The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast - 2017

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David J. Lauten, Kathleen A. Castelein, J. Daniel Farrar, Adam A. Kotaich, Erica Krygsman, and Eleanor P. Gaines

The Oregon Biodiversity Information Center
Institute for Natural Resources
Portland State University/INR
PO Box 751
Portland, Oregon 97207

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Coos Bay District Bureau of Land Management
1300 Airport Way
North Bend, Oregon 97459

Siuslaw National Forest
4077 SW Research Way
Corvallis OR, 97333

U.S. Fish and Wildlife Service
2127 SE OSU Drive
Newport, Oregon 97365
Recovery Permit TE-839094-5

Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive, SE
Salem, OR 97302

Oregon Parks and Recreation Department
725 Summer St. N.E. Suite C
Salem, OR 97301

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David J. Lauten, Kathleen A. Castelein, J. Daniel Farrar, Adam A. Kotaich, Erica Krygsman, and Eleanor P. Gaines

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Institute for Natural Resources
Portland State University/INR
PO Box 751, Portland, Oregon 97207

Abstract

We monitored the distribution, abundance and productivity of the federally threatened Western Snowy Plover (*Charadrius nivosus nivosus*) along the central and south coast of Oregon from 5 April – 14 September 2017. The project area surveyed and monitored for plover activity from north to south included Sutton Beach, Siltcoos River estuary, the Dunes Overlook, North and South Tahkenitch Creek, Tenmile Creek, Coos Bay North Spit, Bandon Snowy Plover Management Area, New River HRA and adjacent lands, and Floras Lake. Our objectives in 2017 were to: 1) estimate the size of the adult Snowy Plover population, 2) locate plover nests, 3) determine nest success, 4) implement nest protection as appropriate (e.g. ropes, signs, exclosures), 5) monitor a sample of broods to determine brood fate and plover productivity, and 6) use cameras and observational data to document predator activity at nests.

We estimated the resident number of Snowy Plovers in Oregon at 468 individuals, a decline from the 2016 season. We monitored 548 nests in 2017. Overall apparent nest success was 42%. Nest failures were attributed to unknown cause, unknown depredation, harrier depredation, corvid depredation, one egg nest, mammalian depredation, unknown avian depredation, wind/weather, abandonment, infertility, overwashing, gull depredation and human caused. We monitored 200 of 229 known broods, and documented a minimum of 285 fledglings. Overall brood success was 75%, fledging success was 50%, based on the overall number of resident males, 1.23 chicks fledged per resident male.

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Introduction

The Western Snowy Plover (*Charadrius nivosus nivosus*) breeds along the coast of the Pacific Ocean in California, Oregon, and Washington and at alkaline lakes in the interior of the western United States (Page *et al.* 1991). Loss of habitat, predation pressures, and disturbance have caused the decline of the coastal population of Snowy Plovers and led to the listing of the Pacific Coast Population of Western Snowy Plovers as threatened on March 5, 1993 (U.S. Fish and Wildlife Service 1993). Oregon Department of Fish and Wildlife lists the Western Snowy Plover as threatened throughout the state (ODFW 2009).

Oregon Biodiversity Information Center (ORBIC, formerly Oregon Natural Heritage Information Center) completed our 28th year of monitoring the distribution, abundance, and productivity of Snowy Plovers along the Oregon coast during the breeding season. In cooperation with Federal and state agencies, plover management has focused on habitat restoration and maintenance at breeding sites, non-lethal and lethal predator management, and management of human related disturbances to nesting plovers. The goal of management is maintaining recent improvements in annual productivity, leading to a sustainable Oregon breeding population at or above recovery levels. Previous work and results have been summarized in annual reports (Stern *et al.* 1990 and 1991, Craig *et al.* 1992, Casler *et al.* 1993, Hallett *et al.* 1994, 1995, Estelle *et al.* 1997, Castelein *et al.* 1997, 1998, 2000a, 2000b, 2001, and 2002, and Lauten *et al.* 2003, 2005, 2006, 2006b, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, and 2016). Our objectives for the Oregon coastal population in 2017 were to: 1) estimate the size of the adult Snowy Plover population, 2) locate plover nests, 3) determine nest success, 4) implement nest protection as appropriate (e.g. ropes, signs, exclosures), 5) monitor a sample of broods to determine brood fate and plover productivity, and 6) use cameras and observational data to document predator activity at nests.

Study Area

Snowy Plover populations have increased in Oregon, and as a result plovers have begun to winter and nest at locations outside of areas traditionally monitored by ORBIC (USFWS, ORPD, and ORBIC unpublished data). Here we report on activities at sites that have been intensively monitored by ORBIC in 2017: from north to south, Sutton Beach, Siltcoos River estuary, the Dunes Overlook, North and South Tahkenitch Creek, Tenmile Creek, Coos Bay North Spit (CBNS), Bandon Snowy Plover Management Area (SPMA), New River (extending from private land south of Bandon SPMA to the south end of the New River Area of Critical Environmental Concern (ACEC) habitat restoration area), and Floras Lake (Figure 1). At these breeding sites along the Oregon coast, we surveyed and monitored Snowy Plover activity along ocean beaches, sandy spits, ocean-overwashed areas within sand dunes dominated by European beachgrass (*Ammophila arenaria*), open estuarine areas with sand flats, a dredge spoil site, and several habitat restoration/management sites. A description of each site occurs in Appendix A. For the purposes of this report and for consistency with previous years' data, we define Bandon Beach as the area from China Creek to the mouth of New River, and Bandon SPMA as all the state land from the north end of the China Creek parking lot south to the south boundary of the State Natural Area, south of the mouth of New River. Information on wintering and nesting at areas outside these sites is available from Oregon Department of Parks and Recreation (OPRD) and U.S. Fish and Wildlife Service (USFWS).

Methods

Window Surveys

Annual breeding season window surveys were coordinated by USFWS in mid-May. Breeding season window surveys were conducted at both currently active and historic nesting areas (Elliott-Smith and Haig 2007). Historic nesting areas searched during the breeding window survey included: Clatsop Spit, Necanicum Spit, Nehalem Spit, Bayocean Spit, Netarts Spit, Sand Lake South Spit, Whiskey Run to Coquille River, and Elk River. There were no surveys or incomplete surveys at Nestucca spit, Sixes River, Euchre Creek, Myers Creeks or Pistol River.

Monitoring

Breeding season fieldwork was conducted from 5 April to 14 September 2017. Survey techniques, data collection methodology, and information regarding locating and documenting nests can be found in Castelein *et al.* 2000a, 2000b, 2001, 2002, and Lauten *et al.* 2003 and are in Appendix B. Some beach surveys, particularly to document brood success and to confirm fledglings, were conducted from a 4x4 truck using a window mounted scope. No other modifications to survey techniques were implemented in 2017.

We report three separate measures of adult population size: resident birds, the minimum number of birds present, and the window survey. Resident plovers are defined here as any adult plover detected during the peak breeding period (between 15 April and 15 July). Plovers present during this period had the potential to attempt to nest. Not all plovers recorded during the summer are Oregon breeding plovers; some are only recorded early or late in the breeding season, suggesting that they are either migrant or wintering birds. These plovers are not included in the tally of resident plovers. The minimum number of Snowy Plovers present includes all adult birds observed within the project area during the field season (5 April through 14 September), and includes breeding birds, birds migrating through the area during that time, and wintering birds that may be present in the project area early or late in the season.

Most adults are banded and thus uniquely identifiable, but unbanded birds are difficult to accurately count because they move within and between sites. To avoid over counting unbanded birds, we recorded the number of unbanded plovers observed at each site within 10-day intervals May through early July. We selected this period because it encompasses the period of maximum nesting effort and minimum movement between sites. For each 10-day interval we subtracted the number of adults that were subsequently banded during the breeding season and selected the 10-day interval with the highest remaining count. This number was added to our count of banded adults present, resulting in the minimum number of adults present. We also added this number of unbanded birds to our count of banded resident adults for a total estimate of resident birds. Based on nesting records and daily observation data, this method underestimates the actual number of unbanded plovers present, but it provides a minimum number of unbanded plovers present (Castelein *et al.*, 2001). We believe the number of resident plovers is the most accurate estimate of the total breeding population because it only includes birds present during the peak breeding period.

We tallied the number of individual banded female and male plovers and the number of individual unbanded female and male plovers that were recorded at each nesting area with the project area from the beginning to the end of the 2017 breeding season. Data from nesting sites with a north and south component (Siltcoos, Overlook, Tahkenitch, and Tenmile) were combined because individual plovers use both sides of these estuaries. Data from CBNS nesting sites were aggregated for the same reason. We separated data from Bandon SPMA, New River HRA, and Floras Lake because of different management at these sites, despite plovers frequently moving between these areas. The total number of individual plovers recorded at each site indicates the overall use of the site, including where plovers congregate during post-breeding and wintering. We also report the number of resident female and male plovers for each site, which indicates the relative level of nesting activity for each site. Because some birds used multiple sites within a season, a tally of the birds at each site does not reflect the total population size.

We calculated overall apparent nest success, which is the number of successful nests divided by the total number of nests observed, for all nests and for each individual site. The cause of nest failure was recorded when identifiable.

Prior to 2016 we attempted to monitor all nests and broods. As the Oregon plover population has grown, the increase in numbers of nests and broods have made it difficult to monitor all broods with existing staff and available funding. In 2016, in conjunction with Point Blue Conservation Science (Lynne Stenzel, pers. comm.), we implemented a spatial and temporal sampling scheme to adequately measure plover productivity (Lauten *et al*., 2016). In 2016 and 2017 we attempted to sample approximately 80% of the hatched nests across all sites and over the course of the entire breeding season. Details of the sampling scheme can be found in Appendix C.

All known nests were monitored to determine fate and cause of failure. We banded a minimum of the first five nests that hatched at each site within fixed 10 day time periods, and these broods comprised our sample. To track the broods, we banded hatched chicks with a USFWS aluminum band covered in color taped on the left leg and a colored plastic band on the right leg. Most nesting adult males or females that tended to broods were already color banded. For unbanded adults, we attempted to trap and mark the tending parent with a combination of a USFWS aluminum band covered with colored taped and colored plastic bands. Trapping techniques are described in Lauten *et al.* 2005 and 2006 (Appendix B). We monitored broods and recorded brood activity or adults exhibiting broody behavior at each site (Page *et al.* 2009). Chicks were considered fledged when they were observed at least 28 days after hatching. Using the sample of banded chicks, we calculated brood success, the number of broods that successfully fledged at least one chick; fledging success, the number of chicks that fledged divided by the number of eggs that hatched from the sample; and the number of fledglings per sampled brood for each site. Using the estimate of the number of fledglings per sampled brood and the total number of known hatched nests, we calculated an estimated number of fledglings produced for each site. We used the number of estimated fledglings per site and the number of resident males to calculate the estimated number of fledglings per resident male for each site and the project area. See Appendix C for further details regarding calculation of the number of fledglings per male. We also calculated a breeding coefficient (Colwell *et al.* 2017) that measures the level of productivity based on the number fledglings versus the level of effort by the plovers in terms of eggs laid; high numbers of eggs laid indicate high effort at a particular site. If the numbers of fledglings produced is large compared to the number of egg laid, the high breeding coefficient indicates that site was very productive. Alternatively, few fledglings relative to a high number of eggs laid results in a low breeding coefficient.

We compared plover productivity in 2017 to average post-predator management hatch rate, fledge rate and fledglings per male for each nesting area. We also compared the average pre-predator management hatch rate, fledge rate, and fledglings per male to the post-predator management averages to continue to evaluate the success of the current predator management actions. Means are reported +/- standard deviation.

We report brood activity based on the nest site (for example, broods that originated from a nest at Overlook, but moved to Tahkenitch, are reported as Overlook broods). We record banded adults and chicks that return to the project area in Oregon from previous seasons and calculate overwinter return rates for each group. Point Blue Conservation Science coordinates observations of banded birds throughout the range, and regularly reports observations of birds banded in Oregon that are sighted elsewhere. Overwinter return rates are the number of banded plovers (adults or first year birds) that returned to the project area in Oregon, divided by the number of banded adults or chicks observed the previous year.

Nest Failure

Nest exclosures are an option for protecting some nests from predation, particularly at sites with high levels of corvid predation and a relatively low number of plover nests (Appendix D). However, exclosures have rarely been used in recent years (Lauten *et al.*, 2012, 2013, 2014, 2015, and 2016) because of the potential for adult mortality at exclosed nests (Lauten *et al.*, 2010, 2011, 2012, and 2013), improved unexclosed nest success, increased numbers of nests at all sites, and an adult population that is over recovery goals. We continue to minimize the use of exclosures, however some were used in 2017 where depredation rates were relatively high.

We used Reconyx PC900 cameras (Reconyx Inc., Holmen, WI), Bushnell Aggressor Trophy Cam HD (Bushnell Outdoor Products, Overland Park, KS), and HCO Spartan SR-1 blackout scouting cameras (HCO Outdoor Products, Norcross, GA) to observe predator activity at plover nests and identify causes of nest failure. Cameras were placed two to four meters from the nest, depending on local conditions (terrain, vegetation height). In general, we placed cameras as far from the nest as possible while keeping the nest visible in the camera's field of view. Cameras were camouflaged with a sand or brown-colored outer case or typical green hunter camouflage painting, and were installed as low to the ground as possible to avoid providing a perch for predators. Cameras were used at Sutton Beach, Siltcoos, Overlook, Tahkenitch, Coos Bay North Spit, Bandon SPMA, and New River. We placed cameras at nests that were well beyond the view of the public to reduce the potential for camera theft, and to avoid creating an attractive nuisance.

Cameras employed a "no glow" infrared illumination system which eliminates glow or flash from the camera that can alert predators to its presence. Images taken during the day are in color; those at night are monochrome. Depending on the suite of suspected predators at a site, some cameras were set to operate 24 hours per day, taking one image every 60 seconds, and a burst of three to four images every second when the motion sensor was triggered. Other cameras were set up to take one image per minute from just prior to dawn to just after dusk, and set to only motion sensor trigger at night. Bushnell cameras took only motion sensor triggered pictures. Predator activity at the nest triggered the motion sensor, but plovers were generally too small to trigger the cameras.

In most cases, we placed cameras at active nests that were already being incubated (Snowy Plovers generally do not incubate until the clutch is complete). However, some cameras were placed on a nest before the clutch was completed to help identify the causes of early nest failures. Cameras were installed at all nests with exclosures. After cameras were installed, we ensured that plovers returned to the nest. Batteries and data cards were replaced approximately weekly. Cameras were typically left in place until the fate of the nest was determined, but on two nests cameras were removed before fate was determined due to battery related issues. Upon visiting failed nests, we recorded the cause of failure based on evidence at the site, before looking at camera data. We compare cause of failure based on evidence at the nest site with the cause of failure as recorded by the cameras.

Lethal predator management was conducted at all active nesting areas by USDA Wildlife Services (Flory *et al*., 2017). ORBIC monitors reported causes of nest failure and daily predator observations to Wildlife Services (WS) staff.

Results and Discussion

Window Surveys and Monitoring

During the May breeding window surveys, 282 plovers were observed in the project area, 93 fewer than in 2016 and the first decline in the survey since 2007-2008. Plovers were also detected during the window survey at locations north of the project area including Nehalem spit, Sitka Sedge State Natural Area, and at Bayocean Spit in Tillamook Co (OPRD pers. comm.). In addition, but outside of the window survey, at least eight banded and three unbanded plovers were found nesting between Sandpiper Village and Driftwood State Park, Lincoln Co. (unpubl. data, USFWS 2017). The annual breeding window survey count for the project area and total number of plovers present are in Table 1.

There were 61 fewer total plovers observed in 2017 compared to 2016; this is the first decline in plovers present since 2001-2002. Of the minimum number of plovers present during the 2017 breeding season, 408 (87%) were banded. The number of unbanded plovers estimated by the 10-day interval method was 60. During the breeding season we observed 210 banded males, 197 banded females, one unknown sex banded adult, 24 unbanded males, and 36 unbanded females.

Of the minimum number of plovers present in 2017, 363 plovers (78%) were documented nesting, equal to the mean percentage for 1993-2017 (78%). A minimum of 171 banded males and 132 banded females nested, and a minimum of 60 unbanded adults (24 unbanded males and 36 unbanded females) nested. Due to higher nest success in 2017, a higher percentage of adults were confirmed nesting compared to 2016 (61% of adults confirmed nesting). There were a total of 208 banded resident males and 190 banded resident females present during the 2017 breeding season (15 April – 15 July). Using the minimum number of unbanded individuals estimated by the 10-day interval method, the minimum estimated Oregon resident plover population was 458. We believe this is the best estimate of the breeding population within the project area.

The plovers within the project area exhibited the largest decline in population since 1997-1998 (ORBIC data). While this decline was substantial, the overall population of plovers in 2017 was still more than double the recovery goal set for the state (U.S. Fish and Wildlife Service 2007), and does not include birds that were present in Oregon outside the project area.

Overwinter Return Rate

Several factors likely contributed to the decline of the population in 2017. Studies have shown that adult survival is an important parameter of population growth (Sandercock 2003, USFWS 2007, Dinsmore *et al.* 2010, Lauten *et al.* 2010, 2011, 2012, and 2013). Of the 468 banded adult plovers recorded in 2016, a minimum of 312 were recorded in 2017 along the Oregon coast. The overwinter return rate based on the minimum number of returning banded adult plovers was 67%, nearly equal to the 1994-2017 mean of 66%, and slightly lower than in 2016 (69%) but well below the previous two years (80% in 2014 and 76% in 2015). Adult females had a substantially lower return rate than adult males. While the adult male return rate was 70% and above average, the adult female return rate was just 62%, well below the average. The low return rate particularly for adult females likely contributed to the decline in the adult population.

The number of fledglings produced in 2016 (Table 2, n = 200) was substantially lower than the previous two years, below half the population estimate, and the number of fledglings per male was well below the goal of 1.00 (Lauten *et al*., 2016, Table 10). Despite the lower productivity of 2016, 200 fledglings were produced and if those fledglings had an average hatch year return rate, we would have expected nearly 94 returning 2016 hatch year birds, larger than the overall decline in the population. Of the 200 fledglings produced in 2016 (Lauten *et al*., 2016), we observed 69 in the project area in 2017. The return rate was well below the 1992-2017 average (Table 2), the second consecutive year below average. The below average hatch year return likely contributed to the decline in the adult plover population in 2017, as fewer young birds returned to replace adults that did not survive overwinter. The lower population estimate in 2017 for the project area may also be a result of increased dispersal to locations outside the project area due to increased densities of plovers at the traditional nesting sites.

