Regional Analyses of Restoration Planning

PART 2 – CALIFORNIA AND THE PACIFIC ISLANDS

ESTUARIES OF CALIFORNIA AND THE PACIFIC ISLANDS

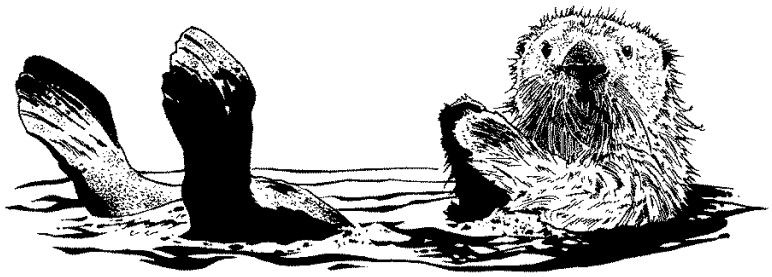
The California and Pacific Islands region is defined here as the northern and southern coasts of California, Hawaii and the Pacific Island/U.S. Pacific Protectorates, including Guam, American Samoa and the Commonwealth of the Northern Marianas (CNMI).

This region:

- Encompasses an area from latitude 15 degrees south to latitude 42 degrees north, and from longitude 117 degrees west to longitude 145 degrees west—a significant portion of the planet.
- Has subregions that are not only distinct from each other ecologically and politically, but as a whole are geologically and ecologically distinct from each other.
- Has lost 9,000 acres (33 percent) of intertidal habitat in the Humboldt Bay estuary (USFWS, 1992).
- Has lost 80 percent of the estuarine area in the Suisun Marsh, Calif. (USFWS, 1981).

SUMMARY

The California and Pacific Islands region covers a large geographic area comprising significant differences in the local extent of coastal and estuarine habitat as well as restoration efforts and planning. In the Pacific Islands, the fact that estuarine habitat is relatively rare makes that habitat uniquely critical to local ecosystem functions. In terms of restoration planning, San Francisco Bay produced the nation's first effort at what has become known as coastal zone management. The Southern California Wetlands Recovery Project is a partnership among 17 federal and state agencies working in concert with a public advisory committee, a science panel and task forces in five coastal counties. The Southern California Wetlands Recovery Project developed a regional restoration strategy that has been evolving over the past four years. In the Pacific Islands, very few plans exist for comprehensive restoration planning for estuarine habitats. This absence of planning is alarming because the populations of these islands are increasing at an extremely high rate and the majority of the populations inhabit the coastal areas. Several government agencies are gathering baseline data that would allow planning efforts to proceed.



INTRODUCTION

Description

For this discussion, the California and Pacific Islands region is defined as the northern and southern coasts of California, Hawaii and the Pacific Island/U.S. Pacific Protectorates.

The Northern California subregion encompasses the coast from the Oregon border to Point Conception, Calif. This subregion covers more than 800 miles of coastline. Because the northern coast is exposed to the Pacific current and cooled from the northern reach, it experiences cooler climates with higher rainfall than the rest of the state. The Southern California subregion includes the area from Point Conception southward to the Mexican border. This part of the coast is subject to a subtropical oceanic gyre that moves northward until it mixes with the cooler Pacific current at Point Conception. This phenomenon creates a warm and semi-arid Mediterranean-like climate unlike that of other parts of the region.

The United States affiliated Pacific islands discussed in this section are the state of Hawaii, the Commonwealth of the Northern Mariana Islands (CNMI) and the territories of Guam and American Samoa. All are tropical oceanic islands; however, they are widely dispersed across the Pacific. Hawaii lies near the edge of the tropics in the north Pacific Ocean and is the most isolated island chain in the world in relation to continental areas. Guam is the southern terminus of the Mariana Islands chain and the remainder are part of the CNMI. These islands lie near the equator in the Western Pacific Ocean. Guam is 3,800 miles west-southwest of Honolulu and 1,500 miles south-southeast of Tokyo. American Samoa is south of the equator in the central Pacific Ocean, approximately 2,500 miles southwest of Hawaii. A triangle formed by these locations encloses an area much larger than the continental United States, and any leg of this triangle is longer than the distance between New York City and Los Angeles.

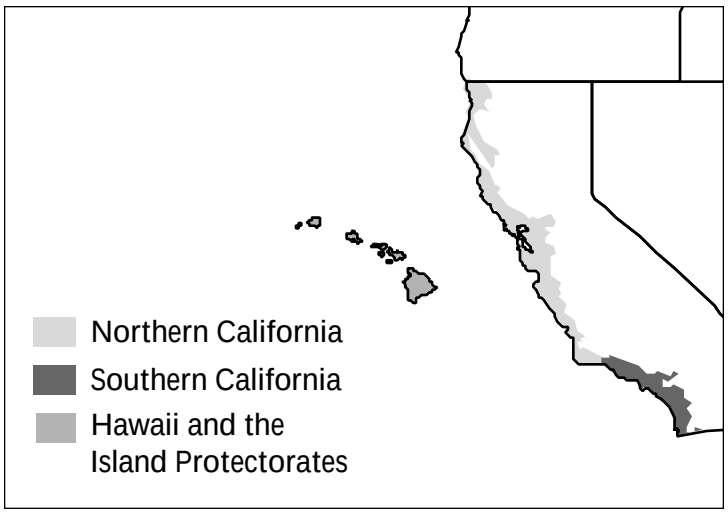


Figure 1. California and the Pacific Islands Region

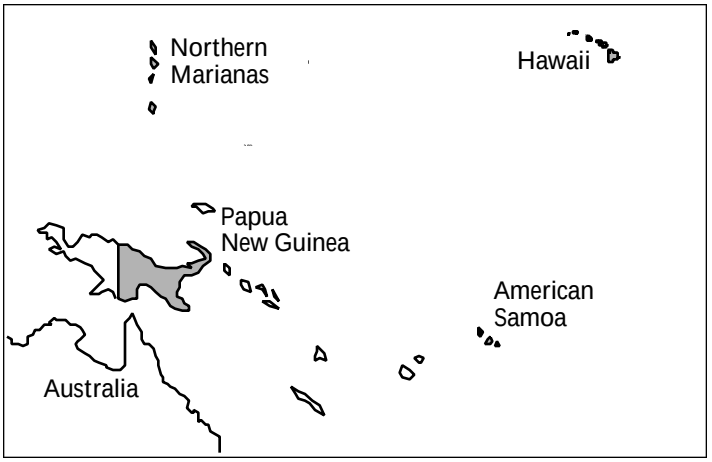


Figure 2. Pacific Protectorates Subregion

Key Habitats and Species

Key habitats within the region include salt, brackish and freshwater marsh; open water lagoon; seasonal wetland; tidal mudflat; beach and dune; upland and riparian habitat; salt ponds; and Hawaiian fishponds. These habitats and their need for restoration are based upon the frequency with which they were mentioned in the restoration plans reviewed. Habitats and the degree of restoration needed vary somewhat between subregions (see Table 1, next page).

Coastal and estuarine habitats within California and the Pacific Islands are designated as essential fish habitat for species managed by the Pacific Fishery Management Council and the Western Pacific Fishery Management Council, indicating that these habitats are necessary to support a sustainable yield from fisheries and to support a healthy ecosystem (NOAA/Pacific Fishery Management Council, 1998; Western Pacific Fishery Management Council, 1998). Many of the estuaries in the region directly support species of fish that are economically important because of their commercial and recreational harvest. These and other estuaries provide habitat for endangered and threatened species of fish and indirectly support important economic species by providing nursery habitat for prey.

The estuaries of California provide important habitat for a host of shore birds and wading birds, fish-eating birds, waterfowl and raptors. Many of these estuarine-dependent species are listed as endangered or threatened; consequently, the limited amounts of healthy estuaries provide critical habitat. Some areas within the region have a high incidence of endemic species, making healthy estuaries essential to

TABLE 1. ESTUARINE HABITATS IN NEED OF RESTORATION IN CALIFORNIA AND THE PACIFIC ISLANDS

Habitat	Northern California	Southern California	Hawaii	U.S. Pacific Protectorates
Tidal salt marsh and freshwater marsh	●	●	●	●
Submerged aquatic vegetation	▲	▲	❍	❍
Diadromous fish corridors	▲	▲	❍	❍
Coastal embayments	▲	▲	▲	▲
Shellfish reefs and coral reefs	▲	▲	●	●
Beaches and dunes	●	●	▲	▲
Intertidal flats	●	●	▲	▲
Salt ponds and salt pannes	❍	❍	❍	❍
Rocky shore and cobble beach	❍	❍	❍	❍
Wetlands	●	●	●	●
Mangroves	❍	❍	❍	●
Estuarine fish corridors	▲	▲	●	●

KEY: ● High need ▲ Moderate need ❍ Low or no need

their survival and regional biodiversity. Across the region, estuaries also play a critical function as resting and feeding areas along the Pacific Flyway (USFWS, 1996).

