subspecies (Reithrodontomys raviventris halicoetes) inhabits wetlands bordering San Pablo and Suisun bays, while the southern subspecies (R. r. raviventris) occurs in Central and South San Francisco Bay. Based on historic vegetative composition and tidal elevations, it is estimated that about 107,000 acres of habitat suitable for the species once existed around the Bay. Following a 95 percent historical decline in these wetlands, primarily through conversion to salt evaporation ponds and agricultural land, about 26,121 acres remain. The salt marsh harvest mouse was listed as an endangered species by the Federal government in 1970 and by the California Fish and Game Commission in 1971.

In general, the role that tidal marshes will play in the survival and recovery of both subspecies is uncertain. Predictions of accelerated rates in sea level rise combined with anticipated reductions in sediment transport into the Bay suggest erosion of Bay marshes will occur at a generally greater rate than accretion. This situation could be exacerbated by existing dikes and urban development which would constrain potential landward marsh expansion as sea level rises.

Diking of tidal marshes also has greatly reduced the availability during high tides of high marsh and transition zone habitat. This loss is most serious in the South Bay where the marshes are narrower and more highly fragmented, the tidal amplitudes are higher, there has been greater land subsidence from groundwater extraction, and shorelines have eroded at relatively higher rates. Also, Krone (1979) described the South Bay as sediment-starved and losing sediments. Most of the remaining tidal marshes in the South Bay support few, if any, harvest mice, and habitat conditions are progressively declining (Shellhammer 1989). Therefore, survival of the southern subspecies depends on the protection and management of remaining formerly tidal marshes which have been diked but continue to support harvest mice (Shellhammer et al. 1988).

Since the mid-1970s, about 1,500 acres of diked salt marsh in the South Bay have been severely degraded or eliminated, and only about 760 acres currently inhabited by the subspecies are known to remain. This remaining habitat supports 18 genetically isolated populations, 15 of which are in areas susceptible to or proposed for commercial development or other forms of habitat loss. Fifteen of the 18 populations are threatened with flooding; no population is secure from both threats. Therefore, the increasing genetic isolation and typically small size of these subpopulations renders them vulnerable to extirpation from a variety of threats. According to criteria in the Recovery Plan for the species (U.S. Fish and Wildlife Service 1984a), none of these subpopulations is large enough to be considered adequately protected.

Though poorly documented, it is estimated that about 6,000 acres of diked salt marsh is currently available for the northern subspecies, primarily in Suisun Marsh. As a mitigation element of the 1986 Suisun Marsh Protection Plan, the California Department of Fish and Game is developing about 1,000 acres of habitat within the Suisun Marsh to be dedicated to the salt marsh harvest mouse. In addition, the Navy has conducted an intensive study of the salt marsh harvest mouse at the Mare Island Naval Shipyard between 1985 and 1991 and found high mouse populations in tidal and non-tidal areas (D. Pomeroy, Department of the Navy, pers. comm.).

4.3.2.9 San Joaquin Valley Woodrat

The San Joaquin valley woodrat is apparently an isolated population of the dusky-footed woodrat which most closely resembles the San Francisco Bay population. Like the riparian brush rabbit, the San Joaquin Valley woodrat is known only from an area along the San Joaquin River in Stanislaus, Merced, and San Joaquin counties (Hall and Kelson 1959, Williams 1986).

Woodrats are found in riparian areas of dense brush where they build large conspicuous lodges of downed woody material. They also nest trees in wood duck nest boxes which may serve as one of the few available refuges from flooding. As cultivation of the San Joaquin Valley continues, habitat loss can be expected to continue. Since this subspecies is strictly confined to already rare riparian habitat, any additional habitat loss is significant (Williams 1986).

The current population status of this subspecies is not well known. In Caswell State Park and Corral Hollow, Alameda County, they have been caught in traps set for riparian brush rabbits. Like the riparian brush rabbit, this woodrat is also listed as a second priority Species of Special Concern by the state as well as a Category 2 Federal candidate for threatened species (Williams 1986).

4.3.2.10 San Pablo Vole

This subspecies historically occurred in about 2,400 acres of salt marsh habitat between Giant and Point Isabel in Contra Costa County (Western Ecological Services Company 1986c). The remaining vole populations occur in three widely isolated fragments of the marsh and associated grassland and riparian habitats totalling 578 acres (Western Ecological Services Company 1986c). These marshes represent about 80 percent of the remaining habitat of this subspecies. U.S. Army Corps of Engineers flood control projects at Wildcat and San Pablo creeks may threaten this habitat. However, until the San Pablo vole is determined to be a valid subspecies, no listing or protection is in place for the remaining populations (Western Ecological Services Company 1986c).

4.3.2.11 Cetaceans

The humpback whale (Megaptera novaeangliae) which is a Federally-designated endangered species, has visited San Francisco Bay recently. One individual, nicknamed "Humphrey," entered the Bay in October 1985 and explored the North Bay area including Suisun Bay and the western Delta. The animal re-entered the Bay in October 1990, beaching itself at Hunter's Point and subsequently left the Bay two days later. A juvenile sperm whale (Physeter macrocephalus) entered the Bay in 1989 and got as far as Point Richmond before dying. During the migration period, gray whales (Eschrichtius robustus) also occasionally enter the Bay. Historically, whales were a common occurrence in bay waters but are a rare event today, possibly due to increased boat traffic and shoaling within the Bay.

Harbor porpoises were commonly observed within the Central Bay in the 1930s where some specimens were collected (Benson and Goody 1942, Yocum 1946); they were also present through the late 1950s and early 1960s (T. Harvey, U.S. Fish and Wildlife Service, unpubl. data). They currently use the Bay infrequently, probably because of heavy boat traffic, human disturbance, and depletion of prey populations.

4.3.2.12 San Joaquin Kit Fox

The San Joaquin kit fox is the largest of four or five subspecies of North American kit fox (Hall 1981). The historic range of the kit fox included the San Joaquin Valley from the vicinity of Tracy to southern Kern County (U.S. Fish and Wildlife Service, unpubl. data). By 1930, its range in the north was reduced, and the subspecies now generally ranges in the Central Valley from Los Banos, Merced County, to southern Kern County. The San Joaquin kit fox is listed as an endangered species by the Federal government and as a threatened species by the State of California (Williams 1986).

The kit fox must be considered rare in the study area (Orloff et al. 1986). Scattered populations may occur between Interstate 5 and the interior coast range, from Los Banos northward. In Contra Costa County they occur on the east slope of Mount Diablo, around Vasco and Marsh Creek roads and in the Altamont Pass area (S. Orloff, Biosystems Analysis, Inc., pers. comm.). Increasing urbanization and proposed projects such as Los Vaqueros Reservoir will continue to reduce suitable habitat in the northern portions of their range east and south of the San Francisco Bay Area (S. Orloff, pers. comm.). The status of the kit fox in Santa Clara County is uncertain, but they are known to occur around San Juan Bautista.

4.3.2.13 Badger

The badger historically occurred in grasslands and chaparral throughout California, except in the humid forests of the northwest portion of the state. The most current distribution data (1970-1987) indicate declines throughout much of its range and disappearance from other areas (Williams 1986). Populations are still present in many parts of the State, but sightings are few and irregular. The badger is most abundant in the northeastern corner of the state and in the southern coastal range. Recent observations indicate declines are greatest in the mid-Central Valley region and in the north coast. The conversion of native scrub habitat to irrigated farmland is the main cause of declines. In addition, poisoning of ground squirrels, the badgers principal prey, and trapping badgers themselves, have also led to a decrease in numbers.

Prior to 1957, badgers were considered to be pests, but now they are classified as furbearers and may be taken with no bag or possession limits during the trapping season. The 51 badgers that were trapped in the study area during 1978-1988 were from Napa, Sonoma, Santa Clara, Alameda, Contra Costa, and San Joaquin counties (California Department of Fish and Game 1980-1983a, 1984-1987a, 1988a, Gould and Escallier 1989, Gould and Hom 1990). Estuary-wide, the badger was the second least harvested furbearer (Table 4-9). The badger is considered a Species of Special Concern by the State (Williams 1986).

4.3.2.14 Ringtail

Ringtails are rare in the Estuary. Adjacent to the study area, they have been occasionally reported in the Bolinas Mesa area of Marin County (D.

Erickson, LSA Associates, pers. comm.). The ringtail has also apparently expanded its distribution in the San Joaquin and Sacramento valleys (Orloff 1980a), since early authorities considered the ringtail historically absent from the Central Valley (Grinnell et al. 1937). Sightings along the major rivers in California attest to its preference for riparian habitats. However, they have also adapted to many other types of habitat in California (S. Orloff, Biosystems Analysis, Inc., pers. comm.).

Prior to 1967, the ringtail was classified as a furbearer, but the species is now listed as a fully protected species by the state of California. Urbanization and loss and degradation of riparian habitat have extirpated some populations and continue to limit any expansion of existing distribution. There is no evidence, however, of threats to the species over a broad area. Current data indicate that ringtail numbers are either stable or increasing (Orloff 1980a). However, surveys for this nocturnal animal are not uniform, and precise population trends are unclear.

4.3.2.15 Raccoon

Raccoons prefer riparian and valley oak woodlands and wetlands (Orloff 1980b), but they have adapted well to urban areas. Raccoons are increasing in cities because of abundant food and are considered pest animals as well as potential vectors of rabies. Studies on wild populations of raccoons in Contra Costa and Alameda counties indicate that numbers are increasing from a population low in the 1970s; age structures in both counties reflect a growing population. During 1978-1988, 10,454 raccoons were trapped, second only to muskrats as the most trapped animal in the study area (California Department of Fish and Game 1980-1983a, 1984-1987a, 1988a, Gould and Escallier 1989, Gould and Hom 1990).

Of all the furbearers, Grinnell et al. (1937) considered the raccoon the most destructive to nesting waterfowl. Prior to 1988, raccoons had not been reported as regular salt marsh inhabitants in the study area. However, by 1990 they were encountered frequently during night surveys on the San Francisco Bay National Wildlife Refuge. Raccoons have destroyed chicks and eggs of the western snowy plover and California clapper rail in the South Bay (K. Foerster, San Francisco Bay National Wildlife Refuge, pers. comm.) and mallard eggs in Suisun Marsh (McLandress et al. 1988).

4.3.2.16 Striped Skunk

Striped skunks are found in semi-open country, mixed woodlands, brushland, open grasslands, and agricultural fields (Burt and Grossenheider 1976). Grinnell et al. (1937) described striped skunks as common below 2,000 feet in the coast ranges north of San Francisco. Denning sites used by skunks include hollow logs, wood or rock piles, beneath buildings, and burrows of other animals (Grinnell et al. 1937). Skunks are omnivores, but insects comprise a major portion of their diet. Mice also play a seasonally important role, while poultry, small birds, reptiles, and amphibians are minor foods. Fruits and berries supplement their diet.

Skunks are classified as nongame furbearers that may be taken year around with no bag or possession limits. At one time, they ranked as the most important furbearer in the state. For example, during the 1927-28 season, an all-time high of 56,478 skunks was taken state-wide. During 1979-1989, 4,184 were taken from within the study area. According to harvest data from 1938-1977, the average numbers of skunks killed per year in the study area by county were San Joaquin (114), Sonoma (112), Sacramento (71), Yolo (37), Marin (34), Santa Clara (31), Napa (27), Alameda (20), and Contra Costa (14) (California Department of Fish and Game, unpubl. data). Animal and Plant Health Inspection Service (U.S. Department of Agriculture) personnel also take skunks when high densities generate concerns about rabies.

4.3.2.17 Harbor Seal

Observed numbers of San Francisco Bay harbor seals fluctuate between 550 in the breeding/molting season to 125 during the winter months (Fancher 1987). These counts may not be indicative of total population size because seals feed away from the rookery. The total population in the Bay is estimated to be about 700 animals, or about 1.4 times more than the maximum number of seals observed hauled out (D. Kopec, Romberg Tiburon Center for Environmental Studies, pers. comm). Recent studies indicate that the harbor seal population in San Francisco Bay has not changed significantly since a bay-wide survey initiated in the mid-1970s (Risebrough et al. 1980, Fancher and Alcorn 1982, Fancher 1987). In contrast, monitoring of coastal haul-outs along Point Reyes have revealed an approximate doubling of spring numbers during the last 15 years (Allen et al. 1989, Kopec 1991). Reduced pup:adult ratios within the Bay, however, suggest that the reproductive rate may be deceasing (D. Kopec, pers. comm.)

The five primary haul-out sites utilized by harbor seals in the Estuary are Mowry Slough, Greco Island, Yerba Buena Island, Castro Rocks near the Richmond-San Rafael Bridge, and Corte Madera Ecological Reserve (D. Kopec, pers. comm.). Mowry Slough is the largest resting and pupping site in the study area, with a population that ranges from an average of 30 seals during the winter to 300 during the height of the pupping season. About 80 seals use this haul-out year round. Numbers of seals currently using Mowry Slough are believed to be comparable to populations reported in the early 1900s (Fancher and Alcorn 1982). The Greco Island population varies from 20 seals in winter to 40 during the pupping season (Fancher 1987). These two South Bay haul-out sites totalled 365 seals in 1976 and at least 366 in 1990 (Greco Island count was not available) (D. Kopec, pers. comm.). Castro Rocks is the main haul-out area for Central San Francisco Bay (Fancher 1987) where the maximum spring count increased from 79 seals in 1976 to 145 in 1990, a 93 percent increase (D. Kopec, pers. comm.). Yerba Buena Island supported 195 seals in the winter of 1989-1990 when herring schools were present. One mother-pup pair was also observed in 1989. The Corte Madera Ecological Reserve is used seasonally, with a population ranging from a low of 10 seals in the winter months to a high of about 30 in the summer pupping and molting season. This represents the first documented use by harbor seals of a newly restored tidal wetland in San Francisco Bay (S. Allen, Point Reyes Bird Observatory, pers. comm.)

Other sites hosting fewer than 10 seals, but with no documented pupping, are Guadalupe Slough at the southern end of San Francisco Bay, Corkscrew Slough near Redwood Creek, and Angel Island and Tubbs Island in San Pablo Bay. A steady increase in disturbance from nearby residents caused the number of harbor seals using Strawberry Spit in Richardson Bay to greatly decline (Fancher 1987) and eventually disappear (S. Allen, pers. comm.). Another factor leading to the abandonment of this site may also have been a shift in herring spawning locations. In June 1990, four harbor seals were hauled out on Blunt Point Rock, Marin County, during U.S. Fish and Wildlife Service seabird surveys (H. Carter, U.S. Fish and Wildlife Service, pers. comm.). Seals, presumably from Castro Rocks, were also regularly seen near the Brothers Islands during 1988 surveys by the Point Reyes Bird Observatory (H. Carter, pers. comm.).

Harbor seals are subject to disturbance in other parts of the study area as well. For example, in the Mowry Slough area, boat and air traffic have harassed the seals. Castro Rocks may be vulnerable to oil spills because the site is one kilometer from the Chevron long wharf which offloads the largest oil tankers in the Bay.

During 1989, blood samples were collected from 21 San Francisco Bay harbor seals and analyzed for organochlorines and trace metals. Preliminary results of those analyses showed detectable concentrations of DDE and PCBs in 95 and 76 percent, respectively, of the samples. Detectable levels of cadmium copper, lead, nickel, mercury, and selenium were also found in the majority of seals sampled. In contrast, six harbor seals from southern Puget Sound had no detectable levels of these contaminants (Kopec 1991).

Radio telemetry data from 37 San Francisco Bay harbor seals indicated that most animals dispersed into the Bay from pupping areas; however, three seals were recorded leaving the Bay, moving along the coast to Bolinas Lagoon and Pillar Point. Two animals subsequently returned to the Bay (D. Kopec, pers. comm.).

Many harbor seals in the Bay are stained by reddish iron oxide which flocculates out at the interface of fresh and salt water which adheres to the seals' pelage. A higher percentage of these red seals occurs in San Francisco Bay than in any other estuary population in the world (S. Allen, pers. comm.).

4.3.2.18 California Sea Lion

Since passage of the Marine Mammal Protection Act in 1971, the California sea lion population has increased along the central California coast. This increase has been shown by monitoring at principal haul-out sites at Año Nuevo State Reserve and the Farallon Islands National Wildlife Refuge. During anchovy and herring runs, 400-500 sea lions (mostly immature males) enter primarily the North and Central Bays to feed (S. Allen, Point Reyes Bird Observatory, pers. comm.). Sea lions have been hauling-out in the San Francisco waterfront area for at least the last five years. Recently, they have begun hauling out during fall and spring at the Pier 39 Marina in San

Francisco, where an estimated 600 animals were observed in January and February, 1991 (A. Mauer, California Marine Mammal Center, pers. comm.).

4.3.2.19 Mountain Lion

Mountain lions are widely distributed in California, especially where deer are present (Mansfield and Weaver 1989). In 1988, the minimum statewide population was estimated at 5,100 mountain lions, based on 80,000 square miles of available habitat. Densities vary according to the availability of prey and habitat and range from 10 adults per 100 square miles in the western Sierras to 5-7 adults per 100 square miles on the central coast to less than one animal per 100 square miles in the southeast deserts (Mansfield and Weaver 1989).

Within the study area, great portions of the chaparral and broad-leaved forests have been converted to agricultural and urban uses, leaving little habitat to support resident or transient mountain lions. In Marin County, mountain lions have occurred along Mount Tamalpais ridge, south of Lucas Valley Road, and on the Point Reyes Peninsula. Within the entire Marin County portion of the study area, however, there is probably no more than one transient lion present, (F. Botti, California Department of Fish and Game, pers. comm.).

In 1963, the mountain lion was designated a nongame animal without protection. In 1967, it was redesignated as a game animal with a regulated harvest, but in 1971, the State Legislature enacted a moratorium on harvest which lasted until 1986. At that time, the mountain lion reverted to a game animal, but court injunctions against the harvest have prevented hunts. The lion's widespread current distribution, adaptability, and stable to increasing populations in some portions of the State indicate that this species will continue as a member of California's wildlife community (Mansfield and Weaver 1989).

4.3.2.20 Bobcat

The bobcat is a wide-ranging, but uncommon resident in California. Optimal habitat includes large areas of rough or broken terrain with dense brush, chaparral adjacent to riparian habitat, or dense stands of conifers. They prefer upland habitat with rocky outcrops and extensive cover where populations of small mammals like hares and voles abound (Gould 1982). Bobcats and coyotes may compete for food (Robinson 1961), and when coyote numbers are reduced, bobcats may increase (Nunley 1978).

The State of California considers the bobcat a furbearer, and it is protected during the breeding season. In the study area, 2,479 bobcat pelts were taken during 1978-1988 (California Department of Fish and Game 1980-1983a, 1984-1987a, 1988a, Gould and Escallier 1989, Gould and Hom 1990). Nationally, the commercial harvest of bobcat pelts has been increasing. Continued harvest pressure has prompted government research on population numbers and the management of pelt export through tagging. The Convention on International Trade in Endangered Species monitors the export of bobcat pelts in the United States and is helping determine if the current level of harvest is detrimental to California's bobcat population (Gould 1982).

4.3.2.21 Tule Elk

Vast herds of tule elk (Cervus elaphus nannodes) once occurred in the Central Valley, roaming the grasslands and wetlands and riparian-oak woodlands near areas with standing water. Within the study area, there are small reintroduced herds on the Concord Naval Weapons Station, Grizzly Island Wildlife Area, and San Francisco Water Department lands in Alameda County, near Sunol. The carrying capacity of the Concord Naval Weapons Station elk herd is estimated at 50 to 100 animals and is maintained through live-capture and relocation of excess animals (D. Pomeroy, Department of the Navy, pers. comm.). The Grizzly Island herd was reintroduced in the early 1970s and has attained a population of 500-1,000 individuals (R. Helm, U.S. Fish and Wildlife Service, pers. comm.). Outside the study area, there are reintroduced herds at Tomales Point in Point Reyes National Seashore, in southern Santa Clara County, and at the San Luis National Wildlife Refuge. Disease and poaching are the main threats to these small, but protected populations.

4.3.2.22 Mule Deer

Columbian black-tailed deer (Odocoileus hemionus columbianus) were historically plentiful until settlers began market and subsistence hunting (Schauss 1984). With the establishment of seasonal protection and hunting licensure requirements in 1907, deer populations began to recover. They peaked in the late 1950s and early 1960s, but then began a marked decline throughout much of the state (Longhurst et al. 1976). For example, reported buck harvest in the Mount Diablo area dropped from 514 in 1954 to 55 in 1974 (Fowler and Curtis 1985).

Deer are still relatively common in grasslands, chaparral, oak, and broad leaved evergreen woodlands in the study area and may be at the current maximum carrying capacity of the available habitat. Six out of the state's 86 deer herds are resident in the study area. The Marin-Sonoma herd is part of the large Santa Rosa herd which extends from the Marin headlands to Cloverdale and Napa. The Monticello herd extends east from Napa County into Yolo County. The Capay/East Park herd includes Yolo and Solano counties. The Mount Diablo herd includes Contra Costa and northern Alameda counties, while southern Alameda and Santa Clara counties encompass the Mount Hamilton herd. The Santa Cruz herd includes San Francisco and San Mateo counties. Deer within the Sacramento-San Joaquin Delta are not considered part of any discrete herd (D. Updike, California Department of Fish and Game, pers. comm.).

Deer herd size is difficult to estimate by standard methods, but, based on deer management plans in the early 1980s, there were about 91,000 deer in these six herds (California Department of Fish and Game, unpubl. data). The total number has probably declined since then. During 1985-1989, 11,799 deer tags were reported by hunters (California Department of Fish and Game, unpubl. data), and 2,330 deer were taken by hunters in the study area in 1989.

Loss of habitat to urban expansion and agricultural intensification is reducing deer populations throughout the study area. Other sources of mortality include collisions with vehicles, poaching, predation by dogs and mountain lions, and disease. Deer hunting on private lands has a relatively minor effect on the population in the study area because so much land is closed to hunting.

Drought-related stress in the deer's environment is sometimes beneficial to deer populations. For example, oaks which were stressed by drought in 1990 produced a bumper crop of acorns, thus increasing food availability for deer. Introduced feral pigs compete with deer for acorns, but their effect is probably small compared to competition from cattle (Schauss 1984). Lack of water, however, may force deer to drink from stock ponds where they may be exposed to livestock diseases such as blue tongue (F. Botti, California Department of Fish and Game, pers. comm.).

4.3.2.23 Introduced Mammals

4.3.2.23.1 Red Fox

The only race of red fox native to California (Vulpes vulpes necator) is found in the Sierra Nevada mountains and foothills at elevations from 5,000 to 8,400 feet. The subspecies (V. v. regalis), which is found in the Great Plains, was probably introduced to California by hunters and released from commercial fur farms in the Sacramento Valley in the early 1900s. These non-native foxes now occur in the Sacramento Valley and parts of coastal California. They have been observed in the east Bay Area (Contra Costa County) since the early 1970s (D. Erickson, LSA Associates, pers. comm.). They are now regularly observed around the South Bay and continue to expand into suitable habitat, most recently invading Bair Island, a major colonial bird nesting area near Redwood City (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.). Foxes are efficient predators and can be expected to increase rapidly as they adapt to urban environments and utilize roads and flood control channels to aid in their dispersal (U.S. Fish and Wildlife Service 1991).

The potential depredation impacts of the introduced red fox are significant. It is estimated that a family of two adults and five pups would require about 317 pounds of prey during the 12-week whelping period (Sargeant 1978). As they continue to expand along the Bayshore, red foxes have been shown to be having a significantly deleterious effect on special status species in the Estuary. For example, they have been directly linked to the failure of a colony of California least terns at the Oakland International Airport and to the population crash of the California clapper rail in the South Bay. It has also been documented that red foxes caused the failure of a significant snowy plover nesting population in the Monterey Bay Area. In addition, during the 1990 season, a Caspian tern colony with 650 nests on the San Francisco Bay National Wildlife Refuge was completely destroyed by red foxes preying on eggs (U.S. Fish and Wildlife Service 1991). The impact of the red fox on species such as the salt marsh harvest mouse, salt marsh wandering shrew, and California black rail is unknown but believed to be significant.

To reduce predation pressure on the endangered and special status wildlife and ground-nesting birds in the study area, trapping and other population control efforts have been proposed by the U.S. Fish and Wildlife Service (1991) as a management technique. These techniques have been successful in Southern California where depredations of red foxes on endangered California least terns and light-footed clapper rails were documented (California Department of Fish and Game, unpubl. data).

4.3.2.23.2 Virginia Opossum

Opossums have also had a significant impact on native bird species. This species was introduced from Missouri into San Jose, California, in 1900. Five released animals, plus perhaps another five escapees from a fur farm, formed the nucleus of the breeding population which has since expanded to every county in the study area (Gordon 1977). Opossums are omnivorous, eating, among other things, plant material, insects, carrion, and bird eggs. Their impact on native wildlife is unknown, but it is likely that ground-nesting birds have suffered as a result of expanding opossum populations.

4.3.2.23.3 Feral Hog and Wild Boar

The feral hog/wild boar population has increased in the study area since the first release in 1925 on the San Francisquito Ranch near the Carmel Valley. Barrett (1977) estimated the California feral hog population at over 30,000, making them the second most important big game animal. In Monterey County they reach densities of about two per square mile (Gordon 1977).

Areas in which coast live oaks dominate are the favored area of feral hogs and wild boars. Their foraging behavior for acorns, roots, and tubers is destructive to the vegetative cover, increasing overall erosion rates and damage to streambeds. In years with poor acorn production, feral hogs may compete directly with deer, black bear, and other animals for forage. Their impact on ground-nesting birds is believed to be significant.

4.3.2.23.4 Rodents

The house mouse, Norway rat, and roof rat were among the first animals unintentionally introduced to California by the earliest settlers (Gordon 1977). Since rats and mice inhabited virtually every sailing ship, their escape to land was inevitable. The house mouse is common in human habitations and abandoned fields but is kept in check by competition with native mice (Gordon 1977). Rats also thrive in human habitations, but they have adapted to the littoral environment as well, living under wharves and riprap where they eat garbage and carrion. Rats also live in salt marshes where they have been identified as major predators of clapper rail eggs within South San Francisco Bay (Harvey 1988, Foerster et al. 1990). Once rats become established on colonial bird nesting islands, the reproductive success of the colony may be greatly affected by these opportunistic predators.

4.4 AMPHIBIANS AND REPTILES

4.4.1 Introduction

Within the study area, widespread agricultural conversion and urbanization have reduced or destroyed much of the habitat required by amphibians and reptiles for breeding, resting, and foraging. These species inhabit Delta channels, smaller rivers, creeks, perennial lakes and ponds, riparian corridors, grasslands, and seasonal wetlands, such as vernal pools. Populations of the following species have been most affected by human alteration of the study area. Some have special status designations, while others are known to have experienced or are experiencing population declines. One introduced species which may be expanding in the region is also presented.

4.4.2 Species Accounts

4.4.2.1 California Tiger Salamander

The California tiger salamander requires large vernal pools for breeding (Feaver 1971) and unobstructed migration routes to rodent burrows for metamorphosed juveniles and adults (Twitty 1941, Holland in press). Rodent burrows also provide these salamanders with sites for hibernation in winter and estivation during hot weather (Storer 1925, Anderson 1968). This habitat has declined greatly, especially in the northwestern and southwestern parts of the Delta, due to agricultural conversion and development (Bury 1972). In addition to habitat destruction, rodent poisoning has also adversely affect tiger salamanders by the outright killing of adults and also by depleting animals which create the burrows used by salamanders (M. Jennings, California Academy of Sciences, pers. comm.). As a result, the subspecies has been designated a Species of Special Concern by the California Department of Fish and Game (Jennings 1987a) and a Federal candidate for listing by the U.S Fish and Wildlife Service.

California tiger salamanders were formerly abundant in the Burlingame/Palo Alto/San Jose Region, based on the number of specimens in the Stanford University collection (now at the California Academy of Sciences). Extensive urbanization and ground water extraction in the first quarter of the 20th century lowered water tables, eliminated wetlands, and significantly reduced populations in the Palo Alto area (Myers, unpubl. ms.). A remnant population at Lake Lagunita on the Stanford Campus has been well documented (Twitty 1941). However, this population is on the verge of extinction due to the decreased water capacity of Lake Lagunita, urbanization of the region, and the introduction of predatory fish. A small population of tiger salamanders exists at The Nature Conservancy Jepson Prairie Preserve, at the Concord Naval Reservation, and in Marsh and Kellogg creeks near Tracy Barry 1981, (Wernette et al. 1982, M. Jennings, pers. comm.). North Bay populations in the Petaluma-Cotati area may have recently disappeared. An old specimen from the Petaluma area (Borland 1857) was verified in the early 1970s, but their current status there requires further investigation due to extensive urbanization in the area (M. Jennings, pers. comm.).

4.4.2.2 California Red-legged Frog

This species is wide-ranging, originally found in coastal regions of the Cascades and the Sierra Nevada crest of the Pacific Coast states (Stebbins 1985). The California subspecies was formerly abundant in marsh lands of the Central Valley and in fresh and brackish water marshes and riparian habitats surrounding San Francisco Bay. Red-legged frogs require willow-lined watercourses with moderate to deep (3 feet) pools surrounded by thick, emergent vegetation which provides critical escape cover (Hayes and Jennings 1986, 1988).

The subspecies is now rare in the San Francisco Bay Area. Commercial overharvest for food contributed to their original decline (Jennings and Hayes 1985), and, in the late 1880s, about 460,000 were taken over a six-year period (Collins 1892, Wilcox 1895, 1898, 1902 in Jennings and Hayes 1985). Harvest figures decline markedly after 1895. In eight years, California went from being a leading U.S. supplier of frog legs to having too few to report (Wright 1920 in Jennings and Hayes 1985).

As red-legged frogs grew scarce around the turn of the century, bullfrogs were introduced into the marshes of the Central Valley and the Estuary area; both sexes of this species grow to harvestable size. Although Moyle (1973) suggested that bullfrogs accelerated the decline of the red-legged frog in the San Joaquin Valley and foothills though predation, this hypothesis is confounded by over-exploitation prior to bullfrog introductions (Jennings and Hayes 1985) and by large-scale habitat changes (Hayes and Jennings 1986). Also, introduced predatory fishes probably adversely affected the remaining red-legged frog populations (Moyle 1973, Hayes and Jennings 1986, 1989). The ongoing loss of wetland habitats in the Sacramento and San Joaquin Valleys has further reduced habitat and the potential for population recovery for this species.

Red-legged frogs have been extirpated from the floor of the Central Valley and are threatened with extirpation in the Delta Region. Remaining populations are at risk due to the proposed Los Vaqueros Project on the Coast Range slope of the Central Valley (Wernette et al. 1982). Continued isolation of red-legged frog subpopulations will also further enhance local extinction rates. Accordingly, the red-legged frog is a candidate for Federal listing and is designated as a State Protected Amphibian (Jennings 1987a).

Within the study area, red-legged frogs are still present in the Santa Cruz Mountains, the San Francisco State Fish and Game Refuge (San Mateo County), and in canals at the San Francisco International Airport (M. Jennings, California Academy of Sciences, pers. comm.). This frog is also known from northern Contra Costa County in the Concord Naval Weapons Station, Marsh and Kellogg creeks, and in the Los Vaqueros area (Wernette et al. 1982).

4.4.2.3 Foothill Yellow-legged Frog

This species has undergone a severe population decline for reasons similar to the red-legged frog. Although no market hunting occurred for this frog (Jennings and Hayes 1985), draining, damming, clearing, and destruction of natural creeks, ponds, and watercourses have reduced or eliminated many populations of this species (Banta and Morafka 1966, Jennings 1988). These frogs prefer partially shaded, shallow streams with water flowing over riffles (Hayes and Jennings 1989). Adults require a solid substrate such as cobble-sized gravel on which to deposit eggs (Storer 1925), and eggs need cool temperatures in which to develop (Zweifel 1955, Jennings 1988). Current watershed management practices generally result in reductions in stream flows and removal of vegetation, resulting in increased ambient water temperatures in riverine systems. Moyle (1973) and Hayes and Jennings (1989) found an inverse correlation between yellow-legged frogs and modified steam habitat. Stream alteration also favors introduced fishes and bullfrogs that prey on all life stages of this species.

Yellow-legged frogs were originally found in the study area only at the edge of the Delta in Putah Creek, the lowlands of the Mokelumne River, and possibly small creeks near Pittsburg and Brentwood. Today, they are probably extirpated from the Delta, but they are still common in the Mount Diablo Range and in the hills east of Petaluma. Sightings of large individuals in these areas indicate that the populations are stable (M. Jennings, California Academy of Sciences, pers. comm.).

4.4.2.4 Western Spadefoot

Historically, western spadefoots were common in the northwest and eastern part of the Delta and ranged through the Central Valley and adjacent hills. They have greatly declined in the study area as vernal pools have been modified or eliminated. Though primarily a grassland species, populations also occurred in valley oak woodlands (Stebbins 1951). The spadefoot is virtually extinct in the Delta area, but a few are still present at a few sites near Dixon and Sacramento (M. Jennings, California Academy of Sciences, pers. comm.). Some populations have persisted for a number of years on agricultural lands in developed orchards and vineyards where shallow temporary pools remain after rains.

