



Snowy Plover Monitoring Protocol for Point Reyes National Seashore

Version 7.1

Natural Resource Report NPS/SFAN/NRR—2014/850



ON THE COVER

Western Snowy Plover at Point Reyes National Seashore.
Photograph by: Kate Peterlein

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Dawn Adams

National Park Service
San Francisco Bay Area I&M Program
Building 1063, Fort Cronkhite
Sausalito, California 94965

Marcus Koenen

National Park Service
Alcatraz Island
Golden Gate National Recreation Area
Fort Mason, B201
San Francisco, California 94123

Kate Peterlein

3180 S. Gila Dr.
Flagstaff, Arizona 86001

David Press

National Park Service
Point Reyes National Seashore
1 Bear Valley Rd
Point Reyes Station, California 94956

Sarah G. Allen

National Park Service
Ocean Stewardship Program
Pacific West Region
c/o Point Reyes National Seashore
1 Bear Valley Rd
Point Reyes Station, California 94956

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Executive Summary

Western snowy plovers were listed as threatened by the United States Fish and Wildlife Service in 1993 (USFWS 1993). These small birds breed regularly at Point Reyes National Seashore (PORE) and a population also inhabits its beaches during the non-breeding season. This protocol documents the sampling design, field methods, analytical techniques, reporting requirements and budget required to monitor breeding plovers annually at PORE. The methods have remained largely unchanged since monitoring began at PORE by PRBO Conservation Science (PRBO) and the national seashore staff since the 1970s.

The monitoring objective is to determine the trends in the estimated breeding population size, distribution, and reproductive success of snowy plovers at known breeding beaches at Point Reyes National Seashore.

The number and length of survey areas beaches and annual average number of nests is small enough that it is possible to do a complete census of the nesting population twice a week during the breeding season (March through September). Nest visits every few days are used to track the fate of nests, eggs, and chicks. During surveys, predators seen are identified within survey areas.

Products including annual reports, regular updates, and long-term trends reports are also described in this protocol. Annual reports are regularly posted to the San Francisco Bay Area Network Inventory and Monitoring Program (SFAN) website.

Funding for monitoring has come from various sources over the years including PORE, PRBO, Point Reyes National Seashore Association, SFAN, and a variety of special grants. The monitoring and reporting will continue to be overseen and implemented by PORE with technical assistance such as data management provided by SFAN.

Every known, historic snowy plover breeding beach within PORE is surveyed for breeding adults. There are six survey areas: four on Point Reyes Beach, one on Limantour Spit, and one on Drake's Spit. Currently at PORE, snowy plovers nest in two of the six survey areas, both on Point Reyes Beach: Kehoe Beach (K) and a section of Point Reyes Beach between Abbott's Lagoon and the North Beach parking lot (NP). In the past, nesting has occurred within Drake's Bay at Drake's Spit (D) and Limantour Spit (L) and additional appropriate habitat is at North Beach (NB) and South Beach (SB).

Annual breeding population sizes range from a high of 50 in 1987 to a low of 10 in 1996. Fledged chicks per egg values (number of fledged chicks per egg) ranged from 0.01 in 1989 to 0.58 in 1996 and 1998. Nest failures have been largely attributed to predators and predator exclosures have been used by the park as a management tool since 1996. Beach visitors especially those with unleashed dogs have sometimes presented a threat to the ground nesting birds. In response, the park established a snowy plover docent program in 2001 to educate beach visitors about the nesting snowy plovers and beach recreation restrictions.

Collection of presence/absence and abundance information of the number of human, pet dogs (leashed and unleashed), and potential snowy plover predators is important to park managers and the data are collected during snowy plover census and nest check surveys. It is recognized that because these data are not currently collected with systematic, standardized sample efforts, the relationship between ancillary data collected on predator populations and plover population trends cannot be determined with statistical estimates of certainty. Results from an ongoing diurnal predator abundance pilot study will be used to revise predator survey methods, data collection, and correlation analyses. In addition, a snowy plover, long-term trend report is due to be completed in 2014 which will further inform future protocol revisions.

Acknowledgements

A draft of this protocol was originally developed by PRBO Conservation Science with staff at Point Reyes National Seashore. K. Steinhorst of the University of Idaho provided guidance for the sample design and data analysis. We also thank J. Whittier, Kansas State University, and G. Page, PRBO Conservation Science, for comments on an earlier draft of this protocol.

List of Terms

Breeding success: see reproductive success.

Brood: groups of chicks hatched from the same nest.

Clutch: group of eggs within a single nest.

Fledging success: percentage of nests that fledge at least one chick from the total of nests that hatched at least one egg. Also see reproductive success.

Hatching success: season total of number of eggs that hatch and percentage of all eggs that hatch. Some plover studies also use number of eggs hatched per nest as a measure of hatching success (e.g., Barber et al. 2010). Also see reproductive success.

Nest fate: determination of outcome of a nesting attempt (e.g., eggs depredated, abandoned, nest covered by wind). See SOP 1: Field Methods for a list of possible nest fates.

Nest success: percentage of nests with at least one egg hatching. Also see reproductive success.

Reproductive success: reported in a variety of ways for comparison to other studies including (1) number and percentage of nests that hatch at least one egg from the total number of nests (nest success); (2) number and percentage of eggs that hatch from the total number of eggs (hatching success); (3) number and percent of chicks that fledge from the total number of eggs that hatched (fledging success); and (4) number of fledged chicks per breeding male (used by the USFWS in recovery criteria).

Survey area: specific beach section that is considered a census unit for determining site-specific breeding and population parameters. There are six different survey areas addressed in this monitoring protocol.

Background and Objectives

In 1992, the National Park Service (NPS) National Inventory and Monitoring Program (I&M) developed a national policy to “monitor park ecosystems to better understand their dynamic nature and condition”, to detect or predict changes that may require intervention, and to serve as reference points for more altered parts of the environment. By integrating this information into NPS planning, management and decision-making, scientific knowledge of natural resources will improve NPS stewardship of our heritage lands (NPS 75: Natural Resources Inventory and Monitoring Guideline [NPS 1992]).

In 1998, the NPS I&M Program created “networks” or groupings of parks in order to develop long-term monitoring plans for suites of parks with ecological similarities. The San Francisco Bay Area Network (SFAN) is one of eight inventory and monitoring networks in the Pacific West Region of the NPS and one of 32 across the country. The networks use common methodologies for data comparability, to reduce the level of effort, and to share resources.

Two SFAN park units, Golden Gate National Recreation Area (GOGA) and Point Reyes National Seashore (PORE), encompass resources utilized by western snowy plovers (*Charadrius alexandrinus nivosus*), a small, rare shorebird. This document describes the SFAN monitoring program for western snowy plover (snowy plover) breeding population that occurs on PORE beaches. A separate SFAN snowy plover monitoring program addresses the non-breeding season snowy plover population on GOGA beaches. Though snowy plovers also over winter on PORE beaches, the emphasis for this protocol is on the breeding season population.

Background

The western snowy plover is found along the Pacific coast from Washington to Baja California, portions of the interior western and southwestern United States, the Gulf coast of Texas, and interior portions of Mexico and is the only recognized snowy plover in the U.S. (Page et al. 2009). The populations of snowy plovers that nest along the Pacific coast of North America from southern Washington to Baja California were declared threatened by the U.S. Fish and Wildlife Service (USFWS) in March 1993 (USFWS 1993, 2007). The populations of snowy plovers that nest in interior California have been classified by the State of California as a bird species of special concern, but have no federal designation (Shuford et al. 2008). Both the federally threatened, Pacific coast population and the non-federally listed, interior nesting snowy plover population winter along the Pacific coast from southern Washington to Baja California (Page et al. 1986, 1995, 2009).

Snowy plovers (15–17 cm long, 34–58 g) are small shorebirds with pale gray-brown backs and white breasts and under parts, with a white hind-neck collar (Page et al. 2009). During the breeding season (mid-March to mid-September), male and females can be differentiated by their plumage characteristics.

The male snowy plover builds the nest, called a scrape, in open, unvegetated or sparsely vegetated, habitat that may have a sparse to moderate scattering of debris such as driftwood. The snowy plover has a serially polygamous, territorial mating system. Both female and male snowy plovers share

incubation but following hatching the female will desert the brood and male to begin another pairing and nesting, and the male broods the chicks (Page et al. 2009).

Snowy plovers usually feed above and below the high-water line, gathering invertebrate prey from above and below beach surface. Plovers also may be found feeding on flies in kelp, on beetles or flies on marine mammal carcasses, on insects in dry sand at the base of vegetation, or in other beach microhabitats. When actively foraging, snowy plovers will pause then run a short distance to peck at the ground using the run-stop-peck method of feeding.

Individual snowy plovers have been observed to range widely among multiple sites within and between breeding seasons. The closest, other breeding location to PORE is San Francisco Bay National Wildlife Refuge. To the south, Pacifica State Beach and the mouth of Pilarcitos Creek on Half Moon Bay have also been used by nesting plovers. In San Francisco, Ocean Beach or Crissy Field may provide nesting habitat, but nests have never been documented in these areas.

Issue being Addressed and Rationale for Monitoring Snowy Plovers

Snowy plover populations have declined over the last century (USFWS 2007). Along the California coast, breeding and wintering populations declined significantly from the late 1970's to 2000 (Page and Stenzel 1981, USFWS 1993, 2007). The reasons for decline and degree of threats vary by geographic area; however, the USFWS has identified the primary threat as habitat destruction and degradation (USFWS 1993, 2007). Habitat degradation is primarily caused by human disturbance, urban development, introduced beach grass, and expanding predator populations. In recent years breeding numbers have increased substantially due to habitat restoration and management, though many breeding sites in southern California have been lost (USFWS 2007).

The USFWS Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (Recovery Plan) sets a goal of 50 adult birds on Point Reyes Beach, ten on Limantour Spit, and four on Drake's Spit (64 snowy plovers total).

At PORE, the survival and reproductive success of this species is affected by human disturbance, habitat degradation due to introduced beach grass, and predation. Annual monitoring to determine the annual status and long term trends of snowy plover reproductive success on PORE beaches is necessary as is collecting information on the presence of predators during plover surveys and the snowy plover use of restored dune habitat. Agents of change such as adverse weather and storms, sea level rise, predator overabundance, and recreational use act through geomorphic change, increased levels of predation, and human and pet disturbance to influence reproductive success and population trends.

Snowy plovers are identified as important to monitor because they (1) come under the legal mandates related to the Endangered Species Act of 1973; (2) comprise part of the coastal dune ecosystem, which is identified in the PORE enabling legislation; (3) are indicators of the condition of the coastal dunes ecosystem and the only nesting shorebird in the coastal strand; and (4) have been monitored at PORE for nearly 30 years.

Legal Mandates

Several federal laws and executive orders provide legal direction and support for expending funds to determine the condition of snowy plover populations in parks:

- Coastal Zone Management Act (1972)
- Endangered Species Act (16 USCA 1531 et. seq., 1973, amended in 1982)
- Executive Order 11900 (Protection of Wetlands)
- Fish and Wildlife Act (16 USCA 742a et. seq., 1956)
- Fish and Wildlife Coordination Acts (16 USCA 661 et. seq., 1958, 1980)
- Natural Resource Protection Act (1990)
- Marine Protection, Research and Sanctuaries Act (33 USCA 1401 et. seq., 16 USCA 1431 and 1431 et. seq., 1972)

The National Parks Omnibus Act of 1998 includes congressional mandate for parks to provide information on the long-term trends in the condition of their natural resources. The Endangered Species Act (ESA: Public Law 93-205) mandates the protection of all threatened, endangered, or candidate species as well as their critical habitats within park boundaries. The Recovery Plan identifies the PORE population for restoration and monitoring.

In addition, under the Government Performance and Results Act of 1993, the NPS annually sets goals for maintaining populations of threatened and endangered species in stable or increasing status.

The USFWS Recovery Plan (2007) provides the framework for recovering this species.

"The primary objective of this recovery plan is to remove the Pacific coast population of the western snowy plover from the List of Endangered and Threatened Wildlife and Plants by: (1) increasing population numbers distributed across the range of the Pacific coast population of the western snowy plover; (2) conducting intensive ongoing management for the species and its habitat and developing mechanisms to ensure management in perpetuity; and (3) monitoring western snowy plover populations and threats to determine success of recovery actions and refine management actions (USFWS 2007)."

Enabling Legislation

PORE was authorized by Congress as a unit of the NPS in the Act of September 1962 (P.L. 87-657), and was officially established in October 1972 (P.L. 92-589). The statement of purpose for the park in this law calls for the preservation and protection of the diminishing seashore of the United States for "public recreation, benefit and inspiration."

The Wilderness Act of 1976 (P.L. 95-544) established 25,370 acres of wilderness and 8,003 acres of potential wilderness in PORE, thereby adding special protection. The Wilderness Act also amended PORE enabling legislation (P.L. 87-657) to include:

"...without impairment of natural values, in a manner which provides for such recreational, educational, historic preservation, interpretation, and scientific research

opportunities as are consistent with, based upon, and supportive of the maximum protection, restoration, and preservation of the natural environment within the area."

Indicator of Ecosystem Condition

At a regional scale, long-term studies can help interpret potential population responses to management strategies. Shorebirds are one of the key components of coastal strand communities, and the snowy plover is the only nesting shorebird in this significantly-degraded dune ecosystem. Originally planted primarily to stabilize blowing sand dunes, the introduction of non-native European beach grass (*Ammophila arenaria*) and iceplant (*Carpobrotus edulis*) have reduced the area available to native plants species. These non-native plant species colonize and stabilize large areas of sand dunes that typically would experience periodic openings from natural forces such as wind and waves. In particular, the European beach grass creates a steeper foredune which prevents snowy plovers from accessing the back dunes where invertebrate prey are located and where a mosaic of native plants provide shelter and camouflage from predators.

Other sensitive species live in the coastal beach-dune ecosystem such as beach layia (*Layia carnosa*), Tidestrom's lupine (*Lupinus tidestromii*), and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*) and have many threats in common with the plover. Snowy plover nesting has been an obvious indicator of dune restoration success at PORE with nests found in restored beach dunes near Abbott's Lagoon beginning in 2003 (Peterlein 2009).

Snowy plovers inhabit PORE beaches year round and in 2010 represented 1.3% of the snowy plovers recorded on the USFWS window breeding season counts of snowy plover seen on the U.S. Pacific coast (USFWS 2010a), and 4.1% of the number of snowy plovers seen on the USFWS window winter season counts on the U.S. Pacific coast (USFWS 2010b).

History of Monitoring Snowy Plovers at PORE

Snowy plovers were initially monitored at PORE in the 1970's by Point Reyes Bird Observatory Conservation Science (PRBO) and a similar current protocol to this one was used from 1986 to 1989, and again in 1995 when declines were significant across the species' range and in particular at PORE beaches. Managers at PORE in conjunction with PRBO plover biologists developed an adaptive management program (White and Allen 1999) structured to collect long-term population data and respond to shifts in distribution. Monitoring efforts have focused on the response of nesting birds to management actions enacted by the park. In 2008, PORE, with assistance from the SFAN I&M Program, took over full responsibility for monitoring plovers within the seashore boundaries, consulting with PRBO as needed. At PORE, the reproductive success of this species is affected by both human disturbance and natural factors, requiring close monitoring to determine the relative importance of each in any given year and over the long-term.

Past Abundance and Distribution of Breeding Snowy Plovers

Snowy plovers previously nested on Drake's Spit, Limantour Spit, and along the entire length of Point Reyes Beach (PRBO unpubl. data; see Figure 1 and SOP 1 for maps). Recently, however, breeding has been confined to Point Reyes Beach between the North Beach parking lot and Kehoe Creek.

Point Reyes Beach - Kehoe to Abbott's

Snowy plovers have consistently nested from Kehoe Creek to Abbott's Lagoon (survey area K in Figure 1), the northern most section of Point Reyes Beach. This area held from five to nine nests each year from 1986 to 1989, and four in 1995. In 1996, 1997, and 1999 breeding seasons, no nests were seen on this section of beach. In 1998 only two nests were found on Kehoe Beach; and from 2000 to 2009 there have been four or more nests found each year including 21 in 2004 (Table 1). Suitable snowy plover nesting habitat exists from Kehoe Creek to Abbott's Lagoon and this area could potentially hold nesting plovers in the future.

Point Reyes Beach - Abbott's to North Beach

The longest and least disturbed section of Point Reyes Beach is from Abbott's Lagoon to the North Beach parking lot (survey area NP in Figure 1). This has been a primary breeding area on Point Reyes Beach during all years of study since 1986 (Table 1).

Point Reyes Beach - North Beach to South Beach

The section of beach from North Beach parking lot to South Beach parking lot (survey area NB in Figure 1) is short and heavily used by park visitors. The number of nests located here ranged from one to seven per year from 1986 to 1989. In 1995, there were five nests in this section of beach, all of which were located just north of the South Beach parking lot. Waves at high tide washed up the beach in between the nesting area and parking lot, which may have limited pedestrian traffic in the nesting area (Hickey et al. 1995; PRBO, Catherine Hickey, Biologist, pers. comm.). Common ravens (*Corvus corax*) are known predators of snowy plover eggs (Page et al. 2009). In 1997 a pair of ravens nested on the bluffs backing this beach (White and Hickey 1997).

Point Reyes Beach – South Beach to Lighthouse

Snowy plovers nested from South Beach parking lot to Lighthouse Beach (survey area SB in Figure 1) from 1986 to 1989, with peak nesting in 1987 and 1988 (Table 1). No plovers nested on this section of beach from 1995 to 2010. The winter storms of 1994–1995 eroded this section of beach leaving a beach profile that is narrow and washed to the cliffs at high tide or clogged with debris left by storms (Hickey et al. 1995, White and Hickey 1997).

Drake's Spit and Limantour Spit

Typically, numbers breeding at Drake's Spit (survey area D in Figure 1) and Limantour Spit (survey area L in Figure 1) have been low as these spits are often inundated by high spring tides, leaving little suitable habitat for nesting plovers (Page and Stenzel 1981, Abbott 2002). In 1977, during the first statewide survey for breeding snowy plovers, one pair was located at Drake's Spit and five pairs were located at Limantour Spit (Page et al. 1977, Page and Stenzel 1981). From 1986 to 1989, at least one pair of breeding snowy plovers were seen at Drake's Spit and produced one to three nests each of those years (PRBO unpubl. data); no pairs or nests were found at Drake's Spit from 1995 to 2010 (Table 1). Limantour Spit had from zero to four breeding pairs per year from 1986 to 1989 and one to five breeding pairs from 1995 to 2000 (producing up to seven nests); no nests have been seen since 2000 (Table 1).

Table 1. Number of nests and estimated number of adult snowy plovers in Point Reyes National Seashore survey areas (by survey area, 1986–1989, and 1995–2010).

Year	Number of Nests by Survey Area ¹						Total Nests	Estimate of total adults
	K	NP	NB	SB	L	D		
1986	5	29	1	2	4	1	42	41–44
1987	9	48	6	11	1	1	76	50–54
1988	5	41	7	12	0	3	68	40–42
1989	6	42	7	6	0	2	63	34–37
1995	4	11	5	0	0	0	20	12
1996	0	8	0	0	1	0	9	10–11
1997	0	18	0	0	7	0	25	25
1998	2	10	0	0	2	0	14	16
1999	0	16	0	0	5	0	21	20
2000	10	15	0	0	3	0	28	31–37
2001	8	26	0	0	0	0	34	27–36
2002	6	24	0	0	0	0	30	34–37
2003	6	16	0	0	0	0	22	23–25
2004	21	16	0	0	0	0	37	34–36
2005	4	15	0	0	0	0	19	19–21
2006	11	13	0	0	0	0	24	30–32
2007	14	14	0	0	0	0	28	30–32
2008	11	10	0	0	0	0	21	23–24
2009	9	12	0	0	0	0	21	24*
2010	7	8	0	0	0	0	15	14*

¹ K = Kehoe Creek to Abbott's Lagoon; NP = Abbott's Lagoon to North Beach parking lot and includes Abbott's Lagoon; NB = North Beach parking lot to South Beach parking lot; SB = South Beach parking lot to Lighthouse Beach; L = Limantour Spit; D = Drake's Spit.

Levels of Past Reproductive Success

Reproductive success of snowy plovers at PORE was low during years of PRBO's study (1986–1989 and 1995–2007). The precipitous population decline from an estimated 40 to 54 breeding adults in the mid to late 1980s to only 10 to 12 adults in 1995 and 1996 was possibly the result of poor reproductive success, and more specifically, a low percentage of clutches hatching. The disparity between the number of adults and the numerous nest attempts from 1987 to 2010 (Table 1) is explained by the fact that pairs will re-nest many times after nest failure. The percent of clutches hatching dropped steadily from 29.0% in 1986 to 1.6% in 1989 (Hickey et al. 1995). The primary causes of clutch loss differ between Point Reyes Beach and Limantour Spit (Page et al. 1977). Clutch loss at Point Reyes Beach was attributed primarily to depredation by common ravens (Page et al. 1977, Hickey et al. 1995), while high tides were the main cause of nest loss on Limantour Spit (Page et al. 1977). The numbers of ravens seen are higher on Point Reyes Beach than on Limantour Spit possibly because Point Reyes Beach is backed by ranching operations while Limantour Spit is backed by wilderness area (NPS, Sarah Allen, Senior Science Advisor, pers. comm.). Both beef cattle and dairy cow operations provide additional food sources to corvids (e.g., common ravens) in

the form of grain sources, manure (and associated invertebrates), and calf birthing fluids (Engle and Young 1992, Roth et al. 1999, Kelly et al. 2002).

During 1999 breeding season surveys along roads in the San Francisco Bay area to determine regional abundance and distribution of common ravens and American crows, Kelly et al. (2002) found the highest density of common ravens were seen in Point Reyes National Seashore along a route dominated by ranching operations, which includes silage fields. This high density of ravens is also supported by 1950–1998 Audubon Christmas Bird Count data (Kelly et al. 2002).

History of Management Actions

In response to a reduction in snowy plover reproductive success, PORE has implemented a number of measures to increase snowy plover hatching success, increase available breeding and chick-rearing habitat, and decrease rates of disturbances from human recreation activities.

Response to Nest Predators

The use of predator exclosures around snowy plover nests was initiated in 1996 on all survey areas on Point Reyes Beach and Limantour Spit to raise the percentage of clutches hatching. PORE worked with PRBO to refine the exclosure design to maximize protection but minimize set up time and the amount and weight of materials. The 3-m × 3-m fenced exclosures consists of 1.5-m tall fencing with 5-cm × 10-cm openings to allow entrance and departure of plovers while keeping out mammalian predators; 10-cm × 10-cm opening crow-mesh netting are used on top to prevent access by avian predators.

These exclosures have been effective at keeping predators away from nests. The percentage of clutches hatching has increased from an average of 14.9% prior to exclosure use (1986–1989) to 69.2% (1996–2008); however the average estimated breeding population size decreased from 41.25 plovers between 1986 and 1989 to 24.8 plovers between 1996 and 2008 (Peterlein 2009).

In 2002, PORE and PRBO began a more focused examination of plover predators that included night surveys and surveys of raptor nesting habitat in the coastal scrub, eucalyptus, and cypress forests near the beach. In 2007 and 2008, predator surveys continued during plover census surveys but not at the same level of effort as 2002–2006. The average number of ravens seen per survey and percentage of surveys with ravens was not different between the two time periods (Peterlein 2009). In 2005 and 2006, the park contacted ranch managers of ranches that backed plover breeding beaches and requested vigilance in the expeditious removal of cow and calf carcasses and encouraged covered feeding stations to reduce raven access to food sources (NPS, D. Adams, PORE Biologist, pers. comm.).

In the last 5–10 years, the use of exclosures has been re-examined for both the snowy plover and the federally endangered piping plover (*Charadrius melodus*). The authors of a review of exclosure use in a Canadian national park population of piping plovers over 22 years found that while exclosures increased the number of successful nests and number of hatched eggs per nest (a measure of hatching success), significantly more exclosed than nonexclosed nests were abandoned by adults, and the exclosed nests had significantly greater adult mortality (Barber et al. 2010). Similar findings were

seen by Neuman et al. (2004) in a review of snowy plover predator management in Monterey Bay and by Hardy and Colwell (2008) in a review of seven years of exclosure use in a Humboldt County, California snowy plover population monitoring program. None of the three studies had equal sample sizes within years or random assignment of exclosures to nests that would control for other confounding factors like time of season, but the authors do suggest that use of exclosures may artificially increase the hatching success at the cost of increased adult mortality and/or nest abandonment. All three of the monitoring programs have either discontinued the use of exclosures or greatly restricted the conditions of exclosure use that depends on the habitat conditions and predator risks. Because of the known high population of common ravens on PORE snowy plover beaches, the use of exclosures to protect snowy plover nests will continue but managers may reconsider the conditions under which exclosures will be used.

Habitat Restoration

In 2001, PORE began a three-year dune restoration project focused on removing non-native European beach grass and iceplant from areas on North Beach, in particular near Abbott's Lagoon. The area was selected because of adjacent snowy plover breeding habitat and the remnant rare plant populations interspersed in the area. Additional restoration funding from the SS *Cape Mohican* oil spill allowed new restoration and follow up work to be continued through 2005. In 2003, the park found two plover nests in areas of non-native beach grass removal (Peterlein and Roth 2003). From 2006 to 2008 there were four nests each year in the restored areas (Peterlein 2009) and in 2009 only one nest was initiated in the treated area and none in 2010 (Hughey 2011). The monitoring data from the 2004 to 2007 breeding seasons indicate that the removal of beach grass had a positive effect on the raising of plover chicks but in 2008 the chick fledging success of 16.7% (percentage of hatched eggs that fledged) was the lowest overall recorded fledging success percentage and no chicks were fledged from the restored areas (Peterlein 2009). In spring and summer 2011, the Abbott's Lagoon Coastal Dune Restoration Project removed 80 acres of non-native European beach grass and iceplant within an approximately 190-acre project area. This restoration has the potential to greatly increase the coastal dune area available for snowy plover nesting, feeding, and chick rearing activities.

Visitor Education

Regular breeding season monitoring and a research study done by PRBO during the 1999 and 2000 snowy plover breeding seasons suggested that an unusually high number of plover chicks disappeared on holiday and weekend days versus weekdays (Ruhlen and White 1999, Ruhlen and Abbott 2000, Ruhlen et al. 2003). In acknowledgement of the possibility of higher weekend disturbance rates, PORE created a seasonal park guide position with the goal to reduce human disturbance to snowy plovers during the nesting season through the presence of a uniformed interpretive rangers and volunteer docents on the beaches. The park guide assists with plover monitoring and coordinates a docent program to provide visitor education and information on snowy plover breeding beaches on weekends and holidays. The docents post signs, create safety exclosures, and make contact with visitors.

Pollution

In 2000 and 2001, an unusually high number of nests, six and ten respectively, failed to hatch or were abandoned by females prior to the hatch date. Eggs were collected from inside the exclosures and

tested for mercury by the California Department of Fish and Game Moss Landing Marine Laboratory. Concentrations of mercury in the 2000–2001 PORE snowy plover eggs were five to ten times higher than mercury concentrations in eggs collected from plovers nesting at five Southern California locations (Schwarzbach et al. 2005).

In 2006, researchers from the USGS Western Ecological Research Center conducted a two-year mercury study. The study objectives were to: (1) determine pathways of elevated levels of mercury to snowy plovers through investigation of common prey items using stable isotope analyses to determine contribution of marine mammal carcasses versus kelp wrack to prey of snowy plovers; (2) continued monitoring of mercury in addled or abandoned snowy plover eggs and feathers collected since 2002; and (3) recommend actions to possibly reduce mercury concentrations in snowy plovers. Beach invertebrates were collected at sites along the California coastline and from beached pinniped carcasses at PORE opportunistically. Unhatched snowy plover eggs were collected from nesting areas at Point Mugu (near Ventura, CA), South San Francisco salt ponds, and PORE.

The USGS researchers concluded that the mercury concentrations in the PORE beach food web were highly variable both spatially and temporally but overall the mercury concentrations in beach food webs were higher in northern California than southern California survey areas (Miles et al. 2010). The researchers also found high levels of mercury in invertebrates associated with pinniped carcasses at PORE, but did not find direct links between invertebrate mercury levels and mercury concentrations in plovers. The authors recommend continuing to remove or bury pinniped carcasses in plover nesting areas as a precaution since mercury concentrations in PORE snowy plover eggs approached toxicity thresholds and could have deleterious effects on reproduction in this threatened population (Miles et al. 2010).

There have been several major oil spills in the San Francisco Bay Area over the last two decades and snowy plovers have been a primary species of interest during events because they are subject to oiling as they forage along the wrack line where oil is deposited. For restoration planning, they are one of the species of focus for Natural Resource Damage Assessments (e.g., *SS Cape Mohican* Trustee Council 2002, *Luckenbach* Trustee Council 2006).

Monitoring Questions

Monitoring questions identified:

1. What is the snowy plover population size at PORE, during the breeding season, with respect to the state and Pacific Coast population?
2. What are the short-term (<5 years) and long-term trends (5–15 years) for the population size?
3. Does the rate of snowy plover use of breeding areas change annually?
4. What are the annual reproductive success rates (e.g., number of fledged chicks per breeding male) for the population and in each survey area?

Monitoring Objectives

The overall objective of the snowy plover monitoring program is to determine trends in the estimated breeding population size, abundance and distribution of nests (number of nests per survey area,

maximum number of nests), and reproductive success (percentage of nests with at least one egg that hatched, percentage of eggs that hatched, percentage of chicks that fledged, number of fledged chicks per male) of snowy plovers at PORE during the breeding season.

Management Objectives

The regional, measureable recovery criteria identified in the Recovery Plan (USFWS 2007) is an average annual productivity of at least one (1.0) fledged chick per male in each recovery unit maintained in the last 5 years prior to delisting and 400 breeding adults Sonoma to Monterey counties (which includes PORE). Specifically, the target for breeding adults at PORE is 32 breeding pairs. The expectation exists that site-specific threats would also be monitored. Attaining the target of 32 breeding pairs at PORE would not change the continued need to monitor but would trigger a review of the monitoring protocol. In addition, USFWS expects that some mechanism will be implemented to assure long-term protection and management of breeding, wintering, and migration areas to maintain the subpopulation sizes and average productivity, which would also require some level of monitoring. These actions can include the creation and implementation of federal land management plans and public outreach and education.

Trigger for Management Activities

Triggers for management include direct response to disturbances to snowy plovers during breeding season. Surveyors and docents may take immediate action by notifying law enforcement rangers upon witnessing events such as humans (including dogs) entering signed, closed snowy plover habitat breeding areas, vandalizing exclosures or habitat fencing, or conducting prohibited activities such as paragliding in or around snowy plover breeding habitat. Triggers for management may also be cumulative in nature; for instance, recurrent trampling of nests by known or unknown forces would trigger a review of the management efforts and possibly increase enforcement efforts.

Additional management activities will also be considered if monitoring detects a significant declining trend in the annual average breeding season snowy plover population size since 2000 or if there is a 50% decline in the annual breeding population size at PORE compared with any of the previous five years of monitoring. The types of management activities considered will depend on the suspected cause of the documented decline. Possible actions may include extending beach closures or increasing enforcement of beach closures, and enhancing the outreach and education component on the beach. If declines are strongly linked with predators, control measures will be considered. If causes for declines are not known, additional research may be required to determine causal relationships.

Identifying or providing examples of specific management actions that may be employed under different scenarios is beyond the scope of this monitoring protocol. In some cases, causes of declines in the PORE snowy plover population, such as a new resident pair of falcons using the snowy plover nesting beaches or loss of nests due to storm events, may be easy to identify. If causes of population declines can be determined, managers may be able to act accordingly in a timely manner. In other cases, however, additional, specific research may be required. A snowy plover population trend analysis is underway in 2014. Depending on the management action(s), a procedural process under the National Environmental Policy Act may be instigated, requiring significant public input.

Consultation with USFWS and other regulatory agencies may also be required especially when there are any catastrophic declines in habitat or mortality events.

Research Questions

Although not part of the monitoring plan, PORE has identified research questions to be addressed in the future. Data from monitoring may be used in part to help address them as park or outside funding becomes available.

