**U.S. Department of the Interior**
**U.S. Geological Survey**

# STATUS, TRENDS AND CONSERVATION OF THE WESTERN SNOWY PLOVER WITH A FOCUS ON THE DEVEREUX SLOUGH POPULATION AT COAL OIL POINT RESERVE, SANTA BARBARA COUNTY, CA

**Museum of Systematics and Ecology Environmental Report No. 15, University of California, Santa Barbara**

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**Executive Summary**

Western snowy plovers are small shorebirds restricted to sandy beaches. Increased habitat destruction, predation, beach access and recreation has led to a region-wide decline in their abundance and in the number of sites where they breed and over-winter. Snowy plovers are federally listed as threatened and are legally protected under the Endangered Species Act. Common management options include beach closure, nest fencing, habitat restoration, predator control, and restrictions on pets, human access and recreation.

The University of California owns and manages Coal Oil Point Reserve to protect fragile coastal habitats for research and education. The U.S. Fish and Wildlife Service has designated Coal Oil Point Reserve and adjacent beaches as Critical Habitat for snowy plovers. Snowy plovers primarily roost near the mouth of Devereux Slough, but forage along the beach to the east and west. Up to 167 individuals, winter at this site, representing about 10% of the entire western snowy plover U.S. population. Ironically, the size of the wintering flock at Devereux has increased over the years, presumably due to an influx of individuals from nearby abandoned wintering sites. In this sense, birds at Devereux are refugees from beach recreation in the region.

Although this refugee population inhabits a nature reserve, these birds are still subjected to many of the same threats they suffer elsewhere. Plovers probably stopped breeding in the area due to increased public access when the University of California purchased the Coal Oil Point area in late 1967. Based on the history of other nearby populations, plovers could soon abandon Devereux for wintering.

Humans, dogs, crows and other birds are the main sources of disturbance at Devereux Slough. Disturbance is 16 times more frequent at Devereux Slough than at nearby protected beaches. Even though wintering plovers are about half as sensitive to activity as breeding snowy plovers, each wintering snowy plover is disturbed an average of once every 27 minutes on the weekend and every 43 minutes on weekdays. Plovers show increased sensitivity to dogs, horses and crows. The likelihood that activity disturbs plovers diminishes as the distance between plovers and the source of disturbance increases. Plovers are less abundant in habitat that is adjacent to points of beach access. Feeding rates decline as human activity increases throughout the day.

There has been little management for plovers at Devereux. For example, existing prohibitions on pets are not enforced. Appropriate management actions are plausible but will require long-term funding. Providing a 30 meter buffer zone around the roost and removing dogs as a disturbance factor could greatly reduce disturbance. Protecting as little as half of the habitat where plovers are observed could protect plovers 90% of the time.

**Purpose**

The western snowy plover, *Charadrius alexandrinus nivosus,* is probably the most sensitive species at Coal Oil Point Reserve. However, at this time, there is no management strategy. In order to guide the potential management of this population, this review considers the regional and local status of plovers and threats to their persistence.

**Snowy Plover Natural History**

There are up to seven recognized subspecies of the snowy plover that occur throughout the world. Coastal populations of the western snowy plover range from Washington State, USA to Baja California, Mexico. They are small birds (6.5" or 15-17 cm in length, 34-58 g), with large black eyes, all black bill, dark legs, pale dorsal plumage and white breast (Ehrlich et al. 1988). Breeding males have a dark brow and ear patch and a dark, incomplete collar. Snowy plovers are very hard to notice unless they move. Their movement is quick, followed by an abrupt halt to a motionless posture that helps them avoid detection. Although they are distinctive in appearance and behavior, novice observers often confuse them with other shorebird species such as sanderlings and semipalmated plovers. Most people, however, do not even notice they are present.

Snowy plovers probe for insects and other small invertebrates among debris (especially drift kelp) along the high-tide line, in the low-tide zone, around marine-mammal carcasses or probe the sand under low foredune vegetation (Page et al. 1995). Foraging can occur up to 6 km from the breeding site (Page et al. 1995). When foraging, they usually pause, look, run and then dart for prey. They may also flush flying insects by charging them or flush aquatic invertebrates by foot-trembling in shallow water (Feeney and Maffei 1991). Page et al. (1995) provide an anecdotal list of terrestrial or aquatic

invertebrates in plover diets; those diet items found on the sandy beaches of Santa Barbara County include small clams, various polychaetes, mole crabs *(Emerita analoga)*, young shore crabs *(Pachygrapsus crassipes)*, amphipods (*Megalorchestia* spp.), kelp flies *(Coelopa)*, and various beetles (including globose dune beetle, *Coelus globosus*, around dune vegetation, C. Sandoval pers. comm.). They presumably eat isopods as well. Tucker and Powell (1999) quantified prey items from feces and the surrounding habitat at the Santa Margarita River Mouth (San Diego Co.). They found 22 families of potential prey (mostly insects). Of the 10 families consumed by plovers, beetles (most commonly rove beetles) and flies (most commonly shore flies) were the most abundant prey. Both of these prey types live in association with drift kelp.

The snowy plover breeding season on the West Coast begins in early March and continues through mid-September. They prefer to breed on sand-spits, dune-backed beaches, unvegetated beach strands, open areas around estuaries, and beaches at river mouths, but they may also breed around lagoons, salt flats, evaporation ponds, and braided river channels (Stenzel et al. 1981, Wilson 1980). Pair bonding can precede egg laying by 50 days (Warriner et al. 1986). Courtship behavior (male scraping bill in sand, raising wings and ruffling feathers, upright displays and horizontal displays) may indicate breeding activity (Purdue 1976). Males construct nests in cryptic, lined scrapes associated with beach debris (Page et al. 1995). Females can lay 2-6 clutches (clutch number decreases with hatching success) through mid-July. Three speckled sand-colored eggs occur per clutch. Both sexes incubate eggs, females by night, males by day (Warriner et al. 1986). Females desert males after the clutch hatches to seek a new mate while males stay with chicks for the month it takes to fledge (Page et al. 1995). Pairs may re-nest if a clutch or brood is lost. Causes of nest loss include predation, damage due to strong winds and high tides, desertion (often from disturbance) and crushing by humans, vehicles or pets (Page et al. 1995).

Nesting females average 0.7 to 0.9 fledged chicks per year (Page et al. 1995). Most individuals return to breed at the site where they were born. Snowy plovers mate in the first nesting season following birth, live an average of 3 years (annual survival rate of 0.75 (Page et al. 1983)) and can live more than 15 years (Page et. al. 1995).

Some snowy plovers winter where they nest, while others migrate (Page et al. 1995). Wintering sites are occupied by a few to over 300 birds that tend to aggregate in a roost (pairs may also use roosting areas in the breeding season, but the space between birds expands due to territoriality). Roosts tend to be in the widest sections of beach. They can extend over 200 meters along the shore but birds are usually more clustered. Individuals often sit in small depressions (on most beaches these are footprints) or, when the wind is blowing, in the lee of beach debris. Wintering birds tend to return to the same sites in consecutive years (Page et al. 1995).

## National and Regional Trends

### *Status*

Approximately 21,000 snowy plovers inhabit the U.S. but they are declining along the Pacific and Gulf Coasts. Only 1200-1900 adult western snowy plovers remain on the Pacific Coast of the U.S. with perhaps an additional 1900 in Baja California, Mexico (Page et al. 1991). Western snowy plovers were once more widely distributed in coastal California (including Baja California), Oregon, and Washington. In 1995, there were about 1000 snowy plovers in coastal California.