Western spadefoots cannot reproduce in ponds with introduced predatory fish such as mosquitofish (Gambusia affinis). The species is also difficult to locate because adults spend virtually all of their time in underground burrows. The western spadefoot is currently designated a Species of Special Concern by the California Department of Fish and Game, and it may become listed in the near future by the State if new data warrant a change in status (Jennings 1987a).

4.4.2.5 Alameda Striped Racer

This subspecies of striped racer is listed by the State as threatened and is also a Federal candidate for listing due to habitat loss. Jennings (1983) summarized the distribution of this snake in the Bay Area and identified the presumed zone of intergradation with another subspecies, _Masticophis lateralis lateralis_. The striped racer prefers rocky areas with southern exposure where it preys mainly on western fence lizards (Hammerson 1979). Additional studies by Hammerson (1978, 1979) describe this species' unique physiological and ecological adaptations.

Alameda striped racers occur in chaparral, grassland, and brushy slopes above riparian areas. The type specimen was taken in 1950 from Big Springs Canyon at Tilden Regional Park, Berkeley (Riemer 1954). Additional specimens have been collected at other East Bay Regional Parks in Alameda and Contra Costa counties (T. Lindenmayer, East Bay Regional Park District, pers. comm.) and from the hills west of Tracy and Brentwood (Collection of Museum of Vertebrate Zoology, University of California, Berkeley). Beyond the boundaries of publicly owned lands and open spaces, hillside development poses the greatest threat to this subspecies. Unfortunately, documenting the presence of these snakes in suitable habitat proposed for development is difficult outside of their breeding season.

4.4.2.6 Giant Garter Snake

Giant garter snakes, which are a highly aquatic species normally found in the immediate vicinity of open water, once occurred on the floor of the Central Valley from near Gridley south to Buena Vista Lake in Kern County (Hansen and Brode 1980). It is now greatly depleted throughout its range in the Central Valley, as natural sloughs and marshes have been eliminated (Brode 1988). The introductions of predatory fish and bullfrogs are also considered to be major factors in the observed decline of this once-common snake (Zeiner et al. 1988). Although recent studies have not shown detrimental effects (Littrell 1983), pesticides may also be a contributing factor. This snake is currently listed as a threatened species by the State (Bury 1972), and has recently been proposed for Federal listing as endangered (P. Sorensen, U.S. Fish and Wildlife Service, pers. comm.).

4.4.2.7 San Francisco Garter Snake

This distinctively colored reptile is classified as endangered by both the State and Federal governments. Historically, the habitat for this species was comprised of scattered wetlands on the San Francisco Peninsula to the foothills of the Santa Cruz Mountains at least to Upper Crystal Springs Reservoir. It remains unclear whether the snake inhabited coastal areas near Redwood City.

Sag ponds formed along the San Andres fault were the preferred habitat of this snake until most of them were eliminated by development and urbanization. Apparently this subspecies relies almost exclusively on ranid frogs for prey because all historic and current localities for this snake also supported California red-legged frog populations (M. Jennings, California Academy of Sciences, pers. comm.).

At present, the San Francisco garter snake has been confirmed at the San Francisco State Fish and Game Refuge, and at Upper and Lower Crystal Springs

Reservoir, Sharp Park golf course (Laguna Salada), Mori Point, Cascade Ranch, and at the San Francisco International Airport. The snake also has colonized habitats such as irrigation ponds along the San Mateo coastline. Over the past ten years, populations have remained fairly stable, especially after the pet trade with this snake was eliminated (M. Jennings, pers. comm.). However, expanding bullfrog populations are progressively eliminating red-legged frog populations in parts of San Mateo County, which may be contributing to undocumented population extirpations of this snake (P. Detrich, U.S. Fish and Wildlife Service, pers. comm.).

4.4.2.8 Coast Horned Lizard

Based on old museum records, coast horned lizards once inhabited the Strawberry Creek watershed in Berkeley where natural grassland and chaparral habitat historically existed. It was apparently extirpated from this area due to urbanization and habitat alteration. In the study area, populations still occur in the Mount Diablo Range (M. Jennings, California Academy of Sciences, pers. comm.).

These specialized lizards are restricted to areas of loose dirt, sand, and gravel with abundant populations of native insects, especially ants (Stebbins 1985). However, this species will not eat the introduced Argentine ants (Iridomyrmex humilis) which have displaced native ant species in many parts of their range (Ward 1987). In addition, horned lizards are susceptible to predation by feral cats, collection by humans, mortality from offroad vehicles, and poisoning by pesticides (Grinnell and Grinnell 1907, Bryant 1911, Jennings 1987b). They have also been adversely affected by loss of habitat to urbanization or conversion to agriculture (Bury 1972).

4.4.2.9 California Legless Lizard

The California legless lizard occurs in coastal dunes, scrub, and chaparral habitat, reaching the northern limit of its geographic range in the study area. This lizard is common in the Coast Ranges south of San Francisco to Baja, Mexico (Hunt 1983) and also occurs in isolated populations on the San Joaquin Valley floor (Stebbins 1985). They are rare or extirpated from most of the study area, but they have been reported from the Antioch Dunes National Wildlife Refuge in northern Contra Costa County (K. Foerster, San Francisco Bay National Wildlife Refuge, pers. comm.).

Legless lizards are generally subterranean, burrowing beneath leaf litter and preferring moist soils, and are active at relatively lower temperatures than most other lizards (Miller 1944). These lizards eat insects and spiders and may be vulnerable to pesticides in agricultural areas.

4.4.2.10 Western Pond Turtle

Populations of western pond turtles in California were greatly reduced due to exploitation for food at the turn of the century. Ongoing loss of suitable nesting habitat has prevented most populations of this turtle on the floor of the Central Valley from reproducing. Habitat requirements include well-vegetated backwater areas with logs for basking and open sunny slopes well away from riparian zones for egg deposition (M. Jennings, California Academy of Sciences, pers. comm). This species is currently a candidate for Federal listing as threatened and is a State Species of Special Concern (Jennings 1987a).

4.4.2.11 Red-eared Slider

Young sliders were introduced as pets prior to their ban in the early 1970s; the species is now common in certain parts of the study area. Sliders are reproducing in Putah Creek, adjacent to the campus of the University of California at Davis, and possibly in other areas in the Delta (Jennings 1987a). Sliders are also reproducing at Stow Lake in San Francisco where they were introduced as early as 1920 (Hanna and Clark 1925), Boronda Lake in Santa Clara County, Jewel lake in Tilden Regional Park, and Walnut Creek in Contra Costa County (Bury and Luckenbach 1976).

4.4.2.12 Upper Sonoran Species

This species guild of reptiles is typical of the Upper Sonoran life zone which covers a broad region extending from Arizona north into the Central Valley of California. General habitats within this life zone include desert, alkali scrub, grassland, and chaparral (Grinnell et al. 1937). The northernmost portion of the Upper Sonoran zone historically included the western half of the San Joaquin Valley, the northernmost part of the Delta, and the uplands near Tracy. Only a small portion of this habitat historically occurred within the study area, and it has been greatly altered in the last seventy years, primarily by conversion to agriculture (M. Jennings, California Academy of Sciences, pers. comm.). Consequently, all these species are now very rare or of questionable status within the study area. With the exception of the blunt-nosed leopard lizard, all the species have healthy populations outside the study area in core areas of their appropriate range and habitat.

Side-blotched lizards are common to abundant throughout the arid regions of the state. They are a main food item for western whiptail, San Joaquin coachwhips (Masticophis flagellum ruddocki), western long-nosed snakes (Rhinochelus lecontei lecontei), California glossy snakes (Arizona elegans occidentalis), and leopard lizards (Stebbins 1951, Ferguson et al. 1982).

Western whiptail lizards are widely distributed throughout the state. They are common in a variety of habitats including oak woodlands, riparian forest, chaparral, alkali scrub, and annual grasslands. They are difficult to locate since they are active for only a month or so in the hottest part of the summer (Zeiner et al. 1988). Whiptails are almost always found around dense vegetation and are often associated with sand areas along gravelly arroyos (Stebbins 1951).

Historic clearing of brush and forested areas for grazing probably benefited grassland species like **coachwhips**. Subsequent urbanization and agricultural conversion of these areas has erased earlier gains and has contributed to the extirpation of this snake from many areas of the San

Joaquin Valley. Although coachwhips are a Species of Special Concern in California (Jennings 1987a), little is known about their ecology.

Based on its association with Upper Sonoran habitats, plus an observation by Stebbins (1985), the blunt-nosed leopard lizard is assumed to have historically ranged into the study area in uplands in the vicinity of Tracy. The species has since been extirpated from the study area and is listed by both State and Federal governments as endangered.

4.5 INSECTS

4.5.1 Lange's Metalmark Butterfly

The Lange's metalmark butterfly is found only in the Antioch dunes, east of the City of Antioch. The larvae of this subspecies feed exclusively on a subspecies of naked buckwheat (Eriogonum nudum var. auriculatum). Adults emerge in late summer, and the life span of the adult is about one week. In 1977, Arnold (1980) estimated a population of 400 adult butterflies at one sample site within the butterfly's range. Since 1986, when 154 adult butterflies were counted at the Antioch Dunes, the numbers have increased each year to a high of 1,198 in 1990 (U.S. Fish and Wildlife Service 1990c).

Loss of dune habitat to agricultural and industrial development led to this butterfly's listing as endangered by the Federal government. The present range of the butterfly has been reduced to only 15 acres of suitable habitat located on the Antioch Dunes National Wildlife Refuge and adjacent PG&E property (U.S. Fish and Wildlife Service 1984b). The U.S. Fish and Wildlife Service owns 55 acres of the dunes and manages this property as part of the San Francisco Bay National Wildlife Refuge Complex. Efforts are continuing to plant and seed buckwheat to provide additional butterfly habitat.

4.5.2 San Bruno Elfin Butterfly

The San Bruno elfin butterfly is a small brown subspecies of the widely distributed Moss's hairstreak. The San Bruno elfin is found in fewer than 20 colonies in the fog belt of steep, north-facing slopes on San Bruno and Montara mountains and Malagra Ridge in San Mateo County. This butterfly occurs only near rocky outcrops that support prolific growth of stonecrop (Sedum spathulifolium), the food plant for both larvae and adults. Adults fly from February to April. The estimated population size from six elfin colonies studied by Arnold (1980) ranged from 401 to 1,088 adults from 1977 to 1979.

Urban development pressure on this butterfly's very small range led to its listing as endangered under the Federal Endangered Species Act in 1976 (U.S. Fish and Wildlife Service 1984c).

4.5.3 Mission Blue Butterfly

The Mission blue butterfly occurs in coastal chaparral and coastal grasslands on the San Francisco Peninsula and in the Marin headlands. More specifically, the butterfly occurs on Twin Peaks in the City of San Francisco and at Fort Baker, Marin County. It is also found at Milagra Ridge, Skyline College (Guadalupe Canyon Parkway), and San Bruno and Montara mountains, all in San Mateo County. The adults lay eggs on and feed upon several native species of lupine. In 1981, Thomas Reid Associates (1982) estimated an average daily population size of 1,200 adults for all colonies on San Bruno Mountain.

Urban development pressure on this butterfly's small range led to its listing as endangered by the Federal government in 1976 (U.S. Fish and Wildlife Service 1984c).

4.5.4 Bay Checkerspot Butterfly

The Bay checkerspot was once probably one of the most common butterflies in the San Francisco Bay area. Adults lay eggs on a native species of plantain; larvae feed on this plant as well as owl's clover. These plants, which were once common, have largely been displaced by exotic grasses and weeds over most of their original range, except on serpentine soils, where exotic plants cannot compete successfully. This butterfly now occurs only at Edgewood Park and Jasper Ridge in San Mateo County and Tulare Hill, Kirby Canyon, Silver Creek, and at Morgan Hill in Santa Clara County.

As with the other listed butterflies, urban development pressure on this butterfly's remaining range led to its listing as threatened by the Federal government.

4.5.5 Valley Elderberry Longhorn Beetle

The valley elderberry longhorn beetle is endemic to moist valley oak woodlands along the margins of rivers and streams in the lower Sacramento and San Joaquin valleys where its primary food, the elderberry (<u>Sambucus</u> spp.), grows. This beetle is found only in the Delta portion of the Estuary study area.

There is little information on former abundance of this beetle for comparison with current population levels. It is believed, however, that it has probably always been rare (U.S. Fish and Wildlife Service 1984d).

Precise threats to survival of the beetle are difficult to enumerate because of the lack of knowledge regarding life history and ecological requirements. The primary threat to the species, however, is the loss and alteration of habitat by agricultural conversion, grazing, levee construction, stream and river channelization, removal of riparian vegetation, shoreline riprapping, and urban, recreational, and industrial development. Use of insecticides and herbicides in agricultural areas may also be a factor limiting the beetle's distribution. Age and quality of individual elderberry shrubs, trees, and stands may also function as a population limiting factor (U.S Fish and Wildlife Service 1984d).

The restricted distribution of riparian habitat within the Central Valley led to the beetle's listing as threatened under the Federal Endangered Species Act.

4.5.6 Delta Green Ground Beetle

The Delta green ground beetle (Elaphrus viridis) is known only from The Nature Conservancy's Jepson Prairie Preserve in the northwestern portion of the Delta. Although the historic distribution of the Delta green ground beetle is unknown, it probably ranged throughout much of the Central Valley. Details on life history and ecology of the beetle are poorly known.

Because of its restricted range, the beetle is listed as threatened by the Federal government. This beetle predominantly inhabits the borders of vernal pools and Orcutt Lake in the vicinity of the Jepson Prairie preserve, and this habitat (560 acres) has been designated as critical for this species by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1985b).

4.6 CURRENT FACTORS AFFECTING WILDLIFE POPULATIONS

4.6.1 Habitat

During the last 140 years, the native wildlife habitats of the Estuary have been reduced drastically to where they now resemble mere islands within a sea of urban and agricultural development. Degradation and loss of habitats, both within and outside of the region, continue to occur. For example, agricultural, municipal, and industrial development of the Central Valley are reducing waterfowl habitat to small, highly "clumped," agriculturally dependent remnants (Gilmer et al. 1982). Habitat loss and fragmentation forces wildlife to concentrate on those remaining areas. In the case of nesting or wintering waterbirds, this increases their vulnerability to contaminants, disease outbreaks, and predation. The availability and quality of habitat for wildlife groups such as waterbirds also varies greatly from year to year, depending on precipitation, agricultural practices, and human disturbance.

For migratory birds, nesting and migratory areas outside the Estuary and wintering habitats used for up to eight months each year within the Estuary, are both critical. The availability and quality of wintering habitats are major influences on the productivity of waterfowl on their breeding grounds. For example, degraded wintering habitat may support a lower prey base, resulting in a poorer body condition for waterfowl nesting in the spring. The quantity and quality of wintering habitat in the Estuary and its effect on the condition of waterfowl during spring migration may be the most important factors limiting waterfowl populations during years of good breeding-ground conditions (U.S. Bureau of Reclamation 1986).

Habitat loss is also critical when it affects resident species within the Estuary, such as salt marsh-dependent birds, mammals, amphibians, and reptiles. The typically fragmented subpopulations of these species are then more vulnerable to local extirpations from causes such as extreme flooding, oil or chemical spills, disease, and environmental contaminants.

4.6.1.1 Habitat within the Estuary

4.6.1.1.1 Agricultural Practices

With the conversion of natural wetlands in the Estuary study area to agriculture, migratory waterfowl and other wildlife have become dependent on these lands for food resources. Geese may feed on germinating grain, tundra swans often feed on waste corn, and mallards and pintails commonly feed in both harvested and unharvested grain fields. These crops are an important energy source, but the primary sources of protein needed during molt and egg production are probably invertebrates and native wetland vegetation (U.S. Bureau of Reclamation 1986). Waterfowl such as green-winged teal, cinnamon teal, northern shoveler, gadwall, and diving ducks have not adapted their feeding habits to agricultural practices.

As agricultural markets and governmental controls vary, sudden large-scale changes in cropping patterns may occur, causing shifts in waterfowl activity patterns. For example, during the 1960s, an expansion of corn production in the Delta contributed to increased pintail use of the area and reduced use of Suisun Marsh (Michny 1979). Major cropping changes could also cause serious declines in food resources and, therefore, a less fit breeding condition for ducks departing in the spring (Gilmer et al. 1982).

Within the Delta, acreages devoted to corn or wheat have been fairly constant since the expansion of these crops in the 1960s. Shifts between corn or wheat and the perennial asparagus crop occur from year to year, but, on the average, the current acreage in grains has been fairly constant since the mid-1970s (F. Wernette, California Department of Fish and Game, pers. comm.). By mid-November, following the annual harvest of corn, many Delta islands are flooded to reduce soil salinities as well as to control weeds and insects. From mid-December into March, as much as 25 percent of the total area may support ponded water or wet soil conditions which provide useful habitat for shorebirds and some waterfowl.

Several advances in agricultural practices within the Central Valley have adversely affected wildlife. For example, more efficient farming produces less waste grain, fewer weed seeds, and less cover for wildlife. This results in a more restricted diet and less overall food for wildlife, especially for waterfowl during fall and winter. Food and protective cover for all species are also reduced during spring and summer (U.S. Bureau of Reclamation 1986). In the Sacramento Valley, extensive land leveling to manage water efficiently has drastically reduced food abundance, nesting cover, and habitat diversity. Leveled fields can be drained rapidly and support fewer wetland plants. Other farming practices, such as repeated discing, plowing, and haying, limit use by both wintering and nesting waterfowl.

4.6.1.1.2 Seasonal Wetlands

Ongoing degradation and destruction of diked and seasonal wetlands around San Francisco Bay continue to reduce the overall capacity of the region to support wintering and breeding waterbirds and threaten the survival of endangered species. Certain activities that contribute to this problem are installation and maintenance of drainage structures at abandoned salt ponds, former duck-hunting areas, and other diked wetlands; discing or heavy grazing of marsh vegetation to obscure evidence of wetlands; conversion to agriculture; and direct filling of wetlands. Seasonal wetlands are also negatively influenced by certain flood control activities, mosquito abatement, and drought. As an illustration of the loss of seasonal wetlands, Alameda County supported 64 private waterfowl hunting clubs in 1959 (U.S. Army Corps of Engineers 1967), but, by 1985, only about seven still existed (California Department of Fish and Game, unpubl. data).

Since much of the above habitat loss has occurred without the monitoring of wildlife populations, the impacts from these activities are difficult to assess. Stenzel and Page (1988b) concluded that losses of high tide roosting and feeding areas may diminish the numbers of shorebirds that an estuary can support. Therefore, this degradation and loss of habitat have probably adversely affected shorebird populations within the study area. Losses of seasonal/diked wetlands around the Bay have already resulted in the elimination of subpopulations of the salt marsh harvest mouse and have reduced suitable habitat for both wintering and nesting waterfowl. These losses have also contributed to destruction of protective buffer zones adjacent to salt ponds and tidal marshes, allowing access to predators (e.g., Norway rats and feral cats) and increased human disturbance. Many diked wetlands which have subsided as much as two feet in elevation due to soil oxidation and compaction, are extremely vulnerable to flooding, which could cause the complete extirpation of resident populations of small mammals.

Between 1956 and 1988, 61 percent of the seasonal wetlands of the South Bay were filled, substantially degraded, or converted to other wetland or aquatic habitats (Granholm 1989). The average loss of seasonal wetlands over this period was about 400 acres per year. Granholm (1989) found that, by 1988, four percent of the 11,341 acres of seasonal wetlands in the South and Central bays and 10,062 acres in San Pablo Bay had been filled; 10 percent had been converted to other wetland types, and 10 percent had been degraded. Urban encroachment onto vernal pool and adjacent upland grassland habitats also continues in both the Bay and Delta Regions. Species affected by this habitat loss include long-billed curlew, Swainson's hawk, burrowing owl, greater sandhill crane, California tiger salamander, and giant garter snake. Loss of adjacent upland grasslands also eliminates nesting cover for species such as mallards, gadwall, cinnamon teal, northern shoveler, and northern pintail.

4.6.1.1.3 Effects of Water Supply on Wetland Habitat Availability

California's tremendous variation in annual precipitation greatly affects the availability of wetlands for waterbirds and other wildlife. In abundant rainfall years, rivers and streams overflow into bypasses and basins, and the acreage of flooded habitats increases as surface water accumulates in fields and vernal pools. The bypass areas of the Central Valley alone contribute over 150 square miles of habitat during floods (U.S. Bureau of Reclamation 1986). The abundance of food resources such as invertebrates that are available under these conditions accounts for the significant use of these areas by waterbirds.

4.6.1.1.4 Loss of Riparian Habitat in the Estuary

Within the Delta, losses of remaining riparian habitat are continuing, primarily on the privately maintained levees where vegetative cover still persists. Continued maintenance of Federal project Delta levees also discourages any reestablishment of riparian vegetation along the riprapped streambanks which are kept nearly devoid of vegetation. The continued shortage of riparian habitat throughout the Estuary limits populations of birds such as the wood duck, Swainson's hawk, and riparian-dependent songbirds. Gadwall, teal, and northern shoveler have also been affected by the reduction and fragmentation of riparian areas. Flood control projects on streams emptying into San Francisco Bay, as well as urban encroachment into these corridors, continue to eliminate or degrade habitat for riparian and freshwater marsh species such as the salt marsh yellowthroat.

4.6.1.1.5 Quality of Tidal Marshes

Much of the Bay's remaining emergent tidal habitat consists of either small outer bayward edges of historic marshes which were spared during salt-pond construction or new marshes that accreted on the bayward sides of dikes following reclamation. The fragmented, reduced condition of the remnant tidal marshes leaves them highly vulnerable to human disturbance, predators, oil spills, and effluents from water treatment plants and industrial sources. Many tidal marshes are being reduced in size and are suffering reduced habitat quality along their bayward and landward margins. In place of any natural higher marsh transition zones or adjacent upland habitat, the landward margins of these marshes consist of steep dikes with little or no vegetation. As a result, little cover is available for salt marsh-dependent species during extreme high tides, possibly resulting in local extirpations of populations of the salt marsh harvest mouse and salt marsh wandering shrew. The lack of high marsh cover and the proximity of dikes also increase the likelihood of predation on marsh-dwellers during high tides since dikes provide predatory mammals easy access to the Bay.

The bayward margins of some tidal marshes, particularly on the eastern shoreline of South San Francisco Bay, have been eroding at a rapid rate. Atwater et al. (1979) reported erosion rates of 3-16 feet per year in the South Bay. For the period from 1857-1984, Dedrick (1985) calculated an average erosion rate of 4 feet per year for Bird Island near Foster City.

Although not as extensive as in the South Bay, erosion of some North Bay tidal marshes is also occurring. Philip Williams and Associates (1989) calculated erosion rates of 1.0-2.9 feet per year for several marshes in Marin County with an acceleration in erosion rates over the last 4 years of their study.

Factors which are contributing to tidal marsh erosion include: (1) a rise in sea level of 0.66 feet in the last century; (2) portions of the Estuary supporting long fetches of open water where wind waves build up; (3) subsidence and tectonic sinking; and (4) the introduced isopod, Sphaeroma quoyana. This burrowing invertebrate causes undercutting of the pickleweed marshplain, reducing the strength of the clay banks (Josselyn 1983).

When considering the entire Estuary, however, significant expansion of tidal marshes has also occurred at numerous locations due to accretion of sediments. For example, by comparing the historic Bay map of Nichols and Wright (1971) with the existing shoreline, K. Dedrick (California State Lands Commission, pers. comm.) estimated that 4,093 acres of tidal marshes have formed in San Francisco and Suisun bays since the 1880's.

Sewage effluent inflows, particularly in the South Bay, have displaced natural water regimes, resulting in undesirable changes in tidal wetlands. The southern portion of San Francisco Bay receives 10 percent of the mean annual river runoff but 76 percent of the Bay's total wastewater inflow (Conomos 1979). This massive discharge of treated sewage effluent (>160 million gallons per day) has primarily occurred in the Coyote Creek-Guadalupe Slough area. Sewage inflow has converted an estimated 270 acres of salt marsh to brackish marsh since 1970 and contributed to habitat degradation on an adjoining 300 acres of salt marsh. As a result, the dominant vegetation has shifted from cordgrass and pickleweed to primarily alkali bulrush. Uniform stands of bulrush are of minimal value to the California clapper rail and salt marsh harvest mouse whose numbers have been greatly reduced in these marshes. Moreover, this vegetation generally provides poor habitat for other species of waterbirds. However, the common yellowthroat, a species that nests in alkalai bulrush stands, may have benefitted from this habitat conversion.

4.6.1.1.6 Loss of Upland Habitats

Losses of upland forested habitats around the Bay Area to other land uses, such as the conversion of oak-woodlands in the Napa County into vineyards, is continuing to eliminate habitat for wildlife such as deer, bobcat, and mountain lion. Oak savannahs, particularly in the North Bay region, are also being rapidly lost to urban encroachment. Agricultural and urban development of grasslands adjacent to the Delta and the Bay is ongoing and is adversely affecting species such as Swainson's hawks, long-billed curlews, grasshopper sparrows, and burrowing owls. Losses of these uplands also eliminates a valuable buffer zone adjacent to estuarine habitats.

4.6.1.2 Habitat Outside the Estuary

The Prairie Pothole Region, located in the north-central United States and south-central Canada, is a major waterfowl breeding ground that covers

300,000 square miles and produces about 50 percent of the ducks in North America. Waterfowl that nest in this region and comprise a significant percentage of species wintering in the Estuary include mallard, American wigeon, gadwall, green-winged teal, northern pintail, northern shoveler, canvasback, redhead, lesser scaup, bufflehead, and ruddy duck.

Over the last 22 years, these breeding grounds have experienced long-term reductions in waterfowl recruitment rates, primarily related to increased agricultural and grazing encroachment causing fragmentation of habitat and major increases in mammalian predation (Caswell 1990). In addition, drought conditions which began in 1979 and extended into 1988, contributed to low recruitment, resulting in major declines in populations of most species. Low rainfall has facilitated conversion to agriculture by enabling accelerated drainage and filling of drought-stricken ponds and plowing of critical upland nesting cover.

Currently, the numbers of ponds available in the pothole region for nesting ducks remain well below long-term averages. Even if rainfall on the prairies returns to normal levels, these habitat losses will likely continue to limit the recovery potential of waterfowl populations. However, with the end of the drought, gradual improvements in the quality of upland habitats adjacent to wetlands and some withdrawal from production of ponds which were farmed during dry conditions may occur.

In the Great Basin Region the combination of accelerated wetland reclamation and drought since the mid-1980s also may be affecting the quality of migratory and nesting habitat available for species such as canvasback, redhead, marbled godwit, long-billed curlew, willet, snipe, American avocet, and black-necked stilt. For example, the breeding range of the marbled godwit has been reduced over former times (American Ornithologists' Union 1983), and the loss of breeding habitat is probably the key factor preventing the long-billed curlew from recovering to former numbers.

4.6.2 Hunting

Hunting is the largest single mortality factor affecting some wildlife groups, especially waterfowl. Bellrose (1980) estimated that hunting accounted for approximately 50 percent of all annual waterfowl losses nationwide. Hunting programs are designed to remove the harvestable excess in the population and is controlled by regulating the length of season, bag limits, and hunting methods. Annual surveys to determine numbers of breeding individuals, habitat conditions, and reproductive success are used to estimate this excess. Dabbling ducks, unlike swans, geese, and diving ducks, generally produce larger clutches, reach sexual maturity earlier, and commonly renest if the first attempt fails. Therefore, dabbling ducks can theoretically withstand more hunting pressure and can have higher bag limits than swans, geese, and diving ducks.

Privately operated gun clubs in Suisun Marsh and the Delta support most of the waterfowl hunting within the Estuary. These clubs use tidal water from major sloughs, construct diked wetlands on formerly tidal wetlands, and then manage them primarily as wintering habitat for dabbling ducks and geese. About 84 private duck clubs are located in the San Joaquin drainage part of the Delta (U.S. Bureau of Reclamation 1986). The majority of these clubs consist of cropland on which hunting is permitted after the crops are harvested and the fall flooding is completed. Other waterfowl hunting occurs on Grizzly Island Wildlife Area, other State-owned areas in the Bay, private duck clubs in the Napa Marsh, certain salt ponds of the Leslie Salt Company, and on portions of the San Francisco Bay National Wildlife Refuge.

The average annual harvest in California during 1986-1989 was estimated to be 814,500 ducks and 65,833 geese. These figures contrast with the long-term (1961-1988) estimated harvest of 1,519,700 ducks and 163,139 geese per year. State-wide, in decreasing order of abundance, the major species harvested are mallard, northern pintail, green-winged teal, snow goose, Canada goose, and white-fronted goose (Table 4-8). In recent years, mallards have replaced northern pintails as the most commonly harvested species in California. This change suggests that a significant percentage of the mallards taken are either locally produced in California or originate from areas outside the currently surveyed breeding grounds.

Table 4-8. Average species composition of California waterfowl harvest during 1986-1989 (J. Bartonek, U.S. Fish and Wildlife Service, pers. comm.).

Species	Percent of Harvest
Ducks	
Mallard	24.3
Green-winged teal	21.0
Northern pintail	18.2
American wigeon	11.3
Northern shoveler	9.3
Gadwall	5.2
Other teal	2.9
Wood duck	1.7
Canvasback	1.1
Other ducks	5.0
Total	100.0
Geese	
Snow goose	44.9
Canada goose	38.8
White-fronted goose	11.7
Ross' goose	4.4
Total	100.0

The average Estuary-wide harvest during 1971-1980, totalled 387,333 ducks per year (Table 4-9). Species with an average annual harvest in the Estuary exceeding 25 percent of their total statewide harvest were scaup, canvasback, goldeneye, northern pintail, bufflehead, and ruddy duck. The most-harvested species in the Estuary during 1971-1980 were northern pintail, mallard, green-winged teal, American wigeon, and northern shoveler. Suisun Marsh accounted for more than 50 percent of the total ducks harvested in the Estuary.

Table 4-9. Average annual harvest of migrating ducks among species from Eleven San Francisco Estuary counties during 1971-1980 (Carney et al. 1983).

Species	Total Estuary-wide Harvest	Percent of State-wide Harvest
Scaup spp.	13,823	53
Canvasback	7,555	38
Goldeneye spp.	1,241	32
Northern pintail	169,473	28
Bufflehead	1,870	27
Ruddy duck	5,042	26
Northern shoveler	34,311	23
American wigeon	41,178	21
Mallard	52,083	19
Ring-neck duck	2,390	18
Scoter spp.	260	17
Green-winged teal	45,115	14
Merganser spp.	193	13
Wood duck	2,704	11
Gadwall	4,923	10
Redhead	747	9
Other teal	4,425	8
Total	387,333	

During 1961-1970, 15 percent of the Canada geese and 7 percent of the snow geese harvested in California were taken in the Delta (Carney et al. 1975). During 1979-1982, the Delta accounted for an average of 2.5 percent (or 52,000 ducks) of the total state-wide duck harvest and 3.1 percent of the state-wide goose harvest (or 3,650 geese) (Bartonek 1983, as cited by Herbold and Moyle 1989).

Cackling Canada and Pacific white-fronted geese nest on the Yukon-Kuskokwim Delta of Alaska. Since the mid-1960s, subsistence hunting has been steadily increasing due to a highly concentrated, rapidly growing and mobile population of eskimos. Despite reduced limits on winter harvest, populations of these two species have declined significantly (by as much as 85 percent in the case of the white-fronted goose) (Raveling 1983). Since 1985-1986, coordinated fall surveys for these species have revealed some moderate population recoveries, to where white-fronted geese are approaching levels at which some liberalization of winter harvest may be considered (J. Bartonek, U.S. Fish and Wildlife Service, pers. comm.). However, significant harvests on the breeding grounds still occur. For example, an estimated 19,000 geese were taken at the Yukon-Kuskokwim Delta in 1989; this was comparable to the 1987 harvest, but exceeded the total for 1986. The total number of cacklers and lesser Canada geese combined, taken in 1989, represented 12 percent of their total estimated population. Many other species of reptiles, amphibians, birds, and mammals may be harvested or collected within the Estuary. Rules governing the take and possession of native amphibians and reptiles are established by the California Fish and Game Commission following any recommendations submitted by the California Department of Fish and Game. A list of the fully protected native reptiles and amphibians is provided with each set of California fishing regulations. Bullfrogs are the only species currently commercially harvested within the Estuary. No records are available of harvest rates for amphibians and reptiles.

Birds other than waterfowl, coots, moorhen, and snipe, which may be harvested within the Estuary, include ring-necked pheasant, California quail, mountain quail, wild turkey, mourning dove, and band-tailed pigeon. Based on recommendations from the California Department of Fish and Game, the Fish and Game Commission establishes seasons, shooting hours, bag and possession limits, and methods of take for most of these species. Maximum allowable take for the migratory mourning dove and band-tailed pigeon is established by the U.S. Fish and Wildlife Service Office of Migratory Bird Management. Harvest limits for mourning dove are calculated from data submitted by each state reporting the results of annual breeding bird transects.

Resident mammals within the study area which are harvested include western gray squirrels, brush rabbits, black-tailed hare, wild pig, and mule deer. Regulations for the harvest of these species are established by the California Fish and Game Commission, but harvest rates of only the mule deer are monitored.

