

Washington State Snowy Plover Population Monitoring, Research, and Management: 2012 Nesting Season Research Progress Report

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Fish and Wildlife
Wildlife Science Division



U.S. Fish and Wildlife Service
Willapa National Wildlife Refuge

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TABLE OF CONTENTS

OVERVIEW	1
INTRODUCTION.....	3
METHODS	5
<i>Study Areas</i>	<i>5</i>
<i>Site Occupancy.....</i>	<i>5</i>
<i>Adult Population Surveys.....</i>	<i>6</i>
<i>Nest phenology and success.....</i>	<i>7</i>
<i>Fledging Success.....</i>	<i>7</i>
<i>Nest Locations.....</i>	<i>8</i>
<i>Reading Color Bands.....</i>	<i>8</i>
RESULTS & DISCUSSION	9
<i>Breeding Window Survey.....</i>	<i>9</i>
<i>Winter Window Survey.....</i>	<i>9</i>
<i>Adult Surveys</i>	<i>9</i>
<i>Clutch Initiation Dates and Breeding Phenology.....</i>	<i>11</i>
<i>Nest success</i>	<i>12</i>
<i>Fledging Success.....</i>	<i>13</i>
<i>Nest Locations.....</i>	<i>14</i>
PROGRESS ON RECOVERY OBJECTIVES.....	15
2012 MANAGEMENT ACTIONS	16
FUTURE RESEARCH & MONITORING CONSIDERATIONS.....	17
ACKNOWLEDGMENTS	18
LITERATURE CITED & REFERENCES	19
APPENDIX I	21

LIST OF TABLES

Table 1. Approximate locations and land ownership for the 2012 Snowy Plover nesting localities.	5
Table 2. Starting and ending locations, survey types and number of surveyors for each survey site in Washington.	6
Table 3. Breeding Window survey counts by site, sex, and age and counts of nests and broods between 2007 and 2012.	9
Table 4. Winter Window survey counts by site, sex, and year.	9
Table 5. Snowy Plover survey dates, number of surveys and surveyors and type of survey by site during the 2012 nesting season.	10
Table 6. Mean counts (95% CI) of the breeding adults at four nesting sites in Washington and the total population estimate for the State in 2006-2012.	10
Table 7. Nest outcomes by Snowy Plover nesting locality in 2012.	12
Table 8. Sources of Snowy Plover nest failure in 2012.	13
Table 9. Mayfield estimates of Snowy Plover nest survival and of daily nest survival probability by site and by enclosed and unenclosed nests in 2012.	13
Table 10. Mayfield estimates of nest survival by site from 2006 – 2012.	13
Table 11. Estimated number of breeding adults in Recovery Unit 1 by year.	15
Table 12. Estimated number of chicks fledged per breeding adult male in Recovery Unit 1 by year.	15
Table 13. Estimated number of breeding pairs in Washington (2006-2012).	15

LIST OF FIGURES

Figure 1. Average number of re-sights per banded adult female (n = 26) and male (n = 13) Snowy Plovers per day (\pm SD) during the 2012 nesting season.	11
Figure 2. Trend (95% CI) of average yearly count for all Washington sites from Washington adult plover population (2006 – 2012).	11
Figure 3. Number of Snowy Plover clutches initiated in 2006-2012 (A) and number of chicks fledged in 2008-2012 (B).	12
Figure 4. Mayfield estimates of nest survival by site and for coastal Washington.	14
Figure 5. Number of Snowy Plover chicks fledged per adult male from 2007-2012 for all Washington nesting sites combined.	14

OVERVIEW

During the 2012 Western Snowy Plover (*Charadrius nivosus nivosus*) nesting season, we monitored breeding phenology, nest success, fledging success and number of nesting adult plovers in Washington. Field monitoring and research was conducted by Sara Peterson, Cyndie Sundstrom, William Ritchie, and Sue Thomas with assistance from Brock Hoenes, Warren Michaelis, Steve Spencer, Lorenz Sollmann, and Sue Mayo. Management activities included restricting human access to nesting sites, exclosing nests to prevent predation, and nesting habitat restoration. A summary of some of our 2012 activities and results:

Breeding Phenology

- Clutches were initiated between 21 April and 13 July (Figure 3). However, very early nests could have gone undetected because intensive surveys did not start until late March on Midway Beach and early April at Leadbetter Point.
- The first chick known to have fledged, fledged around 20 June and the last chick known to fledge, fledged around 7 September.

Breeding Range

- We conducted 31 surveys at 8 sites between 29 April and 15 August 2012 to either assess occupancy or to count the number of nesting adults.
- Snowy Plovers were only found nesting on Leadbetter Point, Midway Beach, and Graveyard Spit. A single male was observed by Refuge Biologist Sue Thomas on 30 April on Dungeness Spit, but was not observed in three subsequent surveys, indicating that there was no local nesting in 2012.

Number of Breeding Adults

- The mean 2012 Washington breeding adult population was 33 (95% Confidence interval: 15-52). All of the breeding adults observed were found on Leadbetter Point, Midway Beach, and Graveyard Spit. Staff and volunteer surveyors conducted surveys.
- The Washington population has declined by approximately 4 birds per year over the past seven years ($p = 0.015$), and has declined from four nesting sites to three over the past seven years.

Nest success

- Forty-seven nests were discovered and monitored.
- The percent of nests that survived from egg laying through hatching during the 2012 nesting season was 21% (includes exclosed and non-exclosed nests).
- As in past years, the primary source of nest failure was predation. Common ravens were the only identified nest predator. However, in many cases we could not identify the nest predator.

Fledging Success

- The average number of young fledged per adult male on the three nesting sites in Washington was 0.68 (range = 0.46-0.94). Population viability analyses indicate that, on average, at least one young must fledge per adult male to have a stable population.

Management Actions

- *Restrictions:* Fireworks were prohibited on beaches where State Parks and U.S. Fish and Wildlife Service (USFWS) are the upland land owners.
- *Nest exclosures:* Three nests were exclosed on State Park land at Midway Beach and ten nests were exclosed at Leadbetter Point (7 on Refuge lands and 3 on State Park lands).
- *Signing:* In an effort to protect nests, approximately 7.5 miles of beach at Leadbetter Point and approximately 1 mile of beach at Midway was signed to restrict human access on the dry portions of the beach to. Access restrictions did not occur on private land.

- *Nest Predation:* Willapa National Wildlife Refuge continued to collect data on nest predators that occurred in and adjacent to the plover and lark nesting areas at Leadbetter Point. Logistics of implementing a proposed predator management strategy were investigated.
- *Restoration:* The U.S. Fish and Wildlife Service habitat restoration area (HRA) at Leadbetter Point now totals over 250 acres with 15 new acres added in 2012. Oyster shell was added to approximately 62 acres. Non-native beachgrass control includes aerial and hand spraying approximately 110 acres in the south central portion of the HRA. The north end of the shelled area in the HRA was harrowed to redistribute shells and bulldozed to remove beachgrass. In addition, the dune cuts in the swale adjacent to the west edge of the south HRA were removed in February 2013 by cutting down the adjacent dune with a bulldozer.
- No habitat restoration work was conducted on State Parks lands at Leadbetter Point or Midway Beach in 2012.

