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Snowy Plover Distribution, Abundance and Reproductive Success: 2006 Research Progress Report

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OVERVIEW

During the 2006 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. In addition, we used occupancy models to determine the number of site visits needed to have a high probability of detecting plovers should they be present. Finally, we examine detectability issues and sources of bias associated with our adult population estimates and make recommendations for future surveys and research. A quick summary of some of our 2006 results:

Breeding Phenology

- Clutches were initiated between 18 April and 8 July. The last chick known to fledge, fledged around 5 September.

Breeding Range

- Snowy plovers nested on Leadbetter, Midway Beach, Graveyard Spit, and the Damon Point area.
- The Graveyard Spit (Shoalwater Indian Reservation) nesting site was discovered this season.
- Our occupancy models indicate a high probability of determining site occupancy with three or four visits to a 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.

Number of Breeding Adults

- Washington breeding adult population = 70 (95% Confidence interval = 56-84). 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

- Nest success in Washington was 25% and 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 several sites in Washington was between 0.76 and 1.45 with a mean of 1.02. It is important to remember that the Leadbetter Point plovers (nearly half the population in Washington) were not included in this estimate and, because we saw very few chicks or juvenile birds at this site, we suspect that fledging success at Leadbetter was lower than at the other Washington sites. As a result, we believe that this estimate is an overly optimistic estimate of fledging success in Washington for the year and also suspect that the Washington population is currently not self-sustaining.

Captive Rearing

- One abandoned chick was collected and taken to the Oregon Coast Aquarium in Newport. The chick was not releasable because of a problem with one of its wings (unable to fly) and it remains in the Snowy Plover exhibit at the aquarium.
- Six eggs were collected from three failed nests (buried with sand) and placed in an incubator to attempt hatching. Three of the six eggs hatched and all chicks were transported to the Oregon Coast Aquarium for captive rearing and all three were released at Leadbetter.

Management Actions

- Numerous management actions benefited plovers including beach access restrictions, enforcement and education activities, habitat restoration area enlargement, and nest exclosures were placed around some plover nests.

Monitoring and Research Recommendations

- Continue testing methods for determining site occupancy and for estimating adult population size.
- Determine fledging success rates for Leadbetter.
- Examine the effectiveness of habitat restoration areas.
- Assess the impact of human disturbance on nesting plovers and on fledging success.
- Examine methods for creating a self-sustaining population.

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 Damon Point, 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 2001). 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 2001). 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 2001).

According to the U.S. Fish and Wildlife Service (2001), "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) and at the beginning of the 2006 nesting season, there were thought to be three active nesting sites in Washington: Leadbetter Point, Midway Beach (Grayland vicinity), and Damon Point. During the 2006 nesting season we discovered a new nesting location in Pacific County, bringing the total number of Washington nesting sites to four.

According to the draft federal Recovery Plan for the Western Snowy Plover, Washington and Oregon compose Recovery Unit 1 (U.S. Fish and Wildlife Service 2001). The primary recovery objectives for this unit are 250 breeding adults and a 5-year average productivity of at least 1.0 fledged chick per male (U.S. Fish and Wildlife Service 2001). 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, WDFW started coordinating its monitoring efforts with USFWS, Washington State Parks, and Oregon Department of Fish and Wildlife during the 2006 nesting season.

The primary objectives of our monitoring for the 2006 nesting season were:

- Conduct breeding window surveys.
- Conduct unoccupied breeding site surveys at Copalis Beach and Connor Creek.
- Determine hatching success and sources of nest mortality during the egg laying/incubation stage for all nesting sites.
- Evaluate methods for determining site occupancy and 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.
- 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, 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). Cyndie Sundstrom discovered a new nesting location at Graveyard Spit during the 2006 field season (Table 1). 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 2006. 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. 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). Leadbetter Point is part of a very long sand spit or peninsula. The Damon Point and Graveyard Spit areas are located on the north shores of Grays Harbor and Willapa Bay respectively. The nesting habitat at these sites 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 2006 Snow Plover nesting localities in Washington.

Site	Approximate Location	Ownership/Management
Damon Point (including Oyhut Wildlife Area)	46° 56' 28", 124° 03' 39"	WDFW, State Parks, Department of Natural Resources
Midway Beach	46° 45' 32", 124° 05' 46"	South Beach State Park, Private
Leadbetter Point	46° 36' 24", 124° 03' 25"	Leadbetter State Park, Willapa National Wildlife Refuge
Graveyard Spit	46° 42' 57", 124° 01' 25"	Shoalwater Indian Reservation, Department of Natural Resources?

Breeding Window Surveys

The breeding window survey occurs annually between 24 May and 7 June along the entire 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 2006, the window survey occurred the week of 22 May. This is the first season that Washington 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, this season's results are not necessarily comparable with those from previous seasons but are comparable to those from other regions/states.

For the sites that were previously occupied by plovers but were thought to be unoccupied at the beginning of the 2006 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. The Leadbetter surveyors consisted of a single observer walking the southern

section (the narrow beach section), 3 observers walking the northern section (the wide beach section) and the biologist most familiar with the habitat restoration area walking a serpentine route through the habitat restoration area. The three observers surveying the northern section, walked approximately 50 m apart but parallel to each other and all plovers observed were communicated to other observers by 2-way radio and 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 the birds to the north, 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. For the Leadbetter surveys, 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.

