Point Blue Report

Use of Estuarine, Intertidal, and Subtidal Habitats by Seabirds Within the MLPA South Coast Study Region

Report to the California Ocean Science Trust and California Sea Grant

January 27, 2015

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EXECUTIVE SUMMARY

Seabirds are long-lived, upper trophic level predators that are integral components of marine ecosystems. During the breeding season, seabirds are central place foragers and must return to their nests to incubate eggs and provision young throughout the day. As such, they have limited foraging ranges during that time and will benefit from protected areas within these ranges. Marine protected areas (MPAs) can provide both direct and indirect benefits to seabirds. Direct benefits involve reducing the direct interactions seabirds have with humans like incidental take and gear entanglement as well as human-caused disturbance to breeding and roosting sites. Indirect benefits involve reducing competition with humans for prey resources. Many coastally breeding seabirds rely on juvenile age classes of fished species. Decreases in adult fish catch can lead to increased spawning biomass and, thus, more seabird prey. Herein, we summarize the results of baseline seabird monitoring within the South Coast Study Region (SCSR) of California's Marine Life Protection Act (MLPA) Initiative in 2012-2013. The long-term objectives of our monitoring are to 1) document how seabirds are using coastal and nearshore habitats in relation to newly established MPAs and 2) develop seabirds as indicators to study the processes (e.g., recruitment) impacting change resulting from MPA establishment, including changes in nearshore fish and invertebrate populations and human use patterns that can impact seabirds.

Methods Overview

We selected seven focal species for baseline seabird monitoring: the California Least Tern, Brandt's Cormorant, Pelagic Cormorant, Pigeon Guillemot, Western Gull, California Brown Pelican, and Black Oystercatcher. The California Least Tern nests on sand associated with a variety of coastal habitats within the SCSR, including coastal beaches, estuaries and bays, while the remaining species breed primarily in rocky coast and bluff habitats. We therefore monitored these groups separately. Additionally, the California Least Tern is an endangered species and data on annual population size and breeding productivity are available from the California Department of Fish and Wildlife. We therefore focused our Least Tern monitoring efforts on documenting diet which has not been thoroughly studied in this species, especially within the SCSR.

Our goal in monitoring Least Tern diet was to determine the extent to which Least Terns foraged in bay/estuary habitats and coastal ocean habitats inside and outside of MPAs. We selected three MPAs and four control sites (Figure A). We investigated diet by collected feces at each site and analyzing the samples for undigested hard parts (mostly fish scales and otoliths). We grouped prey into three categories: bay/estuary fishes, coastal generalists (i.e., fishes that can be found in bay/estuary and coastal ocean habitats), and coastal pelagic fishes.

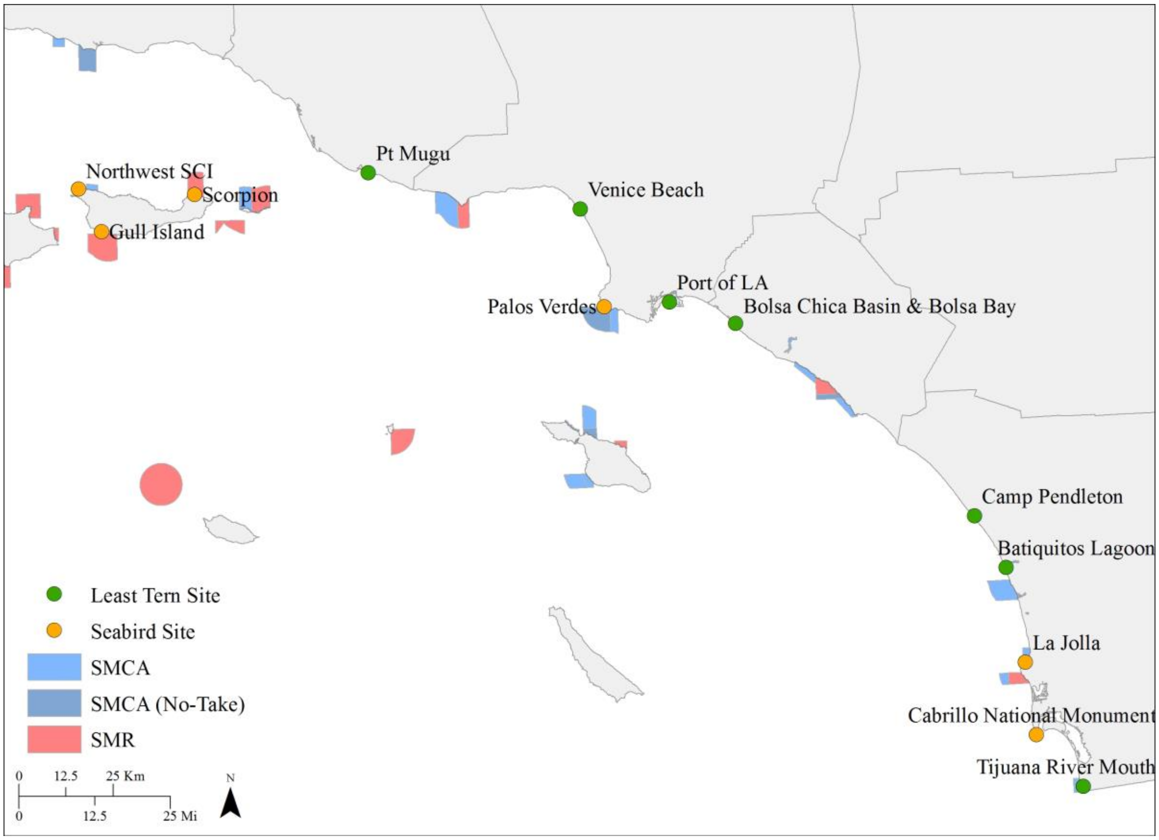


Figure A. Map of Least Tern and rocky coast seabird areas used for baseline monitoring within the South Coast Study Region.

We investigated rocky coast seabirds at three general areas: Palos Verdes Peninsula, San Diego, and Santa Cruz Island. We collected data inside and outside of eight MPAs across six sites (Figure A). We collected data on breeding population size, breeding productivity, roost utilization, foraging rates and rates of human-caused disturbance inside and outside of MPAs. We monitored breeding population size and roost utilization using weekly area counts from April through July. We monitored productivity by following individual nests visible from land and calculated annual breeding productivity as number of fledglings produced per breeding pair. We monitored foraging from land-based observation points, recording all birds foraging within a one km radius of an observation point. We calculated foraging rates as number of birds foraging per hour of observation. We recorded all human-caused disturbances observed during any land-based survey and calculated disturbance rates as number of disturbances per hour of observation.

Key Findings

1) The majority of the breeding populations for all focal species but Western Gulls were found breeding at control sites outside of MPAs. Approximately 65-70% of the Western Gulls at our study sites were breeding inside of MPAs.
2) Approximately 20% of the SCSR Least Tern breeding population was within or adjacent to MPAs. Most of these were within SMCAs that protected estuaries: Bolsa Chica Basin SMCA (3-5%), Upper Newport Bay SMCA (0.3-0.6%), and Batiquitos Lagoon SMCA (10-11%).
3) There were no differences in roost utilization between MPA and control sites for all focal species but Pelagic Cormorants. Roosting numbers for Pelagic Cormorants were highest at control sites. Roosting numbers for all focal species were highest at Santa Cruz Island, though roosting numbers for Brown Pelicans were highest at the Matlahuayl SMR in 2013.
4) Rates of human caused disturbance were highest at San Diego and lowest on Santa Cruz Island (Figure B). Disturbance rates were highest inside MPAs, especially the Matlahuayl SMR, South La Jolla SMR, and Cabrillo SMR.
5) There were no differences in the overall abundance, species richness, and species diversity of foraging seabirds between MPA and control sites. However, some of our focal species foraged more inside MPAs than at control sites. Foraging rates for Brandt's Cormorants, Pigeon Guillemots, and Caspian Terns were higher inside MPAs than control sites. While Least Terns foraged more at control sites, foraging rates for 2013 were highest at the Cabrillo SMR.
5) Least Tern breeding productivity was low at all sites in 2012 and at most sites in 2013. The Port of L.A. (a control site outside MPAs) was the only site that exhibited moderate productivity in 2013.
6) Least Tern diet indicated that foraging occurred mostly within coastal ocean habitats in both years. The only site where diet appeared to be dominated by estuarine species was the Bolsa Chica Basin SMCA. However, breeding productivity was low at this site in both years. Thus, bay/estuary MPAs did not appear to provide benefit to Least Terns during the baseline period.
7) There was no breeding documented along the Palos Verdes Peninsula, but persistent occurrence of Black Oystercatchers indicates the potential for this species to breed along the Peninsula.
8) The Matlahuayl SMR in San Diego was the only mainland MPA with breeding seabirds. It was also an important roosting area for Brandt's Cormorants and California Brown Pelicans. However, it was also the site with the highest rates of human-caused disturbance, with disturbance rates higher than those documented in either the Central Coast Study Region or North Central Coast Study Region (Figure B).

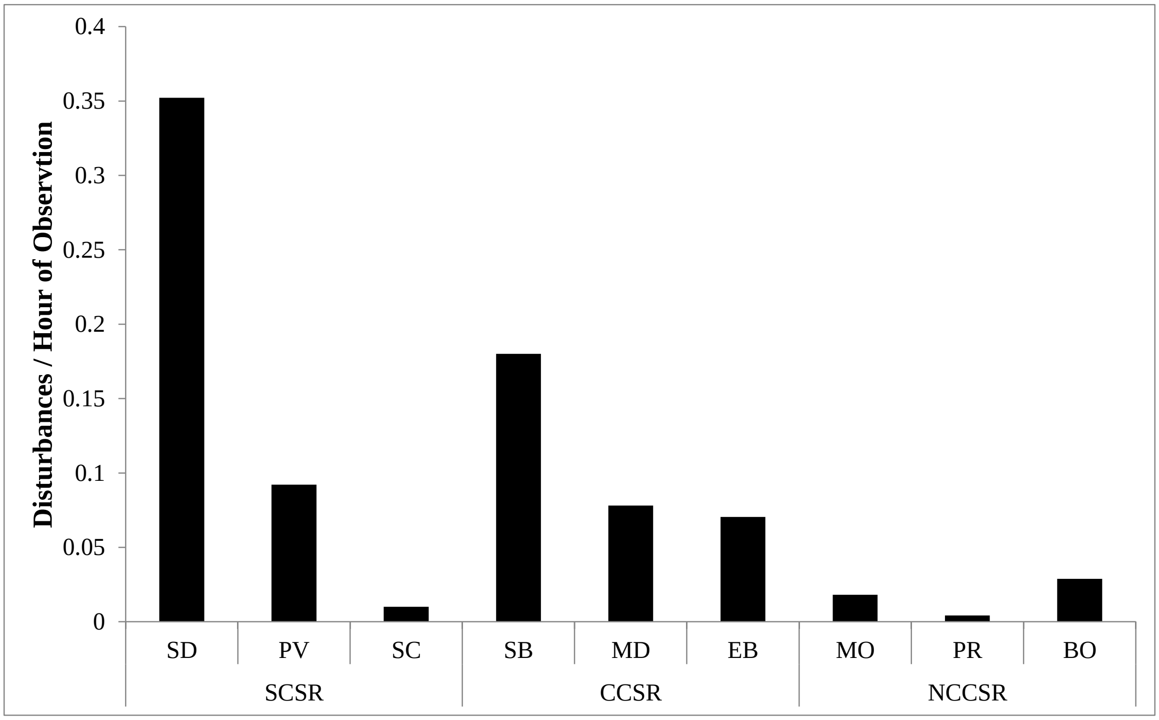


Figure B. Comparison of rates of human-caused disturbance to seabird breeding and roosting sites across the south coast (SCSR), central coast (CCSR), and north central coast (NCCSR) study regions. SD = San Diego, PV = Palos Verdes Peninsula, SC = Santa Cruz Island, SB = Shell Beach, MD = Montaña de Oro, EB = Estero Bluffs, MO = Montara, PR = Point Reyes, BO = Bodega.

Baseline Conditions and Role of Seabirds in MPA Monitoring

There were few differences among MPA and control sites in our study. Additionally, the differences we observed were not always consistent between the two years of our study. We are comfortable with our selection of control sites for the MPAs we investigated and feel that we will be able to detect differences if these MPAs provide benefits to seabird communities. However, given the among year variability we observed in our results, it will be important to continue monitoring these sites over the long term in order to detect lasting changes in community metrics due to MPA establishment.

Our baseline monitoring results are somewhat at odds with expectations from local oceanographic conditions. Recent conditions appear to be favoring species that thrive when nearshore conditions are cool and productive (e.g., rockfishes, flatfishes, etc.). While young-of-the-year rockfish were abundant in Least Tern diets at multiple sites, the poor breeding productivity exhibited throughout the SCSR indicates that the survival of these young-of-the-year fishes may have been low during the baseline period. If this is the case, then we would expect fish recruitment to coastal communities to be low during the baseline period and we should therefore expect changes within MPAs to be slow during the initial years of implementation.

Several studies over the past 30 years have shown that seabirds are reliable indicators of change within marine ecosystems. Additionally, recent studies have shown that seabirds can potentially index recruitment rates of juvenile fish to nearshore habitats. Juvenile recruitment is an important factor influencing the rate of change within MPAs. Rates of juvenile recruitment to nearshore habitats vary among years and with geographic location. Thus, not all MPAs are equal in terms of how long we should expect changes to take place. Furthermore, the timing of MPA establishment will influence the rate of change observed within MPAs. For example, MPAs that are established during periods of high ocean productivity will show change over a shorter period of time than MPAs established during periods of poor ocean productivity.

Seabirds offer a cost effective means by which to monitor ocean productivity and track fish recruitment. Seabirds are highly visible and monitoring can often be easily accomplished from land. Moving forward, seabird monitoring should be used to inform managers in three ways. First, breeding productivity should be integrated with indices of ocean climate (e.g., upwelling, El Niño Southern Oscillation, Pacific Decadal Oscillation) to monitor annual changes in ocean productivity. Second, measures of seabird foraging rates should be integrated with fine-scale maps of ocean currents to track how ocean productivity, including fish larvae, is being delivered to habitats inside and outside of MPAs. Understanding how change in ocean productivity translates into change throughout the SCSR will allow resource managers to establish realistic expectations for the performance of individual MPAs and the SCSR network as a whole. Finally, seabird breeding colonies should continue to be monitored in order to understand the effectiveness of MPAs in reducing the negative impacts of human-caused disturbance.

INTRODUCTION

Seabird Life History and Potential MPA Benefits

Seabirds are long-lived species (often living >20 years; Clapp et al. 1982) that produce few offspring and provide a large amount of parental care compared to most marine species. During the breeding season, seabirds are central place foragers, returning to the nesting colony throughout the day to incubate eggs and provision young. Though most “true” seabirds come to land only to breed, many coastal species in southern California rely on land throughout the year to rest, dry wetted plumage, and defend breeding sites. MPAs can have both direct and indirect benefits to seabird populations. Direct benefits include 1) reduced disturbance to breeding and roosting sites and 2) decreased human interaction (e.g., bycatch, light attraction, gear entanglement) at foraging sites. Indirect benefits include 1) reduced competition with humans for food resources and 2) greater prey supplies resulting from increased prey production.

As upper level predators, seabird populations are regulated primarily from the bottom up (see Ainley et al. 1995) and show quick responses to changes in prey availability. Prey availability has been shown to affect coloniality (whether birds form large or small colonies), the timing of reproduction, clutch sizes, chick growth, non-predator related chick mortality, and reproductive success (Anderson and Gress 1984, Safina and Burger 1988, Pierotti and Annetti 1990, Massey et al. 1992, Ainley et al. 1995, Monagham 1996, Golet et al. 2000). Though top-down regulation does occur, it is often exacerbated by human activities that disturb breeding and resting sites. The impacts of human disturbance tend to be most pronounced when humans enter the immediate area (see Carney and Sydeman 1999). Intrusions often result in most, if not all, birds fleeing from the immediate area, leaving eggs and chicks vulnerable to predators such as gulls and ravens. While some birds return to nests once an intruder has gone, others will abandon nesting efforts. For example, Brandt’s Cormorants have been observed to abandon nests en masse from even single events of human intrusion to the colony (McChesney 1997). Although often not as easily identified, activities such as close approaches (e.g., by boats, surfers, etc.) to colonies and roosts can evoke responses similar to direct human intrusions (Jaques et al. 1996, Carney and Sydeman 1999, Jaques and Strong 2002). Several studies have shown reductions in breeding success or population sizes as a result of close approaches (e.g., Wallace and Wallace 1998, Carney and Sydeman 1999, Thayer et al. 1999, Beale and Monaghan 2004, Bouton et al. 2005, Rojek et al. 2007).

Not all seabird species are equal in their potential to benefit from MPA establishment. Thus, the Science Advisory Team for the South Coast Study Region (SCSR) ranked these species for their likelihood in benefiting from MPA establishment. We selected six focal species that received high ranks during this process: Pelagic Cormorant (*Phalacrocorax pelagicus*), Brandt's Cormorant (*Phalacrocorax penicillatus*), Black Oystercatcher (*Haematopus bachmani*), Pigeon Guillemot (*Cepphus columba*), California Least Tern (*Sterna antillarum browni*), and California Brown Pelican (*Pelecanus occidentalis californicus*). Additionally, we selected the Western Gull (*Larus occidentalis*) as this is an endemic species that breeds and forages within the SCSR, but its diet can be subsidized by fisheries discards and human trash. Life history information for each species can be found in the Focal Species section below. Specifically, we focused on species with a high susceptibility to human disturbance and dependence on locally available prey. For example, Pelagic Cormorants can forage up to 15km away from the breeding colony, but typically stay much closer (Hobson 1997). In California, their diet is dominated by mid-sized rockfish, sculpins, and other rocky-bottom demersal fishes (Ainley et al. 1981). Pigeon Guillemots typically forage within six kilometers of the breeding colony in depths of 6-45 m (Clowater and Burger 1994, Litzow et al. 2000). In California, guillemot diet is dominated by young rockfish and sculpins (Farallon Islands; Ainley and Boekelheide 1990) and young sanddabs (Point Arguello; Robinette et al. 2007). Furthermore, Litzow et al. (2000) found that changes in guillemot diet were sensitive to local prey abundance rather than regional prey abundance. California Least Terns typically forage within 3km of their breeding colony and prey on a variety of juvenile fishes from nearshore ocean and estuarine habitats (Atwood and Minsky 1983, Atwood and Kelly 1984). Black Oystercatchers maintain breeding and foraging territories along rocky shores and, in California, feed primarily on intertidal mussels and limpets (Point Blue unpubl. data).

Our six focal species occupy a wide range of niches within coastal habitats, with some niches fixed to a particular ecosystem feature and others overlapping multiple features. The data we collected provide information on four of the ecosystem features identified within the SCSR Monitoring Plan: 1) estuarine and wetland, 2) rocky intertidal, kelp and shallow rock (0-30m), 3) soft-bottom subtidal, and 4) nearshore pelagic. The California Least Tern breeds on sandy beach along the coast and within coastal lagoons and estuaries. It is state and federally listed as endangered and annual monitoring programs collect data on breeding population size and reproductive success at most breeding sites within the SCSR. We therefore focused our baseline monitoring efforts on documenting annual diet in an effort to better understand the factors contributing to population size and reproductive success. The remaining six focal species breed primarily in rocky coastal habitats and coastal bluffs. There are no programs collecting annual data throughout the SCSR. Thus, we investigated these species simultaneously and focused on documenting coastal habitat use for breeding and roosting and shallow nearshore habitat use for foraging.

Before-After-Impact-Control (BACI) Monitoring Approach

The ultimate goal of an adaptive management program is determining whether management actions result in their intended consequences. With regard to MPA management, biologists and resource managers must determine whether or not changes observed within a given MPA are due to the establishment of that MPA versus factors that are simultaneously acting on communities both inside and outside of MPAs (Rice 2000, Gerber et al. 2005). There are several ways to accomplish this. Some programs may take a 'before-after' approach by comparing performance indicators measured before MPA establishment to those measured afterward. If baseline or 'before' data do not exist, a program may take a 'control-impact' approach by comparing performance indicators inside an MPA (the 'impact' area) to those at a control site outside the MPA. The more robust approach to establishing causation is to combine these into a 'before-after-control-impact' (BACI) monitoring program (McDonald et al. 2000). Such a program involves measuring indicators at impact and control sites before and after MPA establishment. There are two general approaches to BACI monitoring. If a long period of baseline data exists, then the investigator can take a time series approach, monitoring a single pair of impact and control plots. However, if a baseline time series does not exist, then multiple sites must be used (McDonald et al. 2000).

We are using the BACI monitoring design to assess MPA-related changes in 1) California Least Tern diet, 2) seabird foraging rates, 3) breeding population size, and 4) rates of human-caused disturbance to seabird breeding and roosting sites. If prey populations increase within MPAs, then we should see measurable responses in diet and foraging rates. It is important to document the size of breeding populations inside and outside of MPAs in order to track changes in population size attributable to MPAs. The establishment of MPAs should result in decreased disturbance rates due to reduced boat traffic. Though MPAs do not specifically restrict boat traffic, we anticipate that boat traffic will be reduced in areas where fishing is prohibited. If MPAs are effective in reducing boat traffic, then there will be a decrease in both the number of boat approaches and disturbance events at colonies within these areas compared to unprotected areas. For Least Tern diet, we selected seven colonies – three within MPAs (Tijuana River Mouth SMCA, Batiquitos Lagoon SMCA, and Bolsa Chica Basin SMCA) and four control sites (Camp Pendleton, Port of L.A., Venice Beach, and Point Mugu)(see Figure 1). For the other six focal species, we selected three mainland areas and three areas on Santa Cruz Island, covering a total of five SMRs and four SMCAs (Mainland: Point Vicente SMCA, Abalone Cove SMCA, Matlahuayl SMR, South La Jolla SMR, and Cabrillo SMR; Island: Painted Cave SMCA, Scorpion SMR, and Gull Island SMR). Additionally, we selected control sites adjacent to each of the three mainland and three island areas (shown in Figures 3 through 5 in the Methods section below).