Recommendations

- Summarize, write-up and publish population monitoring results from Oregon, Washington, and northern California.
- Continue to examine the effectiveness of habitat restoration areas.
- Identify the conditions where plover populations are more likely to be self-sustaining.
- Conduct research to identify habitat features important to successful plover nesting.
- Begin implementation of a predator control plan for active snowy plover nesting locations.
- Continue to engage volunteers in monitoring.
- Continue to link management activities with research and monitoring.
- Continue to evaluate the effectiveness and continued use of nest exclosures on an annual basis.
- Evaluate impact and timing of clam digging on plover nesting, foraging and fledging.
- Initiate education and outreach activities.

INTRODUCTION

The Pacific coastal population of the Western Snowy Plover (*Charadrius nivosus 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 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, adverse weather, shoreline modification, dune stabilization, and recreational activities have been attributed to reduced nest 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 and 2008 nesting season, three nesting sites were occupied, Leadbetter Point, Midway Beach, and Graveyard Spit. However, because of the very close proximity of Graveyard Spit to Midway Beach, this could be considered one site. During the 2009-2012 nesting seasons, Leadbetter Point and Midway Beach were occupied and Graveyard Spit was again occupied in 2012.

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 adult male (U.S. Fish and Wildlife Service 2007). The recovery plan calls for 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 describes progress on all of these criteria except the final.

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 the federal and state recovery plans require monitoring of breeding adults and monitoring of fledging success to assess progress toward these recovery goals. Monitoring is also necessary to evaluate the impact of conservation actions on plover populations such as the use of wire nest enclosures to exclude potential predators and the effectiveness of habitat restoration efforts. To provide the information needed to assess recovery progress and to assess the effectiveness of conservation actions, Washington Department of Fish and Wildlife is coordinating its monitoring efforts with U.S. Fish and Wildlife Service, and Oregon Department of Fish and Wildlife. This coordinated effort was initiated in 2006 although state-specific monitoring was initiated years before.

The primary objectives of our monitoring for the 2012 nesting season were:

- Conduct winter window surveys.
- Conduct breeding window surveys.
- Conduct unoccupied breeding site surveys at Copalis Spit, Connor Creek, Damon Point, and Graveyard Spit.
- Estimate hatching success rates and sources of nest mortality during the egg laying/incubation stage for all nest locations.
- Provide fledging success and adult breeding plover population size estimates for Washington.
- Attempt to increase nest success through habitat restoration efforts, the use of nest exclosures and by restricting human activities on nesting sites, and evaluate the effectiveness of these activities.
- 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 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 2007 and 2008 nesting seasons, three sites were occupied by breeding plovers, Leadbetter Point, Graveyard Spit, and Midway Beach (Table 1). During the 2009-2011 nesting seasons plovers nested at two sites, Leadbetter Point and Midway Beach. During the 2012 field season plovers nested at 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 2012. Leadbetter Point and Midway Beach are dune backed beaches and have an exceptionally wide area that is unvegetated or sparsely vegetated and is located between the mean high tide and the foredune. Plovers also use the 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. 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 a sparsely vegetated low lying sand spit, with hummocks and swales, and unvegetated deflation plains adjacent to salt marsh communities. For definitions of 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 2012 Snowy Plover nesting localities in Washington.

Site	Approximate Location	Ownership/Management
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 Bay Indian Reservation

Site Occupancy

Our goal was to determine plover presence/absence at sites that are currently occupied and at the sites most likely to become re-occupied where we have failed to detect plovers. Wildlife species are rarely detected with perfect 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. In Pearson et al. (2008), we recommended three to 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 is an 87% - 99% probability of correctly determining site occupancy. We conducted repeated visits to Graveyard Spit, Damon Point, Connor Creek and Copalis Spit to assess occupancy during the 2012 nesting season because these sites were historically occupied.

Adult Population Surveys

Breeding window survey

The breeding window survey occurs annually in late May and early June along the entire U.S. Pacific coastline where Snowy Plovers are known to 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 2012, the window survey occurred between 24 and 30 May. We surveyed Connor Creek, Copalis Spit, Damon Point, Midway Beach, Graveyard Spit, and Leadbetter Point. Our primary intent during breeding window surveys was to determine “population size” at occupied sites (Midway Beach, Leadbetter Point, Graveyard Spit) and site occupancy at unoccupied sites (Connor Creek, Copalis Spit, Damon Point).

Estimating breeding adult population size

In addition to the breeding window survey, we surveyed all occupied sites (Leadbetter Point, Midway Beach) and recently occupied sites (Damon Point and Graveyard Spit) two additional times between 24 May and 10 July following the same breeding window methods. These counts occurred when there was the least amount of immigration and emigration into and out of Washington and before post-nesting dispersal. We used these three surveys to derive estimates of breeding adult abundance. In the Results, we present the mean of these three surveys and the 95% confidence intervals. We rounded all estimates to the nearest whole bird.

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 Refuge boundary).

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	Vehicle/ Foot
Damon Point	46° 56' 05", 124° 09' 18"	46° 56' 11", 124° 06' 18"	1 or 2	Foot
Midway Beach	46° 47' 38", 124° 05' 55"	46° 44' 07", 124° 05' 29"	4 or 5	Foot
Graveyard Spit	46° 43' 33", 124° 03' 07"	46° 42' 25", 124° 00' 36"	1 to 4	
Leadbetter Point North	46° 37' 40.7", 124° 04' 17.4"	46° 38' 50.5", 124° 03' 13.6"	3	Foot
Leadbetter Point HRA	46° 37' 40.9", 124° 04' 07.8"	46° 38' 30.4", 124° 04' 07.2"	2	Foot
Leadbetter Point South	46° 32' 54.0", 124° 03' 40.8"	46° 37' 40.7", 124° 04' 17.4"	1 or 2	Vehicle
Long Beach (S. of Oysterville Rd.	46° 32' 54.0", 124° 03' 40.8"	46° 22' 03.8", 124° 03' 24.4"	1	Vehicle
Dungeness Spit	48° 17' 26.4", 123° 13' 69.2"	48° 17' 60.8", 123° 13' 55.8"	1-3	ATV/Foot

Additional breeding season Graveyard Spit surveys

As part of a monitoring effort associated with a sand deposition project administered by the U.S. Army Corps of Engineers, we conducted 11 surveys by foot at Graveyard spit to assess site occupancy, and number of breeding adults. In addition, we located nests and monitored nest outcome using the methods described below.