Of the returning HY16 birds, 29 (42%) were males and 39 (57%) were females (one HY16 was of unknown sex). Forty-four of the HY16 returning plovers were confirmed breeding (64%). The hatch year return rate does not include HY16 birds that survived the winter and went to sites outside of the project area. HY16 birds were documented using beaches in Lincoln and Tillamook County on the northern Oregon coast, in Washington (Cyndie Sundstrom, WDFW, pers. comm.) and in Humboldt Co., California (Elizabeth Feucht, pers. comm.).

During the 2017 season, we captured and rebanded eight male and four female adult plovers with brood band combinations that needed to be updated to unique adult combinations. We banded two unbanded adult male plovers, one unbanded adult female plover, and 468 chicks. Three additional chicks were banded at Sitka Sedge State Natural Area, Tillamook Co., which is not included in the project area.

Distribution

To show relative plover activity within our study area, we recorded banded and unbanded adults and the number of resident plovers at each site (Table 3). Nesting areas with low activity are at the northern and southern extreme of the study area (i.e., Sutton Beach and Floras Lake). In 2017, the population of plovers at Sutton Beach was similar to 2016, and Siltcoos had a slight decline in overall numbers (n = 8, Lauten *et al*. 2016). Floras Lake had five more plovers in 2017 compared to 2016. All other sites had fewer plovers in 2017 compared to 2016 (Lauten *et al*., 2016). There were nine fewer plovers at Tahkenitch, and more than 20 fewer plovers at Overlook, Tenmile, CBNS, Bandon SPMA and New River HRA. The highest concentration of nesting activity, based on the presence of resident plovers, was between Siltcoos and Bandon SPMA. Because plovers moved between sites and attempted to nest at more than one location, the total number of plovers in Table 3 is higher than the actual population estimate.

We documented plovers occupying available habitat adjacent to the traditional nesting areas in past reports (Lauten *et al.* 2010, 2011, 2012, 2013, 2014, 2015, and 2016). In 2017, plovers occupied sites both within and outside the project area that had limited or no known nesting activity in the past. For the second consecutive year, plovers nested at Nehalem Bay State Park and Sitka Sedge State Natural Area in Tillamook Co. (OPRD, unpublished data). Especially notable were five nests between Sandpiper Village and Driftwood State Park in Lincoln Co., a location that has not had documented plover activity and was not a beach identified for potential occupation by plovers (USFWS, unpublished data). Within the project area, four nests at Sutton Beach were found on the north side of Berry Creek (Figure 2). This area has not had known plover activity within the past 10 years. Plovers nested on the Sutton Creek spit for the second consecutive year (Figure 2). At North Siltcoos, one nest was found along the foredune north of the spit (Figure 3). Plovers continue to occupy all the beach between South Siltcoos and North Tahkenitch (Figures 3 - 5). In 2017 there were two known nesting attempts at South Tahkenitch. At North Tenmile plovers continue to occupy the beach from south of the third parking lot at South Umpqua to the spit; one nest in 2017 was north of the third parking lot, the first nest we have documented in this area (Figure 6). One nest was found in the Horsfall Beach area in 2017 (Figure 8), but was only briefly active. Four nests were found north of the FAA towers at CBNS (Figure 8). All nests at Bandon SPMA were within the defined SPMA boundaries except for one early season nest attempt on the China Creek spit (Figure 10). Plovers continue to occupy the beach adjacent to private lands from south of the Bandon SPMA to the New River HRA (Figures 11 & 12). The New River HRA continues to have few birds and nest attempts. In April we were unable to access the New River area due to high water blocking access to the site from all directions. However, the decline in nest attempts at New River is also related to fewer plovers occupying this site (Table 3). Plovers are spread throughout this large area and nested as far south as Clay Island breach (Figure 12) for the second consecutive year. At Floras Lake we documented three nest attempts, two more than 2016 (Lauten *et al*., 2016), including two along the foredune south of the Conservation Management Area (CMA) (Figure 13). We expect plovers to continue to utilize all available habitat within the project area, and continue to occupy sites along the northern coast because they had successful nests at these sites. We expect dispersing plovers to continue to occupy additional beaches outside the project area both to the north and south if plover populations remain at current levels.

Nest Activity

Table 4 shows the number of nests and broods located during the 2017 nesting season (Figures 2-13). We found 146 fewer nests than in 2016, however the number of nests found was the second highest since monitoring began in 1990. There were fewer nests in 2017 due to a smaller population size, but also due to higher nest success. Higher nest success results in fewer renest attempts. We used six exclosures in 2017 (Table 5). Four exclosures were used on Forest Service land: one at Sutton Beach was depredated by rodents (captured on camera), one at South Overlook that was successful, and two at North Tahkenitch that were successful (Table 5). Two exclosures were used at New River HRA; both were successful. Overall nest success in 2017 was just below average but considerably higher than 2016 (Table 5 and Table 6).

The first nests were initiated about 5 April (Figure 14), later than the previous three years (Lauten *et al*., 2014, 2015, and 2016). Nest initiation increased through mid-April when it declined. Nest initiation then increased throughout May until peaking (n = 175) during the 31 May – 9 June time interval, the same as 2016. The last nest initiation occurred on 1 August.

Nest Failure

Predators were responsible for 53% of nest failures (Table 7) compared to 76% of failures in 2016 (Lauten *et al*., 2016). In 2017 there were fewer corvid, harrier, gull and mammal depredations compared to 2016, and there were 174 fewer unknown depredations in 2017. The decline in depredations was partly a result of effective predator management (e.g., the removal of a Western Gull (*Larus occidentalis*) that was targeting plover nests at Bandon SPMA) and less pressure on plover nests from specific predators at various sites (e.g., no harrier depredations on U. S. Forest Service (USFS) lands, little to no raven activity at Tenmile and Bandon SPMA; see Flory *et al*., 2017 for information regarding predator management activities).

Corvids have traditionally been the most commonly identified nest predator on the study area (Stern *et al.* 1990 and 1991, Craig *et al.* 1992, Casler *et al.* 1993, Hallett *et al.* 1994, 1995, Estelle *et al.* 1997, Castelein *et al.* 1997, 1998, 2000a, 2000b, 2001, and 2002, and Lauten *et al.* 2003, 2005, 2006, 2006b, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, and 2015). In 2016, Northern Harriers (*Circus cyaneus*) were the most frequently identified nest predator (Lauten *et al*., 2016). In 2017 harriers were again the most frequently identified nest predator (Table 7), however all 48 known harrier depredations occurred at CBNS. Northern harriers were not positively identified depredating plover nests on USFS lands in 2017, the first time no harrier depredations were recorded at these sites since 2012. Harriers did not appear to be problematic at USFS sites, despite nesting within close proximity to nesting plovers at North Tahkenitch. Two harriers were removed from CBNS in 2017 (Flory *et al*., 2017), and afterward nest success improved, particularly on South Beach where many nests failed in 2016 due to harrier depredation. A third harrier was noted hunting the nesting area at CBNS, but we have no evidence that this harrier was targeting plover nests. In 2018 we anticipate using cameras and careful monitoring of plover nests to determine whether harriers are an ongoing problem at CBNS.

Corvids remain a commonly identified nest predator (Table 7), however there were 23 fewer depredations identified as corvid-caused in 2017 compared to 2016 (Lauten *et al*., 2016). In 2016 WS and ORBIC staff documented unusually large raven flocks (Lauten *et al*., 2016); in 2017 we did not document similar large flocks of ravens suggesting that there were fewer ravens present though ravens were problematic, particularly between Siltcoos and Tahkenitch. The number of nests depredated by corvids in 2017 was similar to 2016 at Siltcoos and Overlook (Lauten *et al*., 2016), but the number of corvid depredations at Tahkenitch was lower than in 2016. Corvid, especially raven, activity at Tenmile was very low all season. There were a high number of unidentified avian depredations on USFS lands. Despite the presence of harriers at these sites, monitors believe that most of these unidentified avian depredations were due to ravens, but because of poor weather and tracking conditions, positive identification of the predator was difficult. Ravens were present at CBNS early in the season but were effectively removed and did not cause any depredations after April. At Bandon SPMA, corvids were very scarce all season and no nests were documented depredated by corvids. The New River HRA continues to have raven-related issues due to its proximity to the adjacent sheep ranches. Raven numbers on the ranches are high and regardless of continued removal of ravens, spill over from the ranches is an ongoing problem.

In 2016 we documented a minimum of 20 nests depredated by gulls at Bandon SPMA and New River (Lauten *et al*., 2016). Cameras in 2016 confirmed a Western Gull was depredating plover nests, and we suspected just one individual was responsible. We also predicted that the problem may continue the following year due to the likely survival of the gull(s) involved (Lauten *et al*., 2016). In April and early May 2017 we again documented a gull depredating nests (on camera), including four nests at Bandon Beach and one nest at New River spit. WS agents set up a fake plover nest on the New River spit and quickly captured a Western Gull and removed the individual (Flory *et al*., 2017). No gull depredations occurred after this bird was removed, suggesting that one gull was responsible for the plover nest depredations over the past several years (Lauten *et al*., 2015 and 2016).

There were 12 fewer mammal depredation in 2017 (Table 7) compared to 2016 (Lauten *et al*., 2016). The decline in mammal depredations was due to fewer coyote depredations on USFS lands and fewer fox depredations at Bandon SPMA and the New River area. Coyotes tend to be opportunistic predators and have not traditionally targeted plover nests. It is possible that some depredations that were unknown were attributable to coyotes, but we had little indication that coyotes were problematic. At Bandon SPMA and New River, effective predator management kept fox depredations to a minimum. In 2017 only two nests failed to skunk (*Mephitis sp*.) depredations; our observations indicated that skunk activity was much lower in 2017 compared to 2016. One nest failed due to opossum (*Didelphis virginiana*), only the second nest we have ever documented depredated by this species. In past years we have documented evidence of rodents depredating plover nests (Lauten *et al*., 2009, 2010, 2011, and 2013); in 2017 for the first time we obtained photographic evidence of rodents depredating nests. At Sutton Beach and North Overlook cameras photographed deer mice (*Peromyscus sp*.) attacking plover nests and removing whole eggs from the nest bowl. At least three nests were documented failing due to rodent depredations (Table 7).

We continued to use cameras to document nest predators and assist in reducing the number of nest failures that have been ascribed to unknown depredation or unknown cause (Lauten *et al*., 2015). We placed Reconyx, Bushnell, or Spartan cameras at 81 nests in 2017. At 11 nests cameras failed to record the outcome of the nest due to battery or programming related issues. Thirty-six nests with cameras failed and the cameras clearly identified the cause of failure. At 17 of the failed nests, monitors' assessment of the cause of failure matched what was shown on the camera. At 19 of the failed nests, monitors were unable to identify the predator responsible for nest failure based on evidence left at the nest, but we were able to accurately identify the cause of failure based on camera data. Use of cameras did not negatively affect nest success. Apparent success at nests with cameras was 42%, identical to the overall nest success (Table 5), and to apparent success of nests without cameras. We intend to continue to use cameras where they are feasible, as time is available, and where better documentation of the cause of nest failure is needed.

As in previous years, most nests failures were attributed to unknown depredation and unknown cause (Table 7, 43% of the total failures). Nest depredations were classified as unknown because they had clearly been depredated, but the predator could not be identified. Of 28 failed nests with cameras classified as unknown by monitors in the field, cameras recorded raven (11), harrier (4), fox (2), and rodent (2) depredations; at the remaining nine failed nests, the cameras malfunctioned and the cause of failure was inconclusive. Four of the raven depredations occurred at CBNS in April when both ravens and harriers were depredating plover nests; all other raven depredations occurred on USFS lands. Over half of the nest failures attributed to unknown depredation and unknown cause (78 of 136) occurred between Siltcoos and Tahkenitch. The high number of unknown outcomes in this area was due to a combination of poor weather conditions resulting in a lack of evidence at the failed nests, and the variety of predators present in this area, making it difficult for monitors to narrow the possible cause. At CBNS, most of the unknown outcomes are likely attributable to either harriers or ravens, as most of the failures occurred early in the season when both species were present and the weather was poor resulting in inconclusive evidence as to which depredated the nests. At Bandon SPMA and the New River area, there were a larger variety of predators making it difficult to suggest whether any particular predator is responsible for these unknown outcomes.

We continue to minimize the use of exclosures for a variety of reasons including effective lethal predator management, efforts to minimize the impact of exclosures on adult survival, workload limitations, and a plover population well above recovery goals. In 2017 we used six exclosures. One exclosure was used at Sutton Beach. Monitors on USFS lands found evidence that rodents might be attracted to the newly erected exclosures, including photographic evidence from the exclosed Sutton Beach nest showing that the nest failed due to rodents. Three other exclosures were erected on USFS lands, one at South Siltcoos and two at North Overlook; all three successfully hatched. Two exclosures were used on the New River HRA. These exclosures were erected because of the persistent raven activity that was resulting in very poor nest success. Since these two nests were very isolated, far from any other nesting plovers, and in relatively open areas, we elected to exclose the nests. We believe it was likely that all these nests may have hatched without exclosure use as we saw no evidence that predators had visited the area of these nests during the incubation period. In addition, we saw no evidence that any predators were attracted to the exclosures. We will continue to have exclosures available if and when they are determined to be needed, but we will also minimize their use due to the overall success of the plovers under current management practices (see Appendix D for exclosure protocols).

Productivity

We sampled 200 broods from the 229 nests that were known to have hatched (87%), and these broods produced 254 fledglings (Table 8). We counted an additional 31 fledglings from broods that were not part of the sample. The overall minimum number of fledglings we recorded for all broods was 285 (Table 9). The overall fledging success based on the sample broods (Table 8) was higher than the post-predator management average (Table 10). The overall brood success rate of sampled broods (Table 8) was above the 1991 – 2017 average (67% +/- 10). We calculated the number of fledglings per male for each site using the number of resident males from Table 3 (Table 11). The mean number of fledglings per resident male for the project area was higher than in 2016 (Lauten *et al*., 2016) but below the mean post-predator management average (Table 10) and below recovery goals. We report these mean fledglings per male for all sites for comparison with previous years, but because the number of resident males reported by site double counts birds that occur at multiple sites, the resulting mean number of chicks fledged per resident male is biased low. In fact, the minimum number of fledglings counted in 2017 (n = 285) was higher than the total estimated number of resident male plovers (n = 232). We believe the most accurate estimate of productivity is the number of fledglings produced per sample brood; 1.27 (Table 8), which is similar to the total number of fledglings observed divided by the total number of resident males (285/232 = 1.23).

The number of fledglings per male is a very good indicator of plover productivity when the number of males can be accurately estimated. As the plover population has increased, it has become increasingly difficult to positively identify all nesting males, which can have a significant effect on the calculation if the number of males is under or over counted. An alternative measure of productivity is to calculate the number of fledglings produced per eggs laid, or a breeding coefficient. This index removes the uncertainty of counting males from the calculation, and uses the number of eggs laid which can be more accurately measured if most nests are being found by monitors. In addition, eggs laid is a measure of effort for any particular site; a site that had nine eggs laid (i.e., Floras Lake, Table 8) has much less effort than a site that had 355 eggs laid (CBNS, Table 8). Floras Lake produced 1.33 fledglings per male in 2017 (Table 11), and CBNS produced 1.11 fledglings per male in 2017 (Table 11), which indicates that both sites were relatively successful. However, the breeding coefficient for Floras Lake was 0.44, while the breeding coefficient for CBNS was 0.17, indicating that Floras Lake was much more successful for the effort than CBNS. Based on the calculations for the breeding coefficient, any site that produced a breeding coefficient of 0.20 and above was relatively successful for the amount of effort, while sites with a breeding coefficient below 0.15 are generally not very productive for the amount of effort. We used the breeding coefficient as an alternate assessment of the overall productivity of each nesting site (Table 8).

Sutton

For the second consecutive year, the number of nests at Sutton Beach (Table 4) was the highest ever recorded for this site. Only six of the nests hatched, but this was four more than in 2016 (Table 5, Lauten *et al*., 2016). All six hatched nests were used in the sample (Table 8); only one brood was successful and produced two fledglings resulting in poor productivity for this site. While the hatch rate at Sutton Beach improved in 2017 and was over the average (Figure 15), and the number of fledglings per male was above average (Figure 17), this site continues to have the lowest hatch rate, fledge rate, and fledglings per male of all sites (Figures 15 - 17, Table 11). The breeding coefficient for Sutton Beach was very low (Table 8), indicating this site was not productive for the number of nests that were attempted.

Siltcoos

Siltcoos had nearly the same number of nests in 2017 compared to 2016 (Table 4), however nest success was much higher (Table 5) than in 2016 (28%, Lauten *et al*., 2016). Both North and South Siltcoos had above average nest success in 2017 (Table 5, $\bar{x}$ = 39% for NSI, 46% for SSI).

The hatch rate at Siltcoos in 2017 was above the post-predator management average (Figure 15). There were 18 more broods at Siltcoos in 2017 compared to 2016 (Lauten *et al.* 20165) resulting in 13 more fledglings than in 2016 (Table 9). North Siltcoos produced 14 more fledglings in 2017 compared to 2016 while South Siltcoos produced four fewer. Fledging success was above the post-predator management average (Figure 16) and the number of fledglings per resident male was at recovery goals but below the post-predator management average (Figure 17, Table 11). The fledging success rate, fledglings per brood, and breeding coefficient for North Siltcoos all indicate that this site was very productive in 2017 (Table 8). South Siltcoos was not as productive as the north side despite more effort (Table 8); this was partly due to lower brood success compared to the north side. South Siltcoos still had a successful year by all other indices (Table 8).

Overlook

Overlook had similar numbers of nests in 2017 compared to 2016 (Table 4) and nest success was slightly lower (Table 5) but similar to 2016 (36%). North Overlook had poor nest success in 2017 (Table 5), well below the average for this site ($\bar{x}$ = 44%), while South Overlook had slightly above average nest success (Table 5, $\bar{x}$ = 39%).

The hatch rate at Overlook in 2017 was below the post-predator management average (Figure 15). Despite low nest success, the fledging success rate and fledglings per resident male were above the post-predator management averages (Figures 16 and 17, Table 11). Overlook produced nearly the same number of fledglings in 2017 compared to 2016 with South Overlook producing more in 2017, while North Overlook produced more fledglings in 2016 (Table 9). Although fledging success and fledglings per brood indicate good productivity at Overlook (Table 8), the breeding coefficient for North Overlook was poor indicating that there was relatively high plover use of this site but poor fledgling production. South Overlook was much more productive based on effort (Table 8).

