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Snowy Plover Population Monitoring, Research, and Management Actions: 2007 Nesting Season Research Progress Report

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OVERVIEW

During the 2007 Western Snowy Plover (*Charadrius alexandrinus nivosus*) nesting season, we monitored breeding phenology, nesting success, fledging success and the number of nesting adult plovers in Washington. Primarily Kirsten Brennan, Cyndie Sundstrom, and Kathryn Gunther conducted field monitoring and research with assistance from Max Zahn, Warren Michaelis, Marie Fernandez, Scott Pearson, Mark Hopey, Lauren Holman, Steve Spencer, Julie Tennis, and Martha Jensen. Volunteers assisting with occupancy and adult surveys include Craig Zora and Alan Knue. A summary of some of our 2007 results:

Breeding Phenology

- Clutches were initiated between 4 April and 29 June. However, intensive surveys did not start until after April 1.
- The first chick to fledge, fledged around 8 June and the last chick known to fledge, fledged around 13 August.

Breeding Range

- Snowy Plovers nested on Leadbetter, Midway Beach, and Graveyard Spit. Plovers did not nest on Damon Point or surrounding areas.
- We continue to recommend conducting four surveys to a potential nesting site by experienced observers between early to mid-May and the end of the first week of July – the period of greatest plover nesting activity – to have a very high probability of determining site occupancy.

Number of Breeding Adults

- The mean 2007 Washington breeding adult population was 48 (95% Confidence interval: 39-56). Nearly all of the breeding adults were found on Leadbetter Point and Midway Beach.
- Errors associated with double counting and detectability were addressed.

Nesting Success

- Forty-five nests were discovered and monitored.
- The percent of nests that survived from egg laying through hatching during the 2007 nesting season was 37% which was an 11% increase over last season.
- As in past years, the primary sources of nest failure were predation (primarily by crows and ravens) and nest buried by drifting sand.

Fledging Success

- The average number of young fledged per adult male on three nesting sites in Washington was 0.92 (95% Confidence interval: 0.77-1.13). Population viability analyses indicate that at least one young must fledge per adult male to have a stable population. Our results indicate that the Washington population is not being maintained by local production.

Management Actions

- *Education:* Washington State Parks presented 10 educational programs to a total of 50 people that focused on Snowy Plovers at Cape Disappointment State Park and 22 programs to 240 people that included a discussion of Snowy Plovers at Grayland Beach State Park. Washington Department of Fish and Wildlife presented one program on Snowy Plovers to about 20 people.
- *Enforcement*: Washington State Parks rangers patrolled beaches at Leadbetter, Midway/Grayland, and Damon Point. Rangers contacted people walking dogs off leash, driving in closed areas, camping illegally, and so on. Some violations were issued. A U.S. Fish and Wildlife Service federal agent patrolled razor clam tides and issued citations.

- *Restrictions*: Beaches controlled by State Parks were closed to fireworks
- *Nest exclosures*: 16 nests were exclosed on the Wildlife Refuge at Leadbetter, 1 nest was exclosed on State Park land on Leadbetter, and 7 nests were exclosed on State Park land at Midway Beach.
- *Signing*: Approximately 7.5 miles of beach was signed at Leadbetter and approximately 1 mile of Midway Beach was signed to restrict human access and protect nests.
- *Restoration*: U.S. Fish and Wildlife Service cleared approximately 21 acres of non-native beachgrasses and added oyster shell to 13 acres to the Leadbetter restoration bringing the total acres treated at this restoration site to 84. Four new restoration sites were identified on Leadbetter State Park, pre-treatment bird and plant monitoring was conducted by Washington Department of Fish and Wildlife with the assistance of Audubon volunteers and initial treatments to control non-native beachgrasses were conducted by Washington Department of Fish and Wildlife.
- *Environmental cleanup*: The cleanup and removal of the S.S. Catala shipwreck was completed at Damon Point. 34,500 gallons of heavy fuel oil was removed and recycled, 360,000 gallons of oily water was collected and transported offsite for treatment, 2,585 tons of oil-contaminated sand were removed and disposed.

Monitoring and Research Recommendations

- Continue testing methods for determining site occupancy and for estimating adult population size.
- Examine the effectiveness of habitat restoration areas.
- Examine methods for creating a self-sustaining population.
- Conduct research to identify habitat features important to successful plover nesting.
- Initiate a study to examine the effectiveness of predator control.

INTRODUCTION

The Pacific coastal population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) is listed as Threatened under the Endangered Species Act, and is listed as Endangered by Washington State. The current Pacific coast breeding population extends from Midway Beach, Washington, to Bahia Magdalena, Baja California, Mexico. The Snowy Plover winters mainly in coastal areas from southern Washington to Central America. This coastal population nests primarily above the high tide line on a variety of beach and dune types including coastal beaches, sand spits, dune-backed beaches, sparsely-vegetated dunes, beaches at creek and river mouths, and bluff-backed beaches (U.S. Fish and Wildlife Service 2007). In addition, it also nests on sandy river bars, salt pans at lagoons and estuaries, salt pond levees, dry salt ponds, and on dredge spoils (U.S. Fish and Wildlife Service 2007). In winter, Snowy Plovers are found on many of the beaches used for nesting as well as on beaches where they do not nest (U.S. Fish and Wildlife Service 2007).

According to the U.S. Fish and Wildlife Service (2007), "Habitat degradation caused by human disturbance, urban development, introduced beachgrass (*Ammophila* spp.), and expanding predator populations have resulted in a decline in active nesting areas and in the size of the breeding and wintering populations". In Washington, predators eating plover eggs, weather, shoreline modification, dune stabilization, and recreational activities have been attributed to reduced nesting success and have been cited as the causes of local population declines (Washington Department of Fish and Wildlife 1995).

Historically, five areas supported nesting plovers in Washington (Washington Department of Fish and Wildlife 1995). During the 2006 nesting season, there were four nesting locations: Leadbetter Point, Midway Beach (Grayland vicinity), Graveyard Spit, and Damon Point. During the 2007 nesting season, only three nesting sites were occupied, Leadbetter Point, Midway Beach (Grayland vicinity), and Graveyard Spit.

According to the federal Recovery Plan for the Western Snowy Plover, Washington and Oregon compose Recovery Unit 1 (U.S. Fish and Wildlife Service 2007). The primary recovery criterion for this unit are maintaining 250 breeding adults for 10 years and a 5-year average productivity of at least 1.0 fledged chick per male (U.S. Fish and Wildlife Service 2007). The last recovery criterion is the development and implementation of mechanisms to assure long-term protection and management of breeding, wintering, and migration areas in recovery unit 1 (U.S. Fish and Wildlife Service 2007). This report does not address progress on this last criterion.

According to the Washington State Recovery Plan for the Snowy Plover (1995), the plover will be considered for down listing to Threatened when the state supports a 4-year average of at least 25 breeding pairs and fledge at least one young per pair per year, at two or more nesting areas with secure habitat. Delisting will be considered when the average population reaches 40 breeding pairs at three or more secure nesting areas.

Both of these plans require effective monitoring of breeding adults and monitoring of fledging success to assess progress toward these recovery goals. To provide the information needed to assess recovery progress, Washington Department of Fish and Wildlife started coordinating its monitoring efforts with U.S. Fish and Wildlife Service, Washington State Parks, and Oregon Department of Fish and Wildlife during the 2006 nesting season and continued this coordinated effort in 2007.