Winter window survey

The winter window survey occurs annually in January along the entire U.S. Pacific coastline where Snowy Plovers nest or historically nested. All sites are surveyed during a specific week and the U.S. Fish and Wildlife Service selects the dates for any given year. All participants follow the methods of Elliot-Smith and Haig (2006b). In 2012, the window survey occurred from 23-27 January and we surveyed Connor Creek, Copalis Spit, Damon Point, Midway Beach, and Leadbetter Point (north of Oysterville Road).

Nest phenology and success

We visited Leadbetter Point and Midway Beach several times a week from late March until mid-September to search for and monitor Snowy Plover nests. We visited Graveyard Spit approximately weekly between mid-June and mid-August as part of the sand deposition project administered by the U.S. Army Corps of Engineers. We also conducted nest searches during adult surveys and during frequent visits to the nesting sites. In many cases, we located nests by following plover tracks to nests. We also located nests by observing scrape building by males, by locating adults incubating eggs, or by flushing incubating adults. We recorded date and status (presence of adults and eggs) of each nest approximately every 3-5 days.

Unless observed directly, we calculated clutch initiation date by backdating from known laying or hatching dates. Backdating using hatch dates requires information on the time intervals associated with the egg laying and incubation stages. 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. We calculated nest success using the Mayfield method (Mayfield 1961, 1975). We reported nest outcome 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) to exclude larger avian and mammalian predators from nests. Exclosures were cuboid in shape (sides were 4 feet long and wide and 2 feet 8 inches high) with a 'bubble top' making them approximately 3 feet high. Sides were constructed from 2x4 inch mesh wire. Under the wire bubble top we secured a taut layer of 3/4 inch polypropylene black mesh netting. We used this soft layer to keep a startled plover from flying up and hitting the wire bubble top. We cut a door in one side of the exclosure so that eggs could be accessed if necessary; we fastened doors closed with pliable, heavy gauge wire or zip ties. We centered the completed exclosure over the nest creating an imprint in the sand and then removed it. Following the exclosure imprint, we dug an eight inch deep trench and then placed the mini-exclosure in the trench. We placed 15 inch stakes 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 American Crows (*Corvus brachyrhynchos*), Common Ravens (*Corvus corax*) and larger mammals. We did not use exclosures in the early nesting season to reduce the risk of adult predation from migrating raptors.

Fledging Success

Snowy Plover chicks are precocial, leaving the nest within hours after hatching to search for food. They are not capable of sustained flight until 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 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.

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. This threshold of 1.0 is based on the population viability analysis conducted by Nur et al. (1999). Their population modeling indicates that productivity of at least 1.0 chick 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.

Determining the number of young fledged requires following broods from hatch date to 28 days post hatching and determining their fate. To help us identify and follow individual broods, we attempted to identify hatch dates and from successful nests, follow broods post hatching. We estimated hatch date by floating eggs following Hays and LeRoy (1971) or by counting forward from known egg laying dates. Regardless of the method used to estimate hatch dates, we checked nests daily or every other day around predicted hatching dates. We banded some chicks on the hatch date and followed them until fledging or when they were no longer observed. For unbanded chicks, we used 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. For some nests, we determined 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 date when a banded adult male accompanied chicks that allowed us to accurately assign the chicks to a specific nest.

Nest Locations

We photographed each nest and recorded its location using a hand held GPS unit or Trimble. We used both a Trimble and Garmin GPS unit to document nest locations at Leadbetter Point and only a Garmin GPS unit at Midway Beach. The Trimble Unit has approximately 1 m accuracy with post-processing and the Garmin has approximately 15 m accuracy.

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 an 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. We assigned exact color combinations for a banded bird only when the birds were observed with spotting scopes and when we could confidently determine the color combination. To help us determine if a color combination was confidently assigned, we assigned a confidence score (0-100% confident) to each color combination recorded.

RESULTS & DISCUSSION

Breeding Window Survey

We detected 26 adult plovers in Washington during the 2012 breeding window survey, which was the lowest ever recorded in Washington (Table 3).

Table 3. Breeding Window survey counts by site, sex, and age and counts of nests and broods between 2007 and 2012. The South Long Beach survey was not conducted during the prescribed survey period.

Site	2007	2008	2009	2010	2011	2012	2012 Survey Dates	Adult Males	2012 Adult Females	Adult Unknown
Copalis Spit	0	0	0	0	0	0	24 May	0	0	0
Conner Creek	0	0	0	0	0	0	24 May	0	0	0
Damon Point	0	0	0	0	0	0	24 May	0	0	0
Graveyard	0	1	0	0	0	0	10 May	0	0	0
Midway Beach	22	12	16	18	22	11	30 May	6	5	0
Leadbetter Pt.	28	29	26	20	12	15	29 May	10	4	1
S. Long Beach	0	0	0	0	0	0	25 June	0	0	0
Total	50	42	42	38	34	26		16	9	1

Winter Window Survey

We detected 34 adult plovers on two sites during the January 2012 Winter Window Survey (Table 4).

Table 4. Winter Window survey counts by site, sex, and year.

Site	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012	2011 - 2012	Survey Dates	Adult Males	Adult Females	Adult Unkn
Copalis Spit	0	0	0	0	0		23 January	0	0	0
Conner Creek	0	0	0	0	0		23 January	0	0	0
Damon Point	0	0	0	0	0		27 January	0	0	0
Graveyard	-	-	0	-	-		-	0	0	0
Midway Beach	15	10	12	13	22		27 January	2	4	16
Leadbetter Pt.	14	9	23	9	12		23 January	2	4	6
S. Long Beach	-	-	-	0	0		11 January	0	0	0
Total	29	19	35	22	34			4	8	22

Adult Surveys

As indicated in Table 5, we conducted 27 surveys at 7 sites between 29 April and 15 August 2012.

Site occupancy

Because birders reported a snowy plover on Dungeness Spit (a site we had checked for occupancy previously with no success), the Refuge followed up with 4 surveys. Three were conducted with ATVs (stopping and scanning every 50-100m) and one on foot with three observers. A single unbanded male was observed on the 30th of April by Refuge Biologist Sue Thomas (photographs were taken) but was not observed in the three subsequent surveys and there was no evidence of local nesting. Because birds were observed at Graveyard during this season's occupancy surveys and because of a sand deposition project being conducted at this site by the U.S. Army Corps of Engineers, we conducted additional surveys that were funded by the Corps to assess breeding and prevent disturbance to nesting plovers. Adult birds were observed on every Graveyard Spit survey except for the first and last of the season (see Table 5). This site was occupied by one nesting pair that produced one clutch and fledged three young.