1. What are the population trends of snowy plover predators?
2. What are the effects of predators on snowy plover eggs, chicks, and adults? Are there sub-lethal, behavioral changes to snowy plover breeding activities that are induced by increased predator populations?
3. What are the pollutant loads in plover eggs, chicks and adults?
4. Has the available beach habitat at PORE changed in quantity and/or quality?
5. What is the effect of human disturbance from recreation?

Sampling Design

Rationale for Selecting this Sampling Design over Others

The breeding population of snowy plovers is so small that a census of the whole breeding population is feasible. The only stratification in the survey design is based on recent (within the last five years) breeding activity on beaches.

Compared to a sampling scheme, a census is more commonly used to survey for snowy plovers and other rare shorebirds on beaches or in other areas with good visibility. The USFWS Breeding and Winter Season Window Surveys use the census technique to survey for snowy plovers (USFWS 2007). Window surveys are short-term snapshots in time of the size of a range-wide population of animals and used as an index of population size. Lafferty (2001a, b) used census techniques in his studies of snowy plovers and other shorebirds on a beach in Santa Barbara, California.

Survey Area Selection

Every known, historic snowy plover breeding beach within PORE is surveyed for breeding adults. There are six survey areas: four on Point Reyes Beach, one on Limantour Beach, and one on Drake's Beach (Figure 1).

1. K = Kehoe Creek to northwest shore of Abbott's Lagoon on Point Reyes Beach
2. NP = Southwest shore of Abbott's Lagoon to North Beach parking lot on Point Reyes Beach
3. NB = North Beach parking lot to South Beach parking lot on Point Reyes Beach
4. SB = South Beach parking lot to Lighthouse Beach on Point Reyes Beach
5. L = Limantour Spit refers to the beach from the Limantour beach trailhead west to the end of the spit at the mouth of Drake's Estero, which has not been used by snowy plovers during breeding season since 2001, but continues to be surveyed monthly during the breeding season.
6. D = Drake's Spit, refers to the beach spit to the west side of the mouth to Drake's Estero, which has not had active snowy plover breeding activity since 1989 but also continues to be surveyed monthly during the breeding season.

Population being Monitored

The breeding population of snowy plovers on PORE beaches is the monitoring population.

Parameters Sampled

During the breeding season, surveyors record parameters of the snowy plover nesting population to assess the breeding population status. Ultimately, data from the monitoring program is used to determine how many chicks fledge per male, and the causes of variation of this parameter. The specific information recorded includes number of adults, sex, nest occurrence and location, nest fate, number of chicks, and chick fate.

In addition to counting snowy plovers, known sources of disturbance to the plovers are also counted during a snowy plover census survey or nest check. These include people, dogs, equestrians, vehicles, and aircraft. Other shorebird species seen during a plover survey are tallied as are the number of predators (e.g., corvids, hawks, and falcons).

Sampling Frequency and Replication

Annual monitoring will occur during the snowy plover breeding season. Surveys begin March 15 and continue into September, if late season broods have not yet fledged. If nests are already found on March 15, monitoring may need to be moved earlier in future years.

Previously used snowy plover breeding areas within PORE (NB, SB, and D) are surveyed at least twice during the breeding season. Limantour Spit (L) is surveyed twice a month since it has a more recent record of active nesting in 2000. All recently active breeding areas (i.e., NP, K) are surveyed a minimum of two times per week from the beginning of the annual monitoring period through the end of fledging. Additional nest-specific surveys are done two to four times per week. Given the high frequency of surveying that is done during the breeding season on PORE beaches with active breeding activity it is possible to estimate the number of adults close to the real population size.

Other Monitoring Programs

The Gulf of the Farallones National Marine Sanctuary Beach Watch program is conducted on coastal beaches within PORE, including all six snowy plover survey areas. These beaches are surveyed twice per month by trained volunteer observers for all live and dead animals. PORE receives annual reports from the Beach Watch program.

PORE observers also participate in the USFWS Breeding Season Window Survey. The purpose of the survey is to obtain an annual, range-wide minimum estimate of breeding plovers at current, historic, and potential breeding sites within the US. Surveys are conducted during non-migratory periods and over a narrow time frame to minimize the chance of recounting birds moving between sites. Since all plovers are not detected on a single survey, window surveys do not represent a total count, but give an index of population size. Data are collected using standard methods established in the Recovery Plan (USFWS 2007). Data are submitted to the USFWS, and the USFWS is responsible for data management and analysis. Copies of the USFWS protocol for window surveys are available on file on the SFAN I&M Program network drive at GOGA (X:\Individual Vital Signs\SnowyPlover\Literature\Window Surveys). USFWS window survey results are available online (USFWS 2010a, b). The USFWS Winter Window Survey is conducted mid-winter using similar methods to the breeding season window survey. PRBO biologists generally conduct this survey on all Point Reyes beaches.

There are no other SFAN vital signs monitoring programs that are co-located with the snowy plover monitoring protocol.

Field Methods

Field work is conducted during the breeding season (March 15 – September). This section provides a general overview of field methods. Details are provided in SOP 1: Field Methods.

Pre-season Preparations

If the biological technician selected for the monitoring program has no previous snowy plover monitoring experience, he/she will need to train with experienced snowy plover monitors prior to working alone at PORE to accomplish the necessary training as required by the USFWS Section 10 permit. Training with the PORE wildlife biologist, collaborative training with PRBO biologists at their Monterey Bay monitoring sites, or contracting for direct training by other experienced plover biologists in the San Francisco Bay Area will be necessary and should be coordinated by the PORE wildlife biologist. See details in Qualifications and Training section and in SOP 1: Field Methods.

Prior to the start of the March 15 surveys, all gear to support protection measures is prepared for delivery to Point Reyes Beach; gear includes fiberglass posts and rope for symbolic fencing, wire fencing for exclosures, and all signage necessary for the season. Gear should be inspected for defects and repaired or replaced as needed and be ready for deployment no later than March 15. Gear is delivered to the beach with the use of an ATV and trailer and is distributed along the beach according to predicted nesting areas. At least two sets of exclosures are kept in storage and not delivered to Point Reyes Beach in case nests are found in other survey areas. Details are provided in SOP 1: Field Methods and a list of supplies and equipment is in SOP 1A.

Satellite databases are created at the beginning of each monitoring season that parallel the structure of the master database. The SFAN data manager prepares the database and provides it to the PORE field staff.

Field Methods

During census surveys, observers walk just below the high tide line, crossing above the line only when necessary to see the full width of the beach. Observers stop every 50–100 m (164–328 ft) to scan with binoculars at least 100 m (328 ft) ahead for plovers. When a plover(s) is located, observers approach as close as 10 m to determine age, sex, and color band combination if bands are present. Observers record date, location (by sub-area, pre-determined landmarks, and/or GPS coordinates) and the time of sighting. Observers then walk around the bird(s) to prevent flushing.

Nests are located using three methods: (1) systematically searching microhabitats in which plovers are likely to nest; (2) watching potential breeding adults from a concealed position; and (3) following plover footprints in fine sand. Once a nest is located, it is immediately exclosed with a 3-m × 3-m square fence. The UTM coordinates are obtained for each nest using GPS units.

Nests are checked two to four times per week to verify if they are still active. If a nest is not active during a particular visit, then cause of loss is determined using the criteria outlined in SOP 1. If a nest is abandoned by the adult plovers or has failed to hatch in over 35 days, the plover biologist will collect the unhatched eggs. The eggs are stored in a freezer at PORE with the collection information

until they can be transferred to an appropriate facility for methyl mercury and/or fertility testing conducted by USGS and not addressed by this protocol (Miles et al. 2010).

Near the nest's projected hatching date, checks are made more frequently to determine the precise hatch day. Adults and chicks are looked for on follow up visits; once found the number of chicks and location are recorded. If chicks are determined to be lost, then the criteria outlines in SOP 1 are used to determine timing and cause of loss. The chicks are monitored until 28 days after hatching, when they are considered fledged. This has been possible because of the low number of nests in the study area.

Observers use data sheets and field notebooks to record plover nest data and observations (see SOP 1 and appendices for details). Data are recorded on standard field data sheets. Space on the data sheet is provided to allow drawing maps of nest locations in addition to entering GPS location data. A field notebook is used to provide space for additional notes on field conditions or special occurrences. Details on recording data are discussed in SOP 1: Field Methods. This data is then transferred to permanent electronic storage units described later.

Ancillary Data

In addition to monitoring the snowy plover breeding populations size and reproductive success, collection of presence/absence and abundance information of the number of human, pet dogs (leashed and unleashed), and potential snowy plover predators is important to park managers. The observers conduct these surveys along snowy plover breeding beaches during census surveys and nest check surveys. SOP 1 has additional details on predator identification and enumeration. It is recognized that because these data are not currently collected with systematic, standardized sample efforts, the relationship between ancillary data collected on predator populations and plover population trends cannot be determined with statistical estimates of certainty. Results from an ongoing diurnal predator abundance pilot study will be used to revise predator survey methods, data collection, and correlation analyses. New methods and analyses will be incorporated into a future protocol revision.

Because of their regular field presence, observers may also provide recommendations to park managers for additions or changes to the standard pre-season nest and egg protection measures (e.g., habitat fencing, exclosures) used during the breeding season.

Special Field Considerations

Adverse weather conditions that would prevent a survey include winds that blow sand above knee level, precipitation greater than a mist, or visibility less than 50 m (164 ft). If inclement weather occurs observers must wait until conditions clear, or if these conditions arise during a survey, the observers must determine whether they can obtain a reasonable survey. If a census is ended before all ground is covered, a new census must be conducted at a safer time or day.

The number of nests and chicks has been few enough to track chicks through fledging without the need for banding. If the breeding population increases or adult survival monitoring is initiated, banding may be warranted to identify chicks and determine annual survival. When encountering

snowy plovers with colored leg bands, surveyors document the sequence and report to Lynne Stenzel with PRBO Conservation Science (see Appendix C for a description of color bands). PRBO maintains range-wide banded snowy plover records. Leg bands are recorded top to bottom on the left leg, then the right leg. Reading bands can be challenging, so observers should not risk disturbing plovers to deliberately read color bands.

Field Season Closeout

At the end of the field season, signs and all fencing equipment should be removed from the beach and inspected. If new supplies and equipment are needed before the next field season, purchases should be coordinated with the PORE wildlife biologist. Equipment including spotting scope, tripod, binoculars, GPS units, etc., is cleaned and stored at the Resource Management Office. All signs, exclosure tops, and fencing rope should be stored in the garage next to the Resources Building at Bear Valley Headquarters; exclosure fencing and poles are stored at D Ranch and labeled as the snowy plover equipment.

Any remaining data are entered, verified, and archived as described in SOP 4: Database Management. An annual report is written and circulated as described in SOP 5: Data Analysis and Reporting. Photos and project highlights are submitted to the PORE wildlife biologist and SFAN program manager for the PORE and SFAN annual reports.

Data Management

This section briefly describes the data management model and procedures for the PORE plover monitoring program. SOP 4: Data Management describes in more detail how the snowy plover monitoring protocol meets data management objectives through data entry specifications, database design, quality assurance and control measures, metadata development, data maintenance, data storage and archiving, and data distribution.

Database Design

The SFAN staff has developed a relational Microsoft (MS) Access XP database for the PORE snowy plover monitoring program that is compliant with the Natural Resource Database Template (NRDT) Version 3.2, an application developed by the NPS I&M Program.

The plover database is organized by survey events of defined beach segments where plovers nest or have the potential to nest during the breeding season. The primary plover monitoring events table, `tbl_Events`, contains fields for the locations of snowy plovers observed, banded snowy plovers, nest check information, and the list of field staff present on the survey via an `Event_ID` Globally Unique Identifier (GUID).

Beach survey locations are stored in the locations table, `tbl_Locations`. The `Location_ID` value in `tbl_Events` links the user to the parent location record in `tbl_Locations`.

During the course of the season, nest summary records are documented in the master nest table, `tbl_Nest_Master`. Data entry fields include nest location UTM coordinates, estimated establishment and hatching dates, number of eggs, hatchlings, and fledglings.

This monitoring program has been conducted through a cooperative agreement with PRBO from 1995 to 2006, and in 2007, the NPS assumed the lead role in field monitoring and data collection. Prior to 2006, field data was managed by PRBO with annual data summaries and reports provided to PORE. The current database was built to host a variety of additional data fields (i.e., egg collection variables, additional disturbance fields) for concurrent snowy plover research studies that have occurred in the past and which may occur in the future but which are not part of this monitoring protocol.

Use of the database is facilitated by a complete user interface adopted from the NRDT Front-End Application Builder Version 1.0. The user interface is designed to aid with data entry, data maintenance, and database documentation. Command buttons and code-driven text boxes are used to navigate to forms, add data records, and locate and edit data records. Where possible, default values are set and combo boxes with fixed values are used to reduce data entry errors.

Annual Data Work Flow

Rather than entering plover monitoring data directly into the master database, satellite databases are created at the beginning of each monitoring season that parallel the structure of the master database. The SFAN data manager prepares the database and provides it to the PORE field staff.

At the end of each season, the field staff is responsible for proofing the data entry records in the satellite database against field notes and paper datasheets completed during the surveys. When complete, the satellite databases are sent or provided to the SFAN data manager for additional review and certification. A subset of randomly selected records (10%) is reviewed after initial verification by the SFAN data manager. If significant errors are found, the entire data set is verified again by the project field staff.

Once verification procedures are complete, additional validation procedures are implemented by the data manager. Validation procedures include identifying outliers and logic errors, and reviewing the database and data records for completeness and consistency. The data manager works with the project lead and the field staff to complete any final edits or additions to the seasonal dataset. Following annual data certification, the data manager imports the satellite data into the master database, appends the data to the appropriate tables, and archives the satellite database on the I&M directory on the GOGA server.

Quality Assurance and Quality Control

The success of the snowy plover monitoring program is dependent on the quality of the data it collects, manages, and disseminates. Analyses performed to detect ecological trends or patterns require data that are recorded properly and have acceptable precision, accuracy, and minimal bias. Poor-quality data can limit detection of subtle changes in ecosystem patterns and processes, can lead to incorrect interpretations and conclusions, and can greatly compromise the credibility of the program managing it.

Quality assurance (QA) can be defined as an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the consumer. Quality control (QC) is a system of technical activities that measure the attributes and performance of a process, item, or service relative to defined standards (Palmer 2003). While QA procedures maintain quality throughout all stages of data development, QC procedures monitor or evaluate the resulting data products.

To ensure that the snowy plover monitoring program produces and maintains data of the highest possible quality, QA/QC procedures are implemented to identify and minimize errors at each project stage associated with the data life cycle. SOP 4: Data Management outlines specific QA/QC guidelines and procedures to be followed during data entry, data collection, data verification, and data validation.

Version Control Guidelines and Database History

Version control guidelines for the plover monitoring databases follow those presented in the SFAN Data Management Plan (Press 2005). Prior to any major changes to the database design, a back-up copy of the database is made. Once the database design changes are complete, the database is assigned the next incremental version number. The final copy of the previous database version is archived with the version closing date incorporated into the database title. Version numbers increase incrementally by hundredths (e.g., version 1_01, version 1_02, etc.) for minor changes. Major

revisions are designated with the next whole number (e.g., version 2_0, 3_0, 4_0, etc.). Significant database re-design may require approval by the project lead, review by other data management staff, and revisions to the data management SOP. The database version number is included in the file title of the database, for example, SNPL_PORE_Master_v1_00.

The data manager maintains an additional history log of the snowy plover monitoring databases in a MS Word document titled SNPL_PORE_Database_Log.

All design modifications to the databases are tracked within the history logs and are referenced to changes in database version numbers. Design modifications include changes to the table structure, user interface, or underlying macros and Visual Basic code. Major changes to the data themselves are also noted in this document, such as when a new set of annual data are uploaded. It is especially important to note edits to the data that will result in changes to final data summaries previously published in annual reports or other media. This will prove invaluable to data users attempting to understand differences in data between years.

Metadata Procedures

All NPS GIS data layers are required by the NPS GIS Committee to be described with the NPS Metadata Profile, which combines the Federal Geographic Data Center (FGDC) standard, elements of the ESRI metadata profile, the Biological Data Profile, and NPS-specific elements. Although no standard has been applied to natural resource databases and spreadsheets, the NPS Metadata Profile will be completed to the greatest extent possible to document the master snowy plover monitoring database. Because the annual datasets are uploaded into the master databases without alteration, separate metadata records will not be created for each satellite database.

Complete metadata records for the snowy plover monitoring database will be generated in compliance with current NPS standards by the SFAN data manager. Because the location data for this project is stored as UTM coordinates within the MS Access databases, there are no spatial data products associated with this protocol that require metadata records.

When completed, the metadata records, but not the data, will be posted to the NPS Natural Resource Information Portal (NRInfo) for public viewing. Contact information within the metadata records will direct interested parties to the SFAN data manager for further inquiries. Master database metadata records posted to NRInfo will be updated annually after the annual data has been uploaded or following database revision to a new version whole number (i.e., v1_3 to v2_0, but not v2_0 to v2_1).

Data Distribution

For the staff of the snowy plover monitoring program to inform park management and to share its information with other organizations and the general public, guidance documents, reports, and data must be easily discoverable and obtainable. The main mechanism for distribution of the snowy plover monitoring documents and data will be the Internet. The snowy plover monitoring protocol, accompanying SOPs, and all annual reports will be made available for download at the SFAN website: <http://science.nature.nps.gov/im/units/sfan/>. NRInfo records will be created for all of the

snowy plover monitoring documents, including the protocol, annual reports, and any resulting publications.

Although the monitoring database will not be posted for public download, as previously mentioned, metadata records for the master databases will be maintained at NRInfo. The metadata records will direct interested parties to the SFAN Data Manager.

Analysis and Reports

Reporting Schedule and Formats

Reporting results is a critical component of long-term vital signs monitoring in order to ensure that information generated through the program is available to all levels of park management including planning, interpretation, maintenance, and law enforcement. Details for analytical methods and reporting products and requirements are presented in SOP 5: Data Analyses and Reporting, but they are summarized in this section (Table 2).

Seasonal Updates

Short updates on plover progress are created monthly during the summer months by the seasonal snowy plover staff and shared with all park staff. See the PORE website (http://www.nps.gov/pore/naturescience/birds_snowyplover_updates.htm) for examples.

Annual Reports

The annual reporting for the plover breeding season monitoring program is done at the end of each field season. The report follows the template of the NPS Natural Resource Technical Report Series (NRTR). Updated information on this series is available online (<http://www.nature.nps.gov/publications/nrpm>). The document includes general sections including introduction, study area, methods, results, discussion, and management recommendations. The annual report enables readers to determine if the goals of the project are being met and provides an administrative and scientific record of monitoring activities.

Final copies of peer-reviewed annual reports are archived in the SFAN library on the GOGA I&M Server and are uploaded into the NPS Integrated Resource Management Applications portal (<http://irma.nps.gov>), an internet clearinghouse for documents, data and metadata on natural and cultural resources in parks. Annual reports are distributed to the USFWS snowy plover regional recovery coordinator (G. Page, PRBO) and SFAN parks. The report information is used in annual USFWS threatened and endangered species permit reports and in annual park reports.

Results presented in the annual report includes tables showing the estimated number of adult snowy plovers based on minimum population estimate criteria (Table 1, see SOP 5 for more information), the number of nests (season total), reproductive success (number and percentage of nests with at least one egg hatching; number and percentage of eggs that hatch; percentage of chicks that fledge; and the number of chicks that fledge per breeding male). Also summarized in table format are raven occurrence rates and possible or known reasons for nest failures.

The annual report includes a map of the nest locations, identifies the type and extent of plover use of any dune restoration areas, and notes any unusual events (e.g., vandalism of equipment, regular incidences of disturbances). Specific report figures, document details, and additional data tables are provided in SOP 5: Data Analysis and Reporting. Also see recent annual reports (Peterlein 2009, Hughey 2011).

A key component of the annual report is describing events during the season that may inform interpretation of data when long-term trend reports are generated. A summary of predator observations and any predator management activities that occurred during the breeding season is included in the annual report. This aspect is critical since the person collecting the data may or may not be the same person developing the trend reports (see next section).

An annual report on color bands seen during monitoring activities is submitted to PRBO (see SOP 5 for details).

Table 2. Summary of reporting and communication products.

Communication Product	Lead	Audience	Schedule	Purpose
Annual Report	Biological technician / PORE wildlife biologist	Park resource managers	Annually	Archive data and document monitoring activities; describe current condition of the resources; document changes in the monitoring protocol; increase communication within the park and network; satisfy requirements of the USFWS permit
Analysis and Synthesis Report	PORE wildlife biologist / network program manager	Park resource managers	5 years	Determine trends as stated in the monitoring objectives; provide context, interpret data for the park within a multi-park, regional, or national context; recommend changes to management practices
Program and Protocol Reviews	PORE wildlife biologist, network program manager	Park resource managers	5 years	Periodic formal reviews of operations and results; review of protocol design and product to determine if changes are needed; assist in the quality assurance – peer review process
Project Briefing	Biological technician / PORE wildlife biologist	Program managers, superintendents, interpretation staff	Updated annually (upon completion of annual report)	Two-page summary that lists monitoring objectives and questions, discusses annual results, and provides a regional context
Web Site Internet	Biological technician	Park staff, general public	Annually or as needed	Post all project briefings and report cards
Seasonal Updates	Park guide/biological technician	Park staff, public	Monthly during season	Brief updates on the current status of plover breeding for visitors and park staff
Park Presentations	Biological technician / PORE wildlife biologist	Park staff	Annually	Provide a presentation to park management staff, all employee, or division meetings upon request; gives staff an opportunity to ask questions about the program
Quarterly IM Update	Biological technician	Park staff	Quarterly	One-page e-mail that provides park staff with a short update on vital signs projects; text should be no more than one paragraph
Photos	Biological technician	For all reports and publication	Continuous	High-quality photos are used for all communication products (300 ppi in plain or compressed TIF format); photo document ongoing work, special incidents, and site visits for communication product purposes

Long-term Trend Reports

A comprehensive data analysis and synthesis will be written periodically (e.g., every five years) to summarize general trends within a context of the park ecosystem. Having this extra time allows for more thorough data analysis and review of protocols and may give additional opportunity for adaptive management or protocol revision (e.g., changing monitoring intervals and timing, moving/adding survey areas, etc.). The reports summarize data collected over multiple years as presented above and will provide additional interpretation of results to evaluate trends, makes multi-year comparisons, and discuss regional context of snowy plover conservation. Although trend reports as described here have not yet been developed, the following published reports provide examples of how data collected at PORE have been interpreted within a broader context: Schwarzbach et al. 2005, Ruhlen et al. 2003, Abbott 2002, Page et al. 1995, and Page and Stenzel 1981. For more information about analyses, see SOP 5: Data Analysis and Reporting.

Final copies of peer-reviewed long-term trend reports will be archived in the SFAN Library on the GOGA I&M Server and uploaded into the NPS Integrated Resource Management Applications portal (<http://irma.nps.gov>). Long-term trend reports will be distributed to the USFWS snowy plover regional recovery coordinator (G. Page, PRBO) and included in annual USFWS threatened and endangered species permit reports.

Data Summary

As part of the long-term trend reports, the following data will be summarized

1. Abundance Trends: trends in the number of snowy plovers nesting at PORE; trends in the results of USFWS breeding season window surveys at PORE and range-wide
2. Nest Trends: trends in the annual number of snowy plover nests at PORE,
3. Productivity Trends: trends in reproductive success (percentage of nests with at least one egg hatching, percentage of eggs that hatch; percentage of hatched chicks that fledge; number of fledged chicks per breeding male [Figure 2])
4. Nest Failures: summary of observed causes of nest failure

Abundance and Nest Trends

Abundance of plovers and nests: In general, trends will be evaluated by analyzing graphical representations of the data. Graphs will be helpful in evaluating additional parameters to explain why particular years have higher numbers than others. When possible, other regional data sets will be included to provide additional context for viewing changes in snowy plover breeding success measures (Figure 2). Larger-scale stressors such as seasonal weather patterns and events are a common variable affecting breeding success across the snowy plover breeding range.

Without individual identification of snowy plovers, achieving an exact count of male snowy plovers throughout the breeding season is impossible so this protocol relies on estimating a range of possible male population sizes for use in the reproductive measure of number of fledged chicks per breeding male as recommended in the Recovery Plan (USFWS 2007). Using the lower estimate of the annual number of males gives a higher rate of chicks fledged per male but both estimates represent the trend in productivity (Figure 2).

In addition, the Mann-Kendall Trend Test (M-K Test; See Appendix SOP 5A) measures the correlation between rankings (year and number of plovers or nests) to test that there is no statistically significant trend in those rankings (University of Idaho, K. Steinhorst, Professor, pers. comm.). While trends can be rejected or not rejected, failing to reject does not prove that there was no trend. The M-K Test can be run using common statistical software (i.e., SAS, R).

Page's trend test is used for multiple comparisons between ordered correlated variables (Page 1963). In this case it will tell is if there is a trend (upward or downward) for the two series (K and NP).

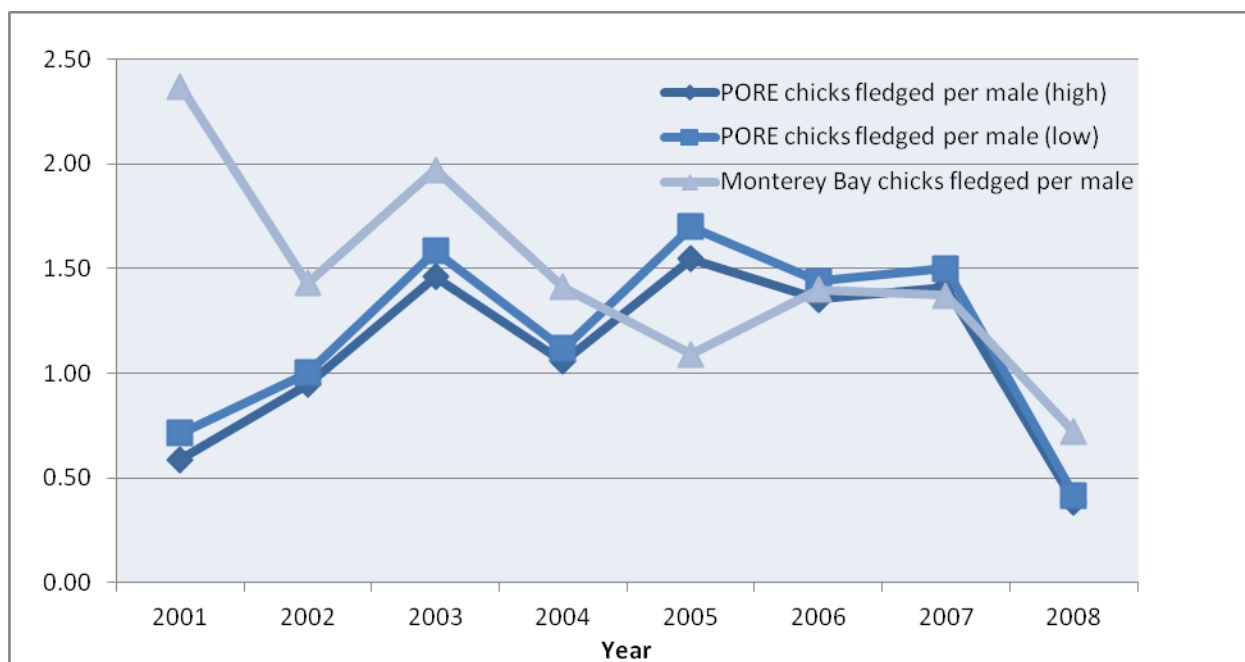


Figure 2. Point Reyes National Seashore (PORE) snowy plover chick fledging rate per breeding male using the low and high male population size estimates with a comparison to the annual chicks fledged per male rate at Monterey Bay, California from 2001 to 2008. *Source:* Peterlein 2009, Page et al. 2010.

Productivity Trends

The reproductive success analysis will be similar to the nest count analysis with the reproductive success variables replacing counts. The M-K Trend test will determine if there is a trend in number of successful nests, the number of eggs that hatch, the number of hatched eggs that fledge, and the number of fledged chicks per breeding male. Additional variables that will be reported in long-term trend reports are trends in the annual maximum number of nests (determined annually to estimate number of chicks per male).

Phenology

Dates of first and last hatch dates will be presented in the trend reports. Julian dates will be used with the M-K and Page's tests described above to determine if there are trends in dates of first nests or first hatching.

Operational Requirements

This program is directed by the PORE wildlife biologist with assistance from a biological technician. The biological technician is responsible for conducting field work, data entry, and communicating results within the survey season. The biological technician position is seasonal (March - September) and has a flexible schedule due to the need for travel time and long hours in the field. The duty station is at PORE, which provides office space and administrative support. The technician is directly supervised by the PORE wildlife biologist (GS-11), who provides training and consistency in implementing the protocol.

Data management is the shared responsibility of the biological technician and the wildlife biologist, with assistance from the network data manager. Typically, the biological technician is responsible for data collection, data entry, data verification, validation, and certification as well as data summary, analysis and reporting. The wildlife biologist is ultimately responsible for adequate QA/QC procedures built into the database management system and appropriate data handling procedures followed by the biological technician. The network data manager creates a satellite database for data entry and uploads data into the main database at the end of the breeding season following QA/QC procedures.

Roles and Responsibilities

Tasks for the PORE Snowy Plover Biological Technician

- Coordinate logistics for field work
- Coordinate field assistance for protocol implementation and provide training to field assistants such as volunteers
- Maintain equipment in good working order and keep maintenance records
- Collect field data and implement field QA/QC measures
- Coordinate data entry, verification, validation, certification and consult with network data managers
- Perform basic statistical analyses on data and present and interpret results in annual reports
- Coordinate with PORE wildlife biologist regarding staff and training needs, data analysis and data interpretation
- Coordinate with PORE wildlife biologist regarding budget, vehicle, and equipment needs
- Complete annual report, USFWS report, and other communication products

Broad Tasks for PORE Wildlife Biologist

- Provide technical assistance and supervision for the biological technician
- Manage snowy plover monitoring program budget
- Provide or coordinate training for the biological technician
- Conduct annual QA/QC field checks
- Present issues with network coordinator for consultation with the I&M Technical Advisory Committee

- Renew and add new names to the USFWS permit
- Review and provide comments on annual report and USFWS permit report
- Attend USFWS annual range-wide plover meetings and regional meetings
- Initiate and complete periodic analysis and synthesis report

Tasks for SFAN I&M Data Manager

- Provide assistance regarding data management, certification, archiving, reporting
- Assist with GIS needs
- Assist with compilation of metadata for past and current monitoring programs

Tasks for SFAN I&M Program Manager

- Provide assistance with periodic formal reviews of operations and results
- Assist with coordinating peer review of protocols and reports.

Qualifications and Training

The USFWS Recovery Plan (2007) outlines the recommended qualifications and amount of training necessary for snowy plover monitoring. The level of training needed is based on the type and timing of monitoring at the study area.

In general, prospective snowy plover surveyors should have good vision, the ability to spend several hours in the sun and wind, and the ability to walk long distances in loose sand (USFWS 2007). In addition, the USFWS has developed minimum training requirements for western snowy plover survey, management, and research activities.

Five activity levels are recognized:

- Level 1: Winter surveys, or surveys outside known nesting areas
- Level 2: Breeding season surveys and censuses of adults, nests, and chicks
- Level 3: Erecting exclosures around nests
- Level 4: Breeding season studies or surveys that include handling eggs
- Level 5: Banding and color marking adults or chicks

Activity levels 1 through 5 are not strictly sequential. For example, a field worker may receive training and be certified at level 3, but cannot participate in level 1 or 2 activities without training specific to those levels (USFWS 2007). The PORE monitoring program encompasses activities that are in levels 1, 2 and 3. Rarely is there a need for a surveyor to handle eggs (other than abandoned eggs) and additional, more highly certified personnel from PRBO could be contracted for that type of work if needed.

No USFWS section 10(a) (1) (A) permit is required for level 1 activities but training is encouraged. Levels 2, 3, 4, and 5 activities require working under a section 10(a) (1) (A) permit. Field staff must be certified at the appropriate activity level to qualify for a permit, or to work independently under the holder of an existing permit. See the Permit Requirements section below.