The primary objectives of our monitoring for the 2007 nesting season were:

- Conduct U.S. Fish and Wildlife Service breeding window surveys.
- Conduct unoccupied breeding site surveys at Copalis Beach and Connor Creek.
- Estimate hatching success rates and sources of nest mortality during the egg laying/incubation stage for all known nesting sites.
- Evaluate methods for estimating fledging success and for estimating the number of adult plovers in Washington.
- Provide information to land management agencies during the field season to help them protect nesting plovers from potential threats.
- Attempt to increase nesting success through habitat restoration efforts, the use of nest exclosures and by restricting human activities in nesting sites.
- Produce a joint report with U.S. Fish and Wildlife Service Willapa National Wildlife Refuge that summarizes methods used, numbers of breeding adults, and hatching success (this report).
- Coordinate monitoring efforts with Oregon Department of Fish and Wildlife to produce consistent monitoring metrics for the entire recovery Unit 1 (Oregon and Washington). However, specific methods may differ between states.

This report summarizes the progress on all of these objectives.

METHODS

Study Areas

During the 2005 nesting season, Snowy Plovers were known to nest at three sites along Washington's coast, the Damon Point area near Ocean Shores, Midway Beach near Grayland, and Leadbetter Point at the tip of the Long Beach Peninsula (Table 1). A new nesting location was discovered at Graveyard Spit during the 2006 field season (Table 1). During the 2007 nesting season, only three sites were occupied, Leadbetter Point, Graveyard Spit, and Midway Beach. The orthographic photos of the nest sites in Appendix I provide a pictorial overview of the primary areas used for nesting in the spring/summer of 2007. Leadbetter Point and Midway Beach are dune backed beaches and have an unusually wide area that is unvegetated or sparsely vegetated located between the mean high tide and the foredune and, in some cases, also consisting of sparsely vegetated foredunes and areas behind the foredune. The Snowy Plover habitat at Midway Beach consists of swales, sparsely vegetated foredunes, and a large deflation plain with ephemeral dune ponds. Leadbetter Point is part of a very long sand spit or peninsula and the habitat at Leadbetter Point consists of unvegetated beach above the summer high tide line, sparsely vegetated foredunes, blowouts, and human modified habitat of sand and oyster shell landward of the foredune (habitat restoration area). Graveyard Spit is located on the north shore of Willapa Bay. The nesting habitat at this site consists of dune backed beach, sparsely vegetated foredunes, sand spits, swales and unvegetated deflation plains adjacent to saltmarsh communities. For definitions of the terms used to describe coastal sand dune morphology in this section, we recommend referring to Wiedemann (1984).

Table 1. Approximate locations and land ownership for the 2007 Snowy Plover nesting localities in Washington.

Site	Approximate Location	Ownership/Management
Midway Beach	46° 45' 32", 124° 05' 46"	South Beach State Park, Private
Graveyard Spit	46° 42' 57", 124° 01' 25"	Shoalwater Indian Reservation
Leadbetter Point	46° 36' 24", 124° 03' 25"	Leadbetter State Park, Willapa National Wildlife Refuge

Breeding Window Surveys

The breeding window survey occurs annually in late May and early June along the entire U.S. Pacific coastline where Snowy Plovers nest. The specific dates for a particular year are selected by the U.S. Fish and Wildlife Service and all participants follow the methods of Elliot-Smith and Haig (2006a). In 2007, the window survey occurred the week of 21 May. We surveyed Connor Creek, Copalis Spit, Damon Point, Midway/Grayland Beach, Graveyard Spit, Leadbetter Point (north of Oysterville Road) and we drove the Long Beach Peninsula south of Oysterville Road.

For the sites that were previously occupied by plovers but were thought to be unoccupied at the beginning of the 2007 field season (Connor Creek and Copalis Spit), an experienced biologist surveyed appropriate habitat on foot. The south Long Beach Peninsula survey was a driving survey with two experienced surveyors looking for plovers on either side of a vehicle moving at approximately 15 mph.

More effort was devoted to surveying occupied sites than unoccupied sites. Because these sites are wider with uneven surfaces and vegetated hummocks than other localities, more observers were required to adequately cover the site. For the Leadbetter survey, a single observer walked the southern section (the narrow beach section) north of the Oysterville Road to the Refuge (just south of the habitat restoration

area), 3 observers walked the wider section of beach from just south of the habitat restoration area to the north and around the tip of the Peninsula to the second cove on the eastern side. Two biologists most familiar with the habitat restoration area walked a serpentine route through the area. The three observers surveying the northern section and walked approximately 50 m apart but parallel to each other and all plovers observed were communicated to other observers by 2-way radio to a single data recorder (usually the middle observer) to avoid double counting. All birds were allowed to pass between observers and every effort was made to avoid flushing plovers, which could result in double counting. This approach was extremely successful but required adjusting distances between observers to allow the birds to pass between them. All observers started at approximately the same time and they walked from south to north. The Midway Beach survey consisted of three observers walking parallel and approximately 50 m apart and again, they communicated by 2-way radios and allowed birds to pass between observers.

Table 2. Starting and ending locations, survey types and number of surveyors for each survey site in Washington. The Leadbetter counts in the figures and tables that follow include birds detected in the Habitat Restoration Area (HRA), the northern Refuge beach section (from the refuge land just south of the habitat restoration area to the tip of the Peninsula and around) and southern beach section (between Oysterville Road and just south of the habitat restoration area on the Refuge).

Site	Starting Point	Ending Point	Number of Surveyors	Survey Type
Copalis Spit	47°07'16.5", 124° 10' 59.9"	47° 08' 15.6", 124° 10' 58.4"	1	Foot
Connor Creek	47° 04' 14", 124° 10' 24"	47° 07' 16.5", 124° 10' 59.9"	1	Foot
Damon Point	46° 56' 05", 124° 09' 18"	46° 56' 11", 124° 06' 18"	1	Foot
Midway Beach	46° 47' 38", 124° 05' 55"	46° 44' 07", 124° 05' 29"	3	Foot
Graveyard Spit	46° 43' 33", 124° 03' 07"	46° 42' 25", 124° 00' 36"		
Leadbetter - North	46° 37' 40.7", 124° 04' 17.4"	46° 38' 50.5", 124° 03' 13.6"	3	Foot
Leadbetter HRA	46° 37' 40.9", 124° 04' 07.8"	46° 38' 30.4", 124° 04' 07.2"	2	Foot
Leadbetter - South	46° 32' 54.0", 124° 03' 40.8"	46° 37' 40.7", 124° 04' 17.4"	1 or 2	Foot
Long Beach	46° 32' 54.0", 124° 03' 40.8	46° 22' 03.8", 124° 03' 24.4"	2	Vehicle

Adult Surveys

We conducted repeated surveys at six sites to test our ability to determine site occupancy. We also used repeated surveys to estimate the number of adults by sex at the three occupied nesting sites. Our goal was to use results from these surveys and from the 2006 season to develop a formal protocol for future monitoring. All sites were surveyed at least five times during the nesting season using the methods described in Elliot-Smith and Haig (2006a). In addition, we used the number of surveyors and methods described under the Breeding Window Survey above.

We also conducted several opportunistic surveys. We visited the area between Ocean City and the Ocean Shores North Jetty and the sandy open area adjacent to the jetty at Westhaven, and Benson Beach one time each to either follow-up on tips of Snowy Plover sightings from State Parks staff or because we suspected that these areas might have potential nesting habitat. We also conducted a driving survey of the South Long Beach area on five occasions again because we suspected that this area might support nesting plovers. Because our visits to these sites were not formal surveys and no birds were detected, they are not included in our analyses.