Table 5. Snowy Plover survey dates, number of surveys and surveyors and type of survey by site during the 2012 nesting season

Site	Type of Survey	# Surveys	# Surveyors	Walking or Driving	Survey Dates
Midway	Breeding Adult/Window	3	4	Foot	5/30,6/15,6/27
Leadbetter	Breeding Adult/Window	3	5	Foot/Drive ¹	5/29, 6/14, 6/26
Graveyard	Occupancy/Window	11	1-3	Foot	5/10, 6/06, 6/20, 7/01, 7/07, 7/14, 7/21, 7/28, 8/04, 8/08, 8/15
Damon Pt.	Occupancy/Window	3	2	Foot	5/24,6/19,7/10
Connor Spit	Occupancy/Window	3	1	Foot/Drive	5/24,6/19,7/10
Copalis Creek	Occupancy/Window	3	1-2	Foot	5/24,6/19,7/10
Dungeness NWR	Occupancy	4	1-3	Foot/ATV	4/30,5/7,5/14,5/21
Ocean Shores/N. Jetty	Opportunistic	1	1	Drive	4/29

¹ Post 1 south to Oysterville Rd driving surveys with 2 vehicles with 3-4 observers

Estimating Number of Adult Plovers

We used the annual mean from the three surveys from pre-determined weeks (23 May and 22 June) to estimate trends in the breeding adult population (Figure 2, Table 6). Adult population counts are declining for the 2006-2012 period (Table 6, Figure 2).

We examined the average re-sights of banded male and female plovers per day during the 2012 nesting season to determine if there are differences in detectability (average re-sights per day) between the sexes (Figure 1). This result, and complete overlap in detectability for the years 2006 – 2012, indicates that there is no need to adjust counts for differences in detectability between males and females.

Table 6. Mean counts (95% CI) of the breeding adults at four nesting sites in Washington and the total population estimate for the State in 2006-2012.

Year	Damon	Midway	Graveyard	Leadbetter	Total
2006	1 (0-2)	21 (14-28)	2 (-1-5)	35 (26-45)	59 (48-70)
2007	0	18 (14-21)	2 (-1-4)	25 (20-30)	44 (36-53)
2008	0	14 (10-19)	1 (0-2)	32 (23-40)	47 (33-60)
2009	0	15 (13-17)	0	17 (10-24)	31 (23-39)
2010	0	14 (11-18)	0	21 (17-26)	36 (33-38)
2011	0	19 (8-30)	0	12 (6-19)	31 (15-47)
2012		14 (5-23)	2 (0-3)	18 (6-29)	33 (15-52)

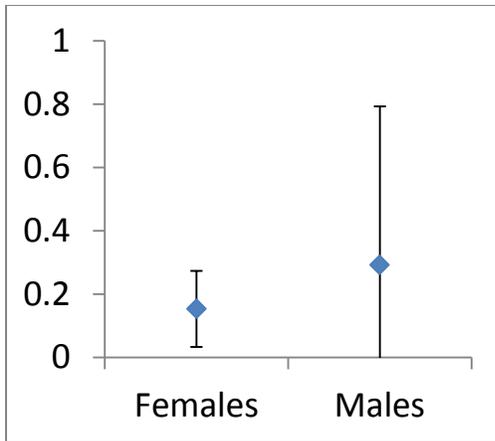


Figure 1. Average number of re-sights per banded adult female (n = 26) and male (n = 13) Snowy Plovers per day (± SD) during the 2012 nesting season.

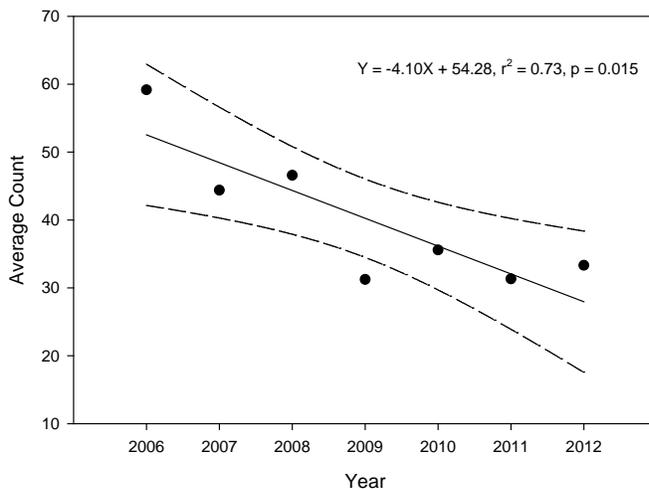


Figure 2. Trend (95% CI) of average yearly count for all Washington sites from Washington adult plover population (2006 – 2012).

Although there is a significant decline between 2006 and 2012, and the overall population is declining by four birds annually, the population has been stable for the past four years.

Clutch Initiation Dates and Breeding Phenology

The active nesting season occurred between late-March and mid-September in 2012. Clutches were initiated between 21 April and 20 July (Figure 3A). However, very early nests could have gone undetected because we did not initiate intensive surveys until late March at Midway Beach and mid-April at Leadbetter Point beaches. Clutch initiation was fairly evenly spread out between mid-April and mid-July. The first chick known to fledge, fledged around 23 July and the last chick known to fledge, fledged around 9 September (Figure 3B). Overall, both nest initiation and fledging occurred much later in 2012 than in recent years. Looking at all years combined, the nesting season starts in late March and continues through mid-September.

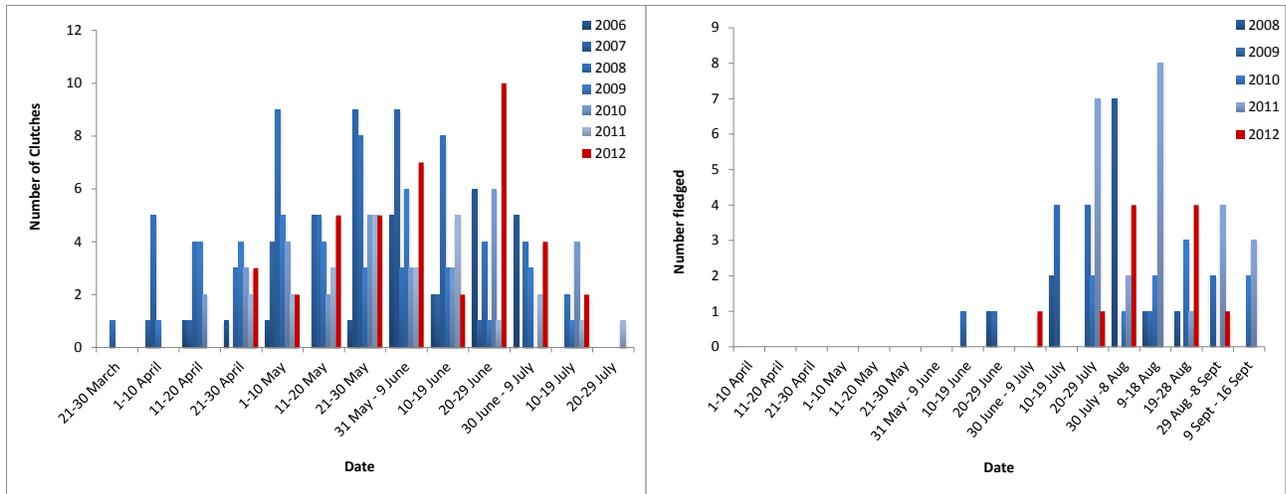


Figure 3. Number of Snowy Plover clutches initiated in 2006-2012 (A) and number of chicks fledged in 2008-2012 (B). Results are presented in 10-day intervals for all Washington nesting sites combined.