PORE will work with PRBO or other plover monitoring groups on joint field training opportunities for field surveyors. Although currently not available, USFWS may, in the future, set up classroom instruction (or equivalent field instruction) for those involved with snowy plover surveys, management, and research (USFWS 2007). At least four hours of instruction are required, on topics including

1. Biology, ecology, and behavior of snowy plovers
2. Identification of adult plovers, their young, and their eggs
3. Threats to plovers and their habitats
4. Survey objectives, protocols, and techniques
5. Regulations governing the salvage of carcasses or eggs
6. Special conditions of the existing recovery permit
7. Other activities (e.g., banding, determining incubation stage, erecting exclosures)

In addition, field instruction is required for activity levels 2, 3, 4, or 5 (USFWS 2007). Instruction should occur under the direct supervision of a section 10(a) (1) (A) permit holder. Previous experience with snowy plovers, piping plovers, or other closely-related species will not substitute for the training described above. Activities for PORE field training include locating, identifying, and monitoring nests (levels 2, 4, and 5), erecting exclosures around nests (level 3), practical field exercises, and field review of appropriate classroom topics.

Volunteer Requirements

Volunteers may assist surveys. They must be able to walk several miles of beach and maintain a level of attentiveness throughout the survey. All volunteers must be able to locate snowy plovers and to distinguish them from other, similar species.

Budget

Personnel expenses for field work are based on using one biological technician for 8 months. Data collection and management are done concurrently throughout the field season. Report writing, photograph updates, and database verification is completed in October. With additional assistance from the SFAN data manager, data management, analysis and reporting accounts for approximately 30% of the biological technician's time.

The park has a long-standing (15+ years) commitment to this monitoring program which will continue. Funding in the past has come from a variety of sources including special grants from the NPS Service-wide Comprehensive Call, Point Reyes National Seashore Association (PRNSA), or from the park budget. During some years funding was also provided by SFAN. A projected budget based on expenses from previous years is provided in Table 3. The budget includes 1-2 pay periods of assistance by the SFAN data manager each year.

Additional periodic costs may be incurred if special training or new equipment (e.g., spotting scopes and binoculars) are needed beyond those allowable by the annual budget. Once every five years, a long-term data analysis and synthesis report is scheduled. If NPS staff cannot accomplish the analysis and reporting (as described in the budget), the PORE wildlife biologist may obtain the necessary

technical assistance through cooperative agreements (e.g., Cooperative Ecosystem Studies Unit) or contracts.

Table 3. Estimated annual snowy plover monitoring budget.

Description		Cost	PORE and PRNSA Support	SFAN Support*
Annual expenses	PORE biological technician (GS-5, 18 payperiods)	\$24,000	\$24,000	
	SFAN data manager (GS-11, 1-2 pp)	\$ 5,000		\$ 5,000
	PORE wildlife biologist (GS-12, 2 pp)	\$ 9,000	\$ 9,000	
	Vehicle	\$ 3,000	\$ 3,000	
	Equipment and Supplies	\$ 500	\$ 500	
	Travel	\$ 500	\$ 500	
Total cost in years with annual reports		\$42,000		
Every 5 th year expenses	PORE biological technician (GS-5, 2 pp)	\$ 2,600	\$ 2,600	
	SFAN data manager (GS-11, 1-2 pp)	\$ 5,000		\$ 5,000
	PORE wildlife biologist (GS-12, 1 pp)	\$ 4,500	\$ 4,500	
	PORE science coordinator (GS-13, 0.5 pp)	\$ 2,500	\$ 2,500	
	Additional cost in years with long-term reports (every five years)	\$14,600		

* The SFAN I&M contribution is an in-kind contribution of assistance from the SFAN data manager.

Annual Workload and Field Schedule

The snowy plover monitoring and protection program requires an average of eight field person days per week from March 1–September 1 (Table 4). This is accomplished with one full-time biological technician. Volunteers are used to supplement field staff as necessary and practical, but typically only four to five experienced volunteers are used throughout the season.

Table 4. Summary of annual snowy plover monitoring schedule.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Advertise Bio-Tech												
Bio-Tech Begins												
Prepare/Train for Field Season												
Breeding Season Field Surveys												
Reporting												

Facility and Equipment Needs

The nature of snowy plover surveys does not require special facilities beyond normal office space and equipment storage needs. Field specific equipment is stored at PORE in the natural resource management building. A list of equipment is provided in SOP 1: Field Methods. Computer equipment for data entry and report writing will be supplied by PORE.

Permit Requirements

The USFWS requires that persons involved in snowy plover breeding census or research activities apply for a section 10 permit through the USFWS Ecological Services field office in the state of the proposed work. Section 10 permits authorize activities, otherwise prohibited under section 9 of the Endangered Species Act, for scientific purposes or to enhance the survival of a listed species. The section 10 permit issued to PORE covers multiple threatened and endangered species and designates specific subpermittees for the plover research and monitoring program. Currently PORE has a section 10 permit (TE-018180-1) with three subpermittees (D. Press, PORE Wildlife Biologist; L. Hughey, Plover Biological Technician; C. Campbell, Plover Docent Coordinator). Annual reporting to the USFWS on permit-related activities is mandatory. Park permits are currently not required by PORE for park staff.

Revising and Archiving the Protocol

Over time, revisions to both the protocol narrative and to specific SOPs are to be expected. Careful documentation of changes to the protocol is essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis. The MS Word documents for each monitoring component contain a field that identifies which version of the protocol was being used when the data were collected. The steps for changing the protocol (either the Protocol Narrative or the SOPs) are outlined in SOP 2: Revising the Protocol. Each SOP contains a Revision History Log that is filled out each time an SOP is revised to explain why the change was made, and to assign a new version number to the revised SOP. The new version of the SOP or protocol narrative is then archived in the SFAN Protocol Library on the GOGA I&M Server. Final copies of peer-reviewed protocol documents are uploaded into the NPS Integrated Resource Management Applications portal (<http://irma.nps.gov>), an internet clearinghouse for documents, data and metadata on natural and cultural resources in parks.

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Appendix A. Snowy plover natural history and identification.

Version 1.1

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	June 2011	D. Adams	Created an appendix for plover natural history and shorebird identification.	In response to peer review comments.	1.0
1.0	July 2012	D. Adams	Moved appendix from end of SOPs to end of narrative; minor edits.	As suggested by NRTR formatting guidelines and examples	1.1

Overview

This appendix provides natural history information for the western snowy plover (*Charadrius alexandrinus nivosus*) and field identification characteristics and behaviors used to distinguish snowy plovers from other shorebirds in the field at Point Reyes National Seashore (PORE). Most of this information is taken from two sources: Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (USFWS 2007) and Snowy Plover, Birds of North America Online (Page et al. 2009).

Natural History

Description

Snowy plovers (15–17 cm long, 34–58 g) are small shorebirds with pale gray-brown backs and white breasts and under parts, with a white hind-neck collar. Snowy plovers have dark lateral breast patches, forehead bar, and eye patches (Figure APP A.1). In breeding plumage, males have black markings across the forehead, on the cheek below and behind the eye, and on either side of the throat; in females, usually one of more of these markings are dark brown (Figure APP A.2). Early in the breeding season a rufous crown may be evident on breeding males, but it is not typically seen on females (USFWS 2007). Markings that are prominent during the breeding season are very faint or absent in basic plumage during the non-breeding season, making gender indistinguishable. Fledged juveniles have white edges on their wing coverts and scapulars and can thus be distinguished from adults until approximately July through October, depending on when the eggs hatch (USFWS 2007). During this period, molt and feather wear makes fledged juveniles indistinguishable from adults.

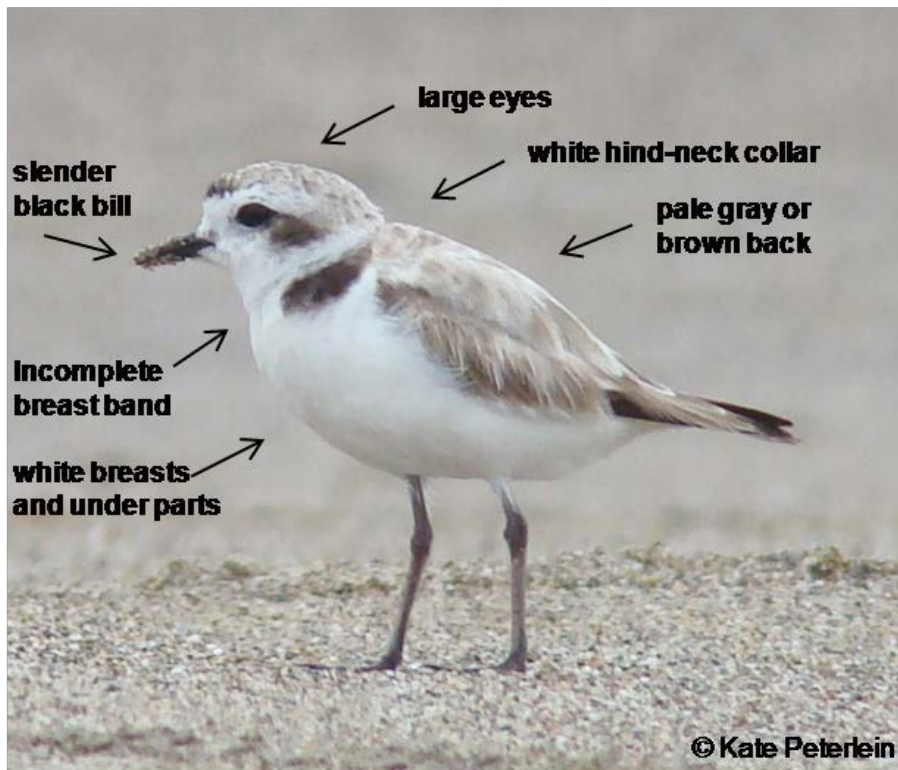


Figure APP A.1. Snowy plover in breeding (July) plumage with identifying features.



Figure APP A.2. Female and male snowy plovers in breeding plumage. Female has dark brown forehead and cheek markings compared to the male with darker, black markings.

Snowy plovers are distinguished from other small shorebirds that use PORE beaches by their pale gray-brown backs, white breasts and under parts, plump profiles, large eyes, and slender black bills (Figure APP A.3). Snowy plovers have dark gray to black legs. Snowy plovers have a shorter, less pointed bill than other sandpipers. Observers should look for the white breasts of roosting plovers as they scan the beach with binoculars, realizing that some white patches are pieces of debris.

Observers on PORE beaches must be able to distinguish snowy plovers from the larger killdeer (*Charadrius vociferous*), semipalmated plover (*Charadrius semipalmatus*), sanderling (*Calidris alba*), dunlin (*Calidris alpina*), and smaller western sandpiper (*Calidris mauri*), and should be familiar with these species (Figure APP A.3). Sanderlings are the most common shorebird on PORE beaches and also the species that is most likely to be confused with snowy plovers, so extra attention should be given to distinguishing plovers from sanderlings. Other common shorebird species on these beaches include willet (*Catoptrophorus semipalmatus*), marbled godwit (*Limosa fedoa*), and whimbrel (*Numenius phaeopus*).

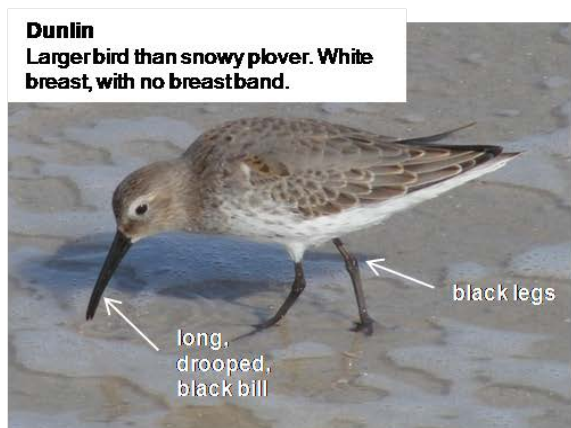
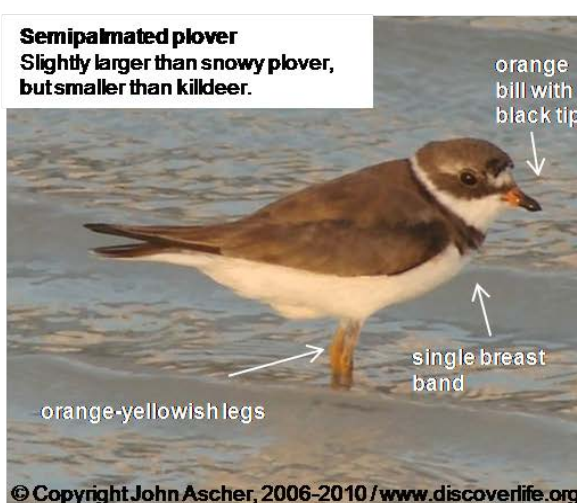
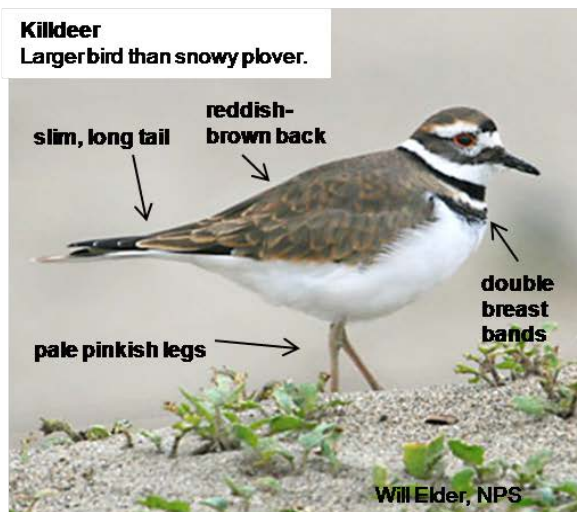
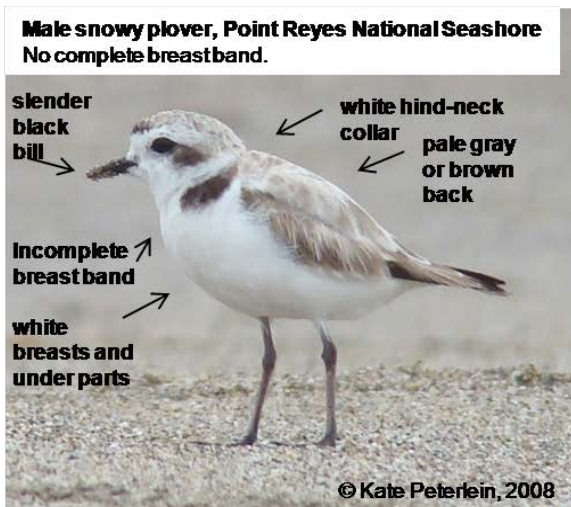


Figure APP A.3. Useful characteristics for field identification of similar shorebirds found on Point Reyes National Seashore beaches, California.

Range and Habitat

The western snowy plover is found along the Pacific Coast from Washington to Baja California, portions of the interior western and southwestern United States, the Gulf Coast of Texas, and interior portions of Mexico and is the only recognized snowy plover in the United States. (Figure APP A.4).

The Pacific Coast population of snowy plovers nests along the coast between central Washington and southern Baja California, including three or four of the Channel Islands off the southern California coast. The closest, other breeding location to PORE is San Francisco Bay National Wildlife Refuge. To the south, Pacifica State Beach and the mouth of Pilarcitos Creek on Half Moon Bay have also been used by nesting plovers. In San Francisco, Ocean Beach or Crissy Field may provide nesting habitat, but nests have never been documented in these areas.

The inland population of snowy plovers nests at locations around the margins of saline lakes mostly in California, Oregon, Nevada, and Utah, and evaporation ponds in the California Central Valley. More rarely they have been found nesting around the unvegetated margins of freshwater lakes. Although researchers have recorded a few cases of coastal-born plovers nesting at inland locations, inland-born plovers have not been documented nesting along the coast.

Most snowy plovers in western North America winter along the coast, although small numbers of snowy plovers regularly winter in the San Joaquin Valley around evaporation ponds and around the Salton Sea. In the winter they use both beaches on which they nest as well as other beaches that are unsuitable for nesting. For wintering sites, the non-breeding season begins when the earliest birds arrive or are moving through (early July), until the departure of the latest bird in mid-May.

Page et al. (1995) found that snowy plovers exhibit strong site fidelity to wintering areas. Approximately 60% of males, females, and immatures from Lake Abert, Oregon, that were located on their coastal California or Baja California wintering areas were present for two consecutive years, and about 30% for at least three years (Page et al. 1995).



Figure APP A.4. Snowy plover seasonal and year-round distribution in North and Central America. *Source:* Page et al. 2009.

Breeding and Nesting

The breeding season is about six months long (mid-March to mid-September). At PORE, the first snowy plover nest is typically seen at the end of March. The last nest to hatch is variable but is typically late July to mid-August.

The snowy plover has a serially polygamous, territorial mating system. Males solicit for females by calling from their territory and making horizontal displays. During courtship, males create multiple scrapes within a territory with the female selecting the final egg-laying location (Page et al. 2009). Both partners line the nest with pebbles and other bits of debris. The clutch size is typically three eggs with an average of 62 hours elapsed time between laying eggs 1 and 2 and 55 hours between eggs 2 and 3 (Warriner et al. 1986). In windy areas, like PORE, scrapes are dug out again following a wind event.



Figure APP A.5. Two biologists setting up an enclosure on typical nesting habitat at Point Reyes Beach. Photo by Heather Jensen.

Snowy plovers nest in open, unvegetated or sparsely vegetated, habitat that may have a sparse to moderate scattering of debris such as driftwood (Figures APP A.5 and APPA.6). Both female and male snowy plovers share incubation but following hatching the female will desert the brood and male to begin another pairing and nesting, and the male broods the chicks. This serial polygamy results in double-brooding and sometimes triple-brooding for females. Following the death or desertion of their mate, the remaining plover usually deserts the clutch; however, some birds of both sexes incubate alone especially if they lose their mate late in the incubation period (Warriner et al. 1986).

Survival

At Point Reyes from 2003 to 2008, on average $88\% \pm 7.9$ SD (range 75–94%, $n=6$ years) of the chicks were lost when they were 1–10 days old (Peterlein 2009).

The 1984–1999 Monterey Bay chick banding study found a mean survival rate from hatching to beginning of first breeding season of 0.179 ± 0.010 SE; survival from 28 days (fledging age) to the beginning of first breeding season to be 0.463 ± 0.018 SE (annual range 0.283 ± 0.028 to 0.575 ± 0.061 ; Stenzel et al. 2007). In a Humboldt County snowy plover survival study, apparent survival was 64% for males and 57% for females (best-fitting model included sex dependence in survival); the difference may be attributed to greater mortality of females or greater breeding site fidelity of males (Mullin 2006).



Figure APP A.6. Examples of snowy plover nests (scrapes) built on PORE beaches.

Dispersal and Philopatry

Individual snowy plovers have been observed to range widely among multiple sites within and between breeding seasons. In California snowy plover dispersal studies, male snowy plovers tend to be more philopatric than females (Colwell et al. 2007b, Stenzel et al. 2007); with an annual range of both genders combined of 13.0 to 16.4% in Northern California (Colwell et al. 2007b).

In a Northern California plover population study, the tendency of snowy plover juveniles to become migratory versus residents correlated with fledging timing during the breeding season; that is, chicks from late-hatching clutches tend to remain as residents, joining wintering flocks (Colwell et al. 2007b).

Based on the known histories of banded individuals, about 40% of females and 16% of males studied on Monterey Bay moved from their regular breeding areas to locations at least 50 km away for additional nesting attempts (Stenzel et al. 1994).

Feeding Behavior

Snowy plovers usually feed above and below the high-water line, gathering invertebrate prey from above and below beach surface. Plovers also may be found feeding on flies in kelp, on beetles or flies on marine mammal carcasses, on insects in dry sand at the base of vegetation, or in other beach microhabitats. When actively foraging, snowy plovers will pause then run a short distance to peck at the ground using the run-stop-peck method of feeding. Sanderlings are most frequently observed foraging at the water's edge running back and forth with incoming and outgoing waves, often as a group with synchronous movement. Snowy plovers are more likely to be found near the wrack line, alone, though are infrequently observed foraging at the water's edge, so observers must confirm identifications.

Roosting Behavior

Snowy plovers typically spend much of the day resting above the current high tide line, often sitting in depressions, such as foot prints, or behind wave-cast debris, such as kelp or surf grass. These habits endow plovers with good camouflage while roosting. Non-breeding snowy plovers tend to be in flocks, which makes them more likely to be detected by observers. Single plovers and small

groups are observed though, and sometimes these are on days when disturbances or weather may have separated larger groups.

Disturbance Behavior

If disturbed, roosting plovers may stand and, when further disturbed, walk, run, or fly away. Potential agents of disturbance include people, dogs, and birds of prey. Adults with broods react to approaching people or dogs with calls and depending on the age of the chick may crouch (younger) or run ahead of people or dogs (Colwell et al. 2007a). If chicks crouch, adults respond further with calls and distraction displays (Colwell et al. 2007a).

Conservation Concerns

Predators

Common predators found throughout the range of snowy plovers include common ravens, domestic dogs, coyotes (*Canis latrans*), striped skunks (*Mephitis mephitis*), ground squirrels (*Spermophilus beecheyi*), and raccoons (*Procyon lotor*), as well as non-native red fox (*Vulpes vulpes*) and domestic cats (*Felis catus*) are other potential mammalian predators (USFWS 2007). Merlins (*Falco columbarius*), peregrine falcons (*Falco peregrinus*), and northern harriers (*Circus cyaneus*) are avian predators that prey on free-flying plover adults or chicks.

Human Disturbance

Recreational activities such as walking, jogging, kite flying, dogs, horseback riding, and vehicle use are sources of disturbance on beaches (USFWS 2007). These disturbances may displace plovers from preferred roosting or foraging areas and cause them to expend energy in flushing or running away.

Habitat Alteration

Loss of nesting and wintering habitat is one of the major threats to snowy plovers (USFWS 2007). This includes building of beach-front developments, shoreline stabilization and also introduced species such as European beach grass (*Ammophila arenaria*) and iceplant (*Carpobrotus edulis*) used to stabilize dunes.

Climate Change

Rising sea-level and increased storm surge associated with climate change threaten snowy plover habitat along the Pacific coast. During storms, waves often wash over the entire beach, into the dunes backing the beach, and periodically open a channel from Abbott's Lagoon to the ocean, draining water out of the lagoon.

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SOP 1: Field Season Methods

Version 5.9

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	Dec 2004	D. Adams, K. Peterlein, S. Allen			4.0
4.0	Nov 2007	M. Koenen, D. Adams	Adapted to formatting standards for the NPS I&M Program	To meet NPS guidelines	5.0
5.0	Oct 2008	M. Koenen, D. Adams	Formatting		5.1
5.1	Feb 2009	M. Koenen		To address review comments from Gary Page, Jodi Whittier	5.2
5.4	May 2009	D. Adams	Formatting for peer review		5.5
5.5	Dec 2009	D. Adams	Formatting		5.6
5.6	August 2011	D. Adams, L. Hughey	Formatting; clarification on survey timing, areas, instructions and training	Response to peer review comments	5.7
5.7	July 2012	D. Adams, L. Hughey	Addition of predator images, formatting updates, survey area naming consistency, minor edits	Response to 2 nd set of peer review comments	5.8
5.8	January 2014	D. Adams	Updated datasheets added, minor text edits	Response to 3 rd set of comments from P. Latham	5.9

Pre-Season Procedures

Equipment Preparation

Field equipment used and carried by the biological technician and volunteers for monitoring includes

- 8x40 or higher power binoculars
- 30x spotting scope
- Data sheets (Appendix SOP 1B data sheets printed on waterproof paper)
- Pencils
- Park radio or cell phone
- Copy of relevant monitoring protocol procedures, bird and mammal identification guides
- Tide chart
- GPS unit

Recommended field equipment depending on conditions and may include

- Warm, layered clothes, including rain shell
- Leather gloves for handling exclosure and fencing equipment
- Sun protection (sunscreen, sun hat, sunglasses)
- Water and snacks
- First aid kit

Prior to the start of the March 15 surveys, all gear to support protection measures (habitat fencing and exclosure construction) is prepared and delivered to Point Reyes Beach locations. Supplies and equipment to be delivered includes fiberglass posts and rope for symbolic fencing, wire fencing for exclosures, and all signage necessary for the season (see Appendix SOP 1A for list). Equipment and supplies should be inspected for defects and repaired or replaced as needed and should be ready for deployment no later than March 15. Equipment and supplies are delivered to the beach with the use of an ATV and trailer and it is important to minimize operating the ATV on the beach during active snowy plover nesting season. Contact the PORE law enforcement supervisor to arrange the use of an ATV, trailer, and a qualified ATV driver. The equipment and supplies are distributed along the beach according to historic nest densities and it usually requires a full day to complete. At least two sets of exclosures are kept in storage and not delivered to Point Reyes Beach in case nests are found in other survey areas.

Qualifications and Training

If the biological technician selected for the monitoring program has no previous snowy plover monitoring experience, he/she will need to be thoroughly familiar with this monitoring protocol and train with experienced snowy plover monitors prior to working alone at PORE to accomplish the necessary training as required by the USFWS Section 10 permit (see topics listed below). Training with the PORE or Golden Gate National Recreation Area wildlife biologists, previous NPS plover monitoring surveyors, PRBO biologists at their Monterey Bay monitoring sites or other experienced

plover biologists in the San Francisco Bay Area will be necessary and should be coordinated by the PORE wildlife biologist.

The USFWS Recovery Plan (2007) outlines the qualifications and amount of training necessary for snowy plover monitoring. The level of training needed is based on the type and timing of monitoring at the study area.

In general, prospective snowy plover surveyors should have good vision, the ability to spend several hours in the sun and wind, and the ability to walk long distances in loose sand (USFWS 2007). In addition, the USFWS has developed minimum training requirements for western snowy plover survey, management, and research activities.

Five activity levels are recognized:

- Level 1: Winter surveys, or surveys outside known nesting areas
- Level 2: Breeding season surveys and censuses of adults, nests, and chicks
- Level 3: Erecting exclosures around nests
- Level 4: Breeding season studies or surveys that include handling eggs
- Level 5: Banding and color marking adults or chicks

Activity levels 1 through 5 are not strictly sequential. For example, a field worker may receive training and be certified at level 3, but cannot participate in level 1 or 2 activities without training specific to those levels (USFWS 2007). The PORE monitoring program encompasses activities that are in level 1, 2 and 3. Rarely is there a need for a surveyor to handle eggs (other than abandoned eggs) and additional, more highly certified personnel from PRBO could be contracted for that type of work if needed.

No section 10(a) (1) (A) permit is required for level 1 activities but training is encouraged. Level 2, 3, 4, and 5 activities require a section 10(a) (1) (A) permit from the USFWS. Field staff must be certified at the appropriate activity level to qualify for a permit, or to work independently under the holder of an existing permit. See the Permit Requirements section below.

PORE will work with PRBO or other plover monitoring groups on training opportunities for field surveyors. Although currently not available, USFWS may, in the future, set up classroom instruction (or equivalent field instruction) for those involved with snowy plover surveys, management, and research (USFWS 2007). At least four hours of instruction are required, on topics including

1. Biology, ecology, and behavior of snowy plovers
2. Identification of adult plovers, their young, and their eggs
3. Threats to plovers and their habitats
4. Survey objectives, protocols, and techniques
5. Regulations governing the salvage of carcasses or eggs
6. Special conditions of the existing recovery permit
7. Other activities (e.g., banding, determining incubation stage, erecting exclosures)

In addition, field instruction is required for activity levels 2, 3, 4, or 5 (USFWS 2007). Instruction should occur under the direct supervision of a section 10(a) (1) (A) permit holder. Previous experience with snowy plovers, piping plovers, or other closely-related species will not substitute for the training described above. Activities for field training include

1. Locating, identifying, and monitoring nests (levels 2, 4, and 5)
2. Handling eggs and capturing and handling adults or chicks (levels 4 and 5)
3. Erecting exclosures around nests (level 3)
4. Specifics on the target activity for which a permit has been issued
5. Practical field exercises
6. Field review of appropriate classroom topics

Volunteer Assistance

Volunteers have played an important role in the monitoring program since its inception serving to increase safety, confirm counts, segregate data collection tasks, and to increase efficiency of the surveys. Volunteers must be able to identify snowy plovers and other shorebirds accurately in the field and should be familiar with the monitoring protocol, and especially with protocol field methods. Volunteers are expected to regularly participate in surveys, ideally working over multiple years. New volunteers will be trained and returning volunteers will receive seasonal refreshers on safety and field methods. The biological technician may contact past volunteers to inquire about availability. Contact information for past volunteers is on file with the PORE wildlife biologist. New volunteers may be recruited as needed. Volunteer waivers (VIP Form 10-85) will have to be signed by volunteers and the biological technician before commencing work.

Sequence of Events during Field Season

Breeding Season Schedule

The snowy plover monitoring and protection program requires an average of five field person days per week from March 15– September 15 (Table SOP 1.1). This has been accomplished with one full-time biological technician. Volunteers are used to supplement field staff as necessary and practical, but typically only four to five experienced volunteers are used to assist monitoring throughout the season. Additional volunteers are used in the snowy plover docent program to make visitor contacts on the beaches to explain beach recreation restrictions during snowy plover breeding season.

Table SOP 1.1. Annual snowy plover monitoring schedule of major events.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Advertise bio-tech position												
Bio-tech begins												
Prepare for field season												
Contact volunteers												
Deliver equipment to beach locations and set up habitat fencing												
Breeding season field surveys												
Annual reporting												

Survey Areas

Every known, historic snowy plover breeding beach within PORE is surveyed for breeding adults during the breeding season, but the surveys occur at different intervals depending on the history of the survey area. There are six survey areas: four on Point Reyes Beach, one on Limantour Beach, and one on Drake's Beach (Figure 1).

Point Reyes Beach is separated into four survey areas:

1. K = Kehoe Creek entrance to northwest of Abbott's Lagoon
(<http://www.bahiker.com/pictures/northbay/kehoebeach/041305/websize/42thead.jpg>Figure SOP 1.1)
2. NP = Southwest shore of Abbott's Lagoon to North Beach parking lot (Figure SOP 1.2)
3. NB = North Beach parking lot to South Beach parking lot (Figure SOP 1.3)
4. SB = South Beach parking lot to Lighthouse Beach (Figure SOP 1.4)

Other PORE survey areas are within Drake's Bay:

5. Limantour Spit (L) has not been used by snowy plovers during breeding season since 2001, but continues to be surveyed monthly during the breeding season (Figure SOP 1.5)
6. Drake's Spit (D) has not had active snowy plover breeding activity since 1989 but also continues to be surveyed monthly during the breeding season (Figure SOP 1.6)



Kehoe Beach Survey Sector (K)



Figure SOP 1.1. Area K: Kehoe Creek to Abbott's Lagoon, Point Reyes National Seashore.



North Beach Survey Sector (NP)



Figure SOP 1.2. Area NP: Abbott's Lagoon to North Beach parking lot, Point Reyes National Seashore.



North Beach to South Beach Survey Sector (NB)



Figure SOP 1.3. Area NB: North Beach parking lot to South Beach parking lot, Point Reyes National Seashore.



South Beach to Lighthouse Survey Sector (SB)



Figure SOP 1.4. Area SB: South Beach parking lot to where beach ends just north of the Point Reyes Lighthouse, Point Reyes National Seashore.



