U.S. Shorebird
Conservation Plan

Southern Pacific Coast Regional Shorebird Plan

Version 1.0

by

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EXECUTIVE SUMMARY

The 1,067-mile coastline and the 40-mile-wide by 400-mile-long Central Valley of California are the main areas where shorebirds concentrate in the Southern Pacific Region. Tidal wetlands, sand beaches, and rocky shoreline are the principal shorebird habitats on the coast. About two-thirds of the estimated 381,000 acres of prime tidal wetlands at the turn of the century have been degraded or destroyed by agricultural, industrial, urban, and military development (Speth 1979). Simultaneously, sand beaches have been heavily developed for human recreation and beach front housing, whereas rocky shoreline has been relatively little altered. In the Central Valley, about 90% of historic wetlands have been altered or destroyed for agriculture or urban development. Today the Central Valley habitats most used by shorebirds are restored, highly managed wetlands, irrigated or flooded agricultural lands, hypersaline agricultural evaporation ponds, municipal sewage ponds, and vernal pool rangelands.

Numbers of Shorebirds

Little quantitative information is available on historic shorebird numbers in the region. Currently the Western Sandpiper is the most abundant species with low millions passing through on migration and over 100,000 present during winter (Shuford et al. 1998, Page et al. 1999). At least 250,000 Dunlin and likely over 100,000 Long-billed Dowitchers winter in the area (PRBO unpubl. data). Over 100,000 Marbled Godwits, Least Sandpipers, and Short-billed Dowitchers likely pass through during migration (PRBO unpubl. data). Tens of thousands of Black-bellied Plovers, Killdeer, Black-necked Stilts, American Avocets, Willets, Marbled Godwits, Sanderlings, Least Sandpipers, and, probably, Black Turnstones and Common Snipe winter in the region. Additionally, tens of thousands of Whimbrels, Wilson's Phalaropes, and Red-necked Phalaropes pass through during migration (PRBO unpubl. data).

Regional Importance of Shorebirds

Based on the proportion of the estimated North American population occurring in the Southern Pacific Region, we ranked the region's importance to species at three levels:

Primary Importance – Black-bellied Plover, Killdeer, Snowy Plover, Mountain Plover, Black Oystercatcher, American Avocet, Greater Yellowlegs, Willet, Whimbrel, Long-billed Curlew, Marbled Godwit, Black Turnstone, Western Sandpiper, Dunlin, Short-billed Dowitcher, Long-billed Dowitcher, Common Snipe, and Red Phalarope.

Secondary Importance – Semipalmated Plover, Black-necked Stilt, Wandering Tattler, Spotted Sandpiper, Red Knot, Sanderling, Least Sandpiper, Wilson's Phalarope, and Red-necked Phalarope.

Limited Importance – American Golden-Plover, Pacific Golden-Plover, Lesser Yellowlegs, Solitary Sandpiper, Ruddy Turnstone, Surfbird, Semipalmated Sandpiper, Baird's Sandpiper, Pectoral Sandpiper, and Rock Sandpiper.

Of all species, the Snowy Plover, Mountain Plover, Long-billed Curlew, and Marbled Godwit are considered the highest priority species for conservation actions in the region based on their high national rankings.

Threats to Shorebirds

Shorebirds of this region have experienced high levels of habitat alteration from agricultural and urban development over the past two centuries. Ongoing urban development is highly likely to remain an agent of habitat loss, especially in agricultural lands of the Central Valley. In this region, changes in cropping patterns – such as from rice to cotton or from cattle grazing to viticulture – also may reduce the value of agricultural land to shorebirds. Expanding urbanization also may in the future reduce the supply of water available for wetlands and agriculture. Accelerated wetland sedimentation from watershed alteration, exacerbated by infrastructure construction within wetlands, is an ongoing problem that has reduced tidal prism and circulation at several coastal wetlands. Watershed run-off or point discharges have contaminated sediments or water at some inland and coastal locations. The spread of exotic plants – such as European beachgrass *(Ammophila arenaria)* on coastal beaches or salt-water cord grass *(Spartina alterniflora)* in San Francisco Bay – has reduced or, in the latter example, threatens to reduce the extent of shorebird habitat. The ongoing introduction of many non-native invertebrates into the benthos of coastal wetlands, through ship ballast discharges and other human activities, is regularly altering the composition of potential shorebird prey in an unpredictable manner. Mosquito abatement programs limit options for habitat management, especially the flooding of inland wetlands during summer. Various oyster culture practices affect shorebird access to potential food resources in species-specific ways (Kelly et al. 1996). Nesting shorebirds in the region have experienced high rates of nest loss to introduced mammalian predators, especially the red fox *(Vulpes vulpes)*, and to expanding populations of native predators, especially the Common Raven *(Corvus corax)*. Growing recreational use of beaches and wetlands appears to be causing increased disturbance of roosting and foraging shorebirds. As shorebirds today live in an environment quite different from two centuries ago, we conclude that shorebird conservation in the Southern Pacific Region will require substantial effort just to maintain current populations.

Conservation Priorities

Priorities for conservation of shorebird populations in the Southern Pacific Region are to:

- Increase breeding populations of the Snowy Plover to 2,750 breeding adults, as recommended in the draft USFWS Snowy Plover Recovery Plan, and double the Central Valley population. On the coast, the Recovery Plan is expected to recommend closing some nesting areas to the public, protecting nests with exclosures and predator management, and restoring nesting habitat through removal of exotic vegetation, especially European beachgrass (*Ammophila arenaria)*. In the Central Valley, plover numbers should be increased by creating more saline wetland habitat.
- Increase or maintain breeding populations of the Killdeer, Black Oystercatcher, Black-necked Stilt, and American Avocet by enhancing, restoring, or creating nesting habitat.
- Increase migratory and wintering populations of all key shorebird species in the region by protecting existing habitat, managing existing habitat more for shorebirds, and creating more shorebirds habitat.

Recommended actions for specific habitats are to:

Tidal Wetlands

- Restore tidal flats and marshes, particularly in San Francisco Bay and on the southern California coast.
- Enhance tidal action in existing wetlands as needed.
- Reduce sedimentation from alteration of wetland watersheds.
- Oppose further fragmentation of wetlands by human infrastructure such as roads and power lines.
- Minimize future introductions of non-native invertebrates and plants.
- Eliminate the exotic plant *Spartina alterniflora* from mudflats, especially in San Francisco Bay.
- Oppose further development of tidal flats for oyster culture on the northern California coast.
- Control human disturbance.

Managed Wetlands

- Create and enhance managed wetlands, especially in the Central Valley.
- Improve the value of managed wetlands to shorebirds by incorporating features such as undulating pond bottoms, gentle levee slopes, and underwater berms.
- Expand current wetland management strategies to benefit shorebirds, particularly by lowering winter water levels and regulating the timing and staggering of late-winter and spring drawdowns.
- Avoid further fragmentation and encroachment of wetlands by development.
- Manage vegetation succession to benefit shorebirds.
- Retain and manage some salt ponds in San Francisco Bay for shorebirds.

Seasonal Coastal Wetlands

- Protect coastal seasonal wetlands from development.

Coastal Beaches

- Rank beaches by importance to shorebirds and restrict dogs on highest ranked beaches.
- Enforce dog leash laws on all beaches.
- Limit other human disturbance of shorebirds on beaches.
- Eliminate exotic plants such as *Ammophila arenaria*.

Agricultural Land

- Protect agricultural land for shorebirds through conservation easements.
- Promote management of agricultural land for shorebirds.
- Promote conventional methods of rice harvest and shallow flooding of riceland in winter.
- Increase acreage of flooded riceland in winter.
- Curtail the rapid loss of vernal pool rangelands.

Agricultural Evaporation Ponds

- Reduce shorebird use of contaminated agricultural evaporation ponds in the San Joaquin Valley while creating nearby mitigation wetlands, particularly saline habitats mimicking historic playa lakes.

Research Priorities

Regional research priorities are to:

- Investigate the extent and reasons why shorebirds move between different wetland complexes and what degree of site fidelity they exhibit.
- Identify the factors limiting shorebird abundance and whether these factors are intrinsic or extrinsic to the region.
- Study how various human disturbances effect shorebirds, including impacts on prey ingestion rates, energy intake, body condition, and survival.
- Determine seasonal and habitat variation in shorebird diets in managed wetlands, the effect of different water drawdown techniques on invertebrate prey production and availability, and how shorebirds respond to different management techniques.
- Study how different oyster culture techniques vary with respect to sedimentation rates, benefits to foraging shorebirds, and levels of human disturbance.
- Experiment with managing salt ponds for shorebirds in the absence of commercial salt production.
- Investigate the effect of introduced invertebrates on shorebird feeding ecology.
- Identify which beaches are most important to migrating and wintering shorebirds.
- Learn more about habitat use, nesting success, and adult and juvenile survival rates of Snowy Plovers in San Francisco Bay.
- Determine the current size and distribution of the breeding populations of the American Avocet and Black-necked Stilt in the region and the best methods of creating good nesting habitat for these species.
- Identify the breeding range of the small population of the Red Knot that uses the region during migration and winter and the wintering range on the coast of the small population of the Marbled Godwit that breeds in Alaska.
- Investigate whether reproductive success of the Black Oystercatcher is impacted by human disturbance or the expanding Common Raven population in the region.

Monitoring Priorities

Regional monitoring priorities are to:

- Develop and implement techniques to assess long-term trends in shorebird abundance.
- Quantify success of restoration projects in meeting shorebird objectives.
- Monitor long-term trends in habitat availability.
- Determine trends in abundance of shorebird predators, especially the Merlin (*Falco columbarius)*, Peregrine Falcon *(Falco peregrinus)*, and Short-eared Owl *(Asio flammeus)*.
- Monitor annual numbers, nesting success, and survival of the Snowy Plover on the coast.
- Conduct annual winter surveys of Mountain Plover numbers.

Education Priorities

Programs should be developed to educate the public about shorebirds and their habitat needs, create sympathy for shorebirds, and provide guidance about what should and should not be done to help shorebirds. Efforts also should focus on generating interest among resource managers in shorebirds and their protection and advising them of the most up-to-date techniques for habitat restoration, enhancement, and management for shorebirds.

Implementation and Coordination

A Working Group should be formed to guide implementation of the goals and priorities of the shorebird conservation plan in the Southern Pacific Region. The Working Group's efforts should be coordinated through the Pacific Coast Joint Venture, San Francisco Bay Joint Venture, and Central Valley Habitat Joint Venture, all of which currently are active in parts of the area. A coordinator should be hired for the southern California coast (Golden Gate to Mexico border), where there currently is no active Joint Venture to implement the plan.

DESCRIPTION OF REGION

The Southern Pacific Region of the U. S. Shorebird Conservation Plan lies completely within the state of California and adjacent U.S. territorial waters. It is bounded seaward by the 200 mile limit and inland by the Cascade and Sierra Nevada mountains. The Southern Pacific Region overlaps two Bird Conservation Regions (BCR) – part of the Pacific Northwest BCR and all of the Coastal California BCR. The Coastal California BCR includes the Central Valley of California.

All or parts of three Joint Ventures of the North American Waterfowl Management Plan are included within the Southern Pacific (shorebird) Region. The Pacific Coast Joint Venture includes all of the portion of the Pacific Northwest BCR within the Southern Pacific (shorebird) Region and overlaps a small part of the Coastal California BCR. The San Francisco Bay Joint Venture and the Central Valley Habitat Joint Venture are both completely contained within the Coastal California BCR.

For planning purposes, the Southern Pacific Region is divided into the following subregions: Northern California Coast, Southern California Coast, San Francisco Bay, and Central Valley. Within the Southern Pacific Region, the major areas of shorebird concentration are the coast, offshore waters (used by migrating phalaropes), and the Central Valley. The coast consists of rocky and sandy shoreline interspersed with wetlands. Shorebirds' main native coastal habitats are tidal sand and mud flats, marshes, rocky shores, and sand beaches. Within San Francisco and San Diego bays, some commercial salt evaporation ponds are important habitat for shorebirds. Diked wetlands, sewage ponds, and agricultural lands, especially heavily grazed pastures, are other human-created habitats along the coast that support shorebirds. The natural wetlands of the coast have been greatly altered by human activities during the past 200 years. So much wetland habitat has been degraded or destroyed that all remaining habitat supporting shorebirds should be preserved or enhanced.

In the Central Valley, over 90% of the historic wetlands have been altered by agricultural and urban development. At present, key shorebird habitats in the Central Valley are restored, highly managed wetlands, irrigated or flooded agricultural lands,

hypersaline agricultural evaporation ponds, and municipal sewage ponds. Shorebird use of agricultural lands is concentrated primarily in Sacramento Valley rice fields and secondarily in various plowed croplands, alfalfa fields, irrigated pastures, and vernal pool rangelands.

The Southern Pacific Region is an important wintering area for shorebirds that breed in the arctic and temperate zones. For example, it is a wintering area for the Dunlin, Willet, and Marbled Godwit, which, respectively, nest in Alaska, the Great Basin, and the Prairie. The region also is important during migration, particularly for arctic-breeding species such as the Whimbrel, Western Sandpiper, and Short-billed Dowitcher. Numbers of these shorebirds in the region swell during migration periods, which, for all species combined, extend primarily from mid-March to mid-May in spring and from mid-June until at least November in autumn. Species with important breeding populations in the region include the Snowy Plover, Killdeer, Black Oystercatcher, Black-necked Stilt, and American Avocet; ones with less significant breeding populations include the Spotted Sandpiper, Common Snipe, and Wilson's Phalarope.

A variety of factors impact shorebird use of the Southern Pacific Region. Historic loss and degradation of native wetlands and shorebirds' exploitation of human-created habitats undoubtedly has altered the abundance and distribution of shorebirds in the region. An increase in sedimentation rates over historical levels, from human alteration of watersheds, threatens to shorten the life spans of some coastal wetlands that are now otherwise protected. Introductions of marsh plants to some large wetlands threaten to reduce the area of unvegetated tidal flats and hence prime foraging habitats for shorebirds. Continually changing benthic invertebrate communities, as a result of ship ballast discharges and other human activities, may impact the food resources of many shorebird species.

While there is considerable effort being made to restore wildlife habitat and listed species along the coast and in the Central Valley, there can be competing needs of other species. For example, recovery of the endangered Peregrine Falcon has likely increased winter mortality of shorebirds as shorebirds are important peregrine prey. Restoring tidal marshes for the recovery of listed populations of marsh-dependent species, such as the California Clapper Rail *(Rallus longirostris obsoletus)* and Salt Marsh Harvest Mouse *(Reithrodontomys raviventris),* could reduce the extent of other habitats, such as salt ponds, that may be more valuable than marshes to shorebirds. In the Central Valley, the focus on habitat restoration for waterfowl often results in wetland water levels too deep for shorebirds.

Competition among agriculture, urban populations, and wildlife for a limited water supply may hamper wetland habitat restoration for all species. Even when water is available, the manner and timing with which it can be applied to wetlands is restricted by mosquito abatement regulations designed to control and prevent human diseases.
The growing demand of an expanding human population for recreational opportunities threatens coastal habitats and especially beaches, which are an important nesting habitat for the threatened Snowy Plover and a foraging habitat for the plover and other shorebirds. On beaches, shorebirds are flushed regularly by pedestrians, joggers, and, especially, unleashed dogs, which sometimes intentionally chase shorebirds. Snowy Plover nests have been stepped on by pedestrians and equestrians and have been

destroyed by dogs. People also have deliberately destroyed plover nests at some locations (PRBO unpubl. data).

OCCURRENCE PATTERNS AND REGIONAL SPECIES PRIORITIES

Thirty-seven species of shorebirds occur regularly within the Southern Pacific Region (see Appendix for scientific names). Based on the proportion of the estimated North American population occurring in the Southern Pacific Region, we ranked the region's importance to species at three levels:

Species of Primary Importance in Region

Eighteen species were ranked of primary importance because their regional populations likely are as high (during one or more seasons) as those in the majority of other shorebird planning regions in the United States. Of the 18 species for which the region stands out, largest numbers and principal habitats of 6 are in the Central Valley and of 8 are on the coast, whereas 4 are relatively abundant in both coastal and inland habitats.

*Species of Importance in the Central Valley. T*he six species for which the Central Valley is particularly important are:

Killdeer – The Killdeer is of primary importance in the Southern Pacific Region because of the large number of wintering birds in the Central Valley. About 11,000 to 17,000 Killdeer have been counted in the Central Valley in mid-winter, but those surveys did not include upland habitats used by many individuals (Shuford et al. 1998). Large numbers also nest in the Central Valley, particularly in and adjacent to the extensive area of Sacramento Valley rice fields (D. Shuford pers. obs.).

Mountain Plover – The majority of the Mountain Plover's entire population winters in California, primarily in the Central and Imperial valleys (Hunting and Fitton 1999). Thousands of wintering Mountain Plovers were regularly recorded in the San Joaquin Valley (southern drainage of the Central Valley) in the 1960s, but numbers have dwindled considerable in recent decades (J. Engler in litt.). The Mountain Plover currently is proposed for listing as a federally Threatened Species. Because of its imperiled status and its concentration in the Central Valley in winter, this species is of primary importance for the Southern Pacific Region.

Greater Yellowlegs – This species is of primary importance in the region because of its large winter numbers in the Central Valley. Using a combination of aerial and ground surveys, Shuford et al's (1998) counts averaged about 4,000 Greater Yellowlegs each winter in the Central Valley, but these undoubtedly are underestimates. From his surveys of rice fields, Chris Elphick (in litt.) extrapolated that roughly 12,300 (confidence interval 3,000-21,600) Greater Yellowlegs winter in Sacramento Valley rice fields.

Whimbrel – This species is of primary importance in the region because a minimum of about 8,000 migrate through the Central Valley in spring (Shuford et al. 1998).

Long-billed Dowitcher – Since over 90,000 Long-billed Dowitchers occur in the Central Valley during midwinter and spring (Shuford et al. 1998), the Southern Pacific Region is of primary importance for this species.

Common Snipe – Although no accurate estimates are available, there likely are tens of thousands of snipe in the Central Valley in winter, indicating the region is of primary importance for this species.