A number of species in California estuaries are either federally listed by the U.S. Fish and Wildlife Service, or have special state status as determined by the California Department of Fish and Game. Federal endangered species include fish (tidewater goby), mammals (saltmarsh harvest mouse), birds (light-footed clapper rail, California clapper rail, San Clemente loggerhead shrike, California least tern, California brown pelican), and plants (salt marsh bird's beak). Federal threatened species include fish (steelhead trout, chinook salmon, coho salmon, delta smelt, sacramento splittail), mammals (southern sea otter) and birds (marbled murlett, snowy plover). Many other species of estuarine fish, mammals, plants, invertebrates, reptiles and amphibians are listed as threatened or endangered by the state of California.

Invasive species are a serious problem in California estuaries. Invertebrates such as the Asian clam, various non-native algae including *Caulerpa taxifolia*, and plants such as peppergrass and smooth cordgrass are threatening the integrity of native habitats. In many cases, these species alter essential properties of existing habitats, and compete with California's native plants and animals. Many of California's listed species are suffering due to the presence of these invasive exotics.

While limited in extent, estuarine habitats in the Pacific Islands can be quite diverse. In Hawaii, brackish-water marshes, fishponds, anchialine pools and mudflats are the most significant estuarine habitats. In the other island areas, most estuarine habitat is mangrove forest. These habitats support a wide variety of invertebrates such as shrimp, crabs and mollusks. Wetland and coastal habitats also support a range of resident and visiting waterfowl, shore birds and seabirds. In addition, a very important group of organisms rely on estuaries to complete their life cycles—freshwater amphidromous fish (gobies), mollusks and crustaceans. These organisms have evolved from marine forms to inhabit freshwater streams in Hawaii, American Samoa, CNMI and Guam. These species live as adults and spawn in streams, after which the young float to the ocean and drift for weeks or months before returning to the streams as juveniles to continue the cycle (Swenson, personal communication).

California's Anadromous Fish Species

Anadromous fish, such as the coho, chinook salmon, steelhead trout, american shad, striped bass (an introduced species) and white sturgeon, require healthy rivers and associated tributaries for migratory routes, as well as for spawning and nursery grounds. Many of these fish pass through wetland, or shallow nearshore water (which have wetland and estuary influence) for survival during at least a portion of their lives. Most often, these areas are nursery grounds for young fish. The young fish benefit from the high food concentrations, shelter and vegetation that these areas provide. Some salmon and steelhead smolts use streamside wetlands for food and protection and then move to estuaries and fringing marshes for weeks or months as they grow and adapt to the salt water environment before moving out to sea. As adults, salmon and steelhead will

utilize the estuaries again for a brief time to feed before heading upstream to spawn. Other fish species use wetlands and estuaries for years at a time, while still others depend on nearshore environments for their whole lives.

Although salmon and steelhead historically used rivers and streams along the entire coast of California, the strongest remaining populations of anadromous fish typically occur in rivers near or north of San Francisco Bay, where 60 percent of California's annual rainfall occurs. The Klamath River, which drains a 12,000-square-mile watershed, is the second largest river in the state, after the Sacramento River. Other anadromous fish, such as striped bass and white sturgeon, mainly spawn in the Sacramento-San Joaquin Delta.

Many anadromous fish have shown significant population declines in the last decade. In 2000, only 1,352 winter-run chinook salmon migrated upstream in the Sacramento River, compared to an average of 35,000 from 1970 to1974 (see Figure 3). Many of California's salmon and steelhead are either threatened, endangered or candidates for listing under the Endangered Species Act (ESA) (see Table 2).

TABLE 2. STATUS OF SALMON AND STEELHEAD POPULATIONS* IN CALIFORNIA

Species Name	Population	Status
Oncorhyncus kisutch	S. Oregon/Northern California coho	T
	Central California coho	T
Oncorhyncus mykiss	Southern California steelhead	E
	Central CA Coast steelhead	T
	South-Central California Coast steelhead	T
	CA Central Valley steelhead	T
	Northern California steelhead	C
	Klamath Mountain Province steelhead	C
Oncorhyncus tshawytscha	Sacramento River winter chinook	E
	CA Central Valley spring chinook	T
	CA Coastal chinook	T
	CA Central Valley fall chinook	C

** These fish populations are those that are listed under the Endangered Species Act (ESA) as being in danger of extinction (E), threatened with becoming endangered (T), or as a candidate (C) for listing under the ESA. These population groupings, called Evolutionarily Significant Units (ESUs), are broad groupings that contain fish of many different stocks (e.g., fish that are adapted to return to specific rivers, often at a particular time of the year).*

Threats to California's Salmon and Steelhead Fisheries

Hydropower

Hydropower dams have dramatically altered flows and riparian habitat for a large number of rivers and streams. Dams and hydropower operations have modified the level, timing, frequency and duration of stream flows. Dams have blocked the movement of fish both upstream and downstream, de-watered stream segments below dams, caused loss of upstream habitat and increased predation in reservoirs.

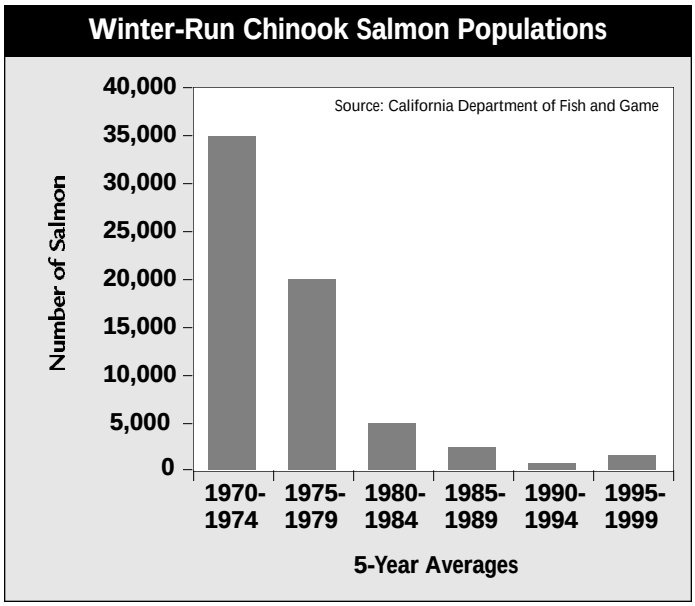


Figure 3. Winter-Run Chinook Salmon Populations

Smolt and juvenile fish migrating downstream through the reservoirs encounter slower moving water. By increasing the time it takes for them to reach the ocean, their chances of dying from predation and diseases increases as well. In addition, the absence or inadequacy of fish ladders or other bypass systems block or limit adult migration upstream, closing off many miles of potential spawning and rearing habitat.

Agricultural Practices

Agricultural practices that may adversely affect salmon include diking, draining, filling, stream channelization, removal of large woody debris, installation of riprap along stream banks, removal of riparian vegetation, road building, diversion of surface and ground water for irrigation and agricultural processing, and pesticide and fertilizer applications. Irrigated agriculture requires diversion of water, which reduces stream flows. In some years, this leaves little or no water for salmon and other aquatic species. Return flows, while perhaps increasing the amount of water in streams, degrade the water quality by rais-

ing its temperature and adding dissolved chemicals. Unscreened or improperly screened diversions can have devastating effects on juvenile fish.

Forest Practices

Forest management activities such as road building, timber harvests near streams or on steep or unstable areas, and the application of chemicals have damaged fish habitat and water quality. The most profound impacts include: increased stream temperature, diminished opportunities for large woody debris recruitment, alteration of groundwater and surface water flows (increased runoff and reduced percolation of rain and snowmelt into the ground), and degradation or loss of riparian habitats. These forest practices also resulted in lost or degraded spawning and rearing habitats, contributing to the ESA listing of some salmon runs.

Urbanization

Urban areas are frequently located in important salmon migration corridors and rearing areas. The areas most significantly affected by urbanization are small streams, riparian corridors and associated wetlands, shorelines and estuaries. Residential, commercial and/or industrial development changes the natural hydrologic cycle by stripping vegetative cover, removing and destroying native soil structure, modifying surface drainage patterns and adding impervious and nearly impervious surfaces, such as roads and other compacted soils. Loss of water in stream channels and riparian areas, due to water withdrawal and consumptive use of water from streams, rivers and aquifers, further reduces groundwater recharge.

Stream Flow Modification

Natural flow conditions have been affected through the diversion of water from streams for irrigation, municipal and industrial uses, water storage operations, and land use changes. Increases in the frequency and duration of both floods and low flows are having considerable detrimental effects on salmon.

Harvest

Harvest rates of adults in many fisheries can reach 50 percent to 80 percent of salmon populations, and though many salmon stocks can sustain this level of harvest, stocks that are challenged by poor productivity or poor ocean conditions cannot. In addition, size-selective gear, coupled with high rates of harvest of larger adults, can result in shifts toward younger, smaller adults with less ability to negotiate the challenges salmon face during their journey (e.g., large barriers) and with lower reproductive potential. Aside from the direct impact of commercial fishing on salmon populations, harvest also reduces the amount of dead salmon that contribute detritus to rivers. This detritus provides nutrients on which new generations of salmon depend.