Limantour Spit Survey Sector (L)

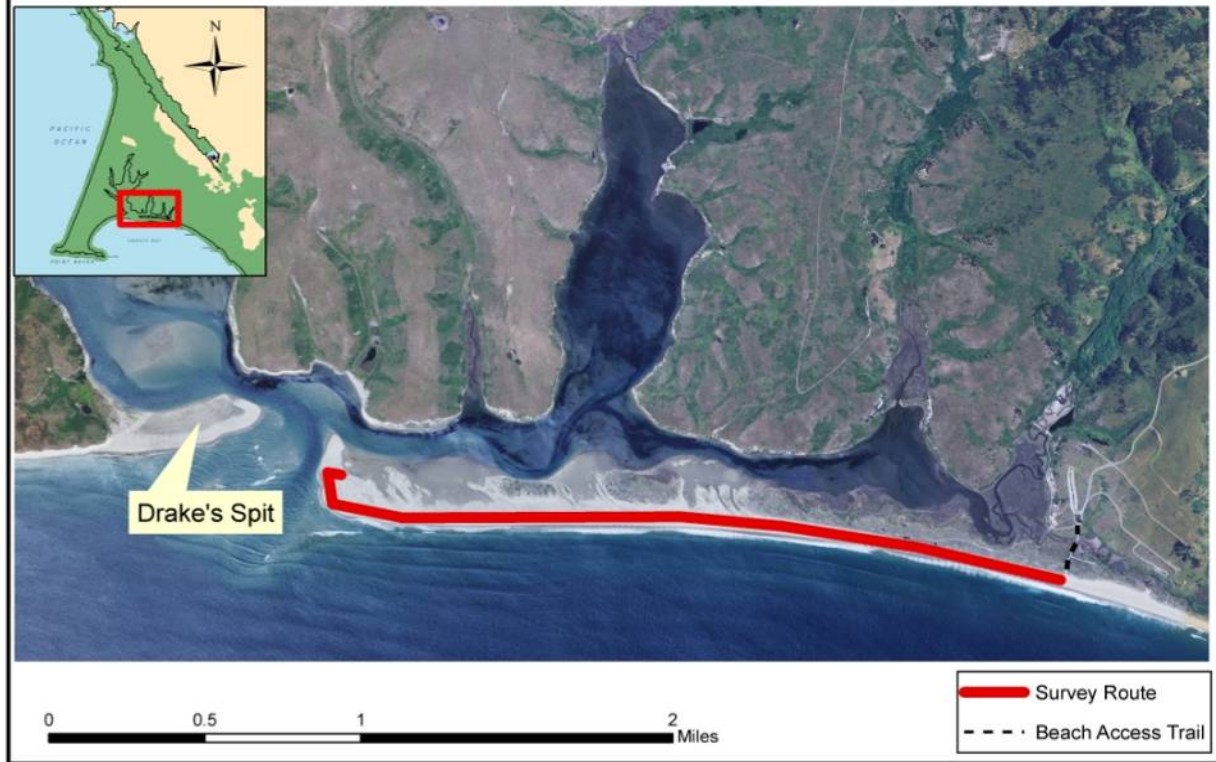


Figure SOP 1.5. Area L: The Limantour Spit, Point Reyes National Seashore. This section starts at Limantour Beach parking lot and goes west along the beach to opening of Drakes Estero.



Drake's Spit Survey Sector (D)

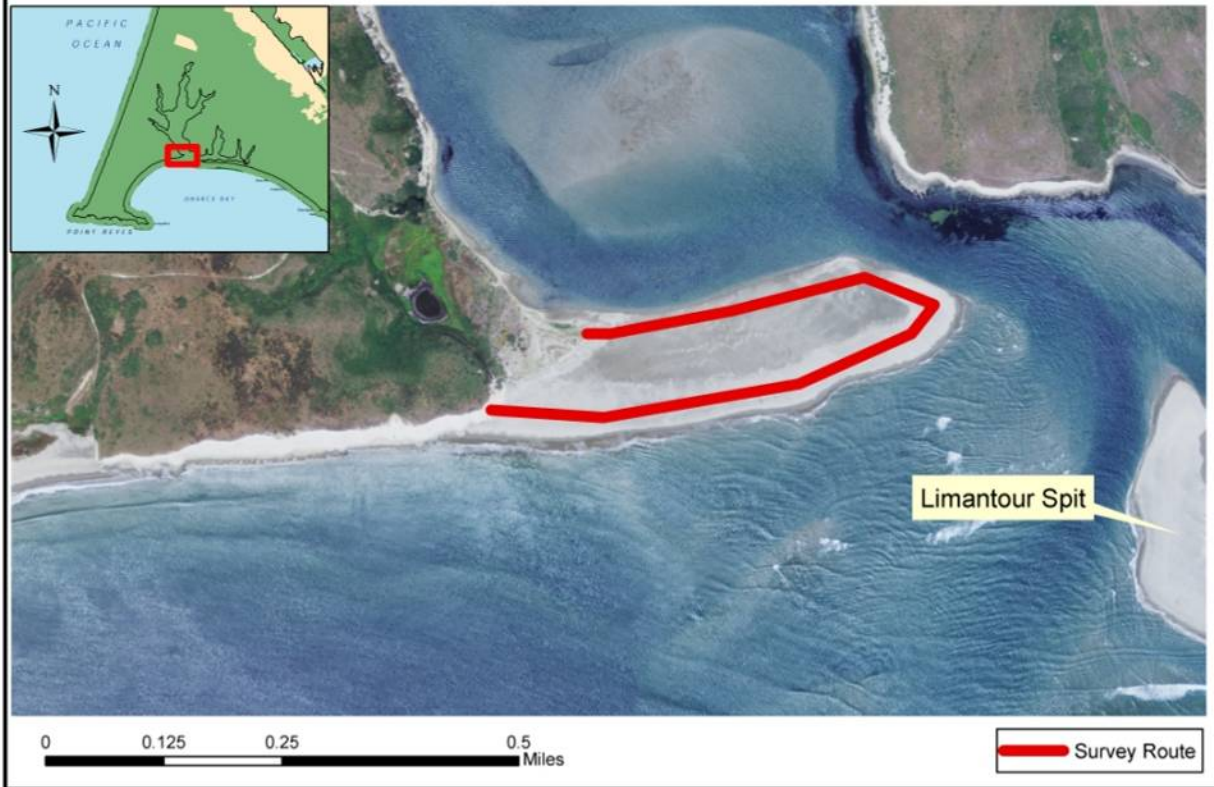


Figure SOP 1.6. Area D: Drake's Beach parking lot to Drake's Spit, Point Reyes National Seashore. Drakes Spit is reached from the Drake's Beach parking lot and walking east to the opening of Drake's Estero.

Field Procedures

Field procedures include censusing snowy plovers, locating and monitoring snowy plover nests, protecting nests, monitoring nest status, determining reasons for chick loss, and making predator or disturbance notes.

Accessing the Beaches

Area K is accessed using a beach trail that starts on Pierce Point Road. Park at the parking pullouts at the Kehoe Beach trailhead and follow the trail (1 km) to the beach. The survey starts on the southern side of Kehoe Creek (UTM easting: 504409, northing: 4222930) and ends at the northwest shore of Abbott's Lagoon (UTM easting: 503656, northing: 4218975). It can be done in either direction and is facilitated by dropping a second vehicle at one end.

Area NP is accessed using a beach trail that starts on Pierce Point Road. Park at the parking lot for the Abbott's Lagoon trailhead and follow the trail (2.4 km) to the lagoon and beach. The survey starts on the southwest shore of the lagoon (UTM easting: 503656, northing: 4218975). Surveys of Area NP should include the back dune areas south of the lagoon where dune restoration work has occurred and where snowy plovers have nested and brooded chicks in recent years. The survey continues to the intersection with the North Beach parking lot. This survey area can also be accessed from an old ranch road near the former AT&T facility, south of the NPS North District Operations Center. Use the NPS gate key to access the facility road and park at the end of the approximately 160-m (528-ft) driveway, next to the facility, walk on foot on the old ranch road through the dunes to the beach. This mid-area access is convenient when there are nests checks necessary on nests in the middle of the survey area but on days when a complete plover survey is not scheduled.

Area NB is accessed from the North Beach parking lot and continues south to the South Beach parking lot. It can be done in either direction and is facilitated by dropping a second vehicle at one end.

Area SB is accessed from the South Beach parking lot and continues south to the end of the beach, below the lighthouse. It can be done in either direction and is facilitated by dropping a second vehicle at one end. The hike up the creek to the Lighthouse Road (across from Sea Lion Overlook) at the southern end of this survey area can be steep and slippery especially under rainy conditions.

Area L starts at Limantour Beach parking lot and goes west along the beach to opening of Drakes Estero. There is no one-way option for this survey.

Area D is reached from the Drake's Beach parking lot and walking east to the opening of Drake's Estero. There is no one-way option for this survey.

Census Methods

A snowy plover census is conducted by one or more surveyors by walking on the survey area beach in one direction. Typically, censuses are conducted by two or three surveyors, led by the biological technician. With more experience and expertise, one person (biological technician) can cover the census areas but two surveyors provide safety, assistance in putting up exclosures, and additional survey area coverage.

The biological technician should confirm that each member of the field team has the required field equipment and clothing for weather conditions, as well as remind everyone about safe work practices before starting the survey.

The whole width of the beach from the tide line to the foredunes and any fingers of sand that reach to the back dunes should be surveyed. During census surveys, observers walk just below the high tide line, crossing above the line only when necessary to see the full width of the beach. Observers stop every 50–100 m (164–328 ft) to scan with binoculars at least 100 m (328 ft) ahead for plovers. When a plover(s) is located, observers approach close enough to determine age, sex, and color band combination if bands are present. Observers record date, location (by sub-area and pre-determined landmarks), and the time of sighting. Observers then walk around the bird(s) to prevent flushing it.

Nests are located using three methods: 1) systematically searching microhabitats in which plovers are likely to nest; 2) watching potential breeding adults from a concealed position; and 3) following plover footprints in fine sand. Once a nest is located, it is immediately exclosed with a 3-m × 3-m square fence. GPS location data are also collected for each nest.

Nests are checked two to four times per week to verify if they are still active. Near the nest's projected hatching date, checks are made more frequently to determine the precise hatch day. Adults and chicks are looked for on follow up visits; once found the number of chicks and location are recorded. The chicks are monitored until 28 days after hatching, when they are considered fledged. This has been possible because of the low number of nests in the study area.

Recording Snowy Plover Census Data

Snowy Plover Observations

Observers use data sheets and field notebooks to record plover nest data and observations. Data are recorded on standard field data sheets (Appendix SOP 1B). A field notebook is used to provide space for additional notes on field conditions or special occurrences.

The biological technician should fill out the headers of PORE Snowy Plover Census Data Sheet (Appendix SOP 1B) with location, date, names of observers, and start time. Weather information is obtained post-survey from hourly averages that are collected by automated equipment maintained by the Western Regional Climate Center at the PORE North District Operations Center (aka "Pt. Reyes RCA"; <http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvprca>). Weather information (wind direction, average wind speed, maximum wind speed, air temperature, and mean relative humidity) should be obtained as soon as possible after returning from the field. Provide an ocular estimate of the percent cloud cover and note on the data sheet. Make note of other important weather information that may affect the ability to observe birds or affect bird behavior. Provide the tidal condition (hi-slack, fall, lo-slack, rise) at the start of the survey by consulting a tide chart for Point Reyes location.

Surveyors count and record data on snowy plovers for each survey area. Each individual snowy plover should be recorded on a separate row on the data sheet indicating the time seen, sex/age (M, F, UN [unknown sex], H [hatchling], FL [fledgling]), nest ID number if the plover is associated with a

nest territory, and additional notes on color bands seen, etc. A GPS coordinate should be obtained for each plover sighting by using a handheld GPS unit. The UTM Easting and UTM Northing coordinates are noted on the data sheet. The type of GPS unit used and accuracy of coordinates should be included in the notes section.

Although uncommonly seen during the breeding season, the number and direction of flying groups of plovers should be recorded, with birds flying from behind to in-front of surveyors subtracted from census totals as they should have already been counted and birds flying from in-front to behind the surveyors retained in the total count. This behavior is typically only seen at the beginning and end of the breeding season when there are some flocks of wintering snowy plovers.

Surveyors should be familiar with the tips given in the sections below entitled General Strategies for Nest Searching, Identifying Territories and Identifying Nesting. Snowy plover color band information will also be noted on the census data sheet (see below).

Ancillary Disturbance and Predator Observation Data

In addition to monitoring the snowy plover breeding populations and reproductive success, collection of presence/absence, abundance, and location information of all potential snowy plover predators and disturbance agents is important to park managers. This includes humans, dogs off leash, dogs on leash, and mammalian and avian predators listed on the data sheet. Surveyors should also note specific law enforcement violations observed (i.e., entrance into a closed area, off-leash dog owners not leashing when requested).

The surveyors will conduct predator surveys along snowy plover breeding beaches during all surveys. Using the snowy plover census data sheet, surveyors will record the type of predator identified to species, number of individuals, behavior of predators (using a list of possible actions found on data sheet), and GPS location (waypoint) of each predator, human, or dog on the census data sheet. Often these surveys are made on the way to and from nest checks when full plover censuses are not being done and the surveyor has the ability to see the skies and dunes more thoroughly. It is recognized that because these data are not currently collected with systematic, standardized sample efforts, the relationship between ancillary data collected on predator populations and plover population trends cannot be determined with statistical estimates of certainty.

Field identification of predators is greatly aided by carrying a bird identification guide. The following corvid and raptor species have been documented on PORE beaches during the snowy plover nesting season:



Common raven (*Corvus corax*): large corvid, black plumage, with long-narrow wings; long-wedge-shaped tail, and heavy bill; adult ravens have a very shaggy throat. Flight is smooth, rowing, and glides with wings flat as opposed to the raised wings of crows. Ravens often soar but crows do not. A large variety of calls from low, deep baritone croaks (kraah) to high-bell-like notes.

Photo: © Copyright John Ascher, 2006–2010. www.discoverlife.org



American crow (*Corvus brachyrhynchos*): large corvid but smaller than ravens, black plumage, short tail that is more straight across than the raven's wedge-shaped tail in flight. Flight is smooth, rowing, and glides with wings slightly raised. Calls are varied, typically the full-voiced hoarse (carr or caaw), with a soft call (prrrk) similar to ravens.

Photo: Will Elder/NPS



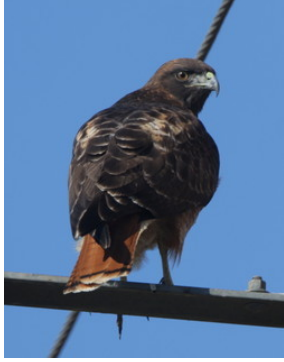
Peregrine falcon (*Falco peregrinus*): large falconid shape and wings, with pointed wingtips and short tail; slate-colored above (with juveniles dark gray-brown above), underside uniformly spotted or barred, with white throat, in flight; heavy moustache contrasts with white throat, breast and belly heavily marked, head appears hooded, while perched. Flight is fluid, with undulating wing beats rippling down length of wings. Deep rek-rek or kek-kek call, similar to prairie but lower, throatier sound.

Photo: © Larry Thompson, 2007–2010. www.discoverlife.org



Merlin (*Falco columbarius*): small and fast falcon found in wide-open space and open woods. Plumage in the Pacific (Black) and Taiga populations is dark gray (males) to dark brown (females) on the back and wings, brown and tan mottling on the breast; yellow lore, beak is yellow at base, black at tip. Short and pointed wings, dark tail bands, and yellow legs. The Taiga population birds have a yellow eye stripe and a weak mustache. Juveniles of all populations resemble adult males. Call is a rapid, accelerating series of strident notes, rising then falling.

Photo: © Larry Thompson, 2007–2010. www.discoverlife.org



Red-tailed hawk (*Buteo jamaicensis*): large buteo shape (stocky body, broad wings, bulging secondaries) with red tail usually distinctive in adults and white/brown banded tail in juveniles. In flight, dark rectangular marking on the underside of the wing's leading edge and patagium. Numerous color morphs, with light morph the most common, rufous morphs less common, and dark morphs the least common. For light morphs, dark head contrasts with pale breast perched and in flight. For rufous morphs, breast is more distinctly rufous / reddish, dark head still distinctive. For dark morphs, dark head blends into color of back, patagial marks, and breast/belly, with flight feathers on underwings pale gray to whitish and contrasting sharply.

Photo: © Larry Thompson, 2007–2010. www.discoverlife.org



Northern harrier (*Circus cyaneus*): slender raptor with long wings and tail; can be confused with buteo, accipiter, or falconid in flight due to variety of flight shapes, but characteristic flapping punctuates flight regularly. White rump very distinctive and visible in low hunting flights over grassland / marsh habitat. Adult male, female, and juvenile plumages all different and distinctive: adult male has ashy, pale gray back, head, and white underwings contrasting with black wing tips; adult female has brownish back, pale shoulder bars, boldly barred secondaries, and brown-streaked belly / patagial marks; juvenile has dark head and barred secondaries contrasting with orangish breast / belly. All have owl-like facial disc and gray / brown barring on tail.

Photo: © Larry Thompson, 2007–2010. www.discoverlife.org



Barn owl (*Tyto alba*): medium-sized owl with relatively long, pointed wings, distinctive plumage characterized by pale tawny back and white breast, belly, underwings. Facial disc round and heart-shaped, white, contrasting with black eyes; no horns on head. Call is a long hissing shriek, screech, or scream.

USFWS photo



Great horned owl (*Bubo virginianus*): large and bulky owl, rather like red-tailed hawk in flight, with broad body and large head, stout ear tufts. Plumage variable, but with dark, brownish, and orangish streaking all usually evident. Facial disc grayish to orangish, with ear tufts and large yellow eyes evident. No vertical stripes through eyes as in long-eared owl, with face more round than long. Call is a deep, muffled hooting in a rhythmic series, similar to that of mourning doves. Vocalizations can be quite loud, and often include a repetition of hoo hoohoo HOOO hoo with variations common.

Photo: © Larry Thompson, 2007-2010. www.discoverlife.org

This avian information was summarized from multiple sources: Dunne et al. 1988, Palmer 1988, Johnsgard 1990, Preston and Beane 1993, MacWhirter and Bildstein 1996, Houston et al. 1998, Dunn 1999, Sibley 2000, Wheeler 2003, Marti et al. 2005.

The most common mammalian predators seen on the PORE beaches are red fox, coyote, and bobcat. Less commonly seen on beaches but present at PORE are striped skunks, ground squirrels, and raccoons. Other mammals that may prey on plover eggs, chicks, and adults are domestic dogs and domestic cats, which are not described here because of the large variability in size and coloring. The descriptions below were taken from Whitaker 1998 or Burt and Grossenheider 1976.



Red fox (*Vulpes vulpes*): 15–16” tall and 35–41” in length. Color is rusty-reddish above with white underparts, chin and throat. Tail is long and bushy with a white tip in all color phases (black phase, silver phase, cross/reddish phase); pointed ears; backs of the ears, lower legs, and feet are black. Shy, cunning, mostly nocturnal; opportunistic hunter that eats a wide variety of prey items and vegetation.

USFWS photo



Coyote (*Canis latrans*): 23–26” tall and approximately 4’ in length. Grizzled gray or orange gray above with buff underparts; long, rusty or yellowish legs with dark vertical line on the lower foreleg. Bushy tail with a black tip. Habitually uses long trails or runways with tracks; scat most often seen at intersections or open spots where coyotes linger to watch for prey. An opportunistic hunter that eats a wide variety of prey items, carrion, and fruit.

Photo: Richard Spencer



Bobcat (*Lynx rufus*): Length is 28–49". Tawny with indistinct spotting; short, stubby tail with black tip above and pale below; ears slightly tufted. Mostly nocturnal and solitary; feeds on small mammals and birds.

Photo: Dave Menke/USFWS



Striped skunk (*Mephitis mephitis*): head and body are 13–18, tail is 7–10" long. Black body, narrow white stripe up middle of forehead and broad white area on nape which appears to be a 'V' at the shoulders and two white lines continue down the back to the base of the bushy tail. Mainly nocturnal; omnivorous, feeding on mice, eggs, insects, grubs, berries, and carrion.

NPS photo



Ground squirrel (*Spermophilus beecheyi*): body and head is 9–11" long, tail is 5–9" long. Head and body are brownish, body flecked with buffy white; sides of neck and shoulders whitish; belly buff; conspicuous dark triangle on back between shoulders; tail bushy. Diurnal, colonial in pastures, grain fields, slopes with scattered trees and rocky ridges. Eats green vegetation, seeds, acorns, mushrooms, fruits berries, birds, eggs, and insects.

Photo: Gary R. Zahm/USFWS



Raccoon (*Procyon lotor*): head and body are 18–28", tail is 8–12" long. Body is salt and pepper in coloration; black mask over eyes; alternating rings of yellowish white and black on tail. Found along streams and lakes near wooded areas or rock cliffs. Mostly nocturnal, omnivorous and opportunistic in prey items which include fruits, nuts, grains, insects, frogs, crayfish, and bird eggs.

Photo: Will Elder/NPS

Snowy Plover Color-band Data

Although surveyors should not risk undo disturbance of nesting plovers to deliberately read color bands, they should survey and report them on the census data sheet. Potential colors include red, dark (royal) blue, light blue, bright green, light pale green, yellow, white, orange, pink, purple, brown, and black. Bands are read as the bird's left leg followed by the bird's right leg, top colors before bottom colors. Separate the colors on the left and right leg with a colon. Two or three colors on a single band are separated by slashes. For example, a bird that has single bands on each leg, yellow on the left leg band with a thin red strip around the center of the band and white on the right leg band, would be Y/R/Y:W. A bird with two bands on each leg, a white band over a green band on the left and a yellow band over a red band on the right, would be WG:YR. A bird that has single bands on each leg, yellow on the left leg band and pink over blue on a single band on the right leg, would be Y:P/B. Also note that sunlight can fade color bands making them more difficult to read. See appendix SOP 1C for additional information on reading and recording snowy plover color bands.

Breeding Activity Identification Methods

Some general strategies that are useful when searching for territories and nests are to

- Review maps in reports from previous field season to become familiar with potential nest site locations.
- Systematically search habitats in which birds are likely to nest, and note where empty nest scrapes are observed, or where pairs of birds are found.
- Follow plover footprints in fine sand working towards increasing densities of tracks.
- Watch potential nesting adults from a concealed position at least 10 m (33 ft) from the birds.
- During a survey identify “hot spots” of nesting behavior which indicate that a pair will be selecting a nest and female laying eggs soon. Make notes on plover activity and location. If necessary, return first thing the next morning to hot spots for more intensive observation from a concealed position (30 minutes to an hour per territory). A concealed position is one at which plovers are unable to detect the observer and is crucial for observation of undisturbed behavior. The dune area in Point Reyes serves as perfect cover for an observer.
- Surveyors should be cautious to not flush birds. Be particularly careful of disturbance when approaching roosting birds closer than 15 m (49 ft).

Territory Identification

Before nesting, snowy plovers establish territories and can be identified by the following behaviors

- Males standing alert and calling.
- Male and female standing or sitting together; occasionally calling to one another (be alert to calls).
- Male and female copulating.
- Males scraping with female nearby.
- A bird running away in a crouched posture.

Nesting Identification

Surveyors should monitor the position of a sitting adult carefully before going to look for a potential nest. Surveyors should look for the following snowy plover behaviors to help locate a nest:

- Females may flush from nests so be alert for running females.
- Males doing horizontal display with bill, body, and tail held parallel to the ground, and neck extended to attract female.
- Male runs repeatedly to a spot in territory and begins scraping (scratching at the ground with feet while rotating on breast).
- Female runs to scrape, steps in and begins scraping.
- Male bows and or fans tail feathers.
- Female stands near scrape with her body parallel to the ground (copulation begging).
- Copulation.
- Repeated distress calls.
- Agitated behavior, alert or feigning injury.
- Nervous preening.
- Female fast foraging.
- Male mate-guarding or chasing other plovers away from female.
- Sneaky behavior such as crouching or low horizontal walking.
- Contact calls between male and female.

If the nesting behaviors described above are seen, surveyors should move out of the area and observe the bird(s) from a concealed position (e.g., in dunes) at least 10 m (33 ft) away without loud talking, rustling, or gesturing. Surveyors should learn to move slowly, quietly and smoothly and be proficient at using binoculars and a spotting scope. If the snowy plovers detect the human presence, they will not act naturally so it is vital to stay concealed. To minimize stress to the birds as much as possible, if a surveyor can't find a nest within 60 minutes, they should leave and return later, or, hide and watch until birds resume undisturbed behavior. Surveyors should be careful where they step because nests blend perfectly with the ground.

Nest Protection

If a nest is located, is safe from high tides, and there is no apparent threat to the incubating adults, an enclosure with top is built, and the area fenced. A 3-m × 3-m fenced enclosure of mesh wire has been used with fiberglass posts on the corners and crow mesh netting on the top. Enclosure hardware is pre-positioned on the beach at the beginning of the nesting season and is carried from the nearest stash site in the dunes. Zip ties, crow netting, collapsible shovel, hammer, and measurement strings should be carried daily by the surveyors during nesting season.

Surveyors should mark a 3-m × 3-m square equidistant around the nest, then dig a one-foot deep trench. Surveyors use the hammer to pound the fiberglass posts into the corners, attach the 3-m lengths of fencing to the corner stakes with nylon-covered twist ties or zip-ties, and then attach the crow mesh netting top using zip-ties. The entire process of building the nest enclosure takes less than

20 minutes. The size of the fence openings are small enough that the plovers can exit and enter the nest enclosure without difficulty, but predators are excluded.

If more than one surveyor is present, the enclosure may also be constructed away from the nest and carried to the nest once complete. At this point, the one-foot deep trench may be dug beneath the fencing and the posts pounded into place. This method reduces the amount of time spent at the nest by about 15 minutes, but should not be attempted by a single surveyor due to the difficulty in placing the completed enclosure over the nest.

Recording Nest Data

Once a nest is found, it should be reported on the nest data sheet (Appendix SOP 1B) and assigned a Nest ID number. The Nest ID number is created using the location code for the survey area (i.e., K, NP), a sequential number for the nests in that survey area, and the survey year (i.e., K01_2009). Nest ID number should be confirmed using the database upon returning from the field. Surveyors should draw a very detailed map on the nest data sheet including notes of established landmarks to assist in nest re-location. The UTM coordinates, GPS accuracy (Estimated Precision Error [EPE]), and type of GPS unit is noted. Surveyors should indicate on the data sheet whether the nest is located within a restored dune area, the zone code (Table SOP 1.2), and the microhabitat code that apply to the nest location (Table SOP 1.3). Surveyors should note if they are able to see and confirm a color band combination for the male or female plover; leave blank until presence or absence of bands confirmed, possibly during subsequent visits if necessary. The original nest data sheets are kept in the office and a copy is taken to the field. On subsequent visit dates, surveyors use the data sheet copy or a field notebook to record the nest id, visit date and time, number of eggs seen, whether the male and female plover were present, and any notes on the condition of the nest or enclosure, signs of predators, etc. In the office, the subsequent nest check visit data is transcribed onto the original nest check data sheet and eventually entered into the program database.

Table SOP 1.2. Zone codes used in the PORE snowy plover monitoring nest check data sheet.

Zone Code	Nest Location
0	Zone unknown
1	Below current high tide line
2	In current high tide line
3	Between current high tide line and old high tide line
4	In old high tide line
5	Above old high tide line

Table SOP 1.3. Microhabitat codes used in the PORE snowy plover monitoring nest check data sheet.

Microhabitat Code	Description
S	Sand
R	Coarse sand, shell, pebble, rock
K	Seaweed or kelp
T	Washed up debris or trash from beach visitors
V	Vegetation or sand at the base of vegetation
C	Carcasses (specify)

If possible, surveyors should note when the first egg was laid and when the clutch was complete. Usually four days occur from the laying of the first to last eggs in the typical snowy plover three-egg clutch. If a one-egg nest is found, surveyors assume that clutch was initiated the day before the nest was found. If a two-egg nest is found, surveyors assume the nest started two days before the date it was found. If a three-egg nest is found, a surveyor cannot determine a clutch initiation date or completion date unless they know the scrape was empty four days prior to the date it was found. If a surveyor can't determine when the clutch was initiated directly, the initiation date can be estimated from the hatching date by estimating the initiation date to be 31 days earlier than the hatching date. That is because egg laying activity averages four days and incubation, from clutch completion to hatching, averages 27 days. If incubation lasts longer than 27 days from the date a three-egg clutch was found, initiation date is assumed to be four days prior to nest discovery date.

Monitoring Nest Status

Revisit the nest every three days to determine nest fate. During each visit record the nest id, visit date and time, number of eggs seen, whether the male and female plover were present, and any notes on the condition of the nest or enclosure, signs of predators, etc. The nest fate and chick fate boxes on the bottom of the data sheet (Appendix SOP 1B) are completed throughout the season as information is confirmed.

Nests should be checked daily starting at 25 days past known clutch completion dates for evidence of hatching. If an exact clutch completion date is not determined, nest checks should be made more frequently starting at 20 days past earliest estimated nest completion date.

Walk different paths to potential nest sites on different days to reduce chance of leaving a trail to the nest. Walk parallel to a nest, not towards it. Never approach a nest while the pair is actively courting. During revisits, walk past the nest just close enough to determine status and then keep walking in the same direction until you are out of the area. If birds make a distress call or seem agitated, leave and sneak back later in the survey period.

Determining if a Clutch Has Hatched

If hatching is determined, the hatch date is noted on the data sheet. Hatching can be determined by

- Tapping or cracks observed in eggs one to two days before eggs disappeared – not fail safe.
- Eggs disappear close to estimated hatch date with no signs of predation.
- Indication of a newly hatched brood in the immediate vicinity (direct observation, broody behavior exhibited by nearby adult).
- Flattened scrape with tiny egg shell fragments located in scrape.

The nest may fail for a variety of reasons. Below is a list of possible reasons for failure and criteria for determining the cause:

Depredated - Unknown Predator: Direct evidence that eggs were destroyed, include

- Substrate in nest scrape cemented together by egg yolk or egg white.
- Eggshell fragments or damaged eggs found well before estimated hatch date.

- Eggs gone well before estimated hatch date, no predator tracks to nest, and wind or tide would not have destroyed nest. Evidence may include:
 - scrape intact or still discernible, or substrate stable or level enough substrate such that wind would not cause clutch to be buried or eggs to roll out of scrape, or
 - substrate is too firm for imprint of predator tracks
- Unidentified predator tracks lead directly to nest site. Note however if potential predator tracks are observed leading towards a nest but gait is unchanging as it passes the nest site, that predator is should not associated with the clutch loss.

Depredated - Identified Predator: Direct evidence that eggs were destroyed, including

- Identifiable predator tracks that lead directly to the nest site.
- Timing of lain predator tracks coincides with nest loss, as indicated by substrate conditions (e.g., rain patterns or wind crust can help date tracks to a specific recent period).
- Potential predators include: coyote, fox, dog, raccoon, raven, weasel, skunk, and gull. In some cases one may only be able to determine if avian or mammalian.

Tide:

- Tide has washed over the original nest location leaving no evidence of the eggs or nest scrape, and there is no indication of a newly hatched brood in the vicinity.
- Eggs located near original location or nest washed over by the tide but no indication eggs being incubated.
- Tide has washed over nest location, eggs located near original nest location, and being incubated well past estimated hatch date.

Non-viable Eggs:

- Intact eggs of full clutch remain well after estimated hatch date along with evidence that there is consistent adult activity at nest location. Adult activity can be determined by presence of adult on nest, egg position changing from survey to survey, and fresh plover foot prints at the nest. Nests should be monitored until adult activity ceases.

Abandoned:

- Intact eggs of clutch remain but evidence of adult activity (footprints) at nest ceased well before the estimated hatching date. No evidence nest was washed over by tides or ever buried by windblown sand or other debris.

Wind:

- Eggs not being incubated and one of the following:
 - Intact eggs located outside of scrape, eggs not being incubated, no indication that any other species may have moved eggs, and nest has not been washed over by the tide.
 - Eggs in scrape and covered by wind-blown sand or other debris.

*Note: The distinctions between the above three categories (non-viable eggs, abandoned, and wind) can be difficult.

Trampled:

- Eggs found destroyed (not depredated) and tracks of a larger species directly through nest location. Nests can be trampled by people, pelicans, gulls, geese and a variety of mammals. Frequently the plovers remove shells of eggs from nests that have been trampled or depredated.

Destroyed – Human:

- Human footprints directly next to or on the nest location and:
 - one or more eggs missing from the clutch or
 - evidence that eggs were destroyed including shell fragments or sand cemented together with egg white or egg yolk in the former nest location.
- Human footprints at nest with evidence that something was dragged over, dropped or placed on nest.

Failed Unknown:

- Scrape and eggs gone well before estimated hatch date, with an absence of clear evidence of depredation, wind loss, tide, or trampling.

Unknown Fate:

- Eggs gone close to estimated hatch date but with evidence of hatch obscured by weather conditions or other factors.

Be careful in areas around abandoned or failed nests, a plover that lost a clutch can quickly re-nest nearby.

