Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2016

Least Terns (left) and Snowy Plovers (right) breeding at Vandenberg Air Force Base

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Executive Summary

Vandenberg Air Force Base (VAFB) contains approximately 13.8 linear miles of important coastal breeding habitat for the state and federally endangered California least tern (*Sternula antillarum browni*) and federally threatened Pacific coast population of the Western snowy plover (*Charadrius nivosus nivosus*). The California least tern is a small colonial seabird that breeds along the Pacific Coast. VAFB manages a least tern colony at Purisima Point, one of only two colonies between Monterey Bay and Point Conception. The Purisima Point least tern colony has been monitored annually since 1995. The Western snowy plover is a shorebird that breeds on coastal beaches from northern Washington to southern Baja California, Mexico. VAFB manages a breeding population of snowy plovers that is dispersed throughout much of the 13.8 miles of coastal beach habitat. The breeding population of snowy plovers has been monitored annually at VAFB since 1993. Staff at Point Blue Conservation Science monitored breeding least terns and snowy plovers at VAFB in 2016. This report summarizes least tern and snowy plover monitoring results from the 2016 breeding season within the context of VAFB's approximately 23-year time series for both species.

<u>California Least Tern</u>

The Purisima Point colony was visited at least five times a week throughout the breeding season. We first observed least terns at the colony on 2 May, which is the earliest arrival date since 2003. Adult colony attendance increased quickly and remained consistent through the egg laying and incubation period. We estimate the 2016 breeding population to be 25 pairs which is 14% larger than 2015, but still well below the 22-year mean. However, the 2016 breeding season showed average productivity (breeding success was 0.72 fledglings per breeding pair). Hatching success (78%) and fledging success (47%) were above or near the 22-year mean (63% and 45% respectively).

The Purisima Point least tern colony continues to be characterized by years of anomalously high and low reproductive success, with very few years consistent with the 22-year mean. Breeding productivity has been mostly above average since 2007, with two years of average to below average productivity (2011 and 2012). Despite warm water conditions that developed late in 2014 and an El Niño event that developed during 2015,

least terns breeding at Purisima Point have continued to have above average reproductive success. Our past studies of least tern diet at the Purisima Point colony have shown that least tern breeding productivity is highest when age 1 northern anchovy (*Engraulis mordax*) and/or young-of-the-year rockfish (*Sebastes* sp.) dominate the diet. Abundance of both species is closely tied to oceanographic conditions. Rockfish were abundant in the 2014 least tern diet and likely contributed to the above average reproductive success that year. We were unable to investigate least tern diet in 2015 and 2016, but suspect that rockfish were again abundant given the above average least tern reproductive success.

<u>Western Snowy Plover</u>

The number of breeding snowy plovers observed and nests initiated in 2016 (289 and 385, respectively) was 6% and 12% lower, respectively, than observed in 2015. We attribute these decreases to loss of breeding habitat due to strong winter storms. A strong El Niño event developed in late 2015 and peaked during the 2015/2016 winter. El Niño events raise the sea level along the California coast and create strong winter storms. Higher sea level and stronger storms lead to higher erosion of beach habitat. Despite these decreases, both metrics were higher than the long term mean (adults = 234.7, nests = 317.3). Clutch hatch success and fledging success were similar to the long term mean for North and South Beaches, though clutch hatch success and fledging success was lower than the long term mean for Purisima Beaches. We attribute the average clutch hatch success in 2016 to effective predator management, and the presence of the contoured restoration sites on South Base. Predators accounted for 58% of nest losses in 2016 compared to 24% in 2015, 34% in 2014, 20% in 2013, 37% in 2012, and 52% in 2011. Due to effective raven management at VAFB, raven predation has decreased in recent years. Ravens took 18% of nests in 2011, 16% of nests in 2012, <1% of nests in 2013, <4% in 2014, 1% in 2015, and 6% in 2016.

Efforts to manage human activities at VAFB appear to be successful. Areas closed to recreational beach access have shown increased nesting effort and clutch hatch success when compared to adjacent open beach areas. Additionally, nesting effort base-wide has increased since closures were established in 2000. Overall, the time series data suggest that large scale processes (e.g., environmental variability) are governing breeding effort and fledging success, while more localized factors (e.g., predation) are governing clutch hatch success at VAFB. Additionally, we found a positive correlation with annual base-wide fledging success and the amount of wrack deposited on Surf North and Wall beach sectors, indicating that these sites may provide a significant prey resource for chicks hatching on both north and south base. These results suggest that management of the snowy plover population on VAFB needs to occur at both base-wide and localized spatial scales, focusing on predators that are significantly impacting local beach sectors while using environmental and oceanographic information to manage VAFB's coastal ecosystem.

Chapter 1: Monitoring and Management of the California Least Tern on Vandenberg Air Force Base, 2016

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Introduction

The California least tern (*Sternula antillarum browni*, least tern) is a small, colonial seabird that breeds along the Pacific Coast from San Francisco Bay, California to Bahia de San Quintin, Baja California, Mexico (Thompson *et al*. 1997). Loss of breeding habitat due to coastal development and increased use of coastal beaches in the 1950s and 1960s led to a decline in breeding population, resulting in their listing under the Endangered Species Act as federally endangered on October 13, 1970 (35 Federal Register 16047). Management in support of recovery has focused on providing secure breeding habitat and predator control. This has proven successful as the population has increased from <700 pairs prior to its federal listing to >7,000 pairs reported for the 2006 breeding season (Marschalek 2007). The population has since declined and has remained between 4,000 and 5,000 pairs since 2010 (Frost 2015). Much of the species' recovery has occurred on military lands (Naval Base Coronado and Marine Corps Base Camp Pendleton) where habitat has been protected from development and the species is actively managed.

Vandenberg Air Force Base (VAFB) resides in northern coastal Santa Barbara County, between two major faunal transitions: Monterey Bay and Point Conception (Hayden and Dolan 1976). While the majority of the least tern population breeds south of Point Conception, there are two currently active breeding colonies within the Monterey/Conception faunal zone (Frost 2015). These colonies are located at the Oceano Dunes State Vehicular Recreation Area and VAFB (Purisima Point)**.** The Monterey/Conception faunal zone portion of the California coastline experiences exceptionally strong, but highly variable upwelling events (Wing *et al.* 1998, Bograd *et al.* 2000). Thus, there is much interannual fluctuation in biological productivity and food web structure, with resulting fluctuations in the size and reproductive performance of breeding seabird populations (Boekelheide and Ainley 1989, Ainley *et al.* 1994, Ainley *et al.* 1995).

Historically, least terns have bred at various locations along the north VAFB coastline from San Antonio Creek to the Santa Ynez River estuary, an area spanning 10 km (Figure 1). Since 1978, least terns have used the Purisima Point colony site on a regular basis (Schultz and Applegate 2000). No data were collected on least tern breeding efforts at VAFB prior to 1978. In addition to the Purisima Point colony, least terns have bred at the Beach 2 colony (see Figure 1) during six breeding seasons between 1990 and 2003 with populations ranging from one to 15 pairs.

The Purisima Point colony consists of sparsely vegetated dune habitat atop a coastal bluff. The historic least tern breeding area is surrounded by electric fences along its northern, eastern, and southern boundaries (see Figure 3). The colony has been characterized by a small population (especially when considering the amount of available breeding habitat) and variable annual productivity (Robinette and Howar 2009). The mean ± standard deviation (SD) number of breeding pairs per year at Purisima Point from 1995 to 2016 was 29.95 ± 19.17 (n=22) with a peak of 79 pairs in 2003. The mean ± SD productivity from 1995 to 2016 was 0.63 ± 0.46 fledglings per pair (n=22) with a peaks of 1.32 in 2001 and 2015. Productivity appears to alternate between above average and below average in brief, three to four year periods. The period from 1995 to 1997 showed below average productivity (ranging from 0.08 to 0.27 fledglings/pair) and was followed by above average productivity from 1998 to 2002 (ranging from 0.6 to 1.32 fledglings/pair) with the exception of 0.39 fledglings/pair produced in 2000 which was below the 22-year average. The period from 2003 to 2006 was again lower than the 21-year average (ranging from 0.0 to 0.4 fledglings/pair). This three year period had the worst productivity on record (<0.02 fledglings/pair); producing only one fledgling during the entire three year period. Another period of above average productivity has occurred since 2007 (ranging from 0.89 to 1.32 fledglings/ pair) with only one year of below average productivity (2011).

Despite the return to productive conditions, the Purisma Point breeding population has decreased in recent years. In order to further the recovery of least terns at VAFB – a goal put forth by the Endangered Species Act and a prerequisite for delisting - it is important to understand the causes of variable productivity at the colony as this variability can have an impact on colony population growth (Burger 1984).

One of the most important factors regulating seabird colony productivity is local prey availability. Prey availability has been shown to affect coloniality (whether birds form large or small colonies), the timing of reproduction, clutch sizes, levels of egg abandonment, chick growth, and non-predator related chick mortality (Anderson and

Gress 1984, Safina and Burger 1988, Pierotti and Annetti 1990, Massey *et al.* 1992, Ainley *et al.* 1995, Monagham 1996, Golet *et al.* 2000). Changes in prey availability can be detected in various aspects of a seabird's biology, including diet, chick provisioning rates, and foraging behavior (Ainley *et al.* 1995, Monagham 1996, Golet *et al.* 2000). Past monitoring efforts at many least tern colonies in California have neglected these aspects of least tern biology. Perhaps this is because there is little resource managers can do to change prey availability (as opposed to predation, which can be controlled to a certain extent). However, if increasing productivity is a management goal, it is important to have an understanding of how different factors affect colony productivity relative to one another.

Another cause of low productivity at least tern colonies is predation. Least terns are prey for many mammalian and avian predators. An efficient predator can take up to 80% of the eggs and chicks at a least tern colony (Thompson *et al.* 1997). Productivity at small colonies, such as the one at Purisima Point, can be completely destroyed by a single predator. At VAFB, the mammalian predator that causes the most concern is the coyote (*Canis latrans*), which can prey on eggs, chicks, and adults. Avian predators that cause concern at VAFB include northern harriers (*Circus cyaneus*), American kestrels (*Falco sparverius*), loggerhead shrikes (*Lanius ludovicianus*), and great-horned owls (*Bubo virginianus*) that nest close to the least tern colony. Kestrels, harriers, and shrikes are efficient chick predators while owls take mostly adults. In recent years, there has been an increase in common raven (*Corvus corax*) sightings along the coast of VAFB. The first raven sighting at the Purisima Point colony occurred in 2010. If ravens become more common at VAFB, they have the potential to become a major threat to the least tern colony as they are efficient predators of least tern eggs and chicks. Ravens are currently a major management concern for the threatened Western snowy plover (*Charadrius alexandrinus nivosus*), a bird with similar nesting habits as the least tern. Ravens depredated 18% of known-fate plover nests at VAFB in 2011 (Ball and Robinette 2011) and 6% in 2012 (Ball and Robinette 2012).

An important goal of the VAFB natural resource program is to promote the growth of the least tern colony at Purisima Point while maintaining the health of the surrounding ecosystem. Non-lethal predator management is used whenever possible. To accomplish this, VAFB established a least tern management team that included members from two organizations in 2016: ManTech SRS Technologies Inc. (ManTech) and Point Blue Conservation Science (Point Blue). ManTech was responsible for mammalian and avian predator management. The first line of defense against mammalian predators at VAFB is a series of fences erected around the least tern management area. Five-foot tall electric fences form the northern, southern, and eastern boundaries of the management area, with an additional six-foot tall chain link fence along the eastern boundary. Fences are not needed along the western boundary of the colony as this section of coastline consists of coastal bluffs inaccessible to terrestrial mammals. Funding for the management team to maintain these fences throughout the breeding season is provided by VAFB. Avian predator management includes monitoring, trapping and removal of corvids, raptors and owls that were determined to be a threat to the least tern colony. All members of the management team monitor avian predators while at the colony. Point Blue was subcontracted through the Santa Barbara Botanic Gardens in 2016 and is responsible for monitoring breeding activities at the least tern colony (under permit TE – 807078-15.5) and reporting to all members of the management team about the colony's status throughout the season. Point Blue monitors colony productivity as well as predator sign and disturbances to the colony. In prior years, Point Blue conducted studies on the foraging habits and diet of the least terns to assess environmental effects on colony productivity. Point Blue also tracked oceanographic conditions to better understand annual variability in prey availability and ocean productivity. The results of these studies are summarized in Robinette et al. (2015) and have been used to guide the adaptive management of the Purisima Point least tern colony.

The timing of predation events can be just as important to productivity as the number of predators in the vicinity of the colony. Least tern colonies are most vulnerable to predation shortly after chicks begin to hatch. About two days after hatching, least tern chicks leave their nest scrapes and begin running freely around the colony site. Some chicks may move hundreds of meters away from their original nest site (Massey 1972, Minsky 1987, Thompson *et al.* 1997). During this time, it is important that chicks have areas of cover to protect them from inclement weather (heat and cold) as well as predators. At many colonies, cover is found in the form of small clumps of vegetation or debris on the colony (Minsky 1987). However, at the Purisima Point colony, there is very little vegetation (or debris) and very few places for least tern chicks to hide. To remedy this, teepee style chick shelters were developed (see Figure 2) following the design in Jenks-Jay (1982). The chick shelters were designed to protect least tern chicks against predation by American kestrels and Northern harriers and have proven to be effective at an Eastern least tern (*Sternula antillarum antillarum*) colony on Nantucket Island, Massachusetts (Jenks-Jay 1982). Forty-five of these shelters were built and installed on the Purisima Point colony in 2001 and 2002. The original chick shelters have been maintained, but unexploded ordnance restrictions in place between 2011 and 2012 prevented the installation of fence posts needed to secure the shelters. We therefore tested a new V-shaped design in 2011 that does not require fence posts (see Figure 2). Both designs will continue to be used to determine whether least tern chicks prefer one design over the other. Though chicks and fledglings at the Purisima Point colony appear to prefer natural vegetation for cover, many of the chick shelters receive use each year and are considered a worthy management tool (Robinette et al. 2004).

The least tern monitoring program was a requirement of the terms and conditions section of the Biological and Conference Opinion (BO) for Delta II Launch Program at Space Launch Complex 2 (SLC 2) and Taurus Launch Program at 576E (1-8-98-F-25R, 11 January 1999) and as part of the Proposed Action of the Biological and Conference Opinion for the Atlas Program (SLC 3, 1-8-99-F/C-79). The SLC 2 BO requires the determination of population trends and reasons for decline as well as enhanced predator management activities looking at populations and behavior of predators in the vicinity of Purisima Point. Subsequently, these BOs were superseded by the Vandenberg Air Force Base Programmatic Biological Opinion (8-8-09-F-10) and management of the California least tern was incorporated into the BO on the Beach Management Plan and Water Rescue Training (8-8-12-F-11R) that includes similar measures.

Methods

Site Preparation

The Purisima Point least tern colony is bordered by a coastal bluff to the west and electric fences on the north, east, and south. All three fences were electrified on or before

15 April. Once the fence was electrified, the voltage was checked during every visit to the colony. This ensured that voltage was measured at various times throughout the day. Special attention was given to voltage readings taken at dawn as voltage tends decline overnight. Voltage was maintained at 3.0 kV or greater and on most days voltage was greater than 5.0 kV. Based on prior experience and recommendation of VAFB's fence contractor, 3.0 kV is recommended as the minimum voltage to exclude coyotes. In addition, Point Blue placed a total of 44 V-shaped chick shelters in areas where nesting occurred within the colony in 2011-2016. The V-shaped chick shelters do not require the use of fence posts. Rather, they are a simple design of two 2-foot long pieces of 2"x 8" wood nailed together at a right angle (see Figure 2). The result is a standalone triangle that lays low to the ground. As such, the new shelters have the risk of being buried by wind-blown sand and will are stored off-colony during winter months. Additionally, Point Blue repaired the existing 45 teepee-style shelters. Figure 3 shows the 2016 placement of the 44 V-shaped shelters and 45 teepee shelters. Shelters were placed mostly on the south and west colony in areas where shelters were used by chicks in 2013 and 2014. There were very few nests in the northern and eastern areas of the colony in those years and we did not find evidence that chicks were using shelters in these areas.

Site Monitoring

Monitoring was conducted in a manner to minimize disturbance or adverse effects to adult birds, nests, and chicks. From 14 April to 9 August, we visited the least tern colony at Purisima Point at least five days a week. Off-colony surveys are completed by making observations with binoculars and spotting scopes from six observation points (or OPs) along the perimeters of the Purisima Point colony. We recorded numbers of adults on the ground and flying in the vicinity of the colony. A total of 56 off-colony survey visits were conducted throughout the season. We did not enter the colony until the first nests were observed. We then continued to enter the colony on foot twice a week to record nest contents. We also entered the colony at times other than our weekly nest surveys in order to retrieve dead chicks or investigate predator tracks. We entered the colony a total of 28 times throughout the season. In addition, historical breeding sites on VAFB were monitored for potential least tern activity. In 2016, we did not observe least tern activity at historic sites and all least tern nests were located at the Purisima Point colony.

Once least terns began to nest, population estimates were made by documenting the number of active nests observed in the colony each day. All nests were monitored in the colony throughout the breeding season to determine nest fate. This allowed us to document second nesting attempts and overall colony site occupancy. As chicks began to hatch and leave nest sites, we began recording the numbers of chicks and fledglings observed during each survey. Visits to the colony were conducted until all chicks had fledged and dispersed. Surveys ended after no adults or fledglings were seen at the colony for three consecutive visits.

On-colony surveys were conducted using two researchers in the early morning when heat and wind were at a minimum. Each active nest site was marked with a tongue depressor placed one meter from the nest. Tongue depressors were placed facing the OP that would best facilitate observations during off-colony surveys. The number of eggs and chicks found in each nest were recorded, and any damaged or abandoned eggs and chick mortality was documented. All data collected on population and breeding biology were compared to past years.

The vicinity of the colony was monitored for predators during each visit. A predator was considered 'inside' the least tern colony if it was <100 m from areas where least terns nest. Thus, predators could penetrate the electric fence and still be considered 'outside' the colony so long as they did not come within 100 m of nest sites. All predator sightings (both inside and outside the colony) were recorded in a logbook located in a metal box at the colony entrance. This provided predator management personnel with the information needed to determine whether a given predator required removal. Additionally, all human- and predator-induced disturbances were recorded throughout the breeding season. A disturbance was defined as any event that caused adult least terns to flush from nesting or roosting areas.

Results

Breeding Phenology

Historically, least terns on VAFB have typically arrived during the last week of April or the first week of May (Table 1). However, from 2005 to 2013 least terns have arrived during the second week of May. This recent trend was broken in 2014, 2015 and 2016 with the first least terns observed on 6 May, 5 May, and 2 May, respectively. Additionally, least terns initiated nests on or after 14 June from 2004 to 2008. Prior to 2004, nest initiation typically began in mid to late May. This trend in late nesting appears to be reversing. In 2009, nest initiation was 10-20 days earlier than that observed during 2004-2008 with the first nest initiated on 4 June. First nests for 2010-2014 ranged from 25 May to 3 June. Nest initiation in 2015 began on 22 May, the earliest initiation date since 2003. The first and last nests of 2016 were initiated on 24 May and 15 July.

In productive years, least terns arrive early in the season and adult colony attendance increases rapidly. Colony attendance remains relatively high and stable throughout the egg laying and chick rearing periods and then both adults and fledglings gradually disperse from the colony (see Robinette et al. 2012). Figure 4 compares colony phenology in 2016 to that in 2015. Like 2015, the 2016 breeding season showed characteristics of a productive year with early adult arrival and colony attendance remaining high and consistent through the chick rearing period. The nest initiation and chick rearing periods were similar, though peaked later, to those observed in 2015, with the number of active nests peaking during the week of 12 June and the number of chicks peaking between 3 July and 10 July. There were two waves of nest initiation in 2016. The first wave occurred between 24 May and 10 June, with the majority of nests being initiated on or around 3 June. The second wave occurred between 17 June and 28 June with the majority of nests initiated on or around 17 June. One final nest was initiated on 15 July. Terns were last observed at the Purisima Point colony on 4 August in 2016 and on 21 August in 2015.

Small numbers of adult terns were observed foraging at the Santa Ynez River estuary between 2 May and 11 July. Fledglings began dispersing to the estuary the week of 24 July at which time adult and fledgling numbers decreased at the colony. Numbers of adults and fledglings observed at the estuary peaked during the week of 31 July and were gone by the week of 14 August.

This is the fourth season since 2004 that the terns used the estuary for an extended period (>1 month) before migrating south. In 2001 and 2004, adults used the estuary from the first week of July to the first week of August. Least terns briefly used the estuary in 2008 (six days) and 2009 (three days). The coastal sandbar at the river mouth often breaks prior to the breeding season, allowing the estuary to drain, though this is not a consistent phenomenon each year. The coastal sandbar has not broken since 2012 and the estuary has been full throughout the breeding seasons of 2013 through 2016. This may have contributed to an abundance of fish available to the least terns within the estuary in these years.

Population Dynamics

We documented a total of 27 nests at the Purisima Point colony during the 2016 breeding season (Table 2). Nineteen nests hatched all eggs and three nests hatched one egg but had one non-viable egg. One unhatched egg was taken to the Santa Barbara Museum of Natural History to determine whether it was viable. The egg showed no evidence of fertilization. Five nests were depredated by coyote, an unknown avian predator, or an unknown predator, in addition to one nest that lost one egg to an unknown predator, but hatched the remaining egg. We estimate renesting attempts by first identifying all failed nests and then identifying nests that were initiated within 60 m of the failed nests between four and 16 days (if failure was due to egg loss) or five and 12 days (if failure was due to chick loss) of the nests failing. Massey and Fancher (1989) noted that the time between nest failure and renesting was four to 16 days for egg loss and five to 12 days for chick loss. They also noted that least terns tend to renest in close proximity to their failed nest site, but did not define close proximity. We suspect there were two renesting attempts in 2016 and therefore estimate the 2016 breeding population to be 25 breeding pairs. This represents a 14% increase in population compared to 2015 and a 10% decrease below the 22-year mean population (30 pairs). As with 2015, most nests in 2016 were located in the southwest portion of the colony and seven nests were located in the central colony (Figure 3). There were no new areas being used by nesting least terns in 2016.

Breeding Biology

Egg Production. We documented a total of 49 eggs at the Purisima Point colony in 2016 (Table 2). Our documented number of eggs is 4% higher than the total eggs produced for 22 nests in 2015. The mean ± SE clutch size for 2016 was 1.81 ± 0.40 (n = 27). Since 2007, mean clutch size at the Purisima Point colony has been relatively stable, staying very close to 2.0 eggs per nest in all years but 2012 when the mean was 1.78 eggs per nest (Figure 5). In contrast, the period between 2001 and 2007 showed high variability in mean clutch, ranging from 1.0 eggs per nest to 2.2 eggs per nest. Mean clutch size in 2016 was slightly below the 16-year mean (2001-2016) of 1.86 eggs per nest. The 2015 breeding season had the largest mean clutch size (2.14 ± 0.47) on record since 2001.

Hatching Success. Twenty-three of the 27 nests initiated in 2016 successfully hatched at least one chick. Of the 49 eggs documented in 2016, we confirmed that 26 hatched (Table 2). We assume twelve additional eggs hatched based on the incubation period and lack of evidence to suggest they were depredated. Three eggs failed to hatch and eight eggs were depredated in 2016. The overall hatching success in 2016 was 78% (Table 3). Hatching success has ranged from 0% in 2004 and 2006 to 96% in 2015. Mean hatching success from 1996-2016 was 63%. Hatching success in 2016 was 19% lower than that in 2015 and 55% higher than the 21-year mean.

Fledging Success. Of the 38 chicks that hatched in 2016, one was found dead of unknown causes (Table 2) and an additional 19 were unaccounted for. We estimated 18 of the 38 chicks fledged; we observed a maximum of 17 fledglings on 21 July and were able to follow one additional chick to fledging age after this date. The fledgling success rate for 2016 was 47%. This fledging rate is 27% lower than 2015 and 4% higher than the 1996-2016 mean of 45%. The 2013 breeding season had the second highest fledging success on record at 76% and 2007 had the highest at 80% (Table 3). The overall breeding success (% of total eggs that fledged) for 2016 was 67% (Table 2). The number of fledglings produced per breeding pair in 2016 was 0.72 (Table 2).

Interannual Productivity and Population Growth

The running 22-year mean productivity for 1995-2016 is 0.63 fledglings per adult breeding pair. With the exception of 2011 and 2012, productivity in recent years (2007-2016) has been well above this mean, marking a strong deviation from the prior three years when virtually no fledglings were produced (Figure 6). The 2007-2016 period is the most productive on record for Purisima Point, with eight of the ten years showing above average productivity. The Purisima Point colony has a history of variable productivity, fluctuating at or above the mean from 1998-2003 and well below the mean prior to 1998 and after 2003.

The Purisima Point breeding population has been slowly increasing since 2013. Despite this, the breeding population is still well below the 22-year mean of 30 breeding pairs (Figure 6). Prior to 2004, the Purisima Point colony showed steady population growth beginning in 1999. This growth was likely due to the above average productivity from 1998 to 2002. From 2003 to 2006, the Purisima Point population showed a declining trend that was reversed beginning in 2007. Despite the recent years of above average productivity, the population has not increased above the 22-year mean and has shown an overall decline since 2010.

Predator Sightings and Predation

There were four nests and one egg from one nest lost to predation. Additionally, one fledgling and one adult were taken by predators in 2016. There was no evidence of chicks taken by predators in 2016. It is difficult, if not impossible, to detect predation on chicks once they leave the nest scrape and wander the colony. Least tern chicks are small and remains are generally not left behind after a depredation event. Coyote tracks were detected inside the colony nine times in 2016 (Table 4) and on 27 July a coyote depredated one nest and passed through an area used by chicks. Only one chick was seen afterwards (Figure 4). The remains of two adults and one fledgling were found on the colony in 2016. The fledgling was taken by a peregrine falcon at the west midden, evidence of which was detected on three motion sensor cameras. One adult was found at the southwest end of the colony and the evidence suggested it was taken by a barn owl.

The remains of the second adult were found on the west slope of the colony and evidence suggests it was taken by a coyote.

The three most persistent predators observed in the vicinity of the Purisima Point colony in 2016 were gulls, American kestrels (*Falco sparverius*), and red-tailed hawks (*Buteo jamaicensis*) (Table 4). Historically, great horned owls have been one of the more persistent predators observed at the colony and have been responsible for much of the depredation on adult terns (Robinette and Howar 2009). Predator management personnel respond quickly to reports of owls and owl tracks at the colony and have been successful in keeping depredation by owls to a minimum. In 2016, we observed owl tracks on eight occasions, three of these observations were in the colony area. After we found evidence of the predation of one adult tern, owls were trapped in 2016. Loggerhead shrikes (*Lanius ludovicianus*) and peregrine falcons were each observed nine and eight times, respectively. Though there was no direct evidence of take by shrikes, we suspect they may have taken snowy plover chicks at the north end of the colony. All other predators were observed less than seven times each, with no evidence of take by any species.

Overall, the number of predators sighted per hour of observation in 2016 was higher than that observed in 2014 and 2015 and similar to that observed in 2013 (Table 6). The high rate of predator observations in 2013 and 2016 was due to groups of 10-200 Western gulls roosting on the west slope of the colony. We observed large numbers of gulls roosting on the west slope in 2016, as well as evidence of roosting (gull tracks on the west slope) on two occasions.

Discussion

The Purisima Point least tern colony continues to be characterized by years of anomalously high and low reproductive success, with very few years consistent with the 22-year mean. Reproductive success can play a key role in the stability of least tern colonies. Burger (1984) reported that least terns are more likely to return to a colony in subsequent years if they have experienced good reproductive success at that colony site. The size of the colony can also play a role in its stability, with smaller colonies tending to be less stable (Thompson *et al.* 1997). This appears to be true with the Purisima Point least tern colony, which is small relative to other colonies in California. Breeding success at VAFB was poor from 1995 to 1997, increased in 1998 and remained at or above average from 1998 through 2002. Two rocket launches adjacent to the tern colony in 1997 may have resulted in decreased reproductive success in that year. Effects of rocket launches from the same facility in 2005 and 2011 were less clear (Robinette and Rogan 2005 and Robinette and Howar 2011). However, our analysis of diet and predation suggests that annual productivity at the Purisima Point colony is primarily driven by oceanographic conditions and predation (Robinette et al. 2015). The high annual productivity from 1998 to 2002 likely contributed to the steadily increasing population from 1999 to 2003. However, the period from 2004-2006 had virtually no reproductive output and the breeding population rapidly decreased. Despite eight of the past 10 years showing above average reproductive output, the Purisima Point population has not climbed above the 22-year mean.

Results from 2011 through 2016 reflect oceanographic changes that have been occurring in the California Current System within the same period. While La Niña conditions persisted through the winter of 2011, Multivariate El Niño Index (MEI) values became increasingly neutral through the spring and summer (PaCOOS 2011). This move toward less productive conditions likely contributed to the below average breeding productivity observed in 2011. In 2012, conditions moved from neutral to more El Niño-like conditions toward the end of the breeding season (PaCOOS 2012) but then returned to neutral (PaCOOS 2013). Despite the less productive El Niño conditions, the PDO was negative from June 2010 through December 2013. This is likely led to the average to above average breeding productive observed from 2010-2013. Additionally, upwelling conditions were stronger than average off central California in 2013 and data from the National Marine Fisheries' juvenile rockfish cruises showed record numbers of young-of-the-year rockfish off central California in 2012 and 2013 (PaCOOS 2012, 2013). Warm water conditions began developing off the central California coast in the late summer of 2014 but appeared to have little impact on least tern reproductive success in 2014 and 2015. El Niño conditions developed in late 2015, persisted through the 2016 spring and dissipated during the summer. El Niño conditions may have contributed to the lower reproductive success observed in 2016 compared to 2014 and 2015.

In past years, reproductive success at the Purisima Point colony has been driven primarily by the occurrence of rockfish and anchovy in the diet (Robinette and Howar 2010). Since 2008, the diet has been dominated by juvenile rockfish. Juvenile rockfish are small and have a low fat content compared to other forage fishes like anchovies (Iverson et al. 2002). However, our results suggest that rockfish can be a suitable prey when least terns do not have to expend much energy to forage for them. In years when rockfish have a high occurrence in the diet, high rates of foraging in the kelp beds at the Purisima South and Pockets Cove foraging plots have been observed. This was especially true in 2009 when there were no anchovy in the least tern diet and least terns showed the highest foraging rates at our study plots. Despite warm water conditions developing off central California in 2014, rockfish remained abundant in the 2014 least tern diet and reproductive success was high. We were unable to analyze least tern diet samples in 2015 and 2016, but the high reproductive success observed in 2015 and lower reproductive success observed in 2016 suggests that prey was locally abundant in 2015 and less abundant in 2016.

Management Recommendations

1) Analysis of diet samples collected at the Purisima Point colony should continue on an annual basis. The overall goal of VAFB's monitoring program is not only to record annual population and productivity, but to present this information in the context of local prey conditions and predator management efforts. This additional information is essential for effective management of the least tern colony. Diet samples were not analyzed for 2015 and 2016 due to decreases in funding. Analysis of annual diet will allow VAFB to better understand the factors regulating reproductive success and ultimately aid VAFB in its efforts to promote the recovery of this species.

2) An effort should be made to remove the vegetation that is growing within the northwest portion of the fenced area. This area has been increasingly covered with vegetation over the past five years. In 2012 and 2013, many of the avian predator sightings were within this area. Additionally, there were several coyote crossings across the north fence, adjacent to this area in 2014 through 2016. We suspect that the increased

vegetation has provided habitat for rodents and this may be attracting avian predators and coyotes to the area. Additionally, the area historically contained suitable nesting habitat for the Western snowy plover. With the growth of vegetation, this habitat is no longer suitable for nesting plovers. Thus, removing the vegetation can potentially decrease the number of avian predators attracted to the area and re-open the habitat to nesting snowy plovers.

3) Where possible, the diet of local avian predators (i.e., gulls and raptors) should be monitored throughout the breeding season. While we do not suspect that avian predation was an issue in 2016, it has been in the past. Furthermore, we do not have a good understanding of what happens to chicks during years of low reproductive success. For example, 81% of the hatched chicks at the Purisima Point colony in 2011 were unaccounted for and we suspect some were depredated. VAFB has initiated a study of Western gull diet at breeding sites throughout VAFB. We recommend continuing this monitoring on an annual basis. Additionally, diet monitoring should be initiated for peregrine falcons breeding on VAFB where possible. Having knowledge of what predators around the colony are eating will give insight as to whether chicks are disappearing due to predation versus dying of starvation.

4) The chain link fence along the eastern perimeter of the colony should continue to be reinforced to prevent coyotes from digging under. Though a new electric fence was installed along the eastern boundary of the colony in 2013, the chain link fence provides additional protection against mammalian predators, including feral pigs that are often observed in the valley between SLC-2 and the tern colony. In past years, ManTech has extended mesh fencing out several feet from the base of the chain link. This has deterred coyotes from attempting to dig under the fence. We support continued effort to prevent these mammalian predators from digging under the fence.

5) Efforts to maintain the electric fences at full working capacity should continue. This includes monitoring fence voltage throughout the season and performing maintenance such as washing all connectors to sustain maximum voltage. The electric fence is an extremely valuable tool which allows VAFB to promote the growth of its least tern colony while maintaining the health of the surrounding ecosystem.

6) The predator management team should continue their protocol of monitoring raptor nest sites and foraging patterns prior to the arrival of least terns to the Purisima Point colony. This will ensure the team has ample time to identify breeding pairs that pose a threat to least terns (i.e., are consistently seen foraging in the colony) prior to the arrival of least terns. However, it is not necessary to trap and relocate all raptors breeding in the vicinity of the Purisima Point colony. Most raptors forage in the chaparral habitat surrounding the colony and only become a threat if their foraging range expands into the colony. Occasional excursions into the colony can generally be defended by adult least terns as long as colony attendance is high. Thus, it is important that the team have time to identify raptors that pose a threat so as not to trap and relocate those that are non-threatening. Non-threatening raptors that are keeping territories may actually benefit least tern conservation by excluding other raptors that could potentially pose a threat. The raptor monitoring component of the VAFB predator management team is critical to promoting growth of the least tern colony while maintaining the health of the surrounding ecosystem.

7) A study should be initiated to identify coastal ecosystem indicators using all data collected on VAFB's coastal populations. This study should also include the use of local oceanographic data (e.g., MEI, PDO, and Upwelling indices), remote sensing data (e.g., sea surface temperature and chlorophyll from satellite images), and data from other marine bird species breeding and roosting along the coast of VAFB. Point Blue's study of the least tern diet indicates that much of the annual variability in reproductive success at the Purisima Point colony is due to oceanographic variability. Developing a suite of coastal ecosystem indicators would allow VAFB to better distinguish between oceanographic and human linked impacts on coastal populations. This study would require extra funding, but would not only improve the management of the least tern population on VAFB, but the populations of other threatened and endangered species, such as the Western snowy plover, utilizing the coast.

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Table 1: Dates of the first adult sighting, egg laying period, chick hatching period, fledgling period, last sighting at Purisima Point, and last sighting at VAFB from 1995 to 2016.

	First Adult Sighting	Egg Laying Period	Chick Hatching Period	Fledging Period	Last Sighting at Purisima	Last Sighting at VAFB
1995	10 May	18 May- 27 Jun	18 Jun - 18 Jul	29 Jun - 6 Aug	10 Aug	10 Aug
1996	30 April	14 May - 1 Jul	4 Jun - 22 Jul	4 Jul - 11 Aug	11 Aug	22 Aug
1997	27 April	22 May -6 Jul	24 Jun - 10 Jul	15 Jul - 15 Jul	20 Jul	20 Jul
1998	6 May	13 Jun - 28 Jun	7 Jul - 21 Jul	12 Jul - 4 Aug	6 Aug	12 Aug
1999	3 May	28 May - 7 Jul	18 Jun - 28 Jul	8 Jul - 19 Aug	1 Sept	3 Sept
2000	5 May	26 May - 11 Jul	18 Jun - 31 Jul	13 Jul - 3 Aug	15 Aug	15 Aug
2001	30 April	21 May - 28 Jun	7 Jun - 19 Jul	28 Jun - 26 Jul	2 Aug	8 Aug
2002	29 April	15 May - 12 Jul	7 Jun - 3 Aug	24 Jun - 7 Aug	7 Aug	7 Aug
2003	1 May	20 May - 21 Jul	13 Jun - 7 Aug	21 Jul - 28 Aug	2 Sept	8 Sept
2004	5 May	15 Jun - 15 Jun	None	None	21 Jul	2 Aug
2005	8 May	14 Jun - 21 Jul	19 Jul - 9 Aug	25 Aug - 25 Aug	25 Aug	25 Aug
2006	15 May	19 Jun - 21 Jun	None	None	11 Jul	11 July
2007	16 May	19 Jun - 24 Jul	13 Jul - 23 Aug	6 Aug - 4 Sept	4 Sept	5 Sept
2008	12 May	17 Jun - 22 Jul	8 Jul - 8 Aug	28 Jul - 15 Aug	15 Aug	21 Aug
2009	11 May	4 Jun - 10 Jul	22 Jun - 29 Jul	13 July - 11 Aug	11 Aug	13 Aug
2010	11 May	25 May - 7 Jul	21 Jun - 23 Jul	12 July - 10 Aug	10 Aug	10 Aug
2011	9 May	27 May - 21 Jun	14 Jun - 8 Jul	4 Jul - 12 Jul	15 Jul	15 Jul
2012	8 May	30 May - 20 Jul	29 Jun -18 Jul	19 Jul - 9 Aug	9 Aug	9 Aug
2013	13 May	3 Jun - 27 Jun	24 Jun - 12 Jul	15 Jul - 6 Aug	6 Aug	19 Aug
2014	6 May	27 May - 17 Jun	11 Jun - 7 Jul	7 Jul - 25 Jul	25 Jul	12 Aug
2015	5 May	22 May - 8 Jul	12 Jun - 21 Jul	29 Jul - 21 Aug	21 Aug	21 Aug
2016	2 May	24 May – 15 Jul	14 Jun – 19 Jul	5 Jul – 4 Aug	4 Aug	17 Aug

Table 2: Summary of least tern breeding activity at the Purisima Point colony during the 2016 breeding season.