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
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"	1	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 using occupancy models. We also used repeated surveys to estimate the number of adults by sex at three sites. Part way through the season, Cyndie Sundstrom found a new plover nesting site at Graveyard Spit where we also attempted to estimate the number of breeding adults using repeated surveys. Our goal was to use results from these surveys to develop a formal protocol for future monitoring. All sites were surveyed at least six times during the breeding season using the methods described in Elliot-Smith and Haig (2006a). In addition, we used the number of surveyors and additional 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 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 breeding habitat. We also conducted a driving survey of the South Long Beach area on two occasions again because we suspected that this area might support breeding plovers. Because our visits to these sites were not formal surveys and no birds were detected, they are not included in our analyses.

Presence - Absence

At the beginning of the field season, we had poor information on site occupancy for formerly occupied sites with apparently suitable habitat in Washington. Consequently, 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 has never been addressed we cannot confidently describe the distribution of nesting plovers in Washington.

To address this issue, we used a 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 between 6 and 12 times this season. We decided to use only 6 visits per site in this analysis (the least number of visits to any given site). Because we surveyed some sites more than 6 times, we used the surveys conducted during the Copalis and Connor Creek survey weeks (the sites with the fewest number of surveys). Selecting a subset of surveys did not affect the ratio of visits when plovers were and were not detected at Midway and Leadbetter because we detected birds on every visit to these sites. At Damon Point, we detected plovers during 4 of 12 surveys and maintained this ratio of detections with the six surveys selected (2 of 6 surveys with detections).

Estimating Number of Adult Plovers

Occupied sites were surveyed 8 - 12 times this season between 12 April and 22 August. 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). To estimate 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. Because the ratio of banded to unbanded birds differed by site and survey we then took the number of double counted banded birds for a given survey and multiplied it by 1 + the fraction of unbanded birds detected during that survey. We also attempted to determine the number birds that should have been detected but were not (omissions). To accomplish this, we looked at our re-sight data of banded birds to determine the number of banded birds that were not observed during the survey but were observed both during the two week period prior to our 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 (omissions). As with the double counts, we adjusted the number of omissions by multiplying the count of omissions by 1 + the fraction of unbanded birds detected during the survey of interest. To adjust our total counts for a given survey to reflect both errors of omission and commission, we subtracted the counts of omission from the counts of commission (almost always a smaller value) and added the resulting value to the adult count for that survey.

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 form the first egg laid until hatching.

Nesting Success

We searched for and monitored Snowy Plover nests from April 1 until Sept. 1, 2006. 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. The mini-exclosure was constructed of 2x4 inch mesh wire fencing with four sides, each 4 feet long 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. A trench, 8 inches deep, was dug and the mini-exclosure was plased in the trench so that the nest was in the center of the exclosure. Twelve 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 2001). 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 2001). At Midway, Damon and Graveyard (but not at Leadbetter), we estimated the number of young fledged per adult male 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 be able to assign a hatch date to each brood and to develop methods for tracking specific broods. Because we were checking nests 1-3 days around hatching we could estimate hatch date to within 3 days. We could often 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 some broods, we observed the young from hatch date to 28

days post-hatching and could correctly track the brood because no other chicks were of similar age along a particular stretch of beach. We could also assign broods to a specific nest and hatch dates when a banded adult male accompanied chicks. Fortunately, nearly all chicks could be assigned to specific nests/hatch dates using both chick age (size and plumage) and location along the beach and/or by using the color band combination of an accompanying adult male. However, at Midway beach three broods hatched at the same time, from the same general location with two broods tended by unbanded males and one brood by a banded male. Initially, the two unbanded male broods frequently foraged and roosted in the same area and the banded male's brood was easily distinguished from the unbanded broods because he and his chicks were often 50 or more meters away from the other two broods. However, as the chicks aged and approached the 28 days post-hatching date, the young intermingled, making it difficult to assign individual chicks to a particular nest or to determine exactly how many chicks fledged. As a result, it was necessary to provide a high and low estimate of the number of young fledged. The sites where fledging success was estimated, were visited 2-5 times per week.

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 WDFW uses Garmin units with approximately 15 m accuracy.

Reading Color Bands

Although Washington does not currently band plovers, a number of Washington's breeding birds are banded. Aluminum bands, provided by the U.S. Fish and Wildlife Service, are used in addition to plastic bands; both are usually covered with colored tape. 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

The total number of birds detected in Washington during the 2006 breeding window survey was considerably higher than was detected in 2005 (67 vs. 37; Table 3) but this 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, this season's results are not necessarily comparable with those from previous seasons but are comparable to those from other regions/states. We believe that several factors contributed to the low 2005 count: 1) the tides were low during the survey week resulting in more exposed area for the birds to occupy and, as a result, decreased detectability; 2) it was quite windy during the surveys reducing detectability; 3) we had fewer observers; and 4) not all of our best observers were able to participate in the survey. As this example illustrates, these surveys can have very large errors associated with estimates.

Table 3. Breeding Window survey counts by site, sex, and age and counts of nests and broods observed in 2006.