Site occupancy

Our goal was to determine presence/absence at the sites most likely to become reoccupied or at sites that are currently occupied but where we may be failing to detect plovers. Wildlife species are rarely detected with prefect accuracy and non-detection does not necessarily mean that a species was absent from a site unless the probability of detecting the species (detectability) was 100%. This leads to a fundamental problem -- the measure of occupancy is confounded with the detectability of the species. Specifically, an observed "absence" occurs if either the species was present at the site but not detected, or the species was truly absent. Because this issue had not been addressed prior to the 2006 nesting season, we could not confidently describe the distribution of nesting plovers in Washington.

To address this issue, we used a relatively new class of models called occupancy models. These models were developed to solve the problems created by imperfect detectability (MacKenzie et al. 2002, 2003, 2004). These models use information from repeated observations at each site to estimate detectability. Repeated observations for the plover involved repeated surveys at each site. The technique uses these repeated visits to derive a detection probability for each site. The product of all the probability statements for all of the sites forms the model likelihood for the observed data and maximum likelihood techniques are then used to estimate model parameters. We used the program PRESENCE to develop our occupancy model for the plover (Hines 2002).

For this analysis we included the repeated visits to Copalis, Connor Creek, Damon Point, Midway Beach, Graveyard Spit, and Leadbetter. All sites were surveyed at least five times this season.

Estimating Number of Adult Plovers

Occupied sites were surveyed 5 times each this season between 19 April and 2 July. We surveyed the entire nesting area with enough surveyors to consider these complete counts. Even though these are complete counts, there are likely errors of both omission (birds missed that should have been counted) and commission (double counted birds).

Even though we likely detected most plovers during these surveys, it is likely that we double counted a few birds or did not detect all of the birds present on the site. As a result, we corrected our counts for both errors of omission and commission. To estimate the number of double counts during each Midway Beach and Leadbetter survey, we determined how many times a color marked bird was double counted during a given survey. To estimate the number of birds not detected that should have been detected (omissions), we used our re-sight data of banded birds to determine the number of banded birds that were not observed during the survey but that were observed both during the two week period before the survey and the two and a half week period after the survey at that site. We used a two and a half week period post surveys because, in one instance, the closest survey in time was two and a half weeks after the survey of interest. These are the birds associated with the site that should have been detected during our survey but were not. To develop a correction factor, we combined the surveys from 2006 and 2007 and used surveys where > 25% of the birds were banded because we wanted a reasonable sample size of banded birds upon which to base our correction factor. The average proportion of double counts per survey (n = 11 surveys) was 0.0376 and the average proportion of missed birds per survey was 0.1326. We then used these two proportions to develop a single correction factor for any survey by subtracting the proportion of double counts from the proportion of omissions and multiplying this resulting value + 1 (= 1.095) by the number of birds detected per survey.

When deriving these population estimates, we only used counts between 19 April and 2 July. These counts occurred when there was the least amount of immigration and emigration into and out of Washington and before post-nesting dispersal. For all sites (Damon Point, Midway Beach, Graveyard Spit and Leadbetter Point) we only used the 5 surveys and survey periods that were assigned before the

nesting season for our estimates. We took the adjusted count of adult birds from these surveys and present the mean value and the 95% confidence interval surrounding this estimate of the mean. We rounded all estimates to the nearest whole bird.

Clutch Initiation Dates

Unless observed directly, we calculated clutch initiation date by backdating from hatching dates. Backdating using hatch dates requires information on the time intervals associated with the egg laying and incubation stages. Because our sample size of nests under observation prior to egg laying was too small to compute these time intervals directly, we used the following time intervals from California and reported in Page et al. (1995) to calculate clutch initiation dates: egg laying = 2.5 days between laying egg 1 and 2 and 2.3 days between laying eggs 2 and 3, incubation = 27 days or 32 days from the first egg laid until hatching.

Nesting Success

Nesting sites were visited several times a week to search for and monitor Snowy Plover nests from April 1 until August 20, 2007. Searching was conducted both during adult surveys and during frequent visits to the nesting sites. Nests were located in most cases by following plover tracks to nests. Nests were also located by observing scrape building by males, locating adults incubating eggs, or by flushing incubating adults. Date and status (presence of parents and eggs) of each nest was recorded approximately every 3-5 days. Nest success was calculated using the Mayfield method (Mayfield 1961, 1975) as modified by Johnson (1979) and Hensler and Nichols (1981). Nest outcome was reported as the number of successful nests, nests that failed, nests lost to predation, nests abandoned, nests covered by drifting sand, nests lost to human activities (vehicles, walking, horseback riding, etc.) or unknown sources of failure.

Nest Exclosures

We used the mini-exclosure design provided by plover biologists Dave Lauten and Kathy Castelein of Oregon (Lauten et al. 2003). The mini-exclosure was constructed of 2x4 inch mesh wire fencing with four sides, 4 feet long and wide and 2 feet 8 inches high. The sides were fastened together to form a square. A 'bubble' top of wire fencing was fastened to the top of the square, making the exclosure approximately 3 feet high. Under the wire bubble top we secured a taut layer of 3/4 inch polypropylene black mesh netting. This soft layer was used to keep a startled plover from flying up and hitting the wire bubble top of the exclosure, if a raptor should land above them. A door was cut in one side of the exclosure so that eggs could be accessed if necessary; doors were fastened closed with pliable, heavy gauge wire. The completed exlosure was centered over the nest creating an imprint in the sand and removed. Following the exclosure imprint, a trench, 8 inches deep, was dug and the mini-exclosure was placed in the trench. Fifteen inch stakes were place on each corner of the exclosure to help hold it in place prior to filling in the trench. The 2 x 4 inch mesh allows adult plovers free access to the nest from all sides but excludes Northwestern Crows, Common Ravens and larger mammals.

Fledging Success

Snowy Plover chicks are precocial, leaving the nest within hours after hatching to search for food. They are not able to fly for approximately 4 weeks after hatching. Adult plovers do not feed their chicks after hatching, but lead them to suitable feeding areas. Adults warn of approaching predators and use distraction displays to lure predators and people away from chicks. Chicks fledge (i.e., are capable of sustained flight) at 28 to 33 days (mean equals 31 days) post hatching (Warriner et al. 1986). The Recovery Plan considers chicks fledged at 28 days post hatching (U.S. Fish and Wildlife Service 2007). According to the recovery plan, the productivity information most useful for determining recovery is the annual number of young fledged per adult male. Because males are responsible for post-hatching parental

care (Warriner et al. 1986) and because male population trends and survivorship can be estimated with greater certainty than for females, they are used in determining this metric of reproductive success (U.S. Fish and Wildlife Service 2007). We estimated the number of young fledged per adult male for all three active nesting sites combined by using the estimates of the number of breeding adult males from the adult surveys described above and by estimating the number of young fledged.

