Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2013

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 three 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 2013. This report summarizes least tern and snowy plover monitoring results from the 2013 breeding season within the context of VAFB's approximately 20-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 13 May, which is late compared to historic arrival dates. Adult colony attendance increased quickly and remained consistent through the egg laying and incubation period. We estimate the 2013 breeding population to be 15 pairs which is 17% smaller than 2012 and 52% smaller than the 19-year mean. However, the 2013 breeding season was one of the most productive seasons on record. Hatching success (83%) was well above the 19-year average (59%) and fledging success (76%) was the second highest on record. Overall breeding success (1.27 fledglings per breeding pair) was also the second highest on record.

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 19-year mean. Breeding productivity has been mostly above average since 2007, with two years of average to below average productivity (2011 and 2012). The breeding

population has not increased past the 19-year mean since 2005 and is even showing signs of a decreasing trend over the last three years (2011-2013). Least tern diet has also been variable since we began collecting diet samples in 2001. Our diet analyses have shown that least tern breeding productivity is highest when northern anchovy (*Engraulis mordax*) and/or rockfish (*Sebastes sp.*) dominate the diet. Abundance of both species is closely tied to oceanographic conditions. Since the winter of 2011, local oceanographic conditions have gone from La Niña (representing productive oceanic conditions) to El Niño neutral, with a brief warming period in 2012. The 2013 breeding may represent a return to productive conditions as both anchovy and rockfish were abundant in the diet.

<u>Western Snowy Plover</u>

The number of breeding snowy plovers observed and nests initiated in 2013 was similar to the long term mean. Clutch hatch success was higher than the long term mean, while fledging success was the highest on record. We attribute the high clutch hatch success in 2013 to lower predation rates compared to previous years while the increased fledging success likely due to increased wrack abundance (a food source for snowy plover prey) in 2013. Wrack abundance was significantly higher at most beach sectors in 2013 compared to 2012. Predators accounted for 20% of nest losses in 2013 compared to 37% in 2012 and 52% in 2011. The decrease in nest predation in recent years is primarily due to decreases in raven predation. Ravens took 18% of nests in 2011, 16% of nests in 2012, and <1% of nests in 2013.

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. 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, 2013

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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 remained between 6,500 and 7,100 pairs since 2006 (Marschalek 2011). Much of this 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 three currently active breeding colonies within the Monterey/Conception faunal zone (Marschalek 2010). These colonies are located at the Oceano Dunes State Vehicular Recreation Area, Rancho Guadalupe County Park, and VAFB (Purisima Point). This 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). We are not aware of any data 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 dune sparsely vegetated dune habitat atop a coastal bluff. The historic least tern breeding area is surrounded by electric fences on 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 ± SD number of breeding pairs per year at Purisima from 1995 to 2013 was 31.32 ± 20.31 (n=19) with a peak of 79 pairs in 2003. The mean ± SD productivity from 1995 to 2013 was 0.56 ± 0.45 fledglings per pair (n=19) with a peak of 1.32 in 2001. 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 very close to the 15-year average. The period from 2003 to 2006 was again lower than the 15-year average (ranging from 0.0 to 0.4 fledglings/pair) with the latter three years of the period having the worst productivity on record (<0.02 fledglings/pair). There was only one fledgling produced through the entire three year period. Another period of above average productivity occurred from 2007 to 2010 (ranging from 0.89 to 1.23 fledglings/ pair). Despite the return to productive conditions, the Purisma Point breeding population has been decreasing 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 will 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 has established a least tern management team that included members from two organizations in 2013: 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 managed area. Five-foot tall electric fences form the northern, southern, and eastern boundaries of the managed area, with an additional six-foot tall chain link fence along the eastern boundary. The Air Force provides funding for the management team to maintain these fences throughout the breeding season. The western boundary of the colony consists of coastal bluffs and not accessible to terrestrial mammals. Therefore, fences are not needed along the western boundary. 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 URS Corporation in 2013 and is responsible for monitoring breeding activities at the least tern colony (under permit TE – 807078-14.1) 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. Point Blue also conducts studies on the foraging habits and diet of the least terns to assess environmental effects on colony productivity. Finally, Point Blue tracks oceanographic conditions to better understand annual variability in prey availability and ocean productivity.

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). Following a lifting of the unexploded ordnance restrictions in 2013, 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 overall goal of the Air Force'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. Therefore, data on diet and foraging behavior is included as well as predator occurrences within this report. These additional studies will ultimately aid VAFB in its efforts to promote the recovery of this species.

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. Most recently, these BOs were superseded by the Vandenberg Air Force Base Programmatic Biological Opinion (8-8-09-F-10) that includes similar measures (see Avoidance and Minimization Measures, California Least Tern, #2, and Reporting Requirements page 128).

Methods

Site Preparation

Prior to the arrival of least terns at VAFB, three new electric fences were erected around the colony. The existing north and south fences were replaced and a new fence was erected along the eastern colony boundary. Figure 3 shows the placement of all three fences. The repairs were to damages incurred during the winter months. The fences were electrified 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 to go down 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 46 V-shaped chick shelters on the colony in areas where nesting occurred in 2011 and 2012. 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"x8" 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 need to be stored off-colony during winter months. Figure 3 shows the 2013 placement of the 46 V-shaped shelters and the remaining 24 permanent teepee shelters that are still functional. The majority of the shelters placed on the southwest side of the colony were used by chicks in 2012. There were very few nests in the northern and eastern areas of the colony 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 15 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 80 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 and collect diet samples (see section on Diet below). 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 18 times throughout the season. In addition, least tern activity was monitored at historic breeding sites. In 2013, 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 was becoming an issue and 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.

Foraging

In 2007, Point Blue expanded on a study investigating the use of the Vandenberg State Marine Reserve by foraging seabirds. Three of the new sites selected were adjacent to the Purisima Point colony (see Figure 1) and data on least tern foraging from those two sites are presented in this report. Each site was visited once a week during one of the following three-hour intervals: 0600-0900, 0900-1200, 1200-1500, or 1500-1800. The time intervals were rotated each week to ensure that each site was monitored during different times of day. At each site, we scanned a semi-circular area of ocean from shore to approximately one kilometer offshore (see Figure 1 for areas scanned) every 15 minutes. We recorded the maximum number of least terns foraging within a given area every 15 minutes. Additionally, we visited the Santa Ynez River estuary at least once per week to document use of this potential foraging habitat. We did not use the stationary protocol outlined above, but rather visited several OPs along the periphery of the lower, upper, and middle estuary to increase our spatial coverage.

In addition to our standardized foraging observations, opportunistic sightings along VAFB's coastal boundary were recorded throughout the season.

Diet

In order to determine the least tern diet at the Purisima Point colony, we collected feces from multiple roosting areas within the colony. If all fecal pellets in a given area were not collected, we wiped the area clean so that all feces were removed. We did this so that we knew upon revisiting these areas the feces would be fresh and could be assigned to a definite time period (or breeding stage). Each sample was sorted in 60% isopropyl alcohol and all scales and otoliths found in the sample were identified to the lowest taxonomic level possible. Larval fish in the samples were detected by the presence of small, undeveloped vertebrae, and sculpins (Family Cottidae) by the presence of preopercle spines. This data is presented as percent occurrence; the percent of the total number of samples that contained identifiable hard parts from a particular taxonomic group.

Oceanographic Variables

We compared least tern diet to oceanographic variables to better understand how oceanographic variables impact breeding parameters at the Purisima Point colony. We investigated these variables in relation to the two most important prey species for the Purisima Point colony: northern anchovy (*Engraulis mordax*) and juvenile rockfish (*Sebastes sp*.). We investigated local larval abundance for each species and oceanographic indices helpful in estimating larval survival to settlement age when the fishes are consumed by least terns. We used larvae data from nearshore stations along lines 77 and 80 of the California Cooperative Oceanic Fisheries Investigation (CalCOFI). Northern anchovies spawn in the spring and summer, so we analyzed larvae data from the spring-summer one year prior to a given least tern breeding season. Rockfish spawn in the winter, so we analyzed larvae data from the winter prior to a given least tern breeding season. We averaged oceanographic indices over the periods between fish spawning and the least tern breeding season to index larval survival to settlement age. We used three oceanographic indices: Multivariate El Nino index (MEI), Pacific Decadal Oscillation (PDO), and sea surface temperature anomaly (SST Anomaly). Values for MEI were obtained from the NOAA Earth System Research Laboratory website (http://www.esrl.noaa.gov/psd/enso/mei/#discussion). Values for the PDO were obtained from the Joint Institute for the Study of the Atmosphere and Ocean website (http://jisao.washington.edu/pdo/). And values for SST Anomaly were calculated using SST data from the National Data Buoy Center buoy #46011 (http://www.ndbc.noaa.gov/station_page.php?station=46011).

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 2012 least terns have arrived during the second week of May. This recent trend of late arrival continued in

2013 with the first least terns observed on 13 May. 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, 2011 and 2012 were 25 May, 27 May, and 30 May, respectively. Nest initiation in 2013 was slightly later with the first nest observed on 3 June and the last nest initiated on 27 June.

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 2013 to that in 2012. The 2012 breeding season initially showed characteristics of a non-productive year, but ended like a productive year. Adult attendance was initially low and did not peak until the week of 30 May. Thereafter, attendance was relatively stable during the incubation period and decreased gradually as chicks hatched and adults spent more time provisioning. Though adult terns arrived later in 2013, initial colony attendance was higher than 2012. Adult attendance was similar during the egg laying and chick rearing periods of both years. Overall, egg laying, chick hatching, and chick fledging appeared more synchronous and succinct in 2013, with the peak fledgling period lasting only one week.

We observed adults foraging at the Santa Ynez River estuary beginning the week of 20 June and consistently observed >10 foraging adults per visit beginning the week of 4 July. During this time, we observed several adults returning to the colony from the direction of the estuary with fish to provision chicks. Fledglings began dispersing to the estuary the week of 18 July at which time adult and fledgling numbers decreased at the colony. By 1 August, numbers of fledglings using the estuary had peaked and <5 adults and fledglings were consistently observed at the Purisima Point colony. The peak number of adults and fledglings observed at the estuary were 20 and 19, respectively; and both adults and fledglings were observed foraging in the estuary and roosting on the coastal sand bar at the mouth of the estuary. Adults and fledglings were consistently observed at the estuary for about one month. The last least tern was observed at the

Purisima Point colony on 6 August and at the estuary on 19 August (Table 1). This is the first time since 2004 that the terns used the estuary for an extended period before migrating south. In both 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 among years. In 2013, the coastal sandbar did not break and the estuary was full throughout the spring and summer. This may have contributed to an abundance of fish available to the terns within the estuary.

Population Dynamics

We documented a total of 15 nests at the Purisima Point colony during the 2013 breeding season (Table 2). Ten nests hatched all eggs, four hatched one egg but had one non-viable egg, and one hatched one egg with the second chick dying while hatching. Additionally, we found two chicks away from nest scrapes that died of unknown causes. We do not have any evidence that renesting occurred in 2013. 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 to16 days for egg loss and five to12 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. Since all nests hatched at least one chick in 2013 and the two dead chicks were found after the last nest was initiated, there was no reason to suspect any renesting attempts in 2013. Thus, we estimate the 2013 breeding population to be 15 breeding pairs. This represents a 17% decrease in population compared to 2012 and a 52% decrease below the 19-year mean population (31 pairs). As with 2012, most nests in 2013 were located in the southwest portion of the colony and five nests were located in the central colony (Figure 3). There were no new areas being used by nesting least terns in 2013.

Breeding Biology

Egg Production. We documented a total of 30 eggs at the Purisima Point colony in 2013 (Table 2). Our documented number of eggs is 6% lower than the total eggs produced for 18 nests in 2012. The mean ± SE clutch size for 2013 was 2.00 ± 0.10 (n = 15). One-way ANOVA showed significant differences in mean clutch size among years from 2001-2013 ($F = 5.182$, $df = 11, 415$, $p < 0.001$), but post hoc tests showed that 2013 was not significantly different than any year in the time series (Table 3). The differences in the post hoc tests were between 2001 and 2002-2005, 2007, and 2012. Mean clutch size in 2001 (2.20 eggs/nest) was the largest in the time series (Figure 5). Aside from 2004 (which was not included in the statistical analysis because it had a sample size of one), 2005 and 2007 had the smallest clutch sizes of the time series (1.68 and 1.61 eggs/nest, respectively). The post hoc tests showed that clutch sizes for these two years were also significantly smaller than 2009. Mean clutch size in 2013 was most similar to that recorded for 2006 and 2009, which was 2.00 and 2.03 eggs/nest, respectively.

Hatching Success. Of the 15 nests initiated in 2013, all successfully hatched at least one chick. Of the 30 eggs documented in 2013, we confirmed 18 hatched (Table 2). We assume seven additional eggs hatched based on the incubation period and lack of evidence to suggest they were depredated. Four eggs failed to hatch. The overall hatching success in 2013 was 83%, which is high relative to the hatching success values recorded since 1996 and the mean for 1995-2013 (Table 4). Hatching success has ranged from 0% in 2004 and 2006 to 94% in 2001 and 2008. Mean hatching success from 1996-2013 was 59%. Hatching success in 2013 was 26% higher than that in 2012.

Fledging Success. Of the 25 chicks that hatched in 2013, two were found dead of unknown causes (Table 2) and an additional four were unaccounted for. We estimated 19 of the 25 chicks fledged; we observed a maximum of 18 fledglings on 22 July and were able to follow one additional chick to fledging age after this date. The fledgling success rate for 2013 was 76%. This fledging rate is second highest rate on record, with 2007 being the highest at 80% (Table 4). The overall breeding success (% of total eggs that fledged) for 2013 was 63% (Table 2). This is the highest breeding success rate on record for the Purisima Point colony (Table 4). The number of fledglings produced per breeding pair in 2013 was 1.27. This is the second highest fledglings/pair value on record, with 2001 being the highest at 1.32 fledglings per adult breeding pair.

Interannual Productivity and Population Growth

The running 17-year mean productivity for 1995-2011 is 0.52 fledglings per adult breeding pair. Productivity in recent years (2007-2010) has been well above this mean, marking a strong deviation from the prior three years when virtually no fledglings were produced (Figure 6). The 2007-2010 period also marks the longest consecutive series of above average productivity on record. The Purisima Point colony has a history of variable productivity, fluctuating at or above the mean from 1998-2003 and below the mean prior to 1998 and after 2003. Productivity in 2011 was well below average, marking the first time productivity had been below average since 2006. Productivity in 2012 was very close to average and well above average in 2013.

Conversely, the 2012 and 2013 breeding populations were 45% and 52% smaller than the 19-year mean, respectively (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 19-year mean and has been declining since 2011.

Predation and Disturbances

We had only one documented instance of predation in 2013 (Table 5). We found the crop and some feathers from a possible least tern adult on the monitoring trail south of the colony. We dissected the crop in the lab and found fish bones, though the bones appeared larger than what we find in least tern diet samples. The feathers were sent to the Smithsonian Museum of Natural History for DNA analysis to confirm the species depredated. The remains were consistent with observations of owl or peregrine falcon predation, but no tracks were found to confirm the source. We therefore identified the source as unknown avian. There were no nests taken by predators and we do not suspect that any chicks were taken by predators in 2013. 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. However, we had no predator sightings or signs of predators within areas used by chicks to indicate that predators were an issue in 2013. Furthermore, a large proportion of the chick population was consistently observed for several weeks and the majority of the chicks were observed as fledglings later in the season (Figure 4). Finally, we do not have any evidence that fledglings were taken by predators in 2013.

The five most persistent predators observed in the vicinity of the Purisima Point colony in 2013 were western gulls, coyotes, unidentified owls, red-tailed hawks (*Buteo jamaicensis*), and northern harriers (Table 6). There were large numbers of western gulls roosting on the northwest and southwest slopes of the colony in 2013. We have seen roosting like this at the colony in the past and suspected gulls may have taken chicks in 2011 (Robinette and Howar 2011). However, the gulls were not roosting in areas used by chicks in 2013 and we do now suspect any predation by gulls. This year, we observed tracks from both great-horned and barn owls, but were often not able to distinguish the tracks of the two species. We therefore reported all tracks as unidentified owl. 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 were successful in keeping depredation by owls to a minimum. Though coyotes were able to breach the electric fence four times in 2013, there was no known take due to coyotes. Red-tailed hawks have shown an increased presence at the colony in recent years. We have never documented any least tern take by red-tailed hawks and suspect they are beneficial in keeping other potential predators such as northern harriers away from the colony. Overall, the number of predators sighted per hour of observation in 2013 was higher than observed in recent years (Table 7). This due to groups of 30-130 gulls observed roosting on the colony. Owl and coyote observations also contributed to this high number.

There were no documented cases of human-caused disturbance to the Purisima Point colony in 2013. We defined a disturbance as any event that caused adult birds to take to the air. No launches from SLC 2 or 576 E occurred during 2013. As in past years, turkey vultures (*Cathartes aura*) flying over the colony caused most of the documented disturbance in 2013 (Table 8). There were a small number of disturbances by great blue herons (*Ardea herodias*), red-tailed hawks, northern harriers, and peregrine falcons.

Diet and Foraging

Table 9 shows the percent frequency of occurrence for all prey taken in 2013. There was a total of 13 different prey types taking by least terns at the Purisima Point colony in 2013. As with 2012, greenling (Family Hexagrammidae) dominated the diet early in the 2013 season. However, there was also a moderate occurrence of rockfish and northern anchovy early in the season. Rockfish maintained a steady occurrence throughout the season, with a slight increase at the end. Northern anchovy increased in occurrence through early July and then decreased through the remainder of the season. We documented two new species for the Purisima Point colony in 2013: western mosquitofish (*Gambusia affinis*) and prickly sculpin (*Cottus asper*). Both species are found in freshwater and brackish habitats and began showing up in the tern diet in mid-July when we began to observe adult least terns foraging in the Santa Ynez River estuary. Overall, the 2013 diet was dominated by northern anchovy and rockfish, with greenling and western mosquitofish making moderate contributions.

Figure 7 compares the occurrence of major prey types among years from 2001 to 2013. We identified major prey types as those having 20% occurrence or more during at least one of the years within the time series. Anchovies and rockfish are abundant in the least tern diet during productive years (2001-2003, 2007-2010) and Pacific saury (*Cololabis saira*) is abundant during non-productive years (2004 and 2005). Furthermore, a diverse diet with moderate contributions by multiple prey types can lead to low least tern productivity (2011 and 2012). One exception has been 2006 when anchovy dominated the tern diet, but productivity was very low. In 2006, anchovy contribution quickly diminished as the breeding season progressed and there were only two nesting attempts that year (Robinette and Howar 2009). The 2013 diet showed signs of a productive year, with rockfish and anchovy dominating the diet and few other prey types making small contributions.

Figure 8 shows the relationship between the occurrence of anchovy and rockfish in the least tern diet and annual reproductive success (fledglings per adult breeding pair). Reproductive success is positively correlated with both anchovy and rockfish occurrence, but only if the analyses are performed without the outliers highlighted in the figure (Anchovy: Spearman's rho = 0.903, p <0.001, n = 10; Rockfish: Spreaman's rho = 0.832, p = 0.001, n = 10). The outliers for the anchovy analysis are 2006, 2008, and 2009. In 2006, anchovy occurrence was high but reproductive success was low. However, anchovy occurrence was high at the beginning of the season but quickly diminished. Adult colony attendance decreased with the diminishing anchovy and there were only two nesting attempts that year (Figure 8). Thus, while overall anchovy occurrence was high for the year, the timing of anchovy availability led to colony failure. In 2008 and 2009, anchovy occurrence was low but reproductive success was high. In these years, rockfish occurrence was high, resulting in high reproductive success. The outliers for the rockfish analysis were 2001, 2007, and 2013. In these years, rockfish occurrence was low but reproductive success was high. Anchovy occurrence was high in these years, leading to the high reproductive success observed. Thus, both anchovy and rockfish are important components of the least tern diet, but the relationship with reproductive success can be complicated by the timing of prey availability.

Figure 9 shows the annual foraging rates at our nearshore foraging stations from 2007 to 2013. Two-way ANOVA showed significant differences in foraging rates both among sites and years (Site: F = 11.68, df = 1, 1,1641, p < 0.001; Year: F= 62.67, df = , 1,1641, p = 0.001) and significant interaction between the two variables (F = 9.07, df = 4, 1,1641, p < 0.001), meaning that differences observed between sites were not consistent among all years. Post hoc tests are shown in Table 10. Foraging rates were significantly higher in 2009 and significantly lower in 2011. There were no significant differences among the other years. Foraging rates were higher at Pockets Cove in 2007, 2009, and 2012 and higher at Purisima Point in 2010 and 2013. This is first year that we observed terns foraging at Lompoc Landing, an observation station between Pockets Cove and the Santa Ynez River Estuary. Terns were observed foraging at this site in mid to late July. Together with the diet analysis, these data suggest terns were relying on nearshore waters adjacent to the colony for prey. As anchovy began to decrease in the diet, the terns began foraging further south of the colony and eventually began foraging in the Santa Ynez River estuary.

Diet and Local Oceanography

Figure 10 shows the comparison of northern anchovy and rockfish occurrence in the Purisima Point least tern diet to larval abundance from nearshore CalCOFI stations along lines 77 and 80. Dietary anchovy occurrence is positively correlated with larval abundance measured during the spring-summer anchovy spawning period one year prior to the least tern breeding season (Spearman's rho = 0.669, p = 0.012, n = 11). Dietary rockfish occurrence is positively correlated with larval abundance during the winter rockfish spawning period, though the relationship is not quite significant (Spearman's rho = 0.445, p = 0.085, n = 11). The relationship between dietary rockfish occurrence and larval abundance is obscured by the 2009 and 2010 data points when an average amount of rockfish larvae were produced, but dietary rockfish occurrence was high. In these years, we suspect that the survival of rockfish larvae to settling age was high (see below). Overall, the correlations between diet and larval abundance further illustrate the importance of these two prey species to least terns breeding at Purisima Point.

Figure 11 shows correlations between least diet and oceanographic indices. For all oceanographic indices shown, negative values represent colder, more productive ocean conditions and positive values represent warmer, less productive conditions. Dietary anchovy occurrence was significantly correlated with ENSO averaged over the fall-summer and PDO averaged over spring-summer after the anchovy spawning period, but only if the outliers are not included in the analysis (ENSO: Spearman's rho = -0.883, p = 0.001, n = 9; PDO: Spearman's rho = -0.767, p = 0.008, n = 9). The outliers for both correlations were 2008-2009 and 2011-2012. In these four years, anchovy larval abundance was very low (see Figure 10). Thus, while oceanographic conditions were conducive to larval survival, there were few larvae produced and thus low anchovy occurrence in the tern diet. Dietary rockfish occurrence was significantly correlated with SST anomaly averaged over the spring-summer after the rockfish spawning period (Spearman's rho = -0.589, p = 0.017, n = 13). Together with the results on larval abundance, these results illustrate that both the amount of larvae produced in a given year and the survival of those larvae to settlement age are important factors determining the availability of anchovy and rockfish to the Purisima Point least terns.

Discussion

The 2013 breeding season was an above average year for productivity, but below average for breeding population size. Though not significantly different from other years, average clutch size was high at 2.0 eggs per nest. Hatching success (83%) was well above the 19-year average (59%) and fledging success (76%) was the second highest on record. Overall breeding success (1.27 fledglings per breeding pair) was also the second highest on record. The breeding population was below average (33 breeding pairs) for the second time since 2008 and is currently showing a decreasing trend from 2011 to 2013.

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 19-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. 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 four consecutive years of above average reproductive output (2007-2010), the Purisima Point population has not climbed above the 19-year mean and appears to be decreasing in recent years (2011-2012).

Results from 2011 and 2012 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 have since returned to neutral (PaCOOS 2013). Despite the less productive El Niño conditions, the PDO has been negative since June 2010. This is likely driving the average to above average breeding productive observed in 2010, 2012, and 2013. Additionally, upwelling conditions were stronger than average off central California in 2013, further illustrating that 2013 was a productive ocean year. Data from the National Marine Fisheries' juvenile rockfish cruises show record numbers of juvenile rockfish off central California in 2012 and 2013 (PaCOOS 2012, 2013). While northern anchovy abundance in 2013 was lower than the long-term mean for the surveys, it was higher than it has been since 2007.

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 on 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. In years when anchovies are present in the diet, foraging rates at our plots are lower (Robinette and Howar 2010). In 2013, both rockfish and anchovy showed a relatively high occurrence in the diet. Foraging rates were highest immediately adjacent to the colony, the terns were also observed foraging at plots south of the colony. Most of the near-colony foraging was observed in July when anchovy occurrence in the diet was decreasing. Thus, it appears that terns were foraging on anchovy farther from the colony and began relying more on the kelp beds later in the season. Additionally, the terns began foraging farther south than we've seen in the past, using both the Lompoc Landing and Santa Ynez River estuary beginning in mid-July. It is likely that the estuary provided a buffer as anchovy became less abundant late in the season. Least tern use of the estuary has been inconsistent over the time series and is likely related to annual breaching of the river mouth. The river mouth did not breach in 2013 and the estuary remained full throughout the breeding season. These conditions may have contributed to an increased abundance of western mosqitofish and prickly sculpin in the estuary. Despite this, our diet and oceanographic analyses indicate that the Purisima Point least terns continue to respond to conditions dictating local rockfish and anchovy abundance.

Management Recommendations

1) 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 four years. In 2012 and 2013, many of our avian predator sightings were within this area. We suspect that the increased vegetation has provided habitat for rodents and this may be attracting avian predators to the area. Additionally, 2013 marks the third consecutive year that the snowy plover has not nested within the fenced area. The nesting habitat that the plovers historically used was primarily within the area now covered by vegetation. 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.

2) 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 predation was an issue in 2013, 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. 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.

3) 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 should and has deterred coyotes from attempting to dig under. We support continued effort to prevent these dig unders.

4) 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.

5) 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.

6) 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 utilizing the coast.

7) An analysis of potential launch impacts should be conducted using VAFB's now 18-year time series of launch activities and least tern population dynamics. A preliminary analysis of launch activities immediately adjacent to the Purisima Point colony (see Robinette et al. 2012) shows no correlation between the number of launches within a given year and breeding population size or reproductive success. However, this analysis does not account for the timing of the launches or stages of the least tern breeding cycle (e.g., arrival to the colony, courtship, nest initiation, etc.). An analysis accounting for these factors would allow VAFB to better assess the potential impacts (if any) of launch activities on the Purisima Point least tern colony.

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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 2012.

	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

Table 2: Summary of least tern breeding activity at the Purisima Point colony during the 2013 breeding season.

Population	**Estimated # of Pairs**	**15**
	Adults Depredated	1
	Adults Dead Cause Unknown	0
Nests	**Total Nests**	**15**
	Hatched all eggs	10
	Abandoned Before Hatch Date	0
	Incubated Past Hatch Date	0
	Hatched, but had ≥ 1 Non-viable Egg	4
	Depredated	0
	Chicks Died/Cause Unknown	1*
Eggs	**Total Eggs**	**30**
	Confirmed Hatched	18
	Assumed Hatched	7
	Depredated	0
	Dead Eggs	4
Chicks	**Total Chicks**	**25**
	Hatching Success	83%
	Depredated	0
	Died of Unknown Cause	2
Fledglings	**Total Fledglings**	**19**
	Fledging Success	76%
	Depredated	0
	Died of Unknown Cause	0
Breeding Success	**% of Total Eggs Fledged**	63%
	Fledglings per Adult Pair	1.27

* One nest hatched one egg and second chick died in the egg while hatching.

Table 3: Results of Tukey's post hoc tests (Daniel 1999) on mean clutch size among years from 2001 to 2013. Significant differences are italicized in red. Data from 2004 were excluded from the analysis as there was only one nest (n=1) initiated that year.