SITE	Date	2005	2006	2006 Break Down					
				Adult Males	Adult Females	Adult Sex?	Juveniles	Broods	Nests
Copalis Spit	26 May	-	0	0	0	0	0	0	0
Conner Creek	26 May	-	0	0	0	0	0	0	0
Damon Point	26 May	5	0	0	0	0	0	0	0
Midway Beach	24 May	23	25	14	10	1	0	0	4
Leadbetter Point	22 May	9	42	22	14	6	0	0	4
South Long Beach	22 May	-	0	0	0	0	0	0	0
Total		37	67	36	24	7	0	0	8

Adult Surveys

As indicated in Table 4 we conducted 52 surveys at 9 sites between 12 April and 22 August 2006.

Table 4. Snowy Plover survey dates, number of surveys and surveyors and type of survey by site during the 2006 nesting season

Site	Number of Surveys	Number of Surveyors	Type of Survey	Dates
Copalis	6	1	Presence/Absence	4/25, 5/9, 5/25, 6/5, 6/19, 7/7
Connor Creek	6	1	Presence/Absence	4/23, 5/9, 5/25, 6/5, 6/23, 7/7
Ocean City to Ocean Shores	1	1	Opportunistic	5/25
Damon Point	12	1-2	Breeding Adult	4/12, 4/19, 4/22, 5/1, 5/6, 5/9, 5/15, 5/18, 5/23, 6/15, 6/29, 7/26
Westhaven	1	1	Opportunistic	8/7
Midway Beach	8	3	Breeding Adult	5/3, 5/19, 5/24, 5/26, 6/7, 6/27, 7/13, 8/03
Graveyard Spit	10	1	Breeding Adult	6/9, 6/22, 6/30, 7/7, 7/14, 7/20, 7/27, 8/4, 8/10, 8/22
Leadbetter Point	8	5	Breeding Adult	4/24, 5/4, 5/22, 6/6, 6/20, 7/6, 7/17, 7/31
Long Beach	2	2	Opportunistic	5/22, 6/2

Note: 2 Breeding Adult Surveys were cancelled part way through the surveys because of weather and are not included in this table.

Our goal was to determine plover presence-absence at Copalis and Connor Creek and we visited each of these sites at least 6 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 visited each site at least 8 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

We used occupancy models to test the effectiveness of our ability to determine presence-absence at any given site. For this analysis we used six visits to Connor Creek, Copalis Spit, Damon Point, Midway Beach, Graveyard Spit and Leadbetter (see Methods). Detection probabilities at all sites except for Damon Point were 100%. Birds were either never detected at a given site (Connor Creek and Copalis) or were always detected (Midway, Graveyard and Leadbetter). At Damon Point, a pair of birds was first detected on 1 May, attempted to nest but failed and then apparently moved elsewhere and consequently, were not detected late. When plovers were present at the site, they were detected on some visits but not on others suggesting that detectability was less than 1.0 at this site. Differences in detectability did not appear to be associated with differences in observers because different observers both detected and did not detect plovers during these surveys.

We used a matrix of plover presence/absence (1,0) from these surveys to examine the effectiveness of two detectability models in the program PRESENCE. The model with the lowest AIC value was the model that indicated that detection probabilities are not time-specific (Table 5).

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

Model	AIC	delta AIC	AIC wgt	Model Likelihood	No.Par.	(-2*LogLike)
Constant P	33.3	0	0.92	0.85	2	29.26
Survey-specific P	39.6	6.4	0.04	0.04	7	25.63

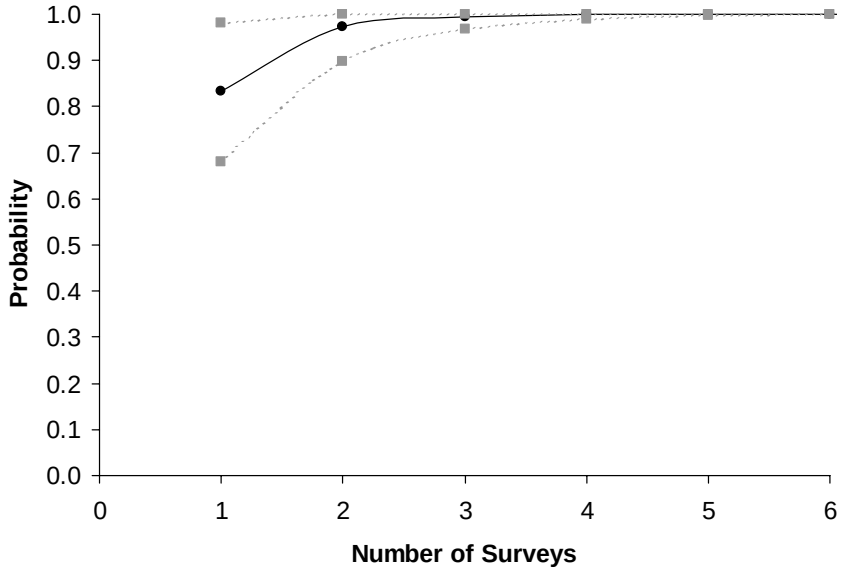

Figure 1. The relationship between the probability of detecting plovers at a given site should they be present and the number of surveys to that site. We used both the detection probability from the selected PRESENCE model above and this same probability ± 2 x SE.

