Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2014

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

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Table of Contents

Acknowledgements **iii**

Executive Summary **1**

Chapter 1: Monitoring and Management of Least Terns **4**

List of Tables 5
List of Figures 6
Introduction 8
Methods 13
Results 16
Discussion 24
Management Recommendations 27
Literature Cited 29
Tables 31
Figures 37

Chapter 2: Monitoring and Management of Snowy Plovers **48**

List of Tables 49
List of Figures 50
Introduction 53
Methods 59
Results 65
Discussion 77
Management Recommendations 85
Literature Cited 86
Tables 90
Figures 97

Appendix A: Determining Snowy Plover Nest Fates **120**
Appendix B: Observations of Banded Plover Adults **122**
Appendix C: Band Combinations for Plover Chicks Banded in 2013 **128**
Appendix D: Detailed Snowy Plover Data Summaries **131**
Appendix E: Maps of Snowy Plover Nest Locations **139**

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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 2014. This report summarizes least tern and snowy plover monitoring results from the 2014 breeding season within the context of VAFB's approximately 21-year time series for both species.

California Least Tern

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 6 May, which is similar to historic arrival dates and earlier than what has been observed in recent years (2005-2013). Adult colony attendance increased quickly and then gradually decreased through the season, likely a result of the terns foraging farther from the colony as the season progressed. Our foraging results show that least terns foraged farther south than they typically have in previous years and began foraging at the Santa Ynez River estuary in early July. We estimate the 2014 breeding population to be 17 pairs which is 14% larger than 2013 (15 pairs) and 44% smaller than the 20-year mean (30.6 pairs). As with 2013, the 2014 breeding season was one of the most productive seasons on record. Hatching success (73%) was well above the 20-year average (60%) and fledging success (67%) was the third highest on record. Overall breeding success (1.18 fledglings per breeding pair) was also the fourth 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 20-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 20-year mean since 2005 and, despite a small increase in 2014, is showing signs of a decreasing trend over the last four years (2011-2014). 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 (representing average oceanic conditions), with a brief warming period in 2012. Despite a developing El Niño event that produced anomalously warm water late in the season, rockfish persisted in the 2014 diet. If the El Niño event continues to develop and persists over the winter, we suspect that the 2015 breeding season will be less productive than has been observed in recent years.

Western Snowy Plover

The number of breeding snowy plovers observed and nests initiated in 2014 (205 and 427, respectively) was higher than the long term mean (adults = 228.6, nests = 308.4). Clutch hatch success was lower than the long term mean, while fledging success was the highest on record for South Beaches and lower than the long term mean for North Beaches. We attribute the low clutch hatch success in 2014 to higher predation rates compared to previous years. Predators accounted for 34% of nest losses in 2014 compared to 20% in 2013, 37% in 2012, and 52% in 2011. The increased nest predation in 2014 was largely due to coyotes. Due to effective raven management at VAFB, raven predation has decreased in recent years. Ravens took 18% of nests in 2011, 16% of nests in 2012, <1% of nests in 2013, and <4% in 2014.

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, 2014

List of Tables

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 2014.

Table 2: Summary of least tern breeding activity at the Purisima Point colony during the 2014 breeding season.

Table 3: Numbers of nests, eggs, chicks, and fledglings observed at VAFB from 1995 to 2014. Also shown are hatching success, fledging success, and breeding success from 1995 to 2014.

Table 4: Documented predation at the Purisima Point colony during the 2014 breeding season.

Table 5: Predators observed at the Purisima Point colony during the 2014 breeding season.

Table 6: Total number of predator visits (all species combined) per hour of researcher observation for the 2001-2014 breeding seasons.

Table 7: Documented events of disturbance at the Purisima Point colony during the 2014 breeding season.

Table 8: Diet composition (% frequency of occurrence) for least terns at the Purisima Point colony during three periods of the 2014 breeding season.

List of Figures

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 2008 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 2014

Figure 3: Location of permanent (teepee) and moveable (V-shaped) chick shelters during the 2014 season. Also shown are the locations of least tern nests initiated in 2014.

Figure 4: Breeding phenology of the Purisima Point colony during the 2013 and 2014 breeding seasons, including use of the Santa Ynez River mouth in 2014. Values shown are 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 2014.

Figure 6: Numbers of adult pairs and fledglings per pair at the Purisima Point colony, 1995 to 2014. Dashed lines show running 20-year mean (1995-2014) 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), 2013 (n=101), and 2014 (n=81). See Table 8 for a list of all prey taken in 2012.

Figure 8: Reproductive success (fledglings per pair) versus percent occurrence of a) anchovy, b) rockfish, and c) anchovy and rockfish combined in the Purisima Point least tern diet. Regression line shows significant linear relationship between reproductive success and occurrence of anchovy and rockfish.

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 2014.

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.

List of Figures continued

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).

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)**.** The Monterey/Conception faunal zone portion of the California coastline experiences exceptionally strong, but highly variable upwelling events (Wing *et al.* 1998, Bograd *et al.* 2000). Thus, there is much interannual fluctuation in biological productivity and food web structure, with resulting fluctuations in the size and reproductive performance of breeding seabird populations (Boekelheide and Ainley 1989, Ainley *et al.* 1994, Ainley *et al.* 1995).

Historically, least terns have bred at various locations along the north VAFB coastline from San Antonio Creek to the Santa Ynez River estuary, an area spanning 10 km (Figure 1). Since 1978, least terns have used the Purisima Point colony site on a regular basis (Schultz and Applegate 2000). No data were collected on least tern breeding efforts at VAFB prior to 1978. In addition to the Purisima Point colony, least

terns have bred at the Beach 2 colony (see Figure 1) during six breeding seasons between 1990 and 2003 with populations ranging from one to 15 pairs.

The Purisima Point colony consists of sparsely vegetated dune habitat atop a coastal bluff. The historic least tern breeding area is surrounded by electric fences along its northern, eastern, and southern boundaries (see Figure 3). The colony has been characterized by a small population (especially when considering the amount of available breeding habitat) and variable annual productivity (Robinette and Howar 2009). The mean ± standard deviation (SD) number of breeding pairs per year at Purisima Point from 1995 to 2014 was 30.60 ± 20.02 (n=20) with a peak of 79 pairs in 2003. The mean ± SD productivity from 1995 to 2014 was 0.60 ± 0.46 fledglings per pair (n=20) 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 below the 20-year average. The period from 2003 to 2006 was again lower than the 20-year average (ranging from 0.0 to 0.4 fledglings/pair). This three year period had the worst productivity on record (<0.02 fledglings/pair); producing only one fledgling during the entire three year period. Another period of above average productivity has occurred since 2007 (ranging from 0.89 to 1.23 fledglings/ pair) with only one year of below average productivity (2011).

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

One of the most important factors regulating seabird colony productivity is local prey availability. Prey availability has been shown to affect coloniality (whether birds form large or small colonies), the timing of reproduction, clutch sizes, levels of egg abandonment, chick growth, and non-predator related chick mortality (Anderson and Gress 1984, Safina and Burger 1988, Pierotti and Annetti 1990, Massey *et al.* 1992,

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

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

An important goal of the VAFB natural resource program is to promote the growth of the least tern colony at Purisima Point while maintaining the health of the surrounding ecosystem. Non-lethal predator management is used whenever possible. To accomplish this, VAFB established a least tern management team that included members

from two organizations in 2014: ManTech SRS Technologies Inc. (ManTech) and Point Blue Conservation Science (Point Blue). ManTech was responsible for mammalian and avian predator management. The first line of defense against mammalian predators at VAFB is a series of fences erected around the least tern management area. Five-foot tall electric fences form the northern, southern, and eastern boundaries of the management area, with an additional six-foot tall chain link fence along the eastern boundary. Fences are not needed along the western boundary of the colony as this section of coastline consists of coastal bluffs inaccessible to terrestrial mammals. Funding for the management team to maintain these fences throughout the breeding season is provided by VAFB. Avian predator management includes monitoring, trapping and removal of corvids, raptors and owls that were determined to be a threat to the least tern colony. All members of the management team monitor avian predators while at the colony. Point Blue was subcontracted through 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). 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 VAFB's monitoring program is not only to record annual population and productivity, but to present this information in the context of local prey conditions and predator management efforts. This additional information is essential for effective management of the least tern colony. Therefore, this report includes data on diet and foraging behavior. 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

The Purisima Point least tern colony is bordered by a coastal bluff to the west and electric fences on the north, east, and south. All three fences were electrified on or before 15 April. Once the fence was electrified, the voltage was checked during every visit to the colony. This ensured that voltage was measured at various times throughout the day. Special attention was given to voltage readings taken at dawn as voltage tends decline overnight. Voltage was maintained at 3.0 kV or greater and on most days voltage was greater than 5.0 kV. Based on prior experience and recommendation of VAFB's fence contractor, 3.0 kV is recommended as the minimum voltage to exclude coyotes. In addition, Point Blue placed a total of 42 V-shaped chick shelters in areas where nesting occurred within the colony in 2011-2013. The V-shaped chick shelters do not require the use of fence posts. Rather, they are a simple design of two 2-foot long pieces of 2"x 8" wood nailed together at a right angle (see Figure 2). The result is a standalone triangle that lays low to the ground. As such, the new shelters have the risk of being buried by wind-blown sand and will need to be stored off-colony during winter months. Additionally, Point Blue repaired the existing 24 teepee-style shelters and installed an additional 21 for a total of 45 teepee shelters. Figure 3 shows the 2014 placement of the 42 V-shaped shelters and 45 teepee shelters. Shelters were placed mostly on the south and west colony in areas where shelters were used by chicks in 2012 and 2013. There were very few nests in the northern and eastern areas of the colony in those years and we did not find evidence that chicks were using shelters in these areas.

Site Monitoring

Monitoring was conducted in a manner to minimize disturbance or adverse effects to adult birds, nests, and chicks. From 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 76 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 14 times throughout the season. In addition, least tern activity was monitored at historic breeding sites. In 2014, all least tern nests were located at the Purisima Point colony.

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

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

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

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 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 (NOAA 2014a). (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 (JISAO 2014) website (http://jisao.washington.edu/pdo/). Values for SST Anomaly were calculated using SST data from the National Data Buoy Center buoy #46011 (NOAA 2014b). (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 2013 least terns have arrived during the second week of May. This recent trend was broken in 2014 with the first least terns observed on 6 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 2010-2013 ranged from 25 May to 3 June. Nest initiation in 2014 was within this range with the first nest observed on 27 May and the last nest initiated on 17 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 2014 to that in 2013. The 2014 breeding season initially showed characteristics of a productive year with early adult arrival and high colony attendance. However, as the season progressed, adult colony attendance gradually decreased rather than remaining stable through the incubation period as was observed in 2013. Nest initiation peaked during the week of 30 May and was more synchronous than nest initiation in 2013. In 2014, the majority of nests were initiated within a one week window between 23 and 30 May. Despite this, the chick rearing and fledging period was slightly more prolonged in 2014 than 2013.

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. Fledglings began dispersing to the estuary the week of 11 July at which time adult and fledgling numbers decreased at the colony. Numbers of adults and fledglings observed at the estuary peaked during the week of 11 July and then gradually decreased through early August. Adults and fledglings were initially observed roosting on the sand bar at the river mouth, but soon began roosting within the Surf North restoration area (see Chapter 2 for more information on the Surf North restoration project). The last least tern was observed at the Purisima Point colony on 25 July and at the estuary on 12 August (Table 1). This is the second season since 2004 that the terns used the estuary for an extended period before migrating south. The most recent year of prolonged estuary use was 2013 when the least terns stayed at the river mouth for a little over one month. In 2001 and 2004, adults used the estuary from the first week of July to the first week of August. Least terns briefly used the estuary in 2008 (six days) and 2009 (three days). The coastal sandbar at the river mouth often breaks prior to the breeding season, allowing the estuary to drain, though this is not a consistent phenomenon each year. In 2013 and

2014, the coastal sandbar did not break and the estuary was full throughout the breeding season of both years. This may have contributed to an abundance of fish available to the least terns within the estuary in both years.

Population Dynamics

We documented a total of 21 nests at the Purisima Point colony during the 2014 breeding season (Table 2). Thirteen nests hatched all eggs, four were depredated, one hatched one egg but had one non-viable egg, one hatched one egg but had one chick die while hatching, one hatched all eggs but had one dead chick (cause unknown), and one incubated past the expected hatch date but never hatched. We suspect that each of the four breeding pairs with depredated nests attempted a second nest. 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 to 12 days for chick loss. They also noted that least terns tend to renest in close proximity to their failed nest site, but did not define close proximity. The four depredated nests were taken by coyote on 6 June and the last four nest initations of the season occurred between 13 and 17 June, which was seven to nine days after the predation event. Thus, we estimate the 2014 breeding population to be 17 breeding pairs. This represents a 14% increase in population compared to 2013 and a 44% decrease below the 20-year mean population (31 pairs). As with 2013, most nests in 2014 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 2014.

Breeding Biology

Egg Production. We documented a total of 41 eggs at the Purisima Point colony in 2014 (Table 2). Our documented number of eggs is 37% higher than the total eggs produced for 15 nests in 2013. The mean ± SE clutch size for 2014 was 1.95 ± 0.13 (n = 21). Since 2007, mean clutch size at the Purisima Point colony has been relatively stable, staying very close to 2.0 eggs per nest in all years but 2012 when the mean was 1.78 eggs

per nest (Figure 5). In contrast, the period between 2001 and 2007 showed high variability in mean clutch, ranging from 1.0 eggs per nest to 2.2 eggs per nest. Mean clutch size in 2014 was slightly above the 14-year (2001-2014) of 1.83 eggs per nest.

Hatching Success. Of the 21 nests initiated in 2014, 16 successfully hatched at least one chick. Of the 41 eggs documented in 2014, we confirmed 25 hatched (Table 2). We assume five additional eggs hatched based on the incubation period and lack of evidence to suggest they were depredated. Eight eggs were depredated by a coyote, two failed to hatch, and one chick died while hatching. The overall hatching success in 2014 was 73%, which is high relative to the hatching success values recorded since 1996 and the mean for 1995-2014 (Table 3). Hatching success has ranged from 0% in 2004 and 2006 to 94% in 2001 and 2008. Mean hatching success from 1996-2014 was 60%. Hatching success in 2014 was 12% lower than that in 2013.

Fledging Success. Of the 30 chicks that hatched in 2014, one was found dead of unknown causes (Table 2) and an additional nine were unaccounted for. We estimated 20 of the 30 chicks fledged; we observed a maximum of 13 fledglings on 7 July and were able to follow seven additional chicks to fledging age after this date. The fledgling success rate for 2014 was 67%. This fledging rate is third highest rate on record, with 2013 being the second highest at 76% and 2007 being the highest at 80% (Table 3). The overall breeding success (% of total eggs that fledged) for 2014 was 49% (Table 2). The number of fledglings produced per breeding pair in 2014 was 1.18 (Table 2).

Interannual Productivity and Population Growth

The running 20-year mean productivity for 1995-2014 is 0.60 fledglings per adult breeding pair. With the exception of 2011 and 2012, productivity in recent years (2007-2014) has been well above this mean, marking a strong deviation from the prior three years when virtually no fledglings were produced (Figure 6). The 2007-2014 period is the most productive on record for Purisima Point, with six of the eight years showing above average productivity. The Purisima Point colony has a history of variable productivity, fluctuating at or above the mean from 1998-2003 and well below the mean prior to 1998 and after 2003. Productivity in 2011 was well below average, marking the

first time productivity had been below average since 2006. Productivity in 2013 and 2014 was well above average.

Conversely, the 2013 and 2014 breeding populations were 51% and 44% smaller than the 20-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 20-year mean and has shown an overall decline since 2010.

Predation and Disturbances

There was only one documented instance of predation in 2014 (Table 4). A coyote breached the electric fence overnight or early in the morning on 6 June and took four nests with a total of eight eggs. There was no evidence of chicks, fledglings, or adults taken by predators in 2014. 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, there were no predator sightings or signs of predators within areas used by chicks to indicate that predators were an issue in 2014. 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). We also did not find any adult or fledgling remains on the colony in 2014 as we have seen in the past when predators were known to take these age classes.

The three most persistent predators observed in the vicinity of the Purisima Point colony in 2014 were Western gulls, coyotes, and greater roadrunners (*Geococcyx californianus*)(Table 5). This was the first year that roadrunners have been documented at the colony. While we have never documented take by roadrunners, they are potential egg and chick predators. All observations of roadrunners were outside the least tern nesting area. There were large numbers of Western gulls roosting on the northwest and southwest slopes of the colony in 2014. 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 2014 and we do not suspect any predation by gulls. With the exception of five colony entrances, the majority of coyote tracks occurred outside the nesting area. Coyotes were able to take eggs during only one of the colony entrances. Historically, great horned owls have been one of the more persistent predators observed at the colony and have been responsible for much of the depredation on adult terns (Robinette and Howar 2009). Predator management personnel respond quickly to reports of owls and owl tracks at the colony and have been successful in keeping depredation by owls to a minimum. In 2014, we observed great horned owl tracks on two occasions and there was no evidence of adult or fledgling mortality. Therefore, owls were not trapped in 2014. All other predators were observed less than five times each. Overall, the number of predators sighted per hour of observation in 2014 was lower than observed in 2013, but higher than observed in recent years (Table 6). The high rate of predator observations in both years was due to groups of 20-200 Western gulls roosting on the west slope of the colony. Additionally, the three Western gull nests initiated along the coastal bluff were taken during the 6 June coyote incident. After this, the breeding gulls spent more time roosting on the west slope of the colony than they have in previous years.

There were no documented cases of human-caused disturbance to the Purisima Point colony in 2014. We defined a disturbance as any event that caused adult birds to take to the air. As in past years, turkey vultures (*Cathartes aura*) flying over the colony caused most of the documented disturbance in 2014 (Table 7). There were a small number of disturbances by great blue herons (*Ardea herodias*), Western gulls, peregrine falcons, and an osprey (*Pandion haliaetus*).

Diet and Foraging

Table 8 shows the percent frequency of occurrence for all prey taken in 2014. There was a total of 11 different prey types taken by least terns at the Purisima Point colony in 2014. Greenling (Family Hexagrammidae) and rockfish dominated the diet early in the 2014 season, and rockfish occurred in moderate frequency throughout the remainder of the season. Northern anchovy increased in occurrence late in the season, but showed an overall low occurrence for the year. Similar to 2013, Western

mosquitofish (*Gambusia affinis*) appeared in the diet late in the season and corresponded to the time we began observing least terns foraging at the Santa Ynez River estuary. Mosquitofish are found in freshwater and brackish habitats. Silverside smelt (Family Atherinopsidae) increased dramatically and dominated the mid-season diet, but then decreased rapidly in the late season. Overall, the 2014 diet was dominated by rockfish, with silverside smelt 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 2014 diet showed signs of a productive year, with rockfish persisting throughout the season and few other prey types making smaller 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). In past analyses, we have found that reproductive success is positively correlated with both anchovy and rockfish occurrence, but only if the analyses are performed without explainable outliers (see Robinette et al. 2013). However, with the addition of 2014 data, these relationships are becoming more difficult to detect. A major part of the issue is that least terns appear to switch from anchovy to rockfish in years where anchovies are not abundance and vice versa. Thus, it is possible to see low anchovy or rockfish in the diet during years with high fledging success. With the 2014 data, there is no significant relationship when analyzing rockfish and anchovy separately (Anchovy: $F = 1.375$, $df = 1,12$, $p = 0.264$, $R^2 = 0.653$; Rockfish: $F = 0.687$, $df = 1,12$, $R^2 = 0.054$). However, when anchovy and rockfish occurrences are combined, there is a positive relationship with least tern reproductive success ($F = 5.787$, $df = 1,12$, $p = 0.033$, $R^2 = 0.325$). Thus, we still

maintain that both anchovy and rockfish are important drivers of reproductive success at the Purisima Point least tern colony. Additionally, the availability of mosquitofish at the Santa Ynez River estuary in 2013 and 2014 may have provided a buffer against a lower occurrence of anchovy and rockfish later in the season; but the moderate occurrence of rockfish during the late season of both years illustrates that it is still an important resource even when alternative prey are present.

Figure 9 shows the annual foraging rates at our nearshore foraging stations from 2007 to 2014. Foraging rates adjacent to the Purisima Point colony were highest in 2009 and lowest in 2011. All other years are similar in terms of foraging rates. However, 2013 and 2014 mark the first years we have observed least terns foraging at Lompoc Landing, the site just north of the Santa Ynez River mouth. This, in addition to our observations of foraging at the Santa Ynez River estuary, indicates that the terns were spreading out more to forage in these years. Together with the diet analysis, these data suggest terns were relying on nearshore waters adjacent to the colony for prey. As rockfish and silverside smelt 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 tern 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 showed a significant positive relationship 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: $F = 37.83$, $df = 1,8$, $p < 0.001$, $R^2 = 0.825$; PDO: $F = 15.053$, $df = 1,8$, $p = 0.005$, $R^2 = 0.825$). 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 showed a positive relationship with SST anomaly averaged over the spring-summer after the rockfish spawning period, but this relationship was marginally significant ($F = 3.541$, $df = 1,12$, $p = 0.084$, $R^2 = 0.228$). The addition of 2014 data obscured this relationship. In 2014, an ensuing El Niño resulted in the warmest waters in our 2001-2014 time series. However, this warm water developed late in the season and likely had less of an impact on juvenile rockfish survival than it would had it developed early in the spring. 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 2014 breeding season produced results similar to those observed in 2013. It 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 (73%) was well above the 20-year average (60%) and fledging success (67%) was the third highest on record. Overall breeding success (1.18 fledglings per breeding pair) was also the fourth highest on record. The breeding

population was below average (31 breeding pairs) for the third time since 2008 and has shown an overall decrease since 2010.

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 20-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 20-year mean and appears to be decreasing in recent years (2010-2014).

Results from 2011 through 2014 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 from June 2010 through December 2013. 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. Similar data have not yet been reported for 2014.

In past years, reproductive success at the Purisima Point colony has been driven primarily by the occurrence of rockfish and anchovy in the diet (Robinette and Howar 2010). Since 2008, the diet has been dominated by juvenile rockfish. Juvenile rockfish are small and have a low fat content compared to other forage fishes like anchovies (Iverson et al. 2002). However, our results suggest that rockfish can be a suitable prey when least terns do not have to expend much energy to forage for them. In years when rockfish have a high occurrence in the diet, high rates of foraging in the kelp beds at the Purisima South and Pockets Cove foraging plots have been observed. This was especially true in 2009 when there were no anchovy in the least tern diet and least terns showed the highest foraging rates at our study plots. In years when anchovies are present in the diet, foraging rates at our plots are lower (Robinette and Howar 2010). In 2013 and 2014, rockfish showed a relatively high occurrence in the diet. Foraging rates were highest immediately adjacent to the colony, the least terns were also observed foraging at plots south of the colony. Additionally, the least 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 rockfish became less abundant late in the season when waters off the coast were beginning to warm. 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 or 2014 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 the avian predator sightings were within this area. Additionally, there were several coyote crossings across the north fence, adjacent to this area in 2014. We suspect that the increased vegetation has provided habitat for rodents and this may be attracting avian predators and coytes to the area. Additionally, 2014 marks the fourth consecutive year that the Western 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 2014, it has been in the past. Furthermore, we do not have a good understanding of what happens to chicks during years of low reproductive success. For example, 81% of the hatched chicks at the Purisima Point colony in 2011 were unaccounted for and we suspect some were depredated. VAFB has initiated a study of Western gull diet at breeding sites throughout VAFB. We recommend continuing this monitoring on an annual basis. Additionally, diet monitoring for should be initiated for peregrine falcons breeding on VAFB where possible. Having knowledge of what predators around the colony are eating will give insight as to whether chicks are disappearing due to predation versus dying of starvation.

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 has deterred

coyotes from attempting to dig under the fence. We support continued effort to prevent these mammalian predators from digging under the fence.

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, such as the Western snowy plover, utilizing the coast.

7) An analysis of potential launch impacts should be conducted using VAFB's now 20-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 2014.

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

Table 2: Summary of least tern breeding activity at the Purisima Point colony during the 2014 breeding season.

Population	**Estimated # of Pairs**	**17**
	Adults Depredated	0
	Adults Dead Cause Unknown	0
Nests	**Total Nests**	**21**
	Hatched all eggs	13
	Abandoned Before Hatch Date	0
	Incubated Past Hatch Date	1
	Hatched, but had ≥ 1 Non-viable Egg	1
	Hatched, but had ≥ 1 Chick Die While Hatching	
	Depredated	4
	Chicks Died/Cause Unknown	1
Eggs	**Total Eggs**	**41**
	Confirmed Hatched	25
	Assumed Hatched	30
	Chick Died While Hatching	1
	Depredated	8
	Dead Eggs	2
Chicks	**Total Chicks**	**30**
	Hatching Success	73%
	Depredated	0
	Died of Unknown Cause	1
Fledglings	**Total Fledglings**	**20**
	Fledging Success	67%
	Depredated	0
	Died of Unknown Cause	0
Breeding Success	**% of Total Eggs Fledged**	49%
	Fledglings per Adult Pair	1.18

Table 3: 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 2014.

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

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

Table 4: Documented predation at the Purisima Point colony during the 2014 breeding season.

Date	Predator	Predated	Description
6/6	Coyote	8 Eggs	On 6 June, 4 nests were taken by a coyote that was able to breach the electric fence. Each nest had a clutch of 2 eggs. Coyote tracks were discovered leading to empty scrapes where complete clutches had previously been recorded.

Table 5: Predators observed at the Purisima Point colony during the 2014 breeding season.

Predator	# Observed in Colony Area	# Observed Inside Colony
Western Gull	170	9
Coyote	36	5
Greater Roadrunner	15	0
Loggerhead Shrike	4	0
American Kestrel	3	0
Bobcat	3	0
Great Blue Heron	3	3
Feral Pig	3	1
Great Horned Owl	2	1
Peregrine Falcon	2	2
Red-tailed Hawk	2	0
Common Raven	1	0
Unidentified Fox	1	1

* There were three Western gull (*Larus occidentalis*) nests adjacent to the colony in 2014 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. All three nests were taken by coyotes in 2014 and the breeding gulls appeared to spend more time roosting on the west slope of the colony than has been observed in previous years.

Table 6: Total number of predator visits (all species combined) per hour of researcher observation for the 2001-2014 breeding seasons.

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

Table 7: Documented events of disturbance at the Purisima Point colony during the 2014 breeding season.

Source	**# of Documented Occurrences**
Turkey Vulture	8
Great Blue Heron	3
Western Gull	3
Peregrine Falcon	2
Osprey	1

Table 8: Diet composition (% frequency of occurrence) for least terns at the Purisima Point colony during five periods of the 2014 breeding season.

Prey Taxon	**27 May**	**6 June**	**20 June**	**9 July**	**All Periods Combined**
Anchovy (*Engraulis mordax*)	8	4	13	13	6
Rockfish (*Sebastes sp.*)	28	68	38	33	35
Unidentified Fish Larvae	4	24	6	13	11
Greenling (Family Hexagrammidae)	64	32	0	0	10
Cabezon (*Scorpaenichthys marmoratus*)	24	16	0	7	6
Silverside Smelt (Family Atherinopsidae)	0	12	75	13	21
Surfperch (Family Embiotocidae)	4	0	6	7	2
Lantern Fishes (Family Myctophidae)	4	20	6	7	10
Unidentified Squid (Order Teuthida)	4	0	0	0	1
Western Mosquitofish (*Gambusia affinis*)	0	0	0	73	14
Unidentified Arthropod (Phylum Arthropoda)	4	4	0	13	5
Sample size (n)	*25*	*25*	*16*	*15*	*81*

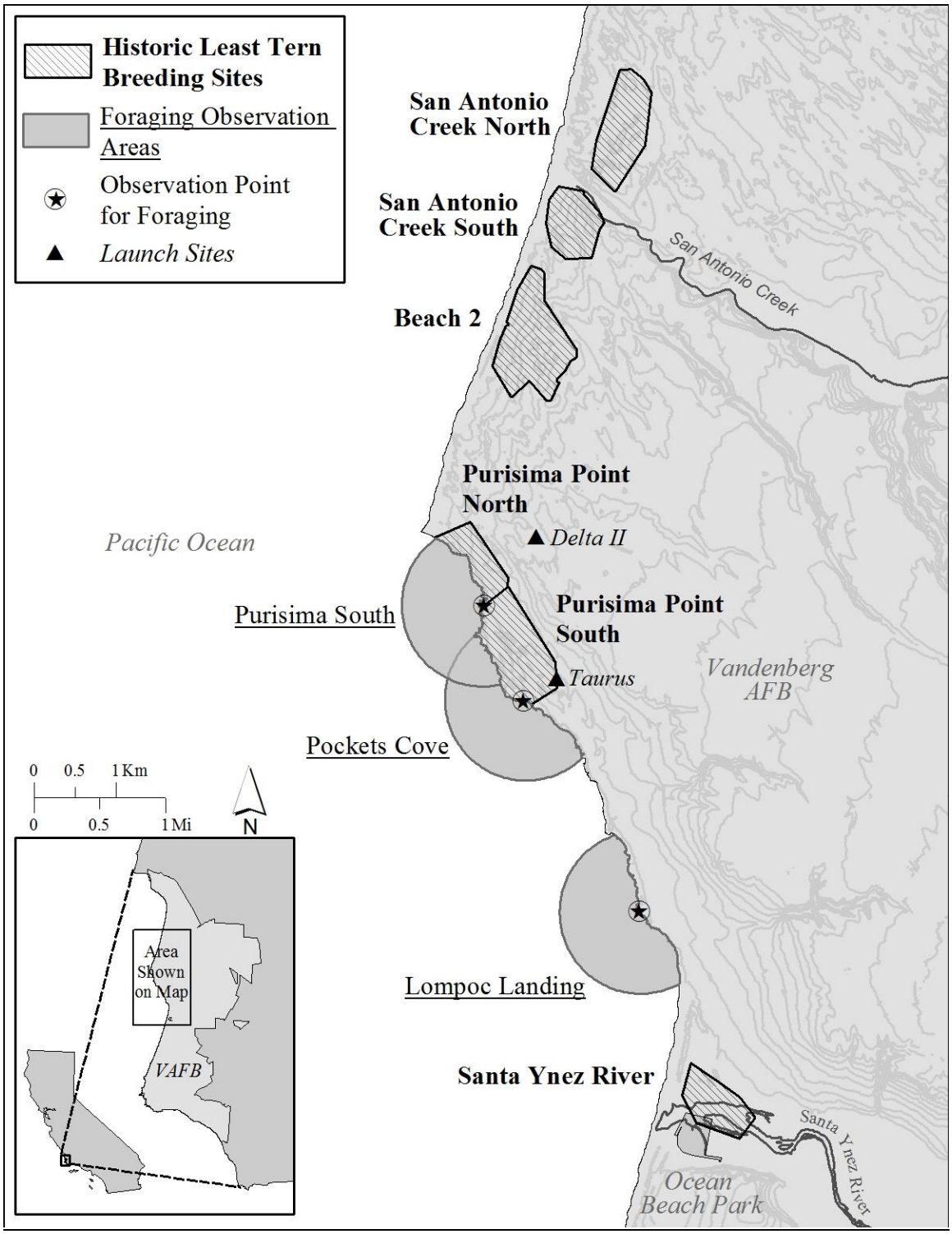

Figure 1: Map of the current least tern colony at Purisima Point, VAFB. Also included are the locations of historic breeding colonies at VAFB (San Antonio Creek North, San Antonio Creek South, Beach 2, and Santa Ynez River) and observation points for foraging observations made during the 2013 breeding 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 2014.