Species of Importance on the Coast. The eight species for which coastal habitats in the Southern Pacific Region are especially important are:

Black-bellied Plover – This species is of primary importance in the region because at least 28,500 birds winter and 42,500 migrate along the coast (PRBO unpubl. data).

Snowy Plover – This plover is of primary importance in the region because over 90% of the listed population along the U.S. Pacific Coast breeds here (U.S. Fish and Wildlife Service draft recovery plan) and most of it also winters here. Snowy Plovers from the Central Valley and western Great Basin also winter along the region's coastline (Page et al. 1995a*)*.

Black Oystercatcher – The oystercatcher is of primary importance in the region because it is limited in distribution to the west coast of the United States, and, hence, the Southern Pacific Region is one of three U.S. shorebird planning regions in which the species is found. Its primary habitat is outer coast rocky shoreline. Carter et al. (1992) recorded 888 Black Oystercatchers on the California coast during a statewide survey of nesting seabirds from 1989 to1991. Although comparable data are lacking, similar numbers appear to occur year round.

Willet – The species' regional importance is based on the 20,000+ Willets that winter along the California coast and the 50,000+ that may migrate through the coastal region (PRBO unpubl. data).

Marbled Godwit – The region is of primary importance to this species because an estimated 37,000 occur along the California coast in winter (PRBO unpubl. data), and up to 138,000 may pass through during migration, assuming the majority of birds wintering in Baja California, Mexico (Page et al. 1997), migrate through California. Wintering numbers on the California coast are unmatched elsewhere in the United States.

Black Turnstone – Because wintering Black Turnstones are restricted to the three shorebird planning regions on the west coast of the United States, the Southern Pacific Region is of primary importance for this species. Black Turnstones forage on rocky outer coast shoreline and estuarine tidal flats.

Short-billed Dowitcher – The region is of primary importance for this species because as many as 150,000 Short-billed Dowitchers probably migrate along the California coast in spring (PRBO unpubl. data).

Red Phalarope – The region is of primary importance for this species because the entire western population migrates over offshore waters off California.

Species Equally Important on the Coast and in the Central Valley. The final four species for which the region is particularly important, and that are relatively abundant both on the coast and in the Central Valley, are:

Long-billed Curlew – The region is of primary importance to the curlew because it holds a large percentage of the species' wintering population. Pacific Flyway project surveys found at least 7,000 curlews in the region in winter (PRBO unpubl. data), but this is a minimum estimate because of a lack of surveys in upland

habitats of the Central Valley. G. Morrison (in litt.) estimates the North American population at 20,000 birds.

Western Sandpiper – The region is of primary importance to this species because over one million Western Sandpipers migrate through the Central Valley and along the coast during spring (PRBO unpubl. data). The entire world population of this species is approximately 2.5 to 4.0 million birds (M. Bishop in litt.).

Dunlin – The region is of primary importance to the species because the minimum estimate of 250,000 individuals of the race *C. a. pacifica* that winter along the coast and in the Central Valley (PRBO unpubl. data) represents about one half of that subspecies' entire population (Page and Gill 1994).

American Avocet – The region is of primary importance to the species because avocet numbers here in winter may be greater than those in any other planning region and in fall may be surpassed only by numbers in the Intermountain Region.

Species of Secondary Importance in Region

Nine species were ranked of secondary importance because their regional populations likely are as high as those in only several other regions. These species are: Semipalmated Plover (on coast and inland during migration and winter), Black-necked Stilt (on coast and inland year round), Wandering Tattler (on coast during migration), Spotted Sandpiper (on coast and inland during migration and winter), Red Knot (on coast during migration and winter), Sanderling (on coast during migration and winter), Least Sandpiper (on coast and inland during migration and winter), and Wilson's and Red-necked phalaropes (on coast and in Central Valley wetlands during migration).

Species of Limited Importance in Region

Ten species were ranked of limited importance because their regional populations likely are very small relative to those in other regions. These species are: American Golden-Plover, Pacific Golden-Plover, Lesser Yellowlegs, Solitary Sandpiper, Ruddy Turnstone, Surfbird, Semipalmated Sandpiper, Baird's Sandpiper, Pectoral Sandpiper, and Rock Sandpiper.

NORTHERN CALIFORNIA COAST SUBREGION

Description of Subregion

The northern California coast extends about 419 miles from the Oregon border south to the entrance of San Francisco Bay. About 40% of the coastline is sand beach, nearly half of which is backed by sand dunes; about 59% is rocky (U.S. Army Corps of Engineers 1971).

Wetlands of Importance to Shorebirds

Along the coast 10 wetlands are known to hold over 1,000 shorebirds during peak periods of occurrence. Seven wetlands are exposed to continuous tidal action and three are usually isolated from the ocean by barrier bars. From north to south by county these wetlands are:

Del Norte County

*S*mith River mouth – this open river estuary has held up to 4,000 shorebirds in fall (PRBO unpubl. data).

Lake Talawa – this brackish lagoon, separated from the ocean by a barrier bar (Funderburk and Springer 1989), has held over 13,000 shorebirds (PRBO unpubl. data).

Humboldt County

Humboldt Bay (including the Eel River mouth) – this large estuary is recognized as a site of International Importance for shorebirds by the Western Hemisphere Shorebird Reserve Network (WHSRN). Depending on season 20,000 to 80,000 shorebirds reside in Humboldt Bay (Colwell 1994).

Sonoma County

Bodega Harbor – this 850-acre estuary regularly holds 2,000 to 6,000 shorebirds and sometimes over 12,000 in winter (PRBO unpubl. data).

Marin County

Estero Americano – this wetland is often cut-off from the tides by a barrier bar, but when open to daily tidal influence, has 1,000 to 3,000 shorebirds in fall and winter (PRBO unpubl. data).

Tomales Bay – this 8,658-acre coastal embayment holds 5,000 to 10,000 shorebirds in spring and fall and up to 20,000 in winter (PRBO unpubl. data), thereby qualifying it as a potential WHSRN site of Regional Importance.

Abbotts Lagoon – this 212-acre wetland consists of three fresh-to-brackish ponds separated from the ocean by a barrier bar. During low tide shorebird numbers are usually in the hundreds but at high tide they may exceed 1,000 from movement of birds from nearby Drakes Estero.

Drakes and Limantour esteros – these two esteros are best considered as a single wetland system because of their common entrance to the ocean and the regular interchange of shorebirds between them. The 1,816-acre Drakes Estero is managed partly for mariculture and the 481-acre Limantour Estero is an Ecological Reserve. Each regularly holds thousands of shorebirds with combined totals sometimes reaching nearly 20,000 individuals in winter (PRBO unpubl. data). Together they could qualify as a WHSRN site of Regional Importance.

Bolinas Lagoon – this 1,100-acre, very shallow estuary regularly holds 5,000 to 10,000 shorebirds (PRBO unpubl. data); during spring migration, numbers have been known to swell to 35,000 (Shuford et al. 1989). Bolinas Lagoon is recognized as a Ramsar site of International Importance to waterbirds and also would qualify as a WHSRN site of Regional Importance.

Beaches of Importance to Shorebirds

Sand beaches associated with wetlands are usually the ones most heavily used by shorebirds in this region. These include the beach at Lake Talawa, Mad River sand spit, beaches to the north and south of the Eel River mouth, sand beaches associated with Humboldt Bay (Colwell and Sundeen in press), Salmon Creek and Doran beaches at Bodega Harbor, Dillon Beach at the entrance of Tomales Bay, Point Reyes Beach at Abbotts Lagoon, the sand spits of Drakes and Limantour esteros, and Bolinas Lagoon spit. Not only are these beaches (except Dillon Beach) current or historic breeding and

foraging areas for the Snowy Plover (Page and Stenzel 1981) and foraging areas for Sanderlings and other shorebirds, they also are important high tide roosting sites for many species of shorebirds that forage on tidal flats at low tide.

Pastures of Importance to Shorebirds

Pastures with associated seasonal wetlands are habitat for shorebirds at the Eel River delta, Humboldt Bay (Colwell and Dodd 1997), Tomales Bay, Drakes Estero, and Bolinas Lagoon (Page et al. 1979). Tilled land at Drakes Estero and Bolinas Lagoon is also used by foraging shorebirds in winter.

Shorebird Species

Humboldt Bay lies at or near the northern boundary of the coastal wintering range of several species that breed at temperate latitudes. It is the northernmost wintering area for the American Avocet, and one of the most northern wintering areas for the Long-billed Curlew, Marbled Godwit, and Willet (Page et al. 1999). Besides their importance for wintering shorebirds from temperate zone breeding areas, northern California coastal wetlands are important wintering areas for species with arctic-breeding ranges, such as the Black-bellied Plover, Western Sandpiper, Least Sandpiper, and Dunlin. During migration, these wetlands are used by even larger numbers of Western Sandpipers than in winter. Other shorebirds migrating through the wetlands, particularly during spring, are the Semipalmated Plover, Whimbrel and Short-billed Dowitcher.

The rocky shoreline of the region is occupied by resident Black Oystercatchers and thousands of wintering Black Turnstones. Other species that use the rocky coast of the region, though in relatively small numbers, are the Wandering Tattler, Spotted Sandpiper, Whimbrel, Ruddy Turnstone, Surfbird, and Rock Sandpiper.

The sand beaches in this subregion are used by large numbers of migrating and wintering Sanderling and are important nesting areas for the Snowy Plover. During the mid-1970s over 100 plovers nested along the region's beaches (Page and Stenzel 1981) but the number is probably less than half that today (PRBO unpubl. data). Other species for which sand beaches are relatively important foraging areas during migration or winter are the Willet and Whimbrel. Beaches associated with wetlands are important high tide roosting sites for many species of shorebirds that forage in the wetlands at low tide (Colwell and Sundeen in press).

The offshore waters of the region are used by large numbers of migrating Red-necked and Red phalaropes (Briggs et al. 1987).

Agricultural lands, especially pastures and associated seasonal wetlands, are important foraging and roosting habitat for many species of shorebirds during winter and spring. Such areas are most heavily used during high tides when tidal habitats are unavailable. The Black-bellied Plover, Killdeer, Greater Yellowlegs, Long-billed Curlew, Marbled Godwit, Least Sandpiper, Dunlin, and Long-billed Dowitcher are characteristic shorebirds of these habitats (Colwell and Dodd 1997).

Regional Population and Habitat Goals

Priority population and habitat conservation goals for the northern California coast are to:

- Attain a breeding population of 210 Snowy Plovers, consistent with the objectives of the draft USFWS Snowy Plover Recovery Plan.
- Maintain current numbers of breeding Black Oystercatchers.
- Maintain numbers of all migrant and wintering shorebirds at current levels.
- Restore mudflats and tidal action in coastal wetlands to compensate for past habitat loss and degradation.
- Eliminate *Ammophila arenaria* from beaches to improve Snowy Plover nesting habitat.
- Protect tidal flats from excessive sedimentation from wetland watershed alteration.
- Protect existing tidal flat habitat from introduced invertebrates and plants.
- Limit human disturbance of nesting, feeding, and roosting shorebirds in all habitats.

Habitat Status, Threats, and Management Needs

Descriptions of historical and current habitat availability, shorebird habitat use patterns, threats to shorebirds, management issues, and needed conservation actions are provided below for the major habitat types in the region.

Tidal Flats. No regional estimates are available of the total current acreage of tidal flat, the most important shorebird habitat within the coastal embayments of northern California. Tidal flat is the primary foraging habitat of many of the region's most abundant shorebirds, including the Black-bellied Plover, Semipalmated Plover, Willet, Long-billed Curlew, Marbled Godwit, Western Sandpiper, Least Sandpiper, Dunlin, and Short-billed Dowitcher. The main shorebird prey in the tidal flats are invertebrates, but many of these are introduced species that arrived through the release of ship ballast and other human actions. Invertebrate introductions are ongoing with unknown consequences for shorebirds. Introduced invertebrates are prominent in the benthos of Humboldt Bay, Bodega Harbor, Estero Americano, and Bolinas Lagoon. They probably also are an important element of the invertebrate benthos of Tomales Bay, Drakes Estero, and Limantour Estero.

Historic loss of tidal habitat from diking or filling has occurred at Humboldt Bay, Bodega Harbor, Estero Americano, Drakes Estero, Tomales Bay, Limantour Estero, and Bolinas Lagoon. Accelerated sedimentation of tidal habitat from historic or ongoing logging or grazing in the watershed has been identified for Humboldt Bay, Bodega Harbor, Estero Americano, Tomales Bay, and Bolinas Lagoon. It also may be occurring at Drakes Estero. Impaired tidal circulation has been identified for Estero Americano, and parts of Tomales Bay, Drakes Estero, and Bolinas Lagoon.

Oyster farming occurs in Humboldt Bay, Tomales Bay, and Drakes Estero. Oyster farming influences shorebird use of tidal flat by enhancing feeding opportunities for some species, such as the Willet, while decreasing them for others, such as the Dunlin (Kelly et al. 1996). Oyster culture may have increased sedimentation rates at Drakes Estero (S. Allen pers. comm.). The effect of oyster culture practices on sedimentation/erosion of tidal flats should be considered in future leases.

Disturbance from human recreation is a potential problem for shorebirds at Lake Talawa, Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, and Bolinas

Lagoon. Specific disturbance agents include wind surfers at Humboldt Bay and Bodega Harbor; dogs chasing birds on tidal flats at Humboldt Bay and Bodega Harbor; people involved in intensive clam harvesting at Tomales Bay and Bodega Harbor; and kayakers at Tomales Bay, Drakes Estero, and Bolinas Lagoon. A study has been proposed at Bolinas Lagoon to determine the degree of disturbance caused by kayakers and the value of educational efforts to lessen this source of disturbance (G. Page pers obs.). Restrictions on kayaking in Drakes Estero from March to June, to reduce disturbance to harbor seals *(Phoca vitulina),* probably also reduces human disturbance of spring-migrating shorebirds (S. Allen pers. comm.).

Contaminants, in the form of non-point pollution sources from neighboring cities, were identified as possibly detrimental to shorebirds at Humboldt Bay (M. Colwell pers. comm.). Oil spills pose a threat to the intertidal habitats of all the wetlands open to daily tidal action, and sea level rise could effect the extent of tidal flat habitat in all the wetlands.

Priority conservation actions for tidal flats are to:

- Improve and revise watershed management actions for all coastal wetlands to reduce sediment accumulation on intertidal habit.
- Restrict use of jet skis in wetlands where they are found to be a major source of disturbance to shorebirds.
- Support legislation restricting ballast discharge to reduce the probability of new invertebrate introductions into coastal wetlands.
- Maintain levee breaks to retain tidal flats currently used by shorebirds at the Eel River Wildlife Area.
- Prohibit further alteration of tidal flats for oyster culture at Humboldt Bay, Tomales Bay, and Drakes Estero.
- Maintain continuous tidal exchange by breaching the barrier bar after closures at Estero Americano.
- Breach levees to restore mud flat and tidal marsh in diked pastures at Giacomini Ranch, Tomales Bay. An estimated 90 acres of tidal flat could be restored through this action (Philip Williams and Associates et al. 1993).
- Increase tidal circulation in the leveed marsh at Tomasini Point, Tomales Bay; examine the potential benefit of a similar action for leveed marsh at Bivalve Point.
- Develop a management plan for the large sandbars north of Tom's Point, Tomales Bay to limit the effect of claming and other recreational activities on foraging shorebirds.
- Increase tidal flat and tidal circulation by removing levees at the Glenbrook and Muddy Hollow ponds, Limantour Estero.
- Restrict kayaking during periods of peak shorebird occurrence at Drakes and Limantour esteros.
- Support the U.S. Army Corps of Engineers study to improve the tidal circulation and increase the tidal prism at Bolinas Lagoon.

Salt Marsh. Shorebirds use salt marsh to a lesser degree than tidal flats. Salt marsh vegetation, growing in the upper part of the intertidal zone, may be too tall or dense to provide much foraging habitat for shorebirds. The larger non-vegetated channels in salt

marsh are used as foraging habitat by the same species that feed on tidal flats. Some species, such as the Willet, Whimbrel, Long-billed Curlew, and Least Sandpiper, also forage on marsh plains with sparse or low vegetation (< about 8 inches). Species such as the Willet, Least Sandpiper, Dunlin, and Long-billed Dowitcher use salt marsh as nocturnal roost sites, possibly to provide some protection from predators such as owls. Inclusion of channels in marsh restoration projects should be promoted to benefit shorebirds, but the spread of salt marsh at the expense of tidal flats should be considered more detrimental than beneficial to most shorebirds.

A priority conservation action for salt marshes is to:

- Eliminate the introduced salt-water cord grass (*Spartina alterniflora)* from the mudflats at Humboldt Bay.

Sand Beach and Dunes. The region has about 166 miles of outer coast sand beach, of which about 77 miles is backed by dunes (U.S. Army Corps of Engineers 1971). Although sand beaches may be used by a large number of species, they are most important to the Snowy Plover, Willet, Whimbrel, and Sanderling. The Snowy Plover nests on the upper beach and forages on invertebrates on the upper and lower beach. Barren to sparsely vegetated sand dunes, which back some beaches, are also important Snowy Plover nesting and foraging areas (Page et al. 1995b). Migrating and wintering Black-bellied Plovers, Semipalmated Plovers, Willets, Whimbrels, Sanderlings, and other shorebirds forage on beaches and roost on the higher portions of the beach (Colwell and Sundeen in press) or in barren to sparsely-vegetated dunes backing beaches, particularly at high tides.

Shorebirds foraging and roosting on coastal beaches experience considerable disturbance from humans. Birds are flushed by off-road-vehicle drivers, especially in Del Norte and Humboldt counties, and by pedestrians and joggers, particularly those with dogs, in all counties. Leash laws are seldom enforced so that dogs are permitted to chase roosting and foraging shorebirds. With the growing human population in California this type of disturbance undoubtedly will increase. Oil spills are another problem shorebirds experience on sand beaches. Shorebirds were oiled on Humboldt Bay and Point Reyes beaches during separate spills in November 1997 and on Point Reyes beaches during a January 1998 spill (PRBO unpubl. data).

Nesting Snowy Plovers face numerous threats on sand beaches. These include loss of dune habitat to the introduced European beachgrass *(Ammophila arenaria),* decreased nesting success from human disturbance, and high levels of egg predation by Common Ravens.

