The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast - 2016

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Abstract

We monitored the distribution, abundance and productivity of the federally threatened Western Snowy Plover (*Charadrius nivosus nivosus*) along the Oregon coast from 5 April – 31 August 2016. From north to south, we surveyed and monitored plover activity at 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 2016 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) develop and test a sampling technique to determine plover productivity, 6) monitor brood outcomes, and 7) collect general observational data about predators and use cameras to document predator activity at nests.

We estimated the resident number of Snowy Plovers in Oregon at 518 individuals. The adult plover population was the highest estimate recorded since monitoring began in 1990. We monitored 694 nests in 2016. Overall apparent nest success was 25%. Nest failures were attributed to unknown depredation, unknown cause, harrier depredation, corvid depredation, mammalian depredation, gull depredation, one-egg nest, wind/weather, abandonment, overwashing and infertility. We monitored a sample of 150 of 192 known broods, and documented a minimum of 197 fledglings. Overall brood success was 71%, fledging success was 43%, but only 0.60 +/- 0.09 fledglings per male were produced.

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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 27th 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 improved annual productivity leading to increases in Oregon's breeding population, sustainable productivity, and stable populations at 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, and 2015). Our objectives for the Oregon coastal population in 2016 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) develop and test a sampling technique to determine plover productivity, 6) monitor brood outcomes, and 7) collect general observational data about predators and use cameras to document predator activity at nests.

Study Area

We surveyed Snowy Plover breeding habitat along the Oregon coast, including 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. From north to south, we surveyed and monitored plover activity at 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). 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.

Methods

Window Surveys

Annual breeding season window surveys were coordinated by US Fish and Wildlife Service 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, Nestucca Spit, South Beach (Newport), Whiskey Run to Coquille River, Elk River, Euchre Creek, Otter Point to Rogue River, and Myers Creek to Pistol River.

Monitoring

Breeding season fieldwork was conducted from 5 April to 31 August 2016. 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 2016.

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 plovers 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 along the Oregon coast during the field season (5 April through 31 August), and includes breeding birds, birds migrating through the area during that time, and wintering birds that may be present in Oregon 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 along the Oregon coast from the beginning to the end of the 2016 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.

In past years, we attempted to color band all broods that were known to have hatched (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 recent years the number of nests and broods has increased with the overall Oregon plover population (Lauten *et al*., 2015). These increases have made it difficult to band and monitor every brood with existing staff levels and available color band combinations. To address these issues, we worked with Point Blue Conservation Science (Lynne Stenzel, pers. comm) to develop a spatial and temporal sampling scheme that would result in approximately 80% of the hatched nests being banded and monitored. Details of the sampling scheme can be found in Appendix C. We implemented this pilot sampling scheme during the 2016 field season.

All known nests were monitored to determine fate and cause of failure. We banded 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. If unbanded, 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. Using the number of estimated fledglings per site and the number of resident males, we calculated the estimated number of fledglings per male for each site and the entire coast. See Appendix C for further details regarding calculation of the number of fledglings per male.

We compared plover productivity in 2016 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.

We report brood movements 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 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 return to 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., 2010, 2011, 2012, 2013, 2014, and 2015) 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. In 2016, no exclosures were implemented.

We used Reconyx PC900 cameras (Reconyx Inc., Holmen, Wisconsin) and Bushnell Aggressor Trophy Cam HD (Bushnell Outdoor Products, Overland Park, KS) to observe predator activity at plover nests and identify causes of nest failure. Cameras were placed from 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, and were installed as low to the ground as possible to avoid providing a perch for predators. Cameras were used at Siltcoos, Overlook, Tahkenitch, Tenmile, Coos Bay North Spit, and Bandon SPMA. 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.

Both types of cameras employ 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. After cameras were installed, we ensured that plovers returned to the nest. Batteries and data cards were replaced approximately weekly. In all cases, cameras were left in place until the fate of the nest was determined. 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 (Bell 2017). ORBIC monitors reported causes of nest failure and daily predator observations to Wildlife Services staff.

Results and Discussion

Window Surveys and Monitoring

During the May breeding window surveys, 375 plovers were observed, and none were detected outside of the current known nesting areas (USFWS 2016). The annual breeding window survey count and total number of plovers present are in Table 1.

Of the minimum number of plovers present during the 2016 breeding season, 468 (88%) were banded. The number of unbanded plovers estimated by the 10-day interval method was 61. During the breeding season we observed 247 banded males, 221 banded females, 22 unbanded males, and 39 unbanded females.

Of the minimum number of plovers present in 2016, 325 plovers (61%) were documented nesting, below the mean percentage for 1993-2015 (79%). A minimum of 158 banded males and 124 banded females nested, and approximately 16 unbanded males and 27 unbanded females nested. Many nests failed soon after initiation, making it impossible to identify the adults associated with those nests. This resulted in a low percentage of confirmed nesting plovers. There were a total of 243 banded resident males and 214 banded resident females present during the 2016 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 518. We believe this is the best estimate of the Oregon breeding population.

By all measures, the Oregon coastal population was the largest recorded since monitoring began in 1990 (Table 1). In 2016, the Oregon coastal plover population was above the recovery goal set for the state (U.S. Fish and Wildlife Service 2007).

Overwinter Return Rate

Adult overwinter survival is known to be an important parameter of population growth (Sandercock 2003, USFWS 2007, Dinsmore *et al.* 2010, Lauten *et al.* 2010, 2011, 2012, and 2013). A large part of overwinter survival is reflected in adults returning to breed the following year. Of the 418 banded adult plovers recorded in 2015, a minimum of 289 were recorded in 2016 along the Oregon coast. The overwinter return rate based on the minimum number of returning banded adult plovers was 69%, above the 1994-2016 mean of 66%, but well below the previous two years (80% in 2014 and 76% in 2015).

In 2015, we recorded a minimum of 333 chicks fledged (Lauten *et al*., 2015). Of these, we observed 135 in Oregon in 2016. There were also six banded hatch year birds in 2016 that had not been documented fledged in 2015, raising the total number of chicks known to have fledged in 2015 to 339 (Table 2). The return rate was well below the 1992-2016 average (Table 2), and the first time the hatch year return rate was below average since 2008. Of the returning HY15 birds, 57 (42%) were males and 78 (58%) were females. Seventy-three of the HY15 returning plovers were confirmed breeding (54%). While the hatch year return rate was below average, it does not account for HY15 birds that survived the winter and went to sites outside Oregon. HY15 birds were documented in Washington and Humboldt Co., California (Cyndie Sundstrom, Elizabeth Feucht, pers. comm.), but are not included in the Oregon return rate.

During the 2016 season, we captured and rebanded three male and two female adult plovers with brood band combinations that needed to be updated to unique adult combinations. We banded two unbanded adult male plovers and 376 chicks.

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 2016, the population of plovers at Sutton Beach doubled compared to 2015 (Lauten *et al*. 2015). Floras Lake had one pair of plovers; there was no use at this site in 2015. Siltcoos, Overlook, and Tenmile had the largest increase in the number of plovers compared to 2015 (ca. 30 - 40 plovers for each site, Lauten *et al*., 2015), while all other nesting sites had similar numbers of plovers compared to 2015 (Lauten *et al.* 2013, 2014, and 2015). The highest concentration of nesting activity based on the presence of resident plovers was between Siltcoos and Bandon SPMA. The increase in plover presence at any site is a reflection of the increase in the overall plover population in 2016 (Table 1). High nest failure rates resulted in birds moving between sites. This is reflected in the relatively high percentage of plovers recorded as resident at each site (Table 3).

As the Oregon population grows, plovers continue to occupy available habitat adjacent to the traditional nesting areas (Lauten *et al.* 2010, 2011, 2012, 2013, 2014, and 2015). In 2016 at Sutton Beach, there were at least five nesting attempts on the Sutton Creek spit south of the HRA (Figure 2). In past years, most nesting activity has been concentrated on the Sutton HRA. Plovers now occupy all the beach between South Siltcoos and North Tahkenitch, with at least 31 nests documented on the beach between the HRAs (Figures 3 - 5). There were no known nesting attempts at South Tahkenitch in 2016, however plovers were documented using the area. At North Tenmile 16 nests were documented on the beach north of the spit, reaching almost to the South Umpqua parking area (Figure 6). At CBNS we documented two nests north of the FAA towers (Figure 7), and we continue to document plover use of the beach from Access 1 to Horsfall Beach. In 2016 we found one active brood from an undiscovered nest just south of Horsfall Beach, and we documented a nesting attempt approximately 0.80 kilometers south of the Horsfall Beach parking lot (Figure 7). Plovers were recorded from Horsfall Beach south to Access 1 from mid-June through most of July (Figures 7 & 8). At Bandon SPMA four nests were found near the mouth of China Creek, including one on the north side of the creek (Figure 9). Plovers occupied the beach between Bandon SPMA and New River HRA all summer, and we documented 18 nests on private lands, the highest number of nests in this area in over 15 years (Figures 10 & 11). We also documented two nests in the Clay Island area of the New River HRA, which has not had consistent plover use in previous years (Figure 11). Throughout our study area, additional habitat is being occupied, both because plovers are searching for new areas to nest after high levels of nest failure at initial sites, and because the population is increasing. We expect the plovers to continue to utilize sections of beach adjacent to and between the main nesting sites. Snowy plovers also nested at Nehalem Bay and Sitka Sedge (South Sand Lake) State Parks in 2016. Information on those nests is available from OPRD.

Nest Activity

Table 4 shows the number of nests and broods we located during the 2016 nesting season (Figures 2-12). We found nearly 200 more nests than in 2015, and more than double the number of any year prior to 2015. No exclosures were used in 2016. Overall nest success in 2016 was well below average and nearly half that of 2015 (Table 5 and Table 6). The high number of nests was due to the large plover population as well as repeated nesting attempts after nest failure.

The first nests were initiated about 31 March (Figure 13), later than the previous two years (Lauten *et al*., 2014 and 2015). Nest initiation increased through mid-April when it declined due to nest failure. Nest initiation then increased throughout May until peaking (n = 208) during the 31 May – 9 June time interval, one interval period earlier than the peak average time interval. This is the highest number of active nests in any time period since monitoring began in 1990, and 49 more nests than the previous high in 2015 (Lauten *et al*. 2015). The last nest initiation occurred on 26 July.

Nest Failure

Predators were responsible for 76% of nest failures (Table 7). In past years, corvids have always been the most commonly identified nest predator (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, depredating a minimum of 61 nests. This was a notable increase from previous years (Lauten *et al*., 2015); the maximum number of nests identified as harrier depredations in past years was 20 (Lauten *et al*., 2013). Northern harriers were positively identified depredating plover nests at Siltcoos, Overlook, Tahkenitch and CBNS in 2016, however the majority of harrier-caused failures (74%) occurred at CBNS. In 2016 one harrier was removed from Overlook on 17 May (Bell 2017); no nests failed to harrier depredations at Overlook after the removal. One harrier was also removed from CBNS in 2016 (Bell 2017), however despite the removal, harrier depredations continued throughout the nesting season on all sections of the nesting area including South Beach. Due to the high plover population and high nest density, we anticipate harriers will continue to be a threat to nesting plovers unless removed from the nesting areas.