The entire Estuary area falls within Deer Hunting Zone A which currently has a two tag limit per hunter for the harvest of forked-horn bucks only. As indicated by hunter tag return data (California Department of Fish and Game, unpubl. data), the total buck harvest during 1985-1989 for the ten Estuary counties ranged from 2,022 to 2,572 animals per year and averaged 2,360. This represents about 8 percent of the total average annual state-wide harvest (28,135) during the same period. Most of the deer harvested in the Estuary were from Sonoma (28 percent), Napa and Santa Clara (both 18 percent), and Marin counties (17 percent).

The California Department of Fish and Game also uses inspections of commercial meat locker plants and hunter check stations to estimate hunter success in the State. These data indicate that the annual California deer harvest is actually about twice ($\pm$60,000) the estimate from tag returns (D. Updike, California Department of Fish and Game, pers. comm).

Although the rate of illegal take or poaching of deer is difficult to estimate, state-wide it is generally considered to range from 50 to 150 percent of the actual reported annual kill (D. Updike, pers. comm.). Within the Bay Region, the illegal deer harvest has been estimated to be low in Contra Costa, Alameda, and Santa Clara counties (Schauss 1984, Fowler and Curtis 1989) and moderate in Marin, Sonoma, Santa Cruz, Santa Clara, and San Mateo counties (Fowler and Curtis 1985, Fowler and Buckman undated). With increasing urbanization and high meat prices, poaching may increase (Schauss 1984).

In addition to hunting and poaching, another significant source of deer mortality is collisions with vehicles. State-wide, collisions kill about 15,000-20,000 deer each year (Ford 1981). Numbers of deer killed annually on highways within the Mount Diablo Herd are believed to exceed the legal reported harvest by a large margin (Fowler and Curtis 1989).

Furbearing mammals within the Estuary which may be harvested include badger, beaver, bobcat, coyote, gray fox, mink, muskrat, opossum, raccoon, spotted skunk, striped skunk, and long-tailed weasel. Harvest rates for these species are also set by the Commission. For the period 1978-1988, the total number of furbearers harvested in ten Estuary counties has declined from a peak of 20,554 in 1980 to a low of 2,259 in 1988, with an average take per year of 9,760 animals (Table 4-10). This represents about 12 percent of the total average annual statewide harvest (86,742). The harvest levels reported here are from tag returns by licensed fur trappers. The estimated total take for bobcat is known to be actually higher, since not all trappers report every year, and tag data on exports reveal a greater harvest. Some possible causes for the decline in the fur harvest observed in the San Francisco and Delta Regions during the last 10 years include: urban encroachment on remaining habitats, decline in number of trappers, and market effects on fur prices.

Table 4-10. Average Annual Harvest of Furbearers from Ten Estuary Counties as Reported by Licensed Trappers during the 1978-1988 season (California Department of Fish Game 1980-1983a, 1984-1987a, 1988a, Gould and Escallier 1989, Gould and Hom 1990).

Species	Average Harvested Per Year
Muskrat	6,962
Raccoon	950
Striped skunk	380
Gray fox	358
Coyote	262
Opossum	241
Bobcat	225
Beaver	206
Mink	131
Spotted skunk	38
Badger	5
Weasel	2
Total	9,760

4.6.3 Wildlife Disease

Disease is a major mortality factor among waterfowl wintering in the Delta, San Francisco Bay, and throughout California. The effects of disease are intensified when birds are forced by habitat destruction and drought to concentrate on increasingly small areas. Poor habitat quality and adverse weather also contribute to the spread of diseases such as avian cholera and botulism (Gilmer et al. 1982). The effects of wildlife disease are most critical for species which are already in reduced numbers such as Aleutian Canada geese, cackling Canada geese, and tule white-fronted geese.

4.6.3.1 Avian Cholera

San Francisco Bay and the Delta are two of the four major enzootic foci of avian cholera within California (Titche 1979). In 1948, an outbreak of avian cholera originated in Alviso, at the south end of San Francisco Bay, and spread northward into the Delta where 40,000 waterfowl were killed (Rosen and Bischoff 1949). As many as 70,000 birds have been lost to avian cholera statewide in one winter (Titche 1979). Waterbirds most commonly affected by avian cholera include coots, ducks, geese, swans, gulls, and shorebirds (Rosen and Morse 1959). Other species that have succumbed to avian cholera in California have included ring-necked pheasants, short-eared owls, northern harriers, herons, meadow mice, weasels, and mink (Rosen and Morse 1959).

Since 1979, annual waterbird losses due to avian cholera in the Delta, have ranged from a low of 769 (1982/83) to a high of 8,217 (1984/85) and averaged 2,937 birds per season (California Department of Fish and Game, Region 2, Avian cholera losses in the Delta, Unpubl., final reps., 1983-1990). Primary species affected by these outbreaks, in decreasing order, have been tundra swan, American coot, snow goose, white-fronted goose, and northern pintail. Also, 460 sandhill cranes were killed during the 1987/88 winter season. Most consistent losses of waterfowl to cholera have occurred on the Webb, Rindge, Terminous, and Lower Jones tracts, Venice Island, and in the Yolo Bypass.

Outbreaks of avian cholera are influenced by water management of impoundments (especially draining and flooding), longevity of the disease organism, the presence of disease carriers, and the timely removal and disposal of carcasses (Titche 1979, Herbold and Moyle 1989). In the Delta, white-fronted geese, muskrats, and possibly gulls are known carriers of avian cholera (Titche 1979). McLandress (1983) suggested that the gradual expansion in the range of avian cholera outbreaks over the last 35 years may reflect a synergistic interaction between the disease and deteriorating habitat and increasing contamination by pesticides.

4.6.3.2 Avian Botulism

State-wide, avian botulism kills more birds than does avian cholera, but in the Delta, botulism is apparently less prevalent than cholera (Hunter et al. 1970, in Herbold and Moyle 1989). During at least the last 20 years, numerous relatively small outbreaks of avian botulism have occurred at various locations in the South Bay, including tidal sloughs near Alviso, the Palo Alto Duck Pond, Mountain View Shoreline Park, Vasona Lake in Los Gatos, Lake Cunningham in east San Jose, and the Sunnyvale Water Pollution Control Plant (Woodin et al. 1987).

Due to its influence on nutrient and dissolved oxygen levels, sewage effluent discharge into the South Bay may have had a role in botulism outbreaks in nearby tidal sloughs and oxidation ponds during the 1980s (Woodin et al. 1987). San Francisco Bay Bird Observatory personnel studied these outbreaks during 1982 to 1986 and recorded the number of birds potentially affected. Species affected included herons, ruddy ducks, mallards, northern shovelers, American coots, gulls, and small numbers of a variety of shorebirds (Woodin et al. 1987). During the five years that the area was monitored, 905 birds killed by botulism were collected. Given the low numbers of birds lost compared to the sizes of waterbird populations in the South Bay, it appears that botulism is not currently a major cause of mortality in the Bay.

4.6.4 Predation

In general, predation may benefit wildlife when it limits populations of those species that, if allowed to expand, would have a detrimental effect on a given community. For example, insectivorous birds consume tremendous quantities of terrestrial insects, many of which are harmful to woodland or agricultural communities. However, many of the Estuary's wildlife populations have lost significant critical habitat and have suffered serious population declines. Since these populations rely on suboptimal conditions, their vulnerability to predation may be high, particularly during breeding periods. For example, California clapper rails historically nested in large uninterrupted tracts of bay tidal marshes, and California least terns nested on coastal beaches. Both species are now attempting to maintain their populations by using small, isolated, poor quality breeding sites. Both also must contend with the pressures from adjacent urban areas and experience heavy predation by red foxes, Norway rats, feral cats, raccoons, and northern harriers. Colonial waterbirds and shorebirds nesting on small islands and along linear constructed dikes in salt ponds, that serve as predator trails, are also extremely vulnerable to mammalian predators.

In California, high rates of waterfowl nest predation have been attributed to losses of suitable nesting habitat to agriculture. Clean farming techniques typically leave the only remaining nesting cover along dikes, ditches, and fence rows which provide easy predator access. The most common waterfowl nesting in the Central Valley and Suisun Marsh are mallard, gadwall, northern pintail, and cinnamon teal, all of which depend on upland nesting sites, thus making them more vulnerable to predation.

Monitoring of duck production in Suisun Marsh in 1985 and 1986 revealed that eggs and ducklings were destroyed by ravens, gulls, skunks, otters, and raccoons, while nesting hens may have been taken by northern harriers, great horned owls, feral cats, and raccoons (McLandress and Yarris 1986). Predation rates on nesting ducks are probably related to annual fluctuations in the abundance of alternate prey, such as rodents and crayfish (McLandress et al. 1988).

Avian predators are probably the most significant predators on wintering shorebirds in the Estuary. For example, Page and Whitacre (1975) estimated that during the winter of 1972-1973, raptors (including merlins, peregrine falcons, and northern harriers) ate 21 percent of the dunlins, 12 percent of the least sandpipers, 7 percent of the western sandpipers, and 14 percent of the sanderlings on Bolinas Lagoon. Following the banning of DDT and other organochlorine pesticides and the successful reintroduction of captive-reared birds into the wild, numbers of peregrine falcons have recovered substantially in the 1980s. This recovery has undoubtedly increased levels of raptor predation on shorebirds compared with the 1960s and 1970s.

Within the Estuary study area, introduced predators which are known to cause major nesting failure and some adult mortality among breeding waterbirds include the Norway rat, Virginia opossum, and red fox. The Norway rat was introduced into California by ship, probably first arriving with the Spanish. Generally, these rats do not range beyond the vicinity of urban areas, but the close proximity of urban development, the presence of numerous sanitary landfills, and the widespread use of rip-rap have resulted in high densities of rats along the Bayshore. Norway rats are known to be significant predators on waterfowl and nesting clapper rails (DeGroot 1927, Applegarth 1938). Recent studies revealed that rats took about 33 percent of the eggs laid by clapper rails in the South Bay (Harvey 1988, Foerster et al. 1990).

The opossum was introduced in the San Jose area in 1900 and became established in the Central Valley by the 1940-50s. McLandress et al. (1988) reported the opossum as one of several primary predators causing duck nest loss in Suisun Marsh.

Beginning in the mid-1980s, there has been a population explosion of introduced red foxes in the San Francisco Bay Region. This northern Great Plains subspecies of red fox was introduced to the Sacramento Valley by hunters or fur farmers during the 1870s and 1880s. During the 1960s, red foxes were also released near Hollister from a defunct fur farm. This species has largely displaced the native gray fox, which is probably a less efficient predator in aquatic and urban settings.

This opportunistic predator continues to threaten resident breeding endangered species, waterfowl, colonial birds, and shorebirds in the San Francisco Bay Region. In 1990, red foxes preying on eggs caused complete nesting failure of entire colonies of Caspian terns and California least terns in the Bay Area. Moreover, they are strongly implicated in the population crash of the California clapper rail over the last five years. From a population estimate of about 1,500 in the early 1980s, biologists estimate the current rail population may be less than 500 individuals in early 1991 (U.S. Fish and Wildlife Service 1991). The recent arrival of red foxes on Bair Island, which is surrounded by wide tidal channels, further attest to the dispersal abilities of this species and the threat it poses to colonially-nesting birds in the Bay Region (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.).

Along the Bayshore, red foxes are probably now preying as heavily on the eggs of stilts, American avocets, and snowy plovers as they are along Monterey Bay (Point Reyes Birds Observatory, unpubl. data), another region where fox numbers have risen dramatically during the 1980s. Leora Feeney (pers. comm.) has observed foxes taking adult shorebirds at salt evaporators near Hayward, and they have been observed stalking shorebirds on tidal mudflats (U.S. Fish and Wildlife Service 1991). The rapid range expansion of the red fox has been facilitated by its ability to adapt to urbanization and the elimination of larger predators, such as the coyote from parts of the Bay Area, which would displace the smaller species.

As a result of encroachment of low density suburban development into surrounding uplands, free-roaming domestic or feral dogs are considered an increasingly serious predation threat in the Bay Region. This problem has been reported most often within the Mount Hamilton and Mount Diablo deer herds (Schauss 1984, Fowler and Curtis 1989). Twenty-seven percent of the reported deer kills in Santa Clara County during 1984 were attributed to dogs. Adults may be harassed, and fawns are susceptible to being killed by dogs. Even though this problem has not been well studied, it may be a locally moderate to serious factor in deer survival.

Recent studies of the nesting success of dabbling ducks in the Prairie Pothole Region of the north-central United States and south-central Canada, have revealed low success rates (5-15 percent) across broad areas of prime breeding grounds. As much as 70 percent of the loss has been attributed to predation (Cowardin et al. 1983). Increasingly intensive agriculture has decreased availability of duck nesting cover and reduced populations of alternate prey. As a result, predators, nesting ducks, and other prey are all concentrated on the remaining untilled areas.

Studies throughout the northern plains have indicated that the red fox is the major predator of adult dabbling ducks (Sargeant et al. 1984, Cowardin et al. 1985). In North Dakota, Cowardin et al. (1983) found that 18 percent of the breeding hen mallards were taken by red foxes. Sargeant et al. (1984) estimated that, during spring and summer of 1969-1973, a yearly average of 900,000 adult nesting ducks were killed by red foxes in the entire Prairie Pothole Region. The period of greatest food demand for foxes occurs while they care for their pups, which coincides with the arrival of nesting ducks. Current levels of fox predation are reducing annual duck production sufficiently to hold duck populations at their currently low levels (Sargeant et al. 1984).

Poor nesting success has been proposed as the "bottleneck" preventing the recovery of duck populations in the Prairie Pothole Region of North America. Management techniques currently being used to improve duck nesting success in the northern prairies include predator removal, predator exclusion from nesting areas with electric fences, and large-scale habitat restorations. Larger blocks of grassland habitat would allow for lower nesting densities and reduced predator foraging success. These large grassland tracts may also support coyotes which are less efficient predators of ducks and duck eggs (Cowardin et al. 1983) and which tend to exclude red foxes (Greenwood et al. 1987).

4.6.5 Contaminants

Environmental contaminants known to be present at concentrations that could threaten wildlife populations in San Francisco Bay Estuary include cadmium, copper, mercury, selenium, and silver (Luoma and Phillips 1988, Ohlendorf and Fleming 1988); chlorinated hydrocarbons, including pesticides such as DDT and its metabolites and polychlorinated biphenyls (PCBs) (Phillips and Spies 1988); and polycyclic aromatic hydrocarbons (PAHs) (Wright and Phillips 1988). A wide variety of other contaminants are present in the Bay ecosystem (See Davis et al. 1990), but for most there is insufficient information to relate their presence and concentrations to threats to wildlife resources of the Bay.

The primary sources of contaminants in the San Francisco Bay Estuary include urban runoff, nonurban runoff, riverine inflows from agricultural lands of the Central Valley, discharges from municipal waste treatment facilities, industrial effluents, dredging and dredged material disposal, and spills (Davis et al. 1990). Although relatively few studies have been conducted to determine the specific biological effects of various contaminants on estuarine wildlife, certain links between contaminants and their effects on wildlife have been either established or strongly suggested.

Contaminants may adversely affect wildlife if they reduce the food base or otherwise disrupt the habitat required for the survival of wildlife. For example, the San Francisco Bay Delta population of anadromous striped bass (Morone saxatilis) has suffered a severe decline in the last 20 years. The accumulation of toxic material, such as petroleum hydrocarbons, heavy metals, and chlorinated hydrocarbons (Whipple et al. 1983) in the ovaries of adult prespawning fish is likely to be a significant factor in the decline of these fish. Striped bass from San Francisco Bay had higher percentages of egg resorption in certain years than striped bass from reference sites. Relatively high residues of chlorinated hydrocarbons, including PCBs, DDT and metabolites, and toxaphene have been found in tissues of Bay striped bass that were at concentrations potentially impacting striped bass adults, eggs, and larvae (Jung et al. 1984, Crosby et al. 1986). If these contaminants are adversely affecting the health and reproduction of striped bass, it is likely that they are also adversely affecting other species of fish that comprise part of the food base required by piscivorous wildlife in the Bay.

Other segments of the food web may also be harmed by environmental contaminants. In a continuing study of potential contamination of waterfowl foods in San Francisco Bay, intertidal invertebrates and algae were collected at eight sites in San Francisco Bay and San Pablo Bay and at a reference site. Concentrations of mercury, selenium, cadmium, aluminum, lead, chromium, copper, and zinc were elevated in samples of sediments, polychaetes, mussels, and/or algae at several sites; each element was found to exceed the LD-50 level (dosage lethal to 50 percent of test population) for invertebrates or algae in laboratory studies at one or more sites (K. Miles, U.S. Fish and Wildlife Service, unpubl. data).

The San Francisco Bay Estuary is a critical wintering area for diving ducks, including scaup, scoter, and canvasbacks. These and other diving ducks feed on benthic organisms, especially mussels and clams (White et al. 1988), which have been shown to contain high concentrations of selenium, heavy metals, and other contaminants (Risebrough et al. 1977, Luoma and Cain 1979, Ladd et al. 1984, Hayes and Phillips 1985). In a study in 1982, livers of surf scoters and greater scaup contained concentrations of mercury, cadmium, and some other metals that were elevated in comparison to concentrations for these species in other published reports (Ohlendorf et al. 1986c). Mercury concentrations were higher than concentrations in mallards that were fed diets containing 0.5 ppm (dry weight) mercury (as methylmercury) for three generations (Heinz 1979). Mallards fed mercury exhibited behavioral differences in nesting females and ducklings, and fewer ducklings were produced than in controls.

Results of sampling for contaminants in surf scoters in January and March 1985 indicate that, overall, mean concentrations of copper and zinc were higher in scoter livers from the South Bay, whereas mean iron and lead were higher in livers from the North Bay (Ohlendorf et al. in press). Body weight was negatively correlated with mercury concentration in the liver. Concentrations of selenium, mercury, and cadmium in scoter livers were significantly higher in March 1985 than in March 1982, but copper and zinc concentrations were not different between years.

Selenium concentrations in livers of Bay surf scoters and scaups (Ohlendorf et al. 1986c) were similar to those in other waterfowl species from a nearby San Joaquin Valley location (Kesterson Reservoir) where severe selenium-caused reproductive impairment and adult mortality were observed (Ohlendorf et al. 1986b). Other studies by Ohlendorf et al. (1989) and the California Department of Fish and Game (White et al. 1988, 1989) have revealed high concentrations of selenium in surf scoters and scaups collected from other parts of the Bay from 1985 to 1988. The highest selenium concentrations were found in birds collected from San Pablo and Suisun bays and from the extreme South Bay.

Surf scoters, scaup, and ruddy ducks were collected in March of 1989 from a site near the Carquinez Straits and from a coastal reference site, Tomales Bay. Liver and kidney biochemical assays were conducted, and, although the data have not undergone statistical analyses, there appear to be differences between the sites that may be due to contaminants (D. Hoffman, U.S. Fish and Wildlife Service, unpubl. data).

Contaminants have been shown to adversely affect reproduction in many species of wildlife, especially birds. Effects of contaminant exposure may range from slight changes in nesting behavior to complete reproductive failure. Organochlorines are well known for their detrimental effects on avian reproduction. Exposure to DDT, for example, has caused eggshell thinning and decreased egg hatchability, a major factor in the decline of several species of birds in California, including raptors, brown pelicans, and double-crested cormorants.

In 1982, organochlorine and mercury concentrations were measured in eggs of Caspian terns, Forster's terns, black-crowned night-herons, and snowy egrets from Bair Island in the South Bay (Ohlendorf et al. 1988). Caspian tern eggs had significantly higher mean concentrations of DDE than those of the other species at Bair Island, and they were higher in PCB concentrations than eggs of the same species from San Diego Bay and Elkhorn Slough in Monterey Bay, California. Both Caspian and Forster's terns had higher mean concentrations of mercury than the two wading bird species at Bair Island. In 1982 and 1983, DDE concentrations in 12.5 percent of black-crowned night-heron eggs exceeded 8 ppm, a concentration associated with impaired reproduction in this species, and DDE concentrations were negatively correlated with eggshell thickness (Ohlendorf and Marois 1990). In followup studies in 1989 and 1990, a number of crushed and failed to hatch eggs were found in both black-crowned night-heron and snowy egret nests. DDE concentrations in randomly collected eggs of night-herons and snowy egrets exceeded the 8-ppm criterion in one random egg from Bair Island (6.7 percent), one at West Marin Island (4.8 percent), and none from Mallard Slough (R. Hothem, U.S. Fish and Wildlife Service, unpubl. data).

At Bair Island in 1983, there was a significant negative correlation between embryonic weight and PCB residues (geometric mean = 4.1 ppm, wet weight) in black-crowned night-herons, suggesting a possible impact of PCBs on embryonic growth (Hoffman et al. 1986). In a study of contaminant acquisition by night-herons and snowy egrets at West Marin Island in 1987, DDE and PCBs were detected in all eggs and chicks that were sampled. DDE and PCBs were found to accumulate as the chicks grew (Custer et al., in press), indicating that these contaminants were being acquired locally.

Eggs of the endangered California clapper rail, collected during 1975 and 1986-1987, were analyzed for organochlorines and trace elements. Organochlorine concentrations declined from 1975 to 1986-87. However, mercury concentrations were higher than North Carolina reference eggs and were similar to concentrations associated with reproductive effects in other avian species. Selenium concentrations were elevated in eggs and were especially high in eggs from a marsh adjacent to a North Bay oil refinery (Lonzarich et al., in prep.)

Little work has been completed on mammals in the Bay. Risebrough et al. (1978) reported limited analyses of organochlorines in the tissues of harbor seals found dead in the Bay. Individual seals contained considerably elevated concentrations of PCBs and DDE. Research on ringed seals in the Bothnian Bay (Helle et al. 1976a, 1976b) and harbor seals in the Wadden Sea (Reijnders 1980, 1986) suggests that PCB concentrations similar to those in the Bay seals would be likely to cause reproductive problems. Currently, a much-needed study of contaminant effects on San Francisco Bay harbor seals is being conducted (D. Kopec, pers. comm.). During July 1989, a study of contaminants in small mammals was conducted in pickleweed marshes at 14 locations in San Francisco Bay. Comparisons were made among localities for each element/tissue (mercury, selenium, lead, and cadmium), and among species. Certain elements were found to be elevated in the mammals, but none of the concentrations in these mammals is known to be associated with harmful effects (D. Clark, Jr., U.S. Fish and Wildlife Service, pers. comm.).

Major sources of trace elements and metals in the Bay are discharges from municipal water treatment facilities. One metal of concern, silver, is especially elevated in South Bay water and biota (Luoma et al. 1985, Smith et al. 1986), but the significance of these elevated concentrations to wildlife remains unknown.

Sewage treatment plant effluent has also been identified as a primary source of dissolved selenium in the South Bay (Cutter and San Diego-McGlone 1990). In the North Bay, oil-refinery effluent may be the major source of selenium, but selenium also enters the Bay from Central Valley agricultural drainage disposal (Cutter 1989). High concentrations of selenium and other contaminants also have been found in the invertebrate prey of diving ducks (Luoma et al. 1985, White et al. 1989). Although it is not known what effects selenium may be having on the health of diving ducks or other wildlife species in the Bay, the California Department of Health Services has issued a health advisory regarding human consumption of scaup and surf scoter from the Bay.

Much of the mercury entering the Estuary is from upstream mining areas from as early as the gold rush period. Some mercury also is leached out of natural cinnabar deposits in the nearby Coast Range, while some is discharged into the Estuary from municipal and industrial sources. Concentrations in striped bass in the Bay and the Delta have resulted in public health warnings from the Department of Health Services regarding the human consumption of these fish (Wright and Phillips 1988).

California's Central Valley is a very important agricultural area, where about 10 percent of the nation's pesticide tonnage is applied to various crops. Although the use of many of these pesticides has been banned or severely restricted (e.g., DDT), residues will persist in valley soils for some time, and these soils will serve as a reservoir for continued input of DDE, chlordane, dieldrin, toxaphene, and other persistent pesticides to the Bay through leaching and erosion processes (Wright and Phillips 1988). This will insure at least a moderate "background" level of contamination for many years, as confirmed by recent data from the state "Mussel Watch" program (Hayes and Phillips 1985, Stephenson et al. 1986). However, the Santa Fe Channel and Lauritzen Canal in Richmond Harbor are heavily contaminated by total DDT, dieldrin, chlordane, and other pesticides, the long-lasting effect of the presence of a former pesticide formulation and packaging plant (Hayes and Phillips 1985, Stephenson et al. 1986).

Mussel Watch data indicate that PCBs are ubiquitous within San Francisco Bay, with concentrations in mussels ranging from about 150 to over 1,000 ppm, dry weight. Specific sources of these residues are not known, but Oakland and Richmond harbors appear to be especially polluted with PCBs (Stephenson et al. 1986).

The large urban area surrounding the Bay and the presence of six major refineries in the North Bay suggest that contamination of the estuary by hydrocarbons from urban runoff and industrial sources is a real possibility. However, to date, relatively few studies of this potential problem have been conducted. Monoaromatic hydrocarbons may be contributing to problems with fisheries, but the available evidence is not conclusive. Polyaromatic hydrocarbons are ubiquitous in San Francisco estuarine sediments, although very little work on PAHs in biota has been undertaken.

The limiting factors which have been discussed so far may affect wildlife populations during various periods in their annual or life-long cycles. In the case of waterfowl, the functional relationships among hunting mortality, non-hunting mortality, recruitment, and population status are not clearly understood (Figure 4-18). Habitat conditions together with hunting influence the mortality and physical state of birds surviving the winter. The number and condition of the survivors and the quality of the breeding habitat in turn determine the breeding population.

4.6.6 Oil Spills

Oil spills constitute an ongoing threat to a wide variety of wildlife of the open Bay waters and those dependent on bayshore habitats. Oil spills have occurred in the Bay since the 1800s, but regulations since the 1950s have reduced chronic spillages and bilge discharges into Bay waters. Groups especially vulnerable to spills include waterbirds, aquatic invertebrates, amphibians, certain reptiles, early life stages of fishes, and marine mammals.

A major spill resulting from a collision of two tankers just outside the Golden Gate Bridge in 1971 caused the deaths of an estimated 20,000 waterbirds (Banks 1979). An estimated total of 10,577 marine birds representing 26 species were believed killed or debilitated by a spill of 25,800 gallons of crude oil from the Apex Houston in 1986 (Page and Carter 1986).

In April 1988, a spill at the Shell Oil Refinery near Martinez resulted in 8,700 barrels of crude oil being released into the Estuary (M. Rugg, California Department of Fish and Game, pers. comm.). A total of 455 individual waterbirds were recorded as killed or oiled during the incident. The spill also affected 64 mammals, including muskrats and river otters. About 760 acres of adjacent tidal marshes were oiled, contaminating habitat suitable for clapper rails, black rails, Suisun song sparrows, Suisun shrews, and salt marsh harvest mice (Palawski and Takekawa 1988).

Seven oil refineries currently operate in the Bay, supplied by a fleet of large-capacity ocean-going tankers. A large oil spill from a refinery or tanker occurring during the height of the migratory waterfowl season could significantly impact local wintering populations for a long period. Moreover, because San Francisco Bay is a major shipping center, the threat of spills from other commercial and military vessels also exists.

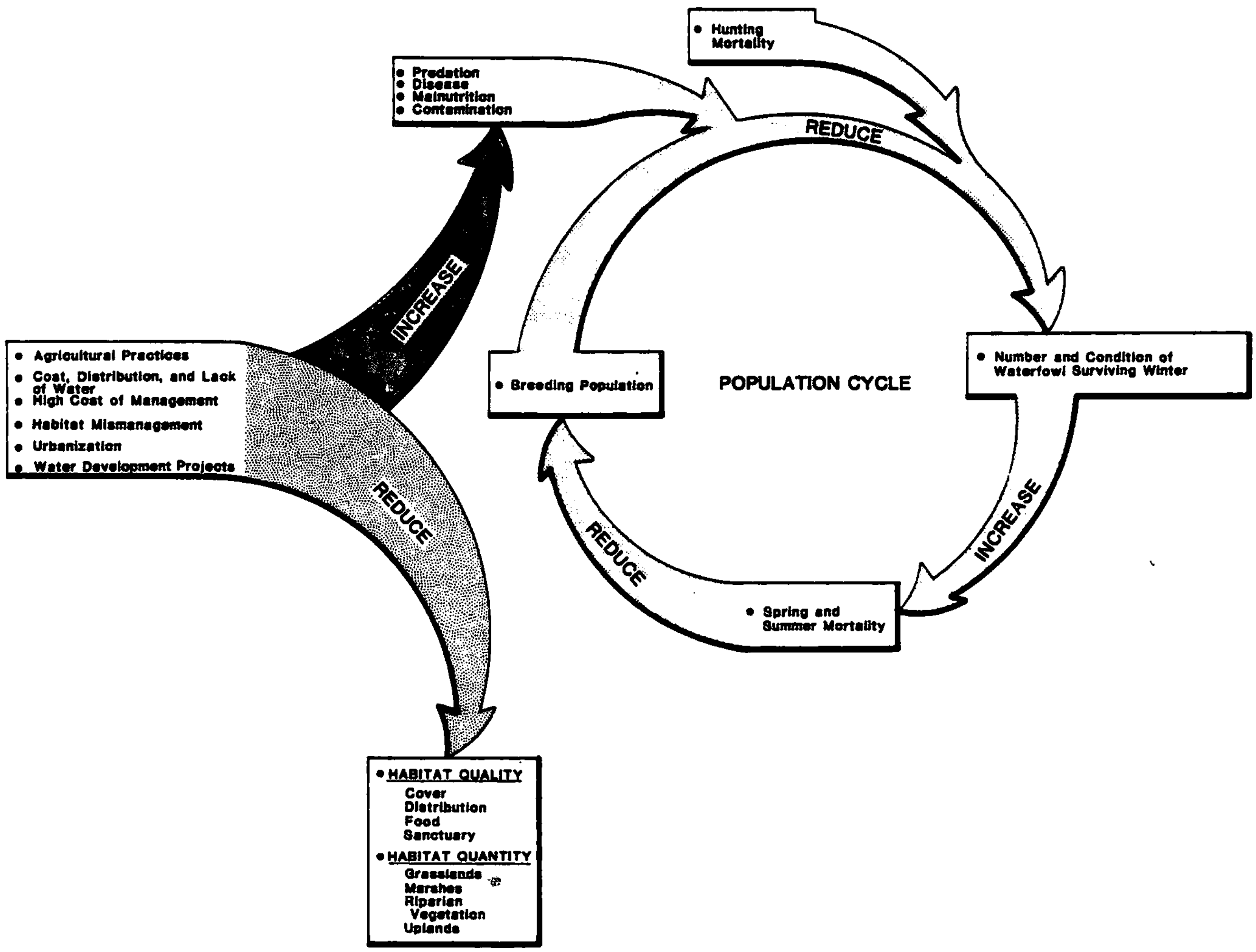

Figure 4-18. Flow Diagram Showing How Different Limiting Factors Affect California Waterfowl Populations (U.S. Bureau of Reclamation 1986).

In large spills, actual mortality of waterbirds is seldom determined because of the difficulty in recovering dead birds which may drift away or sink. If oiling is light, birds may fly considerable distances before death occurs (Banks 1979). Other effects of oil may be more subtle, such as impairment of health or reproduction. Species in the Bay most vulnerable to the effects of a spill include: loons, western grebes, horned grebes, scaup, ruddy ducks, scoters, canvasbacks, common murres, cormorants, and brown pelicans.

4.6.7 Inter-specific Competition

Several species of introduced and some native wildlife have expanded or are expanding their ranges in California, usually as a result of direct introductions or in response to human alteration of habitats. Some of these species are now competing with and adversely affecting populations of native wildlife in the Estuary.

The European starling was introduced in New York in 1890, and by the 1950s it had appeared within the Estuary. The species was well established along the Pacific Coast by 1961 (Gordon 1977) and was first observed in the Sacramento Valley in 1964 (Gaines 1974). Generally, starlings are restricted to urban, pasture, cropland, and orchard-vineyard habitats, but they may be encountered throughout the lower elevations of California. Starlings are aggressive competitors for nesting holes, displacing or evicting bluebirds, titmice, nuthatches, swallows, wrens, and woodpeckers.

English sparrows were introduced in New York during the latter half of the nineteenth century, and the species was first recorded in California in 1871. At present, these sparrows are common throughout lowland California in urban and cropland habitats where they use man-made structures for nesting. English sparrows are considered detrimental to native birds because they compete for nest sites with swallows, bluebirds, wrens, and finches. These sparrows not only evict adult birds, but they also destroy eggs and nestlings.

In response to conversion of land to agriculture and grazing, the brown-headed cowbird, formerly restricted to along the Colorado River in the 1800s, expanded its distribution to encompass all of California by 1960 (Laymon 1987). Cowbirds roost and breed primarily in riparian woodlands or along forest edges and often feed near livestock pasture or irrigated farmlands. The cowbird is a brood-parasite that lays its eggs in the nests of more than 200 host species, but especially in the nests of warblers, vireos, flycatchers, phoebes, sparrows, and finches. By reducing reproductive success of their hosts, cowbirds may have contributed to some reduction in numbers or extirpation from within the study area of riparian-nesting species such as the willow flycatcher, least Bell's vireo, warbling vireo, yellow warbler, common yellowthroat, and song sparrow (Gaines 1974).

During the past nine years, the native California gull has become the most numerous colonial bird breeding in the San Francisco Estuary. Except for early 20th century records for the Sacramento River and northeastern California, the species was not known to nest further west than Mono Lake prior to 1981. Currently they nest in the South Bay salt ponds, but the expansion of their colonies has displaced other nesting species such as Forster's terns, black-necked stilts, and American avocets.