Snowy plover populations are generally in decline along the West Coast. Page et al. (1986) noted a substantial decrease between 1962 and 1984 in the abundance of wintering snowy plovers in southern California. Between 1981 and 1991, snowy plovers experienced at least an 11 percent decline in abundance (Page 1991). More recently, there has been a decline of about 30% throughout the region (in the late 1990s). Counts of breeding birds in the San Luis Obispo, Ventura and Santa Barbara counties have declined from 535 in 1997 to 444 in 1998. At Vandenberg Air Force Base, breeding plovers dropped from 238 in 1997 to 163 in 1998 to 89 in 1999. On the Channel Islands, breeding birds declined from 42 in 1990 to 1 in 1999 at San Miguel (due to displacement by elephant seals) and from 103 in 1991 to a peak of 121 in 1993 to a decade low of 41 in 1999. Some of these recent declines could be related to an unusually strong El Niño and may be related to mortality of over-wintering birds.

Historically, snowy plovers bred at 80 locations (53 in California) prior to 1970 along the coast of the western U.S. (Page and Stenzel

1981). Between 1970 and 1981, birds stopped breeding at 52 of these sites, including parts of San Diego, Ventura and Santa Barbara counties, most of Orange Co. and all of Los Angeles Co. (Page and Stenzel 1981). Eight sites now support 78 percent of the remaining California coastal breeding population. These are: San Francisco Bay, Monterey Bay, Morro Bay, the Callendar-Mussel Rock Dunes area, the Point Sal to Point Conception area, the Oxnard lowland, Santa Rosa Island and San Nicolas Island (Page et al. 1991). Plovers have abandoned all Santa Barbara County breeding sites south of Point Conception (Page and Stenzel 1981), presumably due to disturbance or habitat destruction. Former breeding sites in Santa Barbara County where plovers are now extirpated or rare include Goleta Beach (Page and Stenzel 1981), Goleta Slough (Lehman 1994), Carpinteria beaches (Dawson 1923 for early records) and Jalama Beach (Persons 1994). Snowy plovers no longer breed at Devereux Slough but are abundant there in the winter. The nearest breeding populations to Devereux Slough are at the Santa Clara River Mouth in Ventura Co. and a very small population west of Gaviota (Fahy and Holmgren 1993). The nearest large breeding site (100 pairs) is at Vandenberg AFB.

In contrast to patterns elsewhere, winter counts of the southern Santa Barbara mainland population have remained steady over the past three decades with a slight positive trend in Santa Barbara Christmas Bird Counts (covering the coast from Ellwood to Montecito on the 1st Saturday in January, mean = 102, $R = 0.35$, $N = 37$, years 1962/63 to 1998/99, $P < 0.05$). However, these data are traditionally hard to evaluate as the effort can vary substantially from year to year. The slight positive trend could easily result from an increase in effort associated with increased interest in snowy plovers. Principal wintering locations along the mainland coast of Santa Barbara County are the Santa Maria River Mouth, Vandenberg AFB beaches, Devereux Slough and the Santa Barbara Harbor Sand Spit (Lehman 1994). Wintering has not been regular at the Sand Spit in recent years. However, a group of about 50 snowy plovers was seen regularly at nearby East Beach during the 1999-2000 winter (D. Hubbard pers. comm.). These birds may represent individuals that used to winter at the Sand Spit. Plovers no longer winter at Goleta Beach and Carpinteria. This suggests that individuals may have been shunted to the remaining suitable locations as disturbance intensified elsewhere (Figure 1).

Page et al. (1986) reviewed the distribution of 1,555 (summed medians) wintering plovers along the mainland coast surveyed between 1979 and 1985. They estimate 2.63 wintering birds for every breeding bird. The yearly winter medians for Santa Barbara County beaches were 25 at Shuman Creek, 53 at San Antonio Creek, 18 at Purisima Point, 23 at the Santa Ynez River Mouth, 22 at Jalama Beach, 38 at Devereux Slough, 24 at Goleta Beach, 14 at the Santa Barbara Harbor and 0 at Carpinteria State Beach (as many as 9 birds were seen at Carpinteria). In Ventura County, there were 24 at San Buenaventura, 14 at the Santa Clara River Mouth, 24 at Ormond Beach and 20 at Mugu Lagoon. This study did not cover the offshore Channel Islands, but estimated 33-49 at San Nicolas I., 11-40 birds on Santa Cruz I., 1-40 on Santa Rosa I. and an unknown number on San Miguel I. Ventura County Audubon provide some more recent counts of breeding / wintering birds (Reed Smith pers. comm.). These are 0 / 15-50 at San Buenaventura, 8-10 / 15-75 at Santa Clara River Mouth, 6-8 / 12-20 at Hollywood and 8-10 / 20-75 at Ormond Beach.

In 1988, the Audubon Society petitioned to list the Pacific Coast population of snowy plovers as a threatened species under the Endangered Species Act (ESA). The U.S. Fish and Wildlife Service (FWS) listed it as Threatened in 1993 and is working on a recovery plan.

In 1999, the FWS designated 28 Critical Habitat areas, representing 10% of the west coast shoreline (including Devereux Slough which is included as Unit 1 of CA-14) for the Pacific Coast population of the western snowy plover (Federal Register / Vol. 64, No. 234 / Tuesday, December 7, 1999 / Rules and Regulations. Protection and special management of these sites will form the cornerstone of the recovery plan. Critical Habitat designation identifies areas that contain essential habitat features that require special management. Designation immediately increases the protection given to these essential areas with respect to federal lands or actions carried out by federal agencies (Federal Register 1995 op cit.). The FWS also intends that designation of Critical Habitat will stimulate additional attention to and enforcement of the requirements of Section 9 (prohibition of taking of listed species) of the ESA by private, municipal, county, and state landowners (Federal Register 1995 op cit.). On State Lands, snowy plovers also receive protection from CEQA (California Environmental Quality Act).

