Monitoring and Management of the Western Snowy Plover at Vandenberg Air Force Base, 2012

Western snowy plover chick at Vandenberg Air Force Base, CA.

PRBO Conservation Science

December 14, 2012

Monitoring and Management of the Western Snowy Plover at Vandenberg Air Force Base, 2012

Prepared for:
United States Air Force
30th Space Wing Asset Management Flight
30 CEA/CEANC
1028 Iceland Avenue
Vandenberg Air Force Base, CA 93437

Prepared by:
Regina Ball and Dan P. Robinette
Marine Ecology Division
PRBO Conservation Science
Petaluma, CA 94954

December 14, 2012

Suggested Citation: Ball, R. and D.P. Robinette. 2012. Monitoring and Management of the Western Snowy Plover at Vandenberg Air Force Base, 2012. Unpublished Report, PRBO Conservation Science, Petaluma, CA.

Table of Contents

Page intentionally left blank.

List of Tables

List of Figures

List of Figures Continued

Acknowledgements

This project was funded by the U.S. Department of Defense contract # FA4610-10-D-004 via ManTech SRS Technologies. We would especially like to thank Darryl York and Samantha Kaisersatt for providing us the opportunity to study the Western snowy plover at Vandenberg Air Force Base. We give special thanks to Nick Todd, Lee Aulman, and members of ManTech SRS Technologies, Inc. for their instrumental work in keeping predator events on Vandenberg beaches to a minimum. This is PRBO Conservation Science contribution no. 1902.

Executive Summary

The United States Fish and Wildlife Service listed the Pacific coast population of the Western snowy plover (*Charadrius nivosus nivosus*) as threatened under the Endangered Species Act in 1993 (58 Federal Register 12864). This population of snowy plovers breeds on coastal beaches from northern Washington to southern Baja California, Mexico. The breeding population of snowy plovers has been monitored annually at Vandenberg Air Force Base (VAFB) since 1993. This report summarizes monitoring results from the 2012 breeding season within the context of VAFB's 19-year time series (1994-2012). The number of breeding adults observed and nests initiated in 2012 was similar to the long term mean. Clutch hatch success was close to the long term mean, while fledging success was the highest on record since 1999.

Predation was clearly a limiting factor for clutch hatch success in 2012, with 37% of nests lost to predators. Coyotes and ravens were responsible for 31% of these losses. 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, while more localized factors (e.g., predation) are governing clutch hatch and fledging success at VAFB. Additionally, the time series data suggest that the factors regulating clutch hatch success are likely different than those regulating fledging success. 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 sections while using environmental and oceanographic information to manage VAFB's coastal ecosystem.

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.

SHN – This sector extends from Shuman Creek south for approximately 1.6 miles to No Name Creek. This section 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 is in progress.

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 section.

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.

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. 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 section 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 section 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). Approximately 0.5 mile of SNO was open to public recreational use between the hours of 0800 and 1800 beginning on 1 March, 2012. 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 were closed to recreational access during the 2012 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 18 years (1994-2011) of breeding bird census and nest initiation data from VAFB have yielded similar trends (see Ball and Robinette 2011). Thus, both methods provide useful indices that can be tracked over time; and using both indices in conjunction provides useful information to resource managers.

Since 1994, the snowy plover breeding population size at VAFB has been highly variable (Ball and Robinette 2011). 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 2012 is 240 adults with mean nest number at 340.

Reproductive success is measured by the number of chicks fledged per male plover (fledging success) (USFWS 2007). This is most accurately obtained when all males and chicks at a site are uniquely color banded and the birds are monitored frequently (Nur et al. 1999). This metric has been difficult to track at VAFB due to inconsistent banding effort through the years. Thus, managers at VAFB also track clutch hatch success to better understand trends in reproductive success. Clutch hatch success at VAFB has been highly variable with no apparent trend since 1994 (Ball and Robinette 2011). Mean clutch hatch success (percent of total eggs that hatched) from 1994-2012 was 35% with most years either well below or well above this average. Clutch hatch success at VAFB was lowest in 1997 at 19% and highest in 2006 at 67%.

One of the primary causes of poor clutch hatch success at VAFB is predation. Over the 19 years of monitoring on VAFB, 17%-52% of nests have been lost in a given year to predators (see MSRS 2010, Ball and Robinette 2011). The two main predators observed depredating nests are coyotes (*Canis latrans*) and corvids (i.e., crows and ravens). From 1994-2000 American crows (*Corvus brachyrhynchos*) were the main corvids observed on VAFB beaches, but common ravens (*Corvus corvax*) have become the dominant corvid in recent years. The increase in raven sightings at VAFB has been attributed to a general expanse of the raven population into coastal habitats in central California (Boarman and Heinrich 1999). Corvids have depredated approximately 7% of all known fate nests, confirmed through direct observation or track evidence. It is likely nest losses to raven predation is much higher. Coyote predation has mainly occurred on South Beach sections with 16% of all known fate nests depredated.

The goal of VAFB natural resources management is to manage the snowy plover population on VAFB while maintaining the integrity of the coastal ecosystem. To accomplish this, VAFB has put together a management team to support the adaptive management of the snowy plover breeding population. In 2012, 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. Todd and Aulman selectively trap and relocate avian predators deemed a threat to snowy plovers. PRBO Conservation Science (PRBO) monitored the breeding population of snowy plovers on VAFB, estimating population and reproductive success. PRBO 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 2012 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 19-year time series. We compare trends in population and reproduction among North, Purisima, and South Beaches. Our overarching goal is to provide information to help VAFB make management decisions and understand how military activities affect the population and breeding dynamics of snowy plovers breeding on VAFB beaches. The snowy plover monitoring program is a requirement of the terms and conditions section of the Biological and Conference Opinion (BO) for Beach Management and the Western Snowy Plover (1-8-05-F-5R and amendments), Delta II Launch Program at Space Launch Complex 2 and Taurus Launch Program at 576-E (1-8-98-F-25R) and Atlas Launch Program (1-8-99-F/C-79). The Beach Management and Delta II BOs require the determination of population trends and reasons for decline as well as enhanced predator management activities looking at populations and behavior of predators. Most recently, the Delta II and Taurus BOs were superceded 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, 2012. 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 section 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 section.

Window Surveys

We conducted four breeding window surveys during the same weeks as conducted during all seasons since 2002: 11 May, 20 May (range wide window breeding survey), 10 June and 22 June. During each census, we recorded the number and location of adult snowy plovers by beach sector, their age class, sex, and color band combination for all breading beaches. We also recorded the number and size of all chicks observed.

Nest Monitoring

Beginning 1 March, we surveyed each beach sector to locate nests and nesting territories. We surveyed beach sections 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.

Banding and Estimating Fledging Success

We made an effort to band 50% of all hatched broods to get a representative sample of fledging success for the entire breeding population. We were successful at banding 42.2% of broods in 2012. We color banded a total of 161 chicks from 59 nests. We used a unique band color combination issued by the USFWS for each brood. Additionally, we individually marked chicks within broods from nests of particular interest (e.g., nests in open areas or in the far back of sand sheets that are difficult to monitor) to get a better understanding of fledge rate for these areas of interest. For this, we altered color schemes within each brood using partial exposure of the aluminum band. We individually marked 19 chicks from 7 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. 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 2012 and Appendix C lists all color bands used on chicks hatched at VAFB in 2012.

Transect Surveys

This was the second consecutive year that weekly transect surveys have been conducted at VAFB. Beginning 1 March, we conducted transect surveys along each beach section on a weekly basis. We divided each beach section into “transect blocks” approximately 100-300 meters in length along the coastal strand. We walked each section 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 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 first 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.

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

Results

2012 Breeding Population and Reproductive Success

Detailed data summaries can be found in Appendix D. Metrics for 2012 are summarized in Table 1. The maximum number of adults detected during the 2012 breeding window surveys was 248 (79 females and 132 males). This is an increase of 8% from 2011 where the maximum population was estimated at 230 breeding adults (Table 1). We confirmed nesting activity for 32 snowy plovers color banded as chicks on VAFB in prior years (Appendix B and Table 2). We suspect an additional 15 plovers banded as chicks on VAFB were nesting on VAFB in 2012. We confirmed nesting for 13 snowy plovers banded as chicks outside of VAFB and suspected nesting for an additional nine in 2012 (Appendix B).

A total of 341 nests were located and the fates of 334 of those nests were determined. This represents an 18% decrease in nests initiated compared to 2011. This decrease is likely due to a reduction in re-nesting attempts in 2012. There was a 42% decrease in the number of nests depredated when compared to 2011. Of the 334 known fates nests, 145 successfully hatched. This is a 5% increase in total clutches successfully hatching compared to 2011 (137 clutches hatching in 2011). Hatching success (% of total eggs that hatched) and clutch success (% of clutches that hatched all eggs) in 2012 was 44% and 46%, respectively. This represents an 11% and 13% increase, respectively, from 2011. The primary cause of nest failures was attributed to predation, which accounted for 66% of nest failures or 37% of known fate nests (Table 1). Fledging success in 2012 was 5.6% higher than 2011, with an estimated 51% of chicks successfully fledged in 2012 and 45% in 2011.

Detailed maps of nest locations and fates are provided in Appendix E. Nesting densities for each beach sector are summarized in Figures 2-4 and nest fates are summarized in Figure 5. The highest number of nests occurred on South Beaches and the lowest on Purisima Beaches. There were eight nests initiated on Purisima Beaches. High predation occurred on both North and South Beaches with the lowest hatch rate occurring on South Beaches (41%). Conversely, Purisima Beaches had the highest hatch rate (63%). Fledge rate was the highest on North Beaches (64%, Figure 6), in particular SAN sector, with 68% of all chicks fledged and MIN sector, with 83% fledged. Six chicks on Purisima Beaches were banded with a fledge rate of 33% for this beach section.

Ten nests were located in areas open to recreational use in 2012. 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 was one nest initiated in the open area (2 per linear mile) and 8 nests (13.3 per linear mile) in the closed area. The closed area had a 70% hatch rate and a 29% 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. We located one nest (4 per linear mile) in the open area and 49 (57.8 per linear mile) in the closed area. The open area had a hatch rate of 100% with no data on fledge rate. The closed area had a 44% hatch rate and 33% fledge rate. At SNO there was more habitat available in areas closed to recreational use (1.4 miles) than open to recreational use (0.5 miles). We located 9 nests (18 per linear mile) in the open area and 61 (43.6 per linear mile) in the closed area. The clutch hatch rate was higher in the open area (89%) than the closed area (41%). Fledging rate in the closed area was 31% and in the open area at 60%. Table 3 shows the fates of nests initiated within the open areas on MIN, WAL, and SNO in 2012. Nest failure in the open area at MIN was due to wind where the nest failure in the open area at SNO was attributed to depredation. On 23 July the open area at SNO was closed for the rest of the breeding season due to the maximum number of violation reached. At this time there was still one active nest in the open area which later successfully hatched one chick.

2012 Breeding Phenology

Table 4 shows the egg laying, chick hatching, and fledging periods for VAFB beaches since 1994 (where data has been previously summarized). In 2012, the first known nest was initiated on South Beaches on 18 March and the last nest was initiated on 21 July. This is within the normal range of initial lay dates. The earliest recorded nest initiation of the time series was 2 March in 2009. The chick hatching period was also within the normal range, though we found fewer historic data summarized in past reports. The chick hatching period for 2012 occurred between 20 April and 21 August. The earliest hatch on record was 10 April in 2009. The fledging period was from 18 May to 18 September. We could only find a fledging period for 2009 in past reports. In 2009, the first fledgling was observed on 7 May.

Figure 8 shows the results of weekly transect surveys on each beach section. The number of active nests on North Beaches remained consistent for most of May and June, dropping in mid June with a peak in mid July. North Beaches experienced a significant depredation event by ravens in mid June. The drop in active nests may indicate a lag time between depredated nests followed by a high re-nesting. Conversely, trends in weekly active nests on South Beaches remained relatively consistent from mid-April to mid-July. Brood detection on North Beaches was low through mid-July and peaked in mid-July through mid-August. However, chicks can be difficult to detect for the first two weeks after hatch. This number therefore represents the minimum number of broods that may have been present. Brood detections on South Beaches remained relatively consistent from early June to early September. Fledglings were first detected on North beaches in early June with sightings remaining relatively low through July. There was a sharp increase in detection in August through September. On South Beaches, fledglings were first observed in mid-June and numbers were higher than North Beaches for the July to August period. There was a similar, but very brief, peak in September. Number of active nests, broods and fledglings were low at Purisima Beaches and followed a pattern similar to South Beaches.

Figure 9 shows distribution of flocking and paired birds during weekly transect surveys for North and South beaches. The number of pairs detected on both North and South beaches show a decline in July, whereas the number of birds detected in flocks increase in July. This pattern is consistent with the end of the egg laying period at the end of July when pairs are typically seen individually rather than exhibiting courting behavior within their territories. Overall the number of paired and flocking birds was higher on South Beaches.

2012 Predator Sightings and Nest Predation

Wildlife species identified as predators of adult snowy plovers, nests, and/or chicks during the 2012 breeding season included raven, gull (*Larus* spp.), coyote, and American peregrine falcon (*Falco peregrinus anatum*). In addition, the following potential predators of adult snowy plovers, nests, and/or chicks were detected on the beaches occupied by snowy plovers: great blue heron (*Ardea herodias*), whimbrel (*Numenius phaeopus*), long-billed curlew (*Numenius americanus*), northern harrier (*Circus cyaneus*), American kestrel (*Flaco sparverius*), merlin (*Falco columbarius*), red-tailed hawk (*Buteo jamaicensis*), great-horned owl (*Bubo virginianus*), loggerhead shrike (*Lanius ludovicianus*), American crow, raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*).

Of the 334 known fate nests, 124 (37%) were depredated in 2012 (Table 5). Together, coyotes and common ravens were the most common predators, taking 31% of all known-fate nests (24% coyote and 7% raven). 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 5% of known-fate nests. Another 2% of known-fate nests were taken by gulls or unknown avian predators.

On North Beaches, 23% of nest predations were due to coyote and 13% were due to raven (Figure 10). On South Beaches, the main predator confirmed for nest predation was coyote (24%) while there were no raven nest predations. On North Beaches, sightings of coyotes and ravens showed a similar pattern with nest predation rates by the same predators (Figure 10). However, this was not the case for coyotes on South Beaches. Coyote predation was high on South Beaches, but coyotes accounted for less than 2% of predator sightings. While monitors observed coyote tracks throughout South Beaches, sightings of animals were infrequent. Coyote predation rates did, however, overlap well with nest densities on both North and South Beaches (see Figures 2-4), indicating that a few individuals may have been keying into areas with high nest densities. There were eight transect blocks with medium-high coyote predation rates and four of these overlapped with areas of medium-high nest densities. There were two transect blocks with medium-high raven predation rates, one of which overlapped with high nest density, suggesting that ravens may have keyed in on heavy nesting areas during foraging in 2012. The rest of the transect blocks had low raven predation rates. Overall, there was a 5% decrease in coyote predation in 2012 compared to 2011 (83 nests taken in 2011 and 79 taken in 2012). And raven predation decreased this year by 68% (73 nests in 2011 to 23 in 2012).

Trends in Annual Breeding Population

Figure 11 shows trends in annual breeding population during linear restriction 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 2012, the number of adults observed and number of nests initiated on VAFB remained near the long-term mean.

The mean number of nests initiated over the time series is similar between North and South Beaches (Figure 12). Annual values are highly correlated for the two beaches (Spearman's rho: $r = 0.846$, $p < 0.001$). There is a decreasing trend leading to the 2000 beach closures and a variable but stable population since 2002. The 2004 peak was higher for South Beaches and likely reflects higher predation and subsequent re-nesting during that year (MSRS 2004). Conversely, the number of nests initiated at Purisima Beaches has been declining since 1994. The lowest number of nests initiated at Purisima Beaches in the time series occurred in 2011.

Figure 13 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: $r = 0.686$, $p = 0.005$). Annual values for open and closed area nesting numbers are not correlated for MIN and WAL beaches (Spearman's rho: $r = 0.160$, $p = 0.301$ and $r = 0.239$, $p = 0.216$, respectively). Furthermore, there were no nesting attempts within areas open to recreational use during seven years at MIN and five years at WAL from 2000 through 2011.

Trends in Annual Reproductive Success

Both hatching and fledging success have high variability among years from 1997-2012 with no apparent trend (Figure 14). Patterns in both metrics were similar from 1997-2005, but overall, there is no correlation between annual values (Spearman's rho: $r = 0.190$, $p = 0.240$). It is likely that, in recent years, the factors regulating hatching success are different than those regulating fledging success. For example, in 2010, hatching success (63%) was well above the long-term mean (45.5%) while fledging success remained average (2010 = 29%, long-term mean = 33.5%). This may be due to low coyote nest depredation and effective raven management early in the season before high nest losses could occur (MSRS 2010). In 2011, there was a lower than average hatching success (33%) due to high predation, but a higher than average fledging success (46%). In 2012, fledging success and hatching success both increased (51% and 44% respectively) with higher than average fledging success.

Figure 15 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 on each beach section. Overall, annual values for the two beaches are positively correlated (Spearman's rho: $r = 0.457$, $p = 0.025$). In 2012, hatching success (45%) was close to the long-term mean (46.6%) on North Beaches and below the long-term mean on South Beaches (2012 = 41%, long-term mean = 43.6%). However, there was high coyote predation that contributed to continued nest loss on South Beaches. Despite decreasing nesting effort over the time series, Purisima Beaches maintain a higher hatching success (61%) compared to North and South Beaches. Additionally, hatching success has been less variable at Purisima Beaches.