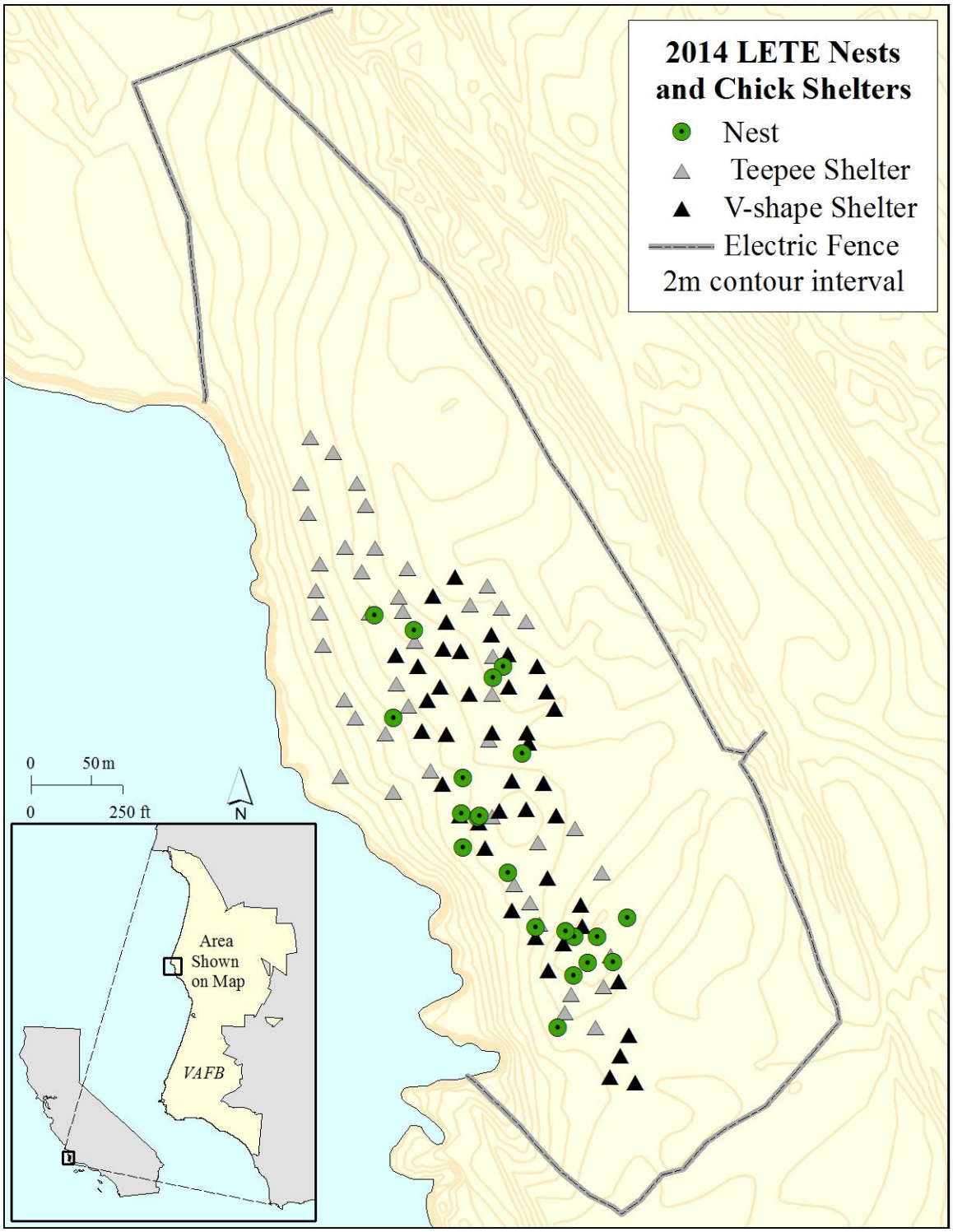

Figure 3. Location of permanent (Teepee) and moveable (V-shape) chick shelters during the 2014 breeding season. Also shown are the locations of Least Tern nests initiated in 2014.

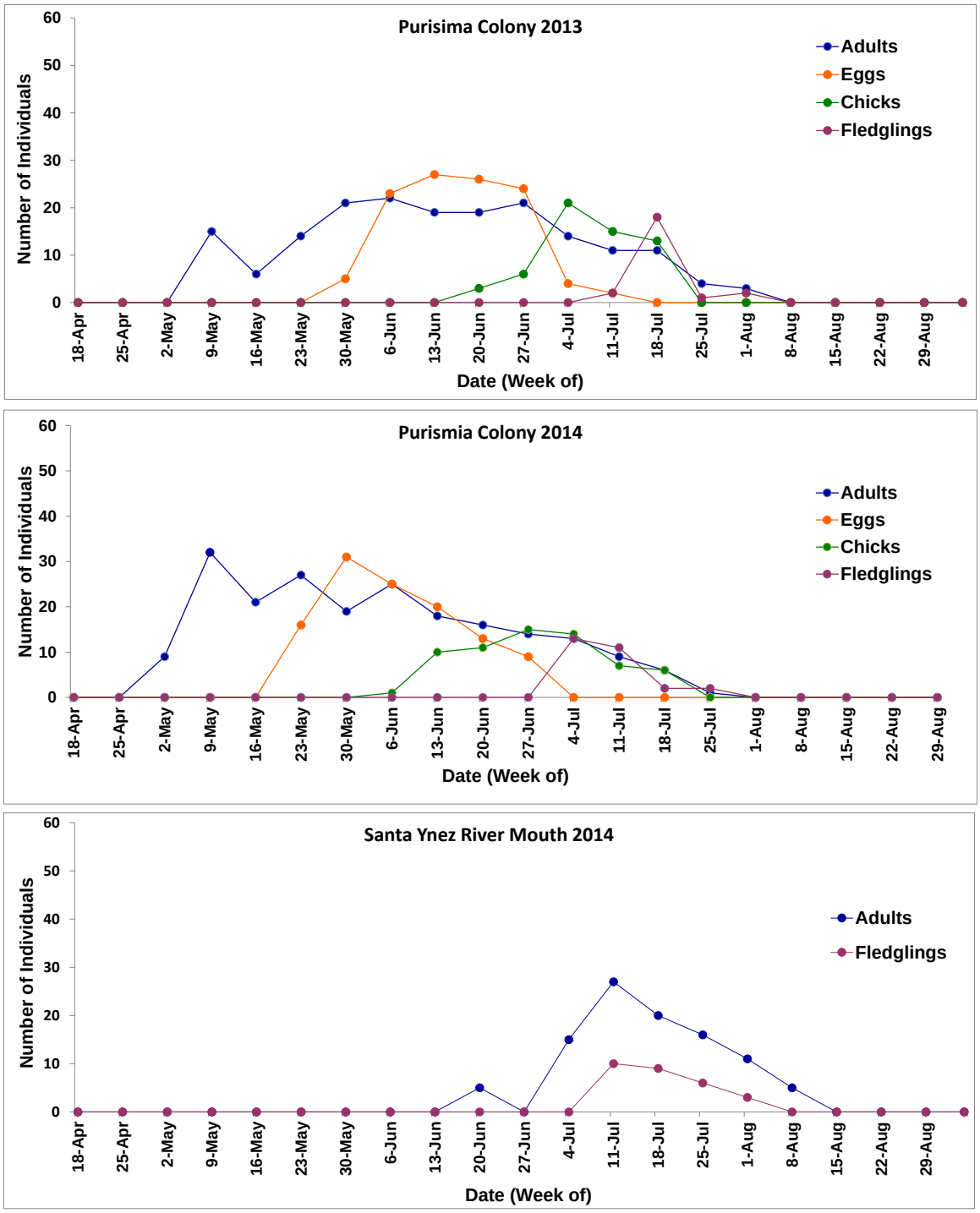

Figure 4: Breeding phenology for the Purisima Point colony during the 2013 and 2014 breeding season, including use of the Santa Ynez River mouth in 2014. Values shown are the maximum number of individuals observed during a given week.

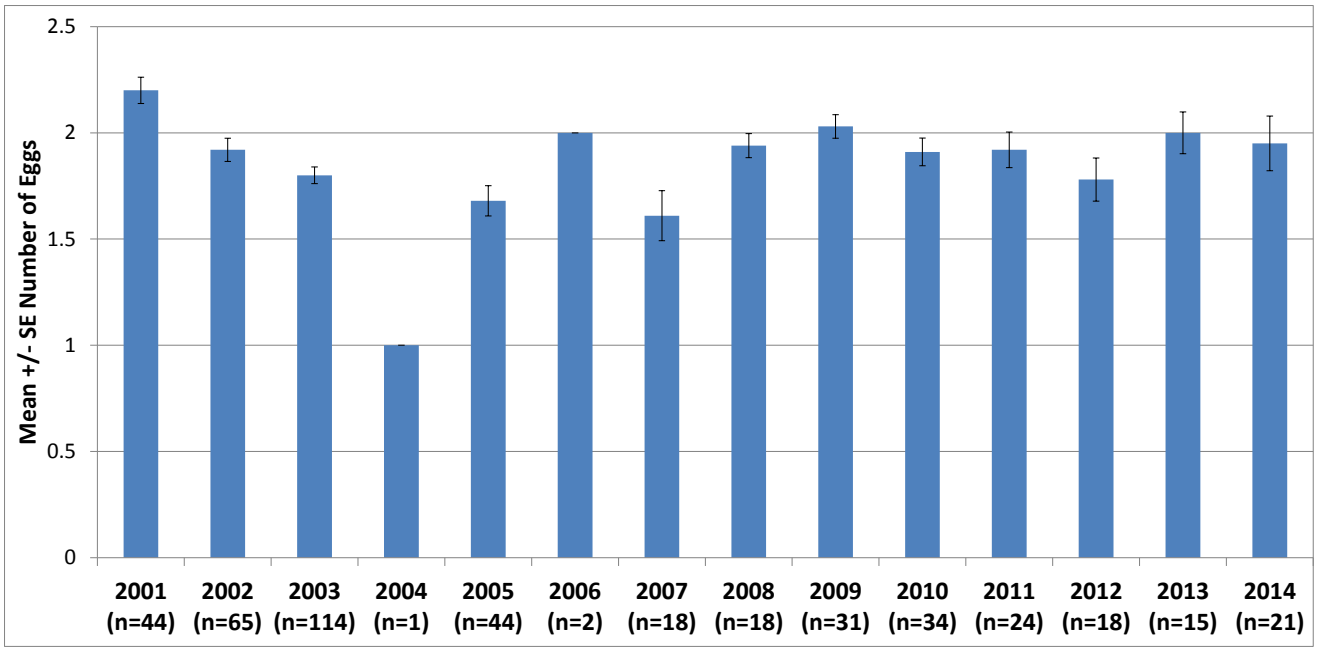

Figure 5: Mean ± SE clutch sizes for all nest attempts at the Purisima Point colony from 2001 to 2014.

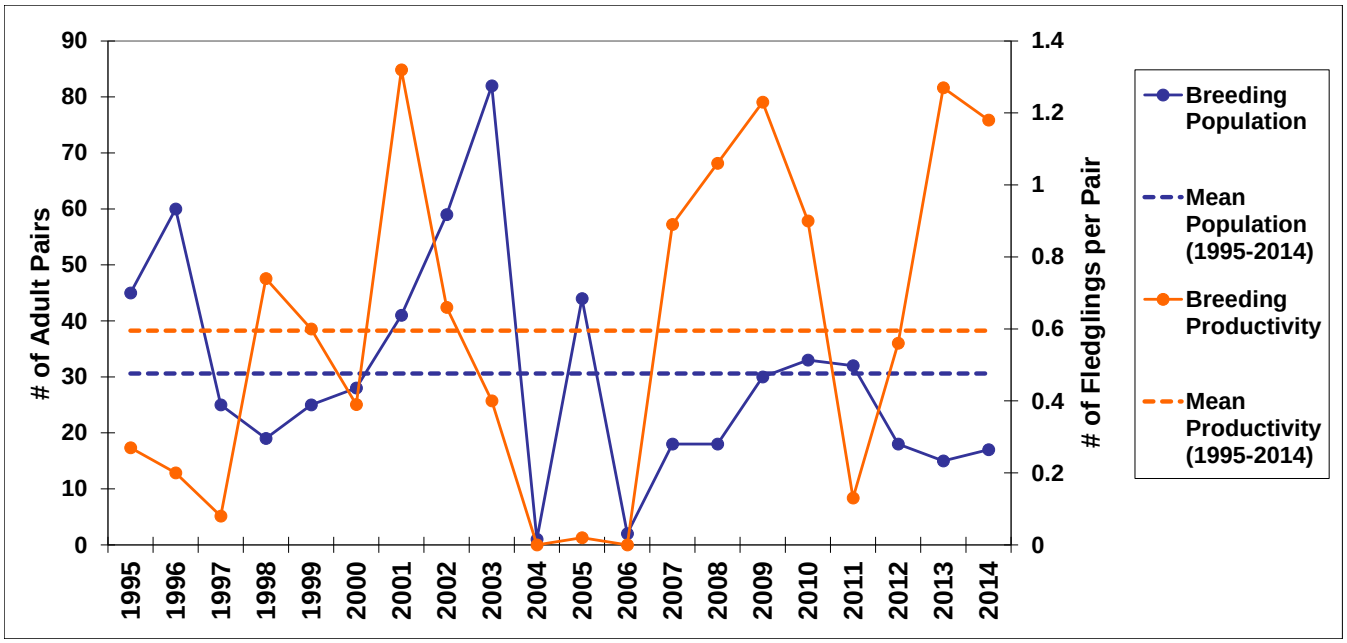

Figure 6: Numbers of adult pairs and fledglings per pair at the Purisima Point colony, 1995 to 2014. Dashed lines show running 20-year mean (1995-2014) for each variable.

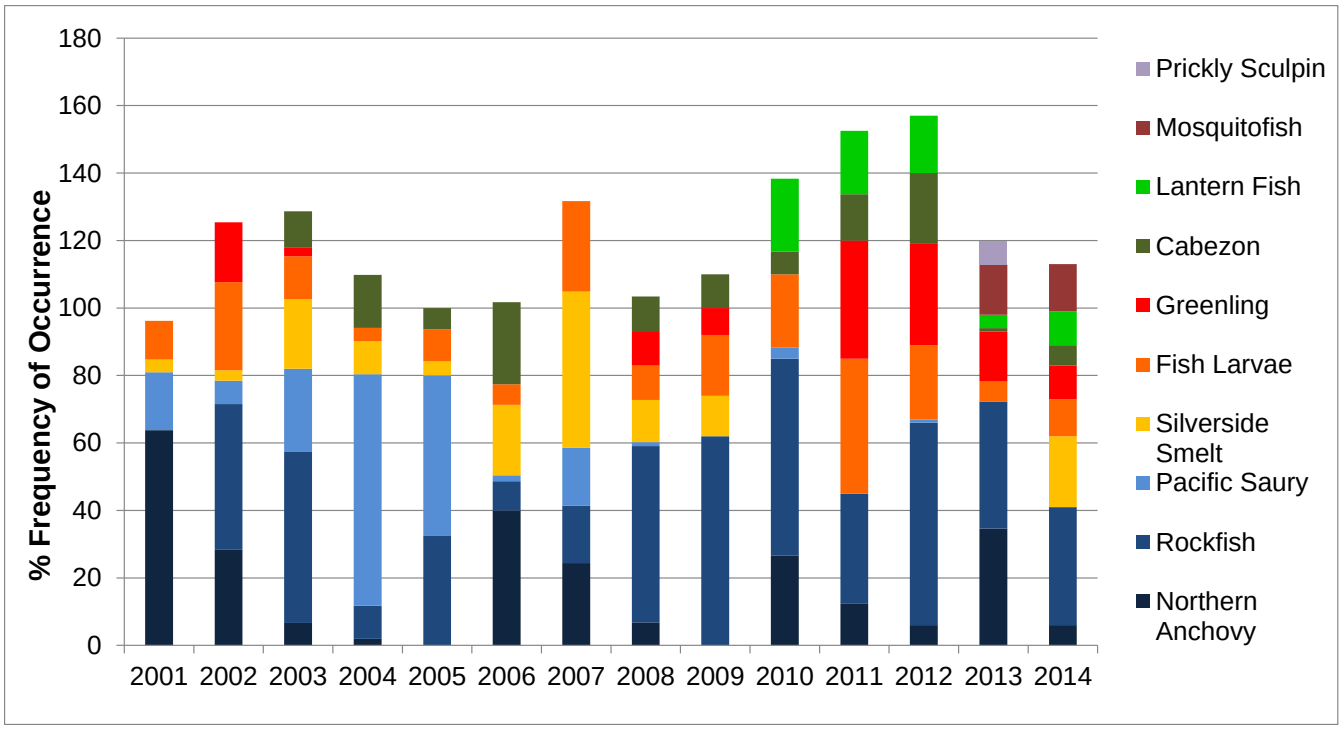

Figure 7: Percent occurrence of major prey in all feces collected from the Purisima Point colony in 2001 (n=105), 2002 (n=120), 2003 (n=154), 2004 (n=51), 2005 (n=95), 2006 (n=115), 2007 (n=41), 2008 (n=88), 2009 (n=50), 2010 (n=60), 2011 (n=80), 2012 (n=100), 2013 (n=101), 2014 (n=81). See Table 8 for a list of all prey taken in 2014.

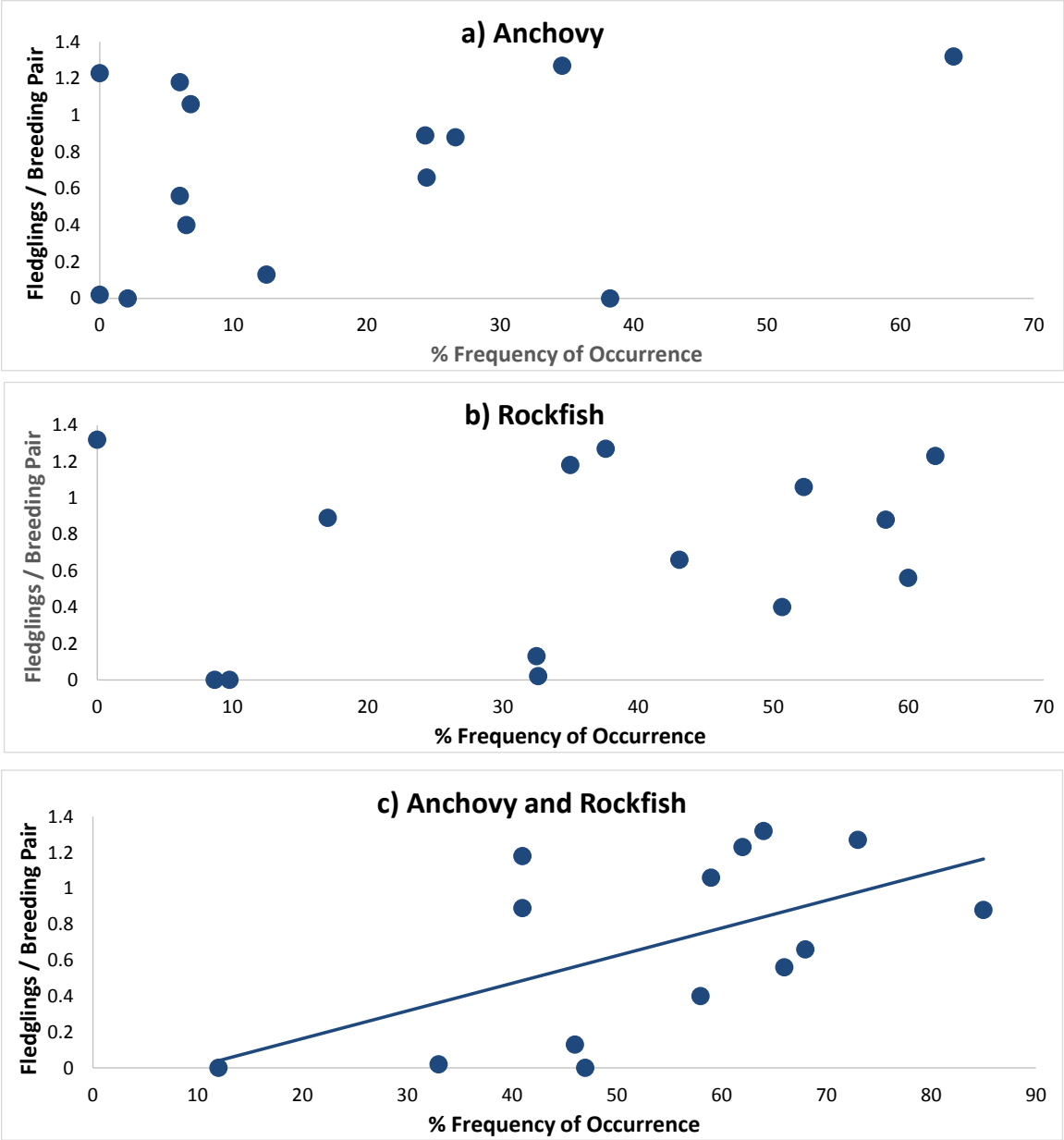

Figure 8: Reproductive success (fledglings per pair) versus percent occurrence of a) anchovy, b) rockfish, and c) anchovy and rockfish combined in the Purisima Point least tern diet. Regression line shows significant linear relationship between reproductive success and occurrence of anchovy and rockfish.

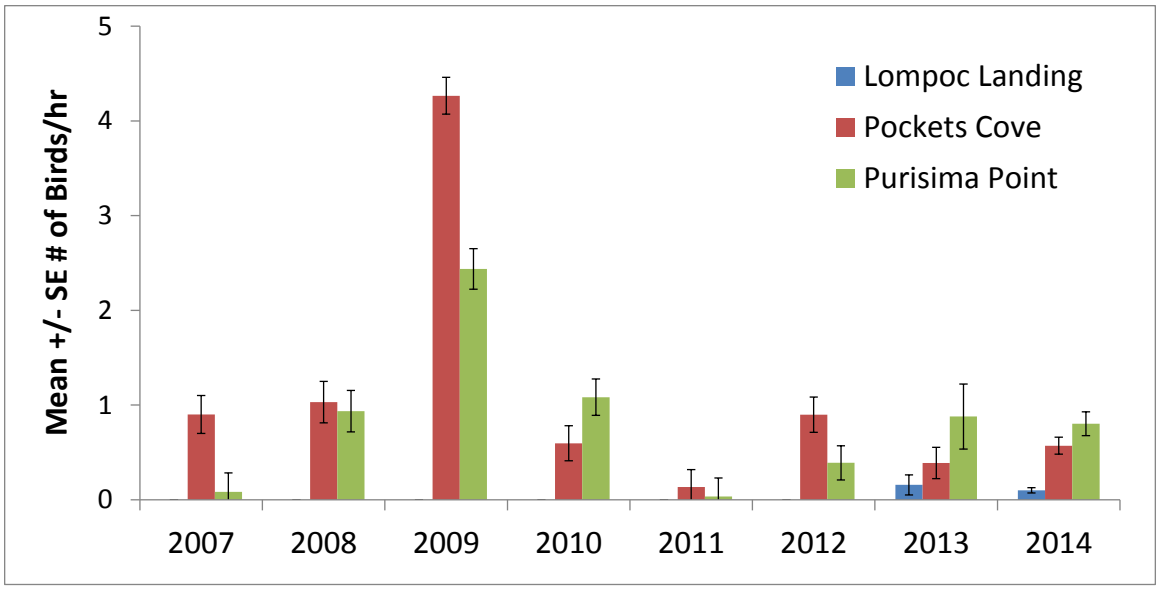

Figure 9: Mean +/- SE number of least terns foraging per 15 minutes of observation at Pockets Cove and Purisima South foraging areas (see Figure 1 map) from 2007 to 2014.

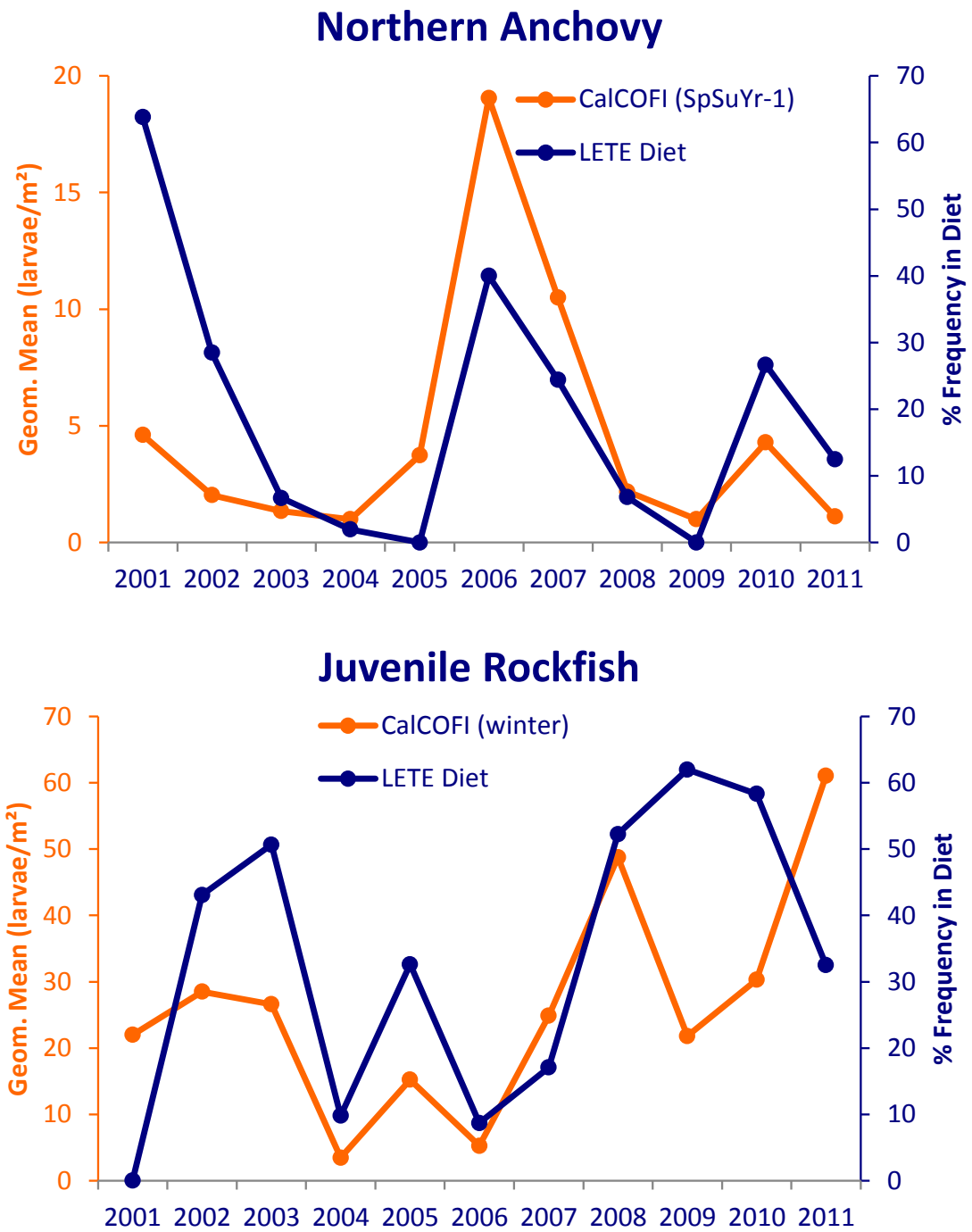

Figure 10: Comparison of annual occurrence of northern anchovy and rockfish in the Purisima Point Least Tern diet to nearshore larval abundance data from CalCOFI lines 77 and 80. Dietary anchovy is compared to larval abundance from the spring-summer spawning period prior to diet analysis and dietary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

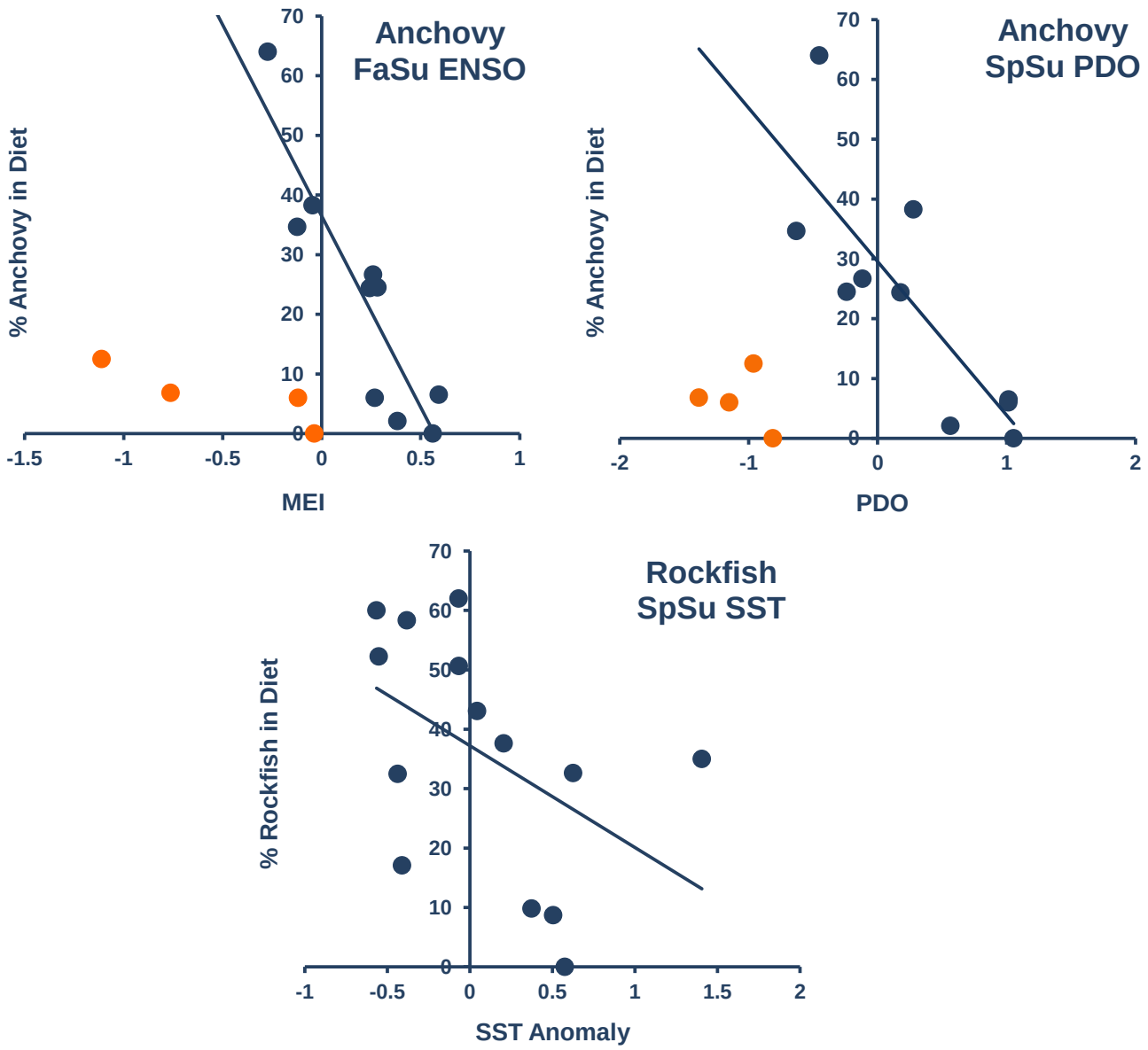

Figure 11: Percent anchovy (top graphs) and rockfish (bottom graph) in the Purisima Point least tern diet versus three oceanographic indices: ENSO, PDO, and SST anomaly. ENSO values were averaged over the fall-summer (FaSU), PDO values were averaged over the spring-summer (SpSu), and SST anomalies were 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, 2014

List of Tables

Table 1. Summary of population and breeding metrics for the Western snowy plover population on VAFB in 2013 and 2014. Also shown is the percent change for each metric in 2014 when compared to 2013.