Priority conservation actions for sand beaches and dunes are to:

- Increase the size of the breeding Snowy Plover population following the detailed guidelines of the draft Snowy Plover Recovery Plan. These include removing non-native vegetation in coastal dunes, restricting human recreation on sand beaches, using nest exclosures, and implementing predator management and public education programs. The draft Snowy Plover Recovery Plan lists site-specific actions, which should be endorsed by the shorebird conservation plan.
- Increase enforcement of dog leash laws on beaches used by nesting Snowy Plovers and other feeding and roosting shorebirds.

- Rank beaches by their importance to shorebirds; restrict dogs from those with highest ranks (Colwell and Sundeen in press).
- Restrict off-road vehicle driving on Snowy Plover nesting beaches.
- Restrict nighttime driving on beaches used by foraging and roosting shorebirds.
- Limit human use of Brazil Beach, Tomales Bay, to protect large flocks of roosting shorebirds.
- Limit human use of the outer beach at Sand Point, Tomales Bay, to protect roosting and feeding Snowy Plovers and potentially produce conditions conducive to nesting.

Rocky Shoreline. There are about 249 miles of rocky coast shoreline in the Northern California Coast Subregion (U.S. Army Corps of Engineers 1971). Resident Black Oystercatchers use this habitat as their primary nesting, foraging, and roosting areas. During winter, the rocky shoreline of the region is the primary habitat of the Black Turnstone, which also forages on tidal flats. Other rocky coast species, occurring in small numbers in migration and winter are the Wandering Tattler, Spotted Sandpiper, Ruddy Turnstone, Surfbird, and Rock Sandpiper. Oil spills are the main threat to the species using this habitat.

A priority conservation action for rocky shorelines is to:

- Limit human access to Black Oystercatcher breeding sites.

Offshore Waters. Offshore waters are important for migrating Red-necked and, particularly, Red phalaropes. Available food supplies in these waters are undoubtedly affected by ocean temperatures and large scale oceanic events such as El Niño conditions. The Red Phalarope may be affected by winter storms, which sometimes cause large numbers to come ashore in a weakened condition that leaves them susceptible to predators. Oil spills are the main human-induced problem for phalaropes in offshore waters.

A priority conservation action for offshore waters is to:

- Promote regulations reducing the probability of oil spills.

Agricultural Lands and Seasonal Wetlands. Heavily grazed pastures – especially at Humboldt Bay, Tomales Bay, Drakes Estero, and Bolinas Lagoon – are important foraging and roosting sites for shorebirds when winter high tides inundate tidal flat foraging areas. Tilled land also is used in the Point Reyes area by some shorebirds, such as the Black-bellied Plover, Semipalmated Plover, and Killdeer. At Humboldt Bay, the California Department of Fish and Game (CDFG) and U.S. Fish and Wildlife Service (USFWS) rely on livestock grazing to manage pasture vegetation height to promote use by shorebirds and waterfowl (M. Colwell pers. comm.). Livestock grazing of flat land near coastal estuaries should be viewed as beneficial to shorebirds as long as the grazing does not contribute to increased sedimentation of intertidal habitats or impact sensitive species. In the Arcata Bottoms at Humboldt Bay, pastureland created by diking of salt marsh, interdigitating with alder and spruce forest, may now provide more habitat for wintering shorebirds than former salt marsh (M. Colwell pers. comm.).

Priority conservation actions for agricultural lands and seasonal wetlands are to:

- Promote conservation easements to protect seasonal wetlands for shorebirds.
- Protect seasonal wetlands and pastures from development at the Eel River lowlands, Humboldt Bay.
- Protect seasonal wetlands in grazed lowlands east of Tomales at Tomales Bay.
- Limit recreational use and restore seasonal wetlands at pastures at Lawson's Landing, Tomales Bay.

Monitoring Priorities

Priorities for monitoring shorebirds on the northern California coast are to:

- Annually monitor shorebirds in coastal wetlands for long-term trends in abundance. The monitoring program should be standardized, thorough, and recognize changing habitat conditions. Prioritization of sites for monitoring should be based on all available information, ease of implementation, and level of bird use. Establish a network of organizations to undertake monitoring activities.
- Annually monitor breeding numbers and nesting success of the Snowy Plover throughout the subregion.
- Annually monitor shorebird foraging and roosting habitat availability and condition, including the level of human disturbance.
- Annually monitor the presence and abundance of key shorebird predators – especially the Merlin, Peregrine Falcon, and Short-eared Owl – at key wintering sites.

Research Priorities

Priority research goals for the northern California coast are to:

- Study the effects on shorebirds of off-road driving on beaches, use of personal water craft in wetlands, and pedestrian and pet use of beaches. In particular, determine how disturbances affect shorebird prey ingestion rates, energy budgets, body condition, and survival rates.
- Determine the costs and benefits to foraging shorebirds of different oyster culture methods (for example bottom seeding versus long-lining), including the effects on shorebird prey ingestion rates and on sedimentation rates of tidal flats.
- Examine the threats posed to nesting Black Oystercatchers by human disturbances and by predators such as the Common Raven.
- Survey all rocky shoreline in the region to determine the most important areas for migrant and wintering shorebirds.
- Investigate why shorebirds consistently use some pastures at Humboldt Bay for foraging more than others.
- Determine the effect of bait digging and claming on shorebirds and their invertebrate prey at Bodega Harbor.
- Delineate shorebird breeding areas, especially for the Red Knot, which winters and migrates along the coast.
- Identify the wintering area(s) of the small population of Marbled Godwits that breeds in Alaska.
- Determine site fidelity and survivorship of migrating and wintering shorebirds.
- Increase understanding of stop-over ecology of migrant shorebirds.

Education Priorities

Priority education goals for the subregion are to:

- Educate adults and children about the potential effect of their actions, or those of their pets, on nesting, feeding, or roosting shorebirds.
- Develop programs to increase public appreciation of shorebirds, their migrations, and life styles.

Implementation and Coordination

The wetlands of the entire coastline are included in the Pacific Coast Joint Venture of the North American Waterfowl Plan. Given the collaboration of many agencies in the Pacific Coast Joint Venture, it is the best entity to coordinate the shorebird management issues for the Northern California Coast Subregion. The many agencies involved in the Joint Venture or that otherwise manage coastal habitats are:

California Coastal Conservancy – a state regulatory agency that also administers programs to improve the natural resources along the entire coastline.

California Department of Fish and Game – the primary agency managing wildlife on state lands; particularly active on the north coast at Lake Talawa, Humboldt Bay, and Tomales Bay.

California Department of Parks and Recreation – manages many of the sand beaches along the northern California coastline.

Golden Gate Biosphere Reserve – a collaborative effort of various agencies, including those with management interests at Point Reyes wetlands.

Golden Gate National Recreation Area – has management responsibilities at Bolinas Lagoon.

Humboldt Bay Harbor District – a group that proposes to balance conservation and development of bay habitats.

Humboldt Bay Management Group – focuses on management issues within Humboldt Bay.

Marin County Open Space District – manages resource protection and recreational activities at Bolinas Lagoon.

National Oceanic and Atmospheric Administration – through the Gulf of the Farallones Marine Sanctuary this agency has regulatory responsibilities at Estero Americano, Tomales Bay, Bolinas Lagoon, and adjacent offshore waters.

Sonoma County – manages bay-front parks at Bodega Harbor.

U.S. Fish and Wildlife Service – manages Humboldt Bay National Wildlife Refuge.

U. S. National Park Service – through the Point Reyes National Seashore (PRNS) manages Tomales Bay (in part), Abbotts Lagoon, Drakes Estero, and Limantour Estero. PRNS is facilitating development of a Tomales Bay User Plan with area stakeholders. It would be desirable if this plan would incorporate the recommendations for Tomales Bay included in the shorebird conservation plan.

Various county park departments – manage some coastal beaches.

SAN FRANCISCO BAY SUBREGION

Description of Subregion

San Francisco Bay is about 516,600 acres in size. For purposes of this plan it is divided into Suisun Bay, North Bay (or San Pablo Bay), Central Bay, and South Bay. Information on historical and current amounts of habitat San Francisco Bay are taken from the Goals Project (1999).

Suisun Bay. Prior to major human alteration, beginning about 200 years ago, Suisun Bay consisted of 16,746 acres of deep bay, 24,095 acres of shallow bay, 2,405 acres of tidal flat, 65,358 acres of tidal marsh, 2 acres of lagoons, and 2 acres of other baylands. Hundreds of small to large natural marsh ponds occurred in the western portion of the marsh. By the late 1990s, human alterations had reduced the area of deep bay 31% to 11,584 acres, shallow bay 7% to 22,428 acres, tidal flat 53% to 1,124 acres, and tidal marsh 79% to 13,562 acres. Replacement habitats include 49,873 acres of diked wetland, 5,544 acres of agricultural land, 720 acres of storage and treatment ponds, 762 acres of undeveloped bay fill, 2,453 acres of developed bay fill, and 570 acres of other bayland. Diking of Suisun Bay, primarily for livestock grazing, commenced about 1865. In the 1870s and 1880s the first duck clubs were established around the marsh ponds. By the early 1900s livestock grazing was giving way to other agricultural activities, such as the production of sugar beets, asparagus, lima beans, oats, and barley. Eventually increasing salinity and land subsidence caused agricultural activities to fail and be replaced by duck clubs in the eastern part of the bay. Currently, the only agricultural activity is some oat hay farming on 1,500 acres of former bayland. Levees originally constructed for farming are now an integral part of the infrastructure of the duck clubs. Suisun Marsh is now considered San Francisco Bay's largest contiguous protected area, consisting of 89,000 acres of wetland, channels, and bays and 22,500 acres of adjacent uplands. Included are 49,873 acres of privately and publicly owned marsh managed primarily for duck hunting. Among the publicly owned areas are the state Grizzly and Joyce Island Wildlife Areas.

North Bay. Historically, the composition of the North Bay was 20,139 acres of deep bay, 55,120 acres of shallow bay, 13,351 acres of tidal flat, 55,076 acres of tidal marsh, 37 acres of lagoons, 270 acres of salt pans, and 24 acres of other baylands. Since 1850 the acreage of deep bay has decreased 49% to 10,362 acres, shallow bay has remained about the same at 53,804 acres, tidal flat has decreased 32% to 9,118 acres, and tidal marsh has decreased 70% to 16,347 acres. Lagoons have increased to 2,353 acres, salt ponds to 7,143 acres, diked wetlands to 7,622 acres, agricultural baylands to 27,732 acres, storage and treatment ponds to 1,266 acres, undeveloped bay fill to 1,648 acres, developed bay fill to 6,211 acres, and other baylands to 565 acres.

Tidal marshes in the North Bay were diked initially to create land for livestock grazing, which remained the sole agricultural practice in the region for many decades; high water tables and soil salinities discouraged other crops. In 1952, Leslie Salt Company expanded salt production into the North Bay by converting agricultural land into salt evaporation ponds. During recent decades, some of the remaining agricultural lands have been managed for the production of cattle silage and vineyards. In 1997, all the salt ponds, except the Napa crystallizer ponds, were sold to the California Department of Fish and Game, which now manages the ponds as a state Wildlife Area.

Central Bay. The Central Bay historically consisted of 55,609 acres of deep bay, 57,272 acres of shallow bay, 13,532 acres of tidal flat, 13,461 acres of tidal marsh, 45 acres of lagoons, and 215 acres of other baylands. Deep bay (now at 53,614 acres) and shallow bay (53,774 acres) have decreased less than 10% from historic levels. In

contrast, the area of tidal flat has decreased 70% to 4,014 acres and tidal marsh 93% to 947 acres. Habitats that have replaced tidal flat and marsh include lagoons (now at 658 acres), diked wetlands (1,314 acres), agricultural bayland (34 acres), storage and treatment ponds (57 acres), undeveloped bay fill (3,420 acres), developed bay fill (21,970 acres), and other baylands (380 acres). Urban development now abuts much of the Central Bay shoreline.

South Bay. Historically the South Bay had 7,035 acres of deep bay, 37,955 acres of shallow bay, 21,181 acres of tidal flat, 56,037 acres of tidal marsh, 1,316 acres of salt pans, 12 acres of undeveloped bay fill, and 13 acres of other baylands. The amount of deep bay has changed little during the past 200 years and today is estimated at 6,851 acres. Shallow bay has increased by 10% to 41,812 acres but tidal flat has declined by 29% to 14,955 acres and tidal marsh by 83% to 9,335 acres. Other habitats that have increased or were not present historically are lagoons (598 acres), commercial salt ponds (27,313 acres), other baylands (347 acres), diked bayland (5,709 acres), agricultural land (1,309 acres), storage and treatment ponds (1,628 acres), undeveloped bay fill (1,768 acres), and developed bay fill (11, 930 acres). Alteration of wetlands for urban development and salt production are the two most prominent causes of habitat change in the South Bay.

Shorebird Species

Overall, San Francisco Bay holds higher proportions of the region's total wintering and migrating shorebirds than any other coastal wetland within the U.S. Pacific coast wetland system (Table 1).

Table 1 Percent of coastal shorebird totals found in San Francisco Bay on PRBO surveys of all the major wetlands of the contiguous U. S. Pacific coast (from Page et al. 1999).

	Season		
Species	Fall	Winter	Spring
Black-bellied Plover	62	59	55
Semipalmated Plover	52	40	47
Black-necked Stilt	78	90	58
American Avocet	96	88	86
Greater Yellowlegs	41	41	26
Willet	69	58	57
Long-billed Curlew	66	49	46
Marbled Godwit	62	46	68
Red Knot	76	43	39
Western Sandpiper	59	68	54
Least Sandpiper	67	39	73
Dunlin	-	38	24
dowitcher spp.	72	65	49

San Francisco Bay is the northernmost regular breeding area of the American Avocet and Black-necked Stilt on the U.S. Pacific coast. About 10% of the U.S. Pacific coast population of the Snowy Plover breeds in South Bay salt ponds. San Francisco Bay is recognized as a WHSRN site of Hemispheric Importance for shorebirds – the highest possible ranking.

Regional Population and Habitat Goals

Priority population and habitat conservation goals for San Francisco Bay are to:

- Attain a breeding population of 500 Snowy Plovers, consistent with the population objectives of the draft Snowy Plover Recovery Plan.
- Maintain or increase current breeding populations of the Killdeer, Black-necked Stilt, and American Avocet.
- Maintain or increase current populations of migrating and wintering shorebirds.
- Restore 4,000 acres of tidal flat habitat throughout the bay.
- Protect existing tidal flat habitat from introduced plants and invertebrates.
- Protect existing habitat from further fragmentation by human-created infrastructures such as power lines.
- Acquire and manage artificial salt ponds specifically for shorebirds.
- Implement wetland management practices favorable to breeding, wintering, and migrating shorebirds.

Habitat Status, Threats, and Management Needs

Descriptions of historical and current habitat availability, shorebird habitat use patterns, threats to shorebirds, management issues, and needed conservation actions are provided below for the major habitat types in the San Francisco Bay estuary.

Tidal Flats. Currently there are about 29,212 acres of tidal flat in San Francisco Bay, a 42% decrease from the historical level of 50,469 acres. Today about 90% of the tidal flats occur on the bay's edges and about 10% along marsh channels. Historically, a greater proportion of the tidal flat occurred along marsh channels. Tidal flats are the principal foraging area for most shorebirds in San Francisco Bay at low tide. Species that forage on tidal flats include the Black-bellied Plover, Semipalmated Plover, Willet, Long-billed Curlew, Marbled Godwit, Red Knot, Dunlin, Western Sandpiper, Least Sandpiper, Short-billed Dowitcher, and Long-billed Dowitcher. Tidal flat invertebrates are the primary shorebird food, but the majority of these have been introduced by man.

Within the past decade, salt-water cord grass (*Spartina alterniflora)* has been introduced into the bay from stock originating on the Atlantic coast of the U.S. This species grows at both lower and higher elevations in the intertidal zone than the native California cord grass (*Spartina foliosa)* and thereby threatens to reduce the amount of unvegetated tidal flat available to foraging shorebirds. The USFWS, East Bay Regional Park District, CDFG, and others have ongoing management programs using physical and chemical methods to control and eliminate *Spartina alterniflora*.

Other factors impacting, or potentially impacting, tidal flats and the invertebrates living in them include sea level rise, contaminants, oil spills, and proposed new ferry systems. Sea level rise, projected from current levels of global warming, is a phenomena that could greatly alter the acreage of tidal flat in the bay. Some communities, such as

Corte Madera, currently are proposing to construct tidal barriers on tidal flats to prevent future flooding of urban areas from sea level rise. Contaminants, such as selenium and mercury, are widespread in bay sediments. There is a high potential for oil spills, which could have a major impact on shorebirds and their food supply. Proposed new ferry transport systems may involve the use of hover craft over tidal flats, where their high noise levels and frequent presence has the potential to disturb foraging shorebirds or their benthic invertebrate prey. Dredging to accommodate ferry facilities also could reduce the amount of available intertidal habitat.

Priority conservation actions for tidal flat habitat are to:

- Increase the extent of tidal flat by adding 4,000 acres throughout the bay.
- Eliminate non-native vegetation (e.g., *Spartina alterniflora)* that threatens tidal flats.
- Develop regulations to reduce invasions of non-native benthic invertebrates.
- Oppose human activities that increase disturbance to shorebirds.

Salt Ponds. Historically, about 1,594 acres of natural salt pans occurred in the tidal marsh of the North and South bays. Most of this habitat was located in the South Bay, primarily near Hayward at San Lorenzo Creek and Mount Eden Slough. The largest pond complex, Crystal Pond, extended over some 1,000 acres. As the demand for salt rose in the mid-1800s, the first artificial salt ponds were developed as extensions and improvements of the natural salt ponds. Subsequently, artificial salt ponds have entirely displaced their natural forerunners. Currently there are 34,455 acres of salt ponds in the bay; the majority were constructed on former salt marsh.