Figure 16 shows annual fledging success on North, Purisima, and South Beaches. In 2012, fledging success on North Beaches (65%) was higher than on South Beaches (40%). There is more annual variability in fledging success than hatching success, with no real long-term patterns. 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 = 43%). The long-term means for North and South beaches are similar (34.6% and 40% respectively), but annual values are not correlated between the two beaches (Spearman's rho: r = 0.341, p = 0.107).

Figure 17 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 = 19.2% closed = 47.4% WAL: open = 41.6%, closed = 45.1%; SNO: open = 41.5%, closed = 49.5%). MIN and WAL are highly variable with many years of no nesting in the open area. However, hatching success appears to be increasing within the area closed to recreational access at MIN. At WAL, clutch hatch success within the area closed to recreational access appears relatively stable, with clutch hatch rates fluctuating near the long-term mean. At SNO, clutch hatch success within the open areas and closed areas appear to follow a similar pattern, but are not significantly correlated (Spearman's rho: r = 0.397, p = 0.089).

Figure 18 shows annual fledging success for open and closed areas using all data available from 2000 - 2012. 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 34.9%. 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 = 29%). At SNO, mean fledging success is similar between open and closed areas (open = 27.1%, closed = 31.5%), but interannual patterns were not significantly correlated (Spearman's rho: r = -0.476, p = 0.116).

Spatial Distribution of Wrack, Nests, and Fledglings

Figure 19 shows mean values for wrack index, nest density and fledgling (number of juveniles observed) density among the major sections of North and South Beaches. Mean wrack index was highest for WAL and very similar for all other beach sections. There was also little variability in nest densities among beach sections. Nest densities were highest for SAN, WAL, SNO, and SSO and lowest for MIN, SHN, and SHS. Fledgling densities were much more variable among beach sections; and this was especially true for North Beaches. The highest fledgling densities were observed at SAN and the lowest at MIN. The highest fledgling densities on South Beaches were at SNO and SSO. There was no significant correlations between wrack index values and nest density or fledgling density (Spearman's rho: $r = -0.184$, $p = 0.331$ and $r = -0.471$, $p = 0.116$, respectively). Overall, South Beaches had more wrack and a higher mean nest density while North Beaches had a higher mean fledgling density.

Recreational Beach Management

A total of 60 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, 83%), the only beach that is open to the general public. Surf Beach reached 50 violations and was closed on 20 July. Nine violations were reported at WAL (15%) and one violation was reported at MIN (2%). The total number of beach violations in 2012 represents a 36% increase from 2011 (44, Table 6). No take of any snowy plovers, their nests, eggs, or chicks, were documented as a result of beach violations.

Discussion

Snowy Plover Nesting Effort

The number of snowy plover adults and nests documented in 2012 were similar to their 19-year means. Both metrics have remained relatively stable over the past five years. The strong correlation among trends on North and South Beaches indicate larger scale mechanisms regulating nesting effort. If localized issues such as predation were important determinants of nesting efforts, then we would expect trends for the two beach sections to be different.

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

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

Many of the above factors regulating nesting habitat availability and prey abundance were correlated in the Dugan et al. (2008) study. For example, macrophyte wrack cover was correlated with dry beach width. Thus, it is difficult to determine whether plover nesting effort responds more to nesting habitat availability or prey abundance. However, it is interesting to note that the peak in 2004 nesting effort was not limited to VAFB and was seen at multiple breeding sites range wide. It is likely that larger scale oceanographic processes regulating wrack cover and prey abundance are at play. The most common macrophytes in the brown algal wrack at VAFB included *Macrocystis pyrifera*, *Egregia menzeii*, and *Nereocystis luetkeana*. Annual growth in *M. pyrifera* has been shown to vary with oceanographic variability (Tegner et al. 1997) and large areas can be severely disturbed during stormy periods such as strong El Niño events (Dayton and Tegner 1984). Additionally, several studies have suggested that the spatial distribution of shorebird abundance is positively correlated with coastal upwelling (see Warnock et al. 2002). The central California coastline experiences exceptionally strong and highly variable upwelling events (Wing et al. 1998, Bograd et al. 2000). Thus, it is possible that much of the interannual variability in snowy plover breeding effort at VAFB can be explained by oceanographic-related variability in annual macrophyte production and invertebrate prey abundance.

The spatial differences we observed in nesting effort may also be explained by spatial variability in habitat conditions. South Beaches have consistently had more annual nesting attempts over the 19-year time series. While we did not see any correlations between our wrack index and nest densities at the beach section scale, overall wrack abundance and nest density was highest on South Beaches. The lack of correlation at the beach section scale may have been due to the low variability in wrack abundance among beach sections in 2012. We may also need to refine our index to better target brown macroalgal cover. Dugan et al. (2008) found that the abundance of talitrid amphipods was 4.5 times greater on South Beaches in 2004 and two times greater in 2005 and associated this with the higher brown macroalgal cover on South Beaches. However, there are other factors that we will need to consider when assessing spatial differences in nesting effort. In addition to differences in wrack cover, Dugan et al. (2008) found that South Beaches had wider dry beach segments on average compared to North Beaches. Also, grain size was generally coarser on North Beaches, especially on the southern portion of the North Beaches adjacent to the Purisima Beach sectors. Because of these differences in habitat among beach sections, it may be that wrack is more important in determining nesting effort among years rather than among beaches. As we improve our wrack index and continue to develop our time series of wrack abundance, we will be able to better understand the role wrack plays in determining spatial and temporal variability in annual nesting effort.

The number of nest initiations on Purisima Beaches has been on the decline since 1994, with the lowest number of nests recorded this season. In fact, 2011 and 2012 were the first seasons in the time series for which there were no nesting attempts within PCO. However, hatching success has been consistently higher than all other beach sections over the 19-year period. Some of this success may be attributed to the predator management conducted at the least tern colony. While predator management is increased at the colony, there is a potential benefit to the nearby PNO sector as well. Needless to say, this beach section still represents an important component of VAFB plover breeding habitat. The overall decline in nest initiations may be attributed to the dramatic increase in vegetation cover such as invasive European beach grass (*Ammophila arenaria*) and native coastal dune lupine (*Lupinus chamissonis*) (MSRS 2010). Banding data from previous years indicate that broods move from PCO and later are observed on the south portion of SAN (Ball unpublished field notes). The corridor traveled between these two sections has gradually increased in vegetation cover since 2000 and may have an influence on nest site selection at the colony. Purisima Beaches were not included in the Dugan et al. (2008) study. However, Dugan et al. noted that the southernmost portion of North Beaches, the portion adjacent to the Purisima Beach section, was backed by an artificial dune stabilized with European beach grass. Dugan et al. (2008) also noted that European beach grass cover was more than three times greater on North Beaches than South Beaches. It is likely that European beach grass will increasingly threaten plover nesting habitat on Purisima and North Beaches if it is not controlled.

Snowy Plover Reproductive Success

Reproductive success (number of chicks fledged per adult male) was 0.8 in 2012. This is below the USFWS recovery goal of 1.0 fledglings per male (USFWS 2007). Because banding efforts have been highly variable in past years, reproductive success has not been reported in past reports. Rather, reproductive performance has been summarized using clutch hatch success and fledgling success. Clutch hatch success in 2012 was close to the long-term mean while fledging success was the highest on record since 1999. Unlike nesting effort, clutch hatch and fledging success were not correlated among North and South Beaches, indicating that more localized forces such as predation are driving reproductive success. In 2012, 34% of all nests initiated were lost to predators. Coyote and common raven were the main nest predators, accounting for 30% of all nest predation. Coyote nest predation accounted for the majority of nest failures on all beach sections (24% of all known fate nests). On South Beach, monitors observed coyote tracks following a search pattern from nest to nest indicating animals keying into nest locations. Furthermore, areas of high coyote predation overlapped with areas of high nest densities. Thus, coyote predation was for the most part a localized issue, likely attributable to one or a few coyotes in the beach sectors where it occurred.

Raven 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, though sightings of ravens decreased in 2012. Ravens continue to be a nest predator on VAFB with 7% of all known fate nests lost to confirmed or suspected raven predation. Unlike coyote predation, raven predation was concentrated on North Beaches and occurred during one week in June. The raven predation was concentrated on SAN beach sector and did not continue for the rest of the season. In prior years, ravens frequently visited the beaches between May and June until they were removed by the predator management team. It is likely that the increased predator management effort and preemptive raven removal contributed to the reduced raven presence on beaches this year.

While coyotes and ravens had a major impact on clutch hatch success in 2012, it is important to note that fledging success was well above the 19-year mean. Furthermore, annual hatching success at VAFB is not correlated with annual fledging success. Thus, there appears to be different mechanisms operating on hatching and fledging success at VAFB. Similarly, Neuman et al. (2004) noted that predator management techniques for increasing snowy plover hatching success did not result in a similar increase in fledging success. Overall, fledging success is likely a more important metric for guiding plover population management because it ultimately determines recruitment rates into the adult population. If the recruitment rate is consistently lower than the adult death rate over several years, then the population will decline and the population may be more at risk in the long-term (Akcakaya et al. 2003). Because snowy plovers are short-lived (Paton [1994] estimated mean adult survival to be 2.7 years), annual fledging success can be an important determinant of variability in short-term population size.

Snowy Plover Management at VAFB

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

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

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

Management Recommendations

1) VAFB should continue to support efforts to preemptively manage ravens both within and adjacent to snowy plover nesting habitat. Ravens have only recently expanded their range into coastal habitats on VAFB and are not a native component of the local ecosystem. Efforts to manage ravens were successful in 2012 as raven predation was limited to only one week in June and accounted for <7% of known-fate nests. Continued preemptive management of ravens will help VAFB meet its management goals for snowy plovers.
2) 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.
3) 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 sections 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.
4) 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.
5) 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.

Literature Cited

Akcayaka, H.R., J.L. Atwood, D. Breininger, C. Collins, and B. Duncan. 2003. Metapopulation dynamics of the California Least Tern. Journal of Wildlife Management 67(4): 829-842.

Ball, R. and D.P. Robinette. 2011. Monitoring and Management of the Western Snowy Plover at Vandenberg Air Force Base, 2011. Unpublished Report, PRBO Conservation Science, Petaluma, CA.

Boarman, W.I. and B. Heinrich. 1999. Common Raven (*Corvus corax*). *In* The Birds of North America, No. 476 (A. Poole and F. Gill eds.). The Birds of North America, Inc., Philadelphia, PA.

Boarman, W.I., M.A. Patten, R.J. Camp, S.J. Collis. 2006. Ecology of a population of subsidized predators: Common ravens in the central Mojave Desert, California. Journal of Arid Environments 67: 248-261.

Bograd, S.J., P.M. DiGiacomo, R. Durazo, T.L. Hayward, K.D. Hyrenbach, R.J. Lynn, A.W. Mantyla, F.B. Schwing, W.J. Sydeman, T. Baumgartner, B. Lavaniegos, and C.S. Moore. 2000. The state of the California Current, 1999-2000: forward to a new regime? CalCOFI Reports 41.

Browman, H.I. and K.I. Stergiou. 2004. Perspectives on ecosystem-based approaches to the management of marine resources. Marine Ecology Progress Series 274: 269-303.

Camp, R.J. and R.L. Knight. 1993. Common Raven populations in Joshua Tree National Monument, California. Western Birds 24: 198-199.

Conner, M.M., M.M. Jaeger, and D.R. McCullough. 1998. Effects of coyote removal on sheep depredation in northern California. Journal of Wildlife Management 62: 690-699.

Dayton, P.K. and M.J. Tegner. 1984. Catastrophic storms, El Niño, and patch stability in a southern California kelp community. Science 224: 283-285.

Dugan, J.E., D.M. Hubbard, and P. Persons. 2008. Assessing habitat and prey resources for Western snowy plovers on exposed sandy beaches of Vandenberg Air Force Base. Draft Final Report to SRS Technologies and U.S. Air Force. Marine Science Institute, University of California, Santa Barbara. 42 pp.

Knowlton, F.F. 1972. Preliminary interpretations of coyote population mechanics with some management implications. Journal of Wildlife Management 36: 369-382.

Knowlton, F.F., E.M. Gese, and M.R. Jaeger. 1999. Coyote depredation control: an interface between biology and management. Journal of Range Management 52: 398-412.

Kristan, W.B. and W.I. Boarman. 2007. Effects of anthropogenic developments on Common Raven nesting biology in the west Mojave Desert, California. Ecological Applications 17(6): 1703-1713.

Linz, G.M., C.E. Knittle, and R.E. Johnson. 1992. Home range of breeding Common Ravens in coastal southern California. Southwestern Naturalist 37: 199-202.

Malm, P. 2011. Do macrophyte wrack species composition and input rates influence the distribution and abundance of talitrid amphipod populations? Abrstract. Beyond the Golden Gate Conference, The Presidio, San Francisco, CA, November 1, 2011.

MSRS. 2004. Breeding Activities of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) on Vandenberg Air Force Base, California. 2004. Final Report.

MSRS. 2010. Breeding Activities of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) on Vandenberg Air Force Base, California. 2010. Final Report.

Neuman, K.K., G.W. Page, L.E. Stenzel, J.C. Warriner, and J.S. Warriner. 2004. Effect of mammalian predator management on Snowy Plover breeding success. Waterbirds 27(3): 257-263.

Nur, N., G. W. Page, and L.E. Stenzel. 1999. Population viability analysis for Pacific coast Western Snowy Plovers. Vol. 2, Appendix D, *in* Western Snowy Plover (*Charadrius alexandrinus nivosus*) Pacific Coast Population Recovery Plan 2007, U.S. Fish and Wildlife Service, Sacramento, CA.

Page, G.W. and L.E. Stenzel. 1981. The breeding status of the snowy plover in California. Western Birds 12(1):1-40.

Page, G.W., L.E. Stenzel, J.S. Warriner, J.C. Warriner, and P.W. Paton. 2009. Snowy Plover (*Charadrius nivosus*), The Birds of North America Online (A. Poole, Ed.), Ithaca: Cornell Lab of Ornithology; Retrieved from The Birds of North America Online: http://bna.birds.cornell.edu/bna/species/154 doi: 10.2173/bna154.

Paton, P.W.C. 1994. Survival estimates of Snowy Plovers at Great Salt Lake, Utah. Condor 96: 1106-1109.

Revell, D.L. pers. comm. David Revell is a Senior Coastal Geomorphologist with ESA/Phil Williams and Associates, Capitolo, CA.

Robinette, D.P and J. Howar. 2011. Monitoring and Management of the California Least Tern at Vandenberg Air Force Base, 2011. Unpublished Report, PRBO Conservation Science, Petaluma, CA.

Sacks, B.N., M.M. Jaeger, J.C.C. Neale, and D.R. McCullough. 1999. Territoriality and breeding status of coyotes relative to sheep predation. Journal of Wildlife Management 63: 593-605.

Stenzel, L. E., J. C. Warriner, J. S. Warriner, K. S. Wilson, F. C. Bidstrup and G. W. Page. 1994. Long distance breeding dispersal of Snowy Plovers in western North America. Journal of Animal Ecology 63:887-902.

Tegner, M.J., P.K. Dayton, P.B. Edwards, and K.L. Riser. 1997. Low-scale, low-frequency oceanographic effects on kelp forest succession: a tale of two cohorts. Marine Ecology Progress Series 146: 117-134.

Tucker, M.A. and A.N. Powell. 1999. Snowy plover diets in 1995 at a coastal southern California breeding site. Western Birds 30: 44-48.

USFWS. 2007. U.S. Fish and Wildlife Service (USFWS). Western Snowy Plover (*Charadrius alexandrinus nivosus*) Pacific Coast Population Recovery Plan.

USFWS. 1993. U.S. Fish and Wildlife Service (USFWS), 58FR 12864, Determination of Threatened Status for the Pacific Coast Population of the Western Snowy Plover, March 5, 1993.

Warnock, N., C. Elphick, and M.A. Rubega. 2002. Shorebirds in the marine environment. In E.A. Schreiber and J. Burger eds., Biology of Marine Birds. CRC Press, London. 722 pp.

Warriner, J. S., J. C. Warriner, G. W. Page and L. E. Stenzel. 1976. Mating system and reproductive success of a small population of polygamous Snowy Plovers. Wilson Bulletin 98:15-37.

Wing, S.R., L.W. Botsford, S.V. Ralston, and J.L. Largier. 1998. Meroplanktonic distribution and circulation in a coastal retention zone of the northern California upwelling system. Limnology and Oceanography 43(7): 1710-1721.

Table 1. Summary of population and breeding metrics for the Western snowy plover population on VAFB in 2011 and 2012. Also shown is the percent change for each metric in 2012 when compared to 2011.

		2011	2012	% Change in 2012
Population	Maximum Adults Observed	230	248	8%
	Number of Nests Initiated	418	341	-18%
Nests	Hatched	137	145	5%
	Abandoned Before Hatch	18	23	27%
	Incubated Past Hatch Date	1	1	0%
	Depredated	213	124	-42%
	Destroyed by Wind	5	11	105%
	Destroyed by Tide	34	25	-26%
	Destroyed by Human(s)	1	0	-100%
	Failed Unknown	4	6	50%
	Unknown Fate	5	7	40%
Eggs & Chicks	Total Known Fate Eggs	1,087	875	-20%
	Total Chicks Hatched	362	382	5%
	Hatching Success	33.3%	44%	10.7%
	Clutch Success	30%	46%	16%
	Known Fate Clutches	397	334	-15.86%
Fledglings	Total Banded Chicks	148	161	8.7%
	Banding Rate	40.9%	42.2%	2.7%
	Total Banded Fledglings Observed	67	82	24%
	Fledging Success	45.3%	50.93%	5.6%
	Estimated # of Fledglings	164	194	18%

Table 2. 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 2012. 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 2012	Number of Confirmed Nesters in 2012	Number of Probable Nesters in 2012
1995	63			
1996	149			
1997	139			
1998 or 1999	114			
2000	52			
2001	58			
2002	61			
2003	56	-	1	1
2004	249	-	2	1
2005	68	4	1	-
2006	110	4	3	1
2007	27	-	-	-
2008	149	13	5	2
2009	182	10	4	-
2010	21	-	-	-
2011	148	39	13	9
Unknown Year	N/A	7	3	1

Table 3. Fates of nests initiated within areas open to recreational activity on Minuteman (MIN), Wall (WAL), and Surf, North (SNO) beach sectors in 2012.