Because most species can forage up to several kilometers from the nest

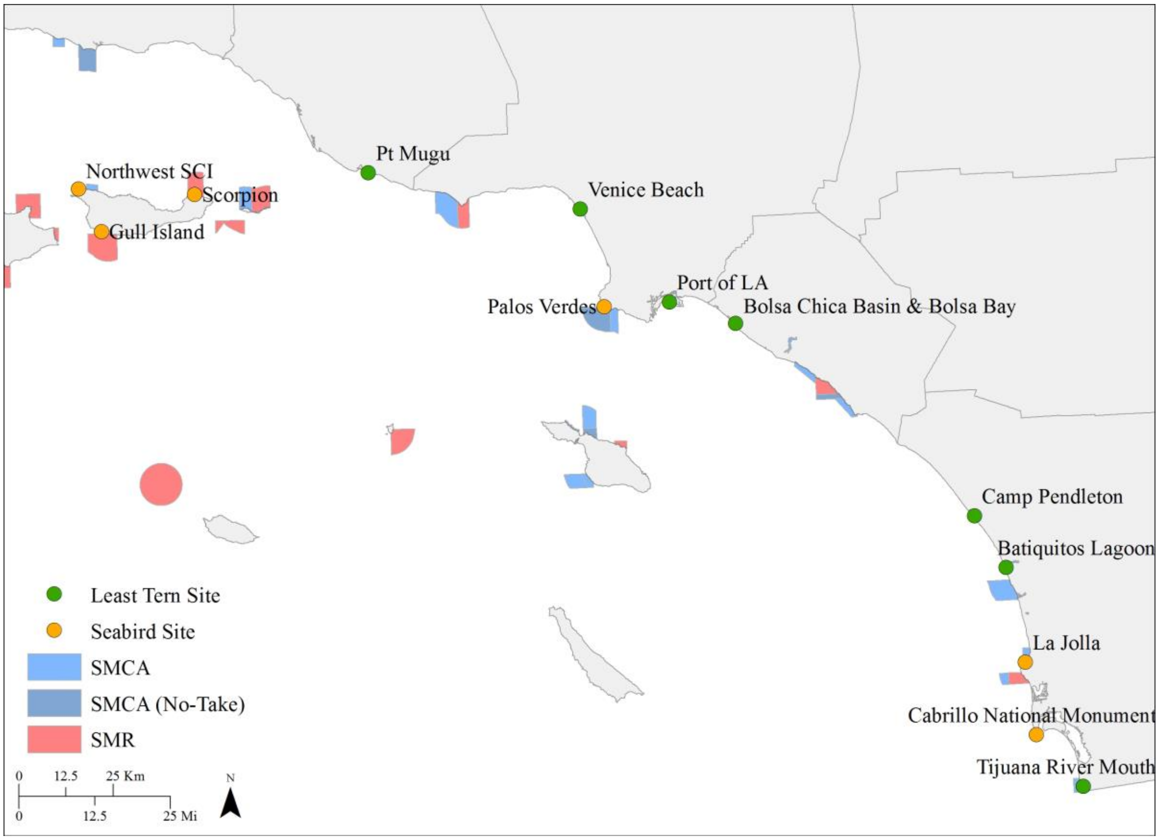


Figure 1. Map of Least Tern and rocky coast seabird areas used for baseline monitoring within the South Coast Study Region.

site, a seabird colony does not have to reside within an MPA to benefit from MPA establishment. As long as an MPA is within foraging range for a given species, then that species can potentially benefit from the increased prey availability created by the MPA. Thus, while we are using the BACI design to look at diet, foraging rates, breeding population size, roost utilization, and disturbance rates inside and outside of MPAs, we are not using the BACI design to assess MPA-related changes in breeding productivity. Breeding productivity will be influenced by factors acting adjacent to the colony as well as those away from the colony (e.g., foraging areas). Thus, the benefits of MPA establishment to breeding productivity are likely to be experienced over a broader spatial scale. Our monitoring design therefore focuses on tracking changes in productivity at each of the study sites over time and performing before-after types of comparisons to measure MPA-related changes within these areas given continued long-term monitoring beyond the baseline period.

Baseline Monitoring Objectives

This report represents a baseline characterization of seabird ecology within the SCSR and the "before" component of our BACI monitoring program.

The objectives of our baseline monitoring efforts were six-fold:

1. Assess baseline diet of the California Least Tern at colonies inside and outside of MPAs.
2. Assess baseline seabird foraging rates at sites inside and outside of MPAs.
3. Assess seabird breeding population size at sites inside and outside of MPAs.
4. Assess seabird roost utilization at sites inside and outside of MPAs.
5. Assess baseline levels of human-caused disturbance at breeding colonies inside and outside of MPAs.
6. Assess baseline breeding productivity at each of the three island and three mainland focal areas.

In order to fully implement our BACI monitoring program, it will be important to revisit these monitoring sites with a minimum of five-year intervals. Additionally, it will be necessary to monitor for multiple years within each interval to account for the effects of oceanographic and prey variability on seabird metrics. The SCSR is greatly influenced by the California Current, an eastern boundary current that creates some of the most oceanographically variable conditions in the world (Ainley et al. 1995), and the Southern California Countercurrent (Hickey 1992). Interannual variability in both of these currents, in addition to variability in larger scale processes such as the El Niño Southern Oscillation and Pacific Decadal Oscillation, creates high interannual fluctuation in biological productivity and food web structure within the SCSR. Continued long-term monitoring, coupled with available oceanographic data, will allow us to use statistical models to determine the degree to which MPAs and oceanographic processes are affecting seabird metrics.

METHODS

Study Area

Sites for Least Tern Monitoring

The California Least Tern nests on sand associated with a variety of coastal habitats within the SCSR, including coastal beaches, estuaries and bays. In addition to investigating the potential benefits of MPAs to this species, we wanted to investigate how the types of foraging habitat available adjacent to breeding sites influenced diet composition. Figure 2 shows the sites selected for monitoring Least Tern diet. We selected three sites within MPAs (Tijuana River Mouth SMCA, Batiquitos Lagoon SMCA, and Bolsa Chica Basin SMCA) and four control sites (Camp Pendleton, Port of L.A, Venice Beach, and Point Mugu). We had originally selected a fourth MPA site within the Campus Point SMCA, but Least Terns did not breed at this location in 2012 or 2013. Least

Terns bred on coastal beaches at four of the sites (Tijuana River Mouth, Camp Pendleton, Venice Beach, and Point Mugu). Tijuana River Mouth, Camp Pendleton, and Point Mugu are all adjacent to estuaries where the terns could forage. Venice Beach is adjacent to a harbor. Two sites (Batiquitos Lagoon and Bolsa Chica Basin) are located within an estuary, and Port of L.A. is located within a harbor.

Sites for Rocky Coast and Bluff Breeding Birds

The majority of rocky coast seabirds breed on the Channel Islands due to the amount of available habitat, inaccessibility to potential predators, and likely decreased rates of human-caused disturbance. We chose to monitor seabirds on Santa Cruz Island because of its accessibility and availability of housing to accommodate our field crew. When selecting mainland sites, coastal access was a major challenge as much of the potential mainland breeding habitat along the southern California mainland resides on or adjacent to private lands. Thus, we chose sites that had potential seabird breeding and roosting habitat and were accessible for frequent monitoring.

Figure 3 shows the sites we selected for Santa Cruz Island. We were able to conduct surveys at three MPAs on Santa Cruz Island: Scorpion SMR, Painted Cave SMCA, and Gull Island SMR. Controls for transect monitoring (for monitoring breeding population and roost utilization, see methods below) were located adjacent to Scorpion SMR and along the northwestern tip of the island. Controls for nearshore foraging surveys were located at Scorpion, North West Point, and South Beach.

Figure 4 shows the sites selected for the Palos Verdes Peninsula. There were no birds breeding on the peninsula, but we wanted to investigate the potential for the habitat to host breeding birds. We were able to conduct transect surveys inside the Point Vicente and Abalone Cove SMCAs and nearshore foraging surveys inside the Point Vicente SMCA. Controls for transect monitoring were located immediately north and south of the SMCAs and the control for nearshore foraging was located at White Point.

Figure 5 shows the sites selected for the San Diego Area. Coastal access for this stretch of coast was much more restricted than that for the Palos Verdes Peninsula. However, this is one of the few stretches of mainland coast in southern California with breeding birds. We were able to conduct transect and foraging surveys inside the Matlahuayl, South La Jolla, and Cabrillo SMRs. The control for transect and nearshore foraging surveys was located at Sunset Cliffs.

Focal Species

The Science Advisory Team (SAT) for the SCSR identified eight locally breeding species that will likely benefit from MPA establishment based on their susceptibility to human disturbance and dependence on locally available prey: California Least Tern, California Brown Pelican, Brandt's Cormorant, Pelagic

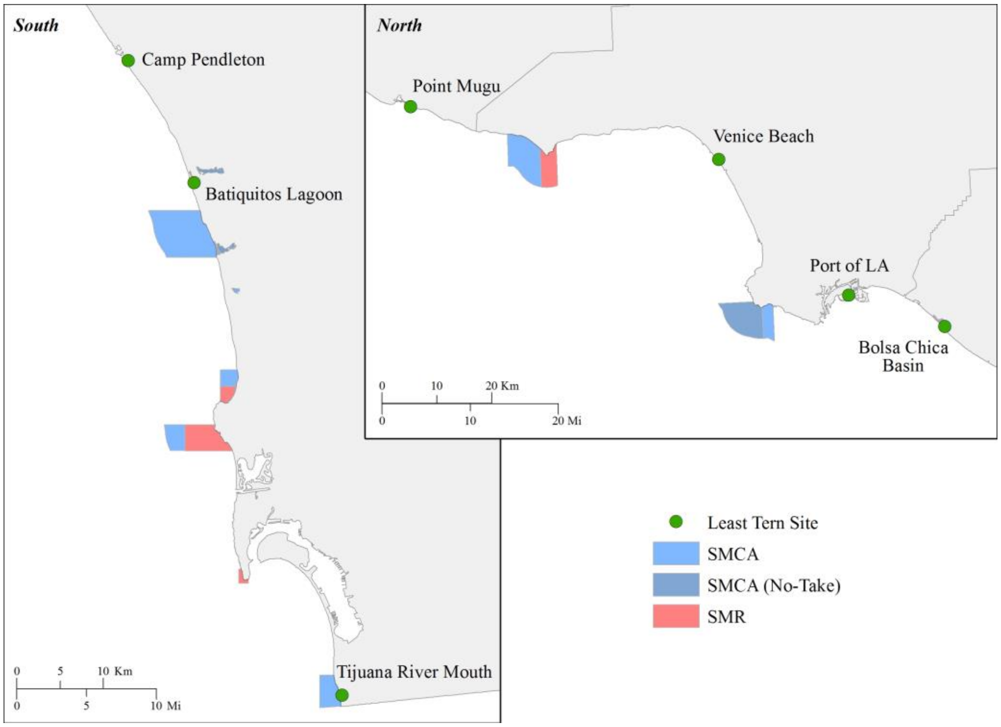


Figure 2. Map showing California Least Tern breeding colonies where diet samples were collected.

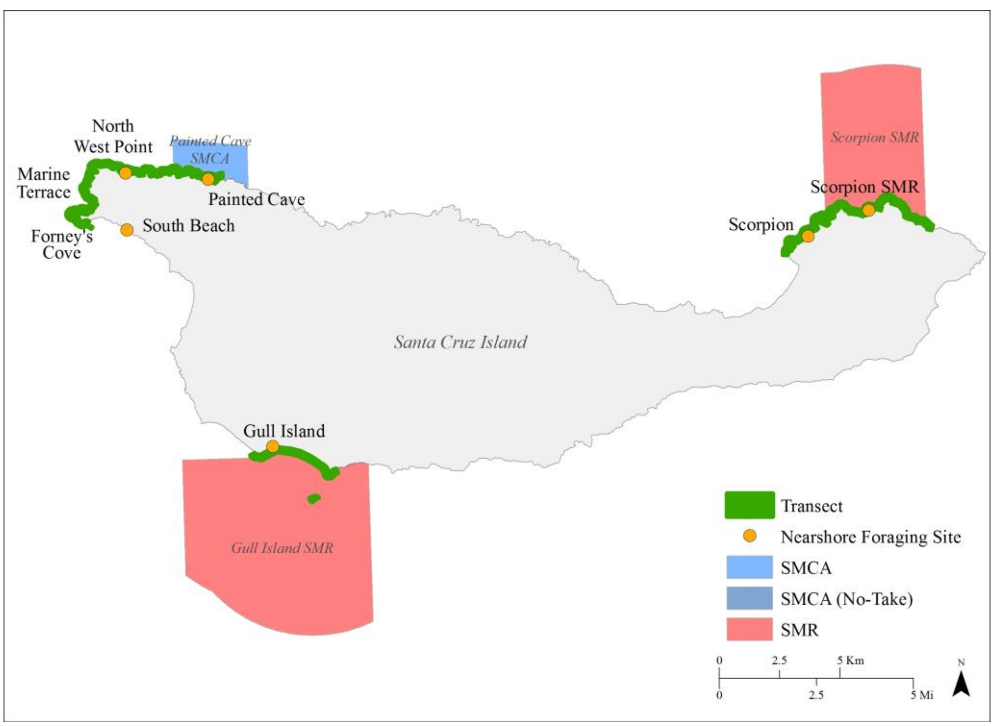


Figure 3. Map showing seabird monitoring locations on Santa Cruz Island.

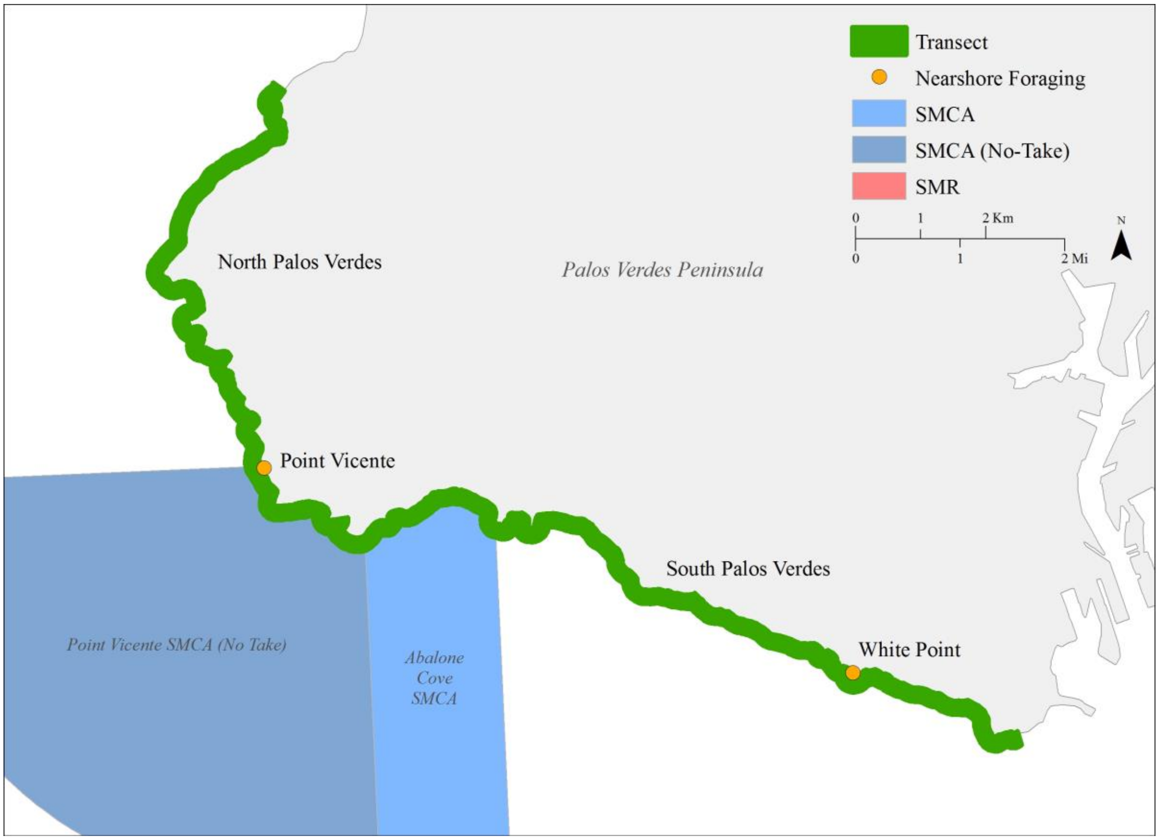


Figure 4. Map showing seabird monitoring locations along the Palos Verdes Peninsula.

Cormorant, Black Oystercatcher, Pigeon Guillemot, Xantus's Murrelet (now recognized as two distinct species: Scripps's Murrelet (*Synthliboramphus scrippsi*) and Guadalupe Murrelet (*S. hypoleucus*)), and Bald Eagle (*Haliaeetus leucocephalus*). We monitored six of these species: California Least Tern, California Brown Pelican, Brandt's Cormorant, Pelagic Cormorant, Pigeon Guillemot, and Black Oystercatcher. Additionally, we monitored Western Gulls as they are an endemic species that can be impacted both positively and negatively by human activities. Life history characteristics for each species are given below.

California Least Tern. California Least Terns breed in southern and central coastal California, with the majority of the population breeding along the mainland coast of the SCSR. After breeding, Least Terns migrate south to central America where their specific wintering location is currently unknown (Thompson et al. 1997). This species attempts only one successful brood per season. However, if the first nesting attempt fails (the eggs do not hatch or chicks are depredated), subsequent "relay" nesting attempts may be undergone. Nest scrapes are produced on the sand of coastal beaches or sandbars within lagoons and estuaries. Least Terns lay 1-3 eggs (2 eggs is most common) during a single nesting attempt. Both sexes incubate the eggs for 19-25 days. Fledging occurs in about 20 days. The California Least Tern forages primarily on young-of-the-year fishes from coastal and estuarine habitats (Robinette 2003). Robinette et al. (2013) have shown a relationship between breeding success and the occurrence of northern anchovy (*Engraulis mordax*) and rockfish (*Sebastes spp.*) at a colony in central California.

Pigeon Guillemot. Pigeon Guillemots typically breed in rocky crevices in coastal cliffs or offshore rocks/islands. This species attempts only one successful brood per season. If the first nesting attempt fails (the egg(s) does not hatch), subsequent "relay" nesting attempts may be undergone. Guillemots typically nest in small colonies. Nests are perennial, with high nest site fidelity. Pigeon Guillemots lay 1-2 eggs (2 is the most common number). Both the male and female incubate the eggs for a period of 25-38 days (with 29 days being average). Young fledge in 29-54 days, with 38 days being the average fledging time. During the breeding season, guillemots form rafts on the water adjacent to their nesting areas. Rafting groups tend to be in the greatest numbers in the early morning hours (Ewins 1993). At Southeast Farallon Island, Warzybok and Bradley (2011) estimated that Pigeon Guillemots fledged an annual average of 0.82 chicks per pair in 1971-2010. Pigeon Guillemots forage mainly among submerged reefs in nearshore waters. Prey fed to chicks includes a variety of small fish and invertebrates such as juvenile rockfish, sanddabs, sculpins, and octopi (Ainley and Boekelheide 1990).

Pelagic Cormorant. Pelagic Cormorants typically breed on steep cliffs along rocky seacoasts and islands. This species attempts only one successful brood per season. If the first nesting attempt fails (the eggs do not hatch), subsequent "relay" nesting attempts may be undergone. Relay attempts will take place at the same nest site, usually in the original nest. Nests are located on the ledges of high, steep, inaccessible rocky cliffs facing water. Nests are of the platform type, and are made of seaweed and other marine algae, terrestrial vegetation, or only moss. Pelagic Cormorants lay 3-7 eggs (3-5 eggs is most common) during a single nesting attempt. Both sexes incubate the eggs for 26-35 days. Fledging occurs in about 40-50 days (Hobson 1997). At Southeast Farallon Island, Pelagic Cormorants fledged an annual average of 1.09 chicks per pair between 1971 and 2010 (Warzybok and Bradley 2011). Similar to the Pigeon Guillemot, Pelagic Cormorants forage mainly among submerged reefs in nearshore waters. Their primary prey in central California includes small fish and invertebrates such as juvenile rockfish, juvenile sculpins, and mysid shrimp (*Spirontocaris* sp.; Ainley et al. 1981).

Brandt's Cormorant. Brandt's Cormorants typically breed on the flatter or sloped portions offshore rocks and islands and on mainland cliffs. This species attempts only one successful brood per season. If the first nesting attempt fails (the eggs do not hatch), subsequent "relay" nesting attempts may be undergone. Relay attempts occur at the same nest site and usually in the original nest. Nests are composed of a variety of seaweed and other marine vegetation as well as terrestrial vegetation. Brandt's Cormorants lay 1-6 eggs (4 eggs is most common). Incubation lasts about 29-30 days. Fledging occurs in about 40-

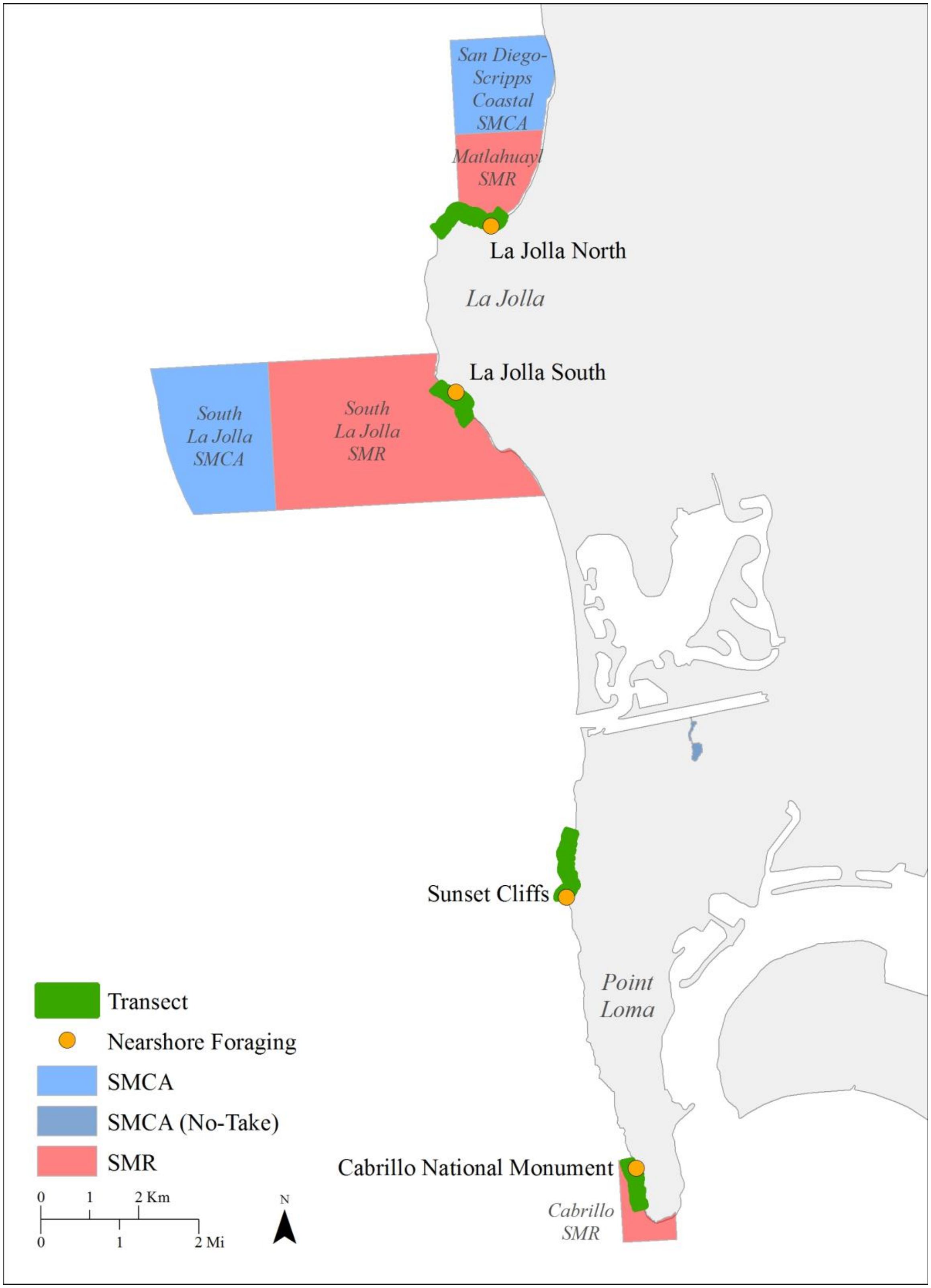


Figure 5. Map showing seabird monitoring locations in San Diego.