Salt ponds are the principal foraging habitat (south of Suisun Bay) of the Black-necked Stilt, Wilson's Phalarope, and Red-necked Phalarope. The large increase in acreage of salt ponds during the past 200 years likely has augmented numbers of these species in the bay over historical levels. On PRBO shorebird surveys of the North, Central, and South bays, the median proportions of Black-necked Stilts found in the salt ponds, versus other habitats, were 86% and 60% for fall and spring, respectively. For the Red-necked Phalarope, comparable proportions were 99% and 93% (PRBO unpubl. data). The American Avocet and Snowy Plover are species that use both salt ponds and tidal flats for foraging and now likely are more abundant in the bay than formerly. Other species that feed principally on tidal flats at low tide, such as the Dunlin, Western Sandpiper, Least Sandpiper, and Willet, also forage in the salt ponds at high tide. Most shorebirds use the salt ponds, especially the levees and islands, as high tide roosting areas.

Dry margins and levees of salt ponds are the chief nesting habitat of the Snowy Plover in San Francisco Bay and also are important nesting areas for the Black-necked Stilt and American Avocet. None of these species may have nested in the bay prior to the development of the salt ponds. The Snowy Plover was known to nest in the bay at salt ponds by 1918, whereas the American Avocet and Black-necked Stilts were first known to breed there in 1926 and 1927, respectively (Harvey et al. 1992).

In the last two decades, shorebirds nesting in the salt ponds have been impacted by introduced mammalian predators and expanding populations of native predators. Feral red foxes have been identified as important predators of plover, avocet, and stilt clutches; feral and free-roaming cats also may be a problem. Common Ravens – important

predators of the eggs of nesting shorebirds – are expanding their breeding range into the bay, where they nest on power line towers and other artificial structures.

Conversion of salt ponds to tidal marsh is a widely supported concept to increase habitat for several threatened and endangered marsh species in the bay. A resulting decrease in salt pond habitat could reduce numbers of some shorebird species, especially the Snowy Plover, Black-necked Stilt, American Avocet, Wilson's Phalarope, and Red-necked Phalarope.

Priority conservation actions for salt ponds are to:

- Acquire and manage 10,000 acres of salt ponds specifically for nesting, feeding, and roosting shorebirds. Of these, 2,000 acres should be managed specifically for nesting Snowy Plovers, as recommended in the draft Snowy Plover Recovery Plan.
- Use fencing and exclosures to protect Snowy Plover nests from egg predators.
- Maintain public closures of Snowy Plover nesting areas during the breeding season on Don Edwards National Wildlife Refuge, Baumberg Eden Landing Ecological Reserve, and Hayward Area Regional Park District lands.
- Continue to manage non-native and native mammalian predators to limit predation of the eggs and chicks of the Snowy Plover and other nesting shorebirds in all important nesting habitat. Predator management by a number of public and private landowners is an ongoing cooperative activity to protect nesting California Clapper Rails, Snowy Plovers, and other migratory birds.
- Develop and implement a strategy to manage avian predators of shorebird eggs and chicks.
- Develop methods to prevent the spread of vegetation in dry salt ponds.
- Determine salt pond salinities most beneficial to shorebirds.

Managed Diked Marsh. Diked wetlands are a human-created habitat currently totaling about 64,518 acres in the bay. Of these, 77% are in Suisun Bay, 11% in North Bay, 2% in Central Bay, and 9% in South Bay. Diked wetlands make up about 67% of all bayland habitat in Suisun Bay. The Suisun Bay diked wetlands, which are privately and publicly owned, are managed primarily for waterfowl hunting. These wetlands provide important foraging habitat for the Black-necked Stilt, American Avocet, Greater Yellowlegs, Dunlin, and Long-billed Dowitcher and nesting habitat for the Killdeer, Black-necked Stilt, and American Avocet. Diked wetlands, whether duck ponds or abandoned salt evaporation ponds, vary considerably in water level, salinity, and amount and type of vegetation. Consequently, shorebird use can be highly variable among ponds.

Priority conservation actions for managed diked marshes are to:

- Time water drawdowns in managed marshes of Suisun Bay to correspond with the peak of spring shorebird migration from mid-April to mid-May. Manage vegetation in some marsh cells to provide broad expanses of open habitat.
- Create 1-6 inch water depths in some Suisun Marsh managed ponds for wintering shorebirds.
- Increase nesting habitat for the Black-necked Stilt and American Avocet in Suisun Bay managed marshes through the strategic placement of islands.

Salt Marsh. There currently are about 40,191 acres of tidal marsh in the bay, a 79% decline from historic levels. Tidal marsh has been lost primarily to the development of salt ponds, agriculture land, and urban areas. Marsh channels, ponds, and wrack are used by many species of shorebirds for foraging, whereas vegetated portions of marsh are relatively little used. Species most likely to be found foraging in marshes are the Willet and Least Sandpiper. Black-necked Stilts nest in marshes with shallow ponds.

Priority conservation actions for tidal marsh are to:

- Include channels in the design of tidal marsh restoration projects.
- Create shallow ponds in marshes for nesting Black-necked Stilts.
- Increase tidal circulation in marshes to enhance invertebrate productivity and shorebird foraging areas.

Agricultural Baylands. Currently there are about 34,620 acres of agricultural baylands of which about 80% are located in the North Bay. Seasonal wetlands that form on these agricultural lands after winter rains are foraging habitat for many shorebirds, such as the Greater Yellowlegs, Western Sandpiper, Least Sandpiper, Dunlin, and Long-billed Dowitcher.

All Habitats. A priority conservation action for all habitats is to:

- Oppose the addition of any more power lines and support the rerouting of existing ones away from bay habitat.

Monitoring Priorities

Priority monitoring needs for the San Francisco Bay estuary are to:

- Devise and implement a method to annually monitor trends in shorebird abundance in San Francisco Bay.
- Conduct annual surveys of Snowy Plover nesting distribution and abundance.

Research Priorities

Priority research needs for the San Francisco Bay estuary are to:

- Identify the salinities, water depths, and physical features of salt ponds most valuable to shorebirds.
- Investigate how to manage salt ponds for shorebirds in the absence of commercial salt production.
- Determine how to replace salt ponds as shorebird roosting sites before undertaking the conversion of pond habitat to marsh habitat.
- Quantify shorebird use of non-fully tidal wetlands, such as muted tidal wetlands, seasonal wetlands, and abandoned salt ponds.
- Measure Snowy Plover reproductive success, survival, habitat selection, and site fidelity within the bay.
- Determine the current abundance and distribution of nesting Black-necked Stilts and American Avocets within the bay.
- Inventory shorebird numbers in Suisun Bay.
- Quantify the nesting habitat requirements of the Black-necked Stilt and American Avocet in Suisun Marsh.

- Identify the characteristics of the most productive nesting islands for Black-necked Stilts.
- Determine water depths of Suisun Bay managed marshes most beneficial to shorebirds.
- Delineate how vegetation and water depth should be managed in seasonal wetlands to benefit shorebirds.
- Quantify the benefits shorebirds gain from restoration projects.
- Determine the effect that bayside trail use, kayaking, and other human recreational activities have on shorebirds.
- Investigate the effects of introduced invertebrate prey on shorebird foraging ecology.

Education Priorities

Education priorities for the subregion are to:

- Support existing education, outreach, and interpretive programs at all sites.
- Initiate focused shorebird conservation and education programs.
- Disseminate information on research-driven adaptive management techniques.

Implementation and Coordination

Because of large reductions in tidal marsh and tidal flat in San Francisco Bay, some endemic marsh subspecies have declined in abundance and have been federally listed as endangered (e.g., California Clapper Rail and salt marsh harvest mouse). There is an urgent need to increase the amount of marsh habitat for these species and consequently much attention is focused on marsh restoration. Since space and opportunities for habitat restoration are finite, there is a need to look at the habitat requirements of all species to develop a comprehensive conservation plan for the wildlife of San Francisco Bay. Accordingly, from 1995 to 1999 scientists and resources managers familiar with the San Francisco Bay ecosystem worked together on the San Francisco Bay Area Wetland Ecosystem Goals Project to produce a blueprint for the kinds, amounts, and distribution of wetland habitats needed in the estuary to sustain diverse and healthy wildlife communities. The results of this planning effort are outlined in the Bay Ecosystem Habitat Goals Report (Goals Project 1999). Although the habitat recommendations in the report are voluntary, they are likely to help guide the efforts of several groups involved in habitat acquisition, restoration, and enhancement in the estuary. These groups include:

CALFED – a collaborative effort of state and federal agencies and urban, agricultural, and environmental interest groups to address the environmental and water management problems of the San Francisco Bay-Delta system. CALFED is developing a long-term comprehensive plan for restoring the ecological health of the bay and delta and for improving water management. Within CALFED, the Ecosystem Restoration Program's stated objectives include increasing and improving aquatic and terrestrial habitats, improving the ecological functioning of the bay-delta system, and increasing the ability of the system to support sustainable populations of diverse plant and animal species. CALFED is a source of funding for restoration and enhancement projects, especially in Suisun Bay and North Bay.

California Coastal Conservancy – a state agency that administers programs to improve natural resources along the California coastline. In 1997 the Conservancy

initiated its San Francisco Bay Area Conservancy Program in an effort to identify and adopt long-term goals for resource protection and recreation in the nine counties surrounding the bay. The California Coastal Conservancy undertakes acquisition projects and awards grants for restoration projects.

California Department of Water Resources – this state agency has developed the Plan of Protection for the Suisun Marsh in recognition of the wildlife values of the managed and tidal marshes.

San Francisco Bay Conservation and Development Commission (BCDC) – BCDC has developed the San Francisco Bay Plan for the conservation of San Francisco Bay waters and the regulation of shoreline development. In 1999, the Commission will commence a five-year process to update the plan. It is expected to use information from the Goals Project for revising its sections on bay habitats and wildlife. BCDC also developed the Suisun Marsh Protection Plan and Act, which the Legislature ratified in 1997. This plan, which has wide support among private landowners and public agencies, decrees that when feasible historic marshes should be returned to either managed or tidal wetland status and that if managed wetlands are not needed for waterfowl hunting they should be restored to tidal marshes.

San Francisco Bay Joint Venture – this public and private partnership was formed in 1996 to promote the acquisition, restoration, and enhancement of bay area wetlands and associated habitats. Operating under the North American Waterfowl Management Plan, this Joint Venture is currently preparing an implementation strategy for habitat acquisition, restoration, and enhancement using the Goals Project. The Joint Venture has identified about 40 pending or proposed restoration projects that could benefit shorebirds in the bay.

Suisun Resource Conservation District – this agency has been working since the 1960s to encourage private landowners to manage lands more effectively.

U.S. Fish and Wildlife Service – USFWS is aiding conservation of bay habitats through its Recovery Plan for Tidal Marsh Ecosystems of Central and Northern California and the Recovery Plan for the Western Snowy Plover, Pacific Coast Population.

It would be appropriate for the San Francisco Bay Joint Venture to take the lead role in implementing the shorebird conservation plan in San Francisco Bay.

SOUTHERN CALIFORNIA COAST SUBREGION

Description of Subregion

The Southern California Coast Subregion encompasses about 648 miles of coastline of which 59% is sand beach, 38% rocky shoreline, and 2% gravel or cobble beach (U.S. Army Corps of Engineers 1971). Dozens of wetlands are interspersed along the coastline.

Wetlands of Importance to Shorebirds

We identified 25 wetlands along the southern California coast that are used by hundreds to ten of thousands of shorebirds. Shorebirds numbers attributed to each of the 25 wetlands below are from unpublished data of Point Reyes Bird Observatory (PRBO) unless otherwise indicated.

Santa Cruz County

Pajaro River Mouth – holds up to 1,800 shorebirds.

Monterey County

Elkhorn Slough – holds over 30,000 shorebirds in fall and winter; a potential WHSRN site of Regional Importance. See also Ramer et al. (1991).

Salinas River Mouth – holds up to 1,000 shorebirds in fall and spring.

San Luis Obispo County

Morro Bay – holds up to 20,000 shorebirds in winter; a potential WHSRN site of Regional Importance.

Santa Maria River Mouth – holds hundreds of shorebirds.

Santa Barbara County

Devereaux Slough – holds hundreds of shorebirds.

Goleta Slough – occasionally holds just over a hundred shorebirds.

Ventura County

Mugu Lagoon – holds up to 66,000 shorebirds during spring and over 10,000 at times in fall and winter; a potential WHSRN site of Regional and possibly International Importance.

Los Angeles County

Malibu Lagoon – holds hundreds of shorebirds.

Los Angeles River Mouth – holds up to 5,800 shorebirds in fall.

San Gabriel River Mouth – holds hundreds of shorebirds.

Orange County

Seal Beach NWR – holds up to 5,500 shorebirds in winter; recognized as a wetland of International Importance by the Ramsar Convention Treaty.

Bolsa Chica – holds up to 5,400 shorebirds in fall, 7,000 in winter, and 7,700 in spring.

Santa Ana River Mouth – holds hundreds of shorebirds (L. Hays pers. comm.).

Upper Newport Bay – holds up to 5,800 shorebirds in fall, 14,800 in winter, and 8,800 in spring; a potential WHSRN site of Regional Importance.

San Joaquin Marsh – holds hundreds of shorebirds (L. Hays pers. comm.).

San Diego County

Santa Margarita River Mouth – holds up to 1,600 shorebirds in fall and hundreds in winter and spring.

Agua Hedionda Lagoon – holds hundreds of shorebirds.

Batiquitos Lagoon – holds up to 1,000 to 2,000 shorebirds at all seasons.

San Elijo Lagoon – holds up to 3,500 shorebirds in fall and 1,500 in spring. See also King et al. (1987).

San Dieguito Lagoon – holds hundreds of shorebirds.

Los Penasquitos Lagoon – holds hundreds of shorebirds.

Mission Bay/San Diego Flood Control Channel – holds up to 5,000 to 6,000 shorebirds depending on season.

San Diego Bay – holds up to 18,000 shorebirds in fall, 11,000 in winter, and 13,000 in spring; recognized as a WHSRN site of Regional Importance. See also Terp (1998).

Tijuana River Estuary – holds up to 1,000 to 2,000 shorebirds at all seasons.

Beaches of Importance to Shorebirds

Over half the southern California shoreline is sand beach, an important habitat for the Snowy Plover year round and for other species during migration and winter. Monterey Bay beaches support thousands of shorebirds during migration and winter; principal species include the Black-bellied Plover, Snowy Plover, Willet, Whimbrel, Marbled Godwit, and Sanderling (PRBO unpubl. data). Beaches in the vicinity of coastal wetlands, such Morro Bay and Mugu Lagoon, also are used by thousands of roosting shorebirds at high tide. Beaches identified as important to nesting or wintering Snowy Plovers in the draft Snowy Plover Recovery Plan also are likely the main beaches used by other shorebirds.

Specific beaches identified as being particularly important to shorebirds, listed north to south by county, are:

San Francisco County – Ocean Beach.

San Mateo County – Pacifica Beach, Half Moon Bay beaches, Tunitas Creek, San Gregorio Creek, Pomponia Creek, Pescadero Creek, Gazos Creek, and Año Nuevo beaches.

Santa Cruz County – Waddell Creek, Scott Creek, Laguna Creek, Baldwin Creek, Wilder Ranch, and the extensive Monterey Bay beach from Santa Cruz to the Pajaro River mouth.

Monterey County – extensive beach along Monterey Bay from the Pajaro River mouth to Monterey, Asilomar Beach, Carmel River, and Point Sur Beach.

San Luis Obispo County – San Carpoforio Creek, Arroyo Hondo Creek, Point Sierra Nevada, Arroyo de la Cruz, Sidneys Lagoon, Piedras Blancas, Arroyo Laguna Creek, Pico Creek, San Simeon Beach, Villa Creek, Toro Creek, Atascadero Beach, Morro Bay sand spit, Avila Beach, and the long beach from Pismo Beach to the Santa Maria River mouth.

Santa Barbara County – beach from Santa Maria River mouth to Point Sal, Vandenberg Air Force Base beaches including Santa Ynez River mouth, Jalama Beach, Hollister Ranch beaches, Devereaux Slough Beach, Goleta Beach, Santa Barbara Harbor beaches, Carpinteria Beach, and the beaches of San Miguel, Santa Rosa, and Santa Cruz islands.

Ventura County – San Buena Ventura Beach, beach from Mandalay Bay to Santa Clara River mouth, Hollywood Beach, Ormond Beach, Mugu Lagoon Beach, and beaches of San Nicolas Island.

Los Angeles County – Zuma Beach, Corral Beach, Malibu Lagoon Beach, Santa Monica Beach, Dockwiller to Hermosa beaches, and the beaches of San Clemente Island.

Orange County – Huntington Beach, Newport Beach, Crystal Cove, Salt Creek, Doheny Beach, and San Onfre Beach (part).

San Diego County – San Onfre Beach (part), Aliso Creek, French Creek, Santa Margarita River, San Luis Rey River, Agua Hedionda Lagoon, South Carlsbad Beach, Batiquitos Lagoon, San Elijo Lagoon, San Dieguito Lagoon, Los Penasquitos Lagoon, South Mission Beach, Ocean Beach, Silver Strand, and Tijuana River Estuary.

Shorebird Species

The Southern California Coast Subregion is an important wintering area for many shorebird species, such as the Black-bellied Plover, Willet, Long-billed Curlew, Marbled Godwit, Red Knot, Western Sandpiper, Least Sandpiper, Dunlin, Short-billed Dowitcher, and Long-billed Dowitcher. It also is an important migration staging area, especially for the Whimbrel, Western Sandpiper, Short-billed Dowitcher, Wilson's Phalarope, and Red-necked Phalarope. Black-necked Stilts and American Avocets nest in some of the wetlands and Black Oystercatchers on the rocky shoreline. Over two thirds of the listed Snowy Plover population breeds at the beaches and wetlands in the subregion.

Regional Population and Habitat Goals

Priority population and habitat goals for the southern California coast are to:

- Attain and maintain a breeding population of 2,040 Snowy Plovers following the management recommendations of the draft Snowy Plover Recovery Plan.
- Maintain or increase current breeding populations of the Killdeer, Black Oystercatcher, Black-necked Stilt, and American Avocet.
- Increase numbers of wintering and migrating shorebirds by increasing and improving habitat, particularly by offsetting historic wetland loss by restoring tidal flat and salt marsh habitat.
- Maintain or increase the current amount and distribution of shorebird nesting habitat.
- Reduce erosion of sediment from watersheds into lagoon and estuarine habitats.
- Prevent further introductions of non-native invertebrates into the benthos.
- Eliminate non-native plants that degrade shorebird habitat (e.g., *Ammophila arenaria* from Snowy Plover nesting areas).
- Prevent further building of roads, power lines, and other human structures on or above wetlands.
- Direct human activities away from nesting, foraging, and roosting areas of the Snowy Plover and other shorebirds.
- Haze shorebirds away from areas containing hazardous levels of environmental contaminants in invertebrates or substrates until the hazardous materials are removed.