Nest success

We located and monitored the outcome of 47 plover nests in 2012. Of these 47 nests, 26 were located at Leadbetter Point and 21 at Midway Beach (Table 7). For a map of nest locations see Appendix I. Fifteen (32%) of the 47 nests we monitored hatched. Predation was the primary source of nest failure (60%) and corvids (crow or raven) were the only identified nest predators (Table 8). Drifting sand was the likely cause of about 20% of the nest failures (Table 8). Six nests were abandoned and three failed for unknown reasons.

In Tables 9 and 10 and Figure 4, we report Mayfield nest success estimates for the 2012 nesting season and compare to the previous nesting seasons. The probability of nest survivorship was 26% at Midway Beach and 17% at Leadbetter Point.

Table 7. Nest outcomes by Snowy Plover nesting locality in 2012. Outcomes include successful (hatched), failed or unknown outcome.

Site	# Nests	Outcome		
		Hatch	Fail	Unknown
Midway	21	7	14	0
Leadbetter	26	8	16	2
Exclosed ¹	13	10	3	0
Not exclosed	34	5	27	2
Totals	47	15	30	2

¹Three exclosures were used at Midway and 10 at Leadbetter

Table 8. Sources of Snowy Plover nest failure in 2012. Sources of failure include predators (American/Northwest Crows, Common Ravens, unknown Corvid, or Unknown predator) eating eggs, or other sources of failure including Human activities, drifting Sand covering the nest, Abandoned nests and Unknown sources of failure.

Site	Failures								
	Predator					Other Sources			
	Crow	Raven	Corvid	Coyote	Unknown	Human	Sand	Abandon	Unknown
Midway	0	6	0	0	1	0	3	1	3
Leadbetter	0	3	1	0	7	0	3	2	0
Exclosed	0	0	0	0	0	0	0	3	0
Not exclosed	0	9	1	0	8	0	6	0	3
Totals	0	9	1	0	8	0	6	3	3

Table 9. Mayfield estimates of Snowy Plover nest survival and of daily nest survival probability by site and by exclosed and unexclosed nests in 2012.

Site	Daily Survival	
	Probability	Nest Survival
Midway	0.958	0.256
Leadbetter	0.947	0.174
Washington exclosed	0.972	0.339
Washington unexclosed	0.869	0.011
Washington total (including exclosures)	0.953	0.211

Table 10. Mayfield estimates of nest survival by site from 2006 – 2012. We also include the percent of nests exclosed by site and year because of the large influence of exclosures on nest success.

Site	Nest Survival						
	2006	2007	2008	2009	2010	2011	2012
Midway and Graveyard	0.23	0.28	0.25	0.15	0.20	0.26	0.26
% Exclosed	0.33	0.39	0	0.06	0.16	0.29	0.15
Leadbetter	0.26	0.51	0.54	0.43	0.83	0.33	0.17
% Exclosed	0.62	0.86	0.97	0.78	0.88	0	0.40
Washington Total (including exclosures)	0.25	0.37	0.36	0.30	0.46	0.28	0.21

Fledging Success

Deriving this metric for Washington requires an estimate of both the number of breeding adult males and the number of chicks fledged. Using direct observations of fledglings on the beach, we estimated between 11 and 15 chicks fledged in 2012. We used the proportion of males from our breeding adult surveys (using known sex birds) to determine the number of breeding males in Washington. Because there was no difference in the sightability of males and females (Figure 2), this result should be unbiased. Using our estimate of breeding males and number of young actually thought to have fledged, we estimate that the number of young fledged per adult male in 2012 was 0.68 (range = 0.46-0.94).

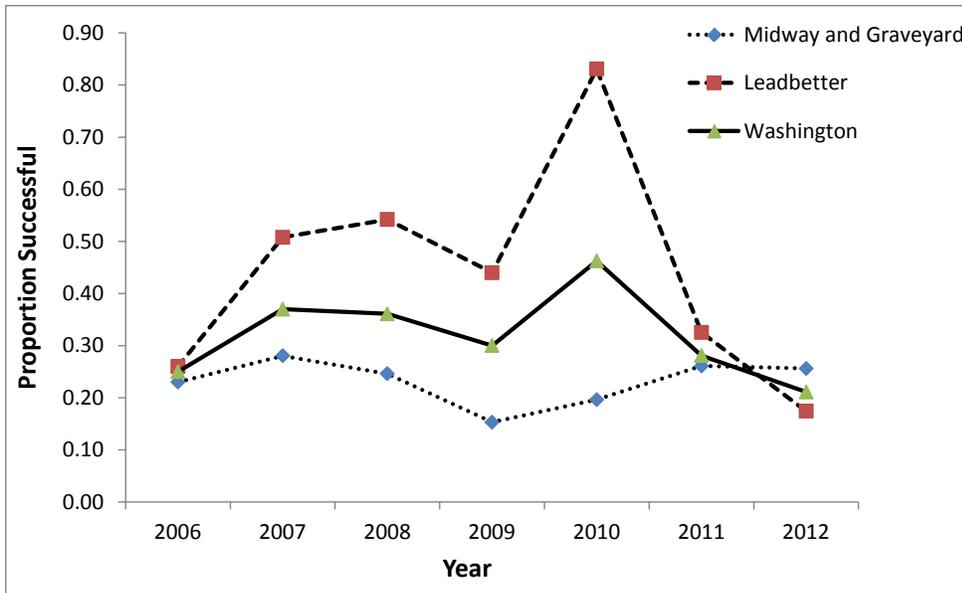


Figure 4. Mayfield estimates of nest survival by site and for coastal Washington. Note that different proportions of nests were exclosed in each site in different years (see Table 10).

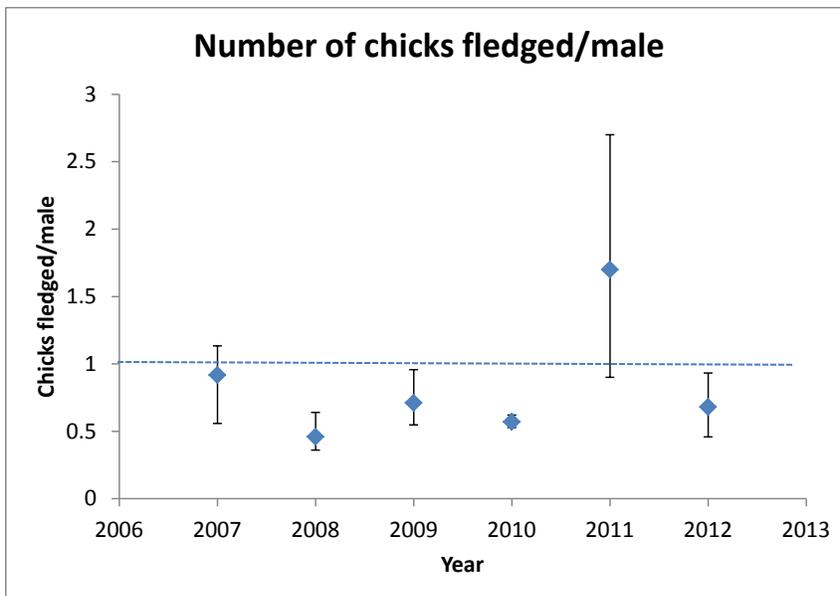


Figure 5. Number of Snowy Plover chicks fledged per adult male from 2007-2012 for all Washington nesting sites combined. Population modeling indicates that one chick fledged per male is needed on average to maintain a stable population – this has occurred in only one year, 2011.