50 days (Wallace and Wallace 1998). In central California, reproductive success appears to vary by colony and by year (Boekelheide et al. 1990, Jones et al. 2007). At one subcolony on Southeast Farallon Island, Brandt's Cormorants fledged an annual average of 1.42 chicks per pair in 1971-2010. At Point Reyes Headlands, birds fledged an average of 1.78 chicks per pair over 9 years between 1997 and 2009. At Devil's Slide Rock and Mainland, annual productivity averaged 2.04 chicks per pair over 12 years between 1997 and 2009 (Eigner et al. 2011). Brandt's Cormorants forage mainly over soft bottom, continental shelf habitats. Their diet in central California includes a fairly wide variety of schooling fish such juvenile rockfish, Northern anchovy, Pacific sandlance (*Ammodytes hexapterus*), and Plainfin midshipman (*Porichthys notatus;* Ainley et al. 1981).

<u>*Black Oystercatcher*</u>. Black Oystercatchers typically breed on rocky coasts and islands, although nests have been occasionally found on sandy beaches. This species attempts only one successful brood per season. If the first nesting attempt fails (the chicks do not survive to fledging), subsequent "relay" nesting attempts may be undergone. Black Oystercatchers are monogamous, and have long-term pair bonds. They are also year round residents who continually defend their feeding territories. Nests are of the scrape form, and are usually built above the high tide line in weedy turf, beach gravel, or rock depressions. Black Oystercatchers lay 1-3 eggs (2 eggs is most common). Incubation lasts 24-29 days. Chicks are precocial at hatching, but highly dependent on their parents for an extended period of time. Chicks rely on parents to show them food, and to teach them about appropriate food selection. Chicks fledge in approximately 35 days. Annual reproductive success ranges from 0.25 to 0.95 chicks per pair across the range. Black Oystercatchers forage in rocky intertidal areas, where they feed mainly on a variety of intertidal marine invertebrates, particularly bivalves and other molluscs (limpets, whelks, and chitons) (Andres and Falxa 1995).

<u>*California Brown Pelican*</u>. California Brown Pelicans breed on the northern Channel Islands (Santa Barbara and Anacapa) and migrate north along the California coast after breeding. Brown Pelicans breeding in Mexico also migrate north after breeding. This species attempts only one successful brood per season. Ground nests are built steep, rocky slopes using vegetation, including kelp. Brown Pelicans lay 2-4 eggs (3 eggs is most common) during a single nesting attempt. Both sexes incubate the eggs for 29-32 days. Fledging occurs in about 70-81 days (Shields 2014). During the post-breeding season, pelicans rely on coastal habitats as important roosting sites. In the SCSR, pelicans can be observed year round with numbers increasing, but variable, through August and September. The California Brown Pelican forages primarily on coastal pelagic fishes and has been recognized as an indicator of northern anchovy (*Engraulis mordax*) and Pacific sardine (*Sardinops sagax*) abundance (Anderson and Gress 1984). The California Brown Pelican was state and federally listed as endangered until 2007. After delisting, there has been little

funding to monitor this species at its breeding colonies. Thus, data summaries in this report are limited to roosting and rates of human-caused disturbance.

Western Gull. Western Gulls typically nest on rocky islets and coastal cliffs. This species attempts only one successful brood per season (Pierotti and Annett 1995). If the first nesting attempt fails (the chicks do not survive to fledging), subsequent "relay" nesting attempts may be undergone. Nests are perennial and are usually located on cliff ledges, grassy hillsides, or sometimes on human built structures. Western Gulls lay 1-5 eggs (3 is the most common number). Western Gulls are colonial and have been known to share nesting sites with other seabirds. Incubation ranges from 25-29 days (26 days is the average length). Chicks fledge in 42-49 days, yet often don't disperse from the colony until after 70 days. Western Gulls have a broad diet that may include subsidies from human landfills and fisheries discards. In central California, Robinette and Howar (2013) found Western Gull diet to be dominated by a variety of rocky intertidal invertebrates and nearshore fishes.

California Least Tern

Population Size and Breeding Productivity

While we did not monitor population size and breeding productivity during our baseline study, we were interested in these metrics as they should be influenced by diet over time. We therefore obtained data from annual reports produced by the California Department of Fish and Wildlife (Frost 2013, Frost *In prep.*). We report population size for each breeding site within the SCSR and calculate the proportion of the SCSR that resides within MPAs. For this, we used the maximum numbers of breeding pairs reported for each breeding site. We also report breeding productivity as the number of fledglings produced per breeding pair for the sites for which we analyzed diet. We calculated breeding productivity by dividing the maximum number of fledglings reported for each site by the maximum number of pairs reported.

Diet

In order to assess Least Tern diet composition, we collected and analyzed fecal samples using methods developed by Robinette (2003). We collected samples from adult and chick roosting sites within each breeding colony. We collected samples twice a year at each of the Least Tern diet sites in 2012 and 2013. The one exception was Camp Pendleton in 2012. We were unable to get permission to access the site until late in the season. We therefore collected samples from Camp Pendleton only once in 2012. For each year, we collected samples during the incubation period of the breeding season (typically early May to early June) and the chick rearing period (typically late June through July).

Dates of sample collection and number of samples processed are shown in Table 1.

We sorted the fecal pellets in 30% isopropyl alcohol to obtain undigested hard parts (e.g., scales, otoliths) which we use to determine the type of prey consumed. Each sample was sorted in a 50mm x 9mm tight sealing petri dish. No sieves are necessary for this process. Fish otoliths are removed and stored dry in labeled gel capsules while all other hard parts store in the petri dish with alcohol. From our experience, the scales and otoliths of certain fish groups do not pass through Least Tern digestive system. We therefore use other identifiable parts to detect the presence of these groups. We detect larval fish in the samples by the presence of small, undeveloped vertebrae, and sculpins (Family Cottidae) by the presence of preopercle spines. Additionally, we detect the presence of squid (Class Cephalopoda, Order Teuthida) by the presence of beaks and statoliths. For each diet sample, we recorded the number of identifiable hard parts observed for each taxonomic group. We summarized the data from each colony as percent occurrence -- the percent of total samples that contained identifiable hard parts from a particular taxonomic group.

Table 1. Dates of sample collection and numbers of samples analyzed for seven Least Tern breeding sites within the SCSR during the early and late breeding stages of 2012 and 2013.

Breeding Site	Breeding Stage	2012		2013	
		Date	Analyzed	Date	Analyzed
Tijuana River Mouth	Early	31 May	25	30 May	25
	Late	12 July	25	11 July	25
Batiquitos Lagoon	Early	3 May	25	28 May	26
	Late	25 June	25	2 July	25
Camp Pendleton	Early	-----	0	4 June	25
	Late	6 July	50	18 July	25
Bolsa Chica Basin	Early	8 May	25	21 May	25
	Late	3 July	25	16 July	25
Port of L.A.	Early	23 May	25	7 June	25
	Late	11 July	50	5 July	25
Venice Beach	Early	22 May	25	24 May	25
	Late	10 July	27	2 July	25
Point Mugu	Early	17 May	25	10 June	25
	Late	5 July	27	3 July	25

We were not always able to identify fish from the Order Clupeiformes (anchovies, sardines, herrings) to species. The scales of this fish break easily during digestion and we can only identify whole scales or otoliths to species. However, we felt it was important to distinguish these species because they represent different habitats where the Least Terns are foraging. We therefore estimated the occurrence of each Clupeiform species by calculating the proportion of positively identified samples attributed to each Clupeiform species and extrapolated that proportion over the proportion of samples containing unidentified Clupeiform parts. We used this process for all samples except those collected in the Tijuana River Mouth site in 2013 as there were no positively identified Clupeiform samples from which to calculate proportions.

We organized all prey groups into three habitat categories based on Allen and Pondella II (2006): Bay/Estuary, Coastal Generalist, and Coastal Pelagic. The Bay/Estuary category contained fishes that were found exclusively in bays and estuaries while the Coastal Generalist category contained fishes that can be found in either bays and estuaries or nearshore ocean habitats (e.g., kelp forests). The coastal pelagic category contained fishes (and squid) that are pelagic in nearshore waters. The coastal pelagic category included young-of-the-year (YOY) fishes that have not yet settled into adult habitat (e.g., YOY rockfish). Table 2 shows the prey groups identified in SCSR diet samples from 2012 and 2013 and the habitat category assigned to each group.

Rocky Coast and Bluff Breeding Birds

Beginning in April (when seabird nest initiation is typically well under way), we monitored breeding and roosting seabirds at each of the three areas in Figures 3-5. We conducted four types of surveys at each location: area count surveys, nest monitoring, foraging surveys, and disturbance monitoring. The goals of these surveys were to assess baseline 1) seabird breeding population size inside and outside of MPAs, 2) seabird roost utilization inside and outside of MPAs, 3) seabird breeding productivity at multiple colonies within the SCSR, 4) seabird foraging rates inside and outside of MPAs and 5) levels of human-caused disturbance inside and outside of MPAs.

Transects

Goals. The goals of transect monitoring are three-fold: 1) to document the size of annual breeding populations for each focal species inside and outside of MPAs, 2) to document roost utilization for each focal species inside and outside of MPAs, and 3) to identify nests that can be followed for estimating annual productivity.

Methods. We conducted area count surveys along the coastal sections highlighted in Figures 3-5. We divided each transect into counting blocks viewable from predetermined observation points. Beginning the week of April 1, we conducted one transect survey per week along each coastal section. The exception was on Santa Cruz Island where researchers followed a schedule of two weeks on island followed by one week off island. On Santa Cruz Island, each coastal section was surveyed twice every three weeks. We conducted surveys between the hours of 0600 and 1000 as this is the peak time for Pigeon Guillemot rafting activity and roosting activity by non-breeding birds. Nests counts were not possible for Pigeon Guillemots as this species nests in mostly inaccessible rock crevices. However, guillemots often raft on the water or roost on rocky shorelines adjacent to nesting areas. Peak numbers usually occur in early morning and in the pre-breeding season (Point Blue, unpubl. data). For

Table 2. List of prey types found in Least Tern diet samples and prey code and habitat category assigned to each. Prey types without a prey code were not common and were lumped into an 'other' category during our analyses.

Prey Type	Taxonomy	Prey Code	Habitat
Bay/Slough Anchovy	*Anchoa spp.*	ANC	Bay/Estuary
Killifish/Mosquitofish	Family Fundulidae	KIL	Bay/Estuary
Silverside Smelt	Family Atherinopsidae	SIL	Coastal Generalist
Pacific Herring	*Clupea pallasii*	PHE	Coastal Generalist
True Smelt	Family Osmeridae	None	Coastal Generalist
Goby	Family Gobiidae	None	Coastal Generalist
Surfperch	Family Embiotocidae	SRF	Coastal Generalist
Sculpins	Family Cottidae	None	Coastal Generalist
Pipefish	*Syngnathus spp.*	None	Coastal Generalist
Northern Anchovy	*Engraulis mordax*	NAN	Coastal Pelagic
Pacific Sardine	*Sardinops sagax*	None	Coastal Pelagic
Pacific Saury	*Cololabis saira*	PSA	Coastal Pelagic
YOY Cabezon	*Scorpaenichthys marmoratus*	None	Coastal Pelagic
YOY Rockfish	*Sebastes spp.*	RCK	Coastal Pelagic
YOY Greenlings	Family Hexagrammidae	GRN	Coastal Pelagic
Lantern Fishes	Family Myctophidae	None	Coastal Pelagic
Cephalopoda	Order Teuthida	SQD	Coastal Pelagic
Fish Larvae	Unknown	FLA	Unknown
Small fish	Unknown	SMF	Unknown
Unidentified	Unknown	UNK	Unknown

each survey, we began at one end of the transect and visited each observation point. We alternated starting points between the north and south ends of the transect on a weekly basis to minimize time bias on guillemot raft counts. From each observation point, we scanned the adjacent count blocks using binoculars and a spotting scope. We recorded the number of nesting, roosting, and rafting (for guillemots only) birds observed within each counting block. We recorded data on each of the focal species identified above. We report breeding population size as the peak number of nesting birds (i.e., peak number of nests multiplied by two) observed during area count surveys for all species but Pigeon Gullimots. For guillemots, we report the peak number of rafting birds for each site. We report roost utilization as the mean ± SE number of birds roosting per week at each site.

Nest Monitoring

Goals. The overarching goal of nest monitoring is to record annual nesting phenology and estimate annual breeding productivity. Both phenology and productivity are good indicators of the underlying oceanographic conditions affecting annual population size. Recording phenology requires weekly checks on individual nests within a given colony. Productivity can be calculated as either 1) the number of fledglings produced per adult breeding pair or 2) the percentage of total eggs laid that hatched and successfully grew into fledglings. The first calculation requires only knowledge of the number of fledglings produced within a given nest. The second requires more detailed knowledge of how many eggs were laid, how many of those eggs hatched, and how many of those chicks fledged. In this report, we use the first method to calculate productivity as we were able to collect this data at all areas. However, in some areas, we were able to obtain views of nests to collect data on number of eggs laid. These data can be analyzed at a later date if a more detailed analysis of productivity is warranted.

Methods. We identified monitorable nests during our area count surveys of each focal area. A monitorable nest is one for which eggs, chicks, and fledglings can be clearly viewed and enumerated without disturbing the nesting adults; though in some cases we were only able to view chicks and fledglings. Once nests were identified, we monitored them every 7 days. The exception was on Santa Cruz Island where researchers followed a schedule of two weeks on island followed by one week off island. On Santa Cruz Island, each nest was monitored twice every three weeks. During each monitoring visit, we recorded 1) nest condition, 2) number of adults attending the nest and whether one is in incubating posture, 3) number of eggs, 4) number of chicks, 5) the feather condition of chicks, 6) number of fledglings and 7) if nest fails, the reason for nest failure to the extent possible (i.e., Were abandoned eggs left in the nest? Were dead chicks observed in the nest? Was there evidence of predation?). We report breeding productivity as number of fledglings produced per breeding pair for each site.

Monitoring Nearshore Foraging

Goals. The goals of nearshore foraging surveys are to document 1) the number of seabirds foraging individually inside and outside of MPAs and 2) the number of seabirds foraging in flocks inside and outside of MPAs. We distinguish between the foraging behaviors for two reasons. First, the numbers of birds participating in foraging flocks can be orders of magnitude higher than the numbers of birds foraging individually and must be analyzed separately. Second, the behaviors represent foraging on different types of prey. Foraging flocks are formed by birds foraging on pelagic schooling prey such as anchovies while individual foraging birds typically prey on mid-water and demersal prey such as young rockfish and flatfish.

Methods. Beginning about April 15 of each survey year, we conducted seabird foraging surveys at each of the survey sites shown in Figures 3-5. We surveyed each site mainland site once a week while Santa Cruz Island sites were surveyed twice every three weeks. We conducted surveys during one of the following time periods: 0600-0900, 0900-1200, 1200-1500, or 1500-1800, rotating sites among the four time periods per week to develop a complete 12-hour assessment of foraging activity. We conducted weekly surveys through the last week of July. We made observations from a single observation point, using binoculars and a 20-60x spotting scope. We divided each three-hour period into 15-minute blocks. During each 15-minute block, we scanned all water within a one-kilometer radius of our observation point and recorded the numbers of actively foraging individuals for all species. We also recorded the presence of all foraging flocks and collected data on the numbers of each species participating in the flock. We defined a foraging flock as five or more birds foraging on an aggregation of prey (e.g., an aggregation of anchovies). For individual foragers, we averaged all 15-minute blocks over a given hour of observation. If 100% of the study area was not visible (e.g., due to fog, sun glare, etc.) during two or more 15-minute blocks for a given hour, that hour was not included in the analysis. Here, we report the mean ± SE number of foraging individuals per hour of observation. We report results for Pigeon Guillemots, Brandt's Cormorants, and Pelagic Cormorants. For foraging flocks, we report the number of flocks observed at each site and the mean number of individuals participating in flocks.

Disturbance Monitoring

Goals. The goals of disturbance monitoring are 1) to identify human activities that cause disturbance, 2) to identify human activities that do not cause disturbance, 3) to estimate rates of human-caused disturbance at individual colonies, and 4) to estimate rates of natural (e.g., predator-caused) disturbance at individual colonies. Disturbance is defined as any event that results in one or more of the following:

1) Birds flushing (birds flying off the rock).
2) Birds displacing (moving from their nest or resting site).
3) Eggs or chicks being:
    a. exposed (adult moves away from the egg or chick),
    b. displaced (egg or chick moves from nest site), or
    c. taken (egg/chick is depredated).
4) Birds becoming visibly agitated.

Methods. We recorded all disturbances observed during any of the surveys mentioned above. At the beginning of each survey, we recorded the number of breeding and roosting birds present for each species. We recorded all land-based human activity and boat traffic within 1,500 feet, and aircraft flying at altitude of $\leq$1000 feet and within 1,500 horizontal feet of breeding/roosting seabirds, regardless of whether disturbance occurred or not. Additionally, we recorded all natural events (e.g., predatory bird flying over, large waves crashing) that cause disturbance. When a disturbance occurred, we recorded the following information:

1. Number of birds disturbed and reaction type for each species.
2. Number of nests with eggs and chicks exposed for each species.
3. Source of disturbance.
4. Source altitude and distance from nesting area affected
5. Activity of disturbance source

6. Identification information (e.g., type of vessel or aircraft and any identifying information like license number).
7. Direction of travel
8. Duration of disturbance event

We calculated the monitoring effort (total hours of observation) for each area. In total, we completed 200 observation hours in 2012 and 98 observation hours in 2013 at San Diego, 86 observation hours in 2012 and 175 observation hours in 2013 at Palos Verdes Peninsula, and 713 observation hours in 2012 and 682 observation hours in 2013 at Santa Cruz Island. Here, we present the number of human-caused (e.g., watercraft, humans on foot) disturbances per hour of observation.

RESULTS AND DISCUSSION

California Least Tern

Breeding Population and Reproductive Success

Table 3 shows the numbers of breeding pairs for each Least Tern breeding site in 2012 and 2013. The total breeding population for the SCSR was 5,749 breeding pairs in 2012 and 5,038 breeding pairs in 2013. Thus, there was a 12% reduction in breeding population between 2012 and 2013. The majority of the SCSR breeding population bred in areas that received some level of management protection. Approximately 20% bred adjacent to SMCAs, 11-13% bred within National Wildlife Refuges, and 50-54% bred on military property where there is no public access and management efforts focus on recovering this endangered species.

Breeding populations at the seven colonies where we analyzed diet ranged from 14 breeding pairs at Venice Beach to 1,231 breeding pairs at Camp Pendleton. Breeding population was similar between 2012 and 2013 for all sites but Bolsa Chica and Point Mugu. At Bolsa Chica, the population decreased from 305 pairs in 2012 to 157 pairs in 2013, a 49% reduction in population. At Point Mugu, the population decreased from 844 pairs in 2012 to 361 pairs in 2013, a 57% reduction. Many of the birds that bred at Point Mugu in 2012 potentially bred at the Hollywood Beach colony to the north in 2013 as this colony's population increased from 1 pair in 2012 to 210 pairs in 2013, a 209% increase. It is not uncommon for Least Terns to move among nearby colonies, especially when breeding productivity has been low at a given colony (Burger 1984).

Breeding productivity was low at all colonies surveyed for diet in 2012 and most in 2013 (Figure 6). While breeding productivity can be highly variableamong sites and among years, Frost (2013) reports that the statewide (using data from all colonies in the state) ratio of fledglings produced to adult breeding pairs has been below 0.5 only 13 times between 1977 and 2012.

Table 3. List of Least Tern breeding sites within the SCSR with level of protection, breeding habitat, and adjacent foraging habitat for each. Also shown are the breeding populations (number of breeding pairs) for each site in 2012 and 2013 and the proportions of the total SCSR population protected by MPAs, National Wildlife Reserves (NWRs), and military land.