Climate Change and Ocean Conditions

Climatic changes can affect the numerous physical, biological and chemical processes in the ocean that influence fish population dynamics and survival. Variations in sea surface temperatures, air temperatures, strength of upwelling, salinity, ocean currents, wind speed and ocean productivity have been shown to cause or correspond with fluctuations in abundance and survival of salmonid populations.

Habitat-Dependent Activities

The fisheries economy of California and the Pacific Islands is directly dependent on healthy estuarine habitats. In 1999, California recorded the landing of nearly 295,000 metric tons of fish, worth nearly $145 million. Landings of chinook salmon alone were valued at nearly $7.5 million. Similarly, recorded landings of all species in Hawaii were nearly 17,000 metric tons, worth $65 million (www.nmfs.noaa.gov).

In addition to the important function estuaries play in the coastal and marine ecosystem, they provide all the benefits to humans that terrestrial wetlands provide: water filtration and purification, aquifer recharge (e.g., help protect against salt water intrusion thereby protecting groundwater and drinking water), flood and erosion control, storm surge protection and areas for recreation.

In the Pacific Islands, estuarine habitats, particularly mangrove areas, are important to recreational and semi-subsistence fisheries. Although native to American Samoa, CNMI and Guam, mangroves are actually an alien species in Hawaii. Historically, preferred areas for human settlement and ocean access were at river mouths and semi-enclosed water bodies such as Honolulu Harbor on Oahu; Agana Harbor and the villages along the southern coastline of Guam; and Pala Lagoon on Tutuila, American Samoa.

Status and Trends

Throughout California and the Pacific Islands, introduction of exotic species, discharge of industrial pollutants, oil spills, filling of wetlands, application of fertilizers and pesticides, military administration of remote islands, and major land use modification to promote agriculture and forestry practices and urban growth have altered estuaries and their associated habitats. Table 3 summarizes some of the major past, present and future threats to estuaries in the California and Pacific Islands region. This table is not meant to be comprehensive but simply provides some key examples of threats in this region.

TABLE 3. KEY THREATS TO HABITATS AND SPECIES OF CONCERN IN CALIFORNIA AND THE PACIFIC ISLANDS

Threat	Northern California	Southern California	Hawaii	U.S. Pacific Protectorates
Direct habitat alteration				
Coastal development	●	●	●	●
Dredging	●	●	●	●
Filling	●	●	●	●
Tidal restrictions	●	●	▲	▲
Dams	▲	▲	❍	❍
Mosquito ditching	❍	❍	❍	❍
Nonpoint source pollution				
Urban runoff	●	●	●	●
Agricultural runoff	●	●	●	●
Pathogens	▲	●	▲	●
Aquaculture	▲	▲	❍	❍
Sewage/septic	▲	▲	▲	●
Toxins	●	●	●	●
Resource harvesting and extraction				
Forestry	▲	▲	▲	▲
Mining	▲	▲	▲	▲
Fisheries	▲	▲	●	●
Nuisance, exotic and invasive species				
Pepper grass	●	▲	❍	❍
Pampas grass	●	▲	❍	❍
Cape ivy	●	▲	❍	❍
Smooth cordgrass	●	●	❍	❍
Non-native predators	●	●	●	●
Mangrove	❍	❍	●	❍
Pickleweed	❍	❍	●	●
Pluchea	❍	❍	●	●
Marine algae*	❍	❍	●	●
Tilapia	❍	❍	●	●
Natural disturbance				
Ice scour	▲	▲	❍	❍
Sea level rise	▲	▲	●	●
Predation and grazing	▲	▲	▲	▲
Storms	▲	▲	▲	●
Sea temperature rise off the Calif. coast	●	●	❍	❍

KEY: ● High concern ▲ Medium concern ❍ Low or no concern

**Note that not all species of marine algae are considered a nuisance. Nuisance species include* Caulerpa taxifolia, *a green alga found in coastal lagoons and in the Long Beach harbor in southern California. This alga is fast growing and toxic to invertebrates, fish and other native algae. It is likely it was introduced to southern California by the aquarium trade. Another nuisance alga is* Unidaria sp., *a brown alga, discovered in Monterey Bay in 2001. This alga contributes to loss of biodiversity by taking over habitat utilized by other native alga and the invertebrates that feed on them.*

Habitat loss in California and the Pacific Islands has been extensive and appears to be increasing because of an ever-increasing pressure of development and population growth. Although the population of the metropolitan Los Angeles area grew by only 45 percent between 1970 and 1990, the urbanized area grew by 200 percent, and land use consumption grew by 300 percent (Hartmann, 2001). In San Francisco Bay, there were roughly 190,000 acres of tidal marsh before the mid-1800s. Today, only about 40,000 acres remain (San Francisco Bay Joint Venture, 2001). In southern California, estuarine wetlands have been eliminated by 75 percent to 90 percent as a result of filling or dredging in the last century (Ferren et al., 1995).

In the Pacific Islands, loss of estuarine habitats also has been significant. The state of Hawaii includes 54.8 square miles of estuaries, 43 percent of which fully support their designated uses, 56 percent of which are impaired by some form of pollution or habitat degradation and one percent of which are threatened for one or more uses (CWAP, undated). Filling of wetlands for development has resulted in the loss of 64 percent of Saipan's wetlands and one-quarter of American Samoa's wetlands (NOAA, 1999; USFWS, 1996).

Introduction of alien species is another major concern in the Pacific Islands and is a dominant threat to the islands' endemic species. Hawaii alone has 280 threatened or endangered species, more than any other state in the United States (USFWS, 1996).

Regional Planning Efforts

Within California and the Pacific Islands, restoration plans are primarily being implemented at the state level or subregional level as discussed below. One example of a planning effort with a regional focus is the Essential Fish Habitat Amendments. A description of this planning effort is provided below. A full listing of plans for the California and Pacific Islands region and additional informa-

tion can be found in the National Strategy Restoration Plan Database (http://restoration.nos.noaa.gov).

Essential Fish Habitat Amendments to the Sustainable Fisheries Act

The Essential Fish Habitat (EFH) Amendments were prepared by the Pacific and West Pacific Fisheries Management Councils and identify and describe essential fish habitats for the coastal pelagic and pelagic fisheries of the Pacific and west Pacific. Also included in the amendments is identification of adverse impacts from both fishing and nonfishing activities, and actions required to conserve and enhance EFH.

California and the Pacific Islands Subregions

For this analysis, the region has been divided into four subregions: two in California (northern California and southern California) and two in the Pacific Islands (Hawaii and the U.S. Pacific Protectorates).

The California coast is characterized by extreme geologic uplifting. In the central and northern areas of the state, coastal mountain formations have restricted the area of low-lying coastal plains and rivers that flow toward the sea, resulting in narrow, deep and steep-sided estuaries. The exception to this is San Francisco Bay, which drains the rest of California. Lower-lying areas with more shallow estuaries characterize much of southern California. Southern California also has a distinct climate. This subregion is subject to a warm-water oceanic gyre and a related Mediterranean-like climate, whereas north of Point Conception, the coast is subject to the cooler Pacific current and a relatively cooler and damper climate (NOAA, 1990).

California is divided into two subregions to represent biogeographical distinctions as well as important regional planning efforts. Each subregion has a coastal zone management plan approved by the National Oceanic and Atmospheric Administration (NOAA). This indicates that the state and local land use plans are consistent with the mandates of the federal Coastal Zone Management Act.

The California Coastal Commission administers the state's coastal zone management under the authority granted by the 1976 Coastal Act. The Coastal Act sets state policy for the conservation and development of California's 1,100 miles of coastline, covering such matters as public access, coastal recreation, the marine environment, coastal land resources and coastal development. Under authority of the Act, each local government along the coast is to develop a local coastal program consistent with state policies. These programs consist of land use plans, zoning documents and other implementing actions. When a local coastal program has been approved by the Coastal Commission, regulatory authority reverts to the region; however, the Coastal Commission retains limited permitting authority, hears appeals and may issue orders for restoration of coastal resources and cease and desist orders for actions violating the Coastal Act. Although the overwhelming majority of the state is regulated under the Coastal Act, authority for coastal zone management in the San Francisco Bay area is delegated to the San Francisco Bay Conservation and Development Commission under the McAteer-Petris Act.

Major cities such as San Diego, Los Angeles and San Francisco are located near major estuaries and are either included in EPA's National Estuary Program (NEP) or designated as a National Estuarine Research Reserve (NERR). The Tijuana Estuary, in San Diego County, has been designated as a NERR. The Santa Monica Bay, in Los Angeles County, has been designated as a NEP. Morro Bay and the Elkhorn Slough in Monterey, both in the Northern California subregion, are designated as an NEP and NERR, respectively.

The Pacific islands include Hawaii, American Samoa, Guam and the Commonwealth of the Northern Mariana Islands (CNMI). Because the great distances between these areas are matched by differences in geology and biogeography, these island areas are divided into two subregions: Hawaii—which is ecologically distinct because of its isolated and borderline tropical location—and the remaining three entities. All these island areas feature steep relief both above and below water; there are no wide and shallow coastal shelves, and coastal plain is limited. Beyond fairly narrow fringing reefs, the reef face and basement rock drop off rapidly to considerable depths. As a result, the area suitable for estuarine habitats is very limited, with restricted occurrence at river mouths and along the shores of a few large embayments.