Nest Locations

2012 nest locations are presented by nesting site in Appendix I. At Midway Beach, birds nested in Grayland Beach State Park and on the beach immediately south of Grayland Beach State Park. At Leadbetter Point plovers nested on the tip of the Peninsula on the outer beach and in the Willapa National Wildlife Refuge HRA. Three of 26 nests found at Leadbetter Point were in the newly created unshelled habitat area, 12 were in the shelled portions of the HRA, 8 were on the outer beach within the refuge, and 3 were located on the outer beach north of Osterville Road within the Seashore Conservation Area managed by Washington State Parks

PROGRESS ON RECOVERY OBJECTIVES

Federal Recovery Objectives:

Objective 1: 250 breeding adults in Recovery Unit 1.

The 2012 Washington nesting population was 33 (95% CI = 15-52) and the 2012 Oregon nesting population was 231-238 (Lauten et al. 2012) for a total of 268 (range = 246-290) nesting adult plovers in Recovery Unit 1.

Table 11. Estimated number of breeding adults in Recovery Unit 1 by year.

2007	2008	2009	2010	2011	2012
210 (201-220)	183 (167-198)	184.5 (175-194)	217 (213-220)	208 (188-228)	268 (246-290)

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

We combined the Oregon and Washington estimates of the number of breeding adult males (n = 162-170) and the number of young fledged (n = 184-188) to derive this combined Unit 1 fledging success per male. The number of chicks fledged per male in Unit 1 was 1.12 (1.08-1.16) in 2012. The average number of young fledged/male for the past five years was 1.15.

Table 12. Estimated number of chicks fledged per breeding adult male in Recovery Unit 1 by year.

	2007	2008	2009	2010	2011	2012
Chicks fledged per adult male	1.43 (1.37-1.50)	0.92 (0.85-1.01)	1.25 (1.18-1.32)	0.85-0.87	1.59 (1.43-1.66)	1.12 (1.08-1.16)

Washington State Recovery Objectives:

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

The 2012 Washington adult nesting population was 33 (95% CI = 15-52) and approximately 56% of these birds were males and 44% were females. If all males paired, these estimates indicate that there were approximately 19 pairs in Washington in 2012. The average number of pairs for the past four years was 20.

Table 13. Estimated number of breeding pairs in Washington (2006-2012).

	2007	2008	2009	2010	2011	2012
Breeding Pairs	24	27	17-18	21-22	22	19

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 in 2012 was 0.68 (range = 0.46-0.94), 1.70 (range = 0.90-2.70) in 2011, 0.57 (range = 0.53-0.62) in 2010, 0.71 (range = 0.55-0.96) in 2009, 0.46 (range = 0.36-0.64) in 2008, and 0.91 (range = 0.77 - 1.13) in 2007. The average Washington fledging rate for the past five years was 0.92. Currently plovers are nesting on two primary sites – one on a National Wildlife Refuge and the other on private and Washington State Park lands.

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”.

2012 MANAGEMENT ACTIONS

A number of the management actions that occurred in 2012 involved minimizing some human activities near active Snowy Plover nesting sites during the nesting season. Human related disturbance negatively affect hatching success of Snowy Plovers (Warriner et al. 1986, Schulz and Stock 1993) and Snowy Plover chick survival by as much as 72% (Ruhlen et. al. 2003). Disturbances to wintering Snowy Plovers are 16 times higher at a public beach than at a protected beach. Humans, dogs, American 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 negatively affects 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 were closed to all human activities where plovers were actively nesting on Grayland and South Beach State Parks and on National Wildlife Refuge and State Park lands on Leadbetter Point. Private lands at Midway/Grayland Beach were not closed to human activities. Approximately 7.5 miles of beach nesting habitat was closed at Leadbetter Point by State Parks and U.S. Fish and Wildlife Service and slightly under a mile of beach was closed to foot traffic at Midway/Grayland Beach by State Parks and Washington Department of Fish and Wildlife. The lower beach, adjacent to the ocean, remained open to the public. There are two dog restriction signs at trail junctions and trailheads on the Leadbetter Point Refuge lands and there is a “Share the Beach” sign posted at Grayland Beach State Park and on the Refuge trails at Leadbetter Point.
- Symbolic fencing was put at established beach access trails at Leadbetter Point by U.S. Fish and Wildlife Service staff to direct people toward the wet sand and away from plover nesting habitat. Symbolic fencing was used on State Park land at Midway/Grayland Beach at 5 specific high-intrusion locations along the posted sign line. Rope was used more as a reinforcement alert to the public not to enter the closed area. This method was very successful in reducing the number of human intrusions into the posted nesting area. We recommend that this selective symbolic fencing method be used in subsequent years. It is also recommended that symbolic fencing be added to trailhead #5 at Grayland Beach State Park if the posted nesting area expands to the north and if nests are discovered adjacent to this trail, we recommend managers considering closing or re-routing this trail.
- On the Long Beach Peninsula, the beach is closed to vehicle traffic north of Oysterville Road from April 15 to the day after Labor Day. Coastal beaches at Willapa National Wildlife Refuge and Leadbetter State Park are closed to vehicle traffic year round. However, driving is allowed on the wet sand portions of the beach in these areas during razor clam harvest openings. All of the Midway/Grayland beach area is open to vehicle traffic and there are vehicle access points at Cranberry Beach Road, Midway Beach Road and Warrenton-Cannery Road. The Midway Beach Road access cuts through the center of the highest use area for plover nesting on this beach but has been closed since 2009. As a result, there was much less disturbance to plovers in this area again this season. Birds now nest on the old roadway and, as a result, opening this gate during the nesting season could result in the loss of plover nests.
- Washington Department of Fish and Wildlife biologists put nest exclosures around 3 nests on Midway Beach. USFWS and WDFW biologists erected nest exclosures over 10 nests on Refuge and State Park lands at Leadbetter Point.
- In 2012 WDFW, State Parks, and U.S. Fish and Wildlife Service coordinated enforcement activities during clam tides which reduced the amount of associated human activity in active nesting areas. In addition, USFWS provided funding for two portable toilets that were placed on the Refuge beaches

during razor clam days. These toilets were successful in reducing the number of human intrusions into the posted nesting area. The refuge received favorable public response to this action.