Tahkenitch

There were 16 fewer nests at Tahkenitch in 2017 compared to 2016 (Table 4), and nest success was poor (Table 5) and well below average ($\bar{x}$ = 41%). There were two nest attempts at South Tahkenitch in 2017, and both failed. Including the discovery of six broods from unknown nests, the total number of broods from Tahkenitch in 2017 (n = 21) was similar to 2016 (n = 22).

The hatch rate at Tahkenitch in 2017 was well below the post-predator management average (Figure 15), but fledging success was above average the post-predator management average (Figure 16). While the number of fledglings per brood (Table 8) was high, the number of fledglings per resident male was below average (Figure 17). This is partly due to the high number of males detected during the resident period for this site, which is frequented by both birds from Siltcoos, Overlook, and Tenmile. The number of fledglings produced from this site was similar to 2016 (Table 9). There was relatively high effort and usage of the site, high brood success and fledging success (Table 8), but slightly poorer productivity for the effort from both the fledglings per resident male (Table 11) and the breeding coefficient (Table 8).

Tenmile

Tenmile had 29 fewer nests in 2017 compared to 2016 (Table 4); most of the decline in nests occurred at South Tenmile. The lower number of nests was partly due to an increase in overall nest success at Tenmile in 2017 (Table 5) compared to 2016 (39%, Lauten *et al*., 2016) resulting in fewer renest attempts. Overall nest success was the highest of any site in 2017 (Table 5), with North Tenmile well above average ($\bar{x}$ = 45%) and South Tenmile at the average ($\bar{x}$ = 51%). Despite the higher nest success, there were only five more hatched nests at Tenmile in 2017 (Table 5) compared to 2016 (n = 36, Lauten *et al*., 2016).

Tenmile was the most productive site on the Oregon coast in 2017 by all measures (Table 8). The hatch rate was considerably higher than post-predator management average (Figure 15), and nearly twice as high as in 2016 (36%, Lauten *et al*., 2016). The fledging success rate and number of fledglings per resident male were well above the post-predator management average for Tenmile (Figure 16 and 17) resulting in 23 more fledglings produced in 2017 compared to 2016 (Table 9). North Tenmile produced 41 fledglings, equal to all of Tenmile in 2016, and 27 more fledglings than in 2016. The number of fledglings produced from Tenmile was the highest ever for this site (Table 9). Tenmile had very high breeding coefficients (Table 8), indicating a very productive season.

Coos Bay North Spit

There were 49 fewer nests at CBNS in 2017 compared to 2016 (Table 4) partly due to a decrease in the number of plovers present (Table 3, Lauten *et al*., 2016) and partly due to an increase in overall nest success (Table 5; 19% in 2016, Lauten *et al*., 2016). Nest success early in the season, when the majority of nests were on South Spoil and the HRAs, was poor due to persistent harrier depredations (and some early raven depredations). Later in the season after two harriers were removed, nest success improved particularly on South Beach but also on South Spoil (Table 5). Nest success was well below average on South Spoil and the HRAs (Table 5, $\bar{x}$ = 61% and 50%, respectively), but above average on South Beach (Table 5, $\bar{x}$ = 61%). There were 21 more hatched nests in 2017 compared to 2016 (Table 5, Lauten *et al*., 2016).

While the hatch rate improved in 2017 compared to 2016 (20%), it was still below the post-predator management average (Figure 15). Brood success, fledgling success, and fledglings per brood were very good for South Beach (Table 8), but South Spoil and in particular the HRAs were less productive. Observations and data suggest that the harriers that were depredating nests may also have had negative impacts on broods that originated from the HRAs and South Spoil, causing lower productivity from these areas. It is difficult to document evidence of harriers depredating plover chicks, however 18 total broods hatched on the HRAs and South Spoil prior to 20 June, the period of highest harrier activity. Of the 18 broods, we were able to determine the outcome of 13; three were successful (23%) and produced four fledglings. One male harrier was removed on 13 June and one female harrier was removed 12 July. After the harriers were removed many of the plovers renested on South Beach. Broods from South Beach were extremely productive with a breeding coefficient of 0.42 (Table 8). We counted 57 fledglings from broods we either sampled or closely monitored, plus an additional estimate of nine fledglings from broods we did not sample (Table 9); this is double the number of fledglings produced in 2016. The overall fledging success rate was equal to the post-predator management average (Figure 16). The number of fledglings per resident male was below the post-predator management average (Figure 17, Table 11), but above recovery goals. The breeding coefficient for South Beach indicates high productivity, producing many fledglings per egg laid, while the nesting areas had high number of eggs laid but very few fledglings produced, indicating very poor productivity from these sites (Table 8). The high productivity of South Beach offset the poor productivity of the nesting areas, resulting in sustainable overall productivity.

Bandon SPMA

There were 49 fewer nests at Bandon SPMA in 2017 compared to 2016 (Table 4). It is likely that we did not find all the nests on the New River spit side due to high water and limited access in April, however there were fewer plovers at Bandon SPMA in 2017 compared to 2016 (ca. 25 fewer resident plovers, Table 3, Lauten *et al*., 2016). In addition, high nest success (Table 5), particularly at Bandon Beach (66%), and high brood success at Bandon Beach, resulted in fewer renest attempts. Overall nest success was above the average (Table 5; $\bar{x}$ = 41%). Early in the season a gull and fox were removed from Bandon SPMA, and corvid activity was very low all season, resulting in very good nest success for this area.

Despite 100 fewer eggs laid at Bandon SPMA in 2017 compared to 2016, 47 more chicks hatched in 2017. The overall hatch rate was above the post-predator management average (Figure 15). Bandon Beach was extremely productive, with 21 broods producing 28 fledglings (Table 9). However, the 23 broods on the New River side only produced eight fledglings (Table 9). The poor productivity of the New River side resulted in overall fledging success and fledglings per resident male for Bandon SPMA equal to the post-predator management averages (Figure 16 and 17, Table 11). The Bandon Beach side of Bandon SPMA was extremely productive in 2017 (the breeding coefficient for this side was 0.31), however due to the very poor productivity of the New River side, the overall breeding coefficient for this site was not very high (Table 8).

New River

New River continues to decline in both numbers of plovers using the area and number of nests particularly on the New River HRA (Table 4). Due to high water and access issues in April, we likely did not find every nest, however, there were only half the number of plovers using this site in 2017 compared to 2016 (Table 3, Lauten *et al*., 2016). There are likely two causes for this decline; first, older established adults did not return and were not replaced by juveniles. Second, plovers tended to concentrate at Bandon SPMA, possibly to avoid predation pressure at New River. Predation pressure is high at New River, particularly by ravens, due to the proximity of sheep ranches. Nest success was very poor on both the HRA and private lands (Table 5), nearly the same as in 2016 (Lauten *et al*. 2016), and well below average ($\bar{x}$ = 52%) due to persistent predation pressure, particularly from ravens. Due to the predation pressure, we erected two exclosures and monitored them with cameras. Both exclosed nests hatched.

The hatch rate at New River was similar to 2016, (Lauten *et al.*, 2016) and well below the post-predator management average (Figure 15). The few broods that did hatch were productive (Table 8) with average fledging success rate (Figure 16). There were a relatively high number of male plovers moving thru the area during the resident period, that were thus counted as resident, contributing to the very low, and below average number of fledglings per resident male (Table 11, Figure 17). Due to the low nest success the breeding coefficients for the HRA and private lands were poor (Table 8).

Floras Lake

There were three nests at Floras Lake in 2017 (Table 4), two more than 2016, and two successfully hatched (Table 8). Both broods fledged two chicks each, resulting in the highest number of fledglings for this site since 1997. The overall productivity of this site was excellent (Table 8). The low density of plovers at this site likely contributed to the success of these two broods, as they drew little attention from predators. Due to the sparse data from this site, there is no summary of productivity data.

Summary

Overall productivity for 2017 was very good with 42% nest success (Table 5), 285 fledglings produced (Table 9) from approximately 232 resident males, 50% fledgling success (Table 10), 1.27 fledglings per sample brood (Table 8), and an overall breeding coefficient of 0.22+/-0.04. While the number of fledglings per resident male was just below recovery goals (Table 11), this number is likely biased low due to double counting of resident males per site. Predation pressure on the plovers was not as high as in 2016, and changes annually from site to site. Maintaining good productivity at most sites each year compensates for sites that may be receiving high predation pressure and thus are not as productive. Maintaining overall average nest success of 40%, fledging success of 40%, fledgling per male at approximately 1.00, and a 0.20 breeding coefficient should result in a stable to growing Oregon coast population.

Productivity Before and After Lethal Predator Management

Data from Floras Lake and Sutton Beach are very sparse and not normally distributed. We did not include data from Floras Lake in the graphs of productivity analysis, and data from Sutton Beach is displayed solely for the purposes of 2017 comparisons.

The 2017 overall nest success was slightly above the ten year (2008 – 2017) average of 39.6% +/- 11.5, within the mean observed and calculated success rates reported by Page et al. (2009) from multiple studies. During this time period exclosure use has declined from a maximum of 67 in 2010 but the number of eggs hatched and chicks fledged has substantially increased (Figure 18). Nest success of unexclosed nests during this same time period has averaged 36.4%+/-13.4, just below the overall average of this period. Post-predator management fledging success rates have improved at all sites except at Tahkenitch and Tenmile where they have remained relatively stable but above 40% (Figure 16). The post-predator management mean brood success rate for all sites (2004-2017; $\bar{x} =$ 72.5%+/-7.9) was higher than the pre-predator management brood success rate (1991-2001; $\bar{x} =$ 62.9%+/-8.5). The post-predator management number of fledglings per male has improved at all sites except Tenmile where it has remained relatively stable and above 1.20 (Figure 17). The overall productivity has increased in the post-predator management time period resulting in a substantial increase in the number of fledglings and the overall population of plovers on the Oregon coast.

Brood Activity

Sutton, Siltcoos, Overlook, and Tahkenitch

There was only one successful brood at Sutton Beach in 2017 that hatched on the Sutton Creek spit and remained at the south end of the beach until fledging. Five other broods originated on the HRA and all failed within about a week of hatching.

Twelve of thirteen broods at North Siltcoos in 2017 were successful. Eleven of the broods originated from the spit and one brood originated from the beach north of the spit. All broods used the spit until they successfully fledged. Thirteen of 15 broods from South Siltcoos originated on the spit and HRA. Three of these broods moved south of Waxmyrtle trail and utilized the beach, while the remainder remained on the spit area. Two other broods originated from nests south of Waxmyrtle trail and remained along the beach.

There were 14 total broods from the North Overlook area. Two originated from south of Carter Lake trail, and three others originated from the beach just north of the HRA. The remainder originated from the HRA. There was brood activity along the beach from Carter Lake south, and all broods remained either on the beach or the adjacent HRA. No broods were known to have moved south to South Overlook. There were 21 broods from South Overlook that originated on the HRA or the adjacent beach. All broods used the HRA or the beach adjacent to the HRA and south of the HRA. One brood wandered south to North Tahkenitch where it fledged

There were 21 broods at North Tahkenitch in 2017; one originated from the beach north of the spit and the remainder originated from the spit. All brood activity was on the HRA and adjacent beach. There was no known brood movements to the north or south of the spit.

Tenmile

At North Tenmile in 2017, 12 broods originated from nests on the beach from south of the third parking lot at South Umpqua to the north spit. The remainder originated from the HRA and large open spit. Due to very good nest, brood, and fledging success at North Tenmile in 2017, there were active broods during most of the season along the entire length of beach and spit, with a concentration from south of the third parking lot and in the area around the John Dellenbach trail, particularly to the south of the trail. There was also high activity north of the HRA and on the spit. All 12 broods from South Tenmile originated on the HRA and brood activity was concentrated on the HRA, spit, and adjacent beach. One brood was noted on the beach south of the HRA, but no broods wandered as far south as the I-beam at the south end of the beach.

Coos Bay North Spit

Lauten *et al*. (2015) showed that fledgling productivity at CBNS tends to decline the further east a brood originates. This may be due to food resources, as the wrack line likely provides the most abundant resources. Harrier activity on the nesting area was very high in 2016 (Lauten *et al*., 2016) and 2017, and likely had a negative impact on broods that originated on the nesting area as noted above. Gaps created and maintained in the foredune facilitating brood movement west to the beach likely resulted in positive impacts on brood survival.

In 2017 we documented at least one brood that exited the north gate and headed north on the foredune road for about one mile. This brood was discovered by a WS agent; we later walked the brood safely back onto the nesting area. There were four nests south of the I-beam near the north jetty; two hatched, producing four chicks. Despite heavy vehicle and recreational activity near the jetty, the southwest most brood fledged three chicks. We repeatedly saw the brood in the tire tracks near the jetty area. We noted several other broods from the south end of the South Beach using the foredune south of the I-beam, the parking area and adjacent dunes, jetty, and beach area. Broods tracks were noted on the foredune road by the jetty area, but we did not see any evidence that they traveled north toward the bay. At the north end of the beach, two nests were near the FAA towers, one just south of the I-beam and one slightly further north. Both broods moved into the closed area after hatching. Two more broods hatched from three nests further north and just south of Access 2. One brood remained in and near the roped area for these nests and fledged before moving south. The second brood moved south into the closed area and fledged. There was no known brood activity north of Access 1.

Bandon SPMA

As noted above, the Bandon Beach side was very productive in 2017. In early July, 12 broods were active simultaneously, with broods from along the foredune south of the I-beam to the river mouth. The distance from China Creek to the mouth of New River was about 1.9 km, resulting in a high density of active broods on this beach. Broods will wander north and south, however at Bandon SPMA there was a tendency for broods to remain in the general vicinity of their nesting area. No broods wandered north of the I-beam or spent any significant time on the China Creek spit.

The New River spit side of the Bandon SPMA was much less productive. Despite good nest success, only five of 23 broods successfully fledged. From 29 June to 29 July, 19 nests hatched, but only three (16%) produced fledglings. During this time period, there was little evidence of diurnal predators such as ravens, gulls, or harriers, nor was there any evidence of fox, skunks, or raccoons. We did repeatedly record Great Horned Owl (*Bubo virginianus*) tracks in this area, including a depredation of a Common Murre (*Uria aalge*), and owl tracks between gaps in the foredune that indicated pouncing and chasing behavior. Some of these owl tracks in overwash areas were amongst plover brood tracks. The last three broods on the Bandon Beach side also failed within a three-day period late in the summer. The extremely poor productivity of broods on the spit, and the synchronous disappearance of about 15 broods in July, was unexpected, and strongly suggests predator activity, especially since this area has very low recreational impacts. Our observations of predator activity along with WS agent's observations potentially point toward Great Horn Owl activity. Owls have been documented using this area in past years (see Lauten *et al*., 2015 and 2016). Survey data indicates that most of the males to these failed broods survived.

New River

Two broods originated on private land in 2017, in addition to one brood from an unknown nest that was discovered on private lands. One brood originated on Bandon Biota property just south of the Bandon SPMA and spent the brood period between Bandon Biota property and the BLM New River HRA. A second brood hatched along the foredune south of Bandon Biota but did not successfully fledge. The brood from the undiscovered nest was found on the beach adjacent to Bandon Biota lands and moved south, spending the brood period along the beach adjacent to private land.   Two other broods that hatched on state lands on the New River spit spent the brood period along the beach adjacent to private lands.

There were only three broods that originated from the New River HRA in 2017; two successfully fledged. One brood hatched from an exclosed nest south of New Lake breach and moved south using the beach adjacent to the camping site and the Clay Island breach area. A second brood hatched from an exclosed nest on Clay Island breach and remained on Clay Island breach until it fledged.   A third nest hatched on the beach just north of Clay Island breach but failed soon after hatching. There was no brood activity on the north end of the HRA south to New Lake breach.

Floras Lake

There were two broods from nests along the beach just south of the CMA at Floras Lake in 2017. One brood spent the brood period along the foredune within the vicinity of the nest until it successfully fledged.   The second brood slowly wandered north to the CMA, and continued north, where it fledged on the beach adjacent to McKenzie's ranch.

Immigrant Plovers

Thirty-three adult plovers banded in California and one adult plover banded in Washington were observed in Oregon in 2017. Eighteen were females and 15 were males. Fourteen females were resident plovers and four were present either early in the season or late in the season and were likely either wintering or visiting plovers. Fourteen males were resident plovers and one male was present briefly at the end of the season.

Of the 32 plovers banded in California, six females and nine males originally hatched in Oregon and were subsequently rebanded at coastal nest sites in California. All other plovers were originally banded in California. The one Washington banded plover was a female originally banded in WA in 2013 and has been present in Oregon since 2014.

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Table 1. Minimum window survey counts and the minimum number of Snowy Plover present on the Oregon Coast, 2006-2017.

YEAR	WINDOW SURVEY	# SNPL PRESENT
2006	91	177
2007	125	181
2008	98	188
2009	136	199
2010	158	232
2011	168	247
2012	206	293
2013	215	304
2014	228	338
2015	277	458
2016	375	529
2017	282	468

Table 2. Number of Snowy Plover fledglings, number of previous year fledglings returning, return rate, number nesting, and percent nesting in first year of return along the Oregon coast, 1992 – 2017.

Year	# of fledglings from previous year	# of HY birds from previous year sighted on OR coast	Return Rate (#HY/#Fled)
2017	200 [a]	69	35%
2016	339	135	40%
2015	276	146	54%
2014	104	54	52%
2013	180	91	51%
2012	172	92	51%
2011	84	53	63%
2010	107	54	50%
2009	73	35	48%
2008	124	52	42%
2007	110	32	29%
2006	78	29	37%
2005	108	43	40%
2004	60	26	43%
2003	31	14	45%
2002	32	18	56%
2001	43	23	53%
2000	53	31	58%
1999	32	18	56%
1998	41	14	34%
1997	47	30	64%
1996	57	18	32%
1995	56	37	66%
1994	36	16	44%
1993	33	10	30%
1992	16	6*	38%
Average return rate			47%
Standard deviation			11%

*- minimum number sighted

[a] – adjusted from 197 to 200 based on hatch year returns

Table 3. Plover activity based on the number of adult plovers at each nesting area on the Oregon Coast, 2017. Plovers move between nesting areas throughout the summer, therefore this is not a tally of the total number of plovers present.