Northern California Subregion

Description

The Northern California subregion encompasses the coast from the Oregon border to Point Conception, Calif. This subregion covers more than 800 miles of coastline. Because the northern coast is exposed to the Pacific current and cooled from the northern reach, it experiences cooler climates with higher rainfall than the rest of the state.

This area has experienced significant geologic uplift and is typically characterized by dramatic topographical relief near the

ocean. This steep relief means that most of the coastal rivers have estuaries that are narrow and deep, with quite short reaches. However, the area also includes significant estuaries, such as San Francisco Bay, Humboldt Bay, Tomales Bay, Drakes Estero, Morro Bay, Eel River and Elkhorn Slough. These estuaries range in size from 452 square miles to one square mile of water surface area and total only 492 square miles (NOAA, 1990). For comparison, this total area is approximately 13 percent the size of the Chesapeake Bay. Nonetheless, these small areas provide critical habitat for numerous species listed as endangered or threatened and often draw large congregations of migratory birds.

Finally, the northern area does not have the overall population density that characterizes the southern area. Except for the San Francisco Bay urban areas, this subregion has relatively sparse populations, and land is typically used for forestry and agricultural purposes.

Among estuaries in this subregion, habitats include salt, brackish and freshwater marsh, mudflats, seasonal wetlands, eelgrass beds, diked baylands (including diked wetlands, agricultural wetlands, managed wetlands and salt ponds), beaches and dunes, open water lagoons, tidal channels, uplands and riparian areas.

Four major habitats make up California's coastal ocean ecosystem:

1. **Inland watershed zone:** Extends from the watersheds of the Sierra Nevada mountains to the California coastline. This zone includes 7,800 miles of rivers, creeks and drainages. Anadromous fish, coastal wetlands and nearshore waters are dependent on these waterways to provide freshwater flows.

2. **Enclosed waters zone:** Includes waters and habitats of bays, estuaries and subtidal areas. Freshwater originating from as far as the Sierra Nevada mountains mixes with saltwater from the Pacific Ocean. The bays and estuaries of northern California are dependent upon nutrient inputs from the inland watershed, nearshore ocean and offshore ocean zones for the maintenance of the organisms that reside, spawn or pass through these water bodies.

3. **Nearshore ocean zone:** Includes nearshore open coastal waters to a depth of 100 meters. This zone comprises over 1,100 miles of coastline, which extends from onshore areas such as sandy beaches, boulder fields and rocky outcroppings to an ocean floor depth of about 100 meters and the associated kelp bed and sandy and muddy bottoms. Waters of this zone are rich in nutrients from freshwater inflows and upwelling events. These waters maintain an abundance and diversity of organisms that support recreational and economic opportunities.

4. **Offshore ocean zone:** Extends from a depth of 100 meters to the edge of the Exclusive Economic Zone (200 miles offshore). Productive oceanographic factors, such as major ocean currents, stimulate biological productivity in both nearshore and offshore ocean waters. The California Current is a cold water current that originates north of California and moves southward along the coast, whereas the Davidson Current is a periodic, nearshore current that flows in a northerly direction, carrying warm waters from semi-tropical seas to southern California. Interactions between the flows of these currents create two distinct marine biological regions along the coast of California. The southern region, extending from the Mexican border to Point Conception near the City of Santa Barbara, is composed of warmer waters and primarily supports temperate- and warm-water fish and invertebrate species. The central and northern coastal region of California, extending from Point Conception to Oregon, contains colder waters and organisms adapted to such conditions. Another oceanographic factor influencing abundance and diversity of biological resources along California's coast is upwelling, the movement of deep ocean waters into shallower, nearshore areas. Upwelling provides essential nutrients needed to support vast populations of microscopic organisms collectively known as plankton. Plankton are a vital component of numerous food webs that support important fish, mammal and bird populations.

Kelp forests

Kelp forests connect the enclosed waters, nearshore, and offshore ocean zones described above. They are among the most productive and diverse ecosystems in the world, and they are a vital source of food for marine animals. Along the northern California coast the major kelp species are the giant kelp (Macrocystis pyrifera) and the bull kelp (Nereocystis luetkeana). Giant kelp forms dense beds in the Monterey Bay area from Cambria to Año Nuevo, except in the area between Monterey and Santa Cruz where the sandy substrate is unsuitable for kelp attachment. North of Santa Cruz, the bull kelp, which occurs from Point Conception northward (Abbott and Hollenberg, 1976; Miller and Estes, 1989), becomes the dominant canopy-forming kelp (Foster, 1982; Foster and Schiel, 1985).

Along the central California coast where the distributions of these two species overlap, giant kelp outcompetes bull kelp for

light. Giant kelp dominates areas of relatively low water motion and is dominant in years with relatively calm sea conditions. The shallow areas inshore of these kelp forests are often characterized by canopies of the feather boa kelp (Egregia menziesii), the intertidal giant kelp *(Macrocystis integrifolia)* and the Fucalean alga *(Cystoseira osmundacea)* (Foster and Schiel, 1985).

Various sea life such as turban snails, kelp crab and isopods, as well as herbivorous fish like the half-moon and the opal eye, graze on the plants directly. Other animals such as sea urchins, bat stars and abalone survive off residues of nutrient-rich drift kelp that sink to the ocean floor. Mature kelp beds contribute up to 30 percent to 40 percent of the net primary production. Filter feeding organisms living in or around the kelp bed derive much of their nourishment from the particulate and dissolved organic matter produced by kelps.

Some species of fish, such as the gopher and black-and-yellow rockfish, rely on the dense canopy for protection and sustenance during warm-water periods. Many juvenile fish (rockfish, senorita, kelp surfperch, blacksmith) spend the early parts of their lives in kelp forests, feeding on plankton concentrated there.

Harbor seals, California sea lions and the federally threatened southern sea otter feed on fish and invertebrates occupying the kelp forests. The sea otter also uses the kelp forest for refuge from predators and as a nursery area for raising pups.

Giant kelp is harvested commercially in both southern and central California, and in the mid-1980s, kelp harvesting supported an industry worth more than $40 million a year (Tarpley, 1992). Kelp was originally harvested as a source of potash for making gunpowder during World War I (Frey, 1971; Tarpley, 1992) but currently the emphasis is on the production of algin, which serves as an emulsifying and binding agent in food and pharmaceutical products (Frey, 1971) and food for use in abalone farms. Currently between 100,000 and 170,000 wet tons of kelp are harvested from California waters each year (Foster and Schiel, 1985; Tarpley, 1992).

In addition to harvesting, kelp forests provide an important source of recreational activities, which range from hook-and-line and spear fishing to sport diving and underwater photography. More is known about kelp forests in southern California and the Monterey Bay area than anywhere else in the world. However, knowledge is lacking on the kelp forests south of Carmel Bay and north of Santa Cruz, and many processes are still poorly understood (e.g., the effects of local fisheries on kelp forest fish populations).

Habitat Issues

Status and Trends

San Francisco Bay is the nation's first effort at what has since come to be known as "coastal zone management." This was spurred by dramatic losses from diking and filling and the recognition that development was slated for every available shallow water area, which would have left only deep-water shipping channels in the Bay.

Since 1850, more than half a million acres of wetlands in the San Francisco Estuary have been modified. In the delta, 97 percent of the original tidal wetlands have been converted to farmland or other uses. In the bay, 82 percent of the original tidal wetlands have been filled or converted to other wetland types (San Francisco Estuary Project, 1992). Approximately 95 percent of the San Francisco Bay's riparian habitat has been damaged or destroyed (San Francisco Bay Joint Venture, 2001).

Sonoma County has the least amount of protected open space: 25,500 hectares (63,013 acres) presently protected out of approximately 409,000 hectares (1,000,000 acres) of land (USFWS: Pacific Coast Joint Venture). In some areas of Morro Bay, 85 percent of the coastal dune scrub community has been converted to suburban or urban development (Morro Bay Estuary Program, 1999).

Threats

Many of the threats that gave rise to past concerns continue today. Among them are direct conversion and loss of habitat from draining, diking and filling. This includes, but is not limited to, conversion of land for agricultural use, urban development, salt ponds and flood control. Remaining areas face many threats, including:

- habitat fragmentation;
- severe sedimentation and erosion;
- point and nonpoint source pollution from adjacent land use (urban and agricultural runoff, storm drains, streams, boating activities);
- reduced tidal influence caused by accumulated sediments or construction of physical barriers;
- dredging and waterway modification;
- intense human activity;
- changes in the volume or timing of freshwater flows because of water storage, diversions and flood control, resulting in increased salinity, poor water circulation or habitat shifts in the estuary;
- invasion of non-native plant species such as pepper grass, pampas grass, cape ivy and smooth cordgrass, which have the potential to alter habitat structure and reduce popula-

tions of native plants and animals;

- invasion of non-native animal species such as the mitten crab, European green crab, New Zealand mud snail, New Zealand sea slug, American bullfrog, Asian clam and the common carp (for a complete list of troublesome species in the San Francisco Estuary, see www.clr.pdx.edn/nis/);
- introduction of non-native predators such as foxes, dogs and cats; and
- potential threats to kelp forests.