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), 2014. 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.

Table 3. Number of plovers banded as chicks at VAFB in all years since 1995. Also shown are the numbers of chicks banded at VAFB that were observed as adults at VAFB in 2014. 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.

Table 4. Fates of nests initiated within areas open to recreational activity on Minuteman (MIN), Wall (WAL), and Surf, North (SNO) beach sectors in 2014.

Table 5. Historic egg laying, chick hatching, and fledging periods for snowy plovers at VAFB. Data for egg laying periods were available for 1995-2014. Data for chick hatching periods were available for 2002-2014 (with the exception of 2010). Data for fledging periods was available for 2009 and 2014.

Table 6. Number and percent of known fate snowy plover nests taken by predators at VAFB in 2014.

Table 7. Fates of 40 nests monitored with cameras on VAFB in 2014, including the dates for which the camera was recording and the date on which the nest's fate was captured (Fate Date).

Table 8. Results of Tukey's post hoc tests on mean wrack values among beach sectors. Significant differences are italicized in red.

Table 9. Number of beach violations per beach sector on VAFB, 2001-2014.

List of Figures

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.

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

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

Figure 5. Nest fates on North, Purisima, and South Beaches in 2014. 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 2014.

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 2014 using banded fledgling counts, unbanded fledgling counts, and banded and unbanded fledglings combined.

Figure 9. Breeding phenology at North, Purisima, and South Beaches in 2014.

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 2014.

Figure 12. Number of nests initiated on MIN, SHN/SHS, and SAN from 1994-2014. Arrow indicates the establishment of a peregrine falcon eerie at Lion's Head. Dashed lines show the 21-year mean for each beach sector.

List of Figures Continued

Figure 13. Snowy plover nest distribution within the north portion of Surf North in 2013 and 2014. The SNO Contoured Area is shaded in green.

Figure 14. Relative nest densities on north SNO inside and outside of the Contoured Area (C.A.).

Figure 15. Relative nest densities on South Beach sectors, oriented north to south, inside and outside of the Contoured Area (C.A.).

Figure 16. Hatch success on North Beaches and South Beaches, inside and outside of the Contoured Area (C.A.). The category "All Depredated" includes coyote depredations.

Figure 17. Fledging success of banded and combined banded/unbanded broods on all sectors of South Beaches. C.A. = Contoured Area.

Figure 18. Trends in annual breeding population assessed using maximum number of adults observed during window surveys and number of nests initiated from 1994-2014. Dashed lines show the long-term means calculated for the periods during linear restriction (1994-1999) and after beach closures took effect (2000-2014).

Figure 19. Trends in annual number of nests initiated for North, South, and Purisima Beaches from 1994-2014. Dashed lines show the 21-year means (1994-2014).

Figure 20. Trends in annual number of nests per linear mile within open and closed sections of Minuteman, Wall, and Surf Beaches, from 2000-2014. Dashed lines show the 15 year means (2000-2014).

Figure 21. Trends in annual snowy plover clutch hatch and fledging success on VAFB from 1994 to 2014. Data on fledging success were not available for 1994-1996.

Figure 22. Trends in annual clutch hatch success on North, South, and Purisima Beaches from 1994 to 2014. Dashed lines show the 21-year mean for each beach section.

Figure 23. Trends in annual fledging success on North, South, and Purisima Beaches from 1997 to 2014. Missing data points indicate years when fledging success was not determined. Dashed lines indicate the 21-year mean for each beach section.

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

List of Figures Continued

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

Figure 26. Trends in annual winter population assessed using maximum number of adults observed during the range wide winter window surveys from 2003/2004 to 2014. Dashed lines indicate the 11-year mean for each beach section.

Figure 27. Mean wrack index values for each beach sector from 2012 to 2014. Error bars represent the standard error.

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 2014, permanent closure began 27 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 20 years (1994-2013) of breeding bird census and nest initiation data from VAFB have yielded similar trends (see Robinette et al. 2013). Thus, both methods provide useful indices that can be tracked over time; and using both indices in conjunction provides useful information to resource managers.

Since 1994, the snowy plover breeding population size at VAFB has been highly variable (Robinette et al. 2013). 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 2014 is 238 adults with mean nest number at 336.

Reproductive success is measured by the number of chicks fledged per male plover (fledging success) (USFWS 2007). Based on a population viability analysis in the USFWS recovery plan, a rate of 1.0 fledglings produced per male is believed necessary to prevent population decline with 1.2 allowing for moderate population growth (assuming 75% annual adult survival and 50% juvenile survival). The number of chicks fledged per male is most accurately obtained when all males and chicks at a site are uniquely color banded and the birds are monitored frequently (Nur et al. 1999). This metric has been difficult to track at VAFB due to inconsistent banding effort through the years. Thus, managers at VAFB also track clutch hatch success to better understand trends in reproductive success. Clutch hatch success at VAFB has been highly variable with no

apparent trend since 1994 (Robinette et al. 2013). Mean clutch hatch success (percent of total nests that hatched) from 1994-2014 was 46% with most years either well below or well above this average. Clutch hatch success at VAFB was lowest in 1997 at 19% and highest in 2006 at 67%.

One of the primary causes of poor clutch hatch success at VAFB is predation. Over the 20 years of monitoring on VAFB, 17%-52% of nests have been lost in a given year to predators (see MSRS 2010, Robinette et al. 2013). 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 expansion of the raven population into coastal habitats in central California (Boarman and Heinrich 1999). Corvids depredated 4% of all known fate nests in 2014 (down from 7% in 2012 and up from <1% in 2013) with the highest predation occurring in 2004 (12% of all known fate nests were taken by common ravens). In prior years, coyote predation has mainly occurred on South Beach sectors with the highest predation occurring in 2004 at 20% of all known fate nests depredated. However, in 2014 both North and South Beaches experienced high coyote predation, with 37% and 34% of all known fate nests lost, respectively. Basewide, 34% of nests were taken by coyote in 2014.

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 2014, 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 2014. 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 2014 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 21-year time series. We compare trends in population size and reproductive success among North, Purisima, and South Beaches as well as inside and outside of management areas closed to the public.

Additionally, in 2014, we assessed the effectiveness of a long-term restoration project on the north end of the SNO sector. The SNO restoration site includes approximately 29.5 acres between the Santa Ynez river mouth and the SNO Area (Figure 1). Much of the area between the foredunes and the railroad was covered with European beach grass (*Ammophila arenaria*), ice plant (*Carpobrotus edulis*), and golden wattle (*Acacia longifolia*). The restoration work was completed by ManTech SRS Technologies with funding from the Torch/Platform Irene Oil Spill Trustee Council. The first stages of the restoration began in 2009 with the manual removal of golden wattle and prescribed burning. Herbicide spray was used on the beach grass and ice plant from 2009 to 2011. To cover the remaining seed bank, the beach was contoured with bulldozers from late 2013 to early 2014. The contouring work was completed in February 2014. There was very little change in plover nest distribution after the burning and herbicide treatments. In 2013 only one nest was initiated in the pre-contoured restoration area and it was depredated by a coyote. However, the contouring process opened up 26.1 acres of bare sand for potential plover nesting. We therefore wanted to assess plover response to the beach contouring with regards to 1) population distribution, 2) nesting distribution, 3) hatch success, and 4) fledge success.

Our overarching goal is to provide information to help VAFB make management decisions and understand how military activities affect the population and breeding dynamics of snowy plovers breeding on VAFB beaches. The snowy plover monitoring program is a requirement of the terms and conditions section of the Biological and Conference Opinion (BO) for Beach Management and the Western Snowy Plover (1-8-05-F-5R and amendments), Delta II Launch Program at Space Launch Complex 2 and

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

Methods

We conducted breeding surveys between 1 March and 30 September, 2014. 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 approximately the same weeks as conducted during all seasons since 2002: 12 May, 19 May (range wide window breeding survey), 9 June and 18 June. Additionally, we conducted one winter window survey on 23 January 2014. 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. For the winter window survey, we also visited Jalama

Beach to look for plovers banded as chicks on VAFB beaches. We assigned one plover monitor to each section and all sections were monitored simultaneously to minimize the chances of double counting individual plovers. For each section, one monitor walked the entire section starting from the north and continuing south. We recorded the number and location of adult snowy plovers by beach sector, 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 two weeks of incubation. Nests with this new nest fate category were located in areas with a high frequency of predator sightings. Furthermore, the nests were not buried and abandonment did not correlate with any wind event.

We used estimated hatch dates (EHD) to help us determine nest fates. We determined EHD by adding 28 days (incubation duration for snowy plovers) to the date of clutch completion. However, when nests were found after clutch completion, we

floated eggs to determine EHD. Floating entails placing each egg in a cup of water and measuring the angle of the egg as it is submerged in water. If the egg floats to the surface, the 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

2014 was the third year that we have placed Reconyx photo and motion sensor video cameras on nests to 1) increase accuracy in determining nest fates, 2) better identify and document nest predators, and 3) identify banded adults at nests. These cameras take photos every minute and a rapid series of photos when the motion sensor is triggered by large animals such as predatory birds or predatory mammals. Snowy plovers are too small to trigger the motion sensor component. Cameras were set four to eight meters from the nest, camouflaged with debris from the immediate area, and utilized on nests where the monitor determined the nest would not be at risk of predation or abandonment due to the camera's presence. We set cameras five to 28 days prior to the EHD. Ideally they were placed as early as possible, but in cases where nests were floated at high values and the EHD could be within a range of dates, we placed cameras at least one week prior to EHD.

Banding and Estimating Fledging Success

We made an effort to band 50% of all hatched broods to get a representative sample of fledging success for the entire breeding population. We successfully banded 49.4% of broods in 2014. We color banded a total of 208 chicks from 81 nests. We used a unique four-band color combination issued by the USFWS for each brood. We individualize the four-band combos by exposing the metal on the FWS band to determine which chicks fledged. Additionally, we individually marked chicks within broods from nests of particular interest (e.g., nests in open areas, the Surf North restoration site, or in the far back of sand sheets that are difficult to monitor) to get a better understanding of

fledge rate for these areas of interest. For this, we used a single color band on the left leg and a bicolor or tricolor band on the right leg. We individually marked 28 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 2014 and Appendix C lists all color bands used on chicks hatched at VAFB in 2014.

Brood Tracking and "Mystery Broods"

It is generally accepted that in a given season, we will not locate every nest initiated due to the challenges of covering every part of the beach with enough consistency. Broods that originate from unknown nests are identified as "mystery broods". Mystery broods have shown up on the shoreline in prior years, but 2014 was the second season we were able to definitively identify and track them. A brood was considered a mystery brood if it was found after it hatched and moved away from the nest. In 2014, 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 yield a more realistic idea of fledge success in the absence of banding all chicks hatched.

Beginning in 2013, nest locations were assigned to the most likely, usually closest, brood. For example, if a nest bowl was found with one egg and pip fragments present, it would be assigned to the two-chick mystery brood nearby. 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 2014.

Transect Surveys

Weekly transect surveys have been conducted at VAFB from 2011 to 2014. 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 third 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 leading into the closed areas and observations of unauthorized individuals in closed sections. Each event was thoroughly investigated by plover monitors to identify any evidence of “take” under the Endangered Species Act. Second, under the direction of VAFB biologists and the USFWS, we erected protective symbolic nest fencing around nests located in the beach areas open for recreational use to prevent accidental trampling of the nest by beach visitors. The protective fencing consisted of plastic link chain or nylon rope erected on four 5-foot garden posts in a square 10x10 foot configuration surrounding the nest. In 2012, we added a “buffer” fence measuring 100x100 feet surrounding the nest fencing with signs posted on each side to prevent beach goers from walking through the nest fencing or disturbing the incubating birds.

Results

2014 Breeding Population and Reproductive Success

Detailed data summaries can be found in Appendix D. Metrics for 2014 are summarized base-wide in Table 1 and by individual beach sector in Table 2. The maximum number of adults detected during the 2014 transect surveys was observed during the week of 18 June. The maximum number of adults was 81 at CA-84 and 124 at CA-85 (Table 2) for a base-wide total of 205 (Table 1). This is a decrease of 12% from 2013 where the maximum population was estimated at 232 breeding adults (Table 1). We confirmed nesting activity for 47 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 2014. We confirmed nesting for 11 snowy plovers banded as chicks outside of VAFB and suspected nesting for two in 2013 (Appendix B).

A total of 427 nests were located and the fates of 425 of those nests were determined. This represents a 39% increase in nests initiated compared to 2013; likely due to an increased number of re-nesting attempts in 2014. There was a 195% increase in the number of nests depredated when compared to 2013. Of the 425 known fate nests, 164 successfully hatched. This is a 6% decrease in total clutches successfully hatching compared to 2013 (174 clutches hatching in 2013). Hatching success (% of total eggs that hatched) and clutch success (% of clutches that hatched all eggs) in 2014 was 40% and 39%, respectively. This represents a 29% and 33% decrease, respectively, from 2013. The primary cause of nest failures was attributed to predation, which accounted for 71% of nest failures or 44% of known fate nests. Fledging success in 2014 was 22% lower than 2013, with an estimated 45% of chicks successfully fledged in 2014 and 57% in 2013 (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 15 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 lower than SAN in 2014.

Hatch rates on North Beaches (36%) and South Beaches (38%) was low compared to Purisima Beaches, mostly due to heavy nest predation by coyotes in 2014 (Figure 6). The hatch rate on Purisima Beaches was 80%. Fledge rate was the highest on South Beaches (56%, Figure 6). Eleven chicks on Purisima Beaches were banded with a fledge rate of 55% for this beach section.

Twenty-four nests were located in areas open to recreational use in 2014. 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 3 nests (5.0 per linear mile) in the closed area. The closed area had a 100% hatch rate and 40% 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 56 (65.9 per linear mile) in the closed area. The closed area had a 42% hatch rate and 62% 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 24 nests (48.0 per linear mile) in the open area and 106 (75.7 per linear mile) in the closed area. The clutch hatch rate was slightly higher in the open area (46%) than the closed area (44%). Fledging rate in the closed area was 54% and in the open area at 55%. Table 4 shows the fates of nests initiated within the open areas on MIN, WAL, and SNO in 2014.

On 27 June, the open area at SNO was closed for the rest of the breeding season after the maximum number of allowed violations had been reached. There was no prior temporary closure this season. Nest failure in the open area at SNO was attributed to nest destruction by high tide events and depredation.

Mystery Broods

We discovered three mystery brood nests that were initiated between 28 March and 9 June. The broods were found 30 May and 6 August as large chicks and just prior to fledge. Due to our brood monitoring and banding efforts, we were able to confirm that

the mystery broods were, in fact, from new, not previously identified nests. All three mystery broods originated from the same counting block in PNO, in a pocket beach where nesting has not been recorded for several years. The first two broods were found on the same day and appeared to be the same age. After this, we nest-searched the pocket beach with greater frequency and later found two active nests, one of which hatched, and the chicks were subsequently banded. Overall, we monitored five chicks from the three broods, and confirmed that all five fledged. We confirmed two unbanded males associated with mystery broods. No females were confirmed. The nest bowls were never found for these nests so we used the 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 221 unbanded chicks and 65 confirmed unbanded fledges from tracked broods for a 29.4% fledge rate. In contrast, 208 chicks were banded and 93 were confirmed fledged for a 44.7% 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 429 chicks hatched and 158 (banded and unbanded) were confirmed fledged for a minimum base-wide fledge rate of 36.8%.

2014 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 2014, the first known nest was initiated on South Beaches on 4 March and the last nest was initiated on 16 July. Though the first initiation date is on the early side, it 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 longer than normal ranges, though we found fewer historic data summarized in past reports. We attribute these lengthened

periods to the high nest predation and greater repeat nesting attempts in 2014. The chick hatching period for 2014 occurred between 8 April and 17 August. Prior to this season, the earliest hatch on record was 10 April in 2009. The fledging period was from 6 May to 14 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 early May and then decreased through early June. There was a second peak in late June. The mid-season drop in number of active nests is similar to the trend we observed in 2012 when ravens depredated 50% of active nests in mid-June (see Ball et al. 2012). The mid-May decrease in 2014 was due to an increase in coyote predation. The increase in active nests in early June is likely the result of predator management efforts on North Beaches. Conversely, trends in weekly active nests on South Beaches was relatively stable with three minor peaks in active nests in mid-April to mid-May, and two minor peaks in early July. This trend is the result of consistent coyote predation on South Beaches from mid-April to early July. Brood detection on North Beaches peaked in early May and early June then stayed low and relatively stable through August. Chicks can be difficult to detect for the first two weeks after hatch; therefore this number represents the minimum number of broods that may have been present. Brood detections on South Beaches remained relatively consistent from early May to mid-June, then decreased in early July, and peaked again in early August. Fledglings were first detected on North beaches in mid-May 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 late-May with steady increases through August. Overall, the number of fledglings observed on South Beaches was higher than North Beaches for the June to August period. There was a similar, but very brief, peak in early September, with a steady decrease through the end of September. The number of active nests, broods and fledglings were low at Purisima Beaches and fluctuated throughout the season.

Figure 10 shows distribution of flocking and paired birds during weekly transect surveys for North and South beaches. In early March, approximately half of the snowy

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 with a sharp peak in paired birds in early April. On North Beaches, the number of flocked birds decreased steadily through March and there was a broad peak in number of paired birds between early and mid-April. There was a sharp decline in number of pairs in mid-April, with a steady increase through early-May. A second decline and peak occurred mid-May to mid-June that is consistent with re-nesting after coyote depredations. The number of pairs detected on both North and South beaches showed a steady decline through July. Plovers began forming flocks again in June on South Beaches and in July on North Beaches, and the number of birds detected in flocks increased steadily through the remainder of the season. This pattern is consistent with the end of the egg laying period at the end of July when adult plovers are typically seen individually or exhibiting flocking behavior rather than exhibiting courting behavior within their territories. Overall the number of paired and flocking birds was higher on South Beaches.

2014 Predator Sightings and Nest Predation

Wildlife species identified as predators of adult snowy plovers, nests, and/or chicks during the 2014 breeding season included raven, gull (*Larus* sp.), 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 425 known fate nests, 186 (44%) were depredated in 2014 (Table 6). Coyotes were the most common predators, taking 34% of all known-fate nests. Ravens or suspected ravens took 4% of known fate nests. Less than 1% of known-fate nests were taken by gulls and skunk in 2014. 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 4% of known-fate nests. On North Beaches, 37% of nest predations were due to coyote, 6% due to raven, <1% due to gull, <1% due to skunk, and 4% were due to unknown predators (Figure 11a). On Purisima, the only confirmed depredated nest was lost to raven (7%). On South Beaches, the main predator confirmed for nest predation was coyote (34%) with 3% due to raven or suspected raven, <1% due to gull, and 3% to unknown predators. On North Beaches and South Beaches, sightings of ravens showed a similar pattern with nest predation rates (Figure 11b). However, this was not the case for coyotes. Though coyotes were seen more frequently on North Beaches, they accounted for high levels of predation on both North and South Beaches. Additionally, coyote predation rates overlapped with areas of high nest densities on North Beaches, but not necessarily on South Beaches (see Figures 2-4). Thus, it appears that a few individuals may have been repeatedly visiting the same beach sectors and keying into areas with high nest densities on North Beaches, especially SAN. Conversely, coyote predation on South Beaches appeared to be more opportunistic over a wider area, but was likely due to one or two individuals. The removal of one coyote on North Beaches and two coyotes on South Beaches resulted in a sharp decrease in nest predation by coyotes on both beach sections. Overall, there was a 179% increase in coyote predation in 2014 compared to 2013 (145 nests taken in 2014 and 52 nests taken in 2013); and raven predation (including suspected raven) increased from 2013 by 1700%, though it decreased from 2012 by 22% (23 in 2012, 1 nest in 2013, and 18 in 2014). Raven predation occurred in three waves in 2014. The first wave occurred 25 and 26 March on South Base where eight nests were lost to raven or suspected raven. The second and third waves occurred on North Base on 1 and 12 July, respectively, when a total of 10 nests were confirmed lost to raven.

We suspect one nest was lost to adult mortality in 2014. This nest was located on SHS. Overall, nest losses to suspected adult mortality accounted for <1% of all failed nests. In 2013, we confirmed the loss of an adult snowy plover by peregrine falcon on North Beaches. No adult snowy plovers were confirmed lost to peregrine falcon in 2014.

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 21 years. Nest

numbers have been decreasing at MIN and SHS/SHN in recent years while numbers at SAN have been increasing. 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 falcons were present prior to establishing the aerie and may be responsible for the apparent shift in snowy plover nesting effort from north beach sectors to SAN. However, the increasing trend at SAN appears to start in 2005 and the decreasing trends at MIN and SHS/SHN may have started as far back as 2003, well before the establishment of the peregrine falcon aerie. An alternative hypothesis for this shift in nesting population is a progressive decrease in nesting habitat quality at MIN and SHS/SHN due to the establishment and expansion of the non-native beach grass (*Ammophila arenaria*). VAFB has taken steps to test both hypotheses. First, VAFB has funded a project to track the movements of the breeding peregrine falcons using satellite telemetry to determine how much time the birds spend foraging at North Beach sectors. Second, VAFB is initiating a dune restoration project in 2015 aimed at removing the non-native beach grass.

Nest Camera Monitoring

We set cameras on 40 nests in 2014. Photo and video footage from the cameras allowed us to confirm the fates of 38 nests; two cameras stopped functioning prior to hatch (Table 7). Twenty-four nests hatched, 11 were depredated by coyote, one was depredated by raven, one was depredated by skunk, two were abandoned, and one was destroyed by tide. Both abandoned nests were abandoned prior to camera placement (photos showed no adults incubating the nest), and were placed to confirm abandonment.

Surf North Restoration Area

Figure 13 shows the nesting distribution on the Surf North restoration site and surrounding areas in 2013 and 2014. On all of South Beaches, there is an overall increase in nests due to re-nesting from predation (Appendix E), but no large-scale north/south shift in territories was observed. However, there is a marked east/west shift in nesting into the contour area from directly west. We also assessed the change relative nest densities on north SNO between 2013 and 2014 (Figure 14). In 2013, only one nest was

initiated in the pre-contoured area of the restoration site. There is a shift from high nest density outside the contoured area in 2013 to lower density both in and outside the contoured area in 2014. To determine if other sectors were influenced by the contoured area, we used the same analysis for all south base (Figure 15). Even with the increased re-nesting in 2014, the relative nest densities decreased on WAL, north SNO and south SNO, and increased in the contour area. Thus, it appears that plovers from both WAL and SNO may have shifted their territories into the contoured area. There appears to be no shift in territories out of SSO as nest densities increased in this sector, likely due to SSO having a higher rate of re-nesting than the other beaches in 2014.

Overall, thirty-eight nests were initiated in the contoured area in 2014. Of these, 28 hatched (74%), two were depredated by coyote (5%), three were depredated by raven or suspected raven (8%), four were abandoned (11%), and one nest had an unknown fate (3%). The contoured area had a higher hatch success than North Base (36%) and South Base outside the contoured area (31%) (Figure 16). A total of 75 chicks hatched inside the contoured area. Of these, thirty-two chicks from 13 nests were banded (42.7% banding rate). The fledge rate from the banded chicks was 50.0% while that of all known chicks (both banded and unbanded) was 36.0%. The fledge rate for the contoured area was lower than that for any of the South Beach sectors (Figure 17), but was still higher than the 18-year mean of 33.0% for banded birds on South Beaches (see Trends in Annual Reproductive Success below).

Trends in Annual Breeding Population

Figure 18 shows trends in annual breeding population before and after beach closures were established in 2000. The mean number of adults and nests initiated increased after closures went into effect. Moreover, the period during linear restriction (1994-1999) shows a decreasing trend, whereas the period after has been variable, but relatively stable. In 2004, there was a spike in population on VAFB that was also observed for the total snowy plover population range-wide (USFWS 2007). In 2014, the number of adults observed was below the long-term mean and number of nests initiated on VAFB was above the long-term mean.

The mean number of nests initiated over the time series is similar between North and South Beaches (Figure 19). Annual values are highly correlated for the two beaches (Spearman's rho: $r = 0.769$, $p < 0.001$). There is a decreasing trend leading to the 2000 beach closures and a variable but stable population since 2002. The 2004 peak was higher for South Beaches and likely reflects higher predation and subsequent re-nesting during that year (MSRS 2004). Conversely, the number of nests initiated at Purisima Beaches declined from 1994 to 2011. The lowest number of nests initiated at Purisima Beaches in the time series occurred in 2011. The number of nests initiated at Purisima Beaches has been increasing since 2011 and was above the long-term average in 2014 for the first time since 2005.

Figure 20 compares the number of nests established per linear mile within areas open to recreational access and closed areas of MIN, WAL and SNO beaches since implementation of VAFB's current beach management. We standardized data to linear mile to account for differences in available habitat within each beach sector. Long-term means for areas closed to recreational access are higher than those for open areas at all three beach sectors, especially MIN and WAL beaches. Long-term means for open and closed areas are more similar for SNO and annual values for the two areas are positively correlated (Spearman's rho: $r = 0.899$, $p < 0.001$). Annual values for open and closed area nesting numbers are not correlated for MIN and WAL beaches (Spearman's rho: $r = 0.350$, $p = 0.100$ and $r = -0.010$, $p = 0.486$, respectively). Furthermore, there were no nesting attempts within areas open to recreational use during 10 years at MIN and seven years at WAL from 2000 through 2014. There were no nests in either of these two sections in 2014.

Trends in Annual Reproductive Success

Both hatching and fledging success have high variability among years from 1997-2014 with no apparent trend (Figure 21). Patterns in both metrics were similar from 1997-2005, but overall, there is no correlation between annual values (Spearman's rho: $r = 0.223$, $p = 0.187$). It is likely that, in recent years, the factors regulating hatching success are different than those regulating fledging success. For example, in 2010, hatching success (63%) was well above the long-term mean (45.8) while fledging success

remained average (2010 = 29%, long-term mean = 33.4%). 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. However, in 2014 hatching success and fledgling success decreased (39% and 45 % respectively), but fledging success remained higher than the long-term mean.

Figure 22 shows the annual hatching success at North, Purisima, and South Beaches. North and South Beaches show similar patterns with divergence in some years (1999, 2003, 2006, and 2011). This divergence is likely due to different levels of predation between North and South Beaches. Overall, annual values for the two beaches are positively correlated (Spearman's rho: $r = 0.463$, $p = 0.017$). In 2014, hatching success was lower than the long-term mean at both North Beaches and South Beaches (North: 2014 = 36%, long-term mean = 47%; South: 2014 = 38%, long-term mean = 44%). Despite overall lower nesting effort, Purisima Beaches maintain a higher hatching success (80%) compared to North and South Beaches. Additionally, hatching success has been less variable at Purisima Beaches.

Figure 23 shows annual fledging success on North, Purisima, and South Beaches. In 2014, fledging success on North Beaches (30%) was lower than on South Beaches (56%). The opposite has been the case for the prior 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 = 46%). The long-term means for North and South beaches are similar (36% and 33%, respectively), and the annual values between the two beaches are positively correlated (Spearman's rho: $r = 0.412$, $p = 0.050$).

Figure 24 shows annual hatching success in areas open to recreational access and closed areas of MIN, WAL and SNO. The long-term means were higher in closed areas for all three beach sectors (MIN: open = 19% closed = 54% WAL: open = 42%, closed =

51%; 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 and are positively correlated (Spearman's rho: $r = 0.468$, $p = 0.039$).

Figure 25 shows annual fledging success based on banded birds for open and closed areas using all data available from 2000 - 2014. 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 = 34%). At SNO, mean fledging success is similar between open and closed areas (open = 34%, closed = 34%), but interannual patterns were not significantly correlated (Spearman's rho: $r = 0.357$, $p = 0.128$). In recent years (2012 and 2013), fledging success has been higher in the open area than the closed area. However, in 2014 fledging success in the open area has been about equal to the closed area (55% and 54% respectively). It is possible that chick survival has increased in the open area due to the use of buffer fencing around nest exclosures which serves as additional protection for broods prior to fledging.

Trends in Annual Wintering Population

Figure 26 shows the results of winter window surveys at North Beaches, South Beaches, and Jalama Beach from 2003 to 2014. Similar to mean breeding population, the mean size of wintering populations from 2003 to 2014 has been larger on North Beaches than South Beaches. Aside from a peak during the 2010/11 winter, wintering population size on North Beaches has been relatively stable since 2006/07. Winter population size on South Beaches appears to be decreasing since 2007/08. Conversely, the winter population size at Jalama Beach has been increasing steadily since 2009/10. Prior to 2009/10, there were no plovers detected at Jalama Beach during winter window surveys in most years.

Annual Wrack Abundance

Mean ± SE wrack values for each beach sector are shown in Figure 27. For this report, we calculated the mean wrack abundance for the chick rearing period (May 1 through September 1; see Figure 9) to determine whether differences in wrack abundance could potentially explain difference observed in fledging rates from 2012 to 2014. Two-way Analysis of Variance (ANOVA) showed significant differences among beach sectors and among years (Year: $F = 9.81$, $df = 2, 399$, $p < 0.001$; Beach: $F = 14.09$, $df = 6, 399$, $p < 0.001$). Post-hoc tests showed that there was significantly more wrack on VAFB beaches in 2013 (2013/2012: MD = 0.24, $p = 0.001$; 2013/2014: MD = 0.29, $p = 0.002$) and no difference between 2012 and 2014 (MD = 0.05, $p = 0.821$). Post-hoc tests for beach sector showed there was significantly more wrack at WAL and SNO than all other beach sectors across the three years (Table 8). There was also significantly more wrack at SSO and MIN than SHS. When looking at 2014 by itself, only WAL showed significantly more wrack than the other beach sectors and there were no differences among any of the other beach sectors (ANOVA: $F = 6.89$, $df = 6, 133$, $p < 0.001$; see Table 8 for post-hoc results).

Recreational Beach Management

Over 64 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 violations or 78% of total violations), the only beach that is open to the general public. Surf Beach reached 50 violations by the end of June and was closed permanently on 27 June. Four violations were reported at WAL (6% of total violations) and 10 violations were reported at MIN (16% of total violations). The total number of beach violations in 2014 represents a 25% increase from 2013 (55, 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 depredation. This season we noted heavy trespass activity from Ocean Park to the sandspit west of the Santa Ynez River mouth. Fresh trespass tracks were consistently recorded between 17 March and 19 September, well

after the permanent closure went into effect. Several incidents involved off-leash dogs. The trespass activity likely impacted brood survival on the Santa Ynez sandspit, particularly when the gull flock was present. Two dead unbanded chicks from two different nests were found at the sandspit on 10 and 16 July. The first chick was from an unknown nest, only a day or two old, and highly decomposed. The second chick hatched from 14WAL045 and was found near the nest bowl with the yolk sac still present. We suspect that a combination of a trespasser event from the day before and a large gull flock near nest area caused disturbance and contributed to chick's death. Few fledges, banded or unbanded, were confirmed on the sandspit. We suspect that the high trespass activity in this area disturbed additional broods such that they were either separated from the adults or pushed into the gull flock, resulting in death from hypothermia or predation.