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

Table 4. Historic egg laying, chick hatching, and fledging periods for snowy plovers at VAFB. Data for egg laying periods were available for 1995-2012. Data for chick hatching periods were available for 2002-2012 (with the exception of 2010). Data for fledging periods was available for 2009 and 2012.

	Egg Laying Period	Chick Hatching Period	Fledging Period
1995	6 Mar – 21 Jul		
1996	24 Mar – 16 Jul		
1997	15 Mar – 25 Jul		
1998	26 Mar – 17 Jul	Not Available	
1999	31 Mar – 25 Jul		
2000	23 Mar – 14 Jul		
2001	20 Mar – 13 Jul		
2002	15 Mar – 17 Jul	17 Apr – 16 Aug	Not Available
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

Table 5. Number and percent of known fate snowy plover nests taken by predators at VAFB in 2012.

	Number of Nests	Percent of Known Fate Nests
Coyote	79	24%
Confirmed Raven	20	6%
Suspected Raven	3	<1%
Unidentified Gull	1	<1%
Unknown Avian	4	1%
Unidentified Predator	17	5%
Total	124	37%

Table 6. Number of beach violations per beach sector on VAFB, 2001-2012.

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

* Closed because violation limit was reached.

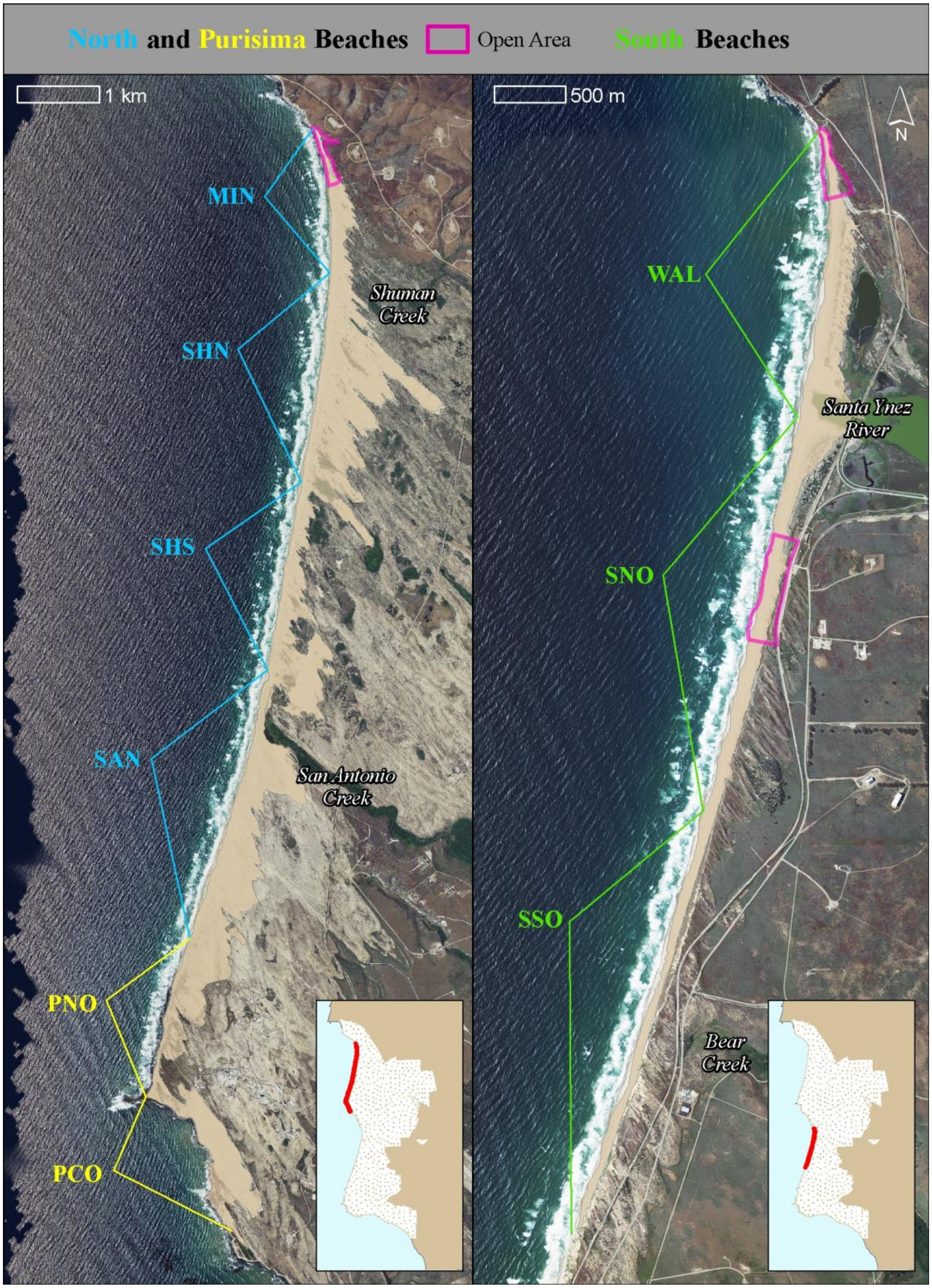


Figure 1. Map of beach sections for North, Purisima, and South Beaches on VAFB. Areas open to public and/or military personnel are outlined in purple. MIN = Minuteman, SHN = Shuman North, SHS = Shuman South, SAN = San Antonio, PNO = Purisima North, PCO = Purisima Colony, WAL = Wall Beach, SNO = Surf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

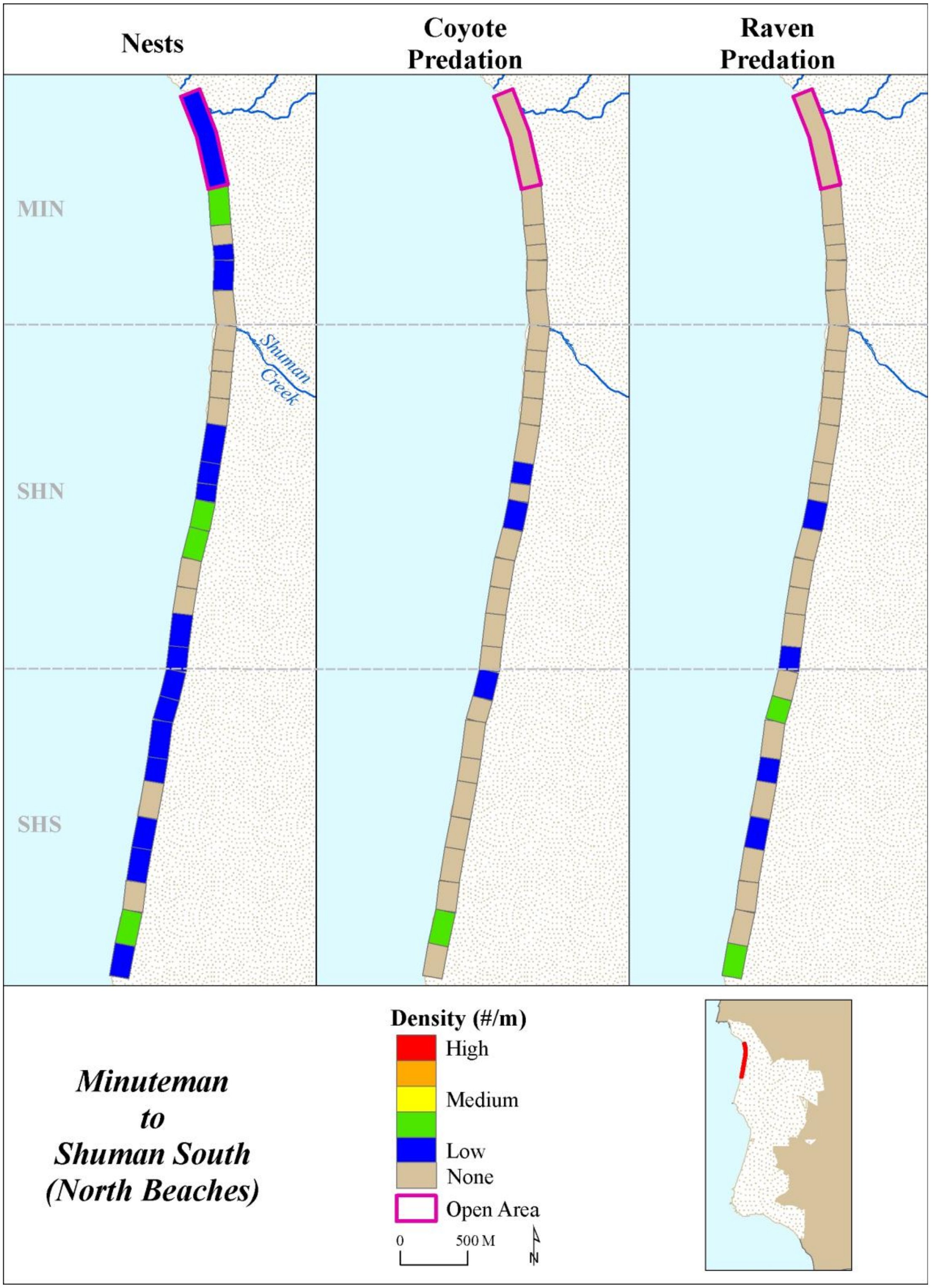


Figure 2. Snowy plover nest densities within North Beach transect blocks from Minuteman to Shuman South (see Figure 1 for boundaries of each beach section). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple.

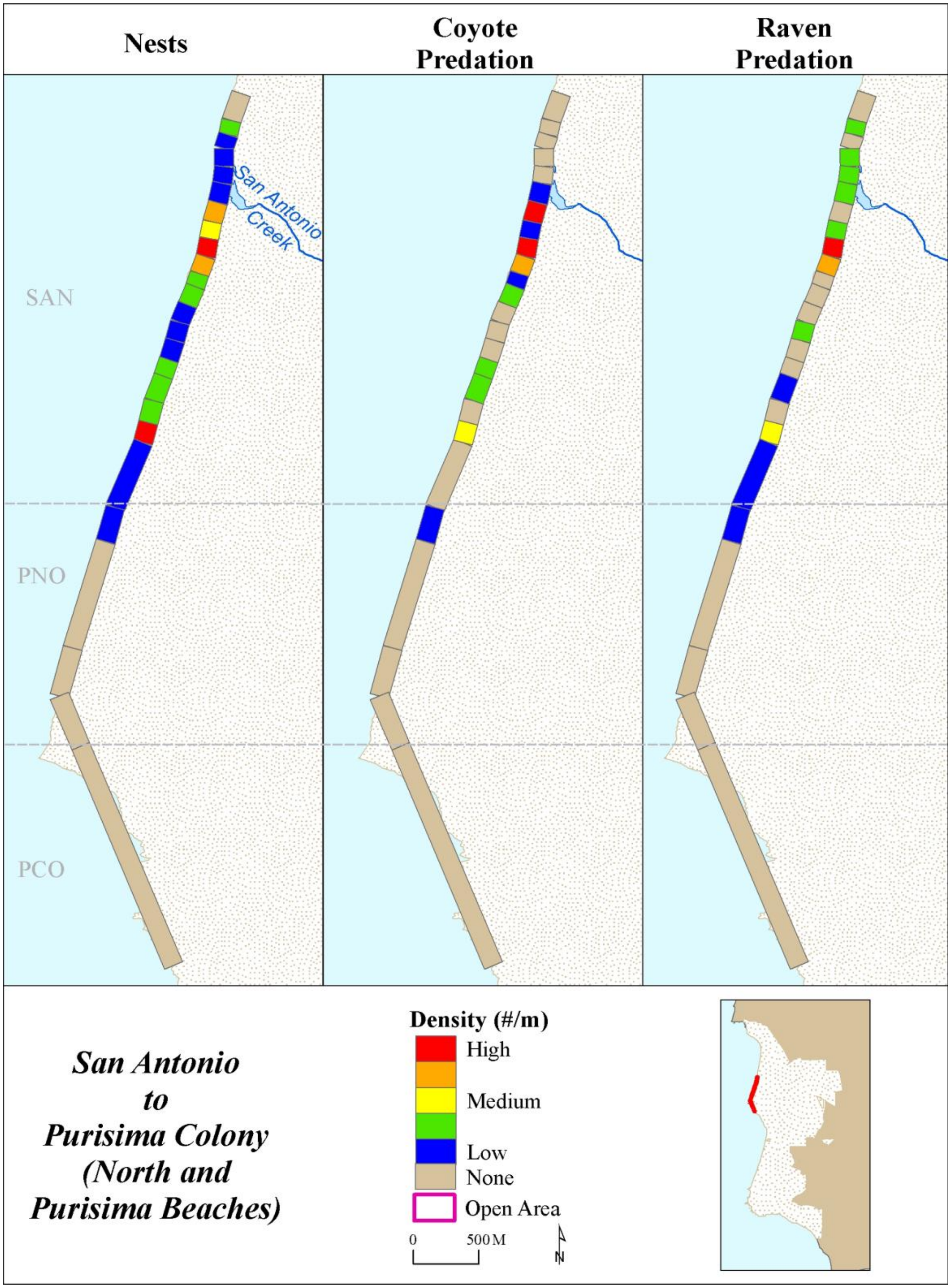


Figure 3. Snowy plover nest densities within North and Purisima Beach transect blocks from San Antonio to Purisima North (see Figure 1 for boundaries of each beach section). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in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

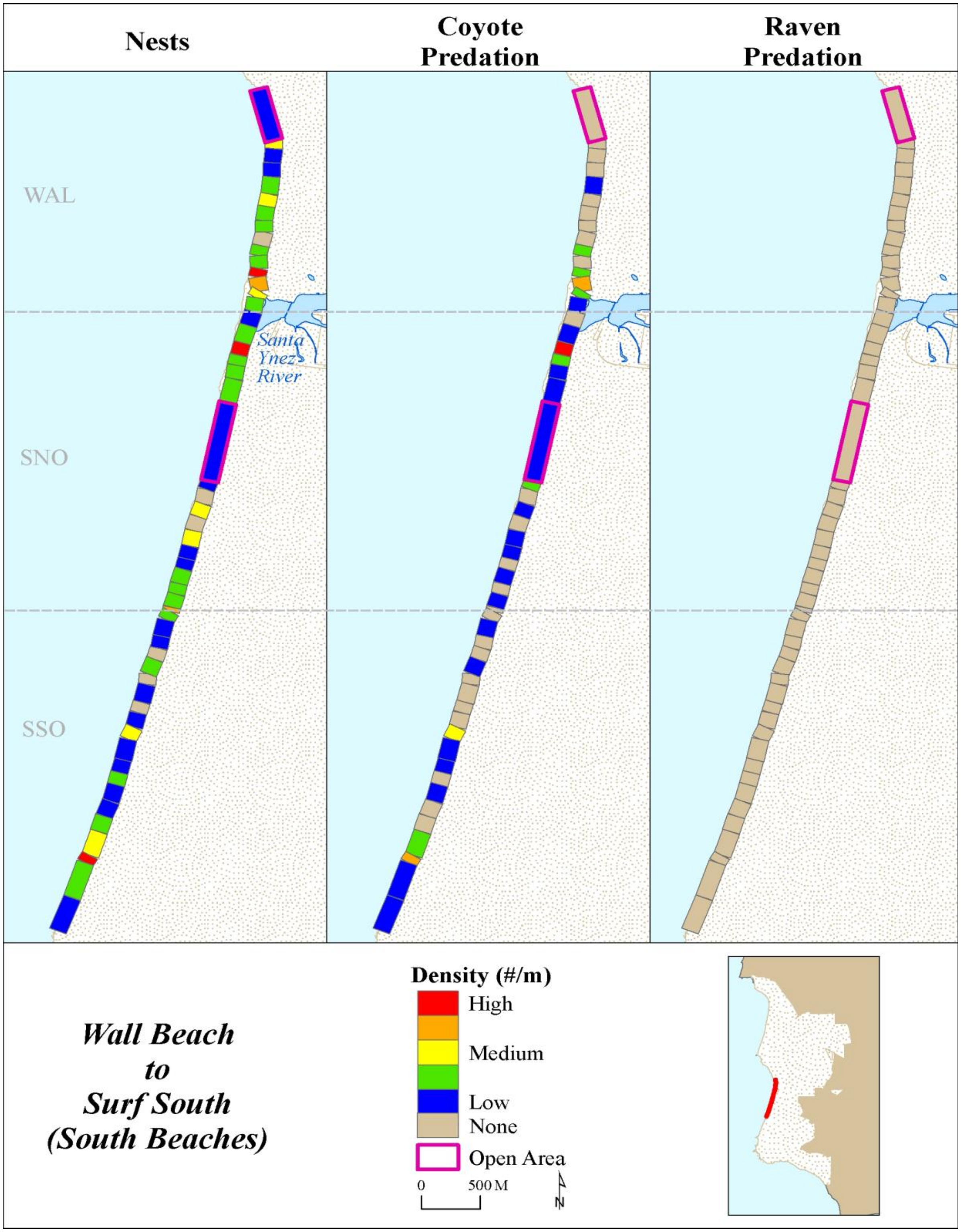


Figure 4. Snowy plover nest densities within South Beach transect blocks (see Figure 1 for boundaries of each beach section). Nest predation rates of common ravens and coyotes are also shown. Areas open to public and/or military personnel are outlined in purple.