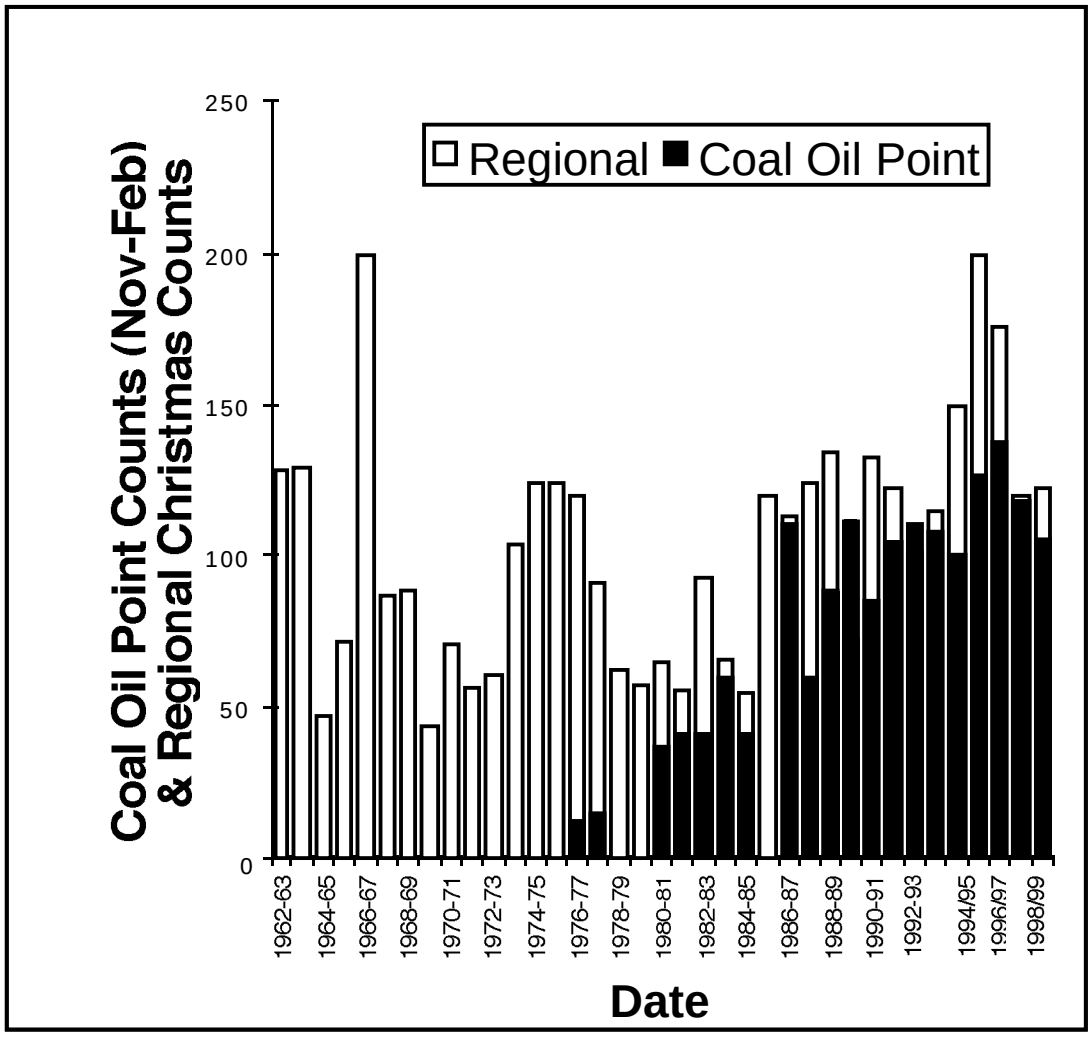


***Figure 1. Potential shift in winter beach use in Santa Barbara County***

Four decades of regional (south Santa Barbara County) plover counts based on Santa Barbara Christmas Bird Counts and over two decades of Devereux Slough counts. Christmas counts vary in effort, particularly with respect to the area covered and the detail provided in the reporting process with respect to where counts were made. Christmas counts are typically made on the first Saturday in January. Each Devereux Slough record is an average for all counts in a particular winter from November to February (from several observers as compiled by Mark Holmgren). Zeros in the Devereux Slough record indicate no records, not zero birds, so comparisons should only be made in years with both black and open bars. In some cases, the Devereux Slough counts include birds seen on Ellwood Beach or on the beach east of the Reserve (areas where few birds are typically seen). In other cases, only birds at the mouth of the slough were counted

***Threats***

The region-wide decline in snowy plovers is most likely due to predation, beach erosion, encroachment of exotic vegetation and disturbance from recreation (Page et al. 1995). All of these threats are increasing in magnitude.

Page et al. (1995) list many known or suspected predators of snowy plovers (on adults: merlin, peregrine falcon, prairie falcon, northern harrier, feral cats; on chicks: loggerhead shrike, raven, gulls, American kestrel, northern harrier, great blue heron, crow, red fox, and opossum; on eggs: raven, crows, California gull, ring-billed gull, great blue heron, coyote, red fox, gray fox, striped skunk, spotted skunk, raccoon and opossum). Crows *(Corvus brachyrhynchos)*, ravens *(Corvus corax)* and introduced red fox *(Vulpes fulva)* have most impacted reproductive success (Wilson-Jacobs and Meslow 1984, Page 1988, J. Warriner in litt. 1989 / Federal Register 1995, Page 1990, Stern et al. 1991). Accumulation of trash at beaches attracts some of these predators (Stern et al. 1990, Hogan 1991, Didion 1997).

Several factors can alter habitat so that it is unsuitable for snowy plovers. Breeding plovers have particularly narrow habitat requirements, as evidenced by the fact that plovers will winter, but rarely breed, on narrow or bluff-backed beaches (Page et al. 1986). Structures that alter sediment flow can alter beach width. The spread of European beachgrass has reduced the amount of potential snowy plover nesting habitat on many beaches by reducing the amount of unvegetated dune area above the tide-line, decreasing the width of the beach, and increasing its slope. Ice plant creates similar problems in southern California (Powell 1995).

Disturbance from human activity is another important factor in the ongoing decline in snowy plover populations as the summer nesting season coincides with intense beach recreation. In this context, disturbances are activities that, although they do not remove habitat or kill plovers directly, cause birds to suspend feeding or expend energy in flight or vigilance. Such disturbances broadly apply to the guild of shorebirds using beach habitats (Burger 1986).

Plovers are particularly susceptible to disturbance when they are breeding (reacting to disturbance at a greater distance, for example). Some plovers will winter, but will rarely breed, at urban beaches with high rates of disturbance (Page et al. 1986). If a parent is forced away from a nest, eggs or chicks may die due to exposure or predation. Human activities detrimental to nesting include: unintentional disturbance and trampling of eggs and chicks, pets (Stenzel et al. 1981, Warriner et al. 1986, P. Persons, in litt. 1992 / Federal Register 1995, D. Hatch unpublished 1998), off-road vehicle use (Stenzel et al. 1981, Warriner et al. 1986, Page 1988, P. Persons, in litt. 1992 / Federal Register 1995 op cit.); horseback riding (Page 1988, P. Persons, in litt. 1992 / Federal Register 1995); beach grooming (Stenzel et al. 1981), falcon flying, camping, jogging, clam digging, livestock grazing, sunbathing, picnicking, hang gliding, kite flying, and model airplane flying (Federal Register 1995). Page et al. (1977) found that snowy plovers were disturbed more than twice as often by such human activities than all other natural causes combined.

For example, because few disturbance acts are directly lethal to wintering plovers, impacts must be viewed in terms of cumulative effects on reproduction and survivorship. These are difficult to observe and can only be indirectly inferred, especially for non-breeding birds. curlew sandpipers that forage slowly or ineffectively may not build the requisite fat reserves needed for migration and reproduction (Puttick 1979). Studies on the ecologically similar piping plover indicate that reproductive success is lower in areas with high human disturbance because of reduced foraging efficiency and the depletion of fat reserves (Burger 1986, 1991, 1994). In areas where people are absent, piping plovers can spend 90% of their foraging time feeding compared with less than 50% in areas where people are common (Burger 1994). Many species of shorebirds react to disturbance by leaving the disturbed area (Burger 1986). In Ventura County, for example, shorebird abundance declines with increased human use, presumably because disturbance causes birds to seek more isolated locations (McCrary and Pierson 1999). Disturbance is least likely to permanently displace gulls and terns, ducks usually move a short distance while herons, egrets and shorebirds are most likely to be displaced a far distance (Burger 1981). Unfortunately, snowy plovers, because of their site fidelity and narrow habitat requirements, are less able to avoid disturbances by moving to other sites.

People can disturb wintering plovers if they approach too closely or too quickly. When beach use is high, plovers will suspend feeding and remain motionless in the roosting area.

Most people passing close to a roosting area probably do not even perceive that the birds are present. However, once a person walks within 15-20 meters, roosting plovers become alert, begin to walk away and displace each other from the depressions where they sit. They may elevate their wings or bob as a sign of distress and, if approached closely, run or take flight. If put into flight, flocks wheel back and forth for several minutes in tight, low altitude formations (Page et al. 1995). After landing, they remain nervous and will take wing with little prompting (Page et al. 1995).