If a nest is abandoned by the adult plovers or has failed to hatch in over 35 days, confer with the PORE Wildlife Biologist on whether to collect the unhatched eggs. In the past, eggs have been collected and transferred to a USGS facility to test for methyl mercury or other pollutants. If eggs are collected, note the # of eggs collected and date collected in the egg analysis box field on the nest check data sheet. The eggs are stored in a freezer at PORE with the collection information until they can be transferred to a laboratory. Note on the nest check data sheet the location, date sent, and results as the information become available.

Monitoring Broods

Once a nest has hatched, chicks should be checked daily if possible but at a minimum of two times per week to determine timing of any loss that may occur. To monitor broods of chicks follow these general procedures

- Approach the area where the brood was last seen slowly and cautiously.
- Note if adults exhibit broody behavior (circling in the air, vocalizing, or feigning injury)
- Chicks can be difficult to see but are often within a few meters of the adult.
- If a brood is located record the number of chicks present, note location, and document behavior. If fewer than expected chicks are observed, continue searching for at least 15 minutes to be sure that other chicks are not hidden in the vicinity. Leave the area quickly, particularly if the tending adult is agitated.

- If the brood is not immediately located move away to a concealed position and wait for the birds to resume undisturbed behavior. Again, record the number of chicks present, location, and behavior.
- Once the chicks have been located and counted, leave the area. Any additional notes should be written well away from the site.
- If additional data collection is required (disturbance study or better aging) do so from a concealed area where your presence is not a factor and the birds are not disturbed further.
- First, determine what information is needed. For example, is it important to know the exact time of loss? Or, does general knowledge of loss suffice for your study area?
- When needing to determine the difference between weekday and weekend loss, all broods should be checked on Friday afternoon and again on Monday morning. If chicks are present on Friday but not on Monday morning, this is considered a weekend loss and should be recorded in your field notebook and data sheets as such.
- When trying to determine whether chick loss occurs in the day, at night, or at dusk or dawn, checks must be made within each of those time periods. For example, if chicks are present at 7 pm and again at 9 pm, but not present at 5 am, the loss event would be recorded as occurring at night (take into consideration changing hours of sunrise and sunset).
- Determining the timing of chick loss events can be time consuming and somewhat difficult. Remember that most brood checks cause some disturbance to the birds and should only be done at a minimum frequency required to answer the monitoring questions.
- If exact date of chick loss cannot be determined, the midpoint between two brood checks when a reduction in brood size is determined should be used as the date of loss.

Field Season Closeout

Equipment

At the end of the field season, signs and all fencing equipment should be removed from the beach and inspected. If new supplies and equipment are needed before the next field season, purchases should be coordinated with the PORE wildlife biologist. Equipment including spotting scope, tripod, binoculars, GPS units, etc., is cleaned and stored at the Resource Management Office. All signs, exclosure tops, and fencing rope should be stored in the garage next to the Resources Building at Bear Valley Headquarters; exclosure fencing and poles are stored at D Ranch and labeled as the snowy plover equipment.

Data Archiving

Any remaining data are entered, verified, and archived as described in SOP 4: Database Management. An annual report is written and circulated as described in SOP 5: Data Analysis and Reporting. Photos and project highlights are submitted to the PORE wildlife biologist and SFAN program manager for the PORE and SFAN annual reports.

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Appendix SOP 1A. Equipment list.

Snowy plover monitoring and protection program equipment and supplies list (updated 05/2007).

Item	Supplier	Approximate Cost	Notes
Habitat Fencing			
Parachute Cord	GSA	\$120/1,000 ft	GSA code: 4020-00-240-2146
Fiberglass Posts	Martin Ranch Supply, Rohnert Park	~\$5/each	6' tall, ½ inch diameter
Bird Nesting Area Signs	J.L. Darling Corp.	\$4.51 each (2005)	Lots of new ones still in box in wildlife garage
Cord Reel	Home Depot	\$5.97 each	Always needing more!
Exclosures			
Nylon-covered wire (dispens-o-wire)	OSH	\$4.49 per package	
Welded wire fencing (2"x4" openings, 5'x100', 14 gauge)	Building Supply/Home Depot	~\$80 per roll	One roll makes 2.5 exclosures.
3" or 4" standard plastic zip ties	GSA/Cyberguys	\$2.45/100	
Black Stealth Net 11'x11' Netting	Bird Barrier America	~\$15/net	
Signs			
Wooden Sign Boards (9'x12")			Lots still around
Laminated Signs			
Posts (1.5", 6–8' long, metal)	Home Depot and other hardware stores	\$5.98/each for 6' length, 16-gauge.	Make each year. Have to drill sign holes 9" apart. Can't use 16-gauge in dirt, only sand. Sign boards and hardware often have to be sawed off at end of season because of rust.
Hardware to attach sign boards (1/4" nuts and washers; 3.5" long x ¼" wide hex cap screws, coarse thread;	Building Supply or OSH (not Home Depot though)		Need new ones each year since old ones rust.

Appendix SOP 1B. Data sheets.

PORE Snowy Plover Census Data Sheet

DATE (mo/ds/yr) _____ OBSERVER(S) _____ TIME: _____ TO _____

Location: 1. Kahoe to Abbott's _____ 2. Abbott's to N. Beach _____
3. N Beach to S. Beach _____ 4. S. Beach to Lighthouse _____
5. Other _____

WIND: Direction _____ Average _____ (mph) Max _____ (mph) Temp _____ (F) rH _____ (rel. humidity) Cloudcover _____ %

OTHER WEATHER NOTES (visibility, precip., changes): _____

TIDE: (circle) HI-SLACK FALL LO-SLACK RISE

LAW ENFORCEMENT VIOLATION? _____

SURVEY NOTES: _____

[illegible]

M=Male, F=Female, H=Hatchling, FL=Fledgling, UN=Unknown Sex

Weather information taken from hourly averages at: <http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvprca>

PREDATOR NOTES:

Predator	Number	Predator	Number
Humans		Dogs off Leash	
Ravens		Dogs on Leash	
American Crows		Foxes	
Red-tailed Hawks		Barn Owl	
Peregrine Falcons		Great-horned Owls	
Northern Harrier		Coyotes	
Other			

SNOWY PLOVER BAND COMBINATIONS:

TIME	COLOR BANDS LEFT LEG	COLOR BANDS RIGHT LEG	NOTES

CODES FOR BAND COLORS:

Aqua (light blue), Blue (royal blue), Green, blacK, Lime (celery color), Orange, Pink, Red, Silver, Violet, White, Yellow, BrowN (tan), Dark (color undistinguishable). Capital letter=band on upper tarsus; lower case letter=band on lower tarsus.

PORE Nest Check Data Sheet

Nest ID Number: _____ (See Access database for proper formatting)

UTM E _____ UTM N _____ GPS Unit: _____

In restored area? Yes No

*Zone Code: _____ **Microhabitat Code: _____ Banded Male: _____ Banded Female: _____

Revisit Dates:

Visit #	Date	Time	# Eggs	M?	F?	Notes
Visit 1						
Visit 2						
Visit 3						
Visit 4						
Visit 5						
Visit 6						
Visit 7						
Visit 8						
Visit 9						
Visit 10						
Visit 11						
Visit 12						
Visit 13						
Visit 14						
Visit 15						
Visit 16						
Visit 17						
Visit 18						

NEST FATE:

CHICK FATE:

Date found: _____ Hatched: _____

Date hatched: _____ # hatched _____

Date exclosure established: _____

Date fledged: _____ # fledged _____

Initiation date: _____ Number of eggs: _____

Date(s)/age(s) at time of chick loss: _____

Date failure: _____ Failure reason: _____

EGG ANALYSIS:

Collected: _____

Sent to: _____

Date Collected: _____

Sent Date: _____ Results: _____

Storage Location: _____

*Zone Codes: 0=UNKNOWN, 1=BELOW CHTL, 2=IN CHTL, 3=BETWEEN CHTL AND OHTL, 4=IN OHTL, 5=ABOVE OHTL (CHTL=CURRENT HIGH TIDE LINE, OHTL=OLD HIGH TIDE LINE)

**Microhabitat Codes: sand=S, coarse sand, shell, pebble, rock=R, seaweed or kelp=K, washed up debris or trash from beach visitors=T, vegetation or sand at the base of vegetation=V, carcasses=C (specify). Substrate Relief: smooth to gently undulating=E, >25% of beach is steeply terraced to ocean=D, with human/dog foot prints=P, with horse prints=H, with vehicle tracks=A

Appendix SOP 1C. Leg bands.

This appendix describes the snowy plover leg band combinations used in the region. It is useful to have the band color list in the field until a surveyor becomes familiar with the different colors and can read bands with certainty.

Color-band Identification

Color-banded plovers from other monitoring sites can occur on PORE beaches. In the region, color banding of snowy plovers occurs at Monterey Bay, San Francisco Bay National Wildlife Refuge, and in November 2007, banding was done in San Francisco on both Ocean Beach and Crissy Field (Golden Gate National Recreation Area) following the Cosco Busan oil spill. Observations of color-banded snowy plovers are recorded on the data sheets (and should be reported to Lynne Stenzel at PRBO Conservation Science (lstenzel@prbo.org)). Reading color bands accurately on snowy plovers can be difficult, and observers should not risk disturbing nesting plovers to deliberately read color bands.



Figure APP SOP 1C.1. Leg band colors used in Northern California for snowy plovers. *Not shown in this list, Brown (N) is also used on coastal plover populations and is usually a tan color rather than a dark brown.*

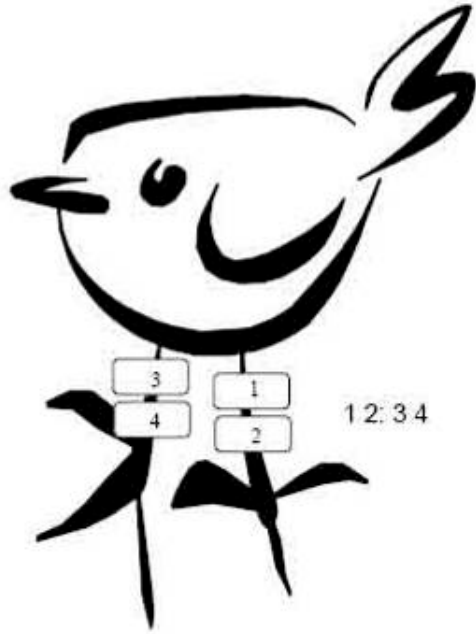


Figure APP SOP 1C.2. Example of the band locations on a banded bird.

There are different color combinations and both solid and striped color bands. Options include:

(1) a bird with a single band on each leg, yellow on the left leg band with a thin red strip around the center of the band and white on the right leg band, would be recorded Y/R/Y:W;

(2) a bird with two bands on each leg, a white over a green band on the left and a yellow over a red band on the right, would be recorded WG:YR;

(3) a single band on each leg, yellow on the left leg and pink over blue on a single band on the right leg, would be recorded Y:P/B.

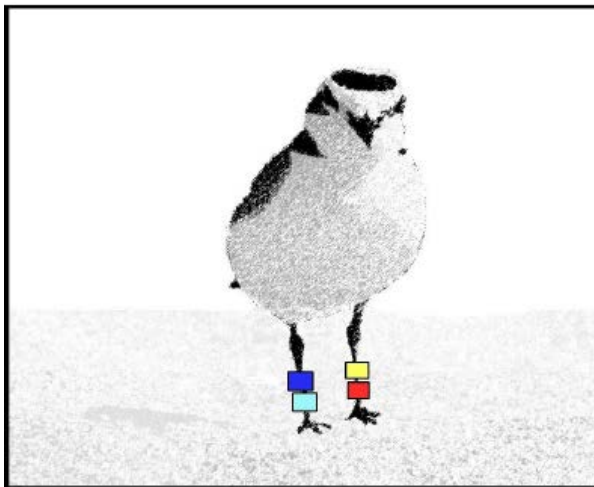


Figure APP SOP 1C.3. Example of a banded snowy plover (YR:BA). Source: USFWS 2007.

In figure APP SOP 1C.3, the bird has a yellow band (Y) above a red band (R) on its left leg and a blue band (B) above an aqua band (A) on its right leg. This combination should be recorded as YR:BA. Some plovers marked in Monterey Bay have a color band on the upper left leg, which make them more difficult to see. The data is recorded the same way, but observers should note that it is an upper leg band.

Literature Cited

U.S. Fish and Wildlife Service (USFWS). 2007. Recovery plan for the Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*). In 2 volumes. U.S. Fish and Wildlife Service, Sacramento, CA.

SOP 2: Field Safety

Version 1.5

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	Nov. 2008	R. Townsend, M. Koenen	Adapted from GOGA Protocol		1.0
1.0	Dec 2008	D. Adams	Formatting, addition of safety text		1.1
1.1	Dec 2009	D. Adams	Formatting		1.2
1.2	August 2011	D. Adams	Formatting, reorganization of SOPs and appendices; added earthquakes and tsunamis as hazards to JHA.	Response to peer review comments	1.3
1.3	July 2012	D. Adams	Minor formatting corrections and edits.	Response to 2 nd set of peer review comments	1.4
1.4	January 2014	D. Adams	Minor reformatting of table	Response to 3 rd set of comments from P. Latham	1.5

Overview

This SOP provides safety information related to monitoring snowy plovers at PORE and includes a job hazard analysis that follows the standard NPS template. Also see SFAN Field Safety SOP maintained on the network drive: X:\Shared\Standard Operating Procedures\SFAN Field SOPs\Standard Operating Procedures.

Weather and Field Attire

Summer conditions are often mild (60–80°F), but when conducting fieldwork along the coastal environment, it is important to dress appropriately for a range of weather conditions. Because of the general uneven terrain inherent in beach hiking and use of fencing equipment, field personnel should wear long pants and hiking boots. Since surveys can last longer than anticipated, field personnel are encouraged to take extra food and drinking water into the field.

Other Field Hazards

Biting or stinging invertebrates (wasps, spiders, ticks) may be encountered. The bites or stings from these animals can be painful, but usually not fatal. If bitten or stung and painful swelling or an allergic reaction occurs, seek medical attention immediately. Check your clothing and exposed skins

frequently when in the field for ticks and upon returning from the field, do a more thorough body search for ticks.

Poison oak is found primarily in the forest, but before doing any fieldwork personnel should be familiar with the dangers associated with exposure to this native plant. If exposure occurs wash thoroughly with soap and rinse with plenty of water upon returning from the field and then apply Tecnu® ointment. If a strong reaction occurs, contact your supervisor and seek medical attention.

A job hazard analysis (JHA) has been developed for the snowy plover monitoring program (Appendix SOP 2A). The JHA analyzes the duties, tasks, and potential hazards that are associated with the activities and addresses the hazards through safe work behaviors and procedures.

Appendix SOP 2A. Job hazard analysis.

Point Reyes National Seashore Job Hazard Analysis		
Division: Natural Resources	Project Title: Snowy Plover Monitoring	Analysis by: Rachel Townsend Date: 10/30/08
Location: Point Reyes National Seashore	Title of person who does job: Bio-Technician - Wildlife	Reviewed by:
Personal Protective Equipment: Long-sleeved shirt, thick pants, good walking shoes, hat, sunglasses and sunscreen, gloves.	Supervisor: David Press	Approved by:
Training and/or certifications		Permits:
A. SEQUENCE OF BASIC JOB STEPS	B. POTENTIAL JOB HAZARDS	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT
Identify steps and sequence of work activities	Task: Identify hazards in each basic step. Site: Identify site hazards that could affect workers	Determine specific controls and safe behaviors for each hazard.
Office Work- Computer use for email and data entry	Muscle and eye strain, repetitive stress injury	Proper posture and use of ergonomic furniture Take breaks every hour
Travel to Field Locations in Vehicle	Driving hazards such as accident	Use defensive driving techniques Expect oncoming traffic on one-lane roads in park Be alert for foggy conditions Obey traffic laws and wear seatbelt at all times Do not drive when fatigued, be familiar with route or prepare for unknown route Do not talk on cell phone while driving Do not put hot drinks on your lap Be familiar with the vehicle and it's operation Check gauges, tires, wipers, fluids and replace when necessary Check vehicle has spare tires, jumper cable and jack with all parts.

A. SEQUENCE OF BASIC JOB STEPS	B. POTENTIAL JOB HAZARDS	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT
Hiking to work areas in the parking lot, on the beach and visitor walkway	Getting lost or confused as a group	Have map and compass and other navigational aids and know how to use them.
	Losing a crew member	Travel together Make sure both members of the team are aware of location Arrange meeting places and times -all crewmembers must wear a watch. Have a travel plan for each day and make sure it is understood by all crewmembers Stay in communication via radio or stay in sight Carry cell phone to call dispatch if necessary If injured, stay put and call dispatch. Carry a light source and extra batteries.
	Lightning storms	In the event of a lightning storm, if near a vehicle, get entirely inside. If in the out of doors try to do the following: separate the group, get off ridge tops and away from trees or telephone/electric poles, get as low as possible and if possible lie on conductive material.
	Wind storms	If it is windy enough to forcefully blow sand and debris, try to get off the beach and away from hazard trees or lines.
	Exposure to cold, wet conditions	Wear proper equipment- and bring extra layers. Recognize the signs of hypothermia in yourself and others
	Exposure to heat and sun Overexertion and dehydration	Carry and eat high-calorie foods, stay well-hydrated Have hat, sunscreen and sunglasses Recognize the signs of dehydration
	Injuries due to hiking (aches, sprains and blisters)	Take rest stops when needed (15 min every 2 hours) and stay hydrated Pay attention to footing- plan ahead for the route to avoid steep, unstable terrain
	Injuries due to falling (lacerations, broken bones, head injuries)	Use appropriate footwear, boots and socks. Prevent blisters and have blister treatments (moleskin, tape, etc.) accessible. Pay particular attention to walking in areas where a lot of debris has washed up, in unstable terrain, and in foggy conditions.
		Have first aid kit, stabilize injured person, treat for shock and know how to initiate rescue via radio

A. SEQUENCE OF BASIC JOB STEPS	B. POTENTIAL JOB HAZARDS	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT
	Injuries due to carrying a heavy pack	Reduce pack weights when possible Pay attention to how you put your pack on (avoid twisting motions- get help or place pack on surface or against tree) Make sure your pack is properly fitted and balanced
Working in the outdoors	Exposure to allergy causing plants and insects	Alert crew members to possible problems with allergens. Be alert for toxic plants and alert to common bee and wasp nesting habitat and activity-especially the person in front.
	Exposure to toxic plants	Carry Benadryl, epic-pen or other anti-histamine Do not eat any fungi or plant unless you are 100% sure it is edible. Wear proper attire (long sleeved shirts and long pants) to avoid exposure to the sun, wind and fog.
	Establishing fence exclosures	Do not drink any water unless it has been filtered, boiled or treated in some fashion
		Wash hands when possible and carry hand cleaner Do not carry too much gear and hurt your back.
	Improper nutrition due to inappropriate food choices	Wear leather gloves. Be careful of wires that may be sticking out. Make sure that tetanus shot are current in case there is contact with skin breaks (e.g., puncture wounds).
	Strange or aggressive human interactions	Bring a variety of healthy, nutritious food that will give you good energy during travel and work. Do not rely on sugar snacks.
	Aggressive or confrontational behavior from canines	Terminate contact with visitor and leave the area, contact dispatch by radio or cell phone as soon as possible.
	Injuries due to dog bites	Remain calm and do not run. Place pack between yourself and the dog, back up slowly while avoiding eye contact, contact dispatch by radio or cell phone as soon as possible. Cover face and ears with arms and curl up. Lie still and try not to scream. If a dog bites, try not to pull back. Seek immediate medical attention. If the dog's owner is known or present, find out if the dog's rabies vaccination is current. Report the bite to the dispatch and local animal control office.

A. SEQUENCE OF BASIC JOB STEPS	B. POTENTIAL JOB HAZARDS	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT
Earthquakes	Injuries due to falling electrical wires, trees, debris, gas leaks, etc.	If the earthquake is detected while outside or driving, check in by radio or cell phone with your supervisor or dispatch and let them know your location and condition. Move immediately to higher ground after an earthquake along the coastline. If inside a building, take cover away from windows and overhead light fixtures. Get under a desk, table, or other strong structure. Move against a wall in the interior of the building, cover and protect yourself. Remember to DUCK, COVER and HOLD. After an earthquake, check for injuries; help others in the area and check the area for hazardous conditions, e.g., fire, electrical wires, fallen debris, gas leaks, etc. Barricade or flag off hazardous areas. Be prepared for aftershocks. Report to your supervisor or Division Chief and check in. Check out with them if you need to leave the area. Do not leave a building unless you know that conditions outside are safe.
Tsunamis	Increase in size of waves hitting the outer coast beaches could knock over a surveyor and pull them into the ocean.	Move immediately to higher ground after an earthquake along the coastline. Marin County emergency officials recommend moving to a point no less than 30 feet above sea level and suggest walking, rather than driving uphill. In general for surveyors out on the beach, this would mean getting off the beach as fast as possible and returning to your vehicle. To reach higher ground, surveyors would need to drive out to Pierce Point, return to Bear Valley Headquarters, or go to the Lighthouse or Chimney Rock areas. Monitor radio communication. Check in by radio with park dispatch or cell phone with your supervisor and let them know your location and condition.

SOP 3: Revising the Protocol

Version 1.5

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	Oct. 2007	M. Koenen		Created	1.0
1.0	Dec 2008	D. Adams	Formatting	For peer review	1.01
1.01	Dec 2009	D. Adams	Formatting	For peer review	1.2
1.2	August 2011	D. Adams	Formatting, reorganization of SOPs and appendixes	Response to peer review comment	1.3
1.3	July 2012	D. Adams	Minor edits and format corrections, updates to Table SOP 3.1.	Response to 2 nd set of peer review comments	1.4

Scope and Application

This SOP explains how to make changes to the snowy plover monitoring protocol narrative and accompanying SOPs and appendices, and tracking these changes. Observers asked to edit the protocol narrative or any one of the SOPs or appendices need to follow this outlined procedure in order to eliminate confusion in how data is collected and analyzed. All observers should be familiar with this SOP in order to identify and use the most current methodologies.

This SOP also contains a table listing the most current version of the protocol narrative and each of the SOP's. This will provide a single reference for ensuring that the most current documents are being used.

Also included in the appendices are comments from protocol reviewer, responses to those comments, and approvals.

Protocol Revision Procedures

Every attempt was made to incorporate the most sound methodologies for collecting and analyzing data. However, all protocols regardless of how sound require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken. Consider these steps when undertaking a review

1. Review edits for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by the SFAN I&M staff. However, if a complete change in methods is sought, an outside review is required. Regional and national staff of the NPS with familiarity in avian research and data analysis may also be utilized as reviewers. Also,

experts in avian research and statistical methodologies outside of the NPS will be utilized in the review process.

2. Document edits and protocol versioning in the Revision History Log that accompanies the protocol narrative and each SOP. Log changes in the protocol narrative or SOP being edited only. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02, etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
3. Inform the SFAN data manager about changes to the protocol narrative or SOP so the new version number can be incorporated in the metadata of the project database. The database may have to be edited by the data manager to accompany changes in the narrative and SOPs.
4. Post new versions on the SFAN internet page and forward copies to all individuals with a previous version of the affected protocol narrative or SOP.
5. Provide a revised copy of all documents to the Natural Resource Stewardship and Science office for uploading to the IRMA portal online library for permanent digital archiving, and submit it to the NPS Technical Information Center office for physical archiving.

Table SOP 3.1. Current snowy plover monitoring protocol documents.

Document Name	Current Version	Version Date
Snowy Plover Monitoring Protocol for Point Reyes National Seashore	7.1	January 2014
SOP 1: Field Methods	5.9	January 2014
SOP 2: Field Safety	1.5	January 2014
SOP 3: Revising the Protocol	1.5	January 2014
SOP 4: Data Management	1.6	January 2014
SOP 5: Data Analysis and Reporting	2.3	July 2012

SOP 4: Data Management

Version 1.6

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
NA	Nov 2008	D. Press	First draft of SOP.		1.0
1.0	Dec 2008	D. Adams	Format edits, SOP #		1.1
1.1	Nov 2009	D. Press	Added user interface features. Format edits.		1.2
1.2	Jan 2010	D. Adams, D. Press	Added data dictionary as appendix	Required element for protocol	1.3
1.3	August 2011	D. Adams	Formatting for consistency with rest of document	Peer review comments	1.4
1.4	July 2012	D. Adams	Formatting updates, minor edits	Response to 2 nd set of peer review comments	1.5
1.5	January 2014	D. Press, D. Adams	Formatting updates, updates to data dictionary appendix	Response to 3 rd set of comments from P. Latham	1.6

Introduction

Two critical long-term goals of the SFAN I&M program are to:

- integrate natural resource inventory and monitoring information into National Park Service (NPS) planning, management, and decision making
- share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives

For the PORE snowy plover monitoring program to meet I&M Program goals, a detailed management plan is needed to ensure data quality, interpretability, security, longevity and availability.

This SOP describes how the monitoring protocol meets these data management objectives through database design, quality assurance and control measures, metadata development, data maintenance, data storage, and data archiving. Procedures for data handling and quality assurance/quality control for all monitoring protocols implemented by the SFAN monitoring program are detailed in the program's Data Management Plan (Press 2005) and in the National I&M Program's Data Management Plan (NPS 2008).

This monitoring program has been conducted through a cooperative agreement with PRBO from 1995 to 2006, and in 2008, the NPS assumed the lead role in field monitoring and data collection. Prior to 2008, field data was managed by PRBO with annual data summaries and reports provided to PORE. The current database was built to host a variety of additional data fields (i.e., egg collection variables, additional disturbance fields) for concurrent snowy plover research studies that have occurred in the past and which may occur in the future but which are not part of this monitoring protocol.

Database Design

Database Model Overview

The SFAN staff has developed a relational Microsoft (MS) Access XP database for the snowy plover monitoring program at PORE compliant with the Natural Resource Database Template (NRDT) Version 3.2, an application developed by the NPS Natural Resource I&M Program. The data in the snowy plover database are simply organized around survey events of defined beach segments where snowy plovers nest or have the potential to nest during the breeding season. The survey or event data is related to the locations of snowy plovers observed, banded snowy plovers, nest check information, and the list of field staff present on the survey. Annual nest location and summary data are stored in a master nest table. Table relationships are displayed in figure SOP 4.1 and a complete data dictionary is included as Appendix SOP 4A.

The user interface for the database is modeled after the NRDT Front-end Application Builder (FAB) Version 1.0, an MS Access user-interface template designed by the NPS Natural Resource GIS Program.

Table Structure

The primary snowy plover monitoring events table, `tbl_Events`, is linked to `tbl_Event_Details` in a one-to-one relationship via an `Event_ID` Globally Unique Identifier (GUID; Figure SOP 4.1).

Whereas, `tbl_Events` is a standardized table that simply stores event location, date, and time values, `tbl_Event_Details` stores data values specific to the snowy plover monitoring events, such as weather details and the number of potential snowy plover predators observed during the survey.

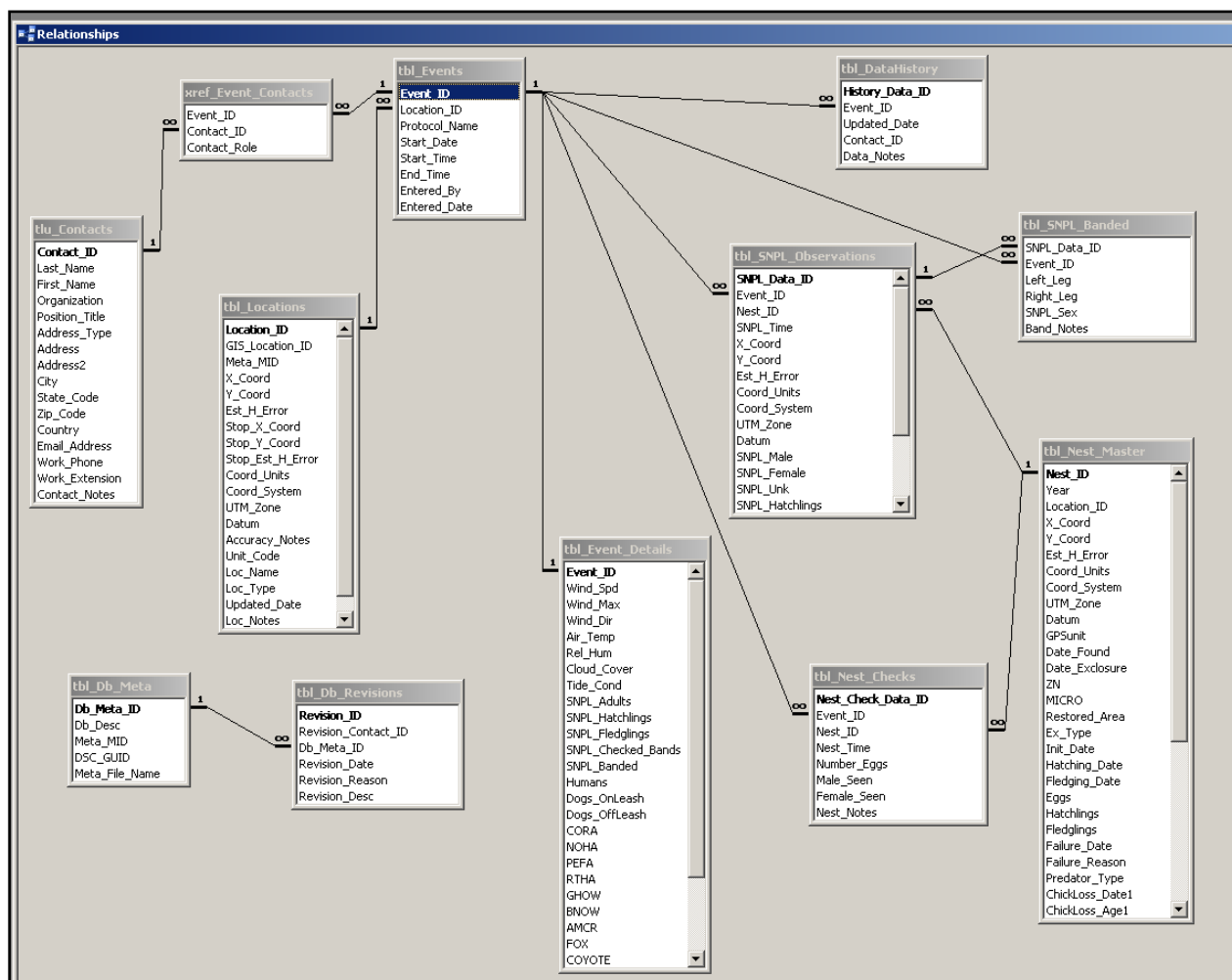


Figure SOP 4.1. Table relationships in the Point Reyes National Seashore snowy plover monitoring database, `SNPL_PORE_Master.mdb`.

`tbl_Events` is linked to five tables by one-to-many relationships (Figure SOP 4.1):

tbl_SNPL_Observations – Stores data regarding the time and location of snowy plovers encountered during a survey. Snowy plovers are categorized by males (M), females (F), adults of unknown sex (UNK), hatchlings (H), and fledglings (F). Locations are stored in the database as UTM coordinates. If plovers are observed at a nest, the nest ID code should be entered and data entry of UTM coordinates, which is stored for all nests in `tbl_Nest_Master`, is not required.

tbl_SNPL_Banded – Stores data regarding the bands observed during snowy plover observation events. Records in the table are linked to tbl_SNPL_Observations by the SNPL_Data_ID field. The two tables are linked by a one-to-many relationship such that multiple band records can occur for one observation record and a band record cannot exist without a related observation record.

tbl_Nest_Checks – Stores data regarding the time and results of observations at established nests.

tbl_Data_History – Records any data verification or editing procedures associated with the monitoring event or related data.

xref_Event_Contacts – A cross-reference table linked to tlu_Contacts which documents the field personnel that collected the snowy plover data.

During the course of the season, nest summary records are documented in the master nest table, tbl_Nest_Master. This table documents the UTM coordinates of each nest, initiation date, number of eggs, number of fledglings, and other information. The Nest_ID value in tbl_SNPL_Banded, tbl_SNPL_Unbanded, and tbl_Nest_Checks links the user to the parent nest record in tbl_Nest_Master. The Location_ID value in tbl_Nest_Master links the nest to the beach section in tbl_Locations where the nest was located.