Corvids also continue to be a commonly identified nest predator (Table 7). In past years we have noted flocks of 25+ Common Ravens (*Corvus corax*) roaming or migrating along the coast, typically in April and May. Observational data suggest that these flocks are often subadults and are not local territorial birds. Their presence is often for a short duration (one to seven days), but they can cause much plover nest failure as they wander around the nesting areas. In April 2016 WS and ORBIC monitors noted flocks of ravens as large as 80 to 100 individuals, the largest flocks we have ever recorded. These flocks persisted for about one week and caused much nest loss, including at CBNS where we have not recorded a corvid depredation since 2005. Ravens depredated at least nine nests at CBNS in 2016. While these early season flocks of ravens depredated nests at almost all sites, there were also raven depredations from Siltcoos to Tahkenitch later in the season, after the northern harrier was removed. ORBIC monitors at these sites noted that when the harrier was present, raven depredations were minimal, but once the harrier was removed, ravens began depredating plover nests and continued to do so through mid-June.

We noted in 2015 that the number of nests that failed due to mammal depredations was higher than in past years (Lauten *et al*., 2015). In 2016 this pattern continued (Table 7). In previous years relatively few depredated nests were identified as having failed due to mammals (Lauten *et al*., 2010, 2011, 2012, 2013, and 2014). In 2016, 11 nests were depredated by coyotes (*Canis latrans*), 11 nests failed to fox (*Vulpes vulpes* and *Urocyon cinereoargenteus*), six nests failed to skunk (*Mephitis sp*.) and one to opossum (*Didelphis virginiana*, the first we have ever documented). We are uncertain whether this represents an increase in mammal predator numbers or whether mammalian predators are reacting to higher densities of plovers and plover nests.

In 2015 we documented one nest failure due to a gull, but we suspected additional nest failures may have been caused by gulls. In 2016 we documented a minimum of 20 nests depredated by gulls, all at Bandon SPMA and the adjacent private lands at New River. Nest cameras documented an adult Western Gull (*Larus occidentalis*) at four of these nests; tracks indicated that Western Gulls were responsible for most of the depredations, however, we did record smaller gull tracks at two nests that may have been a California Gull (*Larus californicus*). It is unclear whether these depredations were by one individual or multiple individuals. Based on the photographs and the evidence at the nest sites, the gull(s) appeared to be hunting on the wing, landing briefly at the nest site, swallowing the eggs, and quickly flying off. The pattern of depredations indicated that the gull(s) had learned of a food source and was repeatedly searching for nests and exploiting the food resource. Since gulls are relatively long lived birds, and this was an adult and thus likely a local individual, we suspect that this behavior could continue into the future especially since the density of plovers and plover nests continues to increase.

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 or Bushnell cameras at 57 unexclosed nests in 2016, however six cameras failed to record the outcome of the nest. Thirty-one nests with cameras failed and the cameras clearly identified the cause of failure. At 14 of the failed nests, monitors' assessment of the cause of failure matched what was shown on the camera. At 17 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. These nests failed to harrier (7), ravens (6), gull (2), and coyote (2). Use of cameras did not negatively affect nest success. Apparent success at nests with cameras was 35% -- higher than overall nest success (Table 5), and higher than apparent success at nests without cameras (24%). 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, 59% of the total failures). Nest depredations were classified as unknown because they had clearly been depredated, but the predator could not be identified. Due to the variety of predators causing nest failure at Siltcoos, Overlook, and Tahkenitch, unknown nest failures are difficult to categorize. Of 14 nests with cameras classified as unknown by monitors in the field, cameras recorded raven (6), harrier (6), and coyote (2). At Tenmile, two of three nests with cameras hatched and one was a known raven depredation. There was no evidence of harrier activity in 2016 at Tenmile, suggesting corvids were the likeliest source of predation.

Of the 223 nest failures to unknown depredation, 65 (29%) occurred at CBNS (Table 7). Some of the 28 unknown predator failures that occurred prior to 23 April were likely caused by the ravens who were present at this time of year. However, 37 of these 65 failed nests (57%) occurred after the third week in April when no ravens were present at CBNS. Only one known nest failure at CBNS was attributed to a predator other than raven or harrier (coyote, Table 7). Despite removing one harrier (Bell 2017), harriers were present all season and noted hunting over the nesting area and the beach. From the pattern of nest failures at CBNS and the limited evidence we did observe, we suspect harriers were likely responsible for all of the unknown depredations at this site after April, and likely were responsible for some of the earlier depredations as well.

At Bandon SPMA, corvids, gulls, skunks, fox, and opossum were all documented depredating nests (Table 7). Corvid activity was highest early in the season, skunks and fox were persistent throughout the breeding season, and gulls were most active towards the end of the season. Due to the persistent predation pressure from a variety of species, we are uncertain if any one particular species is most responsible for the unknown nest failures at this site. Bandon Beach and New River are long beaches and the only areas with two species of fox, skunk, and one or two species of gulls in addition to corvids that are depredating plover nests, making predator management in this area a unique challenge.

While predator management continues to reduce nest predation and increase plover productivity, predators are likely to respond to the increasing plover population, resulting in greater depredations and increasing predator species. See Bell (2017) for a complete discussion of the predator management program.

Exclosure use continues to be minimal due to increased nest success from lethal predator management, the constant presence of predators that can cause adult plover mortalities at exclosed nests (i.e., harriers, Peregrine Falcons (*Falco peregrinus*), Great Horned Owls (*Bubo virginiaus*), fox, and coyotes), workload limitations, and a plover population well above recovery goals. No exclosures were used in 2016 (see Appendix D for exclosure protocols).

Productivity

We sampled 150 broods from the 192 nests that were known to have hatched (78%), and these broods produced 169 fledglings (Table 8). We counted an additional 28 fledglings from broods that were not part of the sample. The overall minimum number of fledglings we recorded for all broods was 197 (Table 9). The overall fledging success based on the sample broods (Table 8) was slightly less than the post-predator management average (Table 10). The overall brood success rate of sampled broods (Table 8) was above the 1991 – 2016 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 male for the entire coast was 0.60 +/-0.09, well below the mean post-predator management average (Table 10) and well below recovery goals.

Sutton

The number of nests at Sutton Beach in 2016 (Table 4) was the highest ever recorded and double the previous year, however only two nests hatched (Table 5). We banded one brood but because of the small number of nests that hatched, we confirmed two fledglings, one from each brood (Table 9). Sutton Beach continues to have the lowest hatch rate of all sites (Figure 14) as well as very low fledging success rates (Figure 15) and fledglings per male (Figure 16, Table 11). While fledging success and the estimated fledgling per male were higher in 2016 than the post-predator management averages, the sample was extremely small and productivity was poor considering the number of nest attempts.

Siltcoos

Overall nest success at Siltcoos in 2016 (Table 5) was very poor and less than half of 2015 (71%, Lauten *et al.*, 2015). North Siltcoos had similar nest success in 2016 (Table 5) compared to 2015 (25%, Lauten *et al.*, 2015) but was well below average (38%). Nest success at South Siltcoos in 2016 (Table 5) declined substantially compared to 2015 (87%, Lauten *et al.*, 2015) and was below the average for this site (46%).

The hatch rate at Siltcoos in 2016 was well below the post-predator management average (Figure 15). There were five fewer broods at Siltcoos in 2016 (Table 8) compared to 2015 (Lauten *et al.* 2015) resulting in fewer fledglings than in 2015 (Table 9). Fledging success was slightly above the post-predator management average (Figure 15) but the number of fledglings per resident male was well below the post-predator management average (Figure 16, Table 11).

Overlook

Nest success at both North and South Overlook in 2016 (Table 5) was lower than 2015 (48% and 52%, respectively, Lauten *et al.*, 2015) and less than the average for these sites (45% and 39%, respectively). Seven fewer nests hatched at Overlook in 2016 compared to 2015 (Lauten *et al.*, 2015).

The hatch rate at Overlook in 2016 was below the post-predator management average (Figure 14). There were five fewer broods at Overlook in 2016 (Table 8) compared to 2015 (Lauten *et al.*, 2015), with South Overlook producing less than half the number of fledglings compared to 2015 (Table 9). Although seven fewer nests hatched at Overlook, two broods from undiscovered nests made up some of the difference. The fledging success rate was near the post-predator management average (Figure 15). Overlook was the only site to reach 1.00 fledglings per resident male, but was still below the post-predator management average (Figure 16, Table 11).

Tahkenitch

Nest success at North Tahkenitch in 2016 (Table 5) was only half the average (41%) and half the rate in 2015 (44%, Lauten *et al.*, 2015). Eleven fewer nests hatched in 2016 compared to 2015 (Table 4). There were no known nest attempts at South Tahkenitch in 2016.

The hatch rate at Tahkenitch in 2016 was well below the post-predator management average (Figure 14). There were eight fewer broods at Tahkenitch in 2016 compared to 2015 (Lauten *et al.*, 2015) and they produced 21 fewer fledglings compared to 2015 (Table 9). There were three broods from undiscovered nests. The fledgling success rate was slightly above average (Figure 15), but the number of fledglings per resident male was much lower than the post-predator management average (Figure 16, Table 11).

Tenmile

Overall nest success at Tenmile in 2016 was similar to 2015 (Table 5, Lauten *et al.*, 2015) but North Tenmile was lower than in 2015 (48%) while South Tenmile was higher than in 2015 (37%). Nest success at both sites was below average (43% at North Tenmile and 51% at South Tenmile). Nearly twice as many nests hatched at South Tenmile compared to 2015 while three fewer nests hatched at North Tenmile compared to 2015 (Lauten *et al.*, 2015).

There was a substantial increase in the number of eggs laid at Tenmile in 2016 compared to 2015 (248 versus 141). The hatch rate was slightly less than post-predator management average (Figure 14) but substantially lower than in 2015 (52%). North Tenmile had three fewer broods in 2016 compared to 2015, but South Tenmile had 12 more broods in 2016 compared to 2015 (Lauten *et al*., 2015), and they produced seven fewer fledglings (Table 9). The fledging success rate was equal to the post-predator management average for Tenmile (Figure 15) but the number of fledglings per resident males was substantially lower than the post-predator management average (Figure 16, Table 11).

Coos Bay North Spit

Overall nest success at CBNS in 2016 was the lowest ever and over 40 percentage points lower than 2015 (Table 5, Lauten *et al*., 2015). Nest success at South Beach, South Spoil, and on the HRAs (Table 5) was substantially lower than the averages for these sites (59%, 61%, and 51% respectively). In 2015, 97 nests hatched at CBNS; in 2016 37 nests hatched.

Over 100 more eggs were laid at CBNS in 2016 compared to 2015, but over 100 fewer eggs hatched. The hatch rate was the lowest ever at CBNS, and was 40 percentage points lower than in 2015 and 30 percentage points below the average for this site (Figure 14). Due to the poor hatch rate, there were 69 fewer fledglings counted in 2016 compared to 2015 (Table 9). The fledging success rate was similar to 2015 (41%) and slightly less than the post-predator management average (Figure 15). The number of fledglings per resident male was the lowest ever, far lower than the average (Figure 16, Table 11).

Bandon SPMA

For the second consecutive year, Bandon SPMA had the highest number of nests ever for this site (Table 4), including 57 nests at Bandon Beach. Despite more nests, five fewer hatched and nest success (Table 5) was lower than in 2015 (32%) and well below the average (41%).