Hatch (1996) classified the broad range of recreational activities near wintering plover roosts. "High-impact" activities included pets, kite flying, falcon flying, campfires, fireworks, ball playing, landing of boats, jogging, horseback riding, cycling and jet skiing. "Low-impact" activities included beach walking, fishing, birding and surfing. The over-all impact of these activities will obviously depend on their frequency and proximity to plovers.

Though they rarely are able to catch and kill shorebirds, pets may actively chase them for prolonged periods. Pet owners sometimes defend their pet's behavior as "natural"' without appreciating that the number of dogs on coastal beaches is orders of magnitude higher than natural predator densities (FWS in litt. in Hatch 1996). Pet activity reduces shorebird abundance (Burger 1981, Klein 1993) and those birds that remain must spend more energy on vigilance and escape at the expense of foraging and rest (Pfister et al. 1992, Burger 1993, Burger 1994). This is especially detrimental to migrants at stop-over sites because such migrants are already stressed and depleted and must rest and feed to successfully resume their migratory journey. The sensitivity of shorebirds to dogs is illustrated by the observation that piping plovers react at twice the distance and are displaced twice as far by dogs than by pedestrians (F.W.S. 1996 revised piping plover recovery plan), perhaps because being chased conditions birds to be wary of dogs or because birds instinctively view dogs as predators (Gabrielsen and Smith 1995).

At Golden Gate National Recreation Area, National Park biologists felt that chasing by off-leash pets was the most significant recreational disturbance for wintering snowy plovers (Hatch 1996). Monitors, observing an area of the National Seashore where federal law requires leashes on pets, found 10% of pets leashed, 30% near their owners and 50% roaming outside of voice control. In 160 hours of observation, about 6% of pets (362 dogs) chased shorebirds (Hatch 1996). Snowy plovers were even sensitive to pets that did not chase them and, like piping plovers, responded substantially more frequently and intensely to people with pets than to people alone (D. Hatch, pers. comm.). Protecting important wintering sites from unleashed dogs and other incompatible uses will be essential to recovery of this threatened species (FWS in litt. in Hatch 1996).

If the rate of disturbance is high, plovers and other shorebirds may have to feed during nights and evenings to meet their energetic needs (Burger and Gochfeld 1991, Staine and Burger 1994). Human activity at night, therefore, may be particularly disruptive to plovers that also receive disturbance during the day (Burger 1993). Lights and fires disturb birds at night and can cause them to fly, become disoriented and become anxious.

In conclusion, based on studies of piping plovers, it seems plausible that snowy plover fitness decreases with human activity. Although the effects of disturbance seem most important during the breeding season, disturbance during non breeding periods can affect fitness if it impairs foraging success to the extent that birds cannot accumulate sufficient fat stores for migration and reproduction.

### *Management Approaches*

Some feel that if management efforts do not increase, snowy plover populations will probably continue to decline (Federal Register 1995). To date, most management has focused on nesting birds, though the draft recovery plan indicates management concerns for wintering birds as well. The broad goal of the FWS's recovery effort will be to promote conservation, recovery and eventual de-listing by increasing plover abundance and securing sufficient suitable habitat. Specifically, this means reducing: (1) predation, (2) non-native vegetation, (3) human associated disturbances, including beach cleaning, pets, off-road vehicles and falcon flying, (4) erosion control structures that alter beach topography and (5) contamination such as oil spills. Management options include predator control, exotic vegetation removal, recreation management, signs, colony boundary marking, colony fencing, nest fencing, dry sand closures, seasonal closures, full closures, and prohibitions/restrictions on vehicles, pets, horses, development, military use and boat landings.

Management actions are ongoing in several areas. For example, a plan exists to reduce introduced red fox populations at the Salinas River National Wildlife Refuge (Parker and Takekawa 1993). In Monterey and at Vandenberg Air Force Base, managers are relocating native birds of prey that are known to feed on nestlings (D. Pereksta, FWS pers. com.). Nest enclosures (designed to reduce predation) increased hatching success fourfold at Monterey (R. Rayburn, in litt. 1992 / Federal Register 1995) and tenfold at Coos Bay (Stern et al. 1991, R. Fisher, in litt. 1992 / Federal Register 1995). At Point Reyes National Seashore, nest enclosures have been used for the past 3 years resulting in an increase of almost fourfold in the number of nests produced (S. Allen 1998 in litt.).

Because a variety of human activities "disturb" snowy plovers and the effects of disturbance depend on their frequency, timing, location and intensity, most management aims to minimize overlaps between human activity and those areas that plovers depend on most for breeding and wintering. In addition, attempts are made to specifically prohibit "High-Impact" activities (sensu Hatch 1996) in areas deemed to be Critical Habitat. At sites with a recreational mission, there is an increasing attempt at active management to promote both restricted recreation and plover protection.

Golden Gate National Recreation Area posted the existing leash law along the two-mile stretch of Ocean Beach frequented by snowy plovers and provided educational signs about plovers. Initially, pet activists complained vocally and compliance changed little (Gustaitis 1998). Posting leash laws generally results in low compliance (Dog PAC 1997). Sporadic enforcement brought compliance to 20%, although the number of pet owners using the leash area declined by approximately 50%. Only with the continual presence of park rangers was compliance brought to near 100%. Concomitant with this was a realization by the dog owner's lobby that the need of dog owners to enjoy a specific stretch of beach at the expense of a threatened species was difficult to sell to the general public (D. Hatch pers. comm.). Eventually, pet owners stopped using the area (even for walking with a leash) and moved their activity to stretches of the beach where the law was not enforced.

Several types of active management are in place to protect plovers. At the Monterey Dunes, State Parks uses enforcement, signs, symbolic fencing (rope between poles) and a new (1998) public outreach program called the Western Snowy Plover Guardian Program (Jean Scott, pers. comm.). Trained volunteers maintain signs and fences, provide education to the public, monitor plovers and beach users and report harassment to State Park rangers. At Half Moon Bay State Park, where up to 60 plovers winter and a few breed over a five acre site, a 10 person volunteer "plover watch" has fenced nests and intercepted dogs off-leash since 1994. A variety of similar efforts have been made to educate the public about piping plovers on the East Coast. These include posters, brochures, T-shirts, news releases, television PSAs, educational presentations, articles in newspapers and magazines, interpretive signs and paid and volunteer "plover wardens" (Melvin et al. 1991). Oregon Dunes National Recreation Area uses temporary fencing and signing to direct beach visitors away from snowy plover nesting areas. The Point Reyes National Seashore feels that symbolic fencing (rope between poles) is more effective than signs at keeping people away from plovers. They prohibit pets and cattle from some beaches.

Beach closure, though obviously unpopular, is often the most tractable option and managers, if they lack the funds or staff for intensive management, may close beaches to comply with the ESA. Closures typically include the breeding season from March 1- September 30. The ability of beach closures to improve nesting success can be dramatic (Saul 1982, W. Shuford, in litt. 1989 / Federal Register 1995, Page 1990). At some sites, the FWS has required that more restrictive management actions be attached to poor nesting performance (Vandenberg) or take violations (Coos Bay). For example, in 1999 and 2000, FWS required Vandenberg Air Force Base to close public access to south Surf Beach at the Santa Ynez River Mouth for the breeding season because signs noting closed areas were not deemed effective at reducing disturbance to breeding birds. For example, at a posted and enforced linear closure during the snowy plover breeding season at nearby Vandenberg Air Force Base (VAFB), 30% of beach users entered posted closed areas (Fahy & Woodhouse 1995). Although this was one of only two sources of public beach access for the City of Lompoc, the Coastal Commission Staff ruled that closure was consistent with the Coastal Act. Vandenberg Air Force Base also restricts military access to other, non-public beaches during the nesting season of least terns and snowy plovers. The majority of beaches at Point Mugu Naval Base are closed

year-round to protect snowy plovers and least terns from disturbance. The Navy closes several beaches on San Nicolas Island during the plover breeding season. At Santa Rosa Island, the National Park Service closes the Skunk Point Breeding area from March 15 through September 30 (P. Martin pers. comm.). Leadbetter Point in Washington, and two sites in Coos Bay prohibit human access specifically for plover nesting.