Determining the number of young fledged requires following broods from hatch date to 28 days post hatching. To accomplish this, we needed to be able to assign a hatch date to each brood and to develop methods for tracking specific broods. We attempted to band nearly all chicks on hatch date. Hatch date was estimated by floating eggs following Hays and LeRoy (1971) or by counting forward from egg laying. For nests where we missed hatching, we were able to estimate hatch dates because we checked nests every 1-3 days around hatching and could therefore estimate hatch date to within 3 days. We were often able to use chick plumage and size for chicks observed within a couple of days of hatching to narrow down the assignment of hatch date to plus or minus one day. We used several methods independently and, when possible, in concert to track chick survival for the 28 days post hatching. For 13 nests out of 21 nests that hatched, we banded one or more chicks. Chicks from banded broods were then followed for at least 28 days post hatching. For some nests without banded young, we were able to track the outcome of the brood because no other chicks were of similar age along a particular stretch of beach. In other cases, we were able to assign broods to a specific nest and hatch dates when a banded adult male accompanied chicks. Fortunately, all chicks could be assigned to specific nests/hatch dates using bands, chick age (size and plumage) and location along the beach and/or by using the color band combination of an accompanying adult male.

Nest Locations

Each nest was photographed and its location was recorded using a hand held GPS unit. On Leadbetter, the U.S. Fish and Wildlife Service uses a Trimble GPS unit with 1 m accuracy with post-processing and on the other sites Washington Department of Fish and Wildlife uses Garmin units with approximately 15 m accuracy.

Banding

The 2007 nesting season is the first season that Washington has banded Western Snowy Plovers for the purpose of estimating fledging success. Only chicks were banded and all chicks were banded on the nest or very near the nest on their hatch date and usually within 3 hours of hatching. Hatch date was determined from known dates, by floating eggs, observing adult behavior, and by examining eggs for signs of hatching or sounds from chicks inside the egg. Each chick was fitted with three XCL Darvic or celluloid color bands and 1-1P U.S. Fish and Wildlife Service band. On the left leg, we placed red over violet bands for Midway Beach birds and violet over either red or dark blue for Leadbetter Beach birds. Two plastic bands were placed on the left leg and a plastic band was placed over the U.S. Fish and Wildlife Service band on the right leg. Darvic bands were sealed shut with a soldering iron and celluloid bands were sealed with acetone. Color auto pin striping tape was placed on top of the U.S. Fish and Wildlife Service band and sealed to transform this metal band into a color band.

Reading Color Bands

A number of Washington's breeding birds were banded in Oregon or California or were banded as young of the year in Washington. Most birds have two color bands on each lower leg and each color combination should be unique. Gary Page with Point Reyes Bird Observatory currently coordinates color banding for the Pacific coast and assigns unique color combinations to each state. Color bands are read

top down from the belly to the foot of the bird. Colors on the birds' left leg are read first, and then the colors on the right leg are read. For example, if a bird has red band on top of a aqua band on the left leg and a white band over a red band on the right, its combination would be red, aqua: white, red or RA:WR. Exact color combinations for a banded bird were only assigned when the birds were observed with spotting scopes and where the color combination could confidentially be determined. To help us determine if a color combination was confidentially assigned, we assigned a confidence score (0-100% confident) to each color combination recorded.

RESULTS & DISCUSSION

Breeding Window Survey

Fifty adult plovers were detected in Washington during the 2007 breeding window survey which was lower than the 2007 count (Table 3) but higher than all other breeding window surveys since 1998. 2006 was the first year that we followed the methods of Elliot-Smith and Haig (2006a), and consequently, more effort was devoted to locating birds than in previous years. As a result, the past two season's results are not necessarily comparable with those from previous seasons.

Table 3. Breeding Window survey counts by site, sex, and age and counts of nests and broods in 2007.

Site	2005	2006	2007	2007 Survey Dates	2007 Adult Males	2007 Adult Females	2007 Adult Unknown	2007 Juveniles	2007 Broods	2007 Nests
Copalis Spit	-	0	0	24 May	0	0	0	0	0	0
Conner Creek	-	0	0	24 May	0	0	0	0	0	0
Damon Point	5	0	0	22 May	0	0	0	0	0	0
Midway Beach	23	25	22	25 May	10	10	2	0	0	1
Leadbetter Point	9	42	28	24 May	16	11	1	3	2	4
South Long Beach	-	0	0	21 May	0	0	0	0	0	0
Total	37	67	50		26	21	3	3	2	5

Adult Surveys

As indicated in Table 4 we conducted 45 surveys at 11 sites between 12 April and 10 August 2007.

Table 4. Snowy Plover survey dates, number of surveys and surveyors and type of survey by site during the 2007 nesting season

Site	Type of Survey	Number of Surveys	Number of Surveyors	Walking or Driving	Survey Dates
Damon Point	Breeding Adult	10	1-2	Walking	4/12, 4/20, 5/1, 5/15, 5/22, 6/7, 6/19, 7/3, 7/17, 8/7
Midway	Breeding Adult	5	3	Walking	4/25, 5/11, 5/25, 6/22, 7/2
Graveyard	Breeding Adult	12	1-3	Walking	4/6, 4/19, 5/4, 5/17, 5/21, 6/5, 6/14, 6/21, 6/30, 7/13, 7/26, 8/3, 8/10
Leadbetter	Breeding Adult	5	6-7	Walking	4/26, 5/10, 5/24, 6/11, 6/25
Midway wrack	Breeding Adult	7	1	Driving	4/27, 5/3, 5/4, 5/17, 5/21, 5/31, 6/4
Connor Creek	Occupancy	4	1-2	Walking	5/24, 6/7, 6/11, 6/25
Copalis Spit	Occupancy	4	1-2	Walking	5/24, 6/7, 6/11, 6/25
Long Beach	Occupancy	5	1	Driving	5/21, 7/19, 7/23, 8/8, 8/9
OC-N Jetty	Opportunistic	1	1	Walking	6/7
Westhaven	Opportunistic	1	1	Walking	8/2
Benson Beach	Opportunistic	1	1	Walking	6/12

Our goal was to determine plover presence-absence at Copalis and Connor Creek and we surveyed each of these sites at least 4 times throughout the season using volunteers. At Damon Point, Midway Beach, Graveyard Spit, and Leadbetter our goal was to estimate the number of breeding adults and we surveyed

each site at least 4 times during the nesting season. We also conducted opportunistic surveys at Long Beach (south of Oysterville Road), Westhaven and the Ocean Shores area.

Presence - Absence

In 2006, we used occupancy models to assign a probability of correctly determining site occupancy status with different numbers of surveys or visits (Pearson et al. 2006). We examined the probability of correctly determining occupancy for all sites with repeated visits and for Damon Point seperately. We looked at Damon Point independently because it was the site with the smallest sample size and therefore had the highest probability of not detecting plovers when they were actually present. At Damon Point, Snowy Plovers were detected on 4 of the 6 surveys during the period when we are fairly confident that plovers were present, or a detection probability of 67%. This probability was very similar to the lower limit of the 95% confidence interval from the selected PRESENCE model for all sites combined (Pearson et al. 2006). Using the Damon Point detection probability, there is a 67% probability of correctly determining presence or absence for that site with one visit, a 89% probability with two visits, a 96% probability with three visits, and a 99% probability with four visits. Because sites are colonized and go extinct within a season as demonstrated by Damon Point, it is important to spread out visits between early to mid-May and the end of the first week of July – the period of greatest nesting activity (see Number of Adults and Clutch Initiation Dates below).