About 100 more eggs were laid in 2016 compared to 2015 but a similar number of eggs hatched (61 in 2015 and 62 in 2016), thus the hatch rate was lower than 2015 (Lauten *et al*., 2015) and substantially lower than the post-predator management average (Figure 14). Despite a similar number of eggs hatching, the fledging success rate was only 20%, less than half of 2015 (Lauten *et al*., 2015) and substantially lower than the post-predator management average (Figure 15), resulting in 17 fewer fledglings for this site (Table 9). Because of the relatively large number of adult plovers using this site, the number of fledglings per resident male was very low (Figure 16, Table 11), below the post-predator management average (Figure 16), and below recovery goals.

New River

The New River HRA had about half the number of nests in 2016 compared to 2015, but the New River private lands had more than double the number of nests (Table 4). Nest success in 2016 was lower on both the New River HRA and private lands compared to 2015 (Lauten *et al*., 2015), and overall nest success for these areas was well below average (53%).

There were slightly fewer eggs laid and slightly fewer eggs hatched in 2016 compared to 2015, but the hatch rate was similar (24% in 2016 verse 29% in 2015) and well below the post-predator management average (Figure 14). The number of fledglings produced from the HRA was less than half of 2015 while private lands produced more fledglings than 2015, but the numbers were still very low (Table 9). Fledgling success was lower than the post-predator management average (Figure 15), and the number of fledglings per resident male was substantially lower than the post-predator management average (Figure 16, Table 11).

Floras Lake

There was one nest at Floras Lake in 2016 (Table 4) and it successfully hatched three chicks and one chick fledged. Due to the low occupancy at Floras Lake, we do not summarize productivity data for this site.

Summary

Overall productivity was very poor in 2016 and well below post-predator management averages, however nearly 200 fledglings were produced, a number that had never been attained prior to 2014 (Table 9). The low productivity was a result of persistent predator pressure throughout the season. Predators had a substantial impact on nest success, but at most sites, nests that hatched had close to average fledging success except at Bandon SPMA and New River. The low number of fledglings per resident male was due to many males never successfully hatching nests, and thus having no productivity in 2016.

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 2016 comparisons.

Post-predator management hatch rates have declined for all sites except Siltcoos (Figure 14). The overall post-predator management nest success rate (42%) is also lower than the pre-predator management nest success rate (51%). The decline in nest success and hatch rates is attributed to the decreased use of exclosures; unexclosed nests have a lower nest success rate than exclosed nests (Table 6). The overall ten year (2007 – 2016) nest success average is 39.6% +/- 11.5, within the mean observed and calculated success rates reported by Page et al. (2009) from multiple studies; in 2016 nest success was lower than the Oregon ten year average. Low nest success in 2016 is attributed to high predation pressure. Despite the lower hatch rates and nest success since implementation of lethal predator management, the actual number of eggs hatched and chicks fledged has increased dramatically (Figure 17).

Productivity, as measured by fledging success, brood success, and the number of fledglings per male, has increased since implementation of predator management. Post-predator management fledging success rates have improved at all sites except at Tahkenitch where they have remained stable and above 40% and Tenmile where they have slightly decreased but remain above 40% (Figure 15). The post-predator management mean brood success rate for all sites (2004-2016; 72.5%) was higher than the pre-predator management brood success rate (1991-2001; 62.9%). 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 16). While 2016 had poor productivity, 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 Movements

Sutton, Siltcoos, Overlook, and Tahkenitch

There were two successful broods at Sutton Beach in 2016; one hatched on the Sutton Creek spit and remained on the spit until fledging. The second brood was from an undiscovered nest and was nearly fledged when found on the Sutton Creek spit. A third brood from a nest on the HRA was never confirmed active or fledged after hatching in mid-July. There were two successful broods at North Siltcoos in 2016; one brood hatched along the beach north of the access trail and moved south to the spit where it fledged. The second successful brood originated from the spit and stayed on the spit until in fledged. Two other broods that originated from the spit both failed. There were no unusual brood movements from South Siltcoos. All broods originated from the spit and adjacent HRA except one that hatched along the beach south of the HRA. All broods remained on the spit and adjacent HRA, with only one brood wandering just south of Waxmyrtle trail before moving back north.

There were no unusual brood movements from North or South Overlook in 2016. At North Overlook, brood activity ranged from near the Dunes Overlook trail, on and adjacent to the HRA, and north along the beach to the Carter Lake trailhead. One brood from the HRA moved south to South Overlook and fledged near the south end the HRA. Broods from South Overlook used the HRA, the beach as far north as the Dunes Overlook trailhead, and the beach south of the HRA. One brood wandered south and fledged at North Tahkenitch.

Only one 2016 brood from North Tahkenitch moved away from the HRA and adjacent beach. This brood moved south, crossed the creek and fledged at South Tahkenitch. All other broods stayed on the spit and HRA area and the adjacent beach or slightly north of North Tahkenitch. There were no other broods at South Tahkenitch in 2016.

Tenmile

At North Tenmile in 2016, six broods originated from nests on the HRA and seven broods from nests on the beach north of the HRA. Broods from the HRA tended to stay on the HRA and the adjacent spit. One of these broods crossed the creek to South Tenmile. Broods that originated on the beach generally stayed on the beach. One brood hatched from a nest just south of the third parking lot at South Umpqua. This brood spent the brood rearing period on the beach around the Dellenbach trailhead. One other brood was confirmed fledged near the tsunami towers, suggesting it moved north during the brood rearing period. At South Tenmile there was brood activity on the spit, HRA, and the beach south of the HRA. While we did not document any brood activity as far south as the I-beam at the south end of the beach, one older chick or recently fledged chick was found crushed by an ATV west of the I-beam by WS Agent Josh Bettesworth, suggesting that there was some brood activity as far south as the I-beam. One brood that hatched from a nest at the north end of the spit crossed the river and fledged on the North Tenmile side.

Coos Bay North Spit

At CBNS broods that originate on the beach tend to stay on the beach, while broods that originate from the nesting area may stay on the nesting, but many broods attempt to move west to the beach. Maintaining and increasing the number of gaps in the foredune road and along the foredune facilitate brood movement west to the beach where food resources are highest. In 2016 the majority of brood activity on the beach occurred from west of the 95 and 98HRA south to the jetty area. Unusual brood movements included one brood from the 95HRA that moved onto the beach and meandered north to the FAA towers before returning south to the jetty area. One brood hatched on the beach just south of the FAA towers and was located near the jetty within five days of hatching. Much of the brood activity on South Beach, particularly in July and August, was focused on the beach between the jetty and the I-beam just north of the jetty, to a half mile north of the jetty area. We documented broods using the jetty rocks for protection from people and vehicles, broods running in tire tracks on the open section of beach near the jetty, broods avoiding vehicle traffic on the beach, and brood use of the foredune road and adjacent area just east of the jetty. The jetty area continues to be a focal point of plover activity including nesting south of the I-beam; this is likely due to the wide beach in this area that is attractive to plovers. There was no brood activity north of the FAA towers in 2016 except near Horsfall Beach where a brood from an undiscovered nest was found in late June and was already over two weeks old. This brood remained in the area until it fledged.

Bandon SPMA

Of the ten nests that hatched in 2016 on the Bandon Beach side of the Bandon SPMA, one hatched at the north end of the beach, west of the parking lot near China Creek. This brood wandered south to the area around China Creek overwash, but shortly thereafter failed. Three broods hatched from nests at the south end of the beach just north of the mouth of New River. All three of these broods remained at the south end of the beach and successfully fledged. The remaining broods originated from the newly created HRA along the mid portion of the beach. All these broods remained on, adjacent, or along the foredune south of the HRA.

There were 14 broods on the south side of New River at Bandon SPMA in 2016, but only five fledged chicks. All brood activity was noted within the SPMA, and we did not document any broods moving south of the SPMA. Broods utilized all the available habitat including near the ocean, in the wrackline west the carsonite signs, within the dunes, and along the river mudflats.

New River

Five broods originated on private land in 2016, and four fledged chicks. Two broods originated on Bandon Biota property just south of the Bandon SPMA. One brood failed quickly after hatching. The second brood was raised by the female; this brood moved north, onto the south end of the Bandon SPMA before returning south to Bandon Biota property where it was confirmed fledged. Two broods originated from nests along the foredune west of Fourmile Creek. One of these broods wandered slightly south and remained on the beach for the brood period. The second brood moved north to the south end of the Bandon SPMA and was confirmed fledged on Bandon Biota land. The fifth brood hatched from a nest along the foredune just north of the New River HRA; this brood moved south to the Croft Lake breach area and was confirmed fledged along the beach adjacent to the HRA.

There were only three broods that originated from the New River HRA in 2016; two successfully fledged. One brood was from an undiscovered nest and was originally detected north of Croft Lake breach. The brood wandered south as far as Hammond breach, and spent the majority of the brood period between New Lake breach and Hammond breach. The other brood was from the only nest on Clay Island breach, where it remained until it fledged.

Floras Lake

There was one brood from a single nest at Floras Lake in 2016. This brood hatched in mid-July, and within six days had moved 4.75 km north to Clay Island breach, and then seven days later was 2 km further north on the New River HRA north of Hammond breach. This brood remained on the south end of the New River HRA until it fledged one chick.

Immigrant Plovers

Forty-two adult plovers banded in California and two adult plovers banded in Washington were observed in Oregon in 2016. Twenty-five were females and 19 were males. Twenty-one 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. Eighteen males were resident plovers and one male was present briefly at the end of the season.

Of the 42 plovers banded in California, 11 females and 11 males originally hatched in Oregon and were subsequently rebanded at coastal nest sites in California. The other 20 plovers, 12 females and eight males were originally banded in California. Both Washington banded plovers were females originally banded in WA in 2013 and both were present in Oregon in 2014 and 2015.

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Table 1. Minimum window survey counts and the minimum number of Snowy Plovers present on the Oregon Coast, 2005-2016.

YEAR	WINDOW SURVEY	# SNPL PRESENT
2005	100	153
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

Table 2. Numbers of banded hatch year Snowy Plovers returning to Oregon, 1992 - 2016.

Year	Minimum # fledglings from previous year	# of banded HY birds returning to OR	Return rate (#HY/#Fled)
2016	339[a]	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%

* - minimum number sighted

Average return rate = 47%
SD = 11.0%

[a] - adjusted from 333 to 339 based on hatch year returns

Table 3. Plover activity based on the number of adult plovers at each nesting area on the Oregon Coast, 2016. 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	8	2	2	8	6	1	1	19	17
Siltcoos	41	33	6	6	47	28	5	4	99	71
Overlook	61	53	8	8	57	54	4	4	130	119
Tahkenitch	42	38	6	6	41	35	3	3	92	79
Tenmile	52	50	6	6	49	47	8	8	115	111
CBNS	52	52	14	14	71	71	12	12	149	149
Bandon SPMA	60	56	10	6	51	48	5	5	126	115
New River HRA	30	25	4	4	25	23	2	2	61	54
Floras Lake	1	1	0	0	0	0	1	1	2	2

Table 4. Number of nests for monitored sites on the Oregon Coast, 2006 – 2016. 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	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
SU	4	3	0	0	1	0	0	1	2	8	19
SI:											
North	12	15	30	14	17	13	10	13	6	8	15
South	13	13	6	9	24	21	22	30	18	23	42
OV:											
North	9	13	14	9	21	29	28	33	35	46	48
South	1	3	1	5	16	28	31	28	23	42	56
TA											
North	4	10	5	6	7	23	36	52	32	61	74
South	0	0	0					6	4	2	0
TM:											
North	10	20	12	13	13	15	17	19	26	29	34
South	12	21	16	41	30	35	29	17	21	32	59
Horsfall											1
CBNS:											
SB	0	8	5	19	17	16	7	36	20	41	48
SS	14	12	18	16	14	15	15	12	13	20	38
HRAs	18	19	26	30	33	26	39	58	43	66	97
BSPMA											
BB	23	30	28	31	26	28	48	44	28	40	57
NR spit	9	16	6	10	12	9	12	20	54	48	73
NR HRA	7	14	27	27	27	29	17	9	15	27	14
NR other	11	5	2	3	3	2	1	3	4	8	18
FL	0	0	0	3	0	0	2	0	2	0	1
Tot nest	**147**	**202**	**196**	**236**	**261**	**289**	**314**	**381**	**346**	**501**	**694**
Tot brood[a]	**15**	**4**	**3**	**8**	**2**	**4**	**11**	**8**	**12**	**32**	**19**

[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, 2016. No exclosures were used in 2016.