Colony Name	MPA/Other Protection	Breeding Habitat	Adjacent Foraging Habitat	Population Size	
				2012	2013
McGrath State Beach	No MPA	Beach	Ocean/Lagoon	39	37
Ormond Beach	No MPA	Beach	Ocean	6	7
Hollywood Beach	No MPA	Beach	Ocean/Bay	1	210
Point Mugu	Military Land	Beach	Ocean/Estuary	844	361
Venice Beach	No MPA	Beach	Ocean/Bay	14	15
L.A. Harbor	No MPA	Bay	Bay	207	245
Seal Beach	NWR	Estuary	Estuary	121	164
Bolsa Chica	SMCA	Estuary	Estuary	305	157
Huntington Beach	No MPA	Beach	Ocean	534	347
Burris Basin	No MPA	River	River	11	23
Upper Newport Bay	SMCA	Estuary	Estuary	21	32
Camp Pendleton	Military Land	Beach	Ocean/Estuary	1,231	1,199
Batiquitos Lagoon	SMCA	Estuary	Estuary	562	559
FAA Island	No MPA	Bay	Bay	46	80
North Fiesta Island	No MPA	Bay	Bay	1	0
Mariner's Point	No MPA	Bay	Bay	135	37
Stony Point	No MPA	Bay	Bay	13	41
San Diego River Mouth	No MPA	Estuary	Estuary	12	0
Lindbergh Field	No MPA	Bay	Bay	124	107
NIMAT	Military Land	Bay	Bay	10	0
Coronado	Military Land	Beach	Ocean/Bay	1,023	937
Sweetwater Marsh	NWR	Estuary	Estuary/Bay	110	129
Chula Vista	NWR	Estuary	Estuary/Bay	51	70
South San Diego Bay	NWR	Estuary	Estuary/Bay	69	37
Tijuanna Estuary	SMCA/NWR	Beach	Ocean/Estuary	259	244
		Total Population		5,749	5,038
		Percent within MPAs		20%	20%
		Percent within NWRs		11%	13%
		Percent on Military Lands		54%	50%

Robinette et al. (2013) report an annual average of 0.56 fledglings per breeding pair for a colony in central California between 1995 and 2013. Breeding productivity at our seven focal colonies ranged from 0.0 to 0.16 fledglings per breeding pair in 2012 and from 0.0 to 0.6 in 2013. Breeding productivity was higher at all colonies but Point Mugu in 2013 compared to 2012. Venice Beach did not produce any fledglings in either year. The Port of L.A. colony was the only colony to produce more than 0.5 fledglings per breeding pair in 2013. The low productivity observed in 2012 and 2013 is part of a concerning trend that has been observed in recent years. Of the 13 years with less than 0.5 fledglings per breeding pair statewide, 11 of these have occurred since 2000 (Frost 2013). Much of this low statewide breeding productivity is a result of low productivity in

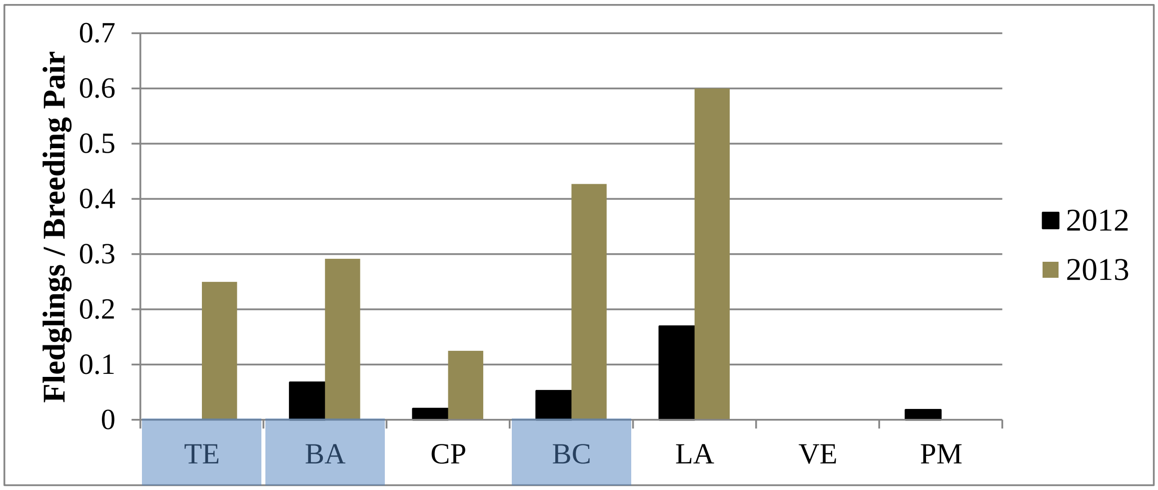


Figure 6. Least Tern breeding productivity (number of fledglings produced per breeding pair) at seven sites within the SCSR in 2012 and 2013. Blue boxes indicate breeding sites within SMCAs. TE = Tijuana River Mouth, BA = Batiquitos Lagoon, CP = Camp Pendleton, BC = Bolsa Chica Basin, LA = Port of L.A., VE = Venice Beach, PM = Point Mugu.

southern California where the majority of the population currently breeds.

Diet

Figures 7 and 8 show Least Tern diet results for 2012 and 2013, respectively. It is important to note that these data represent the presence of individual prey group within each diet sample and that a given diet sample can contain parts from multiple groups. Thus, percent frequencies summed over all categories can be greater than 100%. Bolsa Chica was the only colony that appeared to rely heavily on the bay/estuary habitat for prey. The tern diet at Bolsa Chica was dominated by killifish/mosquitofish (Family Fundulidae) and silverside smelt (Family Atherinopsidae) in both 2012 and 2013. While silverside smelt are coastal generalists, species such as topsmelt (*Atherinops affinis*) are often found in bay/estuary habitats and it is possible that the terns were taking this species from the adjacent estuary. Least terns breeding at Point Mugu also showed high percent frequencies of killifish/mosquitofish and silverside smelt in late 2012 and early 2013, but showed high frequencies for coastal pelagics in both years, even during the two periods when they were taking killifish/mosquitofish and silverside smelt. The remaining colonies took prey primarily from the coastal generalists and coastal pelagics categories. The dominant (showing 20% frequency or more for at least one breeding colony) coastal generalists were silverside smelt (Family Atherinopsidae), Pacific herring (*Clupea pallasii*), and surfperch (Family Embiotocidae), while the dominant coastal pelagics were northern anchovies (*Engraulis mordax*), Pacific saury (*Cololabis saira*), YOY rockfish (Sebastes spp.), YOY greenlings (Family Hexagrammidae), and squid. If a prey group occurred at less than 20%

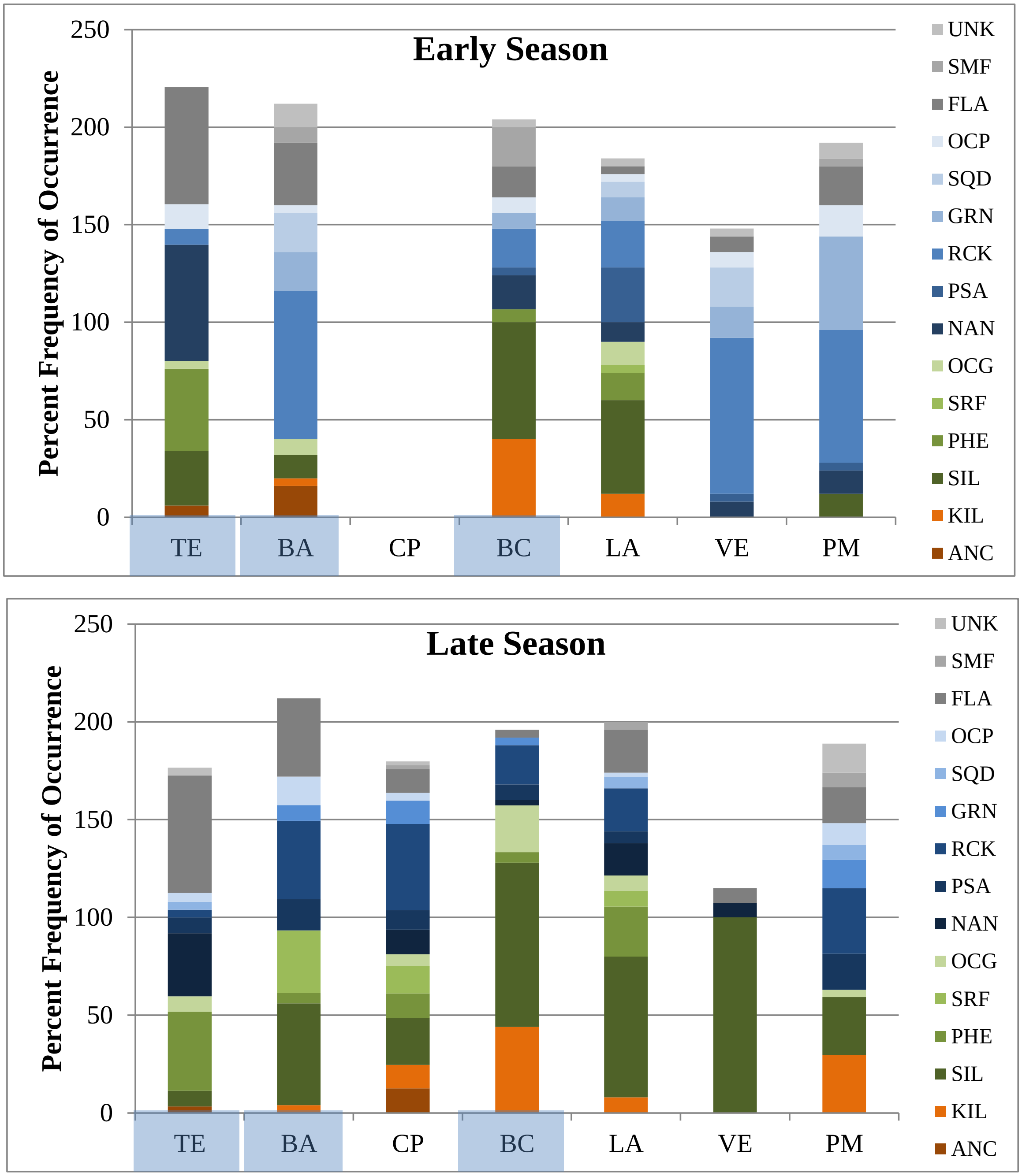


Figure 7. Contents of diet samples collected at seven Least Tern colonies in the SCSR during the early and late breeding stages in 2012. Blue boxes indicate breeding sites within SMCAs. TE = Tijuana River Mouth, BA = Batiquitos Lagoon, CP = Camp Pendleton, BC = Bolsa Chica Basin, LA = Port of L.A., VE = Venice Beach, PM = Point Mugu. OCG = Other Coastal Generalists and OCP = Other Coastal Pelagics. Definitions for all other prey codes can be found in Table 2.

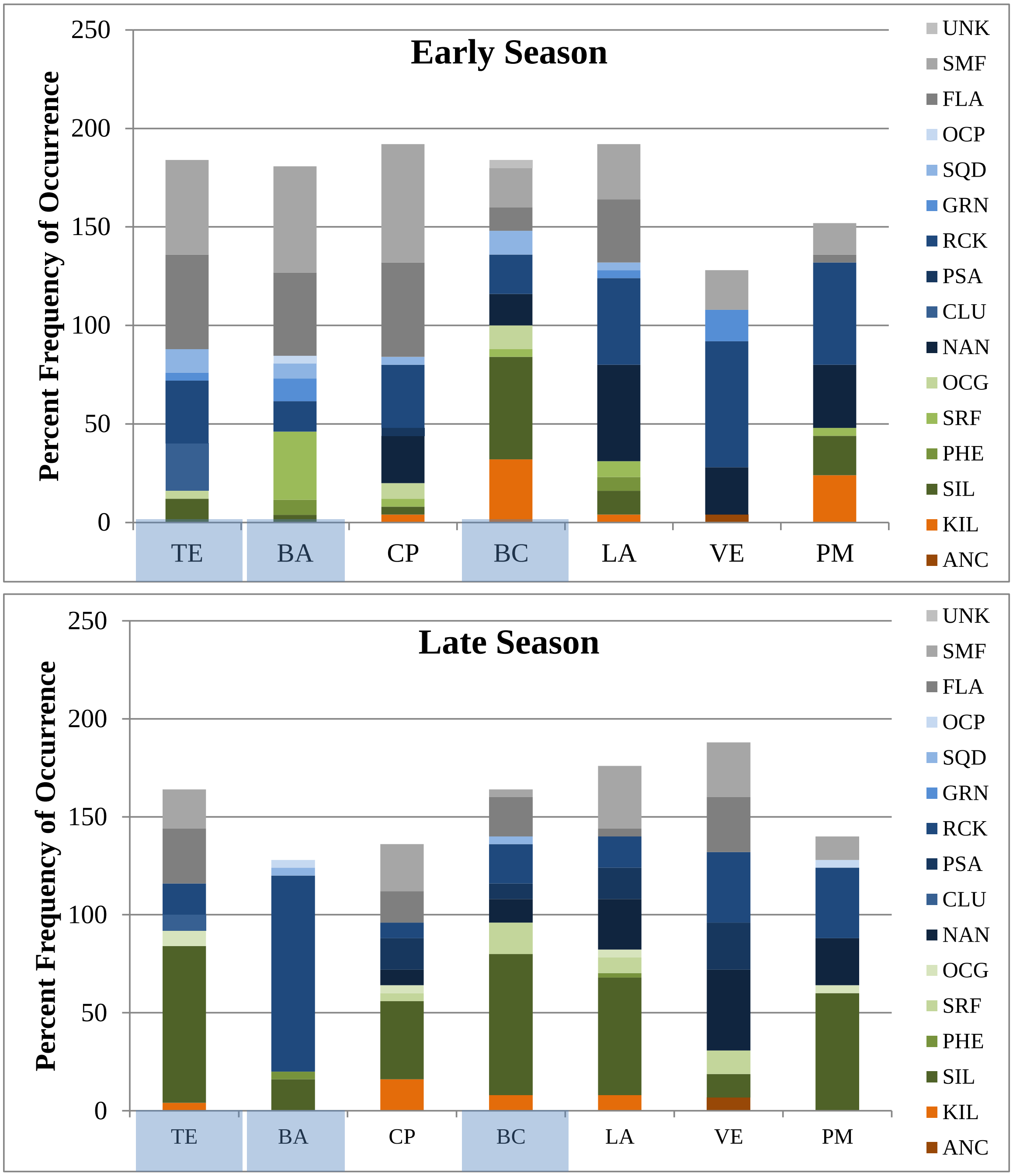


Figure 8. Contents of diet samples collected at seven Least Tern colonies in the SCSR during the early and late breeding stages in 2013. Blue boxes indicate breeding sites within SMCAs. TE = Tijuana River Mouth, BA = Batiquitos Lagoon, CP = Camp Pendleton, BC = Bolsa Chica Basin, LA = Port of L.A., VE = Venice Beach, PM = Point Mugu. OCG = Other Coastal Generalists and OCP = Other Coastal Pelagics. Definitions for all other prey codes can be found in Table 2.

frequency, it was grouped in the other coastal generalist or other coastal pelagic category, respectively.

During the early period of 2012, coastal pelagics dominated the diet at most colonies. The diet at the Tijuana River Mouth was dominated by northern anchovies while the diets at Batiquitos Lagoon, Venice Beach, and Point Mugu were dominated by YOY rockfish. The Port of L.A. showed the most diverse diet and had a high frequency of Pacific saury, a species typically found farther offshore than the other prey groups. There was a decrease in coastal pelagics and an increase in coastal generalists at all colonies in late 2012. Furthermore, there was an increase in overall diet diversity and in the frequency of Pacific saury at all colonies. Together, this indicates that Least Terns were foraging in multiple places and likely farther from the colony (e.g., offshore for saury) in order to find prey. This was likely in response to a decrease in the availability of northern anchovies and YOY rockfish. Additionally, there was an increase in the frequency of fish larvae at most sites. While fish larvae may be appropriate for newly hatched chicks that have a difficult time handling large prey, it is likely not an appropriate prey source to meet the caloric demands for chicks in the later stages of development. Thus, it is possible that a change in prey availability led to an increase in chick mortality and the decreased breeding success observed at all colonies in 2012.

In early 2013, fish larvae and small fish dominated the diets at Tijuana River Mouth, Batiquitos Lagoon, and Camp Pendleton. We assigned scales and otoliths to the small fish category when they were too small to distinguish identifiable features. This category represents multiple species, but we are not certain how many. The diets at Point Mugu, Venice Beach, and Port of L.A. were dominated by northern anchovies and YOY rockfish. Silverside smelt increased in frequency during the late period and dominated the diets at all colonies but Batiquitos Lagoon and Venice Beach. The Batiquitos Lagoon diet became dominated by YOY rockfish while YOY rockfish decreased in frequency at Venice Beach and Pacific saury increased in frequency. Despite these changes, small fish still showed high frequencies at all colonies but Batiquitos Lagoon.

It is difficult to assess the impacts of diet on breeding productivity since both years showed low productivity at all colonies. However, productivity improved at five of the seven colonies in 2013, which may be attributed to a decline in larval fish consumption and an increase in higher-quality prey (e.g., anchovy and rockfish) within that year. The highest breeding productivity was at Port of L.A. in 2013. The higher productivity at this colony was likely due to the high frequency of northern anchovies and YOY rockfish. Using a 13-year time series, Robinette et al. (2013) found strong positive relationships between annual breeding productivity and the occurrence of northern anchovies and YOY rockfish in the diet of Least Terns breeding at a colony in central California. The occurrence of both of these species in the diets of other seabirds has been shown to benefit breeding productivity (Elliott et al. 2014). Had the frequency of northern anchovies and YOY rockfish remained high throughout the 2013 breeding season, breeding productivity at the Port of L.A. would likely have been higher.

Robinette et al. (2013) also found that the occurrence of northern anchovies and YOY rockfish in the Least Tern diet was highly correlated with annual larval abundance during each species' peak spawning period. Furthermore, they found the occurrence of anchovies in the diet to be correlated with the Pacific Decadal Oscillation while the occurrence of rockfish to be correlated with local sea surface temperature. Measuring the contribution of rockfish and anchovy to Least Tern diet in combination with measures of larval abundance and oceanographic indices will likely provide a good indicator of juvenile recruitment to the populations of these species. Understanding variability in juvenile fish recruitment will help resource managers interpret changes observed within SCSR MPAs.

Rocky Coast and Bluff Breeding Birds

Breeding Population Size

Figures 9 through 13 show the breeding population size and distribution of five focal species within the areas we surveyed: Brandt's Cormorant, Pelagic Cormorant, Pigeon Guillemot, Western Gull, and Black Oystercatcher. We did not document any breeding activity along the Palos Verdes Peninsula. However, we did identify potential breeding habitat for Pelagic Cormorants, Western Gulls, and Black Oystercatchers, and small presence of oystercatchers indicated a potential for this species to breed along the peninsula (see Black Oystercatchers below). We documented breeding by Brandt's Cormorants and Western Gulls in San Diego and all five focal species on Santa Cruz Island.

Brandt's Cormorants. We documented a total of 887 breeding pairs in 2012 and 1,742 breeding pairs in 2013. Of these, 16.0% were found breeding inside MPAs in 2012 and 35.3% were found breeding inside MPAs in 2013. We documented a small colony of Brant's Cormorants breeding within the Matlahuayl SMR in 2012 and 2013 (53 and 86 pairs, respectively). In 2012, the cormorants began nest initiation well before our surveys began as we found nests with fully developed chicks. Thus, we likely underestimated the breeding population size at Matlahuayl SMR in 2012. Brandt's Cormorants did not breed at any other San Diego location in either year. We documented breeding activity along all coastal sections surveyed on Santa Cruz Island, with numbers of pairs ranging from 15 to 903. We documented the largest numbers of breeding pairs at Northwest Point (529 in 2012 and 903 in 2013), which is not within an MPA. The Gull Island SMR had 26 pairs and 402 pairs in 2012 and 2013, respectively. Gull Island is not attached to Santa Cruz Island and was difficult to view from our vantage point. It is possible that we underestimated population size at Gull Island in 2012. There were small numbers of Brant's Cormorants breeding within the Painted Cave SMCA (20 pairs in 2012 and 15 pairs in 2013) and the Scorpion SMR (43 pairs in 2012 and 112 pairs in 2013).

Pelagic Cormorants. We documented a total of 90 breeding pairs in 2012 and 129 breeding pairs in 2013. Of these, we found 7.8% breeding inside MPAs in 2012 and 8.5% breeding inside MPAs in 2013. We documented breeding Pelagic Cormorants at Forney's Cove, Marine Terrace, North West Point, Painted Cave SMCA, and Scorpion SMR on Santa Cruz Island. Breeding numbers ranged from 2 pairs to 89 pairs. The largest numbers were observed at Forney's Cove (60 pairs in 2012 and 89 pairs in 2013) which is not within an MPA. The Painted Cave SMCA had 2 breeding pairs in each of 2012 and 2013 while the Scorpion SMR had 5 breeding pairs in 2012 and 9 breeding pairs in 2013.

Pigeon Guillemot. Because Pigeon Guillemots breed in inaccessible rock crevices, we were unable to document the number of active nests for this species. Rather, we used raft counts to estimate breeding population size for this species. We recorded a maximum of 265 guillemots in 2012 and 379 guillemots in 2013. Of these, 14.0% were documented inside MPAs in 2012 and 25.1% were documented inside MPAs in 2013. Guillemots were observed along all coastal sections surveyed on Santa Cruz Island. Maximum numbers of rafting birds observed for each site ranged from one to 190. The largest numbers were documented at North West Cove (155 birds in 2012 and 190 birds in 2013) which is not within and MPA. We documented 19 birds in 2012 and 54 birds in 2013 in Painted Cave SMCA and 17 birds in 2012 and 41 birds in 2013 at Scorpion SMR. We observed three guillemots at North Palos Verdes (outside the MPA) during one survey in 2012 and one guillemots within the Gull Island SMR during one survey in 2012. Given these birds were seen only once, we do not feel they represent a breeding population at either site. Additionally, the Palos Verdes sighting was a rare event for this area.

Western Gulls. We documented a total of 155 breeding pairs in 2012 and 140 breeding pairs in 2013. Of these, 65.2% were found breeding inside MPAs in 2012 and 68.6% were found breeding inside MPAs in 2013. We documented Western Gull breeding in the Matlahuayl SMR, South La Jolla SMR, and the Cabrillo SMR in the San Diego area. We documented the largest numbers within the Matlahuayl SMR (23 pairs in 2012 and 24 pairs in 2013) and one breeding pair in each of the South La Jolla and Cabrillo SMRs in 2012). We did not document any Western Gull breeding at the San Diego control site. We documented Western Gull breeding at all coastal sections surveyed along Santa Cruz Island. Numbers of breeding pairs ranged from two to 48. The largest numbers were documented at North West Point (34 breeding pairs in 2012 and 33 breeding pairs in 2013), Painted Cave SMCA (22 breeding pairs in 2012 and 42 breeding pairs in 2013), and Scorpion SMR (48 breeding pairs in 2012 and 27 breeding pairs in 2013). We documented 6 breeding pairs in 2012 and 3 breeding pairs in 2013 at Gull Island SMR.