User Interface

Use of the database is facilitated by a complete user interface adopted from the NRDT Front-End Application Builder Version 1.0. The user interface is designed to aid with data entry, data maintenance, and database documentation. Command buttons and code driven text boxes are used to navigate to forms, add data records, and locate and edit data records. Where possible, default values are set and combo boxes with fixed values are used to reduce data entry errors. For example, all fields that identify project personnel are set as combo boxes which link to the look-up table tlu_Contacts. The user interface includes the following key features:

frm_Switchboard (Figure SOP 4.2)

A start-up or welcome form which allows the user to navigate to data entry forms, set user default values, and view database release history. The start-up form is displayed automatically when the database is opened. Three tabs are available on the switchboard:

Main Menu

Command buttons for data entry, to view or edit nest records, modify values stored in look-up tables, to view the database window, to back up the back-end data file, and to connect the back-end data file to the front-end.

Defaults

Displays current default values and contains a command button that navigates to a form to change default values. Provides options for backing up the data files upon opening or closing the database, compacting the database on close, and verifying table links upon opening.

About

Contains version release information with command buttons to view more detailed version release history and to report a bug.

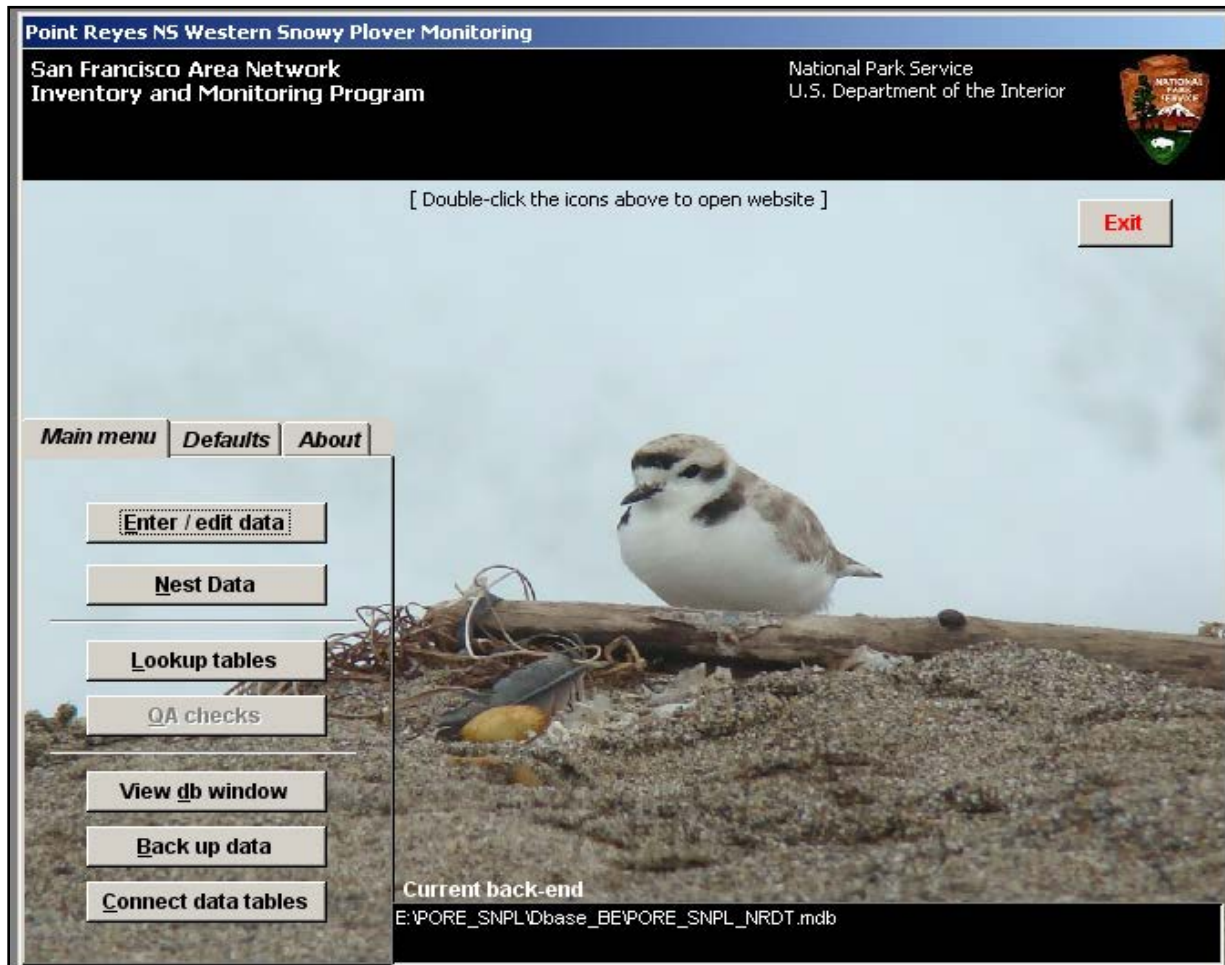


Figure SOP 4.2. Database switchboard - main screen of the user interface, viewed at startup.

frm_Connect_Tables (Figure SOP 4.3)

As previously described, the plover monitoring database application has separate front-end (user interface) and back-end (data tables) files. In order for the application to work properly, the front-end file must be connected to the correct back-end file.

On opening, if the database cannot establish a path to the back-end file, an error message appears which gives the user the option of fixing the connection. Choosing to do so opens `frm_Connect_Tables`, the data table connections form, which can be used to establish or correct the link from the front-end to the back-end. Alternatively, clicking the “Connect data tables” button on the database switchboard’s “Main Menu” also opens the data table connections form.

Update Data Table Connections

Update links to back end database tables

Data tables are stored in one or more separate database files. Check the filename and location on your computer for the following and use the browse button to change the file

Back-end data NRDT back-end database file

Current name: PORE_SNPL_NRD.T.mdb

Path: E:\PORE_SNPL\ibase_BE\PORE_SNPL_NRD.T.mdb

New file: **Browse**

Path:

Figure SOP 4.3. Table connections form used to link to the back-end data tables.

The name, path, and file name of the current back-end file are displayed in the data table connections form. To change the back-end file connection, click the “Browse” button, select a new back-end file, and click the “Open” button. You will be returned to the data table connections form and the “New file” and “Path” text boxes will be filled in. To make the new connection, click the “Update links” button. If the connection is made, a confirmation message will be shown and you will be returned to the database switchboard. As long as the connection remains valid, the user does not need to re-establish the link to the back-end file each time the database is opened.

frm_Set_Defaults (Figure SOP 4.4)

Prior to entering or editing survey data, user default settings must be set or verified.

Frm_Set_Defaults allows the user to specify their name, park, datum, and UTM zone. The values are then used as defaults in the data entry gateway and data entry form. Frm_Set_Defaults can be accessed by clicking the “Enter / Edit Data” button on the “Main Menu” tab of frm_Switchboard or by clicking the “Change” button under the “Defaults” tab of frm_Switchboard. The control source for frm_Set_Defaults is the hidden systems table tsys_App_Defaults.

frm_Data_Gateway (Figure SOP 4.5)

Once the defaults form is completed, frm_Data_Gateway, the data gateway form, will be displayed. This form displays location and event information for each monitoring record currently in the database, and is designed to help the user locate records to edit or view. By default, the data gateway form starts off with a filter for the default park that was selected on the defaults form, which at this time is restricted to PORE. The control source for frm_Data_Gateway is the query qfrm_Data_Gateway.

Set application default values

OK

User: Hughey_Lacey

Park: PORE

Datum: NAD83

UTM Zone: 10N

Protocol: PORE SNPL

Project: PORE SNPL

New user

Figure SOP 4.4. Form for setting application default values.

Sample Data Gateway - List of data that have been entered

* Double-click on the field label to change sort order. Double-click on a Location Name to open the Locations form for that record or a Visit Date to open the Data Entry form for that record.

Add a new record Close

Filters

Park: PORE Location Name: Year: Visit Date: Filter Is On

Unit*	Location Name*	Year*	Visit date*
PORE	Drakes Beach	2009	18 May 2009
PORE	Kehoe Beach	2009	26 Jun 2009
PORE	Kehoe Beach	2009	05 May 2009
PORE	Kehoe Beach	2009	18 Jun 2009
PORE	Kehoe Beach	2009	29 Jun 2009
PORE	Kehoe Beach	2009	21 Jul 2009
PORE	Kehoe Beach	2009	10 Mar 2009
PORE	Kehoe Beach	2009	18 May 2009
PORE	Kehoe Beach	2009	04 Jun 2009
PORE	Kehoe Beach	2009	01 Apr 2009
PORE	Kehoe Beach	2009	16 Jun 2009
PORE	Kehoe Beach	2009	19 May 2009
PORE	Kehoe Beach	2009	10 Aug 2009
PORE	Kehoe Beach	2009	04 Aug 2009
PORE	Kehoe Beach	2009	30 Mar 2009
PORE	Kehoe Beach	2009	22 Jun 2009
PORE	Kehoe Beach	2009	18 Aug 2009
PORE	Kehoe Beach	2009	13 Apr 2009
PORE	Kehoe Beach	2009	16 Mar 2009
PORE	Kehoe Beach	2009	26 May 2009
PORE	Kehoe Beach	2009	28 Jul 2009
PORE	Kehoe Beach	2009	11 May 2009
PORE	Kehoe Beach	2009	07 Aug 2009
PORE	Kehoe Beach	2009	05 Jun 2009

Figure SOP 4.5. Gateway to the data entry screens, for browsing and selecting data records.

Additional filters for Year and Visit Date can be set by selecting from the drop-down lists at the top of the form in the Filters box. Filters can be removed by clicking the toggle button that says “Filter Is On”. It will toggle up and say “Filter Is Off” when the filter is removed. When the filter is removed, all records will again be displayed. Optionally, a specific filter can be removed by deleting the text that is currently displayed in one of the filter controls.

In addition to filters, there are sorting options for the records on the data gateway form. Double-clicking any of the column headings will cause the records to be sorted in ascending order by that column value. The column heading will change to a bold italic format to indicate that it is the column being used to determine sort order. If the same column is double-clicked a second time, the records will be sorted in descending order by that column value.

Double-clicking a “Location Name” value will open the locations form for that particular record (see the locations form section that follows). Double-clicking a “Visit Date” will open the data entry form for that particular record. To add a new data entry record, click the “Add a new record” button at the top of the data gateway form.

frm_Data_Entry (Figure SOP 4.6)

The snowy plover survey data entry form with subforms nested within separate tabs at the bottom of the form. Data entry for beach segment surveys, nest checks, and data history records all occur within this form. The control source is the query qfrm_DataEntry. Frm_Data_Entry is accessed from frm_Data_Gateway. The subforms include:

Observers (Figure SOP 4.6)

The observers subform is located in the top-left of the data entry form. The subform is used to record all observers present during the survey. Observer names are entered using a combo box with look-up values stored in the contacts table (tlu_Contacts). The role of each observer may be designated in the subform. The control source for the form is xref_Event_Contacts.

Snowy Plover Observations (Figure SOP 4.6)

Includes time, location, and number of snowy plovers observed. Snowy plovers are categorized by males (M), females (F), adults of unknown sex (UNK), hatchlings (H), and fledglings (F). Locations are stored in the database as UTM coordinates. If plovers are observed at a nest, the nest ID code should be entered and data entry of UTM coordinates, which is stored for all nests in tbl_Nest_Master, is not required. The control source for the form is tbl_SNPL_Observations. The subform is nested within the first tab at the bottom of the data entry form.

Data Entry Form - Filter by sampling event

Location: North Beach [Add New] [Edit]
 X/Y: X: Y: Unit Code: PORE
 Protocol Name: PORE SNPL
 Start Date: 5/10/2009 Start Time: 9:30 End Time: 13:48
 Survey Notes:
 Law Enforcement Violation: ☒ Notes: dogs in plover area, issued verbal warning from L

Contact: Hughey, Lacey Role: notetaker
 * [] []
 [Add a person] [Add / edit nest data] [Close]
 [New record] [Delete record]

Survey Conditions
 Avg Wind: 14 Relative Humidity: 85
 Max Wind: 24 Cloud Cover: 70
 Air Temp: 51 Wind Dir:
 Tide Condition: Fall

SNPL Summary Results
 SNPL Adults: 13
 SNPL Hatchlings: 0
 SNPL Fledglings: 0
 SNPL Checked Bands: 13
 SNPL Banded: 2

Predators

	Humans	NOHA	
Dogs On Leash	35	CORA	0
Dogs Off Leash	1	FOX	26
COYOTE	1	BNOW	0
RTHA	0	PEFA	0
GHOW	0	AMCR	1
OTHER			
Predator Notes			

SNPL Observations | SNPL Bands | Nest Checks | Data History

	Time	UTME	UTMN	Error	M	F	Unk	H	FL	ACT	ZN	Bands	Nest ID	
▶	10:30	503485	4218472		1	1	0	0	0	N	5	1		Il bo:ov
	11:00	503430	4218387		2	2	0	0	0	F	4	0		male scraping, T-CP
	11:21	503230	4217720		1	0	0	0	0	N	5	1		l yo:w
	12:24	502982	4216995		2	2	0	0	0	N	5	0		Ill
	12:45	502799	4216426		0	1	0	0	0	N	5	0	NP02_2009	2 eggs, female on nest
	13:20	502634	4215850		1	0	0	0	0	N	4	0		I
*														

Record: 1 of 6

Figure SOP 4.6. Primary field data entry form, displaying the observer and snowy plover observation subforms.

Snowy Plover Bands (Figure SOP 4.7)

This subform is for data entry of plover bands observed and recorded during plover observations events. Banded snowy plover records are linked to snowy plover observation records such that the observations must be entered before the band records. In the banded plover subform, the Time field is a drop down menu that lists the available plover observations events for the survey. Selecting the time will set the correct SNPL_Data_ID value to the records and ensure a link between the band record and the correct observation record. The control source for the form is tbl_SNPL_Bands. The subform is nested within the second tab at the bottom of the data entry form.

	Time	Nest_ID	Left Leg	Right Leg	Sex	Notes
▶	10:30		bo	ov	M	
	11:21		yo	w	M	
*						

Record: 1 of 2

Figure SOP 4.7. Subform for entering records of banded snowy plovers observed in the field.

Nest Checks (Figure SOP 4.8)

This subform is for data entry of nest checks that occur during the course of the survey. The Nest_ID must be identified and check boxes indicate if the male and female were present. The number of eggs and any other relevant notes may also be entered. The control source for the form is tbl_Nest_Checks. The subform is nested within the third tab at the bottom of the data entry form.

	NestID	Time	Eggs	Male	Female	Notes
▶	NP02_2009	12:45	2	☐	☒	female on nest, intact after high tide event
*			0	☐	☐	

Record: 1 of 1

Figure SOP 4.8. Subform for entering nest check records.

Data History (Figure SOP 4.9)

The data history subform is used to note data verification events and especially to track relevant edits to existing data. The control source is tbl_DataHistory. Located at the top of the subform are the “Entered By” and “Entered Date” fields, which are stored in tbl_Events. The database populates these two fields automatically, using the default settings at the time of data entry to assign the “Entered By” contact name. The subform is nested within the fourth tab at the bottom of the data entry form.

Date	Contact	Notes
8/18/2009	Press, David	imported survey data from MS Excel file surveys_2009
10/19/2009	Hughey, Lacey	All 2009 data error-checked as of 10/19/09.
* 11/12/2009		

Figure SOP 4.9. Subform for entering data history records events associated with snowy plover surveys.

frm_Locations (Figure SOP 4.10)

A form that allows the user to enter or edit information, including geographic UTM coordinates, for project survey locations. For the snowy plover monitoring program, the survey locations are beach segments. UTM coordinates for both beginning and end points are stored in each beach segment location record. The Location ID value, which uniquely identifies an observation point, is automatically generated by the database. The control source is tbl_Locations. Frm_Locations can be accessed from frm_Data_Gateway by double-clicking any location name. From frm_Data_Entry, the locations form may be opened by either the “Add new” or “Edit” command buttons at the top of the form.

frm_Contacts (Figure SOP 4.11)

The contact information form, frm_Contacts, is used to enter details about individuals who participate in data gathering for the snowy plover monitoring protocol or who enter information in the database. The control source is tlu_Contacts. The contact information form can be accessed from clicking the “New user” button on the defaults form or the “Add a person” button on the data entry form. Values entered in the form include name, organization, position, work phone, email address, and mailing address. Previously entered addresses can be selected from the Address 1 drop-down list, and the associated Street Address, City, State, Zip, and Country values will automatically be filled in. The Organization and Position/Title drop-down lists will also allow selection from previously entered values or new entries. The Contact ID value, which uniquely identifies a contact, is automatically generated by the application.

Locations

Location ID: {764DC5D8-DDE7-49E6-B146-A9328A9BB8B6}

NPS Unit: PORE Location Type: Beach Section

Location Name: North Beach

X Coord. Coord. Units UTM Zone 10N Est. H. Error

Y Coord. Coord. System Datum NAD83 Accuracy Notes

GIS Location ID Meta MID

Location Notes: North Beach to Abbott's Lagoon

Updated Date: 04/30/2009 13:45:1

Close Delete

Record: 3 of 6

Figure SOP 4.10. Form for entering and editing project location information.

View and edit contact information

Filter: ☐ View all contacts ☒ Filter by search

Search: Hughey, Lacey Close

First name: Lacey Edit record New record

Last name: Hughey

Organization: NPS Address Type: mailing and physical

Position/title: Biological Technician Address 1: One Bear Valley Road

Work phone: (415) 464-5910 ext. City: Point Reyes Station

Email: lacey_hughey@nps.gov State Code: CA Zip Code: 94956

Country: USA

Comments:

Contact ID: {F3FD8745-7F34-4152-83DD-D50344CDDCA8}

Record: 1 of 1 (Filtered)

Figure SOP 4.11. Form to view and edit contact information, displayed in view mode.

When the contact information form is in view mode, noted by a blue-grey color background, individual contacts can be shown by selecting from the “Search” drop-down list at the top right of the form. All contact records can be displayed by clicking the “Filter” toggle button to “View all contacts”. To re-activate the “Search” drop-down list, the toggle button must be set back to “Filter by search”.

In view mode, records can only be read, not edited. To enable editing for a record, click the Edit record button. The form can also be set to edit mode, noted by a haystack color background, by clicking the “New record” button. Once you have completed entering data, click the “Done” button to return the form to edit mode and view all records. Alternatively, you may cancel your edits or additions at any time when in edit mode by clicking the “Undo” button.

frm_Nest_Master (Figure SOP 4.12)

During the course of each season, records of snowy plover nests are created and maintained, eventually establishing the chronological history and fate of each nest. Nest records are entered into the nest master form, `frm_Nest_Master`, the control source for which is `tbl_Nest_Master`. The form can be accessed by clicking the “Nest Master” button from the “Main Menu” tab of the database switchboard, or by clicking the “Add/edit nest data” button from the data entry form. Data entry fields include nest location UTM coordinates, estimated establishment and hatching dates, number of eggs, hatchlings, and fledglings. The form design is modeled after the previously described contact information form (`frm_Contacts`), and therefore retains the same view and edit modes of the form, filter capabilities, and command buttons. In this case the form is designed to filter records according to location (i.e., Kehoe Beach), resulting in the display of all records for the specified location for all years.

frm_Lookups (Figure SOP 4.13)

Clicking the “Lookup Tables” button on the database switchboard’s “Main Menu” tab will open `frm_Lookups`, the form for managing lookup tables. On the “Other lookup tables” tab, lookup tables can be selected from the “Table” drop-down list. The values in the lookup table will be displayed in a datasheet view below the drop-down list. If the table is listed as “Editable” in the drop-down list, then records can be edited, deleted, or added in the datasheet view. The FAB database application adopted for the plover database came pre-loaded with the table `tlu_Enumerations`, which stores look-up values for a variety of standard needs, such as NPS park unit codes, state codes, and UTM zones. Additional values and categories may be added to this table. Many of the pre-designed forms that came with the FAB database use combo boxes that refer to values in `tlu_Enumerations`. The only other current look-up table in the database is `tlu_NestFailure`, which stores nest failure values used in the form `frm_NestMaster`.

View and edit SNPL nest summaries

Filter:
☒ View all records
☐ Filter by search
Location:
Kehoe Beach
Close

Year
2009
Edit record
New record

Nest ID
K04_2009

Location
Kehoe Beach

Spatial Information
UTME
503945
UTMN
4220284
UTM Error
Coord Units
m
Coord System
UTM
UTM Zone
10N
Datum
NAD83
GPS Unit

Dates
Date Found
6/14/2009
Date Exclosure
6/14/2009
Initiation Date
6/11/2009
Hatching Date
Fledging Date
Failure Date
6/20/2009

Nest Outcome
Exclosure Type
s
Disturbance
Failure Reason
Tide
Predator Type
Eggs
2
Hatchlings
0
Fledglings
0
Female Band
Male Band

Habitat
ZN
5
MICRO
RPKE
Restored Area
☐

Egg Analysis
When Taken
Where To
Results

Chick Loss

Date	Age	Weekend
1)		☐
2)		☐
3)		☐
4)		☐

Comments

Record:
3
of 229

Figure SOP 4.12. Form to view and edit nest summary records, displayed in edit mode.

Manage Lookup Tables Close

Other lookup tables

Table: lu_Enumerations Note: Only certain lookup tables allow edits. Please contact the Project Lead or Data Manager if you need to change the domain values for non-editable lookup tables.

Enum_Code	Enum_Description	Enum_Group	Sort_Order
9N	UTM Zone 9 North	UTM Zone	8
8N	UTM Zone 8 North	UTM Zone	7
7N	UTM Zone 7 North	UTM Zone	6
6N	UTM Zone 6 North	UTM Zone	5
5N	UTM Zone 5 North	UTM Zone	4
55N	UTM Zone 55 North	UTM Zone	20
4N	UTM Zone 4 North	UTM Zone	3
3N	UTM Zone 3 North	UTM Zone	2
2S	UTM Zone 2 South	UTM Zone	1
20N	UTM Zone 20 North	UTM Zone	19
19N	UTM Zone 19 North	UTM Zone	18
18N	UTM Zone 18 North	UTM Zone	17
17N	UTM Zone 17 North	UTM Zone	16
16N	UTM Zone 16 North	UTM Zone	15
15N	UTM Zone 15 North	UTM Zone	14
14N	UTM Zone 14 North	UTM Zone	13
13N	UTM Zone 13 North	UTM Zone	12
12N	UTM Zone 12 North	UTM Zone	11
11N	UTM Zone 11 North	UTM Zone	10
10N	UTM Zone 10 North	UTM Zone	9
ZUCI	Zuni-Cibola National Historic Pa	Unit Code	536
ZION	Zion National Park	Unit Code	535
YUHO	Yucca House National Monumer	Unit Code	534
YUCH	Yukon-Charley Rivers National F	Unit Code	533
YOSE	Yosemite National Park	Unit Code	532
YORK	Yorktown National Cemetery	Unit Code	531
YONB	Yorktown Battlefield	Unit Code	530
YELL	Yellowstone National Park	Unit Code	529
WWII	World War II Memorial	Unit Code	528
WUPA	Wupatki National Monument	Unit Code	527
WRST	Wrangell-St. Elias National Park	Unit Code	526

Record: 1 of 633

Figure SOP 4.13. Form to manage look-up table values, showing the enumerations look-up table as an example.

Annual Data Work Flow

Rather than enter snowy plover monitoring data directly into the master database, satellite databases are created at the beginning of each monitoring season that parallel the structure of the master database. The SFAN data manager prepares the database and provides it to the PORE field staff. The satellite data tables are blank in each of the databases, but tbl_Locations and the look-up tables are populated and ready for use. The SFAN data manager confirms all default values, such as field season, prior to distribution. The database is provided in MS Access XP format.

Satellite databases should be backed up regularly during the course of the season. CDs are a good option for back-ups. Databases can also be regularly copied to an archive on the network, to a hard drive, or both. File names of back-up databases should include the date of the back-up, such as: SNPL_PORE08_Satellite_050108_BackUp.

At the end of each season, the field staff is responsible for proofing the data entry records in the satellite database against field notes and paper datasheets completed during the surveys. When complete, the satellite databases are sent or provided to the SFAN data manager for additional review and certification. The data manager works with the project lead and the field staff to complete any final edits or additions to the seasonal dataset. See Data Verification and Validation Procedures for more information.

Once certified, the data manager imports the satellite data into the master database, appends the data to the appropriate tables, and archives the satellite database within the I&M directory. A copy of the final satellite database and a new copy of the master database are provided to the PORE snowy plover staff.

Quality Assurance and Quality Control

The success of the snowy plover monitoring program is dependent on the quality of the data it collects, manages, and disseminates. Analyses performed to detect ecological trends or patterns require data that are recorded properly and have acceptable precision, accuracy, and minimal bias. Poor-quality data can limit detection of subtle changes in ecosystem patterns and processes, can lead to incorrect interpretations and conclusions, and can greatly compromise the credibility of the program managing it.

Quality assurance (QA) can be defined as an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the consumer. Quality control (QC) is a system of technical activities that measure the attributes and performance of a process, item, or service relative to defined standards (Palmer 2003). While QA procedures maintain quality throughout all stages of data development, QC procedures monitor or evaluate the resulting data products.

To ensure that the snowy plover monitoring program produces and maintains data of the highest possible quality, QA/QC procedures are implemented to identify and minimize errors at each project stage associated with the data life cycle.

Data Collection

Attention to detail during the data collection phase is crucial to overall data quality. Unlike a typographical error that occurs during data entry, an incorrect observation in the field is not easily corrected. The snowy plover monitoring program adopts the following guidelines regarding data collection that affect data quality:

- Field crews will receive proper training in data collection and recording.
- Field equipment will be regularly maintained and calibrated.
- Data will be recorded on pre-formatted, project-specific datasheets that reflect the overall design of the project and are designed to minimize the amount of writing necessary to effectively record observations.
- The format of field data sheets will be reflected in the computer data entry interface to help ensure all relevant information is recorded and subsequent data entry errors are minimized.
- Field forms will be reviewed for completion and errors each day in the field.
- Nest check data sheets will be copied before taken into the field again.

Data Entry

Data entry is the process whereby the raw data collected in the field are transferred from paper field forms and notes into the project databases. The snowy plover field staff performs all data entry into seasonal satellite databases. The goal of data entry is to transcribe field observations into a computer database with 100% accuracy, although errors are unavoidable. Several QA/QC practices help to reduce errors during the data entry phase:

- Data will be entered as soon as reasonably possible after collection
- Data entry will be completed by someone familiar with data collection.
- The project lead or SFAN data manager must ensure that data entry staff is familiar with the database software, database structure, and any standard codes in the databases. At a minimum, data entry technicians should know how to open a data entry form, create a new record, edit an existing record, and exit the database properly. They must also learn how to correct mistakes made while typing.
- Data will be entered into pre-designed database forms that resemble field sheets to the greatest extent possible. Data entry forms maximize error control wherever possible, include the use of default values, limiting data entry domains to values in drop-down menus, and auto-generating certain codes.
- Data will be entered, one logical "set" at a time. Paper forms are initialed and dated when completed to avoid confusion about what has been entered and what has not.

Data Verification

Following data entry, subsequent data verification is conducted to ensure that the raw data on the paper datasheets matches the entered data. The snowy plover field staff verifies all data in the seasonal satellite databases before forwarding on to the SFAN data manager. The following steps occur during the data verification phase:

1. Data verification is carried out by staff thoroughly familiar with data collection and entry
2. A visual review after data entry is performed with one person reading aloud from the original datasheets while a second person checks the corresponding entered data in the database
3. Errors in the data are immediately corrected once discovered
4. When complete, a verification record is added to the data history table in the database and the paper datasheet is initialed and dated
5. All records (100%) are verified against the original source data
6. A subset of randomly selected records (10%) is reviewed after initial verification by the SFAN data manager and if significant errors are found, the entire data set should be verified again by the project field staff.

Data Validation

Data verification checks that the digitized data match the source data, while *data validation* checks that the data make sense. Although data entry and verification can be handled by personnel who are less familiar with the data, validation requires in-depth knowledge about the data. The SFAN data manager performs all data validation procedures on the seasonal satellite databases before integrating the data into the master databases. The data manager consults with the project lead, the field staff, or directly reviews the datasheets to correct any errors that are discovered.

During the data validation phase, the data manager checks all the satellite databases for the following and makes corrections as needed:

- Verification records for all survey data records.
- Erroneously generated records with no actual data.
- Orphaned records within the sub-tables (i.e., no link back to tbl_Events).
- Data outliers—applies to both numerical and date/time values.
- Logic errors (e.g., start time is after the end time, more snowy plover fledged from a nest than there were eggs).
- Correct values for fields with fixed domains (e.g., nest enclosure type, nest failure reason).
- Complete data entry for all required fields.

Data Certification

The final QA/QC step, and the final step in the annual data work flow, is data certification, which occurs after all of the seasonal data has been verified and validated as described above. The data manager certifies the seasonal data by formally documenting that all QA/QC procedures have been completed and then appends all of the seasonal data in the satellite database to the appropriate tables in the master database. Certification is documented in the snowy plover database history log, which is described in more detail in the next section.

Version Control Guidelines and Database History

Version control guidelines for the snowy plover monitoring database will follow those presented in the SFAN Data Management Plan (Press 2005). Prior to any major changes to the database design, a back-up copy of the database should be made. Once the database design changes are complete, the

database should be assigned the next incremental version number. The final copy of the previous database version should be archived with the version closing date incorporated into the database title. Version numbers should increase incrementally by hundredths (e.g., version 1_01, version 1_02, etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2_0, 3_0, 4_0 ...). With proper controls and communication, versioning ensures that only the most current database version is used for queries and analyses. Significant database re-design may require approval by the project lead, review by other data management staff, and revisions to this data management SOP. The database version number should be included in the file title of the database, for example, SNPL_PORE_Master_v1_00.

Elements within the snowy plover monitoring database help to document database metadata, release and revision history. First, the database retains two tables (tbl_Db_Meta and tbl_Db_Revisions) from the NRDT Version 3.2 for capturing metadata (Figure SOP 4.1) that are maintained by the SFAN data manager. The table tbl_Db_Meta is designed to facilitate metadata creation and integration with I&M metadata systems. The field Db_Meta_ID is the primary key for tbl_Db_Meta and provides the link to revision history records in tbl_Db_Revisions. The Db_Desc field is a memo field for describing the purpose of the database application. When metadata for the NRDT database is uploaded to the NPS Data Store, the Meta_MID field stores the metadata master ID generated upon upload. When metadata for the database is created using the I&M Dataset Catalog desktop metadata application, the globally unique record ID generated by the Dataset Catalog should be copied to the DSC_GUID field. The table tbl_Db_Revisions stores the application revision history. Linking tbl_Db_Revisions to tbl_Db_Meta using Db_Meta_ID facilitates accessing the revision history for inclusion in each metadata record.

Adopted from the NRDT FAB, the hidden systems table tsys_App_Releases is used to document release information for all versions of the database application. It is filled in by the SFAN data manager before the application is distributed. Included in tsys_App_Releases are the title, version, release date, and information about the author of the application. Associated with tsys_App_Releases is tsys_Bug_Reports, where the SFAN data manager can report any known bugs, such as non-working or dysfunctional features of the database. The table includes details of the problem and when / how it was fixed. The form frm_App_Releases (Figure SOP 4.14) allows the database user to view the release history and known bug information in a read-only format. The form can be accessed from frm_Switchboard's "About" tab.

The data manager maintains an additional history log of the snowy plover monitoring databases in a Microsoft Word document titled SNPL_PORE_Database_Log located at:

Inpgogamahe1\Divisions\Network I&M\Individual Vital Signs\SnowyPlover\PORE\data

All design modifications to the databases are logged in more detail within the history logs and are referenced to changes in database version numbers. Design modifications include changes to the table structure, user interface, or underlying macros and Visual Basic code. Major changes to the data themselves are also noted in this document, such as when a new set of annual data is certified and uploaded. It is especially important to note edits to the data that will result in changes to final data

summaries previously published in annual reports or other media. This will prove invaluable to data users attempting to understand differences in data between years.

Application Releases

Release ID: {A8D245EC-1798-4635-AC55-3AD3E06BCD4F}

Database title: Point Reyes NS Western Snowy Plover Monitoring

Version number: 1.0 Release date: 8/10/2009

File name: PORE_SNPL_FrontEnd Release by: Press, David

Author phone: (415) 464-5202 Author email: dave_press@nps.gov

Author org code: SFAN Author org. name: San Francisco Area Netw

Release notes:

Known bugs:

Record: 1 of 1

Figure SOP 4.14. Form for viewing and entering release information with a subform for known bug descriptions.