- Willapa NWR produced and distributed a revised outreach brochure informing the public about Snowy Plover conservation and habitat restoration actions at Leadbetter Point.
- Anthropogenic debris and trash was collected from Snowy Plover nesting beaches at Leadbetter Point after birds had finished nesting and chicks had fledged.

Restoration

- The U.S. Fish and Wildlife Service habitat restoration area (HRA) at Leadbetter Point has annually increased to a total of 121 acres by 2008, of which oyster shell has been added to approximately 62 of the 121 acres. The HRA now totals over 250 acres.
- Dead, non-native beachgrass was cleared using a bulldozer in the foredune and the swale east of the foredune that was treated with herbicide in 2010. The area was subsequently rototilled. This has created an additional 15 acres of habitat south southwest of the existing HRA. Resprouting beachgrass in the unshelled portions of the northern HRA and the swale to the west were also rototilled in early February. Harrowing to redistribute shell in the north end of the shelled area of the HRA, and bulldozing to remove beachgrass and eliminate the dune cuts in the swale adjacent to the west edge of the south HRA, was also conducted in February.
- Aerial application of the herbicides Imazapyr and Glyphosate with MSO as the surfactant occurred on October 12 in the Leadbetter Point HRA. Approximately 110 acres of heavily infested beachgrass was treated in areas within and adjacent to the east and west edges of the south end of the HRA, and areas of resprouting beachgrass to the south landward of the foredune that were treated in 2011. Aerial application is cost effectiveness and results in a more uniform application in rugged, choppy terrain.
- An elk enclosure in the Leadbetter Point HRA placed around a patch of grey beach pea (*Lathyrus japonicas*) was raised in elevation and expanded in size to accommodate drifting sand and to protect spreading plants. Beachgrass sprouts were pulled within and adjacent to the enclosure.
- No habitat restoration work was conducted on State Parks lands at Leadbetter Point or Midway Beach in 2012.

FUTURE RESEARCH & MONITORING CONSIDERATIONS

- Summarize, write-up and publish population monitoring results from Oregon, Washington, and northern California.
- Continue to examine the effectiveness of habitat restoration areas.
- Identify the conditions where plover populations are more likely to be self-sustaining.
- Conduct research to identify habitat features important to successful plover nesting.
- Begin implementing a predator control program for current active nesting locations on Willapa NWR.
- Continue to engage volunteers in monitoring.
- Continue to link management activities with research and monitoring.
- Continue to evaluate the effectiveness and continued use of nest enclosures on an annual basis.
- Increase education and outreach activities.

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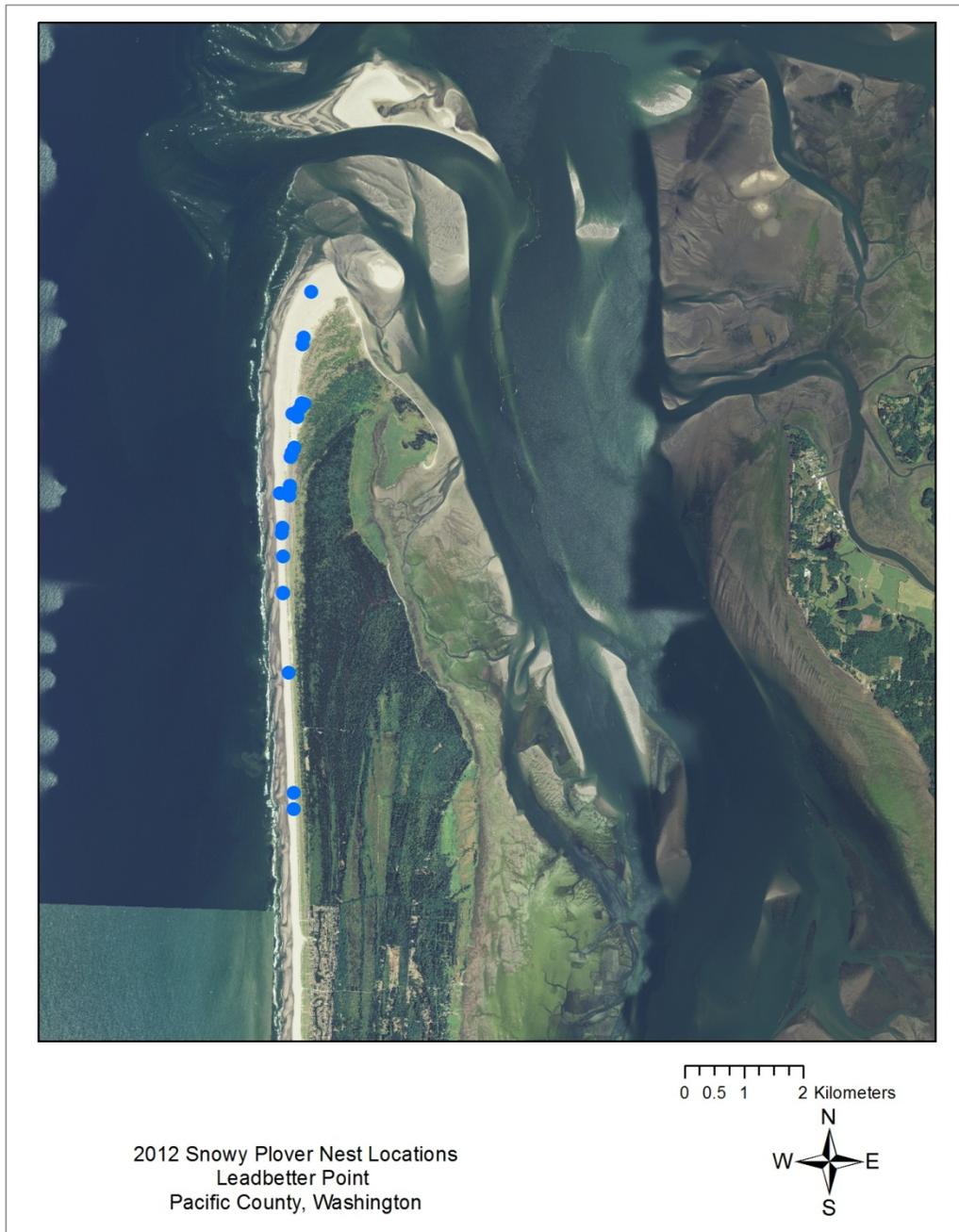
LITERATURE CITED & REFERENCES