Black Oystercatchers. Due to the cryptic nature of Black Oystercatcher nests, it is difficult to confirm breeding activity in this species, especially if the research location is new to the researchers. We were able to confirm nesting at

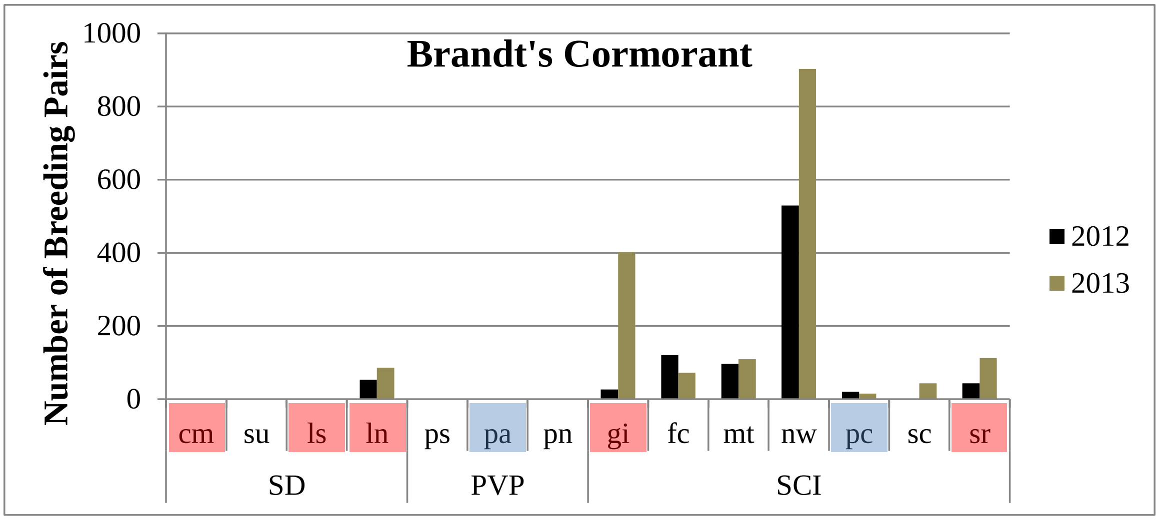


Figure 9. Breeding population sizes for Brandt's Cormorants inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

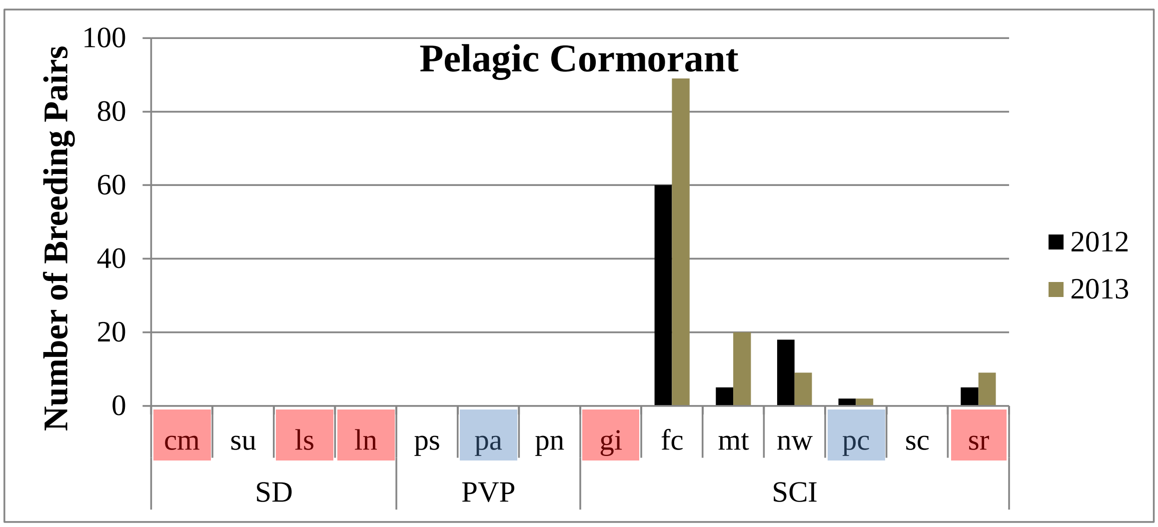


Figure 10. Breeding population sizes for Pelagic Cormorants inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

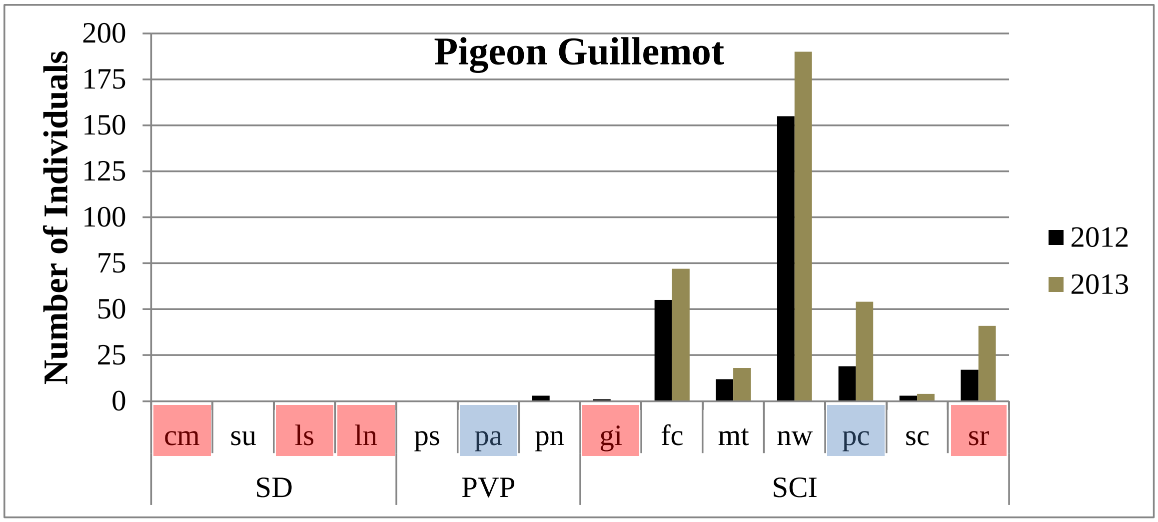


Figure 11. Breeding population sizes for Pigeon Guillemots inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

two coastal sections surveyed on Santa Cruz Island. We documented a total of one breeding pair in 2012 and five breeding pairs in 2013. Of these, 0.0% were found breeding inside MPAs in 2012 and 80.0% were found breeding inside MPAs in 2013. We documented one nest at North West Point in each of 2012 and 2013 and four nests within the Painted Cave SMCA in 2013. However, we documented the presence of oystercatchers at multiple locations. Figure 13b shows the mean ± SE number of oystercatchers observed per area count survey for each coastal section. Oystercatchers were observed at all coastal sections surveyed at Santa Cruz Island, with the highest numbers recorded at Forney's Cove. It is therefore likely that the oystercatcher population on Santa Cruz Island is higher and more widespread than what we were able to document. Further studies and more familiarity with the island would likely improve our breeding population estimates. We also documented the presence of oystercatchers along all three coastal sections of the Palos Verdes Peninsula, with the majority of observations along North Palos Verdes and within the Point Vicente/Abalone Cove SMCAs. We did not find any evidence of breeding activity, but the persistent presence of these birds indicates a potential for breeding in the future.

Breeding Productivity

Figure 14 shows the numbers of fledglings produced per breeding pair for Brandt's Cormorants and Western Gulls breeding at Santa Cruz Island and San Diego and Pelagic Cormorants breeding at Santa Cruz Island in 2012 and

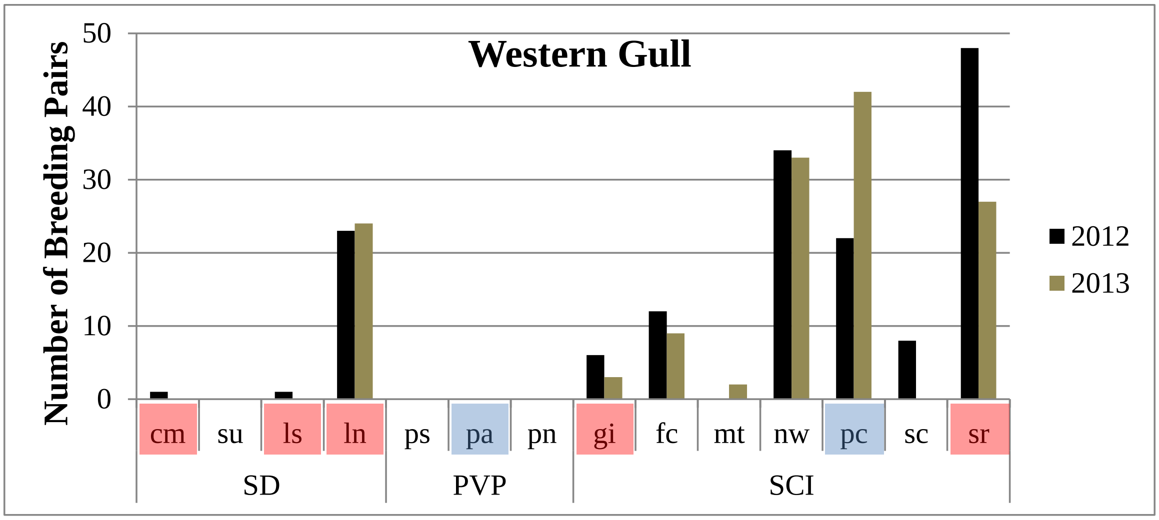


Figure 12. Breeding population sizes for Western Gulls inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

2013. Productivity for Brandt's Cormorants was similar between sites, with Santa Cruz Island showing more variability between years. Productivity at Santa Cruz Island was higher in 2013 than 2012. Conversely, Pelagic Cormorant productivity at Santa Cruz Island was higher in 2012 than 2013. Western Gulls showed the most variability between sites. Gull productivity was higher in San Diego than at Santa Cruz Island in both years. In fact, Gulls on Santa Cruz Island did not produce any fledglings in 2012.

Robinette and Howar (2013) calculated mean breeding productivity for the species above using a 14-year time series (2000-2013). Mean productivity for Brandt's Cormorants over this period was 2.22 fledglings per breeding pair while that for Pelagic Cormorants was 1.69 fledglings per breeding pair. The productivity values we report for these species were well below these averages at both locations (for Brandt's Cormorants) and in both years. Mean productivity reported by Robinette and Howar (2013) for Western Gulls was 1.27 fledglings per breeding pair. The productivity values we report were similar at San Diego in 2012, higher at San Diego in 2013, and much lower at Santa Cruz Island in both years.

We were able to follow all Black Oystercatcher nests that we located on Santa Cruz Island. In 2012, the one nest that we located produced one fledgling. In 2013, the five nests that we located produced three fledglings for a productivity rate of 0.6 fledglings per breeding pair. The 14-year mean reported by Robinette and Howar (2013) was 0.92 fledglings per breeding pair.

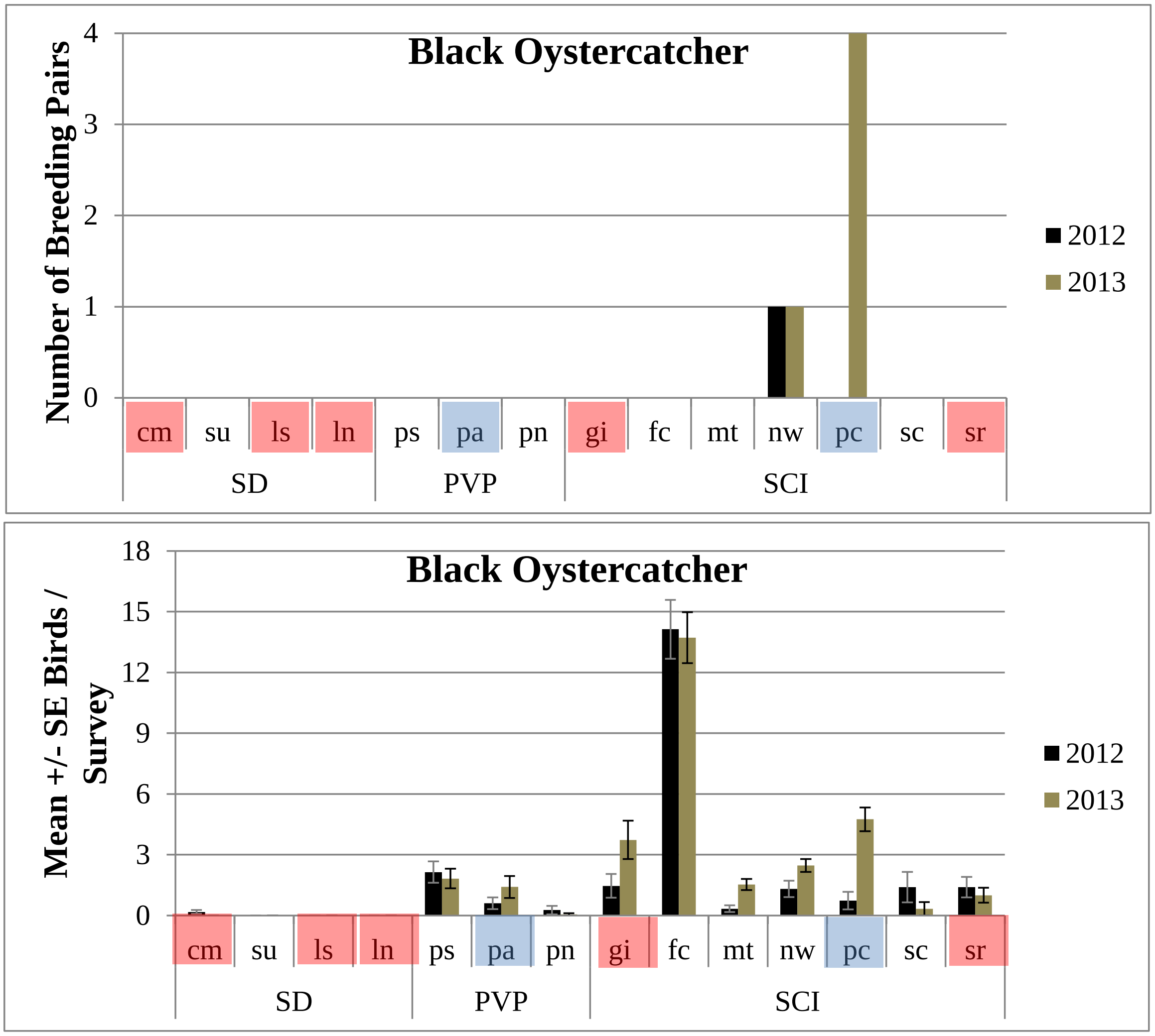


Figure 13. Breeding population sizes expressed as number of breeding pairs (upper) and mean ± SE individuals observed per survey (lower) for Black Oystercatchers inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

Roost Utilization

Cormorants and pelicans have plumage that is wetted when they forage in the ocean. Roosting and conserving energy is an important behavior of these species and much of their day, both during and outside of the breeding season, is spent resting and drying their plumage (Hobson 1997, Wallace and Wallace 1998, Jaques and Strong 2002). Thus, the coastal habitats within the study area provide important year round roosting sites for both cormorants and pelicans. Figures 15 and 16 report the mean ± SE number of birds roosting per survey within each coastal section for Brandt's Cormorants, Pelagic Cormorants, Brown

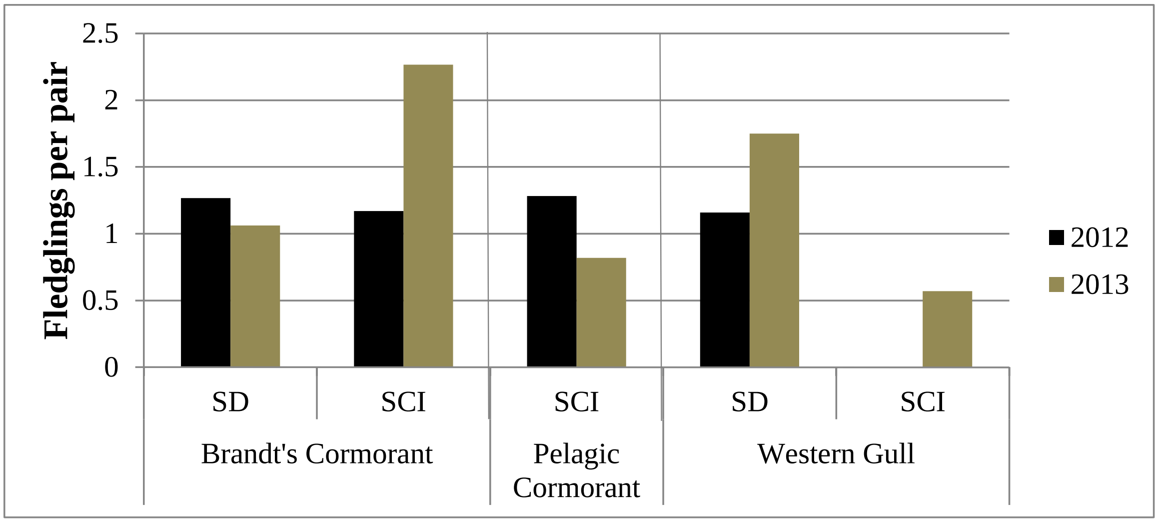


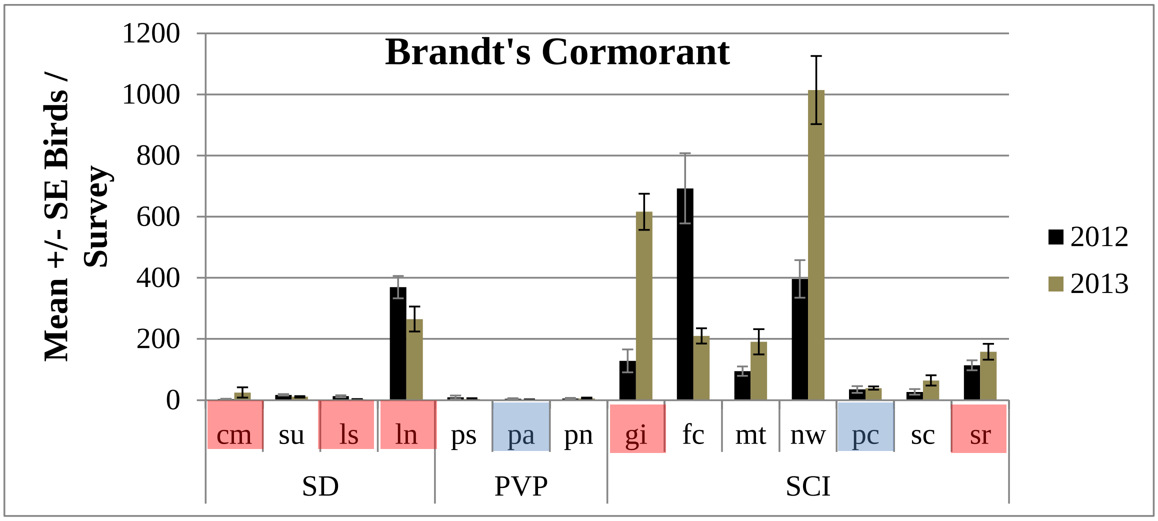
Figure 14. Breeding productivity (fledglings produced per breeding pair) for Brandt's Cormorants, Pelagic Cormorants, and Western Gulls at San Diego and Santa Cruz Island in 2012 and 2013.

Pelicans, and Western Gulls.

Analysis of variance showed no significant differences in Brandt's Cormorant roosting between MPA and control plots (F = 2.03, df = 1, 394, p = 0.155) or between years (F = 0.80, df = 1, 394, p = 0.373). However, there were significant differences among sites (F = 46.40, df = 2, 394, p <0.001), with Santa Cruz Island having the largest numbers of roosting cormorants. There were significant year x site interactions (F = 3.49, df = 2, 394, p = 0.032) and site x MPA interactions (F = 12.83, df = 2, 394, p <0.001). There were more Brandt's Cormorants roosting in San Diego in 2012 than 2013 while there were more cormorants roosting at Santa Cruz Island in 2013 than 2012. Additionally, there were more Brandt's Cormorants roosting inside San Diego MPAs in 2012 and more cormorants roosting inside Santa Cruz Island MPAs in 2013. There was no significant year x MPA interaction (F = 1.86, df = 1, 394, p = 0.174).

There was no significant difference in Pelagic Cormorant roosting between years (F = 1.00, df = 1, 394, p = 0.317), but there were significant differences among sites (F = 31.96, df = 2, 394, p <0.001) and between MPA and control plots (F = 26.09, df = 1, 394, p <0.001). There were larger numbers of cormorants roosting at Santa Cruz Island and more roosting at control sites. There was a significant site x MPA interaction (F = 27.70, df = 2, 394, p <0.001) due to a much greater difference between MPA and control plots at Santa Cruz Island than observed at other sites. There were no significant year x site or year x MPA interactions (year x site: F = 1.07, df = 2, 394, p = 0.345; year x MPA: F = 0.61, df = 1, 394, p = 0.436).