Due to its important habitat functions, kelp harvesting in large quantities may have local ecological effects by removing food, shelter, and important nutrients for large numbers of animals. The cutting and removal of kelp in large quantities can upset the balance of resident communities. Kelp also acts as a buffer, absorbing and dissipating wave energy, thus its removal can lead to increased erosion along the shore. Coastal development may cause an increase in the amount of runoff of fine silts and muds. This will increase the turbidity of the water, thereby affecting the amount of light entering the water and restricting the growth of kelp or having a direct smothering effect on the kelp. Dredging activities offshore may have the same effect.

Restoration Plans

Coastal Zone Management Planning

The San Francisco Bay Conservation and Development Commission (BCDC) and the Coastal Commission have responsibility for the comprehensive planning and management of California's land and water areas along the state's coastline. The BCDC developed the San Francisco Bay Plan and has been carrying out a coastal management program based on this plan.

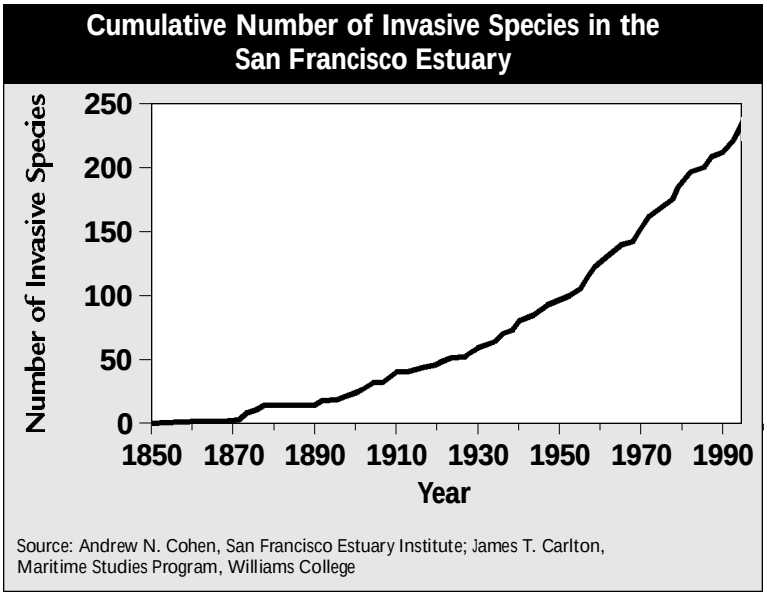


Figure 4. Cumulative Number of Invasive Species in the San Francisco Estuary

The plan was federally approved as a segment of the California coastal management program in 1977. San Francisco Bay and its shoreline continue to be managed under the plan as administered by the BCDC and other state agencies.

San Francisco Bay National Estuarine Research Reserve

The proposed San Francisco Bay National Estuarine Research Reserve encompasses 4,200 acres of California's protected estuarine lands and waters. The reserve management plan was prepared in 2001, and it is expected that the reserve will be designated in late 2001 or early 2002. Important habitats in the proposed reserve that may be useful for investigation and as reference sites include historic saline and brackish tidal marsh, live oak woodlands, coastal scrub and seasonal palustrine wetlands. Restoration priorities include exotic species control, hydrological restoration, prescribed burning and erosion control. Current restoration projects include native species reintroduction, erosion control and prescribed burning.

Morro Bay Comprehensive Conservation Management Plan

The watershed communities of Morro Bay, Los Osos, Baywood, Cuesta-by-the-Sea and Chorro Valley worked together to develop the Morro Bay Comprehensive Conservation Management Plan (CCMP), which is administered under the Morro Bay National Estuary Program. The CCMP addresses seven priority problems causing harmful impacts to the Morro Bay Estuary. Through the development of 61 action plans based on information from scientific studies, the CCMP aims to sustain existing wildlife resources and environmental quality.

Comprehensive Conservation Management Plan for the San Francisco Estuary

The San Francisco Estuary Project, jointly sponsored by the EPA and the state of California, is a public-private partnership that developed the Comprehensive Conservation Management Plan for the San Francisco Estuary. This plan presents a blueprint to restore and maintain the chemical, physical and biological integrity of the bay and delta.

Elkhorn Slough Watershed Conservation Plan

The Elkhorn Slough Watershed Conservation Plan is administered by the Elkhorn Slough Foundation and The Nature Conservancy and was developed to identify and address threats to Elkhorn Slough and to maintain its long-term viability as a significant coastal system. This plan recommends continuation of other federal programs, such as the Natural Resource Conservation Service's Elkhorn Slough Watershed Project.

Elkhorn Slough National Estuarine Research Reserve

The Elkhorn Slough National Estuarine Research Reserve was established in 1980 and currently encompasses 1,385 acres of California's protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1985 and is currently being revised. Important habitats that may be useful for investigation and as reference sites include coastal prairie, oak woodland, coastal scrub, freshwater wetlands and ponds, salt marshes and mud flats. Restoration priorities include monitoring for new invasive species, exotic weed control, aquatic habitat restoration, and replanting grasslands, oak understories and marsh-to-upland transition zones with native species. Current restoration projects include the development of a comprehensive vegetation restoration and management plan, coastal prairie and oak woodland restoration, invasion detection and exotic species control.

Baylands Ecosystem Habitat Goals

Baylands Ecosystem Habitat Goals was developed by a group of representatives from a number of federal and state agencies in support of the San Francisco CCMP. This report identifies types, amounts, and distribution of wetlands and related habitats needed to sustain diverse and healthy communities of fish and wildlife and provides a guide to the regional wetlands planning process.

Restoring the Estuary: Implementation Strategy of the San Francisco Bay Joint Venture

Restoring the Estuary: Implementation Strategy of the San Francisco Bay Joint Venture was developed and adopted to help the San Francisco Bay Joint Venture (SFBJV) partners reach their shared habitat objectives by working from what has already been accomplished and planning for the future. The SFBJV is based on both the San Francisco Bay CCMP and the Baylands Ecosystem Habitat Goals. The CCMP calls for the formation of a joint venture to increase the acreage of wetlands permanently protected in the estuary, and the goals outlined in the strategy are based on the findings and recommendations of the Baylands Ecosystem Habitat Goals.

Plan Elements

Goals

An overriding goal is to approach restoration on an ecosystem basis. Some of the specific goals outlined in restoration documents focus on increasing and preserving the quality and diversity of habitat and living resources within the estuaries; removing invasive non-native plant species, and protecting habitat from the invasion of non-native predators and other exotic species competing for the remaining habitat. Non-native plant removal and control is often followed by efforts to replant areas with native species such as pickleweed, eelgrass, arrowgrass and native cordgrass. Enhancement of water quality involves reducing point and nonpoint source pollution and debris, restoring tidal influence and limiting the discharge of harmful sedimentation.

An example of a crosscutting issue in the San Francisco and Humboldt Bays is the removal of invasive eastern cordgrass, which pushes out native cordgrass and, over time, fills deepwater channels with sediment. Eastern cordgrass has the potential to spread coast-wide, and its eradication is taking on regional and local implications. Finally, plans speak to the need for regional planning and ongoing monitoring and maintenance. Critical to monitoring, maintenance and future restoration planning is the need for developing a widely accepted, standard method for measuring the success of restoration projects.

Methods

The Northern California subregion's plans most commonly recommend implementing best management practices to reduce pollution, erosion and sedimentation from adjacent land use, and offering incentives and assistance to private landowners to do the same. Maintenance of water quality and habitat also is specifically addressed by repairing gullies to reduce erosion in adjacent areas (techniques include constructing checkdams and installing headcut and nickpoint protection), as well as seeding and planting annual and perennial grasses and riparian vegetation to help stabilize soil and prevent erosion. Also, removing debris and eradicating invasive plants that contribute to harmful sedimentation are methods for unblocking channels and streams. In agricultural areas, plans call for preventing livestock grazing by installing fencing in sensitive erosion sites. Where appropriate, plans specify eradicating invasive exotic plants and replanting native wetland vegetation. Public involvement is recommended through public outreach and education activities (e.g., workshops, meetings, reports, brochures and interpretive signs), as well as efforts to design public access that is compatible with and sensitive to environmental needs.

Elements of Success

Many of the plans address the need for good coordination and cooperation between agencies and private landowners. The Baylands Ecosystem Habitat Goals highlight the importance of complete site information and rigorous evaluation of each site's suitability for its proposed project. Careful consideration of such factors as the site's water and sediment supplies, historical drainage patterns and current and future uses of adjacent lands is an important element of regional and site-specific success.

Site plans also emphasized the need for adequate funding to complete projects and provide for long-term monitoring and maintenance.