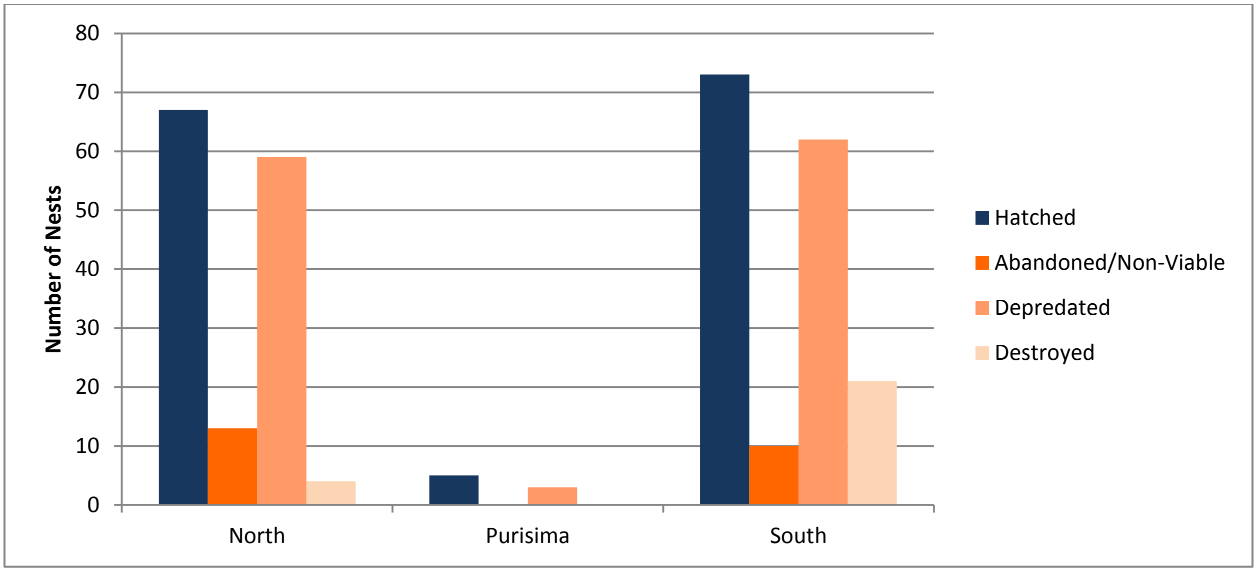


Figure 5. Nest fates on North, Purisima, and South Beaches in 2012. Destroyed nests include those destroyed by both humans and natural causes (e.g., tides and wind).

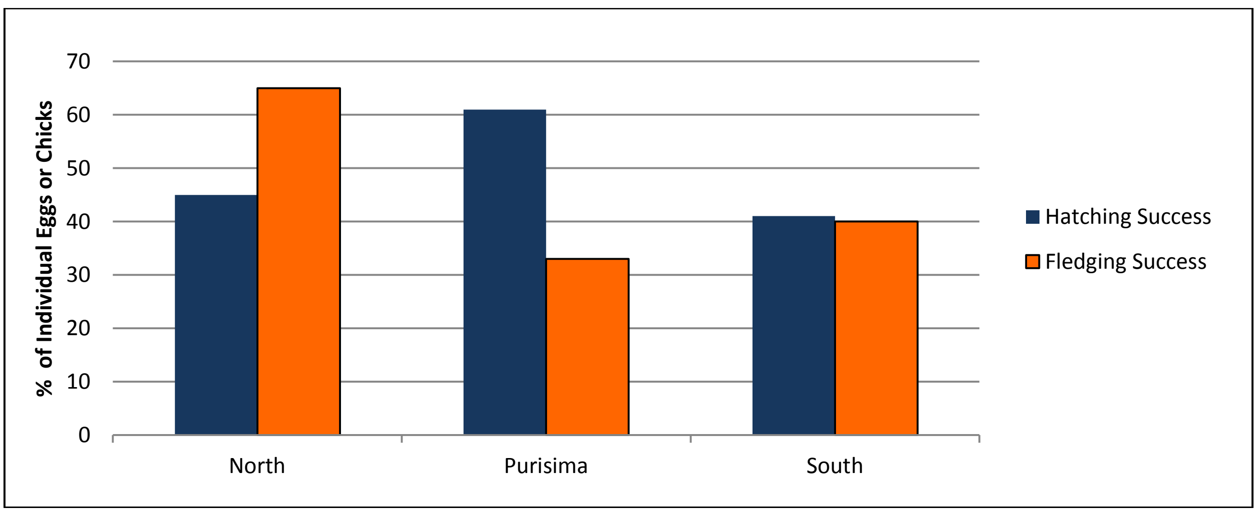


Figure 6. Clutch hatch and fledging success on North, Purisima, and South Beaches in 2012.

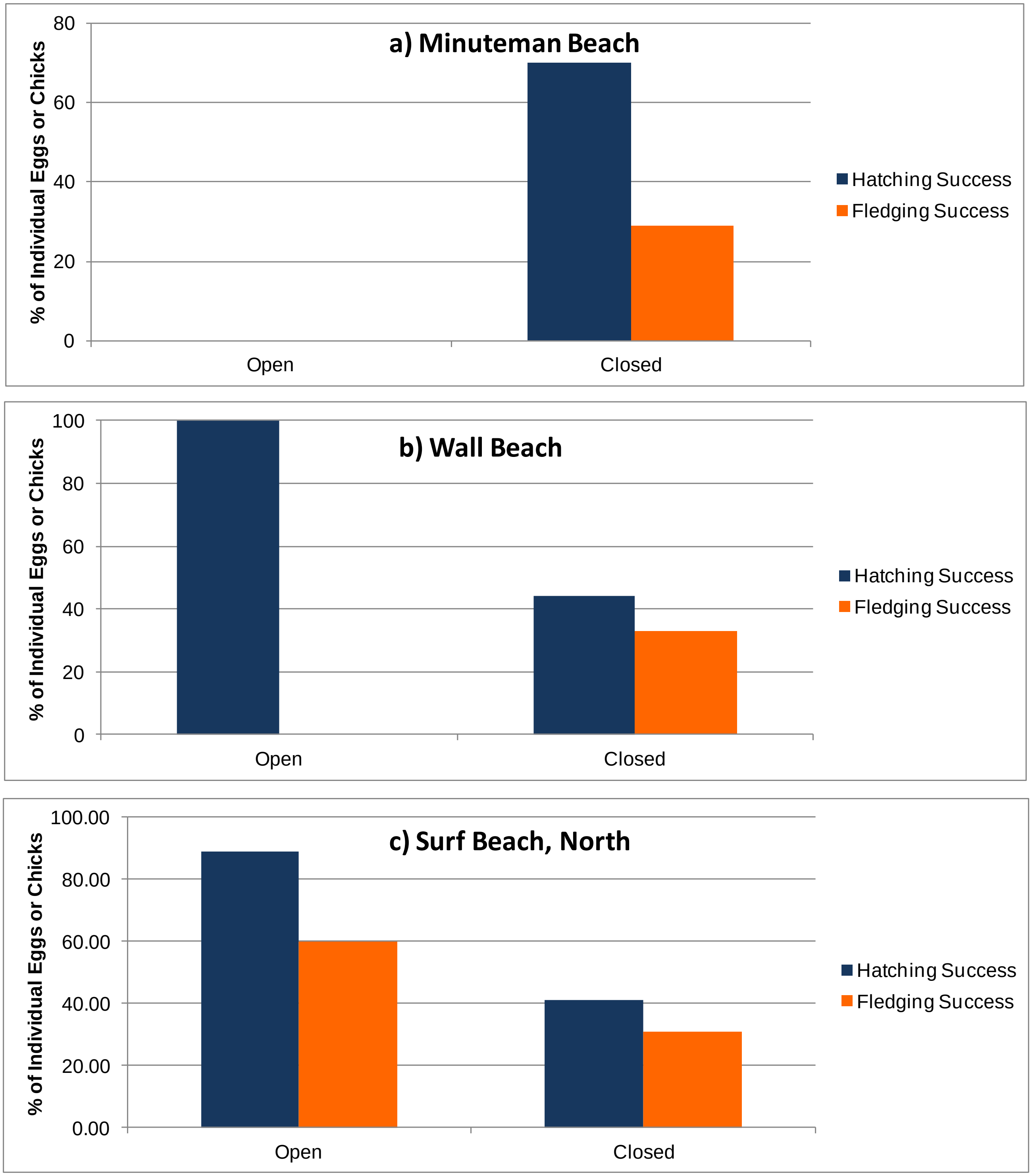


Figure 7. Clutch hatch and fledging success in open and closed areas of Minuteman, Wall, and Surf Beaches.

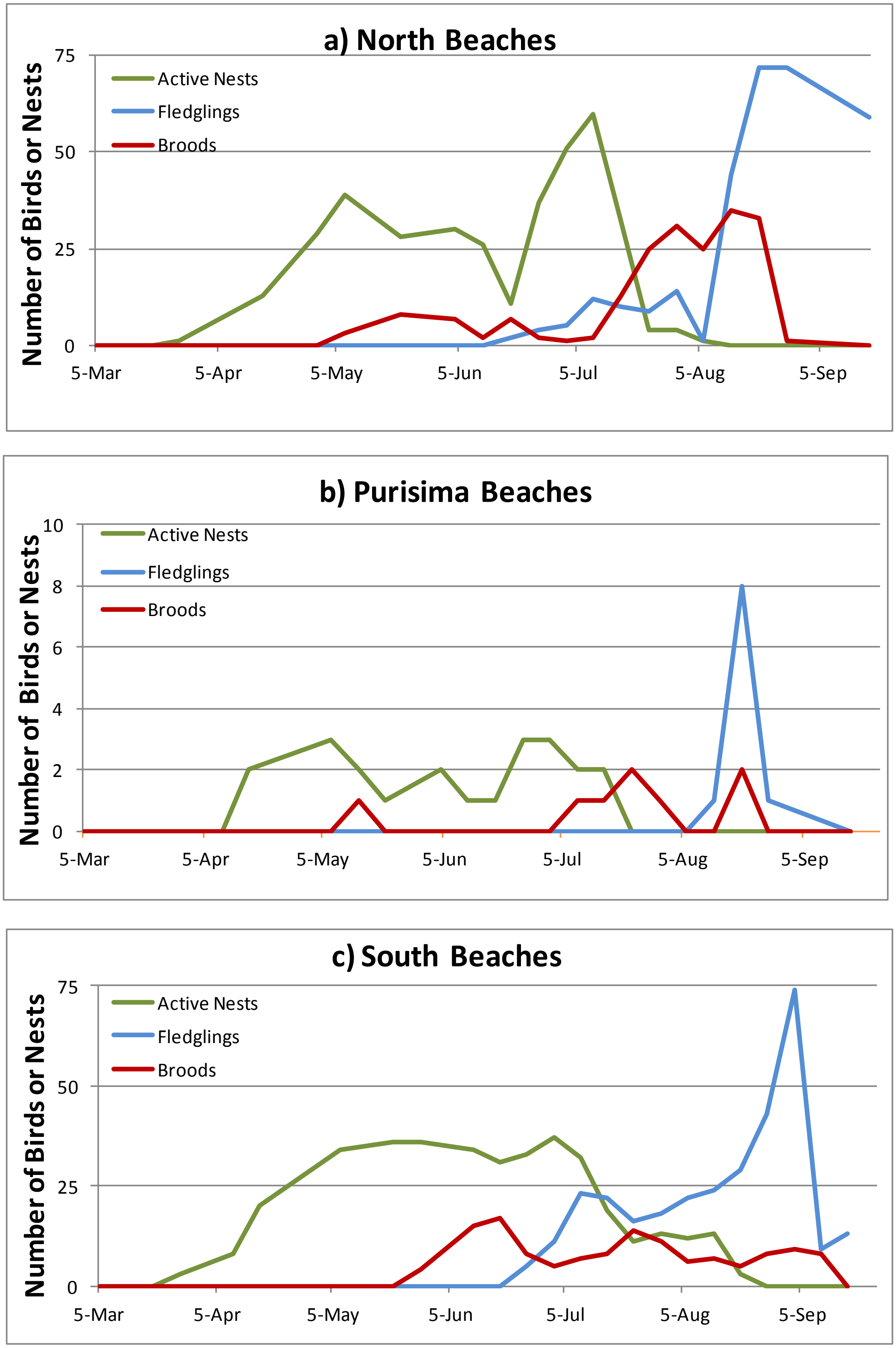


Figure 8. Breeding phenology at North, Purisima, and South Beaches in 2012.

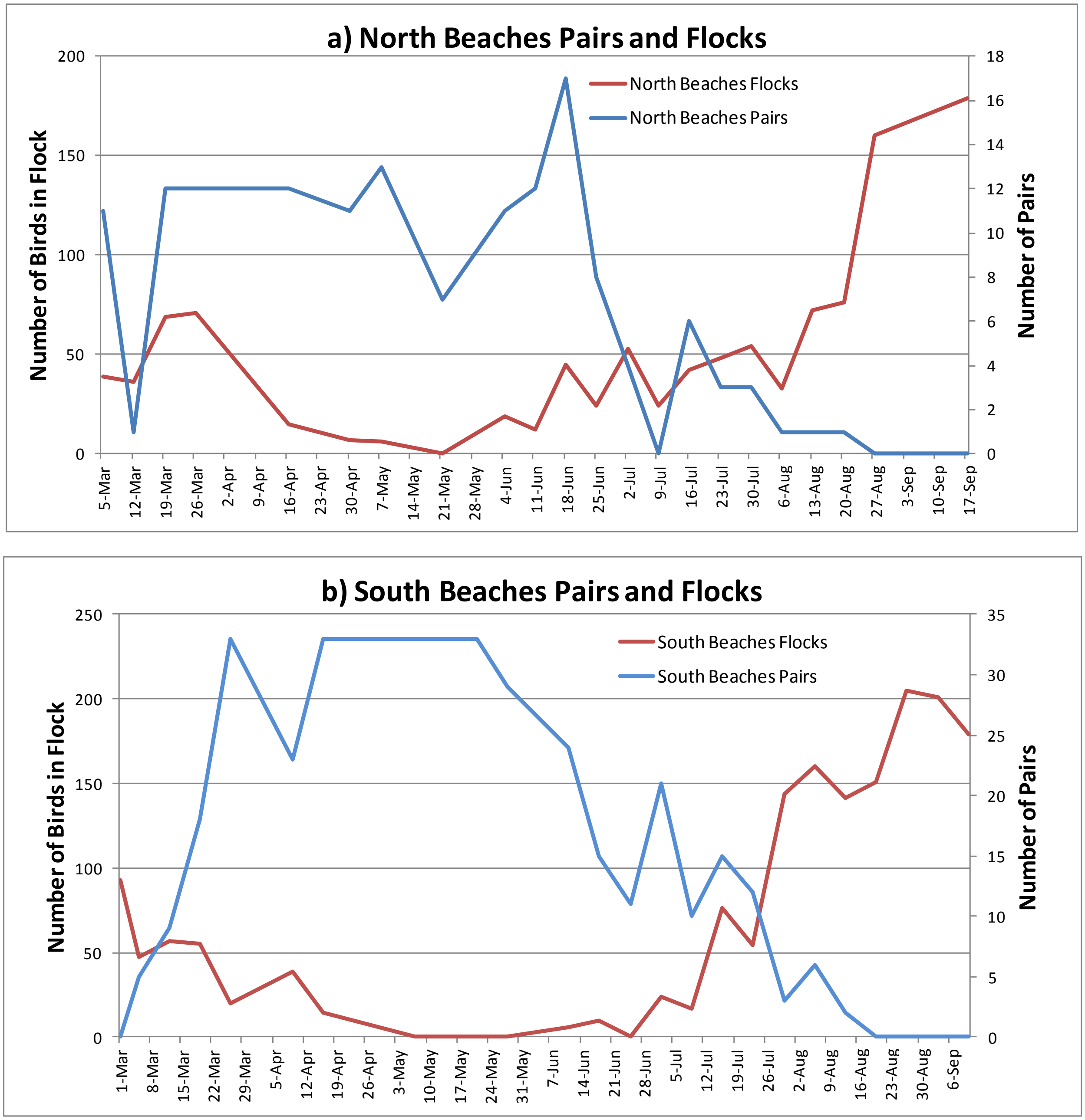


Figure 9. Numbers of plover adult pairs detected during weekly transect surveys versus number of plovers in flocking groups on North and South Beaches.