Site	Total #	Hatch	Fail	Unknown	Overall Nest Success
Sutton	19	2	17		11%
Siltcoos					
North	15	3	12		20%
South	42	13	29		31%
Combined	57	16	41		28%
Overlook					
North	48	19	29		40%
South	56	18	38		32%
Combined	104	37	67		36%
Tahkenitch					
North	74	16	56	2	22%
South	0	-	-		
Combined	74	16	56		
Tenmile					
North	34	11	22	1	32%
South	59	25	34		42%
Combined	93	36	56		39%
Horsfall Bch	1	0	1		0%
CBNS					
South Beach	48	7	39	2	15%
South Spoil	38	7	31		18%
HRAs	97	21	76		22%
Combined	183	35	146		19%
Bandon SPMA	130	23	106	1	22%
New River					
HRA	14	2	12		14%
Other Lands	18	5	13		28%
Floras Lake	1	1	0		100%
Totals	694	173	515	6	25%

Table 6. Apparent nest success of exclosed and unexclosed Snowy Plover nests on the Oregon coast, 1990 - 2016.

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
Average =	46.70370	69.72	22.55556
STDEV =	13.20494	11.60646	18.73157

* Multiple experimental designs used, data not included

Table 7. Causes of Snowy Plover nest failure at survey sites along the Oregon coast, 2016.

Site Name	Tot Nests	# Fail	Depredations					Other					
			Corvid	Unk	Mammal	Harrier	Gull	Wind-Weather	Overwash	Abandon	One Egg Nest	Infer	Unk cause
Sutton	19	17	7	3						1			6
Siltcoos													
North	15	12	4	4									4
South	42	29	4	19	1[a]	1		2					2
Overlook													
North	48	29	3	11	2[b]	5		3		1	1	1	2
South	56	38	3	24	1[c]	5			1	1	1		2
Tahkenitch													
North	74	56	17	27	4[d]	5					3		
South	0												
Tenmile													
North	34	22	1	15	1[e]			2		2			1
South	59	34	8	17	1[f]			1		1	1	1	4
Horsfall Beach	1	1											1
CBNS													
South Beach	48	39		5		17			1	1	3		12
South Spoil	38	31		21		6					3		1
HRAs	97	76	9	39	1[g]	22					2		3
Bandon SPMA	130	106		29	11[h]		16	3	1		5		41
New River HRA	14	12	2	6	3[i]								1
NR Other lands	18	13		3	4[j]		4						2
Floras Lake	1	0											
TOTALS	**694**	**515**	58	223	29	61	20	11	3	7	19	2	82

[a] – 1 coyote depredation
[b] – 2 coyote depredations
[c] - 1 coyote depredation
[d] – 4 coyote depredations
[e] – 1 coyote depredation
[f] – 1 coyote depredation
[g] – 1 coyote depredation
[h] – 6 fox depredations, 1 opossum depredation, 4 skunk depredations
[i] – 2 fox depredations, 1 skunk depredation
[j] - 3 fox depredations, 1 skunk depredation

Table 8. Number of Snowy Plover broods sampled, brood success, and fledging success based on sample along the Oregon coast, 2016.

Site Name	# of broods in sample	% brood success	# of eggs hatched in sample	# of fledglings from sample	% fledging success
Sutton Beach	1	100%	2	1	50%
Siltcoos:					
North Siltcoos	4	50%	11	3	27%
South Siltcoos	11	91%	30	17	57%
Overlook					
North Overlook	17	88%	44	29	66%
South Overlook	13	69%	34	12	35%
Tahkenitch					
North Tahkenitch	18	78%	50	24	48%
South Tahkenitch	0	-		-	-
Tenmile:					
North Tenmile	11	82%	26	11	42%
South Tenmile	20	70%	50	23	46%
Coos Bay N. Spit					
South Spoil	6	83%	17	9	60%
South Beach	6	83%	15	8	53%
HRA	13	62 %	33	12	36%
Bandon SPMA	22	36%	59	12	20%
New River					
HRA	2	50%	5	2	40%
Other lands	5	80%	15	5	33%
Floras Lake	1	100%	3	1	33%
Total	**150**	**71%**	**394**	**169**	**43%**

Table 9. Total number of young fledged from select sites on the Oregon Coast 2000-2016, includes fledglings from broods from undiscovered nests.

Site Name	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
SU	3	0	0	0	0	0	0	0	0						1	3	2
SI:																	
North	0	0	0	0	7	2	11	7	5	8	4	4	1	2	0	4	3
South	7	0	0	2	5	7	7	4	3	11	4	8	16	4	9	25	19
OV:																	
North	5	1	2	3	3	5	8	12	3	7	12	27	22	3	18	26	33
South	0	1	0	0	3	2	0	1	0	2	7	23	27	0	25	39	16
TA:																	
North	2	4	1	3	6	8	5	2	0	1	3	20	26	9	25	49	28
South	3	4	5	2	0	0	0	0	0					3	0	0	
TM:																	
North	0	0	3	1	3	6	12	13	3	2	3	1	5	15	35	26	14
South	5	4	3	9	9	5	7	14	6	19	13	5	5	8	27	21	25
CBNS:																	
SS	3	4	2	7	13	9	11	7	17	4	2	6	10	2	14	13	9
SB	0	1	1	3	0	8	1	10	7	17	13	22	16	18	28	24	12
HRAs	6	6	8	14	22	6	19	9	16	10	5	28	34	3	49	46	12
CBNS																51[a]	
BSPMA																	
BB	0	1	0	4	16	11	12	13	2	6	6	16	11	8	12	12	8
NR spit	0	0	0	1	10	0	3	12	2	1	0	5	1	14	22	19	6
NR HRA	1	3	3	7	5	1	7	16	7	17	12	7	4	12	3	10	4
NR other	4	3	3	4	6	8	7	4	2	2	0	0	0	3	6	2	5
FL	3	0	0	0	0	0	0	0	0	0	0	0	2		2	0	1
Total	**43**	**32**	**31**	**60**	**108**	**78**	**110**	**124**	**73**	**107**	**84**	**172**	**180**	**104**	**276**	**370**[b]	**197**

[a] – fledglings that could not be assigned to a specific brood.

[b] – adjusted from 364 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 Snowy Plover fledglings/male (+/- standard deviation) on the Oregon Coast, 2004 – 2016.

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
’04-’16 mean	46.2 +/- 5.7	1.34 +/- 0.33

Table 11. Number of resident males, estimated number of fledglings, and number of fledglings per male on the Oregon Coast, 2016. 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	7	3	0.43
Siltcoos: North Siltcoos South Siltcoos	32	23	0.72
Overlook North Overlook South Overlook	58	58	1.00
Tahkenitch North Tahkenitch South Tahkenitch	38	29	0.76
Tenmile: North Tenmile South Tenmile	55	42	0.76
Coos Bay N. Spit South Spoil South Beach HRA	83	43	0.52
Bandon SPMA	53	13	0.25
New River HRA Other lands	 17 12	 3 5	 0.18 0.42
Floras Lake	1	1	1.00
Overall			x = 0.60 +/-0.09

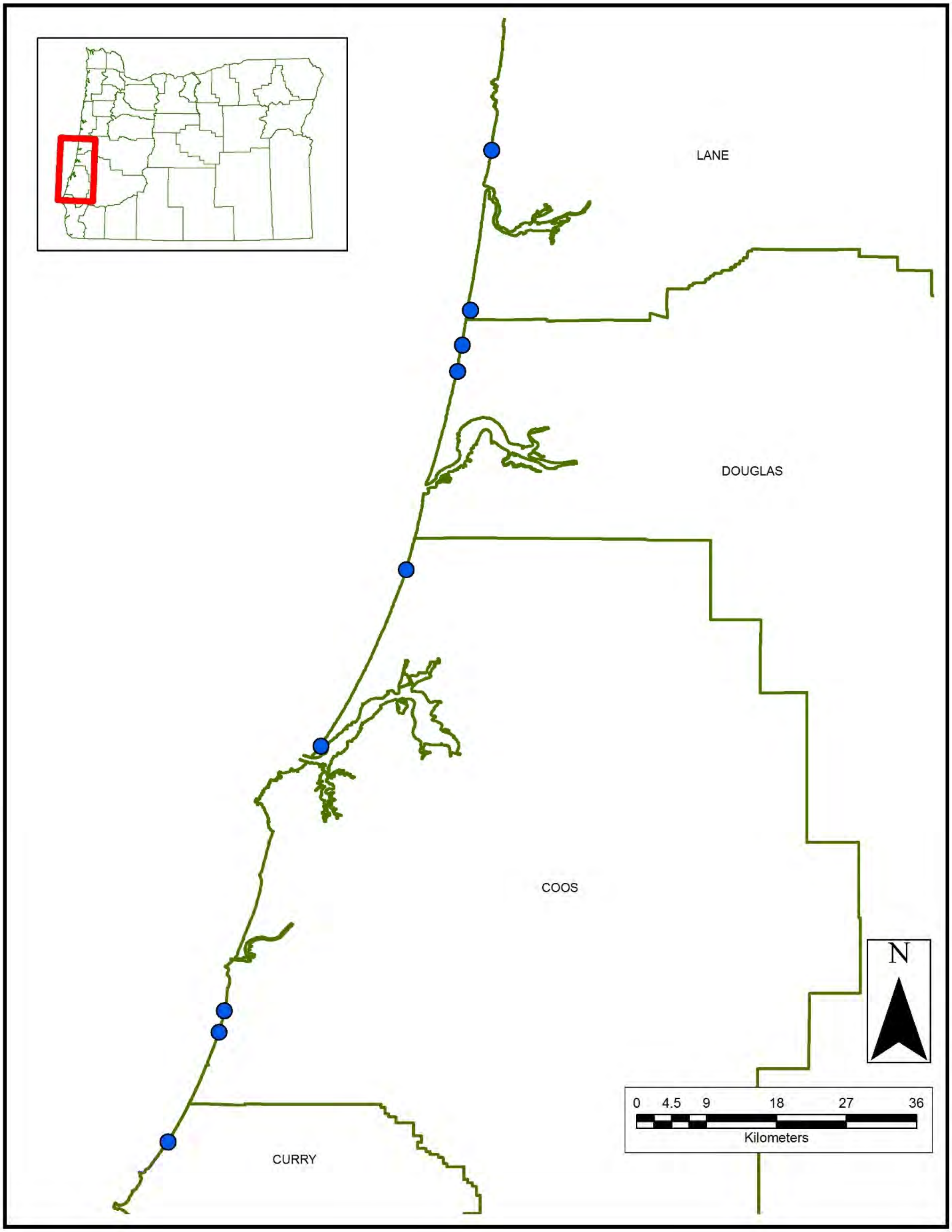


Figure 1. Snowy Plover monitoring locations along the Oregon coast, 2016.