	Females				Males					
	Banded		Unbanded		Banded		Unbanded		Total	
Site	# banded	# residents	# unbanded	# residents	# banded	# residents	# unbanded	# residents	# plovers	# residents
Sutton	8	7	3	3	6	6	4	4	21	20
Siltcoos	44	33	5	5	32	22	10	10	91	70
Overlook	51	45	8	8	46	42	3	3	108	98
Tahkenitch	38	29	5	5	33	29	5	5	81	69
Tenmile	44	35	5	5	39	37	6	6	94	83
CBNS	44	43	15	15	52	51	15	15	126	124
Bandon SPMA	48	37	6	6	44	43	3	3	101	89
New River HRA	15	13	3	3	15	15	1	1	34	32
Floras Lake	3	3	1	1	2	2	1	1	7	7

Table 4. Number of nests for selected sites on the Oregon Coast 2007 – 2017 cells tally nests only and not broods from undiscovered nests. The number of broods from undiscovered nests is totaled for each year only.

Site Name	07	08	09	10	11	12	13	14	15	16	17
SU	3	0	0	1	0	0	1	2	8	19	21
SI:											
North	15	30	14	17	13	10	13	6	8	15	25
South	13	6	9	24	21	22	30	18	23	42	31
OV:											
North	13	14	9	21	29	28	33	35	46	48	61
South	3	1	5	16	28	31	28	23	42	56	47
TA											
North	10	5	6	7	23	36	52	32	61	74	56
South	0	0					6	4	2	0	2
TM:											
North	20	12	13	13	15	17	19	26	29	34	40
South	21	16	41	30	35	29	17	21	32	59	24
Horsefall										1	1
CBNS:											
SB	8	5	19	17	16	7	36	20	41	48	33
SS	12	18	16	14	15	15	12	13	20	38	27
HRAs	19	26	30	33	26	39	58	43	66	97	74
BSPMA											
BB	30	28	31	26	28	48	44	28	40	57	32
NR spit	16	6	10	12	9	12	20	54	48	73	49
NR HRA	14	27	27	27	29	17	9	15	27	14	11
NR other	5	2	3	3	2	1	3	4	8	18	11
FL	0	0	3	0	0	2	0	2	0	1	3
Tot nst	**202**	**196**	**236**	**261**	**289**	**314**	**381**	**346**	**501**	**694**	**548**
Tot brd[a]	**4**	**3**	**8**	**2**	**4**	**11**	**8**	**12**	**32**	**19**	**9**

[a] – broods from undiscovered nests only; these broods are not tallied in the total number of nests

SU – Sutton, SI – Siltcoos, OV – Overlook, TA – Tahkenitch, TM – Tenmile, CBNS – Coos Bay North Spit (SB - South Beach, SS – South Spoil, BSPMA – Bandon Snowy Plover Management Area (BB - Bandon Beach, NR spit - New River spit), NR HRA – New River HRA, NR other - private and other owned lands, FL – Floras Lake

Table 5. Apparent nest success of Snowy Plovers on the Oregon Coast, 2017.

		Nests Exclosed			Nests Not Exclosed			Exclosed Nests	Nests Not Exclosed	
Site	**Total #**	**Hatch**	**Fail**	**Unknown**	**Hatch**	**Fail**	**Unknown**	**App Nest Success**	**App Nest Success**	**Overall Nest Success**
Sutton	21	0	1		6	13	1	0%	30%	29%
Siltcoos										
North	25	-	-		13	12		-	52%	
South	31	1	0		13	17		100%	43%	48%
Combined	56	1	0		26	29		100%	47%	
Overlook										
North	61	-	-		14	47		-	23%	
South	47	-	-		21	26		-	45%	32%
Combined	108				35	73			32%	
Tahkenitch										
North	56	2	0		13	41		100%	24%	
South	2	-	-		0	2		-	0%	26%
Combined	58	2	0		13	43		100%	23%	
Tenmile										
North	40	-	-		29	10	1	-	73%	
South	24	-	-		12	12		-	50%	64%
Combined	64				41	22	1		64%	
Horsfall Beach	1	-	-		0	1		-	0%	0%
CBNS										
South Beach	33	-	-		23	10		-	70%	
South Spoil	27	-	-		12	15		-	44%	
HRAs	74	-	-		21	53		-	28%	42%
Combined	134				56	78			42%	
Bandon SPMA	81	-	-		42	38	1	-	52%	52%
New River										
HRA	11	2	0		1	8		100%	13%	23%
Other Lands	11	-	-		2	9		-	22%	
Floras Lake	3	-	-		2	1		-	67%	67%
Totals	548	5	1	0	224	315	3	89%	42%	42%

Table 6. Apparent nest success of exclosed and unexclosed Snowy Plover nests on the Oregon coast, 1990 - 2017.

Year	All nests (%)	Exclosed (%)	Not Exclosed (%)
1990	31	*	28
1991	33	75	9
1992	67	85	11
1993	68	83	27
1994	75	80	71
1995	50	65	5
1996	56	71	10
1997	48	58	14
1998	56	72	8
1999	56	64	0
2000	38	48	0
2001	35	68	0
2002	44	66	6
2003	51	77	9
2004	62	85	8
2005	48	72	14
2006	47	66	32
2007	42	71	35
2008	34	49	30
2009	33	76	25
2010	35	72	23
2011	50	71	48
2012	45	86	42
2013	24	83	21
2014	60	50	60
2015	48	50	48
2016	25		25
2017	42	89	42
Average	**46.53571**	**70.46154**	**23.25**
STDEV	**12.98855**	**11.98409**	**18.74512**

Table 7. Causes of Snowy Plover nest failure at survey sites along the Oregon coast, 2017.

Site Name	Tot Nsts	# Fail	Depredations					Other						
			Corvid	**Unk**	**Mammal**	**Harrier**	**Avian**	**Wind**	**Human**	**Over-wash**	**Abandon**	**One Egg Nest**	**Infer**	**Unk cause**
Sutton	21	14		1	2[a]		1[b]					2	1	7
Siltcoos:														
North	25	12	1	3	2[c]		1[b]				1		1	3
South	31	17	7	1	1[d]		2[e]	1			2			3
Overlook														
North	61	47	2	8	4[f]		2[e]	6			2	4		19
South	47	26	2	4			4[g]	2			1	1	1	11
Tahkenitch														
North	56	41	8	5			3[g]	1		2	1	1		20
South	2	2								1				1
Tenmile:														
North	40	10	1	2				1				1		5
South	24	12	1	5							2	2	1	1
Horsfall Bch	1	1												1
Coos Bay North Spit:														
South Beach	33	10	1							2	1	1	1	4
South Spoil	27	15				14					1			
HRAs	74	53	4	8	1[a]	34	2[e]					4		
Bandon SPMA	81	38		7	5[h]		5[i]	3	1		3	4		10
New River														
HRA	11	8	6	2										
Other lands	11	9	2	3	1[j]								1	2
Floras Lake	3	1			1[k]									
TOTALS	**548**	**316**	35	49	17	48	20	14	1	5	14	20	6	87

[a] – 1 coyote depredation, 1 rodent depredation
[b] – 1 unknown avian depredation
[c] - 2 coyote depredations
[d] – 1 opossum depredation
[e] – 2 unknown avian depredations
[f] – 2 coyote depredations, 2 rodent depredation
[g] – 3 unknown avian depredations
[h] – 5 fox depredations
[i] – 5 gull depredations
[j] – 1 skunk depredation
[k] – 1 skunk depredation

Table 8. Number of broods sampled, brood success, fledging success, and breeding coefficient based on sample along the Oregon coast, 2017. Breeding coefficient is the number of chicks fledged divided by the number of eggs laid.

Site Name	# of broods in sample	% brood success	# of eggs hatched in sample	# of fledglings from sample	% fledging success	fledglings per sampled brood	breeding coefficient
Sutton Beach	6	17%	18	2	11%	0.33	2/54=0.04
Siltcoos:							
North Siltcoos	11	90%	25	15	60%	1.36	17/58=0.29
South Siltcoos	15	64%	38	16	42%	1.06	16/86=0.19
Overlook							
North Overlook	12	75%	28	17	61%	1.41	17/149=0.11
South Overlook	18	89%	47	26	55%	1.44	29/121=0.24
Tahkenitch							
North Tahkenitch	18	83%	47	25	53%	1.39	27/147=0.18
South Tahkenitch	-						
Tenmile:							
North Tenmile	20	100%	45	32	71%	1.60	41/108=0.38
South Tenmile	12	100%	34	23	68%	1.92	23/61=0.38
Coos Bay N. Spit							
South Beach	20	95%	50	35	70%	1.75	37/89=0.42
South Spoil	10	70%	23	10	43%	1.00	10/71=0.14
HRA	12	58%	31	10	32%	0.83	19/195=0.10
Bandon SPMA	38	47%	97	32	33%	0.84	36/222=0.16
New River							
HRA	3	67%	8	3	38%	1.00	3/28=0.11
Other lands	3	67%	8	4	50%	1.33	4/32=0.13
Floras Lake	2	100%	6	4	67%	2.00	4/9=0.44
Total	**200**	**75%**	**504**	**254**	**50%**	**1.27**	

Table 9. Total number of young fledged from select sites on the Oregon Coast 2000-2017, includes fledglings from broods from undiscovered nests.

Site Name	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
SU	0	0	0	0	0	0	0	0						1	3	2	2
SI:																	
North	0	0	0	7	2	11	7	5	8	4	4	1	2	0	4	3	17
South	0	0	2	5	7	7	4	3	11	4	8	16	4	9	25	20	16
OV:																	
North	1	2	3	3	5	8	12	3	7	12	27	22	3	18	26	33	17
South	1	0	0	3	2	0	1	0	2	7	23	27	0	25	39	16	29
TA:																	
North	4	1	3	6	8	5	2	0	1	3	20	26	9	25	49	28	27
South	4	5	2	0	0	0	0	0					3	0	0		0
TM:																	
North	0	3	1	3	6	12	13	3	2	3	1	5	15	35	26	14	41
South	4	3	9	9	5	7	14	6	19	13	5	5	8	27	21	27	23
CBNS:																	
SS	4	2	7	13	9	11	7	17	4	2	6	10	2	14	13	9	10
SB	1	1	3	0	8	1	10	7	17	13	22	16	18	28	24	12	37
HRAs	6	8	14	22	6	19	9	16	10	5	28	34	3	49	46	12	10
CBNS															51		9
BSPMA																	
BB	1	0	4	16	11	12	13	2	6	6	16	11	8	12	12	8	28
NR spit	0	0	1	10	0	3	12	2	1	0	5	1	14	22	19	6	8
NR HRA	3	3	7	5	1	7	16	7	17	12	7	4	12	3	10	4	3
NR other	3	3	4	6	8	7	4	2	2	0	0	0	3	6	2	5	4
FL	0	0	0	0	0	0	0	0	0	0	0	2		2	0	1	4
Total	**32**	**31**	**60**	**108**	**78**	**110**	**124**	**73**	**107**	**84**	**172**	**180**	**104**	**276**	**370**	**200** [a]	**285**

[a] – adjusted from 197 based on hatch year returns

SU – Sutton, SI – Siltcoos, OV – Overlook, TA – Tahkenitch, TM – Tenmile, CBNS – Coos Bay North Spit (SB - South Beach, SS – South Spoil, BSPMA – Bandon Snowy Plover Management Area (BB - Bandon Beach, NR spit - New River spit), NR HRA – New River HRA, NR other - private and other owned lands, FL – Floras Lake

Table 10. Fledging success and mean number of fledglings/male (+/- standard deviation) on the Oregon Coast, 2005 – 2017.

Year	% Fledging Success	Mean # Fled/Male
2004	55	1.73
2005	41	1.28
2006	48	1.56
2007	54	1.60
2008	47	1.13
2009	50	1.33
2010	35	0.97
2011	47	1.61
2012	44	1.41
2013	39	1.04
2014	48	1.68
2015	49	1.51
2016	43	0.60*
2017	50	0.88*
’04-’17 mean	46.4 +/- 5.6	1.31 +/- 0.34

*Because of sampling methods instituted in 2016, the mean number of fledglings per male pre- and post-2016 are not directly comparable. Prior to 2016 the mean number of fpm is based on the total number of males documented breeding. In 2016 and after, fpm is estimated for each site based on the sample fledglings and the number of resident males at each site. See Appendix C for further details.

Table 11. Number of resident males, estimated number of fledglings, and number of fledglings per male on the Oregon Coast, 2017. Plovers move between nesting areas throughout the summer, therefore the number of resident males is not a tally of the total number of plovers present.

Site Name	# of resident males	estimated # of fledglings	estimated # of fledglings/male
Sutton Beach	10	2	0.20
Siltcoos Spits	32	33	1.03
Dunes Overlook	45	50	1.11
Tahkenitch Creek	34	29	0.85
Tenmile Creek	43	70	1.63
Coos Bay North Spit	66	73	1.11
Bandon SPMA	46	37	0.80
New River			
HRA	9	3	0.33
Other lands	9	4	0.44
Floras Lake	3	4	1.33
Overall			$\bar{x}$ = 0.88 +/-0.45

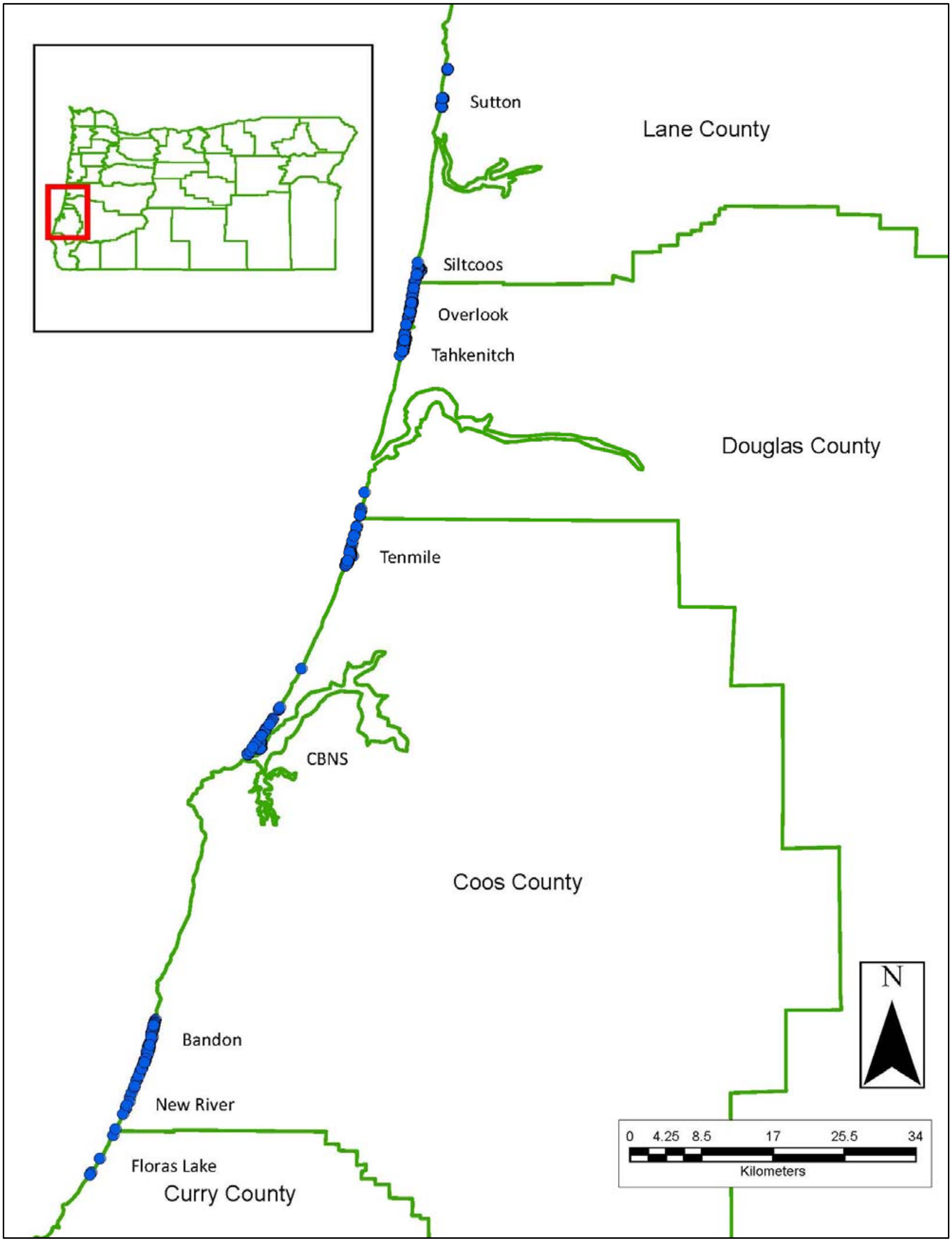


Figure 1. Snowy Plover monitoring locations along the Oregon coast, 2017.

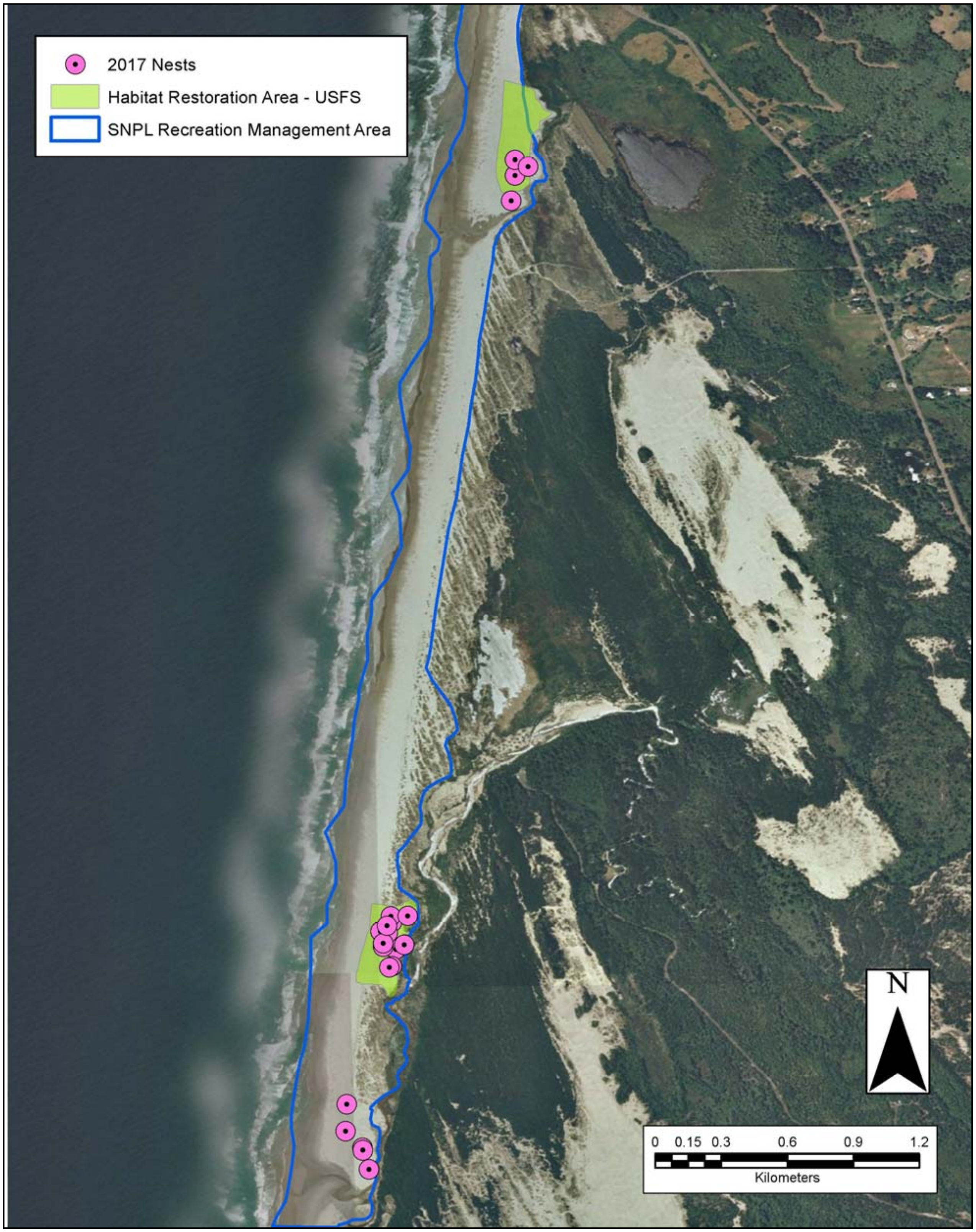


Figure 2. Snowy Plover nest locations at Sutton/Baker Beach, Oregon, 2017.