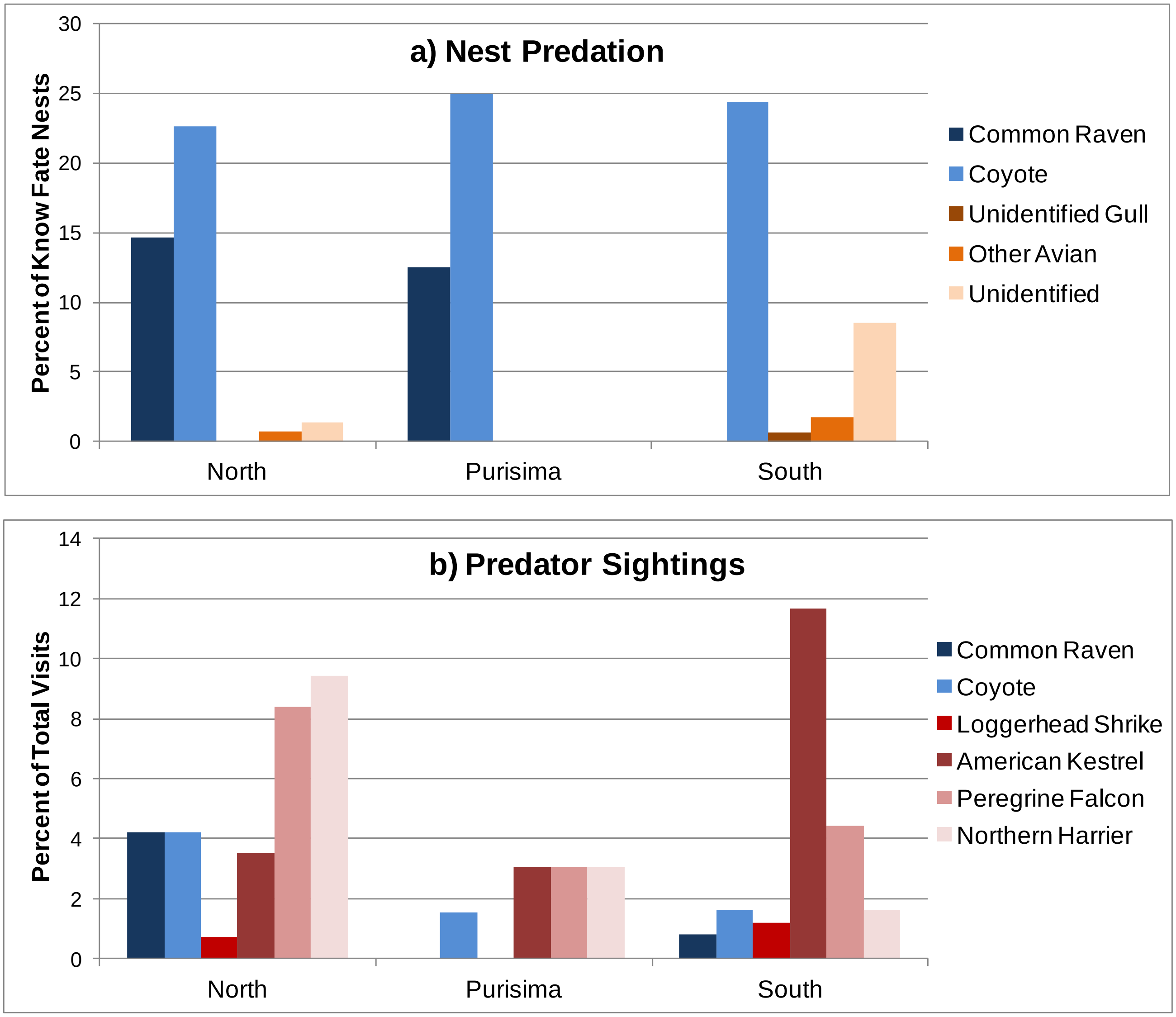


Figure 10. Distribution of known fate nests taken by predators and predator sightings on North, Purisima, and South Beaches in 2012. Numbers of nests taken by common ravens include both confirmed and suspected predation.

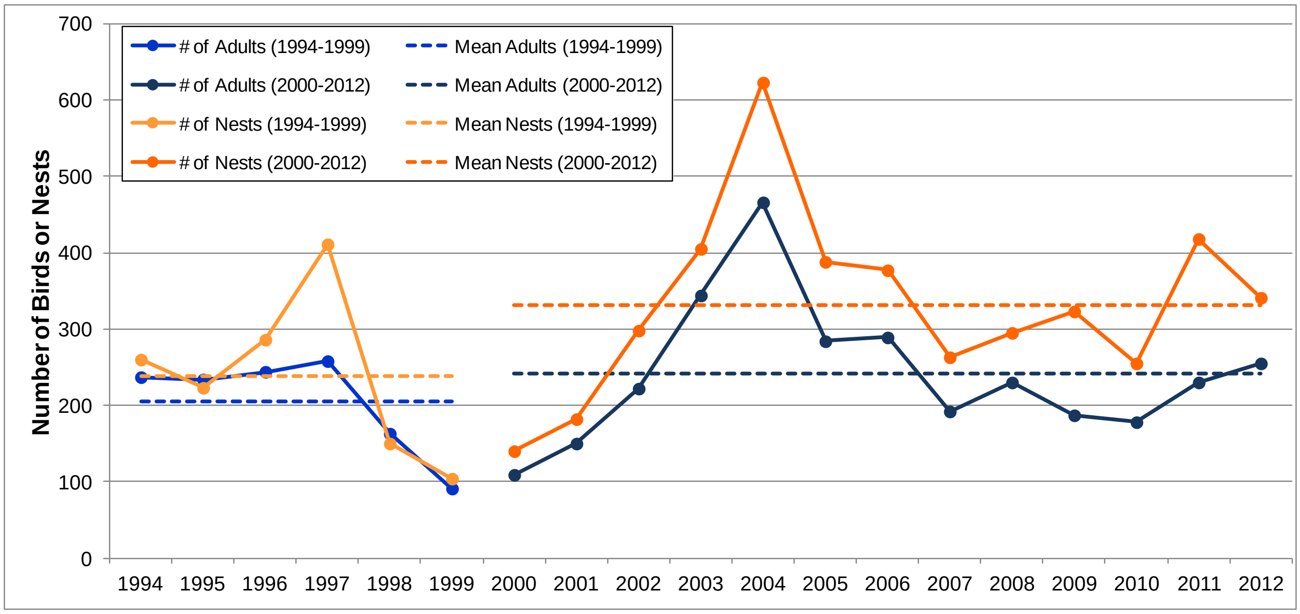


Figure 11. Trends in annual breeding population assessed using maximum number of adults observed during window surveys and number of nests initiated from 1994-2012. Dashed lines show the long-term means calculated for the periods during linear restriction (1994-1999) and after beach closures took effect (2000-2012).

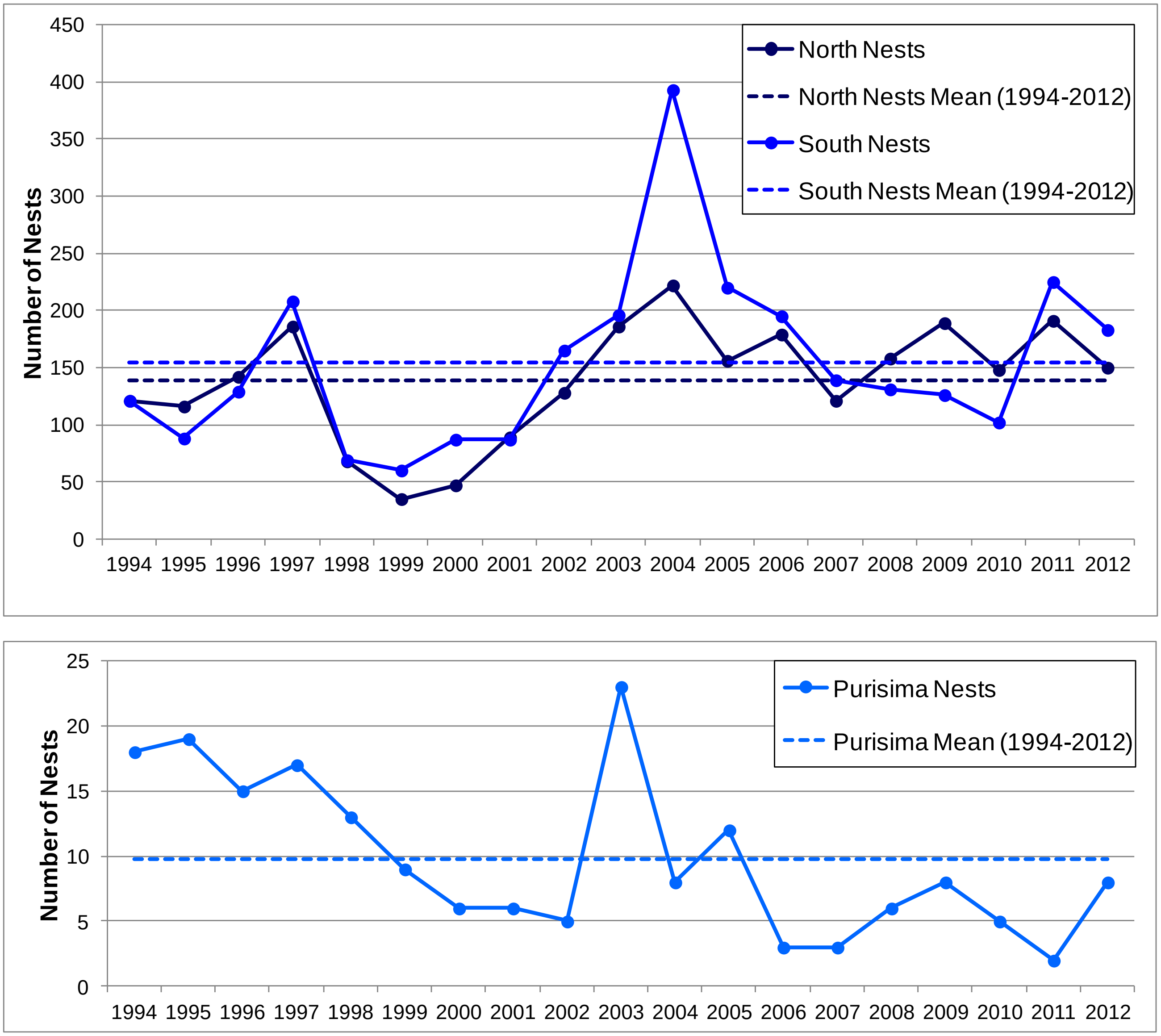


Figure 12. Trends in annual number of nests initiated for North, South, and Purisima Beaches from 1994-2011. Dashed lines show the 17-year means (1994-2012).

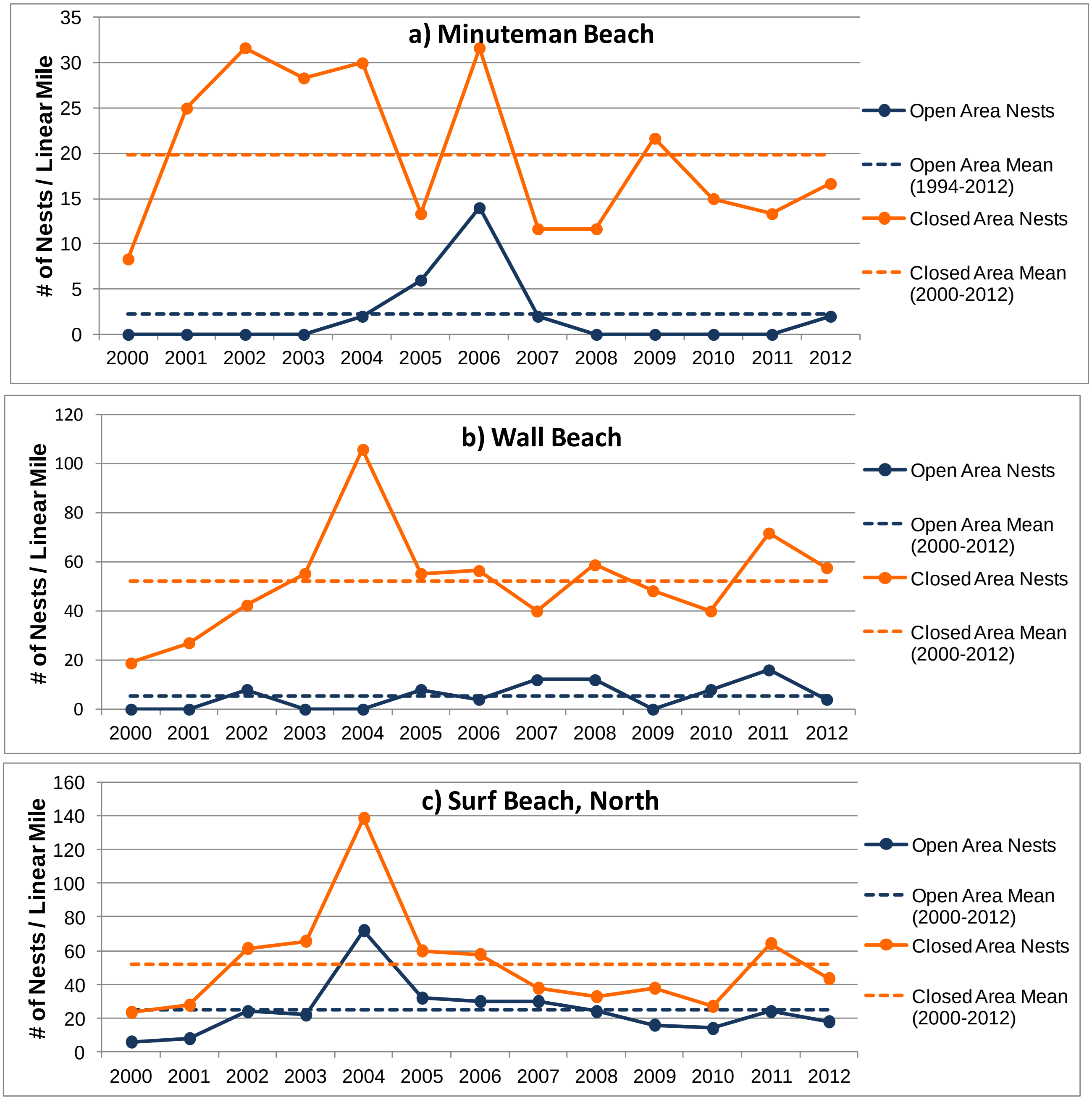


Figure 13. Trends in annual number of nests per linear mile within open and closed sections of Minuteman, Wall, and Surf Beaches, from 2000-2012. Dashed lines show the 12 year means (2000-2012).

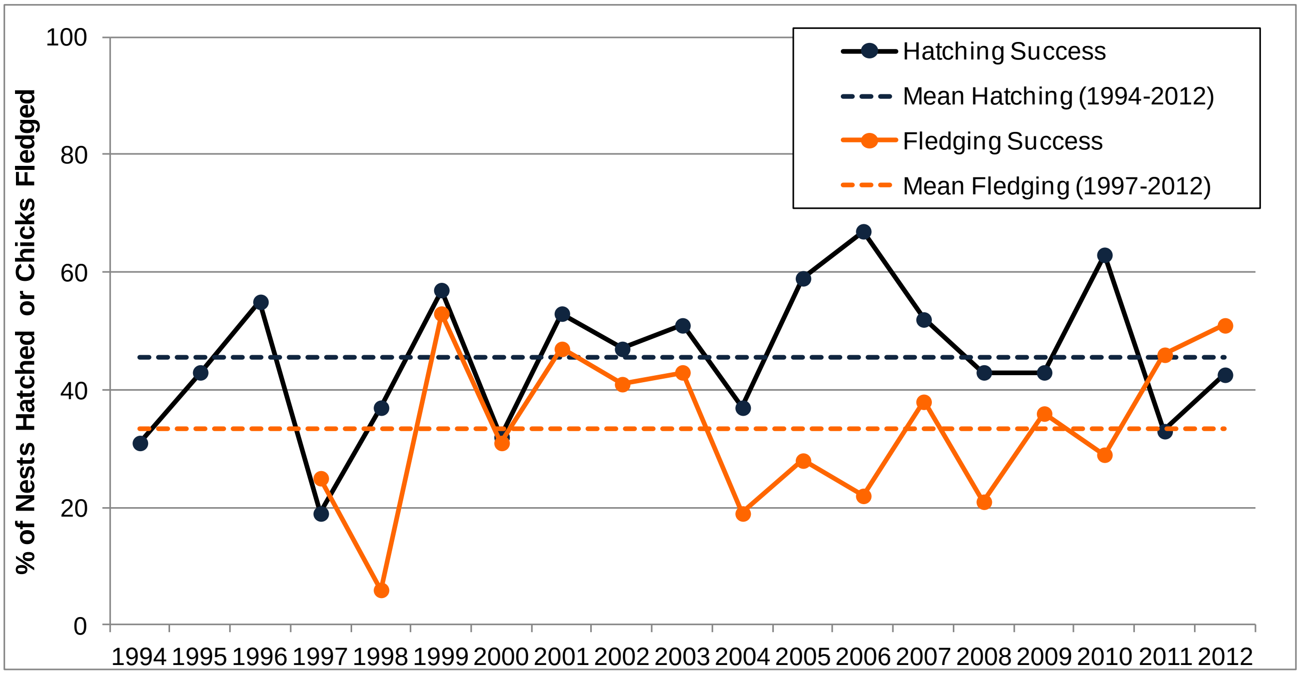
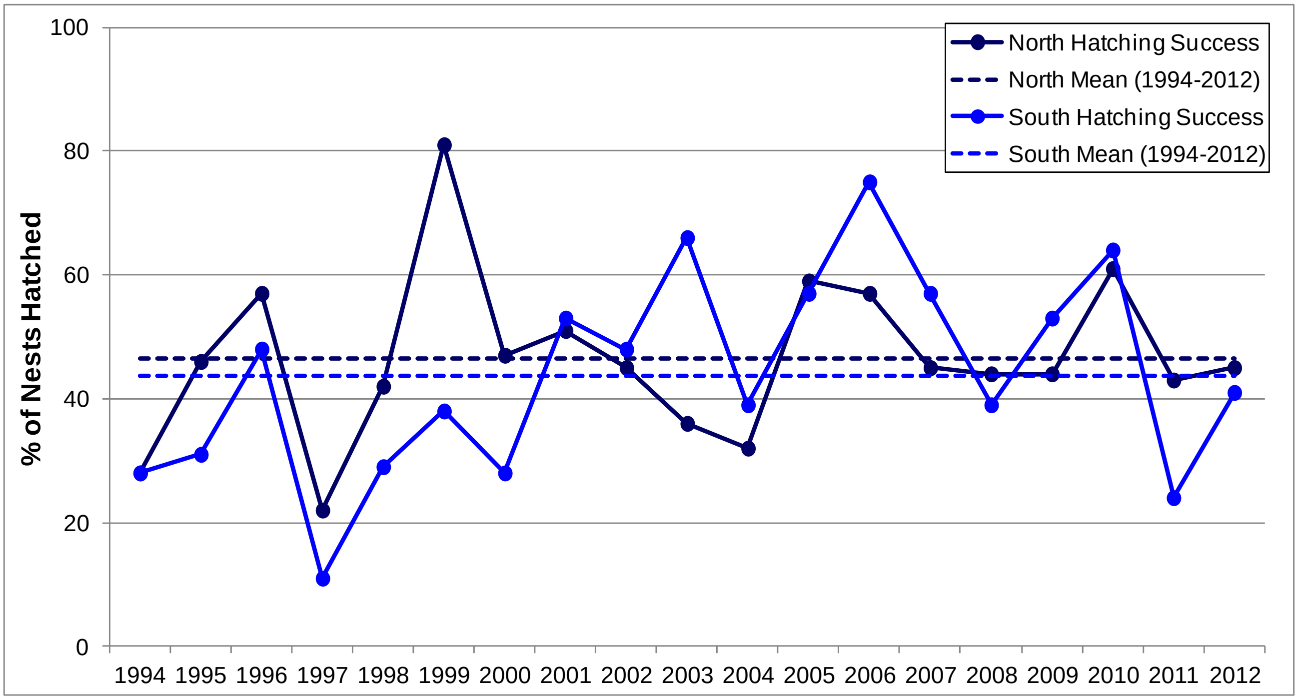


Figure 14. Trends in annual snowy plover clutch hatch and fledging success on VAFB from 1994 to 2012. Data on fledging success were not available for 1994-1996.