Year	2001	2002	2003	2005	2006	2007	2008	2009	2010	2011	2012
2002	***MD = 0.282 p = 0.026***										
2003	***MD = 0.406 p <0.001***	MD = 0.125 p = 0.738									
2005	***MD = 0.523 p <0.001***	MD = 0.241 p = 0.115	MD = 0.116 p = 0.917								
2006	MD = 0.205 p = 1.000	MD = -0.077 p = 1.000	MD = -0.202 p = 1.000	MD = -0.318 p = 0.996							
2007	***MD = 0.593 p <0.001***	MD = 0.312 p = 0.171	MD = 0.187 p = 0.831	MD = 0.071 p = 1.000	MD = 0.389 p = 0.984						
2008	MD = 0.260 p = 0.521	MD = -0.021 p = 1.000	MD = -0.146 p = 0.966	MD = -0.263 p = 0.505	MD = 0.056 p = 1.000	MD = -0.333 p = 0.400					
2009	MD = 0.172 p = 0.835	MD = -0.109 p = 0.989	MD = -0.234 p = 0.187	***MD = -0.350 p = 0.017***	MD = -0.032 p = 1.000	***MD = -0.421 p = 0.031***	MD = -0.088 p = 1.000				
2010	MD = 0.293 p = 0.085	MD = 0.011 p = 1.000	MD = -0.114 p = 0.964	MD = -0.230 p = 0.289	MD = 0.088 p = 1.000	MD = -0.301 p = 0.350	MD = 0.033 p = 1.000	MD = -0.121 p = 0.991			
2011	MD = 0.288 p = 0.210	MD = 0.006 p = 1.000	MD = -0.118 p = 0.983	MD = -0.235 p = 0.528	MD = 0.083 p = 1.000	MD = -0.306 p = 0.434	MD = 0.028 p = 1.000	MD = 0.116 p = 0.997	MD = -0.005 p = 1.000		
2012	***MD = 0.427 p = 0.013***	MD = 0.145 p = 0.978	MD = 0.020 p = 1.000	MD = -0.096 p = 1.000	MD = 0.222 p = 1.000	MD = -0.167 p = 0.989	MD = 0.167 p = 0.909	MD = 0.255 p = 0.646	MD = 0.134 p = 0.994	MD = 0.139 p = 0.996	
2013	MD = 0.205 p =0.891	MD = -0.077 p = 1.000	MD = -0.202 p = 0.835	MD = -0.318 p = 0.301	MD = 0.000 p = 1.000	MD = -0.389 p = 0.237	MD = -0.056 p = 1.000	MD = 0.032 p = 1.000	MD = -0.088 p = 1.000	MD = -0.083 p = 1.000	MD = -0.222 p = 0.932

Table 4: Numbers of nests, eggs, chicks, and fledglings observed at VAFB from 1995 to 2013. Also shown are hatching success, fledging success, and breeding success from 1995 to 2013.

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

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

Table 5: Documented predation at the Purisima Point colony during the 2012 breeding season.

Date	Predator	Predated	Description
7/4	Unknown Avian	1 Adult	On 4 July, a possible Least Tern crop found on the trail south of the colony. The crop was dissected and fish bones were found. DNA analysis is being conducted to confirm the crop from a Least Tern. No predator tracks were found in the area.

Table 6: Predators observed at the Purisima Point colony during the 2013 breeding season.

Predator	# Observed in Colony Area	# Observed Inside Colony
Western Gull	461	461
Coyote	38	4
Unidentified Owl	41	10
Red-tailed Hawk	13	2
Northern Harrier	9	3
Peregrine Falcon	5	3
American Kestrel	4	0
Loggerhead Shrike	4	1
Feral Pig	3	0
Great Blue Heron	2	1
Osprey	2	0
White-tailed Kite	2	0
Bobcat	1	0
Merlin	1	0

* There were three Western gull (*Larus occidentalis*) nest adjacent to the colony in 2013 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.

Table 7: Total number of predator visits (all species combined) per hour of researcher observation for the 2001-2013 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

Table 8: Documented events of disturbance at the Purisima Point colony during the 2013 breeding season.

Source	**# of Documented Occurrences**
Turkey Vulture	14
Great Blue Heron	3
Red-tailed Hawk	2
Northern Harrier	1
Peregrine Falcon	1

Table 9: Diet composition (% frequency of occurrence) for least terns at the Purisima Point colony during five periods of the 2013 breeding season.

Prey Taxon	**3 June**	**14 June**	**1 July**	**17 July**	**30 Jul**	**All Periods Combined**
Anchovy (*Engraulis mordax*)	19	50	80	20	5	35
Rockfish (*Sebastes sp.*)	29	50	25	30	55	38
Unidentified Fish Larvae	14	15	0	0	0	6
Greenling (Family Hexagrammidae)	57	15	0	0	0	15
Cabezon (*Scorpaenichthys marmoratus*)	0	0	0	5	0	1
Surfperch (Family Embiotocidae)	5	0	5	10	5	5
Sanddab (*Citharichthys spp.*)	0	0	0	20	20	8
True Smelt (Family Osmeridae)	0	0	0	5	20	5
Lantern Fishes (Family Myctophidae)	14	0	0	5	0	4
Goby (Family Gobiidae)	0	0	0	10	0	2
Western Mosquitofish (*Gambusia affinis*)	0	0	0	35	40	15
Prickly Sculpin (*Cottus asper*)	0	0	0	30	5	7
Unidentified Arthropod (Family Arthropoda)	5	0	5	0	0	2
Sample size (n)	*21*	*20*	*20*	*20*	*20*	*101*

Table 10. Results of Tukey's post hoc tests (Daniel 1999) on mean foraging rates among years from 2007 to 2013. Significant differences are italicized in red.

Year	2007	2008	2009	2010	2011	2012
2008	MD = -0.488 p = 0.176					
2009	***MD = -0.295 p <0.001***	***MD = -0.256 p <0.001***				
2010	MD = -0.348 p = 0.479	MD = 0.141 p = 0.990	***MD = 2.598 p <0.001***			
2011	MD = 0.407 p = 0.296	***MD = 0.895 p <0.001***	***MD = 3.353 p <0.001***	***MD = 0.754 p <0.001***		
2012	MD = -0.141 p = 0.988	MD = 0.348 p = 0.536	***MD = 2.805 p <0.001***	MD = 0.207 p = 0.900	***MD = -0.548 p = 0.032***	
2013	MD = -0.132 p = 0.991	MD = 0.357 p = 0.505	***MD = 2.814 p <0.001***	MD = 0.216 p = 0.880	***MD = -0.539 p = 0.037***	MD = 0.009 p = 1.000

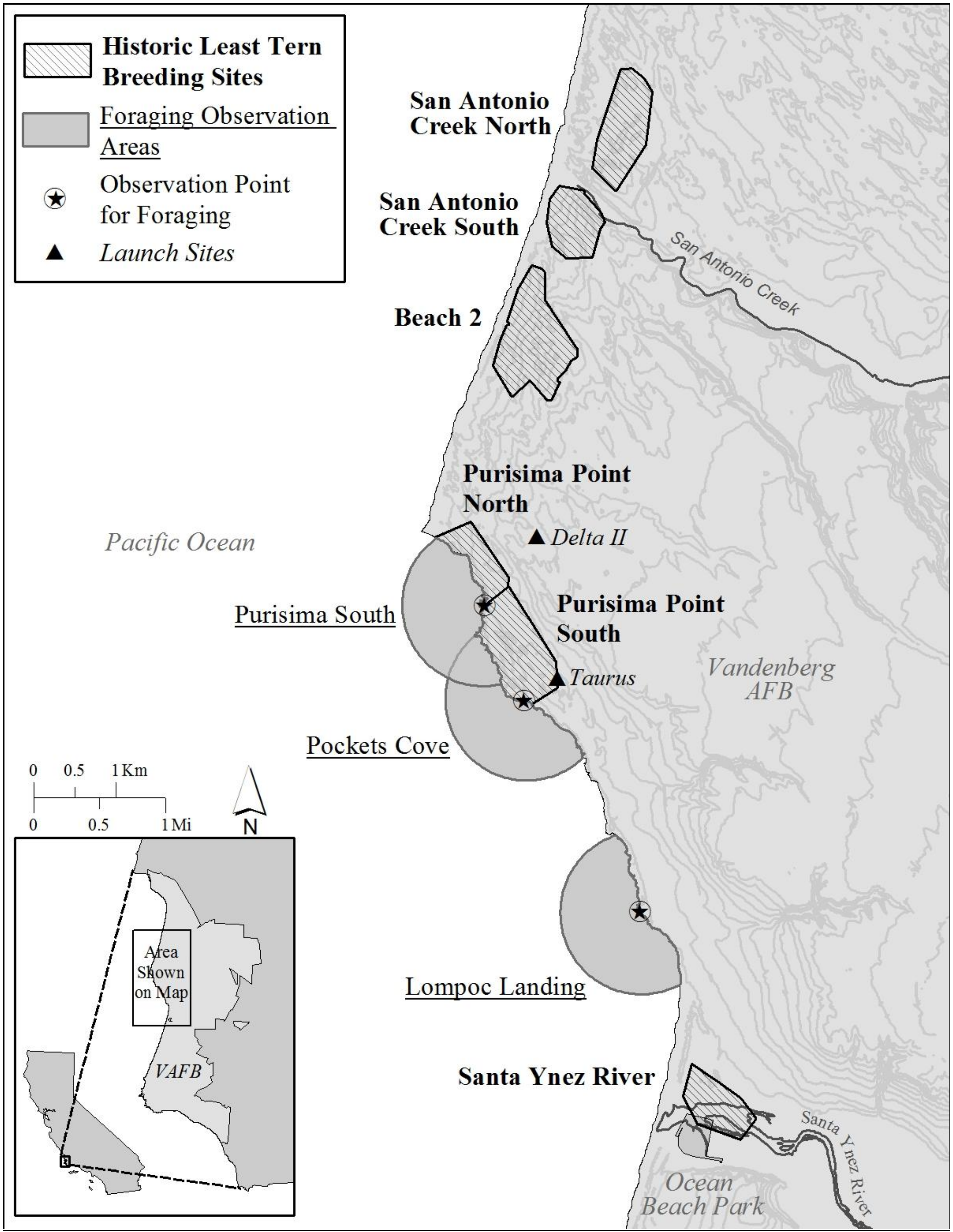

Figure 1: Map of the current least tern colony at Purisima Point, VAFB. Also included are the locations of historic breeding colonies at VAFB (San Antonio Creek North, San Antonio Creek South, Beach 2, and Santa Ynez River) and observation points for foraging observations made during the 2013 breeding season. 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 2013.

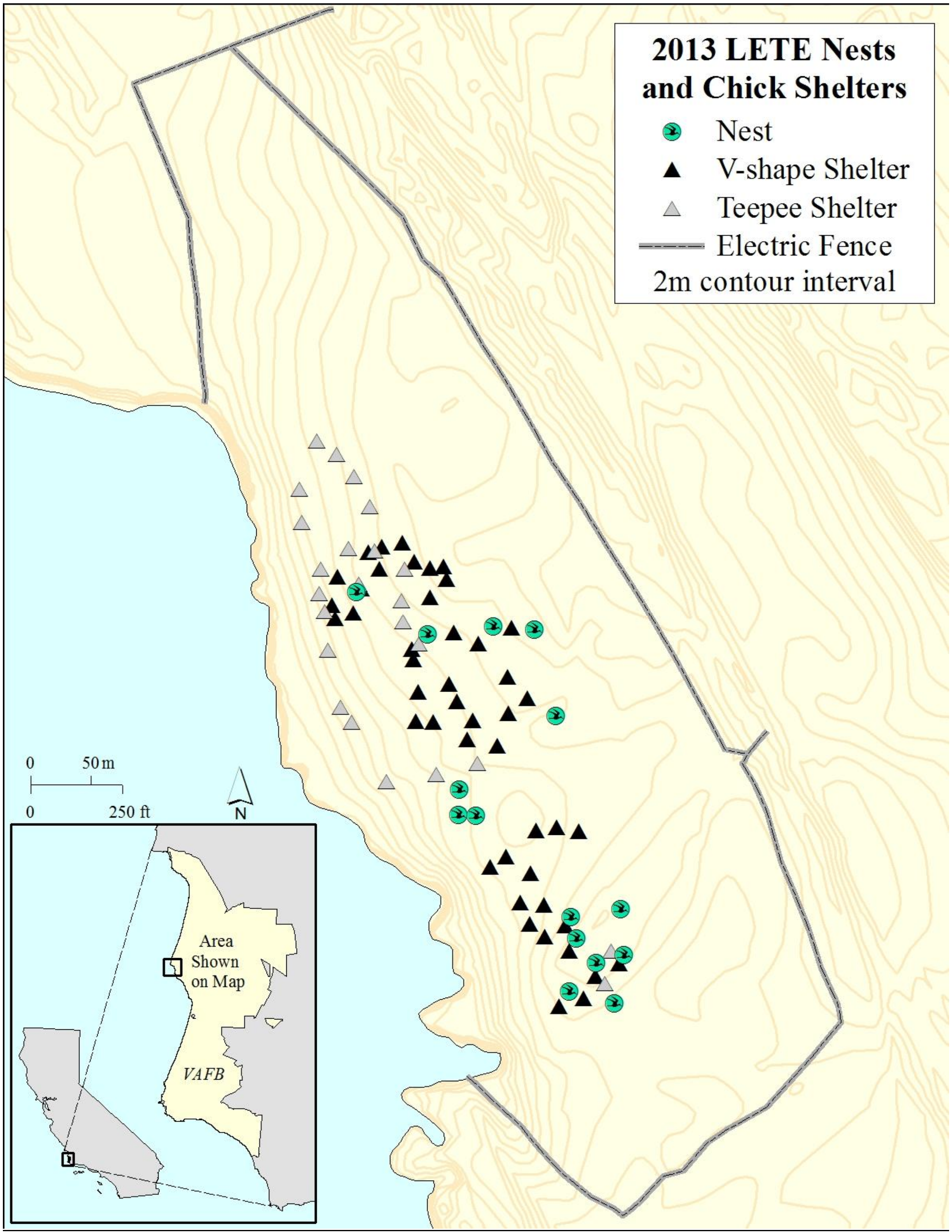

Figure 3. Location of permanent (Teepee) and moveable (V-shape) chick shelters during the 2013 breeding season. Also shown are the locations of Least Tern nests initiated in 2013.

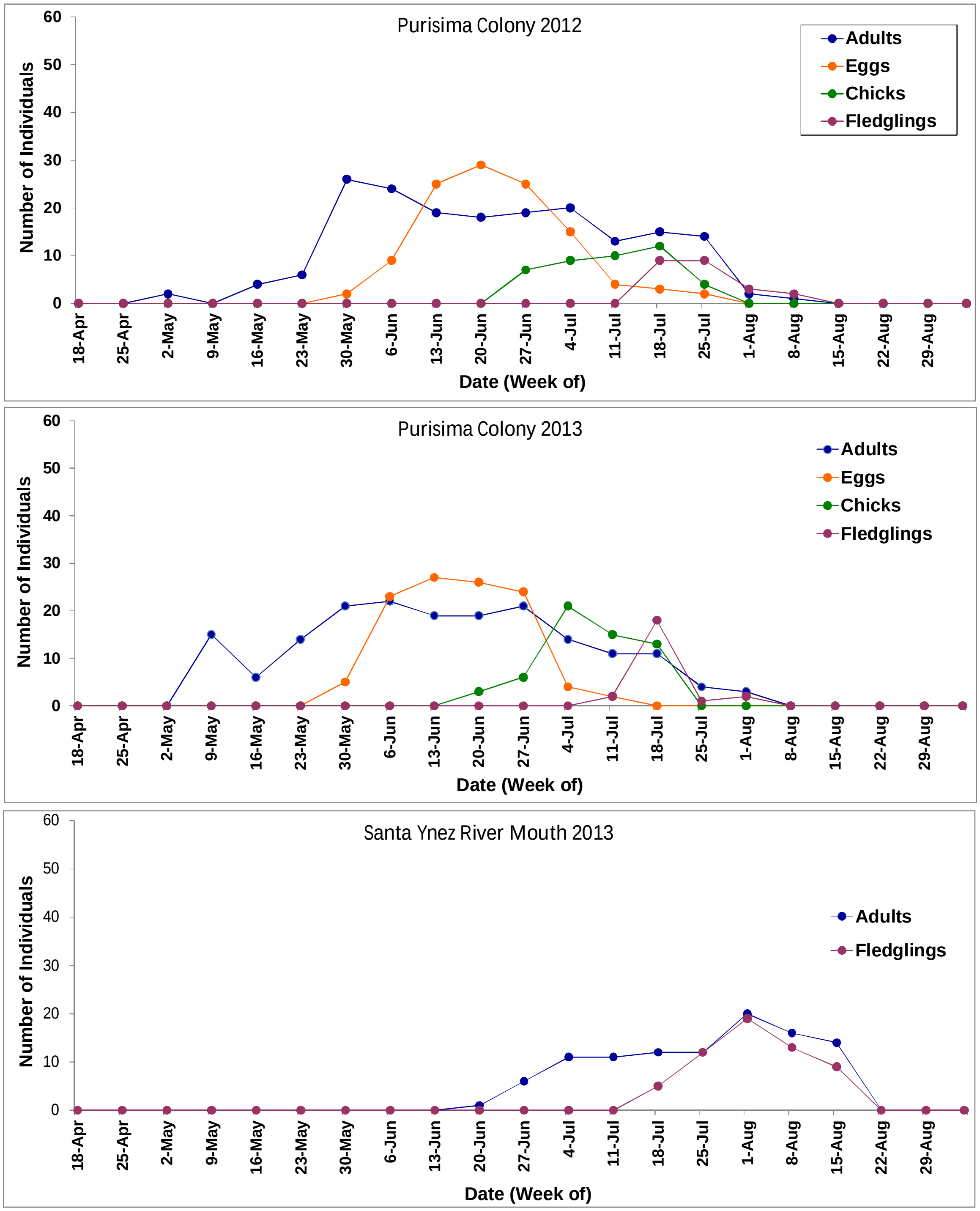

Figure 4: Breeding phenology for the Purisima Point colony during the 2012 and 2013 breeding season, including use of the Santa Ynez River mouth in 2013. Values shown are the maximum number of individuals observed during a given week.

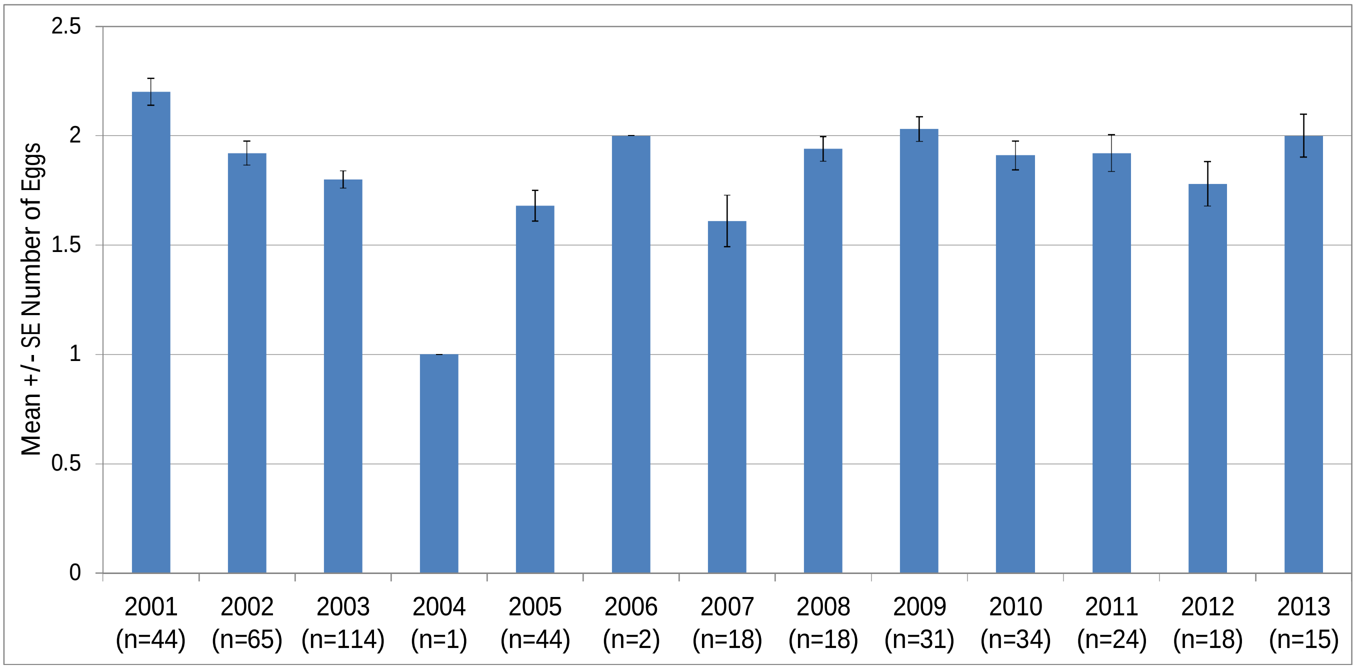

Figure 5: Mean ± SE clutch sizes for all nest attempts at the Purisima Point colony from 2001 to 2013.

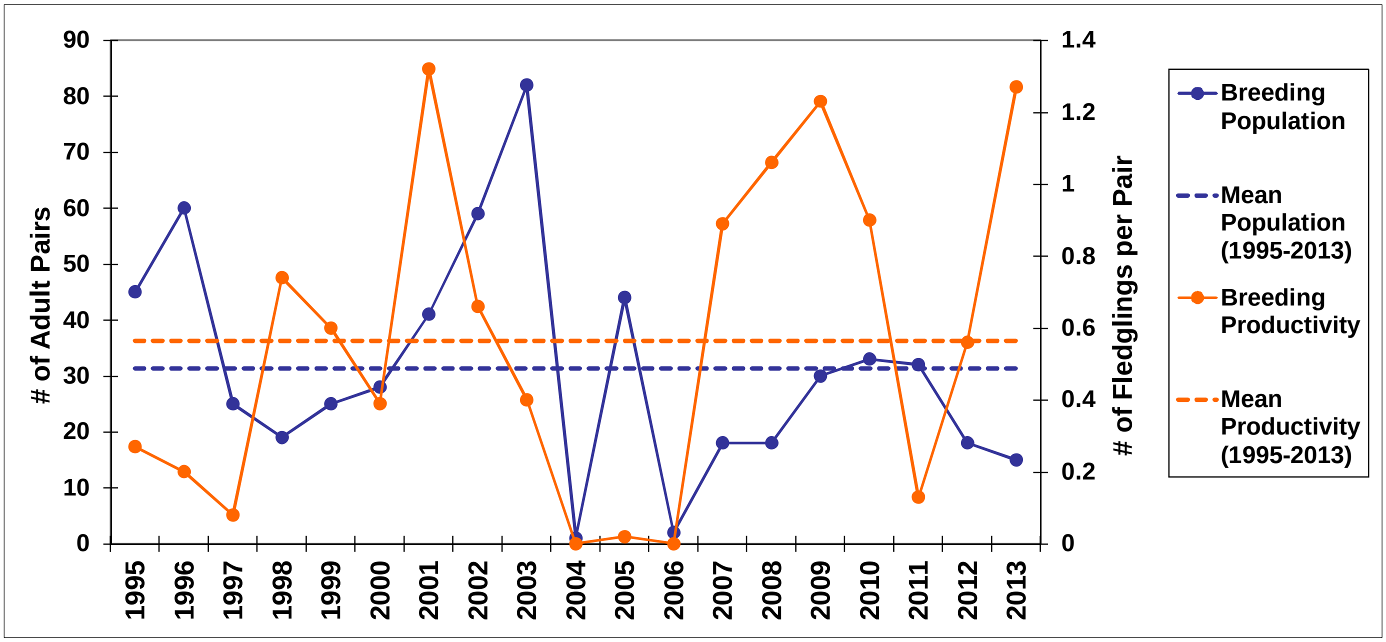

Figure 6: Numbers of adult pairs and fledglings per pair at the Purisima Point colony, 1995 to 2013. Dashed lines show running 19-year mean (1995-2013) for each variable.

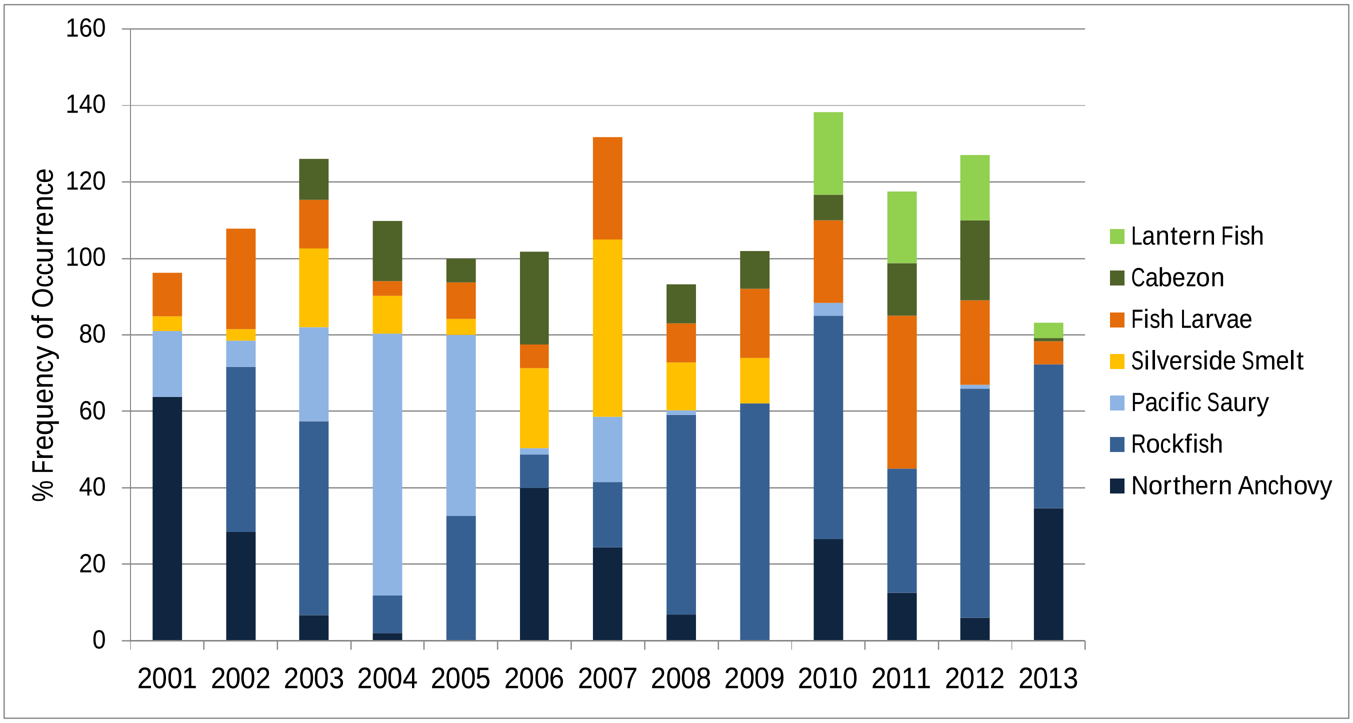

Figure 7: Percent occurrence of major prey in all feces collected from the Purisima Point colony in 2001 (n=105), 2002 (n=120), 2003 (n=154), 2004 (n=51), 2005 (n=95), 2006 (n=115), 2007 (n=41), 2008 (n=88), 2009 (n=50), 2010 (n=60), 2011 (n=80), 2012 (n=100), and 2013 (n=101). See Table 9 for a list of all prey taken in 2013.