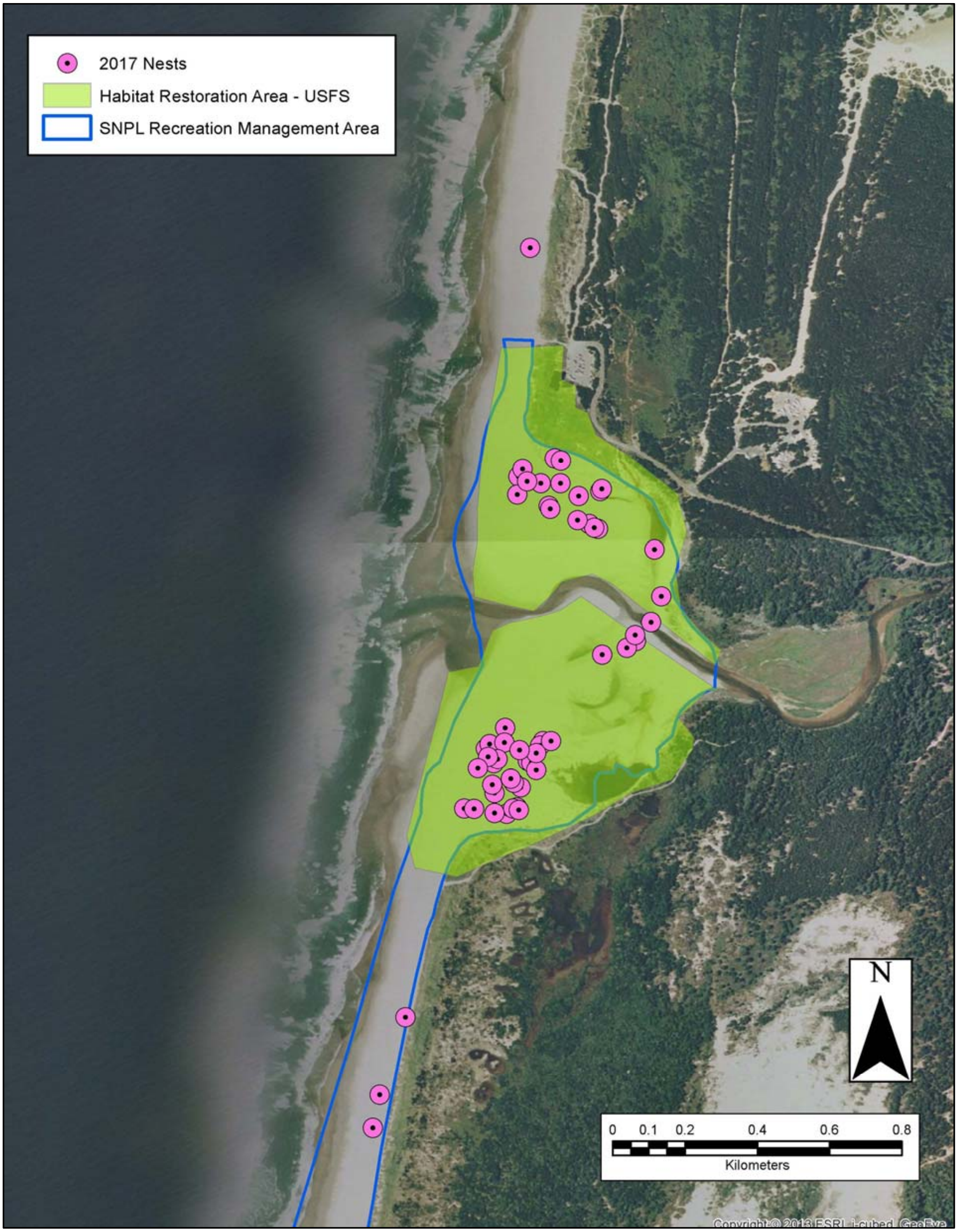


Figure 3. Snowy Plover nest locations at Siltcoos Estuary, Oregon, 2017.

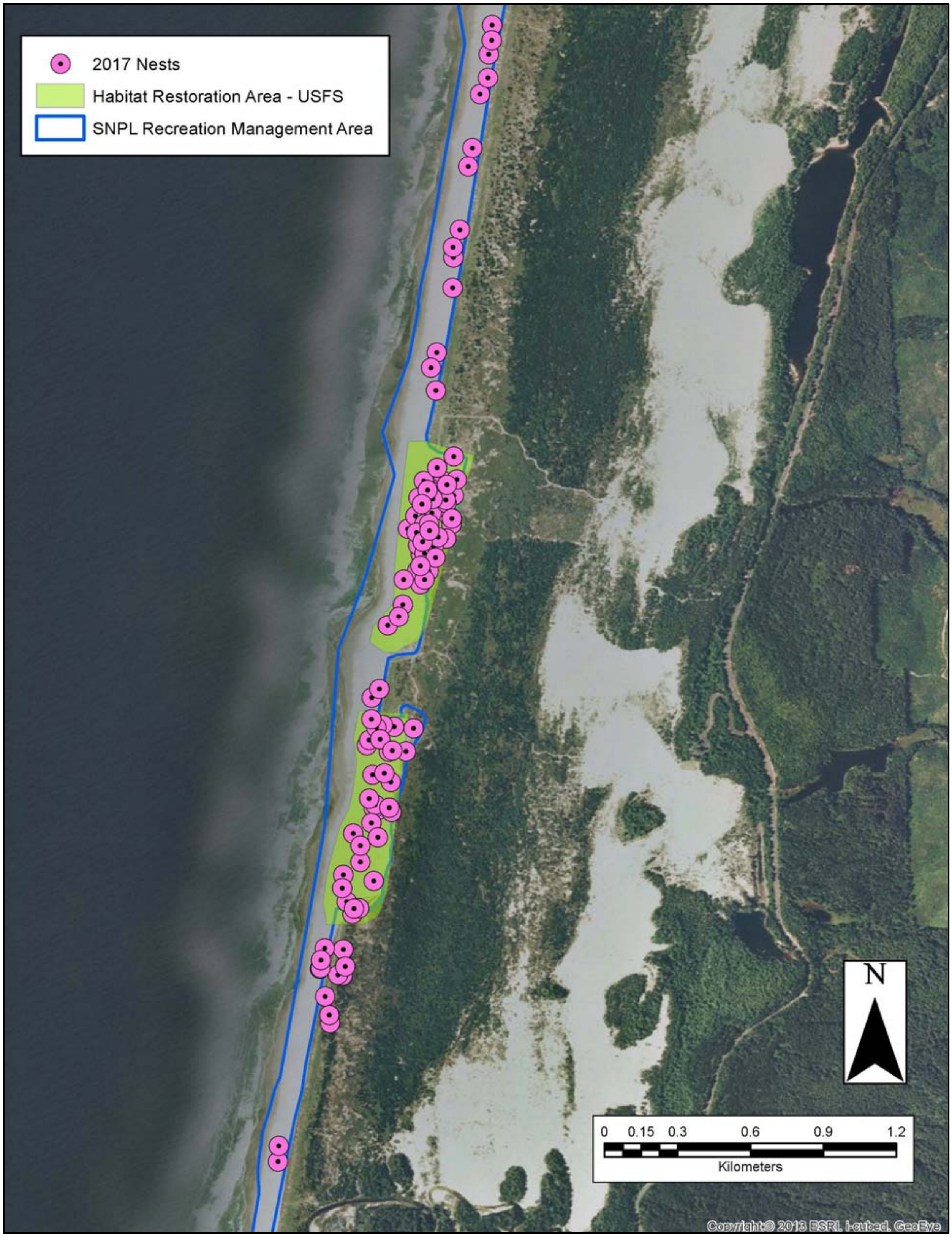


Figure 4. Snowy Plover nest locations at Dunes Overlook, Oregon, 2017.

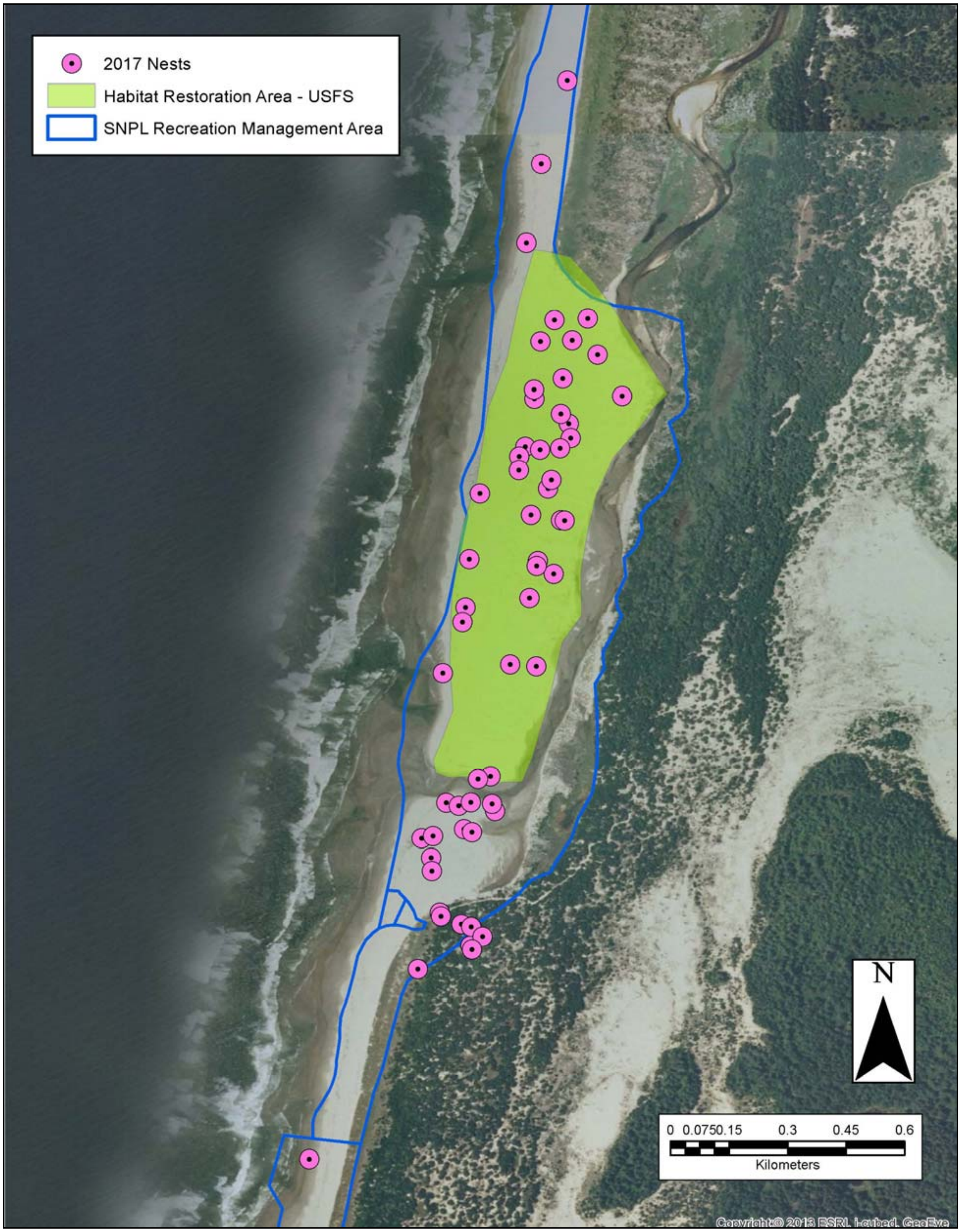


Figure 5. Snowy Plover nest locations at Tahkenitch Creek, Oregon, 2017.

Figure 6. Snowy Plover nest locations at North Tenmile Creek, Oregon, 2017.

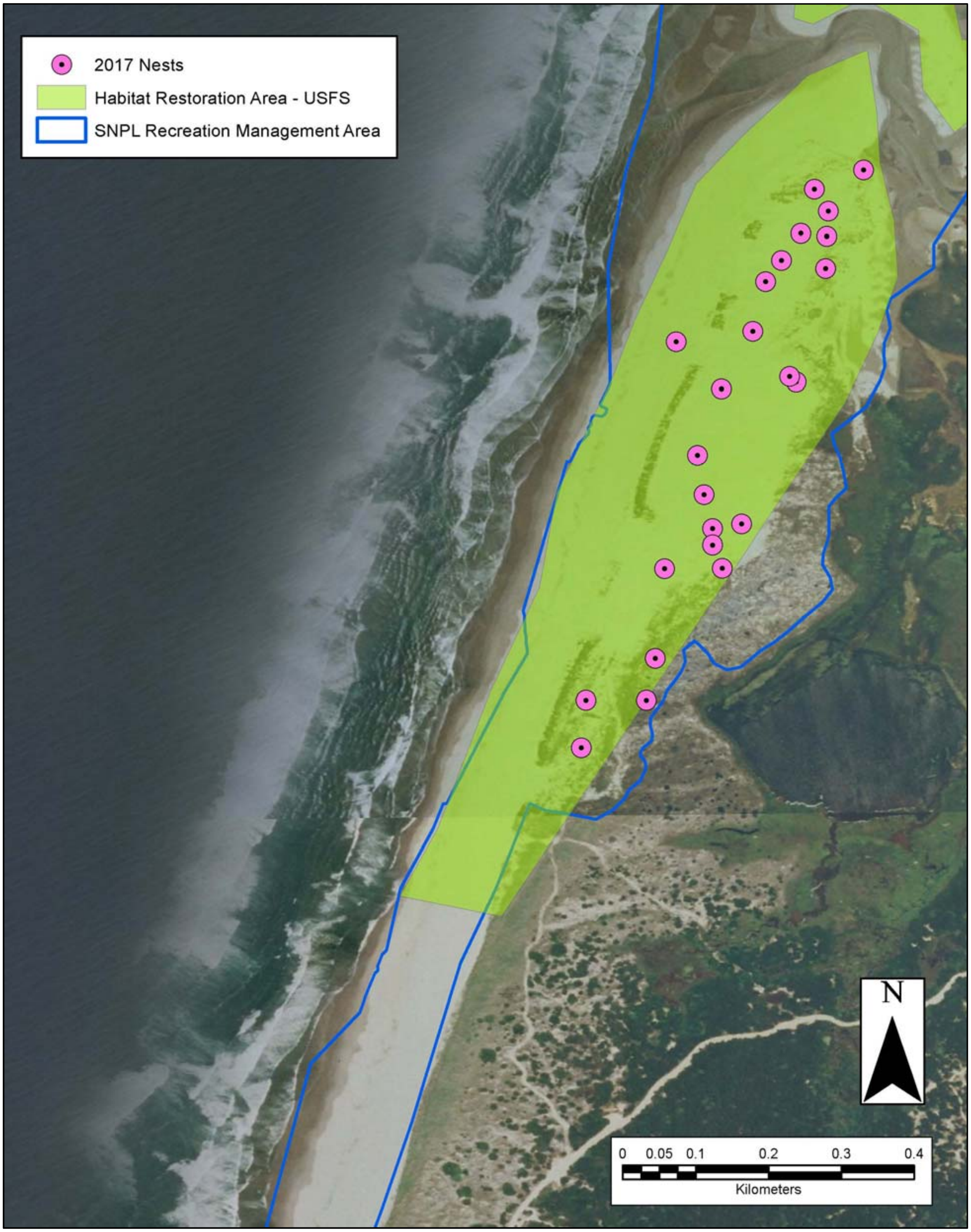


Figure 7. Snowy Plover nest locations at South Tenmile Creek, Oregon, 2017.

Figure 8. Snowy Plover nest locations at North end of Coos Bay North Spit, Oregon, 2017.