- Buick, A.M., and D.C. Paton. 1989. Impact of off-road vehicles on the nesting success of Hooded Plovers *Charadrius rubricollis* in the Coorong region of South Australia. *Emu* 89: 159-172.
- Dowling, B. and M.A. Weston. 1999. Managing a breeding population of the Hooded Plover *Thinornis rubricollis* in a high-use recreational environment. *Bird Conservation International* 9: 253-270.
- Elliot-Smith, E., and S.M. Haig. 2006a. Western Snowy Plover breeding window survey protocol – final draft.
- Elliot-Smith, E., and S.M. Haig. 2006b. Western Snowy Plover winter window survey protocol – final draft.
- Elliot-Smith, E., and S.M. Haig. 2006c. Draft protocol for surveying Snowy Plovers at unoccupied breeding sites on the Oregon coast.
- Flemming, S.P., R.D. Chiasson, P.C. Smith, P.J. Austin-Smith, and R.P. Bancroft. 1988. Piping Plover status in Nova Scotia related to its reproductive and behavioral response to human disturbance. *Journal of Field Ornithology* 59:321-330.
- Hays, H., and M. LeCroy. 1971. Field criteria for determining incubation stage in eggs of the common tern. *Wilson Bulletin* 83:425-429.
- Lafferty, K.D. 2001. Disturbance to wintering western Snowy Plovers. *Biological Conservation* 101:315-325.
- Lauten, D.J., K.A. Castelein, B. Smithers., K.C. Jander, E. Elliot-Smith, E.P. Gaines. 2003. The Distribution and Reproductive Success of the Western Snowy Plover Along the Oregon Coast – 2003. Unpublished report to Coos Bay Bureau of Land Management, Oregon Dunes National Recreation Area, U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, and Oregon Parks and Recreation Department.
- Lauten, D.J., K.A. Castelein, E.P. Gaines, and M.A. Stern. 2004. The efficacy of nest exclosures for the Western Snowy Plovers (*Charadrius alexandrinus nivosus*) on the Oregon Coast, 1990-2003. Unpublished report for U.S. Fish and Wildlife Service, Newport, OR.
- Lauten, D.J., Kathleen A. Castelein, Susan Weston, Krista Eucken, and Eleanor P. Gaines. 2006. The Distribution and Reproductive Success of the Western Snowy Plover Along the Oregon Coast – 2006. Oregon Natural Heritage Information Center, Portland, Oregon.
- Lauten, D.J., Kathleen A. Castelein, Susan Weston, Krista Eucken, and Eleanor P. Gaines. 2007. The Distribution and Reproductive Success of the Western Snowy Plover Along the Oregon Coast – 2007. Oregon Natural Heritage Information Center, Portland, Oregon.
- Lauten, D.J., Kathleen A. Castelein, David C. Bailey, Travis Lewis, and Eleanor P. Gaines. 2008. The Distribution and Reproductive Success of the Western Snowy Plover Along the Oregon Coast – 2008. Oregon Natural Heritage Information Center, Portland, Oregon.
- Lauten, D.J., K.A. Castelein, J.D. Farrar, H.G. Herlyn, and E.P. Gaines. 2009. The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast – 2009. The Oregon Natural Heritage Information Center Institute for Natural Resources, Oregon State University, Portland, Oregon.
- Lauten, D.J., K.A. Castelein, J.D. Farrar, A. Kotiach, and E.P. Gaines. 2010. The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast – 2010. The Oregon Natural Heritage Information Center Institute for Natural Resources, Portland State University, Portland, Oregon.
- Lauten, D.J., K.A. Castelein, J.D. Farrar, A.A. Kotaich, and E.P. Gaines. 2011. The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast – 2011. Unpublished report for the Oregon Department of Fish and Wildlife – Nongame Program, Portland, the Coos Bay District Bureau of Land Management, Coos Bay, and the Dunes Recreational Area, Reedsport.
- Lauten, D.J., K.A. Castelein, J.D. Farrar, A.A. Kotaich, and E.P. Gaines. 2012. The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast – 2012. Unpublished

- report for the Oregon Department of Fish and Wildlife – Nongame Program, Portland, the Coos Bay District Bureau of Land Management, Coos Bay, and the Dunes Recreational Area, Reedsport.
- Mayfield, H. 1961. Nesting success calculated from exposure. *Wilson Bulletin* 73:255-261.
- Mayfield, H. 1975. Suggestions for calculating nest success. *Wilson Bulletin* 87:456-466.
- Nur, N., G.W. Page, and L.E. Stenzel. 1999. Population viability analysis for Pacific Coast Snowy Plovers. Point Reyes Bird Observatory, Stinson Beach, California.
- Page, G.W., J.S. Warriner, J.C. Warriner, and P.W.C. Paton. 1995. Snowy Plover (*Charadrius alexandrinus*). In *The Birds of North America*, No. 154 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
- Pearson, S.F., C. Sundstrom, K. Brennan, and M. Fernandez. 2007. Snowy Plover Distribution, Abundance and Reproductive Success: 2006 Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia.
- Pearson, S.F., K. Brennan, C. Sundstrom, and K. Gunther. 2008. Snowy Plover Population Monitoring, Research, and Management Actions: 2007 Nesting Season Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia.
- Pearson, S.F., C. Sundstrom, and K. Gunther, D. Jaques, and K. Brennan. 2009a. Snowy Plover Population Monitoring, Research, and Management Actions: 2008 Nesting Season Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia.
- Pearson, S.F., C. Sundstrom, and K. Gunther, W. Ritchie, and K. Gunther. 2009b. Snowy Plover Population Monitoring, Research, and Management Actions: 2009 Nesting Season Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia.
- Pearson, S.F., C. Sundstrom, W. Ritchie, and K. Gunther. 2010. Washington State Snowy Plover Population Monitoring, Research, and Management: 2010 Nesting Season Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia.
- Pearson, S.F., C. Sundstrom, W. Ritchie, and W. Pearson. 2012. Washington State Snowy Plover Population Monitoring, Research, and Management: 2011 Nesting Season Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia.
- Ruhlen, T.D., A. Abbot, L.E. Stenzel, and G.W. Page. 2003. Evidence that human disturbance reduces Snowy Plover chick survival. *Journal of Field Ornithology* 74:300-304.
- Schultz, R. and M. Stock. 1993. Kentish plovers and tourists: competitors on sandy coasts? *Wader Study Group Bulletin* 68:83-91.
- U.S. Fish and Wildlife Service. 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). Sacramento, California. xiv + 751 pages.
- Warriner, J.S., J.C. Warriner, G.W. Page, and L.E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous Snowy Plovers. *Wilson Bulletin* 98:15-37.
- Washington Department of Fish and Wildlife. 1995. Washington State recovery plan for the Snowy Plover. Olympia, Washington. 87pp.
- Wiedemann, A. M. 1984. The ecology of Pacific Northwest coastal sand dunes: A community profile. U.S. Fish and Wildlife Service. FWS-OBS-84-04. 130 pp.

APPENDIX I

Blue circles represent locations of Snowy Plover nests in 2012 at Leadbetter Point, U.S. Fish and Wildlife Service Refuge and Washington State Parks lands. All of the orthographic photos are from 2011.



Blue circles represent locations of Snowy Plover nests in 2012 at Midway Beach and Graveyard Spit. All of the orthographic photos are from 2011.