Double-crested cormorants have also been expanding their numbers and range in California and elsewhere. At some colonies, they have also displaced great blue herons from traditional colonies.

Several introduced mammals, including the wild pig, house mouse, Norway rat, and black rat, are also currently competing with native wildlife. Wild pigs are common at scattered low to middle elevation locations in the Coast Range and foothills. Although no attempts have made to quantify their effects, wild pigs may have a major impact on native wildlife such as wild turkey, mule deer, squirrels, and black bear when they compete for acorns in oak woodlands (Schauss 1984). They also may destroy native vegetation and nests of ground-nesting birds. Norway rats, black rats, and house mice are common throughout the study area, particularly near human habitation, along streamcourses and water bodies, and in agricultural land. They compete with native rodents such as the muskrat and salt marsh harvest mouse.

The Argentine ant, which arrived in Louisiana in 1890, now occurs throughout the warmer parts of California. Because it is highly aggressive, this ant displaces native ant species (Ward 1987) which are the only food taken by the coast horned lizard. As a result, it may have contributed to the reduction in distribution and numbers of this native lizard.

4.6.8 Human Disturbance at Wintering and Breeding Sites

Direct human disturbance may interfere with breeding and other activities of wildlife and may reduce the quality of habitat available within the Estuary study area. In California, one form of human disturbance to wintering waterfowl is caused by aircraft. For example, it has been suggested that the observed declines in the use of Suisun Marsh by snow geese may have been related to increased air traffic from Travis Air Force Base (M. Miller, U.S. Fish and Wildlife Service, pers. comm.).

Time-budget studies of northern pintails in Suisun Marsh have revealed that sleeping occupies up to six hours per day for wintering ducks, and is probably as important as feeding. Human disturbance caused by hunting interrupts sleeping and increases energy consumption by stimulating more flying (J. Pirot, California Department of Fish and Game, pers. comm.). Hunting may also discourage waterfowl from exploiting preferred feeding sites during the day.

Significant human disturbance occurs where double-crested cormorants nest on artificial structures in the Estuary. The California Department of Transportation is having difficulty maintaining and painting the Richmond-San Rafael and San Francisco-Oakland bridges without disturbing nesting cormorants from March to September. Cormorant nests have also been removed or abandoned during maintenance of Pacific Gas and Electric Company transmission towers (H. Carter, U.S. Fish and Wildlife Service, pers. comm.).

Tidal and nontidal marshes adjacent to urban centers are subject to frequent human disturbance due to foot traffic and uncontrolled dogs. Unauthorized access by fishermen or boaters occasionally disrupts nesting by colonial species such as herons, egrets, gulls, and terns on islands in the South and Central Bays. Maintenance conducted by the State Transportation Department on bridges used by nesting double-crested cormorants may also cause disturbance.

4.6.9 Transmission Corridor and Wind Energy-related Mortality

Even before the turn of the century, a variety of waterbirds were reportedly killed by hitting power lines over marshes near Hayward (Emerson 1904). Avian mortality resulting from both collisions with these structures and electrocutions is still extremely common throughout the State, affecting a wide variety of birds. As recently as the winters of 1990 and 1991, individual peregrine falcons were killed due to collisions with powerlines in the South Bay (S. Pruszenski, U.S. Fish and Wildlife Service and P. Kelly, California Department of Fish and Game, pers. comm.). With the expansion of wind resource development and associated transmission lines in the San Francisco Bay Region, mortality has increased during the last few years and may be depressing local raptor populations (Estep 1989, S. Pruszenski, pers. comm.).

Most collision and electrocution incidents in the study area occur in the inland passes of Alameda, Contra Costa, and Solano counties which are also favored by migrating, nesting, and wintering raptors. At present, 50 percent of the wind energy generated statewide originates from the Altamont Pass area, and an estimated 500 birds per year are probably lost in that area (R. Andersen, California Energy Commission, pers. comm.). Since 1986, 322 raptors, including 76 golden eagles, have been confirmed to have been killed by these facilities (S. Pruszenski, pers. comm.). Other species killed include red-tailed hawks, American kestrels, turkey vultures, great horned owls, barn owls, ferruginous hawks, and ravens. In general, 33 percent of the mortalities resulted from electrocution, while the remainder were caused by collisions with either rotor, tower, guy wires, or associated power lines (Estep 1989). In response to this problem, a Technical Advisory Committee comprised of the U.S. Fish and Wildlife Service, California Department of Fish and Game, Pacific Gas and Electric Company, California Energy Commission, and County representatives, has been formed to investigate possible mitigation measures.

Methods of raptor-proofing transmission poles exist and, as of 1991, installation is a requirement of all county permits for these facilities. For the period 1985 through June 1987, the Pacific Gas and Electric Company summarized state-wide records of bird-caused electrical outages due to bird-transmission line interactions (Dedon and Colson 1987). Of 174 bird-caused outages in which the birds were killed during 1986-1987, 29 were caused by hawks and owls and 17 by sandhill cranes either hitting wires or contacting pole hardware. Other species implicated in outages and experiencing mortality included crows, ravens, ducks, swans, gulls, and vultures. Nearly 50 percent of all outages were caused by large starling flocks perching on wires and resulted in no avian mortality.

Throughout California, several wildfires each year can be traced to smoldering electrocuted raptors. Two were recorded during summer 1990 in the Alameda-Contra Costa County area (M. Martin, California Department of Forestry, pers. comm).

Since August 1988, Pacific Gas and Electric Company has monitored bird mortality caused by a newly erected 115-kV transmission line for the Mare Island Naval Shipyard in Vallejo. Under a 4.5-mile line they found the remains of 120 ducks, including 106 ruddy ducks, and 69 shorebirds, including 24 black-bellied plovers and 26 western sandpipers (Dedon et al. 1989, 1990). Other birds found dead included grebes, cormorants, gulls, rock doves, owls, sparrows, and blackbirds.

Determining mortality solely through records of bird remains greatly underestimates the level of impact due to transmission lines. This is because scavengers rapidly remove carcasses from the search area, remains in dense cover are hard to detect, and crippled birds fly out of the transect area. Therefore, Pacific Gas and Electric Company researchers also monitored bird remains in a control area where there was no power line. Based on numbers of casualties in the control setting, Dedon et al. (1989) concluded that mortality from collision with the Mare Island power line represented a small proportion of the total mortality of local bird populations. This conclusion applies only to a 4.5-mile length of power line studied at one location. Many miles of power lines stretch across numerous wetland and deepwater habitats throughout the North and South bays, and further study is necessary before their overall effect on the Bay's bird populations can be definitely ascertained.

4.6.10 Freshwater Diversions

The amount and timing of freshwater inflow into San Francisco Bay has been drastically reduced and altered since the late 1800s and early 1900s. Agricultural, municipal, and industrial uses, both upstream and in Central and Southern California, currently divert more than 60 percent of the historic inflow to the Bay and Delta (Nichols et al. 1986). Reductions in inflow are believed by many biologists to be detrimental to fish and wildlife populations of the Estuary. For example, water exports have caused increased salinities in the Delta and have resulted in loss of spawning and nursery areas for species such as chinook salmon, striped bass, and Delta smelt (Nichols et al. 1986, Moyle and Williams 1990). A direct relationship between other wildlife and Bay inflows has yet to be determined. However, ongoing concerns that Suisun Marsh waterfowl managers share over any salinity increases testify to the necessity for implementation of the Suisun Marsh Protection Plan and insuring adequate Bay inflows to maintain suitable dabbling duck habitat. Food organisms that benefit from higher inflow probably also benefit waterfowl and other waterbirds.

Higher relative inflow is also beneficial because it can dilute, transform, or flush contaminants from the Bay. This is particularly important in the South Bay where seasonal winter flushing is dependent on outflows from the Delta (Conomos 1979). Any dampening effect that fluctuating salinities have on invertebrate biomass, and the resulting relatively lower value of mudflats in the northern reaches of the Bay for shorebirds, must be weighed against the overall benefits of nutrient loading, greater productivity, and contaminant dilution that increased freshwater flow brings to the Bay.

While some estuarine species have undoubtedly declined due to reduced outflow, some more marine species may have benefitted. For example, the California clapper rail, which prefers salt marsh, was first encountered in Suisun Marsh following the drought years of 1975-1977 (Harvey 1980).

CHAPTER 5
FUTURE PROJECTIONS ON DISTRIBUTION AND ABUNDANCE OF WILDLIFE POPULATIONS

Although populations of some wildlife groups within the Estuary, such as certain colonial nesting species, may currently be increasing, for most wildlife populations, future trends are likely to be downward. Some endangered species may go extinct. Many of the current causes of wildlife population changes in the Estuary discussed in Chapter 4 are projected to continue into the future. These are primarily human-related factors that affect the habitat in which wildlife live and can be divided into three broad categories: (1) habitat loss, (2) habitat alteration, and (3) habitat degradation.

5.1 HABITAT LOSS

5.1.1 Urban Growth

Historically, habitat loss to urban growth has been one of the most important factors affecting wildlife populations in the Estuary, and it is projected that this trend will continue into the future. According to the Status and Trends Report on Land Use and Population (Association of Bay Area Governments 1989), the human population in the Estuary study area is projected to increase from 7.5 million to 8.7 million between 1990 and 2005. Accommodating this population increase would require an estimated 10,000 acres of wildlife habitat per year, of which 57 percent would be conversion of agricultural land, with the greatest percentage in the Delta (Association of Bay Area Governments 1989). Conversion of agricultural land to urban in the Delta would have negative effects on numerous species of migratory waterfowl and upland animals that depend on agricultural waste grain to meet year round or winter energy requirements. The Delta supports about 10 percent of the Central Valley's waterfowl population during the midwinter period and is particularly important to tundra swans and white-fronted geese. Future losses of agricultural lands critical to the survival of these species would negatively affect their flyway populations.

According to The Association of Bay Area Governments (1989), the remaining urbanization would occur in other upland rather than wetland habitat types. Grassland and oak woodland habitats and their associated wildlife communities will likely continue to suffer the greatest losses, because these habitat types generally lie on terrain most suitable for urban development.

Based on current development proposals, Granholm (1989) projected future seasonal wetland losses in San Francisco and San Pablo bays. He estimated that the Bay Area contained about 21,400 acres of seasonal wetlands in 1975, and, if all proposed developments were approved, 64 percent of that acreage would remain in the future. In San Francisco Bay south of Point Pinole, projected seasonal wetland losses were greater, with only 45 percent of the

1975 acreage left intact in the future. Only those seasonal wetlands already in public ownership would remain in the South Bay.

If these projected trends in wetland losses become a reality, concomitant reductions in populations of Bay migratory waterfowl, shorebirds, and other waterbirds are highly probable. Shorebirds that rely on seasonal wetlands in winter for high tide foraging and roosting habitat would be impacted most severely by reductions in acreage of this habitat type. Populations of species dependent on seasonal wetlands, such as yellowlegs, would decline.

Seasonal wetlands around South San Francisco Bay are believed to be critical for the survival of the southern subspecies of the salt marsh harvest mouse (Shellhammer 1989), but losses of the magnitude projected by Granholm (1989) could imperil its continued existence. Remaining tidal marshes support few harvest mice, and progressively declining habitat conditions because of increasing human intrusion, introduced predators, and contaminants. Seasonal wetland habitat supports eighteen genetically isolated populations of the southern subspecies of the mouse. Of these, 15 populations are in areas susceptible to or proposed for commercial development or other forms of habitat loss. As the Bay area grows, seasonal wetlands and associated wildlife in the North Bay could face a similar fate.

Habitat losses, particularly wetland losses, may be offset somewhat in the future if current federal, state, and private acquisition proposals become a reality. State Senate Concurrent Resolution 28 requires the Department of Fish and Game to increase wetlands within the state by 50 percent by the year 2000, and the State Legislature and voters have provided sources of funding to further this goal. The California Central Valley Habitat Joint Venture and the San Francisco Bay and Central Valley Concept Plans for Waterfowl Habitat Protection, all under the guidance of the North American Waterfowl Management Plan, have set forth objectives for protecting and restoring wetlands in the Estuary. Expansion of the San Francisco Bay National Wildlife Refuge, which has been authorized and partially funded by Congress, will help meet these objectives. Protection of existing habitat and restoration of former wetland habitat would hopefully stabilize flyway waterfowl and shorebird populations or at least slow downward trends. (These acquisition plans are described in greater detail in Chapter 6).

5.1.2 Agricultural Growth

Conversion of native upland habitats to irrigated agricultural land is also expected to continue into the future, with 500,000 acres of new rice land, orchards, and vineyards being developed in California by 2010 (California Department of Water Resources 1983). Within the Bay area, oak woodland and grassland habitats and their associated wildlife communities are likely to be impacted the greatest. Species dependent on these habitats, such as the acorn woodpecker, grasshopper sparrow, and burrowing owl, would likely decline in numbers.

5.1.3 Levee Maintenance

Recent State legislation, the Delta Flood Protection Act of 1988, increases the financial assistance to Delta reclamation and levee districts maintaining non-federal project levees. This act may increase the likelihood that little riparian vegetation and its associated wildlife community will be maintained on Delta levees. However, the act states that projects must be constructed such that there is no net loss of fish and wildlife habitat. The bill also contains provisions for $5 million annually to be deposited in the California Water Fund for mitigation of specified adverse effects of local flood control work. While these projects may reduce the overall rate of riparian habitat loss, they will not increase the net acreage of available habitat.

5.1.4 Shoreline Erosion

Similar or possibly accelerated tidal marsh erosion rates as described in Section 4.6.1.1.5 of this report, are expected to continue into the future. Predicted increases in agricultural and urban growth in the Central Valley may result in further diversions of freshwater out of the Delta, thereby decreasing sediment contributions to the San Francisco Bay system. Assuming reduced sediment inflows, equilibrium between marsh erosion and accretion may be altered. As a result, further losses of habitat for the California clapper rail, salt marsh harvest mouse, salt marsh song sparrow, and salt marsh vagrant shrew may occur in the future.

5.1.5 Sea Level Rise

Concern has been expressed that increased concentrations of greenhouse gases in the atmosphere may result in both global warming and sea level rise by the mid-21st century. However, greenhouse induced sea level rise estimates have been in a state of flux for a decade and evaluating the future threat of gobal warming to San Francisco Estuary wildlife habitats is difficult. Meier (1990) estimated that by about the year 2050, if global air temperatures increase by 3°C to 5°C, a rise by as much as 2.5 feet in ocean levels could occur. (See Williams 1985 and Moffatt and Nichol et al. 1987 for alternate predictions of sea level rise in the Estuary).

An increase in sea level could have a variety of impacts on wildlife habitats in the San Francisco Estuary. For example, rising sea levels could cause loss of existing tidal marshes in the Estuary through conversion to mudflats. This could result in reduction of habitat for the California clapper rail, black rail, salt marsh song sparrow, Suisun song sparrow, salt marsh vagrant shrew, and Suisun ornate shrew, as well as loss of salt marsh harvest mouse populations occurring in tidal marshes. In addition, loss of tidal marshes could reduce detritus and nutrient input to the Bay, decrease nursery habitat for fish, and decrease sediment and contaminant filtering capabilities of the Bay. Since the majority of tidal marshes remaining in the Estuary have lost their natural upland margins, no inland expansion of these marshes could occur in the event of a rise in sea level.

Rising sea levels would also eliminate or greatly reduce available mudflats for shorebirds during low tides and shallow-water feeding habitat for wading birds, such as the great egret and great blue heron. Present harbor seal pupping sites within the Bay would also be inundated, forcing the seals to haul-out on levee tops or other locations vulnerable to disturbance in the Estuary.

Some insight into the potential effects of a possible rise in sea level on tidal habitats, may be gained by considering the results of groundwater withdrawl and subsidence in the South Bay Region. Tidal marshes in Palo Alto subsided as much as 1.94 feet during the 1950's (Poland and Ireland 1988), which is equivalent to a 0.11 feet per year rise in sea level. However, inspection of aerial photographs taken throughout this period, reveals no substantial changes in the extent of tidal marshes or mudflats in this area (K. Dedrick, California State Lands Commission, pers. comm.). Rapid accretion of sediments acted to restore the elevation of these South Bay wetlands as the land subsided.

To withstand the threat of possible rising sea levels, bolstering of levees in the Estuary would necessitate the filling of an undetermined but significant acreage of seasonal wetlands and salt ponds lying adjacent to existing outboard levees. In the Delta, levee reinforcement would result in continued losses of riparian habitat and its associated wildlife community. Moreover, Logan (1990) predicted that a one-foot rise in sea level would double the average number of floods the Delta now experiences annually and result in costs of over $334 million during 50 years if efforts are made to reclaim all flooded islands.

If bolstering of levees was not undertaken, large-scale conversion of presently nontidal wildlife habitats could occur. For example, the extent of acreage of salt ponds would be reduced along with the waterbirds unique to this habitat type. Populations of canvasbacks and northern pintails, which rely heavily on North Bay salt ponds during drought years, would also decline in the Bay. Diked seasonal salt marshes, which have undergone substantial subsidence (e.g., 1-3 feet) in South San Francisco Bay (Moffatt and Nichol et al. 1987), would be inundated, leading to local extirpations of salt marsh harvest mouse populations (Shellhammer 1989). In addition, wintering waterfowl populations of dabbling ducks, geese, and swans in the Estuary would decline as a result of the loss of farmed wetlands and other seasonal wetland habitat.

Conversely, species such as the scaup and surf scoter might increase in numbers in response to the increase in deepwater habitat, particularly in the Delta. Over time, deposition of sediments carried by the Sacramento and San Joaquin rivers would eventually raise bottom elevations in the Delta and allow reestablishment of tule and cattail marshes. This habitat would be more valuable to dabbling ducks, thereby increasing their numbers in the Delta. How many years would be required, however, to naturally create conditions for marsh reestablishment is unknown.

5.2 HABITAT ALTERATION

5.2.1 Asian Clam Invasion

A recently introduced invertebrate, the Asian clam (Potamocorbula amurensis), first discovered in Suisun Bay in 1986, is now found nearly everywhere in the Bay, regardless of salinity, water depth, and sediment type. It is most dense in Suisun Bay but is also found all over San Pablo Bay. A large population occurs south of the Dumbarton Bridge in the South Bay (J. Thompson, U.S. Geological Survey, pers. comm.). In San Pablo Bay, this abundant species has prevented reestablishment of the dry-period estuarine benthic community that was eliminated from the North Bay during the February 1986 flood (Nichols et al. in press). Because of the clam's ability to tolerate a wide range of salinity levels and other environmental variables, the introduction and wide-spread establishment of the clam may pose a threat to the existing benthic community. Accordingly, this small clam may "out-compete" other invertebrates (Carlton et al. in press) that currently serve as prey items in the diet of waterfowl and other waterbirds.

Potamocorbula quickly grows too large for most shorebirds to consume. The degree to which this species may affect shorebird food availability is uncertain, since sampling for the Asian clam in intertidal habitat has not been as extensive as subtidal sampling (Carlton et al. in press). However, during recent sampling following the 1988 Shell Oil Company refinery spill near Martinez, the clams were more commonly encountered on intertidal mudflats (J. Takekawa, U.S. Fish and Wildlife Service, pers. comm.). In addition, two years after the spill, Macoma balthica had not recolonized mudflats where Asian clams were already dominant.

Because the Asian clam is increasing in abundance and spreading into parts of the Estuary that formerly did not support great densities of benthic infauna (e.g., Suisun Bay), permanent reductions in the standing crop and species composition of phytoplankton are feared (Carlton et al. in press). Reductions in the standing crop of phytoplankton could adversely affect water column-feeding fish, and, in turn, could negatively affect fish-eating bird species, such as the western grebe, least tern, brown pelican, and double-crested cormorant.

Conversely, expansion of the clam population into some areas that have traditionally had low numbers of invertebrates may have a positive effect by providing an alternate food source for waterfowl. White et al. (1988) documented use of the Asian clam by scaup and surf scoters, but the nutritional benefit derived by waterfowl from the consumption of the clam is unknown at this time.

5.2.2 Tidal Salt Marsh Conversion

About 270 acres of tidal salt marsh dominated by pickleweed and cordgrass in South San Francisco Bay has been converted, over the last 20 years, to brackish marsh dominated by alkali bulrush (CH2M Hill 1989). A major factor causing this habitat conversion has been the release into the Bay of treated effluent from the San Jose sewage treatment plant. Current releases average 120 million gallons per day. In October 1990, the State Water Resources Control Board issued a ruling that imposes an effluent flow limit to prevent futher habitat conversion and requires the South Bay Dischargers Authority to provide 380 acres of salt marsh mitigation. However, San Francisco Bay National Wildlife Refuge staff maintain that more conversion of salt marsh into freshwater marsh is still likely to occur and should be considered in any future salt marsh restoration planning (J. Takekawa, U.S. Fish and Wildlife Service, pers. comm.).

5.2.3 Freshwater Diversions in the Delta

Projected future increases in California's human population and increased need for water for irrigated agriculture could encourage increased water diversions in the Delta. Reduced freshwater outflow in the Estuary would have a variety of habitat-altering impacts on wildlife, both positive and negative. Salt water intrusion further upstream in the Estuary would favor salt marsh-dependent wildlife as tidal salt marsh habitat expanded further upstream. Nesting populations of dabbling ducks, such as the mallard, and other freshwater marsh-dependent species would decline. Higher salinities would also increase benthic invertebrate diversity upstream in the estuary. This could increase the carrying capacity of San Pablo Bay tidal mudflats for shorebirds, resulting in an increase in shorebird populations in the Bay or a shift in shorebird use of Bay tideflats. Reduced freshwater outflows would also reduce the flushing of contaminants from the Estuary (See following section for more details on contaminant effects).

5.3 HABITAT DEGRADATION

5.3.1 Contaminants

Contaminants pose a potentially serious threat to wildlife of the Estuary, including resident species and those that winter in, and migrate through, San Francisco Bay. Projections of land use and population growth suggest that urban development in the Bay Area will continue for the foreseeable future. Future trends in contaminant loads will depend primarily on the implementation of improvements in the control of point sources of pollution as well as upon control of urban and nonurban runoff, but contaminant loading is likely to increase. As the human population of the Bay Area increases, so will industrial and domestic waste-water inflows. Even with larger and improved treatment facilities, the total volume of contaminants will rise. Population growth, especially around South San Francisco Bay, will lead to increased pollutant loading in the part of the Bay with the poorest circulation. Increased population in the Sacramento-San Joaquin Valley will increase the load of municipal waste-water pollutants, combined with pesticides, nutrients, and salts from agricultural return flows that will further burden the Bay. The manufacture, transportation, and use of pesticides, chlorinated organics, heavy metals, and fossil fuels will further degrade the Estuary. Spills and unchecked discharge of these substances can directly harm the biota or, through bioaccumulation, render them unfit for human consumption. A large oil spill from a refinery or tanker occurring during the height of the migratory waterfowl season could devastate certain bird populations.

Significant problems will continue for the foreseeable future, with contamination of biota with toxic trace metals and toxic trace organic compounds (e.g., PCBs and petroleum hydrocarbons), at least in localized instances and perhaps Bay-wide. Although the biological impacts of trace contaminants may be localized, the number of such impacts may be large, given the number of point sources discharging urban runoff and waste waters from municipal and industrial facilities. DDT and its metabolites continue to wash into the estuary from upstream agricultural areas, almost two decades since restrictions on their local use were introduced. The ubiquitous nature of PCBs in the estuary is of considerable concern, because they are widespread throughout the Estuary and show no signs of temporal reductions over the past decade. Evidence for their detrimental impacts is accumulating, and it appears that PCBs are exerting measurable damage to biological resources in the Estuary. Other chemicals that may be causing problems, but which are not routinely screened for (e.g., PAH metabolites, dibenzofurans, or dioxins) may be responsible for adverse effects on wildlife now or in the future.

5.3.2 Introduced Predators

Introduced predators in the South Bay, particularly the red fox, have in recent years rapidly expanded their ranges around San Francisco Bay. As a result, red foxes, as well as other predators including Norway and black rats, are severely limiting the nesting success of the endangered California clapper rail and other ground nesting species, such as the California least tern, Caspian tern, Forster's tern, and snowy plover. In 1991, red foxes also caused abandonment of Bair Island, a traditional major nesting area for herons, egrets, and terns in the South Bay. To address this problem, the U.S. Fish and Wildlife Service (1991) has begun implementation of an integrated predatory management program on the San Francisco Bay National Wildlife Refuge. Without an effective program, red foxes and other predators will continue to expand their distribution in the Estuary. Increasing, unchecked predation would contribute eventually to extinction of the California clapper rail and least tern and extirpation of nesting populations of other species, such as colonial waterbirds and seabirds, from the Estuary.

5.3.3 Introduced Plants

Two exotic species of cordgrass were introduced in the recent past to San Francisco Bay. These are smooth cordgrass (Spartina alterniflora) and Chilean cordgrass (Spartina densiflora). Smooth cordgrass, which was introduced to San Francisco Bay during a tidal marsh restoration project in Alameda County by the U.S. Army Corps of Engineers in the late 1970s, has now spread throughout the South Bay. This species which originates from the Atlantic and Gulf coasts, is invasive and will displace the native cordgrass (Spartina foliosa). Smooth cordgrass grows much taller than the native species and spreads to lower tidal elevations. The second exotic, Chilean cordgrass, was introduced to the Bay during the Creekside Park marsh restoration project (Marin County) and is spreading from its original site of introduction (Spicher and Josselyn 1985). This species is perennial, spreads vegetatively, and is thus expanding more slowly than smooth cordgrass. Chilean cordgrass displaces pickleweed at its lower marsh elevations.

The impacts on wildlife of the conversion of native cordgrass marshes in the Bay to marshes dominated by exotic cordgrass species are unknown. No studies are being undertaken to determine the ecological impact of these exotic species on San Francisco Bay, and no federal or state programs have been implemented to control or eradicate these species.

Presuming that the spread of these two exotic cordgrasses continues into the future, impacts to wildlife, both positive and negative are possible. The tendency of smooth cordgrass to spread to lower elevations than the native species could result in a significant reduction in mudflat habitat used by migratory shorebirds. The tendency of Chilean cordgrass to displace pickleweed at lower marsh elevations could also reduce the acreage of optimal habitat in tidal wetlands for the endangered salt marsh harvest mouse.

Conversely, both species of cordgrass might prove to be better high tide cover for California clapper rails and black rails. Both cordgrass species might also provide improved nesting habitat for the clapper rail. The more robust, taller-growing smooth cordgrass could contribute greater amounts of detritus to the Estuary, secondarily benefiting wildlife. Finally, both exotic species of cordgrass may prove to be more resistant to shoreline erosion, thereby slowing the rate of tidal salt marsh erosion around the Bay.

5.3.4 Human Intrusion

Josselyn et al. (1989) conducted a study of the impact of recreational use on wetlands. They found that dabbling ducks were the species group most sensitive to human disturbance. Although the distance from a disturbance varied by species and habitat, disturbance responses generally occurred at a distance between 75 and 175 feet. The most important observation made by Josselyn et al. (1989) was that as human activity increased in a wetland area, wildlife use decreased. Upland wildlife species are likely to respond to disturbance in a similar fashion. Even minimal human disturbance in nesting areas, particularly of raptors and colonial nesting waterbirds, can result in complete nest failure. Based on the work of Josselyn et al. (1989), we project that, as population growth continues in the Estuary study area in the future, conflicts between humans and wildlife will increase, the carrying capacity of habitat lying adjacent to development will be reduced by human disturbance, and wildlife populations occupying these areas will decline.

CHAPTER 6
ROLES OF GOVERNMENT AGENCIES IN MANAGING WILDLIFE

This chapter discusses the major agencies and organizations involved in managing wildlife of the San Francisco Estuary study area. This management is accomplished directly or indirectly through a variety of local, regional, state, and federal government agencies, as well as private organizations. Even though the U.S. Army Corps of Engineers, Environmental Protection Agency, and San Francisco Bay Conservation and Development Commission have regulatory permitting responsibilities which encompass wildlife habitats, they are not included in this chapter because their stated missions do not specifically refer to management of wildlife habitat or populations.

6.1 FEDERAL GOVERNMENT

At the federal government level, three agencies play major roles in wildlife management in the San Francisco Estuary. These are the Fish and Wildlife Service (Department of the Interior), the National Marine Fisheries Service (Department of Commerce, National Oceanic and Atmospheric Administration), and the Department of the Navy (Department of Defense). The National Marine Fisheries Service has management authority over all marine mammals and anadromous fishes found within the Estuary; the Fish and Wildlife Service is responsible for all other wildlife. The Department of the Navy manages wildlife populations within their military installations.

6.1.1 Fish and Wildlife Service

The Fish and Wildlife Service is the federal government's lead agency for conserving and managing the nation's fish and wildlife resources. The Fish and Wildlife Service operates under a line authority system of management. An organizational chart for the Fish and Wildlife Service nationwide is presented in Figure 6-1. Fish and Wildlife Service activities fall under six functional areas:

Fish and Wildlife Enhancement
Refuges and Wildlife
Research
Fisheries
Policy, Budget and Administration
External Affairs

The Estuary study area lies in Region One of the Fish and Wildlife Service. Service wildlife management activities in the Estuary fall primarily under the first three functional areas: Fish and Wildlife Enhancement, Refuges and Wildlife, and Research. The principal activities conducted within Fish and Wildlife Enhancement include:

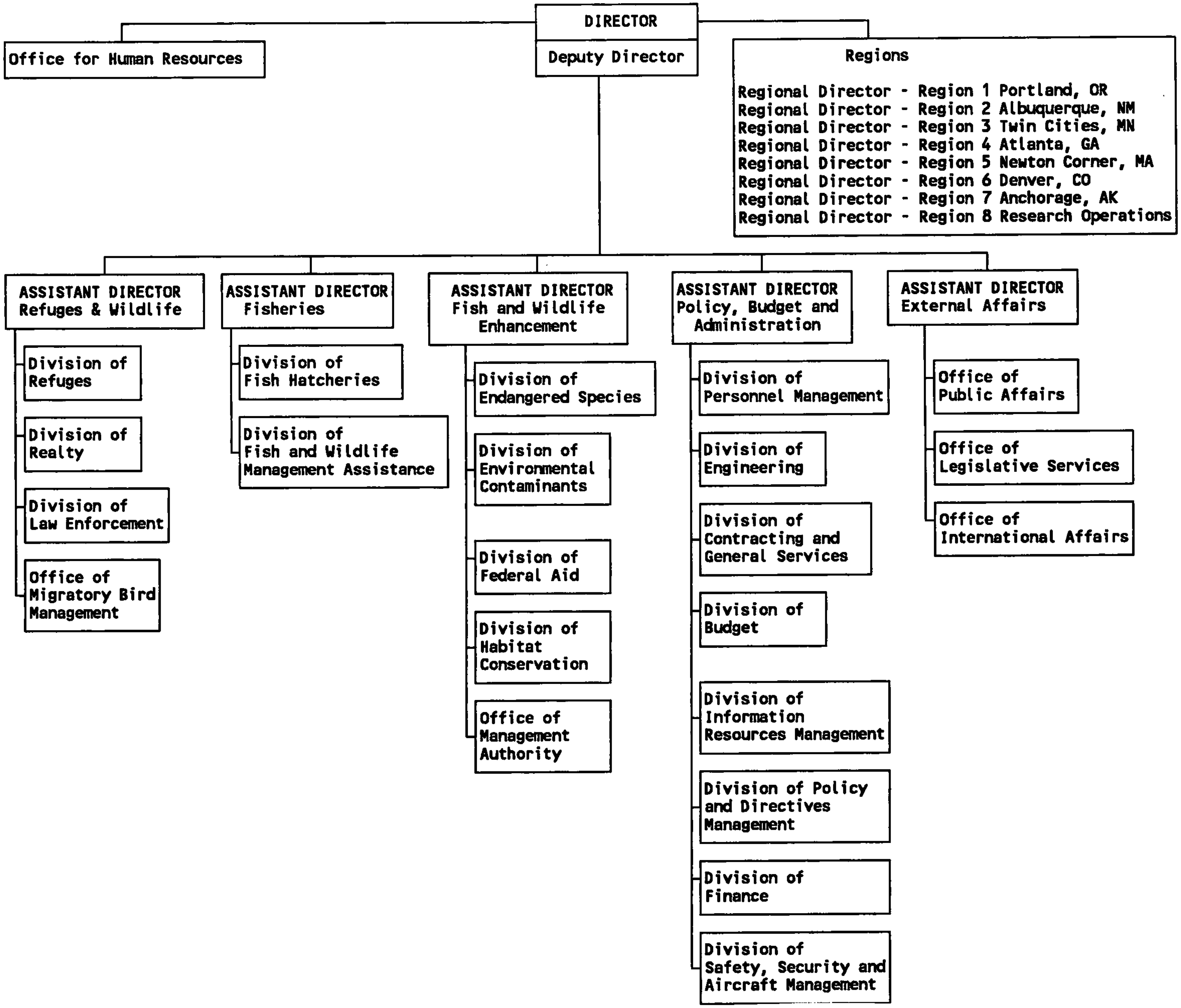

Figure 6-1. Organization Chart for the U.S. Fish and Wildlife Service.