Population	**Estimated # of Pairs**	**25**
	Adults Depredated	2
	Adults Dead Cause Unknown	0
Nests	**Total Nests**	**27**
	Hatched all eggs	19
	Currently active	0
	Abandoned Before Hatch Date	0
	Incubated Past Hatch Date	0
	Hatched, but had ≥ 1 Non-viable Egg	3
	Hatched, but had ≥ 1 Chick Die While Hatching	0
	Depredated	5*
	Chicks Died/Cause Unknown	0
Eggs	**Total Eggs**	**49**
	Confirmed Hatched	26
	Assumed Hatched	38
	Chick Died While Hatching	0
	Depredated	8
	Dead Eggs	3
Chicks	**Total Chicks**	**38**
	Hatching Success	77.6%
	Depredated	0
	Died of Unknown Cause	1
Fledglings	**Total Fledglings**	**18**
	Fledging Success	47.4%
	Depredated	1
	Died of Unknown Cause	0
Breeding Success	**% of Total Eggs Fledged**	36.7%
	Fledglings per Adult Pair	0.72

*One nest had one egg missing to unknown predator, other egg continued to be incubated and hatched

Table 3: Numbers of nests, eggs, chicks, and fledglings observed at VAFB from 1995 to 2016. Also shown are hatching success, fledging success, and breeding success from 1995 to 2016.

Year	# of Nests	# of Adult Pairs	Total Eggs Laid	Total Chicks Hatched	Hatching Success*	Max. Fledglings Observed	Fledging Success*	Breeding Success*	Fledglings per Adult Pair
1995	38	45	unknown	21	unknown	12	57%	unknown	0.27
1996	62	60	121	40	33%	12	30%	10%	0.20
1997	39	25	76	20	26%	2	10%	3%	0.08
1998	20	19	37	23	62%	14	60%	37%	0.75
1999	44	25	91	50	55%	15	30%	17%	0.60
2000	32	28	64	47	73%	11	23%	17%	0.39
2001	44	41	97	78-91	80-94%	54	59-69%	55%	1.32
2002	65	59	125	91-103	73-82%	39	38-43%	31%	0.66
2003	117	82	210	73-91	35-43%	33	36-45%	16%	0.40
2004	1	1	1	0	0%	0	N/A	0%	0.00
2005	44	44	74	31-32	42-43%	1	3%	1%	0.02
2006	2	2	4	0	0%	0	N/A	0%	0.00
2007	18	18	29	20	69%	16	80%	55%	0.89
2008	18	18	35	33	94%	19	58%	54%	1.06
2009	31	30	63	56	89%	37	66%	59%	1.23
2010	34	33	65	56	86%	29	52%	45%	0.88
2011	32	32	53	36	68%	4	11%	8%	0.13
2012	18	18	32	21	66%	10	48%	31%	0.56
2013	15	15	30	25	83%	19	76%	63%	1.27
2014	21	17	41	30	73%	20	67%	49%	1.18
2015	22	22	47	45	96%	29	64%	62%	1.32
2016	27	25	49	38	78%	18	47%	37%	0.72

* Hatching Success = % of total eggs that hatched; Fledging Success = % of total chicks that fledged; Breeding Success = % of total eggs that fledged.

<u>Table 4</u>: Predators observed at the Purisima Point colony during the 2016 breeding season.

Predator	# Observed in Colony Area	# Observed Inside Colony
Unidentified Gull*	566	20
American Kestrel	26	0
Red-tailed Hawk	11	3
Loggerhead Shrike	9	0
Common Raven	6	0
Peregrine Falcon	4	4
American Crow	3	0
Striped Skunk	3	0
Unidentified Owl**	3	5
Brewer's Blackbird	2	2
Northern Harrier	2	2
Bobcat	1	1
Long-billed Curlew	1	1
Coyote	9	9

*There were two Western gull (*Larus occidentalis*) nests adjacent to the colony in 2016 and gulls are consistently observed flying along the coastal margin of the colony. We therefore only record them when they enter the colony area (within 100m of a least tern nest) or roost along the western periphery of the colony.
**Of the 8 owl observations reported above, 2 were confirmed as Great Horned Owl and 2 were confirmed as Barn Owl.

Table 5: Total number of predator visits (all species combined) per hour of researcher observation for the 2001-2016 breeding seasons.

	Predator Sightings per Hour of Observation	
Year	**Colony Area**	**Inside Colony**
2001	0.37	0.25
2002	0.32	0.20
2003	1.03	0.76
2004	1.11	0.59
2005	1.19	0.72
2006	6.40	6.15
2007	0.73	0.23
2008	0.75	0.24
2009	0.65	0.18
2010	0.70	0.22
2011	0.57	0.32
2012	0.65	0.41
2013	3.64	3.01
2014	1.57	0.14
2015	0.70	0.17
2016	5.47	0.40

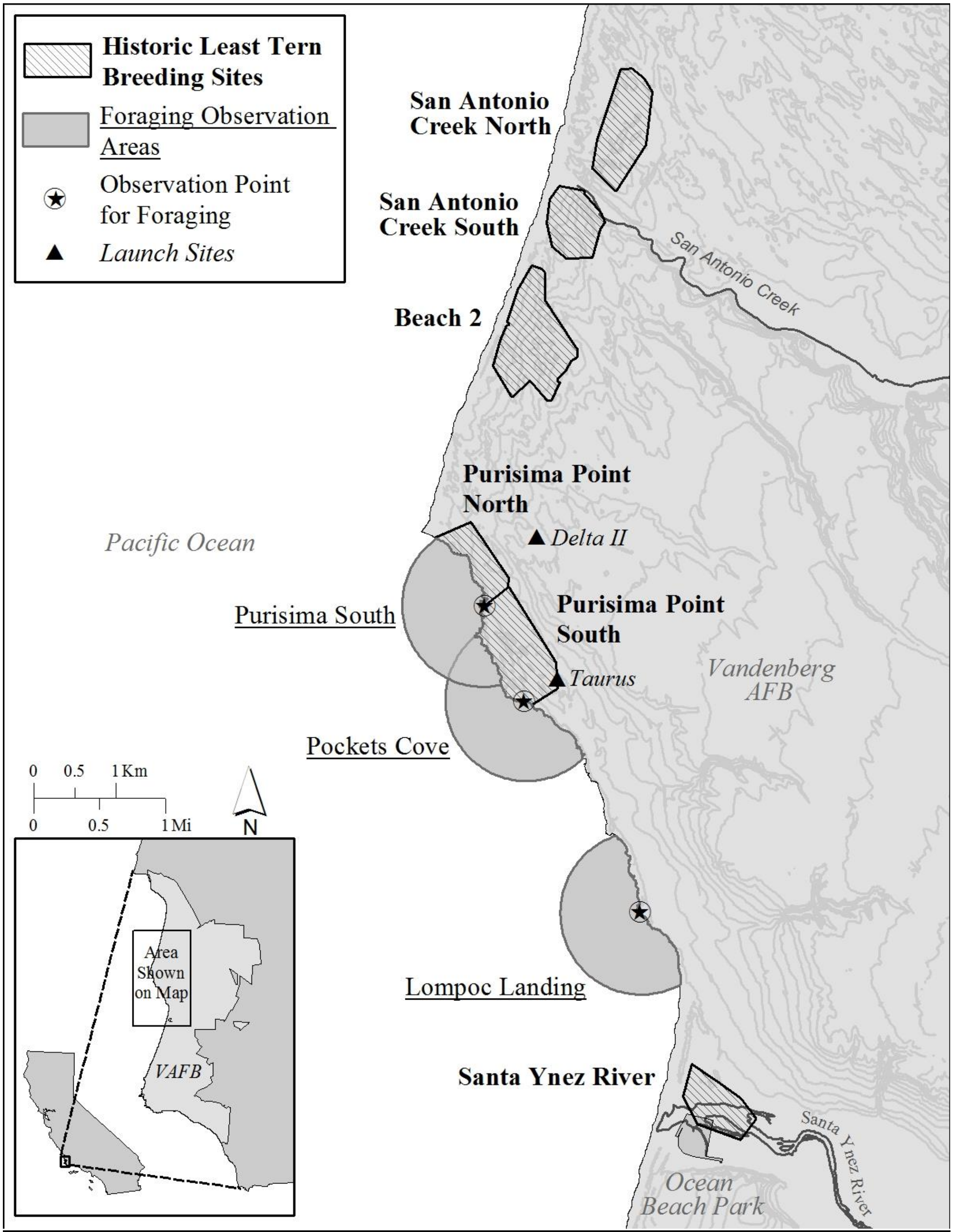

Figure 1: Map of the current least tern colony at Purisima Point, VAFB. Also included are the locations of historic breeding colonies at VAFB (San Antonio Creek North, San Antonio Creek South, Beach 2, and Santa Ynez River) and observation points for foraging observations made during 2007 - 2014. Foraging studies were not conducted in 2015 and 2016. Map redrawn from Schultz and Applegate (2000).

Figure 2. Photograph of V-shape (left) and teepee (right) chick shelters used at the Purisima Point colony in 2016.

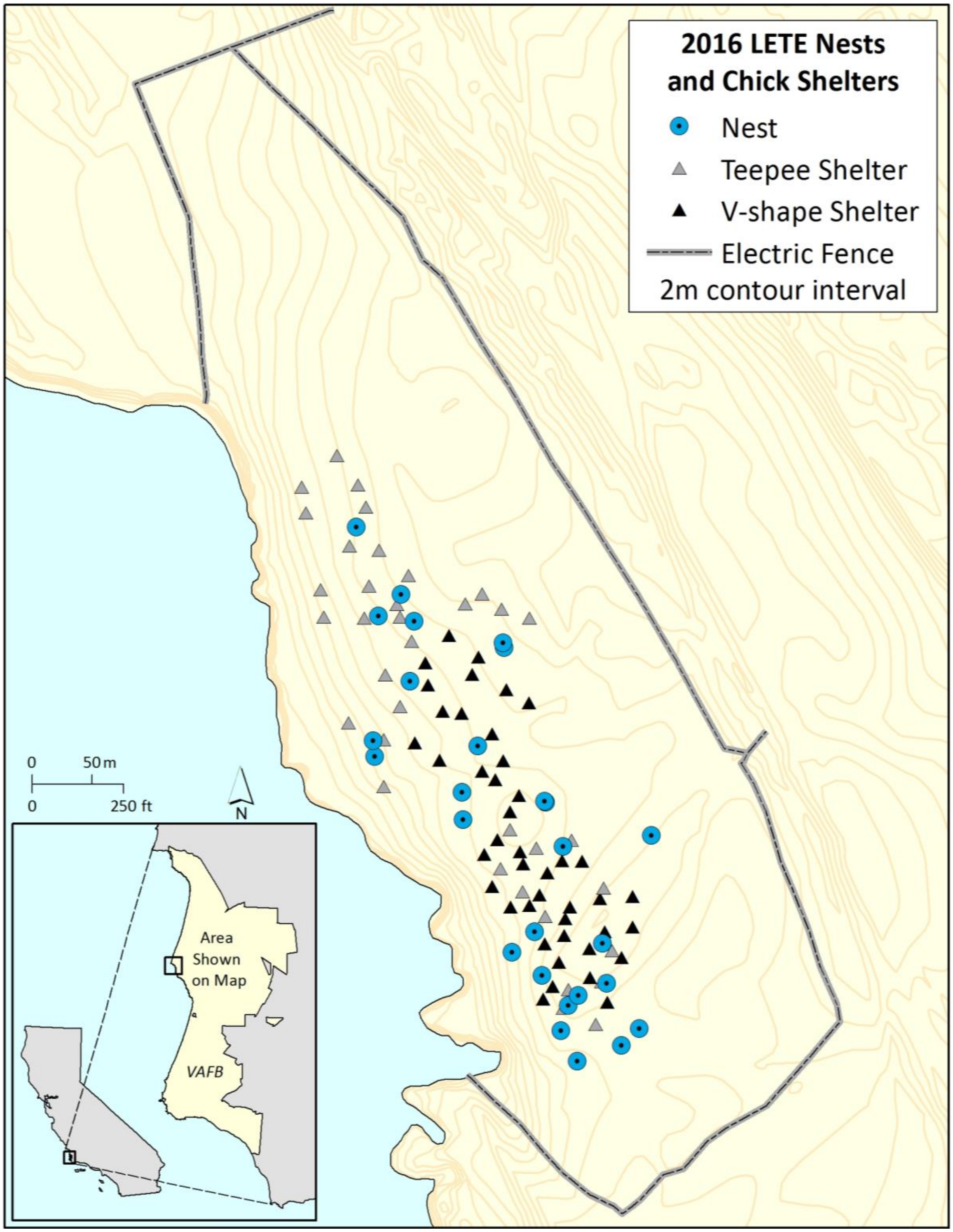

Figure 3. Location of permanent (Teepee) and moveable (V-shape) chick shelters during the 2016 breeding season. Also shown are the locations of Least Tern nests initiated in 2016.

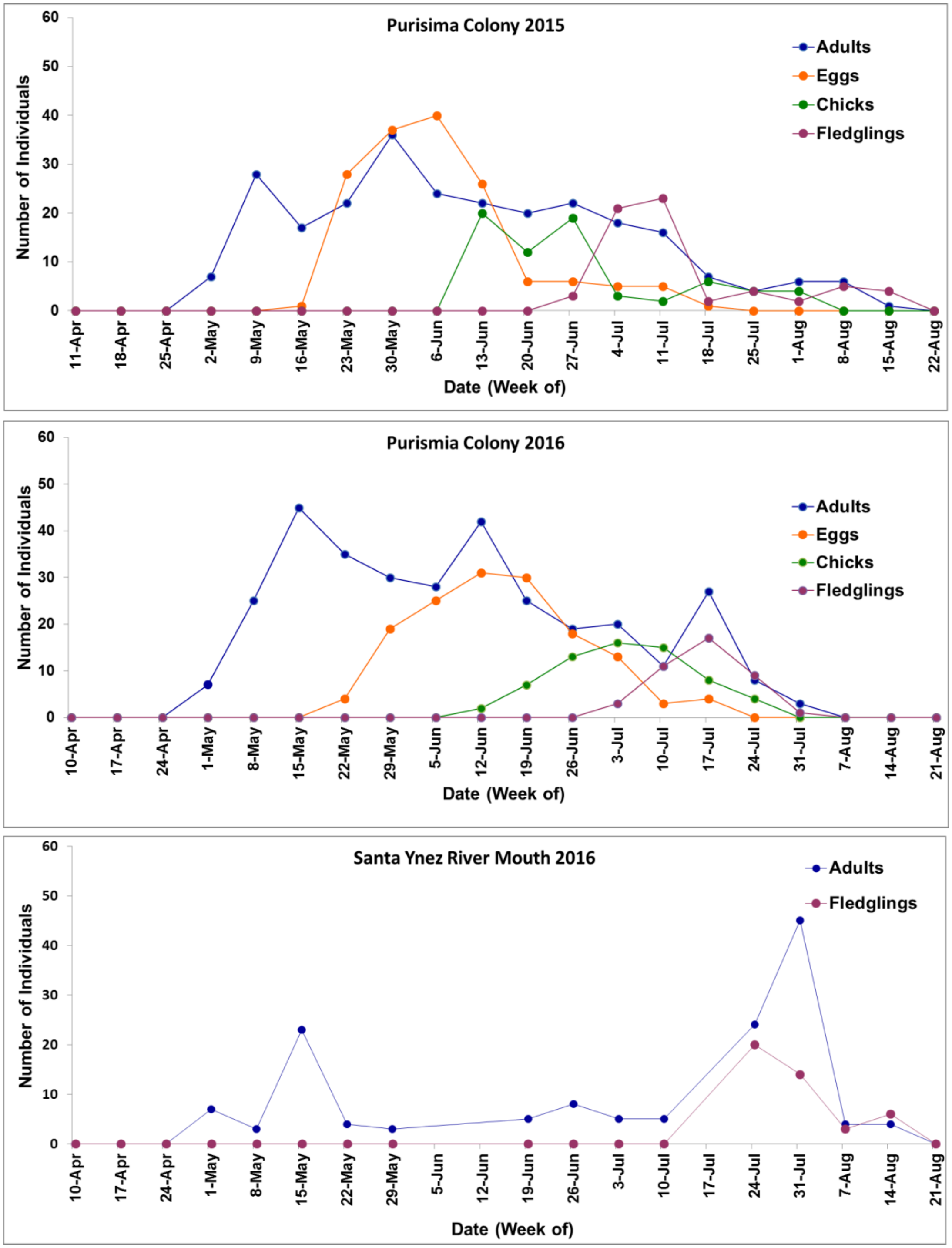

Figure 4: Breeding phenology for the Purisima Point colony during the 2015 and 2016 breeding season, including use of the Santa Ynez River mouth in 2016. Values shown are the maximum number of individuals observed during a given week.

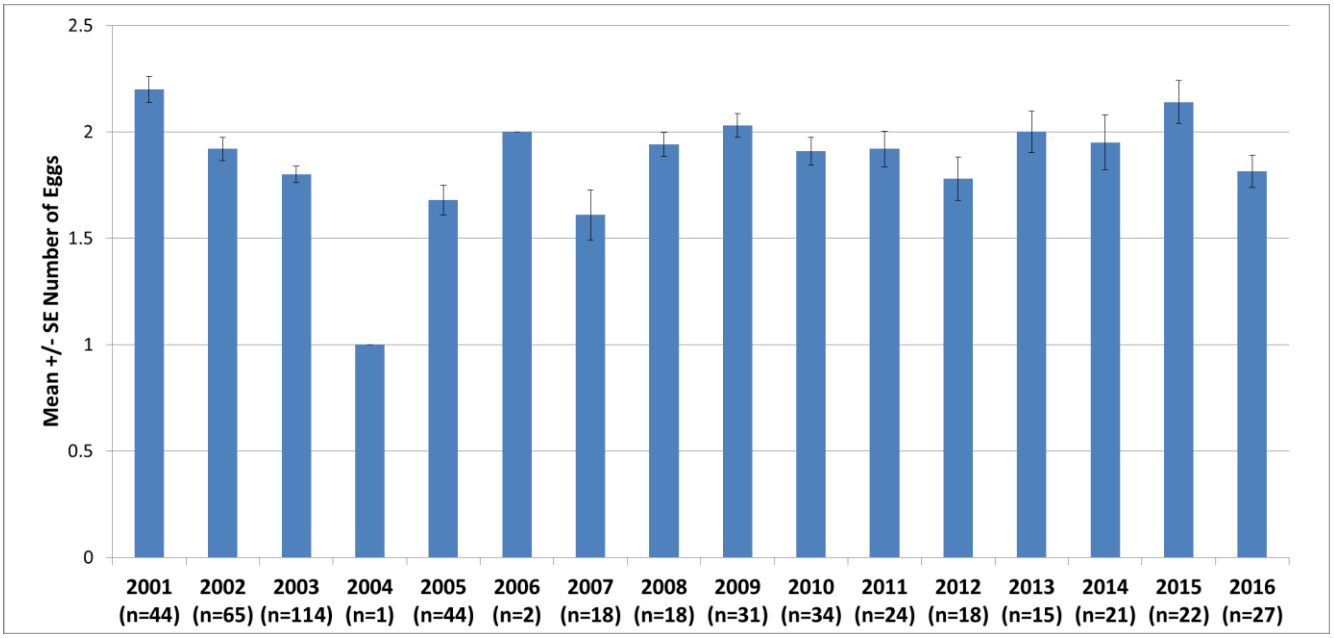

Figure 5: Mean ± SE clutch sizes for all nest attempts at the Purisima Point colony from 2001 to 2016.

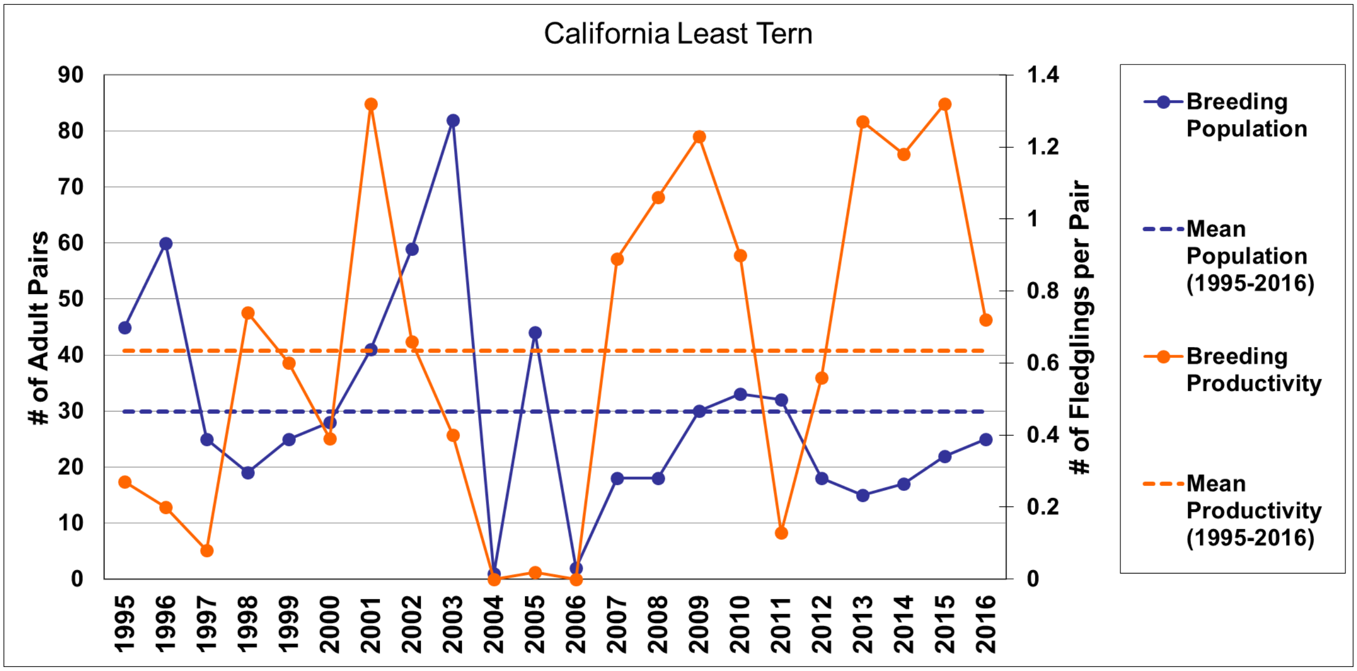

Figure 6: Numbers of adult pairs and fledglings per pair at the Purisima Point colony, 1995 to 2016. Dashed lines show running 22-year mean (1995-2016) for each variable.

Chapter 2: Monitoring and Management of the Western Snowy Plover on Vandenberg Air Force Base, 2016

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Introduction

The Western snowy plover (*Charadrius nivosus nivosus*) is a small, precocial shorebird. The Pacific coast population breeds on coastal beaches, dunes and salt evaporation ponds from southern Washington to southern Baja California, Mexico. Nesting occurs along sandy beaches, sand spits, dune-backed beaches, river mouths, pocket beaches and salt pans (Page and Stenzel 1981; U.S. Fish and Wildlife Service [USFWS 2001]) from 1 March through 30 September. The population has declined primarily due to habitat degradation and loss due to human disturbance, spread of invasive plant species, and expanding predator populations (USFWS 2007). As a result, the USFWS listed the snowy plover as threatened under the Endangered Species Act in March of 1993 (58 Federal Register 12864). Breeding was first documented on the beaches of Vandenberg Air Force Base (VAFB) in 1978 by Page and Stenzel (1981).

At VAFB, breeding occurs along approximately 13.8 miles of sandy coastline which is divided into three geographically separate sections referred to as North, Purisima, and South Beaches (Figure 1). In past reports (e.g., see MSRS 2010), the Purisima Beach section was included as a part of North Beaches. However, the Purisima Beach section is somewhat unique in both habitat (see below) and the management it receives. The state and federally endangered California least tern (*Sternula antillarum browni*) breeds within the Purisima Beach section and the area is actively managed for predators (see Robinette and Howar 2011). We therefore separated the Purisima Beach section from North Beaches in our analyses.

North Beaches encompass approximately 6.2 miles of sandy beach with extensive dune habitat extending from the north end of Minuteman Beach south to the rocky shore that extends north from Purisima Point. For monitoring purposes, North Beaches are divided into four sectors: Minuteman (MIN), Shuman North (SHN), Shuman South (SHS), and San Antonio (SAN).

> **MIN** – This sector extends from the rocky headlands at the north end of Minuteman Beach south 1.1 miles to Shuman Creek. Habitat in this sector is characterized by open sandy beaches backed by moderately to heavily vegetated dunes. The northern 0.25 mile from the access trail to the north end of the beach was open for recreational use by military personnel and their dependents. The

remaining section of MIN was closed to all recreational access during the breeding season.

SHN – This sector extends from Shuman Creek south for approximately 1.6 miles to No Name Creek. This sector is characterized by extensive back dune system and sand sheets separated by low dunes with moderate to heavy vegetation.

SHS – This sector extends from No Name Creek south for approximately 1.4 miles to San Antonio Creek. The habitat is characterized by narrow beaches with blow outs and sand sheets divided from the beach by densely covered vegetation.

SAN – This sector extends from San Antonio Creek south approximately 2.1 miles to the rocky shore north of Purisima Point. Immediately south of San Antonio Creek is a broad open sand sheet that grades into sparsely vegetated flats above the open sand beach. The beach narrows significantly at the southern end of the sector, and is backed by a dense ridge of beach grass where an intensive beach restoration project continues since 2009.

Purisima Beaches encompass the sandy pocket beaches, rocky beaches and dune areas adjacent to Purisima Point. Purisima Beaches are divided into two sectors, Purisima North (PNO) and Purisima Colony (PCO).

PNO – This sector extends from the south end of SAN approximately 1.3 miles to Purisima Point. Snowy plovers nest on the small sand and rocky pocket beaches that characterize this sector.

PCO – This sector extends approximately 1.3 miles south of PNO and includes the fenced California least tern colony, and the nesting habitat adjacent to the north fence. Snowy plover breeding habitat within the Colony consists of broad open dunes and lower gravel area. Much of the area where plovers historically bred has been covered by dense vegetation growth. As a result, snowy plovers did not breed in this sector from 2010 to 2014, though nesting recommenced in 2015.

South Beaches encompass approximately five miles of sandy coastline habitat predominately consisting of small dunes and narrow beaches backed by sheer and vegetated bluffs. South Beaches are divided into three sectors including Wall (WAL), Surf North (SNO), and Surf South (SSO).

WAL – This sector extends from the rocky headlands at the north end of Wall Beach south 1.3 miles to the Santa Ynez River. The northern 0.25 mile from the access trail to the north end of the beach was open for recreational use by military personnel and their dependents. The remaining section of WAL was closed to all recreational access during the breeding season.

SNO – This sector extends from the Santa Ynez River south for 1.8 miles. This sector consists of narrow beaches backed by vegetated foredunes. Approximately 0.5 mile of beach located 0.6 mile south of the Santa Ynez River was open to public recreational use through the breeding season. The remainder of this sector was closed.

SSO – This sector extends from the south end of SNO for 1.9 miles to the rock cliffs at the south end of Surf Beach. Breeding habitat in this sector consists of a narrow beach backed by sheer and vegetated bluffs.

Approximately 1.25 miles of breeding habitat is open to recreational access during the snowy plover breeding season (Figure 1). The remaining habitat is closed to all recreational access from 1 March until 30 September. Approximately 0.5 mile of SNO is open to public recreational use between the hours of 0800 and 1800. In 2016, there was no permanent closure due to the number of violations reaching above the 50 limit. The northernmost 0.5 mile of MIN and 0.25 mile of WAL were open for recreational use every day between dawn and dusk, to military personnel and their dependents, and Department of Defense and VAFB civilian employees. The remaining snowy plover nesting areas are closed to recreational access during the breeding season.

Annual monitoring on VAFB began in 1993 with the goal of estimating annual breeding population and reproductive success and determining the effectiveness of the beach management plan implemented by VAFB. The annual breeding population on VAFB has typically been measured using the mean number of birds observed from four breeding censuses conducted during the peak nesting season. However, the actual number of breeding birds can be undercounted due to the inability to detect every bird during surveys. These surveys also underestimate the actual number of birds breeding at the site during the course of the nesting season because some nesters, particularly females, breed at multiple sites and therefore are absent from a particular site during part of the nesting season (Stenzel et al.1994). Another way to estimate the breeding population uses the total nests initiated to estimate the number of associated pairs. This alternative is inherently flawed due to the complex pair bond dynamics of snowy plovers and the re-nesting attempts that occur after initial attempts fail. Snowy plover pair bonds almost always dissolve when the young from a clutch hatch (Warriner et al. 1976). At hatch the female typically leaves the brood and seeks a new mate leaving the male to rear the young alone until they fledge. If the male loses the young, or if his young fledge early enough in the breeding season, he typically re-nests with a new mate (Warriner et al. 1976). As a result the males may double-brood and females triple-brood in a single breeding season. Nonetheless, analyses of 22 years (1994-2015) of breeding bird census and nest initiation data from VAFB have yielded similar trends (see Robinette et al. 2015). Thus, both methods provide useful indices that can be tracked over time; and using both indices in conjunction provides useful information to resource managers.

Since 1994, the snowy plover breeding population size at VAFB has been highly variable (Robinette et al. 2015). The smallest population occurred in 1999 (78 adults) and the largest in 2004 (420 adults). The population showed decreasing trends between 1997 and 1999 and more recently between 2004 and 2007. The population showed an increasing trend between 1999 and 2004. The population has been variable, but relatively stable since 2007. Mean adults from 2000 to 2016 is 245 adults with mean nest number at 345.

Reproductive success is measured by the number of chicks fledged per male plover (fledging success) (USFWS 2007). Based on a population viability analysis in the USFWS recovery plan, a rate of 1.0 fledglings produced per male is believed necessary to prevent population decline with 1.2 allowing for moderate population growth (assuming 75% annual adult survival and 50% juvenile survival). The number of chicks fledged per male is most accurately obtained when all males and chicks at a site are uniquely color banded and the birds are monitored frequently (Nur et al. 1999). This metric has been difficult to track at VAFB due to inconsistent banding effort through the years. Thus, managers at VAFB also track clutch hatch success to better understand trends in reproductive success. Clutch hatch success at VAFB has been highly variable with no apparent trend since 1994 (Robinette et al. 2015). Mean clutch hatch success (percent of total nests that hatched) from 1994-2016 was 47% with most years either well below or well above this average. Clutch hatch success at VAFB was lowest in 1997 at 19% and highest in 2006 at 67%.

One of the primary causes of poor clutch hatch success at VAFB is predation. Over the 20 years of monitoring on VAFB, 17%-52% of nests have been lost in a given year to predators (see MSRS 2010, Robinette et al. 2015). The two main predators observed depredating nests are coyotes (*Canis latrans*) and corvids (i.e., crows and ravens). From 1994-2000 American crows (*Corvus brachyrhynchos*) were the main corvids observed on VAFB beaches, but common ravens (*Corvus corvax*) have become the dominant corvid in recent years. The increase in raven sightings at VAFB has been attributed to a general expanse of the raven population into coastal habitats in central California (Boarman and Heinrich 1999). Corvids depredated 5.5% of all known fate nests in 2016 (compared to 1% in 2015 and 4% in 2014) with the highest occurring in 2004 with 12% of all known fate nests taken by common ravens. In prior years, coyote predation has mainly occurred on South Beach sectors with the highest occurring in 2004 and 2014 at 20% of all known fate nests depredated. In 2016, both North and South Beaches experienced below-average coyote predation, with 26% and 25% of all known fate nests lost in those beach sectors, respectively. Basewide, 25% of nests were taken by coyote in 2016 (down from 34% in 2014 and up from 19% in 2015).

The goal of VAFB natural resources management is to manage the snowy plover population on VAFB while maintaining the integrity of the coastal ecosystem. To accomplish this, VAFB has put together a management team to support the adaptive management of the snowy plover breeding population. In 2016, mammal, gull, and corvid management was conducted by ManTech SRS Technologies, Inc. (ManTech). ManTech selectively removes ravens as soon as depredation of plover nests is documented. Additionally, individual coyotes that are known to be keying-in on snowy plover nests are lethally removed. Contractors Nick Todd and Lee Aulman monitored the territories and movements of raptors breeding within and around PCO in 2016. Todd and Aulman selectively trap and relocate avian predators deemed a threat to snowy plovers. Point Blue Conservation Science (Point Blue) monitored the breeding population of snowy plovers on VAFB, estimating population and reproductive success. Point Blue communicates predator sightings and depredation with the management team and notifies VAFB Conservation Law Enforcement of beach violations for unauthorized entry into closed beach areas.

Herein, we present the results of the 2016 snowy plover breeding season and compare these results to prior years at VAFB. Specifically, we analyze trends in the population size and reproductive success over a 23-year time series. We compare trends in population and reproduction among North, Purisima, and South Beaches, as well as inside and outside of management areas closed to the public.

Additionally, beginning in 2014, we assessed the effectiveness of a long-term restoration project on Wall and the north end of the SNO sector. The WAL restoration site includes approximately 44.5 acres between the Wall Beach Open Area and the Santa Ynez river mouth. The SNO restoration site includes approximately 30.8 acres between the Santa Ynez river mouth and the Surf Beach Open Area (Figure 1). Much of the area between the foredunes and the railroad was covered with European beach grass (*Ammophila arenaria*), ice plant (*Carpobrotus edulis*), and golden wattle (*Acacia longifolia*). The restoration work was completed by ManTech SRS Technologies with funding from the Air Force and the Torch/Platform Irene Oil Spill Trustee Council. The first stages of the restoration began in 2009 with the manual removal of golden wattle and prescribed burning. Herbicide spray was used on the beach grass and ice plant from 2009 to 2011. To cover the remaining seed bank, the beach was contoured with bulldozers from late 2013 to early 2015. The contouring work was completed on SNO in February 2014 and on WAL in February 2015. There was very little change in plover nest distribution after the burning and herbicide treatments. In 2013 only one nest was initiated in the SNO pre-contoured restoration area and it was depredated by a coyote. However, the contouring process opened up 75.3 acres of bare sand for potential plover nesting. We therefore assessed plover response to the beach contouring with regards to 1) population distribution, 2) nesting distribution, 3) hatch success, and 4) fledge success.

Our overarching goal is to provide information to help VAFB make management decisions and understand how military activities affect the population and breeding dynamics of snowy plovers breeding on VAFB beaches. The snowy plover monitoring program is a requirement of the terms and conditions section of the Biological and

Conference Opinion (BO) for Beach Management and the Western Snowy Plover (1-8-05-F-5R and amendments), Delta II Launch Program at Space Launch Complex 2 and Taurus Launch Program at 576-E (1-8-98-F-25R), and Atlas Launch Program (1-8-99-F/C-79). The Beach Management and Delta II BOs require the determination of population trends and reasons for decline as well as enhanced predator management activities looking at populations and behavior of predators. Most recently, the Delta II and Taurus BOs were superseded by the Vandenberg Air Force Base Programmatic Biological Opinion (8-8-09-F-10) that includes similar measures.

Methods

We conducted breeding surveys between 1 March and 30 September, 2016. Our monitoring regime included five main activities: 1) window surveys, 2) nest searches, 2) chick banding, 4) transect surveys, and 5) predator observations. We used window surveys to estimate the breeding population size. We conducted nest searches to estimate breeding effort (number of nests initiated) and determine the fate of all identified nests. We banded chicks in order to estimate fledging success (number of fledglings per male). We conducted weekly transect surveys to determine patterns of habitat use by plovers on each beach sector throughout the season. Finally, we recorded all predators observed utilizing snowy plover habitat to: 1) better understand patterns of predation, and 2) notify the management team of predator issues as they arose. Detailed methods for each activity are outlined below. Within this report, we make broad comparisons of population and breeding metrics among North, Purisima, and South Beach sectors and more specific comparisons of areas open to recreational beach access to closed areas of MIN, WAL, and SNO. We compared areas open to recreational beach access to adjacent closed areas of similar size for each beach sector.