In 2007, we again examined patterns of occupancy at Copalis Spit, Connor Creek, Damon Point, Midway Beach, Graveyard Spit, and Leadbetter Point. Each site was surveyed at least four times to assess occupancy. No plovers were detected during any of our surveys at Copalis Spit, Connor Creek, and Damon Point. Plovers were detected on every survey on Midway Beach and Leadbetter Point. At Graveyard Spit, no plovers were detected during our first three surveys but were detected on our last two visits. We used a matrix of plover presence/absence (1,0) from these surveys to examine the effectiveness of various detectability models in the program PRESENCE. For 2007, the models with the lowest AIC values were the models that indicated that detection probabilities are not time-specific but that may differ among groups of sites (Table 5). When comparing occupancy between 2006 and 2007, the Seasonal Occupancy and Colonization and the Seasonal Occupancy and Local Extinction models were the models with the lowest AIC values (Table 5). This result was not surprising because we believe that Damon Point was occupied in 2006 and was not occupied in 2007 (local extinction) and Graveyard Spit was not occupied early in both 2006 and 2007 but was occupied later in the season. However, all of the primary assumptions of occupancy modeling are violated by plovers in Washington - occupancy status changes over the survey season, the probability of occupancy likely differs among sites and detection histories at one site appear to influence those at another (birds move among sites) because birds shift from one site to another during the season resulting in changes in occupancy. As a result, we do not recommend using occupancy models for snowy plovers.

Table 5. Occupancy model results for Snowy Plovers in Washington.

Model	AIC	delta AIC	AIC wgt	Model Likelihood	No.Par.	(-2*LogLike)
			2007 Occupancy Model			
2 groups, Constant P	26.66	0	0.5163	0.2666	4	18.66
1 group, Constant P	27.33	0.67	0.3694	0.1907	2	23.33
			2006 and 2007 Occupancy Model			
Season occupancy and colonization	47.59	0	0.3302	0.109	3	41.59
Seasonal occupancy and local extinction	47.59	0	0.3302	0.109	3	41.59

We continue to recommend four visits to a site to determine if it is being used as a nesting site and that those visits occur between early to mid-May and the end of the first week of July. Following this recommendation, there was a 99% probability of correctly determining that Damon Point was occupied in 2006 and an 87% probability of correctly determining that Graveyard Spit was occupied in 2007.

Sources of Bias

Estimating the number of breeding adults requires an understanding of movement patterns among sites within Washington and patterns of immigration and emigration between Washington and localities to the south. When examining the numbers of adult birds detected during our repeated surveys in 2006, numbers declined after the first week in July suggesting that some birds are dispersing from these sites after either failing to breed or females dispersing after leaving their mate with the final clutch or brood of the season (Pearson et al. 2007). This pattern suggests that surveys of breeding adult birds should be completed between late April and before the second week in July. In 2007, we used 5 surveys from pre-determined weeks between 19 April and 10 July to estimate the breeding adult population (Figure 1, Table 5).

We also examined patterns of immigration and emigration using dates when banded birds were either first detected on a nesting site or last detected (Figure 2). We started searching nesting areas for plovers and nests at the beginning of April when most of the breeding birds were already on the nesting sites. As a result, there is an apparent peak in the number of banded birds first observed at this time – these birds may have been present all winter or may have recently arrived. We ended our nest, chick and adult monitoring at the end of August. Again, there is an apparent peak in the number of final observations for the season on the final survey dates – many of the birds last observed during the final surveys of the season likely stayed at these sites for at least a few more weeks and subsequent visits and observations of these birds indicates that some stay on the nesting sites throughout the winter.

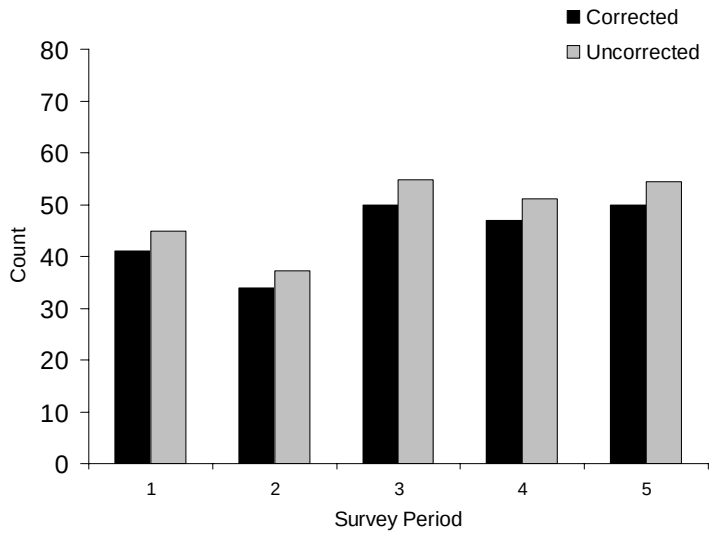

Figure 1. Total counts of adult Snowy Plovers at Midway Beach, Graveyard Spit and Leadbetter Point combined for each of five survey periods. Adult surveys were conducted once at each site during the following survey periods: Period 1 = 19 April – 26 April; Period 2 = 10 May – 17 May; Period 3 = 21 May – 25 May, Period 4 = 11 June – 22 June; Period 5 = 25 June – 2 July. Uncorrected counts are the number of birds actually detected and corrected counts account for both double counts and birds missed that should have been counted (see below).

Examining patterns of arrival and departure after our early monitoring (3-10 April) and before the end of our monitoring (28 Aug. – 7 Sept.) suggest that most banded female plovers are either already present on

these sites or are arriving at the beginning of April, that there are few arrivals or departures in late April, May or early June and that there is increased movement away from Washington in late July and August after nesting (Figure 2). For males, the pattern is similar to that exhibited by females (Figure 2).

Banded juvenile plovers start arriving on Washington nesting sites from their Oregon and California hatch sites in August (Figure 2). Because plovers are moving in and out of the state during the nesting season, actual counts will differ among surveys.

We also examined the number of times each banded male and female was observed in a given season to determine if there are differences in detectability between the sexes and we found no differences even when accounting for potential differences in the amount of time each bird was found on our sites (Figure 3). This result and a nearly identical result in 2006 indicates that there is no need to adjust counts to account for differences in detectability between males and females.