The database history may also be used each year to summarize anything that was unique or changed about the year's methodology and is therefore reflected in the annual dataset. Notes on techniques for collection and review of data are also very helpful. All entries into the database log must be dated and tagged with the name and title of the individual entering the record into the log.

Metadata Procedures

The NPS GIS Committee requires all NPS GIS data layers be described with the NPS Metadata Profile, which combines the FDGC standard, elements of the ESRI metadata profile, the Biological Data Profile, and NPS-specific elements. Although no standard has been applied to natural resource

databases and spreadsheets, SFAN will complete the NPS Metadata Profile to the greatest extent possible to document the master snowy plover monitoring database. Because the annual datasets are uploaded into the master databases without alteration, SFAN will not create separate metadata records each satellite database.

Complete metadata records for the snowy plover monitoring database will be generated in compliance with current NPS standards by the SFAN data manager. Because the location data for this project is stored as UTM coordinates within the MS Access databases, there are no spatial data products associated with this protocol that require metadata records.

The metadata records for the snowy plover monitoring database will initially be developed in Dataset Catalog v3.0, an MS Access metadata development and catalog tool developed by the NPS I&M Program. Dataset Catalog is currently the preferred tool to begin metadata records for MS Access databases because of its ability to harvest entity and attribute information from this database format.

The metadata records will be exported from Dataset Catalog as XML files and completed in NPS Metadata Tools and Editor v1.1 (NPS MTE), thus allowing for all NPS-specific elements in the metadata records to be completed. When completed, metadata records, but not the data themselves, will be posted to the NPS Integrated Resource Management Applications (IRMA) portal (<http://irma.nps.gov>) for public access. Contact information within the metadata records will direct interested parties to the SFAN data manager for further inquiries. Master database metadata records posted to IRMA will be updated annually after the annual data has been uploaded or following database revision to a new version whole number (i.e., v1_3 to v2_0, but not v2_0 to v2_1).

Data Storage and Archival Procedures

At PORE, digital data files are housed at: Inppore05\Resources\Natural_Databases\SNPLOVER

The following folders reside within the above directory:

Master_Database: A copy of the master databases is stored here. The SFAN data manager provides a copy of the master databases to PORE each time it is updated.

Working_Databases: Active seasonal satellite databases are stored here. The field staff may also place copies of the master databases or final satellite databases here for creating queries or data summaries.

All master data files for the snowy plover monitoring project are housed at the SFAN I&M Program office at GOGA. The master database, currently in version 1_00, resides at:

Inpgogamahe1\Divisions\Network I&M\Individual Vital Signs\SnowyPlover\PORE\data

Inpgogamahe1\Divisions\Network I&M must always be mapped as the Z drive. The following folders reside within the above “data” directory:

Master_BackUps: Back-up copies of the active master databases should be stored here. File names of back-up databases should include the date of the back-up, such as: SNPL_PORE_Master_050108_BackUp.

SNPL_Dbase_Archives: When the master database is converted to a new version number, the final previous database version should be archived here. Final seasonal satellite databases and all project legacy databases are also stored in this archive directory.

Data Distribution

For the snowy plover monitoring program to inform park management and to share its information with other organizations and the general public, guidance documents, reports, and data must be easily discoverable and obtainable. The main mechanism for distribution of the snowy plover monitoring documents and data will be the Internet. The snowy plover monitoring protocol, accompanying SOPs, and all annual reports will be made available for download at the SFAN website (<http://science.nature.nps.gov/im/units/sfan/>). NRInfo records will be created for all of the snowy plover monitoring documents, including the protocol, annual reports, and any resulting publications. The public version of NRInfo is in development by the National I&M program.

Although the snowy plover monitoring database will not be posted for public download, as previously noted, metadata records for the master databases will be maintained at the NPS IRMA portal. The metadata records will direct interested parties to the SFAN data manager for inquiries.

All documents produced by the snowy plover monitoring program will be published in either the Natural Resource Report Series (NRR) or the Natural Resource Technical Series (NRTS) Series following guidance from the NPS Natural Resource Stewardship and Science Office in Fort Collins, Colorado. The Natural Resource Publications Management home page hosts a list of all documents published (<http://www.nature.nps.gov/publications/NRPM/>). Final copies of peer-reviewed annual reports and long-term trend reports will be archived in the SFAN Library on the GOGA I&M Server and uploaded into the NPS Integrated Resource Management Applications portal (<http://irma.nps.gov>). Long-term trend reports will be distributed to the USFWS snowy plover regional recovery coordinator (G. Page, PRBO Conservation Science) and included in annual USFWS threatened and endangered species permit reports.

Literature Cited

- National Park Service (NPS). 2008. Data management guidelines for inventory and monitoring networks. Natural Resource Report NPS/NRPC/NRR—2008/035. National Park Service, Fort Collins, CO.
- Palmer, C. J. 2003. Approaches to quality assurance and information management for regional ecological monitoring programs. Pages 211–225 in D. E. Busch, and J. C. Trexler, editors. *Monitoring ecosystems: interdisciplinary approaches for evaluating ecoregional initiatives*. Island Press, Washington, D.C.
- Press, D. T. 2005. Data management plan for the San Francisco Bay Area Network Inventory and Monitoring Program. National Park Service Unpublished Report, San Francisco, CA. 113 pp.

Appendix SOP 4A. PORE western snowy plover data dictionary.

Data Dictionary Report

Data Dictionary for: PORE Western Snowy Plover Monitoring Database, SFAN I&M Program

TABLE NAME: tbl_Events**FILENAME:** SNPL_PORE_Master_v1_00.mdb**DESCRIPTION:** Sampling events – western snowy plover surveys.**FORMAT:** Microsoft Access**NO. OF FIELDS:** 8

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Event_ID	dbText	50	Event identifier.
Location_ID	dbText	50	Link to tbl_Locations
Protocol_Name	dbText	100	The name or code of the protocol governing the event
Start_Date	dbDate	8	Starting date for the event
Start_Time	dbDate	8	Starting time for the event
End_Time	dbDate	8	Ending time for the event
Entered_By	dbText	50	Database user at data entry.
Entered_Date	dbText	50	Date of data entry.

TABLE NAME: tbl_Event_Details**FILENAME:** SNPL_PORE_Master_v1_00.mdb**DESCRIPTION:** Sampling event details – western snowy plover surveys.**FORMAT:** Microsoft Access**NO. OF FIELDS:** 31

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Event_ID	dbText	50	Event identifier. Link to tbl_Events.
Wind_Spd	dbDouble	8	Average wind speed.
Wind_Max	dbDouble	8	Maximum wind speed.
Wind_Dir	dbText	50	Wind direction.
Air_Temp	dbDouble	8	Average air temperature (F).
Rel_Hum	dbDouble	8	Average relative humidity.
Cloud_Cover	dbText	50	Average percent cloud cover.
Tide_Cond	dbText	50	Tide condition (HI-SLACK, FALL, etc).
SNPL_Adults	dbDouble	8	Total number of snowy plover adults seen.
SNPL_Hatchlings	dbDouble	8	Total number of snowy plover hatchlings seen.
SNPL_Fledglings	dbDouble	8	Total number of snowy plover fledglings seen.

SNPL_Checked_			
Bands	dbDouble	8	Total number of snowy plovers checked for bands.
SNPL_Banded	dbDouble	8	Total number of banded snowy plovers.
Humans	dbDouble	8	Total number of humans seen.
Dogs_OnLeash	dbDouble	8	Total number of dogs on leash.
Dogs_OffLeash	dbDouble	8	Total number of dogs off leash.
CORA	dbDouble	8	Total number of ravens seen.
NOHA	dbDouble	8	Total number of northern harriers seen.
PEFA	dbDouble	8	Total number of peregrine falcons seen.
RTHA	dbDouble	8	Total number of red-tailed hawks seen.
GHOW	dbDouble	8	Total number of great-horned owls seen.
BNOW	dbDouble	8	Total number of barn owls seen.
AMCR	dbDouble	8	Total number of crows seen.
FOX	dbDouble	8	Total number of foxes seen.
COYOTE	dbDouble	8	Total number of coyotes seen.
BOBCAT	dbDouble	8	Total number of bobcats seen.
OTHER	dbText	50	Other predators seen.
Predator_Notes	dbText	255	Notes taken regarding predators seen.
LE_Violation	dbBoolean	1	Was a violation of posted SNPL rules observed?
Violation_Notes	dbText	255	Notes on LE violation(s), if applicable.
Event_Notes	dbText	255	General notes on the event.

TABLE NAME: tbl_SNPL_Observations

FILENAME: SNPL_PORE_Master_v1_00.mdb

DESCRIPTION: Protocol-specific field data – western snowy plover observations.

FORMAT: Microsoft Access

NO. OF FIELDS: 21

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
SNPL_Data_ID	dbText	50	Field data table row identifier.
Event_ID	dbText	50	Event identifier. Link to tbl_Events.
Nest_ID	dbText	50	Link to tbl_Nest_Master, if applicable.
SNPL_Time	dbDate	8	Time plover(s) observed.
X_Coord	dbDouble	8	X coordinate.
Y_Coord	dbDouble	8	Y coordinate.
Est_H_Error	dbSingle	4	Estimated horizontal accuracy.
Coord_Units	dbText	50	Coordinate distance units.
Coord_System	dbText	50	Coordinate system.
UTM_Zone	dbText	50	UTM Zone.
Datum	dbText	50	Datum of mapping ellipsoid.

SNPL_Male	dbDouble	8	Number of SNPL male adults seen.
SNPL_Female	dbDouble	8	Number of SNPL female adults seen.
SNPL_Unk	dbDouble	8	Number of SNPL adults seen, sex unknown.
SNPL_Hatchlings	dbDouble	8	Number of SNPL hatchlings seen.
SNPL_Fledglings	dbDouble	8	Number of SNPL fledglings seen.
SNPL_Bands	dbDouble	8	Number of banded SNPL (subset of adults).
SNPL_Notes	dbText	255	General notes on the banded plover.

TABLE NAME: **tbl_SNPL_Banded**

FILENAME: SNPL_PORE_Master_v1_00.mdb

DESCRIPTION: Protocol-specific field data – records of banded western snowy plovers.

FORMAT: Microsoft Access

NO. OF FIELDS: 6

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
SNPL_Data_ID	dbText	50	Field data table row identifier.
Event_ID	dbText	50	Event identifier. Link to tbl_Events.
Left_Leg	dbText	50	Left leg color combination.
Right_Leg	dbText	50	Right leg color combination.
SNPL_Sex	dbText	50	Sex of plover, if known.
Band_Notes	dbText	255	General notes on the banded plover.

TABLE NAME: **tbl_Nest_Checks**

FILENAME: SNPL_PORE_Master_v1_00.mdb

DESCRIPTION: Protocol-specific field data – western snowy plover nest checks.

FORMAT: Microsoft Access

NO. OF FIELDS: 8

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Nest_Check_Data_ID	dbGUID	16	Field data table row identifier.
Event_ID	dbText	50	Event identifier. Link to tbl_Events.
Nest_ID	dbText	50	Link to tbl_Nest_Master.
Nest_Time	dbDate	8	Time of nest check.
Number_Eggs	dbDouble	8	Number of eggs seen in nest.
Male_Seen	dbBoolean	1	Was adult male SNPL seen?
Female_Seen	dbBoolean	1	Was adult female SNPL seen?
Nest_Notes	dbText	255	General notes on the nest check.

TABLE NAME: xref_Event_Contacts
FILENAME: SNPL_PORE_Master_v1_00.mdb
DESCRIPTION: Cross-reference table between events and contacts.
FORMAT: Microsoft Access
NO. OF FIELDS: 3

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Event_ID	dbText	50	Event identifier. Link to tbl_Events.
Contact_ID	dbGUID	16	Link to tlu_Contacts (Contact_ID)
Contact_Role	dbText	50	The contact's role in the protocol (Cnt_Role)

TABLE NAME: tbl_DataHistory
FILENAME: SNPL_PORE_Master_v1_00.mdb
DESCRIPTION: Details of data verification and editing of survey event records.
FORMAT: Microsoft Access
NO. OF FIELDS: 5

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
History_Data_ID	dbLong	4	Data history record ID.
Event_ID	dbText	50	Event identifier. Link to tbl_Events.
Updated_Date	dbText	50	Date of data verification, validation, or last change.
Contact_ID	dbText	50	Database user at data entry. Link to tlu_Contacts.
Data_Notes	dbText	255	Specific description of data history record (error-checking, data fields edited, etc)

TABLE NAME: tbl_Nest_Master
FILENAME: SNPL_PORE_Master_v1_00.mdb
DESCRIPTION: Summary nest information.
FORMAT: Microsoft Access
NO. OF FIELDS: 45

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Nest_ID	dbText	50	Unique nest ID code. Format Loc_Code+Number+Year, ie. K01_2009.
Year	dbInteger	2	Nesting year.
Location_ID	dbText	50	Link to tbl_Locations.
X_Coord	dbDouble	8	X coordinate.
Y_Coord	dbDouble	8	Y coordinate.
Est_H_Error	dbSingle	4	Estimated horizontal accuracy.
Coord_Units	dbText	50	Coordinate distance units.
Coord_System	dbText	50	Coordinate system.
UTM_Zone	dbText	50	UTM Zone.
Datum	dbText	50	Datum of mapping ellipsoid.
GPSunit	dbText	20	type of unit or method used to GPS (i.e ProXL, Garmin 3+, map)

Date_Found	dbDate	8	Date the nest was located
Date_Exclosure	dbDate	8	Date that exclosure was erected around nest.
ZN	dbText	50	Beach elevation zone (1-5 or 0 for unknown).
MICRO	dbText	50	Microhabitat notes (sand=S; coarse sand, shell, pebble, rock=R; seaweed or kelp=K; washed up debris or trash from beach visitors=T; vegetation or sand at the base of vegetation=V; carcasses=C).-no description-
Restored_Area	dbBoolean	1	Check if nest located in a restored area.
Ex_Type	dbText	2	s=square, t=triangle, N= none
Init_Date	dbDate	8	Estimated date of nest initiation
Hatching_Date	dbDate	8	Date of nest hatching, if applicable.
Fledging_Date	dbDate	8	Date of nest fledging, if applicable.
Eggs	dbInteger	2	# of eggs
Hatchlings	dbInteger	2	# of chicks that hatched
Fledglings	dbInteger	2	# of chicks that fledged
Failure_Date	dbDate	8	Date of nest failure, if applicable.
Failure_Reason	dbText	50	Reason for nest failure, if applicable.
Predator_Type	dbText	50	Type of predator if failure reason was predation.
ChickLoss_Date1	dbDate	8	Date of first chick loss, if applicable.
ChickLoss_Age1	dbText	50	Age of first chick when lost, if applicable.
ChickLoss_Weekend1	dbBoolean	1	First chick lost on weekend?
ChickLoss_Date2	dbDate	8	Date of second chick loss, if applicable.
ChickLoss_Age2	dbText	50	Age of second chick when lost, if applicable.
ChickLoss_Weekend2	dbBoolean	1	Second chick lost on weekend?
ChickLoss_Date3	dbDate	8	Date of third chick loss, if applicable.
ChickLoss_Age3	dbText	50	Age of third chick when lost, if applicable.
ChickLoss_Weekend3	dbBoolean	1	Third chick lost on weekend?
Disturbance	dbText	50	disturbances noted during monitoring (whether or not effect shown).
F_Band	dbText	8	Female band. xx/xx format (left bands/right bands)
M_Band	dbText	8	Male Band. xx/xx format (left bands/right bands)
Eggs_When	dbDate	8	Date that eggs collected for testing, if applicable.
Eggs_Where	dbText	50	Where eggs taken for testing, if applicable.
Eggs_Results	dbText	50	Egg analysis results, if applicable.
Comment	dbMemo	0	Additional comments on nest or birds.

TABLE NAME: tbl_Locations

FILENAME: SNPL_PORE_Master_v1_00.mdb

DESCRIPTION: Sampling unit locations.

FORMAT: Microsoft Access

NO. OF FIELDS: 20

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Location_ID	dbText	50	Location identifier
GIS_Location_ID	dbText	50	Link to GIS feature, equivalent to NPS_Location_ID
Meta_MID	dbText	50	Link to NR-GIS Metadata Database
X_Coord	dbDouble	8	Start X coordinate
Y_Coord	dbDouble	8	Start Y coordinate
Est_H_Error	dbSingle	4	Start estimated horizontal accuracy
Stop_X_Coord	dbDouble	8	Stop X coordinate
Stop_Y_Coord	dbDouble	8	Stop Y coordinate
Stop_Est_H_Error	dbSingle	4	Stop estimated horizontal accuracy
Coord_Units	dbText	50	Coordinate distance units
Coord_System	dbText	50	Coordinate system
UTM_Zone	dbText	50	UTM Zone
Datum	dbText	50	Datum of mapping ellipsoid
Accuracy_Notes	dbText	255	Positional accuracy notes
Unit_Code	dbText	12	Park, Monument or Network code
Loc_Name	dbText	100	Name of the location
Loc_Type	dbText	25	Location type category
Updated_Date	dbText	50	Date of entry or last change
Loc_Notes	dbMemo	0	General notes on the location
Loc_Code	dbText	50	Location Code (ie. L = Limantour).

TABLE NAME: tbl_Db_Meta

FILENAME: SNPL_PORE_Master_v1_00.mdb

DESCRIPTION: Database description and links to I&M metadata tools.

FORMAT: Microsoft Access

NO. OF FIELDS: 5

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Db_Meta_ID	dbGUID	16	M. Local primary key
Db_Desc	dbMemo	0	Description of the database purpose
Meta_MID	dbText	255	Link to NPS Data Store
DSC_GUID	dbText	50	Link to I&M Dataset Catalog desktop metadata tool
Meta_File_Name	dbText	50	Name of the metadata file that describes this NRDT data file.

TABLE NAME: tbl_Db_Revisions
FILENAME: SNPL_PORE_Master_v1_00.mdb
DESCRIPTION: Database revision history data.
FORMAT: Microsoft Access
NO. OF FIELDS: 6

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Revision_ID	dbText	50	Database revision (version) number or code
Revision_Contact_ID	dbGUID	16	Link to tlu_Contacts
Db_Meta_ID	dbGUID	16	Link to tbl_DB_Meta
Revision_Date	dbDate	8	Database revision date
Revision_Reason	dbMemo	0	Reason for the database revision
Revision_Desc	dbMemo	0	Revision description

TABLE NAME: tlu_Contacts
FILENAME: SNPL_PORE_Master_v1_00.mdb
DESCRIPTION: Contact data for project-related personnel.
FORMAT: Microsoft Access
NO. OF FIELDS: 16

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Contact_ID	dbGUID	16	Contact identifier
Last_Name	dbText	50	Last name
First_Name	dbText	50	First name
Organization	dbText	50	Organization or employer
Position_Title	dbText	50	Title or position description
Address_Type	dbText	50	Address (mailing, physical, both) type
Address	dbText	50	Street address
Address2	dbText	50	Address line 2, suite, apartment number
City	dbText	100	City or town
State_Code	dbText	8	State or province
Zip_Code	dbText	50	Zip code
Country	dbText	50	Country
Email_Address	dbText	50	E-mail address
Work_Phone	dbText	50	Phone number
Work_Extension	dbText	50	Phone extension
Contact_Notes	dbText	255	Contact notes

TABLE NAME: tlu_Enumerations
FILENAME: SNPL_PORE_Master_v1_00.mdb
DESCRIPTION: Enumerated lookup table.
FORMAT: Microsoft Access
NO. OF FIELDS: 4

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
Enum_Code	dbText	50	Code for lookup values
Enum_Description	dbMemo	0	Lookup value description
Enum_Group	dbText	50	Category for lookup value
Sort_Order	dbInteger	2	Order in which to sort lookup values

TABLE NAME: tlu_NestFailure
FILENAME: SNPL_PORE_Master_v1_00.mdb
DESCRIPTION: Look-up table of nest failure reasons.
FORMAT: Microsoft Access
NO. OF FIELDS: 3

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DESCRIPTION
NestFailureReason	dbText	50	Nest failure reason.
Description	dbMemo	0	Detailed description of nest failure reason.
FailureID_ID	dbLong	4	Record ID. Autonumber.

SOP 5: Data Analysis and Reporting

Version 2.3

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	Jan 08	M. Koenen	Adapted to formatting standards for the NPS I&M Program	To meet NPS guidelines	1.0
1.0	Nov 08	M. Koenen	Added to data analysis and reporting section. Included analysis by Kirk Steinhorst.		1.1
1.1	Dec 2008	D. Adams	Removed Data Management section and changed this doc to SOP 5	New SOP 4 created for just Data Management	2.0
2.0	Dec 2009	D. Adams	Formatting	Peer review	2.1
2.1	August 2011	D. Adams, D. Press, L. Hughey	Review edit suggestions, revised figures to reflect break in monitoring years, added 2009 data, made figure style consistent, added predator data summary information.	Peer review comments	2.2
2.2	July 2012	D. Adams, D. Press, L. Hughey	Revised long-term reporting schedule, addition of mgmt. trigger calculations, minor edits and formatting updates, added 2010 data.	Response to 2 nd set of peer review comments	2.3

Overview

This SOP provides details for conducting data analyses and reporting results. Data management, including database design, data entry, validation, and storage is discussed in SOP 4.

The following section outlines how data will be analyzed and presented in annual and long-term reports. Although the focus of annual reports is to summarize each year's findings, the graphs and tables will show previous year's results for comparison. Long-term reports will provide additional analysis of population trends over the long-term. In general, trends will be evaluated by analyzing graphical representations of the data.

Annual Report Contents

The annual reports provide a concise summary of the field season. The report includes an abstract, introduction, study area, methods, results, discussion, and management recommendations. The results section includes information on census numbers, nest success, causes of nest failure, and predator/common raven occurrence rates. The annual report enables readers to determine if the goals of the project are being met and provides an administrative and scientific record of monitoring activities.

As part of the annual reports (see next section), the following data will be summarized

1. Population Abundance: a minimum estimate of the population size of nesting snowy plovers (total, male, female) at PORE during the breeding season (Table SOP 5.1, Figure SOP 5.1).
2. Nest Abundance: number of snowy plover nests at each nesting beach at PORE (Table SOP 5.2, Figure SOP 5.1); maximum number of simultaneously active nests.
3. Productivity: reproductive success (% nests hatched; % eggs hatched, % chicks fledged; Table SOP 5.3, Figures SOP 5.2 and 5.3).
4. Nest Failures: tally of observed causes of nest failure (Table SOP 5.4).
5. Common Raven Occurrence Rates: number observed per season and rate of observation per survey hour (Table SOP 5.5 and Figure SOP 5.4).

Population and Nest Abundance Calculations

Population abundance is calculated by tracking plovers in the field during the nesting season. Although PORE does not have an active banding program, approximately 5–10% of the breeding population is banded. Between the banded plovers and the unique markings or coloration seen on plovers, field technicians are able to identify most individuals to conduct the census. In some cases, however, it is possible that a nesting plover is either renesting or is a different (new) bird. Two sets of criteria have been used to estimate the annual breeding population at PORE.

Prior to 2009, the number of nesting plovers at PORE is presented as a range with the lower number representing the number of plovers assuming renesting and the higher figure assumes plovers are new to the breeding population (see Table SOP 5.1, Figure SOP 5.1). In 2009, park managers determined that maximum estimates will no longer be made due to the subjectivity involved in analyzing behavioral characteristics. The following guidelines provide more specific criteria used to determine the minimum numbers of plovers in the breeding population beginning in 2009:

1. Determine the time period when the maximum number of simultaneously active nests and broods were present on the beach during the breeding season and use data from this period to calculate the minimum number of breeders using the methods below:
 - a. An active nest represents the presence of 1 male and 1 female (count = 1 male, 1 female).
 - b. If one or more chicks of a brood are known to be alive and less than 3 weeks old, one male is inferred (count = 1 male).
 - c. If a male is present with a brood greater than 3 weeks old, that male is probably with a new mate who may have initiated a new nest. This nest, if found, would result in counting of 1 male and 1 female. Therefore, males with broods of over 3 weeks are not counted (count = 0 male)
 - i. However, if it is possible to determine that there are no available (unpaired) females within the vicinity, one male may be counted (count=1 male).
 - d. One day prior to the estimated initiation date of a nest represents the presence of one male and one female which are about to nest (count=1 male, 1 female).
 - i. This step is only relevant if a pair initiates a nest one day after the last day of the peak number of nests present on the beach.
 - e. If any banded birds had confirmed nests outside of the peak window, add 1 male and 1 female (count = 1 male, 1 female).

Given the relatively small number of birds and few banded ones at PORE, this set of criteria has been determined to provide the best possible **minimum** estimate and comparable with previous years' minimum estimates. However, years with a high rate of nest loss could result in inaccurate estimates since all of the birds won't have active nests. Therefore, results of the USFWS breeding season window survey for that year should also be reported as further corroboration of minimum numbers.

Table SOP 5.1. Snowy plover population estimates for all beaches at Point Reyes National Seashore during the breeding season, 1986–1989 and 1995–2010. *Source:* Peterlein 2009, Hughey 2011.

Year	Females	Males	Total
1986	22–23	19–21	41–44
1987	25–26	25–28	50–54
1988	21–22	19–20	40–42
1989	18–20	16–17	34–37
1995	6	6	12
1996	5–6	5	10–11
1997	12	13	25
1998	7	9	16
1999	9	11	20
2000	17–18	14–19	31–37
2001	13–19	14–17	27–36
2002	17–19	17–18	34–37
2003	11–12	12–13	23–25
2004	17–18	17–18	34–36
2005	9–10	10–11	19–21
2006	14–15	16–17	30–32
2007	14–15	16–17	30–32
2008	11–12	12–13	23–24
2009	11	13	24
2010	6	8	14

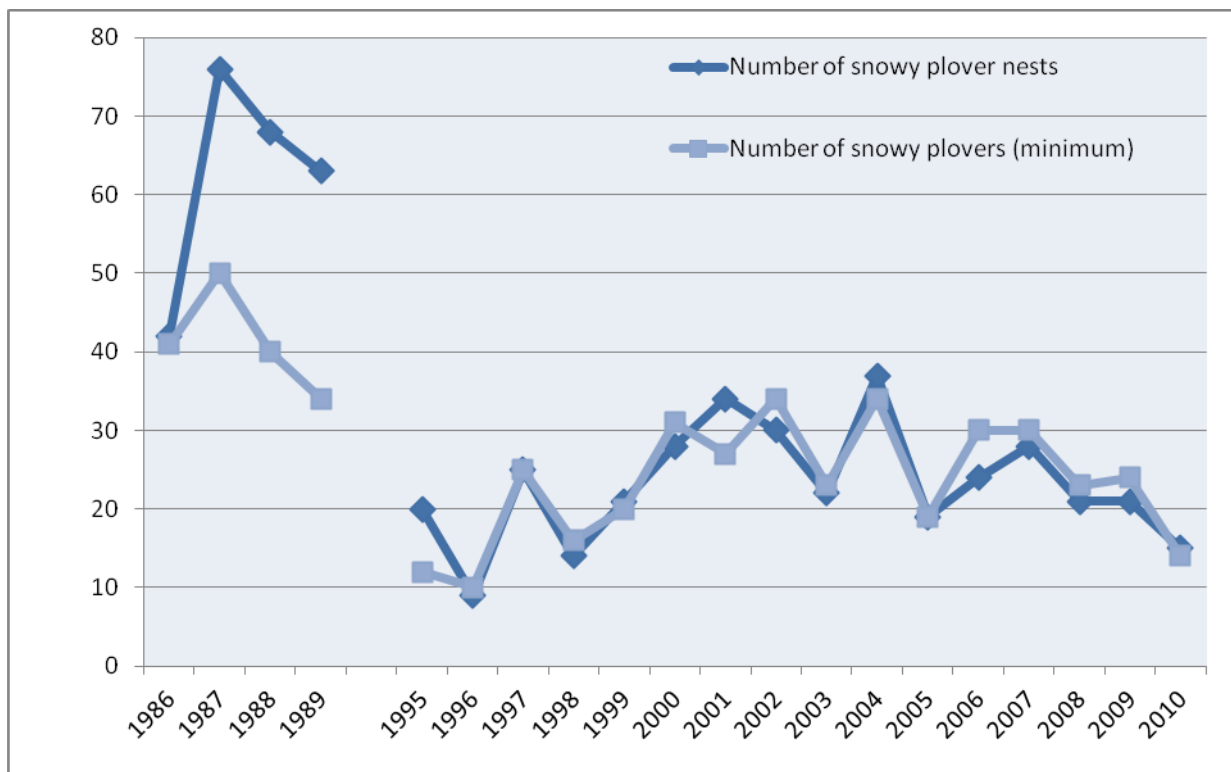


Figure SOP 5.1. Number of snowy plover nests and minimum number of nesting plovers for all survey areas at Point Reyes National Seashore, 1986–1989 and 1995–2010. *Source:* Peterlein 2009, Hughey 2011.

Calculations of Population Size Triggers for Management Activities

An annual analysis of population size data is necessary to provide a coarse threshold in determining when additional management attention and actions are necessary to recover the snowy plover breeding population. The current management triggers and potential management responses are described in the Trigger for Management Activities in the first section of this document.

If monitoring detects a significant declining trend in the annual average breeding season snowy plover population size since 2000 or if there is a 50% decline in the annual breeding population size at PORE compared with any of the previous five years of monitoring. A significant declining trend is determined using the analysis methods described in the long-term analysis of abundance (below). To determine if the 50% decline threshold has been reached, the current season minimum population size is compared to five-year average population sizes calculated using the minimum population size estimates since 2000. Using data from 2000 to 2010 breeding seasons, the annual minimum breeding population ranged from 14 to 34 plovers (Table SOP 5.1) and the five-year population size averages ranged from 27.2 (2003–2007) to 29.8 (2000–2004). In 2010 the minimum population estimate was 14 (less than 50% of the 2003–2007 population size average). In 2010 a review of the program was conducted by the PORE Wildlife Biologist and other PORE park management staff members. In light of current actions such as more intensive raven monitoring program pilot testing combined with directed raven removal efforts (see Hughey 2011 for more information), an increased fledging rate (percentage of chicks that fledge) over 2008 and 2009, and the minimum estimate of 18 plovers (nine males, nine females) as derived from the UFWS Breeding Bird Window Survey in 2010, no additional management actions beyond the existing set were recommended by the group.

Nest Abundance Calculations

The nest abundance is a simple calculation of the number of snowy plover nests found on each survey area within a breeding season at PORE (Table SOP 5.2, Figure SOP 5.1). The information is included in the annual report in tabular format (Table SOP 5.2) and using a stacked bar graph showing the number of nests in each survey area (see Hughey 2011 for example). The maximum number of simultaneously active nests is calculated to determine minimum population size (described above).

Table SOP 5.2. Number of snowy plover nests at Point Reyes National Seashore, 1986–1989 and 1995–2010. *Source:* Peterlein 2009, Hughey 2011.

Year	Number of Nests by Survey Area ¹						Total Nests
	K	NP	NB	SB	L	D	
1986	5	29	1	2	4	1	42
1987	9	48	6	11	1	1	76
1988	5	41	7	12	0	3	68
1989	6	42	7	6	0	2	63
1995	4	11	5	0	0	0	20
1996	0	8	0	0	1	0	9
1997	0	18	0	0	7	0	25
1998	2	10	0	0	2	0	14
1999	0	16	0	0	5	0	21
2000	10	15	0	0	3	0	28
2001	8	26	0	0	0	0	34
2002	6	24	0	0	0	0	30
2003	6	16	0	0	0	0	22
2004	21	16	0	0	0	0	37
2005	4	15	0	0	0	0	19
2006	11	13	0	0	0	0	24
2007	14	14	0	0	0	0	28
2008	11	10	0	0	0	0	21
2009	9	12	0	0	0	0	21
2010	7	8	0	0	0	0	15

1 K = Kehoe Creek to Abbott's Lagoon; NP = Abbott's Lagoon to North Beach parking lot and includes Abbott's Lagoon; NB = North Beach parking lot to South Beach parking lot; SB = South Beach parking lot to Lighthouse Beach; L = Limantour Spit; D = Drake's Spit.