Discussion

2014 Breeding Season Summary

The number of nests initiated in 2014 was similar to 2012 when heavy coyote predation led to high rate of renesting. In 2012, there was also considerable raven predation on plover nests. Management of ravens on VAFB has greatly improved since the program was initiated in 2004; and the successful disruption of active breeding pairs in 2014 is likely responsible for the low raven predation rate observed on North and South Beaches. Overall, hatch rates in 2014 were below long-term means for both North and South Beaches. Fledging rates differed among beaches in 2014. The fledging rate for North Beaches was below the long-term average while the fledgling rate on South Beaches was the highest on record since 1997. WAL continues to have significantly higher wrack abundance than other beach sectors. Fledge rate at WAL (60%) was higher than that of other beach sectors. Mean wrack abundance on all other beach sectors was lower in 2014 than 2013 and similar to 2012. The North Beach population has continued the trend of decrease at MIN, SHN, and SHS and increase at SAN. Some of this shift may be due to the establishment of an active breeding pair of peregrine falcons at Lion’s Head, just north of MIN. However, MIN, SHN, and SHS have also been inundated by the invasive European beach grass that has reduced the amount of available nesting habitat over several years. The shift in nesting to SAN likely began in 2003, well before

the establishment of the peregrine aerie in 2011. Thus, the shift in nest distribution on North Beaches is more likely a result of habitat loss at MIN, SHN, and SHS. VAFB is initiating a project to restore habitat on North Beaches in 2014. This should result in a reversal of the shift in nesting on North Beaches and hopefully an overall increase in the North Beach nesting population. Beach contouring performed at SNO in 2014 resulted in more use by nesting snowy plovers and increased hatching success in 2014.

Overall, 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 abundance) 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.

Annual Snowy Plover Nesting Effort

The number of snowy plover adults documented in 2014 was similar to the 21-year mean while the number of nests was above the long-term mean, mostly due to a high rate of renesting after heavy coyote predation in 2014. Both metrics have remained relatively stable over the past five years with higher among-year variability in numbers of nests, mostly due to variability in predation rates among years. The strong correlation among trends on North and South Beaches indicates 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 for 2012-2014 and at WAL when looking only at 2014. Dugan et al. (2008) found that the abundance of talitrid amphipods was 4.5 times greater on South Beaches in 2004 and two times greater in 2005 and associated this with the higher brown macroalgal cover on South Beaches. However, there are other factors that need to be considered when assessing spatial differences in nesting effort. In addition to differences in wrack cover, Dugan et al. (2008) found that 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 the time series of wrack abundance, we will be able to better understand the role wrack plays in determining spatial and temporal variability in annual nesting effort.

The number of nest initiations on Purisima Beaches has been on the decline in recent years, going from 23 nests in 2003 to two nests in 2011. In fact, 2011 marks the first season in the time series for which there were no nesting attempts within PCO; and the trend continues as there have been no nesting attempts at PCO since 2011. The overall decline in nest initiations is mostly due to the dramatic increase in vegetation cover such as invasive European beach grass and native coastal dune lupine (*Lupinus chamissonis*) (MSRS 2010). Banding data from previous years indicate that broods move from PCO and later are observed on the south portion of SAN (Ball unpublished field notes). The corridor traveled between these two sectors has gradually increased in

vegetation cover since 2000 and may have an influence on nest site selection at the colony. Purisima Beaches were not included in the Dugan et al. (2008) study. However, Dugan et al. noted that the southernmost portion of North Beaches, the portion adjacent to the Purisima Beach section, was backed by an artificial dune stabilized with European beach grass.

Despite the degradation in nesting habitat, hatching success has been consistently higher than all other beach sectors over the 21-year period. Some of this success may be attributed to the predator management conducted at the least tern colony. While there is more intensive predator management at PCO than at other beach sectors, there is a potential benefit to the nearby PNO sector as well. Needless to say, this beach sector still represents an important component of VAFB plover breeding habitat. Currently, VAFB is engaged in a program to control European beach grass on North Beaches and initial spraying has occurred at PNO and PCO. Since 2011, the number of nests on Purisima Beaches has increased annually with 15 nests documented in 2014, the highest number since 2003. Additionally, we located three mystery broods in 2014 at a PNO pocket beach that had not been used by plovers for several years. All nesting effort since 2011 has been at PNO, but we are hopeful that continued restoration efforts will reopen PCO to plover nesting.

Annual Snowy Plover Reproductive Success

We calculated reproductive success (number of fledglings produced per adult male) by taking the estimated number of fledglings and dividing by the maximum number of adult males observed during our four breeding window surveys. We estimated the number of fledglings by multiplying the fledging success rate obtained from banding data by the number of chicks confirmed to have hatched. Reproductive success was 1.85 in 2014. This is above the USFWS recovery goal of 1.0 fledglings per male deemed necessary for population growth (USFWS 2007). Furthermore, reproductive success was above the USFWS recovery goal at both recovery sites (1.4 for CA-84 and 2.2 for CA-85). Because banding efforts have been highly variable in past years, reproductive success has been inconsistently reported in reports prior to 2011. Base-wide reproductive success from 2011 through 2014 has ranged from 0.8 to 1.9 fledglings per adult male.

Mean ± SE reproductive success for 2011-2014 was 1.4 ± 0.2. 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 2014 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. 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 likely caused the differences observed between the beach sections. In 2014, 44% of all nests initiated were lost to predators. Coyotes were the main nest predators, accounting for 78% of all nest predation. Coyote predation occurred on all beach sectors and appeared to be opportunistic on South Beaches and perhaps more focused to dense nesting areas on North Beaches. The removal of one coyote on North Beaches and two coyotes on South Beaches resulted in a sharp decrease in nest predation by coyotes on both beach sections. Thus, coyote predation remains for the most part a localized issue, likely attributable to one or a few coyotes in the beach sectors where it occurs.

Raven predation was low in 2014, 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 the raven population is expected to increase at VAFB. Raven populations in California have been increasing in recent years (Boarman and Heinrich 1999). In the Central Valley, the raven population increased >7,600% between 1968 and 1992. Much of this increase has been attributed to human activities that have subsidized food and habitat for ravens (Camp and King 1993, Boarman et al. 2006, Kristan and Boarman 2007). Additionally, human development has provided nesting habitat allowing ravens to expand their range into areas where habitat was historically a limiting factor (e.g., coastal scrub habitat). Until recently, ravens have been largely absent from the central California coast (Boarman and Heinrich 1999). Ravens were first detected at VAFB in 2004 (MSRS

2004) and the number of observations has been increasing annually. Despite the increased sightings, raven management on VAFB has been very effective, with <1% of all known fate nests lost to ravens in 2013 and <4% in 2014.

While coyotes had an impact on clutch hatch success in 2014, it is important to note that fledging success was well above the 21-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 snowy plover population management because it ultimately determines recruitment rates into the adult population. If the recruitment rate is consistently lower than the adult death rate over several years, then the population will decline and the population may be more at risk in the long-term (Akcakaya et al. 2003). Because snowy plovers are short-lived (Paton [1994] estimated mean adult survival to be 2.7 years), annual fledging success can be an important determinant of variability in short-term population size.

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 on VAFB have been very successful in recent years. Less than 7% of known-fate nests were taken by ravens in 2012, <1% in 2013, and <4% in 2014. Continued preemptive management of ravens will help VAFB meet its management goals for snowy plovers.
2) The Peregrine falcon population on VAFB has recently expanded to support three successful breeding pairs. The increased presence of peregrines on the coast can potentially impact the adult population of snowy plovers by increased adult mortality as confirmed in 2012 and 2013 when plover bands were found among nest contents at the Lion's Head aerie. In response, VAFB has funded an effort to track the movements of the peregrine falcons breeding at Lion's Head. VAFB should continue to support studies that would determine peregrine hunting activities and the extent to which adult plovers are being taken. Due to the fact that only ~20% of the VAFB population of adult snowy plovers is banded, it is difficult to determine the extent of impact the peregrines are having on breeding birds.
3) A comprehensive beach study should be conducted to determine the factors influencing annual nesting effort at VAFB. While Dugan et al. (2008) identified many potential factors, many of the factors covaried over the short time series (2004-2005). A long-term study that incorporates the oceanographic and environmental variables regulating habitat availability and prey abundance will allow VAFB to better understand variability in annual nesting effort. This, in turn, will allow VAFB to take a more ecosystem-based approach to managing coastal biological resources.
4) 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 2013 and 2014. Also shown is the percent change for each metric in 2014 when compared to 2013.

		2014	2013	% Change in 2014
Population	Maximum Adults Observed	205	232	-12%
	Number of Nests Initiated	427	307	39%
Nests	Hatched	164	174	-6%
	Abandoned Before Hatch	27	22	23%
	Incubated Past Hatch Date	0	1	-100%
	Depredated	186	63	195%
	Destroyed by Wind	16	6	167%
	Destroyed by Tide	21	25	-16%
	Destroyed by Human(s)	0	2	
	Failed Unknown	10	3	233%
	Suspected Adult Mortality	1	7	-86%
	Unknown Fate	2	5	-60%
Eggs & Chicks	Total Known Fate Eggs	1066	812	31%
	Total Chicks Hatched	429	456	-6%
	Hatching Success	40%	56%	-29%
	Clutch Success	39%	58%	-33%
	Known Fate Clutches	425	302	41%
Fledglings	Total Banded Chicks	208	172	21%
	Banding Rate	49%	38%	29%
	Total Banded Fledglings Observed	93	98	-5%
	Fledging Success	45%	57%	-22%
	Estimated # of Fledglings	192	259	-26%
	Fledges per male	1.85	1.80	3%

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), 2014. 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	1	18	54	8	0	81	17	70	37	124
	Number of Nests Initiated	3	25	132	15	0	175	56	130	66	252
Nests	Hatched	3	7	47	12	0	69	23	58	14	95
	Abandoned Before Hatch	0	1	13	1	0	15	2	7	3	12
	Incubated Past Hatch Date	0	0	0	0	0	0	0	0	0	0
	Depredated	0	16	65	1	0	82	19	41	44	104
	Destroyed by Wind	0	0	4	0	0	4	4	7	1	12
	Destroyed by Tide	0	0	0	1	0	1	6	10	4	20
	Destroyed by Human(s)	0	0	0	0	0	0	0	0	0	0
	Failed Unknown	0	0	3	0	0	3	1	6	0	7
	Suspected Adult Mortality	0	0	1	0	0	1	0	0	0	0
	Unknown Fate	0	0	0	0	0	0	1	1	0	2
Eggs & Chicks	Total Known Fate Eggs	8	61	332	37	-	438	144	323	161	628
	Total Chicks Hatched	7	17	129	29	-	182	60	154	33	247
	Hatching Success	88%	28%	39%	78%	-	42%	42%	48%	20%	39%
	Clutch Success	100%	28%	36%	80%	-	39%	42%	45%	21%	38%
	Known Fate Clutches	3	25	132	15	-	175	55	129	66	250
Fledglings	Total Banded Chicks	5	4	79	11	-	99	26	72	11	109
	Banding Rate	71%	24%	61%	38%	-	54%	43%	47%	33%	44%
	Total Banded Fledglings Observed	2	2	22	6	-	32	16	39	6	61
	Fledging Success	40%	50%	28%	55%	-	32%	62%	54%	55%	56%
	Estimated # of Fledglings	3	9	36	16	-	58	37	83	18	138
	Fledges per male	-	-	-	-	-	1.4	-	-	-	2.2

Table 3. Number of plovers banded as chicks at VAFB in all years since 1995. Also shown are the numbers of chicks banded at VAFB that were observed as adults at VAFB in 2014. 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 2014	Number of Confirmed Nesters in 2014	Number of Probable Nesters in 2014
1995	63			
1996	149			
1997	139			
1998 or 1999	114			
2000	52			
2001	58			
2002	61			
2003	56			
2004	249	3		
2005	68	1	1	
2006	110	1		
2007	27			
2008	149	4	2	
2009	182	6	2	
2010	21	1		1
2011	148	9	6	1
2012	161	22	13	3
2013	172	49	21	6
Unknown Year	N/A	8	2	1

Table 4. Fates of nests initiated within areas open to recreational activity on Minuteman (MIN), Wall (WAL), and Surf, North (SNO) beach sectors in 2014.

Nest Fate	MIN	WAL	SNO
Hatched	0	0	11
Abandoned	0	0	1
Depredated	0	0	8
Non-viable	0	0	0
Destroyed by Human	0	0	0
Tide/Wind	0	0	4
Failed Unknown	0	0	0

Table 5. Historic egg laying, chick hatching, and fledging periods for snowy plovers at VAFB. Data for egg laying periods were available for 1995-2014. Data for chick hatching periods were available for 2002-2014 (with the exception of 2010). Data for fledging periods was available for 2009 and 2014.

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

Table 6. Number and percent of known fate snowy plover nests taken by predators at VAFB in 2014.

	Number of Nests	Percent of Known Fate Nests
Coyote	145	34%
Confirmed Raven	15	4%
Suspected Raven	3	<1%
Unidentified Gull	3	<1%
Skunk	1	<1%
Unidentified Predator	19	4%
Total	186	44%

Table 7. Fates of 40 nests monitored with cameras on VAFB in 2014, 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
14MIN001	MIN	4/14	5/9	5/2	Hatched	Confirmed hatch date
14MIN003	MIN	7/18	7/29	7/29	Hatched	Camera stopped functioning prior to hatch
14PNO004	PNO	5/5	6/6	6/5	Hatched	Confirmed hatch date and nest departure
14SAN006	SAN	4/4	4/18	4/17	Coyote	Confirmed coyote depredation, date, and time
14SAN007	SAN	4/18	4/21	5/3	Hatched	Camera stopped functioning prior to hatch
14SAN012	SAN	4/21	5/3	5/3	Hatched	Confirmed hatch date
14SAN022	SAN	4/30	5/16	5/14	Hatched	Confirmed hatch date
14SAN038	SAN	5/21	6/2	5/31	Hatched	Confirmed hatch date
14SAN041	SAN	5/17	5/20	5/20	Coyote	Confirmed coyote depredation, date, and time
14SAN068	SAN	6/2	6/3	6/3	Coyote	Confirmed coyote depredation, date, and time
14SAN081	SAN	6/3	6/18	6/13	Coyote	Confirmed coyote depredation, date, and time
14SAN082	SAN	5/29	6/24	6/23	Hatched	Confirmed hatch date and nest departure
14SAN098	SAN	6/20	7/7	7/5	Hatched	Confirmed hatch date, nest departure, and unbanded pair
14SAN116	SAN	7/1	7/14	7/12	Raven	Confirmed raven depredation, date, and time
14SAN117	SAN	7/16	8/6	8/3	Hatched	Confirmed hatch date, nest departure, and unbanded male
14SAN118	SAN	7/7	8/4	8/1	Hatched	Confirmed hatch date and unbanded pair
14SAN126	SAN	8/2	8/28	8/17	Hatched	Confirmed hatch date
14SAN127	SAN	7/31	8/4	8/3	Skunk	Confirmed skunk depredation, date, and time
14SAN130	SAN	8/12	8/13	7/28	Abandoned	Confirmed abandonment, never observed adults incubating
14SHN001	SHN	4/1	4/25	4/21	Hatched	Confirmed hatch date, nest departure, and banded pair
14SHN006	SHN	5/12	5/23	5/22	Coyote	Confirmed coyote depredation, date, and time
14SHS007	SHS	6/19	7/1	7/1	Coyote	Confirmed coyote depredation, date, and time
14SHS014	SHS	7/22	8/18	8/14	Hatched	Confirmed hatch date and nest departure
14SNO051	SNO	5/13	5/21	5/20	Coyote	Confirmed coyote depredation, date, and time; confirmed banded adult
14SNO072	SNO	5/21	5/29	5/29	Abandoned	Confirmed abandonment, never observed adults incubating
14SNO088	SNO	6/6	7/4	7/3	Hatched	Confirmed hatch date, nest departure, and unbanded male
14SNO099	SNO	6/12	6/17	6/13	Coyote	Confirmed coyote depredation, date, and time; detected trespassers
14SNO108	SNO	6/23	7/21	7/17	Hatched	Confirmed hatch date, nest departure, and unbanded male
14SNO117	SNO	7/1	7/14	7/12	Hatched	Confirmed hatch date, nest departure, and unbanded pair
14SNO129	SNO	7/18	8/1	7/31	Coyote	Confirmed coyote depredation, date, and time
14SSO003	SSO	4/3	4/11	4/11	Coyote	Confirmed coyote depredation, date, and time
14SSO015	SSO	4/29	5/19	5/18	Coyote	Confirmed coyote depredation, date, and time
14SSO056	SSO	7/8	7/17	7/16	Hatched	Confirmed hatch date
14SSO061	SSO	7/16	8/1	7/30	Hatched	Confirmed hatch date
14WAL009	WAL	4/18	5/3	5/3	Hatched	Confirmed unbanded female
14WAL028	WAL	5/21	6/9	6/7	Hatched	Confirmed hatch date and coyote depredation of chicks
14WAL034	WAL	5/29	6/18	6/17	Hatched	Confirmed hatch date and nest departure; confirmed gull predation of WAL030
14WAL054	WAL	7/18	8/5	8/4	Hatched	Confirmed hatch date and nest departure
14WAL055	WAL	7/14	7/18	7/15	Tide	Confirmed tide hit nest, date, and time
14WAL056	WAL	8/5	8/20	8/12	Hatched	Confirmed hatch date and nest departure

Table 8. Results of Tukey's post hoc tests on mean wrack values among beach sectors using data from a) 2012-2014 and b) 2014 only. Significant differences are italicized in red.

a) Post-hoc results for 2012-2014 analysis						
Beach	MIN	SHN	SHS	SAN	WAL	SNO
SHN	MD = 0.047 p = 1.00					
SHS	***MD = 0.342*** ***p = 0.040***	MD = 0.295 p = 0.134				
SAN	MD = 0.202 p = 0.581	MD = 0.155 p = 0.840	MD = -0.140 p = 0.893			
WAL	***MD = -0.658*** ***p <0.001***	***MD = -0.705*** ***p <0.001***	***MD = -1.000*** ***p <0.001***	***MD = -0.859*** ***p <0.001***		
SNO	***MD = -0.407*** ***p = 0.007***	***MD = -0.454*** ***p = 0.002***	***MD = -0.748*** ***p <0.001***	***MD = -0.608*** ***p <0.001***	MD = 0.251 p = 0.300	
SSO	MD = -0.039 p = 1.00	MD = -0.086 p = 0.989	***MD = -0.380*** ***p = 0.015***	MD = -0.240 p = 0.370	***MD = 0.619*** ***p <0.001***	***MD = 0.368*** ***p = 0.024***
b) Post-hoc results for 2014 analysis.						
Beach	MIN	SHN	SHS	SAN	WAL	SNO
SHN	MD = 0.062 p = 1.00					
SHS	MD = 0.325 p = 0.589	MD = 0.263 p = 0.798				
SAN	MD = 0.348 p = 0.536	MD = 0.286 p = 0.192	MD = 0.024 p = 1.000			
WAL	***MD = -0.598*** ***p = 0.018***	***MD = -0.660*** ***p = 0.005***	***MD = -0.923*** ***p <0.001***	***MD = -0.947*** ***p <0.001***		
SNO	MD = 0.378 p = 0.431	MD = 0.316 p = 0.649	MD = 0.054 p = 1.000	MD = 0.030 p = 1.000	***MD = 0.977*** ***p <0.001***	
SSO	MD = 0.012 p = 1.00	MD = -0.050 p = 1.000	MD = -0.312 p = 0.607	MD = -0.336 p = 0.553	***MD = 0.611*** ***p = 0.011***	MD = 0.366 p = 0.445

Table 9. Number of beach violations per beach sector on VAFB, 2001-2014.

Beach Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Minuteman (limit 10)	2	3	0	2	5	11*	0	1	4	5	5	1	2	10
Wall (limit 10)	8	0	0	2	8	2	1	1	6	3	7	9	3	4
Surf (limit 50)	34	29	17	28	32	48	30	29	36	19	32	50*	50*	50*
VAFB Total	44	32	17	32	45	62	31	31	46	27	44	60	55	64

* Closed because violation limit was reached.

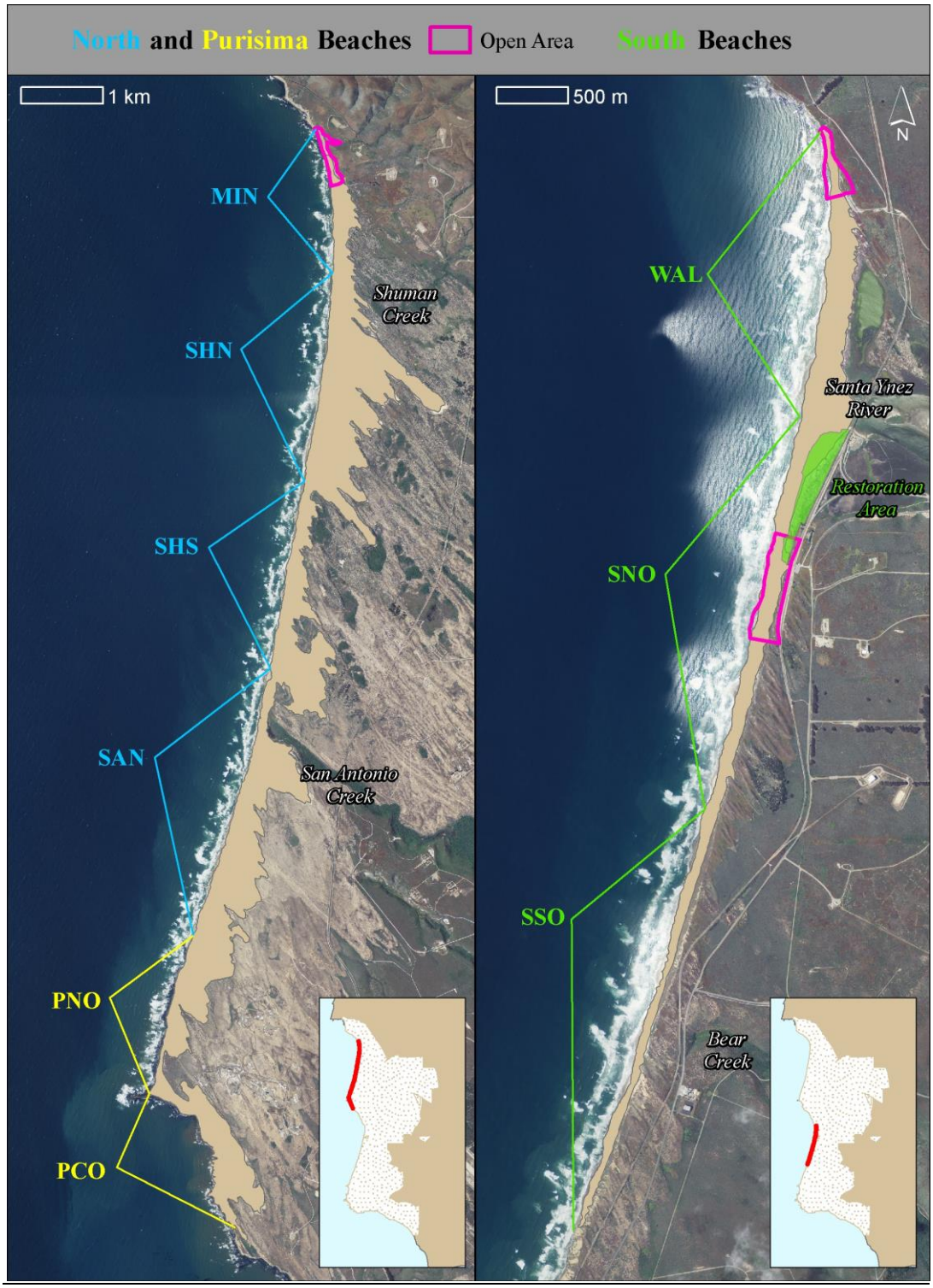


Figure 1. Map of beach sectors for North, Purisima, and South Beaches on VAFB. Areas open to public and/or military personnel are outlined in purple. The Surf North Restoration Area is shaded in green. MIN = Minuteman, SHN = Shuman North, SHS = Shuman South, SAN = San Antonio, PNO = Purisima North, PCO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

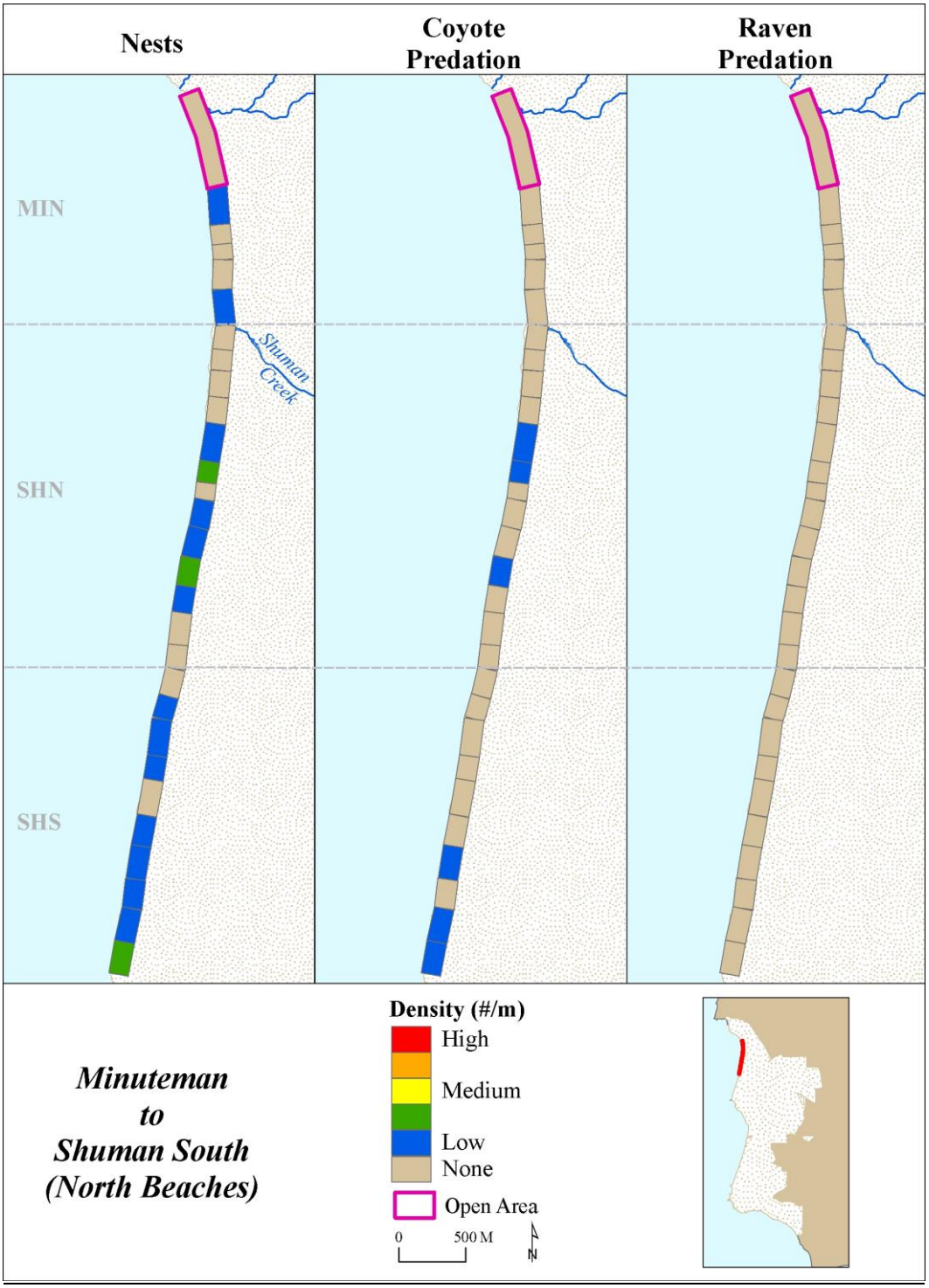


Figure 2. Snowy plover nest densities within North Beach transect blocks from Minuteman to Shuman South (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple.

Values for density (#/m)						
	Nests		Coyotes		Ravens	
High	0.056	0.102	0.045	0.065	0.009	0.014
	0.036	0.056	0.026	0.045	0.008	0.009
Med	0.022	0.036	0.016	0.026	0.006	0.008
	0.011	0.022	0.009	0.016	0.004	0.006
Low	0.001	0.011	0.004	0.009	0.001	0.004

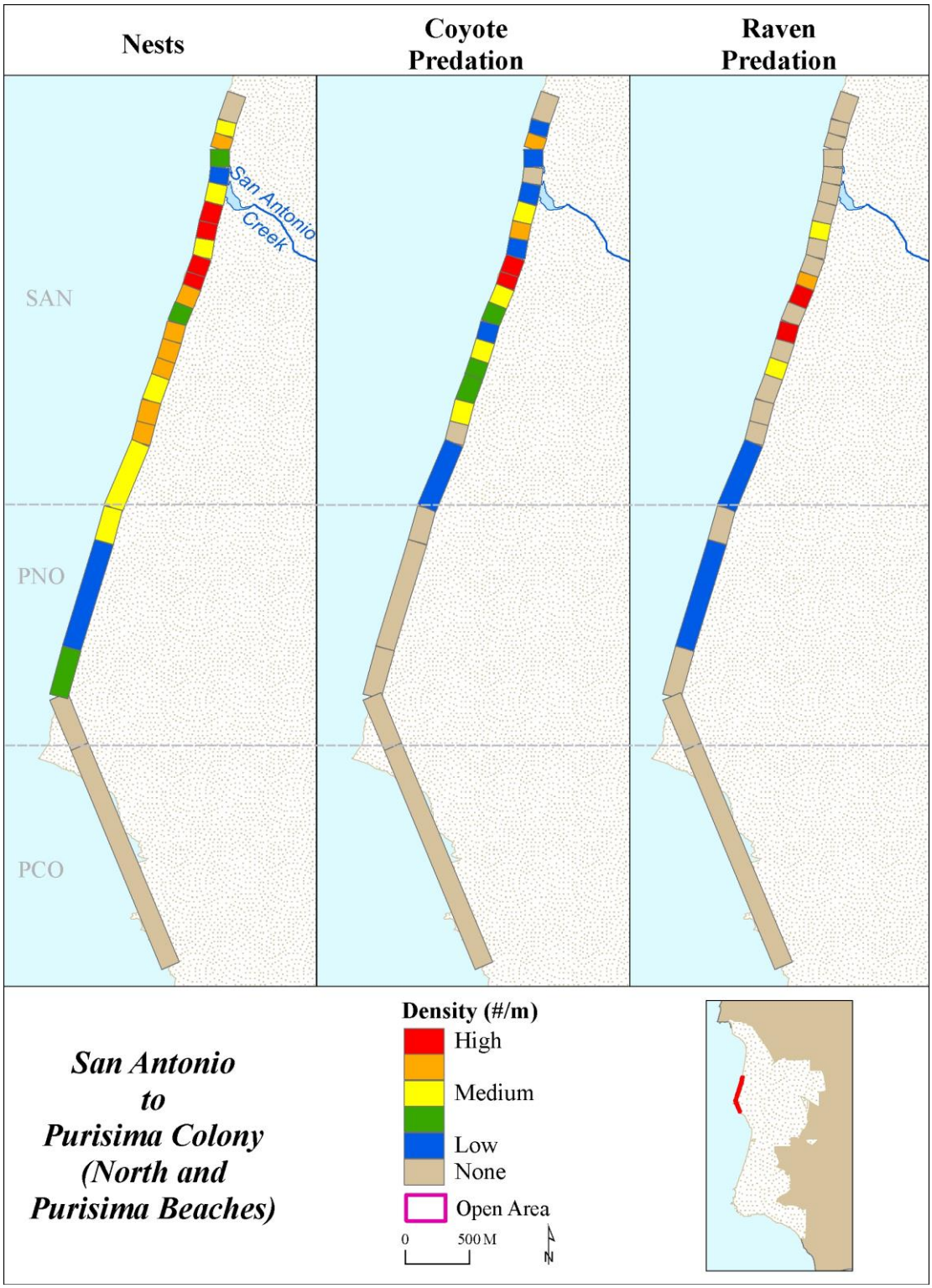


Figure 3. Snowy plover nest densities within North and Purisima Beach transect blocks from San Antonio to Purisima North (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple. See Figure 2 for the values for density.