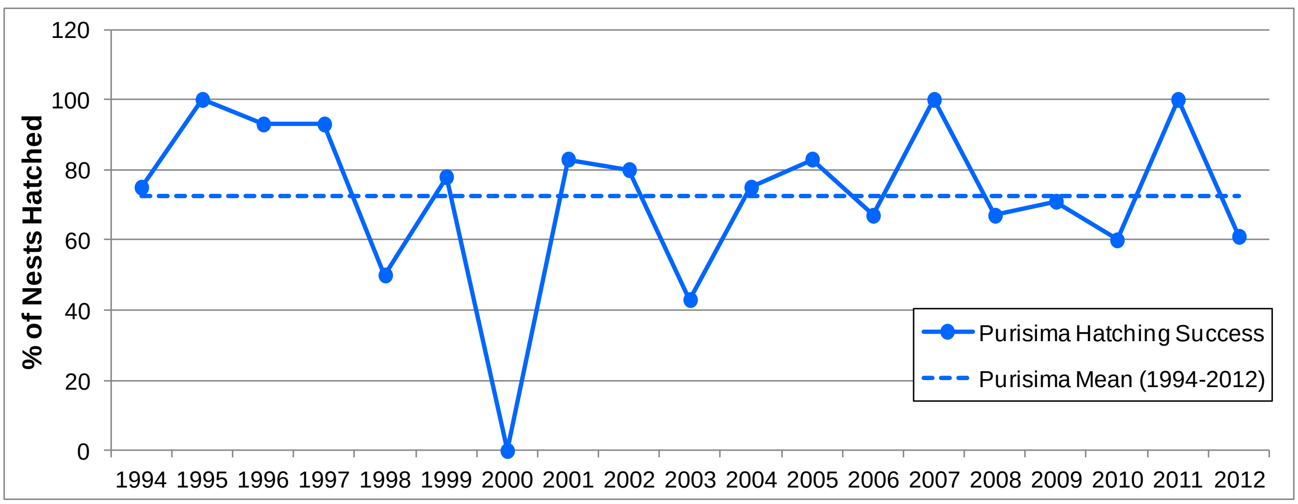


Figure 15. Trends in annual clutch hatch success on North, South, and Purisima Beaches from 1994 to 2012.

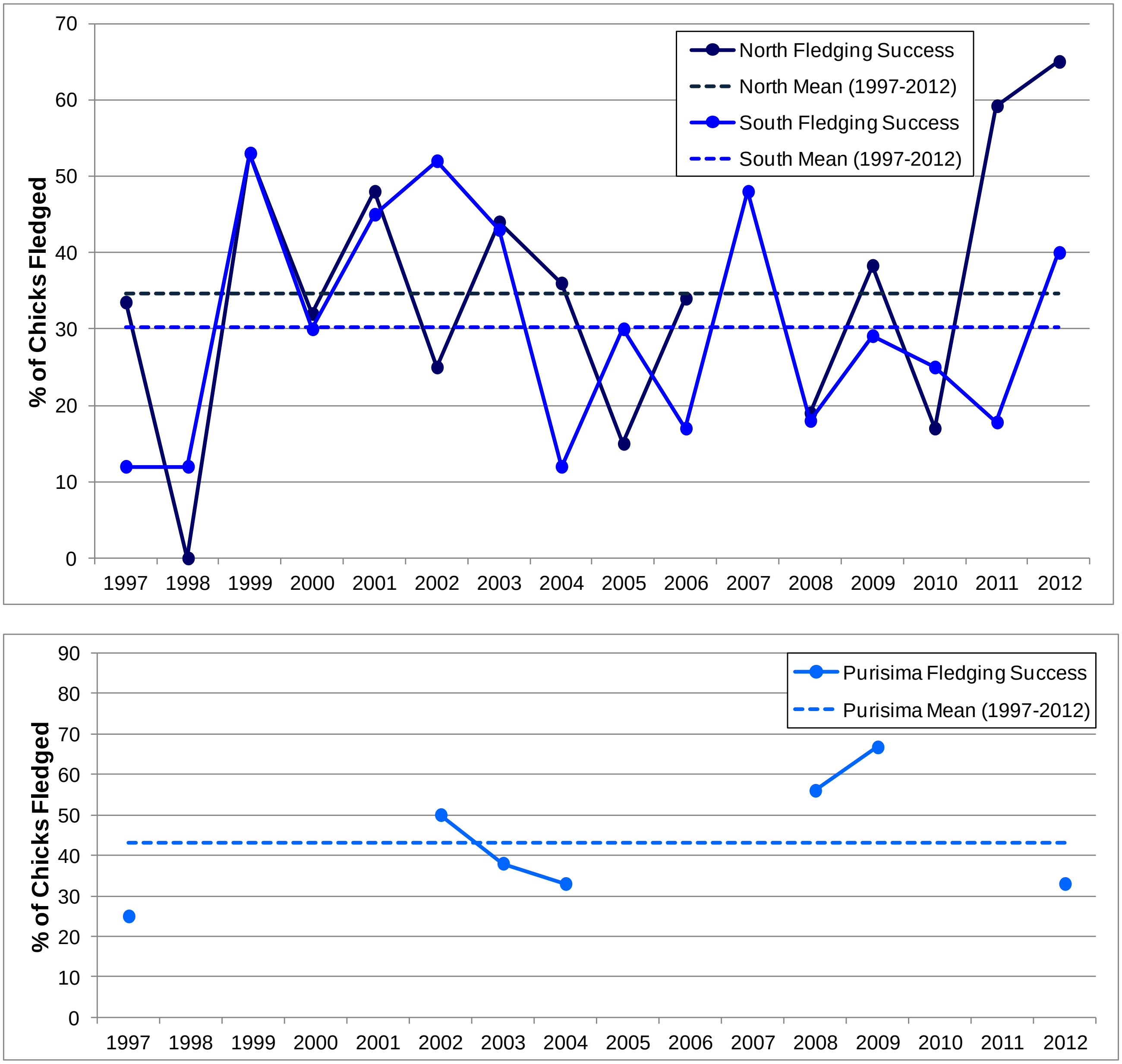


Figure 16. Trends in annual fledging success on North, South, and Purisima Beaches from 1997 to 2012. Missing data points indicate years when fledging success was not determined.

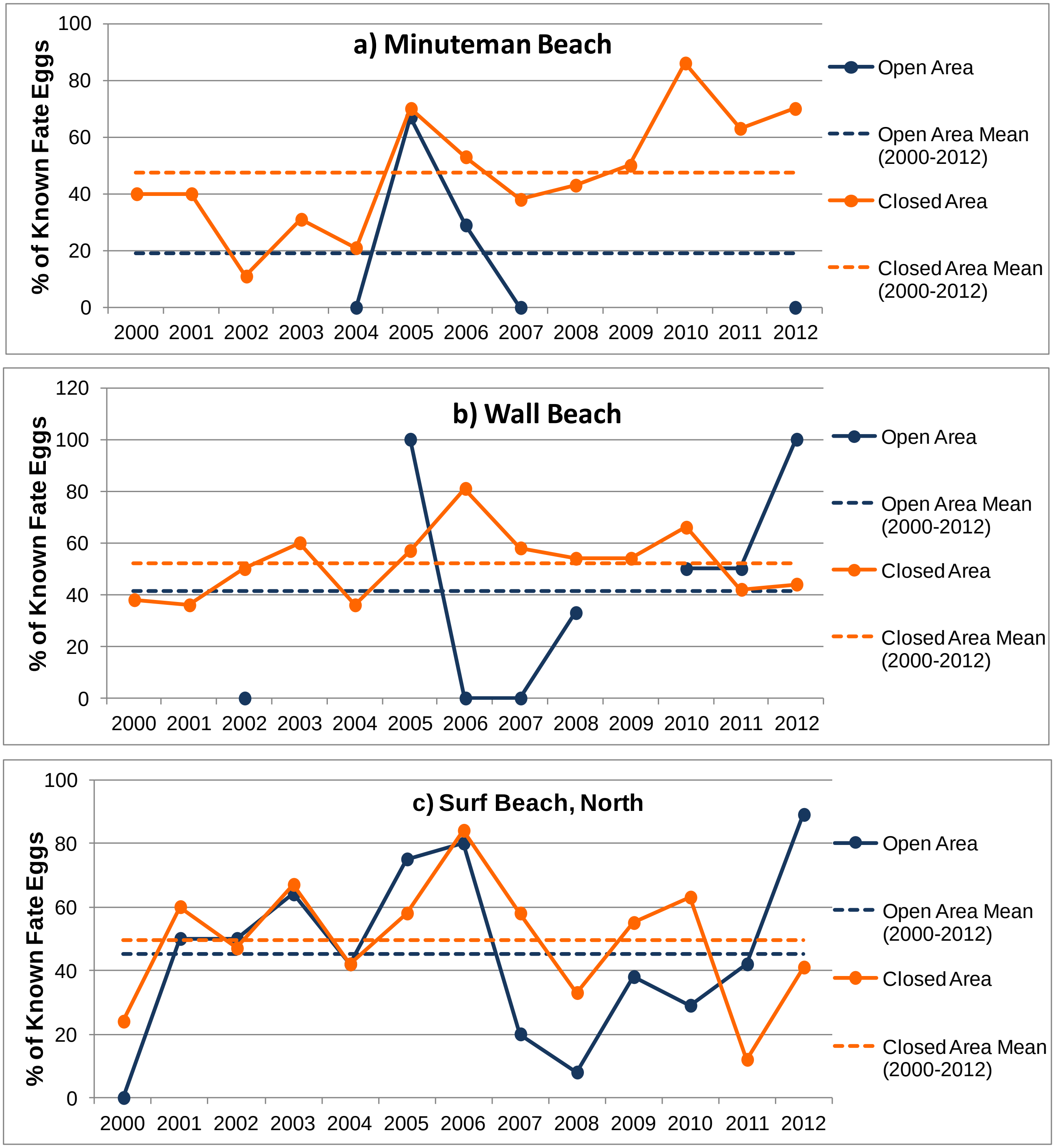


Figure 17. Trends in annual clutch hatch success at open and closed areas of Minuteman, Wall, and Surf beaches. Missing data points indicate years where no nests were initiated within that particular beach sector.

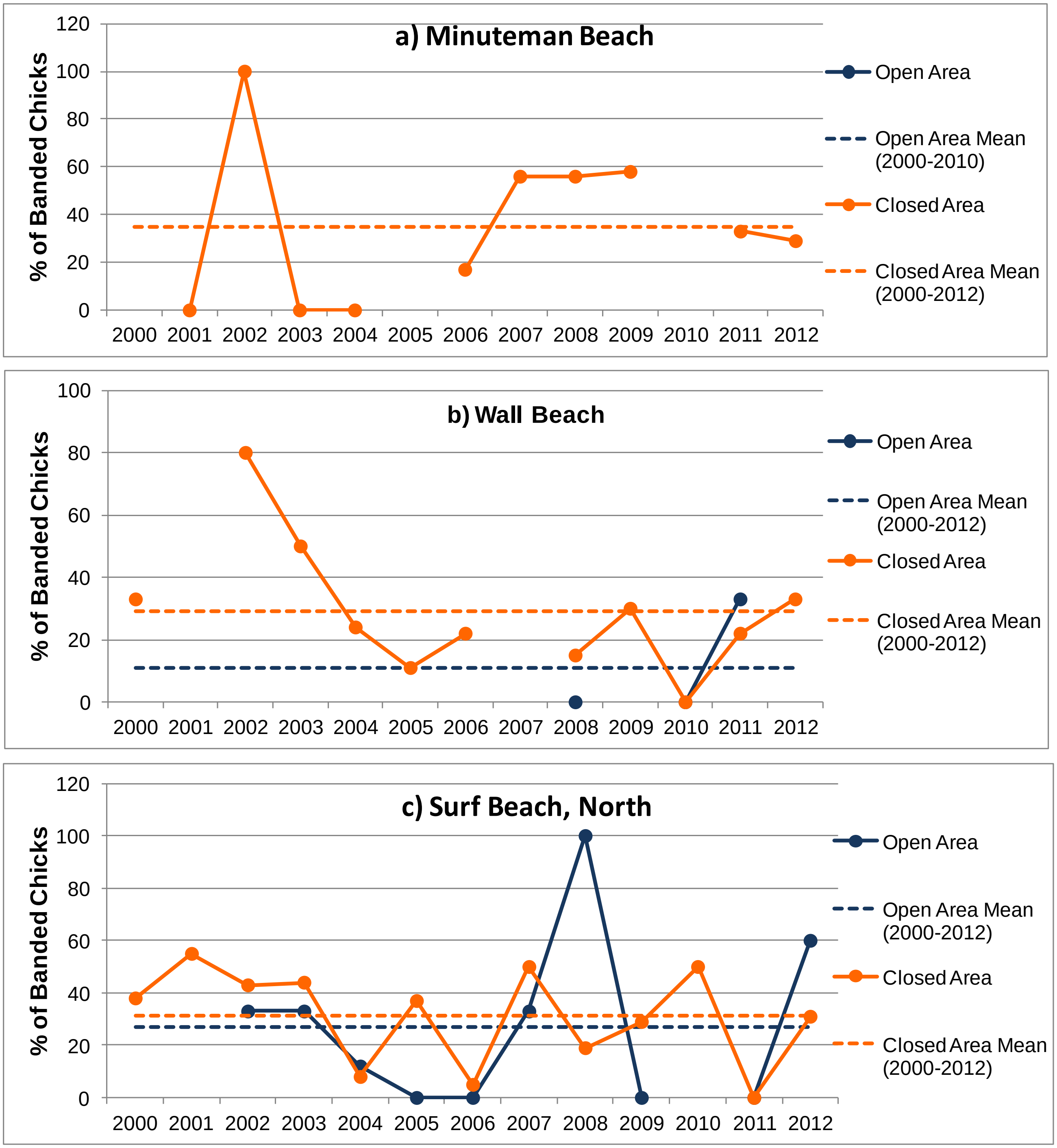


Figure 18. Trends in annual fledging success within open and closed areas of Minuteman, Wall, and Surf Beaches. Missing values indicate years when no nesting occurred or fledging success was not determined for that particular beach sector.