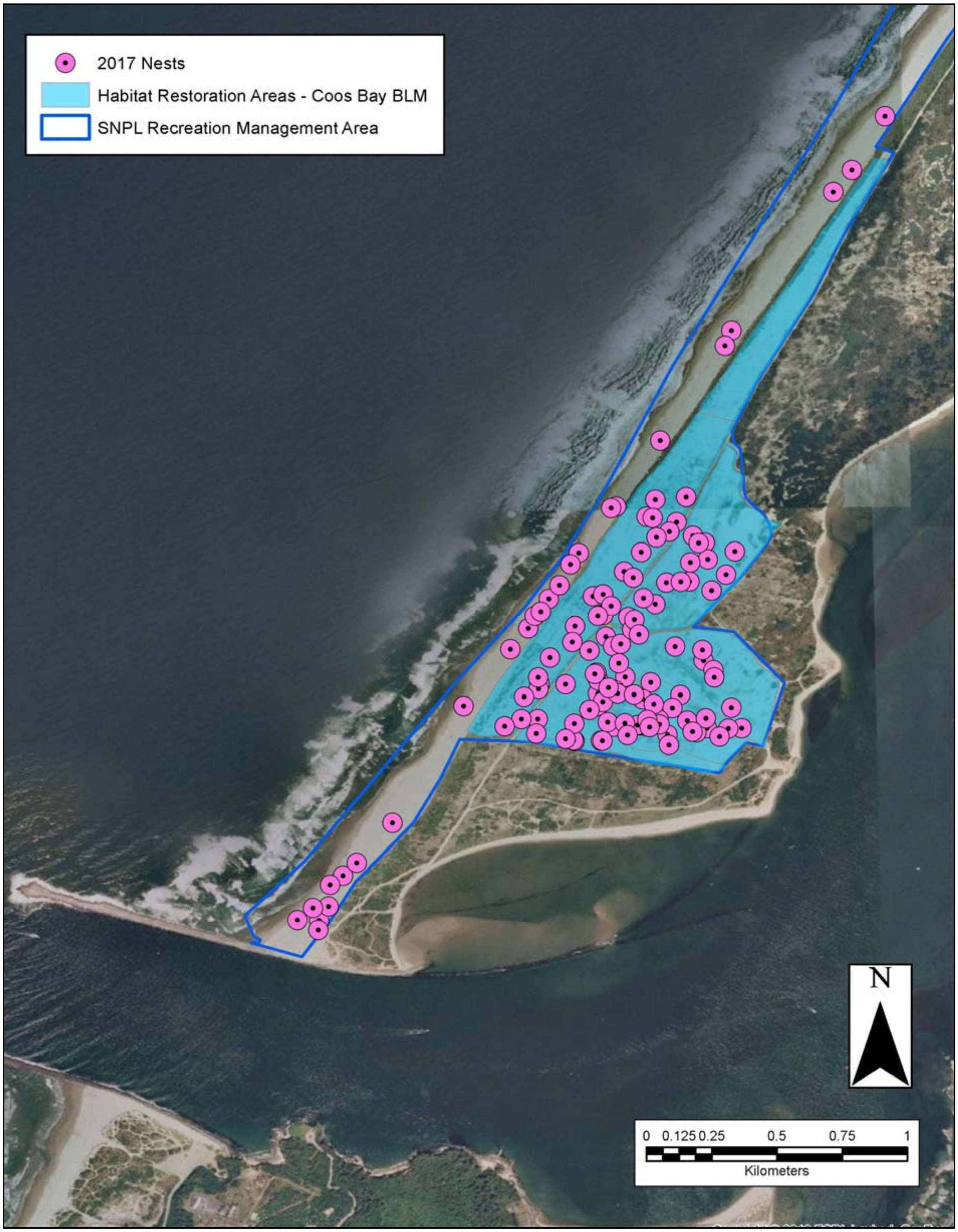


Figure 9. Snowy Plover nest locations at Coos Bay North Spit, Oregon, 2017.

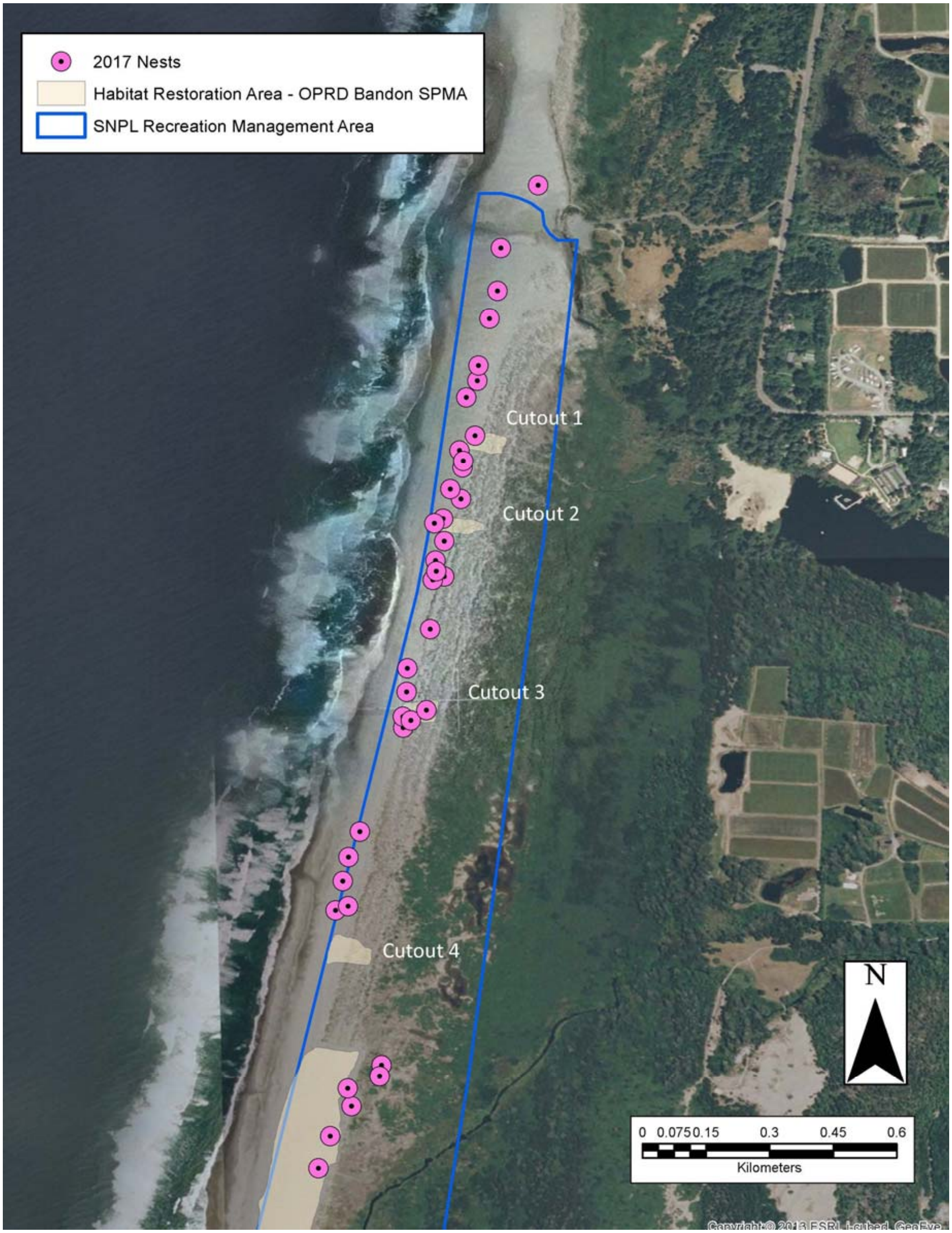


Figure 10. Snowy Plover nest locations at Bandon Beach, North of the New River mouth, Oregon, 2017.

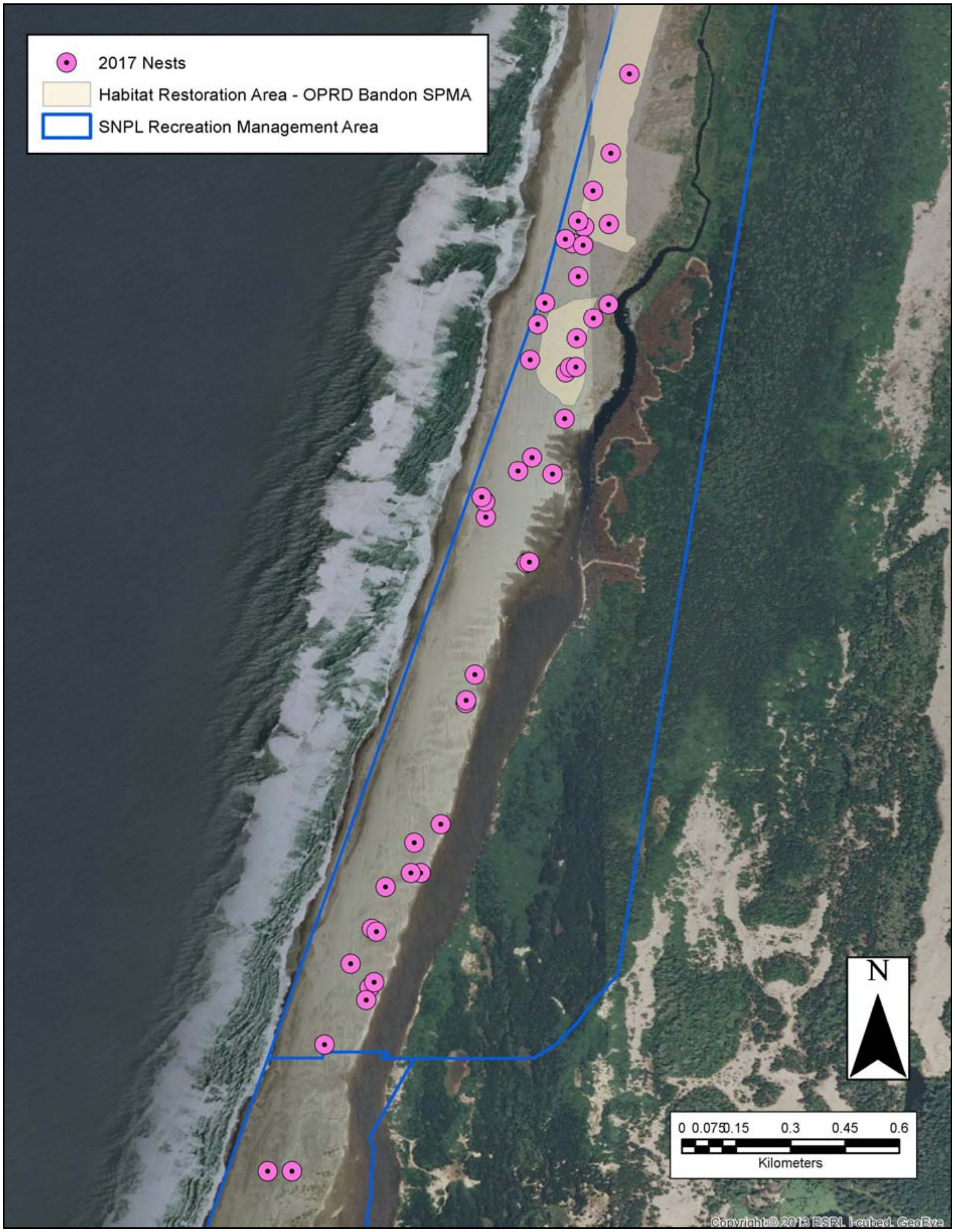


Figure 11. Snowy Plover nest locations on New River Spit, South of river mouth, Oregon, 2017.

Figure 12. Snowy Plover nest locations at New River HRA, Oregon, 2017.

Figure 13. Snowy Plover nest locations at Floras Lake, Oregon, 2017.

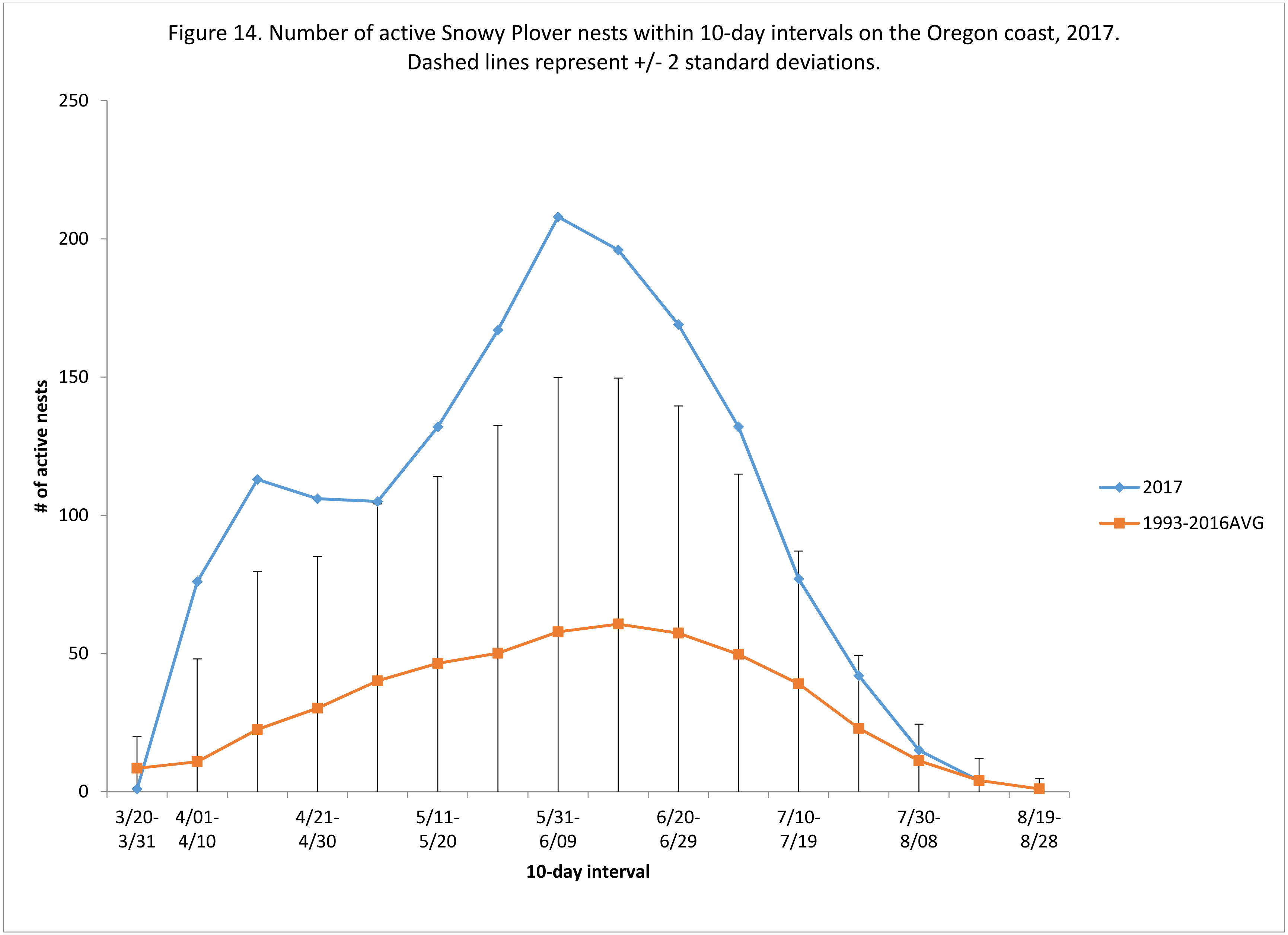


Figure 14. Number of active Snowy Plover nests within 10-day intervals on the Oregon coast, 2017.
Dashed lines represent +/- 2 standard deviations.
250
200
150
100
50
0
# of active nests
3/20-
3/31
4/01-
4/10
4/21-
4/30
5/11-
5/20
5/31-
6/09
6/20-
6/29
7/10-
7/19
7/30-
8/08
8/19-
8/28
10-day interval
2017
1993-2016AVG

Figure 15. 2017 hatch rate, mean pre predator management hatch rate, and mean post predator management hatch rate for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

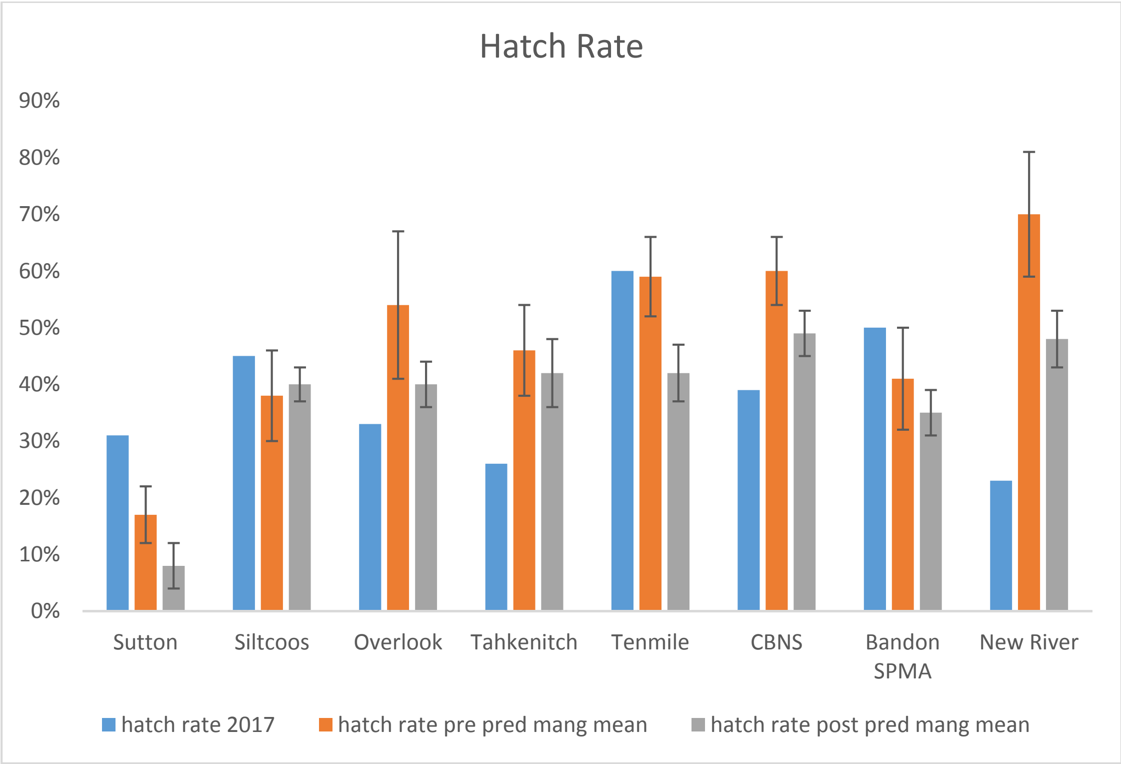


Figure 16. 2017 fledge rate, mean pre predator management fledge rate, and mean post predator management fledge rate for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