There were no differences in Western Gull roosting between years (F = 0.33, df = 1, 394, p = 0.564) or between MPA and control plots (F = 0.91, df = 1, 394, p = 0.341). There was a significant difference in roosting among sites (F =



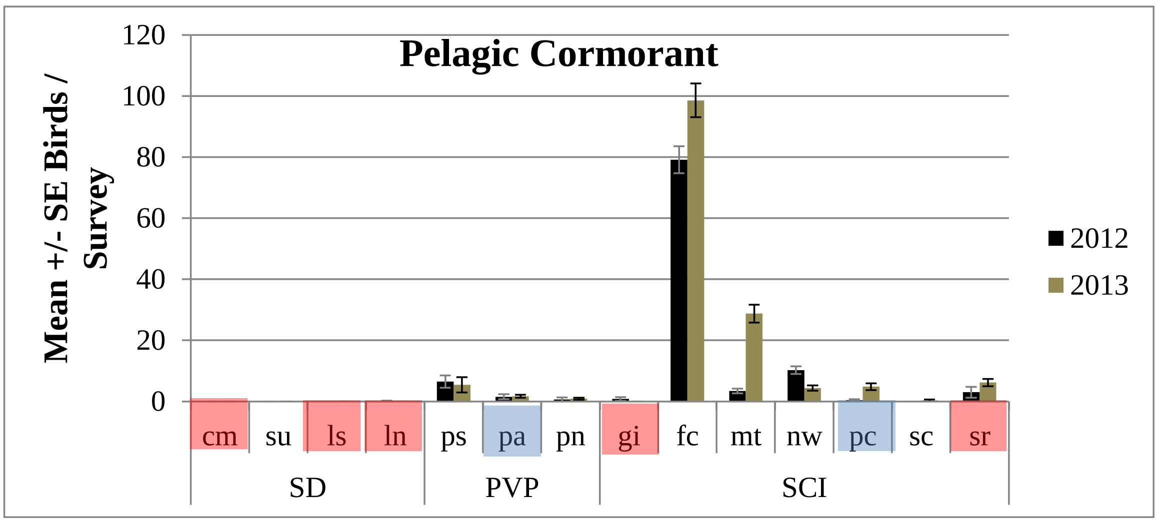
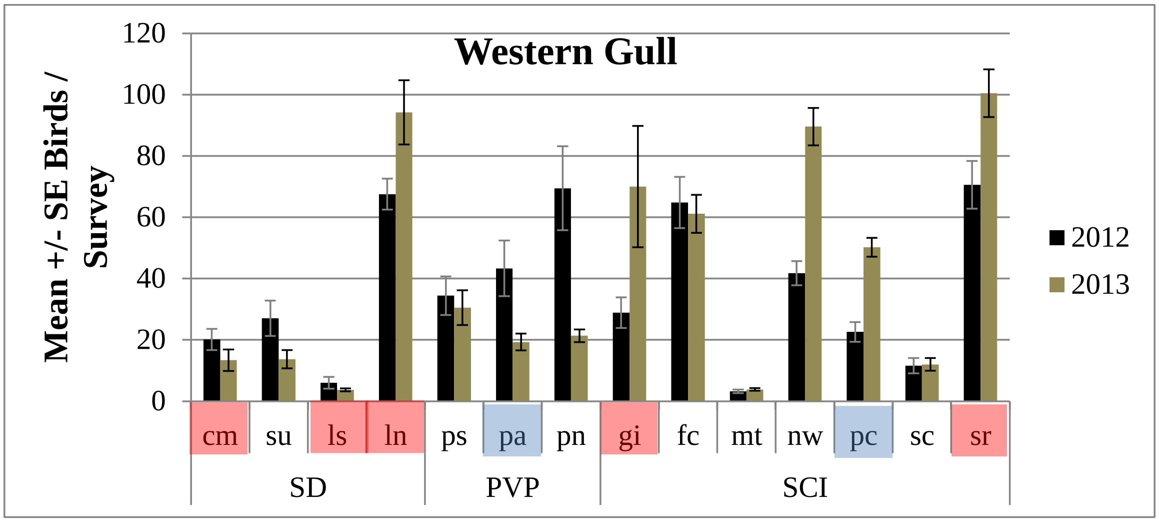


Figure 15. Mean ± SE numbers of Brandt's Cormorants and Pelagic Cormorants roosting inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

9.14, df = 2, 394, p <0.001) with the largest roosting numbers observed at Santa Cruz Island. There was a significant year x site interaction (F = 12.08, df = 2, 394, p <0.001) due to larger numbers of gulls roosting along the Palos Verdes Peninsula than Santa Cruz Island in 2012. There was also a significant year x MPA interaction (F = 5.11, df = 1, 394, p = 0.024) with more gulls roosting inside MPAs at Santa Cruz Island in 2012 and more roosting at control areas in 2013.

There were no significant differences in Brown Pelican roosting between



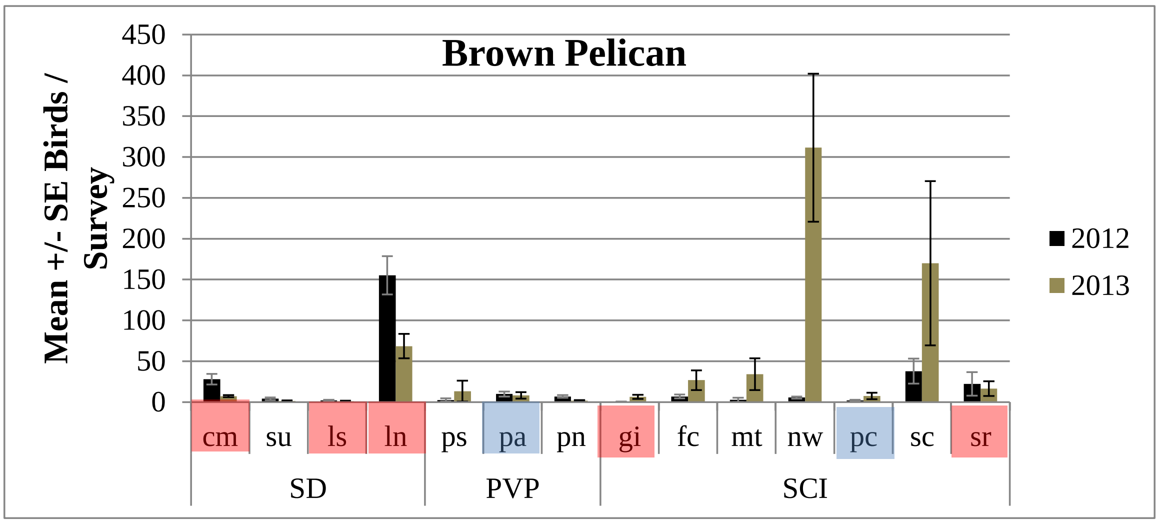


Figure 16. Mean ± SE numbers of Western Gulls and California Brown Pelicans roosting inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

years ($F = 1.86$, df = 1, 394, $p = 0.173$) or between MPAs and control areas ($F = 2.36$, df = 1, 394, p 0.594). There were marginally significant differences in roosting among sites ($F = 2.36$, df = 2, 394, $p = 0.096$), with the largest roosting numbers observed at Santa Cruz Island. There was a significant year x site interaction ($F = 6.51$, df = 2, 394, $p = 0.02$) with the largest numbers for 2012 observed in San Diego and the largest numbers for 2013 observed at Santa Cruz Island. There was a significant year x MPA interaction ($F = 8.85$, df = 1, 394, $p = 0.004$) with more pelicans roosting inside MPAs in 2012 and more roosting at control areas in 2013. Finally, there was a significant site x MPA interaction (F =

8.48, df = 2, 394, $p < 0.001$) with the more of the pelicans at San Diego roosting inside MPAs and more of the pelicans at Santa Cruz Island roosting at control sites.

Overall, patterns in roosting distribution for Brandt's Cormorants and Pelagic Cormorants were similar to those observed in breeding distribution. Roosting was highest for Brandt's Cormorants at North West Point and for Pelagic Cormorants at Forney's Cove on Santa Cruz Island. However, Brandt's Cormorants showed a broader roosting distribution, with large numbers roosting at Forney's Cove and Gull Island SMR and at Matlahuayl SMR in San Diego. Additionally, there were small numbers of Pelagic Cormorants roosting along the Palos Verdes Peninsula, but virtually no Brandt's Cormorants roosting in this area. Western Gulls were more widespread in their roost utilization. The only sites that showed small numbers of roosting gulls were Cabrillo SMR, Sunset Cliffs, and South La Jolla SMR in San Diego and Marine Terrace and Scorpion at Santa Cruz Island. Brown Pelicans were much more variable in their roost utilization among sites and between years. There were large numbers of pelicans roosting at North West Point and Scorpion (outside the SMR) in 2013 and moderate numbers roosting at Matlahuayl SMR in both years.

It is important to note that while we were able to monitor Brown Pelican roost utilization during our study period (April through July), this is not the peak roosting season for Brown Pelicans in southern and central California. Brown Pelicans breed on Anacapa and Santa Barbara Islands in southern California and the islands of Baja California, Mexico. They disperse north along the California coast after their breeding season. Howar and Robinette (2007) monitored seasonal roost utilization in central California over seven years (2001-2006) and showed that pelicans were virtually absent in the spring, appeared in low numbers throughout the summer, and showed moderate to high peaks in the fall and early winter. This is similar to patterns reported by Briggs et al. (1981), Briggs et al. (1983), and Capitolo et al. (2002) who all reported fall peaks in Brown Pelican roosting in southern and central California. We expected numbers at Santa Cruz Island to be higher and less variable given its proximity to the Anacapa Island breeding colony. However, we now suspect that breeding pelicans spend more time roosting at breeding sites during the breeding season.

<u>Human-caused Disturbance</u>

Through our studies in the Central Coast Study Region (CCSR) and the North Central Coast Study Region (NCCSR), we have learned that some seabird species lend themselves to more accurate disturbance monitoring than others due to factors such as habitat use and population size (Robinette et al. 2013b, McChesney and Robinette 2013). For example, Brandt's Cormorants are very abundant and use habitats like large nearshore rocks and coastal bluff tops, whereas Pelagic Cormorants are less abundant and tend to use cliff faces that may or may not be secluded. Thus, the disturbance rates observed in Brandt's

Cormorants may be more accurate due to the ease of viewing this species whereas disturbance rates in Pelagic Cormorants may be underestimated due to the difficulty in observing this species. We did not document any disturbances to Pelagic Cormorants at any study site in 2012 or 2013. Here, we report on three species that we feel are good surrogates to index overall disturbance conditions for each area: Brown Pelicans, Brandt's Cormorants, and Western Gulls.

Figures 17 through 19 show rates of human-caused disturbance organized into three general categories: water based, ground based, and air based. Also shown are levels of natural disturbance averaged over all sites within a given study area (i.e., Palos Verdes Peninsula, San Diego, or Santa Cruz Island). Figures 20 and 21 show more specific sources of both potential and actual disturbance. Potential disturbance includes any activity that occurred within our 1,500 ft (land/water) and 1,000 ft (air) thresholds regardless of whether or not it caused a disturbance. Actual disturbance includes only those activities that caused a disturbance. Only data on actual disturbances were used when calculating the disturbance rates shown in Figures 17 through 19.
Brown Pelican roost utilization was highest at sites on Santa Cruz Island (see Roost Utilization above), but disturbance rates were highest at mainland sites, especially in San Diego. Disturbances in 2012 were from a mix of mostly water and ground based sources (e.g., boats on the water, humans hiking along bluff tops, etc.). Disturbance rates were highest inside the Matlahuayl and Cabrillo SMRs, with ground based sources dominating disturbances at Matlahuayl SMR and ground and water based sources contributing roughly equally to disturbances at Cabrillo SMR. There were also high rates of disturbance inside the Point Vicente/Abalone Cove SMCAs with water and ground based sources contributing roughly equally. In 2013, disturbance rates were highest inside the Matlahuayl SMR and at the Sunset Cliffs control site, with sources being ground based. There were little to no disturbances recorded for other areas in 2013. Where human-caused disturbance was observed, the rates exceeded the natural disturbance rate for the area.

Disturbance rates for Brandt's Cormorants and Western Gulls were similar to those observed in pelicans. Disturbances were more widespread in 2012 and highest in 2013. Disturbance rates were highest at the San Diego sites, especially at the Cabrilloand Matlahuayl SMRs. Western Gull disturbance was also high along the Palos Verdes Peninsula and may be a better indicator of of the 12 categories occurring each year. Potential disturbances were dominated by water based sources in both years at Santa Cruz Island and by water and land based sources in both years at the San Diego sites. Humans on foot and human powered boats (e.g., kayaks) dominated the actual disturbances in both years, with helocopters, humans in the water (e.g., swimming), and recreational powered boats contributing to disturbances in 2012. Humans on foot dominated the disturbances at the Palos Verdes Peninsula in both years Additionally, shore-based fishing, commercial fishing, helocopters, and humans

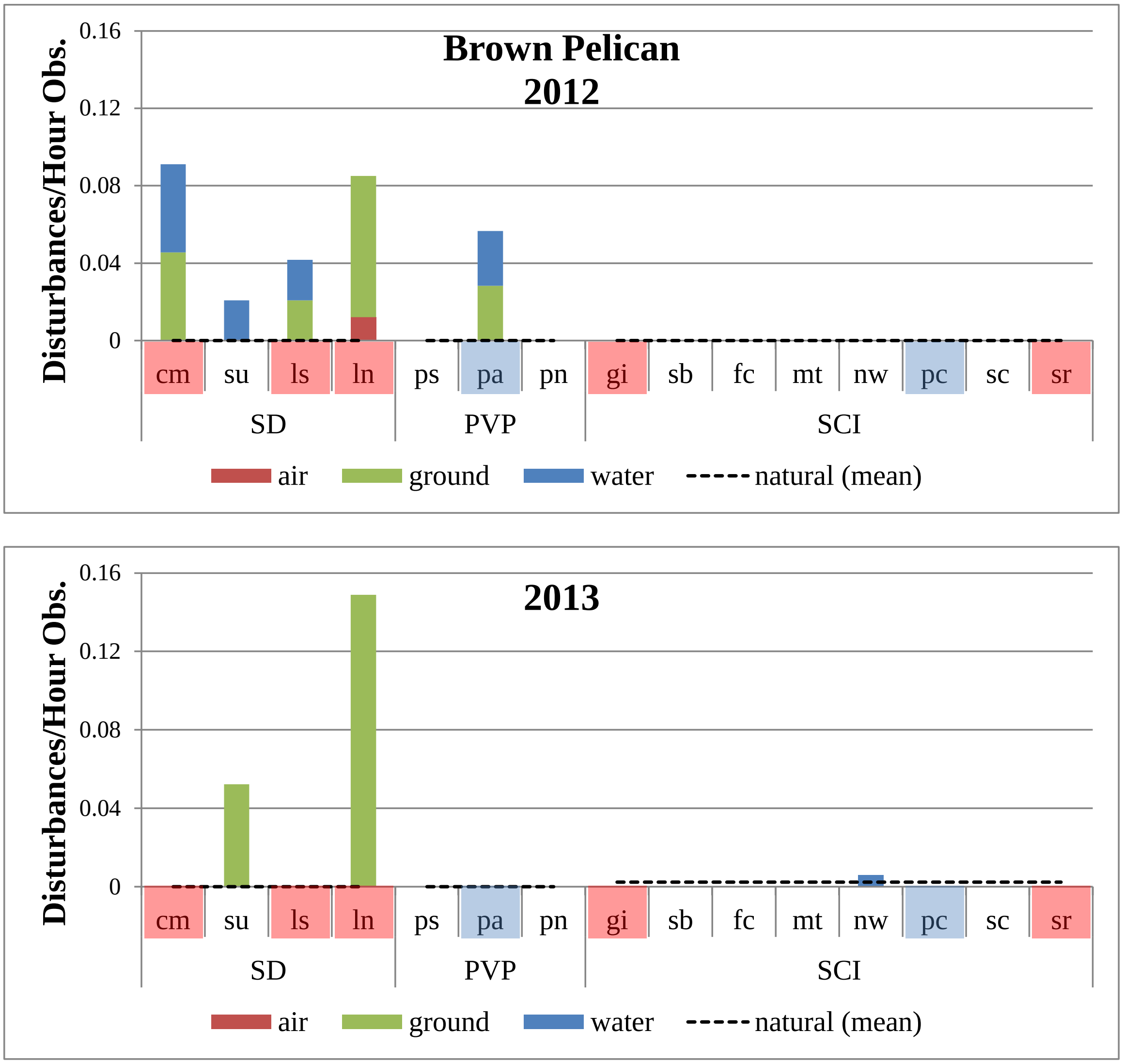


Figure 17. Number of human-caused disturbances per hour of observation for California Brown Pelicans inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

in the water contributed to disturbances in 2012 while shore-based fishing and humans with dogs contributed to disturbances in 2013. The sources causing disturbance at Santa Cruz Island were different each year. Recreational fishing boats, recreational power boats, and airplanes contributed to disturbance in 2012, while human powered boats, recreational powered boats, commercial fishing and helocopters contributed to disturbance in 2013. As mentioned above, disturbance rates were low at Santa Cruz Island.

All disturbances occurred outside of MPAs in 2012, but disturbances were

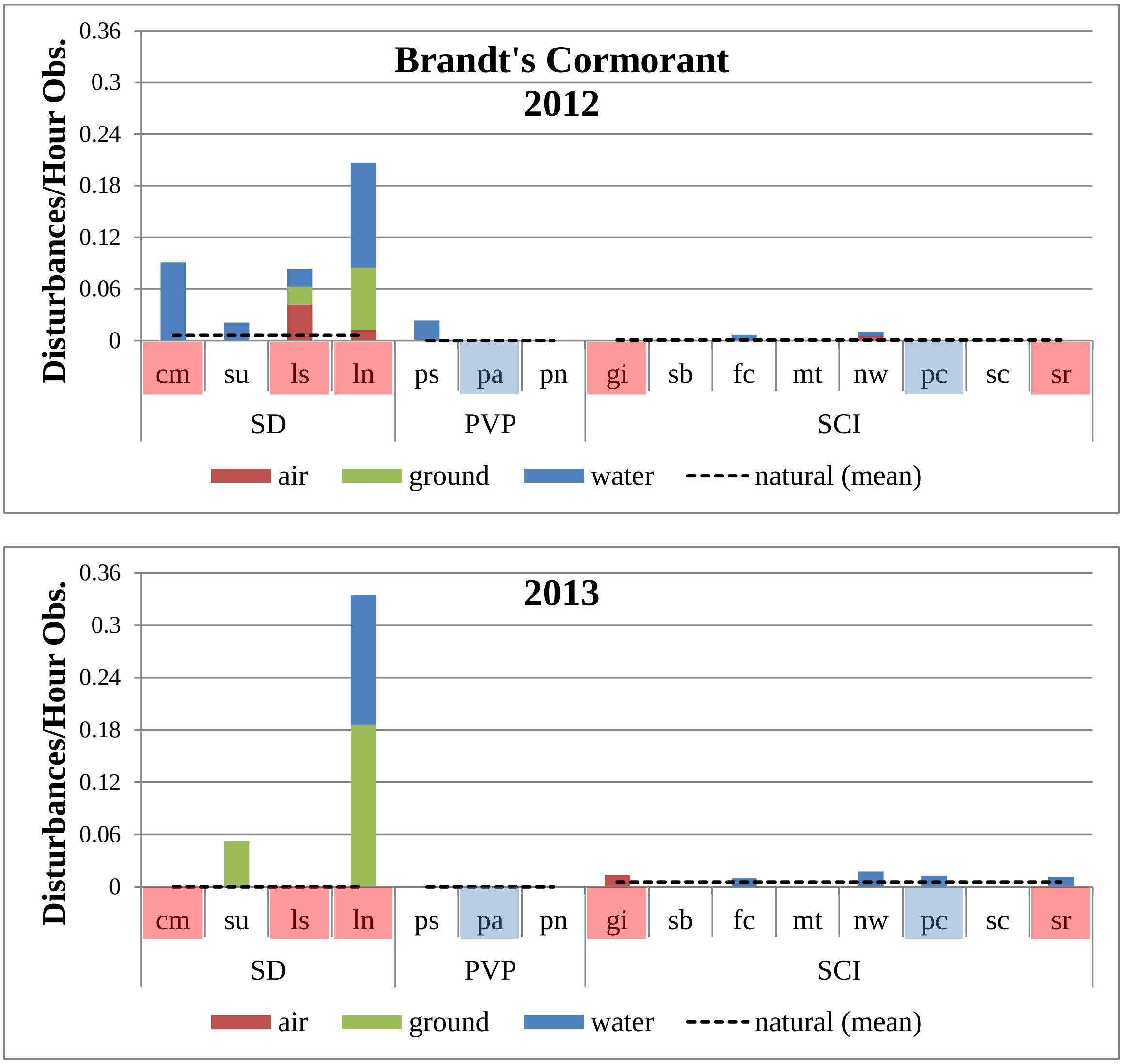
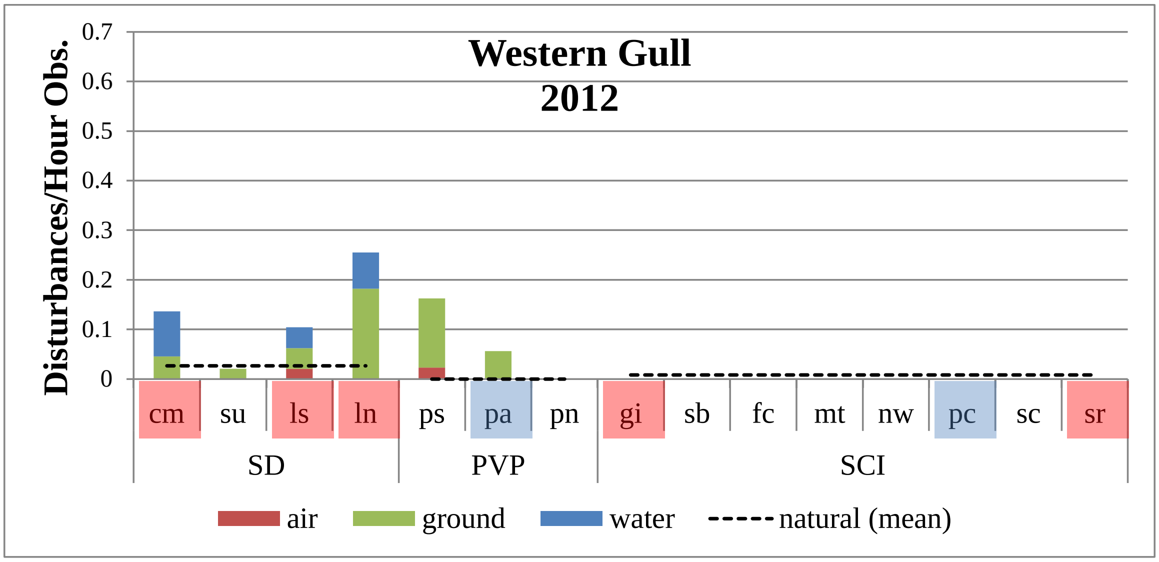


Figure 18. Number of human-caused disturbances per hour of observation for Brandt's Cormorants inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

recorded inside all three MPAs in 2013. Disturbance rates can be difficult to interpret as they can be highly variable among sites and years (Robinette et al. 2013b). In the NCCSR, disturbance rates measured during baseline monitoring did not exceed 0.05 disturbances per hour of observation (McChesney and Robinette 2013). However, Robinette et al. (2013b) measured rates as high as 0.13 disturbances per hour at Shell Beach, a coastal city similar to the Matlahuayl SMR site. Disturbance rates for Brandt's Cormorants inside the Matlahuayl SMR



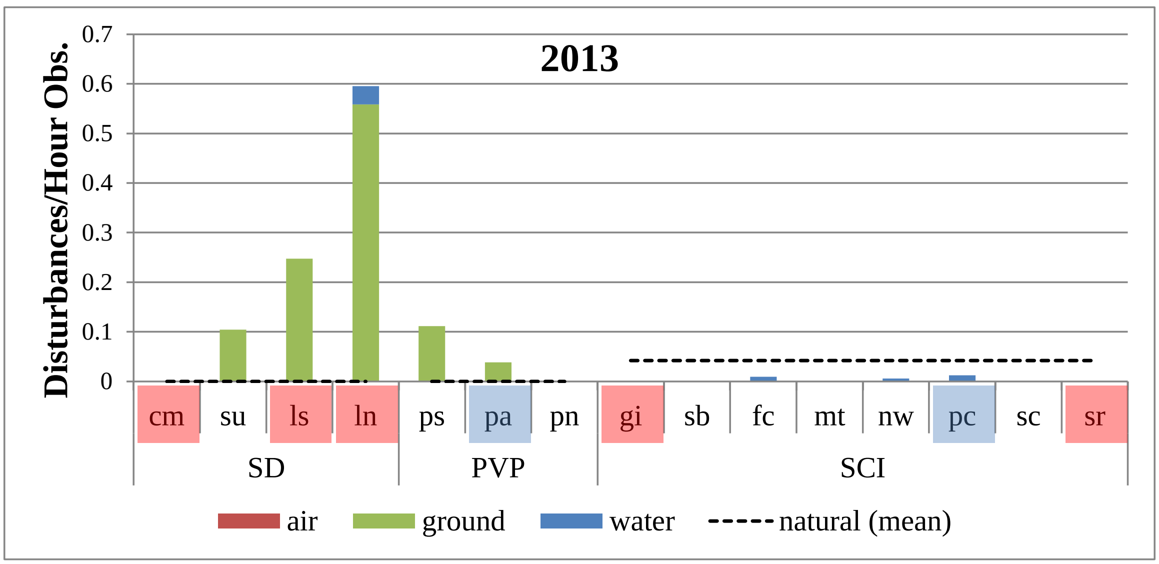


Figure 19. Number of human-caused disturbances per hour of observation for Western Gulls inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate breeding sites within SMRs and blue boxes indicate breeding sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

were as high as 0.12 disturbances per hour in 2012 and 0.19 disturbances per hour in 2013. Thus, disturbance rates at the Matlahuayl SMR appear high compared to other areas of the state. The use of outreach and special closures can be effective in reducing disturbance to seabird colonies. In the NCCSR, McChesney and Robinette (2013) showed a reduction in seabird disturbance after the establishment of the Egg (Devil's Slide) Rock to Devil's Slide Special Closure.