Window Surveys

We conducted four breeding window surveys during approximately the same weeks as conducted during all seasons since 2002: 9 May, 17 May (range wide window breeding survey), 1 June and 23 June. We conducted window surveys using our transect methodology (see below). Additionally, we conducted one winter window survey on 20

January 2016. We divided beach sections into three main segments: MIN-SHS, SAN-PCO, and WAL-SSO. For the winter and breeding window surveys, we also visited Jalama Beach to look for plovers banded as chicks on VAFB beaches. We assigned one plover monitor to each section and all sections were monitored simultaneously to minimize the chances of double counting individual plovers. For each section, one monitor walked the entire section starting from the north and continuing south. We recorded the number and location of adult snowy plovers by beach sector, sex, and color band combination for all breeding beaches. We also recorded the number and size of all chicks and fledglings observed. We use this information to 1) calculate breeding population size in a way comparable to methods dating back to 1994 and 2) estimate the maximum number of males for use in calculating annual reproductive success (number of fledglings produced per adult male).

Nest Monitoring

Beginning 1 March, we surveyed each beach sector to locate nests and nesting territories. We surveyed beach sectors with historical breeding activity a minimum of three times per week. Additionally, we surveyed potential breeding habitat with no known history of nesting once per week. gThe primary means of nest searching included observing plover behavior, locating incubating adults at a distance, following plover tracks, and monitoring scrapes in consecutive visits. Once nests were located, we monitored them to determine nest fate (i.e., hatched, failed or depredated) and clutch hatch success rate. Appendix A outlines the criteria we used to determine nest fates. We photographed each nest, took GPS coordinates of location, and collected data on clutch size and surrounding habitat. In 2013, we added an additional failed nest category – suspected adult mortality. A nest was determined failed by suspected adult mortality if it had been incubated for at least two weeks and then suddenly inactive prior to the expected hatch date and appeared abandoned past 2 weeks of incubation. Nests with this new nest fate category were located in areas with a high frequency of predator sightings. Furthermore, the nests were not buried and abandonment did not correlate with any wind event.

We used estimated hatch dates (EHD) to help us determine nest fates. We determined EHD by adding 28 days (incubation duration for snowy plovers) to the date of clutch completion. However, when nests were found after clutch completion, we floated eggs to determine EHD. Floating entails placing each egg in a cup of water and measuring the angle of the egg as it is submerged in water. If the egg floats to the surface, the diameter of the exposed surface is measured. All measurements were then analyzed using the "float chart" developed by Phil Pearsons and Point Blue in 1993. Values indicate the stage of embryonic development and allows monitors to estimate the remaining days until hatch.

Nest Cameras

2016 was the fifth year we have placed Reconyx time lapse and motion sensor photo cameras on nests to 1) increase accuracy in determining nest fates, 2) better identify and document nest predators, and 3) identify banded adults at nests. These cameras take photos every minute and a rapid series of photos when the motion sensor is triggered by large animals such as predatory birds or predatory mammals. Snowy plovers are too small to trigger the motion sensor component. Cameras were set four to eight meters from the nest, camouflaged with debris from the immediate area, and utilized on nests where the monitor determined the nest would not be at risk of predation or abandonment due to the camera's presence. We set cameras five to 28 days prior to the EHD. Ideally they were placed as early as possible, but in cases where nests were floated at high values and the EHD could be within a range of dates, we placed cameras at least one week prior to EHD.

Banding and Estimating Fledging Success

We made an effort to band 50% of all hatched broods to get a representative sample of fledging success for the entire breeding population. We successfully banded 59.9% of broods and 59.4% of chicks in 2016. We color banded a total of 276 chicks from 103 nests. We used a unique four-band color combination issued by the USFWS for each brood. We individualize the four-band combos by exposing the metal on the FWS band to determine which chicks fledged. Additionally, we individually marked chicks within broods from nests of particular interest (e.g., nests in open areas, the Surf North restoration site, or in the far back of sand sheets that are difficult to monitor) to get a better understanding of fledge rate for these areas of interest. For this, we used a single color band on the left leg and a bicolor or tricolor band on the right leg. Since there were a limited number of band combinations available, in 2016 the bicolor and tricolor combinations were used on 89 chicks from 34 full broods. We exposed metal on the FWS band for these broods, as well. During daily surveys, we checked each snowy plover observed for band combinations in order to identify juvenile birds banded during the season. We made an effort to track banded broods to determine fledging success (see "Brood Tracking" below). We identified a bird as successfully fledged when observed approximately 28 days from hatch. Appendix B lists the color band combinations for adults observed in 2016 and Appendix C lists all color bands used on chicks hatched at VAFB in 2016.

Brood Tracking and "Mystery Broods"

It is generally accepted that in a given season, we will not locate every nest initiated due to the challenges of covering every part of the beach with enough consistency. Broods that originate from unknown nests are identified as "mystery broods". Mystery broods have shown up on the shoreline in prior years, but we have been able to definitively identify and track them since 2013. A brood was considered a mystery brood if it was found after it moved away from the nest. In 2016, we consistently monitored both banded and unbanded broods across all beaches. Broods typically appeared on the shoreline directly west of the nest bowl unless moved by a significant disturbance event (e.g. predator presence, monitoring activities, or partial predation of the nest), or the shoreline was overcrowded with older broods. Our primary goal was to keep track of brood territories. During transect surveys and nest search days, we recorded the number and size of chicks, and bands if any, of every brood observed. We noted the time, location (counting block), male bands, if any, and whether a female was present. The relative ages of unbanded chicks were compared to the known ages of banded chicks for reference. Unbanded broods with unbanded males were assigned to the most likely nest based on location and presence of other broods. Using a combination of estimation methods can give us a more realistic idea of fledge success in the absence of banding all chicks hatched.

Nest locations were assigned to the most likely, usually closest, brood. For example, a nest bowl found with one egg and pip fragments present was assigned to the two-chick brood nearby. Otherwise the counting block and GPS coordinates were assigned as the block in which the broods were found. All nests identified using mystery broods were included in the total nest count for 2016.

Transect Surveys

Weekly transect surveys have been conducted at VAFB since 2011. Beginning 1 March, we conducted transect surveys along each beach sector on a weekly basis, alternating North and South Beaches. We divided each beach sector into “transect blocks” approximately 100-300 meters in length along the coastal strand. We walked each sector counting the number of birds, age, sex, flock size, presence of paired individuals, and presence of broods within each transect block. In addition, we scored the amount of wrack present on each block (see ‘Wrack Monitoring’ below), the number and species of shorebird or seabird utilizing the habitat and predator activity. We used this information to 1) produce a more accurate estimate of population size compared to the four window surveys and 2) track breeding phenology throughout the breeding season. As we build this time series, the information will be useful in determining seasonal distribution of adult breeders, defining high quality breeding habitat, and defining areas likely to be used by adults brooding chicks and fledglings. In 2016 we ended transect surveys in mid-September, right after the last brood fledged, due to multiple fires on North and South Base.

Wrack Monitoring

This was the fifth year where we monitored the occurrence and distribution of wrack at each transect block to understand possible correlations between wrack abundance and plover habitat use. Given the time constraints during our transect monitoring, we were unable to measure percent cover of wrack. Rather, we used a classification system to rank wrack occurrence in each transect block on a scale from zero to five; zero indicates no wrack and five indicates heavy deposits within the last high tide line. All monitors were trained and tested to insure consistency in ranking among observers. We used weekly index values for transect blocks to calculate a weekly index value for each beach sector. The weekly value for a given beach sector was the mean across all counting blocks, weighted by the relative length of each counting block within the greater beach sector. Using the weekly values, we calculated the mean and standard error (SE) across the season for each beach sector.

Predator Observations

We recorded predator activity (i.e., visual observations, tracks, and scat), including all avian predators observed within plover habitat or immediately adjacent to nesting habitat (behind back dunes) during monitoring activities. We recorded the species, location, behavior (e.g., actively foraging versus perching), and the direction of travel. We used this information to aid the implementation of avian predator management by identifying potential territories and daily habits of these birds. Furthermore, we documented all common raven observations throughout VAFB, regardless of whether the birds were within snowy plover habitat. Common ravens have very large home ranges and birds breeding inland can potentially forage along the coast.

Restoration Area Habitat Monitoring

To quantify how habitat changes over time after restoration activities, we collected substrate data (relative location and type of a unique object within a 15cm radius, percent cover and predominant cover type within 0.5m and 2m radii, and percent unobstructed view within a 20m radius) at randomly generated points on North and South Beaches in 2015 and 2016. We divided the beaches by sector (Minuteman/Shuman, San Antonio, Purisima, Wall, Surf North, and Surf South) and restoration application (none and contoured). For each restoration segment we assessed substrate data for 25 random points each year. Since beach restoration activities focus on reducing vegetation, here we analyzed percent vegetation cover within a 2m radius at the Wall Beach and Surf North contoured areas, Surf South, the Minuteman/Shuman restoration site, and San Antonio.

Surf South and San Antonio serve as controls for South and North Beaches, respectively, as they will not undergo the same restoration activities as the other beach sectors.

Recreational Beach Management

In addition to data collection, we conducted two activities to help VAFB manage recreational beach use. First, we reported all unauthorized human intrusion into the closed beach areas. We reported these observations to VAFB Security Forces Conservation Law Enforcement officers and to VAFB biologists as soon as possible. This included human footprints leading into the closed areas and observations of unauthorized individuals in closed sections. Each event was thoroughly investigated by plover monitors to identify any evidence of "take" under the Endangered Species Act. Second, under the direction of VAFB biologists and the USFWS, we erected protective symbolic nest fencing around nests located in the beach areas open for recreational use to prevent accidental trampling of the nest by beach visitors. The protective fencing consisted of plastic link chain or nylon rope erected on four 5-foot garden posts in a square 10x10 foot configuration surrounding the nest. Since 2012, we have added a "buffer" fence measuring 100x100 feet surrounding the nest fencing with signs posted on each side to prevent beach goers from walking through the nest fencing or disturbing the incubating birds.

Results

2016 Breeding Population and Reproductive Success

Detailed data summaries can be found in Appendix D. Metrics for 2016 are summarized base-wide in Table 1 and by individual beach sector in Table 2. The maximum number of adults detected during the 2016 transect surveys was observed during the week of 23 June. The maximum number of adults was 110 at CA-84 and 179 at CA-85 (Table 2) for a base-wide total of 289 (Table 1). This is a 6% decrease from 2015 where the maximum population was estimated at 309 breeding adults (Table 1). We confirmed nesting activity for 73 snowy plovers color banded as chicks on VAFB in prior years (Appendix B and Table 3). We suspect an additional two plovers banded as chicks on VAFB were nesting on VAFB in 2016. We confirmed nesting for eight snowy plovers banded as chicks outside of VAFB and suspected nesting for two in 2016 (Appendix B).

A total of 385 nests were located and the fates of all nests were determined. This represents a 12% decrease in nests initiated compared to 2015. There was a 19% increase in the number of nests depredated when compared to 2015. Of the 385 known fate nests, 172 successfully hatched. This is a 34% decrease in total clutches successfully hatching compared to 2015 (260 clutches hatching in 2015). Hatching success (% of total eggs that hatched) and clutch success (% of clutches that hatched all eggs) in 2016 was 47% and 45%, respectively. This represents an 18% and 25% decrease, respectively, from 2015. The primary cause of nest failures was attributed to predation, which accounted for 58% of nest failures or 32% of known fate nests. In 2016, 40 nests were destroyed by tide, the highest number in recent history, representing 19% of all failed nests and 10% of all known nests. Fledging success in 2016 was 23% lower than 2015, with an estimated 39% of chicks successfully fledged in 2016 and 51% in 2015 (Table 1).

Detailed maps of nest locations and fates are provided in Appendix E. Nesting densities for each beach sector are summarized in Figures 2-4 and nest fates are summarized in Figure 5. The highest number of nests occurred on South Beaches and the lowest on Purisima Beaches. There were 14 nests initiated on Purisima Beaches. Furthermore, the highest nest densities for North Beaches occurred on the southernmost sector (SAN). Nest densities for MIN, SHN, and SHS were low in 2016. Hatch rates on North Beaches (44%), Purisima Beaches (50%), and South Beaches (45%) were near average; the base-wide 23 year (1994-2016) mean hatch rate is 47% (Figure 6). Fledge rate was the highest on South Beaches (42%, Figure 6). Thirteen chicks on Purisima Beaches were banded with a fledge rate of 31% for this beach section.

Twenty nests were located in areas open to recreational use in 2016. Table 4 shows the fates of nests initiated within the open areas on MIN, WAL, and SNO in 2016. Symbolic fencing was erected around nests located in high visitor traffic areas to protect them from accidental trampling. Differences in hatching and fledging rates between areas open to recreation use and closed areas varied between beach sectors (Figure 7). At MIN the amount of habitat available within areas open and closed to recreational activities was similar (0.5 miles open and 0.6 miles closed). There were no nests initiated in the open area and two nests (3.3 per linear mile) in the closed area. The closed area had a 50% hatch rate and 0% fledge rate. At WAL there is more habitat available in areas closed to recreation (0.85 miles) than open to recreational use (0.25 miles). There were three nests (12.0 per linear mile) initiated in the open area and 85 (100.0 per linear mile) in the closed area. The open area had a 33% hatch rate and 67% fledge rate. The closed area had a 44% hatch rate and 47% fledge rate. At SNO there is more habitat available in areas closed to recreational use (1.4 miles) than open to recreational use (0.5 miles). We located 17 nests (34.0 per linear mile) in the open area and 72 (51.4 per linear mile) in the closed area. The clutch hatch rate was lower in the open area (41%) than the closed area (47%). Fledging rate in the closed area was 29% and in the open area at 36%.

The open area at SNO did not close due to excess violations during the 2016 breeding season. Nest failure in the open area at SNO was attributed to nest abandonment, depredation by coyote, and destruction by high tide events.

Mystery Broods

We discovered seven mystery brood nests that were initiated between 8 May and 30 June. The broods were found between 23 June and 19 August as small chicks to just prior to fledge. One nest was found as a freshly hatched nest bowl with broody adults in the immediate area, though chicks were not located. Hatch dates were estimated based on relative ages of nearby broods and the dates the mystery broods appeared fledged. Due to our brood monitoring and banding efforts, we were able to confirm that the mystery broods were, in fact, from new, not previously identified nests. The broods were found on SHN (1), SAN (4), WAL (1), and SNO (1). Overall, we monitored 16 chicks from the seven broods, and confirmed that 11 fledged. We confirmed one banded and five unbanded males associated with mystery broods. The brood on WAL was found on the mudflats east of the nesting habitat; we used the GPS coordinates for a known territory in the area directly west of the brood. For the rest we used the transect block coordinates.

Comparison of Fledge Rate Methods

Figure 8 shows the difference in fledge rates based on banded broods, unbanded broods, and both methods combined. Overall the banded fledge rate is higher than both the combined and unbanded fledge rate, though the fledge rates are similar given our high banding rate this year. There were 189 unbanded chicks and 70 confirmed unbanded fledges from tracked broods for a 37.0% fledge rate. In contrast, 276 chicks were banded and 108 were confirmed fledged for a 39.1% fledge rate. We expected a lower fledge rate for unbanded chicks since some broods may never be detected during a typical survey. We suspect that the banded rate is more accurate based on our ability to detect banded chicks. However, tracking unbanded broods may provide a useful index to analyze trends, especially in years when banding efforts are hampered by factors such as inclement weather. A total of 465 chicks hatched and 178 (banded and unbanded) were confirmed fledged for a minimum base-wide fledge rate of 38.3%.

2016 Breeding Phenology

Table 5 shows the egg laying, chick hatching, and fledging periods for VAFB beaches since 1994 (where data has been previously summarized). In 2016, the first known nest was initiated on South Beaches on 29 March and the last nest was initiated on 20 July. The first initiation date is later than average, though the last initiation date falls within the range of average last initial lay dates. The earliest recorded nest initiation of the time series was 2 March in 2009. The chick hatching and fledging periods were shorter than average, but within normal ranges, though we found fewer historic data summarized in past reports. We attribute these shortened periods to the delayed initiations and nest depredations that occurred mid-season. The chick hatching period for 2016 occurred between 29 April and 12 August. The earliest hatch on record was 8 April in 2014, prior to that it was 10 April in 2009. The fledging period was from 27 May to 9 September. The fledging period was recorded in prior reports beginning in 2009, where the first fledgling was observed on 7 May. The earliest fledge date on record was 6 May in 2014.

Figure 9 shows the results of weekly transect surveys on each beach sector. The number of active nests on North Beaches peaked in late April then again in mid-May and then decreased through early June. There was a third peak in mid-June and a fourth peak in early to mid-July. This pattern of peaks and drops in number of active nests is due in large part to the consistent coyote predation observed on North Base this season, particularly on the northern portion of North Base, and is similar to the trend observed in 2014 when there were high levels of nest depredation (see Robinette et al. 2014). Conversely, trends in weekly active nests on South Beaches was relatively stable with a large peak in active nests in mid-April, and three smaller peaks from early May to late June. We attribute the smaller peaks later in the season to consistent low level coyote predation on South Beaches from mid-May to late July. Brood detection on North Beaches began increasing in late May and gradually increased to a final peak in early August. Chicks can be difficult to detect for the first two weeks after hatch. This number therefore represents the minimum number of broods that may have been present. Brood detections on South Beaches remained relatively consistent from mid-May to late July, with an initial peak in late May, and a final peak in early July. Fledglings were first detected on North beaches in early June with sightings steadily increasing through early August. There was a sharp increase in detection in late July which is likely due to an increase in the number of juvenile migrants from other sites. On South Beaches, fledglings were first observed in mid-May and steadily increasing through early August. On both North and South Beaches, fledgling observations sharply decreased in mid-August then remained steady through September, likely due to a combination of dispersal and the presence of a peregrine falcon at the Santa Ynez river mouth estuary where the wintering flock typically forms. Fledglings observed on South Beaches were overall higher than North Beaches for the June to August period. Number of active nests, broods and fledglings were low at Purisima Beaches and fluctuated throughout the season.

Figure 10 shows distribution of flocking and paired birds during weekly transect surveys for North and South beaches. In early March, approximately half of the plovers detected on South beaches were in flocks and the other half was forming pairs. The number of flocked birds decreased quickly and there as a sharp peak in paired birds in early April. On North Beaches, the number of flocked birds was very low, but stable, through March, and there was a dramatic peak in number of paired birds in late March. There was a sharp decline in number of pairs in mid-April, and then a second sharp increase in mid-May. A second and third decline and peak occurred mid-May to mid-June that is consistent with re-nesting after hatching and coyote depredations. The number of pairs detected on both North and South beaches showed a steady decline through July. Plovers began forming flocks again in late May on South Beaches and mid-June on North Beaches, and the number of birds detected in flocks increased steadily through the remainder of the season. This pattern is consistent with the end of the egg laying period at the end of July when adult plovers are typically seen individually rather than exhibiting courting behavior within their territories. Overall the number of paired and flocking birds was higher on South Beaches.

2016 Predator Sightings and Nest Predation

Wildlife species identified as predators of adult snowy plovers, nests, and/or chicks during the 2016 breeding season included raven, gull (*Larus* spp.), coyote, and American peregrine falcon (*Falco peregrinus anatum*). In addition, the following potential predators of adult snowy plovers, nests, and/or chicks were detected on the beaches occupied by snowy plovers: great blue heron (*Ardea herodias*), whimbrel (*Numenius phaeopus*), long-billed curlew (*Numenius americanus*), northern harrier (*Circus cyaneus*), American kestrel (*Flaco sparverius*), merlin (*Falco columbarius*), red-tailed hawk (*Buteo jamaicensis*), great-horned owl (*Bubo virginianus*), loggerhead shrike (*Lanius ludovicianus*), American crow, striped skunk (*Mephitis mephitis*), and raccoon (*Procyon lotor*).

Of the 385 known fate nests, 124 (32%) were depredated in 2016 (Table 6). Coyotes were the most common predators, taking 25% of all known-fate nests. Ravens or suspected ravens took 5.5% of known fate nests. No known-fate nests were taken by skunk and 1% were taken by gulls in 2016. When nests were confirmed depredated before hatch with no clear evidence such as tracking to identify the predator, they are listed as unknown predators. Unknown predators took 1% of known-fate nests. On North Beaches, 26% of nest predations were due to coyote, 15% due to raven or suspected raven, and 1% were due to unknown predators (Figure 11a). On Purisima, four depredated nests were lost to coyote (29%). On South Beaches, the main predator confirmed for nest predation was coyote (25%) with 5% due to raven or suspected raven, 1% due to gull, and 1% to unknown predators. Predator sightings on North, Purisima, and South Beaches did not match patterns seen in nest predation (Figure 11). Nest predation by ravens was relatively high on North Beaches and low on South Beaches, despite infrequent observations on both North and South Beaches. Additionally, coyote predation was high on all beach sectors despite showing few observations on all beaches.

Coyote predation rates overlapped with areas of high nest densities on both North and South Beaches (see Figures 2-4). The highest densities of coyote depredated nests were near water sources; San Antonio Creek and the Santa Ynez River, respectively. On North Beaches, track evidence suggested that a few individuals may have been repeatedly visiting the same beach sectors and keying into areas with high nest densities, especially SAN and SHS. Coyote predation on South Beaches appeared to be more opportunistic over a wider area, as well as keying in to areas with high densities, particularly near the Santa Ynez River and in the contoured restoration areas. The removal of five coyotes on North Beaches resulted in a decrease in nest predation by coyotes, though low-level predation continued on North Beaches.

Overall, there was a 21% increase in coyote predation in 2016 compared to 2015 (98 nests taken in 2016 and 81 nests taken in 2015); and raven predation (including suspected raven) increased from 2015 by 320%. Raven predation occurred in three main waves on North Base on 22-25 May, 15 June, and 18 June. On South Base only one nest was depredated and was likely opportunistic. Fourteen ravens were removed in 2016 with the focus on removing problem individuals.

We confirmed one and suspected an additional three nests were lost to adult mortality in 2016, all on South Beaches. The confirmed loss occurred on SSO, with evidence suggesting the adult was taken at the nest by an owl or peregrine falcon. The eggs were crushed and plover feathers were found near the destroyed nest. The three additional nests were abandoned at a late stage of incubation. We assessed the embryonic stage and found all embryos had reached two or three weeks of development. Nest camera footage of two nests showed sudden inconsistent incubation, indicating one of the adults stopped incubating the nest before the remaining adult abandoned the nest entirely. Nest losses to confirmed or suspected adult mortality accounted for 2% of all failed nests. From 2013 to 2015, we have confirmed the loss of at least 3 adult plovers by peregrine falcon on North and South Beaches. In 2016 we found evidence of two plovers killed by an unknown raptor, one fledgling on SAN and one adult on SNO. Though there was no direct evidence to confirm it (direct observation of the incident, peregrine falcon tracks, etc.), we suspect the plovers were taken by peregrine falcon based on the appearance of the feather piles and observations of peregrine falcons in the area.

It is possible that an increased peregrine falcon presence on North Beaches has led to a shift in snowy plover nest distribution in recent years. Figure 12 shows the number of nests initiated on MIN, SHS/SHN, and SAN over the last 23 years. Patterns in nest initiation are similar among the beach sectors until 2009 when nest numbers start showing a decreasing trend at MIN and SHS/SHN and an increasing trend at SAN. The MIN and SHS/SHN sectors are the closest sectors to a new peregrine falcon aerie that was established at Lion's Head in 2011. We do not have data on peregrine falcon sightings prior to 2011, but it is possible that the peregrines were present in the two years prior to establishing the eerie and may be responsible for the apparent shift in plover nesting effort from north beach sectors to SAN. However, the increasing trend at SAN appears to start in 2005 and the decreasing trends at MIN and SHS/SHN may have started as far back as 2003, well before the establishment of the peregrine falcon aerie. An alternative hypothesis for this shift in nesting population is a progressive decrease in nesting habitat quality at MIN and SHS/SHN due to the establishment and expansion of the non-native beach grass (see *Restoration Area Habitat Monitoring* below). VAFB has taken steps to test both hypotheses. First, VAFB has funded a project to track the movements of the breeding peregrine falcons using satellite telemetry to determine how much time the birds spend foraging at North Beach sectors. Second, VAFB initiated a dune restoration project in 2015 aimed at removing the non-native beach grass.

Nest Camera Monitoring

We set cameras on 48 nests in 2016. Photo and video footage from the cameras allowed us to confirm the fates of all 48 nests (Table 7). Thirty-one nests hatched, ten were depredated by coyote, three were depredated by raven, two nests were abandoned due to the mortality of at least one of the adults, one nonviable nest was abandoned past the estimated hatch date, and one nest was abandoned for unknown reasons. The abandoned nest was abandoned prior to camera placement (photos showed no adults incubating the nest), and the camera was placed to confirm abandonment. A coyote depredated the abandoned eggs prior to collection.

Restoration Area Habitat Monitoring

Figures 13 and 14 summarize the percent of random points that fall into each of six cover categories (0%, <5%, 5-15%, 16-25%, 26-50%, and >50%) for South Base and North Base random points. We observed a general trend of increasing vegetation cover from 2015 to 2016, though the change was most pronounced at the Wall Beach and Surf North contoured areas, where the percent of points with > 50% vegetation cover increased by 100% and from zero to 16% of points, respectively. At Wall the percent of points with no vegetation increased slightly and the rest of the cover ranges decreased. At Surf North, the percent of points with lower cover ranges (0%, <5%, and 5-15%) either decreased or did not change. The percent of points in the 16-25% cover range increased by 50% and those in the 26-50% range decreased by 20%. At Surf South, the percent of points with 0% and 26-50% vegetation increased by 13% and 300% respectively, and those in the <5% and 5-15% range vanished. Surf South habitat changed dramatically after 2015/2016 winter storms scoured out the beach, leaving habitat that had either higher percent vegetation cover or none at all.

Most vegetation cover categories decreased at the Minuteman/Shuman restoration site. However, there was a 200% increase in the 5-15% cover range and 67% increase in the >50% range. San Antonio changed very little. There was an 8% and 33% decrease in points with 0% and <5% vegetation, and no change in the 5-15%, 26-50% and >50% categories. The percent of points with 16-25% vegetation cover increased from zero to 12% (Figure 14). To compare habitat between North Base beach sectors, we plotted the mean vegetation cover of each sector for the two-year period. San Antonio has more points with lower vegetation cover, with 86% of points containing 15% or less vegetation cover. Whereas Minuteman/Shuman shows a mostly even distribution of vegetation cover categories, each category containing 10-24% of points (Figure 14c). While the higher vegetation cover at Minuteman/Shuman has not completely excluded plovers from the site, San Antonio contains more preferred habitat. Thus, we see disproportionately higher nesting on San Antonio.

Wall and Surf North Restoration Area Nesting

Figure 15 shows the nesting distribution on the WAL and SNO restoration sites and surrounding areas from 2013 to 2016. On all of South Beaches, there was an overall decrease in nests from 2015 (Appendix E), but no large-scale north/south shift in territories was observed near the restoration areas. However, there was a northward shift in nesting territories within SSO due to a high amount of beach habitat loss from winter storms. In the first year post-contouring, there was a marked eastward shift in nesting into the SNO contour area. After contouring was conducted on WAL, nesting increased in the contoured area, though there was still nesting in the adjacent beach. In 2016 we observed at eastward shift early in the season due to the narrowed beach front. As the season progressed and the beach opened up, nesting shifted west. We assessed the change in relative nest densities on WAL, north SNO, and the rest of South Beaches south of Surf Beach open area between 2013 and 2016 (Figure 16). Prior to contouring, very few nests were initiated in the pre-contoured (impact) area of the restoration site. On WAL, nest density both in the contoured and adjacent areas increase in 2015, though more drastically in the contoured (impact) area. In 2016 nest densities slightly increased in the contoured area and decreased in the adjacent area, likely due to the decreased beach front. On SNO, nest densities increased inside the contour area (impact) and decreased in the adjacent area immediately after contouring in 2014. In 2015, the second year post-contouring, nest density decreased slightly in the contoured area, and increased slightly on the adjacent beach. Conversely in 2016, densities slightly increased in the contoured area and drastically decreased in the adjacent area. On both beach sections, nest density is lower in the contoured and adjacent areas than it is at the control away from the contoured area. Nest densities on the rest of South Beaches south of Surf Beach open area (control) decreased in 2016, likely due to the same overwinter beach front narrowing that impacted WAL and SNO adjacent areas.

Overall, 70 nests were initiated in the WAL and SNO contoured areas in 2016; 40 on WAL and 30 on SNO. Of these, 31 hatched (44%), 29 were depredated by coyote (41%), six were abandoned due to unknown causes (9%), three were abandoned due to wind (4%), and one nest was abandoned due to the mortality of at least one adult (1%). The contoured areas had the same hatch success than non-contoured areas on North Base

(44%), and slightly lower hatch success than non-contoured areas on South Base (45%). Hatch success in the SNO contoured area decreased in 2016 from both 2015 and 2014 (44%, 52% and 76%, respectively). Hatch success in the WAL contoured area (40%) was lower than that of the adjacent beach and the rest of South Beaches (46-47%) (Figure 17). A total of 82 chicks hatched inside the contoured area. Of these, 43 chicks from 17 nests were banded (52.4% banding rate). The fledge rate from the banded chicks was 41.9% while that of all known chicks (both banded and unbanded) was 37.8%. The fledge rate for the contoured area was similar to that for all the South Beach sectors, and was still higher than the 19-year mean of 34.0% for banded birds on South Beaches (see Trends in Annual Reproductive Success below).

Trends in Annual Breeding Population

Figure 18 shows trends in annual breeding population before and after beach closures were established in 2000. The mean number of adults and nests initiated increased after closures went into effect. Moreover, the period during linear restriction (1994-1999) shows a decreasing trend, whereas the period after has been variable, but relatively stable. In 2004, there was a spike in population on VAFB that was also observed for the total snowy plover population range-wide (USFWS 2007). In 2016, the number of adults observed was above the long-term mean and number of nests initiated on VAFB was above the long-term mean.

The mean number of nests initiated over the time series is similar between North and South Beaches (Figure 19). Annual values are highly correlated for the two beaches (Spearman’s rho: $r = 0.711$, $p < 0.001$). There is a decreasing trend leading to the 2000 beach closures and a variable but stable population since 2002. The 2004 peak was higher for South Beaches and likely reflects higher predation and subsequent re-nesting during that year (MSRS 2004). Conversely, the number of nests initiated at Purisima Beaches declined from 1994 to 2011. The lowest number of nests initiated at Purisima Beaches in the time series occurred in 2011. The number of nests initiated at Purisima Beaches has been increasing since 2011 and was above the long-term average in 2014 for the first time since 2005.

Figure 20 compares the number of nests established per linear mile within areas open to recreational access and closed areas of MIN, WAL and SNO beaches since implementation of VAFB's current beach management. We standardized data to linear mile to account for differences in available habitat within each beach sector. Long-term means for areas closed to recreational access are higher than those for open areas at all three beach sectors, especially MIN and WAL beaches. Long-term means for open and closed areas are more similar for SNO and annual values for the two areas are positively correlated (Spearman's rho: r = 0.708, p = 0.002). Annual values for open and closed area nesting numbers are not correlated for MIN and WAL beaches (Spearman's rho: r = 0.353, p = 0.164 and r = 0.114, p = 0.663, respectively). Furthermore, there were no nesting attempts within areas open to recreational use during 12 years at MIN and seven years at WAL from 2000 through 2016. There were three nests initiated at the WAL open area and none at MIN in 2016.

Trends in Annual Reproductive Success

Both hatching and fledging success have high variability among years from 1997-2016 with no apparent trend (Figure 21). Patterns in both metrics were similar from 1997-2016, but overall, there is no correlation between annual values (Spearman's rho: r = 0.265, p = 0.259). It is likely that, in recent years, the factors regulating hatching success are different than those regulating fledging success. For example, in 2010, hatching success (63%) was well above the long-term mean (45.8%) while fledging success remained average (2010 = 29%, long-term mean = 33.4% in 2010). This may be due to low coyote nest depredation and effective raven management early in the season before high nest losses could occur (MSRS 2010). In 2011, there was a lower than average hatching success (33%) due to high predation, but a higher than average fledging success (46%). In 2013, fledging success and hatching success both increased (57% and 58% respectively) and both were higher than the long-term mean. However, in 2014 hatching success and fledgling success decreased (39% and 45% respectively), but fledging success remained higher than the long-term mean. Like 2013, in 2015 fledging success and hatching success both increased (51% and 59% respectively) and were higher than the long-term mean. In 2016, fledging and hatching success both decreased (39%

and 45% respectively) and were similar to the current long-term mean (46% and 36% respectively).

Figure 22 shows the annual hatching success at North, Purisima, and South Beaches. North and South Beaches show similar patterns with divergence in some years (1999, 2003, 2006, and 2011). This divergence is likely due to different levels of predation between North and South Beaches. Overall, annual values for the two beaches are positively correlated (Spearman's rho: $r = 0.504$, $p = 0.014$). In 2016, hatching success was lower than the long-term mean at both North Beaches and South Beaches (North: 2016 = 44%, long-term mean = 47%; South: 2016 = 35%, long-term mean = 45%). Despite overall lower nesting effort, Purisima Beaches maintain a higher hatching success (50%) compared to North and South Beaches. Additionally, hatching success has been less variable at Purisima Beaches.

Figure 23 shows annual fledging success on North, Purisima, and South Beaches. In 2016, fledging success on North Beaches (36%) was lower than on South Beaches (42%). The opposite was the case in 2015. There is more interannual variability in fledging success than hatching success, with no real long-term trend. Furthermore, there is an absence of data for Purisima Beaches due to the lack of banding in this area in most years. However, available data appears to show slightly higher long-term fledging success at Purisima Beaches (long-term mean = 44%). The long-term means for North and South beaches are similar (38% and 34%, respectively). However, the annual values between the two beaches were no longer correlated with the addition of data from 2015 and 2016 (Spearman's rho: $r = 0.349$, $p = 0.143$).

Figure 24 shows annual hatching success in areas open to recreational access and closed areas of MIN, WAL and SNO. The long-term means were higher in closed areas for all three beach sectors, though differences between open and closed areas were subtle at WAL and SNO (MIN: open = 19% closed = 54% WAL: open = 47%, closed = 51%; SNO: open = 47%, closed = 50%). MIN and WAL are highly variable with many years of no nesting in the open area. Prior to 2015, hatching success appeared to be increasing within the area closed to recreational access at MIN. However, this year, like 2015, hatching success in the closed area was below average. At WAL, clutch hatch success within the area closed to recreational access appears relatively stable, with clutch hatch rates fluctuating near the long-term mean. At SNO, clutch hatch success within the open areas and closed areas appear to follow a similar pattern, but are only marginally correlated (Spearman's rho: r = 0.429, p = 0.086).

Figure 25 shows annual fledging success based on banded birds for open and closed areas using all data available from 2000 - 2016. Fledging success at MIN is highly variable in the closed area with no banding data available for open area nests. The long-term mean for the closed area is 33%. At WAL, the long-term mean was higher in the closed area compared to the open area, though the mean for the open area was based on only five years of banding data (open = 27%, closed = 36%). At SNO, mean fledging success is similar between open and closed areas (open = 36%, closed = 34%), but interannual patterns were not significantly correlated (Spearman's rho: r = 0.377, p = 0.185). In recent years (2012 to 2015), fledging success has been higher in the open area than the closed area. Though in 2014 fledging success in the open area has been about equal to the closed area (55% and 54% respectively). In 2016, the fledging success in the open area was once again higher than that of the closed area (36% and 29% respectively). It is possible that chick survival has increased in the open area due to the use of buffer fencing around nest exclosures which serves as additional protection for broods prior to fledging.

Trends in Annual Wintering Population

Figure 26 shows the results of winter window surveys at North Beaches, South Beaches, and Jalama Beach from 2003 to 2016. With the exception of three winters (2010/11 to 2012/13), the mean size of wintering populations from 2003 to 2015 has been larger on South Beaches than North Beaches. The wintering population size on North Beaches was relatively stable between 2006 and 2010 and peaked during the 2010/2011 winter. Since 2010/2011, the wintering population on North Beaches appears to be decreasing. Winter population size on South Beaches was decreasing from 2007 to 2012 and appears to be increasing since 2012/13. Conversely, the winter population size at Jalama Beach has been increasing steadily since 2009/10. Prior to 2009/10, there were no plovers detected at Jalama Beach during winter window surveys in most years.

Annual Wrack Abundance

Mean ± SE wrack values for each beach sector are shown in Figure 27. For this report, we calculated the mean for the chick rearing time period (May 1 through September 1; see Figure 9) to determine whether differences in wrack abundance could potentially explain difference observed in fledging rates from 2012 to 2016. Two-way Analysis of Variance (ANOVA) showed significant differences among beach sectors and among years (Year: $F = 70.68$, $df = 4, 403$, $p < 0.001$; Beach: $F = 33.82$, $df = 6, 403$, $p < 0.001$). Post-hoc tests showed that there was significantly more wrack on VAFB beaches in 2013 than any other year and significantly less wrack in 2016 than any other year (Table 8). There was also significantly less wrack in 2015 than 2012. Post-hoc tests for beach sector showed there was significantly more wrack at WAL and SNO than all other beach sectors across the five years (Table 9). There was also significantly more wrack at MIN than SHS and more wrack at SSO than SHS. Given that WAL and SNO have the most wrack across years, we decided to investigate whether base-wide fledging success was correlated to wrack abundance in these sections. We found a positive correlation between base-wide fledging success and mean wrack for WAL and SNO (Spearman's rho = 0.97, $p = 0.005$; Figure 28). We found the same correlation between base-wide fledging success and mean wrack for the SNO beach sector only (Spearman's rho = 0.87, $p = 0.054$; Figure 28). Thus, it is possible that these two beach sectors play an important role in determining fledging success base-wide.