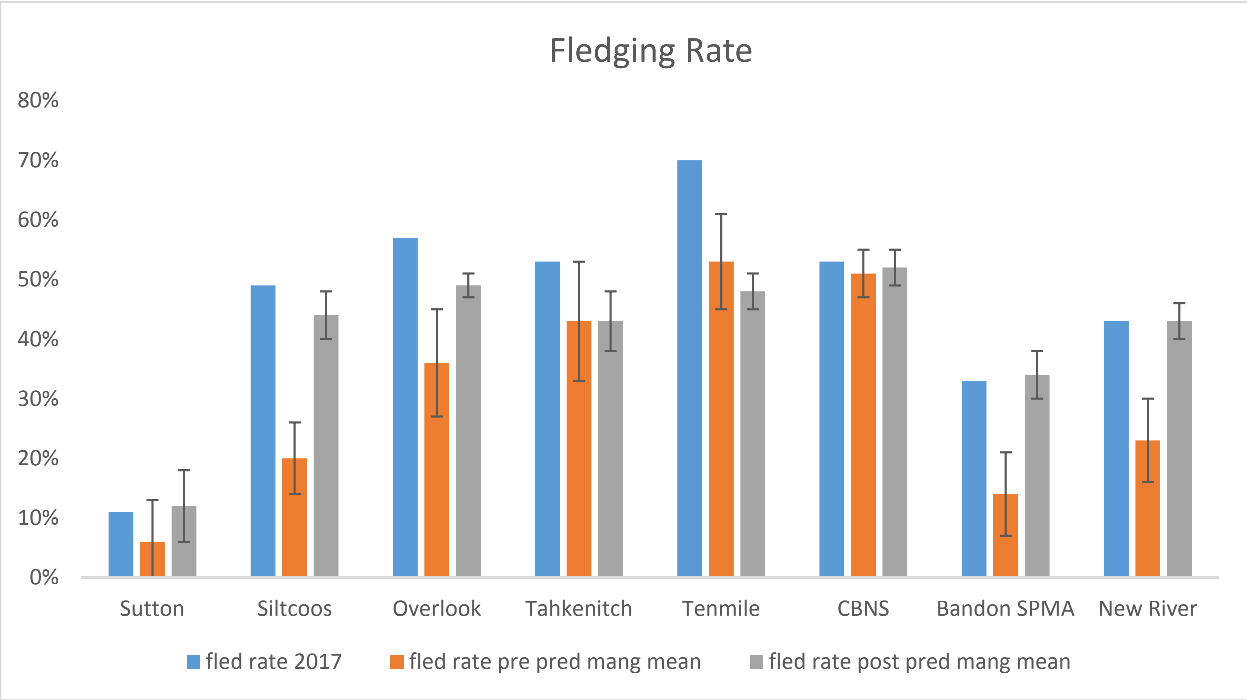


Figure 17. 2017 fledglings per male, mean pre predator management fledglings per male, and post predator management fledglings per male for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

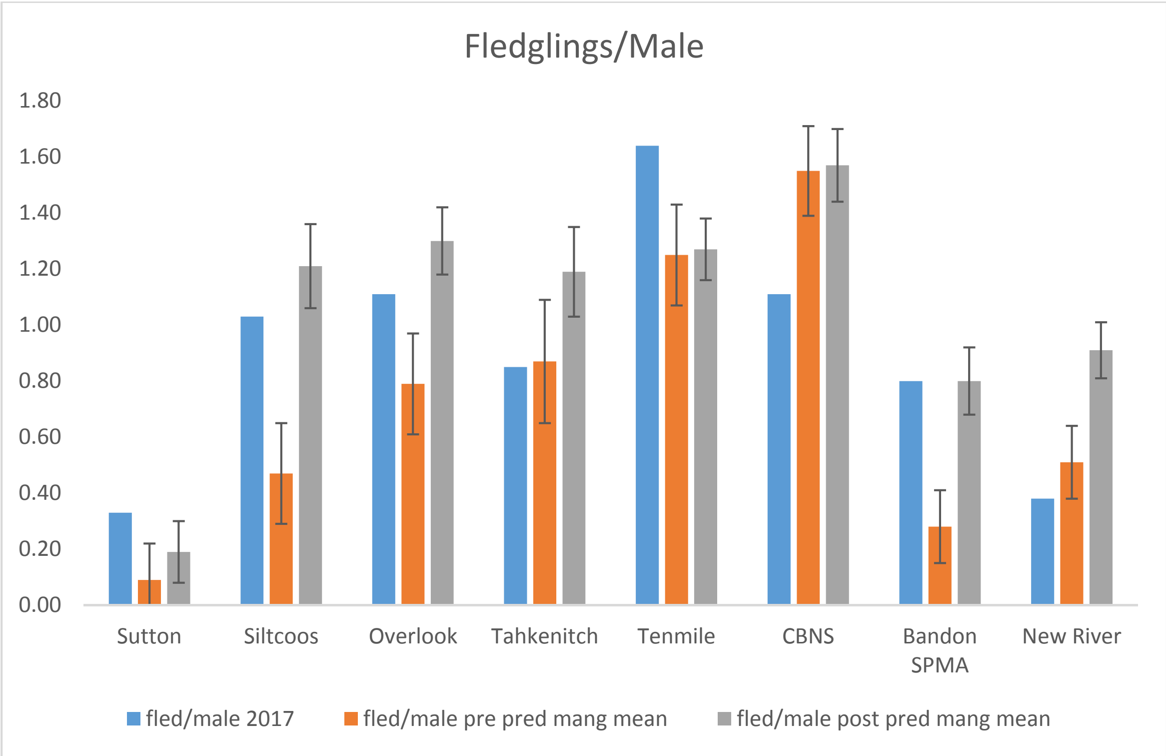
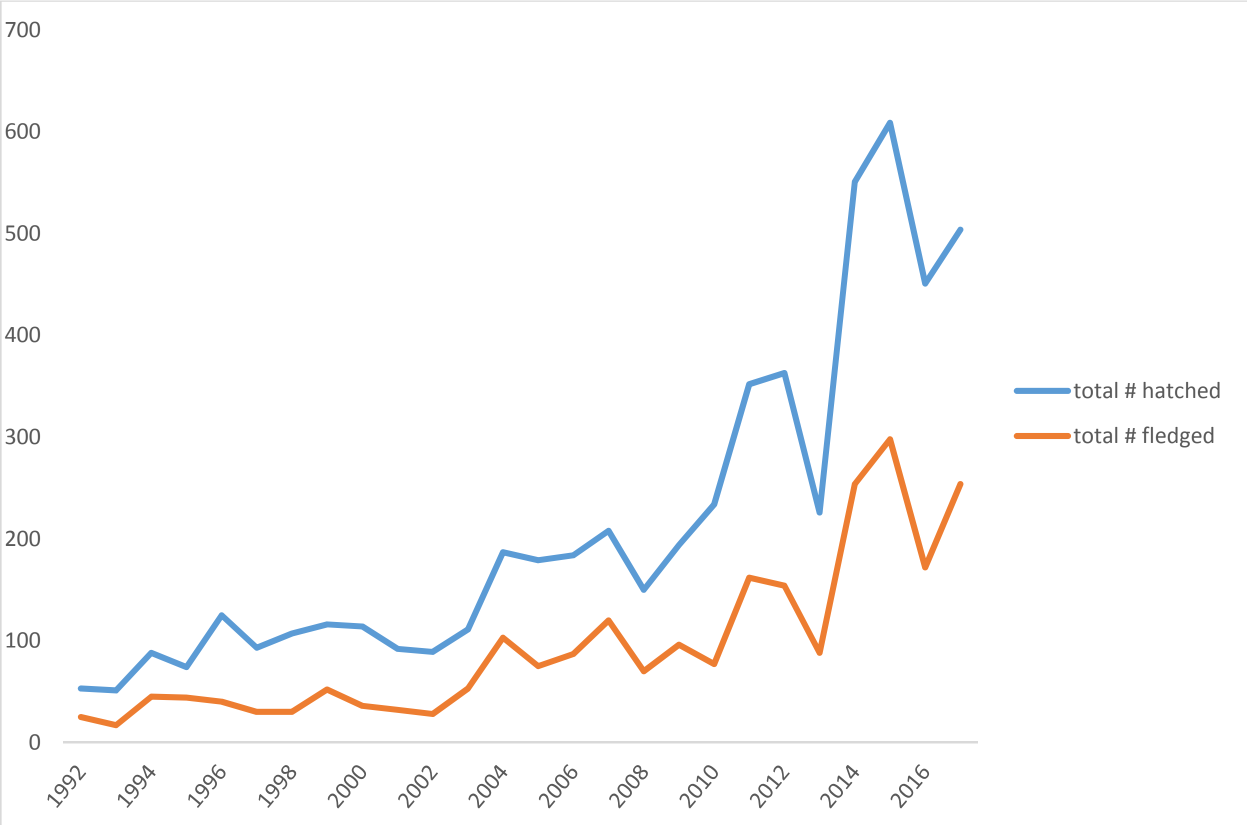


Figure 18. The number of eggs hatched and the number of fledglings on the Oregon coast, 1992-2017.



APPENDIX A.

Study Area

The study area encompassed known nesting areas along the Oregon coast including all sites between Berry Creek, Lane Co., and Floras Lake, Curry Co. (Fig. 1). Survey effort was concentrated at the following sites, listed from north to south:

Sutton Beach, Lane Co. (Figure 2). The beach north of Berry Creek south to the mouth of Sutton Creek.

Siltcoos: North Siltcoos, Lane Co. (Figure 3). The north spit, beach, and open sand areas between Siltcoos River mouth and the parking lot entrance at the end of the paved road on the north side of the Siltcoos River; and South Siltcoos, Lane Co. - the south spit, beach, and open sand areas between Siltcoos River mouth and south to Carter Lake trail beach entrance.

Dunes Overlook Clearing, Douglas Co. (Figure 4). The area directly west of the Oregon Dunes Overlook off of Hwy 101 including the beach from Carter Lake trail to the north clearing, and south to the Overlook trail south of the south clearing.

Tahkenitch Creek, Douglas Co. (Figure 5) Tahkenitch North Spit **-** the spit and beach on the north side of Tahkenitch Creek including the beach north to Overlook trail; and South Tahkenitch – from the south side of Tahkenitch Creek to south of Threemile Creek north of the north Umpqua River jetty.

Tenmile: North Tenmile, Coos and Douglas Cos. (Figures 6 & 7). The spit and ocean beach north of Tenmile Creek, north to the Umpqua River jetty; and South Tenmile, Coos Co. The south spit, beach, and estuary areas within the Tenmile Estuary vehicle closure, and continuing south of the closure for approximately 1/2 mile.

Coos Bay North Spit (CBNS), Coos Co. (Figures 8 & 9): South Beach - the beach from the north jetty north to the Horsfall area; and South Spoil/HRAs - the south dredge spoil and adjacent habitat restoration areas (94HRA, 95HRA, 98HRA).

Bandon Snowy Plover Management Area, Coos Co. (Figures 10 & 11): This site includes the Bandon SPMA and all nesting areas from north of China Creek to the south end of state land south of the mouth of New River.

New River, Coos Co. (Figure 12): The privately owned beach and sand spit south of Bandon Snowy Plover Management Area south to BLM lands, and the BLM Storm Ranch Area of Critical Environmental Concern habitat restoration area (HRA).

Floras Lake, Curry Co. (Figure 13). The beach and overwash areas west of the confluence of Floras Creek and the beginning of New River, north to Hansen Breach.

The following additional areas were either surveyed in early spring or the breeding window survey: Clatsop Spit, Necanicum Spit, Nehalem Spit, Bayocean Spit, Netarts Spit, Sand Lake South Spit, Nestucca Spit, Whiskey Run to Coquille River, Sixes River South Spit, Elk River, Euchre Creek, and Pistol River.

APPENDIX B

Snowy Plover Monitoring Methods

Nest Surveys

Monitoring began the first week in April and continued until all broods fledged, typically by mid-September. We used two teams of two biologists; one team covering Tenmile and sites north, and the other covering Coos Bay North Spit and sites south (Fig. 1). In some years this division has been modified to accommodate staff needs. All data collected in the field was recorded in field notebooks and later transferred onto computer. Surveys were completed on foot and from an all-terrain vehicle (ATV). Data recorded on nest surveys included:

- site name
- weather conditions
- start time and stop time
- direction of survey
- number of plover seen, broken down by age and sex
- band combinations observed
- potential predators or tracks observed
- violations/human disturbance observed

Weekly surveys were attempted, but were not always possible due to increasing workload associated with an increased plover population. Additional visits were made to check nests, band chicks, or monitor broods.

Population Estimation

We estimated the number of Snowy Plovers on the Oregon Coast by counting the number of individually color banded adult Snowy Plovers recorded during the breeding season, and then adding an estimated number of unbanded Snowy Plovers. To arrive at an estimate of the number of unbanded birds present, we counted the number of unbanded birds recorded during each 10-day interval across all sites. We selected the 10-day interval with the highest number of unbanded adults and subtracted the number of unbanded adults that were captured and banded during the breeding season. We added this minimum number of unbanded adults present to the count of banded adults to arrive at the minimum number of adults present during the breeding season. We also determined the number of plovers known to have nested at the study sites, including marked birds and a conservative minimum estimate of the number of unbanded plovers.

Nest Monitoring

We located nests using methods described by Page *et al.* (1985) and Stern *et al.* (1990). We found nests by scoping for incubating plovers, and by watching for female plovers that appeared to have been flushed off a nest. We also used tracks to identify potential nesting areas. We defined a nest as a nest bowl or scrape with eggs or tangible evidence of eggs in the bowl, i.e. egg shells. We predicted hatching dates by floating eggs (Westerskov 1950) and used a schedule, developed by G. Page based on a 29-day incubation period (Gary Page, pers. comm.). We attempted to monitor nests once a week at minimum. We checked nests more frequently as the expected date of hatching approached. We defined a successful nest as one that hatched at least one egg. A failed nest was one where we found buried or abandoned eggs, infertile eggs, depredated eggs, signs of depredation (e.g. mammalian or avian tracks or eggshell remains not typical of hatched eggs or nest cup disturbance) or eggs disappeared prior to the expected hatch date and were presumed to have been predated. In some instances we found nests with only one egg; often there was no indication of incubation or nest defense, and it was uncertain to what extent the nest was abandoned, or simply a "dropped" egg. Because it was difficult to make this determination, we considered all one egg clutches as nest attempts, and classified them as abandoned when there was no indication of incubation or nest defense. Data recorded at nest checks included:

- nest number
- number of eggs in nest
- adult behavior
- description of area immediately around nest
- whether or not the nest is exclosed
- GPS location

Brood Monitoring

We monitored broods during surveys and other field work, and recorded brood activity or males exhibiting brood defense behavior at each site. "Broody" males will feign injury, run away quickly or erratically, fly around and/or vocalize in order to distract a potential threat to his chicks. Information recorded when broods were detected included:

- Number of adults and chicks
- Band combinations of adults/chicks seen
- Sex of adults
- Behavior of adults
- Brood location

See Appendix C for information on brood sampling in 2016.

Banding

Adults were normally trapped for banding on the nest, during incubation, using a lilly pad trap and noose carpets. Lilly pad traps are small circular traps made of hardware cloth with a blueberry net top. The traps have a small door that the plover will enter. Noose carpets are 4" x 30" lengths of hardware cloth covered with small fishing line nooses. Plovers walk over the carpets and the nooses snag their legs. We limited attempts to capture adults to 20 minutes per trapping attempt. Chicks were captured for banding by hand, usually in the nest bowl. Banding was completed in teams of two to minimize time at the nest and disturbance to the plovers. As the Oregon plover population has grown, it has become impossible to band all broods. In 2016 we attempted to band approximately 80% of broods, spread over all sites and across the nesting season. See Appendix C for brood sampling methods.

Adults were banded with a four-band combination of a USFWS aluminum band covered with colored taped and colored plastic bands. We banded broods with a brood-specific two-band combination of USFWS aluminum band covered in colored taped on the left leg and a colored plastic band on the right leg.

APPENDIX C.

Sampling Plan for Banding in 2016 – Oregon

Statement of problem:

In past years, Oregon Snowy Plover monitors have attempted to band all chicks, to allow accurate estimates of number of chicks fledged per male at each site. As the population has grown this has become impossible with existing staff because of limited time and limited band combinations. Banding chicks at the nest is time-intensive because it often requires multiple visits as the anticipated hatch date approaches. Point Blue is experiencing the same problems at sites they monitor. Recovery Unit 1 (Oregon and Washington) is working on developing a sampling plan through structured decision making that will address survival and productivity estimates for the growing Oregon population, but this plan was not ready for the 2016 field season. Thus, ORBIC worked with Lynne Stenzel at Point Blue Conservation Science and Laird Henkel at California Department of Fish and Game to develop a plan to band a spatially and temporally representative sample of broods starting in 2016.

2016 Brood sampling plan:

Plover productivity is a function of nest success (percent of nests that hatch at least one egg) and fledging success (percent of chicks that survive at least 28 days). We identify nest success by determining the fate of all known nests (see Appendix B). In reality, a small proportion of nests are not located each year, but under this plan we will continue to attempt to locate all nests. This intensive effort to locate nests informs adult population estimates and allows us to provide land management agencies and Wildlife Services with timely information on nest predation.

Starting in 2016, we modified our field methods (see Appendix B) to limit banding and brood tracking to a spatially and temporally representative subset of broods. We used this sample of broods to identify fledging success and chicks fledged per male.

We addressed site variation in fledging success (Dinsmore *et al*. 2017) by sampling broods from all currently occupied nesting sites. We incorporated potential temporal variation in fledging success by banding across the season, dividing the nesting season into 15 10-day periods (Table C-1). Other plover populations exhibit seasonal variation in survival to fledging (Colwell *et al*. 2007, Brudney *et al*. 2013, Saunders *et al*. 2014, Catlin *et al*. 2015). We have not documented this in Oregon (Dinsmore *et al*. 2017), but a 10-day interval allows us to collect data that will be comparable with sampling being done in Recovery Unit 3 (Lynne Stenzel, pers. comm.).

For each 10-day period, at each site, we:

- Attempted to locate all nests.
- Estimated hatch date for all known nests based on number of eggs in nest when found, or by floating eggs (Westerskov 1950, Hays and LeCroy 1971, Dunn et al. 1979, Rizzolo and Schmutz 2007, Gary Page personal communication).
- Recorded fate of all known nests.
- Color banded all chicks from a sample of hatched nests. Our sample consisted of the first 5 known nests to hatch at each site in a given 10-day period (Table C-1). At sites with fewer than 5 hatched nests during an interval, we banded all broods from known nests (but see next bullet point). At sites with more than 5 hatched nests during an interval, we banded all chicks from the first 5 known nests that hatched. As in previous years, chicks did not receive unique color combinations; instead we used brood-specific combinations. Each chick received a USGS metal band wrapped with a brood-specific color tape combination on the left leg and a color band on the right leg (see Appendix B).
- It is not necessary to band chicks at sites with fewer than 3 breeding pairs (e.g. Floras Lake in recent years). At low-occupancy sites, even if birds nest simultaneously, the likelihood of all nests surviving to hatch at the same time is extremely low. Thus, the likelihood of these sites having multiple same-age broods is low, and monitors can track broods and determine fledging without banding, thus saving limited band combinations for more populated sites. Because there are not more than 5 nests hatching in a 10-day period at low-occupancy sites, all broods from these sites are included in the sample, whether banded or not.