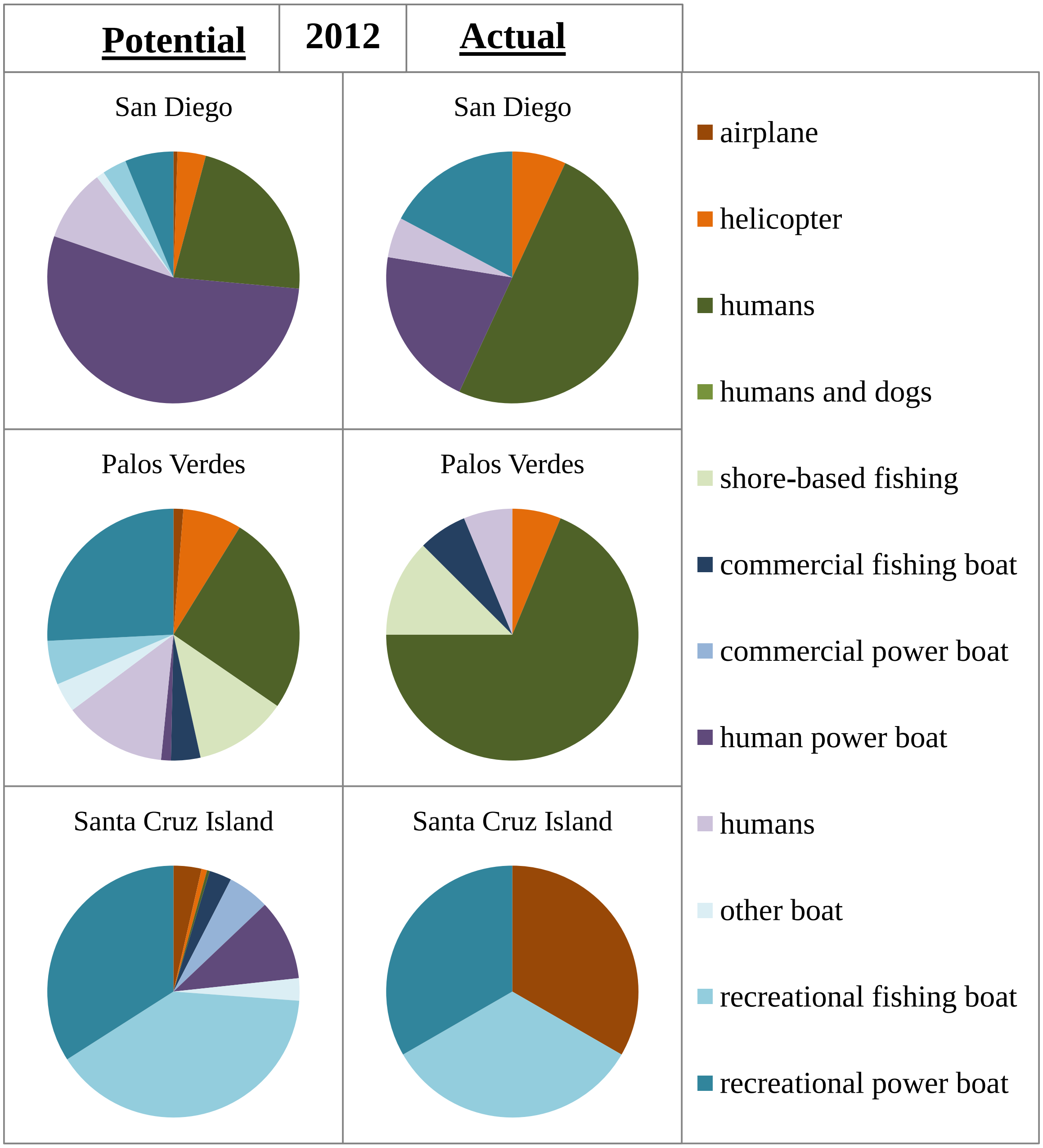


Figure 20. Sources of potential and actual human-caused disturbance to all seabird species at San Diego, Palos Verdes, and Santa Cruz Island in 2012.

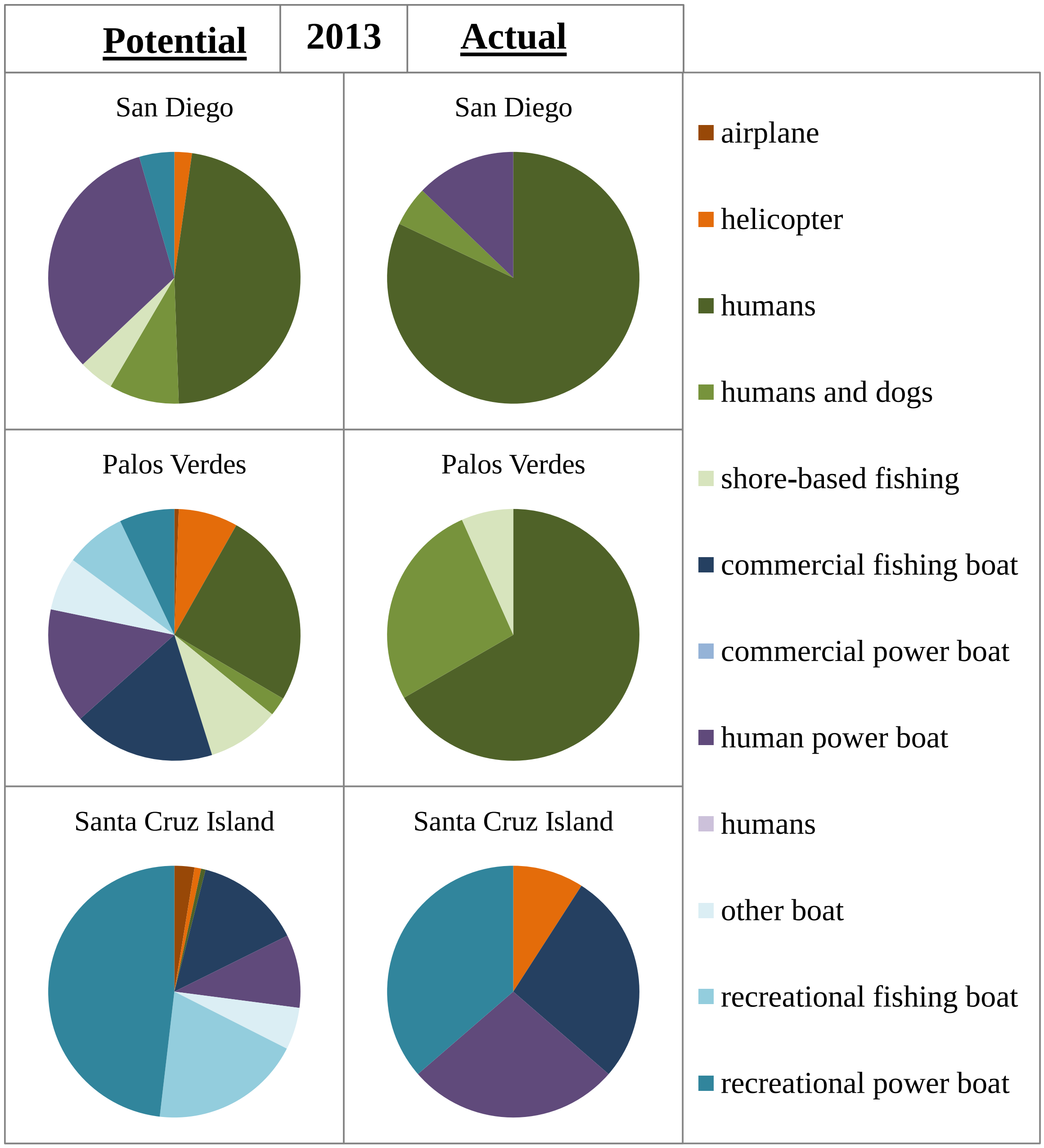


Figure 21. Sources of potential and actual human-caused disturbance to all seabird species at San Diego, Palos Verdes, and Santa Cruz Island in 2012.

Nearshore Foraging

Figure 22 shows the mean ± SE abundance, species richness, and species diversity (Shannon diversity index (H')) per hour of observation at island and mainland foraging plots. Analysis of variance showed no significant MPA impacts for abundance, richness or diversity (abundance: $F = 0.21$, $df = 1, 1047$, $p = 0.646$; richness: $F = 0.41$, $df = 1, 1044$, $p = 0.525$; diversity $F = 0.27$, $df = 1, 842$, $p = 0.600$). There were significant differences in abundance between years and among sites (year: $F = 7.60$, $df = 1, 1047$, $p = 0.006$; sites: $F = 27.41$, $df = 2, 1047$, $p < 0.001$). Overall abundance was higher in 2013 and at the Palos Verdes Peninsula. There were significant differences in species richness among sites ($F = 44.12$, $df = 2, 1044$, $p < 0.001$), but not between years ($F = 2.41$, $df = 1, 1044$, $p = 0.121$). Species richness was higher at the Palos Verdes Peninsula and Santa Cruz Island than at San Diego. Finally, there were significant differences in species diversity between years ($F = 5.77$, $df = 1, 842$, $p = 0.017$) and marginally significant differences among sites ($F = 2.41$, $df = 2, 842$, $p = 0.091$). As with species richness, species diversity was highest at the Palos Verdes Peninsula and Santa Cruz Island. Species diversity was also higher in 2013 than 2012.

Figures 23 and 24 show the three most common species foraging as individuals (as opposed to flocks with multiple birds) at island sites (Figure 23) and mainland sites (Figure 24). The species common at the island sites were the same as those common in foraging studies within the NCCSR and CCSR: Brandt's Cormorants, Pelagic Cormorants, and Pigeon Guillemots. These species prey heavily on young age classes of goundfishes (e.g., rockfishes and flatfishes), though Brandt's cormorants will also prey on pelagic species such as northern anchovies (Robinette et al. 2012). California Least Terns, Caspian Terns, and Double-crested Cormorants were the most common species foraging at mainland sites. All three species forage heavily in bay, estuary, and coastal ocean habitats and are likely taking species such as silverside smelt, surfperch, sculpins, and anchovies from our foraging study plots (Hatch and Weseloh 1999, Robinette 2003).

Analysis of variance showed no significant difference in Brandt's Cormorant foraging rates between years ($F = 2.00$, $df = 1, 1064$, $p = 0.157$), but significant differences among sites and inside versus outside of marine reserves (Sites: $F = 115.95$, $df = 2, 1064$, $p < 0.001$; MPAs: $F = 14.40$, $df = 2, 1064$, $p < 0.001$). Brandt's Cormorant foraging rates were higher at island sites and inside MPAs in both years. There were no significant year x MPA or site x MPA interactions (year x MPA: $F = 2.52$, $df = 1, 1064$, $p = 0.112$; site x MPA: $F = 1.36$, $df = 2, 1064$, $p = 0.255$), indicating that MPAs consistently showed higher foraging rates. However, there was a significant year x site interaction ($F = 22.90$, $df = 2, 1064$, $p < 0.001$). There were larger numbers of Brandt's Cormorants foraging as individuals at the island sites in 2013 than 2012, with highest foraging rates documented at the Gull Island SMR, Painted Cave SMCA and South Beach control sites. Brandt's Cormorants were more evenly

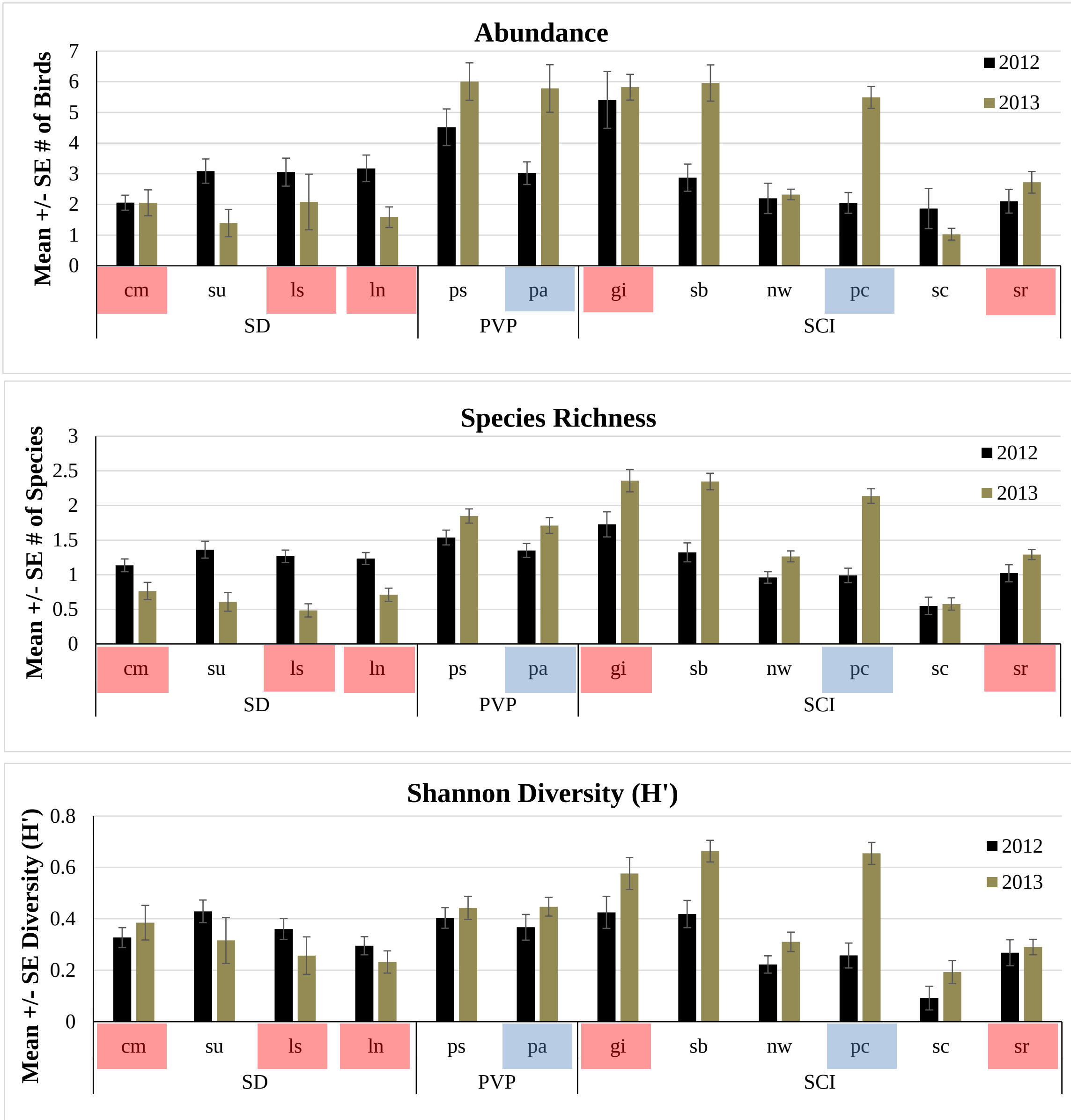


Figure 22. Mean ± SE abundance, species richness, and species diversity of seabirds foraging per hour of observation inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and San Diego (SD) in 2012 and 2013. Red boxes indicate foraging sites within SMRs and blue boxes indicate foraging sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

distributed in 2012, but showed higher rates at the Gull Island SMR.

Foraging rates for Pelagic Cormorants were significantly higher at island sites than the two mainland sites (F = 91.50, df = 2, 1064, p <0.001). There were no significant differences between years (F = 1.54, df = 1,1064, p = 0.215) or inside versus outside of MPAs ($F = 2.75$, df =1,1064, p 0.098). The low p-value for MPA effects reflects the tendency of Pelagic Cormorants to forage more in control plots at the island. Pelagic Cormorants foraged mostly at the South Beach control in both years and at the Scorpion control in 2012. However, foraging rates were high at the Painted Cave SMCA in 2013. There were no significant interactions among any of three factors (year x site: $F = 2.01$, df = 2, 1064, $p = 0.134$; year x MPA: $F = 0.22$, df = 1, 1064, $p = 0.642$; site x MPA: $F = 2.06$, df = 2, 1064, $p = 0.123$).

There were no significant differences in Pigeon Guillemot foraging rates between years ($F = 0.23$, df = 1, 1064, $p = 0.633$). There were significant differences among sites ($F = 60.59$, df = 2, 1064, $p <0.001$) and inside versus outside MPAs ($F = 7.97$, df = 1, 1064, $p = 0.005$), with more guillemots foraging at the island and inside MPAs. There were significant year x site and site x MPA interactions (year x site: $F = 3.25$, df = 2, 1064, $p = 0.039$; site x MPA: $F = 7.19$. df = 2, 1064, $p <0.001$) due to year differences and MPA differences being larger at the island than the mainland sites. Additionally, there was a significant interaction between year and MPA effects ($F = 12.52$, df = 1, 1064, $p <0.001$). Pigeon Guillemots foraged mostly within the Painted Cave SMCA in 2013 and were more evenly distributed among the North West Point, Painted Cave SMCA and Scorpion SMR sites in 2012.

There were significant differences in Least Tern foraging rates between years ($F = 5.54$, df = 1, 1064, $p = 0.019$), among sites ($F = 22.44$, df = 2, 1064, $p <0.001$), and inside versus outside of MPAs ($F = 12.16$, df = 1, 1064, $p <0.001$). Foraging rates were highest in 2012 and at San Diego. Overall, foraging rates were highest outside of reserves, though the highest rates in 2013 were observed inside the Cabrillo SMR. There were significant interactions among all three factors (year x site: $F = 5.79$, df = 2, 1064, $p = 0.003$; year x MPA: $F = 14.10$, df = 1, 1064, $p <0.001$; site x MPA: $F = 9.66$, df = 2, 1064, $p <0.001$) illustrating the opportunistic nature of Least Tern foraging habits. Though Least Terns breed at locations throughout the SCSR, we observed them foraging mostly at the San Diego sites. Foraging rates were highest at the Sunset Cliffs control site in 2012 and within the Cabrillo SMR in 2013. There are high numbers of Least Terns breeding at multiple sites within San Diego Bay and the coastal waters off Point Loma likely support important foraging habitat for these birds. The Palos Verdes Peninsula resides between the Venice Beach and Port of L.A. breeding sites. There were few Least Terns foraging at the Palos Verdes sites in both years. The Palos Verdes sites are likely outside the Least Tern's limited foraging range.