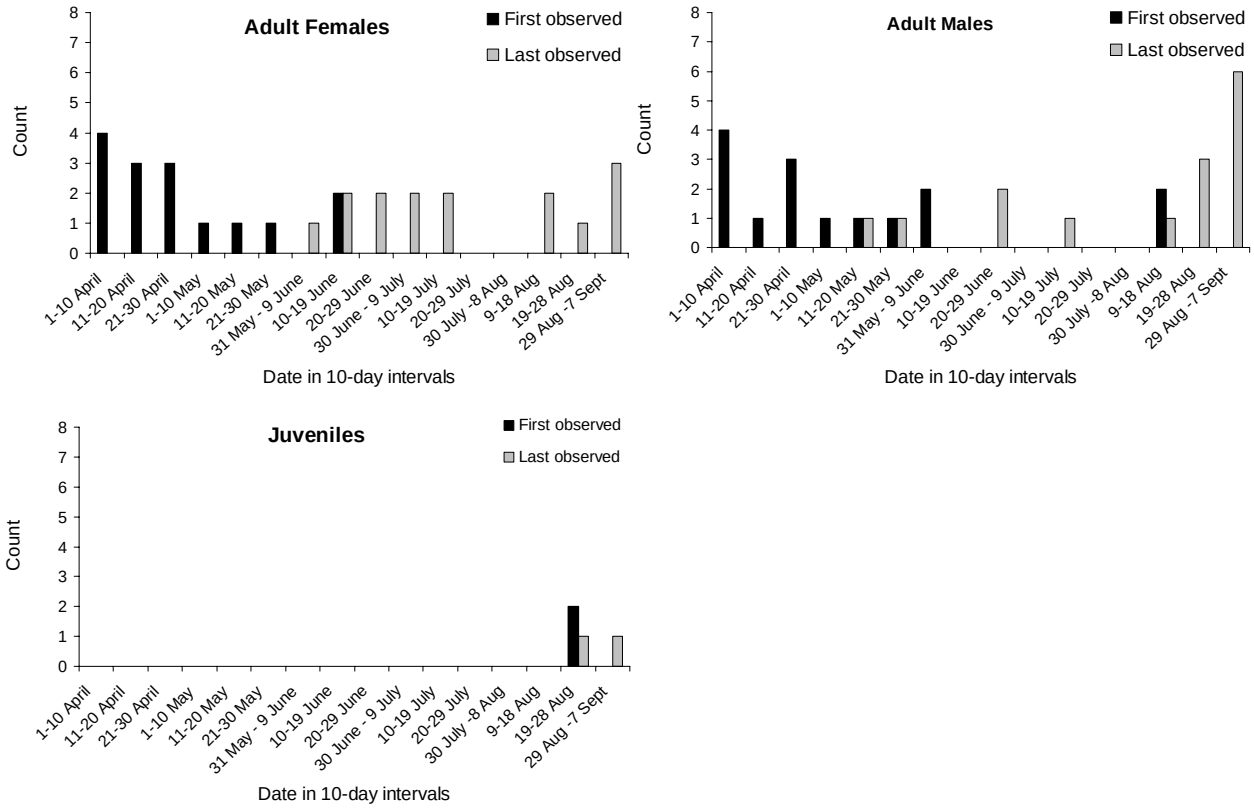

Figure 2. Dates banded male, female and juvenile Snowy Plovers were first and last detected on Midway Beach and Leadbetter Point combined in 2007.

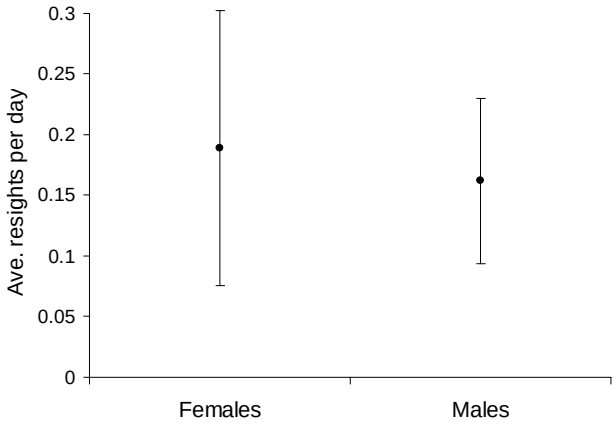

Figure 3. Average number of re-sights per banded adult female (n = 13) and male (n = 14) Snowy Plovers per day during the 2007 nesting season.

Estimating Number of Adult Plovers

In Figure 1, we provide both the uncorrected and corrected counts for each survey period and in Table 6 we present breeding adult population estimates by nesting site and for the entire State.

Table 6. Adjusted counts (95% CI) of the breeding adults at four nesting sites in Washington and the total population estimate for the State in 2007.

	Damon	Midway	Graveyard	Leadbetter	Total
2007 Adjusted Counts	0	19 (16-23)	2(-1-5)	27 (22-33)	48 (39-58)

We considered using Mark – re-sight methods (Pollock et al. 1990, Lebreton et al. 1992) to estimate the population size this year but decided to only use our complete counts because: 1) we had the opportunity to conduct a total count, 2) our re-sights are not a simultaneous sample of the population, 3) we suspect that the variation in the estimator would be larger than our total counts (Pollock et al. 1990), and 4) we do not have the capture history of our banded birds; we don't know the date that the banded birds arrived in our nesting populations.

We also considered using DISTANCE sampling methods (Buckland et al. 2001) to address the effect of detectability on our population estimates and to come up with an unbiased population estimate. This method, requires walking a transect and providing an accurate distance estimate from each bird detected to the transect which is possible with plovers. A detectability function is then derived from these distance estimates (Buckland et al. 2001). However, when walking a transect along a narrow beach, distances are truncated by the ocean on one side and the dune on the other making it difficult to derive detectability functions and, reliable estimates of density. Other assumptions of distance sampling, might also be violated with plovers including the assumption that birds do not move away from the transect line, that the probability of detecting birds close to the line is approximately 1 and that plovers are randomly distributed along the beach. This last assumption is likely violated because plovers tend to forage along the wrack line and are therefore not randomly distributed along the beach.

Opportunistic Surveys

No plovers were observed during opportunistic surveys conducted at the beach near the jetty at Westhaven, on the stretch of beach between Ocean City and Ocean shores north jetty, on the Long Beach Peninsula south of Oysterville Road, or on Benson Beach.

Clutch Initiation Dates and Breeding Phenology

For clutches where we observed clutch initiation or could calculate clutch initiation using back dating, we found that clutches were initiated between 4 April and 29 June. The last chick to fledge, fledged on 13 September. Scrape building and territory defense occurs prior to egg laying consequently, the active nesting season occurred between late March and the middle of September in 2007. In Figure 4, we present the number of clutches initiated in five-day intervals at all sites combined. The vast majority of the nests are initiated between the first week of May and the last week of June.

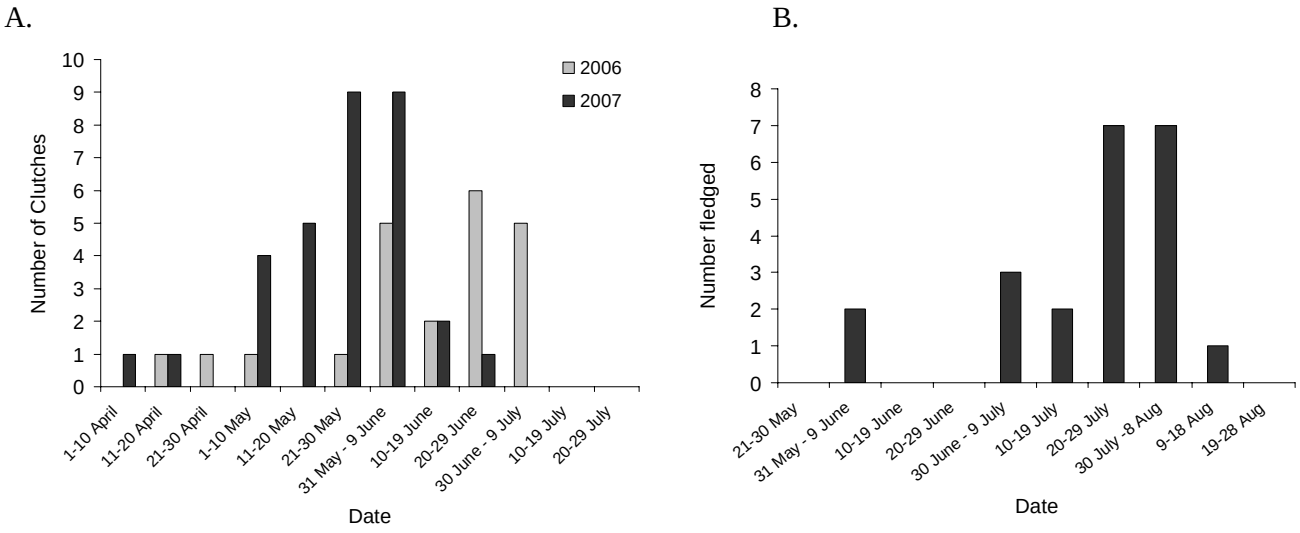

Figure 4. Number of Snowy Plover clutches initiated in 2006 and 2007 (A) and number of chicks fledged (B) in 2007. Counts are presented in 10-day intervals for all Washington nesting sites combined.