To determine the number of surveys necessary to have a high probability of detecting plovers should they be present, we graph the probability of detecting plovers at a site versus the number of surveys (Figure 1). The probability of detecting plovers during a survey to any given site is equal to: $1 – (1 - P)^n$ where "P" is the mean detection probability from the selected model (P = 0.83, SE = 0.076) and "n" is the number of surveys. We also graph this same relationship for the lower and upper 95% confidence interval surrounding this probability estimate which is equal to: $P \pm 2*SE$. When using the average detectability from the selected model, we will correctly determine presence or absence for a given site with 83% probability with one visit, 97% probability two visits and 99% probability with three visits. Using the lower 95% confidence interval of this detection probability estimate, we will correctly determine presence or absence for a given site with 68% probability with one visit, 89% probability with two visits, 96% probability with three visits and 99% probability with four visits. Using the upper 95% confidence interval, we will correctly determine presence or absence for a given site with 98% probability with one visit and 99% probability with two visits.

As indicated above, the birds at Damon Point were not always present and therefore some of the surveys resulting in absences at this site are probably not because of poor detectability but because the birds were not at the site during the survey. This scenario is a violation of one of the key assumptions of detectability models where occupancy state of the sites is assumed to be constant for the duration of the surveying (MacKenzie 2002). Snowy Plovers were detected on 4 of the 6 surveys during the period when we are fairly confident that plovers were present at Damon Point, or a detection probability of 67%. This probability is very similar to the lower limit of the 95% confidence interval from the selected PRESENCE model above. Using this detection probability of 67% from Damon Point, 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).

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, they appeared to decline after the first week in July suggesting that some birds are dispersing from these sites after either failing to breed (Figure 2) or females dispersing after leaving their mate with the final clutch or brood of the season. This pattern suggests that surveys of breeding adult birds should be completed prior to the second week in July.

We also examined patterns of immigration and emigration using dates when banded birds were either first detected on a site or last detected (n = 43; Figure 3). We started our surveys 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 surveys on 28 August at Leadbetter and 7 September at Midway. 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 some may be at the sites throughout the winter. Examining patterns of arrival and departure after the beginning of the surveys (3-10 April) and before the end of the surveys (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 June and that there is increased movement in late July and August after nesting.

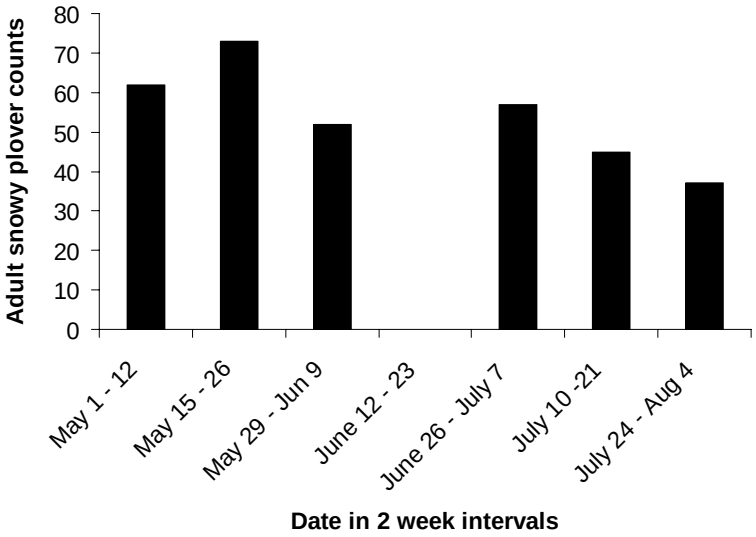

Figure 2. Total counts of adult Snowy Plovers using the high counts during two week intervals from each of four nesting sites in Washington. No surveys were conducted at Midway Beach during the two-week interval between June 12 and 23 and consequently, no total is present for this interval.

For males, the pattern is similar to that exhibited by females but there is more movement in and out of these sites throughout the season (Figure 3).

Banded juvenile plovers start arriving on Washington sites from their Oregon and California hatch sites in August (Figure 3). Because new birds are arriving at these sites during the breeding season and because birds also appear to be leaving Washington during the breeding season, actual counts will differ among surveys.

Only four banded birds were detected at two different sites within the nesting season. Three of these birds were detected at Leadbetter from April until July or Aug. and then moved to Midway where they were observed for the rest of the season. This appears to be a post-breeding movement because these birds did not attempt to breed at Midway. The fourth bird was detected 37 times at Midway between 10 April and 7 Sept. and was detected only once at Leadbetter on 31 July indicating that non-permanent within season moves can occur (but appear to be rare) between Washington sites. Again, this movement appears to be a post-nesting movement. Movement among sites complicates our attempts to estimate the number of breeding adults because the same bird could be counted at both sites on different site surveys if they are conducted at different times on the same day or different days. It appears that most of these between site movements can be avoided by conducting these surveys prior to the beginning of July.

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 4). This result suggests that there is no need to adjust counts to account for differences in detectability between males and females.