- Broods from undiscovered nests that were not banded, were not included as part of the sample, and were not included in productivity estimates for the site. If a brood from an undiscovered nest was found and captured with all three chicks, this brood was used in the productivity calculations.
- Broods were selected for sampling based on actual hatch date, not on expected hatch date.
- If we incorrectly estimated the expected hatch date of a known nest, and the brood was out of the nest before we were able to band it, we skipped that brood and banded the next brood that hatched, up to a total of 5 broods per site per 10-day interval.
- Conducted approximately weekly surveys to relocate banded broods during the fledging period. Banded chicks observed were recorded, but status of very young broods was also confirmed based on adult behavior. As broods approached fledging age, we increased effort to count individual chicks. Chicks observed at or after 28 days after hatching were considered fledged (Warriner et al. 1986).
- The banded sample of broods and their attending male was used to report brood success, fledging success, and to calculate the number of fledglings per sampled brood. The banded sample of chicks that fledged was multiplied by a weighting factor (total broods/broods sampled) to give an estimated number of chicks fledged per site. The number of fledglings per male was then calculated from the estimated number of fledglings and the number of resident males for each site and overall. Standard deviations and 95% confidence intervals will be calculated on these estimates.

This proposed design is flexible; if the population decreases, the sample would return to a census because fewer than 5 nests would hatch within a given interval at a site. We incorporated this plan as a pilot in 2016. We hope that by the 2017 field season a comprehensive sampling plan will have been developed through the strategic decision making process.

Table C-1. Ten-day intervals used to determine brood sample in 2016 and 2017. Within each interval, the first five hatched broods were banded and tracked to fledging.

Ten day intervals	Interval number
April 1 - April 10	1
April 11 - April 20	2
April 21 - April 30	3
May 1 - May 10	4
May 11-May 20	5
May 21 - May 30	6
May 31 - June 9	7
June 10 - June19	8
June 20 - June 29	9
June 30 - July 9	10
July 10 - July 19	11
July 20 - July 29	12
July 30 - August 8	13
August 9 - August 18	14
August 19 - August 28	15

Test of sampling plan using recent data

We used data from 2013 – 2015 to test how well this sampling plan would have estimated the number of fledglings in those years. We chose those years because prior to 2013 the population was small enough that these methods would have resulted in a sample nearly identical to the total number of broods banded and tracked (i.e. we would have sampled the full population under this plan). For this analysis, we only used nests for which we had a hatch date and known brood outcome, so the numbers of total broods and fledglings in this analysis are slightly lower than totals reported in our annual reports. Based on hatch dates, we identified the nests that would have been sampled under this proposed scheme, and recorded the numbers of chicks that fledged from these sampled nests. We then used the sample to estimate the number of chicks fledged by site and across all sites per year. We compared these estimates to the numbers from the full (unsampled) data set (Figure C-1).

This approach used observed data and simulated samples to characterize the population estimates and the accuracy of the estimates. Based on a review of the data and sample variances associated with the historical data it is clear that the sample weights are low and in many cases equal one (and thus are representative of the entire population [i.e. a census]). Confidence intervals are extremely small. In all cases, over 80% of the broods were sampled. Figure C-1 shows that estimates of the number of fledglings derived from this example closely track the observed number of fledglings.

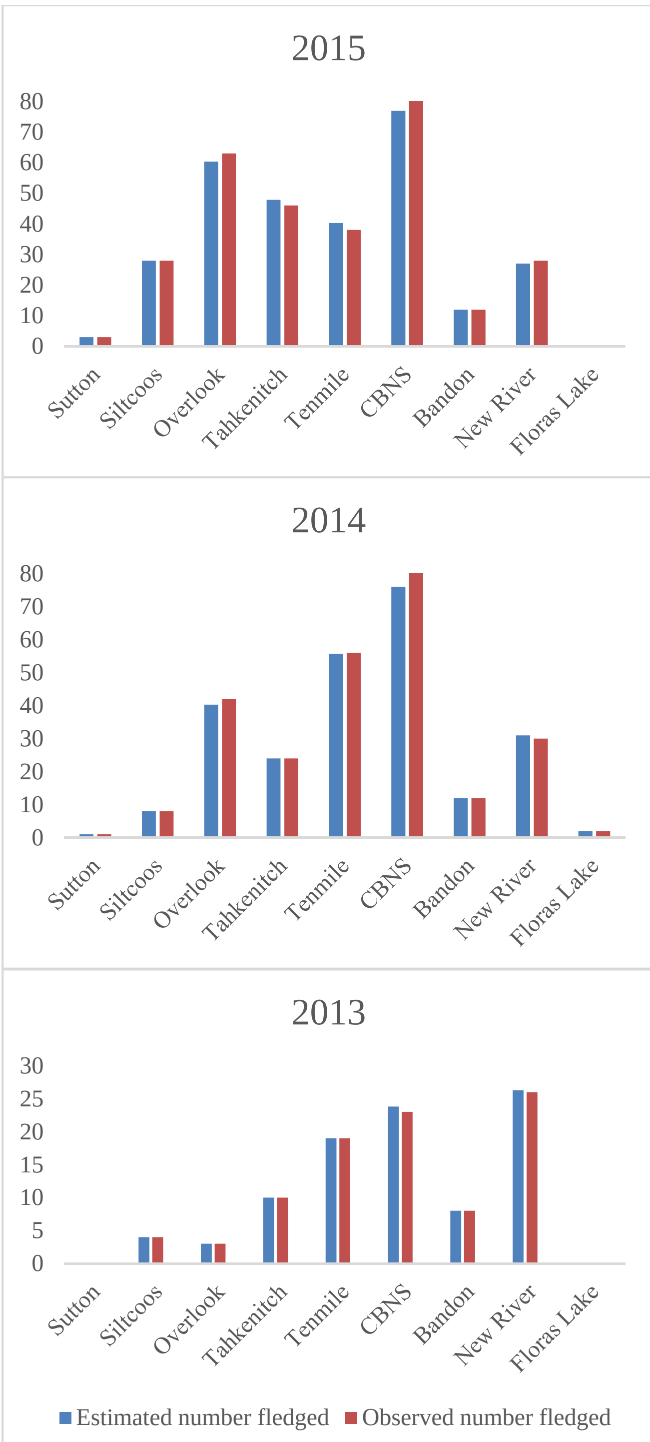


Figure C-1. Comparison of estimated number of fledglings from sample to observed data for 2013 – 2015.

Summary

This conservative sampling plan is intended to continue banding and tracking a large percentage of the plover population to ensure continued highly accurate productivity estimates with associated confidence intervals while using repeatable methods. If the Oregon Snowy Plover population continues to grow, and increased numbers of nests hatch, the percentage of hatched nests sampled will decline and variability estimates may increase. However, as shown in the above review of historic data, variance is small and the estimates are close to the observed data. If the population declines and/or nest success is low, this sampling plan will by design approach a full census.

This sampling plan will save monitors time by allowing them to track a subset of broods through fledging. In 2015, this sampling plan would have reduced the number of broods tracked by 42. Time savings will occur once 5 nests have hatched in a 10-day interval at a site because at that point monitors need only document a nest's fate; they will not have to be physically present while it is hatching. Being present at hatchings is time intensive because monitors may have to make repeated visits to a nest to band all chicks. Timing of these visits is not flexible, affecting monitors' ability to complete other tasks efficiently. Documenting fate of a nest can be determined via camera or by visiting the nest once. After nest fate is determined monitors do not need to return. This plan would allow monitors to skip a small and clearly identified portion of nest hatchings.

Using the sample to estimate plover productivity

Using the sample, we calculated brood success for each site (the number of broods that successfully fledged at least one chick). Based on the number of eggs and fledglings counted from the sample, we calculate fledging success for each site (the number of chicks fledged/the number of eggs laid). In order to determine fledglings per male for each site and the entire coast, we treated each sampled brood as an independent unit and used the sample to calculate the estimated fledglings per sampled brood. Not all males on each site are sampled. To estimate the number of breeding males for each site, we use the survey data to determine how many males were resident at each site. Males were considered resident if they were present at a site between 15 April and 15 July and therefore had an opportunity to attempt to nest. Using the number of fledglings produced per sampled brood, we calculated an estimated number of fledglings produced for all broods at each site:

$$f_{sy} * k_y = E_y$$

where f_{sy} = the number of fledglings per sample brood at site y; k_y = total number of known broods at site y; and E_y = the estimated number of fledglings for site y.

We then divided E_y by the number of resident males for site y (R_y):

$$\frac{E_y}{R_y} = F_y$$

So that F_y is the estimated number of fledglings produced per male for site y.

We calculated the estimated number of fledglings per male for each site. Since males can and do roam between sites, and can breed at more than one site in a given year, to estimate fledglings per male for the entire coast, we determined the total number of resident males for the coast of Oregon, and divided that by the estimated number of fledglings produced for all known broods. We calculated a mean number of fledglings per male from all sites, and display the mean with the standard deviation (Table C-2).

Table C- 2. Data used to calculate estimated number of fledglings by site in 2017.

Site Name	total # of known broods	broods in sample	% brood success of sample	total # of eggs hatched in sample	# fledged from sample	% fledging success from sample	# of fledglings/brood sampled	# of fledglings/brood sampled – combined	# of resident males	estimated # of fledglings[a]	estimated # of fledglings/male[b]
Sutton Beach	6	6	17%	18	2	11%	0.33	0.33	10	2	0.20
Siltcoos:											
North Siltcoos	13	11	90%	25	15	60%	1.36	1.19	32	33	1.03
South Siltcoos	15	15	64%	38	16	42%	1.06				
Overlook											
North Overlook	14	12	75%	28	17	61%	1.41	1.43	45	50	1.11
South Overlook	21	18	89%	47	26	55%	1.44				
Tahkenitch											
North Tahkenitch	21	18	83%	47	25	53%	1.39	1.39	34	29	0.85
South Tahkenitch	0	-									
Tenmile:											
North Tenmile	29	20	100%	45	32	71%	1.60	1.72	43	70	1.63
South Tenmile	12	12	100%	34	23	68%	1.92				
Coos Bay N. Spit											
South Beach	23	20	95%	50	35	70%	1.75	1.31	66	73	1.11
South Spoil	12	10	70%	23	10	43%	1.00				
HRA	21	12	58%	31	10	32%	0.83				
Bandon SPMA	44	38	47%	97	32	33%	0.84	0.84	46	37	0.80
New River											
HRA	3	3	67%	8	3	38%	1.00		9	3	0.33
Other lands	3	3	67%	8	4	50%	1.33		9	4	0.44
Floras Lake	2	2	100%	6	4	67%	2.00	2.00	3	4	1.33
TOTALS	**229**	**200**	**75%**	**504**	**254**	**50%**	**1.27**	**1.27**			$\bar{x}$ = 0.88 +/-0.45

a – number of fledglings/brood sampled x the total number of known broods = estimated number of fledglings produced

b – number of estimated fledglings/number of resident males = estimated number of fledglings per male

APPENDIX D.

Recovery Unit 1 (Oregon & Washington)

Exclosure Use Guidelines Developed by Oregon Biodiversity Information Center for the Western Snowy Plover Working Team

2/27/2012

Nest exclosures are mesh fences that surround a Western Snowy Plover (*Charadrius nivosus nivosus*) nest and act to keep out predators. Nest exclosures have been used in Oregon since 1991 to protect plover nests from depredation by mammalian and avian predators. Prior to implementation of comprehensive predator management, plovers suffered high rates of nest depredation. Exclosures have been successful at increasing nest success rates (Table 6) (Stern *et al.* 1990, 1991, Craig *et al.* 1992, Casler *et al.* 1993, Hallett *et al.* 1994, 1995, Estelle *et al.* 1997, Castelein *et al.* 1997, 1998, 2000a, 2000b, 2001, 2002, Lauten *et al.* 2003, 2005, 2006, 2006b, 2007, 2008, 2009, 2010, 2011). Predators that prey on Snowy Plover eggs include mammalian predators such as skunk (*Mephitis sp*.), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), mice (*Peromyscus* sp.), and weasel (*Mustela sp*.); and avian predators, mostly American Crows (*Corvus brachyrhynchos*) and Common Ravens (*Corvus corax*).

Since 1990, we have found 2650 Snowy Plover nests along the Oregon coast, of which 1057 (40%) have been exclosed. Over the years we have had to adapt exclosure techniques in response to predator behavior around exclosures (see Castelein *et al.* 2000a, 2000b, 2001, Lauten *et al.* 2003).

In 1995 we began seeing evidence of adult Snowy Plover depredations in or immediately outside exclosures. From 1995 to 2011 we documented a minimum of 48 adult losses associated with exclosure use. These losses include 21 cases where blood, feathers, or plover body parts were found in or adjacent to exclosures and 27 cases where incubating adults disappeared from an established, exclosed nest. Forty-eight adult losses associated with 1057 exclosed nests indicate that exclosures subject adult plovers to additional predation risk (approximately 4%). Similar threats associated with exclosures have been reported in other plover populations (Murphy *et al.* 2003, Hardy and Colwell 2008, Pearson *et al.* 2009). We do not have information on how many adults may be lost at nests not associated with exclosures.

Predator exclosures increase Snowy Plover hatching success and the number of chicks hatched per male, but not fledging success or the number of chicks fledged per male (Neuman *et al.* 2004, Dinsmore *et al.*, 2014). In Oregon, they pose an additional risk to incubating adults and may negatively impact adult survival. As in Washington, exclosure use in Oregon has been a management technique, not part of a study of their effectiveness in increasing the overall plover population. Data from Oregon indicates that exclosure use has a strong positive impact on nest success (Dinsmore *et al.* 2014). Further analysis is underway to determine potential impacts of exclosure use on adult success and fledging success *et al.* (see Pearson *et al.* 2009, Neuman *et al.* 2004).

Scott Pearson *et al.* (2009) conducted a search of existing literature on the effects of nest exclosures on nest success for plovers and other ground nesting species (primarily shorebirds). Their findings are summarized below:

- Nest survival of exclosed nests was significantly higher in ten studies (Rimmer and Deblinger 1990, Melvin *et al.* 1992, Estelle *et al.* 1996, Johnson and Oring 2002, Lauten *et al.* 2004, Niehaus *et al.* 2004, Isaksson *et al.* 2007, Hardy and Colwell 2008, Pauliny *et al.* 2008, Pearson *et al.* unpublished), and there was no difference in two studies (Nol and Brooks 1982, Mabee and Estelle 2000).
- Exclosed nests appear to be only vulnerable to reptilian and small mammal predators while unexclosed nests are vulnerable to predators of all sizes (Mabee and Estelle 2000).
- No difference in fledging success between exclosed and unexclosed nests in four studies (Hardy and Colwell 2008, Pauliny *et al.* 2008, Lauten *et al.* 2004, Pearson *et al.* unpublished data) and higher fledging success for exclosed

nests in two studies (Larson *et al.* 2002, Melvin *et al.* 1992). There was no difference in fledging success between exclosed and unexclosed nests for all studies involving Snowy Plovers.

- Adult mortality associated with exclosures was reported in six of the eight studies that included or mentioned this response variable (Murphy *et al.* 2003, Lauten *et al.* 2004, Isaksson *et al.* 2007, Hardy and Colwell 2008, Pauliny *et al.* 2008, Pearson *et al.* unpublished). Only three studies compared adult mortality between exclosed and unexclosed nests and two reported significant increases in adult mortality associated with exclosures (Murphy *et al.* 2003 and Isacsson 2007) and one reported no difference (Pauliny *et al.* 2008).
- Adult mortality appears to be largely attributable to raptors and appears to be episodic (Murphy *et al.* 2003, Neuman *et al*. 2004, Hardy and Colwell 2008) and differs among habitats (Murphy *et al.* 2003).
- Larson *et al.* 2002 examined the effect of exclosures on population growth for piping plovers and found the effect to be positive.
- Abandonment was higher for exclosed nests in two studies where this was compared directly (Isaksson *et al.* 2007, Hardy and Colwell 2008).
- Abandonment was not associated with the construction process, size, shape, mesh size and fence height (Vaske *et al.* 1994). Covered exclosures are more likely to be abandoned than uncovered exclosures (Vaske *et al.* 1994).
- Exclosures increased incubation length by one day but did not influence chick condition (Isaksson *et al.* 2007).
- Egg hatchability was higher in three studies (Melvin *et al.* 1992, Isaksson *et al.* 2007, Pauliny *et al.* 2008) but no difference was observed in one study (Hardy and Colwell 2008).
- Breeding adults may receive false messages regarding site quality and encouragement to continue to breed in sink habitats (Hardy and Colwell 2008). This is an important research question that should be examined but no data support this contention.

Our data and that of others (Murphy *et al.* 2003, Hardy and Colwell 2008, Pearson *et al.* 2009) indicate that adult plovers are at increased risk of predation while in exclosures. In the absence of research to quantify that risk, and based on the above information, we developed the following guidelines for exclosure use in Oregon:

- Since raptors appear to be the primary threat to adult plovers in exclosures, delay use of exclosures until peak raptor migration has passed. Currently, we have identified May 15 as a suitable cutoff, but this date could be altered as needed.
- Delaying exclosure use until May 15 allows field personnel time to assess causes of early nest failures, although weather conditions can make accurate assessment difficult. During this time, and contingent on funding, we recommend an owl survey be run at each site.
- If nests are being lost primarily to mice, exclosures will not help the problem, and may pose additional risk if the mice are being preyed upon by raptors. In this case exclosure use is not appropriate.
- If corvids and/or large mammals are identified as the main predator at a site, removal of the predators should be the primary goal with exclosures used as a supplemental measure to help protect nests.
- Any use of exclosures should be accompanied by close monitoring to evaluate their effectiveness (Hardy and Colwell 2008) and to detect predators of adult plovers early (Pauliny *et al.* 2008). Weather permitting, exclosed nests should be checked at least twice per week. If conditions do not allow checks twice a week, exclosure use should be seriously reconsidered.
- Adult predation associated with exclosures is often episodic (Castelein *et al.* 2000b, Lauten *et al.* 2006). Once adult predation is suspected, all exclosures should be removed from the site and their use discontinued for the season.
- To minimize the risk of episodic predation on adult plovers, additional caution should be used when placing exclosures within sight of each other (this puts multiple adults at risk).
- Exclosures should not be placed along the foredune.
- Exclosures should not be placed in a windy location that might result in nest drifting. Since the ME's are 4 feet per side, the nest is only about 2 feet from each sidewall. If the nest begins to drift, it could come close to a sidewall, and a predator such as a raccoon could reach in and grab the eggs. If an exclosed nest is in a potentially windy location, it must be monitored frequently to ensure the safety of the nest and adults (especially on windy days).