Nesting Success

We located and monitored the outcome of 45 plover nests in 2007. Of these 45 nests, 21 were located at Leadbetter, 22 at Midway Beach, and 2 at Graveyard Spit (Table 7). For a map of nest locations see Appendix I. Corvids eating eggs were the primary cause of nest failure at all sites and the only identified corvid predator this year was the crow (*Corvus caurinus* or *C. brachyrhynchos*; Table 8). Common Ravens (*Corvus corax*) were also observed regularly at the nesting sites and were identified as predators in 2006 (Pearson et al. 2007) and were suspected nest predators in 2007. Drifting sand is another significant source of nest failure especially at the outer beach of Leadbetter (Table 8). Four nests were abandoned for unknown reasons (Table 8).

Table 7. Nest outcomes by Snowy Plover nesting locality in 2007. Outcomes include successful (hatched), failed or unknown outcome.

Site		Outcome		
	# Nests	Hatch	Fail	Unknown
Graveyard	2	2	0	0
Midway	22	7	15	0
Leadbetter	21	13	7	1
Exclosed	25	17	7	1
Not exclosed	20	5	15	0
Totals	45	22	22	1

We used the Mayfield method to estimate nest survival probability. The Mayfield method accounts for potential biases associated with the date of nest discovery and the resulting number of days that a nest is exposed to predators by calculating a probability of survival associated with the number of exposure days (number of days observed). In Tables 9 and 10, we report Mayfield nest success estimates for the 2007 nesting season and compare this year's results to last year. The probability of nest survivorship was 28% at Midway and Graveyard combined and 51% at Leadbetter. This difference in nest success is the result of exclosing 86% of the nests at Leadbetter but only 29% of the nests at Midway. The probability of nest survivorship of unexclosed nests was only 11% (Table 9).

Table 8. Sources of Snowy Plover nest failure in 2007. Sources of failure include predators (Crows, Common Ravens or unknown predator) eating eggs or other sources of failure including human activities (trampling, horseback riding, vehicles, etc.), drifting sand covering the nest, abandoned nests and unknown sources of failure.

Site	Failures							
	Predator				Other Sources			
	crow	Raven	corvid	unknown	Human	Sand	Abandon	unknown
Graveyard	0	0	0	0	0	0	0	0
Midway	4	0	6	0	0	1	3	1
Leadbetter	0	0	1	0	0	5	1	0
Exclosed	0	0	0	0	0	4	3	0
Not exclosed	4	0	7	0	0	2	1	1
Totals	4	0	7	0	0	6	4	1

Table 9. Mayfield estimates of Snowy Plover nest survival and of daily nest survival probability by site and by exclosed and unexclosed nests in 2007.

Site	Daily Survival Probability	Nest Survival
Midway and Graveyard	0.96	0.28
Leadbetter	0.98	0.51
Midway exclosed	0.99	0.72
Midway unexclosed	0.94	0.12
Washington exclosed	0.98	0.60
Washington unexclosed	0.93	0.11
Washington Total (including exclosures)	0.97	0.37

Table 10. Mayfield estimates of nest survival by site in 2006 and 2007. Almost all nests were exclosed at Leadbetter in 2007.

	Nest Survival	
Site	2006	2007
Midway and Graveyard	0.23	0.28
Leadbetter	0.26	0.51
Washington Total (including exclosures)	0.25	0.37

The differences in hatching success between exclosed and unexclosed nests observed here is consistent with other research. Lauten et al. (2004) compared the percent of nests that failed from exclosed (n = 692) and unexclosed (n = 271) nests and found that 67% of the exclosed nests successfully hatched and only 11% of the unexclosed nests successfully hatched. There is some evidence that exclosures may increase adult predation slightly (Lauten et al. 2004).

Fledging Success

The U.S. Fish and Wildlife Service uses the number of young fledged per adult male to determine whether or not the population is growing, stable or decreasing. The recovery objective is at least one young fledged per adult male and is based on the population viability analysis by Nur et al. (1999). Nur et al. (1999) suggested that productivity of at least 1.0 chicks fledged per breeding male per year should result in a stable population and productivity of 1.2 or more chicks fledged per breeding male should increase population size at a moderate pace.

Deriving this metric for Washington requires an estimate of both the number of breeding adult males and the number of chicks fledged. When using just the proportion of the banded chicks that fledged, we estimated that 22.5 chicks should have fledged from the nests that successfully hatched at all three sites combined. We estimated that 22 chicks fledged using direct observations of both banded and unbanded chicks. The very similar results obtained by direct observation of all broods and by the estimate based on the sub-sample of banded chicks suggests that the banding approach gives accurate results. We used the proportion of males from our breeding adult surveys to determine the number breeding males in Washington. Because there was no difference in the sightability of males and females (Figure 3), this result should be unbiased. Using our estimate of breeding males and number of young fledged, we estimate that the number of young fledged per adult male was 0.92 (95% CI = 0.77 - 1.13). This estimate suggests that the plover population on these sites is not being maintained by local production (see Nur et al. 1999).

Why then is the population in Washington apparently increasing or stable over time? We believe that the Washington population is being maintained primarily by immigration of Oregon plovers and secondarily by California plovers. This hypothesis is supported by several lines of evidence: 1) Washington appears to have a declining population growth rate based on fledging success data; 2) Oregon has an increasing plover population (Lauten et al. 2006, 2007); 3) Washington did not banded chicks prior to this season and did not band adult birds this season, yet the number of banded adult birds detected on our adult population surveys at Leadbetter and Midway averaged 40% and 14% respectively indicating that birds are moving into Washington; and 3) of the color banded birds observed at these sites in 2006 where we could determine the location where they were originally banded, approximately 81% were originally banded in Oregon and approximately 19% were originally banded in California indicating that birds are moving into Washington from Oregon and California.

Nest Locations

Nest locations are presented by nesting site in Appendix I. At Midway Beach, birds nested in Twin Harbors State Park south to Washaway Beach. At Graveyard Spit, birds nested on the Shoalwater Indian Reservation and on Leadbetter plovers nested on the tip of the Peninsula primarily on the Willapa National Wildlife Refuge in the Habitat Restoration Area.

PROGRESS ON RECOVERY OBJECTIVES

Federal Recovery Objectives:

Objective 1: 250 breeding adults in recovery unit 1.

The 2007 Washington nesting population is 48 adult plovers (95% CI = 39-58) and the 2007 nesting population in Oregon was 162 plovers (Lauten et al. 2007) for a total of approximately 210 (range = 201-220) nesting adult plovers in recovery unit 1.

Objective 2: A 5-year average productivity of at least 1.0 fledged chick per male

In 2007, the average number of young fledged per adult male in Washington was 0.91 (95% CI = 0.77 - 1.13). The number of young fledged per adult male in Oregon was 1.6 in 2007 (Lauten et al. 2007). We combined the Oregon and Washington estimates of the number of breeding adult males and the number of young fledged (n = 146) to derive a combined Unit 1 fledging success per male of 1.43 (95% CI = 1.37-1.50).