Habitat Status, Threats, and Management Needs

Descriptions of historical and current habitat availability, shorebird habitat use patterns, threats to shorebirds, management issues, and needed conservation actions are provided below for the major wetland areas on the southern California coast..

Pajaro River Mouth. The Pajaro River Mouth and connecting Watsonville Slough are bordered by a residential development, agricultural fields, and Zmudowski State Beach. Although the river mouth is often open to tidal action for extended periods,

especially in winter, it must be opened when it closes to prevent nearby agricultural fields from flooding. The beach is a Snowy Plover nesting area. Small numbers of the American Avocet and Black-necked Stilt periodically nest along Watsonville Slough. The beach and river flats provide valuable foraging and roosting habitat for a wide variety of migrating and wintering shorebirds, including the Black-bellied Plover, Willet, Marbled Godwit, Sanderling, and Western Sandpiper. Known or potential impacts to shorebirds here include human disturbance of nesting Snowy Plovers and other shorebirds feeding or roosting on the beach, colonization of the beach by *Ammophila arenaria*, predation of Snowy Plover eggs by feral red fox, predation of Snowy Plover chicks by Loggerhead Shrikes, and possibly poor water quality from agricultural run-off. The California Department of Parks and Recreation (CDPR) manages the beach for nesting Snowy Plovers by closing areas and erecting exclosures to protect nests from humans and egg predators. CDPR has also commenced an *Ammophila* eradication program to increase Snowy Plover nesting habitat (G. Page pers. obs.).

Elkhorn Slough. In the approximately 4,000-acre Elkhorn Slough and associated wetlands, tidal mudflat is the primary feeding area for most shorebirds. An extensive *Salicornia* marsh is also used for foraging and roosting by the Marbled Godwit, Willet, Long-billed Curlew and Least Sandpiper, particularly at high tide. Tidally-restricted mudflat occurs in North Marsh and Moro Cojo Slough. Although tidal flow into Moro Cojo Slough is restricted by culverts, creating an area where water fluctuations are governed by rainfall and evaporation, the slough is used as a high tide foraging and roosting area by many shorebirds, a foraging area for the Black-necked Stilt and American Avocet on all tides, and a nesting area for the Black-necked Stilt, American Avocet and Killdeer. At the upper end of Elkhorn Slough, Black-necked Stilts also nest in the diked Porter Marsh, which is cut off from tidal influence; tide gates prevent water from entering but not exiting into the main channel of Elkhorn Slough. North and Strawberry marshes are managed for flood and mosquito control but provide important foraging habitat for the American Avocet, Black-necked Stilt, and dowitchers. Strawberry Marsh provides foraging habitat for the Red-necked Phalarope in fall. Former salt ponds are now managed by CDFG as the Moss Landing Wildlife Area. The ponds support nesting Snowy Plovers, Black-necked Stilts, and American Avocets during summer and many other shorebirds at other seasons. Sand beach at Elkhorn Slough mouth is foraging and roosting habitat for several shorebird species and nesting habitat for the Snowy Plover. Issues relevant to shorebirds at Elkhorn Slough are excessive erosion of the salt marsh along the main channel from the construction of Moss Landing Harbor in 1947, which changed the slough from a depositional to an erosional environment; many non-native invertebrates in the benthos; predation of Snowy Plover eggs by feral red fox; an expanding raven population, which also is expected to prey on Snowy Plover eggs; avian predation of Snowy Plover chicks; agricultural run-off contaminating water and sediments with pesticides; degraded salt marsh at Moro Cojo Slough from cattle grazing; and water level manipulation for mosquito control. Elkhorn Slough is owned by CDFG, The Nature Conservancy, and private parties. It is a NOAA National Estuary Research Reserve (S. Connors pers. comm.).

Salinas River Mouth. The Salinas River mouth is bordered by the Salinas River National Wildlife Refuge and Salinas State Beach. Much beach in the area is closed to the public. Nest exclosures also are used to protect Snowy Plover eggs from being

trampled by people or taken by feral red fox, skunks, and gulls. Frequently the river mouth closes during the summer allowing the Snowy Plover, Black-necked Stilt, and American Avocet to nest more safely on islands within a quarter mile of the river mouth. Avocets and stilts also nest in pond and marsh areas adjacent to the river on the wildlife refuge, whereas the Snowy Plover and Killdeer nest on the beach. Water quality of the river is probably poor because of agricultural run-off from extensive farmlands upstream. Human disturbance and shorebird egg and chick loss to predators are management issues at Salinas River mouth (G. Page pers. obs.).

Morro Bay. Morro Bay, a 2,300-acre National and State Estuary, is managed for oyster harvesting, fishing, and hunting. It supports tens of thousands of migrating and wintering shorebirds, including the Black-bellied Plover, Willet, Long-billed Curlew, Marbled Godwit, Sanderling, Western Sandpiper, and Least Sandpiper (PRBO unpubl. data). The Morro Bay sand spit is an important Snowy Plover nesting area. Agencies responsible for Morro Bay oversight include the National Guard, CDPR, CDFG, California Department of Corrections, State Department of Health Services, California Coastal Commission, State Water Resources Control Board, Central Coast Regional Water Quality Control Board, Coastal San Luis Obispo Resource Conservation District, State Coastal Conservancy, California Conservation Corps, California Polytechnic State University, San Luis Obispo, University of California Extension, County of San Luis Obispo, City of Morro Bay, Los Osos Community Services District, U. S. Army Corps of Engineers, USFWS, and U.S. National Marine Fisheries Service. Primary management goals are to ensure that Morro Bay water remains of sufficient quality to support a viable commercial shellfish industry, safe recreation, healthy eelgrass beds, and thriving fish and shellfish populations. Accelerated rates of sedimentation from human alteration of the watershed occur at Morro Bay. The Coastal San Luis Obispo Resource Conservation District is addressing this problem through its 1989 Morro Bay Watershed Enhancement Plan, which focuses on preventing and controlling soil erosion. The District acquires watershed parcels to reestablish natural flood plains and create sediment deposition areas above Morro Bay. Invasion of non-native plants and invertebrates also are management issues at Morro Bay. The spit is covered with the non-native European beachgrass *(Ammophila arenaria)*, which degrades it as a nesting area for the Snowy Plover. Many agencies are now cooperatively producing a Comprehensive Conservation and Management Plan for Morro Bay and its watershed. Management for shorebirds is expected to be compatible with other management goals (K. Kropp pers. comm.).

Santa Maria River Mouth. The Santa Maria River mouth is usually closed to tidal action. The sand beach and river flats are used by hundreds of shorebirds, especially the Black-bellied Plover, Snowy Plover, Willet, and Sanderling. Dry river flats and adjacent beach are important Snowy Plover nesting areas. The river mouth occasionally experiences oil discharges from a former production field encompassing the area (G. Page pers. obs.).

Devereaux Slough. This 8.7-acre salt marsh with channels has been altered historically and subjected to excessive rates of sedimentation. The area is used by hundreds of migrating and wintering shorebirds, and an adjacent beach is an important wintering and potential nesting area for the Snowy Plover. Located in the area is the Coal Oil Point Preserve, owned and managed by the University of California. Important mangement issues for the area are exotic plants, nest predation by introduced and native

predators, human disturbance, and mosquito abatement practices. A management plan is being prepared to reduce disturbance to wintering Snowy Plovers. Management goals for the region that could benefit shorebirds, and especially wintering Snowy Plovers, include limiting human access to trails, enforcing pet restrictions, reducing nighttime recreation activities, controlling feral red fox and raccoons *(Procyon lotor),* and enforcing parking restrictions (K. Lafferty pers. comm.).

Mugu Lagoon. This 1479-acre estuary, within Mugu Naval Air Station, is owned and managed by the U.S. Navy. There are 129 acres of tidal flats, 77 acres of salt pan, 946 acres of tidal marsh, and 327 acres of channels, creeks, and open water. The lagoon is used by tens of thousands of migrating and wintering shorebirds and modest numbers of nesting Snowy Plovers, Black-necked Stilts, and American Avocets. Mugu Lagoon is impacted by run-off from the large adjacent agricultural area, which enters the lagoon through Calleguas Creek. The most serious threat is increased sedimentation from development of the watershed. Pollutants – including lead, mercury, silver, and methoxychlor – have been detected at or above hazardous levels in drains to the lagoon. The lagoon mouth also closes periodically affecting sedimentation rates. A fish and wildlife plan has existed since 1963 and was amended in 1976 (Onuf 1987, Harrington and Perry 1995).

Malibu Lagoon. Malibu Lagoon, fed by Malibu Creek, provides about 92 acres of wetland habitat. It is owned and managed by CDPR. Although surrounded on three sides by residential, commercial, and recreational developments, the wetland's tidal flat, salt marsh, and beach habitats support a wide variety of migrating and wintering shorebirds (L. Hays pers. comm.).

Los Angeles River Mouth. Once part of one of the largest flood plains in the United States, the Los Angeles River is now entirely channelized and operated primarily as a flood control facility by the Los Angeles Department of Water and Power and the U.S. Army Corps of Engineers. Within the intertidal portion of the river, extending inland from the mouth about 2.6 miles to the Willow Street crossing in Long Beach, are approximately 234 acres of wetlands, which provide shorebird habitat when water levels are low. Although the river upstream of Willow Street has a cement bottom, a 4-mile stretch, equivalent to about 40 acres of river channel, annually holds thousands of shorebirds during migration (L. Hays pers. comm.).

San Gabriel River Mouth. The San Gabriel River Mouth/Los Cerritos /Hellman Ranch wetland complex, located primarily in the City of Long Beach, contains a minimum of 155 acres of wetland habitat exclusive of the San Gabriel River channel. Hundreds of shorebirds use the complex. The river channel is mostly subtidal and not extensively used by shorebirds. Adjacent to the channel, within the Los Cerritos wetlands, are 19 acres of salt marsh, about 18 acres of diked wetlands, 8 acres of tidal mudflat, and 95 acres of subtidal habitat. Although the salt marsh north of Westminister Avenue is open to tidal action, levees isolate the remaining marsh from the tides. The Hellman Ranch wetland, adjacent to the San Gabriel River and about 1 mile upstream from the mouth, consists of 3 acres of tidal channel, 15 acres of degraded salt marsh, 2 acres of seasonal ponds, and 7 acres of alkaline flats. The Cerrito and Hellman Ranch wetlands are mostly privately owned (L. Hays pers. comm.).

Seal Beach NWR. The approximately 1,000-acre Seal Beach National Wildlife Refuge lies within the 1,255-acre Anaheim Bay wetland complex, which includes 565

acres of salt marsh, 60 acres of tidal flat, 114 acres of tidal channels and ponds, and 475 acres of human-created waterways and open water. Thousands of shorebirds occur here during migration and winter, feeding primarily on tidal flats; some rocky coast species forage on rock jetties. Over 2,000 acres of surrounding agricultural land, mostly in row crops, buffer the wetlands on two sides from dense urban development and provide additional foraging habitat for wintering shorebirds. About a dozen Black-necked Stilts breed in the wetlands. Anaheim Bay's wetlands have been reduced to about half their former extent during the past 150 years by diking and filling for agriculture and construction of a railway and interstate highway through the marsh, an ammunition depot with connecting harbor, a marine-oriented residential community, and an oil pumping facility. There is a potential for further habitat loss and degradation from development. Habitat also has been altered by the introduction of non-native invertebrates into the benthic invertebrate community and probably by chemical contamination of water and sediments from the oil facility and motor boats. Feral red fox, feral cats, and stripped skunks *(Mephitis mephitis)* impact the reproductive success of nesting birds. The Seal Beach National Wildlife Refuge, contained within the U.S. Navy's Seal Beach Naval Weapons Station, is managed to maintain the quality of wetland habitat, prevent human intrusion, protect threatened and endangered species, and reduce predation pressure on nesting birds. Feral red fox populations have been controlled on the refuge but not in surrounding areas. Human disturbance and habitat needs of endangered species, such as the Light-footed Clapper Rail and Belding Savannah Sparrow, are wildlife management issues. Protection and restoration of adjacent historic coastal wetlands and protection of high tide roosting areas are actions that would benefit shorebirds at the refuge (J. Bradley pers. comm.).

Bolsa Chica. Although recently threatened with development, all 1,300 acres of the Bolsa Chica wetlands are now in state ownership. A project is underway to remove oil field infrastructure and restore tidal influence to about 700 acres, which will create large tidal flats; the largest seasonal ponds and flats will be retained for shorebirds and other species. The existing 330-acre Bolsa Chica Ecological Reserve is managed by CDFG. It consists of open water, tidal marsh, sandy islands, and 80 acres of tidal flats. The remaining 1,000 acres contain an operating oil field with extensive areas of seasonal ponds and non-tidal flats. Bolsa Chica supports nesting Snowy Plovers, Black-necked Stilts, American Avocets, and thousands of migrating and wintering shorebirds. It is smaller than 150 years ago. Remaining habitat is degraded by invasive non-native plants, non-native benthic invertebrates, and restricted tidal circulation. Introduced mammalian predators impact nesting birds. Human disturbance and habitat needs of endangered species also are wildlife management issues. Bolsa Chica currently is protected to provide nesting, feeding, and roosting habitat for aquatic birds, especially listed species, including the Snowy Plover. Shorebirds will benefit from a new tidal entrance for the Ecological Reserve and the wetland habitat restoration being undertaken on the oil field (Hays 1985, E. Burres and L. Hays pers. comm.).

Santa Ana River Mouth. Located about half way between Bolsa Chica and Upper Newport Bay, the Santa Ana River mouth accommodates a large array of shorebirds much of the year, including the Black-bellied Plover, Semipalmated Plover, Willet, Long-billed Curlew, Marbled Godwit, Western Sandpiper, Least Sandpiper, and Long-billed Dowitcher. Although fully channelized at the mouth and considerably smaller than

the 2,950-acre footprint of historic wetlands, the Santa Ana River, adjacent U.S. Army Corps of Engineers (USACE) mitigation wetlands, and Huntington Beach wetlands contain developing salt marsh, over 60 acres of tidal mudflat, and diked wetlands under consideration for restoration to full tidal influence. The USACE mitigation has established a tidal channel, salt marsh, and island nesting habitats. Although much of the Santa Ana River mouth is undeveloped and used for recreation and flood control purposes, oil field operations continue to the northeast. Ownership includes the CDPR (Huntington State Beach); Orange County; the Cities of Huntington Beach, Costa Mesa, and Newport Beach; and private parties (L. Hays pers. comm.).

Upper Newport Bay. Upper Newport Bay, fed by San Diego Creek and Delhi Channel, consists of nearly 1,400 acres of open water, salt marsh, freshwater marsh, and tidal mudflat. Thousands of shorebirds forage on the mudflats much of the year. Willets, Long-billed Curlews, and Marbled Godwits also feed in the salt marsh. Many species forage in the freshwater marsh, and the Black-necked Stilt and American Avocet nest there. Upper Newport Bay was heavily used for salt extraction until the salt works were destroyed by San Diego Creek flood waters. Marinas have been constructed, and now the bay is used intensively for motor boating, camping, and kayaking. There has been accelerated sedimentation from watershed development, degraded water quality, invasion of salt marsh by pampas grass, and introduction of non-native invertebrates into the benthos. There is a risk of further habitat alteration from development. Within the bay, the 729-acre Upper Newport Bay Ecological Reserve is owned by the State Lands Commission and managed cooperatively by CDFG and Orange County as a mix of marsh, mudflat, and open water for migrating and wintering shorebirds and other aquatic species. Important management issues are reduced tidal circulation, disturbance from human recreation, and habitat needs of endangered species, such as the California Least Tern *(Sterna antillarun browni)*. Shorebirds would benefit from improving water quality, removing non-native vegetation, and limiting human disturbance (E. Burres and L. Hays pers. comm.).

San Joaquin Marsh. Located west of Upper Newport Bay Ecological Reserve and connected to it by a 0.6-mi stretch of San Diego Creek, the 492-acre San Joaquin Marsh includes about 305 acres of seasonal ponds, freshwater marsh, and seasonally-wet meadows. The San Joaquin Marsh is the largest coastal freshwater marsh in California; Campus Drive effectively splits it into east and west parcels. The University of California owns the 202-acre San Joaquin Freshwater Marsh Preserve and Irvine Ranch Water District owns the remainder of the area. Although not managed specifically for shorebirds, drying seasonal ponds provide varying amounts of non-tidal flats, which support hundreds (occasionally thousands) of small and large sandpipers, stilts, and avocets. The flats are an important feeding area for shorebirds that commute from Upper Newport Bay, particularly during high tides. Seasonal pond and marsh habitats are currently being restored; construction of islands within some of the larger pond cells has increased numbers of nesting Black-necked Stilts and American Avocets (L. Hays pers. comm.).

Santa Margarita River Mouth. The Santa Margarita River mouth, owned and managed by the U.S. Marine Corps (USMC), covers about 268 acres west of Interstate 5. It includes 95 acres of salt marsh, 35 acres of open water, 7 acres of mudflat, 6 acres of brackish marsh, and 125 acres of salt flat. Formerly, there were about 370 acres of tidal

channels and marsh. The Del Mar Boat Basin was carved out of 153 acres, and until 1970 the marines used the salt flats of the estuary for tank training exercises. Prior to 1940 the estuary mouth remained open year round but it has since closed periodically, probably as a result of the construction of breakwaters at Oceanside. In 1965 the river channel was dredged deeper for waterfowl, and in 1971 the brackish marsh on the north side of the estuary was dredged to make a salt marsh (Marcus and Kondolf 1989). The beach and salt flats are an important nesting area for the Snowy Plover (A. Powell pers. comm.) and a foraging and roosting area for many other species of shorebirds (PRBO unpubl. data). The USMC protects nesting California Least Terns by erecting large enclosures, within which some Snowy Plovers also nest.