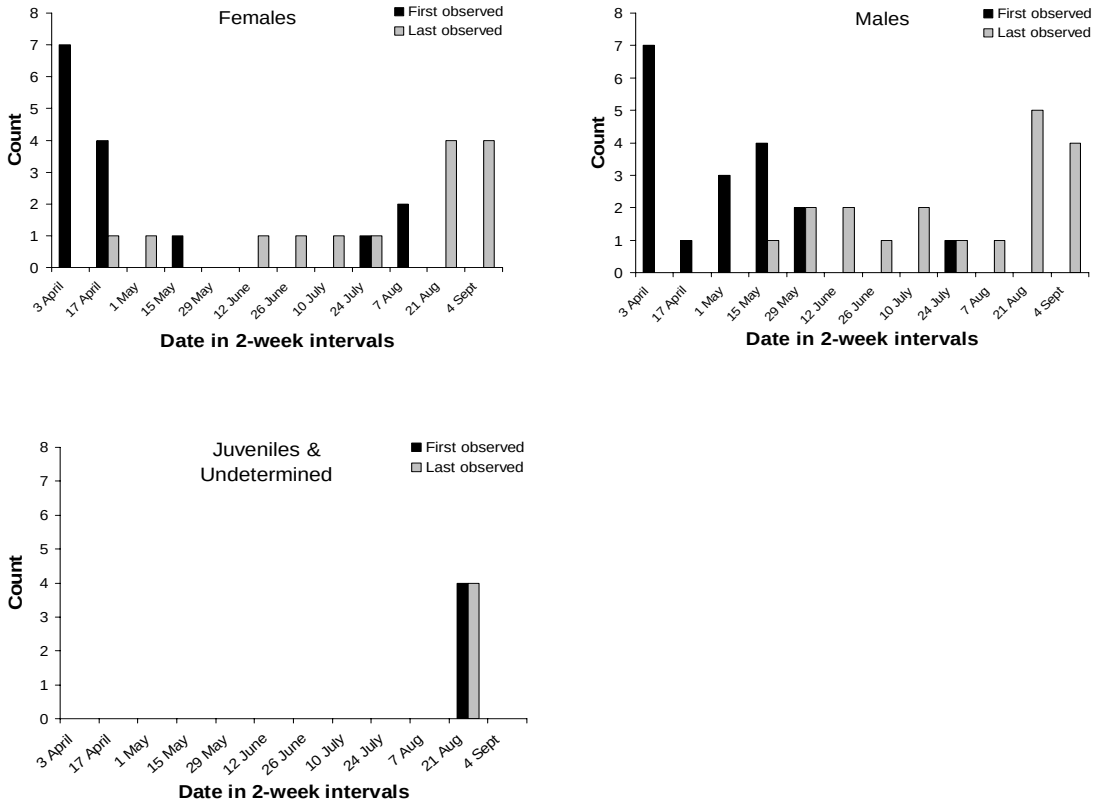

Figure 3. Dates banded male, female and juvenile Snowy Plovers were first and last detected on Midway Beach and Leadbetter Point combined in 2006.

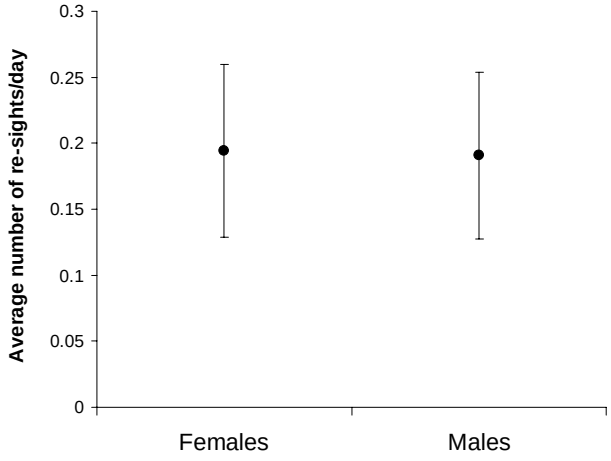

Figure 4. Average number of re-sights per banded adult female (n = 14) and male (n = 20) Snowy Plovers per day during the 2006 nesting season.

Estimating Number of Adult Plovers

Because the entire available habitat was surveyed for plovers during our adult monitoring, we consider our surveys to be complete counts. 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 commission (double counts mean = 1.0, 95% CI = -0.1 - 2.1)) and errors of omission (missed birds, Mean = 3.2, 95% CI = 1.7 - 4.7) as described in the Methods above. Results for the 2006 nesting season are presented in Table 6. For Damon Point and Graveyard Spit we present uncorrected counts because we are quite confident that only two birds attempted to breed at Damon Point and we located their nest. At Graveyard, we are quite confident that three pairs attempted one nest each and all three nests were located. When deriving these population estimates, we only used counts between 24 April and 7 July. These counts occurred when there was the least amount of immigration and emigration and before post-nesting dispersal. For Midway and Leadbetter we completed 6 and 5 surveys respectively during this time period. 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. We suspect that the 6 birds at Graveyard moved to that site from Midway Beach around the 25 of May because our counts at Midway decreased by about 6 birds after that date. The reason that we decided to look for birds at Graveyard Spit was because our counts for Midway were suddenly lower. However, we have no survey data from Graveyard prior to 9 June when birds were first discovered at this site and cannot confirm this suspicion and do not adjust counts to account for this possibility.