Washington State Recovery Objectives:

Downlisting objective 1: A 4-year average of at least 25 breeding pairs

We estimate that there were 48 (95% CI = 39-58) nesting adults in 2007 and approximately 49% of these birds are females and 51% are males. If all females are paired, these estimates indicate that there are approximately 24 pairs (95% CI = 19-28 pairs) in Washington.

Downlisting objective 2: Fledge at least one young per pair per year, at two or more nesting areas with secure habitat.

The average number of young fledged per adult male in Washington was 0.91 (95% CI = 0.77 - 1.13). We have not attempted to determine the number of sites with "secure" habitat.

Delisting objective 1: The average population reaches 40 breeding pairs at three or more secure nesting areas.

See Downlisting Objective 1. Recommend defining the term "secure" and determining the number of sites considered "secure".

2007 MANAGEMENT ACTIONS

A number of the management actions that occurred in 2007 involved restricting some human activities on active Snowy Plover nesting sites during the nesting season. Human disturbance has been shown to negatively affect hatching success of Snowy Plovers (Warriner et al. 1986, Schulz and Stock 1991) and Snowy Plover chick survival by as much as 72% (Ruhlen et. al. 2003). Disturbances to wintering Snowy Plovers is 16 times higher at a public beach than at a protected beach and humans, dogs, crows and other birds are the main sources of disturbance (Lafferty 2001). In addition, Snowy Plover feeding rates declined in response to disturbance (Lafferty 2001). Human disturbance has also been shown to negatively affect hatching rates and chick survival for various plover species (Flemming et al. 1988, Buick and Paton 1989, Dowling and Weston 1999).

Management

- The nesting areas above the wet sand at both Midway and Leadbetter were closed to all human activities at both sites. Approximately 7.5 miles of beach was closed at Leadbetter by State Parks and U.S. Fish and Wildlife Service and slightly under a mile of beach was closed to foot traffic at Midway Beach by State Parks and Washington Department of Fish and Wildlife. Note: all beach closures occurred on state or federal land and not private land. In addition, two dog restriction signs were added to trail junctions and trailheads on Refuge lands at Leadbetter and a "Share the Beach" sign was added to Grayland Beach State Park.
- Symbolic fencing was put along beach access trails at Leadbetter by U.S. Fish and Wildlife Service staff to direct people toward the wet sand and away from plover nesting habitat.
- Seasonal closure to vehicle traffic at Leadbetter. North of Oysterville Road to the southern Leadbetter State Park boundary closed from April 15 to the day after Labor Day. Willapa National Wildlife Refuge closed year round. (Exception: driving allowed during razor clam harvest openings).
- U.S. Fish and Wildlife Service and Washington Department of Fish and Wildlife biologists put nest exclosures around 16 nests on the Willapa National Wildlife Refuge, 1 nest on Leadbetter State Park, and 7 nests on Twin Harbors State Park.
- Fireworks were not allowed along the beach at Grayland Beach and South Beach State Parks during the nesting season.

Environmental Cleanup

- The cleanup and removal of the S.S. Catala shipwreck was completed at Damon Point. 34,500 gallons of heavy fuel oil was removed and recycled, 360,000 gallons of oily water was collected and transported offsite for treatment, 2,585 tons of oil-contaminated sand were removed and disposed. The project was a successful collaboration between Washington departments of Ecology, Natural Resources, Fish and Wildlife, Parks and Recreation and U.S. Fish and Wildlife, Army Corps of Engineers and U.S. Coast Guard.

Enforcement

- State Parks Beach Rangers patrolled nesting habitat at Twin Harbors area (Midway Beach) and Cape Disappointment State Park (Leadbetter)
- Enforcement of closures and other beach regulations occurred along both Midway Beach and Leadbetter Point by State Parks. Rangers contacted people walking dogs off leash, driving in closed areas, camping illegally, etc. Some citations were issued.

- A U.S. Fish and Wildlife Service Federal Agent patrolled clam tides and issued citations on Leadbetter Refuge lands.
- Beaches controlled by State Parks were closed to fireworks

Restoration

- U.S. Fish and Wildlife Service increased the size of the habitat restoration area at Leadbetter from 63 acres to 84 acres in 2007 and oyster shell was added to 13 of these acres to increase the amount of nesting habitat.
- Four experimental openings totaling approximately 4 acres were created on Leadbetter State Park to examine both plover and streaked horned lark response. Pre-treatment bird and plant monitoring was conducted by Washington Department of Fish and Wildlife with the assistance of Audubon volunteers and initial treatments to control non-native beachgrasses were conducted by Washington Department of Fish and Wildlife.

Education

- Enforcement and patrol activities by Beach Rangers includes education.
- Washington State Parks presented 10 educational programs to a total of 50 people that focused on Snowy Plovers at Cape Disappointment State Park and 22 programs to 240 people that discussed Snowy Plovers at Grayland Beach State Park. Washington Department of Fish and Wildlife presented one program on Snowy Plovers to about 20 people.
- Proactive Media Contacts resulted in a Columbian Newspaper article on Sept. 10, 2007 on the Western Snowy Plover, Streaked Horned Lark and Pink Sandverbena and Oregon Public Broadcasting's Oregon Field Guide program filmed a segment on plover habitat at Leadbetter.

Monitoring

- Breeding window surveys were conducted and range-wide protocols were followed.
- Nest monitoring and fledging success and hatching success rates were estimated for all nesting sites.
- Breeding adult surveys were conducted at all nesting sites.

Research

- New methods for determining site occupancy were tested.
- New methods for estimating the number of breeding adults were also tested.

FUTURE RESEARCH & MONITORING CONSIDERATIONS

- Continue testing methods for determining site occupancy and for estimating adult population size.
- Examine the effectiveness of habitat restoration areas.
- Examine methods for creating a self-sustaining population.
- Conduct research to identify habitat features important to successful plover nesting.
- Initiate a study to examine the effectiveness of predator control.

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Max Zahn, Warren Michaelis, Mark Hopey, and Lauren Holman from Washington Department of Fish and Wildlife and Marie Fernandez from U.S. Fish and Wildlife Service conducted adult population surveys and volunteers Alan Knue, Craig Zora, and Martha Jensen conducted surveys of previously occupied but currently unoccupied sites. The Shoalwater Tribe and Steve Spencer in particular provided access to tribal land for plover surveys and assisted with plover surveys. Washington State Parks staff including Lisa Lantz, Julie Tennis, Jim Schmidt, Steve Wood, Evan Roberts, Daniel Yorkston, John Jamieson, and Ed Girard assisted with land management issues including enforcement, signing and fencing. Martha Jensen assisted with surveys, funding, and has been extremely helpful in our monitoring and management actions. Dave Lauten, Kathy Castelein, and Charles Bruce provided invaluable advice on several aspects of this work. This Work was funded by a grant from U.S. Fish and Wildlife Service and by Washington Department of Fish and Wildlife and U.S. Fish and Wildlife Service operating funds. Thank you all!!!

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APPENDIX I


Feet
0 875 1,750 3,500 5,250 7,000
N
W
E
S
2007 Snowy Plover nest locations on Midway Beach, Pacific County

2007 Snowy Plover nest locations at Graveyard Spit, Pacific County

Note: The U.S. Fish and Wildlife Service habitat restoration area at Leadbetter Point is the area in yellow along the beach edge. The Washington Department of Fish and Wildlife and Washington State Parks Habitat Restoration Areas on Leadbetter State Park are the four small areas in coral. All of the orthographic photos above were taken in 2006.