The FWS, along with the California Department of Fish and Game, will likely coordinate ongoing and future management efforts.

**Coal Oil Point Reserve**

Devereux Slough (See Figure 2) is just west of Coal Oil Point on the West Campus of the University of California at Santa Barbara; Santa Barbara County, CA (Latitude 34° 25' 00" N, Longitude 119° 52' 30"). In 1970, UCSB established Coal Oil Point Reserve after two years of open public access had substantially damaged this regionally rare coastal dune habitat used for teaching and research. In 1973, the Reserve expanded to include 117 acres of slough, intertidal, beach, dune, wetland and upland habitats. An additional 40 acres of dunes were added in 1999. The Reserve's mission is to preserve the area for research, education and public outreach. Two Resident Reserve Directors, and a Faculty Manager administer and operate the Reserve on an annual budget of approximately $10,000 per year. At present, well over 1,000 students visit the Reserve each year as part of university and K-12 educational field trips. About 12 researchers use the Reserve during a particular year.

The Campus Long Range Development Plan (LRDP) presently permits beach recreation, but there are no dedicated parking areas or facilities for recreational users adjacent to the Reserve. Some of the dune areas are presently fenced for preservation. The Coal Oil Point Management Plan (in prep.) provides additional details about the Reserve.

**The Devereux Slough Snowy Plover Population**

***Critical Habitat Designation***

The FWS considers Devereux Slough to represent "important feeding or roosting habitat for significant numbers of snowy plovers for migration or wintering" (FWS Western Snowy Plover Recovery Plan, Appendix B, in prep.) and designated the area around Coal Oil Point as Critical Habitat for western snowy plovers (Federal Register 1999). Specifically, it names, "Devereaux (sic) Beach beginning at 34 ° 25' 13" N, 119 ° 53' 31" W, located on 20-foot contour line, thence southeasterly following 20-foot contour line, thence northeasterly around Coal Oil Point to 34 ° 24" 33" N, 119 ° 51" 57" W., located on 20 foot contour line, thence south to MLW, thence westerly following MLW, southwesterly around Coal Oil Point, thence northwesterly to a point south of point of beginning, thence north to point of beginning". In other words, along the beach from the extrapolated terminus of Santa Barbara Shores Dr. at Ellwood Beach to the extrapolated terminus of Camino Corto Rd in Isla Vista. Other designated Critical Habitats in Santa Barbara County are Vandenberg Beach, Jalama Beach and Santa Ynez River mouth to the north and the Santa Barbara Harbor, Sand Spit and Carpinteria Beach to the south.

***Natural History***

The area around Devereux Slough is rich with wildlife, particularly birds. The National Audubon Society designates the coastal area surrounding Coal Oil Point as a "Globally Important Bird Area". Page et al. (1999) include Devereux Slough as among the 38 most important estuaries for birds along the U.S. Pacific Coast. It is important to state that many of the concerns relating to snowy plovers can be extended to the entire shorebird community. One species of particular concern is the endangered least tern (*Sterna antillarum*), which formerly bred at Devereux Slough but is now only a winter visitor (Lehman 1994). In some areas in southern California, protection for least terns has benefited snowy plovers (Powell and Collier in press). But while least terns have increased since being listed, snowy plovers have not (Abby Powell, pers. comm.). There is no management for least terns at Coal Oil Point.

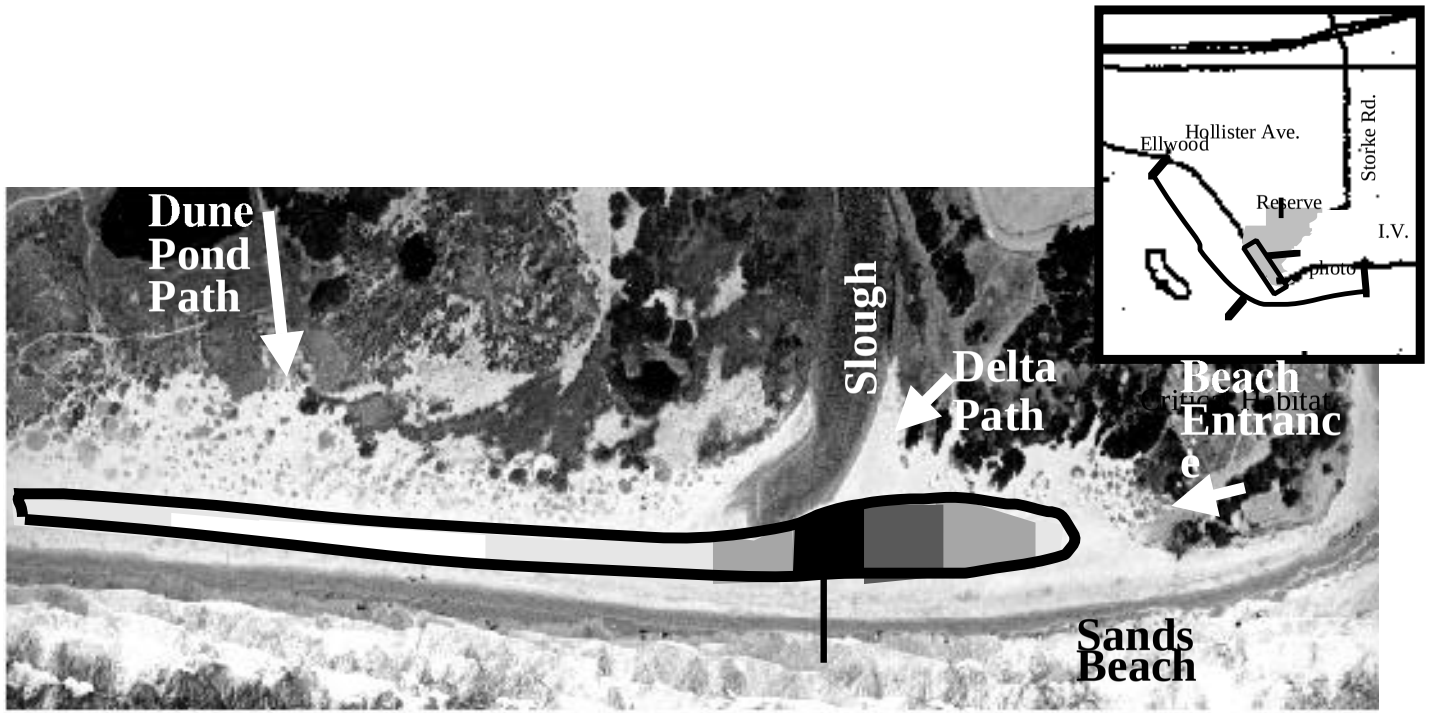


***Figure 2. Winter Roost at Devereux Slough.***

Annotated aerial photo of Sands Beach, a portion of the Critical Habitat Area (see inset box). The asymmetrical ellipse marked with a black outline represents the boundaries of the main roosting area of plovers. Different shading within the ellipse corresponds to different plover densities with dark being higher and light being lower. Key for counts (average number of birds per day) is as follows (polygons, left to right: 2.5, 0, 2.5, 6, 37, 13, 12, <1). Data from Lafferty (submitted B).