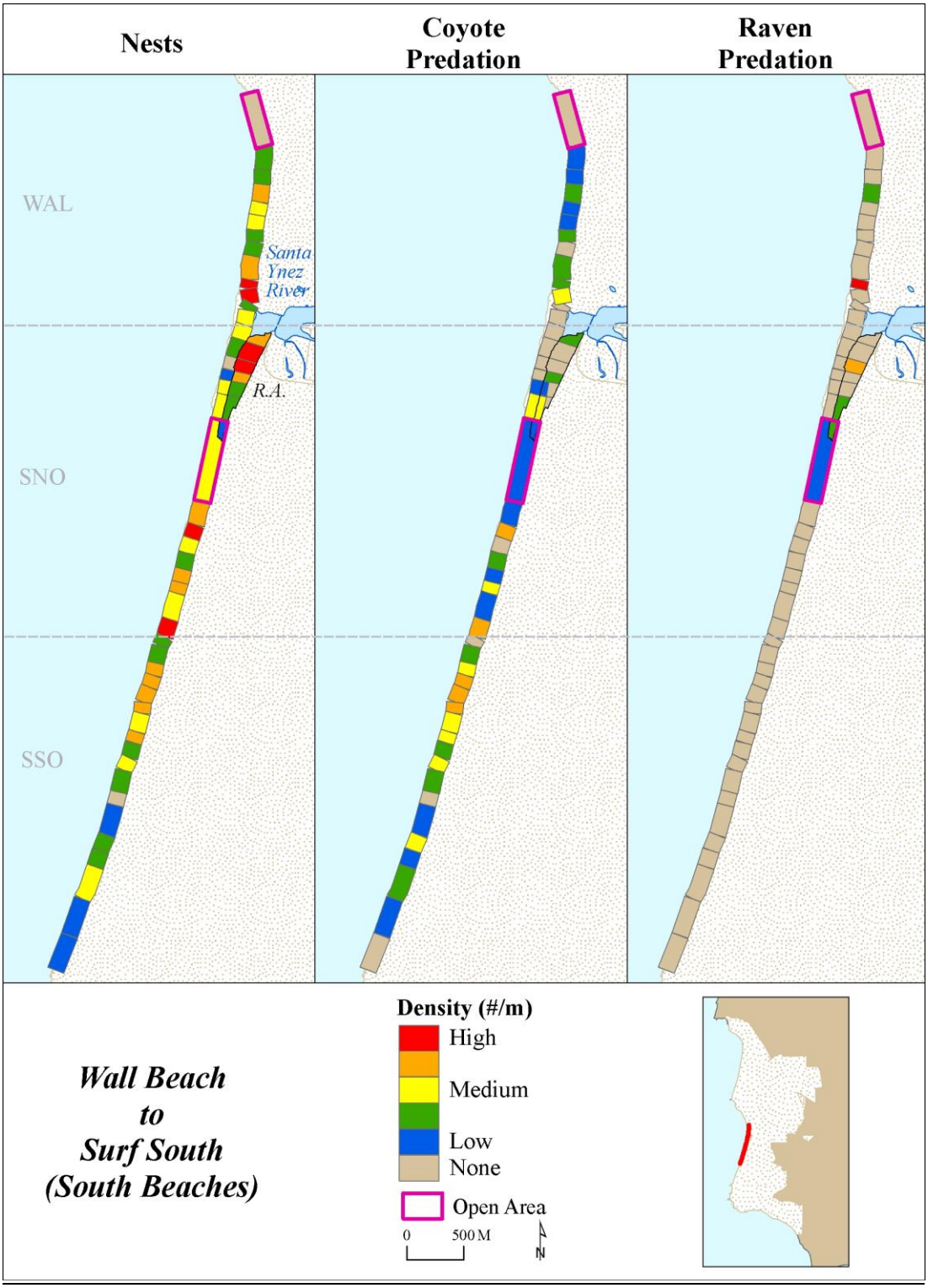


Figure 4. Snowy plover nest densities within South Beach transect blocks (see Figure 1 for boundaries of each beach sector). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple. See Figure 2 for the values for density.

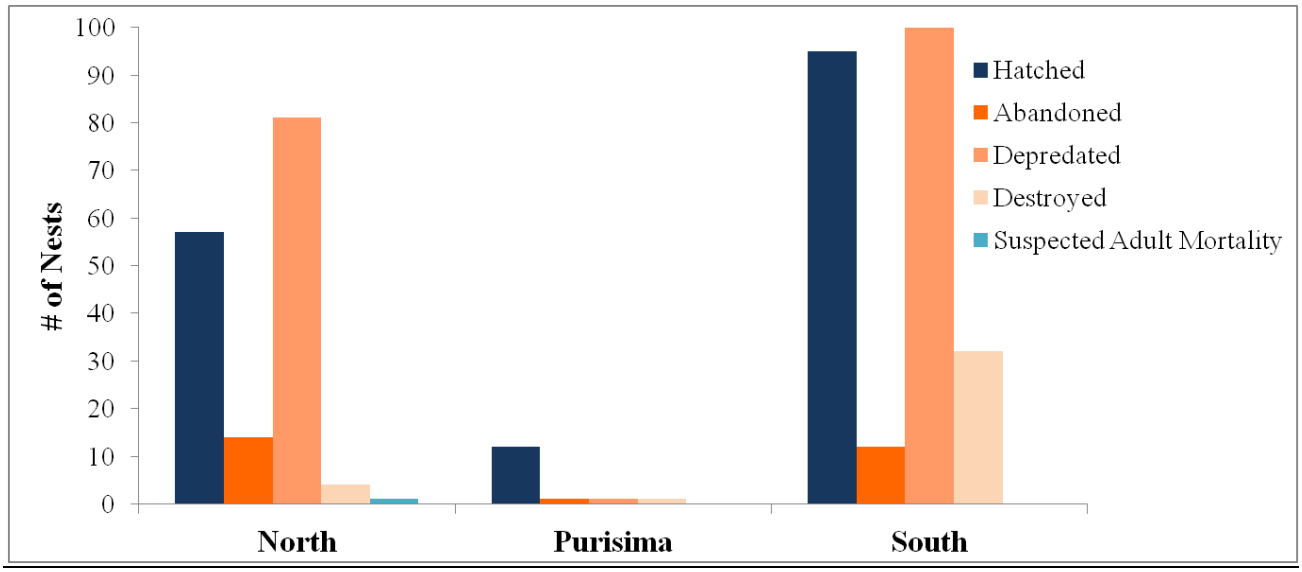


Figure 5. Nest fates on North, Purisima, and South Beaches in 2014. Destroyed nests include those destroyed by both humans and natural causes (e.g., tides and wind).

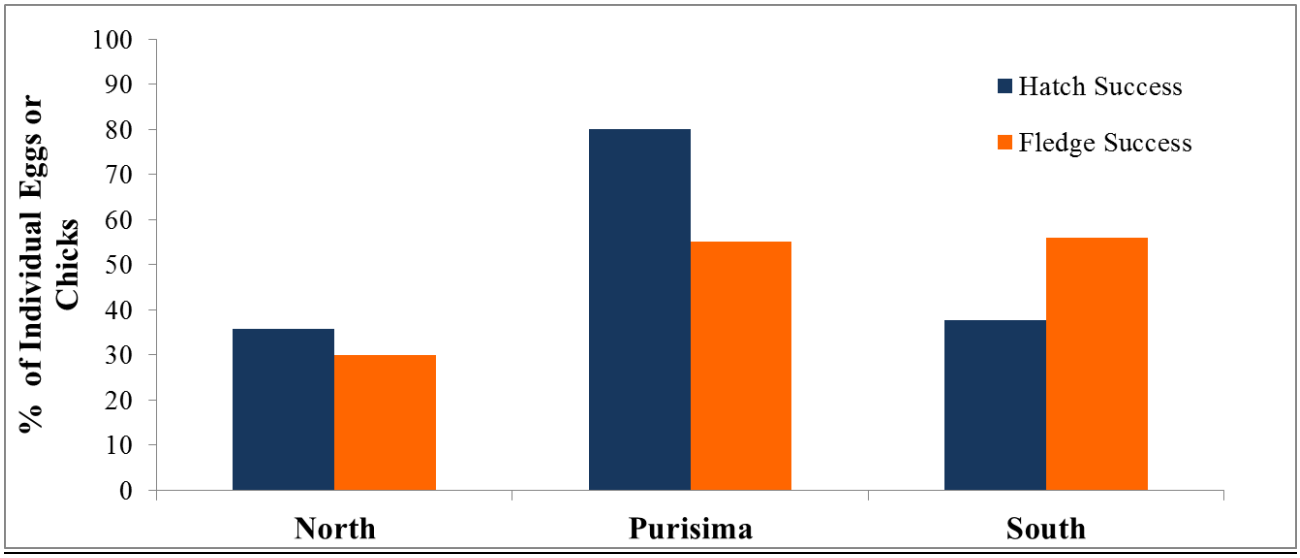


Figure 6. Clutch hatch and fledging success on North, Purisima, and South Beaches in 2014.

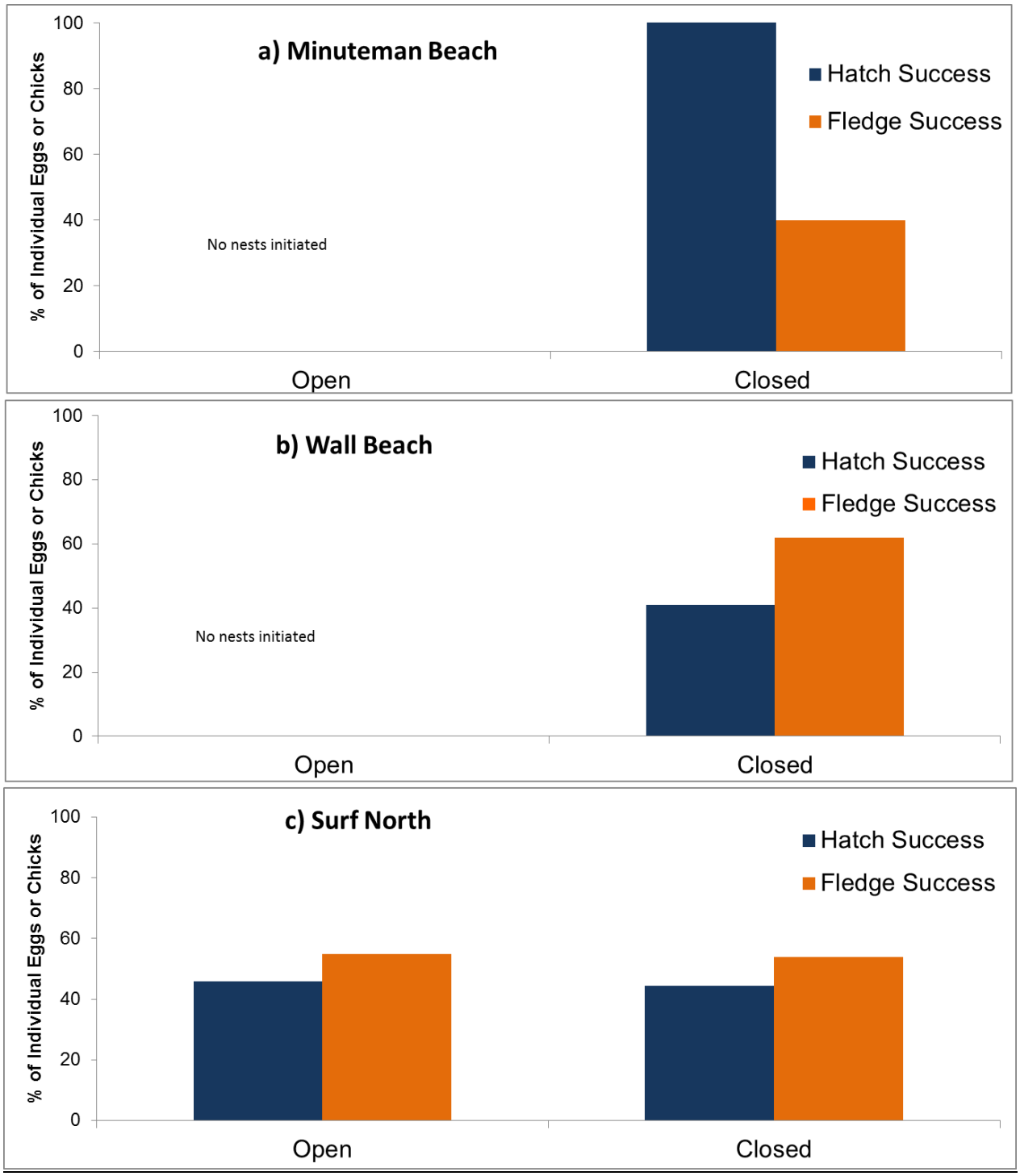


Figure 7. Clutch hatch and fledging success in open and closed areas of Minuteman, Wall, and Surf Beaches.

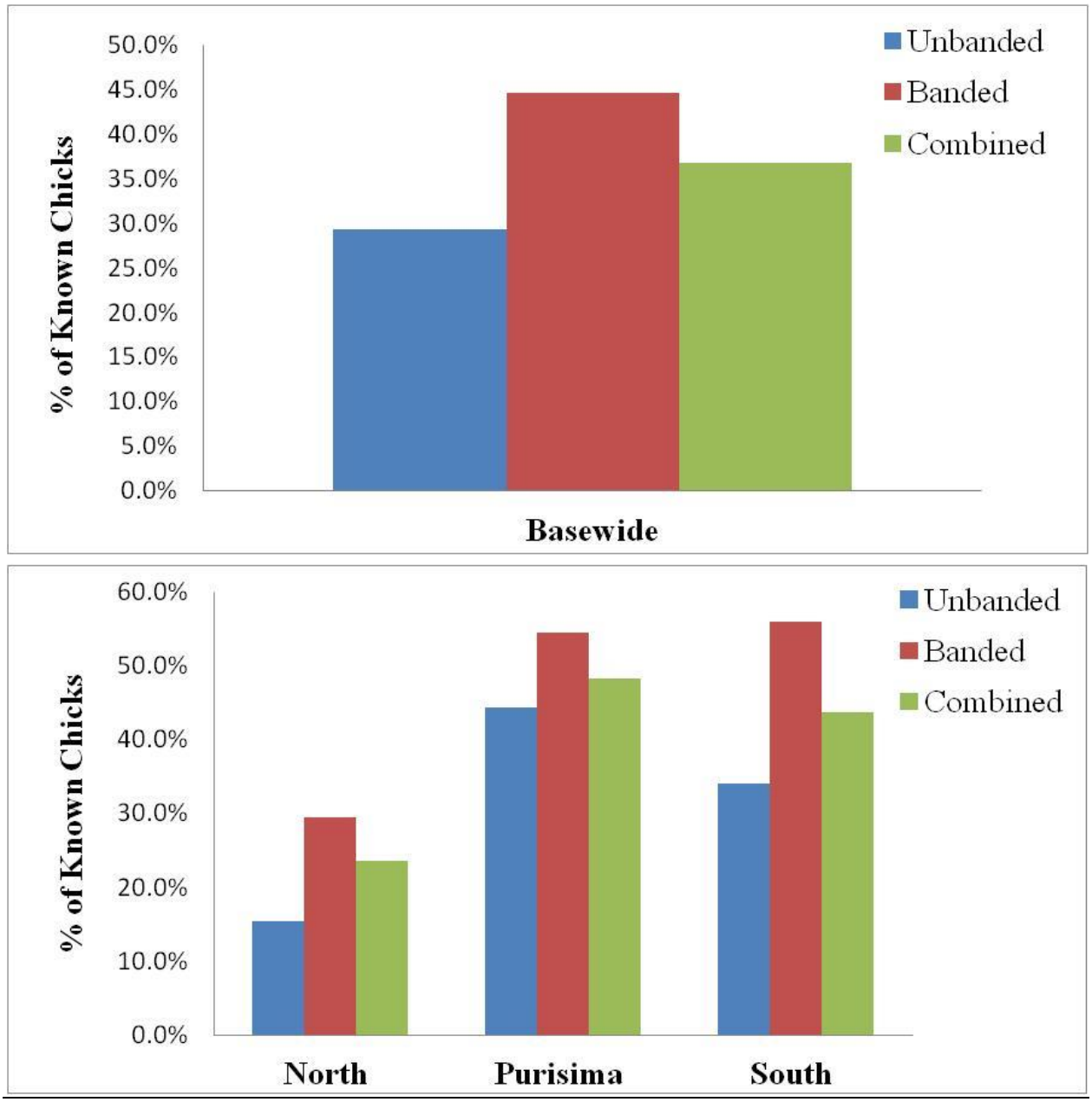


Figure 8. Fledging rates calculated a) basewide and b) for North, Purisima, and South Beach sections in 2014 using banded fledgling counts, unbanded fledgling counts, and banded and unbanded fledglings combined.

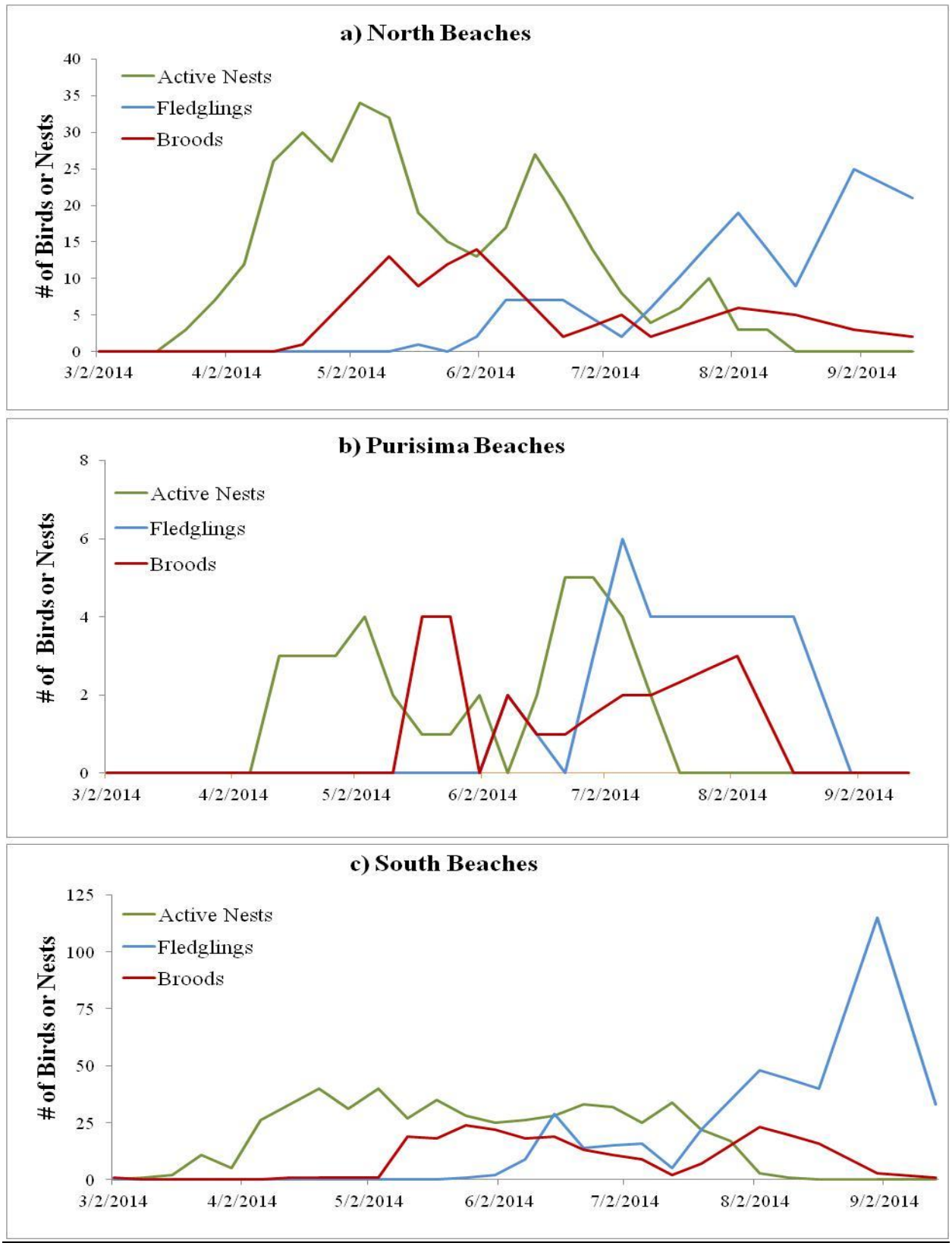


Figure 9. Breeding phenology at North, Purisima, and South Beaches in 2014.

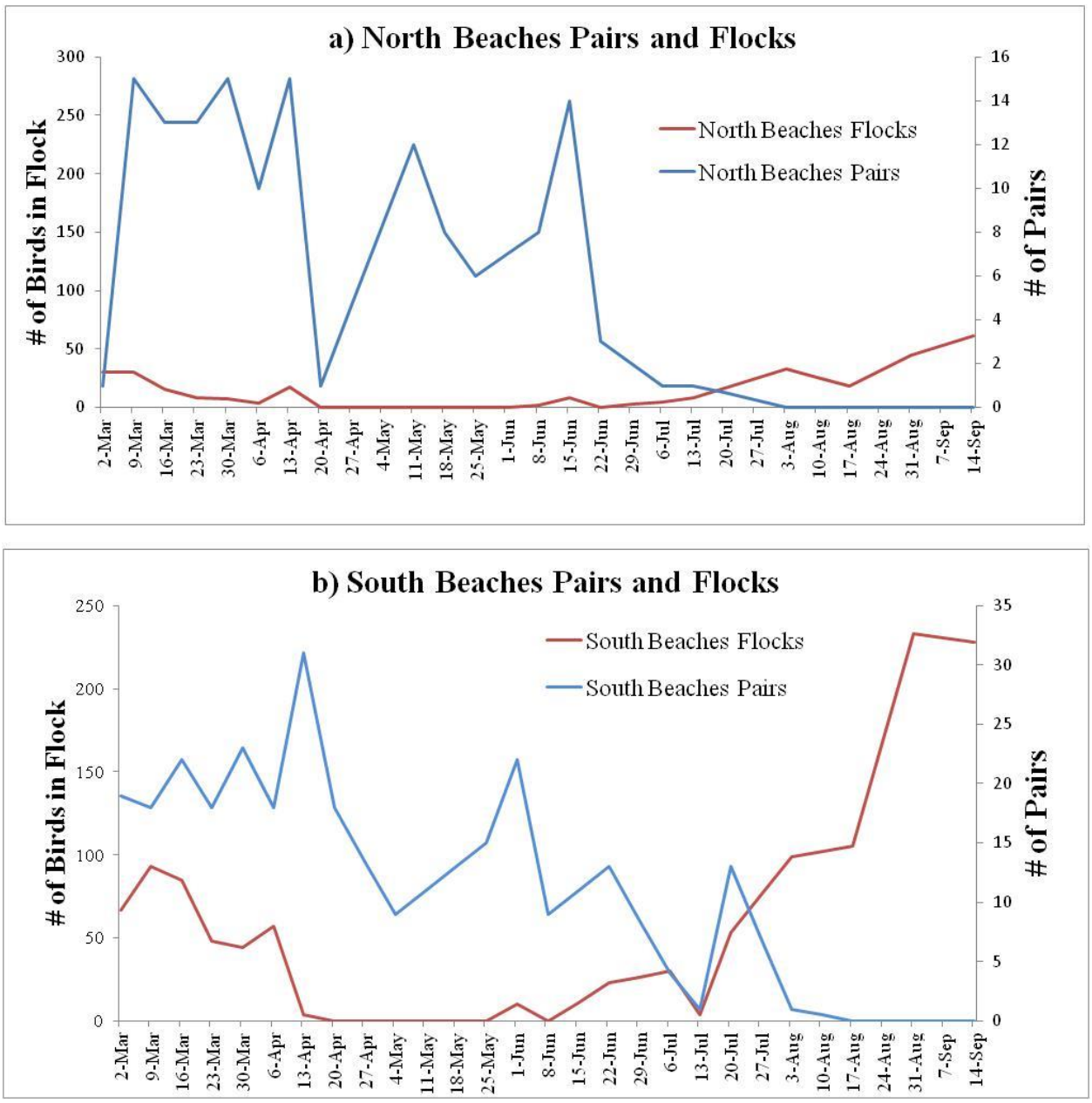


Figure 10. Numbers of plover adult pairs detected during weekly transect surveys versus number of plovers in flocking groups on North and South Beaches.

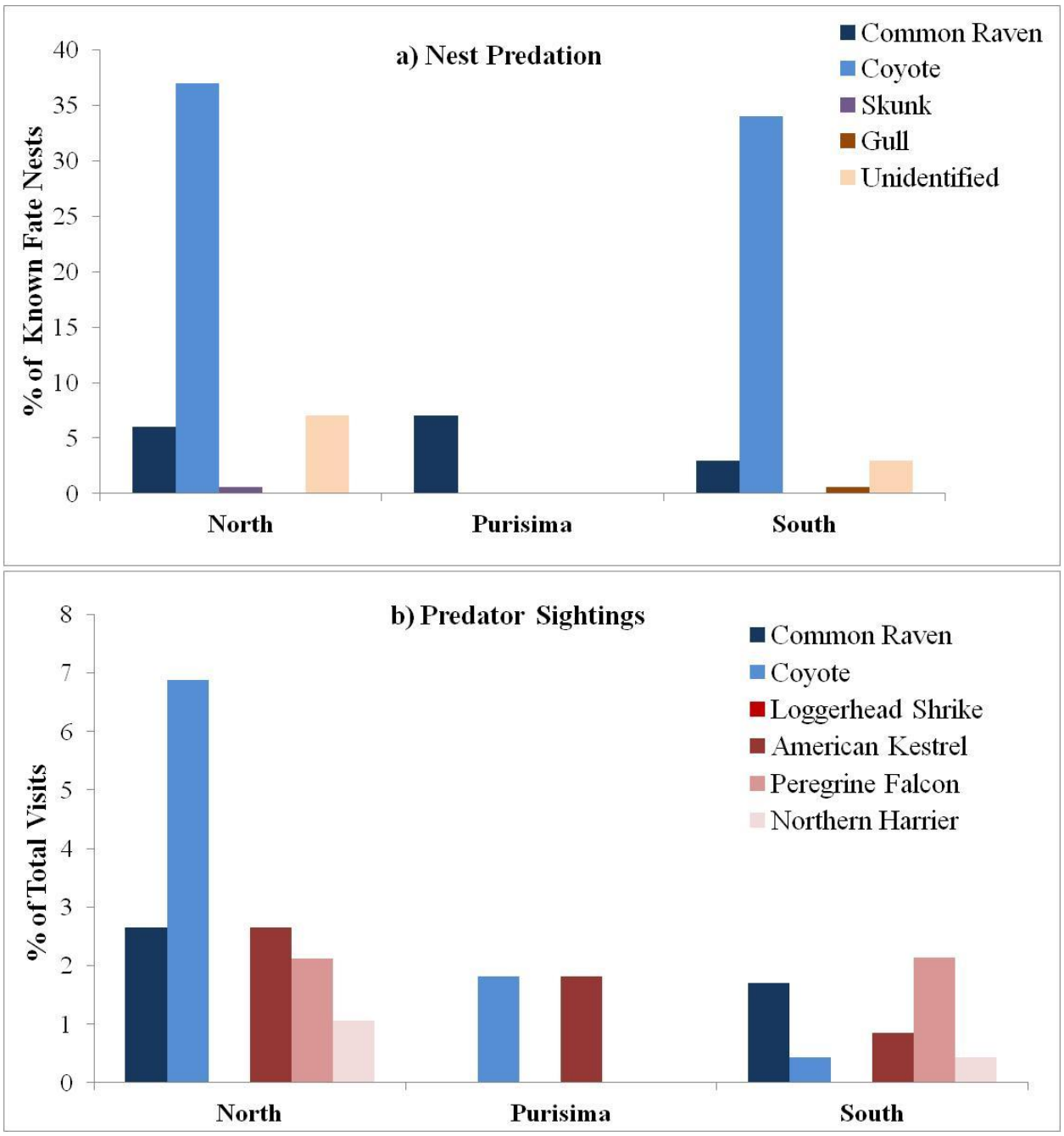


Figure 11. a) Distribution of known fate nests taken by predators and b) predator sightings on North, Purisima, and South Beaches in 2014. Number of nests taken by common ravens includes both confirmed and suspected predation.

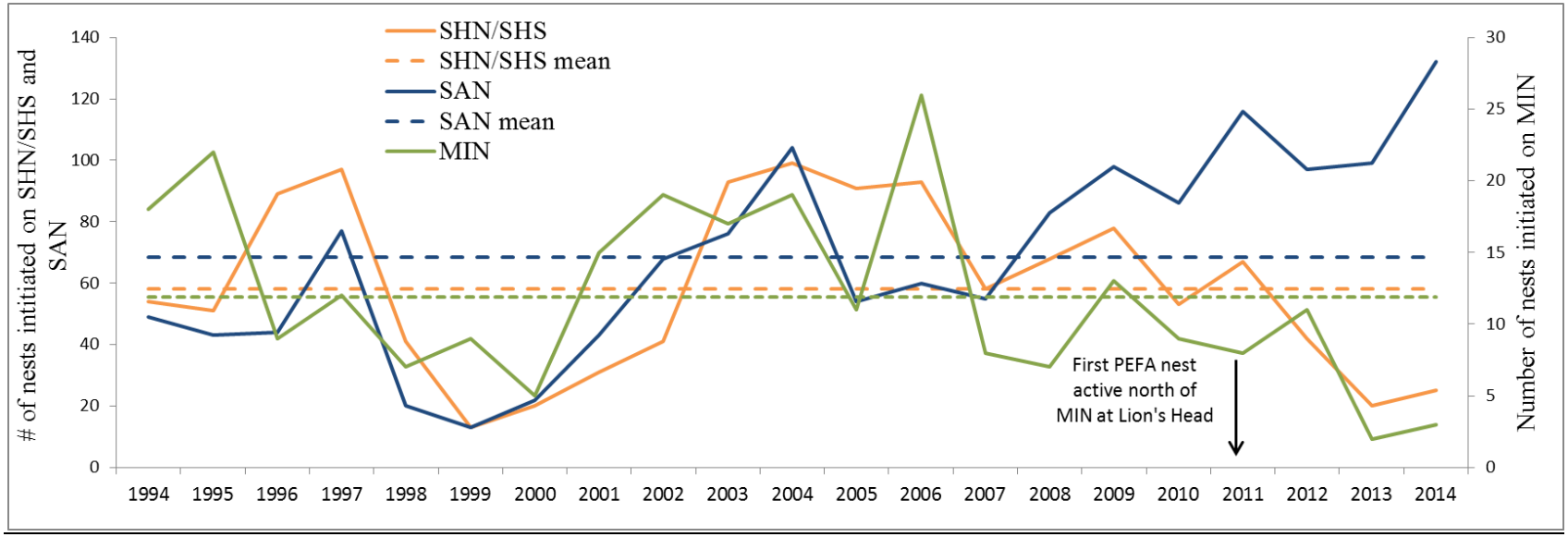


Figure 12. Number of nests initiated on MIN, SHN/SHS, and SAN from 1994-2014. Arrow indicates the establishment of a peregrine falcon eerie at Lion's Head. Dashed lines show the 21-year mean for each beach sector.