Information Needs

Information needs cited in several plans highlight the importance of a comprehensive, watershed-wide, ecosystem approach to restoration and future maintenance. Information needed on a global scale is further research on the potential effects of sea level rise. On a regional scale, examples include a better understanding of the estuarine habitat needs of anadromous fish, the migration patterns of waterfowl and shore birds, the interaction between agricultural and forestry practices and waterfowl use in coastal lowland pastures, and listing the species of fish and wildlife most affected by ecosystem fragmentation. Regional planning also would benefit from a better understanding of water quality issues that would come from studying circulation and dispersion of pollutants in bay ecosystems.

An example of a habitat-specific need is to gain better understanding of tidal marshes. For instance:

- What are the effects of tidal marsh on the sediment budget and tidal prism?
- How does the form of tidal marsh channels vary with salinity?
- What factors affect the evolution of mudflats and tidal marsh features?
- What is the effect of tidal marsh on nutrient supplies to the bay?
- What species comprise the tidal marsh fish community?

Effective planning also requires a better understanding of several controversial topics, including potential uses and availability of dredge material for wetlands restoration, potential reuse of wastewater in creating or improving habitats, disposal of concentrated waste products from salt ponds, and the potential use of created wetlands to treat stormwater runoff. Plans also discuss the pros and cons of public access and balancing public access with natural resource protection.

Finally, more work is needed to develop a widely accepted standard method for measuring the success of restoration projects. An example would be determining the appropriate scale to measure shoreline loss or gain.

Southern California Subregion

Description

The physical features, climate and hydrology of coastal southern California have produced a diversity of plants and animals and a set of unusual conditions that sharply distinguish the region from any other in North America. Unlike the broad, gradually sloping coastal plains of the Atlantic and Gulf coasts, southern California has steep, rugged coastal mountains that descend sharply to the ocean where the underwater topography mirrors that of the craggy, exposed land. Warmer waters from the south meet chillier waters from the north. Summers are hot and dry in this semi-arid, Mediterranean-like climate, while the winters are cool with torrential downpours. The San Gabriel and San Bernardino Mountains can experience more rain in a twelve-hour period than anywhere else in the continental United States. The rains cut numerous short, steep river channels, which, especially in years of fire, can carry large sediment loads to the region's lagoons and estuaries (Potter, personal communication).

A more arid climate and less elevated topography in direct proximity to the shore also create conditions for estuaries that differ significantly from other subregions. Most estuarine areas here are more heavily influenced by marine water than larger estuaries such as the San Francisco Bay. However, irregular, heavy rains can inundate coastal wetlands, and the species associated with these areas are uniquely adapted to rare but heavy freshwater flows (Fancher, personal communication).

Habitats in the Southern California subregion include salt marsh, open water lagoon and tidal channel, seasonal wetland, tidal mudflat, brackish and freshwater marsh, upland and riparian, beach and dune. Estuarine-dependent species in this region are too numerous to list here. However, there are more species listed as threatened or endangered in southern California than in any other region of the state. Listed species include fish (e.g., steelhead trout, tidewater goby, California halibut), birds (e.g., Belding Savannah sparrow, California least tern, clapper rail, snowy plover), plants (salt marsh bird's beak, southern tarplant), insects (salt marsh wandering skipper, Dorothy's El Segundo sand dune weevil), mammals (Pacific little pocket mouse and salt marsh shrew), reptiles (southwestern pond turtle) and amphibians (silvery legless lizard).

In short, the dramatic historical loss of healthy habitat and the associated loss of species make restoration efforts vitally important. However, given the projected rate of coastal population growth, restoration may prove more challenging in the future.

Habitat Issues

Status and Trends

Estuaries in coastal southern California are comparatively small and precious, given the region's narrow coastal shelf and semi-arid climate. But with 8.7 percent of the state's landmass and almost 50 percent of the state's population, coastal southern California has experienced an even greater loss of wetlands than the entire state, which has lost a greater percentage of its wetlands than any other state (National Research Council, 1992). The five counties of coastal Southern California are home to 16 million people; more people than all but two states (New York and Texas) and more people than the 15 least populous states combined. A full 25 percent of the nation's coastal population (those within 50 miles of the coast) lives in southern California (NOAA, 1990).

This ever-increasing population requires housing, flood control, transportation infrastructure, and economic development, all of which have encroached upon and degraded wetlands and streams. The region has a radically altered hydrology, with more flood control dams (227), more debris basins (193), and more concrete channels than any other region in the country. It is the only major region where storm drains carry runoff directly to the ocean rather than through sewage treatment plants, which accounts in large part for the 150 beach closures that occurred in southern California during the summer of 2000, undermining a tourism and recreation industry worth over $7 billion annually to the region. Its network of highways and freeways is unparalleled and the Los Angeles/Long Beach port complex is three times larger than the next largest in the country and the third largest port facility in the world. With a gross regional product of $500 billion, the region has the 12th largest economy in the world. All of these factors have led to the loss and degradation of the region's coastal wetlands (Potter, personal communication).

To quantify the loss of wetlands in the subregion, researchers have compared historical geological surveys to present-day surveys. However, because the historical surveys did not differentiate by specific subhabitat types (e.g., mudflats, salt pannes, low salt marsh), the loss of habitats of concern is not reliably quantifiable. Moreover, radically changed conditions sometimes make restoration of historical habitat types impossible. In this sense, the dramatic decline of every habitat complicates regional priority setting. Restoration efforts are further complicated by the broad array of endangered and threatened species. For instance, restoration of habitat for threatened shore birds may inadvertently attract threatened falcons, which feed on shore birds (Fancher, personal communication).

The following statistics provide some indication of the extent of lost habitat in the southern California subregion.

- Southern California's coastal wetlands have declined from approximately 53,000 acres to 13,000 acres (Hartmann, 2001).
- Southern California's estuarine wetlands have been eliminated by 75 percent to 90 percent as a result of filling or dredging in the last century (Ferren et al., 1995).
- An estimated 95 percent of the historical wetlands acreage of the Santa Monica Bay watershed has been destroyed (Santa Monica Bay Restoration Project, 1994).
- An estimated 55 percent of the animals and 25 percent of the plants designated as threatened or endangered depend on wetland habitats for survival (Hartmann, 2001).

Threats

In addition to the dramatic losses listed above, there is the threat of additional habitat loss associated with urban expansion and direct conversion (e.g., dredging and filling, constructing dikes). Reduced tidal influence, changes in the volume and timing of freshwater flows, habitat fragmentation, invasion by non-native vegetation and predator animals (e.g., domestic dogs and cats), disturbed patterns of erosion and sedimentation, subsidence from oil extraction, and disturbances from human traffic are all significant threats. Remaining estuarine systems and the associated habitat also are degraded due to point and nonpoint source pollution from adjacent land use. Pollutants include, but are not limited to, pesticides and other toxins, bacteria, heavy metals, excess sediments and nutrients, and pathogens.

Restoration Plans

California Coastal Management Program

The California Coastal Management Program was developed to provide effective resource management by protecting, maintaining, restoring and enhancing the resources of the coastal zone. California coastal zone management (excluding the San Francisco Bay area) is administered by the California Coastal Commission under the authority granted by the 1976 Coastal Act. The California Coastal Management Program is a combination of federal, state and local planning and regulatory authorities for controlling the uses of land, air and water resources along the coast.

Southern California Wetlands Recovery Project

The Southern California Wetlands Recovery Project (SCWRP) is a partnership among 17 federal and state agencies working in concert with a public advisory committee, a science panel and task forces in five coastal counties. Southern California has a

draft regional restoration strategy that has been evolving over the past four years and will be formally adopted by the governing board of the SCWRP on November of 2001. The regional restoration strategy establishes a framework for preserving and restoring coastal wetlands; preserving and restoring stream corridors and wetlands in coastal watersheds; recovering habitat and species diversity; advancing the science of wetland restoration in southern California; promoting education and compatible access related to coastal wetlands and watersheds; and integrating wetland recovery with other public objectives.

Santa Monica Bay Restoration Plan

The Santa Monica Bay Restoration Plan was produced by the Santa Monica Bay Restoration Project as a result of being nominated and accepted as a National Estuary Program. The plan serves as a comprehensive blueprint for the bay's recovery and as a guide to dealing with management issues such as interagency coordination, resolution of conflicting or redundant resource management approaches and resolution of conflicting policies among jurisdictions. This plan is composed of six sections that deal with major issues affecting the bay, including restoring, protecting and managing habitats and resources.

Tijuana River National Estuarine Research Reserve

The Tijuana River National Estuarine Research Reserve was established in California in 1982 and currently encompasses 2,513 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1999. Important habitats that may be useful for investigation and as reference sites include uplands, coastal sage, saltwater marsh, mud flats, dunes and beaches. Restoration priorities include sediment and flood control of upstream areas and salt marsh restoration designed to increase endangered species habitat. Current restoration projects include completed and planned large-scale salt marsh restoration as well as upland, dune and riparian restoration projects.