Agua Hedionda Lagoon. The 400-acre Agua Hedionda Lagoon has been fully tidal since it was dredged and its mouth stabilized with jetties in 1954 (Marcus and Kondolf 1989). While tidally well flushed, there is relatively little tidal mudflat (L. Hays pers. comm.). Historically it held a great deal more salt marsh than it does today (Marcus and Kondolf 1989). Roads separate Agua Hedionda Lagoon into three regions. San Diego Gas and Electric owns most of the lagoon, part of which serves as a deepwater reservoir for cooling water for a power plant. The eastern basin, operated by the City of Carlsbad for recreational boating, contains a marina. Two hundred acres of the eastern end are managed by CDFG as an Ecological Reserve. Large sediment inflows from agricultural land around the lagoon are a management problem (Marcus and Kondolf 1989).

Batiquitos Lagoon. Batiquitos Lagoon's 600 acres are divided by roads and a railway. From 1901 to 1910 there were 25 acres of commercial salt ponds. Although historically fully tidal, excessive sedimentation reduced the tidal prism to a fraction of its former size; the lagoon rarely opened to tidal influence after the 1940s (Marcus and Kondolf 1989). It was dredged and reopened to tidal influence in 1996 and now has extensive tidal mudflat and high tide roosting areas available to shorebirds (L. Hays pers. comm.). It is owned by the State Lands Commission and CDFG, which manages the eastern and middle basins as an Ecological Reserve (L. Hays pers. comm.). The lagoon has been impacted from historic habitat loss and is at risk to further degradation from future development. It also is subject to accelerated rates of filling, reduced tidal circulation, poor water quality, detrimental agricultural practices in the watershed, non-native invertebrates in the benthos, and invasive plant species (T. Dillingham pers. comm.). Excessive rates of nest predation by introduced and native predators and human disturbance are management issues. Thirty-two acres are actively managed as nesting habitat for the California Least Tern and Snowy Plover. There is an erosion control plan for the watershed. Shorebirds will benefit by maintaining the lagoon opening to the ocean and limiting sediment input from the watershed (T. Dillingham pers. comm.).

*San Elijo Lagoon***.** Historically, the 530-acre San Elijo Lagoon was fully tidal, but from 1880 to1940 roads, a railway, duck ponds, and sewage ponds were constructed, causing it to become brackish and rarely experience tidal flows (Marcus and Kondolf 1989). Currently an endowment enables maintenance of the lagoon mouth and restoration of tidal influence (L. Hays pers. comm.). Extensive areas of tidal mudflat have been revived. The lagoon is owned by CDFG, San Diego County, San Elijo Foundation, and private owners. CDFG manages the eastern and middle basins as an Ecological Reserve (Marcus and Kondolf 1989). The lagoon has been impacted by historic habitat loss and is at risk to further degradation from future development. It also

is subject to accelerated rates of filling, reduced tidal circulation, poor water quality, detrimental agricultural practices in the watershed, and invasive plant species. Important management issues are excessive rates of nest predation by introduced and native predators, human disturbance, and mosquito abatement practices. Ten acres of the Ecological Reserve are actively managed for waterfowl, shorebirds, and endangered species. Water levels in the lagoon are managed by the San Elijo Lagoon Conservancy through a Memorandum of Understanding with the County of San Diego. Shorebirds would benefit from improved tidal circulation achieved through restoration projects (T. Dillingham pers. comm.).

*San Dieguito Lagoon***.** Historically, San Dieguito Lagoon was fully tidal and the largest of San Diego County's six lagoons but has been reduced from probably 1,000 to 300 acres. Between 1905 to 1970 the marsh was filled for roads, a racetrack, a fair grounds, a shopping center, and a military airfield; much of the San Dieguito River, which flowed into the lagoon, was impounded. Treated waste water was dumped in the lagoon for 20 years. By the 1940s the lagoon mouth closed most years, but in 1983 tidal action was restored to 70 acres. Although San Dieguito Lagoon is mostly privately owned, CDFG owns and manages 107 acres of restored wetland as an Ecological Reserve and the City of San Diego owns a 20-acre abandoned sewage treatment pond and 29 acres of wetlands (Marcus and Kondolf 1989). Ten acres of the Ecological Reserve are managed for nesting California Least Terns and Snowy Plovers, but the managed site is inadequate and should be relocated (T. Dillingham pers. comm.). The Ecological Reserve is impacted by accelerated rates of sedimentation, reduced tidal circulation, agriculture in the watershed, invasive plants, and excessive nest predation by introduced and native predators. Human disturbance also is a management issue. Shorebirds could benefit from multi-agency actions to increase the amount of wetland habitat around the reserve. A project to restore an additional 135 acres to regular tidal influence and create tidal mud flats is imminent (T. Dillingham and L. Hays pers. comm.).

Los Penasquitos Lagoon. The 630-acre Los Penasquitos Lagoon is bisected by a major railway and highway. Once fully tidal, it has been closed to such action for years. Shorebird use is low because there is little tidal mudflat or unvegetated habitat. Problems are sedimentation and lack of tidal flats. CDPR owns and manages most of the lagoon as part of Torrey Pines State Reserve. The Coastal Conservancy is another owner (Marcus and Kondolf 1989).

Mission Bay/San Diego Flood Control Channel. This 4,600-acre area was once a deep water embayment. After the USACE diverted the San Diego River from San Diego Bay to Mission Bay, sediment began to rapidly fill False Bay (part of Mission Bay) making it very shallow by the turn of the century. Mission Bay was then dredged to create a park complex of islands and is now used primarily as a recreation area. Extensive tidal beaches now surround Mission Bay, and large expanses of mudflat occur at the edge of the Kendall Frost Marsh Preserve. This preserve and Famosa Slough (37 acres) contain the only remnants of native marsh. Tributary streams carry in urban pollutants, and sewage lines occasionally back up into the bay (Marcus and Kondolf 1989). Most of area is owned by the City of San Diego, but the University of California Natural Land and Water Reserve System owns Kendall Frost Marsh Preserve (Marcus and Kondolf 1989) and the City of San Diego owns Famosa Slough. Mission Bay has been subject to historic habitat loss, the spread of non-native plants, nest predation by

introduced mammals, and the introduction of non-native invertebrates into the benthic invertebrate community. Key management issues are disturbance from human recreation, needs of endangered species, and, at Famosa Slough, poor water quality and reduced tidal circulation. At Famosa Slough, tidal restoration projects are proceeding. Shorebirds would benefit from a trail system with educational signs to reduce disturbance (L. Hays and R. Stribley pers. comm.).

San Diego Bay. San Diego Bay consists of 11,130 acres of subtidal and intertidal habitat and 1,400 acres of salt ponds (M. Mailander pers. comm.). In 1850, there were nearly solid mudflats around the bay but only half (766 acres) remains today. After the San Diego River was diverted, the large marsh at the river delta was filled and built on by the City of San Diego. The bay has been dredged to fill tide lands, widen beaches along Silver Strand, and create military and domestic ports. The dredged area is much deeper and narrower than 150 years ago. Only the south bay contains significant areas of marsh, mudflat, and salt ponds (Marcus and Kondolf 1989). Tidal mudflats are the main shorebird feeding area; the salt ponds provide additional feeding and roosting habitat (Terp 1998). The San Diego Unified Port District (SDUPD) administers 37% of the bay (includes both submerged and historic tidelands), the State Lands Commission retains ownership of 42%, and the military controls almost 20% (Marcus and Kondolf 1989). Over half the salt ponds are privately owned; the remainder are owned by the State Lands Commission. The USFWS owns and manages the entire 315-acre Sweetwater/Paradise Marsh complex and manages the salt works as part of the national wildlife refuge system (B. Collins pers. comm.). Sweetwater Marsh consists of salt and brackish marsh, salt pan, mudflats, fill, and upland and supports breeding Snowy Plovers and many species of migrating and wintering shorebirds (B. Collins pers. comm.). The SDUPD manages the Emory Cove Reserve (8.5 acres), Chula Vista Wildlife Reserve (72 acres), and D Street Fill (13-20 acres). The latter are is managed jointly with the USFWS, principally for nesting California Least Terns and Snowy Plovers. At Chula Vista Wildlife Reserve, the primary management goal is to preserve the 14 acres of subtidal habitat, 35 acres of mudflat, 11 acres of salt flat, and 12 acres of sand and dune substrate for the long-term benefit of migrating and wintering shorebirds and for nesting Snowy Plovers, California Least Terns, and Belding Savannah Sparrows. SDUPD and the U.S. Navy currently are developing a baywide management plan (M. Mailander pers. comm.).

Tijuana River Estuary. Since 1852 the Tijuana River Estuary has lost 80% of its tidal prism and 250 acres of the southern arm to sedimentation and agricultural reclamation. Apartments have been erected on most of the northern dunes. In 1983 the mouth closed and had to be dredged; now it is susceptible to periodic closure (Marcus and Kondolf 1989). Today the approximately 1,320-acre Tijuana River Estuary is included within the 2,531-acre NOAA Tijuana River National Estuarine Research Reserve consisting of tidally flushed wetland, riparian habitat, and upland. The area is owned and managed cooperatively by the CDPR (Border Field State Park), USFWS (Tijuana Slough National Wildlife Refuge), City and County of San Diego, and U.S. Navy (B. Collins pers. comm.). Beside supporting thousands of migrating and wintering shorebirds, the Tijuana River Estuary is a nesting area for the Snowy Plover, Black-necked Stilt, and American Avocet. Management issues are accelerated sedimentation, reduced tidal circulation, exotic plants, introduced benthic invertebrates, clutch predation of nesting shorebirds by native and non-native predators, and human disturbance. USFWS manages for nesting

Snowy Plovers and California Least Terns through closed areas and predator control. Projects to improve tidal circulation have been recently completed or are planned for the near future. The USFWS annually works on dune stabilization north of the river mouth to protect Oneonta Slough from sand deposition. USFWS projects in the planning stage include dune restoration south of the river mouth (including exotic vegetation removal) and a sediment control project in the Goat Canyon watershed (B. Collins pers comm.).

Priority conservation actions for southern California coastal wetlands are to:

- Acquire, and enhance for migrating and wintering shorebirds, privately owned wetland parcels at Moro Cojo Slough and Porter Marsh, Elkhorn Slough.
- Provide incentives for landowners to reduce run-off (sediment and agricultural chemicals) from farmland into Elkhorn Slough.
- Improve tidal circulation to increase mudflat exposure in Kirby Marsh, Elkhorn Slough.
- Enforce boat speed limits to reduce bank erosion along the main channel of Elkhorn Slough.
- Increase predator control to improve nesting success of the Snowy Plover, Black-necked Stilt, and American Avocet at Moss Landing Wildlife Area and Porter Marsh, Elkhorn Slough.
- Repair water control structures to better manage water levels for nesting and wintering shorebirds at Moss Landing Wildlife Area, Elkhorn Slough.
- Remove cattle to eliminate degradation of salt marsh at Moro Cojo Slough, Elkhorn Slough.
- Support the Coastal San Luis Obispo Resource Conservation District's efforts to reduce watershed erosion at Morro Bay.
- Allow sediment to accrete in the concrete channel of Los Angeles River to increase microhabitat heterogeneity, particularly at the river mouth.
- Regulate water flows at Los Angeles River mouth to provide shallow water for foraging shorebirds.
- Restore tidal action to at least 60 acres of diked and other degraded habitats in the Los Cerritos and Hellman Ranch areas at San Gabriel River.
- Acquire and restore tidal flow to at least 100 acres of degraded diked wetlands east of the river channel at Santa Ana River mouth.
- Prevent unnecessary grading and removal of channel sediments at Santa Ana River mouth to increase the extent and heterogeneity of mudflats.
- Expand Seal Beach NWR at Anaheim Bay by 200 acres through acquisition of adjacent wetland habitat; enhance acquired habitat for nesting, migrating, and wintering shorebirds.
- Remove fill from Shellmaker Island and other locations in Upper Newport Bay to increase intertidal habitat.
- Restrict boat and kayak traffic from areas used heavily by foraging and roosting shorebirds at Upper Newport Bay.
- Maintain closures and increase predator control in shorebird nesting areas in the northeastern part of the Ecological Reserve at Upper Newport Bay.
- Reduce the need for frequent dredging projects at Upper Newport Bay.

- Install silt traps in the creek above Michelson Drive to avoid shorebird habitat loss at San Diego Creek mouth, Upper Newport Bay.
- Create additional marsh and pond habitat for shorebirds by restoring flow to currently degraded wetlands at San Joaquin Marsh.
- Manage island vegetation to improve shorebird nesting, foraging, and roosting habitat at San Joaquin Marsh.
- Manage pond water levels to protect shorebird nesting sites and provide shorebird foraging habitat at San Joaquin Marsh.
- Maintain salt pond habitat for migrating phalaropes and nesting Snowy Plovers at San Diego Bay.

Monitoring Priorities

Priority monitoring needs for the southern California coast are to:

- Annually monitor shorebirds in coastal wetlands for long-term trends in abundance.
- Maintain fall, winter, and spring shorebird monitoring at Upper Newport Bay.
- Monitor numbers, distribution, reproductive success, and predator impact on nests of the Black-necked Stilt and American Avocet at Upper Newport Bay, San Joaquin Marsh, and Tijuana River Estuary.

Research Priorities

Priority research needs for the southern California coast are to:

- Identify the time of year each site is important to shorebirds.
- Identify beaches important to migrating and wintering shorebirds.
- Determine numbers and distribution of nesting Killdeers, Black-necked Stilts, and American Avocets along the coast.
- Evaluate shorebird use of tidally-restricted wetlands relative to tide and water level at Elkhorn Slough.
- Identify uplands important for foraging and roosting shorebirds in winter at Elkhorn Slough.
- Determine physical characteristics of wetlands important to shorebirds at Elkhorn Slough.
- Evaluate the seasonal importance of mudflat, salt marsh, and managed pond habitat to shorebirds at Elkhorn Slough.
- Measure contaminant levels in the invertebrate prey base and fish populations of important shorebird foraging areas at Elkhorn Slough.
- Quantify contaminant levels in shorebirds and their prey at Los Angeles and Orange county wetlands known to contain residual deposits of DDT.
- Investigate the causes of shorebird movement among wetlands to facilitate adaptive habitat management of Orange County wetlands.
- Evaluate how periodic sewage spills affect shorebird food supply at Tijuana River Estuary.
- Determine the level of disturbance to shorebirds from illegal border crossings and activities of the Border Patrol to stop perpetrators at Tijuana River Estuary.

- Determine patterns of shorebird seasonal use of different wetland regions of Elkhorn Slough.
- Assess predator impact on Black-necked Stilt and American Avocet nesting success at the Moss Landing Wildlife Area and Porter Marsh, Elkhorn Slough.
- Study shorebird use of soft-bottomed portions of the river channel relative to substrate disturbances and water column depth at Los Angeles River.
- Assess the degree of shorebird movement among portions of Upper Newport Bay and nearby wetlands, such as San Joaquin Marsh, Santa Ana River, and Bolsa Chica.
- Assess the short- and long-term effects of periodic dredging on shorebirds at Upper Newport Bay.
- Study the impacts of nighttime predators on shorebird eggs and chicks at Tijuana River Estuary.
- Evaluate shorebird use of habitats within Tijuana River Estuary.

Education Priorities

Education priorities for the subregion are to:

- Support existing education, outreach, and interpretive programs at all sites.
- Initiate focused shorebird conservation and education programs.
- Disseminate information on research-driven adaptive management techniques.

Funding Priorities

Funding priorities for the subregion are to:

- Support a shorebird plan coordinator for the Southern California Coast Subregion; estimated cost $100,000 annually.
- Fund habitat restoration projects; estimated cost $2,000,000 annually for 10 years.

Implementation and Coordination

Because shorebird habitat in the Southern California Coast Subregion is owned and managed by so many parties and there is no southern California joint venture, we believe a coordinator should be hired to implement the plan in this subregion. A partial list of the many organizations and agencies with regulatory or management responsibilities in the California coastal zone that might participate in the shorebird conservation plan include:

California Coastal Commission – regulatory responsibilities at all sites.

California Department of Fish and Game – Elkhorn Slough, Morro Bay, Bolsa Chica, Upper Newport Bay, Agua Hedionda Lagoon, Batiquitos Lagoon, San Elijo Lagoon, and San Dieguito Lagoon.

California Department of Parks and Recreation – Pacifica Beach, Half Moon Bay beaches, San Gregorio Creek, Pomponia Beach, Pescadero Beach, Gazos Creek, Año Neuvo beaches, Waddell Creek, Baldwin Creek, Seabright Beach, Monterey Bay beaches, Pajaro River mouth, Salinas River mouth, Asilomar Beach, Point Sur Beach, San Simeon Beach, Atascadero Beach, Morro Bay, Pismo Beach, Carpinteria Beach, San Buenaventura Beach, Mandalay Bay to Santa Clara River mouth beach, Malibu Lagoon, Huntington Beach, Santa Ana River mouth, Doheny Beach, Agua Hedionda Lagoon, South Carlsbad Beach, San Elijo Lagoon, Los Penasquitos Lagoon, and Tijuana River Estuary.