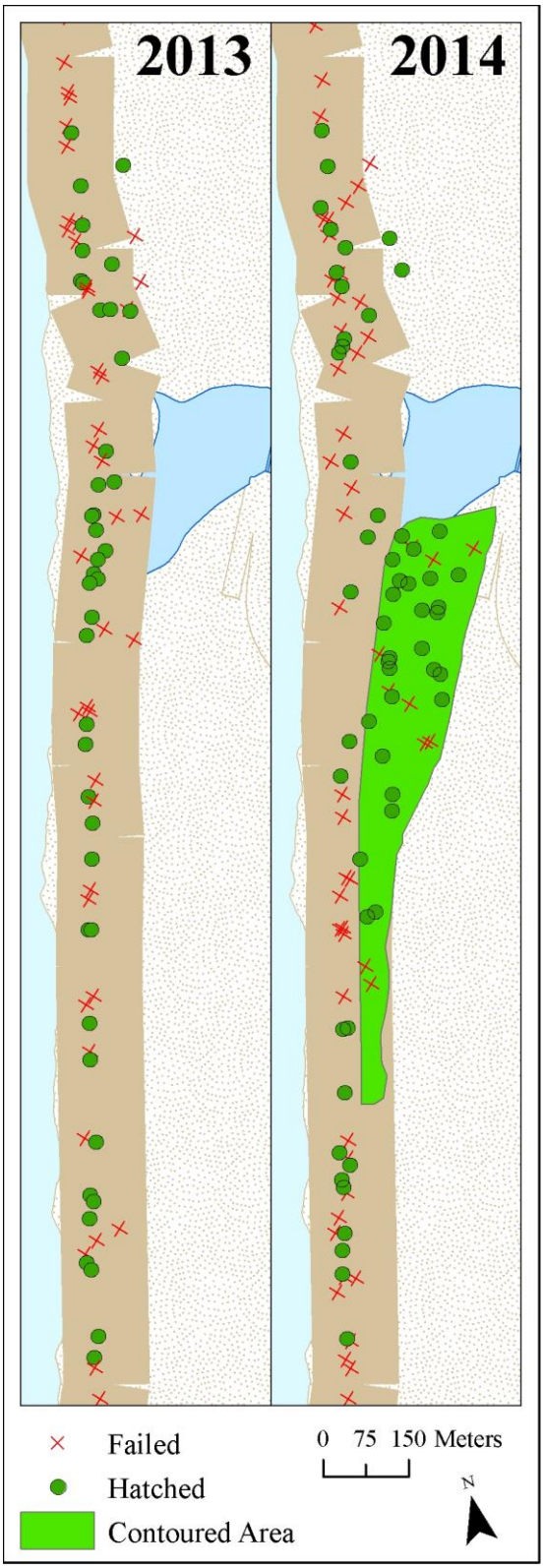


Figure 13. Snowy plover nest distribution within the north portion of Surf North in 2013 and 2014. The SNO Contoured Area is shaded in green.

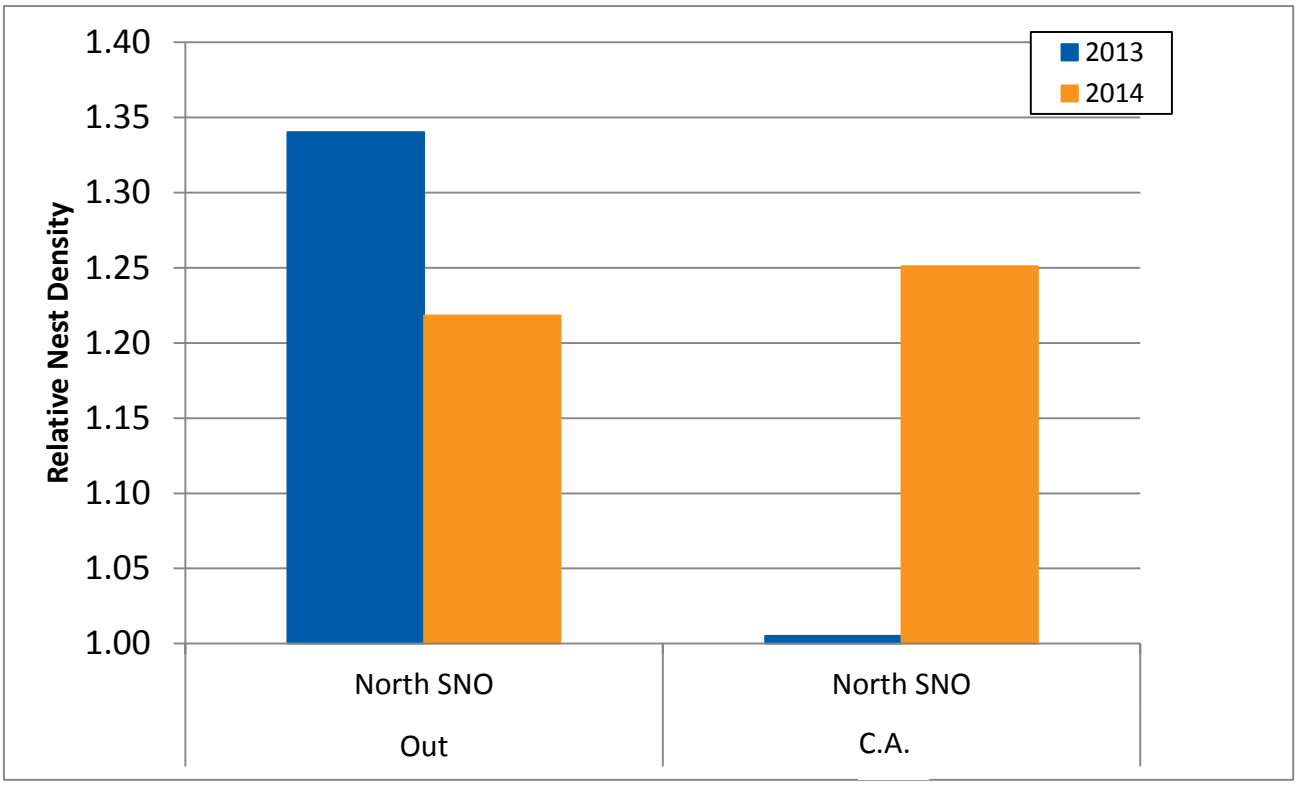


Figure 14. Relative nest densities on north SNO inside and outside of the Contoured Area (C.A.).

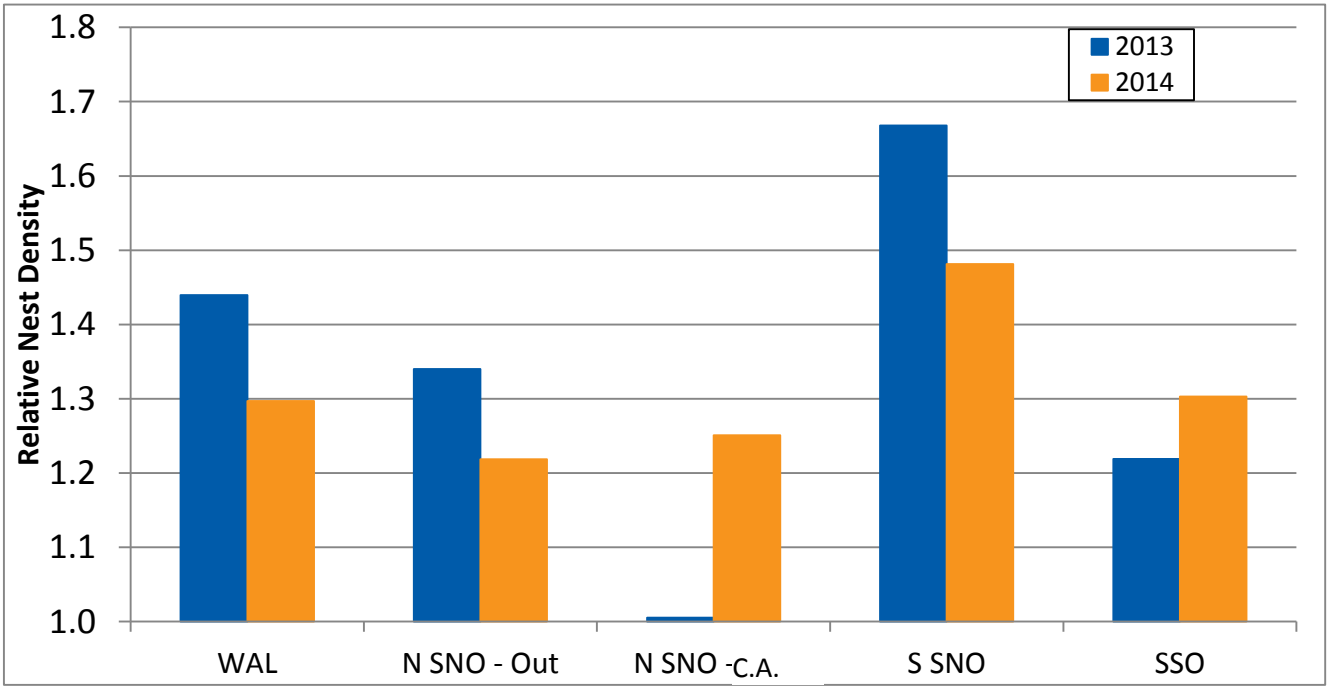


Figure 15. Relative nest densities on South Beach sectors, oriented north to south, inside and outside of the Contoured Area (C.A.).

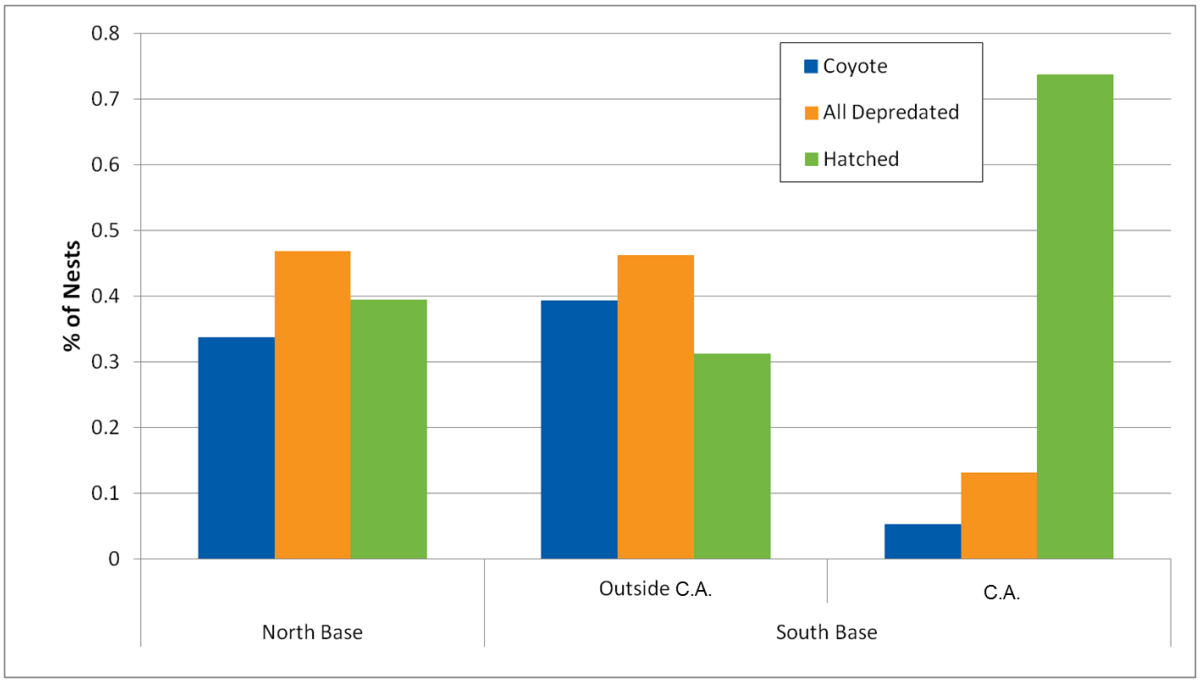


Figure 16. Hatch success on North Beaches and South Beaches, inside and outside of the Contoured Area (C.A.). The category "All Depredated" includes coyote depredations.

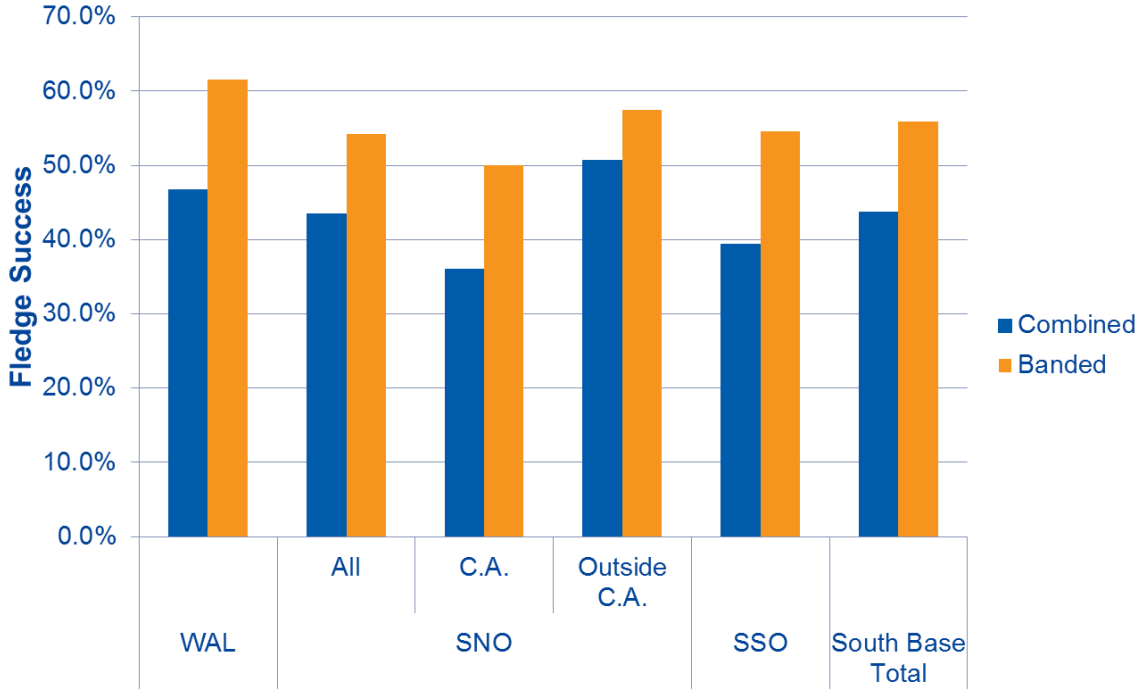


Figure 17. Fledging success of banded and combined banded/unbanded broods on all sectors of South Beaches. C.A. = Contoured Area.

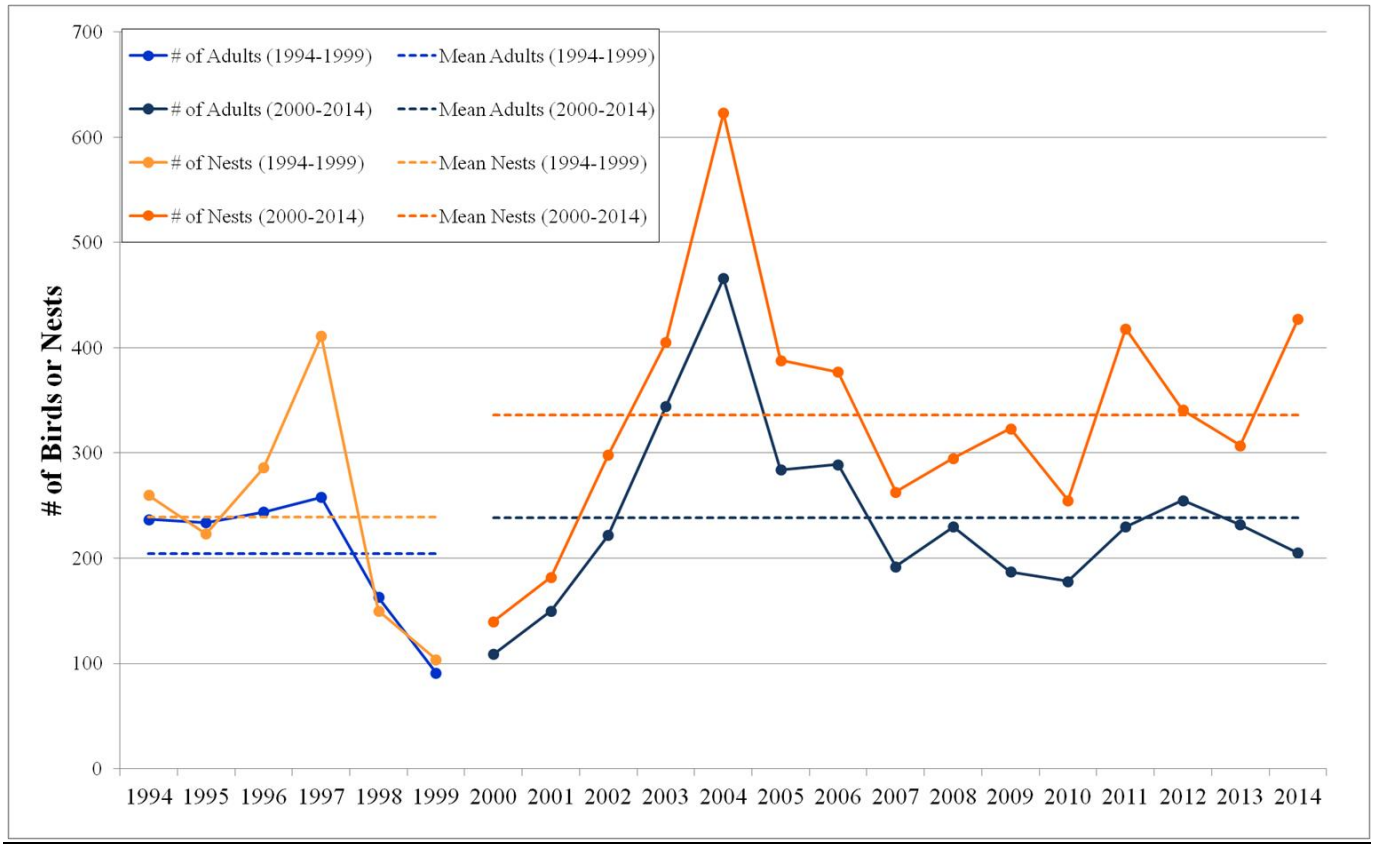


Figure 18. Trends in annual breeding population assessed using maximum number of adults observed during window surveys and number of nests initiated from 1994-2014. Dashed lines show the long-term means calculated for the periods during linear restriction (1994-1999) and after beach closures took effect (2000-2014).

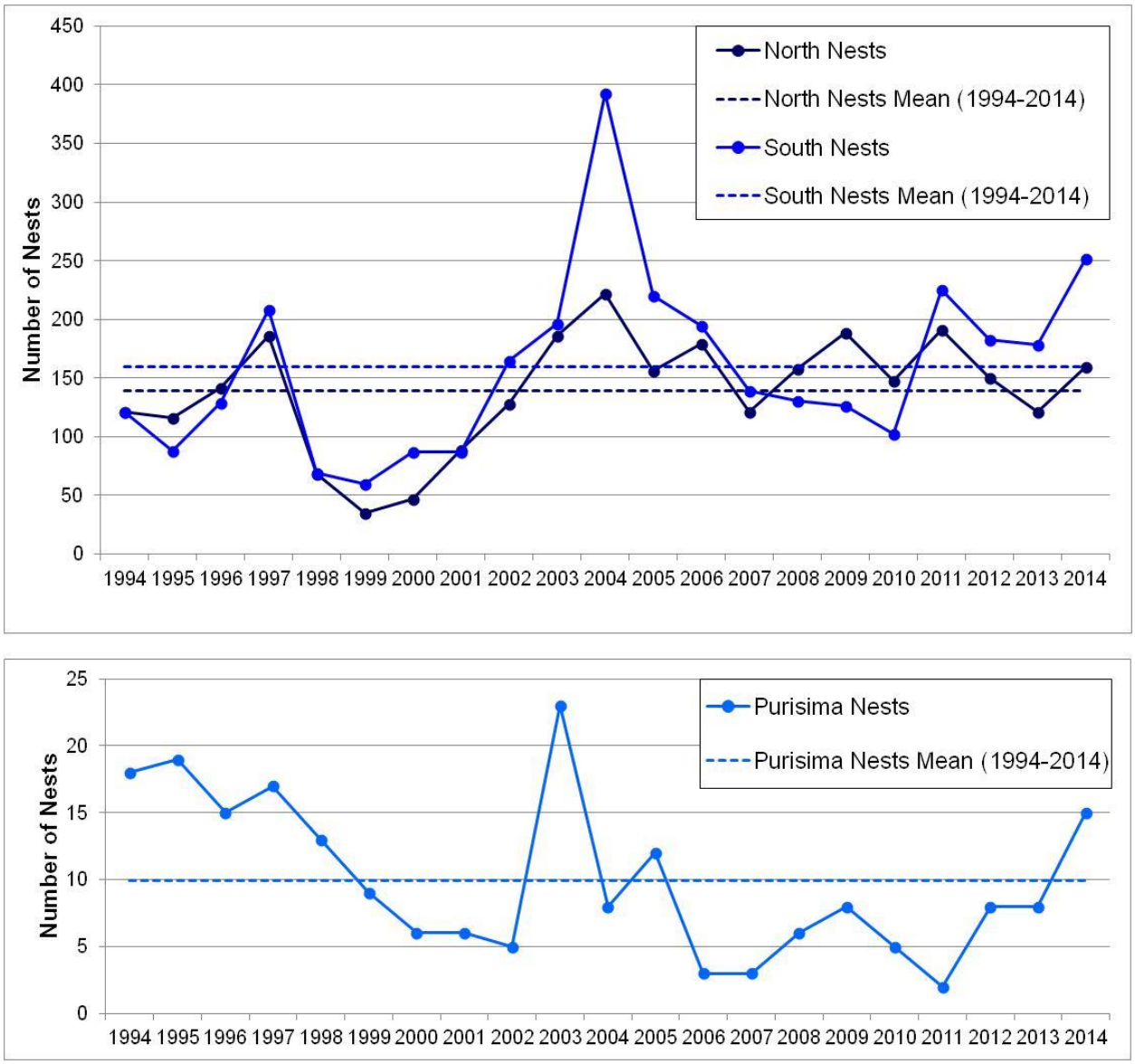


Figure 19. Trends in annual number of nests initiated for North, South, and Purisima Beaches from 1994-2014. Dashed lines show the 21-year means (1994-2014).

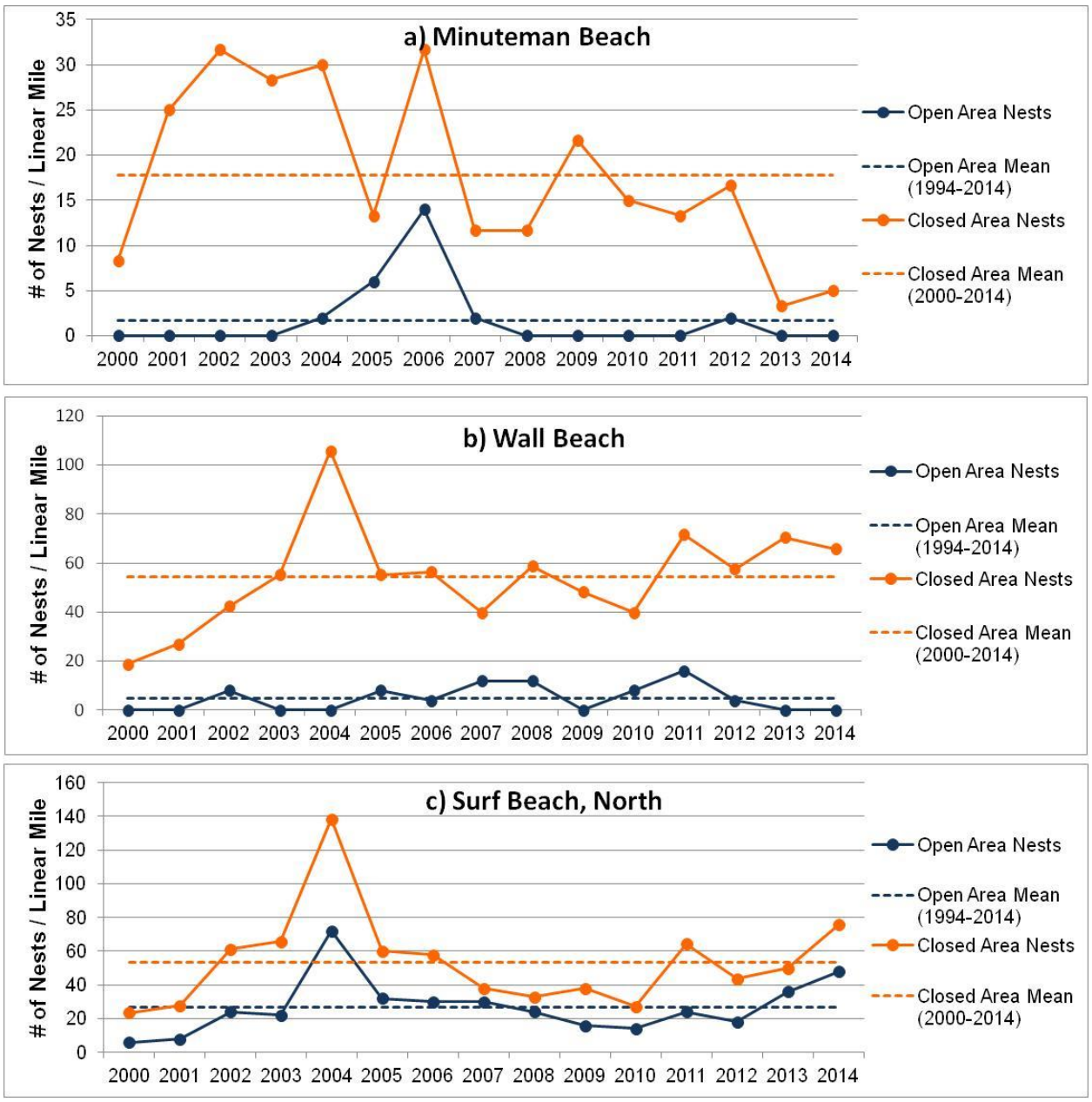


Figure 20. Trends in annual number of nests per linear mile within open and closed sections of Minuteman, Wall, and Surf Beaches, from 2000-2014. Dashed lines show the 15 year means (2000-2014).

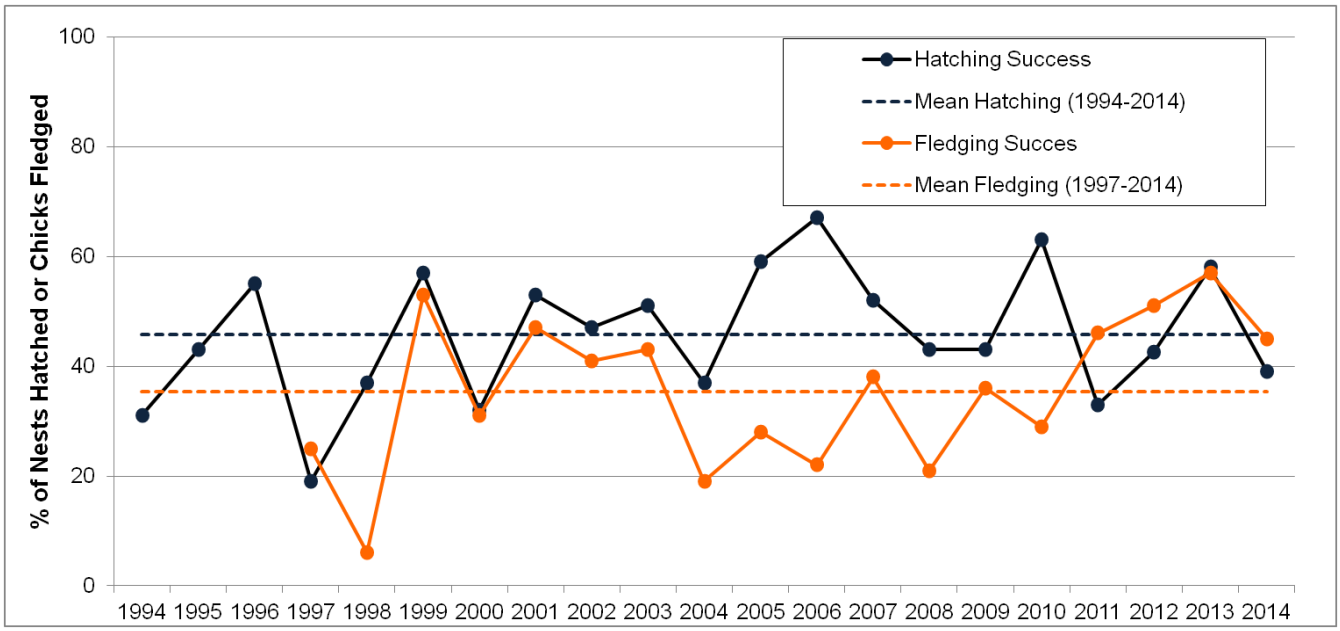


Figure 21. Trends in annual snowy plover clutch hatch and fledging success on VAFB from 1994 to 2014. Data on fledging success were not available for 1994-1996.

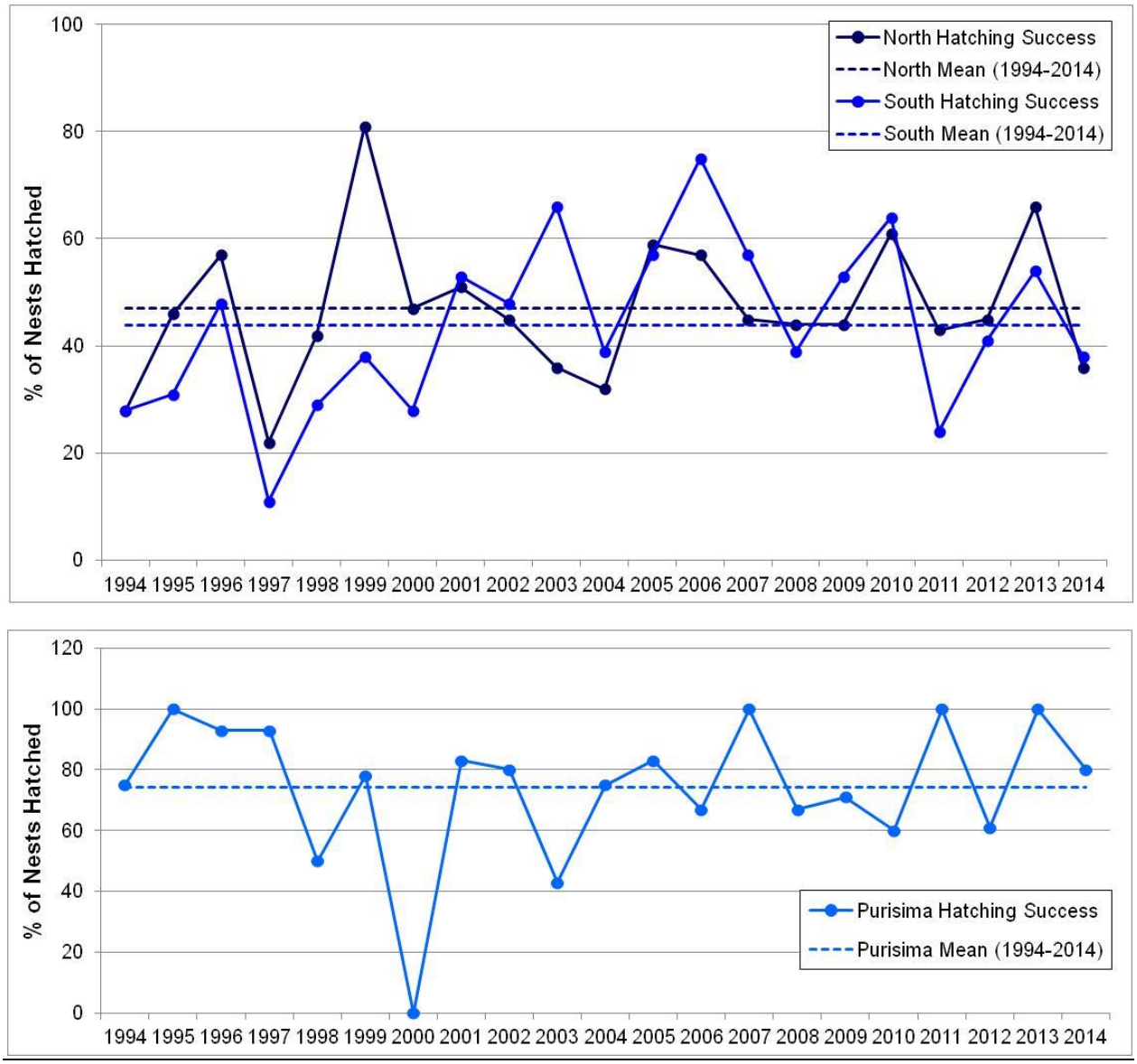


Figure 22. Trends in annual clutch hatch success on North, South, and Purisima Beaches from 1994 to 2014. Dashed lines show the 21-year mean for each beach section.