Plan Elements

Goals

Site restoration plans in the Southern California subregion uniformly focus on increasing habitat values for fish and wildlife and restoring or enhancing native vegetation such as pickleweed and native cordgrass. Under these general principles, specific goals include maintaining water quality through better pollution control, improving the volume and timing of freshwater flows, and restoring tidal influence. Plans also call for long-term maintenance and monitoring of sites to help assess and ensure effectiveness, as well as adaptive management to account for changes in natural dynamics and scientific knowledge. Several plans also mention restricting human intrusion and providing buffer zones to limit human disturbances.

Methods

To meet the restoration goals of site plans, planning documents specify restoration methods. For instance, mechanical breaching or dredging is planned to improve or create tidal influence; grading or filling is recommended to recontour the area for improved water circulation and created habitat. Occasionally, improved water circulation and tidal influence demands rerouting existing infrastructure, such as roads and bridges. Also, ensuring stable bottom contours and shore areas requires control of sediments; for example, constructing sediment basins and stabilizing upstream banks through planting or embankment structures.

Often plans identify the need for removal of invasive plant species followed by replanting with native species. Water quality also is addressed to reroute or treat stormwater drainage and runoff. Some plans call for enhancement or creation of specific habitat for threatened or endangered species.

Elements of Success

Site plans rarely discuss elements of success. The Science Panel of the Southern California Wetlands Recovery Program, however, is developing monitoring protocols to better assess the success of individual projects and of the wetland recovery program region-wide. Public involvement through education and cooperative planning also is emphasized. Ultimately, success is dependent on ongoing regional planning, which is emphasized by the collaborative efforts of the Southern California Wetlands Recovery Project. The plans also focus on a watershed-wide approach to restoration and ecosystem management. Finally, managers often point to the need for a long-term monitoring strategy to ensure implementation and effectiveness, as well as a maintenance strategy that involves adaptive management.

Information Needs

Information needed might be characterized as global, regional or local. For instance, on a global scale, more information is needed regarding impacts associated with global warming and sea level rise. On a regional scale, further research is needed on the chemical and biological processes that control the transfer, fate and toxicity of toxic chemicals; effective means to identify the sources of chemical and bacteriological pollution; and beneficial uses for flood control and dredge spoil sediments. Regional policy needs to address the underlying causes of urban sprawl, standardized methods for measuring the success of restoration projects, and the role of mitigation banks in

helping to accomplish restoration goals. Finally, local research needs to be done on the role tidal creek networks play in the development of wetland habitats in the Tijuana estuary. Considering the overwhelming and urgent need to preserve and restore the limited resources of the Southern California subregion, an overriding question is whether to focus on "quality or quantity." Large sites may offer the best opportunity for overall biodiversity, but small sites may serve the critical function of "stepping stones" for migratory birds or may be unique and critical to the survival of certain species.

HAWAII SUBREGION

Description

The island chain of Hawaii was formed as the Pacific tectonic plate moved northwest over a "hot spot" where, during many millennia, volcanic activity produced a series of high islands. The eight principal islands of the Hawaiian Archipelago are progressive in age, with active volcanoes at the southeastern end on the Big Island and older, inactive and highly eroded volcanoes on Kauai Island to the northwest. The island chain continues with a series of pinnacles, atolls, banks and seamounts representing progressively older and more weathered products of the hot spot. Rugged topography and an impressive range in elevation (from sea level to 4,180 meters [13,794 feet]) interact with a climate regime, resulting in significant spatial variation in rainfall. This produces diverse terrestrial environments (Scott, 1993; Maragos, 1998).

Hawaii's topography results in relatively limited, although biologically important, estuarine habitat. Coastal wetlands of Hawaii provide important wintering habitat for migratory waterfowl and shorebirds. Since the Hawaiian Islands are so isolated, another important characteristic is the high level of endemism. About 10,000 Hawaiian species have been identified as endemics, including 85 percent of birds, 89 percent of flowering plants and 99 percent of snail and insects (USFWS, 1996).

The Hawaiian Islands generally exhibit extremely steep relief and narrow coastal plains. Steep relief continues underwater so that shallow coastal areas are limited; depths can reach more than one thousand feet just a few hundred yards offshore. Rainfall, and consequently stream flow, is low and often intermittent on leeward sides of the islands. As a result, these islands do not have developed river deltas, sheltered embayments are few and shallow coastal habitat is limited.

Limited estuarine habitats are found along the shore of large embayments such as Pearl Harbor and Kaneohe Bay on Oahu, and Hilo Bay on the east coast of the island of Hawaii. Small estuaries also occur at river mouths on all islands and areas of offshore groundwater discharge, primarily on the island of Hawaii, where porous lava rock limits surface flow. Fishponds built by native Hawaiians in the pre-contact period (most common along the south coast of Molokai) are largely abandoned today and may also be considered estuarine (Kirch, 1998).

Anchialine pools, which occur mostly on the south coast of Maui and the west coast of Hawaii, are unique habitats where porous rock allows a subsurface connection to the sea. Salinity is generally marine except for a brackish surface layer. Coastal ponds may be brackish and are important waterfowl habitat. Although considered estuarine in other regions, seagrass beds are largely marine and found on inner reef flats. Mangroves (*Rhizophera mangle* and *Bruguiera gymnorhiza*) were intentionally introduced on Oahu and Molokai in the early 1900s and subsequently spread into estuarine areas. They have colonized estuarine habitats where introduced, taking over brackish mudflats and coastlines in Hawaii and displacing native plants, shore birds and wading birds that would otherwise occupy these areas (Scott, 1993; Maragos, 1998).

Habitat Issues

Status and Trends

Historic losses of native habitats are associated with mining of guano, introduction of alien species, military administration of remote islands, and major land use modifications to promote agriculture, forestry practices and urban growth. The U.S. Fish and Wildlife Service estimate of coastal plain wetlands around 1980 in this subregion is 15,474 acres—a decrease of 31 percent over a 200-year period (USFWS, 1996). Relatively large estuarine areas have been lost to development. The tourist center of Waikiki, for example, was developed by draining and filling coastal wetlands and estuaries. Oahu, which supports approximately 80 percent of the state's population, has more significant wetland loss than the other islands; however, rapid growth and expansion of the tourist industry are a constant threat to the coastal resources of all the main islands (USFWS, 1996). Harbor development, for both military and civil uses, has destroyed or degraded estuarine areas, as exemplified by coastal development in Pearl Harbor. Channel dredging also has eliminated estuarine habitats in some areas. Diversion of stream water for agriculture historically changed coastal salinity regimes in some areas, notably Kaneohe Bay on Oahu, reducing estuarine habitats.

Threats

Introduction of alien species has especially severe impact on Hawaiian ecosystems because of the islands' unique, largely endemic biota. Alien plants—notably mangrove and pickleweed—and alien fish (e.g., mosquito fish) have displaced native species. Introduced mongoose, rats, pigs, dogs and feral cats prey on waterbird eggs. Water quality at the watershed level is a second major concern. For example, Manoa Stream, which flows into the now severely degraded Ala Wai Canal estuary bordering Waikiki, is heavily contaminated by lead and certain organic chemicals. More generally, sedimentation and nutrient loading caused by some land uses can harm coastal ecosystems, including estuaries. The cessation of sugar cane production in central Oahu led to calls (and eventually litigation) by environmentalists to return diverted water to streams on the windward (northeast) side of the island, many of which flow into Kaneohe Bay. These efforts were partly successful, with a return of some of the diverted water to windward streams.

Restoration Plans

Hawaii Coastal Management Program

The Hawaii Coastal Management Program guides government activities related to the protection, preservation and development of Hawaii's natural, cultural and economic coastal resources. A network of seven agencies implements the program, led by the Hawaii Department of Planning and Economic Development. The Hawaii State Plan coordinates the state's planning process through functional plans, agencies and departments, boards, commissions, and county general and development plans. A number of government agencies implement the state and functional plans.

Environmental and Enhancement Plan for Pouhala Marsh, Oahu, Hawaii

The Environmental and Enhancement Plan for Pouhala Marsh, Oahu, Hawaii was a cooperative effort of the Hawaii Division of Forestry and Wildlife, the USFWS, the City and County of Honolulu and Ducks Unlimited. This plan addresses the need to secure and restore nearly 70 acres of wetlands in Pearl Harbor's West Loch.

Aside from the Hawaii Coastal Management Program, there has not been a concerted effort to coordinate with federal activities in restoration planning on a state-wide level. In fact, there has been limited state wetland management, planning and coordination, as well as a lack of state-wide wetlands policies to guide restoration efforts.

The state of Hawaii has very little comprehensive conservation and management planning for estuarine habitats. Very few plans have been developed for restoration of estuarine habitats at a regional or watershed level; those that have been developed usually respond to a specific request or problem. Many relate to mitigation projects, such as the Final Restoration Plan and Environmental Assessment for the May 14, 1996 Chevron Pipeline Oil Spill into Waiau Stream and Pearl Harbor, Oahu, Hawaii.

Plan Elements

Goals

Restoration goals outlined in the few documents available focus on protecting and enhancing the limited estuarine habitat that exists in this region. In particular, restoration activities are pursued to restore essential habitat for a number of endangered or threatened species. Restoration goals also focus on the use of the natural, cultural and economic resources that estuarine habitats provide.