- Reviewing and making recommendations on applications for federal permits and licenses issued by the Corps of Engineers and the Federal Regulatory Commission;
- Reviewing and making recommendations for mitigating adverse impacts of federal water resource development projects;
- Insuring compliance with the National Environmental Policy Act in preparation of environmental impact documents and review of other federal agencies' documents, as well as reviewing environmental impact documents for state and local projects;
- Monitoring pesticides and toxic chemicals to develop and provide information on the build-up of persistent chemicals and pollutants in fish and wildlife populations; providing emergency response action during major spills;
- Conducting the National Wetland Inventory, including preparation of wetland maps and issuance of periodic reports on wetlands status and trends;
- Identifying, listing, protecting, and managing all species of animals and plants that are threatened or endangered with extinction; and
- Coordinating the Federal Aid in Wildlife Restoration Act grant-in-aid program with the State for wildlife restoration, conservation, and management.

The principal activities conducted in Refuges and Wildlife are:

- Acquisition and management of National Wildlife Refuges;
- Enforcement of federal wildlife laws through its Division of Law Enforcement;
- Management of migratory birds, including setting of hunting regulations and conducting migratory bird surveys; and
- Provision of technical assistance on wildlife management to federal, state, and local agencies, and private industry.

The San Francisco National Wildlife Refuge Complex, including San Francisco Bay National Wildlife Refuge, San Pablo Bay National Wildlife Refuge, and Antioch Dunes National Wildlife Refuge, are the major landholdings of the Fish and Wildlife Service in the Estuary study area. The primary wildlife-related purposes of San Francisco Bay and San Pablo Bay National Wildlife Refuges are (1) preservation of a diversity of habitats for wildlife, (2) management of migratory bird populations, and (3) management of endangered species. San Pablo Bay National Wildlife Refuge places special emphasis on management of wintering canvasback populations. The primary purpose of Antioch Dunes National Wildlife Refuge is preservation of endangered plants and insects.

The principal areas of Research are:

- Migratory bird population status;
- Waterfowl ecology, habitat requirements, and habitat manipulation;
- Wildlife health;
- Endangered species; and
- Environmental contaminants.

Currently, research projects conducted in the Estuary study area are associated with two Fish and Wildlife Service research stations, the Pacific Coast Research Group of the Patuxent Wildlife Research Center and the Davis Field Station of the Northern Prairie Wildlife Research Center. Six studies of San Francisco Bay wildlife are currently underway: (1) abundance, distribution, and habitat use of waterfowl in the San Francisco Bay Ecosystem; (2) the contaminant exposure in canvasbacks wintering on San Francisco Bay; (3) the consequences of prey-switching by diving ducks: hierarchies of contaminants in prey from the Chesapeake and San Francisco bays, and relationship to abundance, growth, and caloric values; (4) the biological effects of contaminants in waterfowl wintering on San Francisco Bay; (5) the contaminant effects on small mammals at San Francisco Bay; and (6) the effects of contaminants on reproduction by black-crowned night-herons and snowy egrets in San Francisco Bay (R. Hothem, U.S. Fish and Wildlife Service, pers. comm.). A study on feeding ecology and distribution of shorebirds in the San Francisco Bay Ecosystem during winter will be initiated in fall of 1991 (J. Takekawa, U. S. Fish and Wildlife Service, pers. comm.).

6.1.2 National Marine Fisheries Service

In 1970, Congress created the National Oceanic and Atmospheric Administration within the Department of Commerce. The National Marine Fisheries Service, which was formerly the Bureau of Commercial Fisheries under the Fish and Wildlife Service, was established as one of Administration's divisions. The National Marine Fisheries Service has the primary federal responsibility for maintaining the health and productivity of the nation's marine fish, shellfish, and marine mammals.

The San Francisco Estuary lies within the Southwest Region, one of five regions of the National Marine Fisheries Service. An organizational chart for the Southwest Region of the National Marine Fisheries Service is shown in Figure 6-2. Within the Southwest Region, wildlife-related work is conducted within the following offices or branches:

Habitat Conservation Branch
Protected Resources Branch
Research
Enforcement

Principal activities conducted in the Habitat Conservation Branch include:

- Reviewing and making recommendations on applications for federal permits and licenses issued by the Corps of Engineers and the Federal Regulatory Commission;
- Reviewing and making recommendations for mitigating adverse impacts of federal water resource development projects;
- Insuring compliance with the National Environmental Policy Act in preparation of environmental impact documents and review of other federal agencies' documents, as well as reviewing environmental impact documents for state and local projects; and

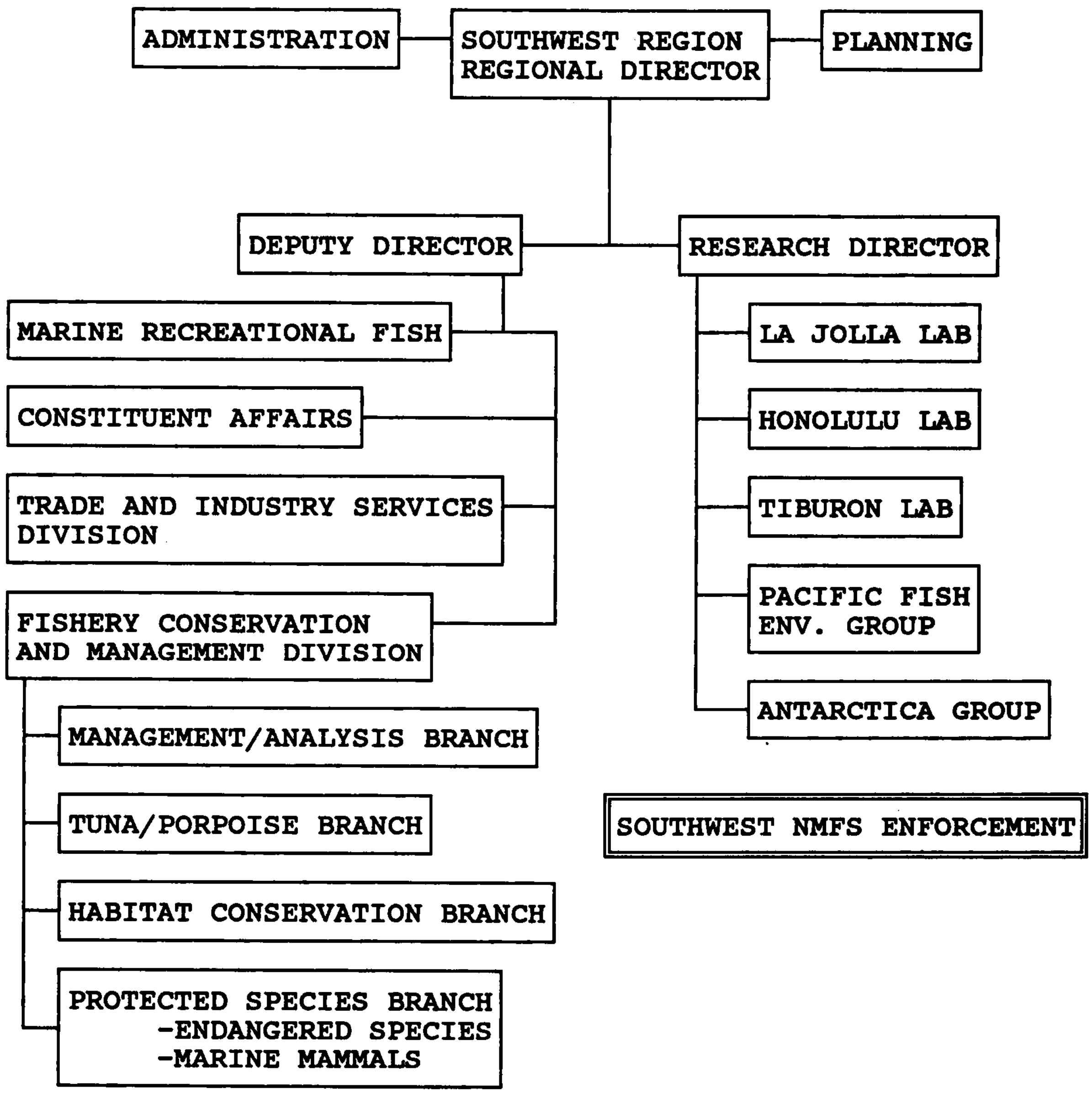

Figure 6-2. Organizational Chart for the National Marine Fisheries Service (Southwest Region).

- Reviewing and making recommendations to the State Regional Water Quality Control Boards on National Pollutant Discharge Elimination System permit applications.

Principle activities conducted in the Protected Species Branch include:

- Management of protected species;
- Conducting research on protected species abundance, distribution, migrations, and bioprofiles; and
- Identifying, listing, and recovering all marine species that are threatened or endangered with extinction.

The National Marine Fisheries Service conducts research primarily through the Southwest Fisheries Center, which maintains a research lab in Tiburon. However, no marine mammal research is currently being conducted within the Estuary by this group (D. DeMaster, National Marine Fisheries Service, pers. comm.).

The Enforcement office of the National Marine Fisheries Service operates independently of the Region, thereby reporting directly to the Enforcement office in Washington D.C. Where marine mammals are concerned, agents of the National Marine Fisheries Service are primarily involved in investigating reports of illegal take of these protected species and importation or interstate transportation of their parts or products, exemption permitting, and observing commercial vessel/marine mammal interactions.

6.1.3 Department of the Navy

The Department of the Navy maintains 11 installations within the Estuary study area extending from the Naval Communications Station at Stockton in the southern Delta to Moffett Field Naval Air Station in South San Francisco Bay. Many of these installations contain significant wildlife habitat. These installations are managed under the direction of the Commanding Naval Officer at each installation with professional technical assistance provided by the natural resources professional staff of the Western Division Naval Facilities Engineering Command. Some installations also have their own natural resources management professional staff.

Wildlife related-activities of the Navy within the Estuary include:

- Preparation of long-term natural resource plans for each installation;
- Development of overlay refuges in coordination with the Fish and Wildlife Service (Concord Naval Weapons Station and Mare Island Naval Shipyard);
- Endangered species inventories, research, and management (Concord Naval Weapons Station, Mare Island Naval Shipyard, Moffett Field Naval Air Station, Alameda Naval Air Station);
- Wetland restoration and enhancement (Mare Island Naval Shipyard, Stockton Naval Communications Station, Point Molate Naval Fuel Depot, Concord Naval Weapons Station);
- Wetland restoration planning (Skaggs Island Naval Reservation); and

- Wildlife resource inventories and wildlife management for all installations (D. Pomeroy, U.S. Navy, pers. comm.).

6.2 FEDERAL AUTHORITY

Congress has passed numerous laws which provide for federal involvement in the protection, conservation, and improvement of wildlife resources. Major wildlife-related authorities are discussed below.

6.2.1 Lacey Act

The Lacey Act of 1900, as amended, regulates the importation, exportation, and interstate transportation of wildlife. The Act provides additional authority for the National Marine Fisheries Service to pursue illegal trade in protected species.

6.2.2 Migratory Bird Treaty Act

In 1916, the United States and Great Britain signed a Convention for the Protection of Migratory Birds. In 1918, Congress passed the Migratory Bird Treaty Act providing statutory authority for implementing the convention in the United States. The Act makes it unlawful to pursue, hunt, take, capture, or kill any migratory bird, part, nest, or egg unless excepted by the regulations. The Act authorizes and directs the Secretary of the Interior to determine when, to what extent, and by what means hunting may be allowed, and to adopt suitable regulations permitting and governing hunting of migratory birds. The Act also provides that states may make and enforce laws or regulations more restrictive than those adopted by the federal government when deemed necessary and advisable for migratory bird conservation.

Migratory bird treaties were later signed with Mexico (1936), Japan (1972), and the Soviet Union (1976), and implemented in the United States by technical amendments to the 1918 Act.

6.2.3 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act of 1934 provides that wildlife conservation receive equal consideration and be coordinated with other features of water resource developments. Any federal agency permitting, licensing, or constructing a project involving the impoundment, diversion, or deepening of the waters of any stream or other water body must first consult with the Department of the Interior, Fish and Wildlife Service, and the Department of Commerce, National Marine Fisheries Service, as well as the State wildlife resource agency to prevent losses or damages to fish and wildlife resources as well as provide for the development and improvement of these resources in connection with the development. Recommendations of the Secretary of the Interior must include impacts of the project on wildlife, measures to mitigate or compensate these impacts, and a description of project features recommended for wildlife conservation and development.

6.2.4 Pittman-Robertson Act

The Pittman-Robertson Act, otherwise known as the Federal Aid in Wildlife Restoration Act, was passed in 1937. The Act established grant-in-aid programs to assist states in wildlife restoration work. Funds from an excise tax on sporting arms and ammunition are provided to states on a matching basis for land acquisition, research, development, and management projects.

6.2.5 Fish and Wildlife Act

Through the Fish and Wildlife Act of 1956, Congress established a national fish and wildlife policy by recognizing the value of the Nation's fish, shellfish, and wildlife resources and the need for proper management. The Act established a Fish and Wildlife Service, consisting of two separate agencies: the Bureau of Commercial Fisheries, with responsibility for commercial fisheries, whales, seals, and sea lions, and the Bureau of Sport Fisheries and Wildlife with responsibility for migratory birds, game management, wildlife refuges, sports fisheries, and certain marine mammals. Regarding wildlife resources, Section 7 of the Act authorized the Secretary of the Interior to "Take such steps as may be required for the development, management, advancement, conservation, and protection of wildlife resources through research, acquisition of refuge lands, development of existing facilities, and other means."

6.2.6 Sikes Act

The Sikes Act of 1960 (Conservation Programs on Military Reservations) authorizes the Department of Defense to prepare fish and wildlife management plans on military reservations in cooperation with the Secretary of the Interior and the appropriate State agency. These Natural Resource Management Plans prepared by the Department of Defense include provisions to improve the quality of land and water resources, protect wetlands and floodplains, conserve fish and wildlife and protected species, and abate nonpoint sources of pollution.

6.2.7 National Environmental Policy Act

The National Environmental Policy Act of 1969, as amended, established a national policy for the environment. The Congress, recognizing the significant impact of human activities on the natural environment, declared that all federal agencies must use all practicable means to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions on the human environment. For all major federal actions significantly affecting the quality of the human environment, the law requires preparation of a detailed Environmental Impact Statement. The document must describe: (1) the impact of the proposed action; (2) adverse effects which cannot be avoided; (3) alternatives to the proposed action; (4) the relationship between local short-term uses of the human environment and the maintenance and enhancement of long-term productivity; and

(5) irreversible and irretrievable commitments of resources which could be involved in the proposed action.

The National Environmental Policy Act requires that the federal agency responsible for developing the Environmental Impact Statement consult with and obtain comments from any other federal agency that has jurisdiction by law or special expertise regarding impacts involved.

6.2.8 Marine Mammal Protection Act

The most comprehensive authority for conservation of marine mammals is the Marine Mammal Protection Act of 1972. This Act placed a moratorium on taking or importing marine mammals or their products into the United States. Responsibility for the protection of marine mammals is divided between the Fish and Wildlife Service and the National Marine Fisheries Service. The Fish and Wildlife Service is responsible for dugongs, manatees, polar bears, sea otters, and walruses. The National Marine Fisheries Service is responsible for whales, dolphins, and all seals and sea lions.

The Act called for creation of the Marine Mammal Commission, an independent body charged with overseeing implementation of the Act by the federal agencies and reviewing permits for the taking of marine mammals.

6.2.9 Endangered Species Act

The Endangered Species Act of 1973 recognized that many species of fish, wildlife, and plants are in danger of or threatened with extinction and established a national policy that all federal agencies should work toward conservation of these species. The Secretary of the Interior and the Secretary of Commerce are designated in the Act as responsible for identifying endangered and threatened species and their critical habitats, carrying out programs for the conservation of these species, and rendering opinions regarding the impact of proposed developments on endangered species. The Act also outlines what constitutes unlawful taking, importation, sale, and possession of endangered species and specifies civil and criminal penalties for unlawful activities.

In general, the National Marine Fisheries Service is responsible for marine and anadromous species and the Fish and Wildlife Service is responsible for all terrestrial and freshwater species. Exceptions are the sea otter and walrus which are under Fish and Wildlife Service authority.

Section 6 of the Endangered Species Act authorizes the federal government to provide financial assistance to aid in the implementation of state endangered species programs.

6.2.10 Clean Water Act

The Clean Water Act of 1977, which substantially amended the Federal Water Pollution Control Act Amendments of 1972, established a national policy to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The Environmental Protection Agency is the primary administrator of the Act. Section 102 of the Act calls for the administrator, in cooperation with other federal, state, and local agencies, to prepare comprehensive programs for preventing, reducing, and eliminating pollution of navigable waters, including provisions for the protection and propagation of fish and wildlife. Section 404 of the Act directs the Secretary of the Army to review and issue permits where appropriate for the discharge of dredged or fill material into navigable waters and wetlands. The Environmental Protection Agency, Fish and Wildlife Service, and National Marine Fisheries Service provide recommendations to the Army Corps of Engineers regarding the impact of proposed developments on wildlife resources.

6.2.11 Comprehensive Environmental Response Compensation and Liability Act

The Comprehensive Environmental Response Compensation and Liability Act of 1980, as amended, provides that the federal government and state governments, as trustees for natural resources, may bring claims against responsible parties for any damages to trust resources caused by the release of hazardous substances. Compensation obtained is used to restore the impacted resources.

6.2.12 Habitat Acquisition Laws

In 1929, Congress passed the Migratory Bird Conservation Act which authorized Federal acquisition of land by purchase or donation and protection of land through rental agreements to preserve both waterfowl and other migratory birds. Few appropriations were made for purchasing bird refuges until 1934 when the Migratory Bird Hunting Stamp Act, also known as the Duck Stamp Act, was passed. The Act required that all migratory waterfowl hunters aged 16 or older purchase a migratory bird hunting stamp, the proceeds of which would go toward purchase of refuge land.

In 1948, the Lea Act was passed by Congress authorizing the acquisition and development of management areas in California for waterfowl and other wildlife.

In 1961, in response to accelerated wetland draining in the United States, Congress passed the Wetlands Loan Act. This Act provided for the direct appropriation of up to $105 million for purchase of refuges and for purchase and easement of waterfowl production areas. The Loan Act was set to expire in 1986, at which time repayment of the loan out of duck stamp revenues would begin.

In 1965, the Land and Water Conservation Fund Act was passed and provided another important source of funds for wetland acquisition. The fund is comprised of proceeds from disposal of surplus federal properties, certain user fees, and receipts from outer continental shelf oil leasing. Money from the Fund is available for expenditure only to the extent that it is appropriated by Congress.

To continue the Wetlands Loan Act of 1961, the Emergency Wetlands Resources Act was passed by Congress in 1986. In addition to extending the repayment of the loan to 1988, the Emergency Wetlands Resources Act also directed the Secretary of the Interior to prepare a National Wetlands Priority Conservation Plan to prioritize wetland acquisitions.

The North American Wetlands Conservation Act of 1989 provides the enabling legislation to fund acquisitions of waterfowl habitat under the North American Waterfowl Management Plan. In this Plan, the San Francisco Bay area and the Central Valley (which includes the Delta) are 2 of 34 Waterfowl Habitat Areas of Major Concern in the United States and Canada. Concept plans developed by the Fish and Wildlife Service for San Francisco Bay and the Central Valley identify important wetlands to be protected, enhanced, and expanded.

6.2.13 Food Security Act of 1985

The Food Security Act was passed by Congress in 1985 to improve conservation features in the United States agricultural policy. The Act includes several conservation provisions of potential benefit to wildlife:

1. Sodbuster provisions - agricultural producers will become ineligible for certain federal assistance if they bring highly erodible land into cultivation unless they do so under a conservation system approved by the soil and water conservation district or the Secretary of Agriculture.
2. Swampbuster provisions - agricultural producers will become ineligible for certain federal assistance if they alter substantially or drain wetlands to produce agricultural commodities. The Secretary of Agriculture shall consult with the Secretary of the Interior to issue regulations to carry out wetland conservation actions.
3. Conservation easement provisions - the Secretary of Agriculture may acquire and retain easements in wetland, upland, or highly erodible land for the conservation, recreation, and wildlife purposes for periods of at least 50 years to cancel part of the debt where a farmer's land is security for a Farmer's Home Administration loan. The Secretary shall consult with the Director of the Fish and Wildlife Service in developing and implementing the easement program.
4. Conservation reserve provisions - allows for 40-45 million acres of highly erodible cropland to be placed in a conservation reserve program. The Secretary of Agriculture shall consult with the Fish and Wildlife Service regarding appropriate enhancement measures for wildlife.

6.3 STATE GOVERNMENT

The primary state agencies, commissions, and boards having management authority over wildlife in the Estuary study area are the Fish and Game Commission, the Department of Fish and Game, the Wildlife Conservation Board, and the Department of Parks and Recreation. The following section describes each entity's role in managing wildlife in the Estuary.

6.3.1 Fish and Game Commission

As directed by the Legislature, the Fish and Game Commission oversees the Department of Fish and Game, assuring that the Department adheres to their policies and objectives regarding fish and wildlife management. Based on recommendations from the Department of Fish and Game, the Commission adopts regulations governing the take and possession of birds, fish, mammals, reptiles, and amphibians within the State. The Department of Fish and Game acts as staff to the Commission by generating biological data on species and making recommendations regarding, for example, listing of endangered species, establishing hunting seasons, bag and possession limits, and special hunts. Regulations adopted by the Commission are enforced by the Department of Fish and Game.

6.3.2 Department of Fish and Game

The Department of Fish and Game is the primary wildlife management agency of the State of California. The general objective of the Department is to insure that fish and wildlife are preserved to be used and enjoyed by the people in the State, now and in the future. Specific objectives include: (1) to maintain all species of fish and wildlife for their natural and ecological values as well as for their direct benefits to the public; (2) to provide for varied recreational use of fish and wildlife; (3) to provide for an economic contribution of fish and wildlife in the best interests of the people of the State; and (4) to provide for scientific and educational use of fish and wildlife. To meet these objectives, the Department of Fish and Game is divided into nine programs:

Enforcement of Laws and Regulations
Licensing
Wildlife Management
Natural Heritage
Inland Fisheries
Anadromous Fisheries
Marine Resources
Environmental Services
Administration

Of these programs, Enforcement, Wildlife Management, Natural Heritage, and the Environmental Services programs deal with wildlife management issues.

Principal activities conducted in the Enforcement program include:

- Protection of game and nongame habitat from willful neglect and destruction;
- Monitoring of public hunting practices;
- Issuing licenses to consumptive users;

- Conducting a hunter safety program; and
- Regulating the importation, transportation, and possession of exotic animals.

Principal activities conducted in the Wildlife Management program include:

- Collection of management data for big game, upland game, waterfowl, and nongame wildlife;
- Disease research;
- Wetlands enhancement; and
- Habitat development and management on 76 designated State-owned Wildlife Areas, Ecological Reserves, and other public lands.

Within the Estuary study area, the Department owns or leases over 35,000 acres of land managed for a wide variety of wildlife and fisheries, both game and nongame species. Table 6-1 contains a partial list of properties managed by the Department.

Table 6-1. A Partial List of Properties Managed by the California Department of Fish and Game within the Estuary Study Area.

Property Name	County
Point Edith	Contra Costa
Corte Madera Ecological Reserve	Marin
Rush Creek	Marin
Day Island	Marin
Petaluma Marsh Wildlife Area	Marin, Sonoma
San Pablo Bay State Wildlife Area	Marin, Sonoma
Tolay Creek Wildlife Area	Sonoma
Coon Island Ecological Reserve	Napa
Fagan Marsh	Napa
Huichica Creek Wildlife Area	Napa, Sonoma
Napa Marsh Wildlife Area	Napa, Solano, Sonoma
Lower Sherman Island	Sacramento
Bair Island	San Mateo
Redwood Shores Ecological Reserve	San Mateo
Grizzly Island Wildlife Area	Solano
Hill Slough Wildlife Area	Solano
Joice Island Wildlife Area	Solano
Peytonia Slough Ecological Reserve	Solano
Sandpiper Point/White Slough	Solano
Crescent Unit	Solano
American Canyon/Mini	Solano

Principal activities conducted in the Natural Heritage program include:

- Maintenance of a statewide inventory of the occurrence of rare and threatened native nongame species and natural communities;
- Identification and protection of endangered and threatened species and significant natural areas;

- Acquisition and management of land; and
- Interpretation of natural diversity for the citizens of the State.

Principal activities conducted in the Environmental Services program include:

- Reviewing and making recommendations on applications for federal permits and licenses issued by the Corps of Engineers and the Federal Regulatory Commission;
- Reviewing and making recommendations for mitigating adverse impacts of state and federal water resource development projects;
- Development of recreational facilities and access;
- Insuring compliance with the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA) in preparation of environmental impact documents and review of other local, state, and federal agencies' documents;
- Reviewing and making recommendations on applications for water rights permits issued by the State Water Resources Control Board; and
- Reviewing and making recommendations on applications for permits issued by the San Francisco Bay Conservation and Development Commission.

6.3.3 Wildlife Conservation Board

The Wildlife Conservation Board is the acquisition arm of the Department of Fish and Game. The Board is composed of the Director of the Department of Fish and Game, the President of the Fish and Game Commission, and the Director of Finance. The Board is advised by a joint interim investigating committee consisting of three members of the Senate and three members of the Assembly. Annually, $750,000 is transferred to the Wildlife Restoration Fund from license fees collected for conducting horseraces. Funding is also provided from the California Environmental License Plate Fund for acquisition and preservation of valuable wildlife habitats (Ecological Reserves). Bond acts providing additional funds include the Fish and Wildlife Habitat Enhancement Act of 1984, the California Park and Recreational Facilities Act of 1984, and the California Wildlife, Coastal, and Park Land Conservation Act of 1988.

Principal activities conducted by the Wildlife Conservation Board include:

- Investigations to determine areas most essential and suitable for wildlife production and preservation and recreation; and
- Acquisition of wildlife habitat.

6.3.4 Department of Parks and Recreation

The Department of Parks and Recreation operates a number of State parks within the Estuary study area. Wildlife and natural community management in State parks are among the objectives of the Department. The Natural Heritage

Section of the Resource Protection Division manages animal and plant communities within the State parks.

Principal activities of the Natural Heritage Section include:

- Conducting resource inventories in State parks;
- Preparing resource management portions of the general plan for each State park;
- Carrying out resource mitigation plans after construction of recreational facilities, such as campgrounds; and
- Administering the Department's resource management funding program.

Three State Parks within the Estuary study area that contain significant wildlife habitat are China Camp State Park, Benicia State Park, and Angel Island State Park. Mount Diablo State Park lies adjacent to the boundary of the study area. In general, resource management projects of the Department primarily involve restoration of native plant communities and control of exotic plants (D. Schaub, State Department of Parks and Recreation, pers. comm.). More specifically within the Estuary study area, the Department is involved in a major tidal marsh restoration effort at Benicia State Park and actively manages the deer herd on Angel Island State Park. Most wildlife management issues are coordinated with the Department of Fish and Game.

6.4 STATE AUTHORITY

Numerous laws and regulations provide for state involvement in the protection, conservation, and improvement of wildlife resources in California. Major wildlife-related authorities are discussed below.

6.4.1 California Constitution

Article IV, Section 20 of the California Constitution establishes the Fish and Game Commission as a five member body appointed by the Governor and approved by the Senate. The Legislature delegates powers to the Commission for the protection and propagation of fish and game.

Article XIII, Section 22 of the California Constitution establishes the Fish and Game Preservation Fund to receive exclusively all money collected relating to the protection, conservation, propagation, or preservation of fish and game, and fines for violation of fish and game laws.

6.4.2 California Fish and Game Code

The Fish and Game Code is the primary authority under which the Department of Fish and Game and the Fish and Game Commission operate. The Code is amended periodically by the State Legislature. Pertinent Code sections are discussed below.

Division 1 (Sections 101-460) describes the Fish and Game Commission, its organization, and its powers.

Several code sections authorize establishment of habitat areas for fish and wildlife, including Wildlife Management Areas (Section 1525), Ecological Reserves (Section 1580), Significant Natural Areas (Sections 1930-1933), and waterfowl habitat leases under the California Waterfowl Habitat Program (Sections 3460-3467).

Code Sections 3450-3453 authorize the Department of Fish and Game to coordinate and cooperate with the United States Department of Defense for the purpose of developing fish and wildlife management plans and programs on military installations.

Code Sections 1601 and 1603 require that any individual or agency proposing to divert, obstruct, or change the natural flow of a stream or lake containing fish and wildlife must submit their plans to the Department of Fish and Game for review. The Department must provide the applicant with a description of resources affected and reasonable modifications to the project that would protect fish and wildlife.

Code Sections 5651-5656 deal with the subject of pollution of waters of the State. Under Section 5651, the Department of Fish and Game must report continuing or chronic pollution conditions to the appropriate Regional Water Quality Control Board.

Division 9 of the Fish and Game Code (Sections 12000-12300) establishes fines and penalties for violation of the Code, or of any rule, regulation, or order made or adopted under the Code.

Division 10 of the Fish and Game Code describes the Fish and Game Preservation Fund and appropriation of money from this account. Money collected for violations is divided equally between the Fund and the county (fish and game propagation fund) in which the violation occurred.

6.4.3 California Public Resources Code

Section 5003.1 of the California Public Resources Code permits hunting in certain state recreation areas provided the State Park Commissioner finds that this use does not threaten the safety and welfare of other recreational area users. The Department of Fish and Game enforces hunting laws and regulations within state parks and state recreation areas.

Section 5019.53 of the Public Resources Code includes, among the purposes of State parks, the preservation of "outstanding natural, scenic, and cultural values, indigenous aquatic and terrestrial fauna and flora ...." Recreational and educational improvements within State parks must be constructed "in a manner consistent with the preservation of natural, scenic, cultural and ecological values...."

6.4.4 California Water Code

Section 233 of the State Water Code requires that the Department of Water Resources seek the comments and recommendations of the Department of Fish and Game on proposed water projects and incorporate into the project any justifiable and feasible fish and wildlife preservation and enhancement measures.

Section 1243 requires the State Water Resources Control Board to notify the Department of Fish and Game of any application for a permit to appropriate water. The Department of Fish and Game recommends the amounts of water, if any, required for the preservation of fish and wildlife resources.

Section 1257 requires the State Water Resources Control Board to consider all beneficial uses of water, including preservation and enhancement of fish and wildlife, when acting upon applications to appropriate water.

6.4.5 Wildlife Conservation Law of 1947

This law established a State policy to preserve, protect, and restore wildlife of the State. To accomplish this goal, a policy was also established to "acquire and restore to the highest possible level, and maintain in a state of high productivity, those areas that can be most successfully used to sustain wildlife and which will provide adequate and suitable recreation." To carry out these purposes, the Wildlife Conservation Board was established within the Department of Fish and Game.

6.4.6 California Environmental Quality Act

The California Environmental Quality Act of 1970 (Public Resources Code Sections 21000-21174) establishes a State policy to develop and maintain a high-quality environment, including protection of fish and wildlife species. The Act requires that all State agencies prepare an Environmental Impact Report for any project which may have a significant effect on the environment.

6.4.7 California Endangered Species Act

The California Endangered Species Act of 1970 (Fish and Game Code Sections 2050-2098) established a State policy to conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat. The Fish and Game Commission is charged with establishing a list of endangered and threatened species. State agencies must consult with the Department of Fish and Game to determine if a proposed project is likely to jeopardize the continued existence of any endangered or threatened species.

6.4.8 Native Species Conservation and Enhancement Act

Through the Native Species Conservation and Enhancement Act of 1974 (Fish and Game Code Sections 1750-1772), the State Legislature recognized the intrinsic and ecological values of all wildlife of the State and that their conservation and enhancement was in the general public interest. As a result, a Native Species Conservation and Enhancement Account was created within the Fish and Game Preservation Fund to support nongame and native plant conservation and enhancement programs.

6.4.9 Suisun Marsh Preservation Act

The State Legislature clearly recognized the importance of Suisun Marsh to wildlife in their passage of the Suisun Marsh Preservation Act of 1974. The Act directed the San Francisco Bay Conservation and Development Commission and the Department of Fish and Game to prepare and implement the Suisun Marsh Protection Plan (San Francisco Bay Conservation and Development Commission 1976). The Fish and Wildlife Element of the Suisun Marsh Protection Plan (Jones and Stokes Associates, Inc. and EDAW, Inc. 1975), among other things, recommends a number of measures to protect wildlife habitat and wildlife viability, and to reduce marsh management problems. The Bay Conservation and Development Commission regulates all land and water uses in the "Primary Management Area" as mapped in the Plan, and local governments primarily regulate land uses within the "Secondary Management Area".

6.4.10 Keene-Nejedly California Wetlands Preservation Act

The Keene-Nejedly California Wetlands Preservation Act of 1976 established a public policy and program directed at wetland preservation, restoration, and enhancement. The Act authorizes a joint study by the Department of Parks and Recreation, the Department of Fish and Game, the State Lands Commission, and local agencies to prepare a wetlands priority plan, with special attention given to acquisition of lands adjacent to existing State parks.

6.4.11 Fish and Wildlife Habitat Enhancement Act

The Fish and Wildlife Habitat Enhancement Act of 1984 (Fish and Game Code Sections 2600-2651) provided financial means to correct the most severe deficiencies in fish and wildlife habitat in California. Of the funds appropriated for acquisition, enhancement, and development of wildlife habitat areas, $5,000,000 was specifically earmarked for acquisition of wetlands and adjacent uplands in the San Francisco Bay region.