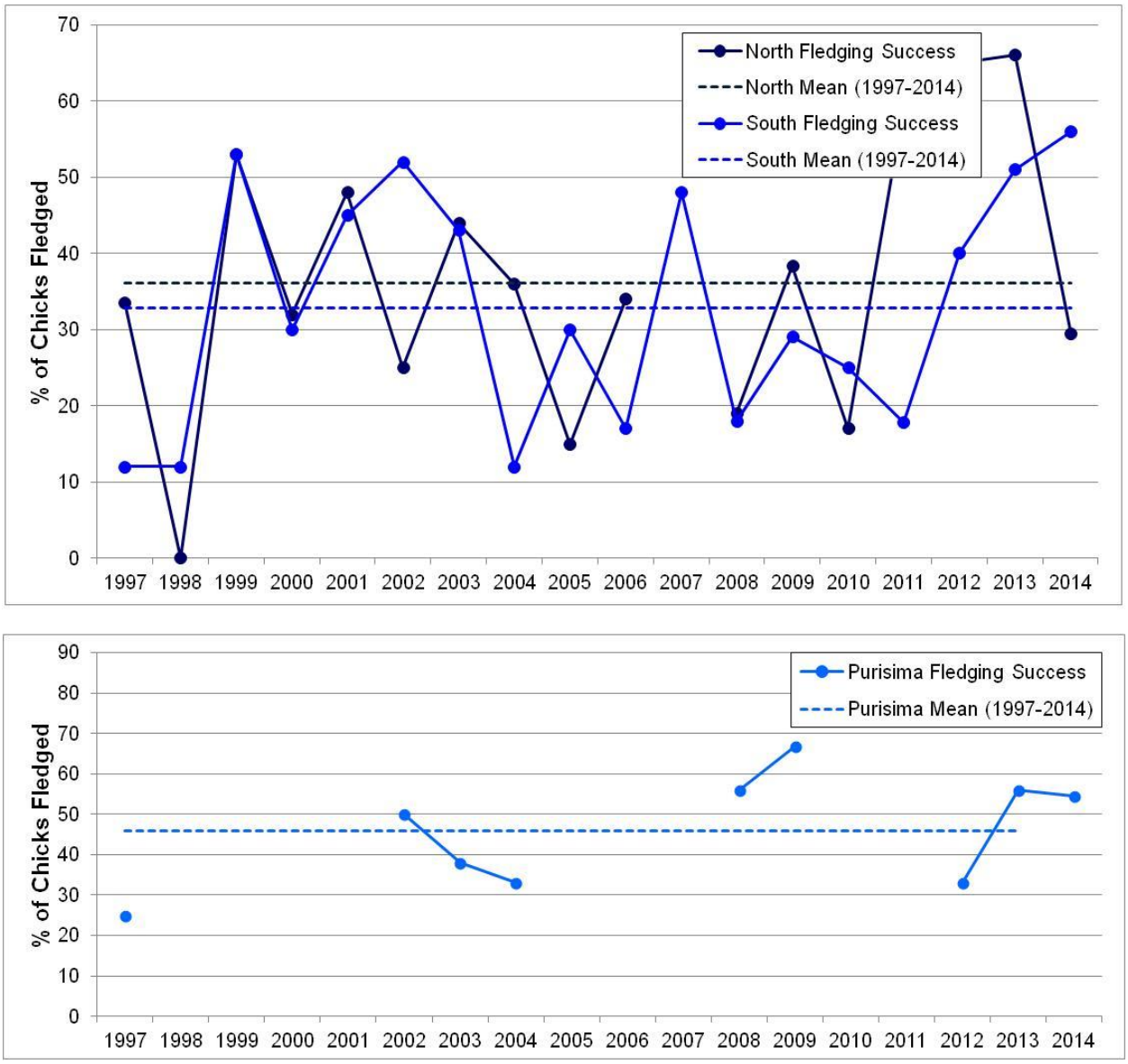


Figure 23. Trends in annual fledging success on North, South, and Purisima Beaches from 1997 to 2014. Missing data points indicate years when fledging success was not determined. Dashed lines indicate the 18-year mean for each beach section.

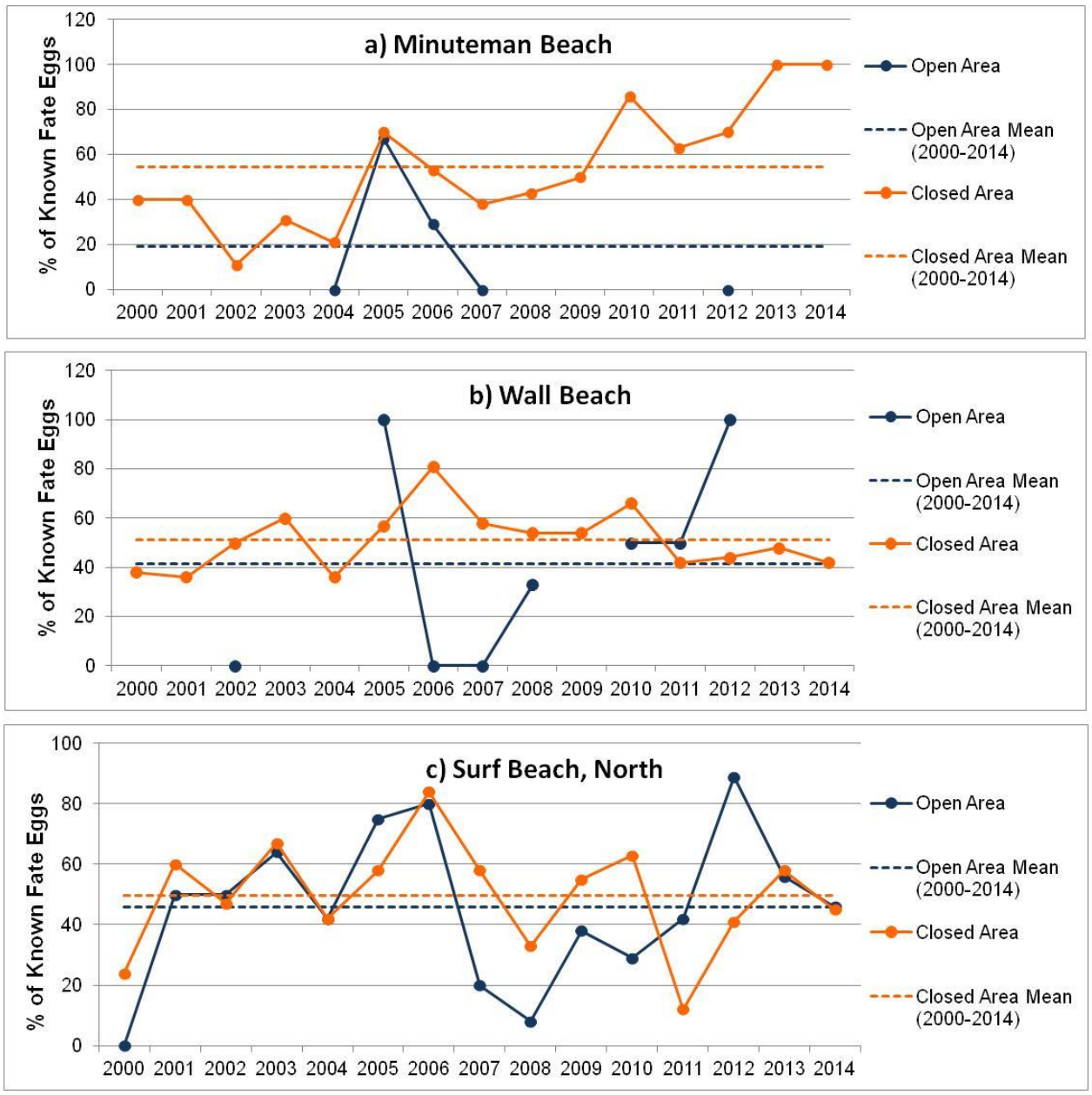


Figure 24. Trends in annual clutch hatch success at open and closed areas of Minuteman, Wall, and Surf beaches. Missing data points indicate years where no nests were initiated within that particular beach sector.

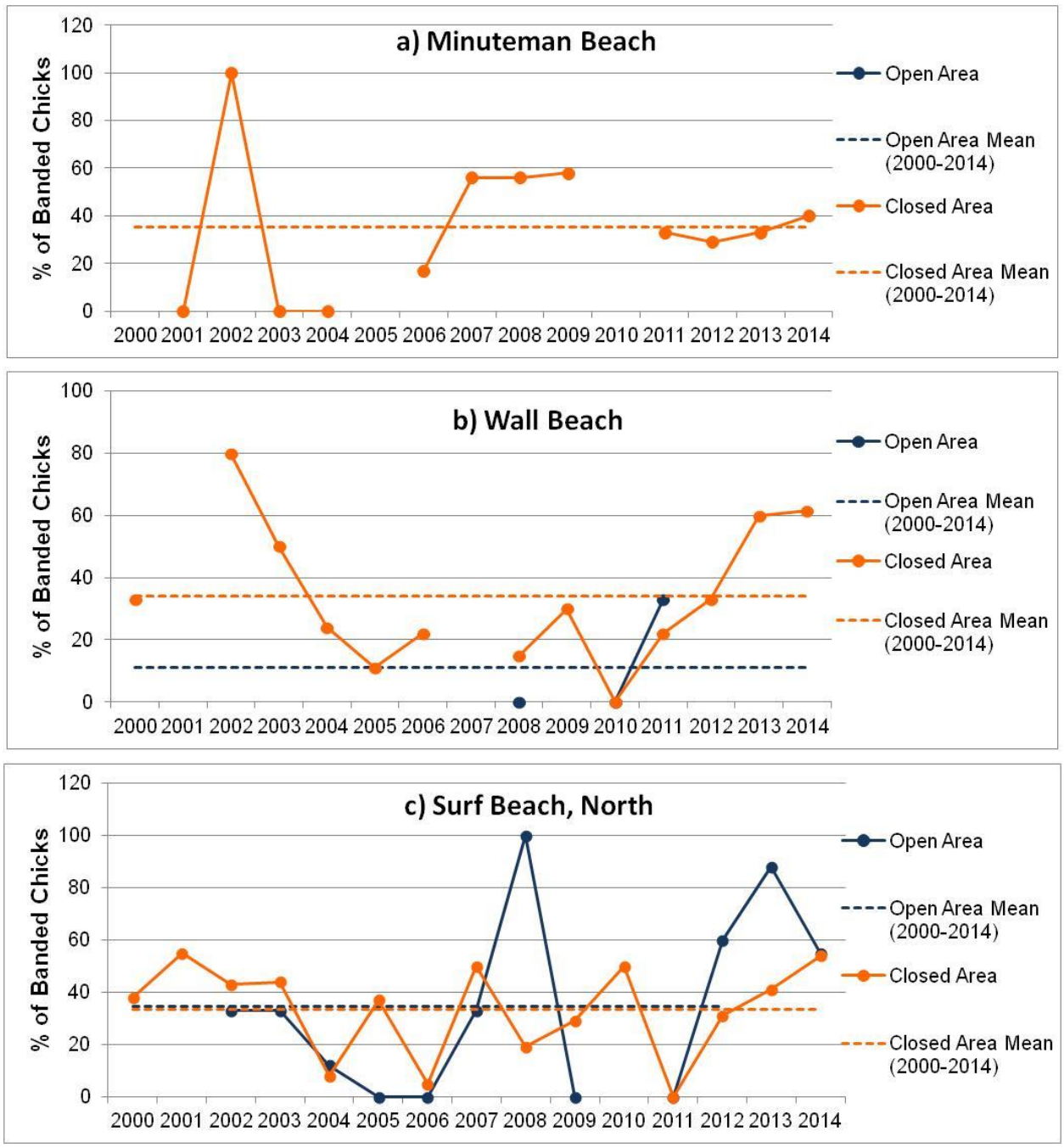


Figure 25. Trends in annual fledging success within open and closed areas of Minuteman, Wall, and Surf Beaches. Missing values indicate years when no nesting occurred or fledging success was not determined for that particular beach sector.

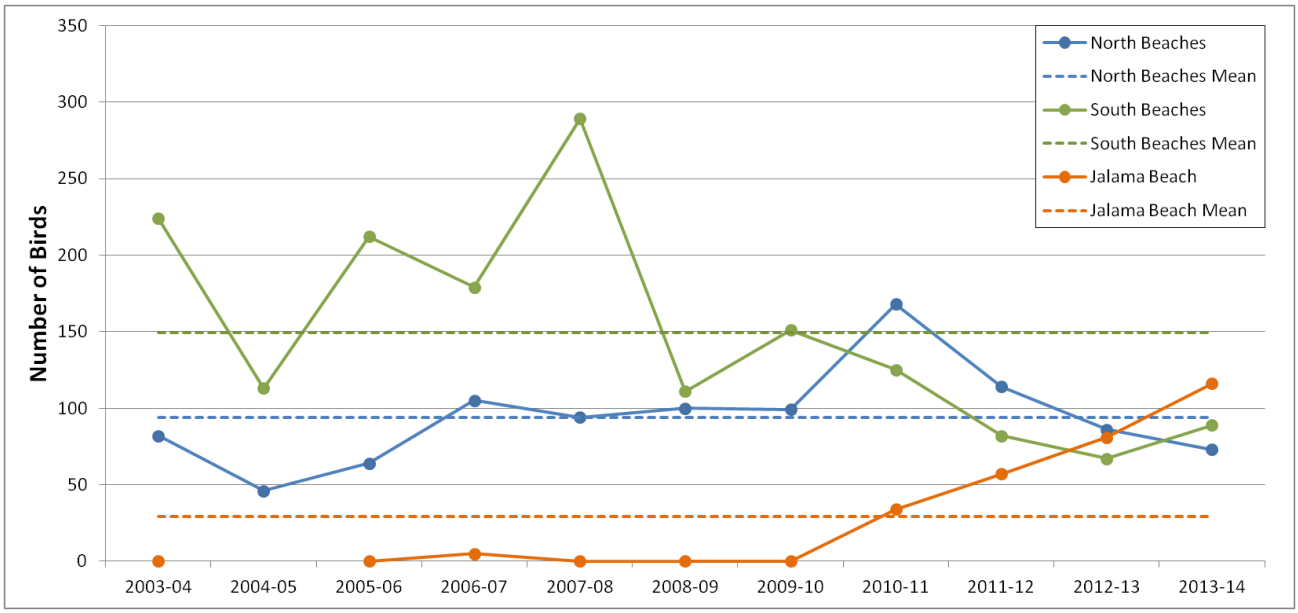


Figure 26. Trends in annual winter population assessed using maximum number of adults observed during the range wide winter window surveys from 2003/2004 to 2014. Dashed lines indicate the 11-year mean for each beach section

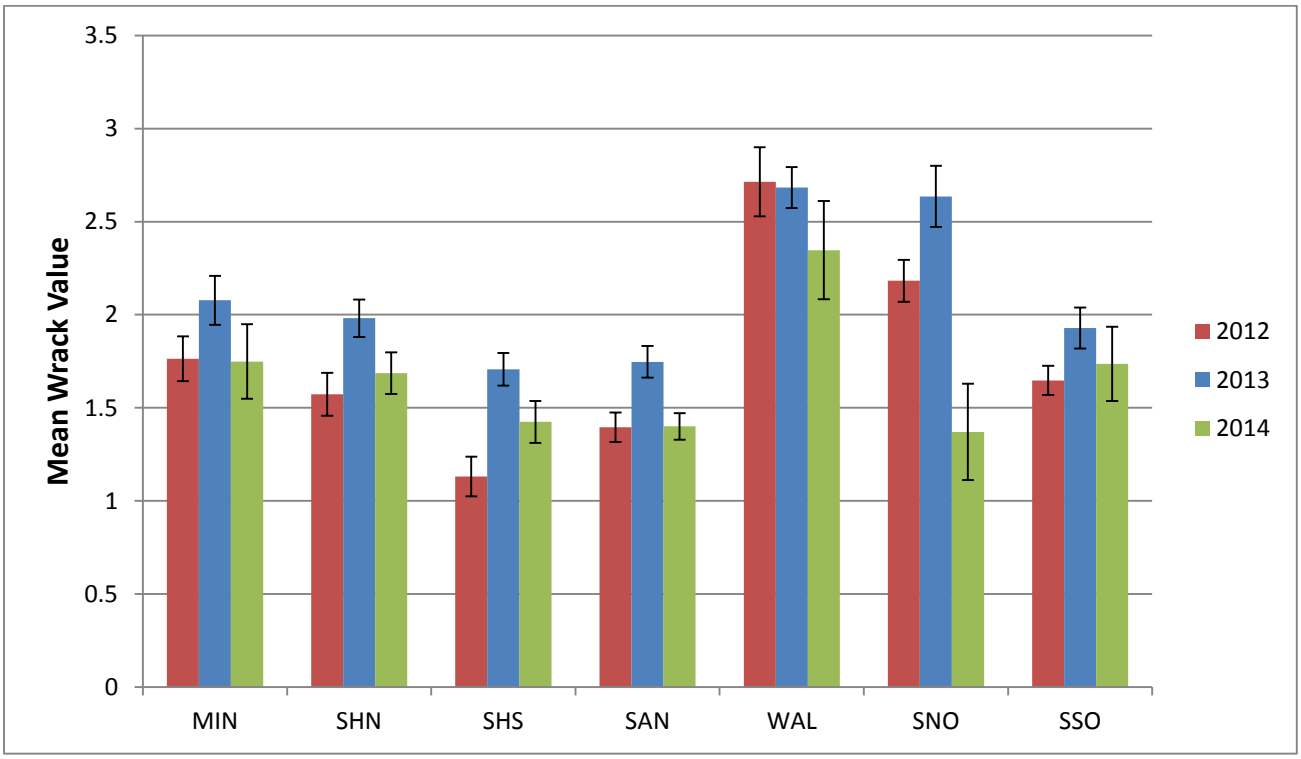


Figure 27. Mean wrack index values for each beach sector from 2012 to 2014. Error bars represent the standard error.

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 2014 breeding season

Observations of Western snowy plovers banded on VAFB prior to 2014

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
(S)	R	M	19 August	VAFB - Year Undeterminable		
A	G/Y	M, U	4 March - 2 September	2012 - VAFB Purisima North	VAFB Breeder	
B	G/Y	F	4 March - 19 September	2009 - VAFB Minuteman	VAFB Breeder	
B	Y/G	U	13 March	2013 - VAFB Shuman South		
G	W/R/W	M, U	9 April - 19 September	2013 - VAFB Wall	VAFB Breeder	
L	-/W	U	27 August - 16 September	2013 - VAFB San Antonio		Former L:G/W
L	O/G	F	14 - 23 July	2013 - VAFB Surf South		
N(S)	AW	F, U	4 March - 25 April , 17 June - 28 July	VAFB - Year Undeterminable	Possible Breeder	
N(S)	AY	U	22 July, 16 September	VAFB - Year Undeterminable		
N(S)	GB	M	16 September	VAFB - Year Undeterminable		
N(S)	GB	U	2 - 10 March	VAFB - Year Undeterminable		
NB	AG	U	23 July - 28 August	2011 - VAFB Surf South		
NB	AR	M	14 April - 8 July	2013 - VAFB San Antonio		
NB	AY	F, M, U	11 March, 26 June - 19 September	2006 - VAFB Shuman North		Just one bird
NB	BG	F	2 May	2011 - VAFB San Antonio		
NB	BW	M	28 - 29 June	2013 - VAFB Surf North		
NB	GR	M	4 March - 10 September	2011 - VAFB San Antonio	VAFB Breeder	
NB	GW	M	4 March - 3 September	2011 - VAFB San Antonio	VAFB Breeder	
NB	GY	M	27 March - 5 June	2011 - VAFB San Antonio	VAFB Breeder	
NB	OB	F	1 April - 1 July	2013 - VAFB San Antonio	VAFB Breeder	
NB	OY	M	14 April	2012 - VAFB San Antonio		
NB	PY	M	4 March - 1 May	2011 - VAFB San Antonio	VAFB Breeder	
NB	WW	M,U	4 March - 2 September	2011 - VAFB Wall	VAFB Breeder	
NB	YB	F, U	19 March - 19 September	2011 - VAFB San Antonio	VAFB Breeder	
NO	AG	M, U	4 March - 11 June	2013 - VAFB San Antonio	VAFB Breeder	
NO	AR	M, U	2 March - 17 September	2013 - VAFB San Antonio	Possible Breeder	
NO	AW	F, U	9 April - 8 August	2013 - VAFB Surf North		
NO	BY	F, U	4 March - 19 September	2013 - VAFB Purisima North	VAFB Breeder	
NO	GG	M	4 March - 1 April	2013 - VAFB Shuman North		
NO	GR	M, U	13 March - 10 September	2013 - VAFB San Antonio	VAFB Breeder	
NO	GW	M	1 July - 16 September	2013 - VAFB Surf South	VAFB Breeder	
NO	GY	F	27 March	2009 - VAFB Minuteman		
NO	NR	M	4 March - 29 May	2009 - VAFB Shuman North	VAFB Breeder	
NO	NY	M	11 March	2013 - VAFB Surf North		
NO	OR	M	31 March	2009 - VAFB San Antonio		
NO	PO	U	13 March	VAFB - Year Undeterminable		
NO	PW	F, U	4 March - 7 July	2013 - VAFB Surf North	VAFB Breeder	
NO	PW	M	11 March	2013 - VAFB Surf North		

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
NO	RB	F, U	29 May - 20 August	2013 - VAFB San Antonio	VAFB Breeder	
NO	RG	U	19 September	2004 - VAFB Surf South		
NO	RY	F, U	4 March - 25 July	2013 - VAFB San Antonio	VAFB Breeder	
NO	RY	M	5 May - 22 August	2013 - VAFB San Antonio	Possible Breeder	
NO	WG	F, U	11 March - 8 August	2012 - VAFB San Antonio	VAFB Breeder	
NO	WY	F	13 March - 5 June	2013 - VAFB San Antonio	VAFB Breeder	
NO	WY	M	8 April - 13 August	2013 - VAFB San Antonio	VAFB Breeder	
NO	WY	U	4 - 19 March, 9 July - 19 September	2013 - VAFB San Antonio		3 individuals
NO	YR	M	11 March	2013 - VAFB Surf South		
NO	YY	F	23-24 June	2013 - VAFB Purisima North	VAFB Breeder	
NR	AY	F, M, U	4 March - 12 May	2013 - VAFB San Antonio	VAFB Breeder	
NR	BW	F	13 March - 9 July	2012 - VAFB San Antonio	VAFB Breeder	
NR	BY	F	17 April, 6 June	2013 - VAFB Wall	VAFB Breeder	
NR	GR	M, U	2 March - 14 July, 19 September	2013 - VAFB Wall		
NR	GW	F	10 March, 17 April	2012 - VAFB San Antonio		
NR	NG	F	30 May - 11 July	2013 - VAFB Surf South	VAFB Breeder	
NR	NY	F, U	4 March - 23 May	2013 - VAFB San Antonio	VAFB Breeder	
NR	OR	M, U	4 March - 5 June	2012 - VAFB San Antonio	VAFB Breeder	
NR	PR	F	4 March - 21 August	2012 - VAFB San Antonio	VAFB Breeder	
NR	PR	M, U	14 August - 19 September	2012 - VAFB San Antonio		
NR	PW	F, M, U	10 March - 14 July	2013 - VAFB Surf North	Possible Breeder	
NR	RB	F	4 March - 15 July	2012 - VAFB San Antonio	Possible Breeder	
NR	RG	M, U	11 March - 2 September	2013 - VAFB Surf South	Possible Breeder	
NR	WR	M, U	4 March - 1 July	2012 - VAFB Wall	Possible Breeder	
NR	WW	M	4 March, 18 April, 18 - 23 June	2011 - VAFB Shuman South	Possible Breeder	
NR	WY	F, U	12 June - 1 July	2013 - VAFB Surf North		
NR	YB	F	12 June	VAFB - Year Undeterminable		
NR	YR	M	29 May - 2 July	2013 - VAFB San Antonio	Possible Breeder	
NW	AB	F	20 June	2012 - VAFB Minuteman		
NW	AB	M, U	19 March - 23 June	2012 - VAFB Minuteman	VAFB Breeder	
NW	AG	M	1 May	2012 - VAFB Shuman South	VAFB Breeder	
NW	AW	F	19 May	2004 - VAFB San Antonio		
NW	AY	F, M, U	4 March - 25 July	2004 - VAFB Purisima Colony		
NW	BG	F, U	19 March - 23 July, 2 September	2012 - VAFB San Antonio	VAFB Breeder	
NW	BY	M, F, U	11 March - 26 June, 2 September	2008 - VAFB Surf North	VAFB Breeder	
NW	GB	U	17 September	2008 - VAFB Wall		
NW	NY	M	4 March - 10 August	2012 - VAFB San Antonio	VAFB Breeder	2 individuals
NW	OB	F, U	13 March - 2 September	2013 - VAFB Surf South	VAFB Breeder	
NW	OB	M, U	4 March - 19 September	2013 - VAFB Surf South		
NW	OG	M	19 May	2009 - VAFB Shuman South		
NW	RB	F, U	30 May - 19 September	2013 - VAFB Surf North	Possible Breeder	
NW	RB	M	21 August	2013 - VAFB Surf North		

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History	Additional Notes
NW	WW	F, U	2 - 11 March	2009 - VAFB Minuteman		
NW	YG	F	10 July	2010 - VAFB Surf North		
NW	YG	M, U	4 March - 14 April, 12 June - 28 August	2010 - VAFB Surf North	Possible Breeder	
NW	YY	M	5 June - 3 July	2013 - VAFB San Antonio	VAFB Breeder	
NY	GB	M, F, U	2 March - 21 July	2008 - VAFB Minuteman	VAFB Breeder	
NY	NG	F	9 April - 16 July	2012 - VAFB Surf North	VAFB Breeder	
NY	NY	F, U	4 March - 1 August	2012 - VAFB Surf South	Possible Breeder	
NY	PB	U	16 September	2012 - VAFB Surf North		
NY	RB	F	12 May	2013 - VAFB Surf North		
NY	RB	M	5 June - 13 August	2013 - VAFB Surf North	VAFB Breeder	
NY	RR	F	4 March - 1 July	2012 - VAFB Surf South	VAFB Breeder	
NY	WG	F	23 April	2008 - VAFB Wall		
NY	WG	M	9 April - 5 May	2008 - VAFB Wall		
NY	Y	F, U	19 May - 16 September	2012 - VAFB Surf South		Former NY:NY
NY	YB	M, U	10 March - 7 April , 17 June - 19 September	2012 - VAFB Surf South	VAFB Breeder	
NY	YY	F	14 - 18 April, 18 - 19 June	2012 - VAFB Surf North		
O	B/Y	U	16 September	VAFB - Year Undeterminable		
O	WG	F, U	5 May - 8 September	2012 - VAFB San Antonio		Former NO:WG
P	W/B/W	F, U	19 March - 17 September	2013 - VAFB San Antonio or Surf North	VAFB Breeder	
P	W/O/W	U	21 - 2 August	2013 - VAFB Surf North		
R	(S)	M, F	9 April - 15 August	VAFB - Year Undeterminable	VAFB Breeder	
V	(S)	F	11 June	VAFB - Year Undeterminable	VAFB Breeder	
V	W/B/W	F	18 April	2013 - VAFB San Antonio		
W	AG	M	4 March - 8 April	2012 - VAFB Shuman South	Possible Breeder	Former NW:AG
W	G/Y	U	25 August	2013 - VAFB San Antonio		
W	G/Y/G	M, U	14 April - 17 September	2013 - VAFB San Antonio	VAFB Breeder	
W	L/Y	U	19 September	2013 - VAFB San Antonio		W:G/Y?
W	NY	M	18 August , 10 September	2012 - VAFB San Antonio		Former NW:NY
W	OG	F	29 July	VAFB - Year Undeterminable		Former NW:OG
W	RB	M	28 March	VAFB - Year Undeterminable		Former NW:RB
W	W/O/W	M	11 March - 1 August	2005 - VAFB Surf North	VAFB Breeder	
W	Y/G	M	16 May	2013 - VAFB Wall		
Y	-/Y	F	11 July - 25 August	2013 - VAFB Wall		Former Y:G/Y
Y	W/B/W	F, U	11 March - 3 April	2013 - VAFB Surf North		
Y	Y/G	F	19 May	2013 - VAFB Shuman South		

Observations of Western snowy plovers banded outside of VAFB

Left	Right	Sex	Observation Dates	Banding Year/Loc	Breeding History
(S)	-	F, M	4 March - 1 July	Unknown	VAFB Breeder
AB	BR	J	27 August	Salinas S.B., Monterey Dunes (2014)	
AB	GO	U	7 - 29 August	Salinas NWR (2011)	
AB	OY	J	7 July	Moss Landing State Beach (2011)	
AO	BW	J	17 June	Moss Landing Salt Ponds (2010)	
AR	OG	F	1 April - 19 June	Salinas S.B., Monterey Dunes (2013)	Possible Breeder
AW	BR	J	27 - 29 August	Reservation Road, Fort Ord (2014)	
AW	OO	F	10 July	Moss Landing State Beach (2011)	
AW	RA	U	3 September	Salinas NWR (2014)	
AW	WA	U	3 September	Pajaro Spit (2014)	
AY	RB	J, U	19 - 21 August	Fort Ord (2014)	
BB	GR	J	27 August	Oceano (2014)	
BB	OY	J, U	28 June - 1 July	Oceano (2014)	
BB	VB	U	10 September	Oceano (unknown year)	
BY	OA	U	10 - 15 September	Salinas NWR (2014)	
GA	AB	F	31 March - 2 May	Oceano (2013)	VAFB Breeder
GA	AB	M	13 March	Oceano (2013)	
GA	GG	J	6 -13 August	Oceano (2014)	
GA	OY	J	8 - 27 August	Oceano (2014)	
GA	VG	F, U	4 March , 13 June - 21 July	Oceano (2008 or 2013)	VAFB Breeder
GA	VY	J	15 August	Oceano (2014)	
GA	WB	F, U	3 - 19 March, 5 June, 1 August - 19 September	Oceano (2012 or 2013)	VAFB Breeder
GA	WY	J	19 August - 2 September	Oceano (2014)	
GA	YW	F	10 March - 11 April, 10 June	Oceano (2010 or 2013)	
GB	OA	J, U	7 - 22 August	Salinas NWR (2014)	
GG	AB	U	19 March	Oceano (2007)	
GG	AG	U	29 August	Oceano (2013 or 2014)	
GG	BB	F	14 April	Oceano (2010 or 2013)	
GG	BW	M	2 June	Oceano (2012)	
GG	GW	U	23 July	Oceano (2014)	
GG	PB	F	28 March - 1 July	Oceano (2012 or 2013)	VAFB Breeder
GG	PB	M	13 March	Oceano (2012 or 2013)	
GG	RW	J	19 August	Oceano (2014)	
GG	VW	J, U	3 - 16 September	Oceano (2014)	
GG	WB	M, U	11 March - 16 September	Oceano (2011 or 2013)	VAFB Breeder
GG	WG	J	7 August	Oceano (2014)	
GG	YY	F, U	2 - 19 March , 6 August - 19 September	Oceano (2011 or 2013)	
KK	BB	M, U	11 March - 17 September	SFBBO, Eden Landing (2010)	VAFB Breeder
O	W/B/W	U	21 - 22 August	Unknown	
OA	BB	U	4 March	Moss Landing Salt Ponds (2011)	

Left	Right	Sex	Observation Dates	Banding Year/Loc	Breeding History
OG	AG	J	15 August	Pajaro Spit (2014)	
OG	OR	M, U	10 March - 2 September	Salinas State Beach (2007)	VAFB Breeder
OO	RB	U	2 June	Moss Landing State Beach (2009) or Fort Ord (2014)	
OY	WA	U	19 August	Moss Landing Salt Ponds (2014)	
PG	AG	J, U	7 August , 8 September	Oceano (2014)	
PG	AR	U	3 September	Oceano (2014)	
PG	BW	J	15 September	Oceano (2014)	
PG	OB	J, U	29 August , 2 September	Oceano (2014)	
PG	VG	J	21 August	Oceano (2014)	
PG	YG	J	25 August	Oceano (2014)	
PV	BB	J, U	3 September , 17 September	Oceano (2014)	
PV	GG	J	28 July	Oceano (2014)	
PV	PY	J	27 August , 2 September	Oceano (2014)	
PV	VR	J	21 - 27 August	Oceano (2014)	
R	-	F	11 - 24 March	Unknown	Former Breeder
R/Y/R	V	J	23 July	Oregon (2014)	
RA	BB	F	19 March	Salinas State Beach (2013)	
RB	RB	J	19 August	Pajaro Spit (2014)	
RO	AB	U	14 August	Unknown	
RO	AR	U	10 September	North Marina State Beach (2014)	
RO	RW	J	27 July	Pajaro Spit (2014)	
RO	RY	M, U	10 August - 19 September	Fort Ord (2013)	
RR	LY	M	4 March - 16 September	Oceano (2010)	VAFB Breeder
VG	*R	J	8 August	Oceano (2014)	
VG	BR	M	19 March	Oceano (2013)	
VG	GY	J	7 July	Oceano (2014)	
VG	PW	J	27 August	Oceano (2014)	
VG	VR	U	20 August - 19 September	Oceano (2011)	
VG	WB	U	3 March	Oceano (2012 or 2013)	
VG	YB	J	6 August	Oceano (2014)	
VO	BW	U	25 August	Oceano (2014)	
VV	AR	M	27 August	Oceano (2014)	
VV	AR	U	3 September	Oceano (2014)	
VV	AW	F, U	13 March - 30 July	Oceano (2013)	VAFB Breeder
VV	GY	J	7 - 8 August	Oceano (2014)	
VV	OA	F	4 March - 10 September	Oceano (2011)	VAFB Breeder
VV	OG	J	8 August	Oceano (2014)	
VV	WB	J	10 September	Oceano (2014)	
WA	GA	J	2 September	Pajaro Spit (2014)	
Y/G/Y	V	J	23 July	Oregon (2014)	
Y/L	B	F, U	4 March - 16 May , 20 August - 19 September	Oregon (2012 or earlier)	Possible Breeder

Left	Right	Sex	Observation Dates	Banding Year/Loc	Breeding History
Y/R/Y	V	U	16 September	Oregon (2014)	
yB	RY	M	4 March	Salinas NWR (2009)	
YG	BA	U	2 September	Salinas S.B., Molera-Potrero (2014)	
YY	BO	F	4 March - 19 March	Moss Landing Salt Ponds (unknown year)	

Appendix C – Western snowy plover banded on VAFB during the 2014 breeding season.