At Coal Oil Point Reserve (Figure 2), snowy plovers roost among cobble, drift and depressions on a sandy delta formed by the mouth of Devereux Slough. This area is known locally as Sands Beach. Roosting birds are usually concentrated in one or two dense aggregations in dry sand near the mouth of the Slough (Figure 2). Aggregations are typically about 40 meters wide in a narrow ellipse that parallels the beach (Lafferty 2001 B). They also have been seen to visit the mud flats of north Devereux Slough (P. Lehman pers. obs.).

In the morning and evening, snowy plovers leave the roost and spread up and down the beach for several hundred meters to forage along the tidal margin on invertebrates associated with decomposing drift kelp. For example, on 16 surveys in the late summer of 1996, Dave Hubbard (UCSB, MSE) observed between one and five snowy plovers foraging east of the Reserve. Sands Beach has a rich high-intertidal invertebrate community, presumably due to the large amount of drift algae deposited on the beach from off-shore kelp forests (Dugan et al. 1999).

Snowy Plovers at Devereux Slough formerly commuted between the extirpated Goleta Beach population to the east (Page et al. 1986). The following notes by Paul Lehman in 1978 denote this trend. "[The snowy plover] is threatened as a breeder in most of coastal California. A low amount of disturbance is needed for successful nesting. Until fairly recently, the sandy area forming the barrier across the mouth of Devereux Slough supported nesting Snowy Plovers. The large number of people and dogs here may be a major factor in the loss of this site. At the present time (1978) about 16 Snowy Plovers are summering at the Devereux Slough. Whether or not these individuals are attempting to nest is not yet known. Another sizeable population of Snowy Plovers exists at the extreme western edge of Goleta Beach Park with some of the individuals "spilling over" onto campus beach property. The population here numbers as many as 100; however, most of these birds are winter visitors. The heavy summer use of Goleta Beach by people precludes nesting by the plovers. A few pairs may be able to nest on the upper, more undisturbed portion of the nearby campus beach." It seems possible that when birds abandoned Goleta Beach (Goleta Beach had about 20 wintering birds as late as the early 1980s), they moved to Devereux Slough, perhaps because disturbance was lower there.

Banded birds from Vandenberg A.F.B., Mono Lake, Monterey, Santa Rosa Island, Oregon (FWS bird banding data), Santa Cruz County (Wilder Beach) and Bolsa Chica (Orange County) (pers. obs.) have roosted at the Reserve, emphasizing the link between the Devereux Slough population and snowy plovers elsewhere.

The proportion of snowy plovers in southern Santa Barbara that winter at Devereux Slough has increased substantially (from around 10% in 1976 to up to 100% in the early 90s, angular transformation, $R = 0.62$, $N = 20$, years 1976/77 to 1998/99, $P = 0.01$, Figure 1). This proportional increase at Devereux Slough is consistent with a consolidation of birds from nearby areas.

Snowy plovers are the most abundant bird species within the Critical Habitat boundaries and are now present in varying numbers for ten to eleven months of the year (mostly from July through April). Despite the cessation of breeding at the site, the number of birds that winter at Devereux Slough has actually increased over time (13 to ~120, $R = 0.92$, $N = 20$, years 1976/77 to 1998/99, $P < 0.01$, Figure 1), indicating that wintering birds tolerate existing levels of disturbance. For the last decade, the wintering population has averaged 111 birds between November and February, with the greatest numbers occurring in November (Figure 3, Fahy and Holmgren 1993). A high count of 167 birds was made by M. Holmgren on 23 November, 1996. Greater than 150 birds occurred during counts in 1992, 1996 and 1997. The 1996/97 winter had the highest average abundance of plovers (138 birds).

Fahy and Holmgren (1993) summarized the historical occurrences of plovers, especially breeding activity, at Devereux Slough. Egmont Rett reported breeding activity as early as 1936. In 1938, Rett had already noted a drop in numbers and suggested that an increasing opossum population was to blame. Waldo Abbott noted that nesting plovers were historically common (Kellogg and Yokota 1972). Nesting plovers were noted to be abundant in 1956 by N. Metcalf. The population stopped breeding successfully at Devereux Slough sometime after 1965, probably due to an increase in human recreational use of the area in the late 1960s that led to broad-scale degradation of the area (Boyce 1972).

Fahy and Holmgren (1993) suggested that the abandonment of Devereux Slough as a breeding site is not necessarily irreversible. Because known egg records in the area extend from the

end of April through the middle of June (Fahy and Holmgren 1993), observations of plovers in May (8-10 birds in 1977 (D. Schroeder, pers. obs.), four birds in 1982 (D. Biazzi, pers. obs), two birds in 1992 (F. Sanchez, pers. obs.) and two birds in 1993 (S. Finnegan, pers. obs.)), suggest that birds in breeding condition still visit the area. For example, on 16 June 1991, Paul Lehman observed an adult and two fledged juveniles.

The following observation, as noted by Mark Holmgren, sheds light on obstacles to breeding at the Reserve. On 2 May 1982, Dean Bazzi observed one female and two male snowy plovers. The female ran to a nest with three eggs. The nest was above the upper swash zone about 10-20 feet from the nearest dune about 1/8 mile west of the Slough outlet (just east of the dune pond). On 5 May, he could not relocate the nest. Footprints and dune buggy tracks were in the area where the nest had been. A second nest with a female incubating three eggs was seen 100-200 feet to the west about 5-10 ft above the swash zone. He checked the nest regularly through 29 May. On 30 May, Biazzi saw ATV tracks very close to the location of the nest along with two dead, unhatched chicks. He could not find the third egg in the clutch.

It has been speculated that cessation of breeding at Devereux Slough foreshadows abandonment of the site as a winter roost (M. Holmgren, pers. comm.). At other locations (e.g., Goleta Beach and Carpinteria), abandonment of the site as a winter roost followed suspension of breeding activities by approximately 30 years.

***Habitat Alteration***

Beach grooming, carcass burial, shoreline erosion control efforts and European beach grass do not occur at the Reserve and, relative to many other beaches, threats from habitat alteration are minimal. Wind, high surf, stream-flow and high tides seasonally alter the delta where snowy plovers roost (Figure 2). Extreme events (such as the 1983 and 1998 El Niños) may remove or substantially alter segments of the habitat. Natural processes rebuild the beach and dunes after storms, but it is worth noting that these processes seem impaired. For example, narrowing of the beach could be due to a region-wide decline in sources of sand and degradation of the dunes probably stems from the trampling of vegetation on embryo dunes (Boyce 1972).

Monterey cypress planted between 1920 and 1945 (Boyce 1972) grow immediately east of the delta. By the late 60s, these trees had grown to the point that the grove earned the title of "enchanted forest". The majority of the cypress trees have now died, except for the dozen trees nearest to the plover roost. These trees presently provide cover and perch sites for crows and other potential plover predators (Hubbard pers. comm.). As the cypress died-back, introduced acacia (Australian wattle) filled in the gaps to cover about 6 acres of former dune habitat. Acacia can transform fore-dunes from sparsely vegetated areas potentially suitable for plovers, to thickly covered areas potentially suitable for plover predators. This acacia was removed in 1999 as part of a large-scale restoration project.