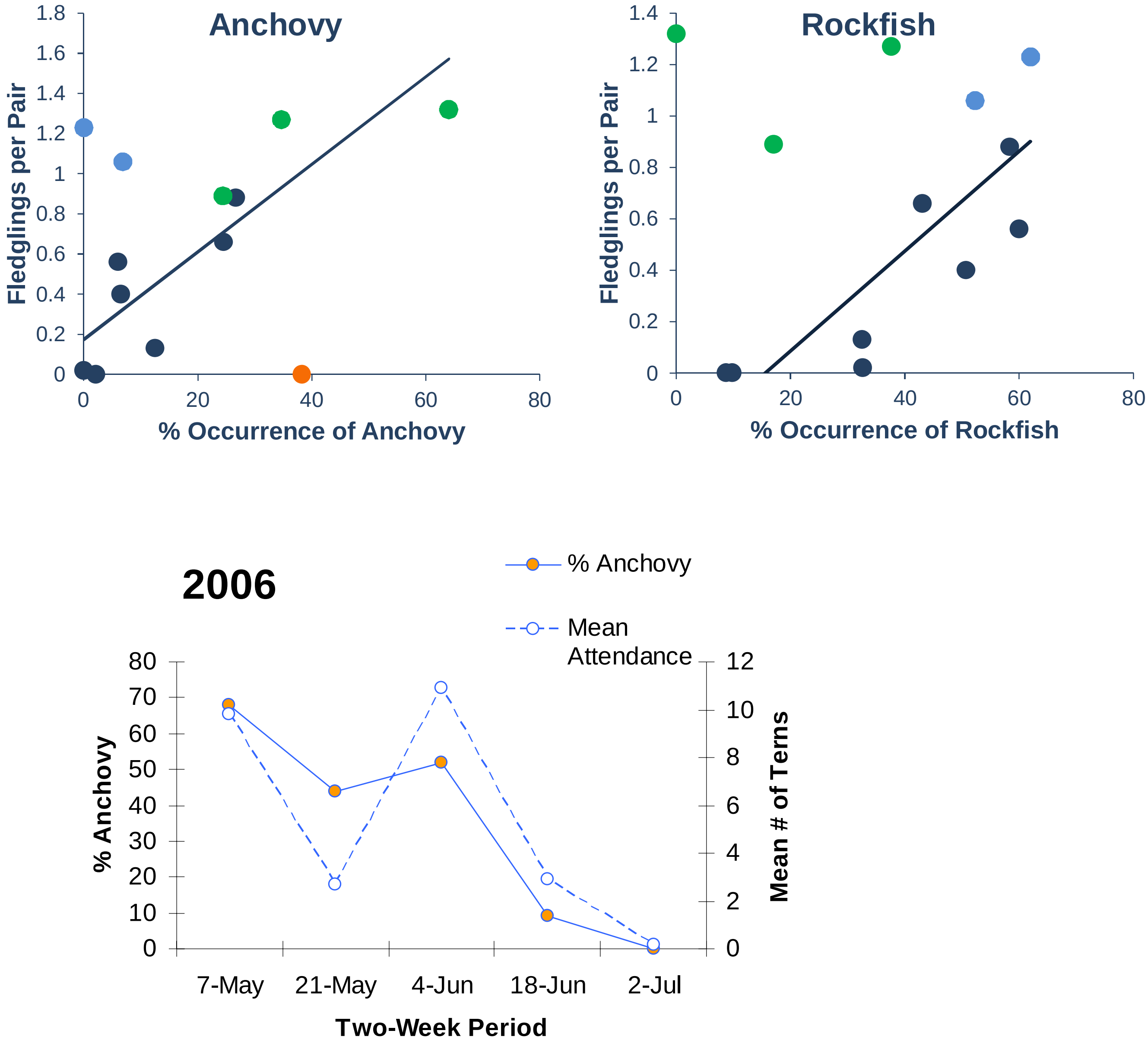

Figure 8: Reproductive success (fledglings per pair) versus percent occurrence of anchovy and rockfish in the Purisima Point least tern diet. Light blue points indicate years that were outliers in the anchovy analysis, but were in line with the rockfish analysis. Green points indicate years that were outliers in the rockfish analysis, but were in line with the anchovy analysis. The orange point represents 2006 when anchovy occurrence was high early in the season, but quickly decreased leading to early colony abandonment (see bottom graph).

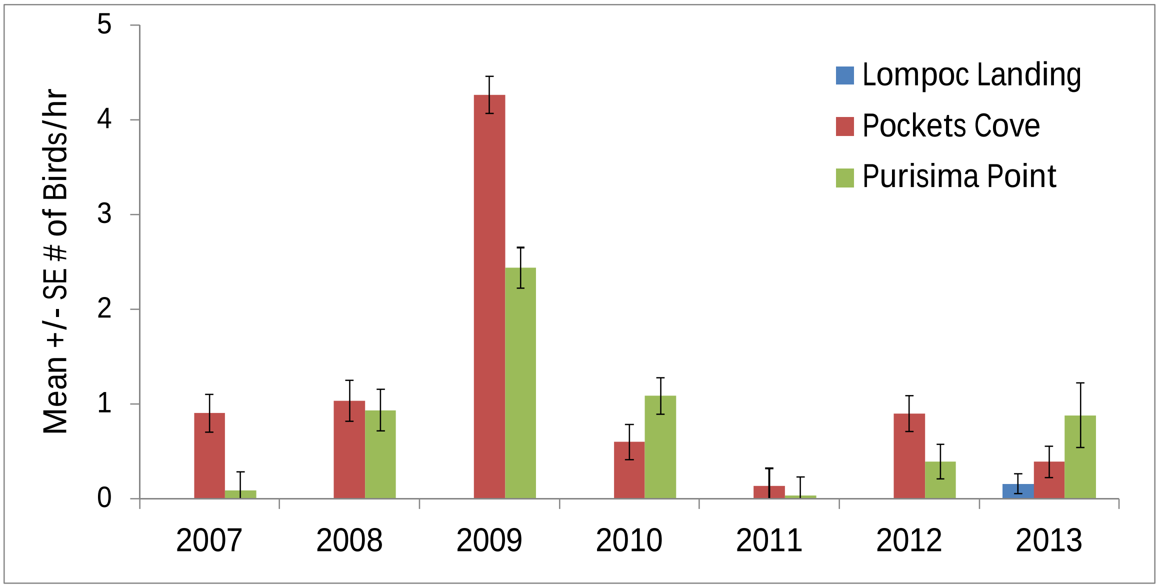

Figure 9: Mean +/- SE number of least terns foraging per 15 minutes of observation at Pockets Cove and Purisima South foraging areas (see Figure 1 map) from 2007 to 2012.

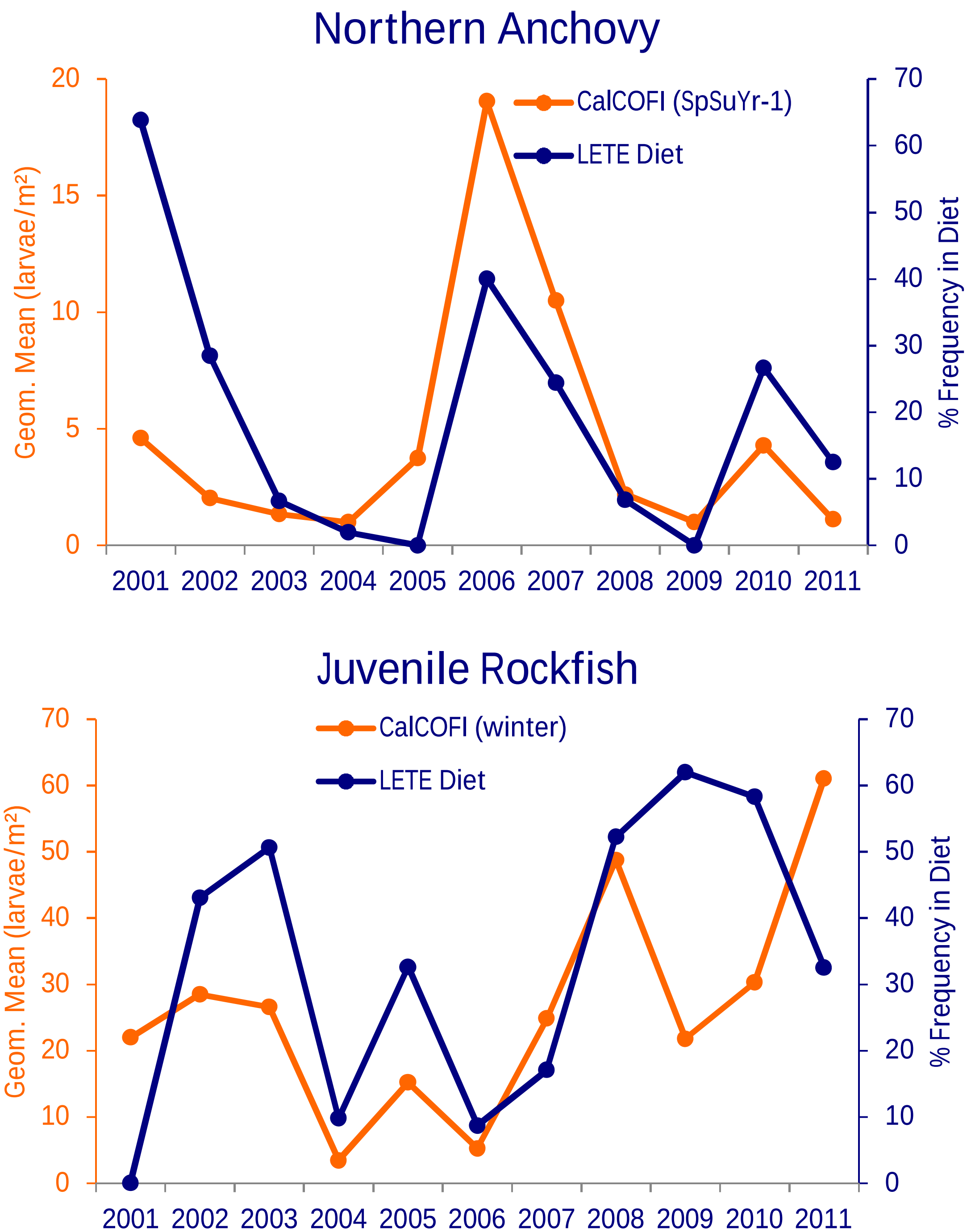

Figure 10: Comparison of annual occurrence of northern anchovy and rockfish in the Purisima Point Least Tern diet to nearshore larval abundance data from CalCOFI lines 77 and 80. Dietary anchovy is compared to larval abundance from the spring-summer spawning period prior to diet analysis and dietary rockfish is compared to larval abundance from the winter spawning period prior to diet analysis.

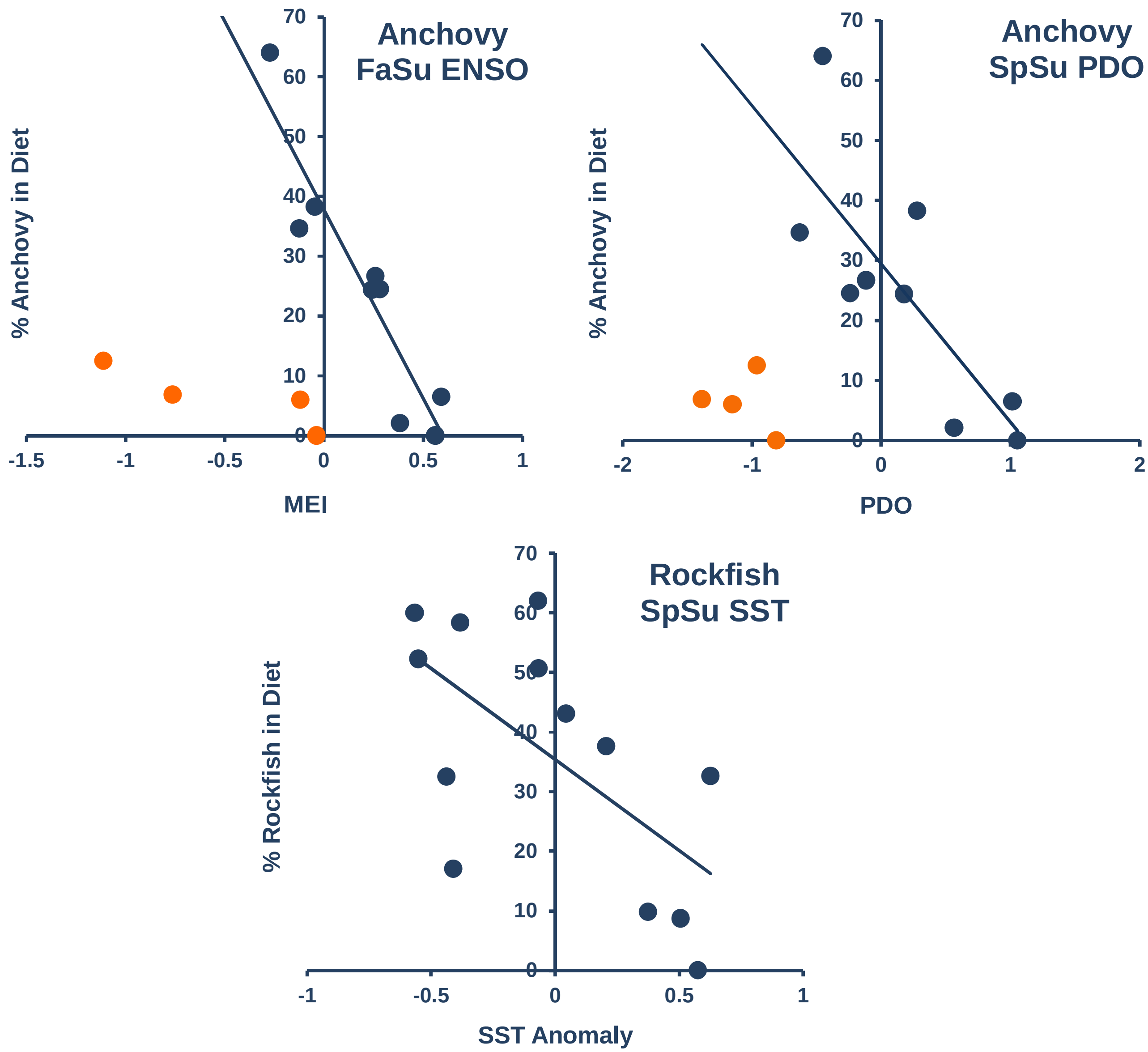

Figure 11: Percent anchovy (top graphs) and rockfish (bottom graph) in the Purisima Point least tern diet versus three oceanographic indices: ENSO, PDO, and SST anomaly. ENSO values were averaged over the fall-summer (FaSU), PDO values were averaged over the spring-summer (SpSu), and SST anomalies were averaged over the spring-summer (SpSu). In all cases, negative index values represent productive ocean conditions. Orange points are outliers where dietary anchovy occurrence is low despite productive ocean conditions. In these years (2008-2009 and 2011-2012), anchovy larval abundance was low (see Figure 10).

Chapter 2: Monitoring and Management of the Western Snowy Plover on Vandenberg Air Force Base, 2013

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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 have not bred in this sector since 2010.

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 2013, temporary closure occurred from 10 April through 1 May due to a high number of violations into the closed area. Permanent closure began 3 June through 1 October 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 19 years (1994-2012) of breeding bird census and nest initiation data from VAFB have yielded similar trends (see Ball and Robinette 2012). 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 (Ball and Robinette 2012). 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 2013 is 240 adults with mean nest number at 330.

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 (Ball and Robinette 2012). Mean clutch hatch success (percent of total eggs that hatched) from 1994-2013 was 35% 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, Ball and Robinette 2012). 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 <1% of all known fate nests in 2013 (down from 7% in 2012) with the highest occurring in 2004 with 12% of all known fate nests taken by common ravens. Coyote predation has mainly occurred on South Beach sectors with the highest occurring in 2004 at 20% of all known fate nests depredated.

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 2013, mammal, gull, and corvid management was conducted by ManTech SRS Technologies, Inc. (MSRS). MSRS 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 2013. Todd and Aulman selectively trap and relocate avian predators deemed a threat to snowy plovers. Point Blue (formerly PRBO) 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 2013 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 20-year time series. We compare trends in population and reproduction among North, Purisima, and South Beaches. 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, 2013. 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, SNO, and SSO. 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 the same weeks as conducted during all seasons since 2002: 13 May, 21 May (range wide window breeding survey), 10 June and 24 June. We conducted window surveys using our transect methodology (see below). We divided beach sections into three main segments: MIN-SHS, SAN-PCO, and WAL-SSO. 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, their age class, sex, and color band combination for all breeding beaches. We also recorded the number and size of all chicks 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. The 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. These nests 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 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

2013 was the second consecutive year we have placed Reconyx photo and motion sensor video cameras on nests 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 video when the motion sensor is triggered by large animals such as predatory birds or predatory mammals. Snowy plovers are too small to trigger the video component. Cameras were set four to eight meters from the nest, camouflaged with debris from the immediate area, and placed 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 estimated hatch date (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. One camera was placed five days prior to the EHD, approximately 20 meters away from the nest in an *Ammophila*-covered dune.

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 were successful at banding 38% of broods in 2013. We color banded a total of 171 chicks from 62 nests. We used a unique band color combination issued by the USFWS for each brood. Additionally, we individually marked chicks within broods from nests of particular interest (e.g., nests in open areas 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 altered color schemes within each brood using partial exposure of the aluminum band. We individually marked 41 chicks from 16 broods. 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 2013 and Appendix C lists all color bands used on chicks hatched at VAFB in 2013.

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. "Mystery broods" are broods that originate from unknown nests. Mystery broods have shown up on the shoreline in prior years, but this is the first season we were able to definitively identify and track them. A brood was considered a mystery brood if it was found after at least one egg hatched. In 2013, 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.

Since we monitored all banded and unbanded broods, we were able to identify eight "mystery broods," or broods that originated from unknown nests. Due to our brood monitoring and banding efforts, we were able to determine that the mystery broods were, in fact, from new nests. Nest locations were assigned to the most likely, usually closest, brood. For example, a nest bowl was found with one egg and pip fragments present, so was assigned to the two-chick brood nearby. Nest bowls were eventually located for four San Antonio broods, so we were able to confirm clutch size for these nests. The nest bowls for the Shuman South, Surf North, and two other San Antonio broods were never located, so 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 2013.

Transect Surveys

This was the third consecutive year that weekly transect surveys have been conducted at VAFB. Beginning 1 March, we conducted transect surveys along each beach sector on a weekly basis. 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.

Wrack Monitoring

This was the second 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 these index values to calculate a weekly index value for each beach sector (e.g., MIN, SHS, SHN, etc.). The weekly value for a given beach sector was the mean across all counting blocks, weighted by the relative size of each counting block. In other words, we calculated the proportion that each counting block contributed to the total transect length, multiplied the wrack index value for that counting block by its contribution to the transect, and then summed these weighted values for all counting blocks within the transect. 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 dune) 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.

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 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. In 2012, we added a "buffer" fence measuring 100x100 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

2013 Breeding Population and Reproductive Success

Detailed data summaries can be found in Appendix D. Metrics for 2013 are summarized base-wide in Table 1 and by individual beach sector in Table 2. The maximum number of adults detected during the 2013 transect surveys was observed during the week of 3 June. The maximum number of adults was 114 at CA-84 and 165 at CA-85 (Table 2) for a base-wide total of 279 (Table 1). This is a increase of 12% from 2012 where the maximum population was estimated at 248 breeding adults (Table 1). We confirmed nesting activity for 37 snowy plovers color banded as chicks on VAFB in prior years (Appendix B and Table 3). We suspect an additional 12 plovers banded as chicks on VAFB were nesting on VAFB in 2013. We confirmed nesting for 13 snowy plovers banded as chicks outside of VAFB and suspected nesting for one in 2013 (Appendix B).

A total of 307 nests were located and the fates of 302 of those nests were determined. This represents a 10% decrease in nests initiated compared to 2012. This decrease is likely due to a reduction in re-nesting attempts in 2013. There was a 50% decrease in the number of nests depredated when compared to 2012. Of the 302 known fates nests, 174 successfully hatched. This is a 20% increase in total clutches successfully hatching compared to 2012 (145 clutches hatching in 2012). Hatching success (% of total eggs that hatched) and clutch success (% of clutches that hatched all eggs) in 2013 was 56% and 58%, respectively. This represents a 27% and 26% increase, respectively, from 2012. The primary cause of nest failures was attributed to predation, which accounted for 50% of nest failures or 21% of known fate nests (a decrease of 50% from 2012). Fledging success in 2013 was 12% higher than 2012, with an estimated 57% of chicks successfully fledged in 2013 and 51% in 2012 (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 eight 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 2013. Predation occurred on both North and South Beaches with the lowest hatch rate occurring on South Beaches (54%). Conversely, Purisima Beaches had the highest hatch rate (100%) and North Beaches hatch rate (64%) was slightly higher than South Beaches. Fledge rate was the highest on North Beaches (66%, Figure 6). Nine chicks on Purisima Beaches were banded with a fledge rate of 56% for this beach section.

Eighteen nests were located in areas open to recreational use in 2013. 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). The amount of habitat available within areas open and closed to recreational activities was similar at MIN (0.5 miles open and 0.6 miles closed). There were no nests initiated in the open area and 2 nests (3.3 per linear mile) in the closed area. The closed area had a 100% hatch rate with no data on banded fledge rate. There is more habitat available in areas closed to recreation (0.85 miles) than open to recreational use (0.25 miles) at WAL. There were no nests initiated in the open area and 47 (54.1 per linear mile) in the closed area. The closed area had a 48% hatch rate and 60% 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 18 nests (36 per linear mile) in the open area and 70 (50 per linear mile) in the closed area. The clutch hatch rate was slightly higher in the open area (56%) than the closed area (58%). Fledging rate in the closed area was 41% and in the open area at 88%. Table 4 shows the fates of nests initiated within the open areas on MIN, WAL, and SNO in 2013.

On 10 April the open area at SNO was temporarily closed until 1 May due to a concerning number of beach violations. SNO was then closed on 1 June for the rest of the breeding season after the maximum number of allowed violations had been reached. Nest failure in the open area at SNO was attributed to nest destruction by high tide events and human trespassers. On 30 June (after the permanent closure of the open area), eggs from two nests were taken by trespasser, it is unknown if the adult pairs from those nests re-nested.

Mystery Broods

Mystery brood nests were initiated 28 May to 9 July. The broods were found 28 June to 26 August at any age between just hatched and just prior to fledge. Six broods were found on San Antonio zero to eight days after hatch. One three-chick brood was found during hatch and was subsequently banded. Two chicks from that brood fledged. Overall, we monitored 17 chicks from the eight broods, and confirmed that 11 fledged. We confirmed two banded males, six unbanded males, one banded female, and one unbanded female associated with mystery broods. The banded adults were not confirmed with any other nests initiated around the same time. A total of eight nests were added to total nests found based on finding newly hatched chicks on the beach front. For four of these nests, we found the nest bowl with pip fragments and recorded the coordinates. For the other mystery broods we used the nearest transect block for nest 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. There were 285 unbanded chicks and 107 confirmed unbanded fledges from tracked broods for a 37.5% fledge rate. In contrast, 172 chicks were banded and 98 were confirmed fledged for a 57.0% 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 457 chicks hatched and 205 (banded and unbanded) were confirmed fledged for a minimum base-wide fledge rate of 44.9%.

2013 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 2013, the first known nest was initiated on South Beaches on 20 March and the last nest was initiated on 12 July. This is within the normal range of 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 normal ranges, though we found fewer historic data summarized in past reports. We attribute these shortened periods to the low nest predation and fewer second nesting attempts in 2013. The chick hatching period for 2013 occurred between 21 April and 9 August. The earliest hatch on record was 10 April in 2009. The fledging period was from 18 May to 5 September. We could only find a fledging period for 2009 in past reports. In 2009, the first fledgling was observed on 7 May.

Figure 9 shows the results of weekly transect surveys on each beach sector. The number of active nests on North Beaches peaked in May with a drop in July. We did not see a mid-season drop in number of active nests as we did in 2012 when ravens depredated 50% of active nests in mid-June. However, there was an increase in opportunistic coyote depredation in July which may attribute to the decrease in active nests. Conversely, trends in weekly active nests on South Beaches showed two peaks in active nests in mid-April to mid-July. These peaks account for an increase in opportunistic coyote depredation that occurred in April and June. Brood detection on North Beaches peaked in late April and steadily decreased through August. However, 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 early June to mid-August. Fledglings were first detected on North beaches in early June with sightings steadily increasing through August. There was a sharp increase in detection in August through September 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-June and numbers fluctuated but were overall higher than North Beaches for the July to August period. There was a similar, but very brief, peak in early September and a decrease towards the end of that month. Number of active nests, broods and fledglings were low at Purisima Beaches and followed a pattern similar to South Beaches.

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 both North and South beaches were in flocks and the other half was forming pairs. The number of flocked birds decreased quickly on South Beaches and there as a sharp peak in paired birds in early April. On North Beaches, the number of flocked birds decreased steadily through April and there was a broad peak in number of paired birds between early and mid-April. The number of pairs detected on both North and South beaches showed a steady decline through July. Plovers began forming flocks again in July and 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.

2013 Predator Sightings and Nest Predation

Wildlife species identified as predators of adult snowy plovers, nests, and/or chicks during the 2013 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, raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*).

Of the 307 known fate nests, 61 (20%) were depredated in 2013 (Table 6). Coyotes were the most common predators, taking 17% of all known-fate nests. 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 3% of known-fate nests. Less than 1% of known-fate nests were taken by gulls and ravens in 2013.

On North Beaches, 21% of nest predations were due to coyote and 4% were due to unknown predators (Figure 11a). On South Beaches, the main predator confirmed for nest predation was coyote (15%) and one nest taken by raven (<1%). On North Beaches and South Beaches, sightings of coyotes showed a similar pattern with nest predation rates (Figure 11b). However, this was not the case for ravens. Raven sightings were frequent on both beaches, but ravens accounted for less than 1% of the nest predations. Additionally, coyote predation rates overlapped with areas of high nest densities on both North and South Beaches (see Figures 2-4), indicating that a few individuals may have been keying into areas with high nest densities. There were twelve transect blocks with medium-high coyote predation rates and seven of these overlapped with areas of medium-high nest densities. Overall, there was a 37% decrease in coyote predation in 2013 compared to 2012 (52 nests taken in 2013 and 83 taken in 2012); and raven predation decreased this year by almost 100% (23 in 2012 to 1 nest in 2013). The single raven nest predation was likely taken opportunistically by a raven attracted to a large whale carcass on the beach front at WAL.

Seven nests were documented as failed due to suspected adult mortality. Four of these were on North Beaches (three on SHN/SHS, one SAN) and three were on South Beaches (one on SNO and two on SSO). These nests differ from those deemed abandoned due to the late stage of incubation (>than two weeks) and the confirmed loss of an adult plover by peregrine falcon on North Beaches and persistent owl tracks observed on South Beaches. Nest losses to suspected adult mortality accounted for 40% of all failed nests.

Due to the increased peregrine falcon sightings (8% of all visits on North Beaches in 2013) and plover bands found in the peregrine falcon nest, we believe that all four nests on North Beaches were lost due to adult mortality by peregrine falcons. Bands from adult plovers (GG:BW and NR:OR) were found within the nest contents of the Lion's Head peregrine falcon pair. GG:BW female was confirmed on nest number 13SHN003. This nest became inactive 7 days prior to hatch. NR:OR was suspected to be on nest number 13SAN046 that became inactive in late May, 10 days prior to hatch. Both of these nests were believed to be abandoned, however, after the discovery of the color combinations within the peregrine falcon nest, the fate was changed to failed due to suspected adult mortality. The two other North Beach nests (nest numbers 13SHN009 and 13SHS006) were in close proximity to the above nests and showed the same evidence upon "abandonment" – the eggs were not buried and the nest bowl remained intact. We did not confirm any banded adults associated with these nests.

On South Beaches, owl sightings (evidence from tracks) were the highest among predators observed during surveys (11% of all visits to south beaches). We believe that adult mortality occurring on South Beaches was most likely caused by owl species. Nest number 13SNO056 failed 6 days prior to suspected adult loss. Owl tracks were found within a few feet of the nest and the eggs remained on the surface with some plover track evidence. Nest number 13SSO013 was visited in the afternoon of 5/19/13 and eggs were checked for hatching stage. All eggs were heavily cracked and tapping and the female was observed incubating. The next morning the nest was checked for hatch and the eggs were moist with dew and cold. Again, we recorded this nest as failed due to adult mortality. Nest number 13SSO039 became inactive a week prior to hatch while the nest bowl remained intact. We did not confirm any banded adults associated with these nests.

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 20 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.