Recreational Beach Management

Over 42 beach violations for unauthorized human intrusion into closed beach areas were recorded by Point Blue biologists from 1 March through 30 September, 2016 (Table 10). Most of the violations occurred at SNO (31, 74%), the only beach that is open to the general public. Eight violations were reported at WAL (19%) and three violations were reported at MIN (7%). The total number of beach violations in 2015 represents a 33% decrease from 2015 (63, Table 10). Nest failure in the open area of SNO was attributed to nest destruction by high tide events, coyote depredations, and nest abandonment. Similar to 2015, this season we noted heavy trespass activity from Ocean Park to the sandspit west of the Santa Ynez River mouth. Fresh trespass tracks were consistently recorded between 17 March and 6 September, well after the permanent closure went into effect. Several incidents involved off-leash dogs. The trespass activity likely impacted brood survival on the Santa Ynez sandspit, particularly when the gull flock was present. With the closure of Surf Beach in recent years and the recent removal of the dense beach grass stand at Purisima Point, we have recorded several trespasses in the San Antonio/Purisima area. In 2016 we detected 14 violations between 17 March and 14 July. Trespass evidence was usually detected during the surveys immediately following weekends. At least one incident at the end of May likely caused the loss of several broods on San Antonio.

Discussion

2016 Breeding Season Summary

The decrease in number of nests observed in 2016 was likely due to a combination of the decreased population size (number of adults) and loss of breeding habitat due to large winter storms. A strong El Niño event developed in late 2015 and peaked during the 2015/2016 winter. El Niño events raise the sea level along the California coast and create strong winter storms. Higher sea level and stronger storms lead to higher erosion of beach habitat. Most of the decrease in adult and nest numbers was due to decreases on South Beaches where nesting habitat is already limited by a narrow beach and dune area. Despite this, number of adults and nests on South Beaches in 2016 were still well above the long-term mean. The SNO and WAL beach sectors continue to have significantly more wrack than other beach sectors and may be attracting nesting adults to South Beaches. Additionally, annual base-wide fledging success was positively correlated with annual wrack abundance on SNO and WAL. It is possible that these sectors provide important prey resources for plovers base-wide. As with 2015, large numbers of fledglings were observed on south beaches during early to mid-July and numbers remained relatively high through September. There were fewer fledglings observed on north beaches. Additionally, large flocks of adults began forming on South Beaches in late June and numbers continued to increase through mid-August. Numbers of flocking adults were lower on North Beaches. Finally, annual winter surveys have shown an increase in the number of plovers using South Beaches since 2013. Numbers of plovers wintering on North Beaches have decreased since 2013.

On north beaches, nest numbers continue to generally increase at SAN and decrease at MIN, SHN and SHS. Some of this shift may be due to the establishment of an active breeding pair of peregrine falcons at Lion's Head, just north of MIN. However, MIN, SHN, and SHS have also been inundated by the invasive European beach grass that has reduced the amount of available nesting habitat over several years. The shift in nesting to SAN likely began in 2003, well before the establishment of the peregrine aerie in 2011. Thus, the shift in nest distribution on North Beaches is more likely a result of habitat loss at MIN, SHN, and SHS. The results of our habitat analysis on North Beaches supports this hypothesis as SAN had a higher proportion of preferred nesting habitat than MIN, SHN, and SHS. VAFB has initiated a project to restore habitat on North Beaches. This should result in a reversal of the shift in nesting on North Beaches and hopefully an overall increase in the North Beach nesting population as was seen at SNO and WAL after contouring was performed in those sectors.

Annual nest initiation continues to be correlated for North and South Beaches, as does annual hatching success. Thus, there is evidence that large scale mechanisms such as regional kelp abundance (an important factor determining wrack abundance) are influencing these metrics. If localized issues such as predation were important determinants of nesting efforts, then we would expect trends for the two beach sections to be different. However, fledging success was no longer correlated for North and South Beaches with the addition of data from 2015 and 2016. There are also multiple years in the time series where hatching success differs between North and South beaches, illustrating how localized mechanisms such as nest and chick predation can obscure regional impacts.

Annual Snowy Plover Nesting Effort

The number of snowy plover adults and nests have remained relatively stable since 2006 with higher among-year variability in numbers of nests, mostly due to variability in predation rates among years. There are many factors contributing to annual nesting effort, but most are attributed to nesting habitat availability and prey availability

(Page et al. 2009). Nesting habitat availability is influenced by dry beach width and overall beach morphology (e.g., how much upper beach terrace is available for nesting). Dugan et al. (2008) studied nesting habitat availability and prey abundance at VAFB in 2004 and 2005 and found that beach width varied within and among seasons. Both North and South Beaches were wider in 2004 than 2005. Additionally, there were fewer terraces documented in 2005. The 2004 season had the highest nesting effort on record with a subsequent 38% drop in nesting effort in 2005. Furthermore, nesting densities were positively correlated with terrace width in 2004.

Invertebrate prey availability is influenced by the amount of wrack cover on beaches and, for some species, sand grain size. Dugan et al. (2008) found that the diversity of invertebrates on VAFB beaches was positively correlated with brown algal wrack cover. Both wrack cover and invertebrate abundance was higher in 2004 than 2005. Additionally, the abundance of talitrid amphipods, an important prey for snowy plovers (see Tucker and Powell 1999) was positively correlated with brown algal wrack cover. However, Malm (2011) found that sand grain size was a better correlate for talitrid amphipod abundance than wrack cover. On VAFB, grain size was coarser and more spatially variable on North Beaches (Dugan et al. 2008). It is possible that grain size may also explain differences in talitrid amphipod abundance between North and South beaches (see below). Overall, annual nest density in the Dugan et al. (2008) study was positively correlated with talitrid amphipod abundance and wrack cover.

Many of the above factors regulating nesting habitat availability and prey abundance were correlated in the Dugan et al. (2008) study. For example, macrophyte wrack cover was correlated with dry beach width. Thus, it is difficult to determine whether plover nesting effort responds more to nesting habitat availability or prey abundance. However, it is interesting to note that the peak in 2004 nesting effort was not limited to VAFB and was seen at multiple breeding sites range wide. It is likely that larger scale oceanographic processes regulating wrack cover and prey abundance are at play. The most common macrophytes in the brown algal wrack at VAFB included Macrocystis pyrifera, Egregia menzeii, and Nereocystis luetkeana. Annual growth in M. pyrifera has been shown to vary with oceanographic variability (Tegner et al. 1997) and large areas can be severely disturbed during stormy periods such as strong El Niño events

(Dayton and Tegner 1984). Additionally, several studies have suggested that the spatial distribution of shorebird abundance is positively correlated with coastal upwelling (see Warnock et al. 2002). The central California coastline experiences exceptionally strong and highly variable upwelling events (Wing et al. 1998, Bograd et al. 2000). Thus, it is possible that much of the interannual variability in snowy plover breeding effort at VAFB can be explained by oceanographic-related variability in annual macrophyte production and invertebrate prey abundance.

The spatial differences we observed in nesting effort may also be explained by spatial variability in habitat conditions. South Beaches have consistently had more annual nesting attempts over the 23-year time series and we found significantly higher wrack abundance at WAL and SNO for 2012-2016. Dugan et al. (2008) found that the abundance of talitrid amphipods was 4.5 times greater on South Beaches in 2004 and two times greater in 2005 and associated this with the higher brown macroalgal cover on South Beaches. However, there are other factors that need to be considered when assessing spatial differences in nesting effort. In addition to differences in wrack cover, Dugan et al. (2008) found that grain size was generally coarser on North Beaches, especially on the southern portion of the North Beaches adjacent to the Purisima Beach sectors. Because of these differences in habitat among beach sections, it may be that wrack is more important in determining nesting effort among years rather than among beaches. As we continue to develop the time series of wrack abundance, we will be able to better understand the role wrack plays in determining spatial and temporal variability in annual nesting effort.

The number of nest initiations on Purisima Beaches has been increasing since hitting an all-time low of two nests in 2011. Number of nests initiated on Purisima Beaches was well above the long-term mean for three consecutive years (2014-2016). Prior to 2012, nest numbers on Purisima Beaches were declining, going from 23 nests in 2003 to two nests in 2011. In fact, 2011 marked the first season in the time series for which there were no nesting attempts within PCO. The overall decline in nest initiations was mostly due to the dramatic increase in vegetation cover such as invasive European beach grass and native coastal dune lupine (*Lupinus chamissonis*) (MSRS 2010). Banding data from previous years indicate that broods move from PCO and later are observed on the south portion of SAN (Ball unpublished field notes). The corridor traveled between these two sectors has gradually increased in vegetation cover since 2000 and may have an influence on nest site selection at the colony. Purisima Beaches were not included in the Dugan et al. (2008) study. However, Dugan et al. noted that the southernmost portion of North Beaches, the portion adjacent to the Purisima Beach section, was backed by an artificial dune stabilized with European beach grass. Currently, VAFB is engaged in a program to control European beach grass on North Beaches and initial spraying controlled burns have occurred at PNO and PCO. Since 2011, the number of nests on Purisima Beaches has increased annually with 14 nests documented in 2016, the third highest number since 2003. While the corridor between PCO and SAN is still mostly blocked by vegetation, plovers nested at PCO in 2015 for the first time since 2010. For the second year, plovers nested at PCO with a total of seven nests initiated in 2016.

Despite the degradation in nesting habitat, hatching success at Purisima Beaches has been consistently higher than all other beach sectors over the 23-year period. Some of this success may be attributed to the predator management conducted at the least tern colony. While there is more intensive predator management at PCO than at other beach sectors, there is a potential benefit to the nearby PNO sector as well. Needless to say, this beach sector still represents an important component of VAFB plover breeding habitat.

Annual Snowy Plover Reproductive Success

We calculated reproductive success (number of fledglings produced per adult male) by taking the estimated number of fledglings and dividing by the maximum number of adult males observed during our four breeding window surveys. We estimated the number of fledglings by multiplying the fledging success rate obtained from banding data by the number of chicks confirmed to have hatched. Reproductive success was 1.2 in 2016. This is above the USFWS recovery goal of 1.0 fledglings per male deemed necessary for population growth (USFWS 2007). Furthermore, reproductive success was above the USFWS recovery goal at both recovery sites (1.2 for CA-84 and 1.2 for CA-85). Because banding efforts have been highly variable in past years, reproductive success has been inconsistently reported in reports prior to 2011. Base-wide reproductive success from 2011 through 2016 has ranged from 0.8 to 1.9 fledglings per adult male and has been above the USFWS recovery goal in most years.

Reproductive performance in prior reports has been summarized using clutch hatch success and fledgling success. Both clutch hatch success and fledging success for 2016 were near the 23-year mean. While coyotes took and estimated 25% of nests in 2016, an increase from 19% in 2015, the impact on hatching success and fledgling success was reduced compared to 2014 when coyotes took 34% of nests. As with 2014 and 2015, coyote predation in 2016 occurred on all beach sectors and appeared to be opportunistic on South Beaches and perhaps more focused to dense nesting areas on North Beaches. Coyote predation remains for the most part a localized issue, likely attributable to one or a few coyotes in the beach sectors where it occurs.

Raven predation was higher than in recent years, but still relatively low in 2016, despite a moderate raven presence on North and South Beaches. This is in contrast to prior years when ravens have been a leading cause of nest predation. We attribute much of this decrease in nest predation to preemptive raven management. Preemptive management of ravens should continue as the raven population is expected to increase at VAFB. Raven populations in California have been increasing in recent years (Boarman and Heinrich 1999). In the Central Valley, the raven population increased >7,600% between 1968 and 1992. Much of this increase has been attributed to human activities that have subsidized food and habitat for ravens (Camp and King 1993, Boarman et al. 2006, Kristan and Boarman 2007). Additionally, human development has provided nesting habitat allowing ravens to expand their range into areas where habitat was historically a limiting factor (e.g., coastal scrub habitat). Until recently, ravens have been largely absent from the central California coast (Boarman and Heinrich 1999). Ravens were first detected at VAFB in 2004 (MSRS 2004) and the number of observations has been increasing annually. Despite the increased sightings, raven management on VAFB has been very effective, with <1% of all known fate nests lost to ravens in 2013, <4% in 2014, 1% in 2015, and 5.5% in 2016.

In 2016, 40 nests were destroyed by tide, the highest number in recent history. Over the 2014-2015 winter, a series of storms scoured the beach front, mostly on South Beaches. This resulted in nesting habitat that was much narrower, steeper, and lower in elevation. Some areas were repeatedly wiped clean by high tides such that nesting territories shifted northward and regularly-seen broods disappeared. We suspect the altered beach front contributed to the decreased fledge rate in 2016.

Restoration Area Management

According to a prior analysis on snowy plover nesting substrate, we found plovers prefer vegetation cover in the 5-15% range (Miller et al. 2016). The proportion of points in that category decreased at the Wall contoured area and Surf South, remained the same at the SNO contoured area and SAN, and increased substantially in the MIN/SHN/SHS restoration site. The proportion of points in the higher cover ranges that should exclude snowy plover nesting increased at all the restoration areas and remained the same at the control sites. When comparing mean vegetation cover between North Beach sectors, SAN contains more preferred habitat than the other sectors. This is likely the reason for disproportionately higher nesting on SAN. On South Beaches the changes in vegetation cover did not drastically change the number of plover nests in each restoration segment. However, we did observe small-scale shifts in nest territories within those segments. The most pronounced shift was along the east side of the Surf North contoured area where large swaths of verbena (*Abronia sp.*) and sea rocket (*Cakile maritima*) have excluded plovers from nesting in much of the area, pushing their territories north and west. Additionally, at SSO the increase of points with 0% and 26-50% vegetation and disappearance of points in the <5% and 5-15% range show how the habitat changed after 2015/2016 winter storms scoured out the beach. The remaining habitat had either higher vegetation cover or none at all. In response, nest territories shifted north and into condensed areas, with 51% of SSO nests initiated in only 3 transect blocks, 26% in just one block. The remaining 49% were spread out over 12 blocks. This has some major implications for nesting success on South Base and highlights the importance of maintaining contoured restoration sites as snowy plover nesting habitat, especially in light of climate change-related sea level rise. In 2016 we saw nesting shift westward either out of the contoured sites or to the fringes. We also saw a remarkable increase in nests lost to tide, 33 out of 40 nests on South Base and 15 of 40 nests on Surf South. In years where the beach front is exceptionally narrow due to tidal action, pockets of wider beach and the contoured areas offer a refuge to plovers. Therefore it is crucial that contoured sites are maintained regularly to provide adequate nesting habitat with reduced vegetation cover.

Snowy Plover Management at VAFB

Several recent studies have recognized the need for management programs to manage beyond the species of concern (see Browman and Stergiou 2004). While managing single species can have desired short-term results (e.g., see Marschalek 2010), these results can inflict a cost to the surrounding ecosystem. Thus, long-term management of biological resources should take an ecosystem-based approach, looking beyond the species of concern and incorporating information on both the bottom-up and top-down forces acting on populations. Ecosystem-based management (EBM) involves managing all components of the ecosystem, including human activities. To date, VAFB has been successful at managing human activities on its beaches. Closed beach areas have shown increased nesting effort and hatching success compared to areas open to human use. In fact, nesting effort base-wide has increased since beach closures were established in 2000. However, it is important to incorporate these results into a broader context of predator and environmental impacts to fully understand the effectiveness of VAFB's management efforts.

Predator management should, for the most part, be focused at the beach sector scale, targeting problem animals in localized areas. This is especially true for predators like coyotes where a few animals can cause damage in concentrated areas. Trying to manage these predators on a broader scale will be counterproductive to an EBM approach. Conner et al. (1998) found no correlation between coyote removal and predation rates when non-selective removal was used. They concluded that non-selective methods lead to the removal of predators not creating a problem. Similarly, Sacks (1999) found that most predation was by few individuals. Coyotes are territorial and removal of dominant adults has been shown to increase the number of young, transient individuals seeking territories in the area (Knowlton 1972). Knowlton et al. (1999) also found an increase in the reproductive rates and overall populations of younger coyotes in areas where coyotes are heavily exploited. Thus, developing methods to key in on problem predators will further VAFB's ability to keep the surrounding ecosystem intact. The exception to this would be in the case of ravens which have large home ranges and represent a recent invasion into the VAFB coastal ecosystem.

Additionally, predator management that leads to increased hatching success does not necessarily lead to increased fledgling success. Neuman et al. (2004) noted that predator management techniques for increasing snowy plover hatching success did not result in a similar increase in fledging success. Overall, fledging success is likely a more important metric for guiding snowy plover population management because it ultimately determines recruitment rates into the adult population. If the recruitment rate is consistently lower than the adult death rate over several years, then the population will decline and the population may be more at risk in the long-term (Akcakaya et al. 2003). Because snowy plovers are short-lived (Paton [1994] estimated mean adult survival to be 2.7 years), annual fledging success can be an important determinant of variability in short-term population size.

Decisions on when to actively manage predator populations should consider the larger context of annual environmental variability. It is important to distinguish when predators are having an impact versus when bottom-up forces are playing a larger role in breeding dynamics. In years when bottom-up forces are the cause of poor reproductive performance, there will be little gain from predator management efforts. Ultimately, EBM at VAFB needs to occur on both base-wide and localized spatial scales, focusing on predators that are significantly impacting local beach sectors and using habitat and oceanographic information to manage VAFB's coastal ecosystem. To accomplish this, it will be important to develop a better understanding of the role oceanographic forces play in determining annual nesting habitat availability and invertebrate prey abundance.

Management Recommendations

1) VAFB should continue to support efforts to preemptively manage ravens both within and adjacent to snowy plover nesting habitat. Ravens have only recently expanded their range into coastal habitats on VAFB and are not a native component of the local ecosystem. Efforts to manage ravens on VAFB have been very successful in recent

years. Less than 7% of known-fate nests were taken by ravens in 2012, <1% in 2013, <4% in 2014, 1% in 2015, and 5.5% in 2016. Continued preemptive management of ravens will help VAFB meet its management goals for snowy plovers.

2) The Peregrine falcon population on VAFB has recently expanded to support three successful breeding pairs. The increased presence of peregrines on the coast can potentially impact the adult population of snowy plovers by increased adult mortality as confirmed in 2012 and 2013 when plover bands were found among nest contents at the Lion's Head aerie. In response, VAFB has funded an effort to track the movements of the peregrine falcons breeding at Lion's Head. VAFB should continue to support studies that would determine peregrine hunting activities and the extent to which adult plovers are being taken. Due to the fact that only ~20% of the VAFB population of adult snowy plovers is banded, it is difficult to determine the extent of impact the peregrines are having on breeding birds.
3) A comprehensive beach study should be conducted to determine the factors influencing annual nesting effort at VAFB. While Dugan et al. (2008) identified many potential factors, many of the factors covaried over the short time series (2004-2005). A long-term study that incorporates the oceanographic and environmental variables regulating habitat availability and prey abundance will allow VAFB to better understand variability in annual nesting effort. This, in turn, will allow VAFB to take a more ecosystem-based approach to managing coastal biological resources.
4) VAFB should continue efforts to restore habitat on North and Purisima Beaches. Invasive weeds persist on these beach sections and have become more prevalent in areas of WAL, MIN, SHN, SHS sectors. Large scale restoration efforts on SAN and SNO have proven successful as the numbers of nests initiated in these areas has increased substantially. Restoring habitats on North and Purisima beaches should have similar results. Restored habitat should be maintained as annual vegetation will encroach on nesting habitat.
5) The banding program on VAFB should continue yearly in order to assess population composition of breeding adults and annual fledge rates. There are many gaps in the fledge rate time series due to variable banding effort among years. This has made it difficult to determine the factors regulating fledging success at VAFB. Having a more

robust time series on fledging success will allow VAFB to more selectively manage predators and promote the health of the coastal ecosystem.

6) The measurements of beach topography (e.g., beach width, slope, etc.) conducted by Dugan et al. (2008) should be repeated. The Santa Ynez River experienced a 25-year flood event over the 2010/2011 winter (D. Revell, pers. comm.). This event has likely changed much of the beach morphology on south beaches. Additionally, the sand bar at the mouth of the Santa Ynez River has not breached since 2012. This has also likely impacted beach topography in the areas. Finally, strong El Niño related storms caused intense beach erosion during the 2015/2016 winter and loss of nesting habitat on North and South Beaches. As Dugan et al. (2008) showed, beach topography can change both annually and seasonally, it is important to conduct periodic surveys to understand the dynamics of beach topography at VAFB. Understanding the dynamics of beach topography will allow VAFB to better understand annual variability in snowy plover nesting effort.

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Table 1. Summary of population and breeding metrics for the Western snowy plover population on VAFB in 2016 and 2015. Also shown is the percent change for each metric in 2016 when compared to 2015.

		2016	2015	% Change in 2016
Population	Maximum Adults Observed	289	309	-6%
	Number of Nests Initiated	385	437	-12%
Nests	Hatched	172	260	-34%
	Abandoned Before Hatch	23	43	-47%
	Incubated Past Hatch Date	3	1	200%
	Depredated	124	104	19%
	Destroyed by Wind	17	7	143%
	Destroyed by Tide	40	17	135%
	Destroyed by Human(s)	0	0	0%
	Failed Unknown	2	4	-50%
	Suspected Adult Mortality	4	1	300%
	Unknown Fate	0	0	0%
Eggs & Chicks	Total Known Fate Eggs	987	1177	-16%
	Total Chicks Hatched	465	680	-32%
	Hatching Success	47.1%	57.8%	-18%
	Clutch Success	44.7%	59.5%	-25%
	Known Fate Clutches	385	437	-12%
Fledglings	Total Banded Chicks	276	336	-18%
	Banding Rate	59.4%	49.4%	20%
	Total Banded Fledglings Observed	108	170	-37%
	Fledging Success	39.1%	50.6%	-23%
	Estimated # of Fledglings	181	344	-48%
	Fledges per male	1.19	1.79	-34%

Table 2. Summary of population and breeding metrics for the Western snowy plover population on VAFB per beach section and recovery site (highlighted in blue), 2016. Population estimates are based on maximum number of adults observed during all transect surveys. Reproductive success (fledglings per adult male) was calculated using maximum number of males observed during the four window surveys in order to keep consistent with historic calculations.

		MIN	SHN/ SHS	SAN	PNO	PCO	CA-84	WAL	SNO	SSO	CA-85
Population	Maximum Adults Observed	4	25	76	8	3	110	59	75	61	179
	Number of Nests Initiated	2	30	105	7	7	151	88	89	57	234
Nests	Hatched	1	7	52	1	6	67	38	41	26	105
	Abandoned Before Hatch	0	1	5	1	0	7	4	7	5	16
	Incubated Past Hatch Date	0	0	2	0	1	3	0	0	0	0
	Depredated	1	16	41	4	0	62	34	22	6	62
	Destroyed by Wind	0	1	4	0	0	5	6	4	2	12
	Destroyed by Tide	0	5	1	1	0	7	4	14	15	33
	Destroyed by Human(s)	0	0	0	0	0	0	0	0	0	0
	Failed Unknown	0	0	0	0	0	0	1	0	1	2
	Suspected Adult Mortality	0	0	0	0	0	0	1	1	2	4
	Unknown Fate	0	0	0	0	0	0	0	0	0	0
Eggs & Chicks	Total Known Fate Eggs	6	72	277	18	19	392	224	231	140	595
	Total Chicks Hatched	3	18	144	1	17	183	103	110	69	282
	Hatching Success	50%	25%	52%	6%	89%	47%	46%	48%	49%	47%
	Clutch Success	50%	23%	50%	14%	86%	44%	43%	46%	46%	45%
	Known Fate Clutches	2	30	105	7	7	151	88	89	57	234
Fledglings	Total Banded Chicks	0	12	86	1	12	111	52	79	34	165
	Banding Rate	0%	67%	60%	100%	71%	61%	50%	72%	49%	59%
	Total Banded Fledglings Observed	0	4	31	0	4	39	25	24	20	69
	Fledging Success	0%	33%	36%	0%	33%	35%	48%	30%	59%	42%
	Estimated # of Fledglings	0	6	52	0	6	64	50	33	41	118
	Fledges per male	-	-	-	-	-	1.2	-	-	-	1.2

Table 3. Number of plovers banded as chicks at VAFB in all years since 1995. Also shown are the numbers of chicks banded at VAFB that were observed as adults at VAFB in 2016. Band combinations used at VAFB in 1998 and 1999 were the same for both years. Additionally, some birds were identified as being banded at VAFB, but the year banded was not determined.

Year Banded at VAFB	Number of Chicks Banded	Number of Adults Observed in 2016	Number of Confirmed Nesters in 2016	Number of Probable Nesters in 2016
1995	63			
1996	149			
1997	139			
1998 or 1999	114			
2000	52			
2001	58			
2002	61			
2003	56			
2004	249			
2005	68			
2006	110	1		
2007	27			
2008	149			
2009	182			
2010	21			
2011	148	6	1	1
2012	161	15	6	2
2013	172	22	15	3
2014	208	31	16	4
2015	336	69	33	8
Unknown Year	N/A	7	2	

Table 4. Fates of nests initiated within areas open to recreational activity on Minuteman (MIN), Wall (WAL), and Surf, North (SNO) beach sectors in 2016.

Nest Fate	MIN	WAL	SNO
Hatched	0	1	7
Abandoned	0	2	3
Depredated	0	0	5
Non-viable	0	0	0
Destroyed by Human	0	0	0
Tide/Wind	0	0	2
Failed Unknown	0	0	0

Table 5. Historic egg laying, chick hatching, and fledging periods for snowy plovers at VAFB. Data for egg laying periods were available for 1995-2016. Data for chick hatching periods were available for 2002-2016 (with the exception of 2010). Data for fledging periods was available for 2009-2016 (with the exception of 2010).

	Egg Laying Period	Chick Hatching Period	Fledging Period
1995	6 Mar – 21 Jul	Not Available	Not Available
1996	24 Mar – 16 Jul		
1997	15 Mar – 25 Jul		
1998	26 Mar – 17 Jul		
1999	31 Mar – 25 Jul		
2000	23 Mar – 14 Jul		
2001	20 Mar – 13 Jul		
2002	15 Mar – 17 Jul	17 Apr – 16 Aug	
2003	17 Mar – 25 Jul	23 Apr – 22 Aug	
2004	14 Mar – 24 Jul	18 Apr – 26 Aug	
2005	20 Mar – 17 Jul	28 Apr – 14 Aug	
2006	26 Mar – 23 Jul	28 Apr – 19 Aug	
2007	9 Mar – 22 Jul	20 Apr – 22 Aug	
2008	14 Mar – 20 Jul	21 Apr – 21 Aug	
2009	2 Mar – 17 Jul	10 Apr – 17 Aug	7 May – 12 Sep
2010	23 Mar – 20 Jul	Not Available	Not Available
2011	18 Mar – 24 Jul	19 Apr – 27 Aug	16 May – 23 Sep
2012	18 Mar – 21 Jul	20 Apr – 21 Aug	18 May – 18 Sep
2013	20 Mar – 12 Jul	21 Apr – 9 Aug	18 May – 5 Sep
2014	4 Mar – 27 Jul	8 Apr – 17 Aug	6 May – 14 Sep
2015	20 Mar – 10 Jul	22 Apr – 9 Aug	20 May – 6 Sep
2016	29 Mar – 20 Jul	29 Apr – 12 Aug	27 May – 9 Sep

Table 6. Number and percent of known fate snowy plover nests taken by predators at VAFB in 2016.

	Number of Nests	Percent of Known Fate Nests
Coyote	98	25%
Confirmed Raven	16	4%
Suspected Raven	5	1%
Unidentified Gull	2	1%
Skunk	0	0%
Unidentified Predator	3	1%
Total	124	32%

Table 7. Fates of 48 nests monitored with cameras on VAFB in 2016, including the dates for which the camera was recording and the date on which the nest's fate was captured (Fate Date).

Nest ID	Beach Section	Camera Dates		Fate Date	Fate	Comments	Trespass Detected
16MIN001	MIN	4/20	5/23	5/21	Hatched	Confirmed incubation/clutch completion and hatch date	
16SAN002	SAN	4/18	4/27	4/24	Coyote	Confirmed coyote depredation, fate date and time	
16SAN003	SAN	4/18	5/3	4/30	Coyote	Confirmed coyote depredation, fate date and time	
16SAN007	SAN	4/27	5/3	4/30	Coyote	Confirmed coyote depredation, fate date and time	
16SAN024	SAN	5/4	5/23	5/20	Hatched	Confirmed hatch date and nest departure	
16SAN032	SAN	5/6	5/24	5/23	Raven	Confirmed CORA depredation, fate date and time	
16SAN044	SAN	5/23	6/29	6/21	Nonviable	Confirmed sustained incubation of non-viable eggs, abandonment date, and unbanded female	
16SAN049	SAN	5/25	5/26	5/25	Raven	Confirmed CORA depredation, fate date and time	
16SAN058	SAN	5/31	6/20	6/17	Hatched	Confirmed hatch date and nest departure	
16SAN060	SAN	6/20	7/2	7/1	Hatched	Confirmed hatch date and nest departure	
16SAN067	SAN	6/6	7/2	7/1	Hatched	Confirmed hatch date and nest departure	
16SAN073	SAN	7/2	7/20	7/19	Hatched	Confirmed hatch date and nest departure	
16SAN079	SAN	6/29	7/25	7/24	Hatched	Confirmed hatch date and time, and chick mobility timing	
16SAN086	SAN	7/20	7/27	7/26	Hatched	Confirmed hatch date and nest departure	
16SAN087	SAN	7/27	7/29	7/27	Hatched	Confirmed hatch date and nest departure	
16SAN089	SAN	7/2	7/26	7/25	Hatched	Confirmed hatch date, nest departure, and banded male	
16SAN093	SAN	7/26	7/29	8/2	Hatched	Camera malfunctioned and was replaced prior to hatch	
16SAN093	SAN	7/29	8/9	8/2	Hatched	Confirmed hatch date and nest departure	
16SAN094	SAN	7/25	8/16	8/4	Hatched	Confirmed hatch date and nest departure	
16SHN001	SHN	5/24	6/17	6/11	Hatched	Confirmed hatch date and nest departure	
16SHN003	SHN	6/17	6/23	6/18	Raven	Confirmed CORA depredation, fate date and time	
16SHN006	SHN	6/23	7/20	7/19	Hatched	Confirmed hatch date and nest departure	
16SHN007	SHN	7/20	8/3	7/24	Hatched	Confirmed hatch date and nest departure	
16SHS001	SHS	4/21	4/27	4/25	Coyote	Confirmed coyote depredation, fate date and time	
16SHS007	SHS	5/6	5/9	5/8	Coyote	Confirmed coyote depredation, fate date and time	
16SHS011	SHS	5/13	5/24	5/20	Coyote	Confirmed coyote depredation, fate date and time	
16SNO002	SNO	4/18	5/9	5/7	Hatched	Confirmed hatch date and nest departure	
16SNO003	SNO	4/18	5/6	5/4	Hatched	Confirmed hatch date and nest departure	
16SNO004	SNO	4/11	5/2	4/29	Hatched	Confirmed hatch date and nest departure	Yes
16SNO031	SNO	5/18	5/23	5/20	Coyote	Confirmed coyote depredation, fate date and time	
16SNO037	SNO	5/25	6/20	6/17	Hatched	Confirmed hatch date and nest departure	
16SNO068	SNO	6/20	7/8	7/7	Hatched	Confirmed hatch date and nest departure	Yes
16SNO075	SNO	7/6	8/1	7/13	Adult Mortality	Confirmed probable mortality of male and final abandonment date and time	
16SNO087	SNO	7/23	8/10	8/8	Hatched	Confirmed hatch date and nest departure	

Table 7 (continued). Fates of 48 nests monitored with cameras on VAFB in 2016, including the dates for which the camera was recording and the date on which the nest's fate was captured (Fate Date).

Nest ID	Beach Section	Camera Dates		Fate Date	Fate	Comments	Trespass Detected
16SSO004	SSO	4/18	5/12	5/12	Hatched	Confirmed hatch date and nest departure	
16SSO009	SSO	5/9	5/18	5/13	Coyote	Confirmed coyote depredation, fate date and time	
16SSO023	SSO	5/21	6/6	6/4	Hatched	Confirmed hatch date and nest departure	
16SSO028	SSO	5/12	5/25	5/24	Coyote	Confirmed coyote depredation, fate date and time	
16SSO045	SSO	7/13	7/21	7/20	Hatched	Confirmed fate, hatch date, tide event date and time, recovery of egg, inconsistent incubation and abandonment of recovered egg that hatched	
16SSO056	SSO	7/26	8/1	7/24	Abandoned	Confirmed abandonment prior to camera placement and coyote depredation of abandoned eggs	
16WAL015	WAL	4/29	5/23	5/18	Hatched	Confirmed hatch date and time, unbanded pair, and nest departure	
16WAL032	WAL	5/25	6/13	6/10	Hatched	Confirmed hatch date and time, unbanded pair, and nest departure	
16WAL038	WAL	5/27	6/27	6/22	Hatched	Confirmed hatch date and nest departure	
16WAL041	WAL	5/27	5/30	5/29	Coyote	Confirmed coyote depredation, fate date and time	
16WAL050	WAL	6/13	7/6	7/3	Hatched	Confirmed hatch date and nest departure	
16WAL057	WAL	6/9	7/4	7/2	Hatched	Confirmed hatch date and nest departure	
16WAL070	WAL	6/29	7/6	7/4	Hatched	Confirmed hatch date and nest departure	
16WAL074	WAL	7/6	7/23	7/21	Hatched	Confirmed hatch date and nest departure	
16WAL083	WAL	7/6	8/1	7/20	Adult Mortality	Confirmed adult mortality date and time	

Table 8. Results of Bonferroni post hoc tests on mean wrack values among years. Significant differences are italicized in red.

	2012	2013	2014	2015
2013	***MD = 0.378 p <0.001***			
2014	MD = -0.099 p = 1.000	***MD = -0.477 p <0.001***		
2015	***MD = -0.340 p = 0.003***	***MD = -0.719 p <0.001***	MD = -0.242 p = 0.197	
2016	***MD = -0.899 p <0.001***	***MD = -1.277 P <0.001***	***MD = -0.800 P <0.001***	***MD = -0.559 P <0.001***

Table 9. Results of Bonferroni post hoc tests on mean wrack values among beach sectors. Significant differences are italicized in red.

Beach	MIN	SHN	SHS	SAN	WAL	SNO
SHN	MD = -0.168 p = 1.000					
SHS	***MD = -0.422 p = 0.004***	MD = -0.254 p = 0.531				
SAN	MD = -0.370 p = 0.086	MD = -0.162 p = 1.000	MD = 0.092 p = 1.000			
WAL	***MD = 0.758 p <0.001***	***MD = 0.926 p <0.001***	***MD = 1.181 p <0.001***	***MD =1.088 p <0.001***		
SNO	MD = 0.352 p = 0.058	***MD = 0.519 p <0.001***	***MD = 0.740 p <0.001***	***MD = 0.681 p <0.001***	***MD = -0.407 p = 0.014***	
SSO	MD = -0.094 p = 1.000	MD = 0.132 p = 1.000	***MD = 0.386 p = 0.018***	MD = 0.294 p = 0.250	***MD = -0.794 p <0.001***	***MD = -0.387 p = 0.026***

Table 10. Number of beach violations per beach sector on VAFB, 2001-2016.

Beach Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Minuteman (limit 10)	2	3	0	2	5	11*	0	1	4	5	5	1	2	10 (12)	0	4
Wall (limit 10)	8	0	0	2	8	2	1	1	6	3	7	9	3	5	2	3
Surf (limit 50)	34	29	17	28	32	48	30	29	36	19	32	50*	50*	50* (63)	50* (83)	46
VAFB Total	44	32	17	32	45	62	31	31	46	27	44	60	55	65	52	53

* Closed because violation limit was reached.
( ) Values indicate total violations recorded, including violations after beach limit.