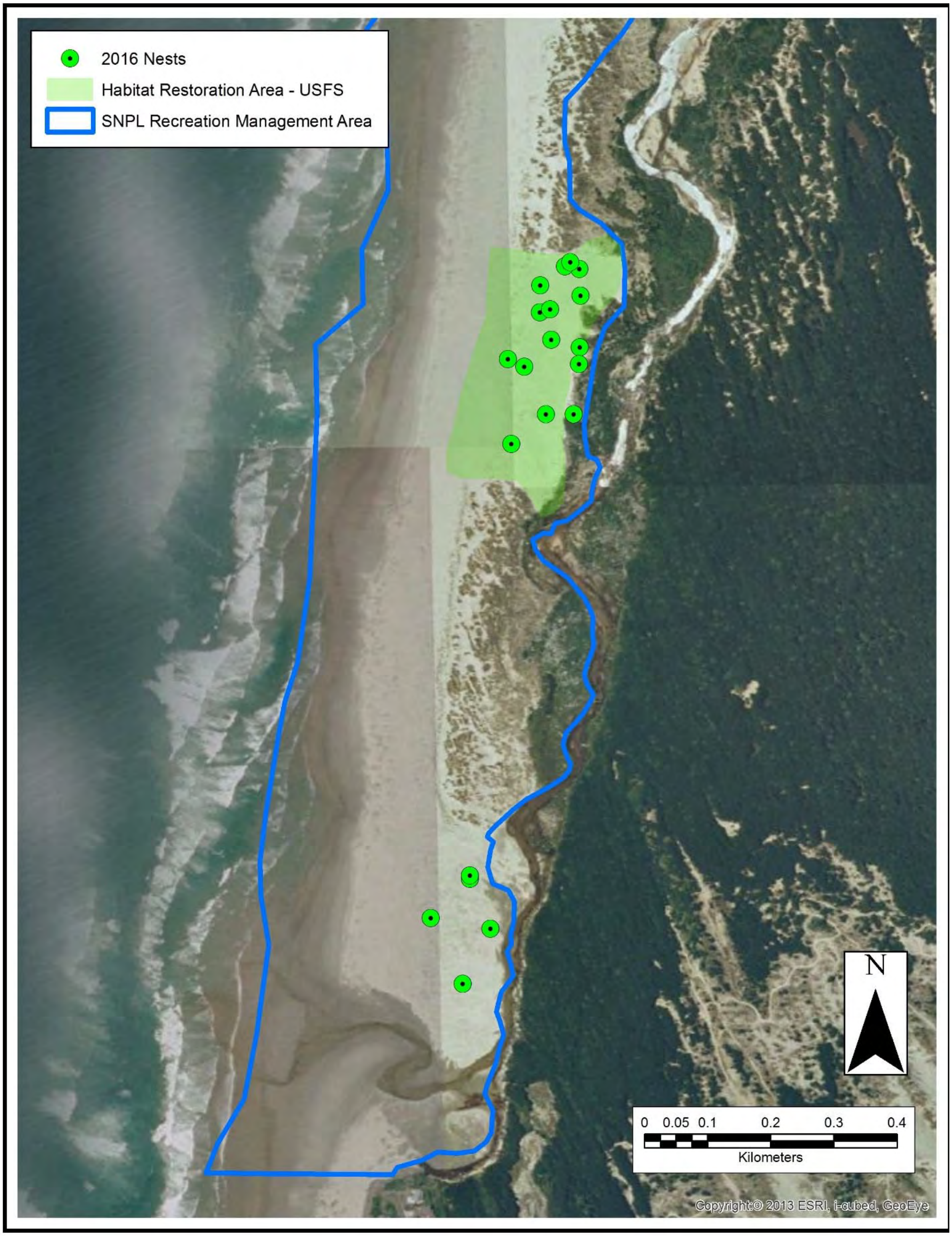


Figure 2. Snowy Plover nest locations at Sutton Beach, Oregon, 2016.

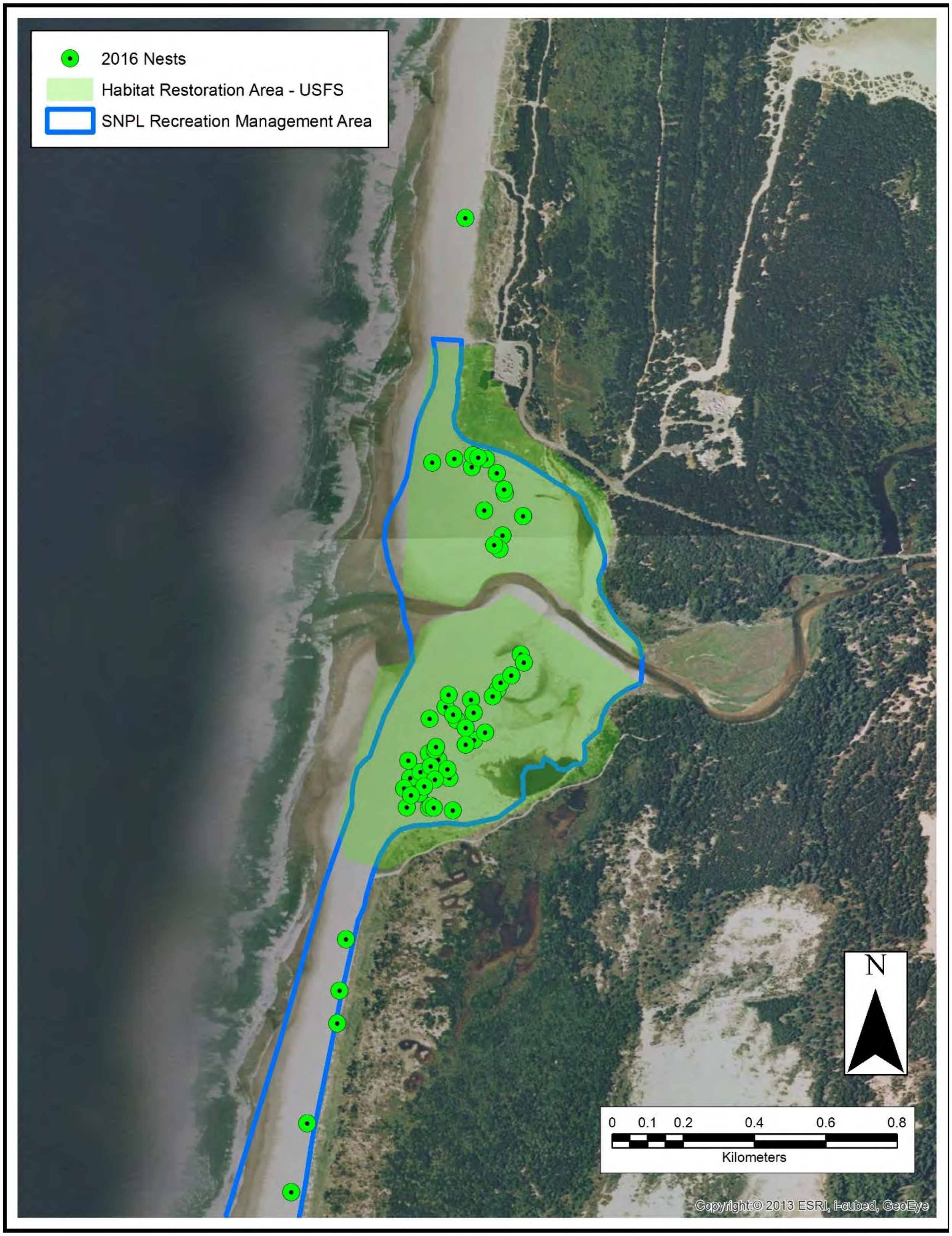


Figure 3. Snowy Plover nest locations at Siltcoos Estuary, Oregon, 2016.

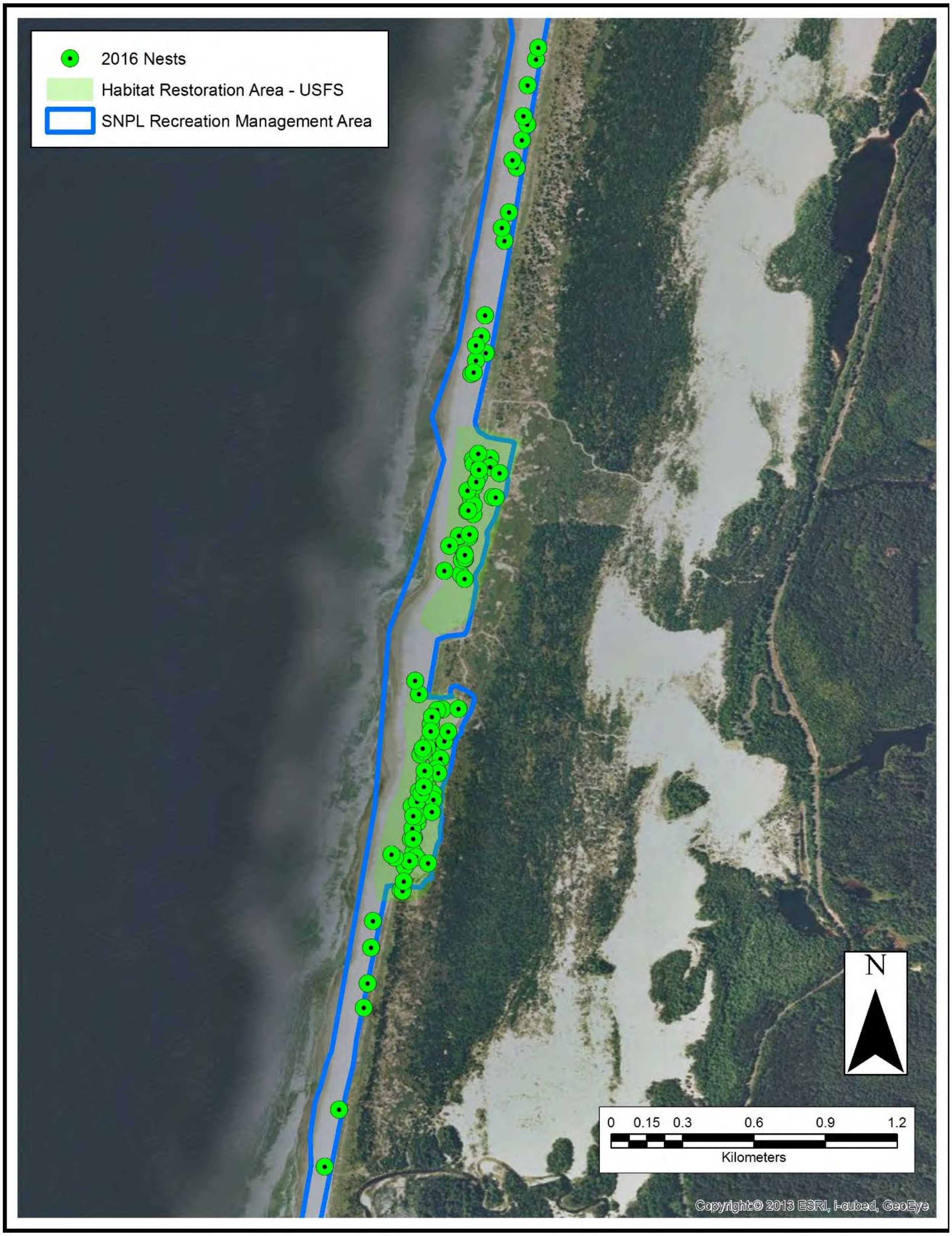


Figure 4. Snowy Plover nest locations at Dunes Overlook, Oregon, 2016.