Nest Camera Monitoring

We set cameras on 21 nests in 2013. Photo and video footage from the cameras allowed us to confirm the fates of all 21 nests (Table 7). Fifteen nests hatched, two were depredated by coyote, three nests were abandoned, and one nest was destroyed by tide. The two depredated nests were located fairly close to each other in an area heavily used by coyotes and were depredated two days apart. Of the three abandoned nests, one was likely abandoned prior to camera placement (photos showed no adults incubating the nest), one was a one-egg nest abandoned two days prior to the estimated hatch date, and one was abandoned three weeks post-term. The one-egg nest may have had a three egg clutch as this nest was hit by tide once prior to discovery and again two weeks prior to hatch. After the second tide hit, only the male was observed incubating the nest until abandonment. The two-egg nest had an unbanded female and a banded male associated with it. Both were observed on camera incubing a week past hatch and the eggs never hatched. Camera photos indicated that the female remained off nest for long periods of time post EHD, whereas the male remained longer incubating in the evenings and off and on in the daytime. The one nest that was completely destroyed by tide had narrowly missed destruction during the prior night’s high tide.

Trends in Annual Breeding Population

Figure 13 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 2013, the number of adults observed and number of nests initiated on VAFB remained near the long-term mean.

The mean number of nests initiated over the time series is similar between North and South Beaches (Figure 14). Annual values are highly correlated for the two beaches (Spearman's rho: $r = 0.822$, $p < 0.001$). 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 has been declining since 1994. The lowest number of nests initiated at Purisima Beaches in the time series occurred in 2011.

Figure 15 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: $r = 0.658$, $p = 0.005$). Annual values for open and closed area nesting numbers are not correlated for MIN and WAL beaches (Spearman's rho: $r = 0.228$, $p = 0.217$ and $r = 0.125$, $p = 0.336$, respectively). Furthermore, there were no nesting attempts within areas open to recreational use during nine years at MIN and six years at WAL from 2000 through 2013. There were no nests in either of these two sections in 2013.

Trends in Annual Reproductive Success

Both hatching and fledging success have high variability among years from 1997-2013 with no apparent trend (Figure 16). Patterns in both metrics were similar from 1997-2005, but overall, there is no correlation between annual values (Spearman's rho: $r = 0.220$, $p = 0.198$). 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 (45.5%) while fledging success remained average (2010 = 29%, long-term mean = 33.5%). 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 average.

Figure 17 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: $r = 0.469$, $p = 0.018$). In 2013, hatching success (66%) was higher than the long-term mean (48%) on North Beaches and South Beaches (2013 = 54%, long-term mean = 44%). Despite decreasing nesting effort over the time series, Purisima Beaches maintain a higher hatching success (100%) compared to North and South Beaches. Additionally, hatching success has been less variable at Purisima Beaches.

Figure 18 shows annual fledging success on North, Purisima, and South Beaches. In 2013, fledging success on North Beaches (66%) was higher than on South Beaches (51%). This has been the case for the past three years (2011-2013). 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 = 45%). The long-term means for North and South beaches are similar (37% and 32% respectively), and the low p-value from the correlation analysis suggests that annual values between the two beaches are potentially correlated (Spearman's rho: $r = 0.416$, $p = 0.054$).

Figure 19 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 (MIN: open = 16% closed = 51% WAL: open = 41.6%, closed = 52%; SNO: open = 46%, closed = 50%). MIN and WAL are highly variable with many years of no nesting in the open area. However, hatching success appears to be increasing within the area closed to recreational access at MIN. 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 not significantly correlated (Spearman's rho: $r = 0.412$, $p = 0.072$).

Figure 20 shows annual fledging success based on banded birds for open and closed areas using all data available from 2000 - 2013. 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 35%. 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 three years of banding data (open = 11%, closed = 32%). At SNO, mean fledging success is similar between open and closed areas (open = 33%, closed = 32%), but interannual patterns were not significantly correlated (Spearman's rho: $r = -0.418$, $p = 0.100$). In recent years (2012 and 2013), fledging success has been higher in the open area than the closed area. 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.

Annual Wrack Abundance

Mean ± SE wrack values for each beach sector are shown in Figure 21. 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 between 2012 and 2013. Wrack abundance was significantly higher for all beach sectors but WAL in 2013 (ANOVA: $F = 13.78$, $df = 1,336$, $p < 0.001$). We also found significant differences among beach sectors (ANOVA: $F = 17.901$, $df = 6, 336$, $p < 0.001$). Table 8 shows the results of post hoc comparisons among beach sectors. WAL and SNO had significantly higher wrack values than all other beach sectors. Additionally, SSO had significantly higher wrack values than SHS. There were no significant differences among the remaining beach sectors. There was no significant interaction between year and beach sector in our analysis, indicating that differences among beach sectors were similar in both years (ANOVA: $F = 0.736$, $df = 6, 336$, $p = 0.621$).

Recreational Beach Management

Over 55 beach violations for unauthorized human intrusion into closed beach areas were recorded from 1 March through 30 September. Most of the violations occurred at SNO (50, 90%), the only beach that is open to the general public. On 10 April, the open area at SNO was temporarily closed until 1 May after reaching more than 25 violations. Surf Beach reached 50 violations by the end of May and was closed permanently on 1 June. Three violations were reported at WAL (5%) and two violations were reported at MIN (4%). The total number of beach violations in 2013 represents an 8% increase from 2012 (60, Table 9). However, VAFB discontinued counting violations at SNO after the 50 beach limit was met and the beaches were closed. Nest failure in the open area of SNO was attributed to nest destruction by high tide events and human trespassers. On 30 June (after the permanent closure of the open area), eggs from two nests were taken by trespasser. It is unknown if the adult pairs from those nests re-nested.

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 24 June and 1 August, 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. Three nests were initiated on the sandspit in July. All three nests hatched at least two chicks each, and two broods were banded. One two-chick brood was banded in the early afternoon on 29 July. The following morning the chicks were observed still in the nest bowl and no adults were observed tending. The chicks were never seen away from the nest bowl and never confirmed as fledged. The second brood was banded on 30 July and only one of three chicks fledged. Several unbanded broods went missing from this location throughout the season and were never seen elsewhere. We suspect that the high trespass activity in this area disturbed broods such that they were either separated from the adults or pushed into the gull flock, resulting in death from hypothermia or predation.

Several anecdotal late-July trespass incidents at WAL were reported by a docent and a beachgoer. These trespass events possibly contributed to the loss of a brood at the north end of the closed section of WAL. A banded male and an unbanded chick were consistently seen approximately 100 meters south of the WAL border fence. The chick was last seen 19 July at two weeks old. The banded male was seen outside of his typical territory without a chick on 24 July. Other Wall broods moved around during this time, but it is difficult to say if the movement was due to the trespass events, or was a by-product of the changing beach topography and the frequency with which we monitored.

Discussion

2013 Breeding Season Summary

The 2013 breeding season was the shortest and most productive season on record since 1994. Egg laying, chick rearing and fledging periods were up to one week shorter than prior seasons. This may be a result of lower nest predation rates reducing the need for several re-nesting attempts by mating pairs as seen in 2012. Fledging rate was the highest on record in all the years that monitoring has occurred on VAFB. Increased effort in detecting banded broods and monitoring unbanded broods likely contributed to these higher rates. However, reduced predation and increased wrack abundance in 2013 were likely the ultimate cause of higher fledge rates. Annual nest initiation, hatching success, and fledging success for North and South Beaches continue to be positively correlated, indicating that large scale mechanisms such as regional kelp abundance (an important factor determining wrack abudance) are influencing these metrics. However, there are multiple years in the time series where hatching success differs between North and South beaches, illustrating how localized mechanisms such as nest predation can be important regulators. To better understand the role of these localized mechanisms, we initiated two new analyses in 2013. First, we attempted to document the impact of adult mortality on hatching success and, second, we attempted to improve population estimates on challenging beach sectors by tracking ‘mystery broods’ (see below). By increasing our understanding of how localized and regional forces are regulating breeding parameters, we hope to improve VAFB’s ability to manage its coastal resources at the appropriate spatial scales.

Suspected Adult Mortality

This season we added 'suspected adult mortality' to our categories of nest fates. Documenting predation at the nest site is relatively easy as nest contents will be removed or at least disturbed. But documenting predation away from the nest site can be difficult, if not impossible. In past seasons, nests that appeared to be in-active prior to the hatch date were categorized as failed due to adult abandonment. This season's documented evidence of adult losses to peregrine falcons caused us to look more closely at these "abandoned" nests. Furthermore, since nest predation has been the focus of reproductive losses during past seasons, it is unclear how many past "abandoned" nests in the past were actually due to the loss of adults. It is possible that the shift in nest distribution on North Beaches is a result of the peregrine falcon presence, but there was no such shift on South Beaches where we suspect owls caused adult mortality in 2013. It is possible that adult loss on South Beaches is a more recent phenomenon or that adult losses happen sporadically and have not caused a population-level response. It will be important to continue documenting suspected adult mortality to better understand the possible population-level impacts.

Use of Mystery Broods

This season, broods were relatively easy to find on SAN in comparison to nests, primarily due to topography. SAN is a wide beach backed with rolling dunes where birds nested anywhere from the high tide line to the tops of massive sandsheets, usually in cryptic locations. Additionally, in June and July we avoided walking along certain areas of the shoreline for a few weeks at a time due to existing brood activity, especially when very young broods were present. Based on the presence of mystery broods, we know that several nests in these areas were missed. However, there was sufficient foredune cover that allowed us to covertly and efficiently monitor broods. On SHS, we found one two-week old brood with a banded male. This nest was missed due to our survey schedule at that point in the season. We were only conducting weekly transect surveys and minimal nest searching due to the lack of nesting on that stretch of beach. On SNO we found one brood with an unbanded male close to fledge. It was located in an area that was difficult to survey for broods due to the wave slope, and the nesting area in foredunes was surveyed infrequently. In total, eight mystery broods were located and assigned nests numbers that increased our nest initiation and hatch total.

Annual Snowy Plover Nesting Effort

The number of snowy plover adults and nests documented in 2013 were similar to their 20-year means. Both metrics have remained relatively stable over the past five years. The strong correlation among trends on North and South Beaches indicate larger scale mechanisms regulating nesting effort. 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.

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 20-year time series and we found significantly higher wrack abundance at WAL and SNO in both 2012 and 2013. 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 we will need to consider when assessing spatial differences in nesting effort. In addition to differences in wrack cover, Dugan et al. (2008) found that South Beaches had wider dry beach segments on average compared to North Beaches. Also, 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 our 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 on the decline since 1994, with the lowest number of nests recorded this season. In fact, 2011 through 2013 were the first seasons in the time series for which there were no nesting attempts within PCO. However, hatching success has been consistently higher than all other beach sectors over the 20-year period. Some of this success may be attributed to the predator management conducted at the least tern colony. While predator management is increased at the colony, 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. The overall decline in nest initiations may be attributed to the dramatic increase in vegetation cover such as invasive European beach grass (*Ammophila arenaria*) 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. Dugan et al. (2008) also noted that European beach grass cover was more than three times greater on North Beaches than South Beaches. It is likely that European beach grass will increasingly threaten plover nesting habitat on Purisima and North Beaches if it is not controlled. Currently, VAFB is engaged in a program to control European beach grass on North Beaches.

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 of obtained from banding data by the number of chicks confirmed to have hatched in. Reproductive success was 1.8 in 2013. This is above the USFWS recovery goal of 1.0 fledglings per male, which allowed for population growth (USFWS 2007). Furthermore, reproductive success was above the USFWS recovery goal at both recovery sites -- 1.4 for CA-84 and 1.3 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 in 2011 and 2012 was 1.3 and 0.8 fledglings per adult male, respectively. Mean ± SE reproductive success for 2011-2013 was 1.3 ± 0.3. Thus, in recent years, mean base-wide reproductive success has been above the USFWS recovery goal.

Reproductive performance in prior reports has been summarized using clutch hatch success and fledgling success. Clutch hatch success in 2013 was close to the long-term mean while fledging success was the highest on record since 1999. Like nesting effort, clutch hatch and fledging success were correlated among North and South Beaches, indicating that regional forces like ocean and kelp productivity may be driving reproductive success. In fact, wrack abundance, clutch hatch success, and fledging success were all higher in 2013 than 2012. The exceptions in the time series were 1999, 2003, 2006, and 2011 when hatching success differed among North and South Beaches. In these years, localized predation was likely causing the differences observed between the beach sections. In 2013, 21% of all nests initiated were lost to predators. Coyotes were the main nest predators, accounting for 82% of all nest predation. Coyote predation occurred on all beach sectors and appeared to be opportunistic. However, areas of high coyote predation overlapped with areas of high nest densities. Thus, coyote predation was for the most part a localized issue, likely attributable to one or a few coyotes in the beach sectors where it occurred.

Raven predation was low in 2013, despite a moderate raven presence on North and South Beaches. This is in contrast to recent 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 we expect their population to continue increasing 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. Ravens continue to be a nest predator on VAFB in previous years but in 2013, <1% of all known fate nest loss was to raven predation. Similar to coyote predation, raven predation appeared opportunistic. The single documented event occurred near a whale carcass on South Beaches. The raven was most likely attracted to the whale carcass and then discovered the plover nest. In prior years, ravens frequently visited the beaches between May and June until they were removed by the predator management team. It is likely that the increased predator management effort and preemptive raven removal contributed to the reduced raven presence on beaches this year.

While coyotes had an impact on clutch hatch success in 2013, it is important to note that fledging success was well above the 20-year mean. Furthermore, annual hatching success at VAFB is not correlated with annual fledging success. Thus, there appear to be different mechanisms operating on hatching and fledging success at VAFB. Similarly, 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 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.

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.

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 were successful in 2012 as raven predation was limited to only one week in June and accounted for <7% of known-fate nests. This success continued in 2013 with <1% of known-fate nests depredated. 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 has likely impacted the adult population of snowy plovers by increased adult mortality as confirmed this year and in 2012 from the analysis of nest contents. VAFB should begin 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) Invasive weeds persist on all beach sectors and have become more prevalent in areas of WAL, MIN, SHN, SHS sectors. Although a large scale restoration effort is underway on SAN and SNO, an intensive effort to collect baseline information on other beach sectors is necessary to determine the extent of invasive infestation and rate of spread. In addition, management should consider controlling the conversion of sand dune habitat to coastal scrub in the Purisima area.
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. As Dugan et al. (2008) showed, beach morphology can change both annually and seasonally, it is important to conduct periodic surveys to understand the dynamics of beach morphology at VAFB. Understanding the dynamics of beach morphology 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 2012 and 2013. Also shown is the percent change for each metric in 2013 when compared to 2012.

		2013	2012	% Change in 2013
Population	Maximum Adults Observed	279	248	12%
	Number of Nests Initiated	307	341	-10%
Nests	Hatched	174	145	20%
	Abandoned Before Hatch	22	23	-4%
	Incubated Past Hatch Date	0	1	-100%
	Depredated	63	124	-50%
	Destroyed by Wind	6	11	-45%
	Destroyed by Tide	25	25	0%
	Destroyed by Human(s)	2	0	
	Failed Unknown	3	6	-50%
	Suspected Adult Mortality	7	0	
	Unknown Fate	5	7	-29%
Eggs & Chicks	Total Known Fate Eggs	812	875	-7%
	Total Chicks Hatched	456	382	19%
	Hatching Success	56%	44%	27.27%
	Clutch Success	58%	46%	26%
	Known Fate Clutches	302	334	-9.58%
Fledglings	Total Banded Chicks	172	161	6.83%
	Banding Rate	38%	42.2%	-9.95%
	Total Banded Fledglings Observed	98	82	20%
	Fledging Success	57%	50.93%	11.91%
	Estimated # of Fledglings	259	194	34%
	Fledges per male	1.8	0.8	125%

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), 2013. 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	0	14	91	9	0	114	38	86	41	165
	Number of Nests Initiated	2	20	99	8	0	121	47	88	43	178
Nests	Hatched	2	12	56	8	0	78	22	50	24	96
	Abandoned Before Hatch	0	0	5	0	0	5	4	8	5	17
	Incubated Past Hatch Date	0	0	0	0	0	0	0	0	0	0
	Depredated	0	2	27	0	0	29	15	15	4	34
	Destroyed by Wind	0	0	5	0	0	5	1	0	0	1
	Destroyed by Tide	0	2	3	0	0	5	4	8	8	20
	Destroyed by Human(s)	0	0	0	0	0	0	0	2	0	2
	Failed Unknown	0	0	0	0	0	0	0	3	0	3
	Suspected Adult Mortality	0	3	1	0	0	4	0	1	2	3
	Unknown Fate	0	1	2	0	0	3	1	1	0	2
Eggs & Chicks	Total Known Fate Eggs	6	53	258	24	-	341	126	237	108	471
	Total Chicks Hatched	6	29	145	22	-	102	56	137	61	254
	Hatching Success	100%	55%	56%	92%	-	60%	44%	58%	56%	54%
	Clutch Success	100%	63%	59%	100%	-	63%	48%	72%	38%	54%
	Known Fate Clutches	2	19	97	8	-	128	46	69	63	178
Fledglings	Total Banded Chicks	0	6	62	9	-	77	15	52	28	95
	Banding Rate	0	21%	43%	41%	-	75%	27%	38%	46%	37%
	Total Banded Fledglings Observed	0	4	41	5	-	50	9	25	14	48
	Fledging Success	0	67%	66%	56%	-	65%	60%	48%	50%	51%
	Estimated # of Fledglings	0	19	96	12	-	66	34	66	31	130
	Fledge per male	-	-	-	-	-	1.4	-	-	-	1.3

*Fledgling Success could not be calculated for MIN due to a lack of banded chicks for this beach sector.

<u>Table 3</u>. 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 2013. 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 2013	Number of Confirmed Nesters in 2013	Number of Probable Nesters in 2013
1995	63			
1996	149			
1997	139			
1998 or 1999	114			
2000	52			
2001	58			
2002	61			
2003	56			
2004	249	2	1	
2005	68	2	1	
2006	110	1		1
2007	27			
2008	149	6	3	2
2009	182	5	3	
2010	21	1	1	
2011	148	27	14	
2012	161	34	13	8
Unknown Year	N/A	5	1	

<u>Table 4</u>. Fates of nests initiated within areas open to recreational activity on Minuteman (MIN), Wall (WAL), and Surf, North (SNO) beach sectors in 2013.

Nest Fate	MIN	WAL	SNO
Hatched	0	0	10
Abandoned	0	0	2
Depredated	0	0	0
Non-viable	0	0	0
Destroyed by Human	0	0	2
Tide/Wind	0	0	3
Failed Unknown	0	0	1

Table 5. Historic egg laying, chick hatching, and fledging periods for snowy plovers at VAFB. Data for egg laying periods were available for 1995-2013. Data for chick hatching periods were available for 2002-2013 (with the exception of 2010). Data for fledging periods was available for 2009 and 2013.

	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

Table 6. Number and percent of known fate snowy plover nests taken by predators at VAFB in 2013.

	Number of Nests	Percent of Known Fate Nests
Coyote	52	17%
Confirmed Raven	1	<1%
Unidentified Gull	1	<1%
Unidentified Predator	9	3%
Total	63	20%

Table 7. Fates of 21 nests monitored with cameras on VAFB in 2013, 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
13SAN090	SAN	7/24 - 8/13	8/5/2013	Abandoned	never observed adult incubating
13SAN093	SAN	8/3 - 9/11	9/2/2013	Abandoned	camera confirmed when abandoned by male
13WAL047	WAL	8/1 - 8/22	8/10/2013	Abandoned	camera confirmed abandoned
13SAN079	SAN	7/19 - 7/23	7/21/2013	Coyote	confirmed coyote depredation
13SAN086	SAN	7/12 - 7/19	7/19/2013	Coyote	confirmed unbanded female and coyote depredation
13MIN001	MIN	4/10 - 5/13	5/10/2013	Hatched	camera confirmed hatch and hatch date
13PNO005	PNO	6/10 -6/14	6/13/2013	Hatched	camera confirmed hatch and hatch date
13PNO008	PNO	7/1 -7/8	7/7/2013	Hatched	camera confirmed hatch and hatch date
13SAN024	SAN	5/8 - 5/15	5/14/2013	Hatched	camera confirmed hatch and hatch date
13SAN044	SAN	5/15 - 6/10	6/8/2013	Hatched	camera confirmed hatch and hatch date
13SAN057	SAN	6/14 - 7/1	6/26/2013	Hatched	camera confirmed hatch and hatch date
13SAN058	SAN	5/31 - 6/14	6/13/2013	Hatched	camera confirmed hatch and hatch date
13SHN006	SHN	6/6 - 7/1	7/1/2013	Hatched	camera confirmed hatch and hatch date
13SHN010	SHN	7/9 - 8/1	7/29/2013	Hatched	camera confirmed hatch and hatch date
13SNO032	SNO	5/14 -5/27	5/24/2013	Hatched	camera confirmed hatch and hatch date
13SNO034	SNO	5/16 - 5/29	5/26/2013	Hatched	camera confirmed hatch and hatch date
13SSO007	SSO	4/12-5/8	5/3/2013	Hatched	camera confirmed hatch and hatch date
13SSO042	SSO	7/8 - 7/31	7/28/2013	Hatched	camera confirmed hatch and hatch date
13WAL002	WAL	4/12 - 5/7	5/7/2013	Hatched	camera confirmed hatch and hatch date
13WAL030	WAL	6/14 - 6/28	6/27/2013	Hatched	camera confirmed hatch and hatch date
13SSO001	SSO	4/5 - 4/12	4/11/2013	Tide	camera confirmed tide

Table 8. Results of Tukey's 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 = 0.044 p = 1.00					
SHS	MD = 0.345 p = 0.081	MD = 0.301 p = 0.204				
SAN	MD = 0.174 p = 0.816	MD = 0.130 p = 0.952	MD = -0.172 p = 0.834			
WAL	***MD = -0.671 p <0.001***	***MD = -0.715 p <0.001***	***MD = -1.016 p <0.001***	***MD = -0.844 p <0.001***		
SNO	***MD = -0.554 p <0.001***	***MD = -0.598 p <0.001***	***MD = -0.899 p <0.001***	***MD = -0.727 p <0.001***	MD = 0.117 p = 0.968	
SSO	MD = -0.050 p = 1.00	MD = -0.094 p = 0.990	***MD = -0.395 p = 0.029***	MD = -0.224 p = 0.584	***MD = 0.620 p <0.001***	***MD = 0.503 p = 0.002***

Table 9. Number of beach violations per beach sector on VAFB, 2001-2013.

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

* Closed because violation limit was reached.

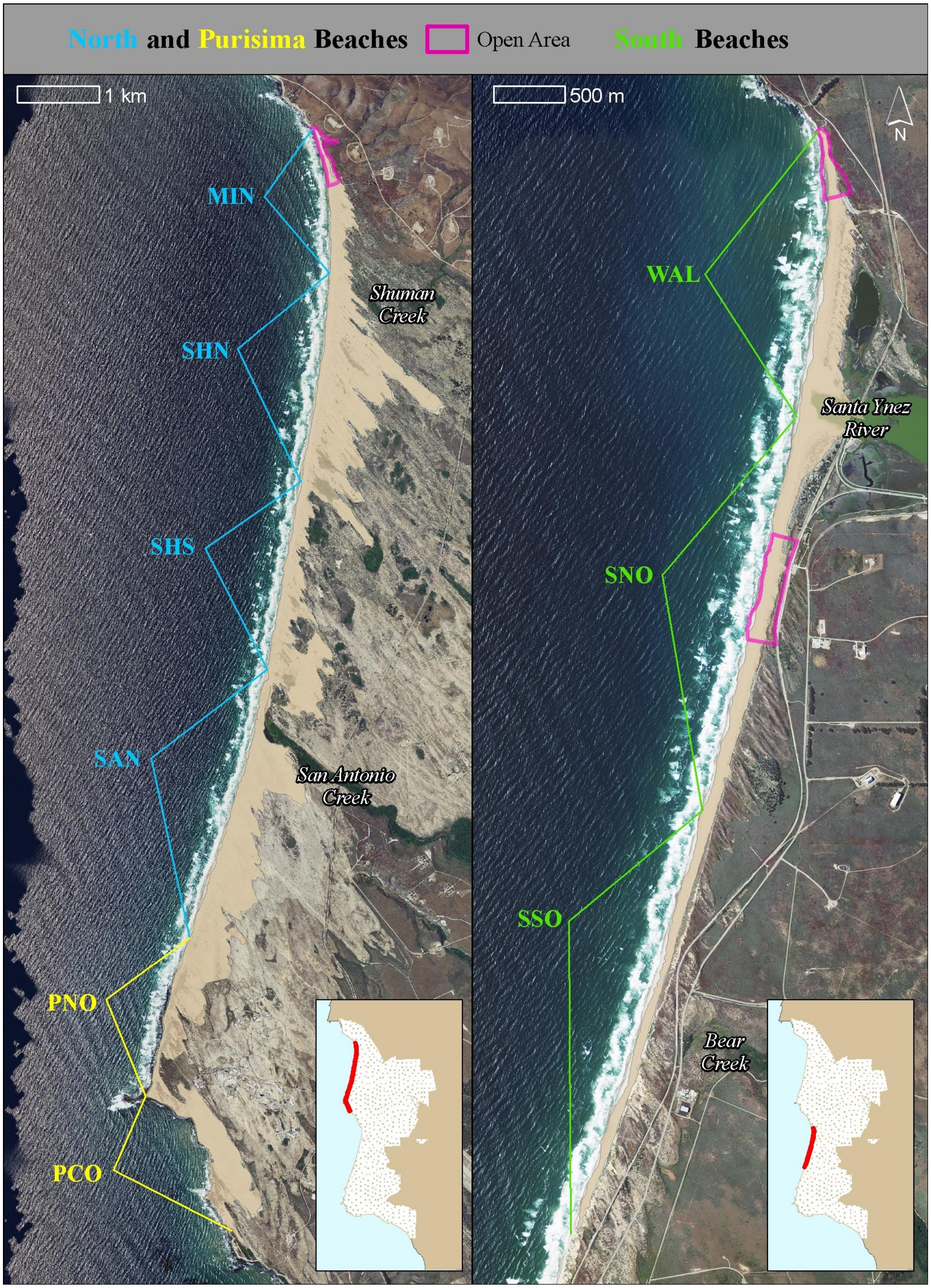


Figure 1. Map of beach sectors for North, Purisima, and South Beaches on VAFB. Areas open to public and/or military personnel are outlined in purple. MIN = Minuteman, SHN = Shuman North, SHS = Shuman South, SAN = San Antonio, PNO = Purisima North, PCO = Purisima Colony, WAL = Wall Beach, SNO = Surf North,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

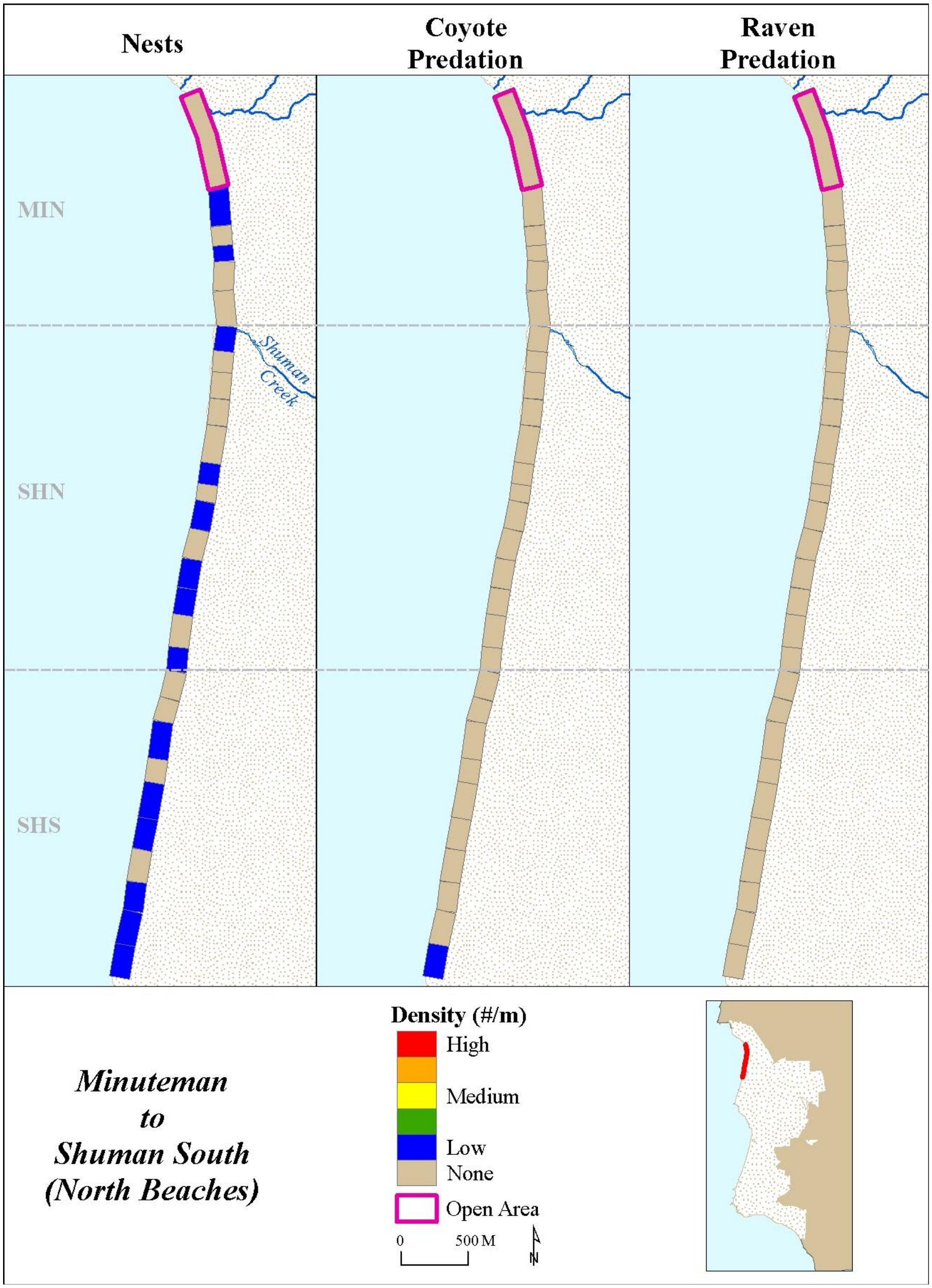


Figure 2. Snowy plover nest densities within North Beach transect blocks from Minuteman to Shuman South (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple. Categories for nest density (nests/m) from high to low are: 0.071 - 0.089, 0.054 - 0.071, 0.036 - 0.054, 0.019 - 0.036, and 0.001 - 0.019. Categories for predator density (coyotes/m or ravens/m) are: 0.021 - 0.025, 0.017 - 0.021, 0.012 - 0.017, 0.008 - 0.012, and 0.004 - 0.008.