Beach Sector	Color Bands		Date Banded	Chicks Banded	Confirmed Fledged
	Left	Right			
Minuteman					
	NW	BB	5/3	1	1
	NW	BR	5/3	2	1
	NY	GG	7/30	2	0
Shuman					
	NW	PB	5/17	3	1
	V	G/W/G	8/14	1	1
San Antonio					
	A	G	5/21	2	1
	A	G/O/G	6/23	1	0
	AN	OG	6/6	3	1
	B	G/O/G	5/16	1	0
	G	G/O/G	6/23	1	0
	NB	GG	5/1	3	0
	NB	NW	5/16	2	0
	NB	RG	5/16	3	0
	NO	PG	6/30	3	1
	NW	BB	5/2	3	1
	NW	BW	5/3	3	0
	NW	NB	5/3	3	2
	NW	NG	5/12	3	2
	NW	OY	5/14	3	0
	NW	PG	5/20	3	1
	NW	PR	5/20	3	0
	NW	PY	5/29	3	0
	NW	RW	5/17	3	0
	NW	WB	5/30	3	1
	NW	WR	6/5	3	2
	NW	WY	6/6	3	1
	NY	AB	6/21	3	1
	NY	AG	6/23	3	0
	NY	AW	7/3	3	1
	NY	BB	7/7	3	1
	NY	PR	8/7	3	0
	NY	RG	8/13	2	1
	NY	RY	8/18	3	3
	O	G/O/G	5/16	1	1
	O	G/Y	4/21	1	0
	O	W/G	4/21	1	1
	O	Y/G	4/21	1	0
Purisima North					
	G	G/W/G	7/9	1	1
	NO	OG	7/11	3	3
	NW	WG	6/5	3	1
	NY	BW	7/17	3	1
	O	W/O/W	7/17	1	0

Beach Sector	Color Bands		Date Banded	Chicks Banded	Confirmed Fledged
	Left	Right			
Wall					
	A	G/B/G	5/17	1	0
	A	G/W/G	5/17	1	0
	A	G/Y/G	5/17	1	1
	A	W/G	5/19	1	0
	A	W/O/W	5/5	1	1
	A	W/R/W	5/5	1	0
	B	G/W	5/19	1	1
	NB	BY	5/3	2	2
	NO	BB	6/7	2	0
	NO	PB	6/17	3	2
	NW	RG	5/29	3	1
	NY	BR	7/11	3	3
	NY	GA	7/29	3	2
	O	G/W/G	8/12	1	1
	W	G/O/G	7/7	1	1
	W	G/W/G	7/7	1	1
Surf North					
	AN	AR	7/21	2	1
	AN	BG	5/5	3	2
	AN	BR	5/8	3	1
	AN	BW	5/8	3	3
	AN	BY	5/21	3	0
	AN	GR	7/2	2	2
	AN	GW	6/13	3	0
	AN	GY	6/6	3	1
	AN	OB	6/11	3	2
	AN	OR	6/11	3	2
	AN	OW	6/21	3	0
	AN	OY	7/1	3	1
	AN	RB	7/21	3	2
	AN	RG	7/27	3	1
	AN	RW	8/10	3	2
	B	G/W/G	7/18	1	2
	B	W/B/W	5/19	1	1
	G/O/G	R	6/13	1	0
	NB	NB	5/12	3	2
	NB	NG	5/12	2	2
	NB	PB	5/3	3	1
	NB	PW	5/14	3	1
	NB	RY	5/17	2	1
	NB	YY	5/22	3	2
	NY	BY	7/28	3	2
	NY	NB	7/30	2	1
	O	B/W	6/18	1	1
	O	W/B	6/18	1	1
	O	Y/G	6/6	1	1
	R	Y/G	6/6	1	0
	W	W/R/W	5/19	1	1

Beach Sector	Color Bands		Date Banded	Chicks Banded	Confirmed Fledged
	Left	Right			
Surf South					
	NY	AY	7/8	3	2
	NY	BG	7/16	2	1
	NY	OG	7/30	2	0
	NY	OW	7/30	2	1
	NY	PG	8/5	2	2
Total				208	93

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 2014 window surveys.

12-May-14	Male	Female	Unk Adult	PR	Total
Minuteman	1	0	0	0	**1**
Shuman North	0	4	0	0	**4**
Shuman South	2	3	0	1	**5**
San Antonio	30	32	6	11	**68**
Purisima North	3	3	0	0	**6**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***36***	***42***	***6***	***12***	***84***
Wall	10	12	3	2	**25**
Surf North	37	27	6	7	**70**
Surf South	8	14	1	2	**23**
Total South VAFB	***55***	***53***	***10***	***11***	***118***
TOTAL VAFB	**91**	**95**	**16**	**23**	**202**

19-May-14	Male	Female	Unk Adult	PR	Total
Minuteman	2	1	0	1	**3**
Shuman North	2	2	1	1	**5**
Shuman South	1	1	0	0	**2**
San Antonio	31	19	0	6	**50**
Purisima North	5	4	0	1	**9**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***41***	***27***	***1***	***9***	***69***
Wall	22	18	2	4	**42**
Surf North	30	23	7	8	**60**
Surf South	10	14	0	1	**24**
Total South VAFB	***62***	***55***	***9***	***13***	***126***
TOTAL VAFB	**103**	**82**	**10**	**22**	**195**

9-Jun-14	Male	Female	Unk Adult	PR	Total
Minuteman	0	1	0	0	**1**
Shuman North	1	2	0	1	**3**
Shuman South	5	6	2	1	**13**
San Antonio	29	17	0	6	**46**
Purisima North	4	1	2	1	**7**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***39***	***27***	***4***	***9***	***70***
Wall	19	13	0	3	**32**
Surf North	39	35	1	4	**75**
Surf South	5	6	2	2	**13**
Total South VAFB	***63***	***54***	***3***	***9***	***120***
TOTAL VAFB	**102**	**81**	**7**	**18**	**190**

18-Jun-14	Male	Female	Unk Adult	PR	Total
Minuteman	1	0	0	0	**1**
Shuman North	2	2	0	1	**4**
Shuman South	6	7	1	4	**14**
San Antonio	30	19	5	9	**54**
Purisima North	2	3	3	0	**8**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***41***	***31***	***9***	***14***	***81***
Wall	9	4	4	0	**17**
Surf North	34	31	5	4	**70**
Surf South	20	11	6	9	**37**
Total South VAFB	***63***	***46***	***15***	***13***	***124***
TOTAL VAFB	**104**	**77**	**24**	**27**	**205**

MEAN	Male	Female	Unk Adult		Mean
Minuteman	1.00	0.50	0.00		**1.50**
Shuman North	1.25	2.50	0.25		**4.00**
Shuman South	3.50	4.25	0.75		**8.50**
San Antonio	30.00	21.75	2.75		**54.50**
Purisima North	3.50	2.75	1.25		**7.50**
Purisima Colony	0.00	0.00	0.00		**0.00**
Mean North VAFB	***39.25***	***31.75***	***5.00***		***76.00***
Wall	15.00	11.75	2.25		**29.00**
Surf North	35.00	29.00	4.75		**68.75**
Surf South	10.75	11.25	2.25		**24.25**
Mean South VAFB	***60.75***	***52.00***	***9.25***		***122.00***
MEAN VAFB	**100.00**	**83.75**	**14.25**		**198.00**

Table 2. Summary of breeding window surveys from 1994 to 2014.

Year	Early to Mid May	Mid to Late May	Early to Mid June	Mid to Late June	Mean	% Change over Prior Year	% Change in 2014
1994	237	--	199	217	218	n/a	-9%
1995	213	234	193	202	211	-3%	-6%
1996	230	229	234	244	234	11%	-15%
1997	258	196	256	245	239	2%	-17%
1998	103	130	132	163	132	-45%	50%
1999	91	64	67	89	78	-41%	154%
2000	98	106	107	109	105	35%	89%
2001	115	100	123	150	122	16%	62%
2002	222	213	174	195	201	65%	-1%
2003	344	256	295	232	282	40%	-30%
2004	363	420	466	431	420	49%	-53%
2005	277	259	284	280	275	-35%	-28%
2006	289	245	261	279	269	-2%	-26%
2007	153	165	192	172	171	-36%	16%
2008	230	207	199	193	207	21%	-4%
2009	158	162	187	183	173	-17%	15%
2010	178	167	176	175	174	1%	14%
2011	215	230	223	196	216	24%	-8%
2012	206	170	196	248	205	-5%	-3%
2013	214	204	208	232	220	7%	-10%
2014	202	195	190	205	198	-10%	

Table 3. Summary of winter window surveys from 2004 to 2014.

Year	North Beach	South Beach	Basewide	Jalama Beach
2003-04	82	224	306	0
2004-05	46	113	159	
2005-06	64	212	276	0
2006-07	105	179	284	5
2007-08	94	289	383	0
2008-09	100	111	211	0
2009-10	99	151	250	0
2010-11	168	125	293	34
2011-12	114	82	196	57
2012-13	86	67	153	81
2013-14	73	89	162	116
Mean	93.7	149.3	243.0	29.3

Table 4. Distribution of nests by beach section from 1994 to 2014.

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%**

2008		2009		2010		2011		2012		2013		2014	
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	Clutch hatch success	Egg hatch success
43%	50%	50%	69%	86%	84%	63%	61%	58%	55%	100%	100%	100%	88%
36%	34%	33%	37%	58%	58%	20%	15%	63%	32%	63%	55%	28%	28%
51%	48%	51%	55%	61%	57%	55%	51%	48%	49%	59%	56%	36%	39%
44%	***42%***	***44%***	***48%***	***61%***	***59%***	***43%***	***39%***	***50%***	***45%***	***60%***	***57%***	***36%***	***38%***
60%	64%	33%	38%	75%	90%	100%	83%	63%	61%	100%	92%	80%	78%
100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
67%	***71%***	***71%***	***75%***	***60%***	***69%***	***100%***	***83%***	***63%***	***61%***	***100%***	***92%***	***80%***	***78%***
54%	52%	54%	57%	66%	68%	43%	47%	58%	56%	48%	44%	42%	42%
33%	31%	55%	60%	63%	63%	16%	17%	43%	45%	72%	58%	45%	48%
20%	20%	46%	49%	65%	65%	19%	22%	25%	25%	38%	56%	21%	20%
39%	***37%***	***53%***	***57%***	***64%***	***65%***	***24%***	***27%***	***41%***	***41%***	***54%***	***54%***	***38%***	***39%***
43%	**41%**	**43%**	**41%**	**63%**	**61%**	**33%**	**33%**	**46%**	**44%**	**58%**	**56%**	**39%**	**40%**

Table 5. Clutch hatch success for each beach section in 2014.

Beach Sector	Hatched clutches	Known fate clutches	Clutch success	Hatched eggs	Total known fate eggs	Egg hatch success
North Beaches						
Minuteman	3	3	100%	7	8	88%
Shuman	7	25	28%	17	61	28%
San Antonio	47	132	36%	129	332	39%
Total North Beaches	***57***	***160***	**36%**	***153***	***401***	**38%**
Purisima Beaches						
Purisima North	12	15	80%	29	37	78%
Purisima Colony	0	0	0%	0	0	0%
Total Purisima Beaches	***12***	***15***	**80%**	***29***	***37***	**78%**
South Beaches						
Wall	23	55	42%	60	144	42%
Surf North	58	129	45%	154	323	48%
Surf South	14	66	21%	33	161	20%
Total South Beaches	***95***	***250***	**38%**	***247***	***628***	**39%**
TOTAL VAFB	**164**	**425**	**39%**	**429**	**1066**	**40%**

Table 6. Number of nests lost to predators in 2014 by beach section.

Beach Sector	Coyote		RAVEN		Suspected Raven		Other Avian		Gull		Skunk		Unidentified Predator		Total	
North Beaches																
Minuteman	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Shuman	7	28%	0	0%	0	0%	0	0%	0	0%	0	0%	9	36%	16	64%
San Antonio	52	39%	9	7%	0	0%	0	0%	1	1%	1	1%	2	2%	65	49%
Total North Beaches	**59**	**37%**	**9**	**6%**	**0**	**0%**	**0**	**0%**	**1**	**1%**	**1**	**1%**	**11**	**7%**	**81**	**51%**
Purisima Beaches																
Purisima North	0	0%	1	7%	0	0%	0	0%	0	0%	0	0%	0	0%	1	7%
Purisima Colony	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Total Purisima Beaches	**0**	**0%**	**1**	**7%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**1**	**7%**
South Beaches																
Wall	14	25%	1	2%	1	2%	0	0%	1	2%	0	0%	2	4%	20	36%
Surf North	31	24%	0	0%	2	2%	0	0%	0	0%	0	0%	4	3%	42	33%
Surf South	41	62%	4	6%	0	0%	0	0%	1	2%	0	0%	2	3%	44	67%
Total South Beaches	**86**	**34%**	**5**	**2%**	**3**	**1%**	**0**	**0%**	**2**	**1%**	**0**	**0%**	**8**	**3%**	**106**	**42%**
VAFB TOTAL	**145**	**34%**	**15**	**4%**	**3**	**1%**	**0**	**0%**	**3**	**1%**	**1**	**0%**	**19**	**4%**	**188**	**44%**

Table 7. Numbers of nest lost to predators from 1994 to 2014.

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

Table 8. Nest predation by month on VAFB 2014.

Beach Sector	March	April	May	June	July	August	Total
North Beaches							
Minuteman	0	0	0	0	0	0	0
Shuman	0	3	2	7	4	0	16
San Antonio	1	9	14	26	13	2	65
Total North Beaches	***1***	***12***	***16***	***33***	***17***	***2***	***81***
Purisima Beaches							
Purisima North	0	0	0	0	1	0	1
Purisima Colony	0	0	0	0	0	0	0
Total Purisima Beaches	***0***	***0***	***0***	***0***	***1***	***0***	***1***
South Beaches							
Wall	5	1	5	3	5	0	19
Surf North	8	4	3	23	3	0	41
Surf South	2	6	11	22	3	0	44
Total South Beaches	***15***	***11***	***19***	***48***	***11***	***0***	***104***
TOTAL VAFB	**16**	**23**	**35**	**81**	**29**	**2**	**186**

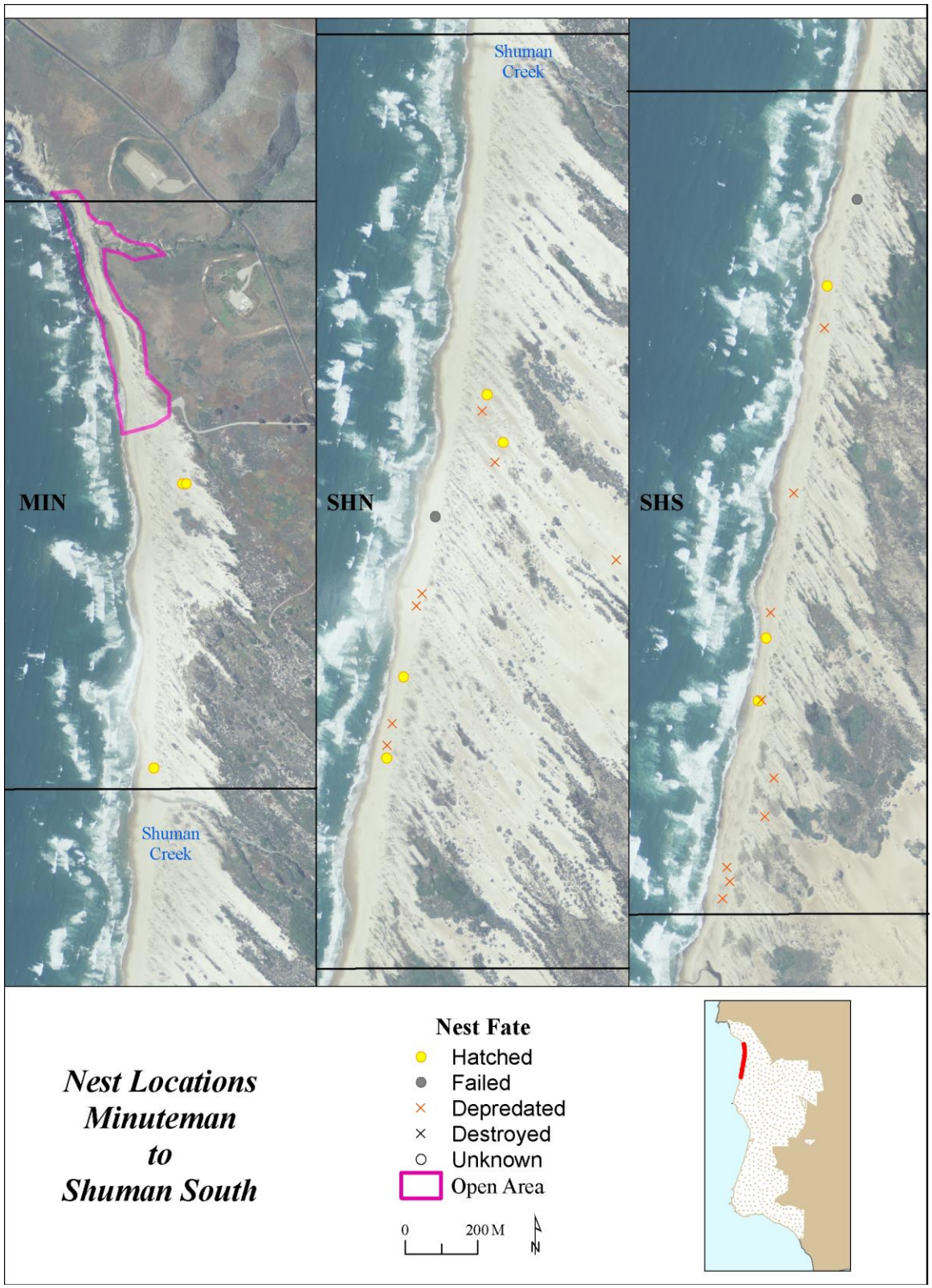
Table 9. Numbers of chicks banded and fledged per beach sector in 2014.

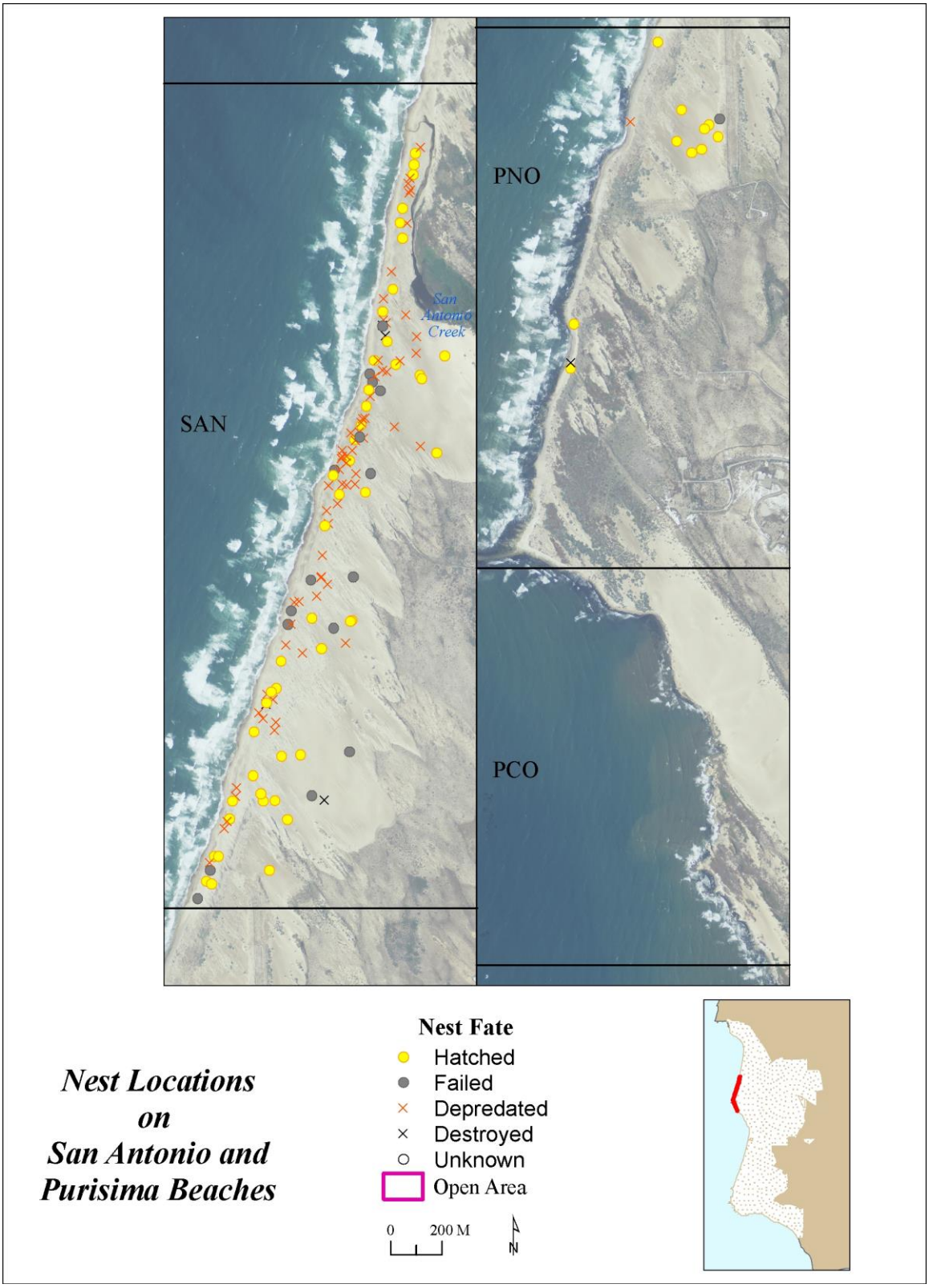
Beach Sector	Chicks Banded	Chicks Fledged	Chick Fledging Rate	% Broods Fledging >1 Chick
North Beaches				
Minuteman	5	2	0%	50%
Shuman	4	2	50%	100%
San Antonio	79	22	28%	61%
Total North Beaches	***88***	***26***	***30%***	***63%***
Purisima Beaches				
Purisima North	11	6	55%	80%
Purisima Colony	0	0	0%	0%
Total Purisima Beaches	***11***	***6***	***55%***	***80%***
South Beaches				
Wall	26	16	62%	92%
Surf North	72	39	54%	83%
Surf South	11	6	55%	80%
Total South Beaches	***109***	***61***	***56%***	***85%***
TOTAL VAFB	**208**	**93**	***45%***	***76%***

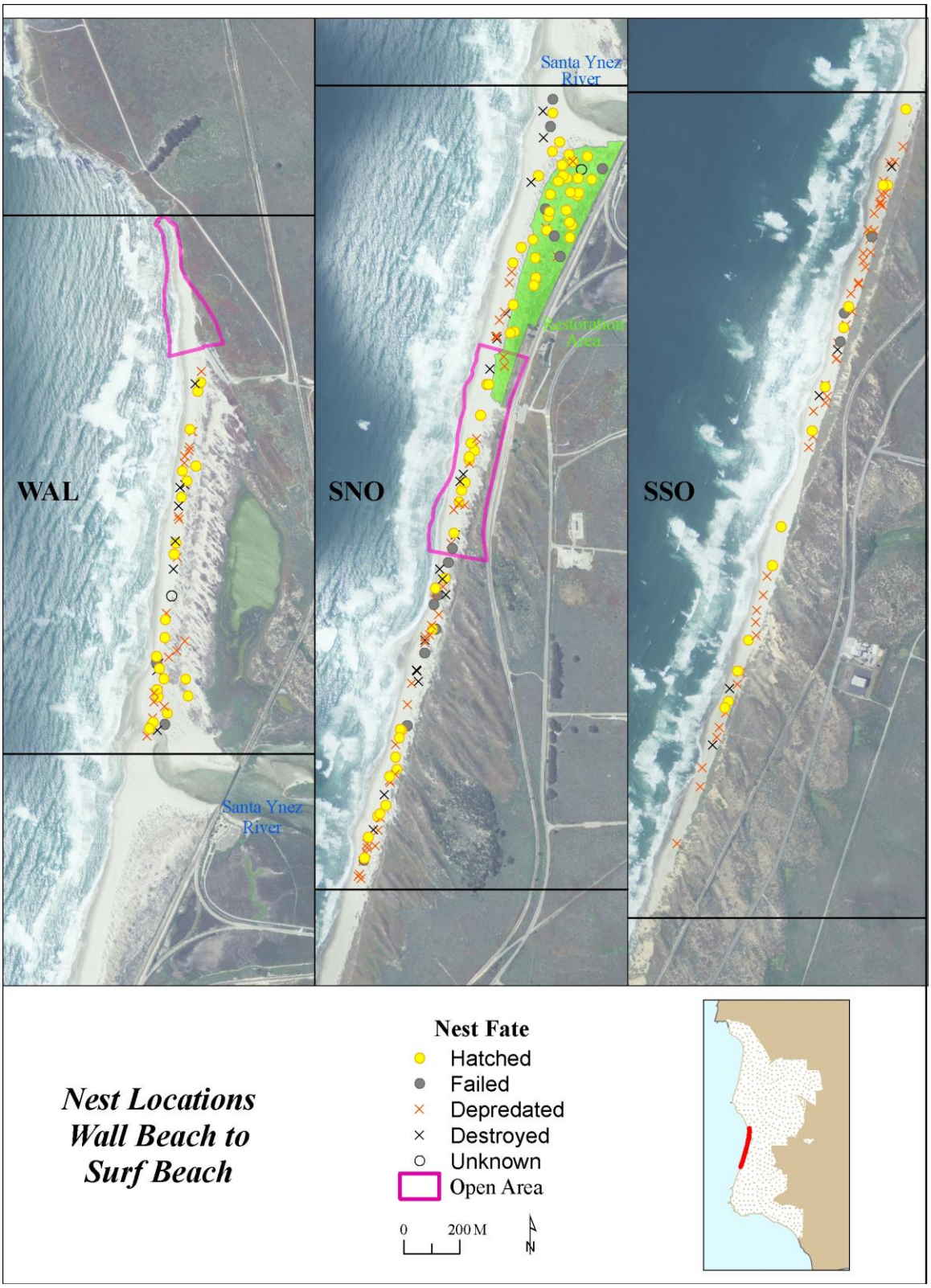
Table 10. Numbers of broods banded and fledged one chick per beach sector in 2014.

Beach Sector	Broods Banded	Broods Fledging at Least One Chick	Percent Fledging at Least One Chick
North Beaches			
Minuteman	2	1	50%
Shuman	2	2	100%
San Antonio	28	17	61%
Total North Beaches	***32***	***20***	63%
Purisima Beaches			
Purisima North	5	4	80%
Purisima Colony	0	0	0%
Total Purisima Beaches	***5***	***4***	80%
South Beaches			
Wall	12	11	92%
Surf North	29	24	83%
Surf South	5	4	80%
Total South Beaches	***46***	***39***	85%
TOTAL VAFB	**83**	**63**	**76%**

Appendix E: Maps of Nest Locations and Nest Fates on VAFB Beaches in 2014




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


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