Figure 5. Snowy Plover nest locations at Tahkenitch Creek, Oregon, 2016.

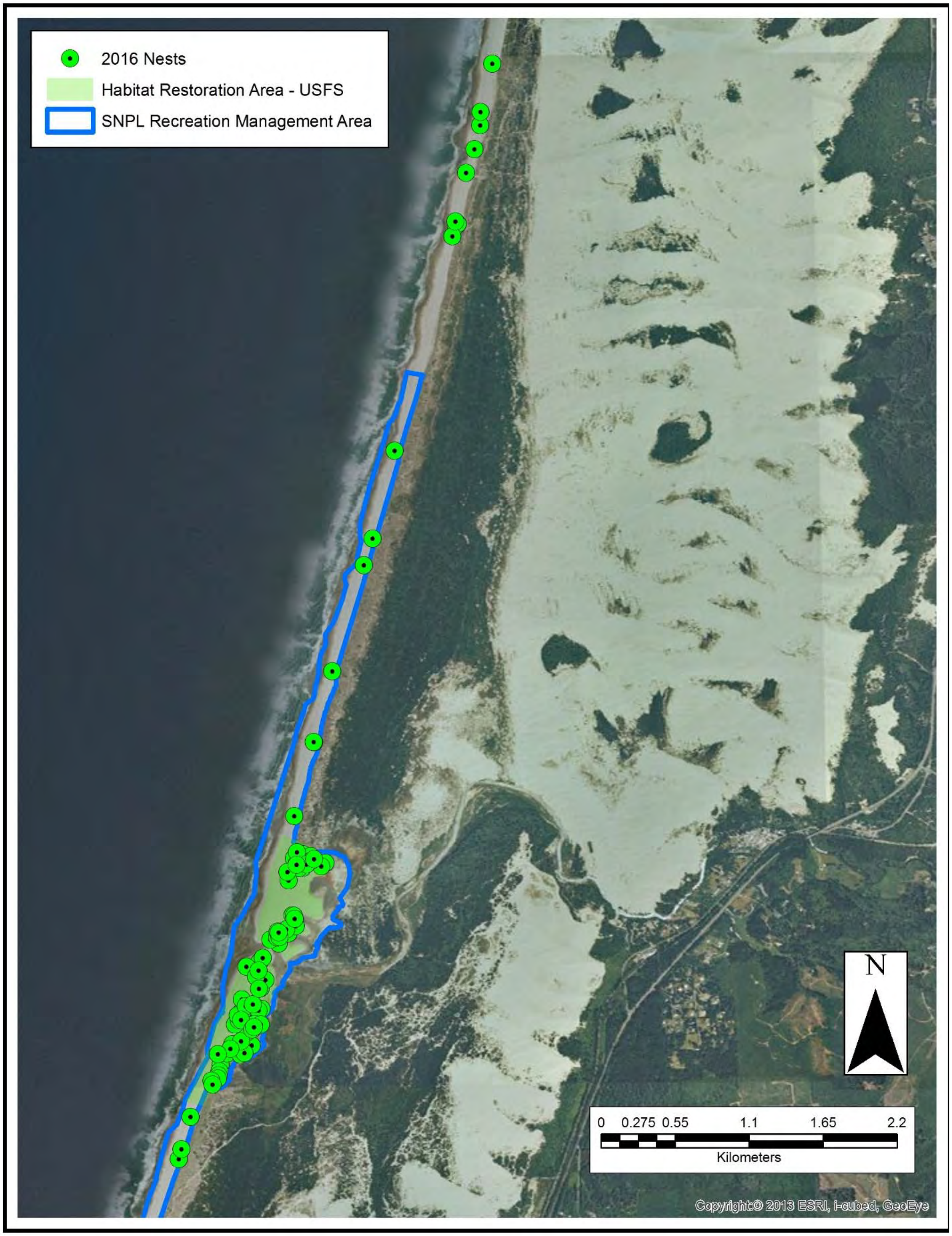


Figure 6. Snowy Plover nest locations at Tenmile Creek, Oregon, 2016.

Figure 7. Snowy Plover nest locations at North end of Coos Bay North Spit, Oregon, 2016.

Figure 8. Snowy Plover nest locations at Coos Bay North Spit, Oregon, 2016.

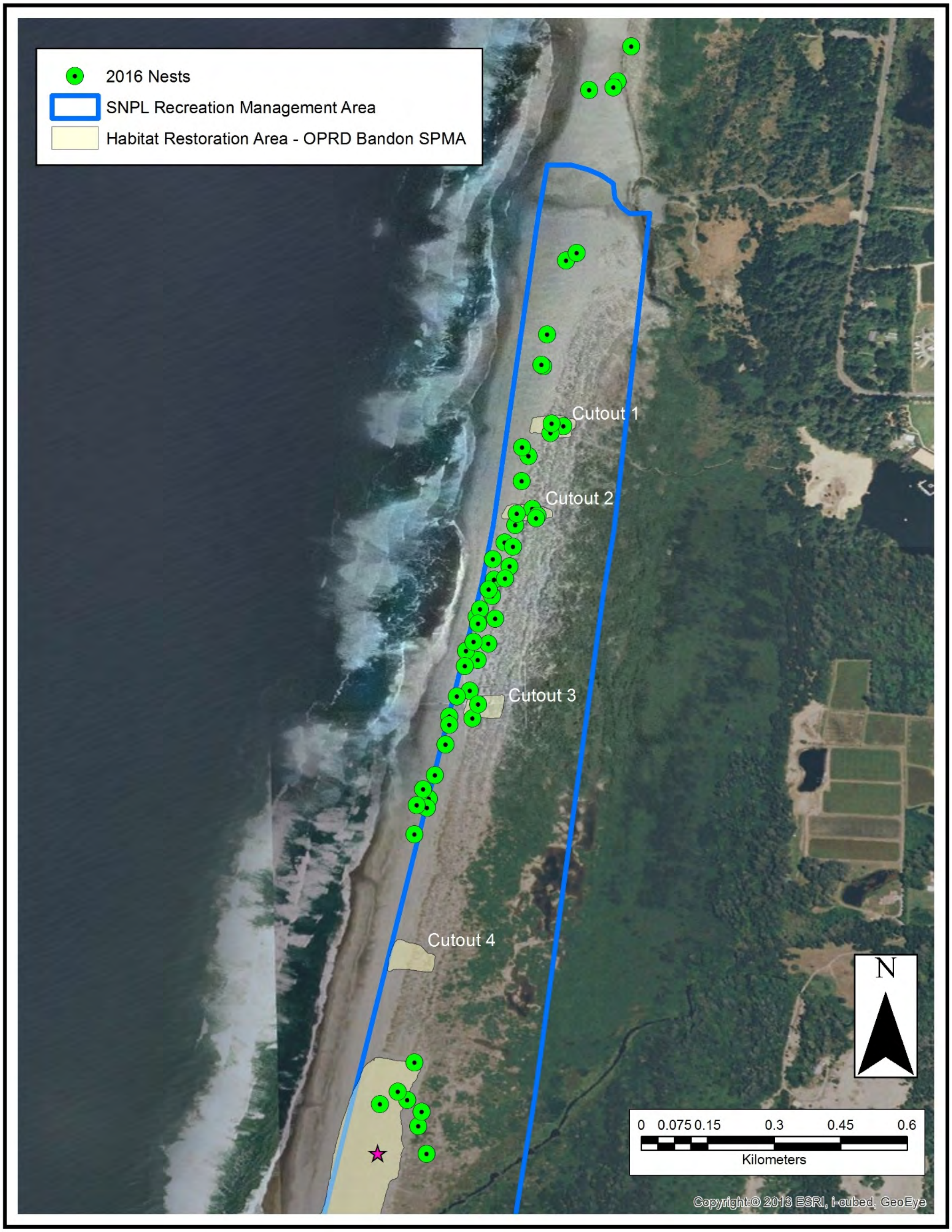


Figure 9. Snowy Plover nest locations at Bandon Beach, North of the New River mouth, Oregon, 2016.

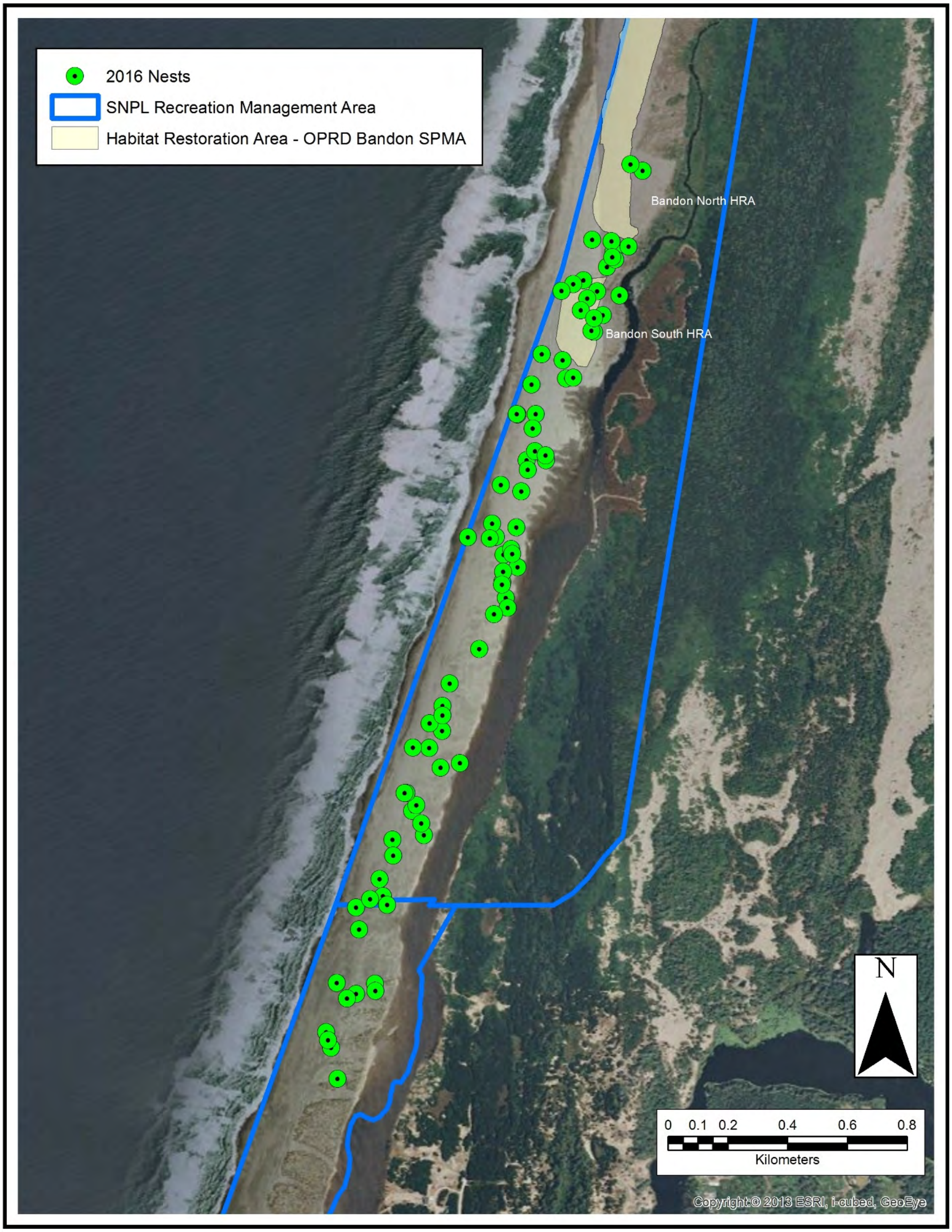


Figure 10. Snowy Plover nest locations on New River Spit, South of river mouth, Oregon, 2016.