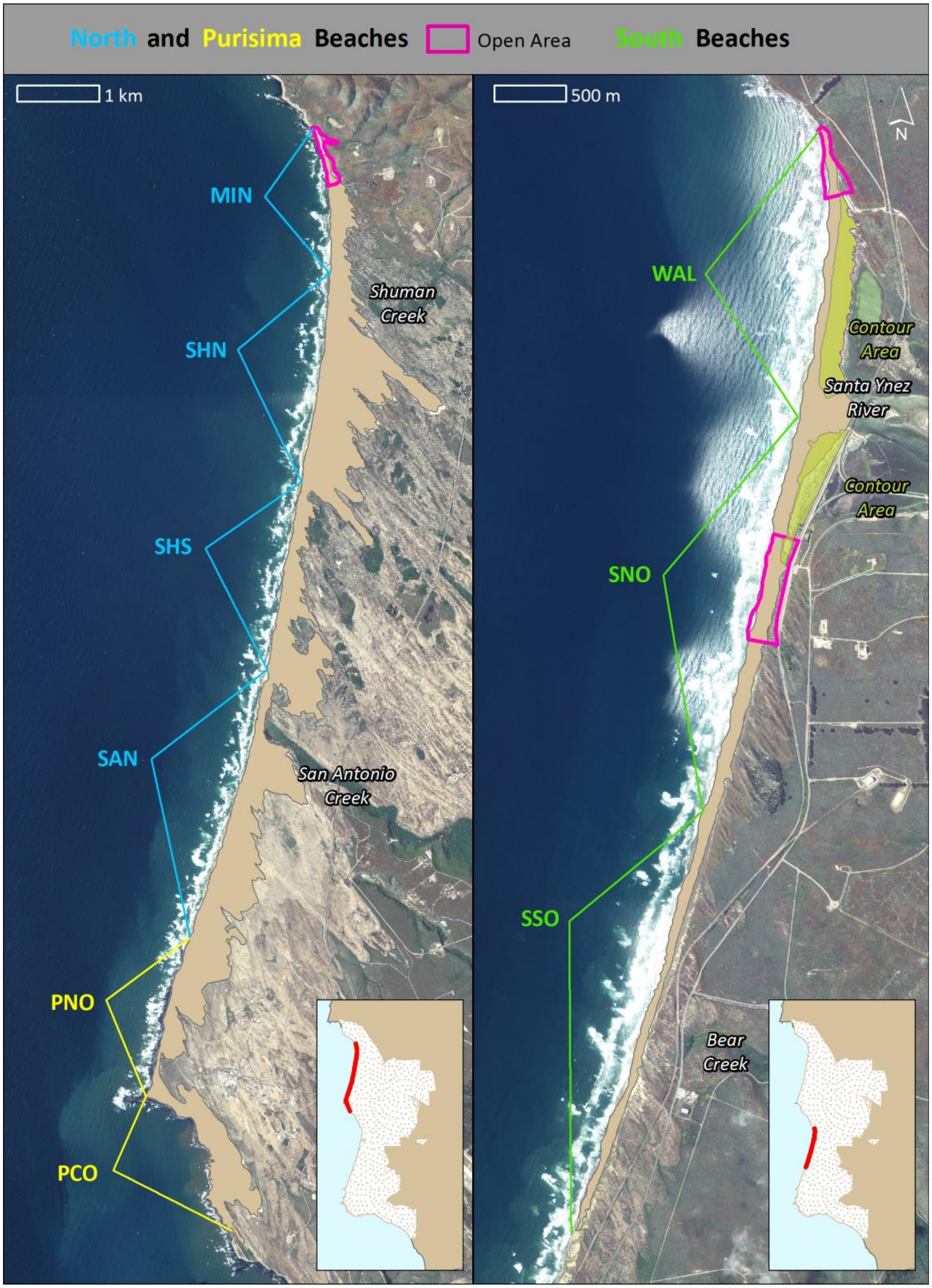


Figure 1. Map of beach sectors for North, Purisima, and South Beaches on VAFB. Areas open to public and/or military personnel are outlined in purple. The Surf North Restoration Area is shaded in green. MIN = Minuteman, SHN = Shuman North, SHS = Shuman South, SAN = San Antonio, PNO = Purisima North, PCO = Purisima Colony, WAL = Wall Beach, SNO = Surf North, SSO = Surf South.

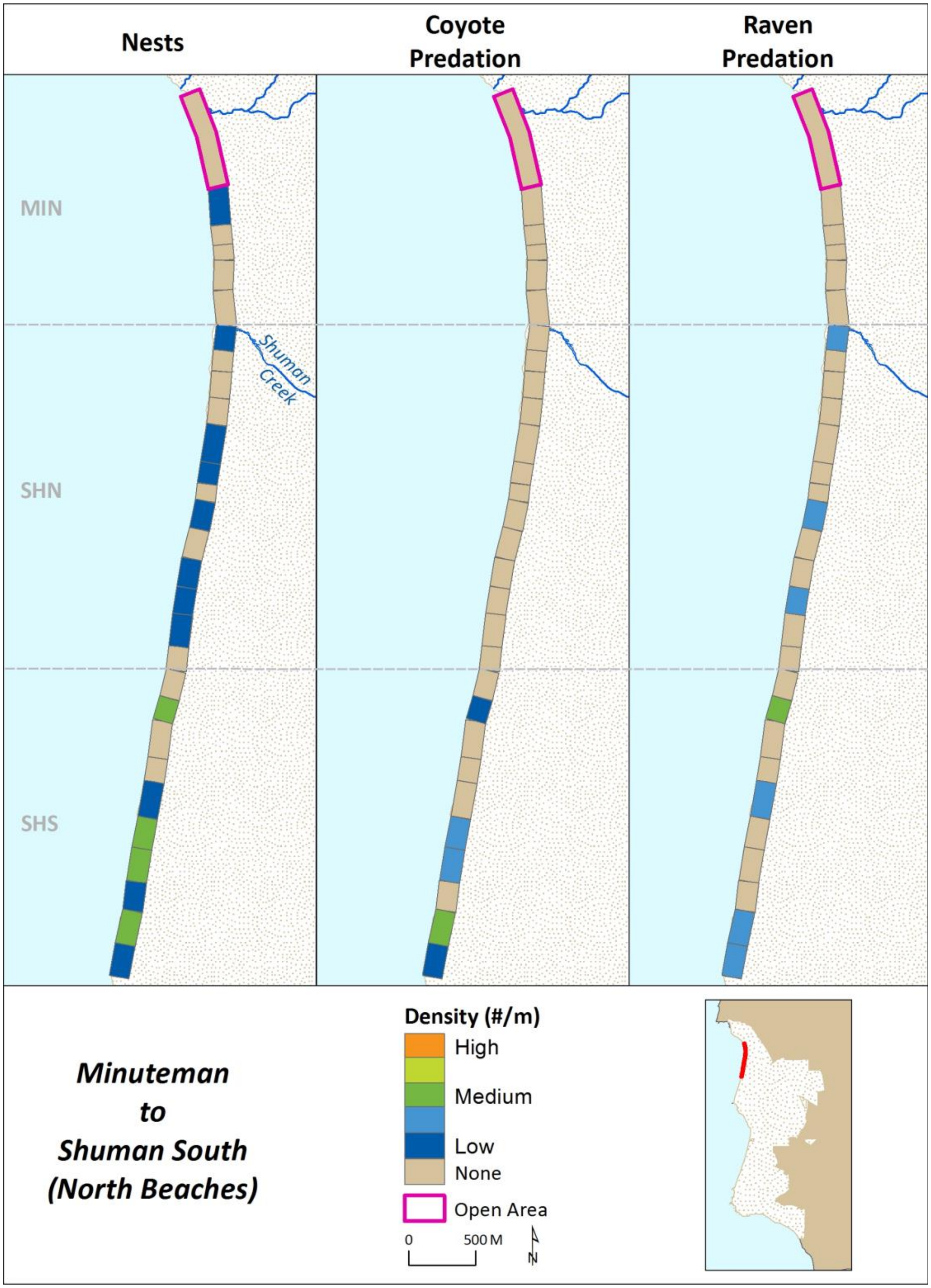


Figure 2. Snowy plover nest densities within North Beach transect blocks from Minuteman to Shuman South (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple.

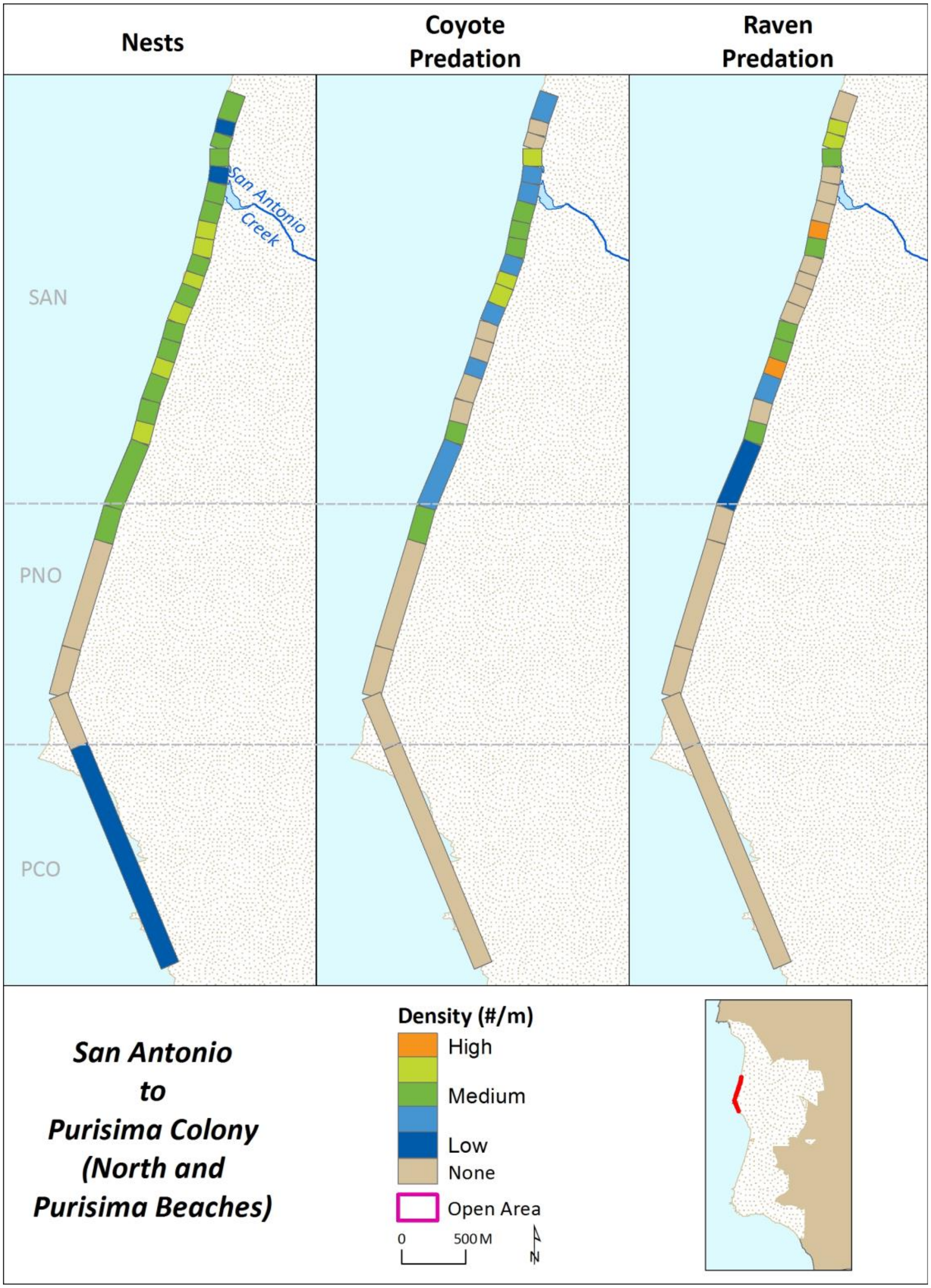


Figure 3. Snowy plover nest densities within North and Purisima Beach transect blocks from San Antonio to Purisima North (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple.

Figure 4. Snowy plover nest densities within South Beach transect blocks (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple.

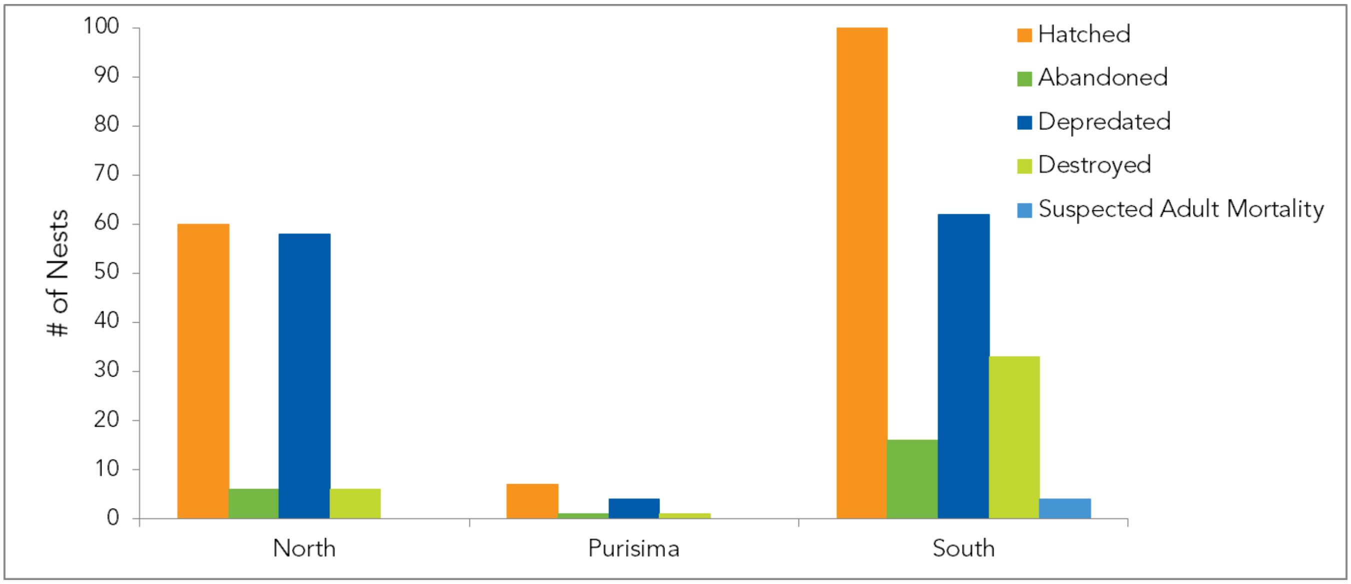


Figure 5. Nest fates on North, Purisima, and South Beaches in 2016. Destroyed nests include those destroyed by both humans and natural causes (e.g., tides and wind).

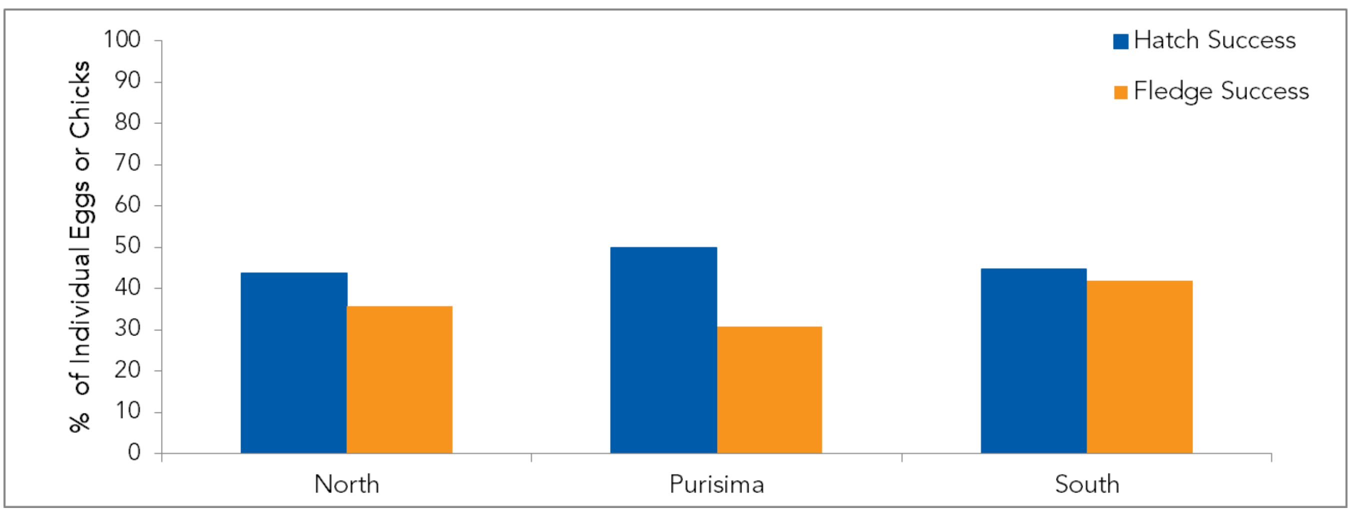


Figure 6. Clutch hatch and fledging success on North, Purisima, and South Beaches in 2016.

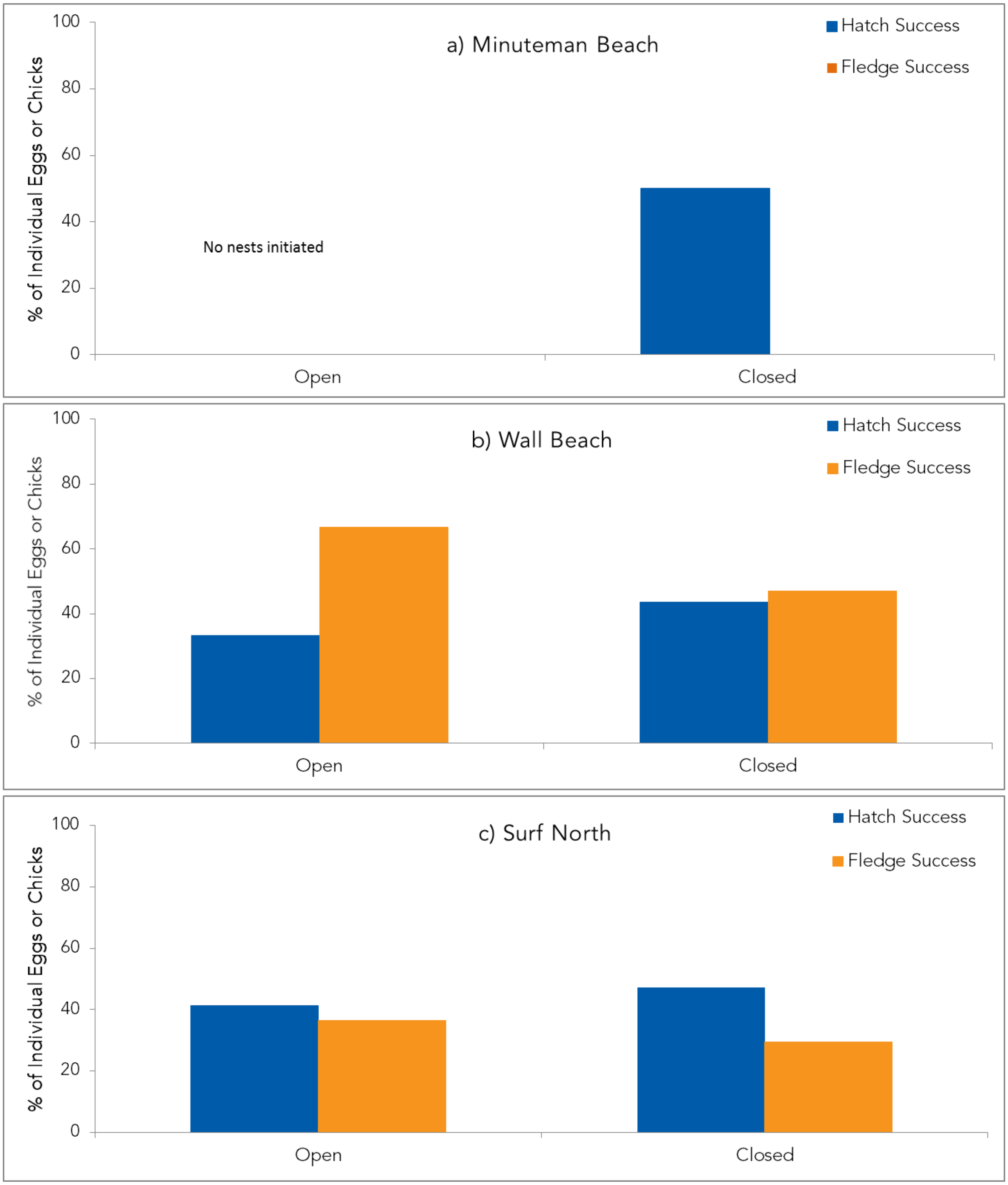


Figure 7. Clutch hatch and fledging success in open and closed areas of Minuteman, Wall, and Surf Beaches.

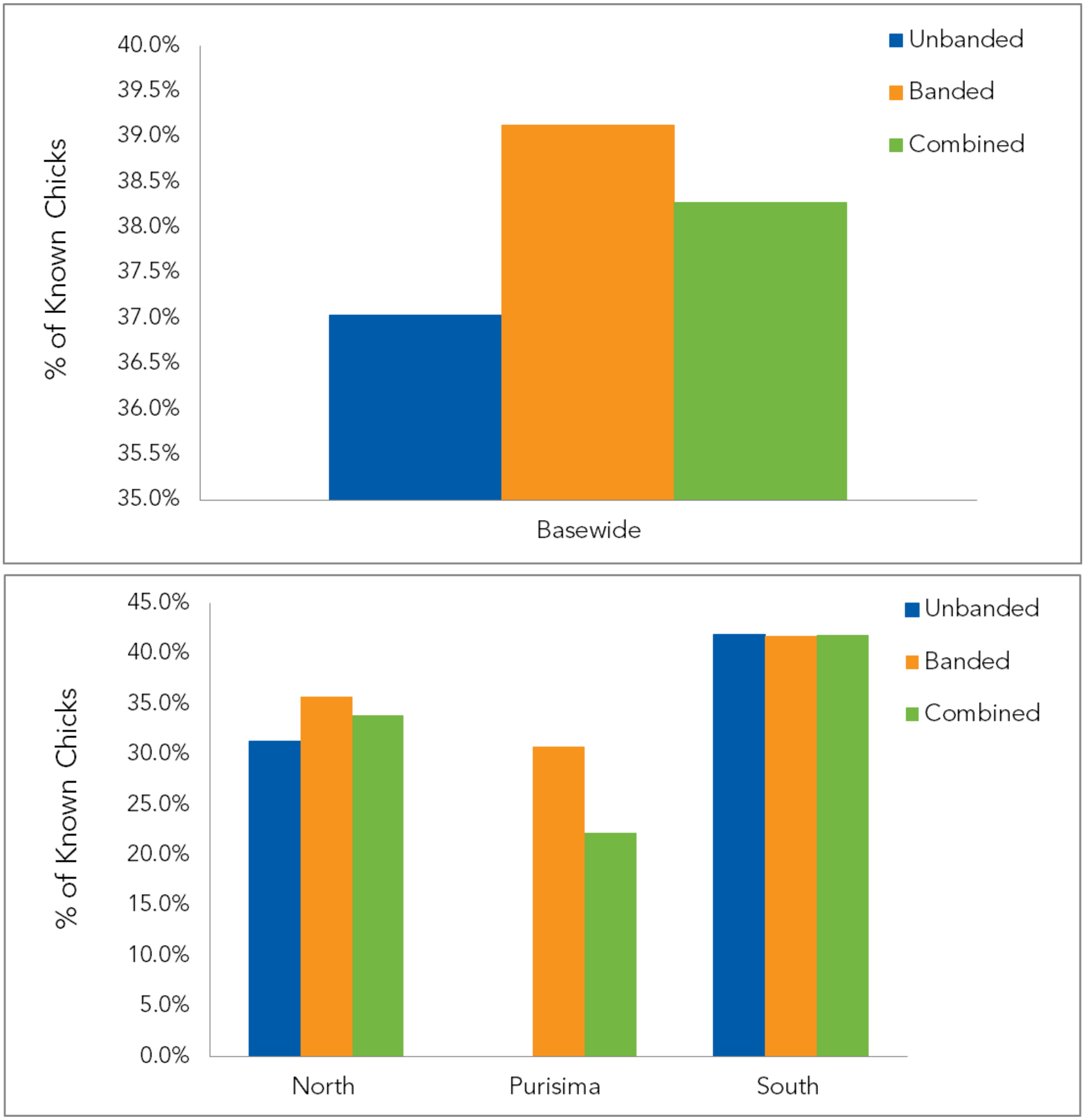


Figure 8. Fledging rates calculated a) basewide and b) for North, Purisima, and South Beach sections in 2016 using banded fledgling counts, unbanded fledgling counts, and banded and unbanded fledglings combined.

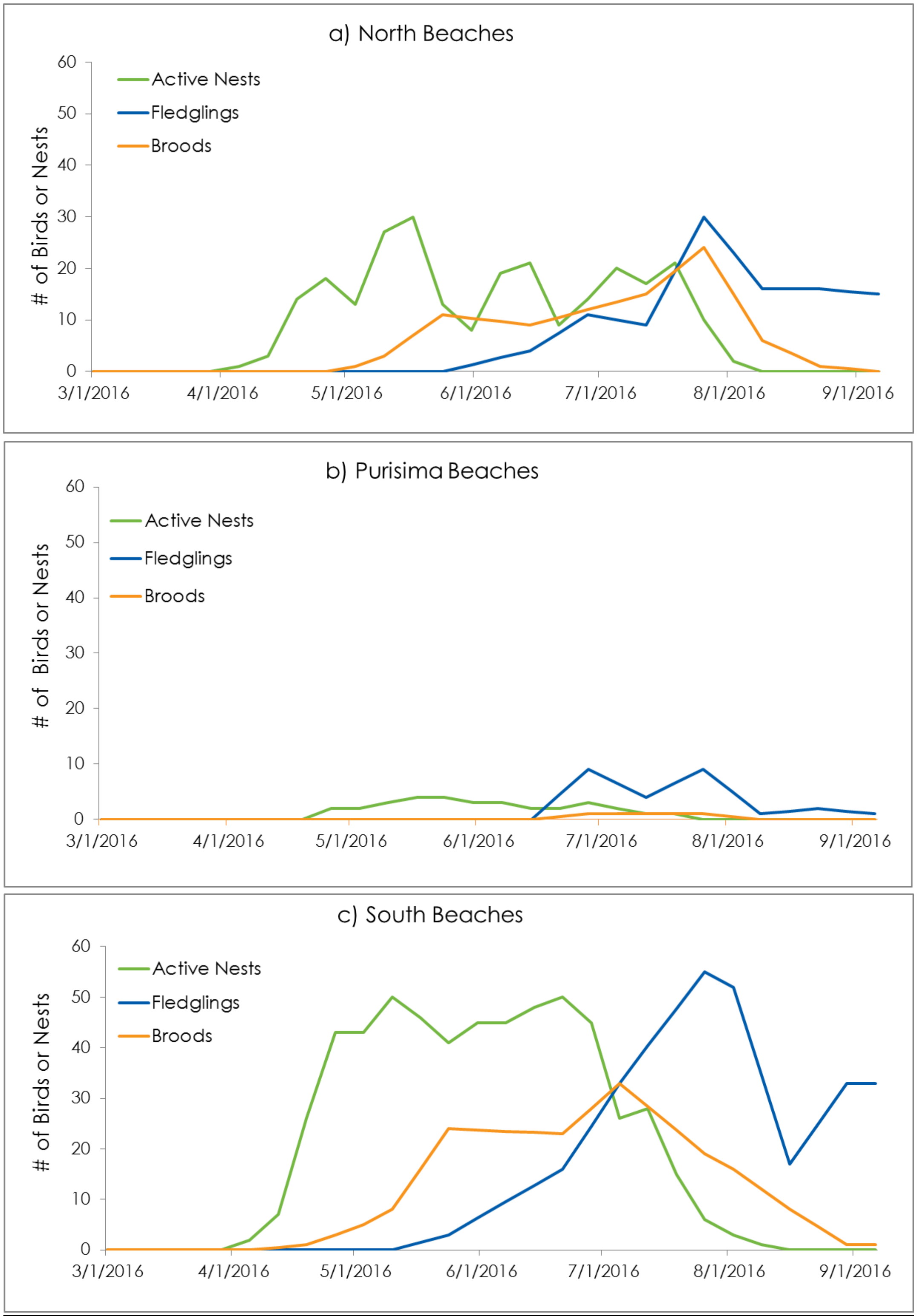


Figure 9. Breeding phenology at North, Purisima, and South Beaches in 2016.

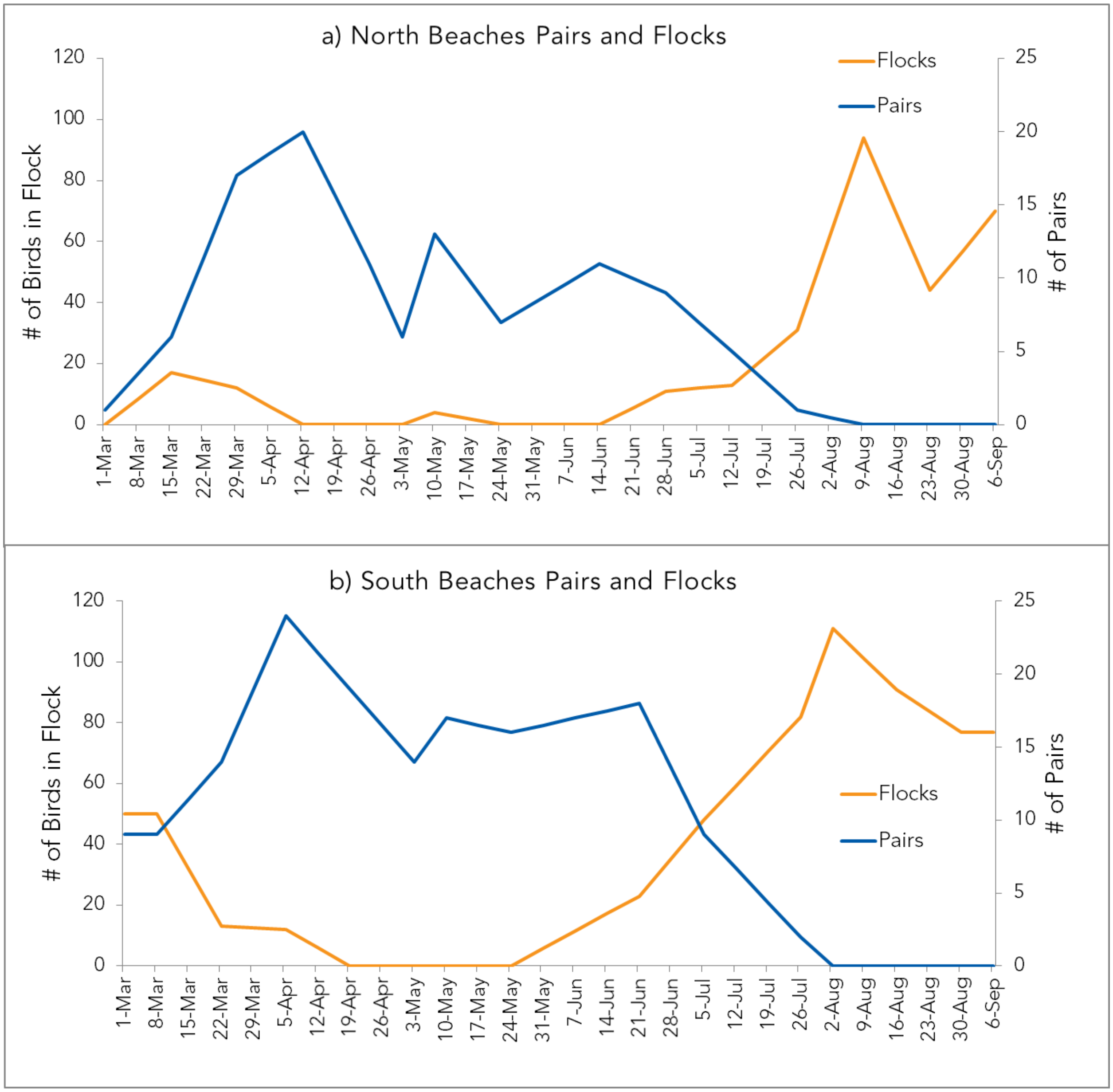


Figure 10. Numbers of plover adult pairs detected during weekly transect surveys versus number of plovers in flocking groups on North and South Beaches.

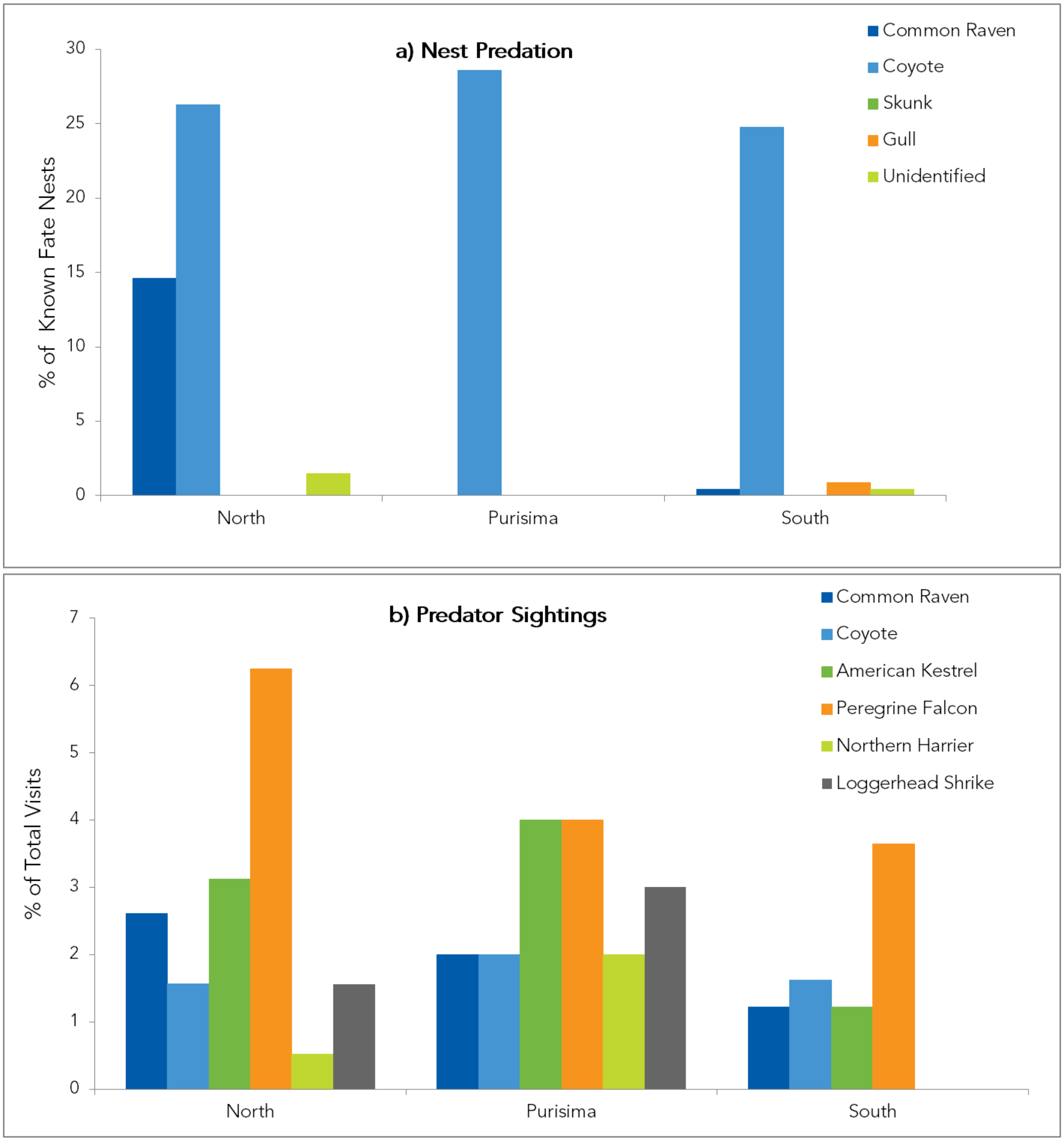


Figure 11. a) Distribution of known fate nests taken by predators and b) predator sightings on North, Purisima, and South Beaches in 2016. Number of nests taken by common ravens includes both confirmed and suspected predation.

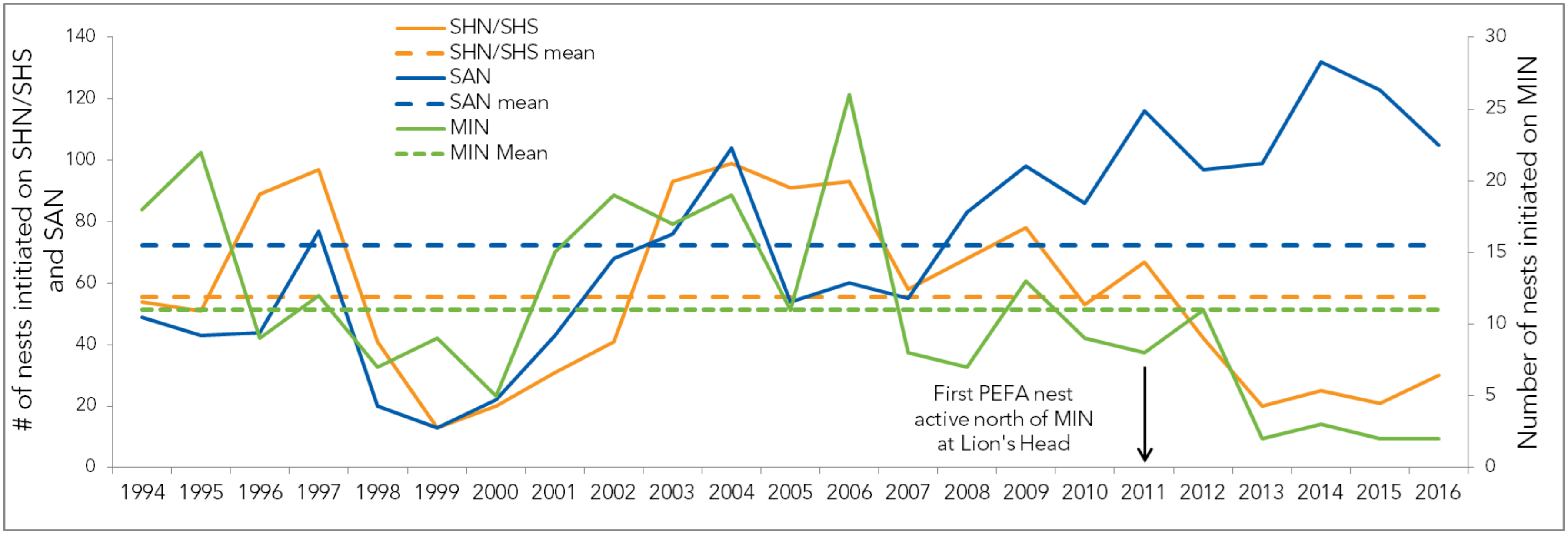


Figure 12. Number of nests initiated on MIN, SHN/SHS, and SAN from 1994-2016. Arrow indicates the 2011 establishment of a peregrine falcon eerie at Lion’s Head. Dashed lines show the 23-year mean for each beach sector.