Table 6. Estimates of the breeding adult populations at the four nesting sites in Washington and the total population estimate for the State.

	Damon	Midway	Graveyard	Leadbetter	Total
Adult Plover Estimates	2	23 (15-31)	6	39 (33-45)	70 (56-84)

Next year, we propose examining sources of error and bias with our adult plover estimates in more detail. We have already demonstrated that counts can go up and down as a result of birds immigrating in or emigrating out of Washington. Next year we will continue to examine movement in and out of the state by documenting the arrival and departure of banded birds (note: some of the “departing birds” may actually be mortalities). To control for the effects of movements within the State on our estimates, we propose to conduct simultaneous surveys at all nesting sites on at least two occassions. When surveys are conducted on different sites on different days, there is the possibility of counting the same bird(s) on multiple sites. Simultaneous surveys reduce the likelihood of this occurring. To examine differences in detectability among observers, we propose to conduct double counts (two observers counting the same area at the same time).

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. Next year we will be banding birds (birds with known capture histories) and may attempt to use these models as another unbiased estimate of our population size.

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 and that the probability of detecting birds close to the line is approximately 1.

Opportunistic Surveys

Plovers were detected at Graveyard Spit during the first opportunistic survey at this site and all subsequent 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, or on the Long Beach Peninsula south of Oysterville Road.

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 18 April and 8 July. The last clutch initiated during the season successfully hatched and fledged young around 5 September indicating that the active breeding season was between 18 April and 5 September. In figure 5, we present the number of clutches initiated in five-day intervals at all sites combined. The vast majority of the nests are initiated between 21 May and 8 July.

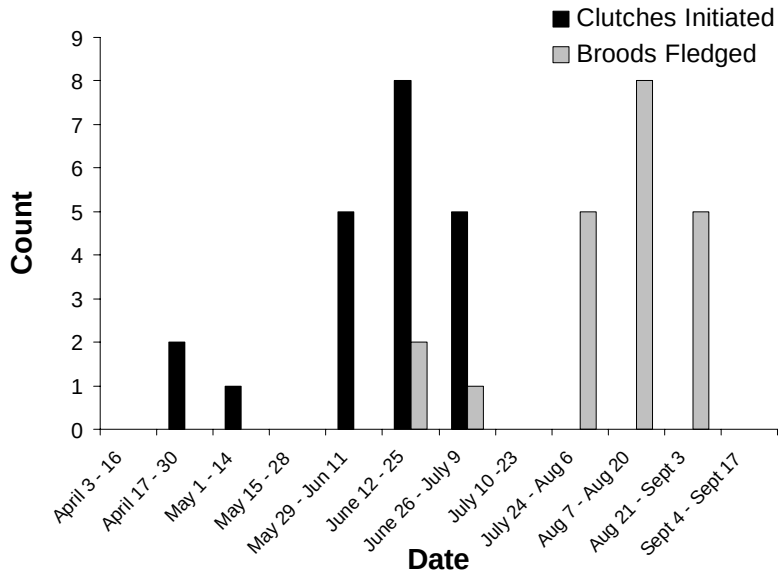

Figure 5. Number of Snowy Plover clutches initiated in 2-week intervals at all Washington nesting sites combined during the 2006 (n = 22 nests where clutch initiation date could be determined). We also present the dates that chicks from these nests would have fledged in 2-week intervals to provide an indication of the potential length of the breeding season.

Nesting Success

We located and monitored the outcome of 62 plover nests this season. Of these 62 nests, 29 were located at Leadbetter, 29 at Midway Beach, 3 at Graveyard Spit and 1 at the Damon Point area (Table 7). For nest locations see Appendix I.

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 Table 8, we report Mayfield nest success estimates for the 2006 nesting season. The probability of nest survivorship was fairly consistent among sites and ranged from 23% at Damon, Midway, and Graveyard combined to 26% at Leadbetter. This Leadbetter nest success figure

includes both exclosed and non-exclosed nests (nest exclosures were only used at Leadbetter this season). The probability of nest survivorship of the unexclosed nests at Leadbetter was only 2% (Table 8). The primary cause of nest failure at all sites (45% of failed nests) was predators eating the eggs and the only identified predators were Common Ravens (*Corvus corax*; n = 5) and Northwestern Crows (Corvus caurinus; n = 3; Table 7). Drifting sand is another significant source of nest failure (20% of the failed nests) especially at the outer beach of Leadbetter. The cause of nest failure for a significant portion of the failed nests is unknown (25%).

Table 7. Nest outcomes by Snowy Plover nesting locality. Outcomes include successful (hatched) or failed. Sources of failure include predators (Northwestern Crows, Common Ravens or an unknown predator) eating the 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	Outcome			Sources of Nest Failure						
				Predator			Other			
	# Nests	Hatch	Fail	Crow	Raven	Unknown	Human	Sand	Abandon	Unknown
Damon	1	0	1	0	0	0	0	0	0	1
Graveyard	3	3	0	0	0	0	0	0	0	0
Midway	29	8	21	0	5	5	2	2	0	7
Leadbetter	29	11	18	3	0	5	0	6	1	3
Totals	62	22	40	3	5	10	2	8	1	11

Table 8. Mayfield estimates of Snowy Plover nest survival and of daily nest survival probability by site.