Figure 11. Snowy Plover nest locations at New River HRA, Oregon, 2016.

Figure 12. Snowy Plover nest locations at Floras Lake, Oregon, 2016.

Figure 13. Number of active Snowy Plover nests within 10-day intervals on the Oregon coast, 2016. Dashed lines represent +/- 2 standard deviations.

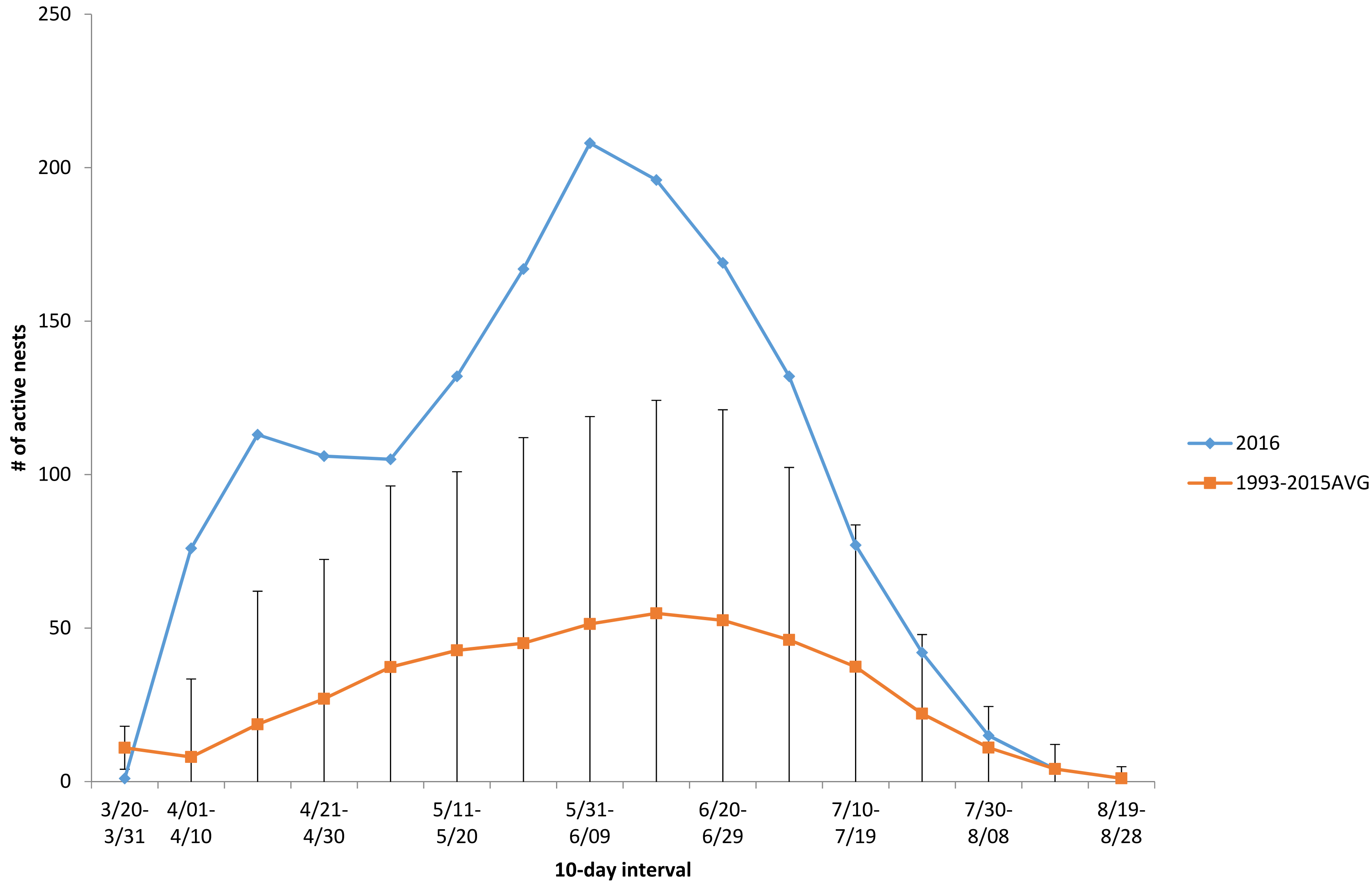


Figure 14. 2016 hatch rate, mean pre predator management hatch rate, and mean post predator management hatch rate for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

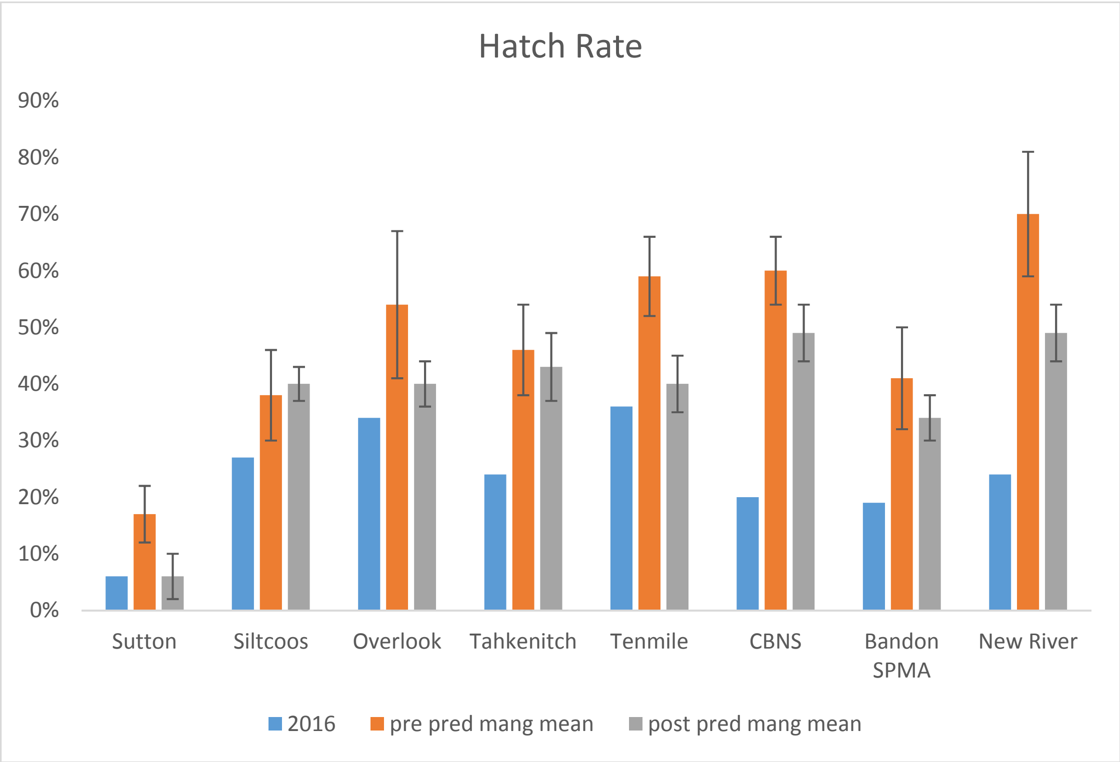


Figure 15. 2016 fledge rate, mean pre predator management fledge rate, and mean post predator management fledge rate for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

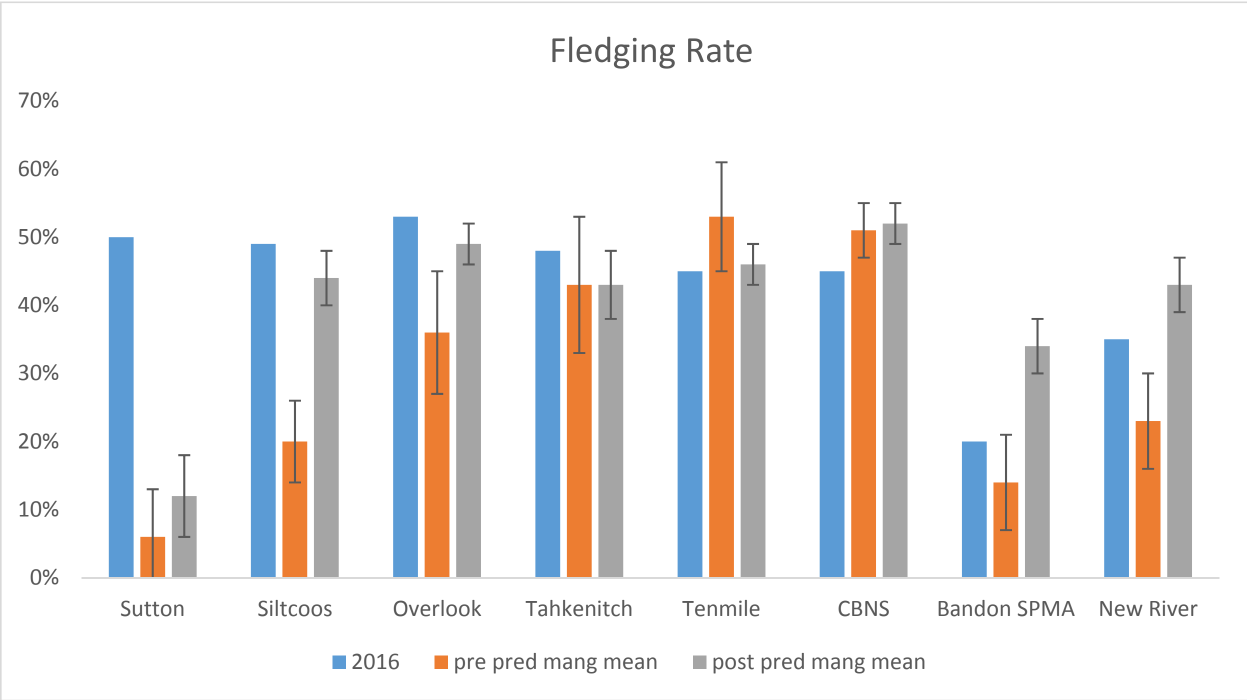


Figure 16. 2016 fledglings per male, mean pre predator management fledglings per male, and post predator management fledglings per male for Sutton, Siltcoos, Overlook, Tahkenitch, Tenmile, CBNS, Bandon SPMA and New River, Oregon coast, with standard error bars.