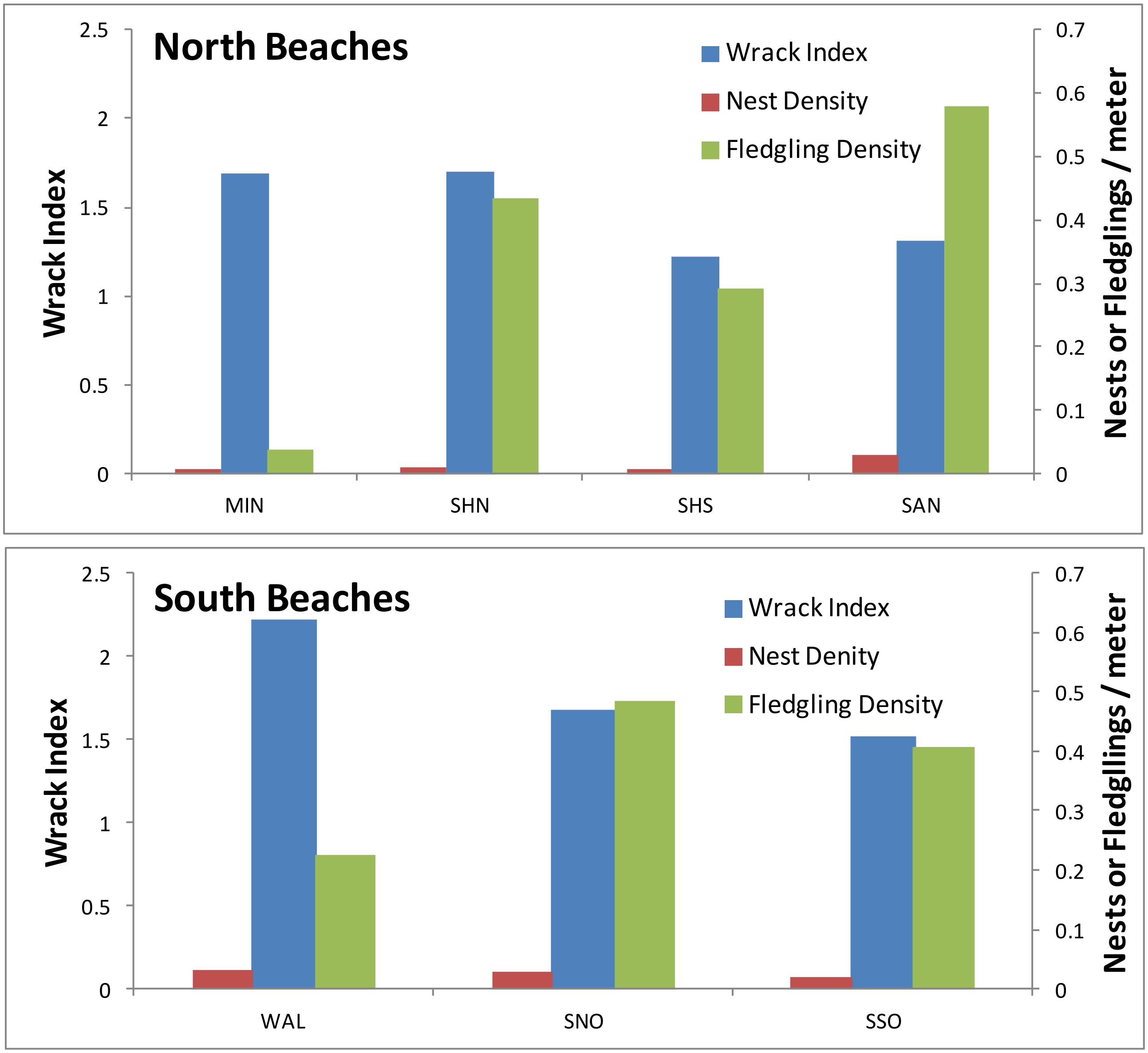


Figure 19. Mean wrack index values, nest densities and fledgling densities for the major beach sections of the North and South Beaches.

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 2012 breeding season

Observations of Western snowy plovers banded on VAFB prior to 2012

Left	Right	Sex	Observation Dates	Year/Location	Breeding History
B	G/Y	U,F	30 January, 9 March - 10 September	2009	VAFB Breeder
N	BG	F	4 June - 24 July	VAFB- Unknown Year	VAFB Breeder
N(S)	AW	F	22 March - 19 July	VAFB- Unknown Year	VAFB Breeder
N(S)	GW	M	31-May	VAFB- Unknown Year	
N(S)	WW	F	26 July - 17 September	VAFB- Unknown Year	Possible Breeder
NB	AG	U, M	10 February - 29 August	2011	VAFB Breeder
NB	AG	F	18 April - 30 July	2011	Possible Breeder
NB	AW	U, F	10 February - 17 September	2011	VAFB Breeder
NB	AY	U, M	3 February, 12 March - 13 July	2006	Possible Breeder
NB	AY	F	12 April - 29 August	2006	VAFB Breeder
NB	BB	M	3 May - 22 August	2011	VAFB Breeder
NB	BG	F	11 June - 12 July	2011	VAFB Breeder
NB	BG	M	18-Jul	2011	
NB	BR	M	14 March - 19 June	2006	VAFB Breeder
NB	BR	F	8 May - 18 July	2006	VAFB Breeder
NB	GB	F	17 April -2 May	2011	
NB	GB	M	29 May - 17 September	2011	VAFB Breeder
NB	GG	M	26-Mar	2011	
NB	GR	U	30-Jan	2011	
NB	GR	F	9-Mar	2011	
NB	GR	M	30 March - 15 August	2011	VAFB Breeder
NB	GW	U	30-Jan	2011	
NB	GW	M	5 March - 22 August	2011	Possible Breeder
NB	GY	M	14 May -3 August	2011	VAFB Breeder
NB	NR	U	30 January - 14 March, 10 September	2011	
NB	NR	M	30 March - 31 August	2011	VAFB Breeder
NB	NR	F	12 April , 29 June	2011	
NB	OG	M	29 March - 30 August	2011	VAFB Breeder
NB	OY	M	20 April, 22 August	2011	
NB	PG	U	13-Mar	2011	
NB	PG	M	29 March - 10 April	2011	Possible Breeder
NB	PR	M	12 June - 10 September	2011	Possible Breeder
NB	PY	M	18 April - 17 September	2011	VAFB Breeder
NB	RR	U	26-Jun	2011	
NB	RW	M	9 April - 22 August	2011	Possible Breeder
NB	WB	F	15-Jul	2011	NEW Fledge 2011
NB	WR	F	28 May - 29 August	2011	VAFB Breeder
NB	WW	M	6-Jul	2011	
NB	WY	F	25 May - 30 June	2011	Possible Breeder
NB	YB	M	8 March , 21 June, 31 August	2011	Possible Breeder
NB	YB	F	19 April - 31 August	2011	Possible Breeder

NB	YG	M	9 April- 23 August	2011	VAFB Breeder
NO	BR	U	30-Jan	2004	
NO	BR	F	9 March - 31 August	2004	VAFB Breeder
NO	NR	U	30-Jan	2009	
NO	NR	M	9 March - 22 August	2009	VAFB Breeder
NO	OG	U	30 January, 17 September	2004	
NO	OG	F	14 March - 29 August	2004	Possible Breeder
NO	YB	F	15-Apr	2009	
NR	PB	U	17-Sep	2011	
NR	PG	U	9-Mar	2011	
NR	WW	M	22 March - 17 September	2011	VAFB Breeder
N(S)	AW	F	20 June - 25 July	VAFB- Unknown Year	VAFB Breeder
NW	AY	U	1 March - 10 September	2004	VAFB Breeder
NW	BY	U	10-Feb	2008	
NW	BY	M	29 March - 6 August	2008	VAFB Breeder
NW	GR	M	29-May	2008	
NW	GW	M	17 April - 4 June	2008	VAFB Breeder
NW	OG	U	30-Jan	2009	
NW	WW	M	14 March, 8 August	2009	
NW	WW	F	2 July -3 August	2009	VAFB Breeder
NW	WY	F	19-Jun	2009	NEW Fledge 2009
NW	YB	M	11 June, 10 September	2009	
NW	YG	M	8 March - 17 September	2009	VAFB Breeder
NY	AR	M	26 March - 17 September	2011	Possible Breeder
NY	AR	U	23 August - 13 September	2011	
NY	GB	U	30-Jan	2008	
NY	GB	M	29 March - 31 August	2008	Possible Breeder
NY	GB	F	11-May	2008	
NY	GR	M	14 March - 6 July	2008	VAFB Breeder
NY	GW	M	9 May, 11 July	2008	Possible Breeder
NY	OY	M	Januray	2008	
NY	PY	M	14 March - 15 August	2008	VAFB Breeder
NY	WG	U	Januray	2008	
NY	WG	M	7 May - 30 July	2008	VAFB Breeder
O	G/W/G	F	5-Mar	2005	
O	G/Y/G	U	30 January -10 February	2003	
O	G/Y/G	F	21 March -28 May	2003	Possible Breeder
P	G	M	19-Apr	VAFB- Unknown Year	
P	G/O/G	U	10-Feb	2003	
P	G/O/G	M	14 March - 6 September	2003	VAFB Breeder
P	G/W/G	U	13-Mar	2005	
R	G	M	9-Jul	VAFB- Unknown Year	
R	G/Y	M	21 June -18 July	2011	
W	W/O/W	U	10-Feb	2005	
W	W/O/W	M	14 March - 30 April, 13 July-17 September	2005	VAFB Breeder

Observations of Western snowy plovers banded outside of VAFB

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History
(S)	--	M	10-Apr	Unknown	
(S)	K/P	M	8 March - 17 September	Unknown	VAFB Breeder
(S)	K/Y	M	3 April - 29 August	Unknown	VAFB Breeder
**	BG	F	1-Jun	Unknown	missing left foot
A/W/A	R	U	10-Feb	Unknown	
A/W/A	R	M	18 April, 13 August	Unknown	
AW	PY	U	7-Aug	Unknown	
AY	RV	U, M	30 January, 9 March - 22 August	Fort Ord (2006)	VAFB Breeder
B	R	F	11-Jun	Unknown	
BA	AW	M	18-Apr	Unknown	
BA	GA	M	19-Apr	Unknown	
BB	AW	F	22-Mar	Unknown	
BB	AY	F	9 April - 23 July	Unknown	VAFB Breeder
BB	PR	F	17 April - 30 August	Unknown	VAFB Breeder
BB	PR	M	17-Apr	Unknown	
BO	OO	U	29-Aug	Unknown	
BO	YA	U	30-Jan	Unknown	
BR	WY	F	13 March - 17 April	Unknown	
BR	WY	U	3-Jan	Unknown	
BW	GW	M	18-Apr	Unknown	
G	-	F	14 March - 13 July	Unknown	Possible Breeder
GA	OR	F	13 March - 18 July	Oceano (2004)	VAFB Breeder
GA	VB	M	21 June - 6 September	Oceano	Possible Breeder
GA	YW	M	5 March - 28 May	Oceano (2005)	VAFB Breeder
GG	BB	M	10-Mar	Oceano	
GG	GB	M	9-Apr	Oceano (2011)	
GG	VB	U	3-Mar	Oceano (2008)	Possible Breeder
GG	YY	F	24-Apr	Oceano (2011)	
KK	BB	U, M	10 February, 8 March - 29 August	Unknown	VAFB Breeder
LO	GG	F	5-Jun	Unknown	
LY	RR		17-Sep	Unknown	
LY	WO	U	30-Jan	Salinas State Beach (2007)	
O/K/O	W	M	13 July - 26 July	Unknown	
O/V/O	w	F	24-Jul	Unknown	
OA	OR	M	5-Jun	Unknown	
OB	YA	U	10-Feb	Unknown	
OG	AY	U	10-Feb	Unknown	
OG	OL	U	6-Sep	Unknown	
OG	OR	M	12 March - 10 September	Salinas State Beach (2007)	VAFB Breeder

Left	Right	Sex	Observation Dates	Banding Year/Location	Breeding History
OG	OR	U	10-Feb	Salinas State Beach (2007)	
OO	BO	F	20 July - 15 August	Unknown	
OR	OR	M	27-Jun	Unknown	
OY	AR	F	25-Jun	Unknown	
PG	OG	M	30-Mar	Oceano (2006)	
PV	OG	M	9 July - 10 September	Oceano (2011)	Possible Breeder
PV	WB		17-Sep	Oceano (2007)	
PW	AW	F	8 June - 23 August	Unknown	Possible Breeder
R	--	U	1 March - 12 July	Unknown	Possible Breeder
R	AY	F	5-Jul	Unknown	
R*	LG	M	11-Jun	Unknown	VAFB Breeder
RB	AG	M	16-Mar	Unknown	
RR	GG	F	26-Jul	Oceano (2003)	
RR	LY	M	19 March - 20 August	Oceano (2009)	VAFB Breeder
RR	LY	U	10-Feb	Oceano (2009)	
RR	OG	F	29-Aug	Oceano	
RR	PG	F	6-Apr	Oceano	
RR	W(S)	F	15-Apr	Oceano	
RR	WA	F	22 May - 7 June	Oceano	VAFB Breeder
RR	WB	F	19-Jun	Oceano (2010)	
RR	WB	U	10-Sep	Oceano (2010)	
RR	WG	U	19 March -29 March	Oceano (2003)	
RR	WG	F	8 April - 23 August	Oceano (2003)	Possible Breeder
RR	WW	U	30-Jan	Oceano (2005)	
RR	WW	F	25-May	Oceano (2005)	
RW	AO	F	25-Jul	Unknown	
RY	AR	M	21-Jun	Unknown	
RY	AR	F	29-Aug	Unknown	
VB	AG	M	28-Jun	Unknown	
VG	VR	F	8 March -30 March,25 July - 6 September	Oceano (2011)	Possible Breeder
VV	OA	U	30-Jan	Oceano (2011)	
VV	OA	F	5 March - 17 September	Oceano (2011)	VAFB Breeder
VV	YW	U	10-Feb	Oceano	
VV	YW	F	31 July- 10 September	Oceano	
Y(S)	WA	F	21-Mar	Unknown	
YB	BY	F	25 July - 10 September	Unknown	Possible Breeder
YY	R	M	29-Mar	Unknown	

Appendix C – Western snowy plover banded on VAFB during the 2012 breeding season.

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

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

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

Appendix D: Detailed Data Summaries

Table 1. Results from 2012 window surveys.

7-May-12	Male	Female	Unk Adult	PR	Total
Minuteman	4	5	0	2	**9**
Shuman North	9	4	0	2	**13**
Shuman South	3	6	0	1	**9**
San Antonio	33	18	2	8	**53**
Purisima North	0	0	1	0	**1**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***49***	***33***	***3***	***13***	***85***
Wall	17	13	0	9	**30**
Surf North	28	25	2	12	**55**
Surf South	16	18	2	12	**36**
Total South VAFB	***61***	***56***	***4***	***33***	***121***
TOTAL VAFB	**110**	**89**	**7**	**46**	**206**

21-May-12	Male	Female	Unk Adult	PR	Total
Minuteman	2	0	1	0	**3**
Shuman North	6	4	0	1	**10**
Shuman South	2	4	0	1	**6**
San Antonio	17	16	4	6	**37**
Purisima North	4	5	0	1	**6**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***31***	***29***	***5***	***9***	***62***
Wall	18	15	1	6	**34**
Surf North	17	20	2	14	**39**
Surf South	17	17	1	13	**35**
Total South VAFB	***52***	***52***	***4***	***33***	***108***
TOTAL VAFB	**83**	**81**	**9**	**42**	**170**

18-Jun-12	Male	Female	Unk Adult	PR	Total
Minuteman	1	2	0	1	**3**
Shuman North	7	3	0	3	**10**
Shuman South	1	2	0	1	**3**
San Antonio	73	34	8	12	**115**
Purisima North	0	0	0	0	**0**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***82***	***41***	***8***	***17***	***131***
Wall	17	18	4	7	**39**
Surf North	11	3	18	0	**32**
Surf South	22	17	7	8	**46**
Total South VAFB	***50***	***38***	***29***	***15***	***117***
TOTAL VAFB	**132**	**79**	**37**	**32**	**248**

11-Jun-12	Male	Female	Unk Adult	PR	Total
Minuteman	0	2	0	0	**2**
Shuman North	11	3	0	1	**14**
Shuman South	4	2	0	2	**6**
San Antonio	15	11	3	7	**29**
Purisima North	2	3	1	2	**6**
Purisima Colony	0	0	0	0	**0**
Total North VAFB	***20***	***9***	***4***	***12***	***57***
Wall	12	11	5	6	**28**
Surf North	44	30	0	10	**74**
Surf South	22	13	2	8	**37**
Total South VAFB	***54***	***30***	***7***	***24***	***139***
TOTAL VAFB	**74**	**39**	**11**	**36**	**196**

MEAN	Male	Female	Unk Adult	PR	Mean
Minuteman	2	2	0	1	**4**
Shuman North	8	4	0	2	**12**
Shuman South	3	4	0	1	**7**
San Antonio	35	20	4	8	**59**
Purisima North	2	2	1	3	**5**
Purisima Colony	0	0	0	0	**0**
Mean North VAFB	***49***	***31***	***5***	***15***	***85***
Wall	16	14	3	7	**33**
Surf North	25	20	6	9	**51**
Surf South	19	16	3	10	**38**
Mean South VAFB	***60***	***50***	***11***	***26***	***121***
MEAN VAFB	**109**	**81**	**16**	**41**	**206**

Table 2. Summary of window surveys from 1994 to 2012.

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

Table 3. Distribution of nests by beach section from 1994 to 2012.

Beach Sector	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
North Beaches																			
Minuteman	15%	19%	6%	6%	10%	26%	11%	17%	15%	9%	9%	7%	15%	7%	4%	7%	6%	4%	7%
Shuman	45%	44%	63%	52%	60%	37%	43%	35%	32%	50%	45%	58%	52%	48%	43%	41%	36%	35%	28%
San Antonio	40%	37%	31%	41%	29%	37%	47%	48%	53%	41%	47%	35%	34%	45%	53%	52%	58%	61%	65%
Total North Beaches	***47%***	***52%***	***50%***	***45%***	***45%***	***34%***	***34%***	***49%***	***43%***	***46%***	***36%***	***40%***	***47%***	***46%***	***54%***	***59%***	***58%***	***46%***	***44%***
Purisima Beaches																			
Purisima North	39%	21%	7%	18%	31%	11%	50%	33%	20%	83%	50%	83%	67%	67%	83%	50%	80%	100%	100%
Purisima Colony	61%	79%	93%	82%	69%	89%	50%	67%	80%	17%	50%	17%	33%	33%	17%	50%	20%	0%	0%
Total North Beaches	***7%***	***9%***	***5%***	***4%***	***9%***	***9%***	***4%***	***3%***	***2%***	***6%***	***1%***	***3%***	***1%***	***1%***	***2%***	***2%***	***2%***	***0%***	***2%***
South Beaches																			
Wall	17%	31%	26%	17%	45%	27%	18%	26%	23%	24%	23%	22%	25%	27%	40%	33%	35%	29%	27%
Surf North	42%	33%	32%	31%	16%	27%	38%	49%	59%	53%	49%	45%	49%	49%	44%	48%	44%	45%	38%
Surf South	41%	36%	42%	51%	39%	47%	44%	24%	18%	23%	28%	32%	26%	24%	15%	19%	21%	26%	34%
Total South Beaches	***47%***	***39%***	***45%***	***51%***	***46%***	***58%***	***62%***	***48%***	***55%***	***48%***	***63%***	***57%***	***52%***	***53%***	***44%***	***39%***	***40%***	***54%***	***54%***
TOTAL VAFB	**260**	**223**	**286**	**411**	**150**	**104**	**140**	**182**	**298**	**405**	**623**	**388**	**377**	**263**	**295**	**323**	**255**	**418**	**341**

Table 4. Clutch hatch success for each beach section in 2012.