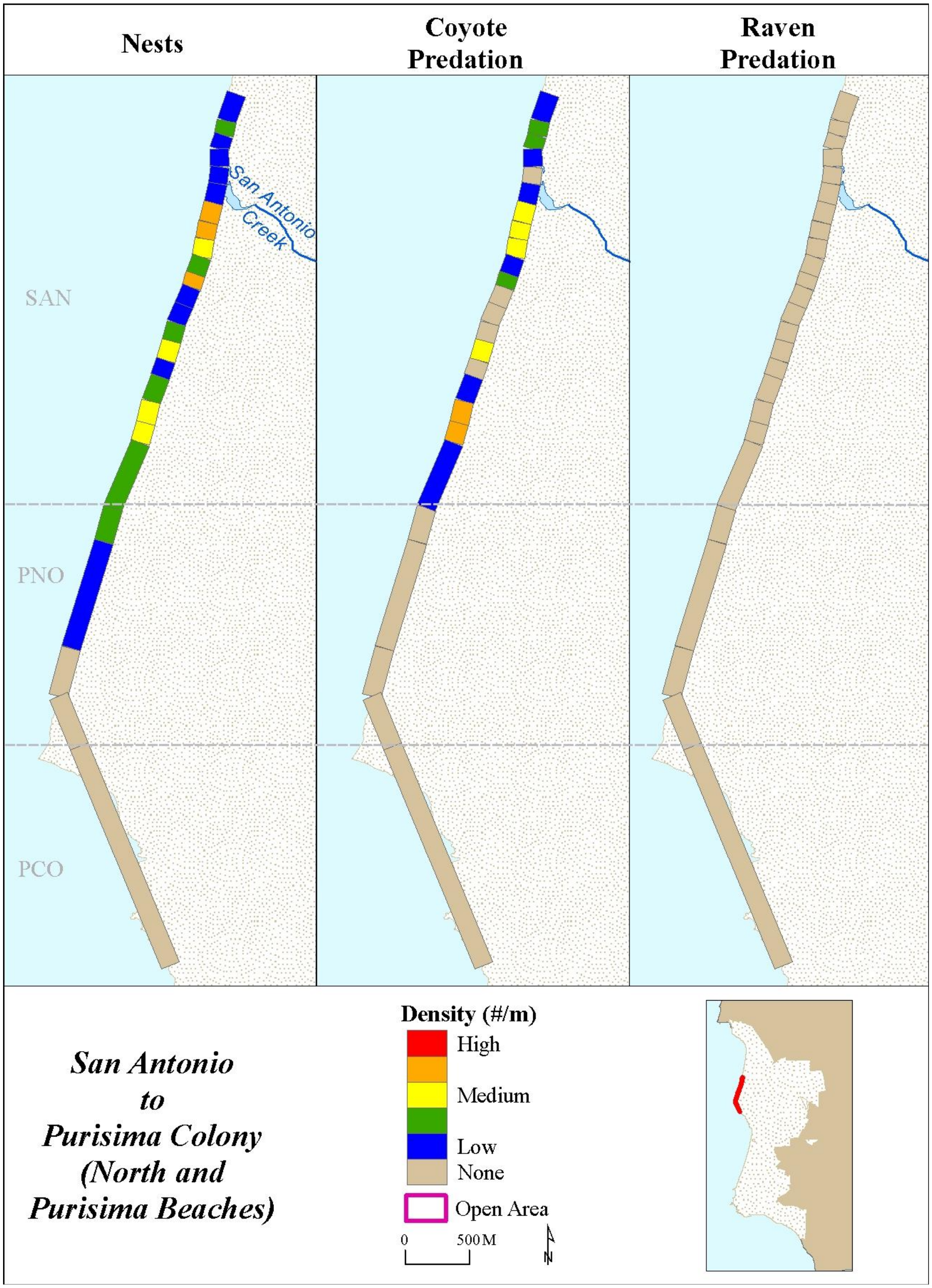


Figure 3. Snowy plover nest densities within North and Purisima Beach transect blocks from San Antonio to Purisima North (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple. Categories for nest density (nests/m) from high to low are: 0.071 - 0.089, 0.054 - 0.071, 0.036 - 0.054, 0.019 - 0.036, and 0.001 - 0.019. Categories for predator density (coyotes/m or ravens/m) are: 0.021 - 0.025, 0.017 - 0.021, 0.012 - 0.017, 0.008 - 0.012, and 0.004 - 0.008.

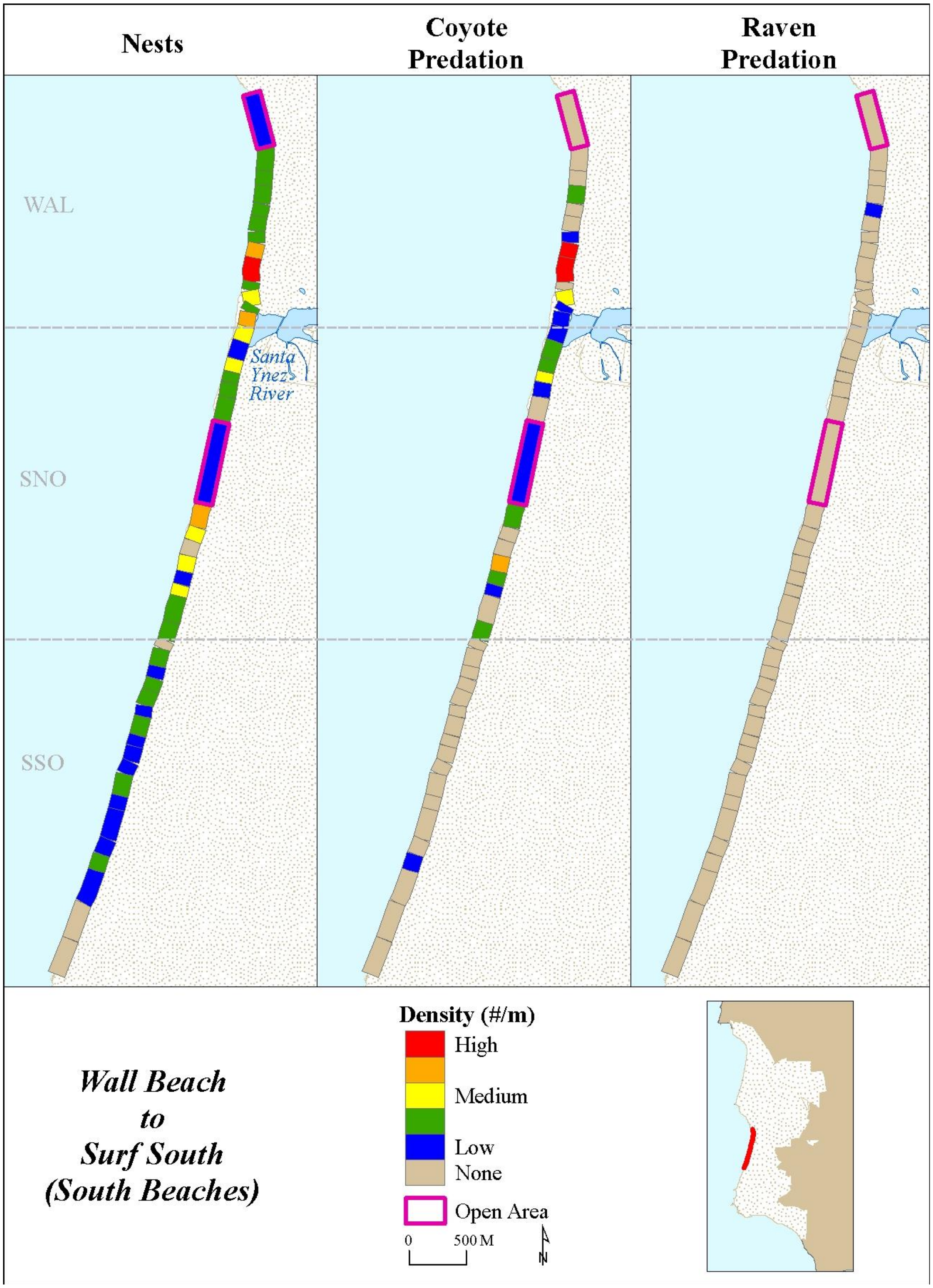


Figure 4. Snowy plover nest densities within South Beach transect blocks (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple. Categories for nest density (nests/m) from high to low are: 0.071 - 0.089, 0.054 - 0.071, 0.036 - 0.054, 0.019 - 0.036, and 0.001 - 0.019. Categories for predator density (coyotes/m or ravens/m) are: 0.021 - 0.025, 0.017 - 0.021, 0.012 - 0.017, 0.008 - 0.012, and 0.004 - 0.008.

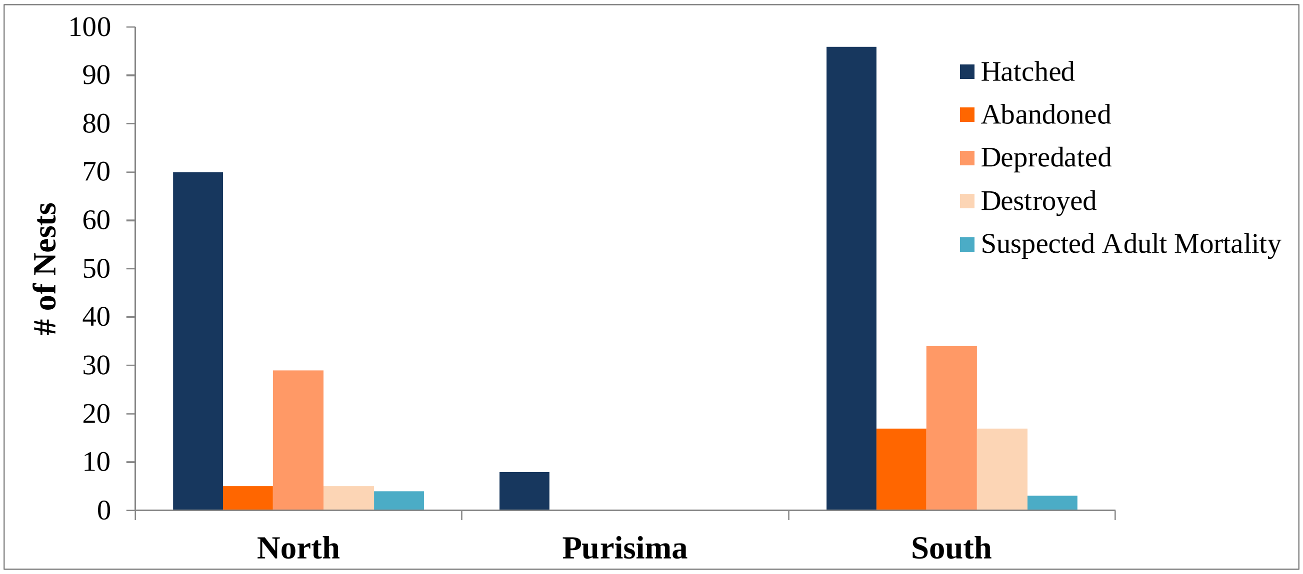


Figure 5. Nest fates on North, Purisima, and South Beaches in 2013. Destroyed nests include those destroyed by both humans and natural causes (e.g., tides and wind).

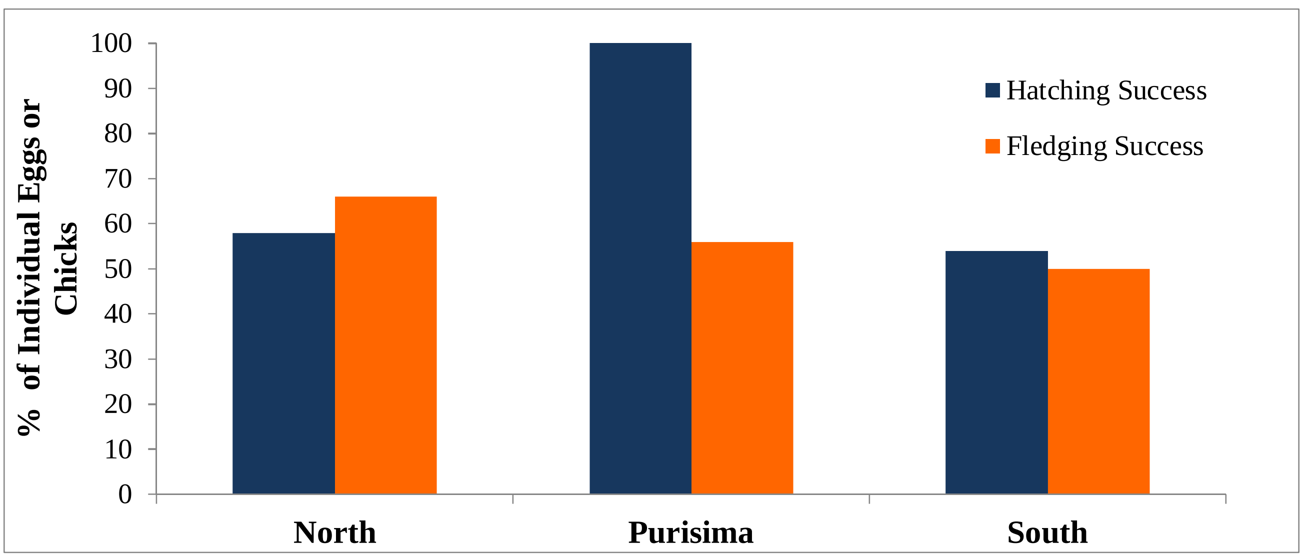


Figure 6. Clutch hatch and fledging success on North, Purisima, and South Beaches in 2013.

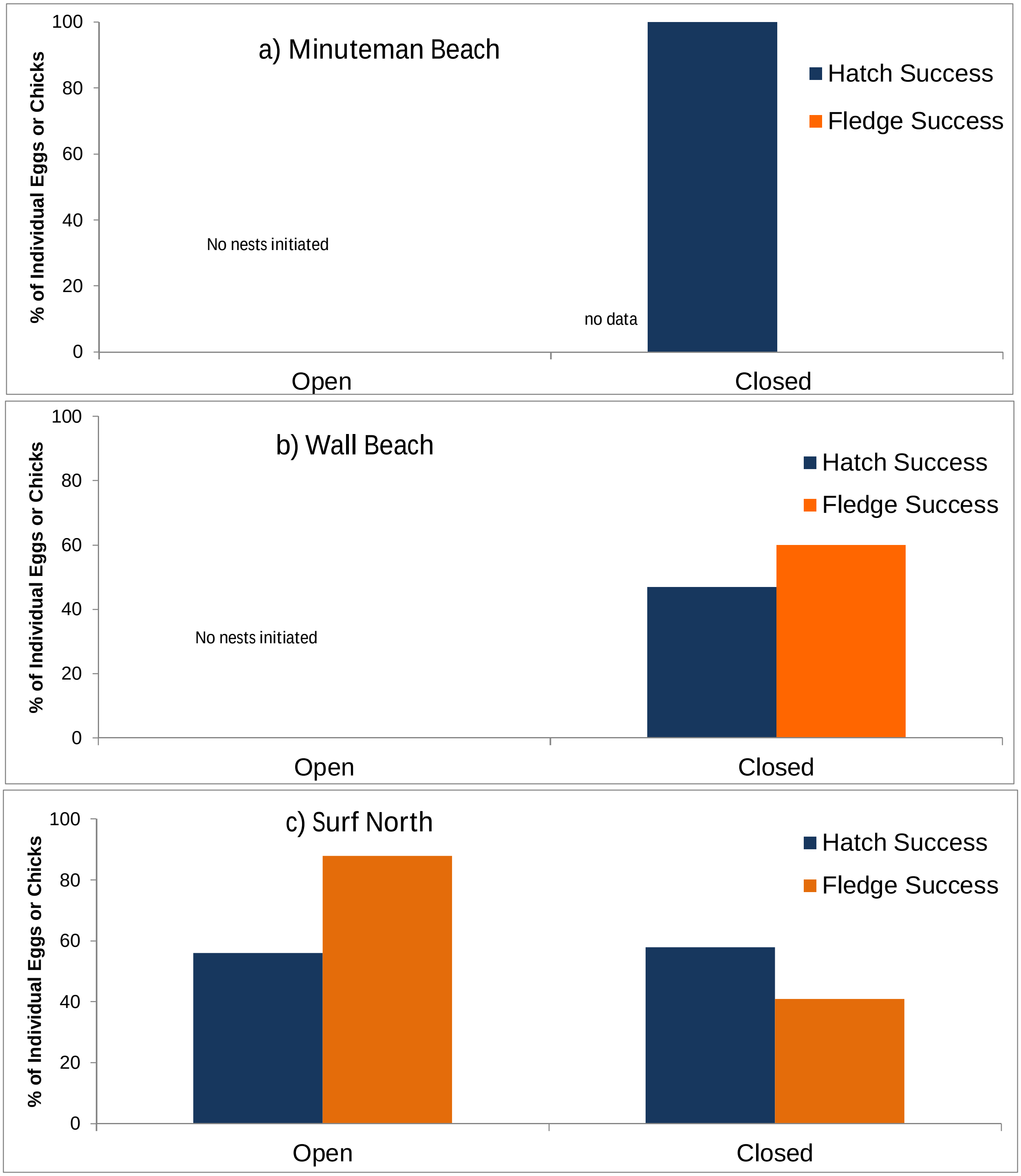


Figure 7. Clutch hatch and fledging success in open and closed areas of Minuteman, Wall, and Surf Beaches.

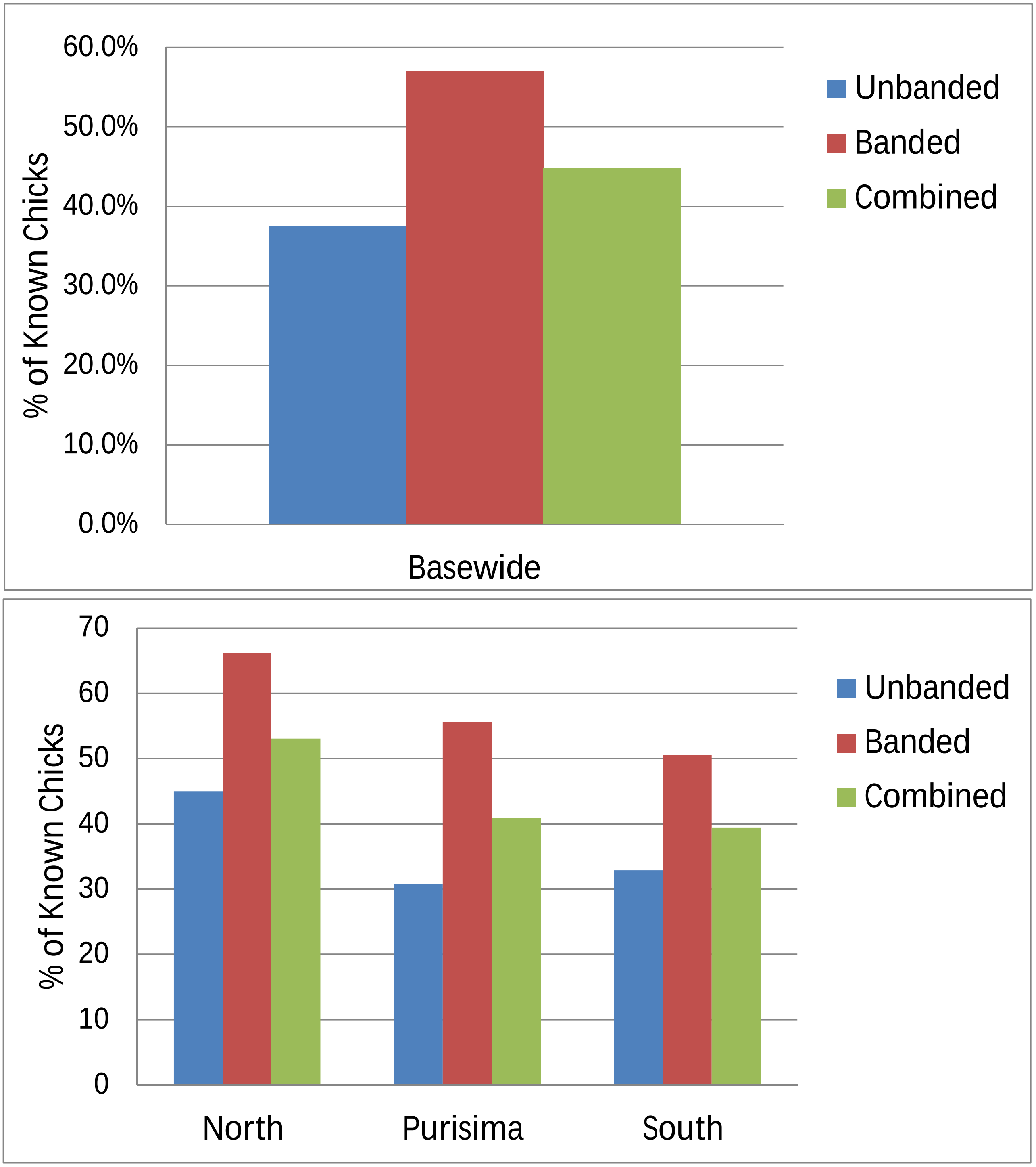


Figure 8. Fledging rates calculated a) basewide and b) for North, Purisima, and South Beach sections in 2013 using banded fledgling counts, unbanded fledgling counts, and banded and unbanded fledglings combined.

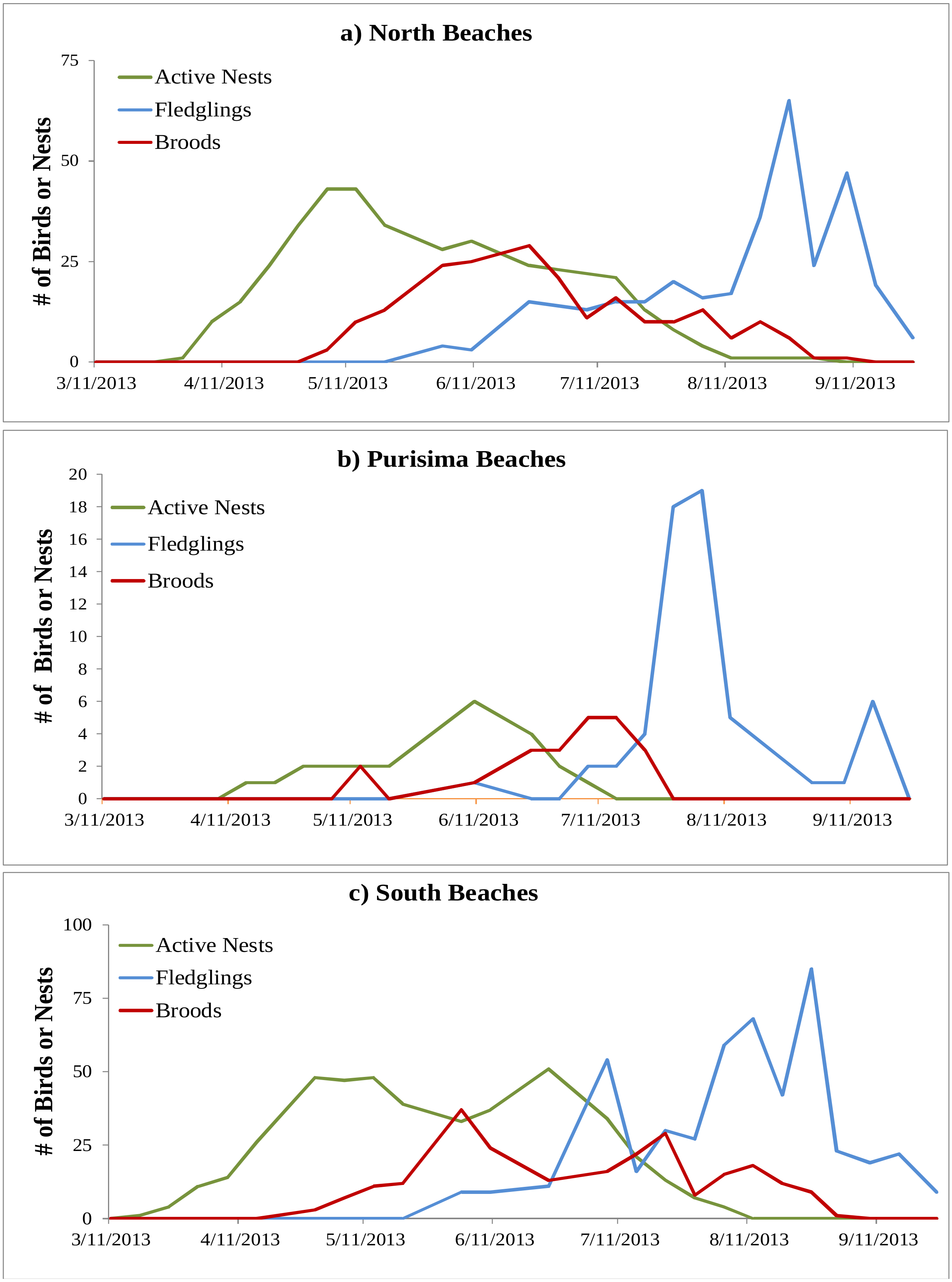


Figure 9. Breeding phenology at North, Purisima, and South Beaches in 2013.