6.4.12 California Wildlife, Coastal, and Park Land Conservation Act

The California Wildlife, Coastal, and Park Land Conservation Act of 1988 (Proposition 70) provided $81,300,000 for acquisition of wildlife habitat and natural areas in California. For San Francisco Bay, $13,000,000 is earmarked for wetland acquisition with $8,000,000 of this amount to be spent south of the San Mateo Bridge. Additional amounts are set aside for wetland acquisition in Sonoma County, including San Pablo Bay ($4,000,000) and Napa Marsh ($2,000,000). A total of $4,000,000 is also set aside for acquisition of riparian habitat along the Sacramento River between Collinsville and Shasta Dam.

6.5 REGIONAL GOVERNMENT

Several regional agencies own land within the Estuary study area which supports significant wildlife populations. These regional entities include the East Bay Regional Park District, Mid Peninsula Regional Open Space District, and the Marin County Open Space District. The East Bay Regional Park District has the largest land holdings of these agencies.

6.5.1 East Bay Regional Park District

The primary regional agency involved with wildlife management in the Estuary study area is the East Bay Regional Park District. The District is a limited-purpose governmental agency that operates in Alameda and Contra Costa Counties. An elected board of directors governs the District. The District owns over 53,000 acres of land within the Estuary study area, much of which provides valuable wildlife habitat. Park lands containing significant wildlife habitat are listed in Table 6-2. Wildlife management activities of the District are carried out by the District's wildlife specialist. Wildlife management issues and decisions are coordinated with the Department of Fish and Game. Wildlife management projects underway in the District include (1) monitoring of salt marsh harvest mouse populations at the Hayward Shoreline and Coyote Hills Regional Park, (2) inventorying wildlife resource, (3) surveying raptor populations, and (4) rehabilitating springs (former cattle watering holes).

6.6. REGIONAL AUTHORITY

6.6.1 California Public Resources Code

Sections 5500-5595 of the Public Resources Code establishes the concept of regional park and open space districts, their organization, and formation. Under the Code, the Districts are given the power "... to acquire land, to plan, develop and operate a system of public parks,... natural areas, ecological and open space preserves...."

6.6.2 East Bay Regional Park District Master Plan

East Bay Regional Park District's Master Plan (1988a) states that the purpose of the District is to "... acquire, preserve, protect, develop, and operate regional parklands... in perpetuity for public use." Among the objectives of the District are (1) to acquire and preserve significant systems of the natural environment including biologic resources on District lands and

Table 6-2. East Bay Regional Park District Lands Containing Significant Wildlife Habitat within the Estuary Study Area. Source: East Bay Regional Park District (1988a,b).

Property	County
Antioch Regional Shoreline	Contra Costa
Ardenwood Regional Preserve	Alameda
Bishop Ranch Regional Open Space	Contra Costa
Briones Regional Park	Contra Costa
Brooks Island Regional Shoreline	Contra Costa
Browns Island Regional Shoreline	Contra Costa
Carquinez Strait Shoreline Park	Contra Costa
Chabot Regional Park	Alameda
Claremont Canyon Regional Preserve	Alameda
Coyote Hills Regional Park	Alameda
Cull Canyon Regional Recreation Area	Alameda
Del Valle Regional Park	Alameda
Diablo Foothills Regional Park	Contra Costa
Garin/Dry Creek/Pioneer Regional Park	Alameda
Hayward Regional Shoreline	Alameda
Huckleberry Botanic Regional Preserve/ Sibley Volcanic Regional Preserve	Alameda/Contra Costa
Las Trampas Regional Wilderness	Contra Costa
Leona Regional Open Space	Alameda
Martinez Regional Shoreline	Contra Costa
Miller/Knox Regional Shoreline	Contra Costa
Mission Peak Regional Preserve	Alameda
Ohlone Regional Wilderness	Alameda
Oyster Bay Regional Shoreline	Alameda
Pleasanton Ridge	Alameda
Point Isabel Regional Shoreline	Contra Costa
Point Pinole Regional Shoreline	Contra Costa
Redwood Regional Park	Alameda/Contra Costa
San Leandro Bay Regional Shoreline	Alameda
San Pablo Bay Regional Shoreline	Contra Costa
Sobrante Ridge Preserve	Contra Costa
Sunol Regional Wilderness	Alameda
Tassajara Creek Regional Park	Alameda
Tilden Regional Park	Alameda/Contra Costa
Wildcat Canyon Regional Park/ Kennedy Grove	Contra Costa

(2) to preserve and manage parklands so that they retain their natural values. Resource policies regarding vegetation management, habitat restoration, wildlife management, and endangered species reflect the District's objective to properly manage natural biotic communities.

6.7 LOCAL AND PRIVATE AGENCIES AND ORGANIZATIONS

Several counties, recreation districts, cities, and private organizations own land within the Estuary study area that is preserved for wildlife. Some of these are listed below. Wildlife management activities on these properties, however, are generally minimal. Any such activities would be subject to all state and federal laws and regulations previously discussed.

Marin County
Sacramento County
City and County of San Francisco
City of Oakland
City of Palo Alto
City of San Jose
City of Sunnyvale
City of Corte Madera
City of San Rafael
City of Mountain View
Peninsula Open Space Trust
Committee for Green Foothills
The Nature Conservancy
The National Audubon Society
Marin Conservation League
Sonoma Land Trust
Ducks Unlimited
Las Gallinas Sanitary District
Novato Sanitation District
Hayward Area Recreation District

6.8 PLANS FOR WILDLIFE HABITAT PRESERVATION AND ENHANCEMENT

In recent years a number of plans have been forwarded by federal, state, and private organizations specifically designed to protect, restore, and enhance habitat for diminishing wildlife populations in California. In 1979, Senate Concurrent Resolution 28 was passed. This resolution directed the Department of Fish and Game to prepare a plan to reverse the trend of conversion of important waterfowl wetlands to other land uses, improve the value of existing wetlands for wintering waterfowl, and increase the acreage of wetlands in the state by 50 percent by the year 2000. In 1983, the California Department of Fish and Game (1983) prepared a plan to implement these goals. Several funding sources provided by the legislature and by voters since passage of SCR 28 have aided the habitat acquisition portion of this plan (See sections 6.4.11 and 6.4.12 above).

At about the same time, the U.S. Fish and Wildlife Service and the California Department of Fish and Game prepared a Delta Wildlife Habitat Protection and Restoration Plan (Madrone Associates et al. 1980) in an attempt to seek more effective ways to protect, enhance, and restore wildlife resources of the Delta. The following recommendations were made in this report:

1. The State should enact legislation to require local governments of the Delta to develop, adopt, and implement "Local Delta Programs;"

2. The State should establish an "Office of Delta Coordination" within the Resources Agency;
3. Local governments should adopt the significant resource areas identified in the Plan as part of open space/conservation elements of their general plans and protect such areas with appropriate zoning;
4. The existing classification of State lands in the Delta should be reevaluated for possible upward reclassification to better protect areas possessing significant environmental values;
5. The State Lands Commission should seek Funds and legislative directives to substantiate State ownership of lands in the Delta;
6. The Department of Water Resources and Corps of Engineers should revise levee design criteria and maintenance manuals in accordance with guidelines for levee vegetation management contained in the Plan;
7. The Corps of Engineers should obtain "administrative law" procedures to expeditiously prosecute violations of its permit authority; and
8. The State should determine the feasibility of publicly acquiring a Delta island for marsh and/or riparian restoration purposes.

In 1986, the North American Waterfowl Management Plan was signed by the Secretary of the Interior for the United States and the Minister of the Environment for Canada (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986). The plan was amended in 1988 to include Mexico. The goal of this plan is to protect and improve existing wetlands as well as to create new wetlands to restore duck, goose, and swan populations to viable levels. In response to this plan, a concept plan for waterfowl wintering habitat preservation was developed by the Fish and Wildlife Service for San Francisco Bay (Houghten et al. 1989), and a previous plan prepared for the Central Valley (U.S. Fish and Wildlife Service 1978a) was updated (U.S. Fish and Wildlife Service 1987b). The principal objectives of both concept plans are to (1) identify important waterfowl habitats; (2) document other fish and wildlife species that utilize wetlands and associated habitats; (3) lay out a framework plan for the preservation, restoration, and enhancement of important wetland habitats which are critical to the perpetuation of the waterfowl resource of the Pacific Flyway; and (4) establish goals and strategies to achieve the above objectives.

The Concept Plan for San Francisco Bay identifies 51,291 acres of important wetlands in the North Bay and 22,398 acres in the South Bay to be protected, enhanced, and expanded. In South San Francisco Bay, congressional legislation was passed in October 1988 to expand San Francisco Bay National Wildlife Refuge. This effort provides for a 20,000-acre expansion of the Refuge boundary. About 3.5 million dollars have been appropriated for land acquisition, with an additional 4.0 million dollars earmarked in the fiscal year 1990 budget. The Fish and Wildlife Service is actively pursuing acquisition of several wetland properties around San Francisco Bay for addition to the Refuge.

The Concept Plan for the Central Valley identifies fee and easement acquisition of 6,000 acres of existing wetlands in the Stone Lakes/Consumnes/Mokelumne Rivers region of the Delta and 2,000 acres of easement acquisition in the Yolo Bypass, a portion of which lies in the Estuary study area. These 8,000 acres represent 10 percent of the 80,000 acres of existing wetlands identified in the Plan for acquisition in the Central Valley. The Service is currently pursuing establishment of a National Wildlife Refuge in the Stone Lake Basin (northeastern Delta) involving acquisition and easements of up to 30,000 acres of existing wetlands and uplands. Appropriation of money from the Land and Water Conservation Fund is being pursued through Congress.

The North American Waterfowl Management Plan called for the establishment of joint ventures between government agencies and private organizations to pool resources to solve waterfowl habitat problems. The California Central Valley Habitat Joint Venture, guided by an Implementation Board comprised of representatives from the California Waterfowl Association, Defenders of Wildlife, Ducks Unlimited, National Audubon Society, Waterfowl Habitat Owners Alliance, and The Nature Conservancy, was formally established in July 1988. Technical assistance is provided to the Board by the Fish and Wildlife Service, California Department of Fish and Game, California Department of Food and Agriculture, and other agencies and organizations.

The Board developed the following objectives in their Central Valley Habitat Joint Venture (1990) Implementation Plan: (1) protect 80,000 acres of existing unprotected wetlands, (2) restore an additional 120,000 acres of wetlands, and (3) enhance water and power supplies for waterfowl and other wildlife by the year 2000. Specific objectives for the Delta and Yolo Basin include 3,000 and 5,000 acres, respectively, for wetland habitat acquisition, and 20,000 and 10,000 acres, respectively, for wetland restoration.

The North American Waterfowl Management Plan also encourages conservation and management of waterfowl habitat by the private sector on private lands. In furtherance of this objective, in 1990, the U.S. Fish and Wildlife Service, Ducks Unlimited, The Nature Conservancy, and California Waterfowl Association entered into an agreement with several farmland owners to enhance wildlife and agricultural management on Delta islands. The agreement, known as the Delta Farmland Wildlife Conservation Program, calls for identification of agricultural practices that, if properly designed and managed, will enhance waterfowl and other wildlife habitat. Signatory agencies provide technical assistance to landowners, who enter into the program on a voluntary basis.

In accordance with the Emergency Wetlands Resources Act of 1986, the U.S. Fish and Wildlife Service (1990d) prepared a Regional Wetlands Concept Plan to identify priority acquisition sites based on wetland functions, values, and threats within the Service's Pacific Coast Region. Within the Estuary study area, this plan identifies the National Wildlife Refuge expansion area in South San Francisco Bay, the Cullinan Ranch property in the North Bay, and the Stone Lakes area as priority acquisition sites. Inclusion on the priority acquisition lists means that these sites are eligible for acquisition with Land and Water Conservation Act funds.

CHAPTER 7
GAPS IN INFORMATION AND KNOWLEDGE

Because the relationship of wildlife to its environment is complex, there are naturally many gaps in the knowledge of how that relationship functions. Additional research in the areas of habitat requirements, limiting factors, and life history is warranted on nearly every wildlife species found in the Estuary. Although the list of information needs is long, some needs are more important than others. Some of the species emphasized here are unique to the Estuary and are also threatened with extinction. For other species groups, the Estuary provides valuable habitat for significantly large populations of wintering or nesting species. This chapter discusses the major informational needs for various species groups and their habitats. Research to fill these data gaps is essential to provide the proper tools to most effectively manage wildlife in the San Francisco Estuary. In this chapter, major gaps in information are discussed under the following headings:

Special Status Species
Waterfowl
Shorebirds
Colonial Birds
Other Wildlife
Wildlife Habitats
Contaminants

7.1 SPECIAL STATUS SPECIES

Numerous special status amphibians, reptiles, birds, and mammals that breed within the Estuary study area are known or believed to be currently experiencing population declines (Table 7-1). More detailed research is needed on the distribution and status of these species within the Estuary study area as well as on the migratory routes and wintering grounds outside the study area for migratory species. Other areas deserving of research efforts, where applicable, include: (1) life history, (2) migration and movements, (3) limiting factors, (4) habitat requirements (on both breeding and wintering grounds), (5) population dynamics, and (6) contaminant effects.

Because of recent dramatic population declines in the California clapper rail, special attention to the research needs of this species in San Francisco Bay is warranted. Suspected factors contributing to this population decline include predation, contaminants, and habitat degradation. There is a critical need for information on the effect of contaminants in the food web on which clapper rails rely. Invertebrate foods of the rail should be analyzed for contaminants in all portions of the Bay currently or recently inhabited by rails. Laboratory toxicological studies should be conducted to determine the effects of contaminants on adult and young birds, as well as egg viability. A red fox control program should be initiated immediately and monitored to determine its efficacy in reducing predation pressure on the Bay's rail

Table 7-1. Special Status Wildlife Species Currently Known or Believed to be Experiencing Population Declines.

SPECIES	STATUS[1]	HABITAT
Amphibians and Reptiles		
San Francisco Garter snake	FE,SE	freshwater marshes, sagponds
Alameda striped racer	ST,FC2	coastal scrub, chaparral
Western spadefoot	SSC	grassland, vernal pools
California tiger salamander	FC2,SSC	vernal pools
Red-legged frog	FC2,SSC	freshwater marshes, riparian
Giant garter snake	ST,FC2	lakes, freshwater marshes
Western pond turtle	FC3,SSC	rivers, lakes
Birds		
Swainson's hawk	ST	riparian, grassland
Golden eagle	SSC	open country, cliffs
Burrowing owl	SSC	grassland
Short-eared owl	SSC	seasonal wetlands, grassland
Long-eared owl	SSC	riparian woodlands
Cooper's hawk	SSC	woodlands
Sharp-shinned hawk	SSC	woodlands
Northern harrier	SSC	seasonal wetlands, grassland
Black rail	ST,FC1	salt marshes
California clapper rail	FE,SE	salt marshes
Western snowy plover	FC2,SSC	salt ponds
Long-billed curlew	FC2,SSC	grassland, intertidal mudflat
California least tern	FE,SE	salt ponds, sandy bayshore
Saltmarsh yellowthroat	FC2,SSC	marshes, riparian
Alameda song sparrow	FC2,SSC	salt marshes
San Pablo song sparrow	FC2,SSC	salt marshes
Suisun song sparrow	FC2,SSC	salt marshes
Tricolored blackbird	FC2,SSC	freshwater marshes, grassland
Mammals		
San Joaquin kit fox	FE,ST	grassland
Salt marsh harvest mouse	FE,SE	salt marshes
Salt marsh wandering shrew	FC1,SSC	salt marshes
Suisun ornate shrew	FC1,SSC	salt marshes
San Joaquin Valley woodrat	FC2,SSC	riparian
Riparian brush rabbit	FC1,SSC	riparian
American badger	SSC	grassland
Townsend's big-eared bat	SSC	conifer-hardwood, structures

[1] Status:

FE - Federally endangered
SE - State endangered
ST - State threatened
FC1- Federal candidate for listing, Category 1 - Taxon for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
FC2- Federal candidate for listing, Category 2 - Taxa for which existing information indicated may warrant listing, but for which substantial information to support a proposed rule is lacking.
SSC- State Species of Special Concern

population. Monitoring of the effects of freshwater sewage effluent on habitat conversion in the South Bay should continue, and rail invertebrate prey populations should be assessed in areas of marsh conversion.

Information on these as well as other potential limiting factors could be gathered through studies of rails during the breeding and non-breeding seasons. Breeding activities and non-breeding season movements of clapper rails in the wild should be monitored using radio telemetry. These studies would provide information on reproductive success, predation, and patterns of dispersal of young and adults.

Annual surveys in all tidal habitats in the Estuary should be conducted to determine the clapper rail's distribution and population status. In addition, the quality and extent of rail habitat, including any habitat threats, should be quantified. The extent and characteristics of upland refugia for the clapper rail, as well as the salt marsh harvest mouse, also should be quantified.

The existence of the California least tern in the Estuary is also precarious, warranting special attention to research needs for this species. More information is needed on the population dynamics and movements of this species. Banding and marking least tern chicks would provide information on age-class structure, mortality rates, and estimates of longevity. These factors could be used to predict long-range stability of tern populations. Other needed information include the degree of colony fidelity, shifts between colonies, establishment of new colonies, age at first nesting, factors affecting clutch size, and breeding success.

To properly manage the tern, additional research is also needed on: (1) the effects of environmental contaminants; (2) factors affecting the choice of location for roosting, loafing, and feeding areas used during the breeding and post-breeding seasons; (3) the amount of habitat needed (measured in terms of fish density) to maintain the current population size or increase it; (4) what constitutes suitable nesting habitat, including beaches, landfills, salt ponds, and estuarine areas; and (5) factors leading to colony disruption and nest site abandonment.

As discussed previously, expansion of the introduced bullfrog has contributed to declines in the California red-legged frog. The nature of this interaction should be investigated further. In addition, the possible effects of contaminants on populations of red-legged frogs and the San Francisco garter snake deserves special attention.

For many of the special status wildlife species considered to be State Species of Special Concern very little information exists on distribution, abundance, or population status. Included in this group are species such as the coast horned lizard, western spadefoot, ringtail, northern harrier, and burrowing owl. This information is needed to determine if populations of these species have declined to a point where they should be considered threatened with extinction. Information on distribution and population status is sorely needed for three species considered to be candidates for the State's

Species of Special Concern list. These are the Alameda Island mole, Angel Island mole, and Berkeley kangaroo rat. Virtually no recent information is available on these species.

7.2 WATERFOWL

The San Francisco Bay Estuary supports a significant proportion of the Pacific Flyway wintering waterfowl population. To adequately manage this important wildlife resource, further research is needed. One of the most pressing needs is to determine the effects of contaminants on wintering waterfowl, particularly diving ducks. According to Takekawa et al. (1988), to assess the effects of contaminants on waterfowl, more information is needed on how the waterfowl community utilizes habitats within the San Francisco Estuary. Radio telemetry studies in the Bay and Delta would provide information on where wintering waterfowl concentrate in the Estuary and how long they remain in the Estuary. An estimate of the carrying capacity of the Estuary for waterfowl should be made by assessing available food resources and the use of those resources.

Of particular importance in an assessment of available food resources is quantification of the value of salt ponds and seasonal wetlands to wintering waterfowl. Little support data exist on this topic even though these habitat types are often most threatened by development. Information on waterfowl food habits and time budgets in these two habitat types would improve understanding of their value to wintering waterfowl.

Further research is also warranted for the western population of the canvasback because of the critically low population levels reached in 1988-1989 (Takekawa et al. 1988). Because a significant proportion of this population winters in San Francisco Bay, it is important to determine the relationship between wintering habitat quality and reproduction.

Gilmer et al. (1982) recommended a number of more general waterfowl research topics for the Central Valley, which includes the Delta, including: (1) an assessment of winter food requirements for certain key species and the ability of major habitats to provide these resources; (2) an evaluation of the influence of weather, agriculture, and hunting on the distribution and abundance of waterfowl; (3) an evaluation of the cause, chronology, and magnitude of non-hunting mortality; and (4) an assessment of the physical condition and reproductive potential of waterfowl relative to winter habitat conditions.

Further research on limiting factors of waterfowl wintering in the Estuary is warranted. As a beginning, all waterfowl habitats (wetlands, riparian vegetation, agricultural land, and uplands) need to be quantified according to waterfowl requirements. This would include the amount of available habitat that fulfills waterfowl food, shelter, loafing, nesting, and sanctuary needs during the period of the year when these habitats are available. From this information, we may be able to determine which of the wintering requirements (e.g., food, cover, and sanctuary) is limiting populations.

7.3 SHOREBIRDS

Unlike waterfowl, yearly inventories of shorebird populations in California have not been conducted on a regular basis. To manage the Bay properly to sustain migratory shorebirds, more information is needed on the seasonal abundance patterns of shorebirds. A long-term monitoring program should be initiated to establish population trend data. Coupled with this, improved techniques should be developed to estimate population sizes. Because almost no information is available on shorebird abundance and distribution in Suisun Marsh/Bay and the Delta, long-term monitoring programs should be initiated for these areas of the Estuary as well.

Research is also needed to precisely define the roles that seasonal wetlands and salt ponds play in maintaining the Bay's shorebird population in winter. Research on the availability of roosts and patterns of use by shorebirds in the central regions of the Bay should be conducted to promote protection of suitable roosts in the future.

More information is needed regarding factors limiting shorebird populations in the Estuary. One area needing research is the effects of contaminants, especially selenium, on wintering shorebirds (Ohlendorf and Fleming 1988). Also in need of study are the effects of power lines on shorebird mortality and the effect of the introduced Asian clam on benthic invertebrates, the major prey of shorebirds. In addition, ways of limiting red fox predation on shorebird nests and young need to be found.

7.4 COLONIAL WATER BIRDS AND SEABIRDS

A long-term consistent monitoring program that documents population size and breeding success of all species of colonial water birds and seabirds within the Estuary needs to be implemented. Research should continue into the effects of contaminants on colonial nesting species. The presence of contaminants in the food web should be investigated throughout the Estuary through sampling of sediments, invertebrates, and fish. This information will shed light on the pathways through which contaminants enter the food web and better define background contaminant levels and hot spots in the Bay. Telemetry studies of black-crowned night-herons and other colonial nesting birds during both the breeding and non-breeding season would help to determine where the birds are being exposed to the various contaminants. Species such as the double-crested cormorant or black-crowned night-heron, both widespread colonially nesting species in the Estuary, could serve as biological indicators of background contaminant levels.

Studies of breeding biology, diet, feeding areas, foraging behavior, and winter movements should be conducted. Studies should also be undertaken to determine the impact of human disturbance and predators on nesting colonial birds in the Estuary. For instance, the National Park Service plans to open to tourists, areas of Alcatraz Island which are currently gull nesting sites. Similarly, the East Bay Regional Park District is considering allowing public access to Brooks Island, despite the presence of sensitive Caspian tern and western gull colonies.

7.5 OTHER WILDLIFE

There is a critical need for studies of populations of mammalian predators in the Estuary. More information is needed on the distribution and abundance of predators, such as the red fox, Norway rat, and black rat. Research is needed on various control techniques, including the feasibility of reintroducing the coyote in the South Bay Area to control red foxes, where appropriate.

Because the harbor seal is a conspicuous mammalian member of the Bay food web, research is needed into the possible effects of environmental contaminants on this species. Research is also warranted on the effects of sea level rise on Bay wildlife.

Cowbirds and starlings are well known for their abilities to displace other nesting bird species. The impacts these two species are having on native nesting birds, however, is largely unknown in the Estuary. Research is needed to quantify this potential impact.

7.6 WILDLIFE HABITATS

7.6.1 Restored Wildlife Habitats

As the human population of the Estuary expands, the number of habitat restoration projects will probably also increase to mitigate habitat losses associated with urban and industrial development. One of the primary goals of wetland or other habitat restoration projects is to create habitat of high quality to wildlife. There are, however, few examples of habitat restoration projects where wildlife values of the restoration site have been documented. Most restoration projects involve performance standards measured in terms of the success of vegetative plantings. However, because of lack of knowledge of the dynamic relationship of wildlife to its habitat, it is risky to assume that if the vegetation is restored, the wildlife community is also automatically restored. Long-term wildlife monitoring studies of several habitat restoration sites are needed to document wildlife recolonization. This information would determine the true success of each restoration effort.

7.6.2 Tidal Marsh Erosion

Because tidal marsh erosion is proceeding at an alarming rate in the Bay, particularly in the South Bay, additional research into this subject is warranted. First of all, Baywide studies of tidal marshes should be conducted to (1) update where marsh erosion and accretion is taking place and (2) determine if accelerated rates of erosion are occurring in other locations of the Bay besides those studied by Philip Williams and Associates (1989). Research is also needed to determine if structural techniques exist to retard erosion and possibly promote marsh expansion. Marsh expansion outboard of existing Bay levees could also prove to be an important alternative to rip-rapping for bank protection.

7.7 CONTAMINANTS

There is a need for basic research at every level to identify significant estuarine processes and to quantify relationships between wildlife and the many and varied contaminants present in the Estuary. However, because certain research needs of the San Francisco Bay Estuary are being addressed, a first step would be to improve coordination of existing programs to benefit the overall effort.

Certain areas of extreme pollution have not been well studied with respect to sources or effects of the pollutants in place. Further studies are needed regarding forms of arsenic in the Estuary and the biological effects of tin (especially TBT). More congener-specific studies of PCBs are needed, since the toxicological effects of PCBs may be related to only a small number of co-planar forms of these compounds. In the case of correlations of PCBs with reproductive effects in fish and birds, more evidence is needed to determine the significance of the observed effects. Additional studies are needed to clarify the role of PCBs in known areas of contamination in affecting organisms of high trophic levels of particular economic or biological importance. Investigations should seek to identify cause-and-effect relationships wherever possible.

Clear evidence linking pollution with specific biological effects is lacking in the San Francisco Estuary. Further study needs to be done on the occurrence of chronic or sub-chronic impacts on the biota of the Estuary as the result of exposure to pollutants. In this regard, particular emphasis should be placed upon developing realistic biological indicators of pollutant effects, such as genotoxic effects, physiological effects, or effects on the immune system. The complex relationships between the accumulation of complex mixtures of pollutants and their effects on the biota of the Estuary should also receive attention.

The effects of many contaminants, including polycyclic aromatic hydrocarbons, industrial chemicals, organotins, current-generation pesticides, and mosquito control agents, on wildlife, and particularly birds, have not been well studied in the San Francisco Estuary. It is important to establish relationships between contaminant concentrations in bird tissues and in those found in their foods to determine sources of contaminants, routes of exposure, and the effects on wildlife.

There is also a need for field studies and controlled experimental studies that are conceptually related to field observations to determine: (1) acute and chronic toxicity of chemicals for important food-chain organisms and wildlife; (2) the association of contaminant burdens with morphological, histopathological, and biochemical/physiological indices in free-ranging animals; and (3) reproductive success in resident birds and in birds that winter in the bay but nest elsewhere.

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APPENDIX A
Wildlife Species of the San Francisco Estuary

Introduction
This appendix includes all species of amphibians, reptiles, birds, and mammals, both native and introduced, which are either currently or were historically considered to occur annually within the San Francisco Estuary study area. The list was derived from the State Wildlife Habitat Relationships database and refined through review of literature and consultation with experts. Species for which an account is presented in Chapter 4 are denoted with an asterisk (*) preceding their common name. The appendix addresses the following information:

Special Status:
The following abbreviations refer to taxa designated as special status by agency and private interests. Complete scientific names for these taxa, except the Audubon Blue List, Federal Management Concern, harvested, and introduced species, are provided in Appendix B.

FE - Federally-listed as an **endangered** species under the authority of the Endangered Species Act of 1973. The term "endangered" as defined in the Act, refers to "any species which is in danger of extinction throughout all or a significant portion of its range."

FT - Federally-listed as a **threatened** species. The term "threatened" as defined by the Endangered Species Act, describes "any species which is likely to become endangered in the foreseeable future throughout all or a significant portion of its range."

SE - State-listed as an **endangered** species under the authority of section 2062 of the Fish and Game Code. The State considers a species to be "endangered" when it "is in serious danger of becoming extinct throughout all, or a significant portion, of its range"

ST - State-listed as a **threatened** species. The State considers a species to be "threatened" when "although not presently threatened with extinction, [it] is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [the Fish and Game Codes]" (Section 2067 of the Fish and Game Code).

FC - Federal candidate - taxa under consideration by the U.S. Fish and Wildlife Service for listing as endangered and threatened species (FC1 = Category 1, FC2 = Category 2)

SSC - California Department of Fish and Game Species of Special Concern

SBS - Sensitive bird species - U.S. Fish and Wildlife Service designation of birds, including subspecies or distinct populations, which could become Federally listed as endangered or threatened in the foreseeable future, throughout all or in a significant portion of their ranges, without active management and/or removal of threats.

AB - Audubon blue list - birds designated by the National Audubon Society which are believed to be experiencing a population decline in all or a major portion of its range.

MC - Federal management concern - designation of nongame migratory birds because of 1) documented or apparent population declines, 2) small or restricted populations, and 3) dependence on restricted or vulnerable habitats.

HA - Harvested species - species designated for harvest under the California State Fish and Game Code and U.S. Fish and Wildlife Service regulations.

EX - Extirpated - from the Estuary study area.

IN - Introduced - not native or indigenous within the Estuary study area.

Seasonal Occurrence:

R - resident: found in the study area throughout the designated season(s).
M - migrant: species occurring in the study area during seasonal (usually spring and fall) movements between breeding and nonbreeding areas.

Sp - Spring (March - May)
Su - Summer (June - August)
F - Fall (September - November)
W - Winter (December - February)

Relative Abundance:

A - abundant: almost always encountered, usually in great numbers
C - common: usually or often encountered in considerable numbers
U - uncommon: occasionally encountered, usually in small numbers
R - rare: rarely encountered, usually in very small numbers

Wildlife Habitat Types:

Wetland and Deepwater Habitats

OW - Open water
IM - Intertidal mudflat
RS - Rocky shores
SM - Tidal salt marsh
BM - Tidal brackish marsh
FM - Tidal fresh water marsh
DM - Diked seasonal marsh
FH - Other freshwater habitats
FW - Farmed wetlands
RW - Riparian woodland
SP - Salt ponds
LP - Lakes and ponds

Upland Habitats

GR - Grassland
CS - Coastal shrub
MC - Mixed chaparral
WS - Oak woodland
BF - Broad-leaved evergreen forest
AL - Agricultural land
UR - Urban

Sources:
Grinnell and Wythe (1927), Grinnell and Miller (1944), Small (1974), Burt and Grossenheider (1976), Cogswell (1977), Erickson (1982), Stebbins (1985), U.S. Fish and Wildlife Service (1987c), Jameson and Peeters (1988), Zeiner et al. (1988, 1990a+b), Peterson (1990).