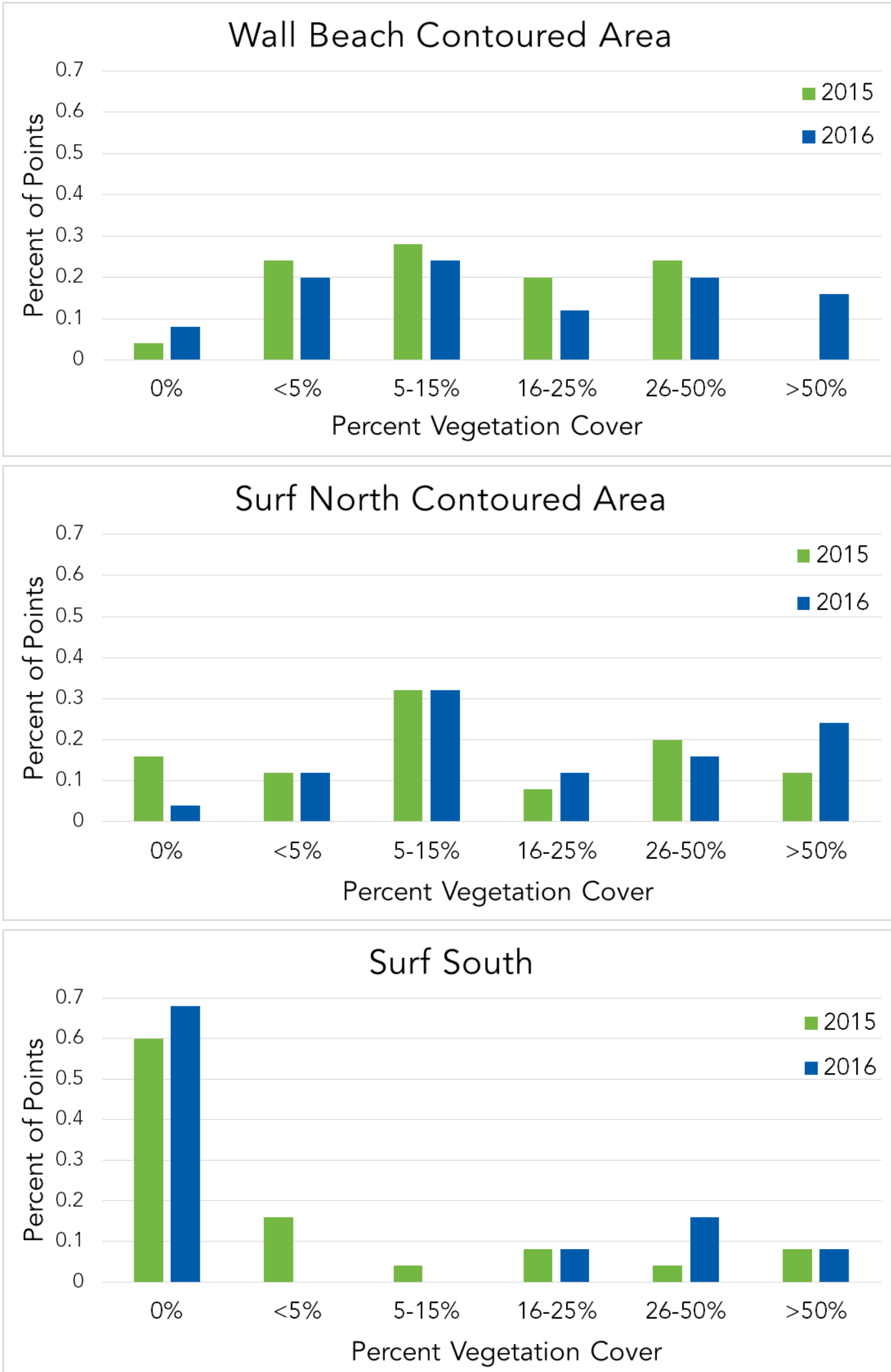


Figure 13. Percent vegetation cover within a 2m radius of random points at Wall Beach and Surf North contoured areas, and Surf South from 2015-2016.

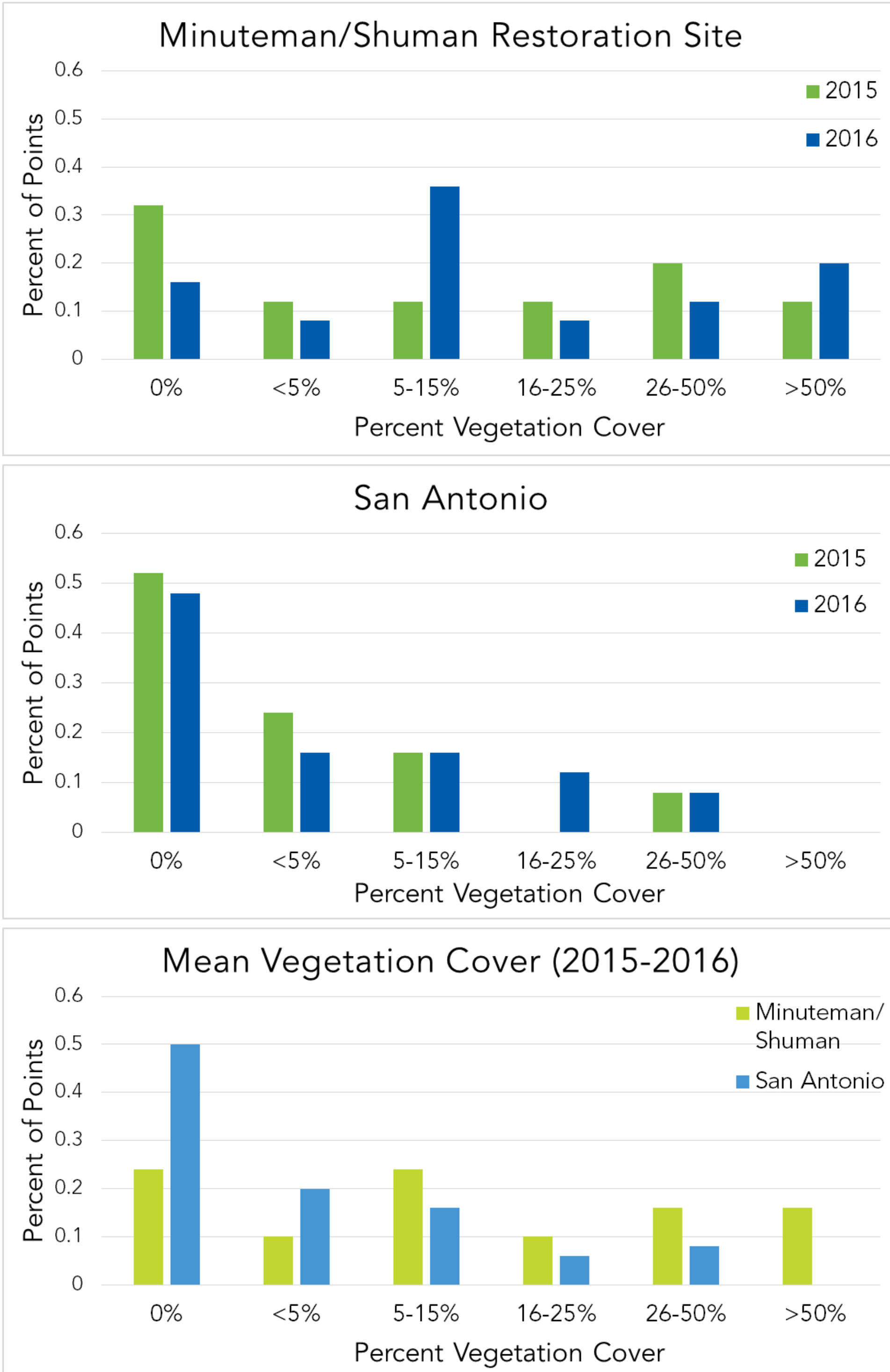


Figure 14. Percent vegetation cover within a 2m radius of random points at the Minuteman/Shuman restoration site and San Antonio from 2015-2016, and the mean percent vegetation cover from each beach sector for both years.

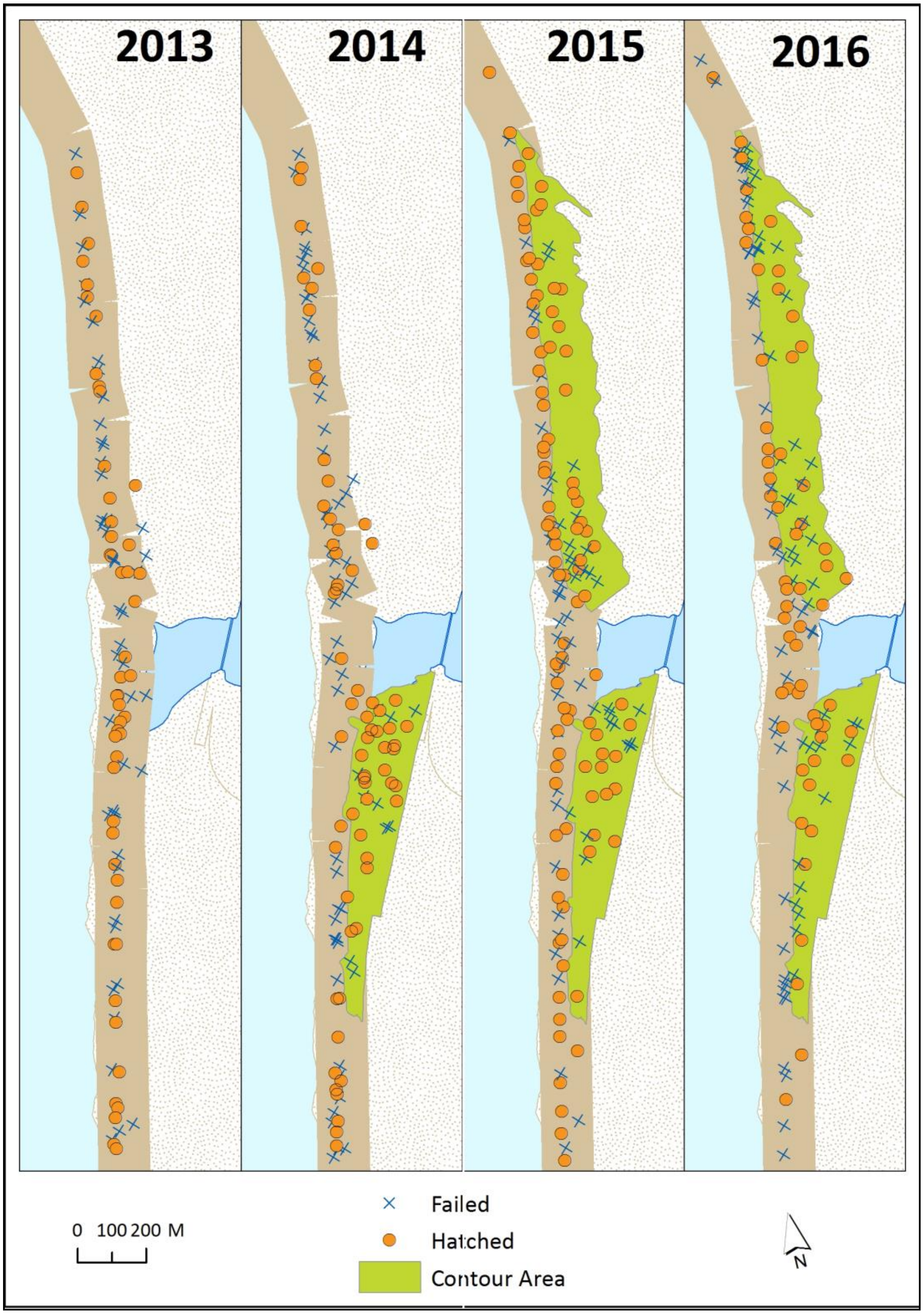


Figure 15. Snowy plover nest distribution within Wall and the north portion of Surf North from 2013-2016. The contoured areas are shaded in green.

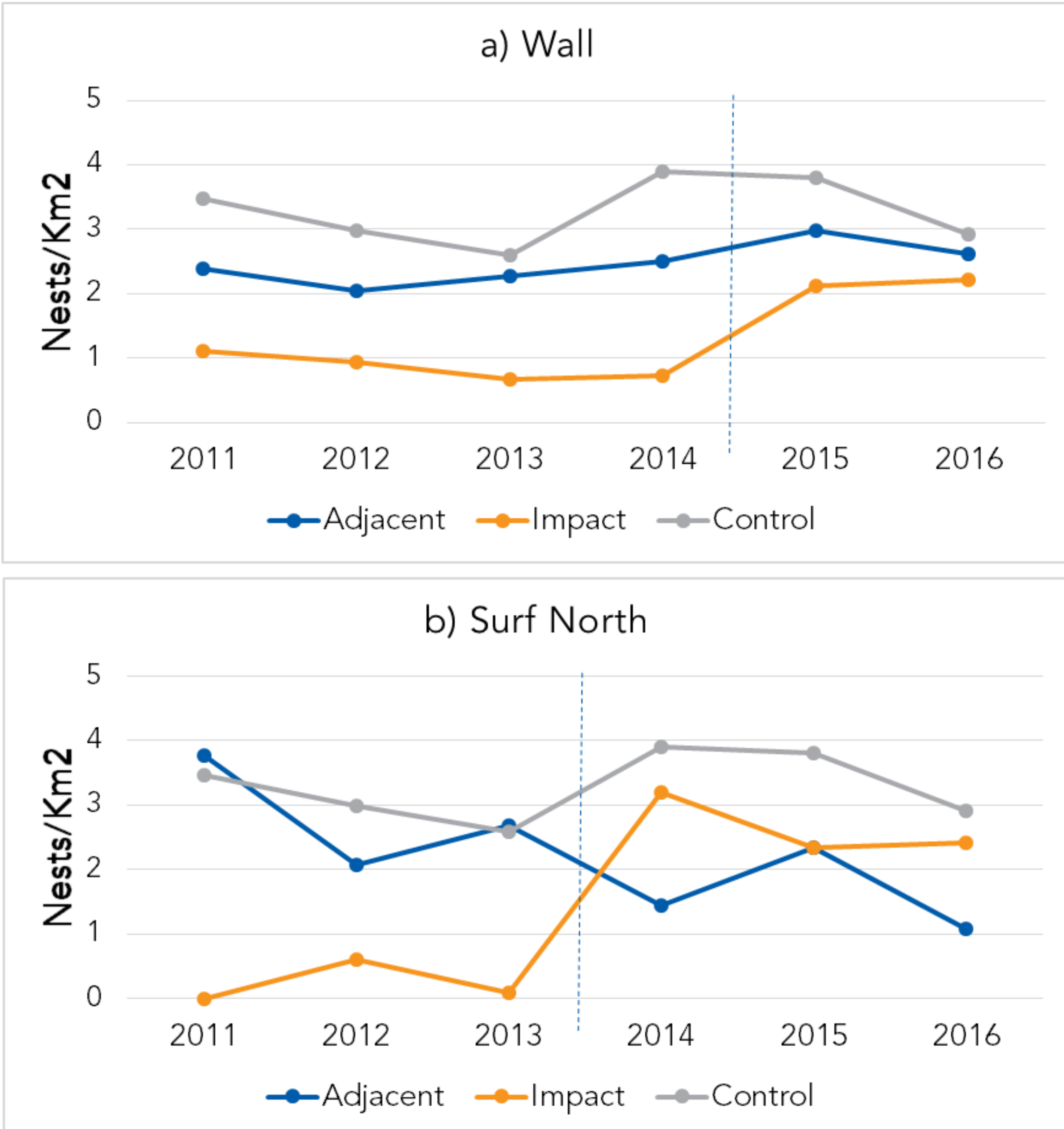


Figure 16. Relative nest densities on a) Wall and b) Surf North in the contoured areas, the adjacent beach immediately west of the contoured areas, and all of South Beaches south of Surf Open Area (control) from 2011-2016. The vertical dashed line represents when the dunes were contoured.

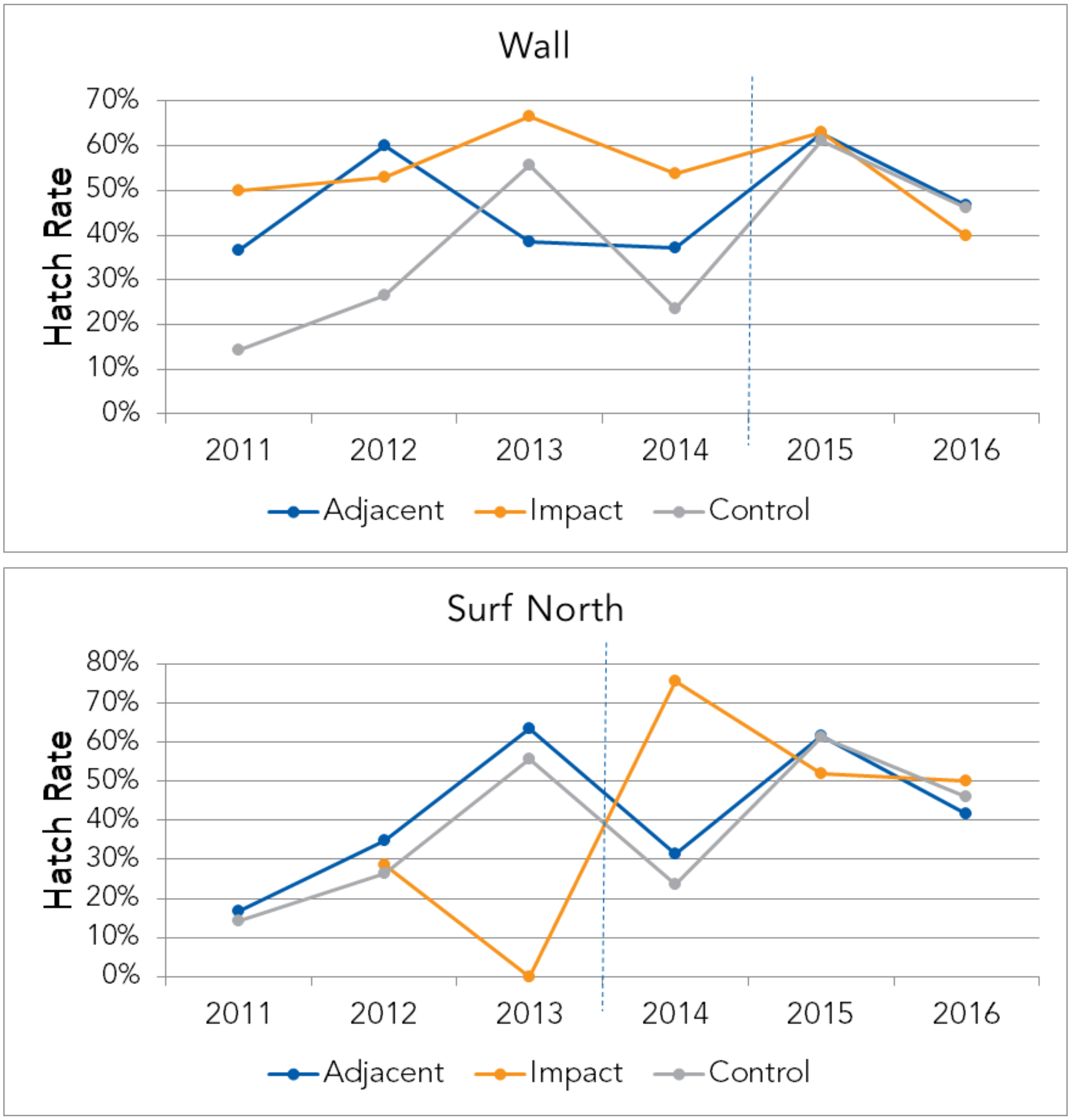


Figure 17. Hatch rate on a) Wall and b) Surf North in the contoured areas, the adjacent beach immediately west of the contoured areas, and all of South Beaches south of Surf Open Area (control) from 2011-2016. The vertical dashed line represents when the dunes were contoured.

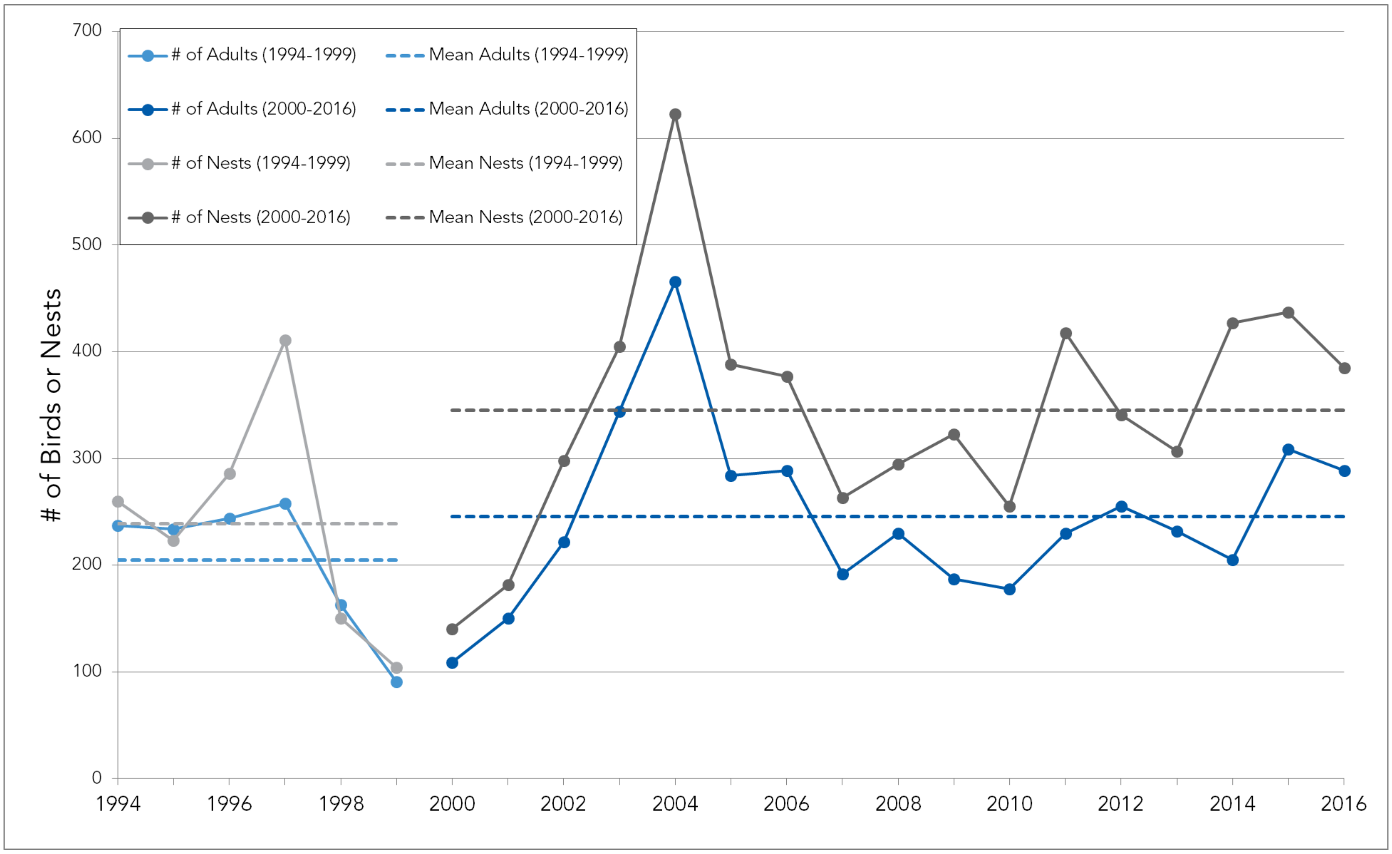
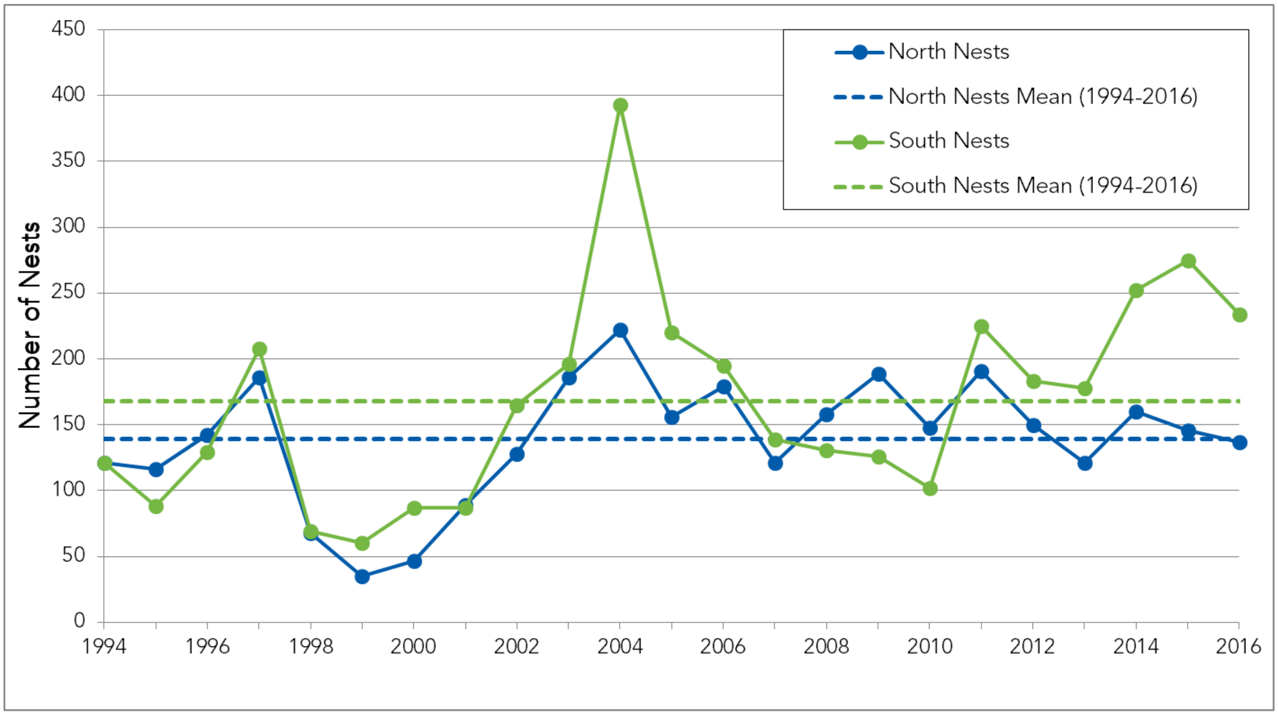


Figure 18. Trends in annual breeding population assessed using maximum number of adults observed during window surveys and number of nests initiated from 1994-2016. Dashed lines show the long-term means calculated for the periods during linear restriction (1994-1999) and after beach closures took effect (2000-2016).



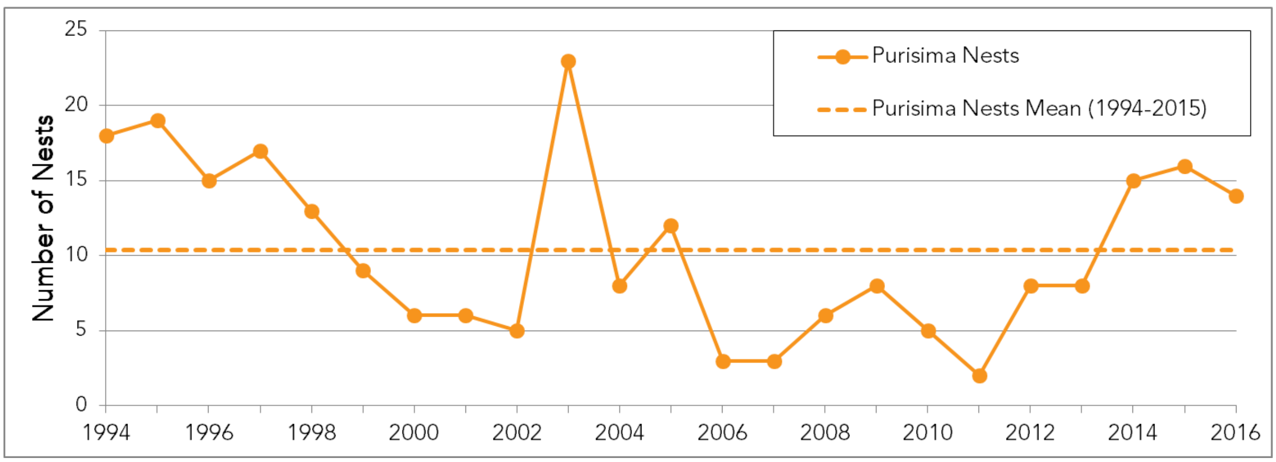


Figure 19. Trends in annual number of nests initiated for North, South, and Purisima Beaches from 1994-2016. Dashed lines show the 23-year means (1994-2016).

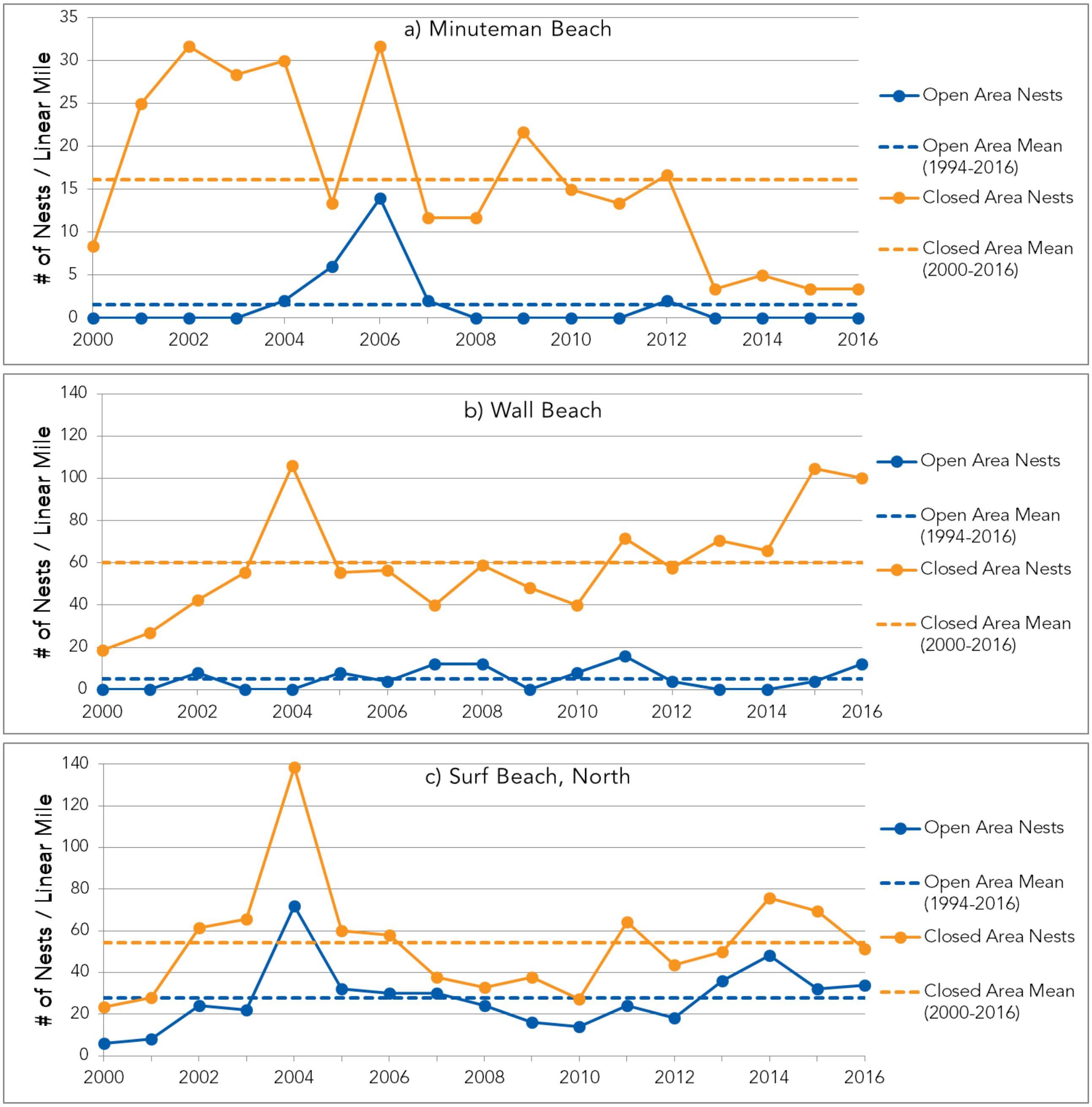


Figure 20. Trends in annual number of nests per linear mile within open and closed sections of Minuteman, Wall, and Surf Beaches, from 2000-2016. Dashed lines show the 17 year means (2000-2016).

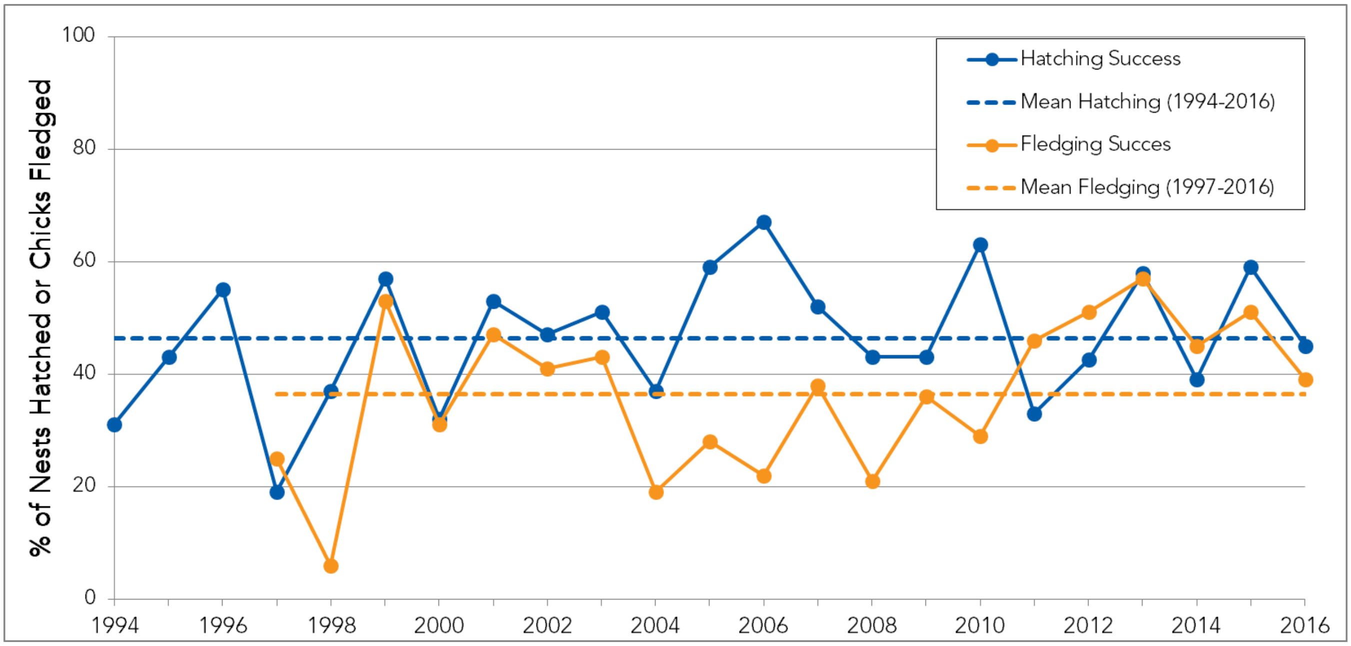


Figure 21. Trends in annual snowy plover clutch hatch and fledging success on VAFB from 1994 to 2016. Data on fledging success were not available for 1994-1996.