Productivity Calculations

Productivity is estimated by using several calculations that may be compared to other studies (USFWS 2007; Table SOP 5.3):

Nest Success: percent of nests with at least one egg hatching (Table SOP 5.3).

Egg and Hatching Success: number of eggs, number of eggs that hatched, and percent of eggs that hatched (Table SOP 5.3).

Fledging Success: number of chicks that fledged (Table SOP 5.3), percent of chicks that fledged (Table SOP 5.3, Figure SOP 5.2), number of fledged chicks per eggs laid (Table SOP 5.3), number of fledged chicks per breeding male (Figure SOP 5.3).

These are relatively unbiased measures of plover reproductive success if based on regular site visits and an accounting of breeding pairs as outlined in this protocol. An "unknown" category is seldom used or appropriate; plover chicks are accounted for during several brood visits between hatching and fledging, or they can be considered lost which is often attributable to decimating factors (e.g.,

predation, storm events). The USFWS has a recovery goal of maintaining fledge rates of at least one chick per male to attain a sustainable population (USFWS 2007; Figure SOP 5.3).

Table SOP 5.3. Snowy plover breeding success on Point Reyes Beach survey areas only (K, NP, NB, SB), 1986–1989 and 1995–2010. *Source:* Peterlein 2009, Hughey 2011.

Year	Nest Success		Hatch (Egg) Success			Fledging Success		
	Number Nests	% Nests Successful ¹	Number	Number Hatched	% Hatched	Number Fledged	% Fledged	Fledged Per Egg
1986	35 ²	31.4	99	31	31.3	8	25.8	0.08
1987	74	19.0	198	35	17.7	15	42.9	0.08
1988	65	7.7	161	11	6.8	5	45.5	0.03
1989	61	1.6	146	3	2.1	1	33.3	0.01
NO DATA	-	-	-	-	-	-	-	-
1995	20	10.0	55	5	9.1	4	80.0	0.07
1996	8	75.0	24	16	66.7	14	87.5	0.58
1997	18	72.2	44	33	75.0	20	60.6	0.45
1998	12	100.0	36	35	97.2	21	60.0	0.58
1999	16	87.5	47	39 ³	83.0	22	56.4	0.47
2000	25	56.0	72 ⁴	41	57.3	14	34.1	0.20
2001	34	26.5	86 ⁵	25	29.1	10	40.0	0.12
2002	30	50.0	76	41	53.9	17	41.5	0.22
2003	22	77.2	63	43	68.3	19	44.2	0.30
2004	37	78.3	107	86	80.4	19	22.1	0.18
2005	19	63.1	53	33	62.3	17	51.5	0.32
2006	24	79.2	69	51	73.9	23	45.0	0.33
2007	28	82.1	83	64	77.1	24	37.5	0.29
2008	21	52.3	55	30	54.5	5	16.1	0.09
2009	21	66.6	60	38	63.3	8	21.0	0.13
2010	15	60.0	42	21	50.0	7	33.3	0.17
Mean ⁶	22	69.0	63	41	67.3	17	44.1	0.30

¹ Nests successful if at least one egg hatched.

² 37 nests were located in 1986 but only 35 were monitored for success.

³ 38–40 eggs hatched.

⁴ 71–72 eggs laid.

⁵ 85–87 eggs laid.

⁶ Mean includes data from first year exclosures were used (1996) through 2010.



Figure SOP 5.2. Percentage of hatched chicks that fledged at Point Reyes National Seashore, 1986–1989 and 1995–2010 for all survey areas. *Source:* Peterlein 2009, Hughey 2011.

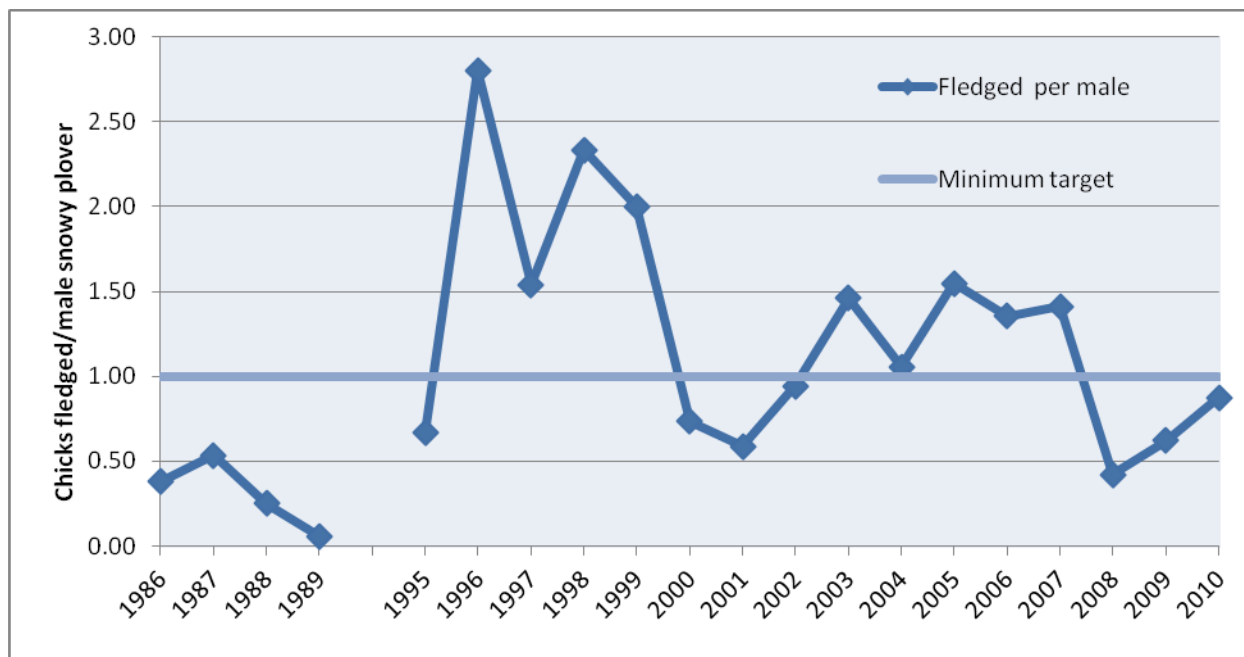


Figure SOP 5.3. Number of fledged chicks per male snowy plover for all survey areas at Point Reyes National Seashore, 1986–1989 and 1995–2010. *Source:* Peterlein 2009, Hughey 2011.

Nest Failures

Nest failures are presented in tabular format (Table SOP 5.4) and could also be presented using a pie chart or other visual format (see Hughey 2011 for an example). This presentation of data is important to evaluate efficacy of management activities including visitor education and construction of nest exclosures. Additional discussion will be provided in the report narrative on any potential predators encountered during surveys. While this information will not allow us to determine trends, it may provide additional information for management or identify new research questions.

Table SOP 5.4. Causes of snowy plover nest loss on Point Reyes Beach (survey areas K, NP, NB, and SB), 1996–2010. *Source:* Peterlein 2009, Hughey 2011.

Year	Total Nests	Nests Exclosed	Predator								Other Causes		
			Raven	Raptor	Avian	Fox	Coyote	Bobcat	Unidentified Mammal	Unknown Predator	Abandonment	Environment (e.g., wind, tide)	Infertile Eggs
1996	8	7	1								1 *		
1997	18	13	3							2			
1998	12	12											
1999	16	16						1 *		1*		1 *	
2000	25	25								1*	5 *	1 *	4*
2001	34	16	11	1			2			2	8*	1	
2002	30	20	5		1 *	1			2		3 *	2, 1 *	
2003	22	22									2 *	3 *	
2004	37	32				1					1, 1 *	5 *	
2005	19	16				2, 1 *					2 *	2	
2006	24	23				1 *					2 *		2 *
2007	28	22	1							3		1*	
2008	21	18	2							3		5*	
2009	21	19	1						1*			3*	
2010	15	15							2*				

*Nests protected by exclosures.

Predator Occurrence Rates

Predator occurrence rates are tabulated from survey data sheets. Although all potential predators seen during surveys are noted on the data sheets, the current focus for data analysis is on common raven sightings because ravens represent a known nest threat and source of disturbance (Table SOP 5.4). In annual reports, common raven occurrence data is reported for each survey area as number and percentage of surveys that common raven is present, number of surveys and total survey hours, total number of sightings, average number of common ravens per survey, and average number of common ravens per survey hour (Table SOP 5.5, Figure SOP 5.4). This type of predator survey summary could also be done for other predator species or groups of species as the need arises.

An assumption is that, in the past, there was a similar predator survey effort per survey from year to year, which may not be true in all years given that the typical researcher focus is for plovers on the ground. In 2011, a pilot predator study was initiated to employ a consistent survey effort with survey periods clearly documented to arrive at an annual raven density variable. Results from a diurnal predator abundance pilot study will be used to revise predator survey methods, data collection, and correlation analyses. New methods and analyses will be incorporated into a future protocol revision.

Table SOP 5.5. Common raven occurrence on surveys on Kehoe and North Beach, 2002–2010. *Source:* Peterlein 2009, Hughey 2011.

Year	No. of Surveys	Total Survey Hours	Surveys with Ravens	Total Raven Sightings	% Surveys with Ravens	Average Ravens per Survey	Average Ravens per Survey Hour
Kehoe (K)							
2002	47	120.16	39	470	83.0	10.00	3.91
2003	41	128.14	22	300	53.7	7.32	2.34
2004	72	291.97	66	1062	91.7	14.75	3.64
2005	40	95.40	34	291	85.0	7.28	3.05
2006	76	210.75	68	836	89.4	11.00	3.97
2007	78	312.00	71	795	91.0	10.19	2.55
2008	86	344.00	64	666	74.4	7.74	1.94
2009	50	125.00	49	512	98.0	10.24	4.11
2010	68	132.00	55	449	80.9	8.00	2.90
Average	62	195.49	52	598	83.01	9.61	3.16
North Beach (NP)							
2002	57	172.36	31	141	54.4	2.47	0.82
2003	72	230.99	20	108	27.8	1.50	0.47
2004	62	149.66	25	158	40.3	2.55	1.06
2005	68	120.80	18	65	26.5	0.96	0.54
2006	76	204.25	48	230	63.2	3.03	1.13
2007	70	350.00	68	228	97.1	3.26	0.65
2008	61	305.00	45	169	73.7	2.77	0.55
2009	45	165.00	30	194	66.7	4.21	0.98
2010	58	143.00	36	160	62.1	4.00	0.94
Average	64	212.30	36	162	56.20	2.60	0.80

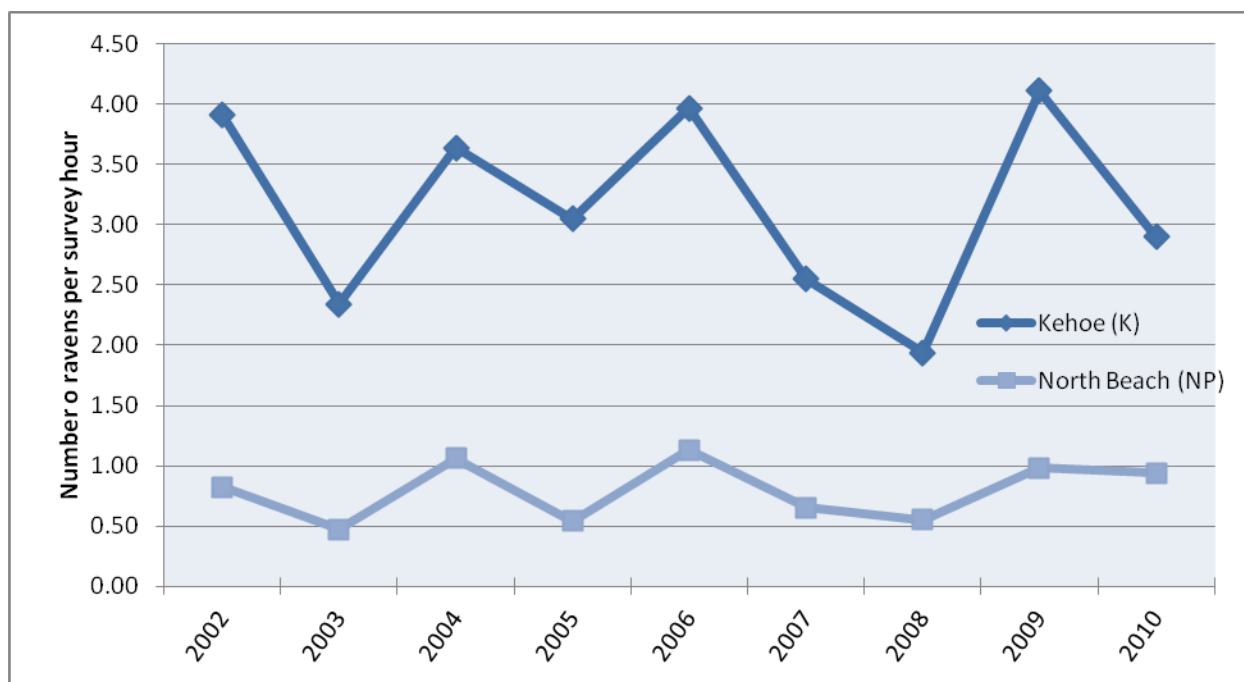


Figure SOP 5.4. Number of ravens observed per survey hour at Point Reyes National Seashore 2002–2010. *Source:* Peterlein 2009, Hughey 2011.

Annual Color Band Report

Annual reports on color bands observed on snowy plovers during the monitoring activities should be reported to Lynn Stenzel at PRBO following the end of the breeding season (USFWS 2007). Observation data to be included in color band reports is date, time, location, GPS coordinates if known, sex of plover if known, color band combination, and nesting status (See Appendix SOP 1C for more information on reading and reporting snowy plover leg color bands).

Long-term Trends and Synthesis Reports

A comprehensive data analysis and synthesis will be written periodically (e.g., every five years) to summarize general trends within a context of the park ecosystem and range-wide plover population trends. Having this extra time allows for more thorough data analysis and review of protocols and may give additional opportunity for adaptive management or protocol revision (e.g., changing monitoring intervals and timing, moving/adding sites, etc.). The reports summarize data collected over multiple years as presented above and will provide additional interpretation of results to evaluate trends, makes multi-year comparisons, and discuss regional context of snowy plover conservation. Although trend reports as described here have not yet been developed, the following published reports provide examples of how data collected at PORE have been interpreted within a broader context: Page and Stenzel 1981, Page et al. 1986, 1995, Abbott 2002, Ruhlen et al. 2003, and Schwarzbach et al. 2005.

As part of the long-term trend reports, the following data will be summarized

1. Abundance Trends: trends in the number of snowy plovers nesting at PORE; trends in the results of USFWS breeding season window surveys at PORE and range-wide

2. Nest Trends: trends in the annual number of snowy plover nests at PORE,
3. Productivity Trends: trends in reproductive success (percentage of nests with at least one egg hatching, percentage of eggs that hatch; percentage of hatched chicks that fledge; number of fledged chicks per breeding male)
4. Nest Failures: summary of observed causes of nest failure

Abundance and Nest Trends

Abundance of plovers and nests: In general, trends will be evaluated by analyzing graphical representations of the data (See Figures SOP 5.1–5.3 and 5.5). Graphs will be helpful in evaluating additional parameters to explain why particular years have higher population sizes than others. In addition, the Mann-Kendall Trend Test (M-K Test; See Appendix SOP 5A) measures the correlation between rankings (year and number of plovers or nests) to test that there is no statistically significant trend in those rankings (University of Idaho, K. Steinhorst, Professor, pers. comm.). This test measures the trend of a variable (e.g., annual number of nests) against time (year) or correlations between any set of paired observations if one variable is not time. While trends can be rejected or not rejected, failing to reject does not prove that there was no trend. The M-K Test can be run using common statistical software (i.e., SAS, R).

Examination of the snowy plover nest data through 2008 revealed that there was a significant upward trend in the number of nests (K and NP; $p = 0.0428$) and an even stronger trend just looking at the number of nests at K ($p = 0.0093$; University of Idaho, K. Steinhorst, Professor, pers. comm.). In addition, the K (Kehoe to Abbott's Lagoon) and NP (Abbott's Lagoon to North Beach parking lot) series can be kept separate because they are the two most used sites for a simple repeated measures design that is equivalent to a randomized block design where blocks are equal to locations and years equal to treatment. Page's trend test is used for multiple comparisons between ordered correlated variables (Page 1963). In this case it will tell is if there is a trend (upward or downward) for the two series (K and NP). The results from the most recently completed Page's trend test for the number of nests in K and NP from 1995 to 2008 indicates an upward trend ($z = 2.031$; $p = 0.0210$; University of Idaho, K. Steinhorst, Professor, pers. comm.).

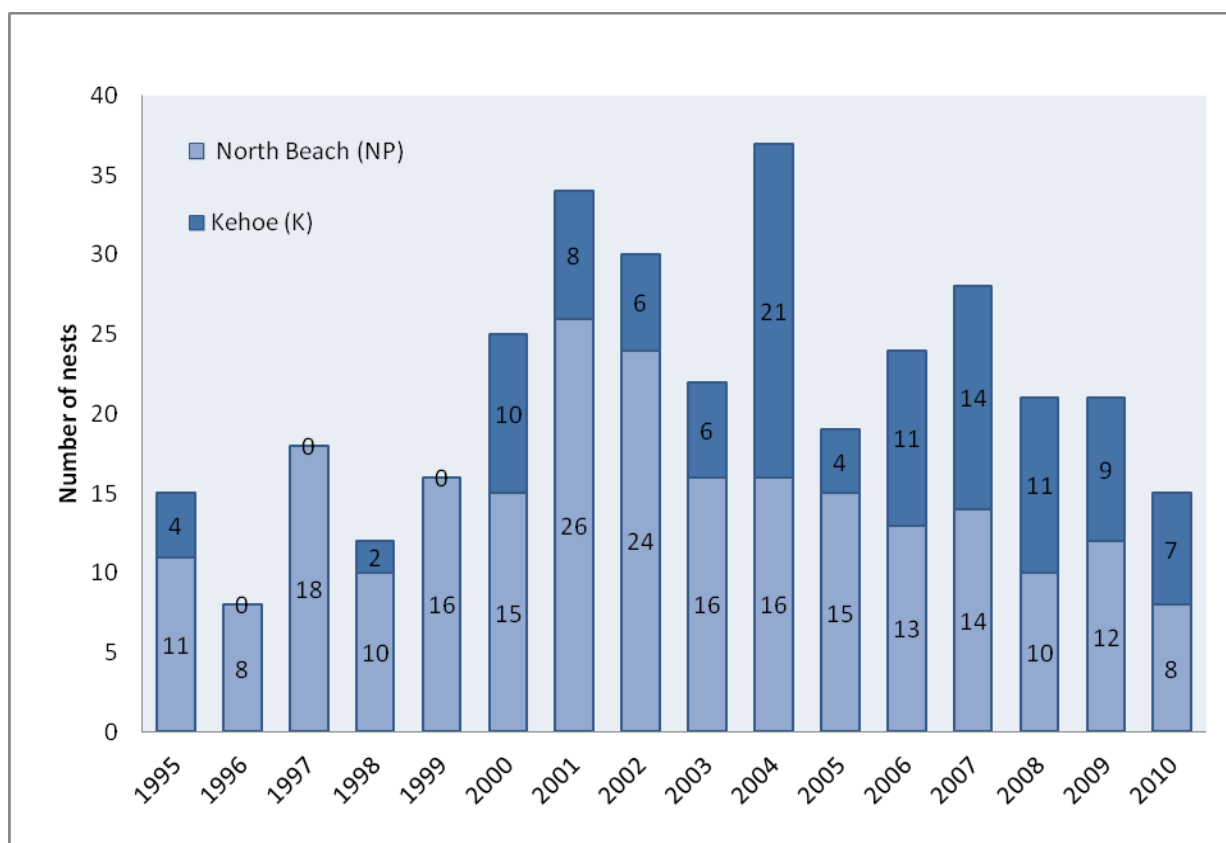


Figure SOP 5.5. Total number of nests on Kehoe (K) and North Beach (NP) survey areas from 1995 to 2010. *Source:* Peterlein 2009, Hughey 2011.

Productivity Trends

The reproductive success analysis will be similar to the nest count analysis with the reproductive success variables replacing counts. The M-K Trend test will determine if there is a trend in number of successful nests, the number of eggs that hatch, or the number of hatched eggs that fledge. Additional variables that will be reported in long-term trend reports are trends in the annual maximum number of nests which can help estimate the number of males and determine the number of chicks per male. The number of fledged chicks per breeding male is a target metric used in the Recovery Plan (USFWS 2007) to gauge the relative success of breeding sites against range-wide results. PORE results using both low and high male snowy plover population size estimates (Table SOP 5.1) can be compared to the closest beach breeding snowy plover population at Monterey Bay (Figure SOP 5.6).

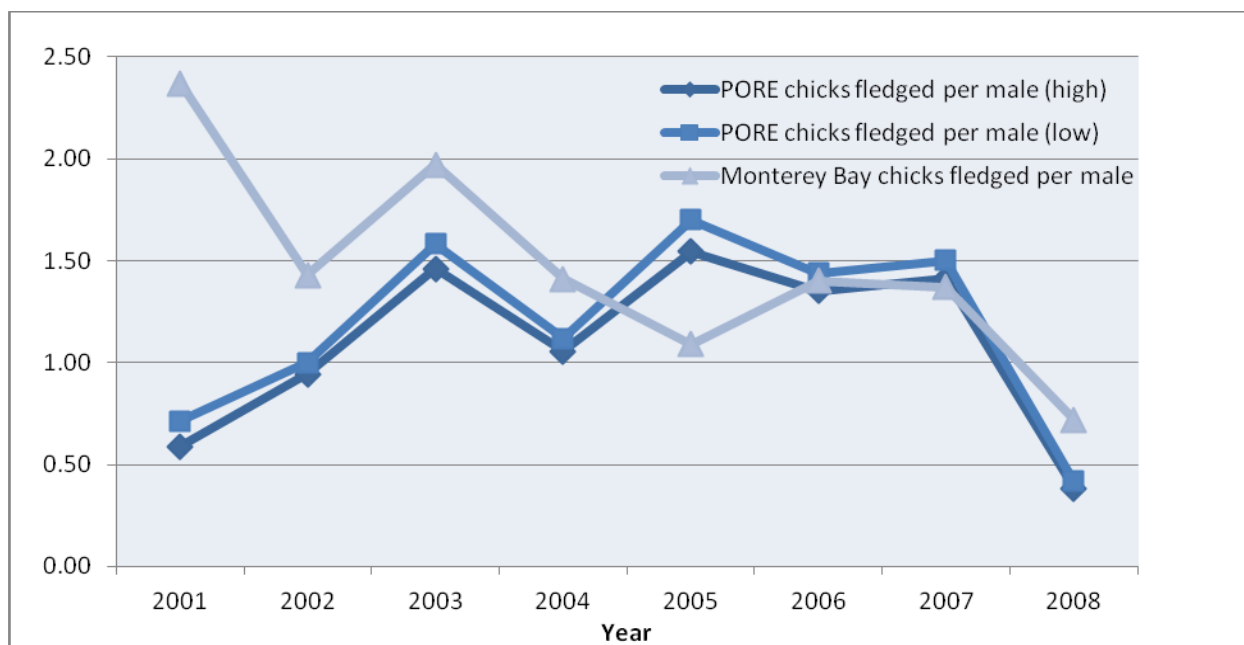


Figure SOP 5.6. Point Reyes National Seashore (PORE) snowy plover chick fledging rate per breeding male using the low and high male population size estimates with a comparison to the annual chicks fledged per male rate at Monterey Bay, California, 2001–2008. *Source:* Peterlein 2009, Page et al. 2010.

Phenology

Dates of first and last hatch dates will be presented in the trend reports (see Table SOP 5.6 for a sample table that will be populated with data in a future long-term trend and synthesis report. To determine if there are trends in the dates of the first nests or first hatch dates, Julian dates will be used in an analysis using the M-K and Page's tests as described above.

Table SOP 5.6. First survey dates, plovers observed, nests, hatch dates, and last hatch dates of snowy plovers nesting at PORE, 2007–2010. *Hatch dates observed in 2009 and 2010 were later because initial nests did not make it to hatch date.*

Survey Year	Date of First Complete Survey	First Date Plovers Observed	# of Plovers	Date of First Nest	First Hatch Date Observed	Last Hatch Date Observed
2007	15 March	28 March	4	29 March	28 April	15 August
2008	13 March	15 March	6	1 April	29 April	31 July
2009	10 March (Kehoe)	10 March	22	16 April	27 May	16 August
2010	1 March (North Beach)	1 March	20	7 April	24 May	6 August

Correlations

In addition, future exploratory analyses could include a variety of correlations with SFAN weather monitoring data and data sets available from other monitoring programs (e.g., temperature, precipitation, predator abundance, predator distribution, or food availability) to provide explanations for response variables.

Report Formats

Starting in 2008, the annual report format follows the national guidelines established for natural resource technical reports in the Natural Resource Publications Manual (<http://nature.nps.gov/publications/NRPM>). Trend and synthesis reports will follow the natural resource report series and will be peer reviewed prior to approval.

Report Distribution

The annual and trend and synthesis reports will be distributed to the PORE superintendent, PORE chief of natural resources, PORE science advisor, PORE wildlife biologist, USFWS regional recovery coordinator, and SFAN I&M staff. All reports will be included in annual USFWS threatened and endangered species permit reports. Electronic copies will be archived on the SFAN intranet page and the SFAN I&M archive on the GOGA I&M server.

Public access to snowy plover reports is available through the SFAN website (<http://science.nature.nps.gov/im/units/sfan/index.cfm>) in resource briefings and program reports. Final copies of peer-reviewed annual and long-term trend and synthesis reports will also be uploaded into the NPS Integrated Resource Management Applications (IRMA) portal (<http://irma.nps.gov>), an internet clearinghouse for documents, data and metadata on natural and cultural resources in parks. IRMA records will be created for all of the snowy plover monitoring documents, including the protocol, annual reports, and any resulting publications. When completed, metadata records, but not the data, will be posted to the NPS IRMA portal for public discovery and consumption. Contact information within the metadata records will direct interested parties to the SFAN data manager for inquiries. Master database metadata records posted to IRMA will be updated annually after the annual data has been uploaded or following database revision to a new version whole number (i.e., v1_3 to v2_0, but not v2_0 to v2_1).

Monthly E-Mail Update

During the breeding season, a monthly update is posted to the SFAN and PORE internet sites and e-mailed to all park staff including the beach safety patrol, law enforcement, interpreters, managers, and snowy plover program volunteers. This email provides a brief summary of monthly activities that include interesting observations; table with running monthly counts of snowy plovers and snowy plover nests; management activities that have occurred; and photos. See http://www.nps.gov/pore/naturescience/birds_snowyplover_updates.htm for examples.

The monthly update must include the following disclaimer:

The National Park Service shall not be held liable for improper or incorrect use of the data described and/or contained herein. These data and related graphics (if available) are not legal documents and are not intended to be used as such. The information contained in these data is dynamic and may change over time. The National Park Service gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. For more information: http://science.nature.nps.gov/im/units/sfan/data_liability.cfm.

Monthly I&M Update

The SFAN I&M Program also produces a monthly update. Projects are encouraged to submit a short paragraph every few month to update staff throughout the network about I&M activities. The snowy plover project should also submit paragraphs at least twice a year.

Resource Briefing

A resource briefing for the PORE snowy plover monitoring program should be updated annually or at least every two years. A briefing is a two-page summary following a standard template used to inform park staff and the public about project status. A briefing summarizes key findings, especially population trends and conservation issues. Photographs and an illustrative figure are used to engage readers. Examples of briefings, including the snowy plover briefing are posted to the SFAN website: <http://science.nature.nps.gov/im/units/sfan/index.cfm>.

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Appendix SOP 5A. Kendall rank correlation.

Taken from McLeod, A. I. 2008. The Kendall Package: Kendall Rank Correlation and Mann-Kendall Trend Test. Available at <http://cran.r-project.org/web/packages/Kendall/Kendall.pdf>. Accessed October 2008.

Kendall

3

Kendall

Kendall rank correlation

Description

Computes the Kendall rank correlation and its p-value on a two-sided test of H_0 : x and y are independent.

Usage

`Kendall(x, y)`

Arguments

x first variable, a vector
 y second variable, a vector the same length as x

Details

In many applications x and y may be ranks or even ordered categorical variables. In our function x and y should be numeric vectors. Any observations corresponding to NA in either x or y are removed.

Kendall's rank correlation measures the strength of monotonic association between the vectors x and y . In the case of no ties in the x and y variables, Kendall's rank correlation coefficient, τ , may be expressed as $\tau = S/D$ where

$$S = \sum_{i < j} (\text{sign}(x[j] - x[i]) * \text{sign}(y[j] - y[i]))$$

and $D = n(n - 1)/2$. S is called the score and D , the denominator, is the maximum possible value of S . When there are ties, the formula for D is more complicated (Kendall, 1974, Ch. 3).

The p-value of τ under the null hypothesis of no association is computed by in the case of no ties using an exact algorithm given by Best and Gipps (1974).

When ties are present, a normal approximation with continuity correction is used by taking S as normally distributed with mean zero and variance $\text{var}(S)$, where $\text{var}(S)$ is given by Kendall (1976, eqn 4.4, p.55). Unless ties are very extensive and/or the data is very short, this approximation is adequate. If extensive ties are present then the bootstrap provides an expedient solution (Davis and Hinkley, 1997). Alternatively an exact method based on exhaustive enumeration is also available (Valz and Thompson, 1994) but this is not implemented in this package.

An advantage of the Kendall rank correlation over the Spearman rank correlation is that the score function S is nearly normally distributed for small n and the distribution of S is easier to work with.

It may also be noted that usual Pearson correlation is fairly robust and it usually agrees well in terms of statistical significance with results obtained using Kendall's rank correlation.

Value

A list with class `Kendall` is returned with the following components:

<code>tau</code>	Kendall's tau statistic
<code>sl</code>	two-sided p-value
<code>S</code>	Kendall Score
<code>D</code>	denominator, $\tau = S/D$
<code>varS</code>	variance of S

Generic functions `print.Kendall` and `summary.Kendall` are provided.

Note

If you want to use the output from `Kendall`, save the result as in `res<-Kendall(x,y)` and then select from the list `res` the value(s) needed.

Author(s)

A.I. McLeod, aim@uwo.ca

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See Also

`cor`, `print.Kendall`, `summary.Kendall`, `MannKendall`, `SeasonalMannKendall`

Examples

```
#First Example
#From Kendall (1976, p.42-43, Example 3.4)
A<-c(2.5,2.5,2.5,2.5,5,6.5,6.5,10,10,10,10,10,14,14,14,16,17)
B<-c(1,1,1,1,2,1,1,2,1,1,1,1,1,1,2,2,2)
summary(Kendall(A,B))
#Kendall obtains S=34, D=sqrt(116*60), tau=0.41

#Second Example
#From Kendall (1976, p.55, Example 4.3)
```

```
x<-c(1.5,1.5,3,4,6,6,6,8,9.5,9.5,11,12)
y<-c(2.5,2.5,7,4.5,1,4.5,6,11.5,11.5,8.5,8.5,10)
summary(Kendall(x,y))
#Kendall obtains S=34 and Var(S)=203.30
```

MannKendall

*Mann-Kendall trend test***Description**

This is a test for monotonic trend in a time series $z[t]$ based on the Kendall rank correlation of $z[t]$ and t .

Usage

```
MannKendall(x)
```

Arguments

x a vector of data, often a time series

Details

The test was suggested by Mann (1945) and has been extensively used with environmental time series (Hipel and McLeod, 2005). For autocorrelated time series, the block bootstrap may be used to obtain an improved significance test.

Value

A list with class Kendall.

<code>tau</code>	Kendall's tau statistic
<code>sl</code>	two-sided p-value
<code>S</code>	Kendall Score
<code>D</code>	denominator, $\tau=S/D$
<code>varS</code>	variance of S

Generic function `print.Kendall` and `summary.Kendall` are provided to print the output.

Note

If you want to use the output from `MannKendall`, save the result as in `res<-MannKendall(x,y)` and then select from the list `res` the value(s) needed.

Author(s)

A.I. McLeod, aimcleod@uwo.ca

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 612/126255, August 2014

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