APPENDIX A
Wildlife Species of the
San Francisco Bay Estuary
(* denotes species account in text)

Common Name	Scientific Name	Status	Seasonal Occurrence	Abun-dance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
AMPHIBIANS																							
*tiger salamander	Ambystoma tigrinum	FC2,SSC	R-YR	U						X		X					X			X			
Pacific giant salamander	Dicamptodon ensatus		R-YR	C										X							X		
California newt	Taricha torosa		R-YR	C										X				X	X	X			
rough-skinned newt	Taricha granulosa		R-YR	C								X		X		X				X	X		
Ensatina	Ensatina eschscholtzii		R-YR	U										X				X	X	X	X		
California slender salamander	Batrachoseps attenuatus		R-YR	C										X				X	X	X	X		X
arboreal salamander	Aneides lugubris		R-YR	C										X						X			X
black salamander	Aneides flavipunctatus		R-YR	U								X		X			X			X	X		
western toad	Bufo boreas		R-YR	C								X		X		X	X			X	X	X	X
*western spadefoot	Scaphiopus hammondii	SSC	R-YR	U								X					X			X			
Pacific treefrog	Pseudacris regilla		R-YR	C					X	X	X	X		X		X	X			X	X		X
*red-legged frog	Rana aurora	FC2,SSC	R-YR	U					X	X	X	X		X		X	X				X		
*foothill yellow-legged frog	Rana boylii	SSC	R-YR	U						X	X	X		X		X	X	X	X	X	X		
bullfrog	Rana catesbeiana	IN,HA	R-YR	C						X	X	X		X		X	X			X		X	
REPTILES																							
*blunt-nosed leopard lizard	Gambelia sila	EX,FE,SE																X	X				
western fence lizard	Sceloporus occidentalis		R-YR	A										X			X	X	X	X	X	X	X
sagebrush lizard	Sceloporus graciosus		R-YR	C										X			X	X	X	X	X		
*side-blotched lizard	Uta stansburiana		R-YR	C										X			X	X	X	X	X		
*coast horned lizard	Phrynosoma coronatum	SSC	R-YR	U										X			X	X	X	X	X		
western skink	Eumeces skiltonianus		R-YR	C										X			X	X	X	X	X	X	
Gilbert's skink	Eumeces gilberti		R-YR	C										X			X			X		X	
*western whiptail	Cnemidophorus tigris		R-YR	U										X			X	X	X	X			
southern alligator lizard	Gerrhonotus multicarinatus		R-YR	C					X					X				X	X	X	X		X
northern alligator lizard	Gerrhonotus coeruleus		R-YR	C					X					X				X	X		X		X
*California legless lizard	Anniella pulchra		R-YR	U										X			X	X	X				
rubber boa	Charina bottae		R-YR	U						X		X	X	X			X				X		
ring-necked snake	Diadophis punctatus		R-YR	C						X		X	X	X			X	X	X			X	

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Common Name	Scientific Name	Status	Seasonal Occurrence	Abun-dance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
sharp-tailed snake	Contia tenuis		R-YR	C								X	X	X			X				X	X	
racer	Coluber constrictor		R-YR	C								X	X	X			X			X	X	X	
*coachwhip	Masticophis flagellum		R-YR	R													X	X	X			X	
*striped racer	Masticophis lateralis	FC2,ST	R-YR	C										X			X	X	X	X			
*glossy snake	Arizona elegans		R-YR	R													X	X	X	X	X		
gopher snake	Pituophis melanoleucus		R-YR	A								X	X	X			X	X	X	X			
common kingsnake	Lampropeltis getulus		R-YR	C													X	X	X	X	X		
*long-nosed snake	Rhinocheilus lecontei		R-YR	R													X	X	X				
*common garter snake	Thamnophis sirtalis	FE,SE	R-YR	C						X	X	X	X	X		X	X			X	X	X	X
western terrestrial garter snake	Thamnophis elegans		R-YR	C					X	X	X	X	X	X		X				X		X	X
*giant garter snake	Thamnophis gigas	FC2,ST	R-YR	U								X				X	X			X			
California black-headed snake	Tantilla planiceps		R-YR	U													X	X	X	X	X	X	
night snake	Hypsiglena torquata		R-YR	U													X	X	X	X		X	
western rattlesnake	Crotalus viridis		R-YR	C													X	X	X	X			
*western pond turtle	Clemmys marmorata	FC	R-YR	U						X	X	X	X	X		X	X						
*red-eared slider	Pseudemys scripta	IN	R-YR	C						X		X	X	X		X	X			X			
BIRDS																							
*red-throated loon	Gavia stellata		R-W	C	X										X								
*Pacific loon	Gavia pacifica		R-W	U	X										X								
*common loon	Gavia immer	SSC,MC,SBS	R-W	C	X											X							
*pied-billed grebe	Podilymbus podiceps		R-YR	C	X				X	X					X	X							
*horned grebe	Podiceps auritus	AB	R-W	C	X			X	X	X					X								
red-necked grebe	Podiceps grisegena		R-W	U	X				X	X													
*eared grebe	Podiceps nigricollis		R-W,S	C	X					X					X	X							
*western grebe	Aechmophorus occidentalis		R-W	A	X				X	X					X	X							
*Clark's grebe	Aechmophorus clarkii		R-W	A	X				X	X					X	X							
*American white pelican	Pelecanus erythrorhynchos	SSC,SBS	R-W	U	X					X					X	X							
*brown pelican	Pelecanus occidentalis	FE,SE	R-SU,F	C	X		X								X								
*double-crested cormorant	Phalacrocorax auritus	SSC	R-YR	C	X		X	X	X	X	X				X	X							

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(* denotes species account in text)

Common Name	Scientific Name	Status	Seasonal Occurrence	Abundance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
*Brandt's cormorant	Phalacrocorax penicillatus		R-YR	U	X		X																
*pelagic cormorant	Phalacrocorax pelagicus		R-YR	U	X		X																
*American bittern	Botaurus lentiginosus	AB	R-YR	U						X													
least bittern	Ixobrychus exilis	SSC	R-YR	R																			
*great blue heron	Ardea herodias		R-YR	C		X	X	X	X	X	X	X	X	X	X	X	X					X	
*great egret	Casmerodius albus		R-YR	C		X	X	X	X	X	X	X	X	X	X	X	X					X	
*snowy egret	Egretta thula		R-YR	C		X	X	X	X	X	X				X	X	X						
little blue heron	Egretta caerulea		R-SU	R		X		X	X		X				X								
*cattle egret	Bubulcus ibis		R-YR	R					X			X	X				X					X	
green-backed heron	Butorides striatus		R-YR	U		X			X	X				X									
*black-crowned night-heron	Nycticorax nycticorax		R-YR	C		X		X	X	X		X	X		X								
*white-faced ibis	Plegadis chihi	FC2,SSC,SBS,MC	R-SU	R					X	X	X	X	X				X						
*fulvous whistling-duck	Dendrocygna bicolor	SSC,SBS,HA	R-YR	R					X														
*tundra swan	Cygnus columbianus		R-W	C	X						X		X			X						X	
trumpeter swan	Cygnus buccinator		R-W	R						X			X										
*greater white-fronted goose	Anser albifrons	SBS,HA,FC	R-W	U					X	X	X						X					X	
*snow goose	Chen caerulescens	HA	R-W	U					X	X	X						X					X	
Ross' goose	Chen rossii	HA	R-W	R					X													X	
brant	Branta bernicla	SSC,HA			X																		
*Canada goose	Branta canadensis	FE,SE,SBS,HA	R-W	C	X				X	X	X		X		X	X	X					X	
wood duck	Aix sponsa	HA	R-YR	U					X	X		X		X		X							
*green-winged teal	Anas crecca	HA	R-W	C	X	X		X	X	X	X		X		X	X							
*mallard	Anas platyrhynchos	HA	R-SU,W	C				X	X	X	X	X	X	X	X	X						X	X
*northern pintail	Anas acuta	HA	R-SU,W	C	X	X		X	X	X	X	X	X		X	X						X	
blue-winged teal	Anas discors	HA	R-YR	R				X	X	X	X	X	X			X							
cinnamon teal	Anas cyanoptera	HA	R-SU,W	C				X	X	X	X	X	X		X	X							
*northern shoveler	Anas clypeata	HA	R-SU,W	C				X	X	X	X	X	X		X	X							
gadwall	Anas strepera	HA	R-SU,W	C	X	X		X	X	X	X	X	X		X	X	X						
Eurasian wigeon	Anas penelope		R-W	R	X	X		X	X	X	X	X	X		X	X	X						
*American wigeon	Anas americana	HA	R-W	C	X	X		X	X	X	X	X	X		X	X	X						

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Common Name	Scientific Name	Status	Seasonal Occurrence	Abun-dance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
*canvasback	Aythya valisineria	HA	R-W	C	X			X	X	X					X	X	X						
redhead	Aythya americana	HA	R-W	U	X			X	X	X					X	X	X						
ring-necked duck	Aythya collaris	HA	R-W	U	X				X	X					X	X	X						
tufted duck	Aythya fuligula		R-W	R	X				X	X					X	X							
*greater scaup	Aythya marila	HA	R-W	C	X				X	X					X	X							
*lesser scaup	Aythya affinis	HA	R-W	C	X			X	X	X													
oldsquaw	Clangula hyemalis	HA	R-W	R	X				X														
black scoter	Melanitta nigra	HA	R-W	R	X				X														
*surf scoter	Melanitta perspicillata	HA	R-W	C	X			X	X							X							
white-winged scoter	Melanitta fusca	HA	R-W	U	X			X	X														
common goldeneye	Bucephala clangula	HA	R-W	C	X			X	X	X	X				X	X							
Barrow's goldeneye	Bucephala islandica	SSC,HA	R-W	U	X				X						X	X							
*bufflehead	Bucephala albeola	HA	R-W	C	X			X	X	X					X	X							
hooded merganser	Lophodytes cucullatus	HA	R-W	U	X				X	X						X							
common merganser	Mergus merganser	HA	R-SU,W	U	X			X	X	X					X	X							
red-breasted merganser	Mergus serrator	HA	R-W	U	X										X	X							
*ruddy duck	Oxyura jamaicensis	HA	R-SU,W	A	X			X	X	X					X	X							
California condor	Gymnogyps californianus	EX,FE,SE																					
turkey vulture	Cathartes aura		R-YR	C					X	X			X	X	X	X	X	X	X	X		X	
osprey	Pandion haliaetus	SSC	R-YR	U	X									X		X							
black-shouldered kite	Elanus caeruleus		R-YR	C				X	X	X				X			X			X		X	
*bald eagle	Haliaeetus leucocephalus	FE,SE	R-W	R					X	X				X		X	X			X		X	
*northern harrier	Circus cyaneus	SSC,AB	R-YR	U				X	X	X	X	X	X		X		X					X	
*sharp-shinned hawk	Accipiter striatus	SSC	R-YR	U					X	X				X						X			X
*Cooper's hawk	Accipiter cooperii	SSC,AB	R-YR	U					X	X				X						X	X		
red-shouldered hawk	Buteo lineatus	AB	R-YR	R										X						X	X		
broad-winged hawk	Buteo platypterus		M-F	R													X	X					
*Swainson's hawk	Buteo swainsoni	FC,ST	R-SU M-SP,F	U										X			X			X		X	
red-tailed hawk	Buteo jamaicensis		R-YR	C					X	X				X			X	X	X	X		X	X
ferruginous hawk	Buteo regalis	FC2,SSC	M-W	U					X	X				X			X					X	

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rough-legged hawk	Buteo lagopus		M-W	U					X	X							X					X	
*golden eagle	Aquila chrysaetos	SSC	R-YR	U					X	X				X			X			X		X	
American kestrel	Falco sparverius		R-YR	C						X				X	X		X			X		X	X
merlin	Falco columbarius	SSC	R-W	R					X	X					X		X			X		X	
*peregrine falcon	Falco peregrinus	FE,SE	R-SU,W	R		X		X	X	X				X			X	X	X				
prairie falcon	Falco mexicanus	SSC	R-YR	R						X							X	X	X			X	
*ring-necked pheasant	Phasianus colchicus	IN,HA	R-YR	C						X			X				X	X				X	
*California quail	Callipepla californica	HA	R-YR	C										X				X	X	X	X	X	X
mountain quail	Oreortyx pictus	HA	R-YR	U										X				X	X		X		
wild turkey	Meleagris gallopavo	HA,IN	R-YR	U																X	X		
yellow rail	Coturnicops noveboracensis	SSC		R					X	X		X											
*black rail	Laterallus jamaicensis	FC1,ST,MC	R-YR	R				X	X	X													
*clapper rail	Rallus longirostris	FE,SE	R-YR	R				X	X														
Virginia rail	Rallus limicola		R-YR	U				X	X	X	X	X											
sora	Porzana carolina		R-YR	U				X	X	X	X	X											
common moorhen	Gallinula chloropus	HA	R-YR	U				X	X	X	X	X	X										
American coot	Fulica americana	HA	R-YR	A	X			X	X	X	X	X	X			X	X					X	
*sandhill crane	Grus canadensis	ST,SBS	R-W	C					X	X	X		X			X	X					X	
*black-bellied plover	Pluvialis squatarola		R-W	C		X		X	X	X	X	X	X		X		X					X	
*lesser golden-plover	Pluvialis dominica		R-W	R		X		X	X	X		X	X		X		X					X	
snowy plover	Charadrius alexandrinus	FC2,SSC,SBS,MC	R-YR	U		X									X							X	
semipalmated plover	Charadrius semipalmatus		R-W	U		X		X	X	X		X	X			X						X	
killdeer	Charadrius vociferus		R-YR	C		X		X	X	X	X	X	X		X	X	X					X	X
mountain plover	Charadrius montanus	SSC	R-W	R													X					X	
black oystercatcher	Haematopus bachmani		R-YR	R			X																
*black-necked stilt	Himantopus mexicanus		R-SU,W	C		X		X	X	X	X	X	X		X	X							
*American avocet	Recurvirostra americana		R-SU,W	C	X	X		X	X	X	X	X	X		X								
greater yellowlegs	Tringa melanoleuca		R-W	U		X		X	X	X	X	X	X		X	X							
lesser yellowlegs	Tringa flavipes		R-W	R		X		X	X	X	X	X	X		X								
solitary sandpiper	Tringa solitaria		M-SP,F	R					X	X						X							

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*willet	Catoptrophorus semipalmatus		R-YR	C		X	X	X	X	X	X				X	X	X					X	
wandering tattler	Heteroscelus incanus		R-W	R		X	X																
spotted sandpiper	Actitis macularia		R-W,S	U		X	X								X	X							
whimbrel	Numenius phaeopus		R-W,S	U		X	X	X	X				X		X	X	X					X	
*long-billed curlew	Numenius americanus	FC,SSC	R-W,S	U		X		X	X	X	X	X	X		X	X	X					X	
*marbled godwit	Limosa fedoa		R-YR	C		X			X						X		X					X	
ruddy turnstone	Arenaria interpres		R-W	U		X	X								X								
black turnstone	Arenaria melanocephala		R-W	U		X	X	X							X								
*surfbird	Aphriza virgata		R-W	R			X																
red knot	Calidris canutus		R-W	U		X							X		X	X							
sanderling	Calidris alba		R-W	C		X	X	X		X					X	X							
semipalmated sandpiper	Calidris pusilla		M-F	R		X		X	X	X	X	X	X		X	X							
*western sandpiper	Calidris mauri		R-W	A		X	X	X	X	X	X	X	X		X	X	X					X	
*least sandpiper	Calidris minutilla		R-W	A		X		X	X	X	X	X	X		X	X							
Baird's sandpiper	Calidris bairdii		M-F	R		X		X	X	X	X	X	X		X	X							
pectoral sandpiper	Calidris melanotos		M-F	R		X		X	X	X	X	X	X			X	X						
stilt sandpiper	Calidris himantopus		M-F	R		X		X	X				X			X							
*dunlin	Calidris alpina		R-W	A		X		X	X	X		X	X		X	X							
*short-billed dowitcher	Limnodromus griseus		R-W	C		X		X	X	X	X	X	X		X								
*long-billed dowitcher	Limnodromus scolopaceus		R-W	C		X		X	X	X	X	X	X		X								
common snipe	Gallinago gallinago	HA	R-W	U				X	X	X		X	X			X	X						
*Wilson's phalarope	Phalaropus tricolor		M-SP,F	C	X			X	X	X	X	X	X		X	X							
*red-necked phalarope	Phalaropus lobatus		M-SP,F	C	X			X	X	X	X	X	X		X	X							
red phalarope	Phalaropus fulicaria		M-SP,F	R	X	X									X	X							
parasitic jaeges	stercorarius parasiticus		M-F	R	X																		
*Bonaparte's gull	Larus philadelphia		R-W	C	X	X		X	X	X					X	X							
*Heermann's gull	Larus heermanni		M-SU,F	U	X		X								X								
mew gull	Larus canus		R-W	C	X	X	X		X	X			X		X	X	X					X	
ring-billed gull	Larus delawarensis		R-YR	C		X		X	X	X			X		X	X	X					X	X
*California gull	Larus californicus	SSC	R-YR	C	X	X	X	X	X	X		X	X		X	X	X					X	X

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*herring gull	Larus argentatus		R-W	C	X	X	X	X	X	X			X		X	X	X					X	X
*Thayer's gull	Larus thayeri		R-W	U	X	X	X	X	X	X			X		X	X						X	X
*western gull	Larus occidentalis		R-YR	A	X	X	X	X	X						X	X							X
*glaucous-winged gull	Larus glaucescens		R-W	C	X	X	X	X	X	X					X	X						X	X
*glaucous gull	Larus hyperboreus		R-W	R	X	X																X	X
*Caspian tern	Sterna caspia	SBS	R-SU	C	X	X		X	X	X					X	X							
*elegant tern	Sterna elegans	SSC	M-SU,F	C	X	X		X							X								
common tern	Sterna hirundo		M-SP,F	U	X	X		X							X	X							
*Forster's tern	Sterna forsteri		R-YR	C	X	X		X	X	X					X	X							
*least tern	Sterna antillarum	FE,SE	R-SU	U	X	X		X							X	X							
black tern	Chlidonias niger	AB,MC	M-SP,F	R	X			X	X	X		X			X	X							
common murre	Uria aalge		M-F	U	X																		
*pigeon guillemot	Cepphus columba		R-SU	U	X		X																
rock dove	Columba livia	IN	R-YR	A									X									X	X
band-tailed pigeon	Columba fasciata	HA	R-YR	C										X						X	X		
mourning dove	Zenaida macroura	HA	R-YR	A										X			X	X		X		X	X
yellow-billed cuckoo	Coccyzus americanus	EX,AB,SBS,SE																					
greater roadrunner	Geococcyx californianus		R-YR	R														X	X				
barn owl	Tyto alba		R-YR	C					X				X	X			X			X		X	X
western screech-owl	Otus kennicottii		R-YR	C										X						X	X		
great horned owl	Bubo virginianus		R-YR	C				X	X	X				X			X	X	X	X	X	X	
northern pygmy-owl	Glaucidium gnoma		R-YR	R																X	X		
*burrowing owl	Athene cunicularia	SSC	R-YR	U				X	X								X			X		X	
*long-eared owl	Asio otus	SSC	R-YR	R				X	X	X				X			X			X	X	X	
*short-eared owl	Asio flammeus	SSC,SBS,AB	R-YR	U				X	X	X	X	X	X				X					X	
northern saw-whet owl	Aegolius acadicus		R-YR	U																X	X		
spotted owl	Strix occidentalis	FT,SSC,AB	R-YR	R																	X		
lesser nighthawk	Chordeiles acutipennis		R-SU	R													X					X	
common poorwill	Phalaenoptilus nuttallii		R-SU	U													X	X	X	X			
black swift	Cypseloides niger	SSC	M-SP,F	R			X											X	X				
Vaux's swift	Chaetura vauxi		M-SP,F	U										X				X	X	X	X		

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white-throated swift	Aeronautes saxatalis		R-YR	C			X		X									X	X			X	
black-chinned hummingbird	Archilochus alexandri		R-SU	R										X				X	X	X		X	
Anna's hummingbird	Calypte anna		R-YR	C										X				X	X	X	X		X
calliope hummingbird	Stellula calliope		M-SP	U										X				X	X	X	X		
rufous hummingbird	Selasphorus rufus		M-SP,F	U										X				X	X	X		X	
Allen's hummingbird	Selasphorus sasin		R-SU	C										X				X	X	X	X		X
belted kingfisher	Ceryle alcyon		R-YR	U			X							X		X							
Lewis' woodpecker	Melanerpes lewis	SBS	R-YR	R										X						X			
acorn woodpecker	Melanerpes formicivorus		R-YR	C										X						X	X		
red-breasted sapsucker	Sphyrapicus ruber		R-W	U										X						X	X		X
Nuttall's woodpecker	Picoides nuttallii		R-YR	C										X						X	X		
downy woodpecker	Picoides pubescens		R-YR	C										X						X	X		X
hairy woodpecker	Picoides villosus		R-YR	C										X						X	X		
northern flicker	Colaptes auratus		R-YR	C										X			X	X	X	X	X	X	X
pileated woodpecker	Dryocopus pileatus		R-YR	R																X	X		
olive-sided flycatcher	Contopus borealis		R-SU	U																	X		X
western wood-pewee	Contopus sordidulus		R-SU	C										X						X	X		
willow flycatcher	Empidonax traillii	ST,SBS	M-SP,F	U								X		X		X							
Hammond's flycatcher	Empidonax hammondii		M-SP,F	R										X						X	X		
dusky flycatcher	Empidonax oberholseri		M-SP	R										X				X	X	X	X		
gray flycatcher	Empidonax wrightii		M-SP	R										X				X	X	X	X		
Pacific-slope flycatcher	Empidonax difficilis	SBS	R-SU	C										X						X	X		
black phoebe	Sayornis nigricans		R-YR	C					X		X	X	X	X		X	X			X		X	X
Say's phoebe	Sayornis saya		R-YR	U					X				X				X	X	X			X	X
ash-throated flycatcher	Myiarchus cinerascens		R-SU	C										X				X	X	X	X		
western kingbird	Tyrannus verticalis		R-SU	C													X	X	X	X		X	
horned lark	Eremophila alpestris		R-YR	C											X		X	X				X	
purple martin	Progne subis	SSC	M-SP,F	U										X						X	X		
tree swallow	Tachycineta bicolor		R-SU,W	C				X	X	X	X	X	X	X	X	X	X			X		X	
violet-green swallow	Tachycineta thalassina		R-SU	C				X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
northern rough-winged swallow	Stelgidopteryx serripennis		R-SU	C				X	X	X				X	X	X	X			X		X	

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*bank swallow	Riparia riparia	ST,SSC	M-SP,F	R						X				X			X	X	X			X	
cliff swallow	Hirundo pyrrhonota		R-SU	A				X	X	X			X	X	X	X	X	X	X	X	X	X	X
barn swallow	Hirundo rustica		R-SU	C				X	X	X			X		X	X	X	X	X	X	X	X	X
Steller's jay	Cyanocitta stelleri		R-YR	C										X						X	X		X
scrub jay	Aphelocoma coerulescens		R-YR	C										X				X	X	X	X	X	X
yellow-billed magpie	Pica nuttalli		R-YR	C										X			X			X		X	X
American crow	Corvus brachyrhynchos	HA	R-YR	A					X	X			X	X			X			X	X	X	X
common raven	Corvus corax		R-YR	U					X				X	X			X	X	X	X		X	
chestnut-backed chickadee	Parus rufescens		R-YR	C										X						X	X		X
plain titmouse	Parus inornatus		R-YR	C										X						X	X		X
bushtit	Psaltriparus minimus		R-YR	C										X				X	X	X	X		X
white-breasted nuthatch	Sitta carolinensis		R-YR	U										X						X	X		
red-breasted nuthatch	Sitta canadensis		R-YR	U										X						X	X		X
pygmy nuthatch	Sitta pygmaea		R-YR	R																	X		X
brown creeper	Certhia americana		R-YR	U										X						X	X		
rock wren	Salpinctes obsoletus		R-YR	U													X	X	X				
canyon wren	Catherpes mexicanus		R-YR	R										X				X	X	X			
Bewick's wren	Thryomanes bewickii	AB	R-YR	C					X					X				X	X	X	X		X
house wren	Troglodytes aedon		R-SU	C					X					X				X	X	X	X	X	X
winter wren	Troglodytes troglodytes		R-YR	U										X							X		
marsh wren	Cistothorus palustris		R-YR	C					X	X	X	X	X										
American dipper	Cinclus mexicanus		FFYR	R							X												
golden-crowned kinglet	Regulus satrapa		R-W	C										X						X	X		X
ruby-crowned kinglet	Regulus calendula		R-W	C					X	X				X				X	X	X	X	X	X
blue-gray gnatcatcher	Polyoptila caerulea		R-YR	U										X				X	X	X	X		
western bluebird	Sialia mexicana	SBS	R-YR	C					X					X			X	X	X	X	X	X	
mountain bluebird	Sialia currucoides		R-W	R										X			X					X	
Townsend's solitaire	Myadestes townsendi		R-W	R										X				X	X	X			
Swainson's thrush	Catharus ustulatus		R-SU	C										X							X		
hermit thrush	Catharus guttatus		R-W	C										X				X	X	X	X	X	X
American robin	Turdus migratorius		R-YR	A										X			X			X	X	X	X

APPENDIX A
Wildlife Species of the
San Francisco Bay Estuary
(* denotes species account in text)

Common Name	Scientific Name	Status	Seasonal Occurrence	Abun-dance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
varied thrush	Ixoreus naevius		R-W	U										X						X	X		
wrentit	Chamaea fasciata		R-YR	C										X				X	X		X		
northern mockingbird	Mimus polyglottos		R-YR	C										X			X	X	X	X		X	X
California thrasher	Toxostoma redivivum		R-YR	C										X				X	X	X	X		
American pipit	Anthus rubescens		R-W	C		X	X	X		X	X	X	X		X	X	X					X	X
cedar waxwing	Bobycilla cedrorum		R-W	C					X					X				X	X	X	X	X	X
phainopepla	Phainopepla nitens		R-YR	R										X				X	X	X			
European starling	Sturnus vulgaris	IN	R-YR	A					X	X				X			X			X		X	X
Bell's vireo	Vireo bellii	EX,SSC																					
solitary vireo	Vireo solitarius		R-SU	U										X						X	X		
Hutton's vireo	Vireo huttoni		R-YR	C										X						X	X		
warbling vireo	Vireo gilvus		R-SU	C										X						X	X	X	X
orange-crowned warbler	Vermivora celata		R-SU	C										X				X	X	X	X	X	X
Nashville warbler	Vermivora ruficapilla		M-SP,F	R										X					X	X	X		
yellow warbler	Dendroica petechia	SSC	R-SU	C										X				X	X	X	X	X	X
yellow-rumped warbler	Dendroica coronata		R-W	C										X				X	X	X	X	X	X
black-throated gray warbler	Dendroca nigrescens		R-SU	U										X				X	X	X	X		
Townsend's warbler	Dendroica townsendi		R-W	U										X				X	X	X	X		X
hermit warbler	Dendroica occidentalis		M-SP,F	R										X						X	X		X
MacGillivray's warbler	Oporornis tolmiei		R-SU	U										X							X		
*common yellowthroat	Geothlypis trichas	FC2,SBS,SSC	R-YR	U				X	X	X				X									
Wilson's warbler	Wilsonia pulsilla		R-SU	C										X				X	X	X	X		
yellow-breasted chat	Icteria virens	SSC	R-SU	R										X									
western tanager	Piranga ludoviciana		M-SP,F	C										X						X	X		
black-headed grosbeak	Pheucticus melanocephalus		R-SU	C										X						X	X		
blue grosbeak	Guiraca caerulea		R-SU	U										X			X						
Lazuli bunting	Passerina amoena		R-SU	C								X	X	X			X	X	X	X	X		
rufous-sided towhee	Pipilo erythrophthalmus		R-YR	C										X				X	X	X	X		X
California towhee	Pipilo crissalis		R-YR	C										X				X	X	X	X	X	X
rufous-crowned sparrow	Aimophila ruficeps		R-YR	U													X	X	X				
chipping sparrow	Spizella passerina		R-SU	U										X			X	X	X	X	X	X	X

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Wildlife Species of the
San Francisco Bay Estuary
(* denotes species account in text)

Common Name	Scientific Name	Status	Seasonal Occurrence	Abun-dance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
black-chinned sparrow	Spizella atrogularis		R-SU	U														X	X				
vesper sparrow	Pooecetes gramineus		R-W	R													X	X	X			X	
lark sparrow	Chondestes grammacus		R-YR	C													X	X	X	X		X	
sage sparrow	Amphispiza belli		R-YR	U														X	X				
Savannah sparrow	Passerculus sandwichensis		R-YR	C				X	X	X	X	X	X				X						
grasshopper sparrow	Ammodramus savannarum	AB	R-SU	R													X						
fox sparrow	Passerella iliaca		R-W	C										X				X	X		X		X
*song sparrow	Melospiza melodia	FC2,SSC	R-YR	C				X	X	X	X	X	X	X			X	X	X		X	X	X
Lincoln's sparrow	Melospiza lincolnii		R-W	U				X	X	X				X			X	X	X	X			
white-throated sparrow	Zontrichia albicollis		R-W	R										X				X	X	X	X	X	X
golden-crowned sparrow	Zonotrichia atricapilla		R-W	C										X				X	X	X	X	X	X
white-crowned sparrow	Zonotrichia leucophrys		R-YR	C					X	X		X	X	X			X	X	X	X	X	X	X
dark-eyed junco	Junco hyemalis		R-YR	C										X				X	X	X	X	X	X
red-winged blackbird	Agelaius phoeniceus		R-YR	A				X	X	X	X	X	X	X			X					X	X
*tricolored blackbird	Agelaius tricolor	FC2,SSC	R-YR	C					X	X	X	X	X	X		X	X					X	
western meadowlark	Sturnella neglecta		R-YR	C					X	X			X				X	X		X		X	X
yellow-headed blackbird	Xanthocephalus xanthocephalus		R-W	U					X	X		X	X			X	X					X	
Brewer's blackbird	Euphagus cyanocephalus		R-YR	A						X		X	X	X		X	X					X	X
brown-headed cowbird	Molothrus ater		R-YR	C						X				X			X	X	X	X	X	X	X
hooded oriole	Icterus cucullatus		R-SU	U										X								X	X
northern oriole	Icterus galbula		R-SU	C										X						X		X	X
purple finch	Carpodacus purpureus		R-YR	C										X						X	X	X	X
house finch	Carpodacus mexicanus		R-YR	A					X	X			X	X			X	X		X	X	X	X
red crossbill	Loxia curvirostra		R-W,SU	U										X							X		X
pine siskin	Carduelis pinus		R-YR	C										X						X	X		X
lesser goldfinch	Carduelis psaltria		R-YR	C										X			X	X	X	X	X	X	X
Lawrence's goldfinch	Carduelis lawrencei		R-YR	U										X			X	X	X	X			
American goldfinch	Carduelis tristis		R-YR	C										X			X			X	X	X	X
evening grosbeak	Coccothraustes vespertinus		R-W M-SP,F	R										X							X		X

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Wildlife Species of the
San Francisco Bay Estuary
(* denotes species account in text)

Common Name	Scientific Name	Status	Seasonal Occurrence	Abun-dance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
house sparrow	Passer domesticus	IN	R-YR	A																		X	X
MAMMALS																							
*Virginia opossum	Didelphis virginiana	HA,IN	R-YR	C						X	X	X	X	X		X	X	X	X		X	X	X
*vagrant shrew	Sorex vagrans	FC1,SSC	R-YR	A				X	X	X		X		X			X	X	X		X	X	
Pacific shrew	Sorex pacificus		R-YR	C						X		X	X					X	X		X		
*ornate shrew	Sorex ornatus	FC1,SSC	R-YR	U				X	X	X	X	X	X	X			X	X	X	X	X	X	
Trowbridge's shrew	Sorex trowbridgii		R-YR	C										X				X	X	X	X		
shrew-mole	Neurotrichus gibbsii		R-YR	C						X		X		X							X		
*broad-footed mole	Scapanus latimanus		R-YR	C										X			X			X	X	X	
little brown bat	Myotis lucifugus		R-YR	C								X		X			X	X	X		X		
Yuma myotis	Myotis yumanensis		R-YR	U										X							X		
long-eared myotis	Myotis evotis		R-YR	U										X				X	X	X	X		
fringed myotis	Myotis thysanodes		R-YR	U																X	X	X	
long-legged myotis	Myotis volans		R-YR	C										X				X	X	X	X		
California bat	Myotis californicus		R-YR	C										X				X	X	X	X		
small-footed myotis	Myotis leibii		R-YR	C										X			X	X	X	X	X		
silver-haired bat	Lasionycteris noctivagans		R-YR	C										X						X	X		
western pipistrelle	Pipistrellus hesperus		R-YR	C													X	X	X	X	X		
big brown bat	Eptesicus fuscus		R-YR	A														X		X			
red bat	Lasiurus borealis		R-YR	C										X			X	X	X	X		X	
hoary bat	Lasiurus cinereus		M-W	U										X						X	X		
*Townsend's big-eared bat	Plecotus townsendii	FC2,SSC	R-YR	R										X						X			
pallid bat	Antrozous pallidus	SSC	R-YR	U										X			X	X	X	X	X	X	
Brazilian free-tailed bat	Tadarida brasiliensis		R-YR	U										X			X	X	X	X		X	
*western mastiff bat	Eumops perotis	FC2,SSC	R-YR	U										X			X	X	X	X		X	
*brush rabbit	Sylvilagus bachmani	FC1,SSC,HA	R-YR	A										X				X	X	X	X		
desert cottontail	Sylvilagus audubonii	HA	R-YR	A										X			X	X	X	X		X	
black-tailed hare	Lepus californicus	HA	R-YR	C					X		X	X	X	X			X	X	X	X	X	X	
Sonoma chipmunk	Tamius sonomae		R-YR	C										X			X	X	X	X	X		
Merriam's chipmunk	Tamius merriami		R-YR	C										X				X	X	X	X		

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Wildlife Species of the
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Common Name	Scientific Name	Status	Seasonal Occurrence	Abun-dance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
California ground squirrel	Spermophilus beecheyi		R-YR	A									X	X			X	X	X	X	X	X	X
eastern gray squirrel	Sciurus carolinenses	IN	R-YR	C																			X
western gray squirrel	Sciurus griseus	HA	R-YR	C										X						X		X	X
fox squirrel	Sciurus niger	HA,IN	R-YR	C										X						X	X	X	X
Douglas' squirrel	Tamiasciurus douglasii	HA	R-YR	C																X	X		
Botta's pocket gopher	Thomomys bottae		R-YR	C								X	X	X			X	X		X		X	X
little pocket mouse	Perognathus longimembris		R-YR	C														X	X				
*San Joaquin pocket mouse	Perognathus inornatus	FC2,SSC	R-YR	U													X	X	X				
California pocket mouse	Perognathus californicus		R-YR	U										X			X	X	X	X	X		
narrow-faced kangaroo rat	Dipodomys venustus		R-YR	C										X			X	X	X	X			
*Heerman's kangaroo rat	Dipodomys heermanni		R-YR	U										X			X	X	X	X	X		
California kangaroo rat	Dipodomys californicus		R-YR	C													X	X	X				
beaver	Castor canadensis	HA	R-YR	C					X	X		X	X	X		X	X			X	X		
western harvest mouse	Reithrodontomys megalotis		R-YR	C						X		X		X			X	X	X	X	X	X	
*salt-marsh harvest mouse	Reithrodontomys raviventris	FE,SE	R-YR	R				X	X		X												
California mouse	Permomyscus californicus		R-YR	A										X				X	X	X	X		
deer mouse	Peromyscus maniculatus		R-YR	A				X		X	X	X	X	X		X	X	X	X	X	X	X	X
brush mouse	Peromyscus boylii		R-YR	U										X				X	X	X	X		
pinyon mouse	Permomyscus truei		R-YR	U														X	X		X		
desert woodrat	Neotoma lepida		R-YR	U														X	X				
*dusky-footed woodrat	Neotoma fuscipes	FC2,SSC	R-YR	C										X				X	X	X	X		
western red-backed vole	Clethrionomys californicus		R-YR	U										X							X		
*California vole	Microtus californicus	SSC	R-YR	U					X			X	X	X			X				X		X
muskrat	Ondatra zibethicus	HA,IN	R-YR	A					X	X		X		X		X				X	X	X	
black rat	Rattus rattus	IN	R-YR	A										X				X	X	X			X
Norway rat	Rattus norvegicus	IN	R-YR	A				X	X	X	X	X	X										X
house mouse	Mus musculus	IN	R-YR	A				X	X	X	X	X	X									X	X
*Pacific jumping mouse	Zapus trinotatus	FC2,SSC	R-YR	C						X	X	X	X	X			X				X	X	
porcupine	Erethizon dorsatum		R-YR	C						X		X	X	X		X		X	X	X	X		

APPENDIX A
Wildlife Species of the
San Francisco Bay Estuary
(* denotes species account in text)

Common Name	Scientific Name	Status	Seasonal Occurrence	Abundance	OW	IM	RS	SM	BM	FM	DM	FH	FW	RW	SP	LP	GR	CS	MC	WS	BF	AL	UR
harbor porpoise	Phocoena phocoena		M-SP,F	R	X																		
coyote	Canis latrans	HA	R-YR	C				X	X	X	X	X	X	X			X	X	X	X	X	X	
gray wolf	Canis lupis	EX																					
red fox	Vulpes vulpes	IN	R-YR	C				X	X	X		X					X	X	X			X	
*kit fox	Vulpes macrotis	FE,ST	R-YR	R													X					X	
gray fox	Urocyon cinereoargenteus	HA	R-YR	C										X			X	X	X	X	X	X	
grizzly bear	Ursus horribilis	EX																					
*ringtail	Bassariscus astutus	HA	R-YR	U										X			X	X	X	X		X	
*raccoon	Procyon lotor		R-YR	C							X	X	X	X						X	X	X	X
long-tailed weasel	Mustela frenata	HA	R-YR	C													X	X	X				
mink	Mustela vison	HA	R-YR	C	X	X	X	X	X	X	X					X							
*badger	Taxidea taxus	SSC,HA	R-YR	C													X						
feral house cat	Felis catus	IN	R-YR	U						X		X	X	X		X	X	X	X	X	X	X	X
spotted skunk	Spilogale putorius	HA	R-YR	U					X	X	X	X	X	X			X	X	X	X	X		
*striped skunk	Mephitis mephitis	HA	R-YR	C					X	X	X	X	X	X			X	X	X	X	X	X	X
sea otter	Enhydra lutris	EX,FT																					
river otter	Lutra canadensis		R-YR	C					X	X				X		X							
*mountain lion	Felis concolor	FC2	R-YR	C										X			X	X	X	X	X		
*bobcat	Lynx rufus	HA	R-YR	U										X			X	X	X	X	X		
*California sea lion	Zalophus californianus		R-YR	C	X	X	X	X	X														
*harbor seal	Phoca vitulina		R-YR	C	X	X	X	X	X														
*feral hog and wild boar	Sus scrofa	HA,IN	R-YR	C										X			X	X	X	X	X		
*elk	Cervus elaphus	EX,HA	R-YR	C																			
*mule deer	Odocoileus hemionus	HA	R-YR	A										X			X	X	X	X	X	X	X
pronghorn	Antilocapra americana	EX,HA																					X

APPENDIX B
Special Status, Extirpated, and Extinct Wildlife and Plant[1] Species of the San Francisco Estuary Study Area.