City of Carlsbad – Agua Hedionda Lagoon.
Cities of Costa Mesa, Huntington Beach, Newport Beach – Santa Ana River mouth.
City of Del Mar – San Dieguito Lagoon Beach.
City of Hermosa – Hermosa Beach.
City of Morro Bay – Atascadero Beach and Morro Bay.
City of Long Beach – San Gabriel River mouth.
City of Oceanside – San Luis Rey River mouth.
City of Oxnard – Ormond Beach.
City of Pacifica – Pacifica Beach.
City of San Diego – San Dieguito Lagoon, Mission Bay, San Diego Flood Control Channel, Ocean Beach, and Tijuana River Estuary.
City of Santa Monica – Santa Monica Beach.
City of Ventura – San Buenaventura Beach.
Irvine Water District – San Joaquin Marsh.
Los Angeles County – Zuma Beach and Corral Beach.
Los Angeles Department of Water and Power – Los Angeles River mouth.
The Nature Conservancy – Elkhorn Slough, Nipomo Dunes, and Santa Cruz Island beaches.
Orange County – Santa Ana River Mouth, Upper Newport Bay, Crystal Cove Beach, and Salt Creek Beach.
San Diego County – San Elijo Lagoon and Tijuana River Estuary.
San Diego Gas and Electric – Agua Hedionda Lagoon.
San Diego Unified Port District – San Diego Bay.
The San Elijo Foundation – San Elijo Lagoon.
The San Elijo Lagoon Conservancy – San Elijo Lagoon.
Santa Barbara County – Jalama Beach.
Santa Cruz County – Scott Creek Beach.
State Water Control Board – Morro Bay.
State Lands Commission – Upper Newport Bay and San Diego Bay.
U.S. Air Force – Vandenberg Air Force Base beaches, including Santa Ynez River mouth and Jalama Beach.
U.S. Army Corps of Engineers – Los Angeles River Mouth and Santa Ana River mouth.
U.S. Fish and Wildlife Service – Salinas River Mouth, Morro Bay, Anaheim Bay, San Diego Bay, and Tijuana River Estuary.
U.S. Marine Corps – San Onofre Beach, Aliso Creek, French Creek, and Santa Margarita River mouth.
U.S. National Oceanic and Atmospheric Administration – Elkhorn Slough, Morro Bay, and Tijuana River Estuary.
U.S. National Park Service – Ocean Beach and beaches of San Miguel and Santa Rosa islands.
U.S. Navy – Mugu Lagoon, San Nicolas Island, Anaheim Bay, San Diego Bay, and San Clemente Island.
University of California – Devereaux Slough, San Joaquin Marsh, and Mission Bay.
Various private property owners – Tunitas Creek, Gazos Creek, Elkhorn Slough, Monterey Bay beaches, Point Sur Beach, San Carpoforio Creek, Arroyo Hondo

Creek, Point Sierra Nevada Beach, Arroyo de la Cruz, Sidneys Lagoon, Piedras Blancas Beach, Arroyo Laguna Creek, Pico Creek, Villa Creek, Toro Creek, Avila Creek, Nipomo Dunes, Hollister Ranch, Hollywood Beach, Ormond Beach, Santa Ana River mouth, Corral Beach, Agua Hedionda Lagoon, San Elijo Lagoon, San Dieguito Lagoon, and Tijuana River Estuary.

Ventura County – beach between Mandalay Bay and Santa Clara River mouth, Hollywood Beach, and Dockweiller Beach.

CENTRAL VALLEY SUBREGION

Description of Subregion

The Central Valley – stretching northwest to southeast through the heart of the state – is California's largest valley. Surrounded by mountains, except for its western drainage into San Francisco Bay, the Central Valley averages about 400 mi long and 40 mi wide. It is divided into the Sacramento Valley, draining southward, the San Joaquin Valley draining northward, and the Sacramento-San Joaquin River Delta (hereafter Delta) where these rivers converge. The Sacramento Valley is further divided into the Colusa, Butte, Sutter, American, and Yolo drainage basins, and the San Joaquin Valley into the San Joaquin Basin and the, usually closed, Tulare Basin. Further discussion will focus primarily on the four major subdivisions of the Central Valley – the Sacramento Valley, Delta, San Joaquin Basin, and Tulare Basin.

The Central Valley has lost about 90% of its historic wetlands (Frayer et al. 1989), and the region is now dominated by agricultural lands. Readers should consult Heitmeyer et al. (1989) for an overview of the physiography and extent of historical and recent wetlands and croplands by subregion of the Central Valley. Primary shorebird habitats in the Central Valley currently are restored and highly managed wetlands, flooded agricultural lands, hypersaline agricultural evaporation ponds, and municipal sewage ponds (Table 2). The Central Valley's vernal pool rangelands probably also provide important shorebird habitat (Silveira 1998) but use of these pools by shorebirds has been poorly studied. During comprehensive surveys of shorebirds in the Central Valley in the early 1990s, managed wetlands, agricultural fields (especially rice), and agricultural evaporation ponds held the most shorebirds (Shuford et al. 1998). These authors provide additional detail on habitat use by various species of shorebird throughout the Central Valley.

Shorebird Species

Surveys have shown the Central Valley to be one of the most important regions in western North America for migrating and wintering shorebirds. Shorebird populations in the Central Valley in the early 1990s averaged 134,000 individuals in August, 211,000 in November, 303,000 in January, and 335,000 in April (Shuford et al. 1998). Of 33 species recorded on these surveys, the 10 or 11 that averaged over 1000 individuals each season accounted for 99% of total numbers. In winter and spring, the Central Valley supports more shorebirds than any other inland site in western North America, and in winter is the only inland area, other than California's Salton Sea and Oregon's Willamette Valley, that supports tens of thousands of shorebirds. In fall, it is the second most important inland

site to shorebirds after Great Salt Lake, Utah. Shorebird totals in the Valley seasonally range from about 20% to 40% of those on the California coast, but seven species have Valley populations that can exceed those on the coast in at least one season. The Valley is less important as a breeding area for shorebirds, but three species – Killdeer, Black-necked Stilt, and American Avocet – nest there in moderate numbers and four species – Snowy Plover, Spotted Sandpiper, Common Snipe, and Wilson's Phalarope – breed there in small numbers.

Table 2 Extent (acres) of key shorebird habitats in the Central Valley, 1992 to 1995 (from Shuford et al. 1998).

Basin	Habitats[a]				
	MGWE[b]	AGLA[b]	AGRI[c]	EVAP[d]	SEPO[e]
Colusa	24,359	200,885	33,790	0	136
Butte	23,235	156,240	61,078	0	116
Sutter	5093	92,958	13,452	0	79
American	7336	116,875	30,043	0	274
Yolo	10,305	51,532	3927	0	620
Delta	17,389	36,791	291	0	1032
San Joaquin	?[f]	?	?	0	2507
Tulare	15,260	132,449	0	5409	3648
Total	___	___	142,581	5409	8412

[a] MGWE = managed wetlands: palustrine habitat of permanent and seasonal marshes; AGLA = all agricultural lands (including ricelands) in winter with standing water or moist soil; AGRI = ricelands intentionally flooded in winter; EVAP = hypersaline agricultural evaporation ponds; SEPO = municipal sewage ponds.

[b] Data from GIS mapping of satellite images from 3 Jan 1993, except that images from 20 Dec 1992 used for the Tulare Basin (D. Kempka in litt.); ? = no data available for San Joaquin Basin in winter 1992-93.

[c] Data for 6 Jan 1994 from Spell et al. 1995); ? = no data available for San Joaquin Basin.

[d] The 6264 acres of ponds active in 1992 (Moore et al. 1990) had been reduced to 5409 acres in 1995 (A. Toto pers. comm.), and structural changes were made at some remaining ponds to limit bird use. Creation of mitigation wetlands may have compensated for some of these habitat losses.

[e] Data from Chilcott and Johnson (1991) and R. Diekstra (pers. comm.). Figures are minimums; throughout the Central Valley some small sewage ponds not reported and none north of Chico in the Butte Basin reported.

[f] GIS data from 13 Nov 1990 (in dry winter) estimated 59,408 acres of wetlands (R. Spell in litt.); recent Central Valley Habitat Joint Venture figures estimated 135,620 acres (D. Paullin in litt.).

Species with regionally important populations in the Central Valley are the Black-bellied Plover (winter, spring), Snowy Plover (winter), Killdeer (winter, summer), Mountain Plover (winter), Black-necked Stilt (fall-spring), American Avocet (fall-spring), Greater Yellowlegs (fall, winter), Whimbrel (spring), Long-billed Curlew (fall, winter), Western Sandpiper (spring), Least Sandpiper (winter), Dunlin (winter), and Long-billed Dowitcher (fall-spring). A number of these species are differentially distributed within subregions of the Central Valley (Shuford et al. 1998), indicating a need to adapt management efforts locally.

The Central Valley is one of only a few key wintering areas in the World for the Mountain Plover, a species currently proposed for federal threatened status (Edson and Hunting 1999, USFWS 1999). The Central Valley also hosts two other Bird Species of Special Concern in California, the Snowy Plover and the Long-billed Curlew (CDFG 1992). The San Joaquin Valley is one of two key inland wintering areas in western North America for the Snowy Plover (Shuford et al. 1995). See Barnum et al. (1992) and Roster et al. (1992) regarding Snowy Plovers breeding on agricultural evaportation ponds in the San Joaquin Valley.

Within the Central Valley, the Grasslands Ecological Area in the San Joaquin Basin near Los Banos has been designated a WHSRN site of International Importance to shorebirds. The ricelands and wildlife refuges of the Sacramento Valley appear to qualify for similar status, and an application for designation currently is being prepared.

Regional Population and Habitat Goals

Priority conservation goals for the Central Valley are to:

- Increase the wintering population of the Mountain Plover in the Central Valley. Create suitable open foraging habitat by managing for giant kangaroo rats *(Dipodomys ingens)* and using fire and grazing, as appropriate.
- Increase populations of breeding and wintering Snowy Plovers and wintering Long-billed Curlews in the Central Valley.
- Increase breeding and wintering populations of other shorebirds in the Central Valley.
- Restore, enhance, and manage wetlands with integrated wetland management goals, which accommodate the needs of a greater diversity of birds, including shorebirds (Isola 1998).
- Ensure the availability of high quality water for wetlands.
- Resist fragmentation or loss of existing wetland complexes by urban encroachment.
- Promote management practices in agricultural lands and vernal pool rangelands that will provide for a greater diversity of birds, including shorebirds. Also promote easements and other options for maintaining wildlife-friendly agricultural lands and vernal pool rangelands.
- Reduce use of contaminated agricultural evaporation ponds by shorebirds and other waterbirds while creating alternative uncontaminated habitats that will mimic historic saline playa wetlands thereby maintaining the current mix of waterbird communities.
- Increase shorebird use of sewage ponds or wetlands using treated sewage effluent if issues of disease transmission and contaminants can be addressed.

Habitat Status, Threats, and Management Needs

Descriptions of current habitat availability, shorebird habitat use patterns, threats to shorebirds, management issues, and needed conservation actions are provided below for the major habitat types in the Central Valley overall or for the valley's major habitat types.

Valleywide Habitat Status and Concerns. Given that 90% of the Central Valley's historic wetlands have been lost, the main concerns for shorebirds are water availability, poor and sometimes toxic water quality, habitat loss and degradation from urbanization, and changing agricultural practices (see Shuford et al. 1998). Other concerns of lesser or unknown magnitude are disturbance from human recreation activities, effects of mosquito control, competing needs of other species (e.g., salmon), and improper management (e.g., lack of grazing where needed).

Availability of high quality water is a perennial problem throughout the Central Valley because of competition for limited supplies among agricultural, urban, and wildlife uses. Shorebirds should, however, benefit from the sizeable acreage of habitat recently created for waterfowl and dependable supplies secured for wetlands via the Central Valley Project Improvement Act. Still, wetlands upon which shorebirds depend receive only about 1% of the states' water supply, and future legislation potentially could reverse past gains, particularly as the state's population and water costs increase. The need for increased water supplies to meet the requirements of other species, such as salmon, potentially could limit the amount available for shorebird habitat. Mosquito control efforts also may limit options for managing for shallow-water for shorebirds in summer and early fall, when such habitat is particularly in short supply.

Pesticides used on agricultural fields have caused limited direct mortality of shorebirds and other species, but they may reduce shorebirds' invertebrate prey in winter or perhaps have other sublethal effects. Similarly, concern has been expressed about the impact on fish and wildlife of chemicals used for mosquito control in wetlands (Washino and Dritz 1995). A study at the Sacramento National Wildlife Refuge complex in the Sacramento Valley, however, suggested that ultra low volume applications of insecticides to control adult mosquitoes did not substantially affect the abundance of aquatic macro-invertebrates or fish in treated waters (Lawler et al. 1995). Still, more needs to be known about the potential effects of pesticides on shorebirds or their invertebrate prey.

Expanding urban development directly threatens wetlands, most notably at the Grasslands near Los Banos in the San Joaquin Basin and near Yuba City in the Sacramento Valley. Urbanization continues to reduce agricultural lands in the Central Valley at a rate among the highest of any region in North America (American Farmland Trust 1995, Sorensen et al. 1997), although the effect on shorebirds is undocumented. Similarly, conversion of thousands of acres of land valleywide to vineyards, orchards, and row crops likely has reduced foraging habitat for shorebirds, particularly species using vernal pools and those using uplands, such as the Black-bellied Plover, Killdeer, Mountain Plover, Whimbrel, and Long-billed Curlew.

Although many of the problems listed above are faced by shorebirds valleywide, some have been or are restricted primarily to certain subregions of the Valley. For example, as recently as the 1980s, agricultural drain water used to flood wetlands in the Grasslands Ecological Area of the San Joaquin Basin resulted in biological accumulation of selenium sufficient to harm reproduction of shorebirds and other wildlife (Ohlendorf et al. 1987). Conditions in the Grasslands have steadily improved after replacement with uncontaminated water in 1985 (references in Shuford et al. 1998). Similarly, concentrations of salts and trace elements, such as selenium, at agricultural evaporation ponds in the Tulare Basin have caused reproductive impairment in the Black-necked Stilt and American Avocet (Skorupa and Ohlendorf 1991, Ohlendorf et al. 1993). Efforts are

being made to reduce use of these ponds by hazing, altering their physical structure, and creating nearby uncontaminated wetlands. How this has changed the size and species composition of shorebird populations in the Tulare Basin is currently being examined.

Because agriculture is by far the dominant land use in the Central Valley, any broadscale changes in farming practices could tremendously influence shorebird habitat. For example, some Sacramento Valley riceland could be lost to the current expansion of cotton, a less friendly crop to shorebirds, although 80% of the region's riceland is incapable of supporting other economically viable crops. Conversely, an increase in flooded acreage of rice fields in winter to aid in stubble decomposition should benefit shorebirds. In the Tulare Basin, changing irrigation practices in recent decades have reduced the amount of shallow-water agricultural habitat available to ducks and shorebirds (Barnum and Euliss 1991). Concentrations of salts in agricultural fields may lead to abandonment of these lands and reversion to habitats less suitable to shorebirds.

Anecdotal evidence suggests invasive exotic plants are degrading wetland habitats, but more needs to be known of the extent of this problem in the Central Valley. Bermuda grass *(Cynodon dactylon)* and knot grass *(Paspalum distichum)* pose problems in the Butte Sink and major bypasses of the Sacramento Valley where the water table is high.

Limited anecdotal evidence suggests that human recreational activities may potentially cause harm to shorebirds in the Central Valley, but this may be a greater issue in coastal areas.

Overall Management Needs. With the limited amount of wetlands now available in the Central Valley, it is imperative that remaining habitat be managed to maximize the diversity and abundance of wetland-dependent species. Studies in ricelands in the Sacramento Valley (Elphick and Oring 1998) and managed wetlands of the Grasslands in the San Joaquin Valley (Williams 1996) both have shown that the greatest diversity of waterbirds in winter is found when water depths *average* about 6 inches. Hence, a reduction in water depths in these habitats over those of previous management practices would benefit shorebirds without harming dabbling ducks. As outlined below, a number of other specific management recommendations have been made to increase wetland use of shorebirds during winter, migratory, and breeding periods.

Managed Wetlands. Managed wetlands on refuges and private duck clubs cover about 162,000 to 239,000 acres in the Central Valley (Table 2). These wetlands provide important shorebird habitat in the Central Valley in winter and, especially, spring, when receding water levels expose extensive mudflats. Species that forage extensively in shallow water or mudflats in managed wetlands are the Killdeer, Black-necked Stilt, American Avocet, Greater Yellowlegs, Western and Least sandpipers, Dunlin, and Long-billed Dowitcher. The amount of acreage of managed wetlands has increased in the Central Valley in recent years, in large part from the efforts of the Central Valley Habitat Joint Venture (USFWS 1990).

Personal communications with refuge and duck club managers indicate that most wetlands in the Central Valley currently are managed to benefit shorebirds to some degree but that management is habitat- rather than species-based. The main management techniques used to benefit shorebirds are water level management, slow or staggered drawdowns, timing of drawdowns to match periods of peak use, mechanical

vegetation control (burning, disking, mowing), and creation of a variety of habitats and varied topography within and among management units. Education is viewed as the best tool to convince private landowners to incorporate shorebird management into existing wetland management for waterfowl. While most respondents indicated their management efforts were successful, few had specifically defined goals; monitoring effort varied from regular unit-by-unit monitoring to anecdotal observations. Many respondents indicated there was inadequate knowledge of shorebird habitat requirements. Most land managers indicated that management for shorebirds posed little conflict with other management goals, though one person felt conflicts could arise if there was a major shift in water management to target shorebird use exclusively.

Williams (1996) studied the responses of shorebirds and other waterbirds to late winter and early spring drawdowns of moist-soil managed wetlands in the Grasslands of the San Joaquin Valley. During winter, shorebird diversity and density increased significantly, peaking during the mid-point of drawdowns when habitat diversity was greatest. Densities of large shorebirds (Black-necked Stilt, American Avocet, yellowlegs spp., dowitcher spp.) and sandpipers (Western Sandpiper, Least Sandpiper, Dunlin) in winter correlated with availability of habitat 2 to 6 inches and <2 inches deep, respectively. By contrast, densities of shorebirds during spring drawdowns were not correlated with the amount of shallow habitat. These patterns of shorebird occurrence may at least in part reflect patterns of habitat availability on a landscape level across the entire Grasslands. Large responses to the provision of shallow-water habitat in winter may reflect the usually limited supply of this type of habitat in this region at this season. Conversely, shorebirds may not respond as well to similar experimental drawdowns in spring because shallow water typically is widely available during this period when extensive areas of wetland are dewatered for moist-soil plant management. A lack of significant response in spring also may reflect the transitory and variable use of wetlands by migratory shorebirds. Williams (1996) recommended that managers could provide for the greatest diversity of waterbirds, including shorebirds, by flooding most Grasslands wetlands less deep in autumn or partially dewatering them in winter to *average* depths of 6 to 8 inches.