Site	Number of Nests	Daily Survival Probability	Nest Survival
Midway, Damon and Graveyard	33	0.96	0.23
Leadbetter	29	0.96	0.26
Leadbetter without exclosures	11	0.88	0.02
Washington Total (including exclosures)	62	0.96	0.25

Table 9. Snowy Plover nest outcomes for nests with and without nest exclosures at Leadbetter Point.

	# Nests	Hatch	Predator	Sand	Abandon	Unknown
Leadbetter nests with exclosures	18	10	1	5	1	1
Leadbetter nests without exclosures	11	1	7	1	0	2

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), but the population benefits appear to outweigh the costs.

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. To estimate this metric for Washington, we need both estimates of the number of young fledged and the number of breeding adult males.

Using only counts from Midway and Leadbetter before counts started to decline (before the second week in July; this decline may be the result of females dispersing after a second nesting attempt) we estimated that the sex ratio was 54% male at Midway and 55% male at Leadbetter. Using this sex ratio and our counts of the number of breeding males at Damon Point, Midway Beach and Graveyard Spit combined, we estimated that there were between 12 and 21 males with a mean of 17 at these sites. We could have used direct counts of males from our surveys but for every survey there are birds that could not be assigned to one sex or the other for a variety of reasons. For these same sites, we followed the fate of the chicks from 11 nests that successfully hatched and estimate that between 16 and 18 chicks fledged. These estimates of adult males and number of chicks fledged indicate that the number of chicks fledged per adult male was between 0.76 and 1.45 with a mean of 1.02. This estimate suggests that the population on these sites is approximately stable but could be declining or increasing slightly (see Nur et al. 1999). Additional years of monitoring (preferably with banded chicks) are needed to accurately assess fledging success for the State. Leadbetter birds were not included in this estimate because we did not conduct enough surveys at this site to reliably assess fledging success. We suspect that fledging success at Leadbetter was considerably lower than this estimate for the other sites based on few observations of chicks or juvenile birds.

If our estimates of the number of chicks fledged per adult male indicate that the population is stable or declining, why then is the population in Washington apparently increasing? We believe that the Washington population is increasing primarily because of the immigration of Oregon and California plovers. This hypothesis is supported by several lines of evidence: 1) Washington appears to have a stable population based on fledging success data; 2) Oregon has an increasing plover population (Lauten et al. 2006); 3) Washington does not and has not banded birds and the number of banded birds at Leadbetter ranged between 34% and 55% this season and the percent of banded birds at Midway ranged between 0 and 15% this season indicating that birds are moving into Washington; and 3) Of the color banded birds observed at these sites this season 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 the State from Oregon and California.

Captive Rearing and Salvaged Eggs

Genetic material was collected from salvaged eggs of six western Snowy Plover nests that failed at Leadbetter and four eggs from three nests at Midway Beach. Samples were extracted and all materials were sent to Sue Haig and Tom Mullins at the USGS Forest and Rangeland Ecosystem Science Center in Corvallis, Oregon for analysis.

One abandoned chick was found on 6 June, in an exclosure, located within the habitat restoration area at Leadbetter. The adults and the chicks from the other two eggs associated with this nest were no longer in the area. Biologists from USFWS and WDFW collected the chick and placed it in an incubator and it was transported to the Oregon Coast Aquarium in Newport the following day. The chick was not releasable because of a problem with one of its wings (unable to fly) and it remains in the Snowy Plover exhibit at the aquarium. This bird was banded by Dave Lauten and Kathy Castelein (Color combination = S:G; USFWS band number = 2271-00743).

Six other eggs were collected from three failed nests (buried with sand) and placed in an incubator to attempt hatching of viable embryos. Three of the six eggs hatched and all chicks were transported to the Oregon Coast Aquarium for captive rearing. One fledgling was banded by Dave Lauten and Kathy Castelein (Color combination = V:S, USFWS band number = 8021-23336) and released at Leadbetter on 22 August with a small group of plovers. Two other fledglings were banded (Color combination = VR:GR, USFWS band number = 2271-01601; Color combination = VR:OR, USFWS band number = 2271-01602) and released at Leadbetter on 20 September by USFWS and WDFW biologists.

Nest Locations

Nest locations by site are presented in Appendix I. Only one nest was located on Damon Point area in 2006 and it was found on Oyhut Spit. At Midway Beach, birds nested in Twin Harbors State Park south to Washaway Beach. Note that few nests are found near the beach access roads suggesting that human activity associated with these roads may be influencing the distribution of nests. At Graveyard Spit, birds nested on the Shoalwater Indian Reservation and on Leadbetter plovers nested on the tip of the Peninsula on the Willapa National Wildlife Refuge.

PROGRESS ON RECOVERY OBJECTIVES

Federal Recovery Objectives:

Objective 1: 250 breeding adults in recovery unit 1.

The 2006 Washington nesting population is 70 adult plovers (95% CI = 56-84) and the 2006 nesting population in Oregon is 135 plovers (Lauten et al. 2006) for a total of approximately 205 nesting adult plovers in recovery unit 1.