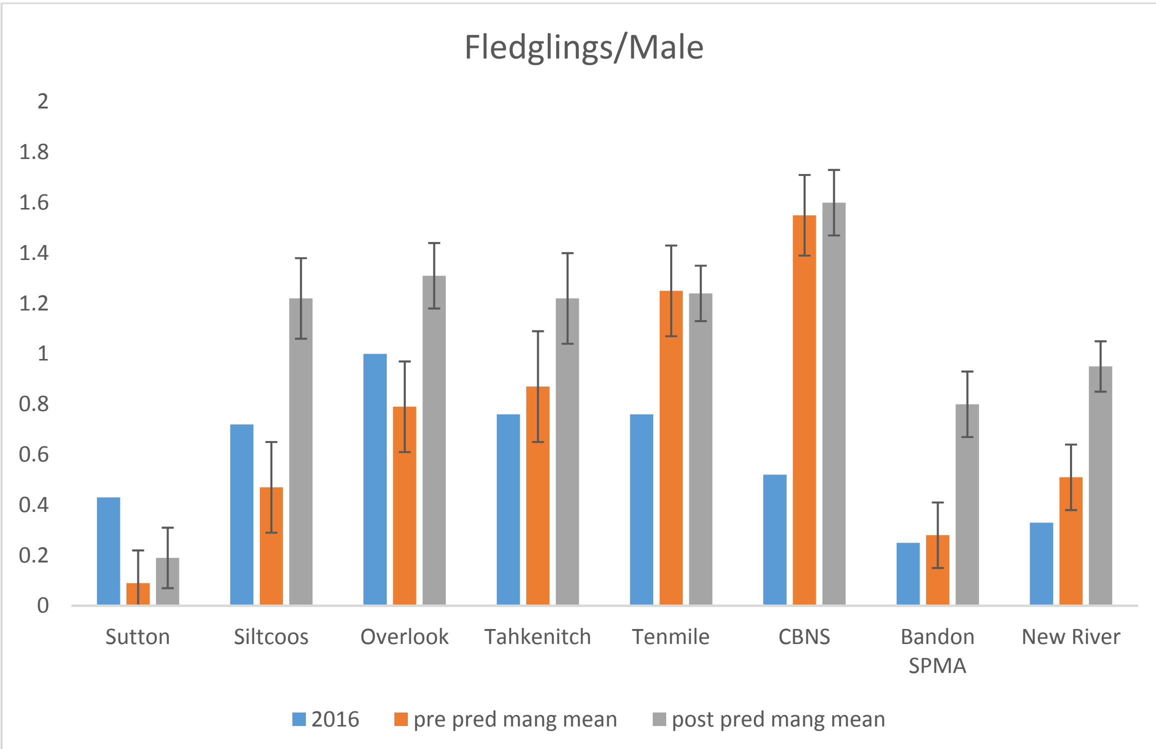
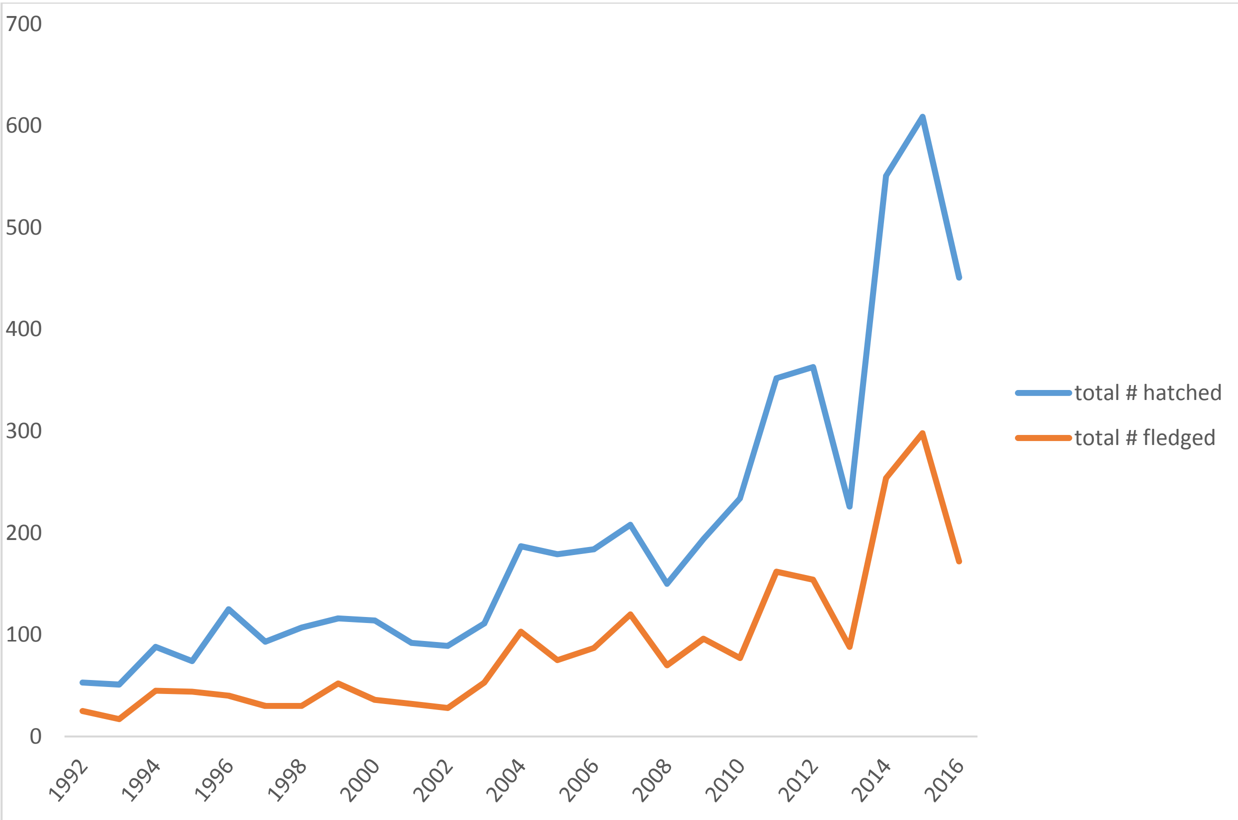


Figure 17. The number of eggs hatched and the number of fledglings on the Oregon coast, 1992-2016.



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. (Figure 6). 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 7 & 8): 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 9 & 10): 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. (Figures 10 & 11): 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 12). 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 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 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 1. Ten-day intervals used to determine brood sample in 2016. 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 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 1 shows that estimates of the number of fledglings derived from this example closely track the observed number of fledglings.

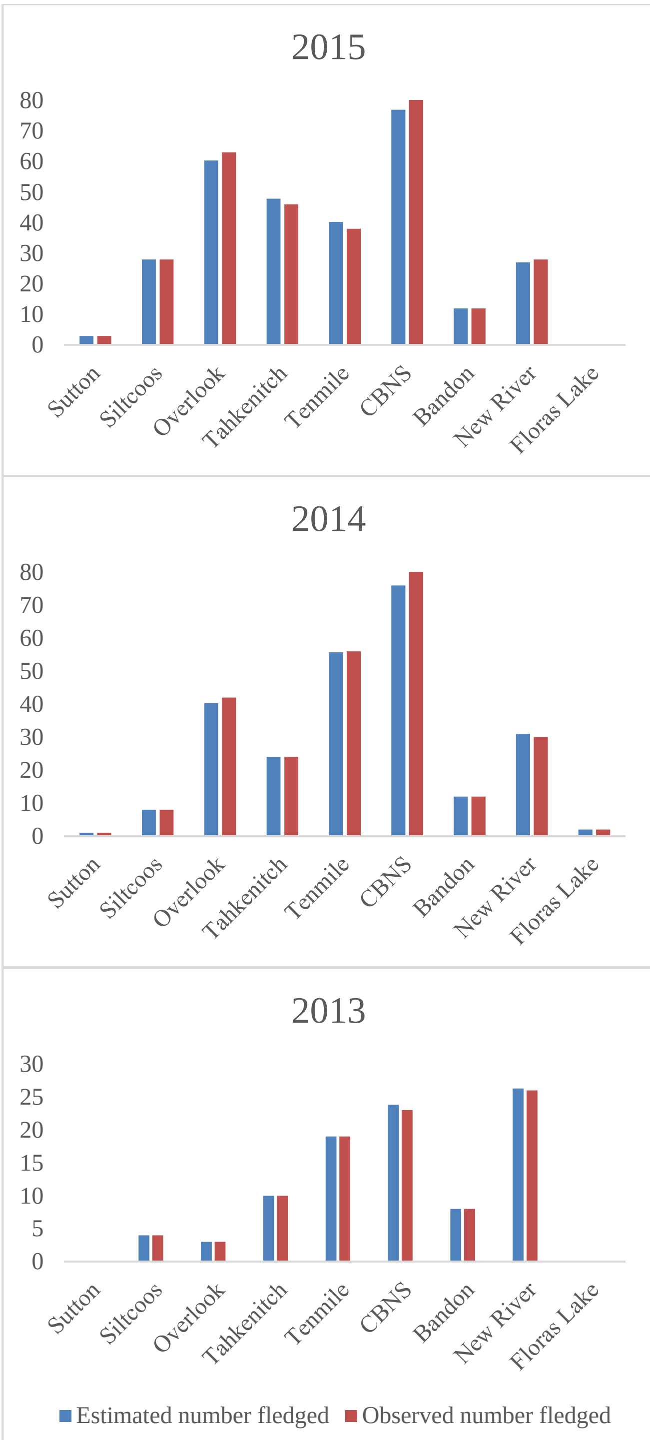


Figure 1. Comparison of estimated number of fledglings from sample to observed data for 2013 – 2015.

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 error (Table 2).

Table 2. Data used to calculate estimated number of fledglings by site in 2016.

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	3	1	100%	2	1	50%	1.00	1.00	7	3	0.43
Siltcoos:											
N. Siltcoos	4	4	50%	11	3	27%	0.75	1.33	32	23	0.72
S. Siltcoos	13	11	91%	30	17	57%	1.55				
Overlook											
N. Overlook	21	17	88%	44	29	66%	1.71	1.37	58	58	1.00
S. Overlook	21	13	69%	34	12	35%	1.00				
Tahkenitch											
N. Tahkenitch	22	18	78%	50	24	48%	1.33	1.33	38	29	0.76
S. Tahkenitch	0										
Tenmile:											
N. Tenmile	13	11	82%	26	11	42%	1.00	1.10	55	42	0.76
S. Tenmile	25	20	70%	50	23	46%	1.15				
Coos Bay N. Spit											
South Spoil	7	6	83%	17	9	60%	1.50	1.16	83	43	0.52
South Beach	9	6	83%	15	8	53%	1.33				
HRA	21	13	62 %	33	12	36%	0.92				
Bandon SPMA	24	22	36%	59	12	20%	0.55	0.55	53	13	0.25
New River											
HRA	3	2	50%	5	2	40%	1.00	1.00	17	3	0.18
Other lands	5	5	80%	15	5	33%	1.00		12	5	0.42
Floras Lake	1	1	100%	3	1	33%	1.00	1.00-	1	1	1.00
TOTALS	**192**	**149**	**70%**	**391**	**168**	**43%**					x = 0.60 +/-0.09

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).