Water depth is the most important variable influencing habitat use by foraging waterbirds in the late winter and early spring in the Grasslands of the San Joaquin Valley (Williams 1996, Safran et al. 1997, Isola 1998). Isola (1998) identified four waterbird foraging groups based on similarities in water depth use. Of these, small shorebirds (Western Sandpiper, Least Sandpiper, and Dunlin) foraged in waters 0.7 to 1.4 inches deep and large shorebirds (Black-necked Stilt, American Avocet, and dowitcher spp.) in waters 2.3 to 4.3 inches deep. Small shorebirds, particularly Least and Western sandpipers, foraged at shallower depths than found at random sites. Large shorebirds did not appear, at the level of the individual wetland, to select foraging depths that were shallower than random. On a landscape level, though, they may have selected wetlands that tended to be shallower than other available habitats. Isola concluded that differences in observed foraging depth variation indicated that habitat use of small shorebirds and, to a lesser degree, large shorebirds is more constrained by water depth than that of waterfowl.

A two-year study at Sacramento NWR in the Sacramento Valley showed differential shorebird use between a wet and a dry spring and among various wetland types

(Feldheim et al. 1999). Substantially higher peak shorebird numbers in a dry versus a wet year likely reflected concentration of shorebirds on the refuge when valleywide habitat was limited in the dry year. These results suggest the need to tailor management actions to varying climatic conditions. Most shorebird species preferred seasonally-flooded marshes or vernal pools, but the Long-billed Curlew and Whimbrel preferred watergrass production units. Although vernal pools comprised less than 2% of the refuge's total available wetland habitat, they held the highest shorebird densities, and more species preferred vernal pools than other wetland types.

Priority conservation actions for managed wetlands of the Central Valley are to:

- Promote wetland restoration projects that show high potential to benefit shorebirds. Regional experts indicated a few sites or regions of the Central Valley that had a high potential for large-scale restoration of habitats important to shorebirds. The most notable of these were in the Tulare Basin of the southern San Joaquin Valley, where a unique opportunity now exists to obtain retired agricultural lands with water rights from willing sellers (H. T. Harvey and Associates 1998). Still, a dependable and substantial water supply will be needed to maximize benefits to shorebirds and other wetland-dependent species. Additionally, private lands in the South Wilbur Flood Area and the Hacienda Ranch hold high potential for wetland restoration if cooperation can be obtained from private landowners.
- Restore, and secure with conservation easements, habitats that have been greatly reduced historically, such as playa lake wetlands.
- Expand current management strategies that benefit shorebirds:

  (a) Keep water levels that benefit both waterfowl and shorebirds during periods when water is maintained at relatively constant levels. *Average* depths of 6 to 8 inches are recommended for managed wetlands in the Grasslands (Williams 1996, Safran et al. 1997, Isola 1998).

  (b) Conduct slow (~2 weeks) and staggered drawdowns of water throughout wetland complexes. Slow drawdowns should be discouraged in wetlands of high salinity in the Grasslands, as this practice can increase salt levels in the soil and impede plant growth (Isola 1998).

  (c) Time drawdowns to coincide with periods of peak shorebird abundance and need, such as during migration, or when suitable habitat might otherwise be limited. For instance, increase drawdowns in the Grasslands during late winter (Jan to mid-Mar) when dynamic shallow water habitat is in short supply (Williams 1996, Isola 1998). Increase the practice of temporary drawdowns in late winter to help flush salts from degraded wetlands in the Grasslands.

  (d) Mimic historic hydrologic conditions by fluctuating water levels in wetlands throughout the winter and spring (Isola 1998).

  (e) Design new wetlands based on integrated wetland management goals (Williams 1996, Isola 1998). Create a variety of habitats and varied topography within and among management units to maximize diversity of waterbirds, including shorebirds. When enhancing and rehabilitating existing wetlands, take care to maintain habitat and topographic diversity. For wetlands with diverse topography with varied depths and (generally gentle) elevational gradients, *average* depths should be about 6 to 8 inches when fully flooded. Less topographically diverse wetlands will have to be flooded more shallowly (1-6

inches) to provide shorebird habitat. Gentle grading of side slopes of levees, islands, underwater berms, and drainage swales should provide structural integrity and greater diversity of water depths.

(f) Set vegetation succession back by various means of mechanical control, fire, or grazing.

(g) Provide predator-free, sparsely vegetated nesting islands for breeding shorebirds, which also may serve as roost sites for other shorebirds during the non-breeding season. Islands most suitable for shorebirds are low and shallowly sloped, thereby providing shoreline foraging areas for both adults and chicks (Engilis and Reid 1996). Be careful not to flood nests during spring irrigations or leave them high and dry during drawdowns.

- Coordinate, if possible, management practices over large wetland complexes of state, federal, and private lands, such as the Grasslands Ecological Area.
- Devise wet-year, dry-year management strategies to best use water when it is available and/or most needed.
- Work with the Central Valley Habitat Joint Venture in the current revision of its waterfowl plan and goals to further incorporate shorebird needs. Work with joint venture agencies and their various programs to implement shorebird-friendly projects on the ground.
- Adopt new management strategies proven to be valuable.

Agricultural Fields. With the exception of rice, few data are available on the acreage of irrigated or flooded agricultural lands in the Central Valley at any specific time, although this habitat is very extensive seasonally. In January 1994, about 142,000 acres of rice were flooded in the Central Valley, primarily in the Sacramento Valley (Table 2). Flooded agricultural fields support large numbers of shorebirds, particularly in winter, and the amount of flooded habitat can vary greatly both seasonally and among years of varying precipitation. Rice fields alone can hold 20% to 30% of valleywide shorebird totals (Shuford et al. 1998). Species that forage extensively in flooded fields are the Killdeer, Greater Yellowlegs, small sandpipers (especially Dunlin in winter), and Long-billed Dowitcher. The Black-bellied Plover, Killdeer, Whimbrel (mainly in spring), and Long-billed Curlew use both flooded and drier upland fields for foraging. By contrast, the Mountain Plover almost exclusively uses dry, very open upland habitats, such as heavily grazed pastures, plowed fields, and alkali flats (Knopf and Rupert 1995).

To meet a legislative mandate to reduce air pollution in the Sacramento Valley, farmers recently have begun winter flooding of fields as an alternative to burning to dispose of rice stubble. Although the increase in winter-flooded habitat so far has been modest (Spell et al. 1995), it is expected to expand from the current level of 140,000 acres to 190,000 to 200,000 acres (F. Reid pers. comm.). This change in land use has prompted new research on the effects of various harvest, flooding, and rice straw manipulation techniques. Elphick and Oring (1998) studied the effect of various water depth and straw treatments on waterbird use of Sacramento Valley rice fields in winter. Median water depths of flooded rice fields used by shorebirds in winter were about 1 to 5 inches, whereas in early winter median depths of most fields were greater than 8 inches. The Killdeer, Least Sandpiper, Dunlin, and Long-billed Dowitcher occurred in highest densities in fields in which straw had been incorporated in the soil prior to flooding,

though this may have been due to shallower water in incorporated fields. By contrast, the American Avocet was most abundant in fields that had no treatment except flooding. These authors recommended that reducing water depths in rice fields in the early part of the winter would lead to use by a wider variety of species while also lowering water costs. Results of across habitat measures of food abundance, perceived predation threat, foraging performance, and time allocation suggest that flooded rice fields may provide equivalent foraging habitat to semi-natural wetlands and, because of reduced predation threat, may be safer habitat for waterbirds (Elphick 1998).

Elphick (1998) also found shorebirds responding differentially to features in the landscape at various scales. Shorebird densities in rice fields were positively related to the proportion of the surrounding landscape at the 2 km (1.2 mi) scale that was a wildlife refuge, semi-natural wetland, or both. Conversely, shorebird densities were negatively correlated with an abundance of flooded agricultural land at the 10 km (6.2 mi) scale.

Day and Colwell (1998) also studied the effects of harvest method, post-harvest treatment of straw, and extent of flooding on waterbird use of Sacramento Valley rice fields in winter. Shorebirds occurred primarily in conventionally-harvested (vs. "stripped") fields that were puddled or flooded; species richness of waterbirds did not differ among straw treatments.

Priority conservation actions for agricultural lands of the Central Valley are to:

- Promote conservation easements and agricultural (vs. wetland) easements , protecting lands of both high and low productivity.
- Promote harvesting of rice fields by conventional methods (or add secondary efforts to cut stubble) and promote winter flooding to water depths suitable for a high diversity of waterbirds, including shorebirds.
- Increase the acreage of flooded rice in winter and reduce water depths in rice fields early in the winter relative to current practices.
- Curtail loss and restore habitats, such as vernal pool rangelands, that currently are diminishing at a rapid rate.

Agricultural Evaporation Ponds. The approximately 5409 acres of very saline agricultural evaporation ponds in the Tulare Basin of the southern San Joaquin Valley (Table 2) can support high densities of shorebirds seasonally. In fall, highest numbers of shorebirds in the Central Valley can occur in these evaporation ponds (Shuford et al. 1998). In that season, key species foraging in these ponds include the Black-necked Stilt, American Avocet, small sandpipers (Western and Least sandpipers), and Wilson's and Red-necked phalaropes. Shorebird numbers in these ponds appear to be declining because of management efforts to limit their use and thereby reduce the risk of exposure to concentrated contaminants, such as selenium. Pond owners have sought to reduce the risk to wildlife of these ponds by hazing, physically altering ponds to make them less attractive, and creating nearby uncontaminated wetlands as alternative habitat.

Priority conservation actions for agricultural evaporation ponds in the Central Valley are to:

- Continue to devise strategies to reduce shorebird use on contaminated evaporation ponds while increasing shorebird use of nearby mitigation wetlands.
- Ensure that alternative habitats created provide suitable conditions for species, such as the Snowy Plover, that favor shallow saline water and alkali flats.

Sewage Ponds. A minimum of 8413 acres of sewage ponds are present in the Central Valley, with the greatest extent of this habitat occurring in the San Joaquin and Tulare basins (Table 2). Although sewage ponds hold a relatively small percentage of the valleywide shorebird total at any season, particular pond systems periodically may host large numbers of shorebirds. Sewage ponds also may serve as important roosting sites for species, such as the Black-bellied Plover, that forage in nearby fields.

Although various management actions potentially could increase the use of sewage ponds by shorebirds, pre-implementation studies are needed first to determine if transmission of diseases or concentrations of toxic substances pose substantial threats to shorebirds or other species of wildlife using these ponds.

Vernal Pool Rangelands. Holland (1998) mapped the distribution of grassland-vernal pool complexes in California and found them scattered widely around the perimeter of the Central Valley and in a swath in the basin lands along the valley trough. A total of 999,319 acres of this habitat occurred in counties with valley floor terrain; roughly 31% was in the Sacramento Valley, 14% in the Delta, 47% in the San Joaquin Basin, and 8% in the Tulare Basin. Although these figures include both vernal pools and surrounding grasslands, nevertheless the total acreage of wetlands represented by vernal pools valleywide is impressive. Although there has been considerable historical loss of vernal pool habitat, the extent of this loss is unknown.

Silveira (1998) described the importance of vernal pools to birds, but use of these pools by shorebirds has been poorly studied. Shuford et al's (1998) study of shorebird use of Central Valley habitats did not find especially large numbers of shorebirds in vernal pools, though their surveys did not include large areas of vernal pool rangelands on the periphery of the valley (D. Shuford, G. Page pers. obs.). Although used by a variety of shorebirds, vernal pools probably are particularly important to species, such as the Greater Yellowlegs, that occur singly or in small loose flocks. Feldheim et al. (1999) conducted a two-year study of shorebird habitat use at Sacramento NWR in the Sacramento Valley. Although vernal pools comprised less than 2% of the refuge's total available wetland habitat, they held the highest shorebird densities, and more species preferred vernal pools than other wetland types.

Priority conservation actions for vernal pool landscapes in the Central Valley are to (Silveira 1998):

- Identify large intact vernal pool complexes and develop conservation plans for these complexes and surrounding vernal pool landscapes.
- Develop a vernal pool conservation team.
- Create patterns of land use in and around vernal pool landscapes consistent with agriculture and open space conservation.
- Develop public private partnerships and obtain (and monitor) conservation easements on large private cattle ranches via Land and Water Conservation Funds.

Monitoring Priorities

Monitoring shorebird populations in the Central Valley will be very challenging because of the large geographic size of the area and the great seasonal and annual

variation in extent of habitat, particularly as influenced by cycles of drought and flood. With this in mind, the priorities for monitoring for the subregion are to:

- Devise a long-term monitoring scheme to detect overall trends in shorebird abundance and habitat use in the Central Valley; ensure repeatability and reliability of results. Such a scheme needs specific protocols, including census methodology, periodicity of surveys, procedures to deal with fluctuations in habitat availability, etc.
- Devise long-term monitoring protocols for restoration and enhancement projects to ensure they meet goals of shorebird use. Such efforts should recognize that landscape level effects, such as the extremes of drought and flooding on nearby and/or widely distributed agricultural lands, may override beneficial wetland practices in certain years.
- Establish long-term monitoring schemes for sensitive shorebird species – Mountain Plover, Snowy Plover, Long-billed Curlew – in the Central Valley.
- Conduct valleywide surveys of populations of breeding shorebirds in years of varying environmental conditions to establish baseline data useful in establishing recommendations for actions to increase these populations.
- Monitor shorebird habitats at the landscape level using GIS technology.

Research Priorities

Research priorities for the Central Valley are to:

- Identify limiting factors and specific habitat needs of shorebirds.
- Obtain information on the diets of shorebirds at different seasons and in various habitats.
- Determine how various drawdown regimes influence the production of invertebrates and their availability to shorebirds.
- Investigate how shorebirds move within and among wetland complexes. Determine the needs of shorebirds for roosting habitat.
- Quantitatively monitor the responses of shorebirds to various management strategies.
- Assess fidelity and survivorship of shorebirds using the Central Valley.
- Examine the potential effects on shorebirds of biosolids (sewage sludge) spread on agricultural fields as a fertilizer.
- Study shorebird use of grazed habitats, such as irrigated pastures and seasonally grazed wetlands, as has been done for coastal pastures (Colwell and Dodd 1995).
- Conduct broadscale surveys of vernal pools to determine their importance to shorebirds.
- Investigate whether concerns over mosquito control, vegetation management, and water costs can be overcome while providing shallow water habitat in summer (Jul-Aug) for autumn migrant shorebirds.

Education Priorities

Priority education goals for the Central Valley are to:

- Educate landowners and the public of the direct economic benefit of ecotourism and wetland festivals (e.g., Wild on Wetlands Weekend) and the consequent need to

manage for a diversity of species, including shorebirds. Also, illustrate how ecotourism can help fend off urban encroachment on wetlands.

- Inform private landowners and public resource managers how to incorporate shorebird management strategies into existing wetland management schemes, thereby blending practices for waterfowl and shorebirds. Emphasize that management for shorebirds can benefit waterfowl. For example, certain dabbling ducks prefer to feed in shallow flooded marshes, drawdowns increase marsh productivity, and seasonally flooded wetlands receive greater waterfowl use in winter than permanent ponds.
- Work with agricultural interests to promote management that benefits both shorebirds and crop production. Work with agricultural extension specialists to educate landowners regarding how minor changes in farming practices may provide large benefits to shorebirds and other wildlife.

Implementation and Coordination

Conservation of shorebirds in the Central Valley will of necessity involve a host of public and private agencies and individuals to ensure its success. It will be particularly important to coordinate with already established collaborative efforts, such as the Central Valley Habitat Joint Venture of the North American Waterfowl Management Plan, Partners in Flight, the California Riparian Joint Venture, and other natural resource programs like Partners for Wildlife, and to integrate with other formative efforts, such as the Colonial Waterbird Conservation Plan and the North American Bird Conservation Initiative. Coordination already exists at the local level at wetlands complexes such at the Grasslands Ecological Area in the San Joaquin Valley. There shorebird concerns can be brought to their Habitat Coordination Committee, which has representatives from U.S. Fish and Wildlife Service, California Department of Fish and Game, Grasslands Water District, Grasslands Resource Conservation District, and private landowners.

Various wetland incentive and technical assistance programs offered by federal, state, and private agencies are the best means to coordinate drawdowns and implement integrated management practices on private lands (Isola 1998).

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APPENDIX: LIST OF COMMON AND SCIENTIFIC NAMES OF SHOREBIRD SPECIES CITED IN THE TEXT

Black-bellied Plover	*(Pluvialis squatarola)*
American Golden-Plover	*(Pluvialis dominica)*
Pacific Golden-Plover	*(Pluvialis fulva)*
Snowy Plover	*(Charadrius alexandrinus)*
Semipalmated Plover	*(Charadrius semipalmatus)*
Killdeer	*(Charadrius vociferus)*
Mountain Plover	*(Charadrius montanus)*
Black Oystercatcher	*(Haematopus bachmani)*
Black-necked Stilt	*(Himantopus mexicanus)*
American Avocet	*(Recurvirostra americana)*
Greater Yellowlegs	*(Tringa melanoleuca)*
Lesser Yellowlegs	*(Tringa flavipes)*
Solitary Sandpiper	*(Tringa solitaria)*
Willet	*(Catoptrophorus semipalmatus)*
Wandering Tattler	*(Heteroscelus incanus)*
Spotted Sandpiper	*(Actitis macularia)*
Whimbrel	*(Numenius phaeopus)*
Long-billed Curlew	*(Numenius americanus)*
Marbled Godwit	*(Limosa fedoa)*
Ruddy Turnstone	*(Arenaria interpres)*
Black Turnstone	*(Arenaria melanocephala)*
Surfbird	*(Aphriza virgata)*
Red Knot	*(Calidris canutus)*
Sanderling	*(Calidris alba)*
Semipalmated Sandpiper	*(Calidris pusilla)*
Western Sandpiper	*(Calidris mauri)*
Least Sandpiper	*(Calidris minutilla)*
Baird's Sandpiper	*(Calidris bairdii)*
Pectoral Sandpiper	*(Calidris melanotos)*
Rock Sandpiper	*(Calidris ptilocnemis)*
Dunlin	*(Calidris alpina)*
Short-billed Dowitcher	*(Limnodromus griseus)*
Long-billed Dowitcher	*(Limnodromus scolopaceus)*
Common Snipe	*(Gallinago gallinago)*
Wilson's Phalarope	*(Phalaropus tricolor)*
Red-necked Phalarope	*(Phalaropus lobatus)*
Red Phalarope	*(Phalaropus fulicaria)*