Species	Status[2]	Habitat Type[3]
BIRDS		
Common loon <u>Gavia</u> <u>immer</u>	SSC	1
American white pelican <u>Pelecanus</u> <u>erythrorhynchos</u>	SSC	1,6
California brown pelican <u>Pelecanus</u> <u>occidentalis</u> <u>californicus</u>	FE,SE	1,6
Double-crested cormorant <u>Phalacrocorax</u> <u>auritis</u>	SSC	1,2b,3a,3b,3c,5,6,7
Least bittern <u>Ixobrychus</u> <u>exilis</u>	SSC	3a,3b,3c
White-faced ibis <u>Plegadis</u> <u>chihi</u>	FC2,SSC	3b,3c,4a,4b,4c,8
Fulvous whistling duck <u>Dendrocygna</u> <u>bicolor</u>	SSC	3b
Aleutian Canada goose <u>Branta</u> <u>canadensis</u> <u>leucopareia</u>	FT,SE	4a,4b,4c,8
Barrow's goldeneye <u>Bucephala</u> <u>islandica</u>	SSC	1,3b,6
California condor <u>Gymnogyps</u> <u>californianus</u>	FE,SE,EXT	8,11, cliffs
Osprey <u>Pandion</u> <u>haliaetus</u>	SSC	1
Northern harrier <u>Circus</u> <u>cyaneus</u>	SSC	3a,3b,3c,4a,4b,6,8,13
Sharp-shinned hawk <u>Accipiter</u> <u>striatus</u>	SSC	3b,3c,5,11,14
Cooper's hawk <u>Accipiter</u> <u>cooperii</u>	SSC	3b,3c,5,11
Swainson's hawk <u>Buteo</u> <u>swainsoni</u>	ST	5,8,11
Ferruginous hawk <u>Buteo</u> <u>regalis</u>	FC2,SSC	3b,3c,5,8
Bald eagle <u>Haliaeetus</u> <u>leucocephalus</u>	FE,SE	1,3b,3c,5,7
Golden eagle <u>Aquila</u> <u>chrysaetos</u>	SSC	3a,3b,3c,8,13,cliffs
Merlin <u>Falco</u> <u>columbarius</u>	SSC	3b,3c,6,8,11,13
American peregrine falcon <u>Falco</u> <u>peregrinus</u> <u>anatum</u>	FE,SE	3a,3b,3c,5,9,10
Prairie falcon <u>Falco</u> <u>mexicanus</u>	SSC	3c,8,13
Yellow rail <u>Coturnicops</u> <u>noveboracensis</u>	SSC	3a,3b,3c,4b
California black rail <u>Laterallus</u> <u>jamaicensis</u> <u>coturniculus</u>	ST,FC1	3a
California clapper rail <u>Rallus</u> <u>longirostris</u> <u>obsoletus</u>	FE,SE	3a
Greater sandhill crane <u>Grus</u> <u>canadensis</u> <u>tabida</u>	ST	3b,3c,4a,4c,7,8,13
Western snowy plover <u>Charadruis</u> <u>alexandrinus</u> <u>nivosa</u>	FC2,SSC	2a,6,7,13

Appendix B. (continued) Special status, extirpated, and extinct wildlife and plant[1] species of the San Francisco Estuary study area.

Species	Status[2]	Habitat Type[3]
BIRDS		
Mountain plover *Charadrius montanus*	FC2	8,13
Long-billed curlew *Numenius americanus*	FC2,SSC	2a,3a,3b,3c,4a,4b, 4c,6,7,8,13
California gull *Larus californicus*	SSC	1,2a,2b,3,6,7,14
Elegant tern *Sterna elegans*	SSC	1,2a,2b,6
California least tern *Sterna antillarum browni*	FE,SE	1,3a,6
Marbled murrelet *Brachyramphus marmoratus*	SE,FT(proposed)	1,12
Yellow-billed cuckoo *Coccyzus americanus occidentalis*	SE,EXT	5
Burrowing owl *Athene cunicularia*	SSC	3a,3b,8,13
Long-eared owl *Asio otus*	SSC	3a,3b,3c,5,8,11,13
Short-eared owl *Asio flammeus*	SSC	3a,3b,3c,4a,4b,4c,8
Northern spotted owl *Strix occidentalis caurina*	FT,SSC	12
Black swift *Cypeloides niger*	SSC	rocky cliffs
Willow flycatcher *Empidonax traillii*	SSC	5
Purple martin *Progne subis*	SSC	11,12
Bank swallow *Riparia riparia*	ST	5
Least Bell's vireo *Vireo bellii pusillus*	FE,SE,EXT	5
Yellow warbler *Dendroica petechia morcomi*	SSC	5
Saltmarsh common yellowthroat *Geothlypis trichas sinuosa*	FC2,SSC	3a
Yellow-breasted chat *Icteria virens*	SSC	5
Alameda song sparrow *Melospiza melodia pusillula*	FC2,SSC	3a
Suisun song sparrow *Melospiza melodia maxillaris*	FC2,SSC	3a
San Pablo song sparrow *Melospiza melodia samuelis*	FC2,SSC	3a
Tricolored blackbird *Agelaius tricolor*	FC2,SSC	3b,3c,4b,4c,7,8,13
MAMMALS		
Saltmarsh wandering shrew *Sorex vagrans halicoetes*	FC1,SSC	3a,4a
Suisun ornate shrew *Sorex ornatus sinuosus*	FC1,SSC	3a,4a
Pacific western big-eared bat *Plecotus townsendii townsendii*	FC2,SSC	5,11

Appendix B. (continued) Special status, extirpated, and extinct wildlife and plant[1] species of the San Francisco Estuary study area.

Species	Status[2]	Habitat Type[3]
MAMMALS		
Pallid bat Antrozous pallidus	SSC	5,8,9,10,11,12,13
Greater western mastiff bat Eumops perotis californicus	FC2,SSC	5,8,9,10,11,13
Riparian brush rabbit Sylvilagus bachmani riparius	FC1,SSC	5
Salt marsh harvest mouse Reithrodontomys raviventris	FE,SE	3a,4a,8
San Joaquin valley woodrat Neotoma fuscipes riparia	FC2,SSC	5
San Pablo vole Microtus californicus sanpabloensis	SSC	4a,4b,8
Gray wolf Canis lupus fuscus	EXT	8,9,10,11,12
San Joaquin kit fox Vulpes macrotis mutica	FE,ST	8
Grizzly bear Ursus arctos	EXT	3a,3b,3c,4b,5,8,11
Badger Taxidea taxus	SSC	8
Sea otter Enhydra lutris	FT,EXT	1
Roosevelt elk Cervus elaphus roosevelti	EXT	8,9,10,11,12
Pronghorn Antilocapra americana	EXT	8
REPTILES AND AMPHIBIANS		
California tiger salamander Ambystoma tigrinum californiense	FC2,SSC	4b,8
California red-legged frog Rana aurora draytoni	FC2,SSC	3c,4b,5,7,8,12
Foothill yellow-legged frog Rana boylii	SSC	3c,4b,5,7,8,9,10,11,12
Western spadefoot Scaphiopus hammondii	SSC	4b,8,11,13
Blunt-nosed leopard lizard Gambelia sila	FE,SE,EXT	8
California horned lizard Phrynosoma coronatum frontale	SSC	5,8,9,10,11,12
San Francisco garter snake Thamnophis sirtalis tetrataenia	FE,SE	4b,7
Giant garter snake Thamnophis gigas	ST,FC2	4b,7
Alameda striped racer Masticophis lateralis euryxanthus	ST,FC2	8,9,10,11
INSECTS		
Lange's metalmark butterfly Apodemia mormo langei	FE	dunes

Appendix B. (continued) Special status, extirpated, and extinct wildlife and plant[1] species of the San Francisco Estuary study area.

Species	Status[2]	Habitat Type[3]
INSECTS		
Mission blue butterfly *Plebejus icariodes missionensis*	FE	8,9
San Bruno elfin butterfly *Incisalia mossii bayensis*	FE	8,9
Bay checkerspot butterfly *Euphydryas editha bayensis*	FT	8,serpentine soils
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	FT	5
Delta green ground beetle *Elaphrus viridus*	FT	4b,8
San Francisco forktail damselfly *Ischnura gemina*	FC2	5
Ricksecker's water scavenger beetle *Hydrochara rickseckeri*	FC2	4b,5,7
Callippe silverspot butterfly *Speyeria callippe callippe*	FC2	8
Leech's skyline diving beetle *Hydroporus leechi*	FC2	5,7
Middlekauf's shieldback katydid *Idiostatus middlekaufi*	FC2	dunes
San Francisco lacewing *Nothochrysa californica*	FC2	unknown
Antioch dunes anthicid beetle *Anthicus antiochensis*	FC2	dunes
Bumblebee scarab beetle *Lichnanthe ursina*	FC2	dunes
Delta June beetle *Polyphylla stellata*	FC2	5
Antioch cophuran robberfly *Cophura hurdi*	FC2	dunes
Antioch efferian robberfly *Efferia antiochi*	FC2	dunes
Hurd's metapogon robberfly *Metapogon hurdi*	FC2	dunes
Unsilvered fritillary butterfly *Speyeria adiaste adiaste*	FC2	5,8
Edgewood Park microblind harvestman *Microcina edgewoodensis*	FC2	8,serpentine
Hom's microblind harvestman *Microcina homi*	FC2	8,serpentine
Lum's microblind harvestman *Microcina lumi*	FC2	8, serpentine
Jung's microblind harvestman *Microcina jungi*	FC2	8,serpentine
Lee's microblind harvestman *Microcina leei*	FC2	8,serpentine
Edgewood Park blind harvestman *Calicina minor*	FC2	8,serpentine
Marin blind harvestman *Calicina diminua*	FC2	8,serpentine
Opler's longhorn moth *Adella oplerella*	FC2	8,serpentine
Marin elfin butterfly *Incisalia mossii*	FC2	rock outcrops with Sedum north-facing slopes

Appendix B. (continued) Special status, extirpated, and extinct wildlife and plant[1] species of the San Francisco Estuary study area.

Species	Status[2]	Habitat Type[3]
INSECTS		
Curve-foot diving beetle *Hygrotus curvipes*	FC2	4b
Valley flower-loving fly *Raphiomydas trochilus*	EXT	dunes
Antioch shield-back katydid *Neduba extincta*	EXT	dunes
Sthenele satyr butterfly *Cercyonis sthenele sthenele*	EXT	8,9
Xerces blue butterfly *Glaucopsyche xerces*	EXT	9
Antioch robber fly *Cophura hurdi*	EXT	dunes
Antioch specid wasp *Philanthus nasalis*	EXT	dunes
Yellow-banded andrenid bee *Perdita hirticeps luteocincta*	EXT	dunes
PLANTS		
Large-flowered fiddleneck, *Amsinckia grandiflora*	FE,SE	8,12
Alameda manzanita, *Arctostaphylos papallida*	FC1,SC	10
Palmate-bracted bird's-beak, *Cordylanthus palmatus*	FE,SE	8,9
Tiburon paintbrush, *Castilleja neglecta*	FC1	8
South Bay clarkia, *Clarkia concinna* ssp. *automixa*	FC2	8,9
Presidio clarkia, *Clarkia franciscana*	FC1,SE	8,9
Hispid bird's-beak, *Cordylanthus mollis ssp. hispidus*	FC2,SR	8
Baker's larkspur, *Delphinium bakeri*	FC1,SR	9
Yellow larkspur, *Delphinium luteum*	FC1,SR	9
Coyote Valley dudleya, *Dudleya setchellii*	FC1	8
Contra Costa buckwheat, *Eriogonum truncatum*	FC2	8,9,10
Hoover's button-celery, *Eryngium aristulatum* var. *hooveri*	FC2	unknown
San Francisco wallflower, *Erysimum franciscanum*	FC2	9
Diamond-petaled poppy, *Eschscholzia rhombipetala*	FC2	8
Talus fritillary, *Fritillaria falcata*	FC2	10,11,12
Fragrant fritillary, *Fritillaria liliacea*	FC2	8,9
Adobe lily, *Fritillaria pluriflora*	FC2	8,10,11,12
San Francisco gumplant, *Grindelia maritima*	FC2	8,9

Appendix B. (continued) Special status, extirpated, and extinct wildlife and plant[1] species of the San Francisco Estuary study area.

Species	Status[2]	Habitat Type[3]
Diablo rock-rose, Helianthella castanea	FC2	10,12
Tiburon tarweed, Hemizonia multicaulis ssp. vernalis	FC2	8
Marin dwarf-flax, Hesperolinon congestum	FC1	8
Santa Cruz tarweed, Holocarpha macradenia	FC1,SE	8
Wedge-leaved horkelia, Horkelia cuneata ssp. sericea	FC2	9,10,12
Hinds' walnut, Juglans hindsii	FC2	5
Hall's madia, Madia hallii	FC2	10
San Francisco owl's-clover, Orthocarpus floribundus	FC2	8
White-rayed pentachaeta, Pentachaeta bellidiflora	FC2	8
Slender pentachaeta, Pentachaeta exilis ssp. aeolica	FC2	8,11
Gairdner's yampah, Perideridia gairdneri ssp. gairdneri	FC2	10,12
Mt. Diablo phacelia, Phacelia phacelioides	FC2	10,11
Hairless allocarya, Plagiobothrys glaber	FC2	8
Hickman's cinquefoil, Potentilla hickmanii	FC1,SE	9,10
Adobe sanicle, Sanicula maritima	FC2,SR	8
Rock sanicle, Sanicula saxatilis	FC2,SR	10,12
Marin checkermallow, Sidalcea hickmanii ssp. viridis	FC2,SR	10
Mission Delores campion, Silene verecunda ssp. verecunda	FC2	8,9
Metcalf Canyon jewelflower, Streptanthus albidus ssp. albidus	FC1	8
Uncommon jewelflower, Streptanthus albidus ssp. peramoenus	FC1	10
Showy Indian clover, Trifolium amoenum	FC2	8
Caper-fruited tropidocarpum, Tropidocarpum capparideum	FC2	8

1 Plant species listed are those found only in the upland habitats of the study area. A complete list of special status plant species of the wetland habitats is available in the Status and Trends Report on Wetlands and Related Habitats in the San Francisco Estuary.

2 Status:

FE - Federally Endangered
FT - Federally Threatened
SE - State Endangered
ST - State Threatened
SR - State Rare
SC - State Candidate

FC - Candidate for Federal Listing
FC1 - Category 1
FC2 - Category 2
SSC - State Species of Special Concern
EXT - Extirpated from the Study Area or Extinct in the Case of Insects

[3] Habitat Type:

1 - Open Water
2a - Intertidal Mudflat
2b - Rocky Shores
3a - Tidal Salt Marsh
3b - Tidal Brackish Marsh
3c - Tidal Freshwater Marsh
4a - Diked Seasonal Marsh
4b - Freshwater Seasonal Marsh (includes vernal pools)
4c - Farmed Wetlands
5 - Riparian Woodland
6 - Salt Ponds
7 - Lakes and Ponds
8 - Grassland
9 - Coastal Scrub
10 - Mixed Chaparral
11 - Oak Woodland
12 - Broad-leaved Evergreen Forest
13 - Agricultural Land
14 - Urban

APPENDIX C
MANAGEMENT GOALS AND RECOMMENDATIONS

These goals and recommendations are intended to address ongoing threats to wildlife populations of the Estuary and their habitats. Recommendations are divided into four broad goals addressing: (1) wetland and riparian habitats of the Estuary, (2) special status species, (3) research, and (4) public education and involvement. The following proposed management actions were developed primarily through discussion among the authors and various reviewers of this report, members of the Biological Resources Subcommittee, and San Francisco Estuary Project staff. Effective implementation of many of the following management recommendations will first depend upon addressing the gaps in knowledge presented in Chapter 7 and cited under the research management goal (3) in this section.

In the course of development of the Comprehensive Conservation Management Plan by the San Francisco Estuary Project, funding sources and implementation strategies to translate these management recommendations into an action plan and environmental programs which will extend beyond the Project's five-year planning period, will be identified.

I. WETLAND AND RIPARIAN HABITATS OF THE ESTUARY

A. Goal

Protect, enhance and restore wetland and riparian habitat quantity and quality within the San Francisco Estuary.

B. Management Recommendations

1. San Francisco Estuary Fish and Wildlife Habitat Plan

The U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, and the California Department of Fish and Game should lead a coordinated effort to develop a wildlife habitat restoration plan for the entire Estuary which would then be appended to the Comprehensive Conservation Management Plan. This plan would include the following elements:

- i. Identification of wildlife groups of concern, with particular emphasis on endemic species;
- ii. Analysis of management alternatives to maintain and restore wetland and riparian communities and biodiversity;
- iii. Assessment of impacts of various management alternatives;
- iv. Implementation and acquisition strategies; and
- v. Identification of possible funding sources and lead agencies.

2. Tidal Marsh Restoration in San Francisco Bay

Large-scale, fast-track restorations of tidal marsh should be pursued, particularly in the South Bay where remaining habitat is most fragmented and salt marsh wildlife are most threatened. All possible habitat acquisition strategies by public agencies, including eminent domain, should be considered.

salt marsh wildlife are most threatened. All possible habitat acquisition strategies by public agencies, including eminent domain, should be considered. Restorations should be sufficiently large (>1000 acres) to support extensive tidal channel systems. Tidal restoration of currently active salt ponds should also be investigated.

3. Management Planning for San Francisco Bay National Wildlife Refuge

In anticipation of San Francisco Bay National Wildlife Refuge assuming full land management responsibility over significant salt pond acreage, the U.S. Fish and Wildlife Service should prepare a refuge habitat management plan. A goal of the plan would be maintenance of sufficient acreage of managed and tidal wetlands to support the unique migratory bird community relying on these habitats. This plan would include the following:

i. Identification of appropriate combination of tidal and managed wetlands to maintain greatest species diversity and population stability;
ii. Identification of most suitable tidal marsh restoration areas;
iii. Identification of most optimal and economically feasible wetland management techniques; and
iv. Environmental assessment of various management approaches.

4. Federal, State, and Local Acquisition, Protection, and Enhancement of Wetland and Riparian Habitat.

a. Areas proposed for acquisition for the San Francisco Bay and San Pablo Bay National Wildlife Refuges and the proposed Stone Lakes National Wildlife Refuge, should be acquired and managed to maximize their values for migratory birds and endangered species.

b. The U.S. Fish and Wildlife Service, California Department of Fish and Game, and other land management agencies should complete and implement predator control plans, where appropriate, for all refuges and management areas supporting tidal marshes within the Estuary. Responsible agencies should also pursue control and eradication of introduced smooth cordgrass from all tidal habitats.

c. Federal, State and local laws and policies should be amended as necessary to prevent an overall loss of either wetland acreage or values on an individual project basis in the San Francisco Estuary. In addition, placement of fill on any wetland site should be limited to water-dependent uses and compensation for alteration of wetlands should be in place and functioning or otherwise guaranteed prior to wetland alteration.

d. The U.S. Environmental Protection Agency should conduct the following efforts as authorized under Section 404 of the Clean Water Act:

i. Designation of all South Bay seasonal wetlands under Section 404 (c) as wetlands the loss of which would have "an unacceptable adverse effect;"

ii. Undertake an advanced identification procedure to protect all important diked historic baylands, seasonal wetlands, and riparian habitat in the Bay Region; and
iii. Regulate all diked historic baylands of the Bay Region as waters of the United States.

e. Local County, Regional and Municipal governments within the Estuary Region should protect and enhance wetland and riparian habitats through implementation of the following measures:
i. Adopt general plan policies and zoning ordinances that protect diked historic baylands both for any existing seasonal wetland values as well as their potential for tidal restoration; ordinances should also be enacted which ensure the protection of riparian corridors;
ii. Mosquito abatement agencies should develop new techniques cooperatively with the California Department of Fish and Game and the U.S. Fish and Wildlife Service, and provide these techniques to private and public wetland managers as guidelines for enhancing seasonal wetlands while addressing vector control; and
iii. Lands controlled by local flood control districts should be managed to maximize their wetland characteristics; bank protection projects should be designed for maximum maintenance and enhancement of riparian habitat.

f. Federal, State and local regulatory agencies should require, when issuing permits, that an upland buffer be provided between wetland sites and any adjacent human uses such as public access paths or other developments. Buffer zones should be adequate to provide high tide cover if needed, as well as nesting, foraging and resting habitat for wildlife.

5. Enhancement and Protection of Delta Habitats

a. Legislation should be enacted to require the relevant State and Federal agencies and local governments to cooperatively develop, adopt, and implement a Delta protection and management program. This will promote a coordinated and consistent approach to Delta regional planning.

b. The functions of the California State Resources Agency or State Lands Commission should be expanded to include implementation of a Delta protection and management program. In this capacity, this agency would review plans, projects, and studies proposed for the Delta and monitor issuance of U.S. Army Corps of Engineers Section 10/404 permits.

c. Accelerated management of several Delta islands for wetland habitat enhancement should be pursued. This could be accomplished through the cooperative efforts of private landowners, the California Department of Water Resources, California Department of Fish and Game, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers, as well as through public acquisition. These efforts could include:
i. More precise management of water levels during normal agricultural flooding to improve conditions for waterbirds;

ii. Development of seasonal shallowly-flooded impoundments for wintering waterfowl, cranes, and shorebirds; and

iii. Creation of permanent freshwater marsh to provide year-around habitat and production areas for wetland-dependent wildlife; and

Techniques of implementation of these efforts could include:

i. Construction of interior cross dikes;

ii. Installation of water control structures; and

iii. Complete or partial tidal restoration, including if appropriate, placement of clean dredge spoils to raise elevations of island interiors.

d. Economic incentives should be made available to Delta landowners to encourage production of crops and land-use practices on Delta islands which benefit migratory and resident wetland-dependent wildlife. For example, protection and restoration of existing and potential wintering wildlife habitat values, particularly for wintering waterfowl and special status species such as the Aleutian Canada goose and greater sandhill crane, should be pursued. This may be accomplished through implementation of the Delta Mitigation Guidelines developed by the California Department of Fish and Game, or through economic incentives such as tax breaks and conservation easements.

e. Through the State Water Resources Control Board Bay-Delta Hearing process, adequate freshwater flows throughout the Delta should be maintained by the California Department of Water Resources, U.S. Bureau of Reclamation, and local and upstream diverters. These flows should satisfy the water quality and quantity needs of Delta farmers for irrigation and ensure the quality of water available to farmers during early fall through late winter. Any increase in soil salinities will adversely affect the ability to grow crops important to wintering waterfowl and to flood fields for insect and weed control. Such releases should also be adequate to maintain the null zone in Suisun Bay, and Suisun Marsh as brackish and freshwater habitat and to maintain seasonal spawning and nursery habitat for the Delta smelt.

f. Any use of State funds available under the Delta Flood Protection Act of 1988 (Senate Bill 34) for the maintenance of private levees should result in no net loss of fish and wildlife habitat, as required by the legislation, and where possible, should result in a habitat increase.

g. Additional economic incentives, such as conservation easements, should be created to encourage Delta landowners to establish buffer zones around the outer margins of their islands where emergent wetlands and riparian vegetation could be reestablished. Implementation of alternatives to riprapping of island levees should also be pursued.

II. SPECIAL STATUS SPECIES

A. Goal

Monitor, protect and restore populations of special status species, such as Federal and State-listed, and candidate species, species of special concern, colonial waterbirds, seabirds, raptors, and other identified declining nongame migratory birds.

B. Management Recommendations

1. Listed and Candidate Species

a. Substantial new funds and staffing should be provided to the U.S. Fish and Wildlife Service and the California Department of Fish and Game to:

- i. Monitor the status of all candidate species and list them if warranted; and
- ii. Update recovery plans as needed and implement all necessary recovery actions for listed species occurring within the Estuary study area; recovery implementation should emphasize those taxa which are exhibiting the greatest rate of recent population decline.

b. Predator control and habitat management efforts for all Bay Area **California least tern** nesting colonies should be adequately funded and staffed, as needed. Management efforts should also focus on expansion of existing colonies and exploration of alternate nesting sites. These efforts should be accomplished through cooperative efforts of the:

- i. U.S. Fish and Wildlife Service;
- ii. Department of the Navy;
- iii. California Department of Fish and Game;
- iv. Port of Oakland; and
- v. Pacific Gas and Electric Company.

c. Ongoing efforts to ensure protection of **California least tern** foraging areas adjacent to colonies (e.g., eel grass beds) from threats such as dredging, boat traffic, and pollution should be continued and considered in future U.S. Army Corps of Engineers and San Francisco Bay Conservation and Development Commission permitting actions.

d. Even with implementation of the tidal marsh restoration proposals discussed above, the U.S. Fish and Wildlife Service and the California Department of Fish and Game should develop a combined captive propagation program for the **California and light-footed clapper rails**, given the uncertain success and time required for marsh restorations to provide suitable habitat.

e. Hunting closures to protect wintering flocks of the **Aleutian Canada goose** in California should be continued by the California Department of Fish and Game until the subspecies is delisted.

2. Colonial Waterbirds

a. Predator populations should be monitored and control plans prepared and implemented as needed for all public refuges, reserves, and management areas within the Estuary, that support nesting colonial waterbirds.

b. During the course of Federal and State permitting for routine salt pond maintenance activities, regulatory incentives should be provided to Leslie Salt Company to enhance and create additional colonial waterbird nesting sites. Examples are the creation of pond dredge spoil islands, the severing of the land connections for interior salt pond cross dikes, and maintenance of adequate ponds water levels for predator exclusion during the breeding season.

c. Potentially disruptive human activities at seabird and waterbird colony sites on the major Bay bridges, other structures such as utility towers and navigational aids, the Alameda Naval Air Station breakwater, Alcatraz Island, and Brooks Island should be minimized through cooperative agreements or regulations, as appropriate, involving the:

- i. U.S. Fish and Wildlife Service;
- ii. National Park Service;
- iii. Department of the Navy;
- iv. California Department of Transportation;
- v. East Bay Regional Park District; and
- vi. National Audubon Society.

d. The U.S. Fish and Wildlife Service should commit resources to long-term monitoring of populations and breeding efforts of colonial waterbird and seabirds as well as maintaining the appropriate databases.

3. Raptors

a. Protection and restoration of existing and potential Swainson's hawk nesting trees and favorable cropping patterns should be encouraged. This may be accomplished through:

- i. Implementation of the Swainson's hawk mitigation guidelines developed by the California Department of Fish and Game;
- ii. Economic incentives such as tax breaks and conservation easements; and
- iii. State-initiated efforts to increase awareness within the agricultural community of the importance of riparian habitats and valley oaks for Swainson's hawks.

b. The Pacific Gas and Electric Company, Western Area Power Administration, and private wind power companies should modify any transmission and distribution towers/poles currently posing an electrocution threat to raptors and other birds through the installation of features such as:

- i. Insulator covers on transformers;
- ii. Perch guards; and
- iii. Pole top extensions.

c. Public and private resources should be committed for raptor breeding enhancement efforts to reestablish nesting pairs of bald eagles and osprey at locations within the Estuary where deemed appropriate.

4. Nongame Migratory Birds

The U.S. Fish and Wildlife Service should assume a higher agency profile and greater commitment in staff and financial resources to the monitoring and management of nongame migratory bird populations. This could be accomplished through developing and implementing a Nongame Migratory Bird Monitoring Plan which proposes population goals and objectives and outlines a cooperative Federal, State, local, and private population monitoring program. Under this plan, the Service would take the lead in:

i. Providing and generating necessary information on species life history, habitat requirements, limiting factors, and threats; and
ii. Identifying declining species before they attain special Federal or State status.

III. RESEARCH

A. Goal

Needed biological research on wildlife of the Estuary should be conducted; this information plus the results of other related studies should be made more readily available to both the scientific and general communities.

B. Management Recommendations

1. Gaps in Information and Knowledge

As discussed in Chapter 7 of the Status and Trends Report on Wildlife of the San Francisco Estuary, additional research relating to population dynamics, limiting factors, and habitat requirements considered necessary for the protection and recovery of special status species, waterfowl, shorebirds, colonial and seabirds, other wildlife, and their habitats should be pursued. Addressing these research needs will necessitate the enhanced participation of several federal and state agencies, local academic institutions, as well as private conservation organizations.

2. Centralized Estuary Wildlife Research Facility

A present limitation on biological research in the Estuary is the lack of a centralized office, agency, or clearing-house facility for wildlife research and habitat management activities. Such an office could either be designated among existing facilities or created through other possible funding sources. The function of this laboratory would be to house research results, assist with coordination among agencies and researchers by monitoring any ongoing studies and management efforts, and provide temporary support for academic research projects.

IV. PUBLIC EDUCATION AND INVOLVEMENT PROGRAM

A. Goal

Increase public awareness of and participation in ongoing efforts to protect and restore the wildlife populations and habitats of the Estuary.

B. Management Recommendation

In conjunction with other public involvement and monitoring efforts being pursued by the San Francisco Estuary Project, a well-coordinated, consistent public education and involvement program should be implemented. This program would eventually be included within the CCMP and encompass the following:

i. Develop a citizen's wildlife and habitat monitoring program;
ii. Provide for greater public participation in permit review and other actions by Federal, State and local agencies affecting wildlife and their habitats;
iii. Develop a handbook and provide educational material on habitat protection and enhancement for private landowners, developers, contractors, realtors, and business and industrial organizations;
iv. Fund and expand teacher training opportunities and curriculum in environmental education for grades K-12;
v. Increase Federal, State and local agency funding for wildlife interpretive centers; and
vi. Increase Federal, State and local funding to allow agencies involved with Estuary wildlife issues and legal system representatives, to hold regular interdisciplinary public conferences with the goal of developing a more coordinated approach to resource protection and management.