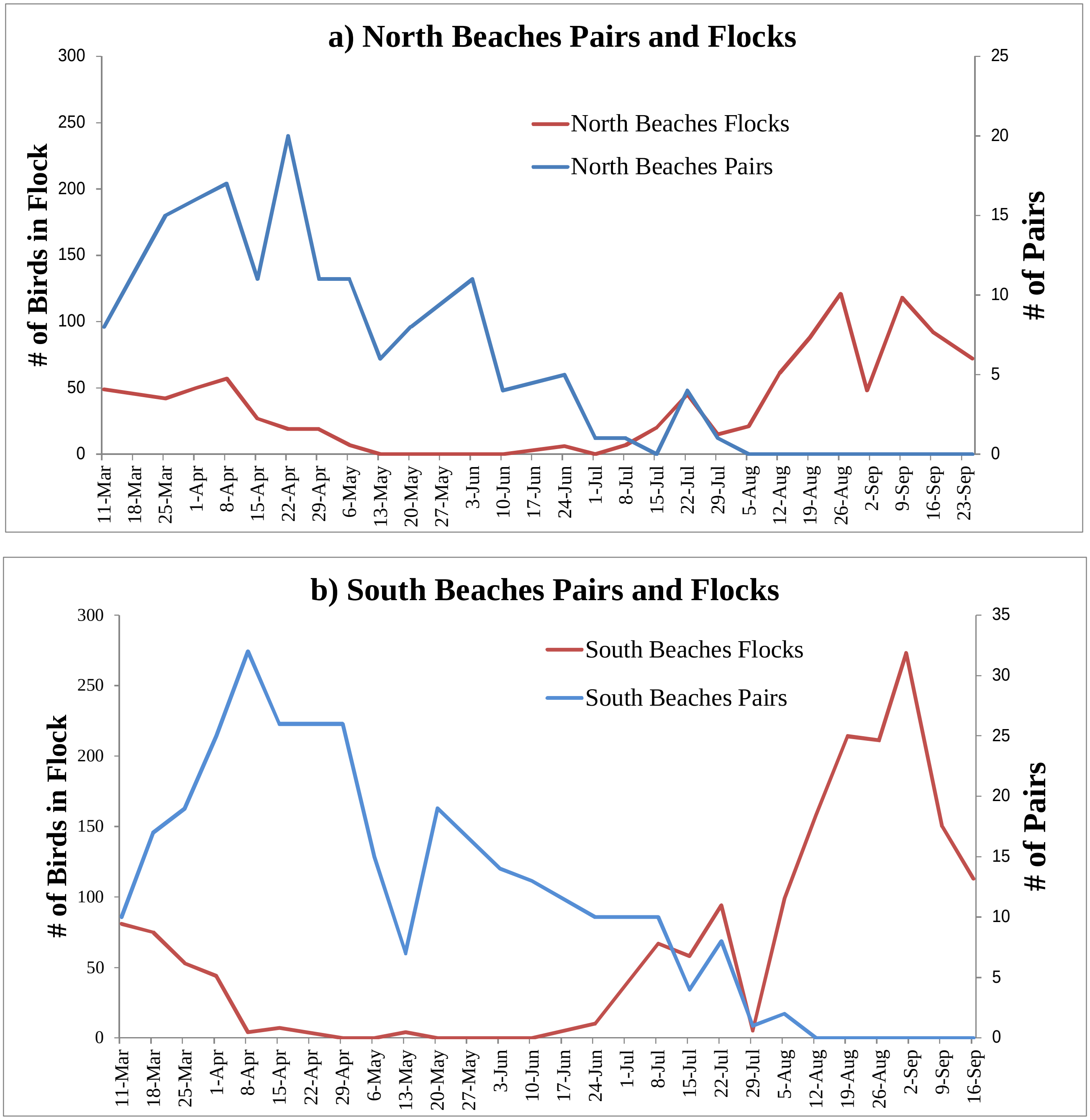


Figure 10. Numbers of plover adult pairs detected during weekly transect surveys versus number of plovers in flocking groups on North and South Beaches.

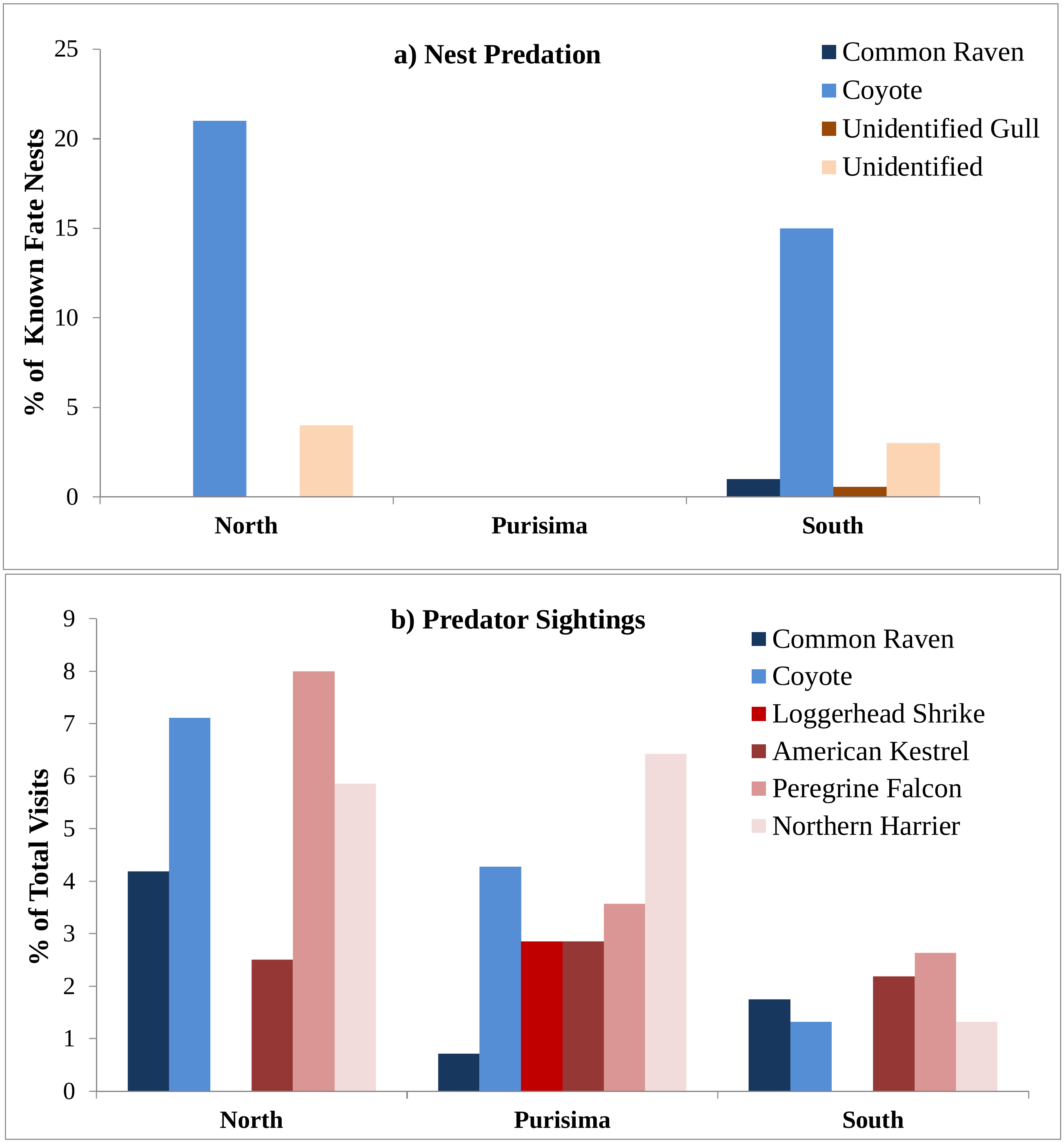


Figure 11. a) Distribution of known fate nests taken by predators and b) predator sightings on North, Purisima, and South Beaches in 2013.

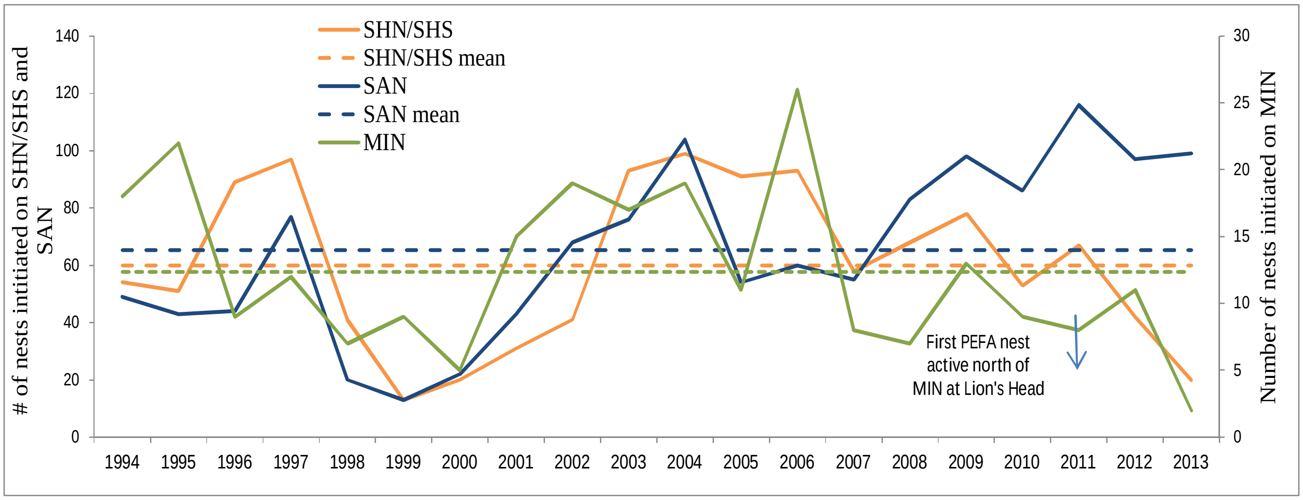


Figure 12. Number of nests initiated on MIN, SHN/SHS, and SAN from 1994-2013. Arrow indicates the establishment of a peregrine falcon eerie at Lion's Head. Dashed lines show the 20-year mean for each beach sector.

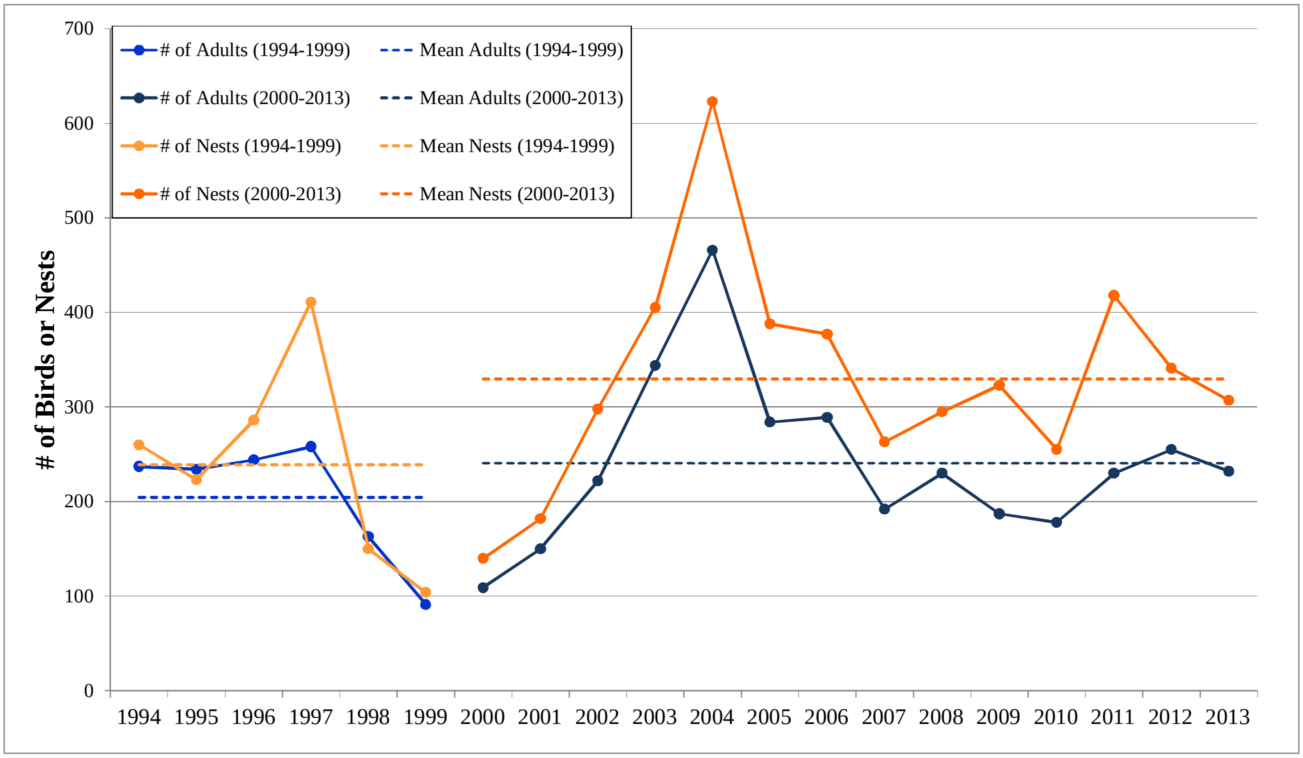
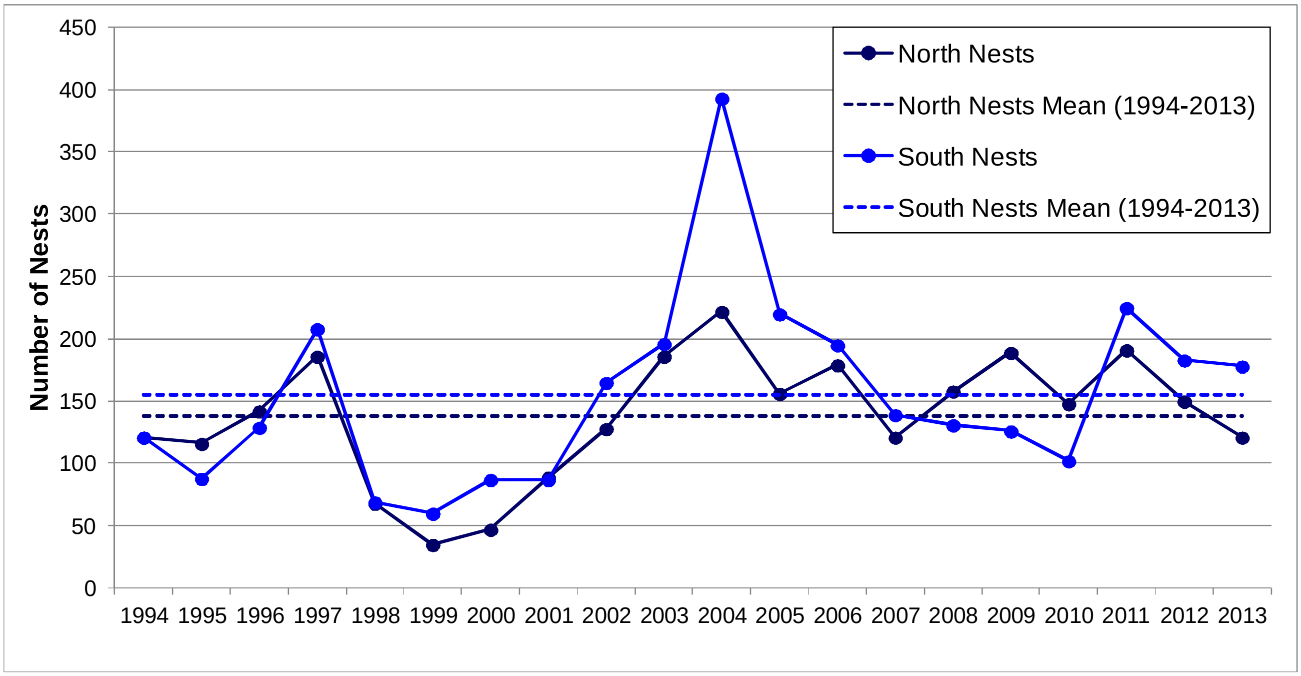


Figure 13. Trends in annual breeding population assessed using maximum number of adults observed during window surveys and number of nests initiated from 1994-2013. Dashed lines show the long-term means calculated for the periods during linear restriction (1994-1999) and after beach closures took effect (2000-2013).



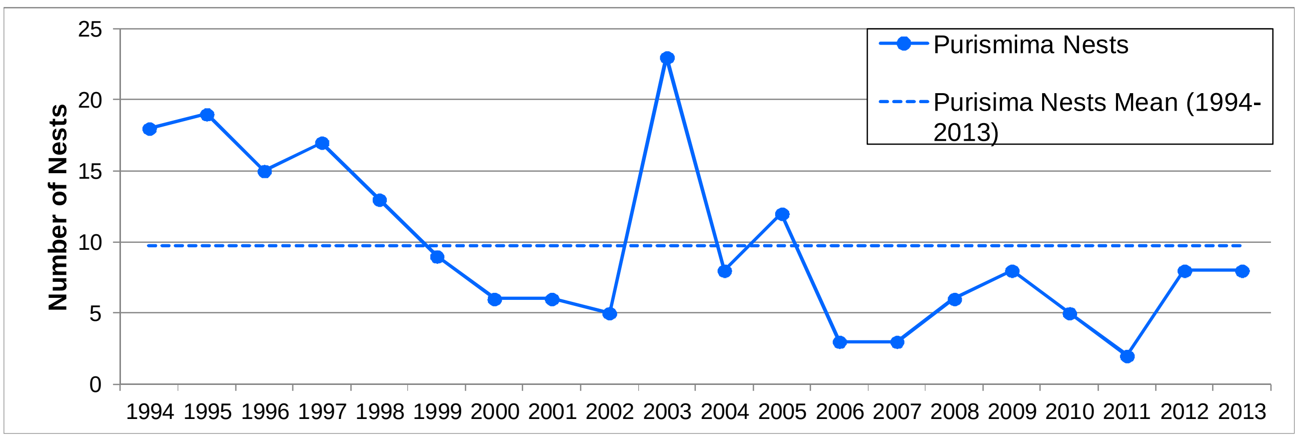


Figure 14. Trends in annual number of nests initiated for North, South, and Purisima Beaches from 1994-2013. Dashed lines show the 20-year means (1994-2013).

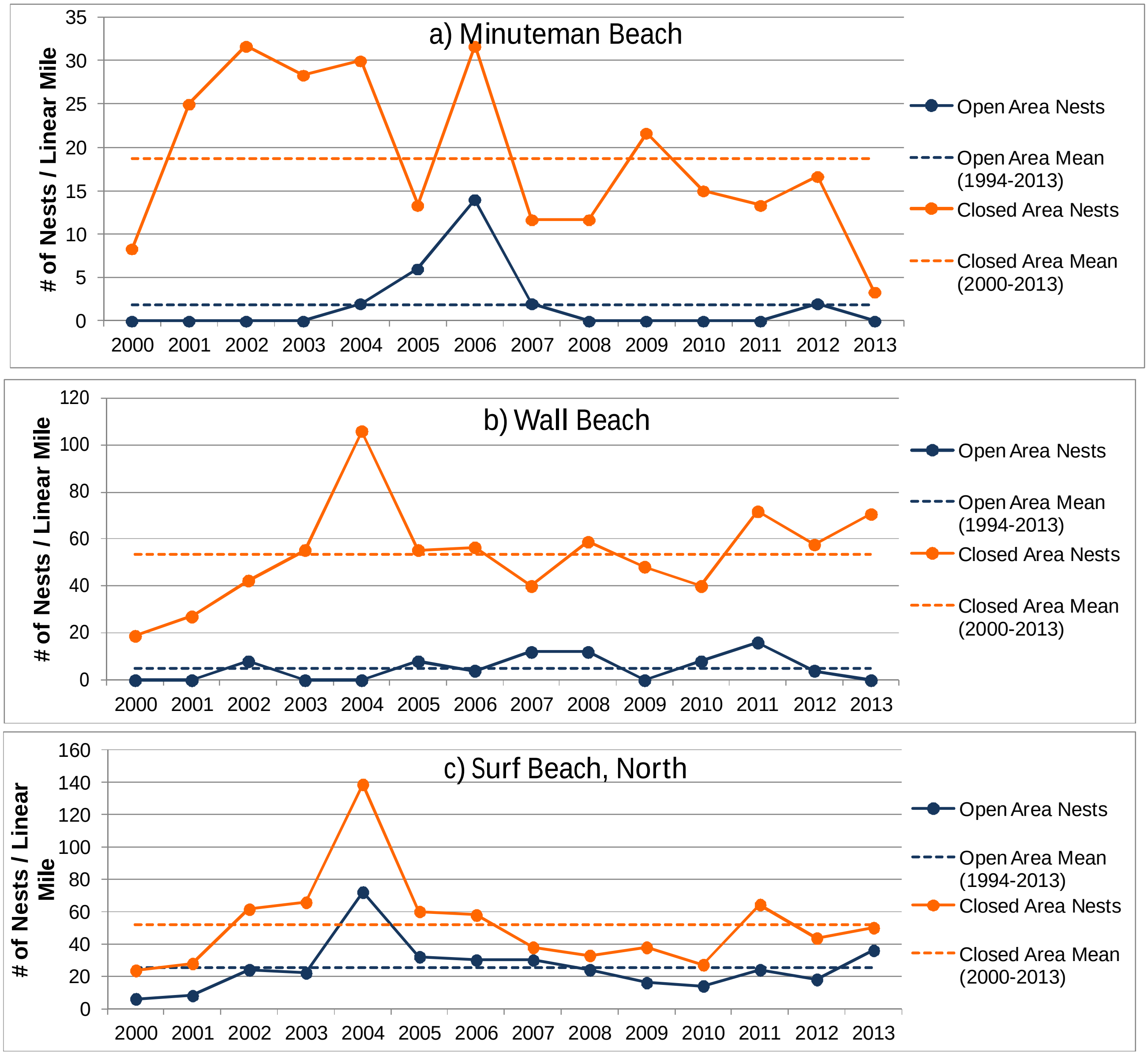


Figure 15. Trends in annual number of nests per linear mile within open and closed sections of Minuteman, Wall, and Surf Beaches, from 2000-2013. Dashed lines show the 13 year means (2000-2013).

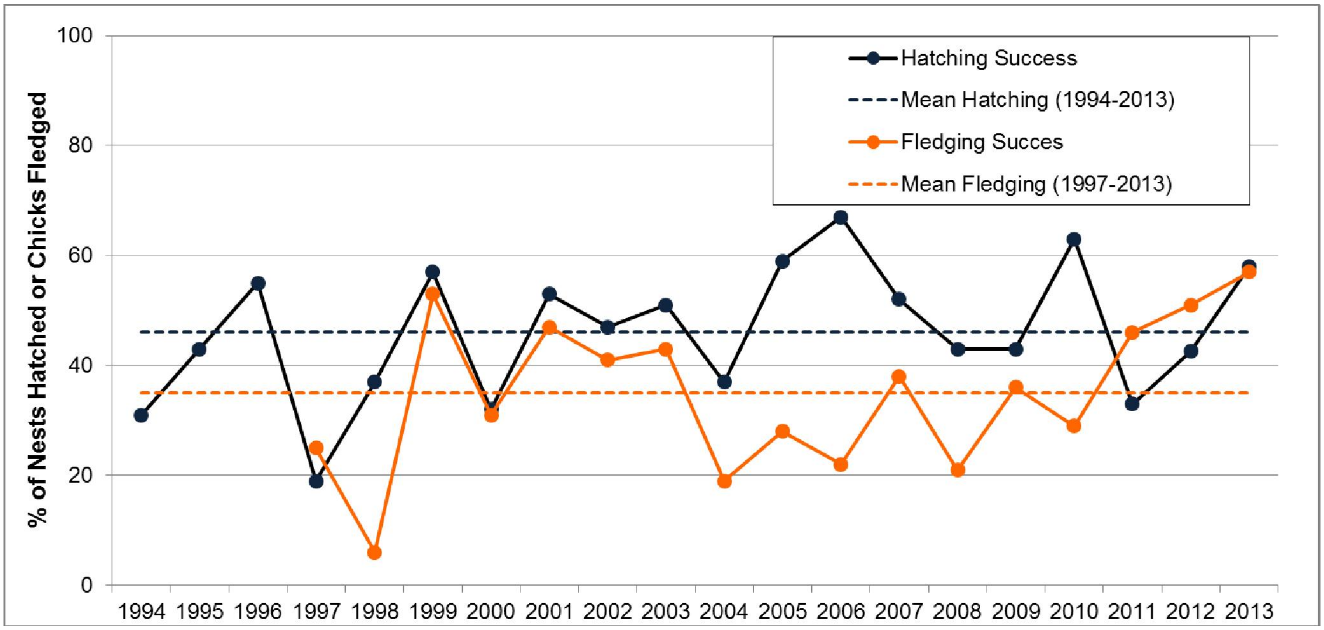
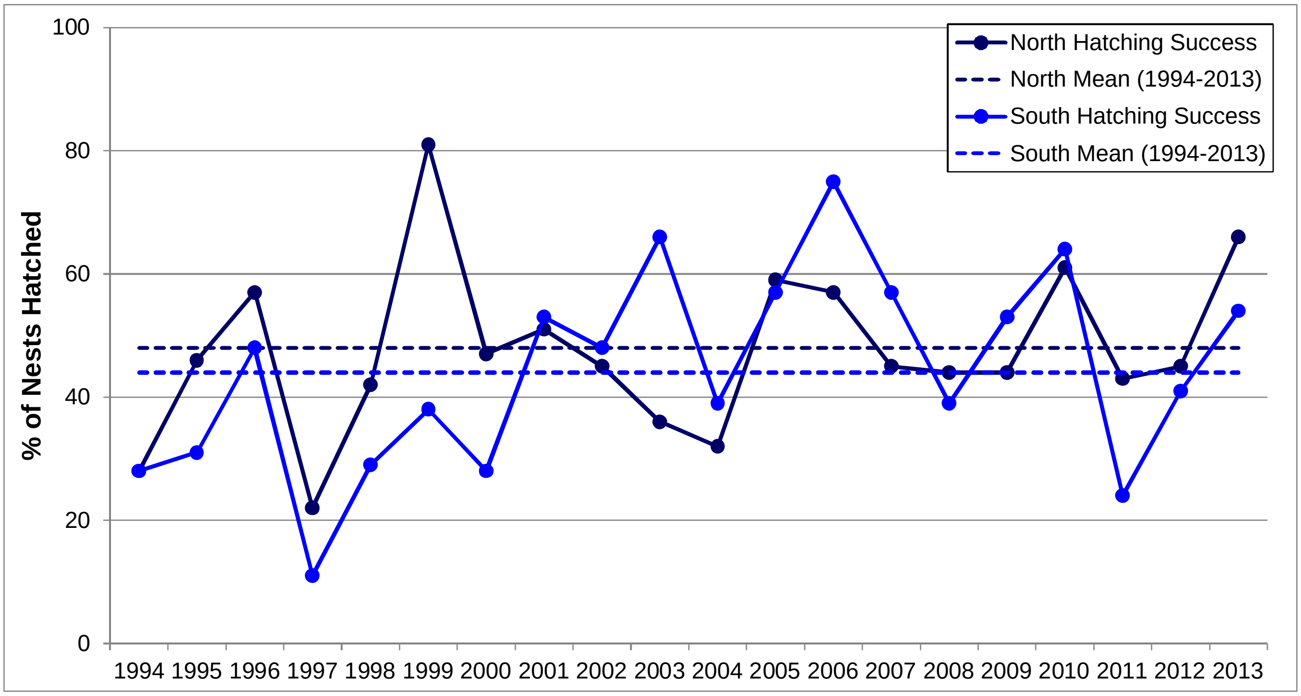


Figure 16. Trends in annual snowy plover clutch hatch and fledging success on VAFB from 1994 to 2013. Data on fledging success were not available for 1994-1996.