Methods

In the few plans reviewed, several methods have been outlined for reaching the state's restoration goals. These methods consist of three components: economic, cultural and ecological. The methods include designation of habitat as sanctuaries and refuges and intensification of management and development of those areas; acquisition of habitat by fee or long-term lease to prevent alteration or conversion to other uses; removal of excess vegetation and landfill; and discontinuation of sewage discharge.

Elements of Success

The plans that have been developed rarely discuss elements of success but do acknowledge a need for coordination and cooperation among public and private organizations and agencies. Most plans also mention the need for monitoring and assessment of baseline conditions.

Information Needs

Data and information on the status of wetlands and estuarine habitats in Hawaii are needed. There is a significant shortage of baseline data, sustainable capacity data and resource value data for many resources and geographic areas of the state. Basic data on the location and various functions of wetlands are lacking, as are maps showing all regulated wetlands in Hawaii. However, the U.S. Fish and Wildlife Service's National Wetland Inventory group is planning to update the wetland maps for Hawaii.

Pacific Protectorate Subregion

Description

Guam and the Commonwealth of the Northern Marianas (CNMI) are part of the same island arc, which was formed by volcanism and uplifting along the converging edges of the Pacific and Philippine tectonic plates. For this reason, although they are politically distinct, they are treated together in this discussion. Population is concentrated on the southern islands of Guam, Rota, Tinian and Saipan. The islands north of Saipan are isolated, small and essentially uninhabited. Several are volcanically active. Their geology is a mix of upraised limestone features and material derived from volcanism. Raised limestone is highly porous. Streams in these areas are either nonexistent or ephemeral. As a result, most estuarine habitats occur on the southern part of Guam, which is mountainous and volcanically derived. The main habitats are mangroves and lower river channels. The largest mangrove stand in the Mariana Islands (approximately 85 acres) occurs at Sasa Bay in inner Apra Harbor. Smaller stands occur elsewhere in Apra Harbor, along the southern coast of Guam, and the west coast of Saipan. Mudflat or reef flat on the seaward mangrove margin may be included as estuarine habitat. Aside from mangrove areas in Apra Harbor, additional estuarine habitat can be found in the island's largest watershed in lower Talafofo River valley on Guam's southeast coast. Brackish water extends about one mile upstream from the river mouth. Other estuarine habitats include limited marshland located on the interior to mangroves and river mouths. Saipan has an extensive lagoon, which is influenced by the freshwater drainage along the western side of the island. It contains the largest area of seagrass habitat in the CNMI and probably in all of the Marinas (Scott, 1993; Maragos, 1998).

American Samoa consists of five high islands, the largest of which is Tutuila, where most of the population is concentrated. Aunu'u is less than a mile from Tutuila. The Manu'a group, consisting of Ofu, Olosenga, and Ta'u, lies 60 miles to the east. These islands are volcanic in origin and generally very rugged. Rose Atoll, a national wildlife refuge, and privately owned Swains Island (a raised atoll) are smaller and relatively isolated, lying to the southeast and north respectively. There are extremely limited estuarine habitats in American Samoa, and these are primarily located on Tutuila, with mangrove forest being the predominant habitat type. (The enclosed lagoon at Swains Island contains some brackish water marsh.) Mangroves reach their eastern limit in Samoa, and no mangroves occur in the Manu'a group. Streams are relatively abundant on Tutuila but tend to be small and short (generally less than two miles). There are sheltered bays on Tutuila but, as with Pago Pago Harbor, they may be quite deep, limiting estuarine habitats. The most significant river-associated estuarine habitats occur at Leone Bay, where two streams discharge into a sheltered embayment. In addition to mangroves, estuarine habitats in this bay include tidal mudflat and salt marsh. The other major estuarine area in American Samoa is Pala Lagoon, located on the southwest coast of Tutuila on the margin of a relatively large coastal plain. Estuarine habitats in the bay include mangroves and shallow muddy or sandy bay floor (Scott, 1993; Maragos, 1998).

Habitat Issues

Status and Trends

Large expanses of estuarine habitats have been lost as a result of filling in all island areas. Guam has experienced a large historic loss because of military construction in Apra Harbor in the years immediately after World War II. More recently, an oil spill killed mangrove trees in Sasa Bay. Because it is difficult to estimate the size, location and type of wetlands that existed before European contact, estimates of loss are usually calculated from more recent years as wetlands have begun to be mapped and measured. It is estimated that filling has resulted in the loss of 64 percent of Saipan's wetlands (USFWS, 1996). In American Samoa, it is estimated that wetland loss has averaged 4.5 acres per year with accelerated decline over the past 10 years. To date, it is likely that American Samoa has lost approximately 60 percent to 70 percent of its original wetlands (American Samoa EPA, 2000). Pala Lagoon, for example, has been partially filled and its entrance narrowed to build an airport runway.

Threats

Threats to the wetlands of the U.S. Pacific Protectorates can be split into two separate categories: agriculture before World War II and urbanization and infrastructure development after World War II. A major concern of the U.S. Pacific Protectorates is the clearing and filling of wetlands for development. In addition, oil spills, effluent from sugar cane mills, heavy metals and other contaminated runoff from military bases are all concerns that threaten estuarine health (USFWS, 1996). The CNMI is currently concerned with the impacts of nonpoint source pollution, especially in the Saipan Lagoon. Although nonpoint source pollution results from a number of sources, infrastructure shortfalls are probably the largest contributor and are starting to be addressed by a number of local and federal government agencies.

Restoration Plans

Very few plans exist with comprehensive restoration planning for estuarine habitats in the Pacific Protectorate subregion. Although the amount of estuarine habitat is small, this absence of planning is alarming because the populations of these islands are increasing at an extremely high rate and the majority of the populations inhabit the coastal areas. Several government agencies are gathering baseline data that would allow such a plan to be created. The Division of Environmental Quality is looking at restoring or creating estuarine habitat to reduce the effects of nonpoint source pollution.

CNMI Coastal Resources Management Program

The CNMI Coastal Resources Management Program guides governmental activities related to the protection, preservation and development of the coastal resources of the CNMI. This program was developed by the Commonwealth's Planning and Budget Affairs Office. With the installation of a new constitutional government in 1978, it was recognized that there was a need to establish a policy base sensitive to the needs of both economic development and resource protection and the authorities and government organization required to implement the policies.

American Samoa Coastal Management Program

The American Samoa Coastal Management Program was developed to provide effective resource management by protecting, maintaining, restoring and enhancing the resources of the coastal zone. Responsibility for development of the program was given to the Development Planning Office (which has subsequently become the Department of Commerce). This program is designed to accommodate and complement other planning efforts (e.g., Economic Development Plan and Quality of Life Plan) that will guide the socioeconomic development of American Samoa.

Guam Coastal Management Program

The Guam Coastal Management Program guides the use, protection and development of land and ocean resources within Guam's coastal zone. The program was developed by the Guam Coastal Management Bureau of Planning, and its policies can be divided into three categories: resource protection, coastal development and simplification of government process.

Wetlands Conservation Plan

Guam's Wetlands Conservation Plan was developed by the U.S. EPA and a steering committee of representatives from a number of federal and state agencies. This plan was prepared to review existing Guam and federal regulations and to determine how to update, simplify and improve their application in Guam. It was prepared as a guide to assist the government of Guam with future wetland resource conservation and management.

A Comprehensive Wetlands Management Plan for the Islands of Tutuila and Aunu'u, American Samoa

This plan is administered by the Department of Commerce as a means for the American Samoan government to anticipate, rather than merely react to, wetland problems and conflicts. The plan provides a policy framework to manage the wetland resources of American Samoa.

The above-mentioned plans were developed with the coordination of local and federal government agencies. However, it has been noted that there is a significant lack of coordination among agencies, particularly in CNMI, which affects the adherence to and enforcement of regulations and agreements.

Plan Elements

Goals

Goals identified in the plans reviewed for the U.S. Pacific Protectorates focus on restoration and protection of wetland resources to ensure "no net loss" of those resources. Developing policy guidance for wetlands management may help local governments mitigate potential conflicts in this subregion.

Methods

For many of these plans, the first step toward restoration is compiling information on the wetland resources in the area. The extent of wetland areas in many of the islands has not been documented. Public participation in and coordination of restoration efforts also are acknowledged as crucial components in the restoration process. Specific restoration activities include excavating formerly filled wetlands and revegetating the sites.

Elements of Success

The plans that have been developed rarely discuss elements of success but do acknowledge the need for coordination amount federal and state agencies. Monitoring and public involvement are also acknowledged as important components of successful restoration.

Information Needs

Basic information on the extent and condition of wetland and estuarine habitats in the islands is needed. Up-to-date and precise wetland maps are needed for this subregion. In American Samoa, more hydrological assessments of wetlands are needed, as well as a technical mapping system to assist with a more

accurate delineation and survey process. The U.S. Fish and Wildlife Service is trying to gather support for obtaining aerial photos and mapping of American Samoa's wetlands for the first time. A need to address the management of cumulative and secondary impacts to wetlands in CNMI also has been identified.

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