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

In 2006, the average number of young fledged per adult male on several sites in Washington was between 0.76 and 1.45 with a mean of 1.02. It is important to remember that the Leadbetter plovers (nearly half the population in Washington) were not included in this estimate and, because we saw very few chicks or juvenile birds at this site, we suspect that fledging success at Leadbetter was considerably lower than at the other Washington sites. As a result, we believe that this result is an overly optimistic estimate of fledging success in Washington for the year and also suspect that the Washington population is currently not self-sustaining. Estimates for previous years are not available for Washington. The number of young fledged per adult male in Oregon was 1.56 in 2006 (Lauten et al. 2006).

Washington State Recovery Objectives:

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

We estimate that there were 70 (95% CI = 56-84) nesting adults in 2006 and approximately 46% of these birds are females. If all females are paired, these estimates indicate that there are approximately 32 pairs (95% CI = 26 – 39 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 number of young fledged per adult male on several sites in Washington in 2006 was between 0.76 and 1.45 with a mean of 1.02. Again, it is important to remember that the Leadbetter plovers (nearly half the population in Washington) were not included in this estimate (see comments above).

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”.

2006 MANAGEMENT ACTIONS

A number of the management actions that occurred in 2006 involved restricting some human activities on active Snowy Plover nesting sites during the active nesting season (1 April and 5 September for the 2006 season but clutch initiation dates from the 2005 nesting season suggests that active nesting occurs from 15 March – 5 Sept.). These actions were taken because 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 (Ruhlen et al. 2003). 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 8.3 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. Note: all beach closures occurred on state or federal land and not private land.
- Symbolic fencing was put along beach access trails at both Leadbetter and Midway Beach by State Parks and 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 refuge 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).
- Nest exclosures were put around 18 of the 29 nests located at Leadbetter by U.S. Fish and Wildlife Service biologists.
- Fireworks were not allowed along the beach at Grayland Beach and South Beach State Parks during the nesting season.
- Efforts were made by State Parks, Department of Natural Resources, U.S. Fish and Wildlife Service, U.S. Coast Guard, and WDFW to minimize the impacts of oil cleanup from the SS Catala at Damon Point on plovers. Activities included adjusting the timing of clean up activities, using vibratory pile drivers instead of pounding drivers, limiting human access and minimizing the footprint of activities.

Enforcement

- Two State Parks Beach Rangers were hired for the 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

Restoration

- U.S. Fish and Wildlife Service increased the size of the habitat restoration area at Leadbetter from 40 acres in 2005 with 14 acres covered with oyster shell to 63 acres with 28 acres covered in shell in 2006.

Education

- Enforcement activities by Beach Rangers also includes education.
- Two "Share the Beach" signs were purchased by Willapa National Wildlife Refuge and installed by Washington State Parks on two beach trailheads at Leadbetter.

Monitoring

- Breeding window surveys were conducted and range-wide protocols were used
- Nest monitoring and hatching success was determined at all nesting sites
- Fledging success was determined for Damon Point, Midway Beach and Graveyard Spit
- 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

Monitoring

- Continue adult population, occupancy, nest outcome, and fledging success monitoring efforts following the recommendations included in this report.
- Estimate fledging success at Leadbetter Point

Research

- Continue testing methods for determining occupancy and for estimating adult population size. Ideally, this effort would be tested across the entire range of the Western Snowy Plover.
- Continue to identify sources of bias and their impact on estimates of adult plovers and fledging success.
- Examine the use of mark-recapture methods for estimating adult population size and fledging success.
- Examine the effectiveness of habitat restoration areas.
- Investigate the feasibility of creating small openings in the non-native beachgrass (*Ammophila* spp.) on State Park lands to benefit Snowy Plovers, Streaked Horned Larks (*Eremophila alpestris strigata*), and pink sand verbena (*Abronia umbellata*).
- Assess the impact of human disturbance on nesting plovers and on fledging success. 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 (Ruhlen et al. 2003). 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).
- Assess methods for creating a self-sustaining population.
    - Identify the habitat conditions where plovers are more likely to successfully reproduce
    - Examine corvid behavior and distribution with the ultimate goal of identifying methods to reduce plover nest predation

ACKNOWLEDGMENTS

Max Zahn and Warren Michaelis from WDFW conducted adult population surveys and volunteers Larry Lock, Alan Knue, Craig Zora, Martha Jensen, and John Grettenberger 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, 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. Wan-Ying Chang and Gail Olsen provided excellent statistical advice. Dave Lauten and Kathy Castelein provided invaluable advice on several aspects of this work. Stephen J. Davies gave us permission to use his Snowy Plover pictures. This Work was funded by a grant from U.S. Fish and Wildlife Service. Thank you all!!!

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APPENDIX I*

Damon Point Snowy Plover nest locations in 2006

* Note: all orthographic photographs used in this appendix were taken in 2003 and the locations of the nest sites were measured in 2006.

Midway Beach Snowy Plover nest locations in 2006

Graveyard Spit Snowy Plover nest locations in 2006

Leadbetter Point Snowy Plover nest locations in 2006. The habitat restoration area is the area in light green along the beach edge. The orthographic photo below was taken in 2003 but the nest locations were measured in 2006. Additional beach accreted at the north end of the point since this photo was taken and, as a result, the most northerly nests are actually located on land (a more recent photo was not available).