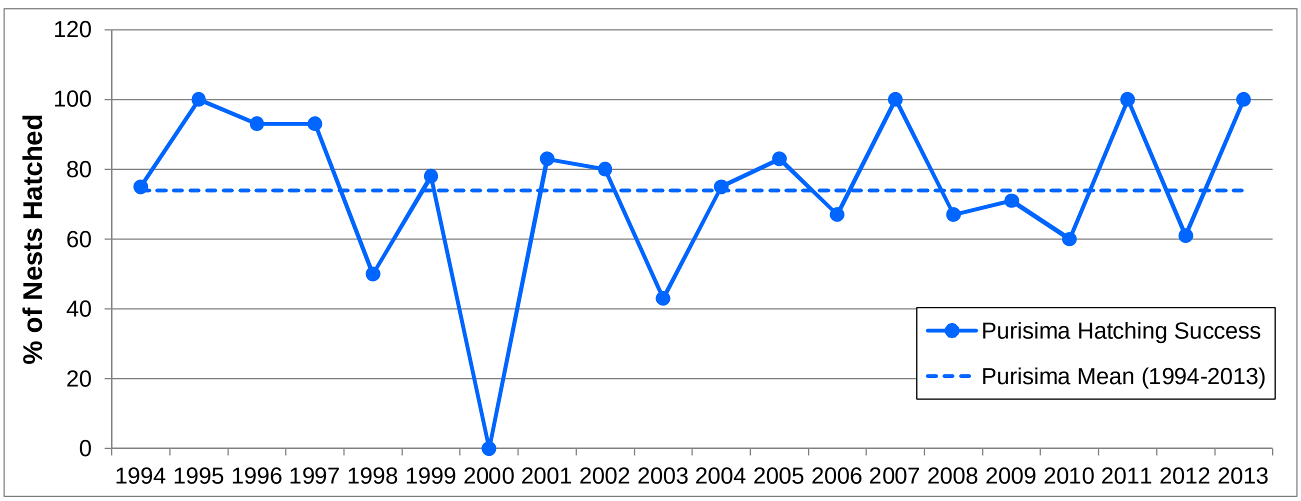
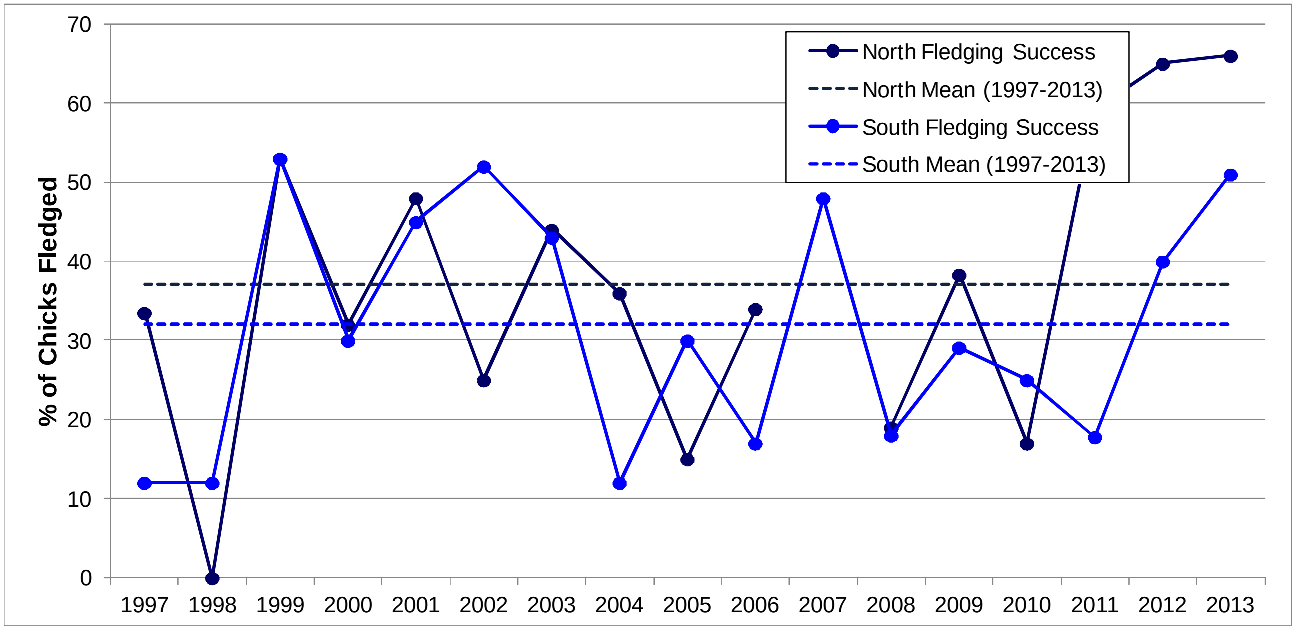


Figure 17. Trends in annual clutch hatch success on North, South, and Purisima Beaches from 1994 to 2013. Dashed lines show the 20-year mean for each beach section.



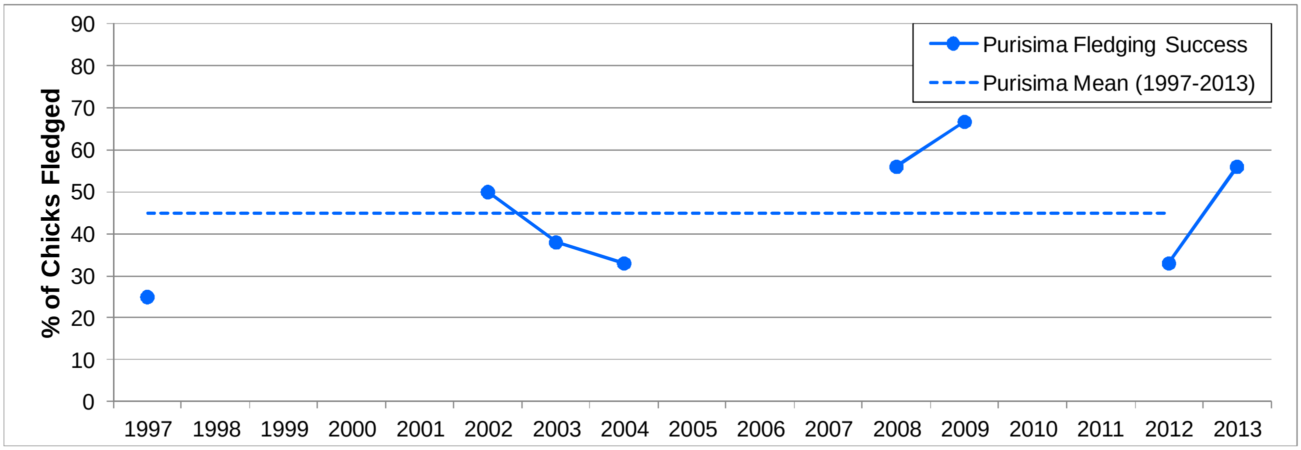


Figure 18. Trends in annual fledging success on North, South, and Purisima Beaches from 1997 to 2013. Missing data points indicate years when fledging success was not determined. Dashed lines indicate the 20-year mean for each beach section.

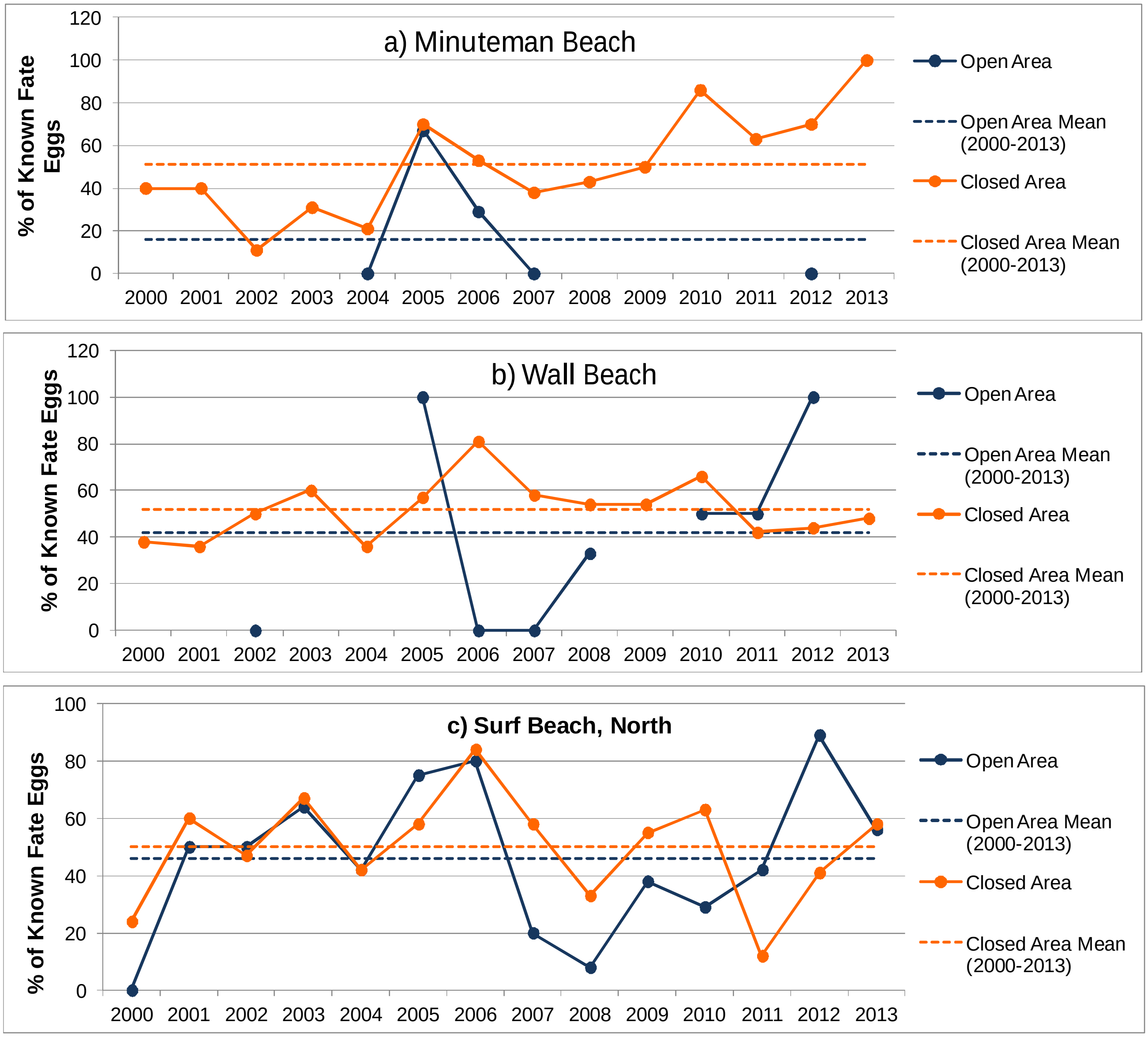


Figure 19. Trends in annual clutch hatch success at open and closed areas of Minuteman, Wall, and Surf beaches. Missing data points indicate years where no nests were initiated within that particular beach sector.

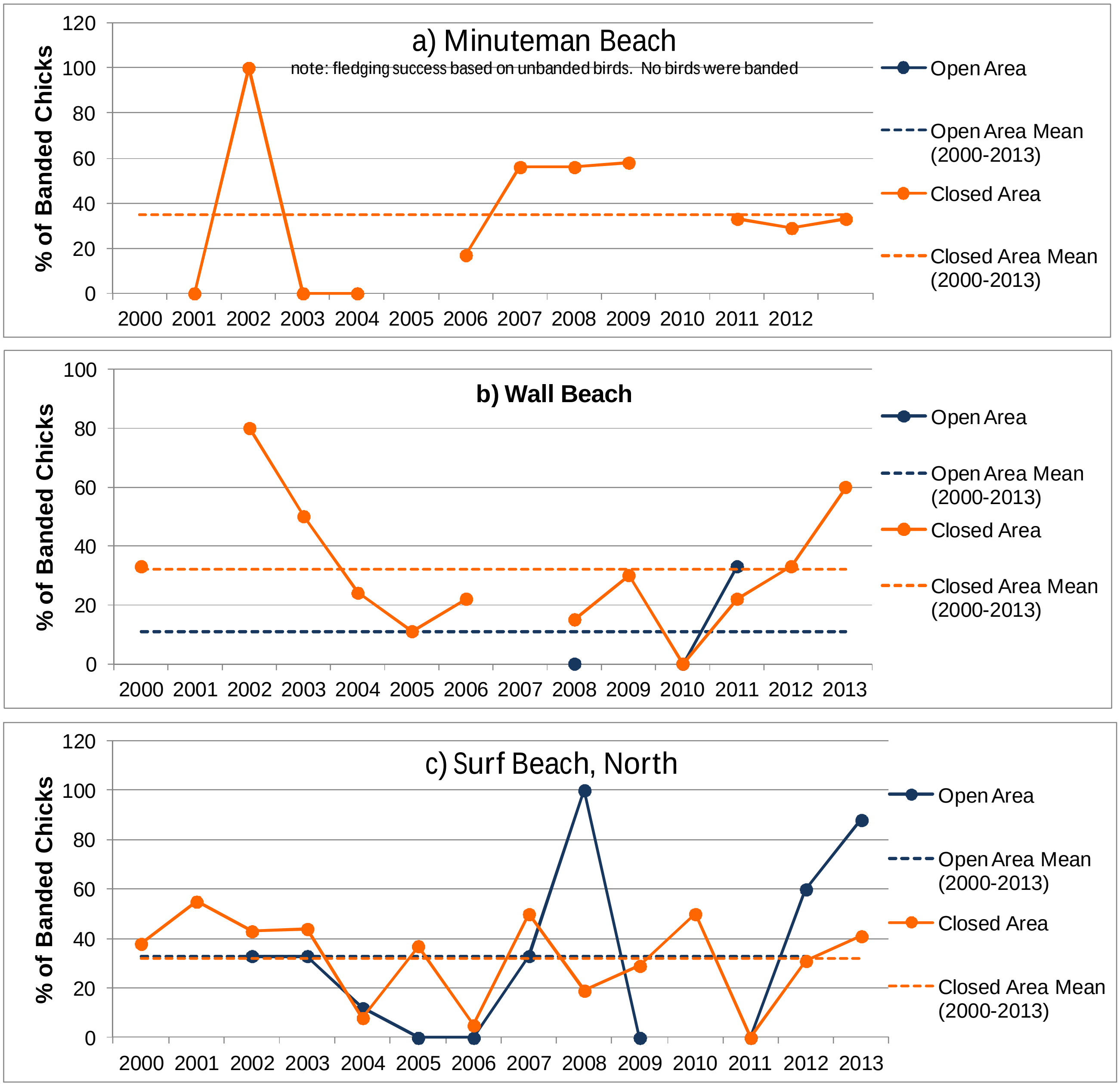


Figure 20. Trends in annual fledging success within open and closed areas of Minuteman, Wall, and Surf Beaches. Missing values indicate years when no nesting occurred or fledging success was not determined for that particular beach sector.

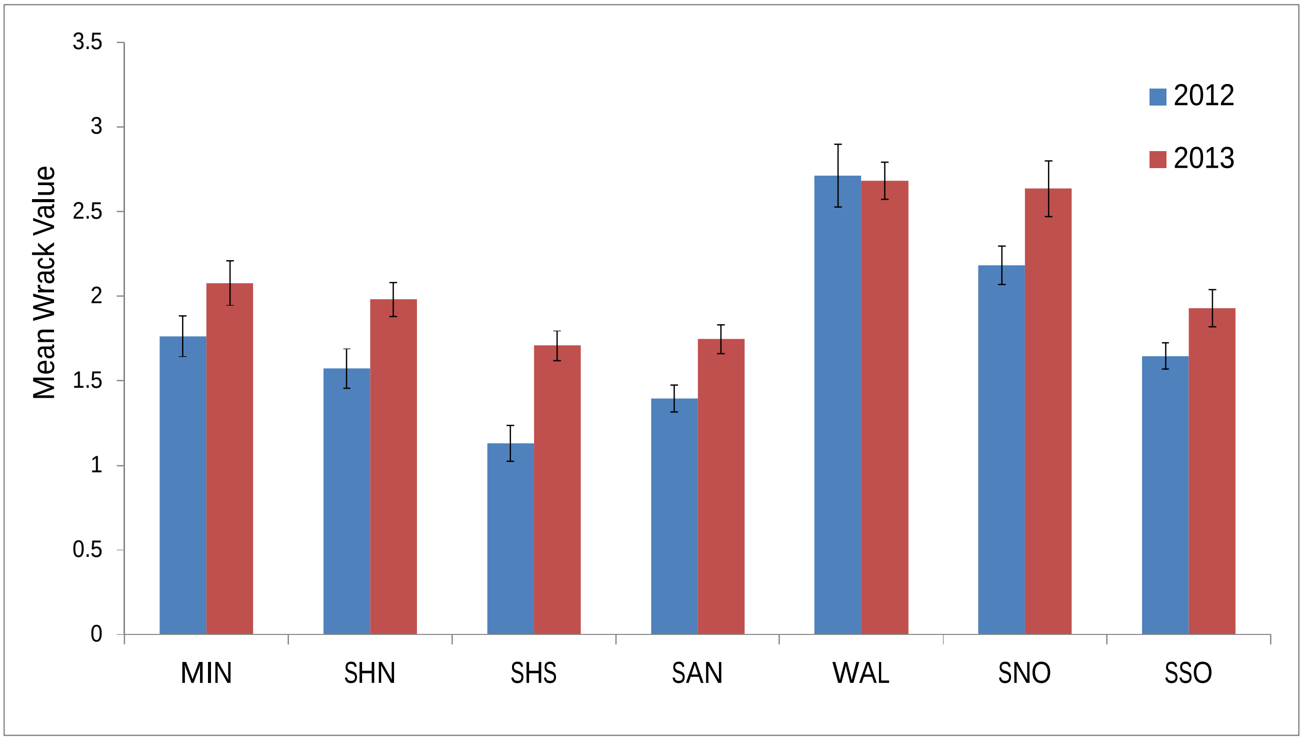


Figure 21. Mean wrack index values for each beach sector in 2012 and 2013. Error bars represent the standard error.

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 2013 breeding season

Observations of Western snowy plovers banded on VAFB prior to 2013

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History
A	G/Y	U, M	11 March - 26 September	2012 - VAFB Purisima North	VAFB Breeder
A	Y	U, M	29 April - 13 September	2012 - VAFB Purisima North	VAFB Breeder
B	G/Y	U, F	11 March - 6 September	2009 - VAFB Minuteman	VAFB Breeder
L	Y	M	23 April - 4 July	2012 - VAFB	Possible Breeder
N(S)	AW	F	12 March - 27 July	VAFB - Year Undeterminable	VAFB Breeder
N(S)	AY	F	17 May	VAFB - Year Undeterminable	
NB	AB	F	7 August	2011 - VAFB Wall	
NB	AG	F	11 July	2011 - VAFB Surf South	VAFB Breeder
NB	AG	U	15 August	2011 - VAFB Surf South	
NB	AG	U	6 September	2011 - VAFB Surf South	
NB	AW	U, F	12 March - 17 September	2011 - VAFB San Antonio	VAFB Breeder
NB	AY	U, F, M	12 March - 12 September	2006 - VAFB Shuman North	Possible Breeder, likely just one bird
NB	BG	F	7 June - 2 July	2011 - VAFB San Antonio	VAFB Breeder
NB	BG	U	19 July	2011 - VAFB San Antonio	
NB	BY	U	14 June	2011 - VAFB	
NB	GB	F	1 April - 18 July	2011 - VAFB San Antonio	VAFB Breeder
NB	GB	U, M	29 April, 12 June, 26 July	2011 - VAFB San Antonio	
NB	GR	U, M	11 March - 26 September	2011 - VAFB San Antonio	VAFB Breeder
NB	GR	F	2 May	2011 - VAFB San Antonio	
NB	GW	U, M	11 March - 26 September	2011 - VAFB San Antonio	VAFB Breeder
NB	GY	M	8 May - 23 July	2011 - VAFB San Antonio	VAFB Breeder
NB	NY	F	12 Apr	2011 - VAFB San Antonio	
NB	NY	M	12 Apr	2011 - VAFB San Antonio	
NB	NY	M	19 Jul	2011 - VAFB San Antonio	
NB	OY	U, M	29 March - 7 Aug	2011 - VAFB	VAFB Breeder
NB	PB	U	27 July	2011 - VAFB	
NB	PY	U, M	11 March - 13 September	2011 - VAFB	VAFB Breeder
NB	RB	M	15 May	2011 - VAFB	
NB	WG	M	12 April	2011 - VAFB Wall	
NB	WW	U, M	12 April - 5 July	2011 - VAFB	VAFB Breeder
NB	WY	U, F	22 April - 15 July	2011 - VAFB	VAFB Breeder
NB	YB	U, F	12 March - 17 September	2011 - VAFB	VAFB Breeder
NO	NR	M	11 March - 9 July, 27 August	2009 - VAFB Shuman North	VAFB Breeder
NO	OG	F	11 - 18 March	2004 - VAFB San Antonio	Former Breeder
NO	WG	U, F	14 March - 14 June, 15 August - 20 September	2012 - VAFB San Antonio	Possible Breeder
NO	WG	U	7 August	2012 - VAFB San Antonio	

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History
NR	AG	M	22 April	VAFB - Year Undeterminable	
NR	BW	F	22 April - 8 July	2012 - VAFB San Antonio	VAFB Breeder
NR	GW	U, F	14 March - 20 September	2012 - VAFB San Antonio	VAFB Breeder
NR	GW	M	3 - 6 June	2012 - VAFB San Antonio	
NR	NR	M	10 April	VAFB - Year Undeterminable	
NR	OR	F	11 March - 29 April	2012 - VAFB San Antonio	Possible Breeder, depredated by PEFA
NR	OR	U	3 May	2012 - VAFB San Antonio	
NR	OR	U, M	3 May - 3 September	2012 - VAFB San Antonio	Possible Breeder
NR	PR	U, F	3 April - 11 September	2012 - VAFB San Antonio	VAFB Breeder
NR	RB	U	2 April	2012 - VAFB San Antonio	
NR	RB	U, F	4 April - 31 July	2012 - VAFB San Antonio	VAFB Breeder
NR	WR	U	12 March, 12 September	2012 - VAFB Wall	
NR	WR	M	12 March - 29 August	2012 - VAFB Wall	VAFB Breeder
NR	WR	F	19 March	2012 - VAFB Wall	
NR	WW	M	27 March - 16 September	2011 - VAFB Shuman South	VAFB Breeder
NR	WW	M	31 May	2011 - VAFB Shuman South	
NW	AB	M	29 April - 12 July	2012 - VAFB Minuteman	Possible Breeder
NW	AG	U	25 March - 3 April	2012 - VAFB Shuman South	
NW	AG	M	4 April - 16 September	2012 - VAFB Shuman South	Possible Breeder
NW	AG	F	4 April - 13 August	2012 - VAFB Shuman South	VAFB Breeder
NW	AY	U, F	19 March - 12 September	2004 - VAFB Purisima Colony	VAFB Breeder
NW	BG	U, M	14 March - 3 July, 20 September	2012 - VAFB San Antonio	VAFB Breeder
NW	BG	U, F	22 April - 29 August	2012 - VAFB San Antonio	Possible Breeder
NW	BG	U	24 July	2012 - VAFB San Antonio	
NW	BY	U, M	12 March - 12 September	2008 - VAFB Surf North	VAFB Breeder
NW	GB	M	8 May, 12 July	2008 - VAFB Wall	
NW	GY	F	21 May	2009 - VAFB Surf South	
NW	NY	U, M	23 April - 13 September	2012 - VAFB San Antonio	VAFB Breeder
NW	WW	U, F, M	12 March - 2 September	2009 - VAFB Minuteman	VAFB Breeder, likey just one bird
NW	WY	M	7 August	2009 - VAFB Minuteman	
NW	YG	U, M	12 March - 12 September	2010 - VAFB Surf North	VAFB Breeder
NY	GB	U, M	19 March - 12 September	2008 - VAFB Minuteman	VAFB Breeder
NY	GR	M	23 April - 28 June	2008 - VAFB San Antonio	VAFB Breeder
NY	GR	F	20 June	2008 - VAFB San Antonio	Possible Breeder
NY	NG	F	11 April - 12 July	2012 - VAFB Surf North	Possible Breeder
NY	NG	U	6 September	2012 - VAFB Surf North	
NY	NW	M	6 - 24 May	2012 - VAFB San Antonio	
NY	NY	U, F	12 March - 6 September	2012 - VAFB Surf South	VAFB Breeder
NY	PB	U	27 July	2012 – VAFB Surf North	

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History
NY	RR	U, F	12 March - 3 July	2012 - VAFB Surf South	Possible Breeder
NY	WG	M	1 April - 15 July	2008 - VAFB Wall	Possible Breeder
NY	YB	U, M	12 March - 17 September	2012 - VAFB Surf South	VAFB Breeder
NY	YY	F	14 May - 26 June	2012 - VAFB Surf North	VAFB Breeder
P	G/W/G	U	25 March	2005 - VAFB Surf North	
P	Y/G	U, M	11 March - 2 May	2012 - VAFB San Antonio	
R	G	M	3 - 14 June	VAFB - Year Undeterminable	
R	G/Y	M	16 May - 17 July	2011 - VAFB Surf South	VAFB Breeder
W	W/O/W	M	19 March - 24 July	2005 - VAFB Surf North	VAFB Breeder

Observations of Western snowy plovers banded outside of VAFB

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
-	YG	U, M	11 March - 24 April	Unknown		missing left foot
(S)	-	F	5 July	Unknown	VAFB Breeder	
AA	AY	J	7 July	Unknown		
AB	GO	U	20 August - 12 September	Unknown		
AR	BW	U	20 - 22 August	Unknown		
AY	OY	M	12 April	Unknown		
B	B/Y	U	22 August	Unknown		
BB	AG	J	16 July	Oceano (2013)		
BB	BY	J	31 July	Oceano (2013)		
BB	GW	J	18 July	Oceano (2013)		
BB	WW	U	23 August	Oceano (2013 or 2010)		
BB	YW	U	13 September	Oceano (2013 or 2010)		
BG	AW	J	20 July	Unknown		
BG	WW	M	19 July	Unknown		
BO	WY	U	11 - 25 March	Unknown		
BO	YY	F	14 June	Unknown		
BR	OR	U	1 April	Unknown		
BR	WY	U, M	18 March - 3 April	Unknown		
G	-	U, M	22 April - 13 August	Unknown	VAFB Breeder	
GA	AG	F	15 August	Oceano (2013)		
GA	AY	U	5 July	Oceano (2013)		
GA	BW	F	8 - 21 May	Oceano (2011)		
GA	GW	U	24 July	Oceano (2013)		
GA	OR	F	4 April - 8 July	Oceano (2005)	VAFB Breeder	

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
GA	OW	J	5 July	Oceano (2013)		
GA	VB	M	12 June - 22 August	Oceano (2008 or 2011)		
GA	VG	U, F	14 March, 26 July - 20 September	Oceano (2008 or 2013)		
GA	WA	F	11 March	Unknown		
GA	WB	U, F	20 March - 16 September	Oceano (2012)	VAFB Breeder	
GA	YG	J	23 - 27 August	Oceano (2013)		
GG	BW	U, F	11 March - 3 May, 23 August	Oceano (2012)	VAFB Breeder	2 breeders, 1 possibly depredated by PEFA
GG	GA	J	13 August	Unknown		
GG	GG	J	26 July	Oceano (2013)		
GG	OW	J	3 July	Oceano (2009)		or PW
GG	PB	U, F	29 April - 3 July	Oceano (2004 or 2012)	VAFB Breeder	
GG	VW	U	27 August - 10 September	Oceano (2013)		
GG	WB	U, F	15 August - 11 September	Oceano (2011)		
GG	WW	M	3 June - 26 July	Oceano (2012)	Possible Breeder	
GG	WY	U, J	26 August - 20 September	Oceano (2013)		
GG	YW	U	20 September	Oceano (2013)		
GG	YY	U	11 - 16 September	Oceano (2011 or 2013)		
GO	AB	J	6 september	Unknown		
GP	GA	M	1 - 3 April	Unknown		
GR	KY	M	22 April	Unknown		
KK	BB	U, M	19 March - 6 September	Unknown	VAFB Breeder	
KY	GR	M	24 April	Unknown		
LL	BW	F	10 April	Unknown		
LL	PB	F	4 April	Unknown		
O	*	M	12 April	Unknown		O:- or O:(S)
OB	WW	U	27 August	Unknown		
OG	OR	U, M	12 March - 12 September	Salinas State Beach (2007)	VAFB Breeder	
P	G/Y	M	22 April	Unknown		
PB	LL	U, F	14 - 20 March	Unknown		
PG	RR	M	6 May	Oceano (2004)		
PG	YB	M	25 March	Oceano (2009)		
R	-	F	19 March - 24 July	Unknown	VAFB Breeder	
RR	GW	U, F	11 - 25 March	Oceano (2003)		maybe OO:GW
RR	LY	U, M	12 March - 2 September	Oceano (2010)	VAFB Breeder	
RR	WW	M	25 March	Oceano (2005)		
S	-	M	12 - 19 March	Unknown		
V	(S)	U, M	10 April - 13 August	Unknown	VAFB Breeder	
VG	AW	U	22 July	Oceano (2011 or 2013)		
VG	GA	F	20 March	Unknown		

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
VG	GA	U	6 September	Unknown		
VG	VR	U, F	19 March - 11 April, 22 August - 12 September	Oceano (2011)		R could be P
VV	AW	U	22 - 29 August	Oceano (2013)		
VV	BB	J	18 July	Oceano (2013)		
VV	GB	J	7 August	Oceano (2009)		
VV	GR	J	24 July	Oceano (2013)		
VV	OA	U, F	25 March - 8 May, 13 August - 16 September	Oceano (2011)	VAFB Breeder	
VV	VB	U, J	29 July - 23 August	Oceano (2013)		
Y/L	B	U, F	27 March - 12 April, 13 August - 12 September	Unknown		
yB	BY	U, F	14 March - 9 April, 15 August - 20 September	Unknown		
YB	RR	J	27 August	Unknown		
yB	YB	U	29 August	Unknown		
YY	BO	U, F	14 May - 12 September	Unknown	Possible Breeder	
YY	BP	F	3 June	Unknown		
YY	BR	U	20 August	Unknown		
YY	R	M	22 March	Unknown		

Appendix C – Western snowy plover banded on VAFB during the 2013 breeding season.