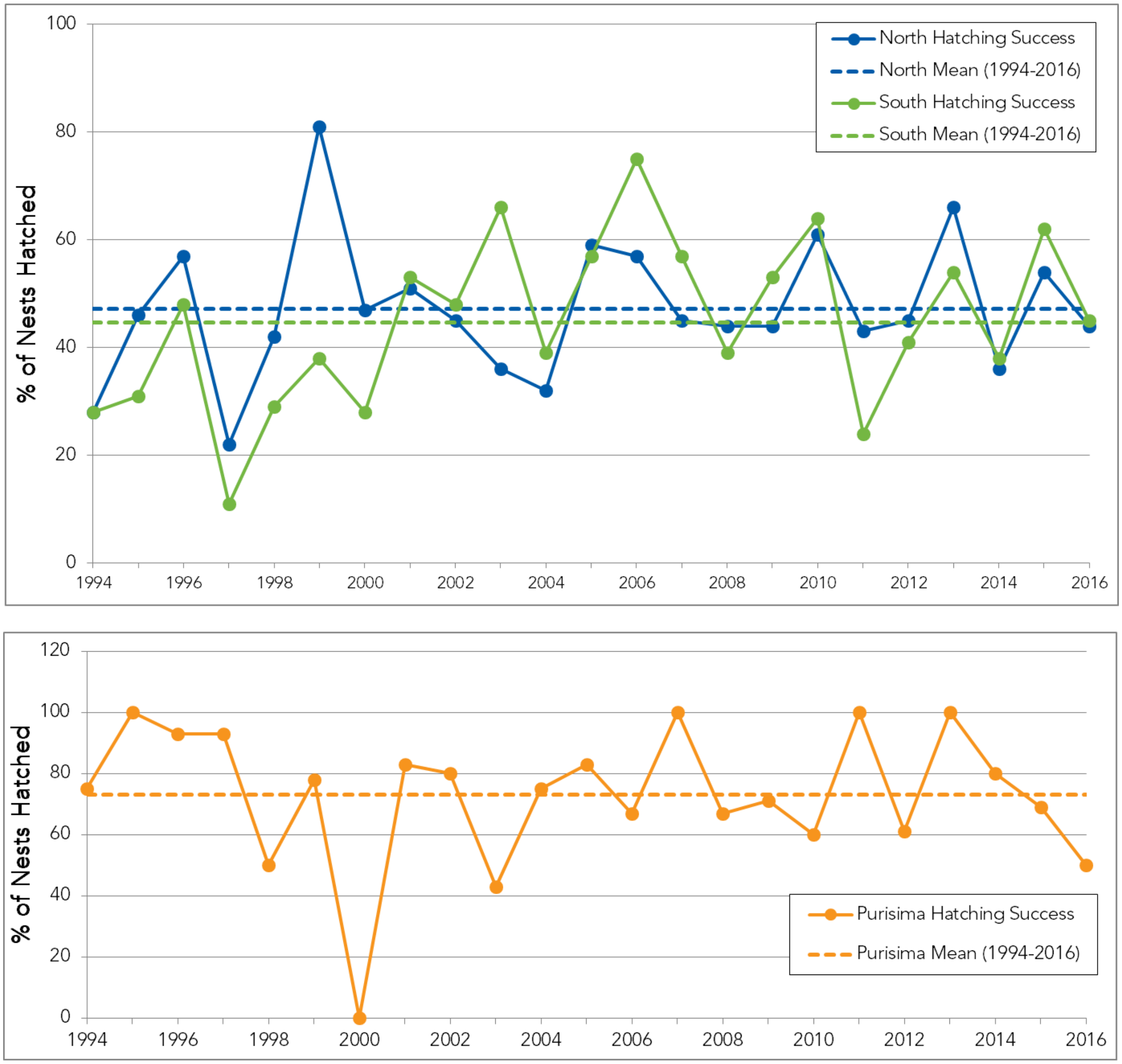
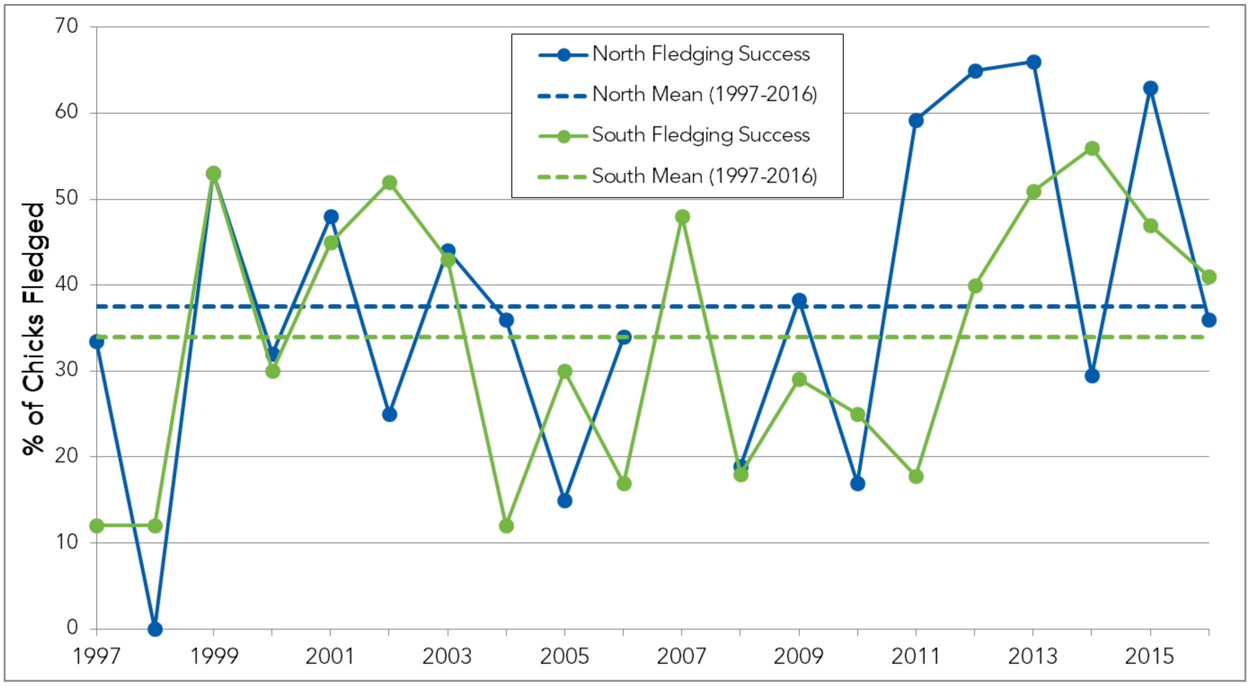


Figure 22. Trends in annual clutch hatch success on North, South, and Purisima Beaches from 1994 to 2016. Dashed lines show the 23-year mean for each beach section.



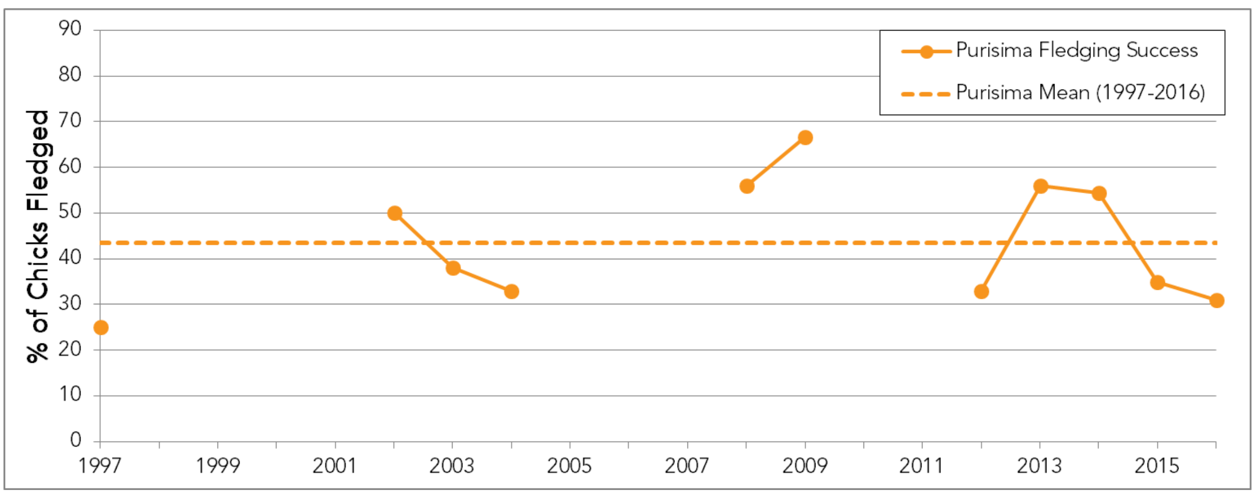


Figure 23. Trends in annual fledging success on North, South, and Purisima Beaches from 1997 to 2016. Missing data points indicate years when fledging success was not determined. Dashed lines indicate the 20-year mean for each beach section.

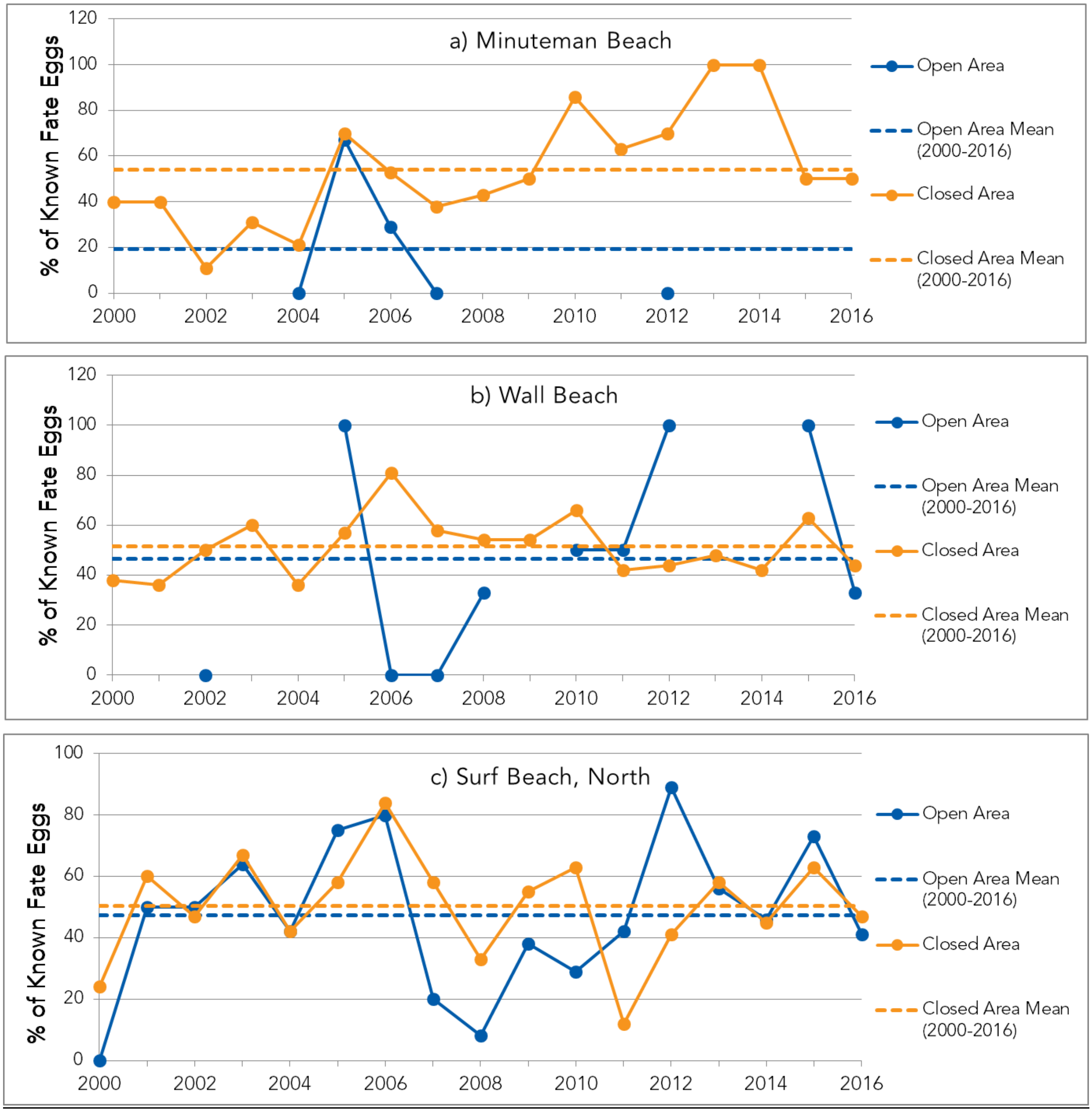


Figure 24. Trends in annual clutch hatch success at open and closed areas of Minuteman, Wall, and Surf beaches. Missing data points indicate years where no nests were initiated within that particular beach sector.

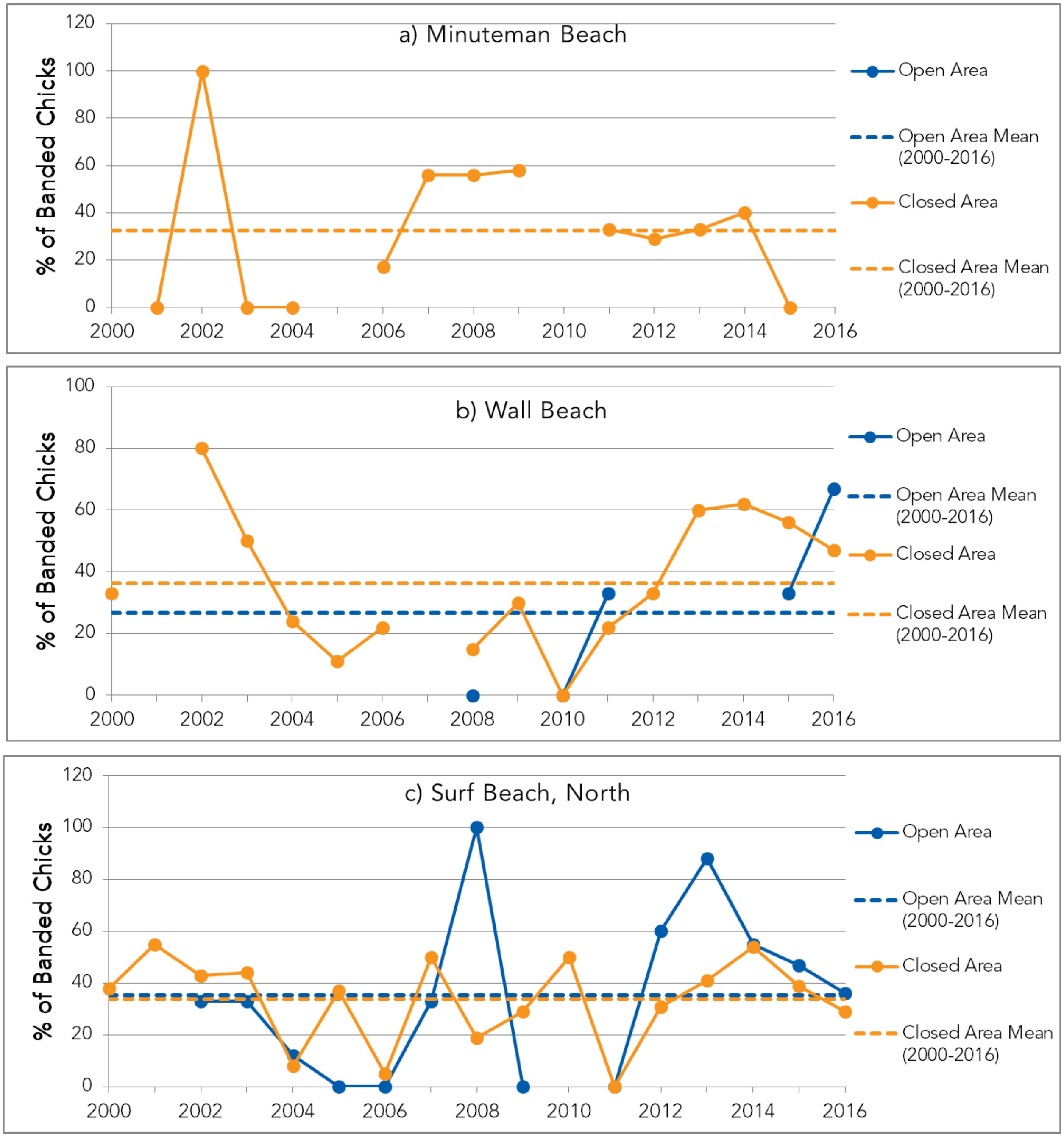


Figure 25. Trends in annual fledging success within open and closed areas of Minuteman, Wall, and Surf Beaches. Missing values indicate years when no nesting occurred or fledging success was not determined for that particular beach sector.

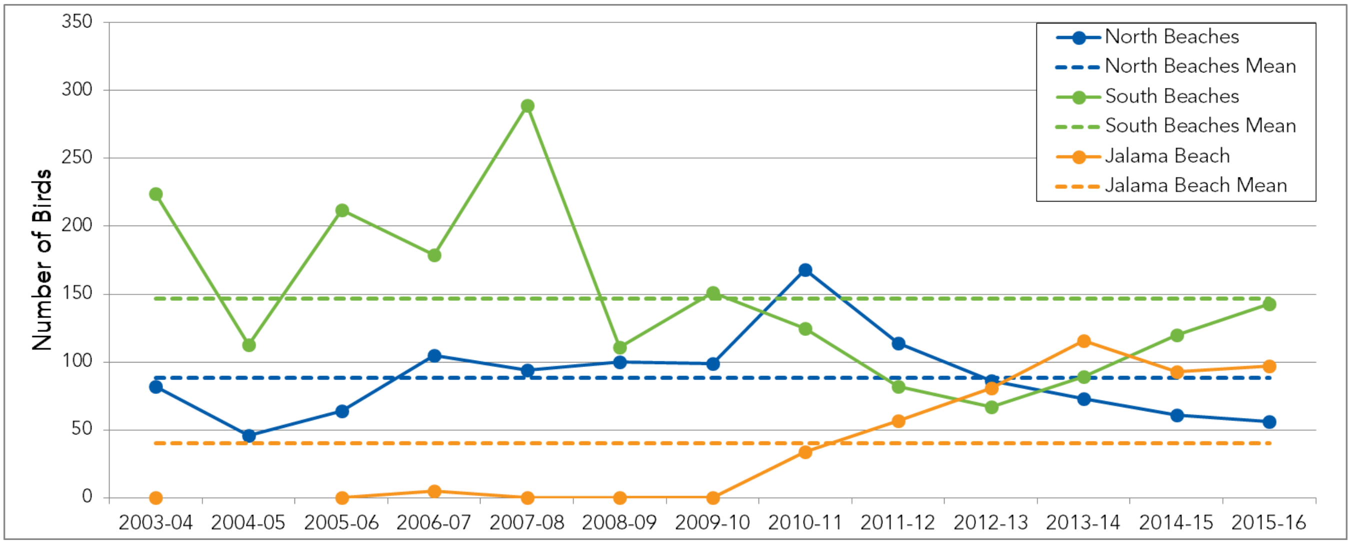


Figure 26. Trends in annual winter population assessed using maximum number of adults observed during the range wide winter window surveys from 2003/2004 to 2016. Dashed lines indicate the 13-year mean for each beach section.

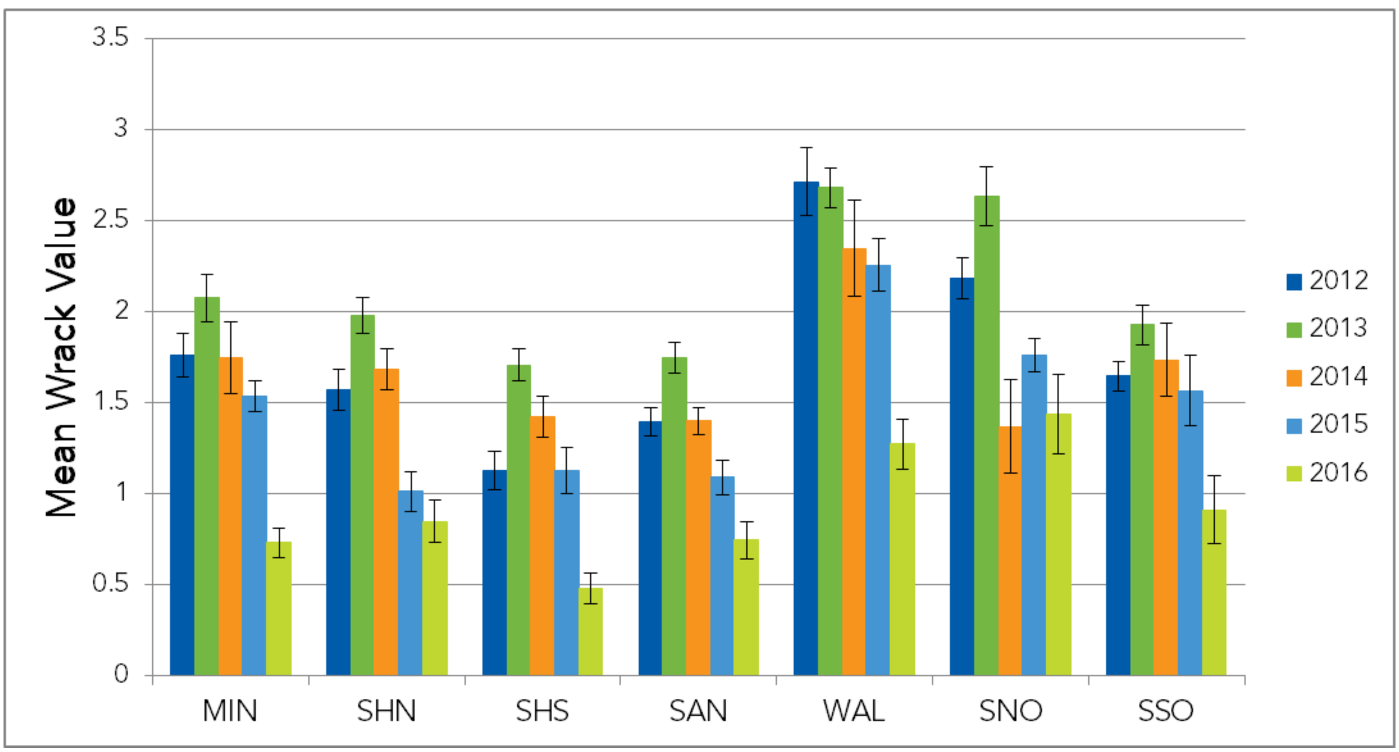


Figure 27. Mean wrack index values for each beach sector from 2012 to 2016. Error bars represent the standard error.

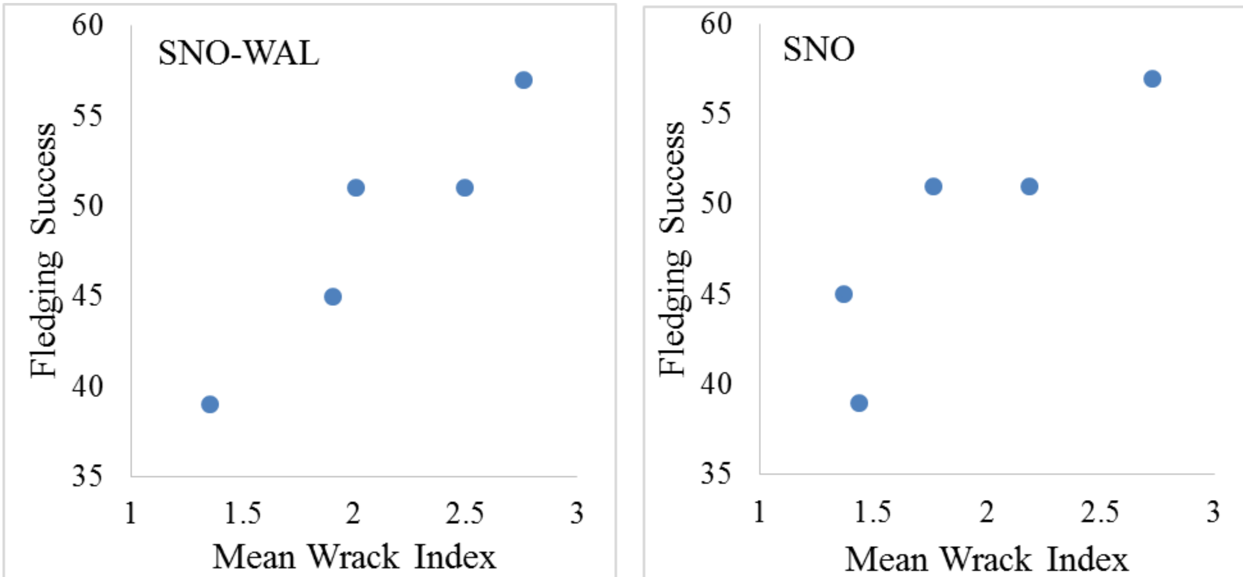


Figure 28. Base-wide fledging success plotted against mean wrack index calculated for a) SNO and WAL beach sections combined and b) SNO beach section only.

Appendix A – Criteria and evidence for determining the fate of Western snowy plover clutches (PRBO 2001)

The criteria below apply when monitors are permitted to handle and float eggs for estimation of hatch date.

HATCHED

Eggs gone close to estimated hatch date, predator tracks would be evident in substrate yet no obvious tracks to or at nest, along with one or more of the following:

1. flattened scrape and pip fragments located in scrape;
2. tapping or cracks observed in eggs on recent visit to nest; or
3. indication of presence of newly hatched brood in immediate vicinity (e.g. direct observation, broody behavior exhibited by nearby adult, ideally by banded adult previously associated with nest).

PREDATED – UNKNOWN PREDATOR

1. Direct evidence that eggs were destroyed, including:
    a) substrate cemented together by egg contents; or
    b) eggshell fragments or intact but damaged eggs found well before estimated hatch date.
2. Eggs gone well before estimated hatch date, no predator tracks to nest, but weather would not have destroyed nest. Evidence may include:
    a) scrape intact or still discernible; or
    b) substrate stable or level enough such that wind would not cause clutch to be buried or eggs to roll out of scrape; or
    c) substrate too firm for imprint of predator tracks.
3. Unidentified potential predator tracks directly to and at nest site (if potential predator tracks are observed leading towards nest site but gait is unchanging directly past nest site, that predator is not associated with clutch loss).

PREDATED – IDENTIFIED PREDATOR

1. Identified predator tracks directly to and at nest site; and
2. Timing of lain predator tracks coincides with nest loss, as indicated by substrate conditions. If two or more potential predator species are identified to and at nest site, and timing of visits can be determined, first predator to nest site associated with nest loss.

TIDE

Tide had washed over original nest location and:

1. eggs gone well before estimated hatch date; or
2. eggs gone close to estimated hatch date, but no indication of a newly hatched brood in the immediate vicinity; or
3. eggs located near original nest location but no indication eggs being incubated; or
4. eggs located near original nest location, eggs being incubated by adults well past estimated hatch date.

NON-VIABLE EGGS

Intact eggs of full clutch remain well after estimated hatch date along with evidence that there is consistent adult activity at nest location.

ABANDONED

Intact eggs of clutch remain but evidence of adult activity at nest ceased well before the estimated hatching date. No evidence nest was washed over by tides or ever buried by windblown sand or other debris.

WIND

Eggs not being incubated and one of the following:

1. intact eggs located outside of scrape, eggs not being incubated, and no indication that any other species may have moved eggs; or
2. eggs in scrape and covered by wind-blown sand or other debris.

***Note:** Distinction between the above three categories (non-viable eggs, abandoned, and wind) can be difficult and may require additional information.

TRAMPLED

Eggs found destroyed (not predated) and tracks of a larger species directly through nest location.

DESTROYED – HUMAN

1. Human footprints directly next to or on the nest location and:
   a) one or more eggs missing from the clutch; or
   b) evidence that eggs were destroyed including shell fragments or contents.
2. Human footprints near nest with evidence that was something was dragged over, dropped or placed on nest.

FAILED UNKNOWN

Eggs gone well before estimated hatch date, but absence of clear evidence of depredation, wind loss, tide, or trampling.

FATE UNKNOWN

Eggs gone close to estimated hatch date but evidence of hatch would have been obscured by weather conditions or other factors.

Appendix B – Color banded Western snowy plovers observed on VAFB beaches during the 2016 breeding season

Observations of Western snowy plovers banded on VAFB prior to 2016

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
A	G/Y	M	21 March, 4 July - 10 August	2012 - VAFB Purisima North		
A	G/Y/G	F, U	19 April - 31 August	2014 - VAFB Wall Beach	VAFB Breeder	
A	W/O/W	M, U	30 March - 6 July	2014 - VAFB Wall Beach	VAFB Breeder	
A	W/R/W	M, F, U	3 March - 6 September	2015 - VAFB Wall Beach		
A	Y/G	M	17 June - 21 July	2015 - VAFB Surf North	VAFB Breeder	
AN	AG	F	22 March - 1 August	2015 - VAFB Wall Beach	VAFB Breeder	
AN	AG	M	21 April - 6 July	2015 - VAFB Wall Beach	Suspected VAFB	
AN	AG	U	19 July - 6 September	2015 - VAFB Wall Beach		
AN	AR	M	25 July	2014 - VAFB Surf North		
AN	AW	M, U	18 May - 22 August	2015 - VAFB Surf North	VAFB Breeder	
AN	BG	M, U	30 March - 27 July	2014 - VAFB Surf North	VAFB Breeder	
AN	GO	F	14 April, 1 August	2014 - VAFB Surf North		AN:GR misread
AN	GR	F	17 June - 28 July	2014 - VAFB Surf North		
AN	GR	M	12 April - 6 July	2014 - VAFB Surf North		
AN	GR	U	14 April, 29 July - 13 September	2014 - VAFB Surf North		
AN	NY	M	9 - 24 June	2015 - VAFB Wall Beach		
AN	OG	M, F, U	5 April - 9 June	2014 - VAFB San Antonio	Suspected VAFB	
AN	OR	F	21 April - 1 August	2014 - VAFB Surf North		
AN	OR	M	30 March - 9 May	2014 - VAFB Surf North	VAFB Breeder	
AN	OR	U	16 March, 1 July - 13 September	2014 - VAFB Surf North		
AN	PY	M, U	3 March - 6 September	2015 - VAFB Wall Beach	VAFB Breeder	
AN	RG	M, F, U	3 March - 13 July	2014 - VAFB Surf North	VAFB Breeder	
AN	RW	F	21 June - 19 July	2014 - VAFB Surf North	VAFB Breeder	
AN	RY	F, U	30 March - 22 June, 24 August	2015 - VAFB Surf North	VAFB Breeder	
AN	WW	F	14 April - 6 July	2015 - VAFB Wall Beach	VAFB Breeder	
AN	WW	M	30 March - 28 June	2015 - VAFB Wall Beach	VAFB Breeder	
AN	WW	U	1 - 12 April, 20 June - 13 September	2015 - VAFB Wall Beach		
AN	YY	F, M, U	9 May - 6 September	2015 - VAFB Wall Beach	VAFB Breeder	
B	GY	M	19 April - 26 July	2011 - VAFB San Antonio		former NB:GY
B	RB	F	28 June - 1 August	2011 - VAFB Wall Beach	Suspected VAFB	former NB:RB
B	W/B/W	M	2 June - 18 August	2014 - VAFB Surf North	VAFB Breeder	
G	G/W	M, U	12 April - 21 July	2015 - VAFB Surf North	Suspected VAFB	
G	G/W/G	F	8 July	2014 - VAFB Purisima North		
G	G/Y	M	29 April	2015 - VAFB Purisima Colony		
L	-/W	U	25 August	2013 - VAFB San Antonio		
N(S)	RB	U	16 March	VAFB - Year Undeterminable		

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
N*	GW	M	7 July	VAFB - Year Undeterminable		
N*	NW	F	7 July	VAFB - Year Undeterminable		
N*	WY	M	7 April	VAFB - Year Undeterminable		
NB	AY	F, M, U	5 May - 20 June, 22 - 26 August	2006 - VAFB Shuman North		possibly missing N band; B:AY, RS:AY
NB	BB	M, U	10 March - 14 September	2015 - VAFB Surf North	VAFB Breeder	
NB	BR	M	6 - 9 May	2015 - VAFB Surf North		
NB	BY	F, U	19 May - 21 July	2014 - VAFB Wall Beach	VAFB Breeder	
NB	BY	M	1 April - 25 July	2014 - VAFB Wall Beach	VAFB Breeder	
NB	GR	M	1 June	2011 - VAFB San Antonio		
NB	GY	M	6 - 10 May	2011 - VAFB San Antonio		
NB	NR	F, U	22 March - 13 September	2015 - VAFB Surf North	Suspected VAFB	
NB	NW	F, U	2 March - 28 July	2015 - VAFB San Antonio	VAFB Breeder	
NB	NW	M	21 March - 5 July	2015 - VAFB San Antonio		
NB	OG	U	10 August - 6 September	2015 - VAFB Surf North		
NB	OW	F	6 May - 22 June	2011 - VAFB San Antonio		
NB	RW	F, U	7 April - 27 June, 24 August	2015 - VAFB Surf South	VAFB Breeder	
NB	RW	M, U	30 March - 11 May	2015 - VAFB Surf South		
NB	RY	F, U	3 March - 13 September	2014 - VAFB Surf North	Suspected VAFB	
NB	W*	M	24 May	VAFB - Year Undeterminable		
NB	WG	M	31 May - 26 July	2015 - VAFB San Antonio	VAFB Breeder	
NB	WW	M	3 March - 26 August	2011 - VAFB Wall Beach	VAFB Breeder	
NB	WY	F, U	31 March - 25 August	2015 - VAFB Wall Beach	VAFB Breeder	
NB	YB	U	22 March	2011 - VAFB San Antonio		
NB	YG	F, M, U	30 May - 6 September	2015 - VAFB Surf South		
NB	YR	M, U	11 May - 28 June	2015 - VAFB Surf South		
NB	YW	F	19 April	2015 - VAFB Surf North		
NB	YY	M	4 May - 14 July	2014 - VAFB Surf North	VAFB Breeder	
NO	AB	U	29 August	2012 - VAFB Shuman North		
NO	AW	F, U	3 March - 8 September	2013 - VAFB Surf North	VAFB Breeder	
NO	BB	M	6 May - 21 July	2015 - VAFB Surf North	VAFB Breeder	
NO	BR	M, F, U	1 March - 13 September	2015 - VAFB Surf North	VAFB Breeder	
NO	BY	F	23 May - 18 July	2013 - VAFB Purisima North	VAFB Breeder	
NO	GR	M, U	3 May - 2 June, 29 - 31 August	2013 - VAFB San Antonio		
NO	GW	M	30 March - 14 April, 6 - 13 June	2013 - VAFB Surf South		
NO	GY	M, F, U	3 March - 8 September	2015 - VAFB Wall Beach	VAFB Breeder	
NO	NB	F	3 May - 20 July	2015 - VAFB Purisima North	VAFB Breeder	
NO	NR	M, U	3 March - 18 July	2015 - VAFB Surf North	Suspected VAFB	
NO	OW	M, U	3 March - 13 September	2015 - VAFB Surf North	VAFB Breeder	
NO	PB	F	27 July	2014 - VAFB Wall Beach		
NO	PR	F	19 April - 29 July	2015 - VAFB San Antonio	VAFB Breeder	

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
NO	PR	M	19 April - 3 May	2015 - VAFB San Antonio		
NO	RB	U	13 June	2013 - VAFB San Antonio		
NO	RR	F	17 June - 20 July	2015 - VAFB San Antonio		
NO	RR	M, U	7 April - 3 May, 7 July - 19 August	2015 - VAFB San Antonio		
NO	RY	M, U	1 April - 13 July	2013 - VAFB San Antonio	Suspected VAFB	Possibly missing N band; O:RY
NO	WY	F, U	2 March - 28 July	2013 - VAFB San Antonio	VAFB Breeder	
NO	WY	M, U	2 March - 29 June, 22 August	2013 - VAFB San Antonio	VAFB Breeder	
NO	WY	U	14 September	2013 - VAFB San Antonio		
NO	YW	F, U	21 March - 25 August	2015 - VAFB Shuman South	VAFB Breeder	
NR	AB	M, U	2 March - 25 August	2015 - VAFB San Antonio	VAFB Breeder	2 breeding males with this combo
NR	AG	M, U	7 April - 10 August	2015 - VAFB San Antonio	VAFB Breeder	
NR	BB	M, U	3 May - 8 September	2015 - VAFB Surf North	VAFB Breeder	
NR	BW	U	20 July	2012 - VAFB San Antonio		
NR	GB	M	27 May	2015 - VAFB Wall Beach		
NR	GG	M, U	3 March - 18 May, 26 - 31 August	2015 - VAFB Surf North		
NR	GR	M	1 March - 7 July	2013 - VAFB Wall Beach	VAFB Breeder	
NR	NW	M, U	2 March - 3 August	2015 - VAFB San Antonio	VAFB Breeder	
NR	OB	M, F, U	22 April - 6 July	2015 - VAFB Wall Beach	VAFB Breeder	
NR	OG	M, F, U	5 May - 13 July	2015 - VAFB Surf South	Suspected VAFB	
NR	OR	F	25 May	2012 - VAFB San Antonio		
NR	OW	M	18 April	2015 - VAFB Surf North		
NR	RG	M	9 June	2013 - VAFB Surf South		
NR	WY	F, M	19 May - 23 June	2013 - VAFB Surf North	VAFB Breeder	
NR	YB	U	2 March	2015 - VAFB Surf North		
NR	YR	M	7 April - 20 July	2013 - VAFB San Antonio		
NR	YW	F	23 June	2013 - VAFB Wall Beach		
NW	AW	F, U	29 March - 19 July	2015 - VAFB San Antonio	VAFB Breeder	
NW	BB	M, U	14 April - 5 July	2014 - VAFB San Antonio or Minuteman	VAFB Breeder	
NW	BW	U	16 March	2015 - VAFB Surf North		
NW	GG	M	21 April - 13 July	2015 - VAFB San Antonio	VAFB Breeder	
NW	NB	F	18 April - 8 July	2014 - VAFB San Antonio	VAFB Breeder	
NW	NG	F, M, U	1 March - 23 September	2014 - VAFB San Antonio	VAFB Breeder	
NW	OB	F	30 March - 13 July	2013 - VAFB Surf South	VAFB Breeder	Missing N band; W:OB
NW	OB	M	14 April - 27 June	2013 - VAFB Surf South	VAFB Breeder	
NW	OB	U	20 June - 8 September	2013 - VAFB Surf South		
NW	OY	M, U	7 April - 3 August	2015 - VAFB San Antonio		
NW	PB	F, U	19 May, 17 - 24 August	2014 - VAFB Shuman South	VAFB Breeder	
NW	PG	M	5 April - 6 May	2014 - VAFB San Antonio	Suspected VAFB	
NW	PW	M, U	30 March - 13 September	2015 - VAFB Surf South	VAFB Breeder	