Plovers might perceive artificial structures as predator perches. Large timbers from a disintegrating seawall to the west arrive as drift near the delta and, when erected by beach goers, may heighten plover vigilance (D. Hubbard, pers. comm.). The use of protective fencing around the dunes (see Public Access) by predators is probably minor as these fence posts typically serve as perch sites for black phoebe and Say's phoebe, not crows or raptors (pers. obs.).

An oil spill has the potential to negatively alter the habitat and directly harm birds as demonstrated by the oiling of a dozen snowy plovers at Ocean Beach during the 1996 Cape Mohican oil spill. At Coos Bay, half of Oregon’s snowy plovers were oiled by a spill from a grounded freighter. Oil is a particular threat at the Reserve because an oil barge-loading station lies 400 meters offshore of the Devereux Slough plover roosting area and Platform Holly is three kilometers offshore. Natural offshore seeps in the area occasionally cause birds to become oiled. Surface tar cover is the highest in the County and lower beach prey are highly contaminated with hydrocarbons (J. Dugan pers. comm.).

***Predators***

Although there are no direct observations of predation on plovers by predators at Devereux Slough, as ground nesters, snowy plovers are susceptible to predators (Page et al. 1995). Those that may pose a significant threat to eggs and nestlings at the Reserve are crows, coyotes, opossums, raccoons, skunks, gulls, cats, dogs, kestrels and introduced red foxes. A decline in large predators (coyote, mountain lion and bobcat) and access to beach litter and refuse bins

probably increases medium-sized predator numbers at the Reserve (Fahy and Holmgren 1993). However, at least one bobcat lives in the dunes behind the roost and coyotes have been frequently seen in the area from 1998- to present. Crows are conspicuously abundant on the beach and are responsible for many of the disturbances to shorebirds in the Critical Habitat area (Lafferty 2001 A). Although roosting plovers are less at risk to predation than eggs and nestlings, they are taken by raptors (e.g., merlin, great horned owl and peregrine falcon which occur near the Devereux Slough roost) or cats at other sites (Page et al. 1995). In addition, one might speculate that roosting plovers could perceive an area as unsafe for nesting if egg and chick predators, such as crows or red foxes, are abundant.

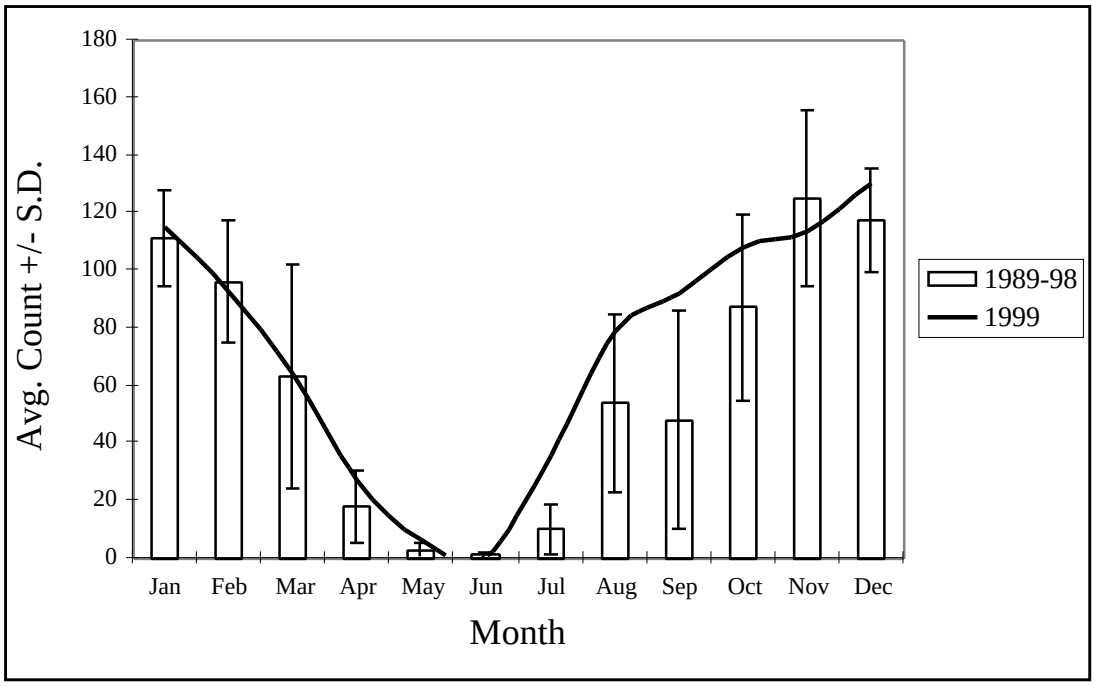


***Figure 3. Seasonal variation in abundance.***

Monthly mean counts for snowy plovers at the Devereux Slough for the last decade and for data collected in 1999. Error bars are standard deviations.

***Public Access***

The most common recreational activities on the beaches near Devereux Slough are sunbathing, surfing, beach walking, jogging, picnicking, bonfires and pet walking. Less common are kite flying, fishing, horseback riding, cycling, off-road driving, surf contests, and group gatherings. Falconry does not occur on the Reserve. Pet walking, bonfires and off-roading are prohibited (the latter two are enforced). New and future residential development to the West and North will increase public use.

Prior to 1967, the Campbell family and Devereux Santa Barbara controlled access to the Coal Oil Point area (Boyce 1972). When Devereux Santa Barbara sold the West Campus parcel to the University, UCSB greatly expanded access and the UCSB Recreation Department opened an equestrian facility (Boyce 1972). By 1969, campus biologists (J. R. Haller and J. P. Broughton) recognized that the natural value of the dunes had greatly deteriorated due to off-road vehicles, horses and pedestrians (Boyce 1972). They also recognized that sand dunes were disappearing throughout the state and that Coal Oil Point was the only remaining sand dune habitat in southern Santa Barbara County. The University initially established Coal Oil Point Reserve to preserve the western dune area. Now it encompasses a wider area and additional habitats. The delta and the beach are open to the

public. Fencing has protected the western dunes over the past three decades. Dramatic differences in the quality of habitat in the fenced and unfenced area indicated both the success of fencing and the impacts of public access to the east dunes. Restoration and protection of a section of the east dues are in progress.

Human activity is substantially higher on weekends, low tides and warm days but does not vary significantly among seasons (Lafferty 2001 A). Although one might expect summer beach crowds, winter months have as much activity, presumably due to surf, foggy summer weather and the fact that many students are away during summer break. Human activity is lowest in the mornings and increases throughout the day but may decline in the afternoon if the wind blows strong (Lafferty 2001 B).

In 1999, there were 18 people per kilometer of beach along the Critical Habitat. Between 40,000 and 80,000 people walked past the Slough Mouth in 1999 and there were about 125,000 annual people-hours on Reserve beaches.

To determine who these people were, Darcie Goodman, an undergraduate at UCSB, questioned 117 people at Sands Beach (winter/spring 2000); 72% of these were college aged students. On average, they visited 7 times per month. They had been coming to Sands Beach a median of 2 years and 5% were there for the first time. Activities engaged in at least once (each person typically listed more than one activity) were walking (85%), jogging (68%), sunbathing (46%), surfing (38%), watching the sunset (21%), partying (20%), beach cleanup (15%), dog walking (14%), bird watching (13%), painting (12%) and horseback riding (12%). Only 37% of those questioned were aware the area was UCSB property (most were unsure). As for the designation of the area, 33% knew the property was a nature reserve, 53% were unsure what it was and the rest thought it was a park for recreation. 35% said they had heard of a snowy plover, while 3 of the 117 people could identify a photograph of a snowy plover (in comparison, 84% could identify a photograph of a pelican).