Beach Sector	Color Bands		Date Banded	Chicks Banded	Confirmed Fledged
	Left	Right			
Minuteman					
	NW	AB	7/2	3	3
	NW	WB	5/14	3	2
Shuman					
	NO	AB	7/19	3	2
	NW	AG	7/17	3	0
	NY	WW	6/1	3	0
San Antonio					
	NO	WG	7/20	3	2
	NR	BW	7/18	3	3
	NR	GW	7/18	3	3
	NR	OR	7/19	3	3
	NR	PB	8/8	3	1
	NR	PR	7/18	3	2
	NR	PY	7/18	3	1
	NR	RB	7/19	3	3
	NW	AR	7/14	3	2
	NW	BG	7/18	3	2
	NW	NR	7/14	3	3
	NW	NW	7/14	3	3
	NW	NY	7/14	3	1
	NW	YR	7/8	3	3
	NY	NW	5/9	3	2
	NY	OG	6/7	2	0
	NY	PR	5/12	3	0
	P	G/W	7/18	1	1
	P	W/G	7/18	1	1
	P	Y/G	7/18	1	1
	W	W/G	7/19	1	1
	W	G/W	7/19	1	1
	W	Y/G	7/19	1	0
	B	W/G	7/13	1	0
	B	G/W	7/13	1	1
	G	W/G	7/19	1	1
	G	G/W	7/19	1	0
	G	G/Y	7/19	1	0
	L	G/Y	7/12	1	0
	L	Y/G	7/12	1	0
Purisima North					
	A	G/W	7/18	1	0
	A	Y/G	7/18	1	1
	A	G/Y	7/18	1	1
	NO	OY	7/20	3	0
Wall					
	NR	AR	7/24	3	1
	NR	RY	8/10	3	2
	NR	WR	8/10	2	1
	NW	AG	7/11	3	1
	NW	GG	7/2	3	0
	NW	OR	7/4	3	3
	NW	OW	7/8	3	0
	NW	RR	7/6	3	2
	NY	OB	7/1	3	0
	NY	WR	6/14	2	1
	Y	G/W	7/14	1	0
	Y	W/G	7/14	1	0
Surf North					
	NY	GG	5/11	2	0
	NY	NG	6/12	3	1
	NY	NR	6/14	3	0
	NY	OR	5/16	3	2

Beach Sector	Color Bands		Date Banded	Chicks Banded	Confirmed Fledged
	Left	Right			
	NY	PB	6/11	3	1
	NY	PG	6/1	3	0
	NY	RW	6/30	3	3
	NY	YR	6/14	2	0
	NY	YW	6/11	3	2
	NY	YY	5/15	2	2
	R	Y/G	8/10	1	0
	R	G/W	8/10	1	0
	V	G/W	7/12	1	1
	V	G/Y	7/12	1	1
	V	Y/G	7/12	1	1
Surf South					
	NY	GY	6/11	3	1
	NY	NB	4/20	3	0
	NY	NY	6/19	2	1
	NY	OW	6/20	3	0
	NY	PW	6/4	2	2
	NY	RR	5/15	2	1
	NY	YB	6/7	3	2
Total				161	82

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 2013 window surveys.

13-May-13	Male	Female	Unk Adult	PR	Total
Minuteman	1	0	0	0	**1**
Shuman North	6	1	2	0	**9**
Shuman South	1	2	1	0	**4**
San Antonio	43	41	4	6	**88**
Purisima North	4	2	0	0	**6**
Purisima Colony					
Total North VAFB	***55***	***46***	***7***	***6***	***108***
Wall	12	5	0	2	**17**
Surf North	34	25	1	2	**60**
Surf South	14	15	0	3	**29**
Total South VAFB	***60***	***45***	***1***	***7***	***106***
TOTAL VAFB	**115**	**91**	**8**	**13**	**214**

21-May-13	Male	Female	Unk Adult	PR	Total
Minuteman	0	0	0	0	**0**
Shuman North	7	2	0	1	**9**
Shuman South	3	3	0	3	**6**
San Antonio	40	32	1	4	**73**
Purisima North	1	1	2	0	**4**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***51***	***38***	***3***	***8***	***92***
Wall	17	17	0	6	**34**
Surf North	29	28	0	8	**57**
Surf South	11	10	0	5	**21**
Total South VAFB	***57***	***55***	***0***	***19***	***112***
TOTAL VAFB	**108**	**93**	**3**	**27**	**204**

10-Jun-13	Male	Female	Unk Adult	PR	Total
Minuteman	0	0	0	0	**0**
Shuman North	7	2	0	1	**9**
Shuman South	3	2	1	1	**6**
San Antonio	35	22	6	2	**63**
Purisima North	2	5	0	1	**7**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***47***	***31***	***7***	***5***	***85***
Wall	33	20	0	6	**53**
Surf North	37	19	0	2	**56**
Surf South	27	7	1	5	**34**
Total South VAFB	***97***	***46***	***1***	***13***	***143***
TOTAL VAFB	**144**	**77**	**8**	**18**	**228**

24-Jun-13	Male	Female	Unk Adult	PR	Total
Minuteman	0	0	0	0	**0**
Shuman North	1	4	0	0	**5**
Shuman South	4	0	3	0	**7**
San Antonio	51	29	4	5	**84**
Purisima North	9	7	0	2	**16**
Purisima Colony	0	1	0	0	**1**
Total North VAFB	***65***	***41***	***7***	***7***	***113***
Wall	19	7	6	3	**32**
Surf North	40	19	8	3	**67**
Surf South	12	8	0	4	**20**
Total South VAFB	***71***	***34***	***14***	***10***	***119***
TOTAL VAFB	**136**	**75**	**21**	**17**	**232**

MEAN	Male	Female	Unk Adult		Mean
Minuteman	0	0	0		**0**
Shuman North	5	2	1		**8**
Shuman South	3	2	1		**6**
San Antonio	42	31	4		**77**
Purisima North	4	4	1		**8**
Purisima Colony	0	0	0		**0**
Mean North VAFB	***55***	***39***	***6***		***100***
Wall	20	12	2		**34**
Surf North	35	23	2		**60**
Surf South	16	10	0		**26**
Mean South VAFB	***71***	***45***	***4***		***120***
MEAN VAFB	**126**	**84**	**10**		**220**

Table 2. Summary of window surveys from 1994 to 2013.

Year	Early to Mid May	Mid to Late May	Early to Mid June	Mid to Late June	Mean	% Change over Prior Year	% Change in 2013
1994	237	--	199	217	218	n/a	-1%
1995	213	234	193	202	211	-3%	2%
1996	230	229	234	244	234	11%	-8%
1997	258	196	256	245	239	2%	-10%
1998	103	130	132	163	132	-45%	32%
1999	91	64	67	89	78	-41%	177%
2000	98	106	107	109	105	35%	106%
2001	115	100	123	150	122	16%	77%
2002	222	213	174	195	201	65%	7%
2003	344	256	295	232	282	40%	-23%
2004	363	420	466	431	420	49%	-49%
2005	277	259	284	280	275	-35%	-21%
2006	289	245	261	279	269	-2%	-20%
2007	153	165	192	172	171	-36%	26%
2008	230	207	199	193	207	21%	4%
2009	158	162	187	183	173	-17%	25%
2010	178	167	176	175	174	1%	24%
2011	215	230	223	196	216	24%	-5%
2012	206	170	196	248	205	-5%	7%
2013	214	204	208	232	220	7%	

Table 3. Distribution of nests by beach section from 1994 to 2013.

Beach Sector	2002		2003		2004		2005		2006		2007	
	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success
North Beaches												
Minuteman	11%	12%	31%	31%	21%	28%	70%	66%	48%	46%	38%	36%
Shuman	44%	51%	33%	29%	25%	27%	48%	46%	55%	54%	34%	34%
San Antonio	55%	54%	41%	42%	42%	46%	75%	72%	65%	65%	56%	56%
Total North Beaches	***45%***	***47%***	***36%***	***35%***	***32%***	***36%***	***59%***	***57%***	***57%***	***57%***	***45%***	***45%***
Purisima Beaches												
Purisima North	0%	0%	42%	48%	100%	83%	90%	86%	50%	50%	100%	100%
Purisima Colony	100%	100%	50%	25%	50%	60%	50%	33%	100%	100%	100%	100%
Total Purisima Beaches	***80%***	***80%***	***43%***	***43%***	***75%***	***73%***	***83%***	***77%***	***67%***	***67%***	***100%***	***100%***
South Beaches												
Wall	50%	48%	60%	58%	36%	36%	59%	62%	83%	83%	58%	56%
Surf North	47%	47%	68%	65%	42%	42%	61%	61%	83%	83%	59%	60%
Surf South	48%	52%	65%	64%	38%	40%	50%	50%	52%	50%	53%	54%
Total South Beaches	***48%***	***48%***	***66%***	***63%***	***39%***	***40%***	***57%***	***58%***	***75%***	***75%***	***57%***	***58%***
TOTAL VAFB	**47%**	**48%**	**51%**	**49%**	**37%**	**39%**	**59%**	**58%**	**67%**	**66%**	**52%**	**53%**

Beach Sector	2008		2009		2010		2011		2012		2013	
	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success	Clutch hatch success	Egg hatch success
North Beaches												
Minuteman	43%	50%	50%	69%	86%	84%	63%	61%	58%	55%	100%	100%
Shuman	36%	34%	33%	37%	58%	58%	20%	15%	63%	32%	63%	55%
San Antonio	51%	48%	51%	55%	61%	57%	55%	51%	48%	49%	59%	56%
Total North Beaches	***44%***	***42%***	***44%***	***48%***	***61%***	***59%***	***43%***	***39%***	***50%***	***45%***	***60%***	***57%***
Purisima Beaches												
Purisima North	60%	64%	33%	38%	75%	90%	100%	83%	63%	61%	100%	92%
Purisima Colony	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%
Total Purisima Beaches	***67%***	***71%***	***71%***	***75%***	***60%***	***69%***	***100%***	***83%***	***63%***	***61%***	***100%***	***92%***
South Beaches												
Wall	54%	52%	54%	57%	66%	68%	43%	47%	58%	56%	48%	44%
Surf North	33%	31%	55%	60%	63%	63%	16%	17%	43%	45%	72%	58%
Surf South	20%	20%	46%	49%	65%	65%	19%	22%	25%	25%	38%	56%
Total South Beaches	***39%***	***37%***	***53%***	***57%***	***64%***	***65%***	***24%***	***27%***	***41%***	***41%***	***54%***	***54%***
TOTAL VAFB	**43%**	**41%**	**43%**	**41%**	**63%**	**61%**	**33%**	**33%**	**46%**	**44%**	**58%**	**56%**

Table 4. Clutch hatch success for each beach section in 2013.

Beach Sector	Hatched clutches	Known fate clutches	Clutch success	Hatched eggs	Total known fate eggs	Egg hatch success
North Beaches						
Minuteman	2	2	100%	6	6	100%
Shuman	12	19	63%	29	53	55%
San Antonio	57	97	59%	145	258	56%
Total North Beaches	***71***	***118***	60%	***180***	***317***	57%
Purisima Beaches						
Purisima North	8	8	100%	22	24	92%
Purisima Colony	0	0	0%	0	0	0%
Total Purisima Beaches	***8***	***8***	100%	***22***	***24***	92%
South Beaches						
Wall	22	46	48%	56	126	44%
Surf North	50	69	72%	137	237	58%
Surf South	24	63	38%	61	108	56%
Total South Beaches	***96***	***178***	54%	***254***	***471***	54%
TOTAL VAFB	**175**	**304**	58%	**456**	**812**	56%

Table 5. Number of nests lost to predators in 2013 by beach section.

Beach Sector	Coyote		RAVEN		Suspected Raven		Other Avian		Gull		Unidentified Predator		Total	
North Beaches														
Minuteman	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Shuman	1	5%	0	0%	0	0%	0	0%	0	0%	1	5%	2	11%
San Antonio	24	25%	0	0%	0	0%	0	0%	0	0%	3	3%	27	28%
Total North Beaches	**25**	21%	**0**	0%	**0**	0%	0	0%	**0**	0%	**4**	3%	**29**	25%
Purisima Beaches														
Purisima North	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Purisima Colony	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Total Purisima Beaches	**0**	0%	**0**	0%	**0**	0%	**0**	**0%**	**0**	0%	**0**	**0%**	**0**	0%
South Beaches														
Wall	10	22%	1	1%	0	0%	0	0%	0	0%	4	9%	15	33%
Surf North	14	16%	0	0%	0	0%	0	0%	1	1%	0	0%	15	17%
Surf South	3	7%	0	0%	0	0%	0	0%	0	0%	1	2%	4	9%
Total South Beaches	**27**	15%	**0**	0%	**0**	0%	**0**	0%	**0**	0%	**5**	3%	**32**	18%
VAFB TOTAL	**52**	17%	**1**	1%	**0**	0%	**0**	0%	**1**	**0%**	**9**	3%	**61**	**20%**

Table 6. Numbers of nest lost to predators from 1994 to 2013.

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%

Table 7. Nest predation by month on VAFB 2013

Beach Sector	March	April	May	June	July	August	Total
North Beaches							
Minuteman	0	0	0	0	0	0	0
Shuman	0	1	1	0	0	0	2
San Antonio	0	5	4	6	10	2	27
Total North Beaches	***0***	***6***	***5***	***6***	***10***	***2***	***29***
Purisima Beaches							
Purisima North	0	0	0	0	0	0	0
Purisima Colony	0	0	0	0	0	0	0
Total Purisima Beaches	***0***	***0***	***0***	***0***	***0***	***0***	***0***
South Beaches							
Wall	0	5	1	2	7	0	15
Surf North	0	5	4	6	0	0	15
Surf South	0	0	1	2	1	0	4
Total South Beaches	***0***	***10***	***6***	***10***	***8***	***0***	***34***
TOTAL VAFB	**0**	**16**	**11**	**16**	**18**	**2**	**63**

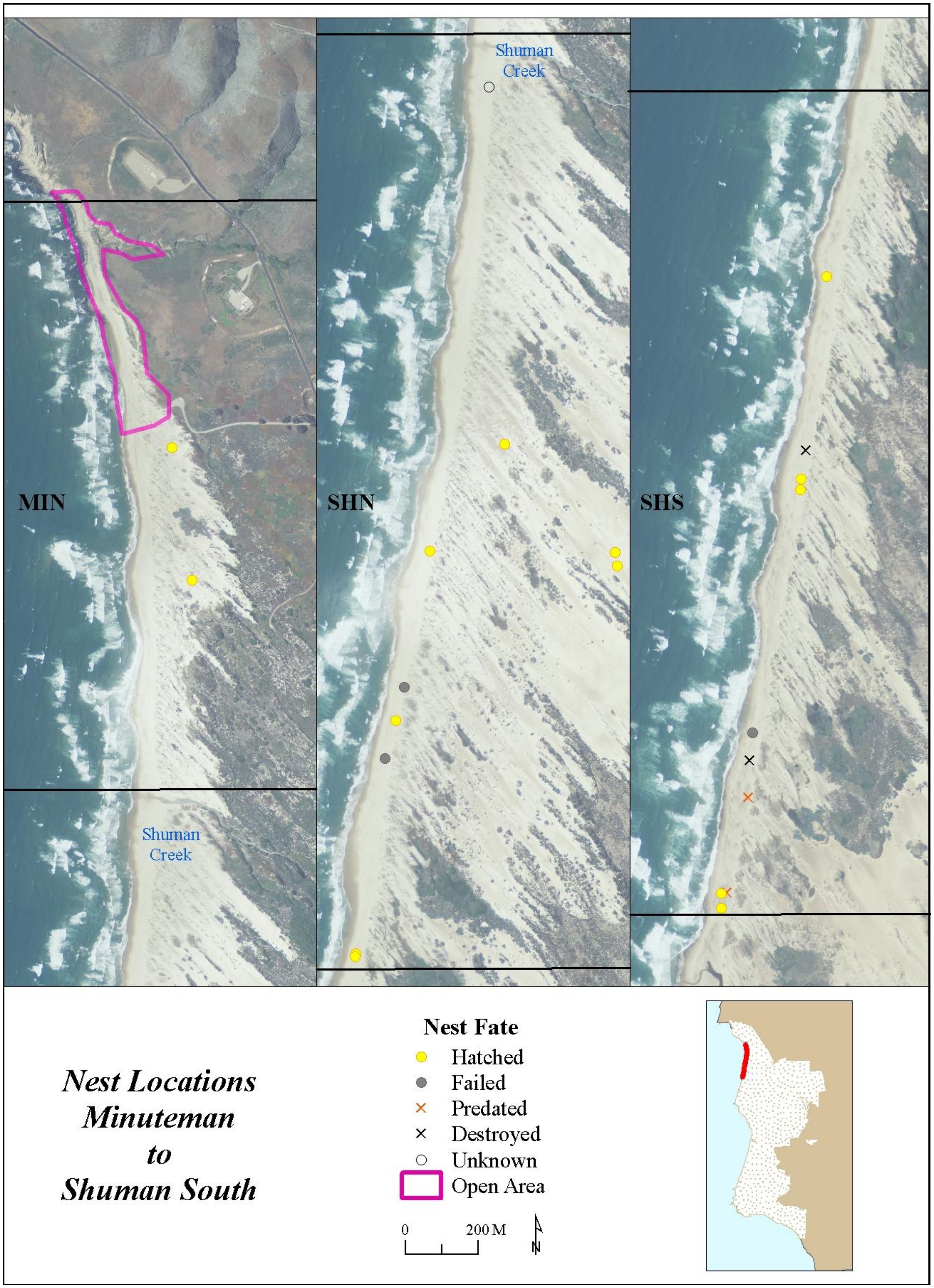
Table 8. Numbers of chicks banded and fledged per beach sector in 2013.

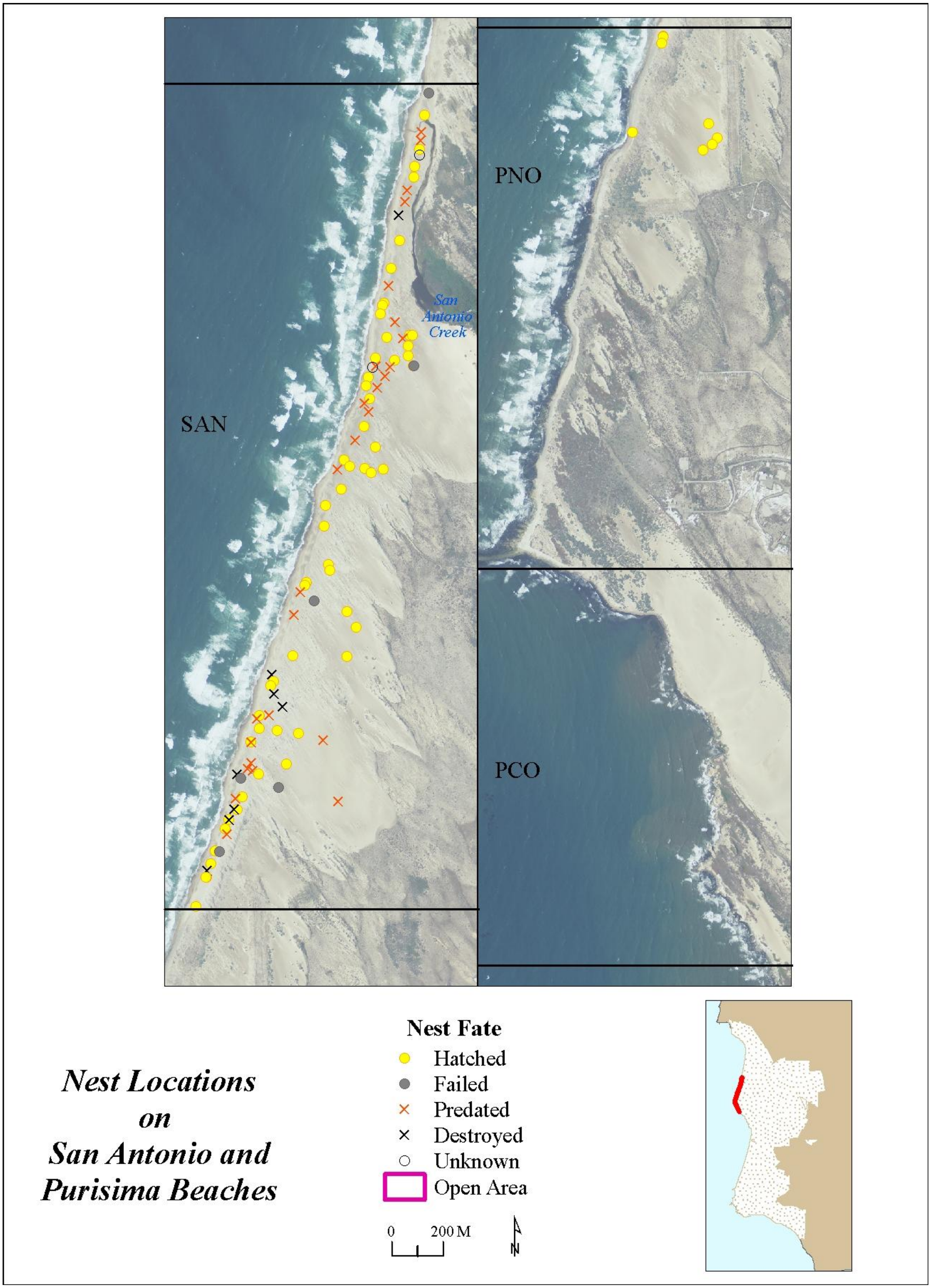
Beach Sector	Chicks Banded	Chicks Fledged	Chick Fledging Rate	% Broods Fledging >1 Chick
North Beaches				
Minuteman	6	5	83%	100%
Shuman	9	2	22%	33%
San Antonio	62	42	68%	86%
Total North Beaches	***77***	***49***	***64%***	***81%***
Purisima Beaches				
Purisima North	6	2	33%	100%
Purisima Colony	0	0	0%	0%
Total Purisima Beaches	***6***	***2***	***33%***	***100%***
South Beaches				
Wall	30	10	33%	55%
Surf North	32	15	47%	67%
Surf South	18	7	39%	71%
Total South Beaches	***80***	***32***	***40%***	***63%***
TOTAL VAFB	**163**	**83**	**51%**	**73%**

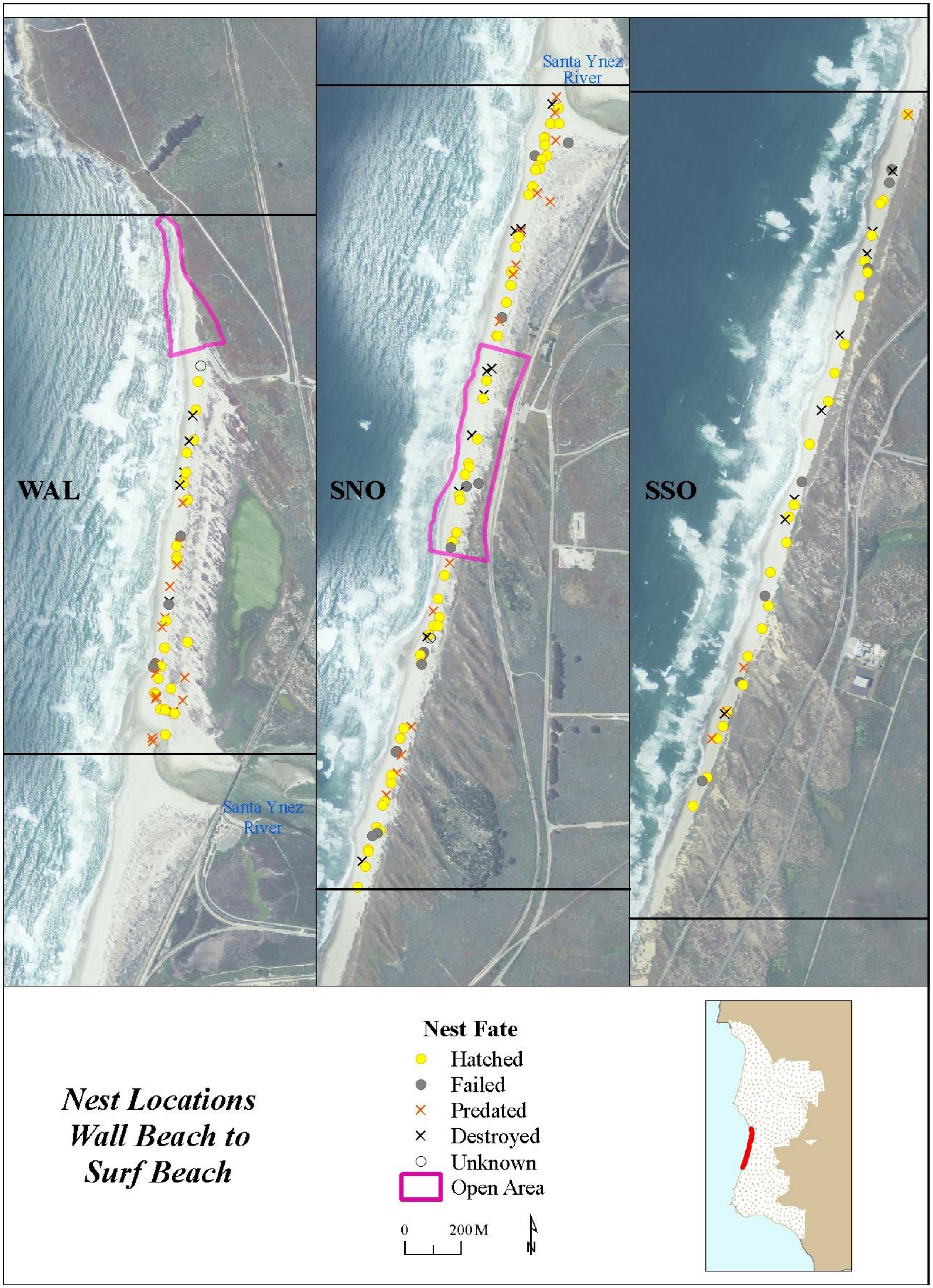
Table 9. Numbers of broods banded and fledged one chick per beach sector in 2013.

Beach Sector	Broods Banded	Broods Fledging at Least One Chick	Percent Fledging at Least One Chick
North Beaches			
Minuteman	2	2	100%
Shuman	3	1	33%
San Antonio	22	19	86%
Total North Beaches	***27***	***22***	***81%***
Purisima Beaches			
Purisima North	2	2	100%
Purisima Colony	0	0	0%
Total Purisima Beaches	***2***	***2***	***100%***
South Beaches			
Wall	11	6	55%
Surf North	12	8	67%
Surf South	7	5	71%
Total South Beaches	***30***	***19***	***63%***
TOTAL VAFB	**59**	**43**	**73%**

Appendix E: Maps of Nest Locations and Nest Fates on VAFB Beaches in 2013




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


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