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
NW	PY	M, U	7 April - 14 September	2015 - VAFB San Antonio	VAFB Breeder	
NW	RB	F, U	3 March - 22 August	2013 - VAFB Surf North	Suspected VAFB	
NW	WR	F	17 May - 18 August	2014 - VAFB San Antonio	VAFB Breeder	
NW	Y	M	29 March - 19 April, 17 June - 5 July	2012 - VAFB San Antonio	VAFB Breeder	Missing right N band; former NW:NY
NW	YW	U	14 September	2015 - VAFB Surf South		
NY	AB	M, U	7 April - 29 August	2014 - VAFB San Antonio	Suspected VAFB	
NY	AG	F, M, U	18 April - 23 June	2015 - VAFB Shuman South	Suspected VAFB	
NY	BB	M	3 August	2014 - VAFB San Antonio		
NY	BG	F, U	3 March - 23 September	2014 - VAFB Surf South		
NY	GW	M	3 May - 8 July	2015 - VAFB San Antonio	Suspected VAFB	
NY	NB	M	5 - 21 April	2014 - VAFB Surf North		
NY	NG	F	20 June	2012 - VAFB Surf North		
NY	NR	U	2 September	2015 - VAFB San Antonio		
NY	PG	U	6 May	2014 - VAFB Surf South		
NY	RB	M	7 April - 13 July	2013 - VAFB Surf North	VAFB Breeder	
NY	WW	M, U	21 March - 18 August	2015 - VAFB San Antonio	VAFB Breeder	
NY	WY	F, U	22 March - 19 May	2015 - VAFB San Antonio	VAFB Breeder	
NY	YG	M	13 June - 13 July	2015 - VAFB Surf South	VAFB Breeder	
O	AR	M	2 March - 18 August	2013 - VAFB San Antonio	VAFB Breeder	former NO:AR
O	B/W	M	1 - 11 April	2014 - VAFB Surf North		
O	G/Y/G	F, U	3 March - 5 April	2015 - VAFB Surf North		
O	GR	M, U	2 March - 26 July	2013 - VAFB San Antonio	Suspected VAFB	former NO:GR
O	GW	M, U	16 March - 23 September	2013 - VAFB Surf South	VAFB Breeder	former NO:GW
O	RY	M	3 March - 24 June	2013 - VAFB San Antonio	Suspected VAFB	former NO:RY
O	WG	M	1 June	2012 - VAFB San Antonio		former NO:WG
O	WY	U	2 June, 14 September	2013 - VAFB San Antonio		former NO:WY
P	G/Y	F, M, U	3 May - 14 September	2015 - VAFB San Antonio		
P	W/B/W	F, U	3 March - 6 September	2013 - VAFB Surf North	VAFB Breeder	
P	W/G	F, U	21 March, 12 July - 23 September	2015 - VAFB San Antonio		
R	(S)	M, U	9 May - 22 August	VAFB - Year Undeterminable	VAFB Breeder	
R	G	F, U	7 -19 April, 20 June - 27 July	2013 - VAFB Surf South	VAFB Breeder	former NR:NG
R	G/O/G	M, U	2 March - 7 April	2015 - VAFB Surf North		
R	G/W/G	M	19 April - 17 May	2015 - VAFB Shuman South		
R	GR	M	11 April - 22 June	2013 - VAFB Wall Beach	VAFB Breeder	former NR:GR
R	RB	F, U	10 March - 18 August	2012 - VAFB San Antonio	Suspected VAFB	former NR:RB
R	RG	M, U	1 March - 6 September	2013 - VAFB Surf South	VAFB Breeder	former NR:RG
R	YR	M	25 July - 25 August	2013 - VAFB San Antonio	VAFB Breeder	former NR:YR
V	(S)	F	30 March, 30 May - 15 July	VAFB - Year Undeterminable	VAFB Breeder	
V	G/O/G	M, U	14 April, 13 June	2015 - VAFB Wall Beach		
W	AB	M	2 March - 28 July	2012 - VAFB Minuteman	VAFB Breeder	former NW:AB

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
W	G/O/G	F, U	3 March - 6 September	2014 - VAFB Wall Beach	VAFB Breeder	
W	OB	F	27 June - 10 August	2013 - VAFB Surf South	VAFB Breeder	former NW:OB
W	OB	M	12 April, 29 July - 10 August	2013 - VAFB Surf South	VAFB Breeder	former NW:OB
W	OB	U	1 April, 17 Aug - 8 September	2013 - VAFB Surf South		former NW:OB
W	Y	M	17 March - 23 August	2012 - VAFB San Antonio	VAFB Breeder	former NW:NY
Y	G	F, U	1 April - 6 July	2012 - VAFB Surf North	Suspected VAFB	former NY:NG
Y	G	M	18 April, 20 June - 18 August	2015 - VAFB San Antonio	Suspected VAFB	
Y	RR	F, U	16 March - 22 June	2012 - VAFB Surf South	VAFB Breeder	
Y	Y	F, U	3 March - 8 September	2012 - VAFB Surf South	VAFB Breeder	
Y	YB	M, U	3 March - 31 August	2012 - VAFB Surf South	VAFB Breeder	
Y	YY	F	7 - 21 April	2012 - VAFB Surf North		

Observations of Western snowy plovers banded outside of VAFB

Left	Right	Sex	Observation Dates	Banding Year/Location Code	Breeding History	Additional Notes
(s)K	(K/A)(K/G)	M	9 May	Unknown		
-	Y	U	31 August	Unknown		
AB	AG	F	31 March	Unknown		
AB	RR	J	27 June	Unknown		
B	B/W/B	M	29 June	Unknown		B:W/B/W misread?
BR	BB	U	13 June	Unknown		
BW	BG	J	2 August	Unknown		
G	Y	M	2 June	Unknown		
OO	RW	J	27 July	Unknown		
VB	WW	M	2 June	Unknown		VW:BB?
VW	BA	M	19 April	Unknown		VW:BB?
A/B	W	U	23 September	Oregon, Overlook (2016)		
AB	GO	U	10 August - 13 September	Salinas NWR (2011)		
AB	OG	U	24 August	Fort Ord (2015)		possible AB:GO misread
BA	BR	M	19 April - 3 August	Salinas State Beach (2013)	VAFB Breeder	
BB	OB	J	1 - 2 August	Oceano (2016)		
BB	OW	F	27 June	Oceano (2016)		
BB	PB	J	2 August	Oceano (2013)		
BB	RR	J	22 June - 2 July	Oceano (2016)		
BB	VY	J	13 July - 3 August	Oceano (2016)		
BB	YG	F	3 May - 13 July	Oceano (2011 or 2015)	VAFB Breeder	
BB	YR	J	3 August	Oceano (2015)		
BG	OW	J	18 July	Sunset Beach, Santa Cruz Co. (2013)		
BW	AW	M	6 May	Salinas NWR (2015)		
BY	RA	M	29 March	Pajaro Spit (2014)		

Left	Right	Sex	Observation Dates	Banding Year/Location Code	Breeding History	Additional Notes
GA	AB	F, U	21 March - 14 April, 21 June - 28 July	Oceano (2013 or 2015)	VAFB Breeder	
GA	BB	M	24 July	Oceano (2013)		
GA	OG	M, U	16 March - 18 April	Oceano (2014 or 2015)		
GA	VB	U	18 July	Oceano (2011 or 2013)		
GA	WG	U	10 August	Oceano (2016)		
GA	WR	J	27 July - 2 August	Oceano (2016)		
GA	Y	M	1 April	Oceano (Year Unknown)		
GB	AY	J	1 July	Salinas State Beach (2013)		
GG	AG	F	14 April - 8 July	Oceano (2013 or 2014)	VAFB Breeder	
GG	AY	U	21 March	Oceano (2012 or 2013)		
GG	GY	J	19 July	Oceano (2016)		
GG	WB	M	1 June - 13 July	Oceano (2011 or 2013)	VAFB Breeder	
GO	WW	M	9 May	Moss Landing State Beach (2015)		
OG	OR	M, U	1 March - 6 September	Salinas State Beach (2007)	VAFB Breeder	
PG	RB	U	26 - 30 August	Oceano (Year Unknown)		
PG	VB	J	19 July	Oceano (2016)		
PG	YG	U	18 - 29 August	Oceano (2016)		
PG	YW	F, U	21 March - 13 May	Oceano (2014)	Suspected VAFB	
PV	AW	J	2 - 9 August	Oceano (2016)		
PV	GY	U	19 August	Oceano (2008)		
PV	RB	J	2 August	Oceano (2016)		
PV	RY	F	11 April	Oceano (2015)		
PV	YG	U	18 August - 14 September	Oceano (2015)		
RR	BB	J	27 July - 4 August	Oceano (2016)		
RR	LY	M, U	3 March - 6 September	Oceano (2010)	VAFB Breeder	
RW	GO	M	10 May	Salinas NWR (2015)		
V	AW	F	12 April, 1 June - 1 August	Oceano (2013 or 2014)		VV:AW
VG	OW	J	26 August	Oceano (2016)		
VG	VY	J	29 July - 3 August	Oceano (2016)		
VV	AW	F, U	16 March - 13 September	Oceano (2013 or 2014)	Suspected VAFB	also seen as V:AW
VV	RB	J	19 - 27 July	Oceano (2016)		
VW	BB	M	23 May - 22 August	Oceano (2015)	VAFB Breeder	
Y/R	W	U	26 August	Oregon, Overlook (2016)		
YA	RL	J	6 September	Salinas State Beach (2016)		
YY	RL	J	30 August	Pajaro Spit (2016)		

Appendix C – Western snowy plover banded on VAFB during the 2016 breeding season.

Beach Sector	Color Bands Left	Color Bands Right	Date Banded	Chicks Banded	Confirmed Fledge
Shuman North					
	B	G/Y	7/20	2	
	NR	RW	7/26	2	
	NY	PB	6/11	3	1
	G	G/Y/G	7/12	3	2
	NR	PY	7/26	2	1
San Antonio					
	B	G/O/G	5/24	2	1
	B	W/G	7/26	2	1
	L	G/O/G	7/2	3	1
	L	G/W	7/20	2	1
	L	G/W/G	7/2	2	2
	NB	AG	5/17	3	1
	NB	BW	6/20	3	2
	NB	OY	5/21	3	2
	NO	NG	7/19	3	
	NO	OR	6/29	3	3
	NO	OY	6/6	3	0
	NO	PW	7/25	3	
	NR	AR	5/17	3	
	NR	NR	6/11	3	2
	NR	NY	7/22	3	1
	NR	WB	7/5	3	2
	NW	AR	7/26	3	1
	NW	BY	7/27	3	
	NW	YR	8/4	3	1
	NY	GB	7/29	2	
	NY	GG	7/26	3	
	NY	NW	7/25	3	2
	NY	PY	7/26	3	
	NY	WR	7/7	3	2
	NY	YW	8/2	3	2
	P	G/W	7/28	1	
	R	G/Y/G	7/25	3	
	V	W/B/W	7/20	2	1
	W	G/O	5/21	2	1
	Y	W/B/W	5/30	2	1
	Y	W/O/W	7/27	2	
	Y	W/R/W	5/17	1	1
	Y	Y/G	8/2	3	
Purisima North					
	V	W/G	6/11	1	
Purisima Colony					
	B	G/Y	6/15	3	0
	B	W/R/W	7/1	3	2
	NW	AG	7/2	3	
	NW	WW	5/30	3	2

Beach Sector	Color Bands		Date	Chicks	Confirmed
	Left	Right	Banded	Banded	Fledge
Wall Beach					
	AN	PR	7/27	3	
	AN	PW	6/13	3	2
	G	G/O/G	6/27	3	2
	GN	AB	5/18	3	2
	GN	AY	5/24	3	3
	GN	BB	6/10	3	3
	GN	BR	7/6	3	3
	GN	BW	7/23	2	1
	GN	NW	7/22	2	
	GN	NY	7/21	2	
	GN	PG	6/30	3	
	GN	PR	7/12	3	
	L	Y/G	7/25	2	2
	NB	AB	6/28	3	1
	NW	NR	8/1	3	
	NW	OR	7/1	3	1
	P	G/W/G	6/23	3	2
	R	G/W	6/23	2	2
	V	G/W	7/13	3	1
Surf North					
	AN	BY	5/4	2	2
	AN	GW	5/21	3	1
	AN	OW	6/10	3	1
	AN	PG	5/7	2	1
	AN	WB	8/8	3	
	GN	AR	5/19	2	
	GN	BG	7/11	3	1
	GN	GB	5/24	3	1
	GN	OR	5/26	3	
	GN	PW	7/23	2	
	L	G/Y/G	7/7	2	
	L	W/G	6/9	3	1
	NO	NY	6/30	3	1
	NO	WB	6/7	3	3
	NR	GW	6/2	3	1
	NR	WR	6/16	3	1
	NW	GB	6/17	3	2
	NW	RW	5/4	3	2
	NY	OB	5/30	2	
	NY	OR	6/29	3	1
	NY	RR	6/13	3	
	NY	RW	7/1	3	1
	P	W/R/W	7/7	3	
	R	W/B/W	7/15	3	2
	R	W/O/W	4/29	3	1
	V	W/R/W	7/25	2	
	W	G/Y	5/20	3	
	W	O/G	5/25	2	1
	Y	W/O/W	6/22	3	

Beach Sector	Color Bands Left	Color Bands Right	Date Banded	Chicks Banded	Confirmed Fledge
Surf South					
	A	G/W/G	6/22	3	2
	NB	BG	6/6	3	2
	NB	GB	6/28	3	1
	NO	GG	5/9	2	2
	NO	YR	5/21	3	1
	NR	BR	5/21	3	3
	NW	NW	8/8	3	1
	NW	OG	6/17	3	3
	NW	OW	5/25	3	1
	NW	RR	5/23	2	
	NY	WB	7/4	3	2
	V	G/Y	6/27	3	2

A = Aqua; B = Blue; G = Green; N = Brown; O = Orange;
P = Pink; R = Red; W = White; Y = Yellow

Appendix D: Detailed Data Summaries

Table 1. Results from 2016 window surveys.

9-May-16	Male	Female	Unk Adult	PR	Total
Minuteman	0	1	0	0	**1**
Shuman North	3	0	1	0	**4**
Shuman South	4	4	0	2	**8**
San Antonio	27	14	9	4	**50**
Purisima North	1	0	2	0	**3**
Purisima Colony	1	1	0	0	**2**
Total North VAFB	***36***	***20***	***12***	***6***	***68***
Wall	13	14	0	4	**27**
Surf North	19	14	3	5	**36**
Surf South	11	18	0	5	**29**
Total South VAFB	***43***	***46***	***3***	***14***	***92***
TOTAL VAFB	**79**	**66**	**15**	**20**	**160**

17-May-16	Male	Female	Unk Adult	PR	Total
Minuteman	0	0	0	0	**0**
Shuman North	6	2	0	1	**8**
Shuman South	5	5	0	1	**10**
San Antonio	26	20	3	11	**49**
Purisima North	3	3	1	1	**7**
Purisima Colony	0	1	2	0	**3**
Total North VAFB	***40***	***31***	***6***	***14***	***77***
Wall	25	17	0	3	**42**
Surf North	33	14	0	8	**47**
Surf South	11	15	0	6	**26**
Total South VAFB	***69***	***46***	***0***	***17***	***115***
TOTAL VAFB	**109**	**77**	**6**	**31**	**192**

1-Jun-16	Male	Female	Unk Adult	PR	Total
Minuteman	2	0	2	0	**4**
Shuman North	2	2	0	1	**4**
Shuman South	4	4	3	2	**11**
San Antonio	34	17	11	4	**62**
Purisima North	4	2	0	1	**6**
Purisima Colony	3	0	0	0	**3**
Total North VAFB	***49***	***25***	***16***	***8***	***90***
Wall	30	17	7	4	**54**
Surf North	46	27	2	8	**75**
Surf South	15	16	1	4	**32**
Total South VAFB	***91***	***60***	***10***	***16***	***161***
TOTAL VAFB	**140**	**85**	**26**	**24**	**251**

23-Jun-16	Male	Female	Unk Adult	PR	Total
Minuteman	0	0	0	0	**0**
Shuman North	5	7	2	4	**14**
Shuman South	4	3	4	1	**11**
San Antonio	42	34	0	6	**76**
Purisima North	4	4	0	1	**8**
Purisima Colony	0	1	0	0	**1**
Total North VAFB	***55***	***49***	***6***	***12***	***110***
Wall	33	24	2	12	**59**
Surf North	35	24	0	5	**59**
Surf South	29	27	5	1	**61**
Total South VAFB	***97***	***75***	***7***	***18***	***179***
TOTAL VAFB	**152**	**124**	**13**	**30**	**289**

MEAN	Male	Female	Unk Adult		Mean
Minuteman	0.50	0.25	0.50		**1.25**
Shuman North	4.00	2.75	0.75		**7.50**
Shuman South	4.25	4.00	1.75		**10.00**
San Antonio	32.25	21.25	5.75		**59.25**
Purisima North	3.00	2.25	0.75		**6.00**
Purisima Colony	1.00	0.75	0.50		**2.25**
Mean North VAFB	***45.00***	***31.25***	***10.00***		***86.25***
Wall	25.25	18.00	2.25		**45.50**
Surf North	33.25	19.75	1.25		**54.25**
Surf South	16.50	19.00	1.50		**37.00**
Mean South VAFB	***75.00***	***56.75***	***5.00***		***136.75***
MEAN VAFB	**120.00**	**88.00**	**15.00**		**223.00**

Table 2. Summary of breeding window surveys from 1994 to 2016.

Year	Early to Mid May	Mid to Late May	Early to Mid June	Mid to Late June	Mean	% Change over Prior Year	% Change in 2016
1994	237	--	199	217	218	n/a	2%
1995	213	234	193	202	211	-3%	6%
1996	230	229	234	244	234	11%	-5%
1997	258	196	256	245	239	2%	-7%
1998	103	130	132	163	132	-45%	69%
1999	91	64	67	89	78	-41%	186%
2000	98	106	107	109	105	35%	112%
2001	115	100	123	150	122	16%	83%
2002	222	213	174	195	201	65%	11%
2003	344	256	295	232	282	40%	-21%
2004	363	420	466	431	420	49%	-47%
2005	277	259	284	280	275	-35%	-19%
2006	289	245	261	279	269	-2%	-17%
2007	153	165	192	172	171	-36%	30%
2008	230	207	199	193	207	21%	8%
2009	158	162	187	183	173	-17%	29%
2010	178	167	176	175	174	1%	28%
2011	215	230	223	196	216	24%	3%
2012	206	170	196	248	205	-5%	9%
2013	214	204	208	232	220	2%	1%
2014	202	195	190	205	198	-3%	13%
2015	240	309	248	277	269	22%	-17%
2016	160	192	251	289	223	13%	

Table 3. Summary of winter window surveys from 2004 to 2016.

Year	North Beach	South Beach	Basewide	Jalama Beach
2003-04	82	224	306	0
2004-05	46	113	159	
2005-06	64	212	276	0
2006-07	105	179	284	5
2007-08	94	289	383	0
2008-09	100	111	211	0
2009-10	99	151	250	0
2010-11	168	125	293	34
2011-12	114	82	196	57
2012-13	86	67	153	81
2013-14	73	89	162	116
2014-15	61	120	181	93
2015-16	56	143	199	97
Mean	88.3	146.5	234.8	40.3

Table 4. Clutch hatch success for each beach section in 2016.

Beach Sector	Hatched clutches	Known fate clutches	Clutch success	Hatched eggs	Total known fate eggs	Egg hatch success
North Beaches						
Minuteman	1	2	50%	3	6	50%
Shuman	7	30	23%	18	72	25%
San Antonio	52	105	50%	144	277	52%
Total North Beaches	***60***	***137***	**44%**	***165***	***355***	**46%**
Purisima Beaches						
Purisima North	1	7	14%	1	18	6%
Purisima Colony	6	7	86%	17	19	89%
Total Purisima Beaches	***7***	***14***	**50%**	***18***	***37***	**49%**
South Beaches						
Wall	38	88	43%	103	224	46%
Surf North	41	89	46%	110	231	48%
Surf South	26	57	46%	69	140	49%
Total South Beaches	***105***	***234***	**45%**	***282***	***595***	**47%**
TOTAL VAFB	**172**	**385**	**45%**	**465**	**987**	**47%**

Table 5. Number of nests lost to predators in 2016 by beach section.

Beach Sector	Coyote		RAVEN		Suspected Raven		Other Avian		Gull		Skunk		Unidentified Predator		Total		Known Fate
North Beaches																	
Minuteman	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	1	50%	1	50%	2
Shuman	9	30%	6	20%	1	3%	0	0%	0	0%	0	0%	0	0%	16	53%	30
San Antonio	27	26%	9	9%	4	4%	0	0%	0	0%	0	0%	1	1%	41	39%	105
Total North Beaches	**36**	**26%**	**15**	**11%**	**5**	**4%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**2**	**1%**	**58**	**42%**	**137**
Purisima Beaches																	
Purisima North	4	57%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	4	57%	7
Purisima Colony	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	7
Total Purisima Beaches	**4**	**29%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**4**	**29%**	**14**
South Beaches																	
Wall	32	36%	0	0%	0	0%	0	0%	2	2%	0	0%	0	0%	34	39%	88
Surf North	21	24%	0	0%	0	0%	0	0%	0	0%	0	0%	1	1%	22	25%	89
Surf South	5	9%	1	2%	0	0%	0	0%	0	0%	0	0%	0	0%	6	11%	57
Total South Beaches	**58**	**25%**	**1**	**0%**	**0**	**0%**	**0**	**0%**	**2**	**1%**	**0**	**0%**	**1**	**0%**	**62**	**26%**	**234**
VAFB TOTAL	**98**	**25%**	**16**	**4%**	**5**	**1%**	**0**	**0%**	**2**	**1%**	**0**	**0%**	**3**	**1%**	**124**	**32%**	**385**

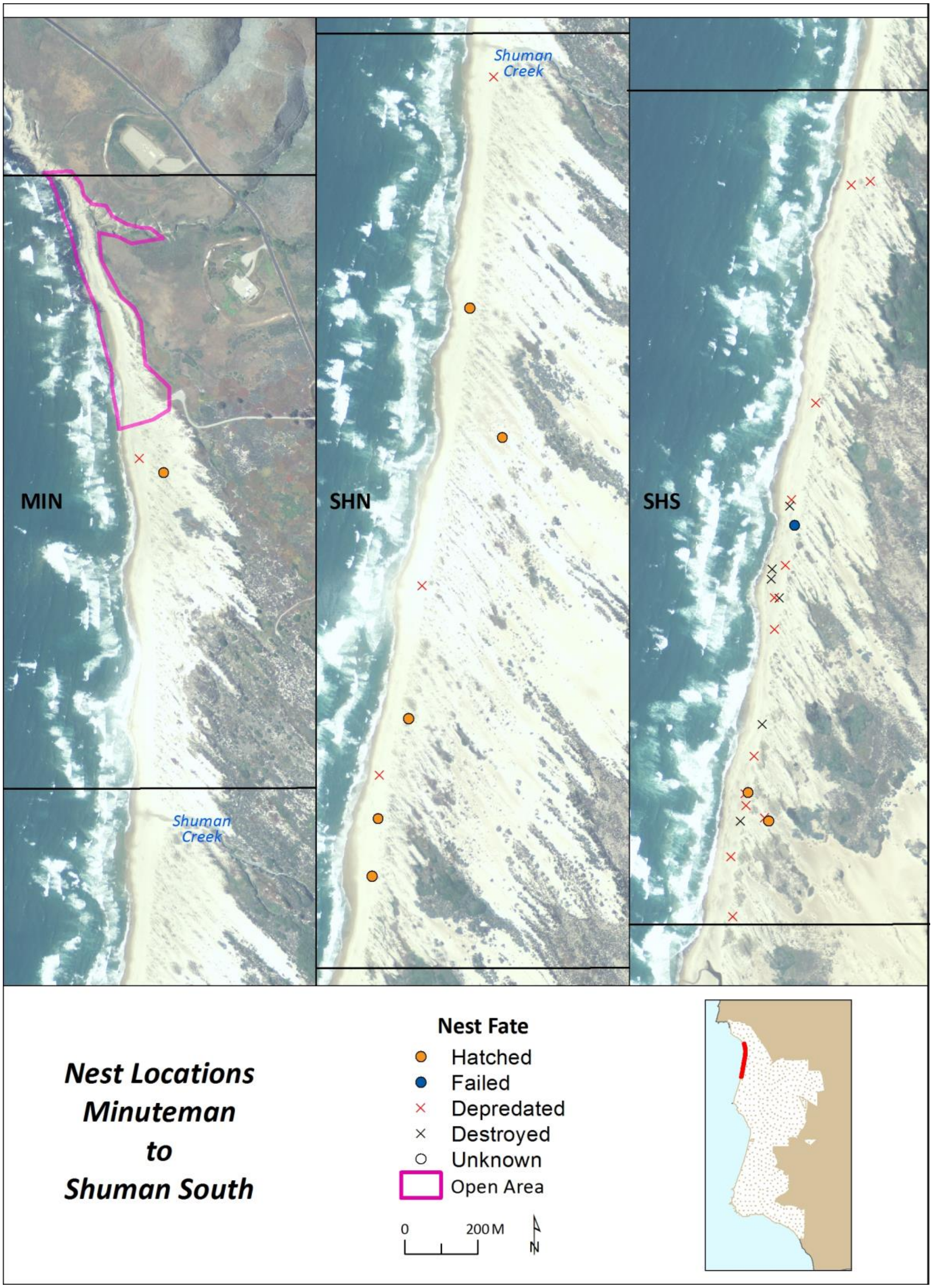
Table 6. Numbers of nest lost to predators from 1994 to 2016.

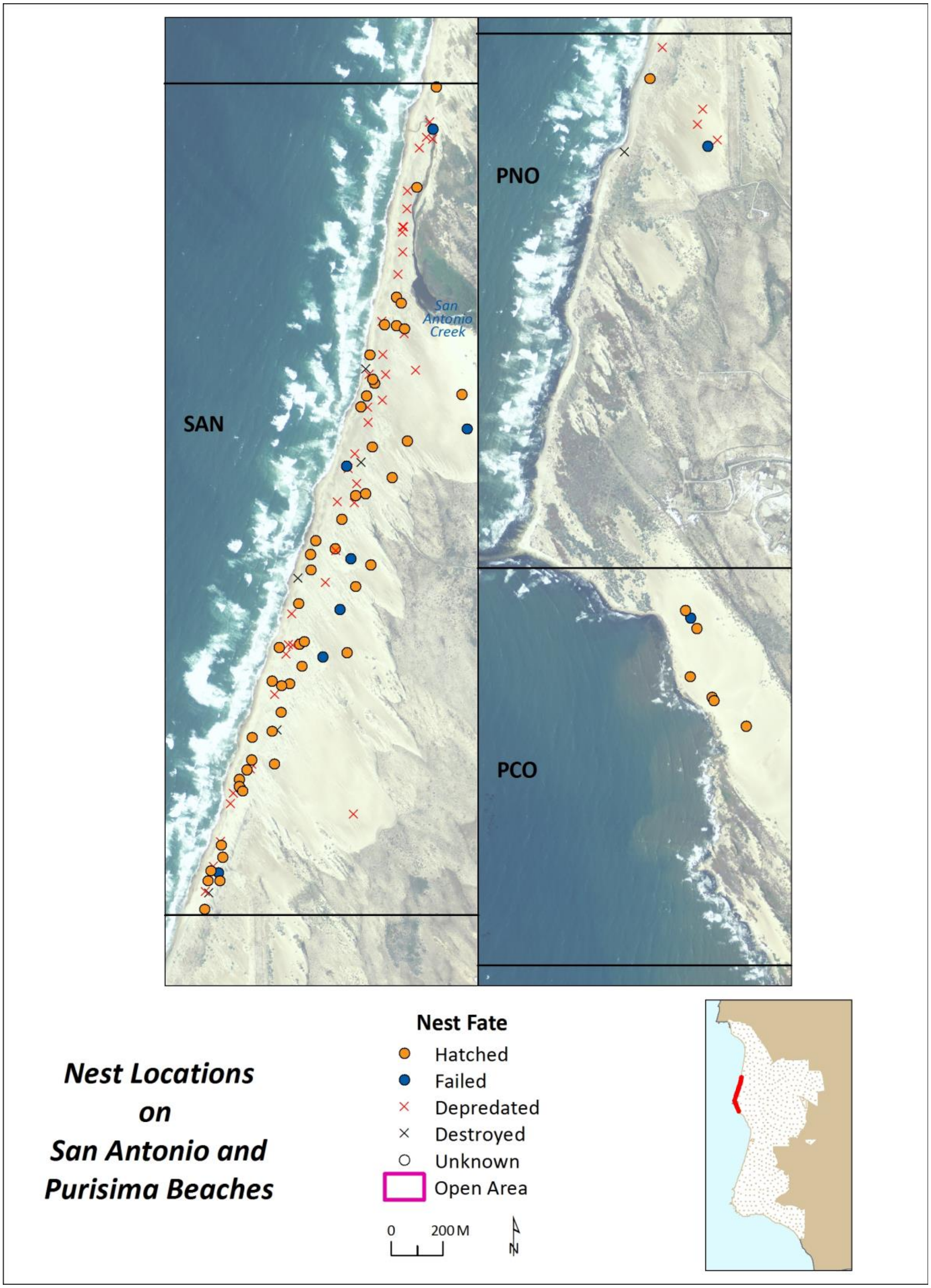
Year	VAFB Known Fate Nests	South Beaches Known Fate Nests	South Beaches Coyote Predation	% of VAFB	% of South Beaches
1994	231	110	N/A	--	--
1995	195	81	N/A	--	--
1996	271	123	19	7%	15%
1997	398	205	49	12%	24%
1998	134	62	26	19%	42%
1999	97	56	15	15%	27%
2000	127	83	27	21%	33%
2001	181	86	8	4%	9%
2002	296	164	32	11%	20%
2003	393	192	6	2%	3%
2004	590	375	118	20%	31%
2005	371	216	40	11%	19%
2006	366	194	23	6%	12%
2007	251	138	16	6%	12%
2008	284	125	25	9%	20%
2009	305	121	10	3%	8%
2010	240	98	16	7%	16%
2011	413	222	60	15%	27%
2012	334	176	43	13%	24%
2013	302	176	27	9%	15%
2014	425	250	86	20%	34%
2015	437	275	43	10%	16%
2016	385	234	58	15%	25%

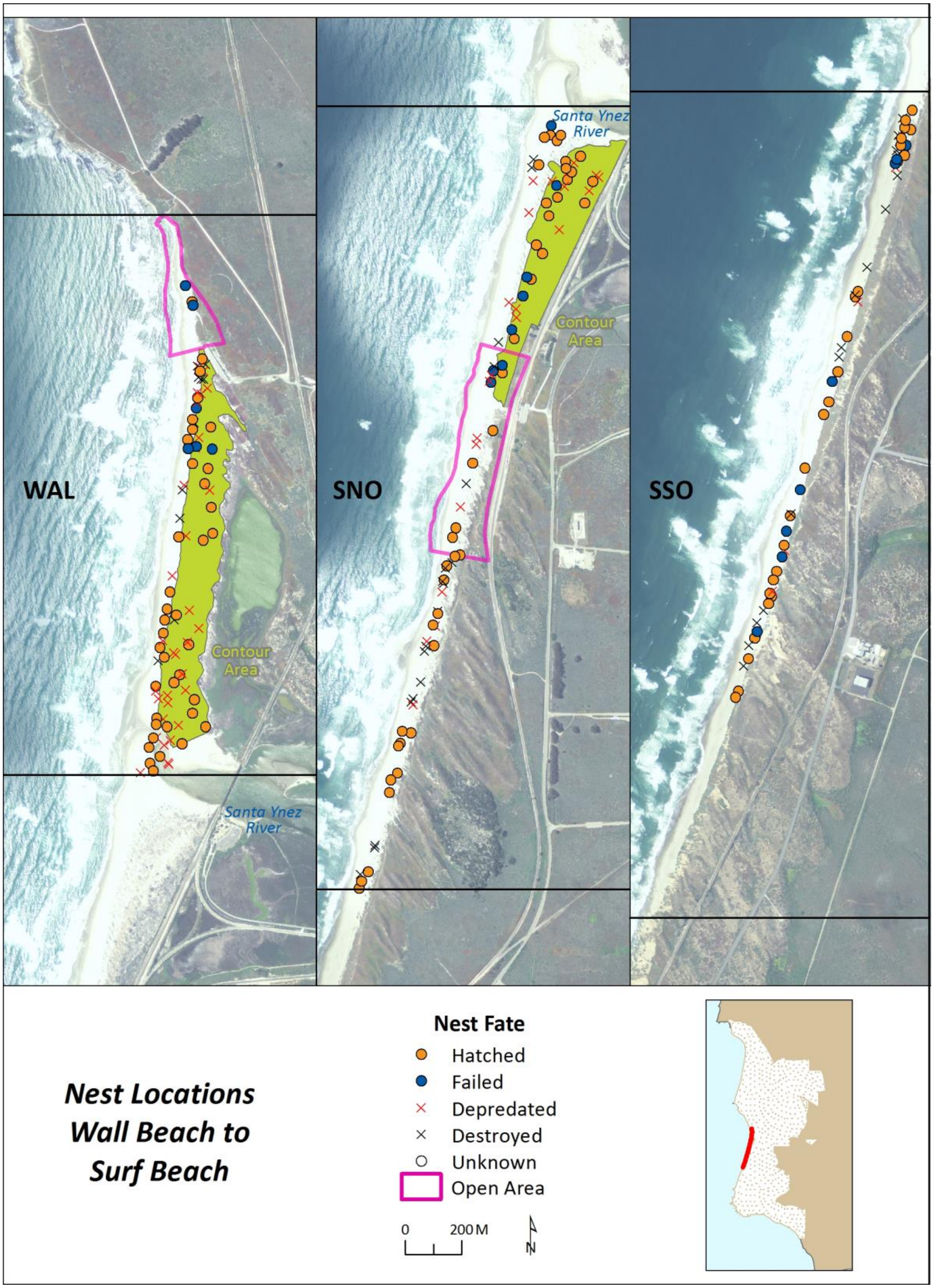
Table 7. Numbers of chicks and broods banded and fledged per beach sector in 2016.

Beach Sector	Banded		Fledged		Fledge Rate	
	Chicks	Broods	Chicks	Broods (at least one chick)	Chicks	Broods (at least one chick)
North Beaches						
Minuteman	0	0	0	0	0%	0%
Shuman	12	5	4	3	33%	60%
San Antonio	86	33	31	23	36%	70%
Total North Beaches	***98***	***38***	***35***	***26***	***36%***	***68%***
Purisima Beaches						
Purisima North	1	1	0	0	0%	0%
Purisima Colony	12	4	4	3	33%	75%
Total Purisima Beaches	***13***	***5***	***4***	***3***	***31%***	***60%***
South Beaches						
Wall	52	19	25	13	48%	68%
Surf North	79	29	24	19	30%	66%
Surf South	34	12	20	11	59%	92%
Total South Beaches	***165***	***60***	***69***	***43***	***42%***	***72%***
TOTAL VAFB	**276**	**103**	**108**	**72**	**39%**	**70%**

Appendix E: Maps of Nest Locations and Nest Fates on VAFB Beaches in 2016.




SAN
San Antonio Creek
PNO
PCO
Nest Fate
Hatched
Failed
Depredated
Destroyed
Unknown
Open Area
0
200 M
N
Nest Locations on San Antonio and Purisima Beaches


Santa Ynez
River
Contour
Area
WAL
SNO
SSO
Contour
Area
Santa Ynez
River
Nest Fate
Hatched
Failed
Depredated
Destroyed
Unknown
Open Area
0
200 M
N
Nest Locations
Wall Beach to
Surf Beach