People can access Sands Beach along the beach from the east and west (Figure 2). Most people bike or walk along the bluffs from Isla Vista and use the Sands Beach entrance. This is the pedestrian access way that the Campus provides under the conditions of the 1990 Long Range Development Plan (UCSB - LRDP 30210.19). Eventually, a fenced constriction at the Sands Beach entrance prevented motor vehicles and horses and discouraged cyclists from getting on to the beach at this point.

Parking at Coal Oil Point is officially limited to appropriate users and requires a special West Campus parking permit. Unauthorized parking is a chronic problem because it increases inappropriate access to the plover roost. In addition, people that arrive in vehicles can carry more items with them, contributing to litter, beach fires and parties near the roost.

A path, herein referred to as the Delta Path (Figure 2), is the access point in the closest proximity to the plover roost and is worth describing in detail. With its purchase of Coal Oil Point, the University allotted Devereux Santa Barbara an easement to a gated path that extends along the east of the slough channel to the slough mouth (the delta). The path formerly followed a fence that angled south through the dunes before reaching the delta. The portion of the fence that deflected foot traffic to the south was repeatedly vandalized, presumably to provide convenient access to the delta area. At some point, the University gave up repairing the fence (D. Coon, pers. com.). Individuals accessing the beach from the Delta Path typically walk directly through the plover roost.

Despite the relatively limited use the Delta Path receives, a disproportionate amount of the disturbance to snowy plovers is associated with it. Plovers react more intensely and at a greater distance to people entering the beach from the Delta Path than they do to people walking along the water's edge (Meeker 1996), creating a small but chronic stream of disturbance. In addition, since it lacks access controls, it is the most convenient way for motorcycles to access the beach. Fortunately, motorcycles are infrequent (approximately once monthly, pers. obs.) and prohibitions are actively enforced. Vehicle tracks do appear in the plover roost area once every month or two.

A stable is located on University property near the Reserve and some of the two dozen members of the UCSB Horseboarders Association use the Reserve's beach areas for riding. Equestrians trailer horses to the area as well. On average, 0.4 horses enter the site every 30 minutes during mid-day (Lafferty 2001 B). When the Reserve was established, equestrians were encouraged to use a beach path east of Coal Oil Point to reduce their impact on the dunes. Erosion now makes this area unsafe for horses and equestrians often use the Delta Path to access the beach. The present placement of fencing to protect dune habitat increases this

problem because it blocks an equestrian path slightly further to the East. Three beach trails west of the Delta Path also allow access to the beach but require riding around the slough. Plans by Santa Barbara County Parks and Recreation to build a large stable to the west may increase future equestrian use.

Pets are technically prohibited from the Reserve but the University has rarely enforced this policy or the standard leash laws that apply to public areas. In 1999, there were 11 dogs to every 100 people using the Critical Habitat area for an average density of 2 dogs per kilometer, of which 7% were leashed (Lafferty 2001 A). This was slightly less than the 15 dogs per 100 people observed at 13 Ventura County beaches where three beaches had over 30 dogs per 100 people (McCrary and Pierson 1999).

***Disturbance***

This section summarizes results of a USGS study (Lafferty 2001 B) that determined the rates and source of disturbances to snowy plovers at Devereux Slough. The study found that each plover is disturbed, on average, 1.4 times per midday hour (or every 43 minutes) on weekdays and 2.2 times per hour (or every 27 minutes) on weekends. 17-27% of the disturbed plovers fly. There is an estimated 115 disturbances per plover, per week and 356,000 disturbances to plovers each year. Rates of disturbance at Devereux Slough are 16 times higher than at protected beaches (Santa Rosa I., San Nicolas I. and Point Mugu) but nearly identical to Ocean Beach (San Francisco) where plovers roost but do not nest.

The study also found that the likelihood and impact of a disturbance varies with the type of activity and the distance from plovers. Not surprisingly, the probability of a disturbance decreases with the distance from activity (few disturbances occur at a distance greater than 30 meters). At any particular distance, dogs have a higher probability of disturbing plovers than do humans. The distance between people and the plover roost increases on days when the beach is wide, presumably because this decreases the potential overlap between beach users and snowy plovers. Much of the variation in beach width is a function of tidal height but is also affected by seasonal variation in the distribution of sand; in the winter and early spring, the beach is narrower due to the scouring action of storms (Lafferty 2001 A).

The study found that disturbance varies according to activity type. For example, 12% of humans disturb plovers at a rate of 20% of the roost per disturbing person, while 25% of dogs disturb plovers at a rate of 50% of the roost per disturbing dog. Although joggers are more likely to disturb shorebirds than walkers (Lafferty 2001 A), they are less likely than walkers to disturb snowy plovers, perhaps because joggers are further from the plover roost, due to their tendency to run on moist, packed sand. 60% of horses disturb plovers at a rate of 34% of the roost per disturbing horse. Crows disturb plovers at a rate of 29% of the roost per disturbing crow. Birds other than crows cause 2% of the total disturbances. One of twelve aircraft flying directly over the roost disturbed plovers. Although the study did not observe the effects of vehicles, motorcycles and other vehicles occasionally enter the roost area illegally. Due to their high speeds and loud noise, they can be very disruptive to plovers and other wildlife.

The study found some impacts of disturbance. Plovers fly relatively little in response to other birds and humans, an intermediate amount in response to dogs and horses and most in response to crows. The most intense disturbances occur when dogs chase plovers. After chased plovers take flight, they typically fly over the ocean and attempt to return to the roosting area. In some cases, pets chase the plovers again once they land. Chasing episodes last up to 20 minutes and can happen several times an hour (Meeker 1996). In most cases, the owner is present but makes no effort to call or restrain their pet. Disturbance may make some parts of the delta unsuitable for roosting. The density of plovers is lower in areas at the heads of 4 beach access trails compared with other areas where plovers roost. Disturbance may also alter plover foraging. Plover feeding activity declines with the abundance of beach users who are more abundant in the afternoon. Less late-day feeding occurs at Devereux Slough relative to protected beaches where plovers nest, suggesting that foraging shifts more dramatically from afternoon to the early morning at Devereux Slough, perhaps due to higher amounts of disturbance in the afternoon.

In summary, under the FWS definition, “take” of plovers is commonplace at the Devereux Slough and the FWS believes that management actions need to be taken to avoid a Section 9 violation (Noda in litt. 1999). A hypothetical management model parameterized

with data from Devereux Slough reveals the efficacy of some basic management options (Lafferty 2001 B). Providing a 30 meter buffer zone around the roost and removing dogs as a disturbance factor could greatly reduce disturbance. Protecting as little as half of the habitat where plovers are observed could protect plovers 90% of the time (see Figure 2).

**Conclusion**

The population of snowy plovers at Devereux Slough is apparently a consolidation of smaller wintering populations that were formerly more widely distributed. These populations probably abandoned their former habitats, first for breeding and then for roosting, as recreational beach use increased in the region. They appear to have found asylum at Devereux Slough, but no longer breed, presumably due to a high rate of disturbance. Dramatic increases in development of the Goleta Valley may increase beach use and subsequent disturbance.

Snowy plovers at Devereux Slough presently suffer a number of threats that proper management can reduce. It is particularly fortuitous that Devereux Slough is within a nature reserve that emphasizes preservation. Although many threats to plovers are officially prohibited by local policies, they are not actively enforced. An active management approach could reduce disturbances from people, pets and predators. Preliminary actions to monitor the existing population should help to both track the population and to provide insight into whether management actions succeed.

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