Beach Sector	Hatched clutches	Known fate clutches	Clutch success	Hatched eggs	Total known fate eggs	Egg hatch success
North Beaches						
Minuteman	7	12	58%	17	31	55%
Shuman	5	8	63%	33	102	32%
San Antonio	47	97	48%	125	253	49%
Total North Beaches	***59***	***117***	50%	***175***	***386***	45%
Purisima Beaches						
Purisima North	5	8	63%	14	23	61%
Purisima Colony	0	0	0%	0	0	0%
Total Purisima Beaches	***5***	***8***	63%	***14***	***23***	61%
South Beaches						
Wall	29	50	58%	78	140	56%
Surf North	29	67	43%	77	171	45%
Surf South	15	59	25%	38	155	25%
Total South Beaches	***73***	***176***	41%	***193***	***466***	41%
TOTAL VAFB	**137**	**301**	46%	**382**	**875**	44%

Table 5. Number of nests lost to predators in 2012 by beach section.

Beach Sector	Coyote		RAVEN		Suspected Raven		Other Avian		Gull		Unidentified Predator		Total	
North Beaches														
Minuteman	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Shuman	6	14%	4	10%	3	7%	1	2%	0	0%	0	0%	14	33%
San Antonio	28	29%	15	15%	0	0%	0	0%	0	0%	2	2%	45	46%
Total North Beaches	**34**	23%	**19**	13%	**3**	2%	1	1%	**0**	0%	**2**	1%	**59**	39%
Purisima Beaches														
Purisima North	2	25%	1	13%	0	0%	0	0%	0	0%	0	0%	3	38%
Purisima Colony	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Total Purisima Beaches	**2**	25%	**1**	13%	**0**	0%	**0**	**0%**	**0**	0%	**0**	**0%**	**3**	38%
South Beaches														
Wall	8	16%	0	0%	0	0%	0	0%	1	2%	2	4%	11	22%
Surf North	17	25%	0	0%	0	0%	0	0%	0	0%	4	6%	21	31%
Surf South	18	31%	0	0%	0	0%	3	5%	0	0%	9	15%	30	51%
Total South Beaches	**43**	24%	**0**	0%	**0**	0%	**3**	2%	**1**	1%	**15**	9%	**62**	35%
VAFB TOTAL	**79**	24%	**20**	6%	**3**	1%	**4**	1%	**2**	**1%**	**17**	5%	**124**	**37%**

Table 6. Numbers of nest lost to predators from 1994 to 2012.

Year	Coyote		Raccoon		Raven		Suspected Raven		Gull		Whimbrel		Unidentified mammal		Unidentified avian		Unidentified predator		Known Fate Nests	Total Predation
1994	41	18%			13	6%			2	1%							26	11%	231	35%
1995	20	10%			4	2%							8	4%			9	5%	195	21%
1996	31	11%			5	2%			2	1%			6	2%			11	4%	271	20%
1997	73	18%			43	11%			18	5%							72	18%	398	52%
1998	32	24%			19	14%			2	1%							10	7%	134	47%
1999	16	16%			4	4%													97	21%
2000	34	27%			6	5%									1	1%	25	20%	127	52%
2001	10	6%	1	1%	8	4%			2	1%			3	2%	3	2%	27	15%	181	30%
2002	41	14%	2	1%	26	9%			3	1%	1	0%	1	0%			1	0%	296	25%
2003	15	4%			63	16%			5	1%					6	2%	15	4%	393	26%
2004	130	22%	2	0%	66	11%									7	1%	28	5%	590	39%
2005	49	13%			2	1%			4	1%					4	1%	12	3%	371	19%
2006	47	13%							4	1%							10	3%	366	17%
2007	24	10%			25	10%									3	1%	18	7%	251	28%
2008	73	26%			15	5%			1	0%							10	4%	284	35%
2009	37	12%			29	10%									1	0%	28	9%	305	31%
2010	36	15%							1	0%							6	3%	240	18%
2011	83	35%	0	0	21	9%	52	22%	20	8%	0	0	0	0	4	1%	33	14%	413	52%
2012	79	24%	0	0	20	6%	3	1%	2	1%	0	0	0	0	4	1%	17	5%	334	37%

Year	Number of known fate nests	Number lost to predators	Percent lost predators
1994	231	82	35%
1995	195	41	21%
1996	271	55	20%
1997	398	206	52%
1998	134	63	47%
1999	97	20	21%
2000	127	66	52%
2001	181	54	30%
2002	296	75	25%
2003	393	104	26%
2004	590	233	39%
2005	371	71	19%
2006	366	61	17%
2007	251	70	28%
2008	284	99	35%
2009	305	95	31%
2010	240	43	18%
2011	413	214	52%
2012	334	124	37%
Total	**5477**	**1776**	**32%**

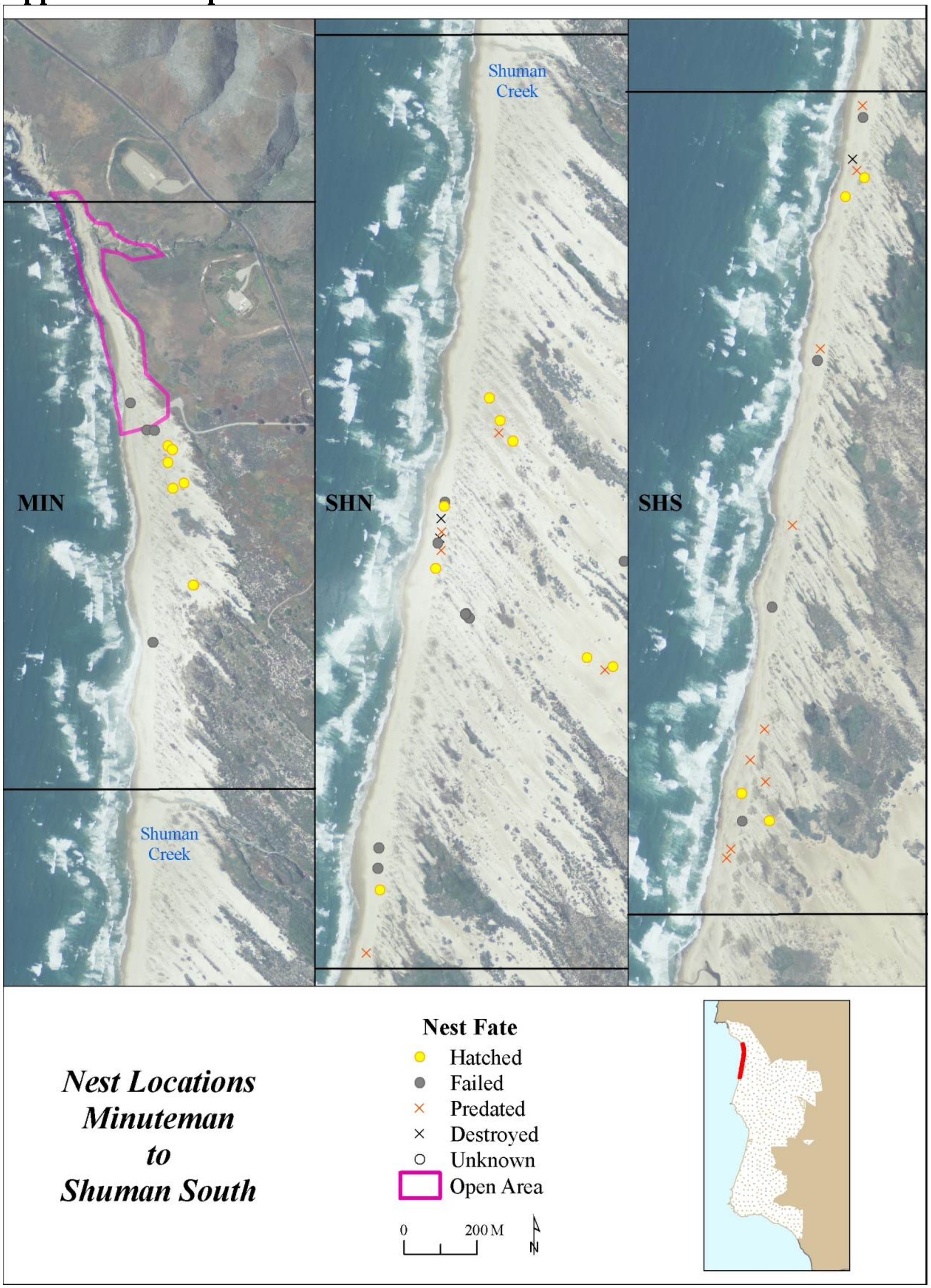
Table 7. Numbers of chicks banded and fledged per beach sector in 2012.

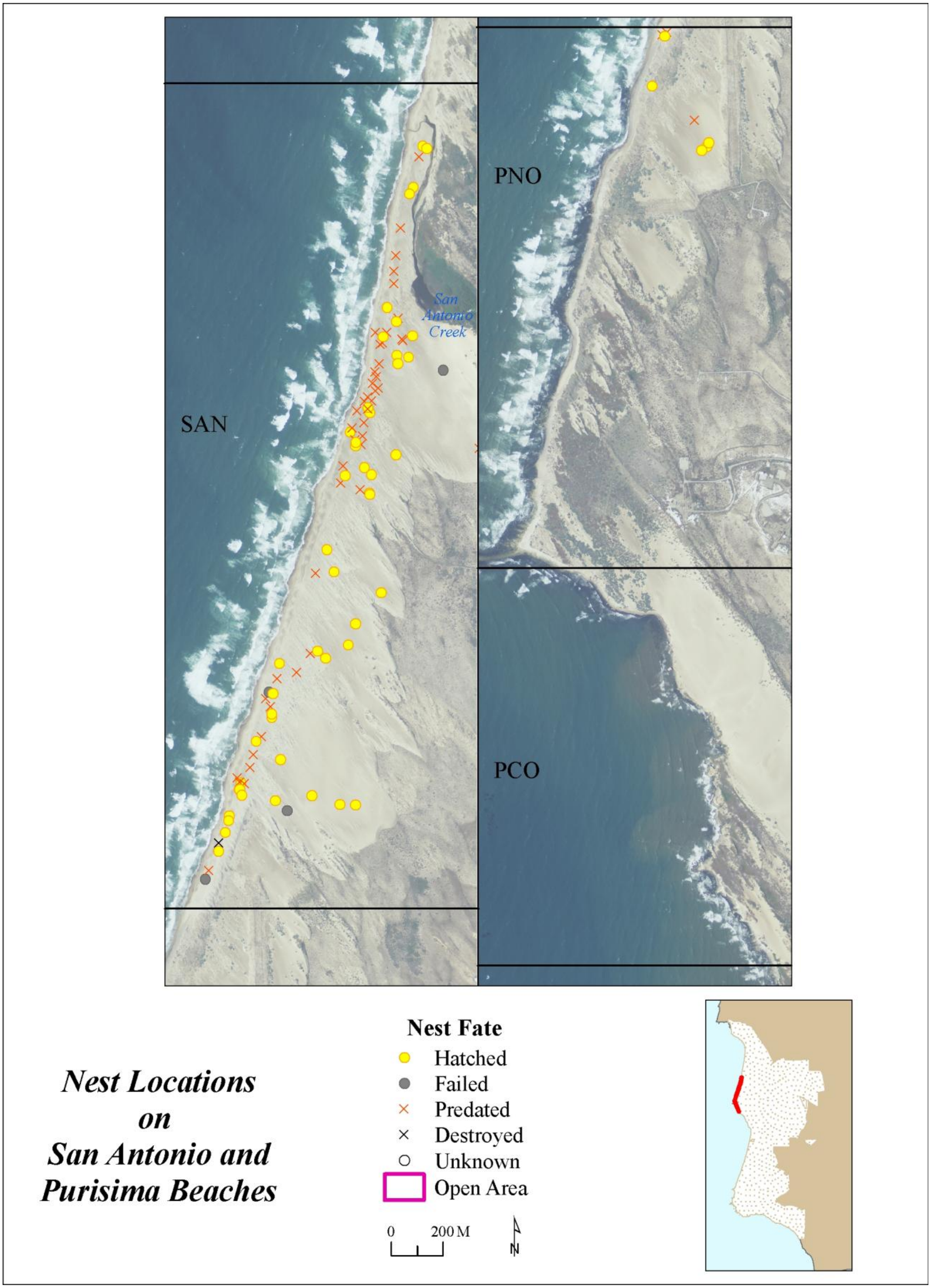
Beach Sector	Chicks Banded	Chicks Fledged	Chick Fledging Rate	% Broods Fledging >1 Chick
North Beaches				
Minuteman	6	5	83%	100%
Shuman	9	2	22%	33%
San Antonio	62	42	68%	86%
Total North Beaches	***77***	***49***	***64%***	***81%***
Purisima Beaches				
Purisima North	6	2	33%	100%
Purisima Colony	0	0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

Table 8. Numbers of broods banded and fledged one chick per beach sector in 2012.

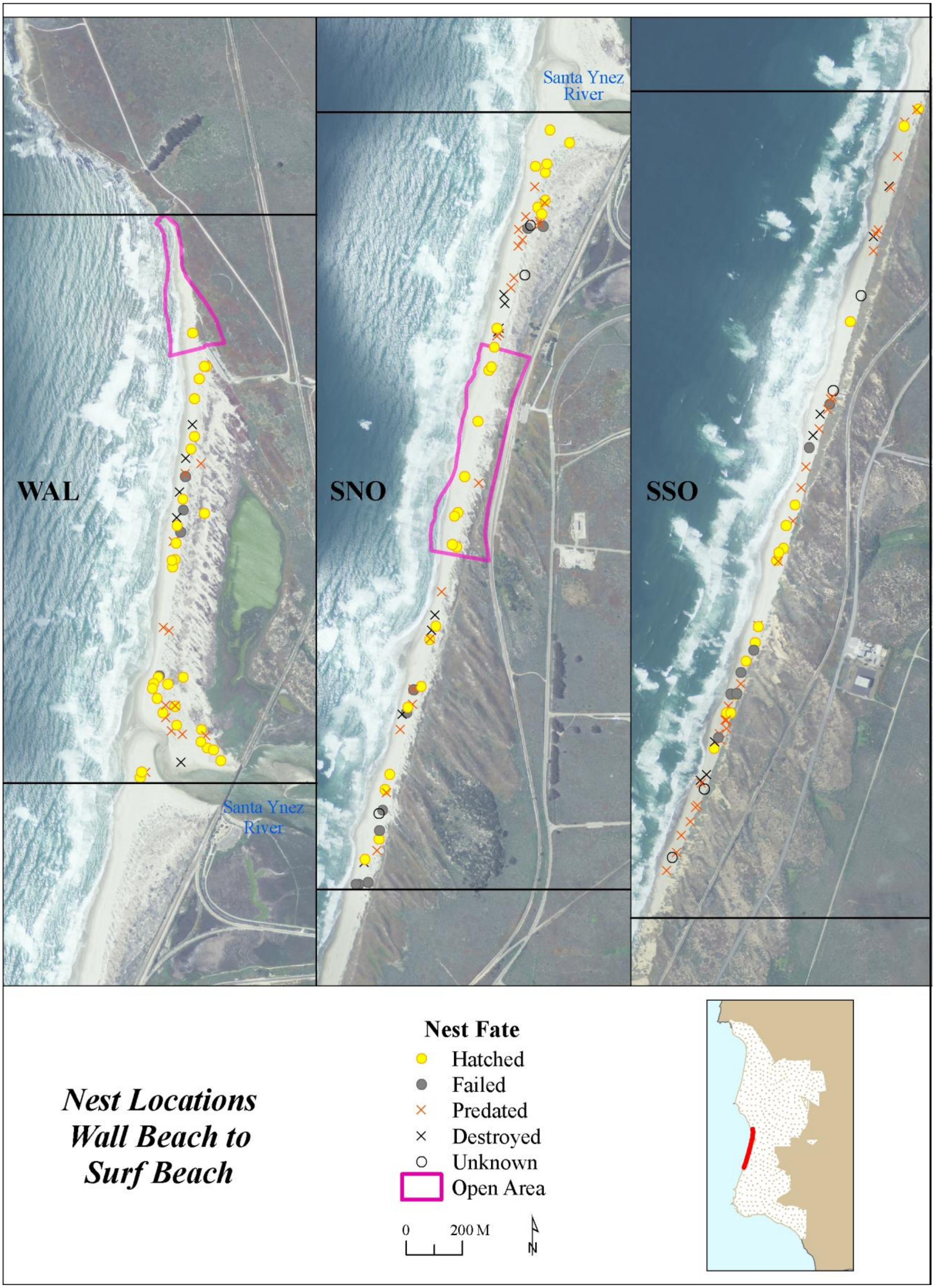
Beach Sector	Broods Banded	Broods Fledging at Least One Chick	Percent Fledging at Least One Chick
North Beaches			
Minuteman	2	2	100%
Shuman	3	1	33%
San Antonio	22	19	86%
Total North Beaches	***27***	***22***	***81%***
Purisima Beaches			
Purisima North	2	2	100%
Purisima Colony	0	0	0%
Total Purisima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

Appendix E: Maps of Nest Locations and Nest Fates on VAFB Beaches in 2012





Nest Locations on San Antonio and Purisima Beaches



Nest Locations Wall Beach to Surf Beach