There were significant differences in Caspian Tern foraging rates between years ($F = 8.65$, df = 1, 1064, $p = 0.003$), with higher rates observed in 2012; among sites ($F = 81.25$, df = 2, 1064, $p <0.001$), with higher rates observed in San Diego; and inside of MPAs ($F = 4.10$, df = 1, 1064, $p = 0.043$). There was a significant year x site interaction ($F = 12.25$, df = 2, 1064, $p <0.001$) with foraging rates decreasing between 2012 and 2013 at San Diego while increasing

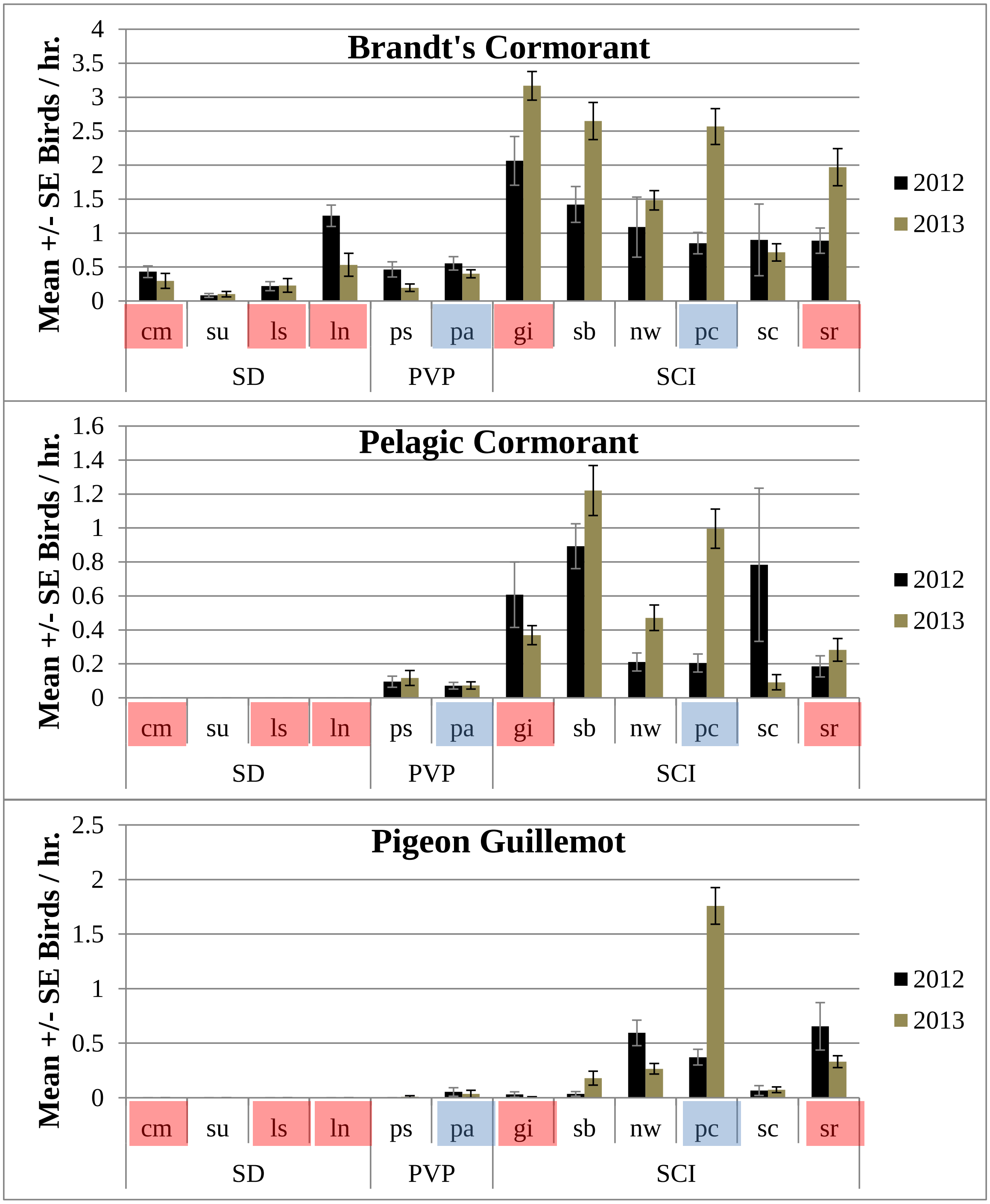


Figure 23. Mean ± SE number of Brandt's Cormorants, Pelagic Cormorants, and Pigeon Guillemots foraging per hour of observation inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and San Diego (SD) in 2012 and 2013. Red boxes indicate foraging sites within SMRs and blue boxes indicate foraging sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

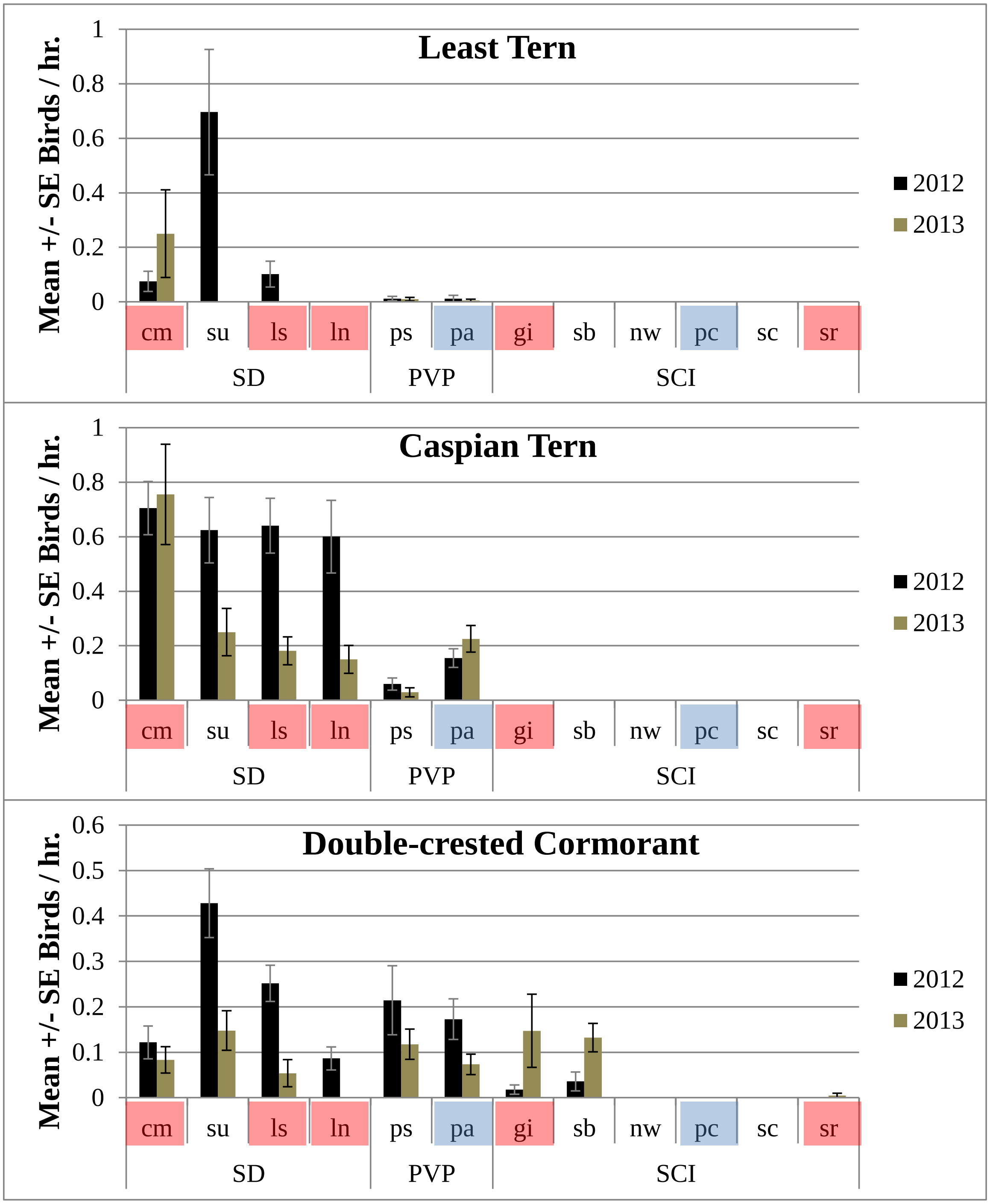


Figure 24. Mean ± SE number of California Least Terns, Caspian Terns, and Double-crested Cormorants foraging per hour of observation inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and San Diego (SD) in 2012 and 2013. Red boxes indicate foraging sites within SMRs and blue boxes indicate foraging sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

between years at Palos Verdes Peninsula. There were no significant year x MPA or site x MPA interactions (year x MPA: $F = 0.52$, $df = 1, 1064$, $p = 0.469$; site x MPA: $F = 1.65$, $df = 2, 1064$, $p = 0.193$). Overall, foraging rates for Caspian Terns were highest within the Cabrillo SMR in 2013 and the terns more evenly dispersed among San Diego sites in 2012. Foraging rates at the Palos Verdes Peninsula were low compared to San Diego sites, with more foraging inside the Point Vicente/Abalone Cove SMCAs than the control site.

There were significant differences in Double-crested Cormorant foraging rates between years ($F = 17.27$, $df = 1, 1064$, $p <0.001$), with higher rates observed in 2012; among sites ($F = 38.55$, $df = 2, 1064$, $p <0.001$), with higher rates observed in San Diego; and outside of MPAs ($F = 19.86$, $df = 1, 1064$, $p <0.001$). There were significant year x site and site x MPA interactions (year x site: $F = 16.45$, $df = 2, 1064$, $p <0.001$; site x MPA: $F = 11.65$, $df = 2, 1064$, $p <0.001$) and marginally significant year x reserve interactions ($F = 2.82$, $df = 1, 1064$, $p = 0.094$). Overall, foraging rates for Double-crested Cormorants were highest at the Sunset Cliffs control site, South La Jolla SMR and both Palos Verdes sites in 2012. Double-crested comorants were more evenly dispersed across sites in 2013 and showed moderate foraging rates at the Gull Island SMR and South Beach control site in Santa Cruz Island.

Figure 24 shows the number of foraging flocks observed at all sites in 2012 and 2013. There were more foraging flocks observed at mainland sites in 2012 and more at Santa Cruz Island in 2013. The largest flocks observed in both years were at SCI and dominated by Brandt's Cormorants (Figure 25). The largest numbers of Brandt's Cormorants in foraging flocks occurred inside the Painted Cave SMCA in both years. There were also large numbers of Brandt's Cormorants foraging within the Gull Island SMR and at South Beach in 2013. With the excepton of Western Gulls within the Gull Island SMR in 2013, abundances for all other species were higher at mainland sites. Western Gulls and Brown Pelicans appeared evenly distributed among mainland sites with no obvious preference for MPAs. There was a greater diversity of species foraging in flocks off the Palos Verdes Peninsula and greater numbers of Elegant Terns and Sooty Shearwaters in both years.

One interesting observation was that Brandt's Cormorants foraged more in flocks at Santa Cruz Island sites in 2012 and as individuals in 2013. Breeding productivity for Brandt's Cormorants at Santa Cruz Island was higher in 2013 than 2012. We are not entirely sure how to interpret these results as we have only two years' worth of data. Diet data from the Farallone Islands and Point Arguello in central California can switch between pelagic and demersal prey, depending on what is available (Elliott et al. 2014). Thus, we suspect that Brandt's Cormorant foraging behavior is illustrating differences in the abundance of particular fish groups between the islands and mainland. In 2012, there was likely a low abundance of available prey around the islands as reflected in the low breeding productivity at Santa Cruz Island in that year. While there was a higher abundance of anchovies within the SCSR in 2013 (see

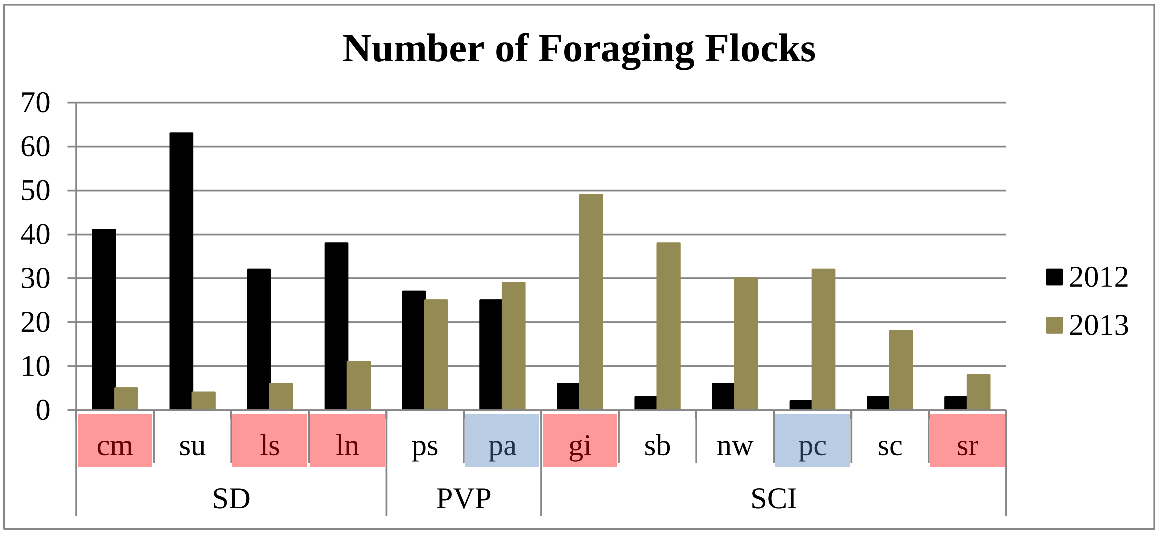


Figure 25. Number of foraging flocks observed inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate foraging sites within SMRs and blue boxes indicate foraging sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

Baseline Conditions below), they likely had a more coastal distribution and were less available to Brandt's Cormorants breeding on the island. The higher occurrence of individually foraging Brandt's Cormorants at island sites in 2013 indicates that they were taking more mid-water and demersal prey in that year. Developing a time series of seabird foraging throughout the SCSR will allow us to better interpret these types of results.

Characterization of Baseline Conditions

Oceanographic conditions during the baseline period appeared somewhat contradictory, with cool productive waters persisting throughout the period, but low abundances of species like Clupeiform fishes (e.g., anchovies, herrings) that typically thrive under these conditions. The cool, productive conditions are the result of a generally negative state of the Pacific Decadal Oscillation (PDO) that has persisted since 2007 and above average upwelling conditions in 2012 and 2013 (Wells et al. 2013). However, the offshore advection created during intense upwelling may have pushed the feeding and spawning habitat of Clupeiform species further offshore, perhaps beyond the shelf break. Upwelling conditions relaxed in the summer of 2013, and anchovy abundance increased in trawl surveys (PacOOS 2013) and in the diet of Least Terns at many of the colonies we surveyed. In 2012, El Nino like conditions developed in spring and summer, but then dissipated by fall. While these conditions had no apparent impact on sea surface temperatures, Least Tern

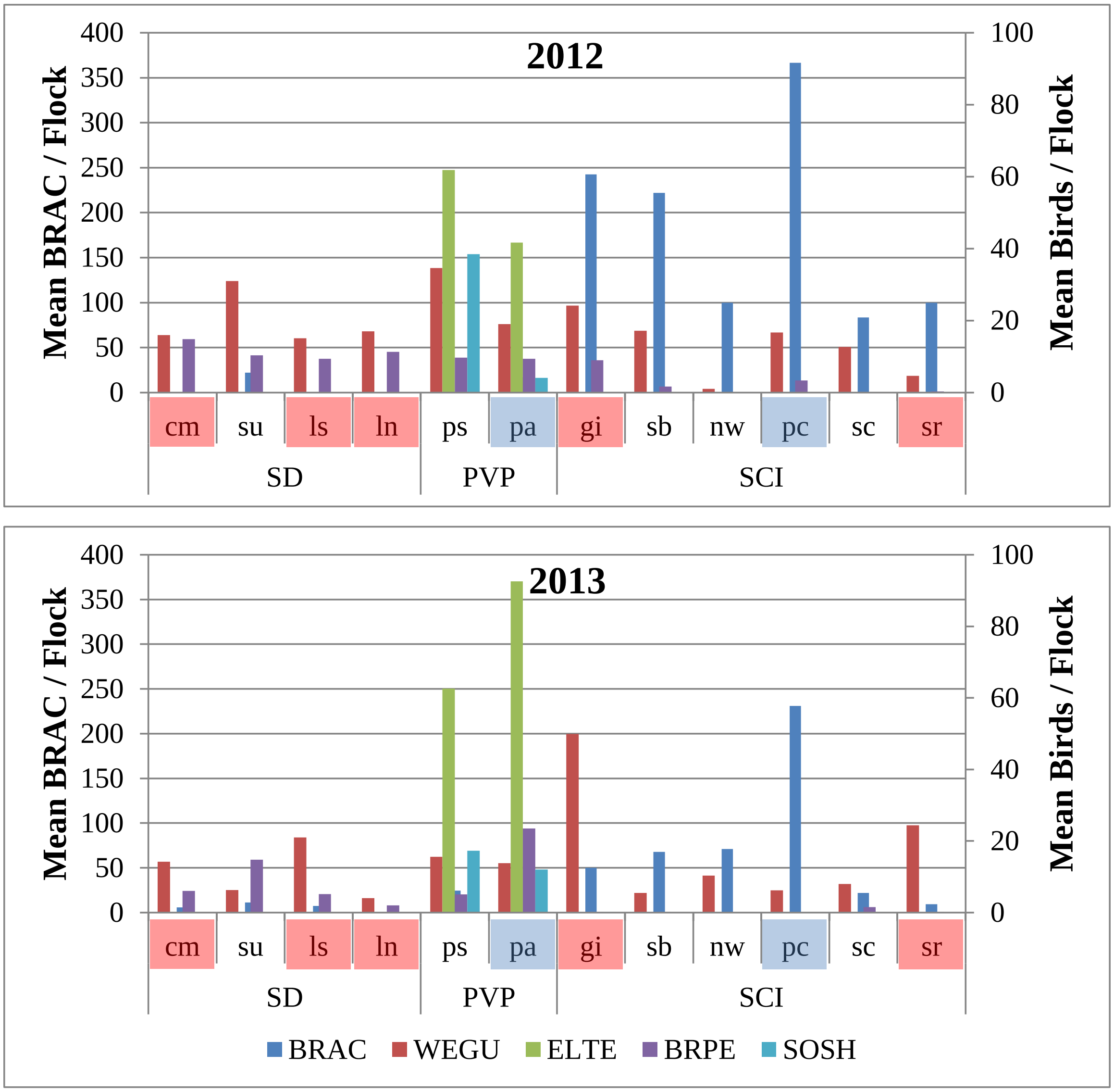


Figure 26. Mean number of Brandt's Cormorants (BRAC), Western Gulls (WEGU), Elegant Terns (ELTE), Brown Pelicans (BRPE), and Sooty Shearwaters (SOSH) per flock observed inside and outside of MPAs at San Diego (SD), Palos Verdes Peninsula (PVP), and Santa Cruz Island (SCI) in 2012 and 2013. Red boxes indicate foraging sites within SMRs and blue boxes indicate foraging sites within SMCAs. cm = Cabrillo SMR, su = Sunset Cliffs, ls = South La Jolla SMR, ln = Matlahuayl SMR, ps = South Palos Verdes, pa = Point Vicente/Abalone Cove SMCA, pn = North Palos Verdes, gi = Gull Island SMR, fc = Forney's Cove, mt = Marine Terrace, nw = North West Point, pc = Painted Cave SMCA, sc = Scorpion, and sr = Scoprion SMR.

breeding productivity was low at all sites. Breeding productivity for Brandt's Cormorants at Santa Cruz Island was also low in 2012, indicating a possible response to the El Nino-like conditions.

Recent conditions appear to be favoring species that thrive when nearshore conditions are cool and productive (e.g., rockfishes, flatfishes, market squid, lingcod). YOY rockfish were abundant in Least Tern diets at multiple sites in both years. However, the poor reproductive success shown in Least Terns throughout the SCSR in both years indicates that the survival of these young-of-the-year fishes may have been low during the baseline period. If this is the case, then we would expect fish recruitment to coastal communities to be low during the baseline period and we should therefore expect changes within MPAs to be slow during the initial years of implementation. At the very least, our results indicate that assessing ocean productivity during the baseline period will not be straightforward and will require hindsight as monitoring time series are further developed.

There was no single MPA on Santa Cruz Island that provided blanket protection for all seabirds. In fact, most breeding and roosting occurred outside of MPAs. The Gull Island SMR hosted moderate numbers of breeding and roosting Brandt's Cormorants. All rocky coast focal species showed high foraging rates in the Painted Cave SMCA and Brandt's and Pelagic Cormorants also showed high rates for the Gull Island SMR. Alongthe mainland coast, the Point Vicente/Abalone Cove SMCAs are protecting important foraging habitat for flock forming seabirds like Brown Pelicans, Elegant Terns, and Sooty Shearwaters, the Cabrillo SMR is protecting important habitat for coastal foragers like Least Terns, Caspian Terns and Double-crested Cormorants, and the Matlahuayl SMR is protecting important foraging habitat for Brandt's Cormorants. The Matlahuayl SMR is also protecting important breeding and roosting habitat for Brandt's Cormorants and important roosting habitat for Brown Pelicans. However, we recorded the highest disturbance rates at this location. While the presence of the Matlahuayl SMR should help with reducing disturbance rates, outreach efforts that target specific user groups will be necessary to effectively reduce human-caused disturbance at this site.

Our results from Least Tern diet indicate that most colonies are relying on nearshore ocean habitats for prey. Only the colony within the Bolsa Chica Basin SMCA appears to be foraging almost exclusively within the estuary. This may have been due to poor foraging conditions in coastal waters. Robinette (2003) found northern anchovies in the diet of Least Terns at Bolsa Chica in 2000. Thus, these birds appear to forage in coastal ocean habitats when prey is available. The lack of exclusively estuarine prey in the diets at other colonies located adjacent to estuaries may indicate that these estuaries are not providing adequate prey for Least Terns. Even with the alternative estuarine habitat available to terns at Bolsa Chica, breeding productivity was low at this site. Robinette et al. (2013) found a similar dependence on nearshore fishes at a Least Tern colony in central California. Using a 13-year time series, they showed a positive relationship with breeding productivity and the occurrence of juvenile anchovy and YOY rockfish in the diet. If this relationship proves to be true for Least Terns within the SCSR, then this species will be a good broad scale indicator juvenile fish survival and recruitment to habitats throughout the mainland coast of the SCSR.

<u>Initial Changes Within the SCSR</u>

We did not to expect to observe changes in the parameters we measured within our two-year baseline study period. While there is short-term variability in all the parameters we measured, changes due to MPA implementation will happen over longer periods of time. For example, changes in breeding productivity will respond to variability in ocean productivity over the short term and to MPA establishment over the long term as adult fish stocks, and thus spawning biomass, are built up within protected areas. Similarly, breeding populations may initially respond to reduced disturbance rates to breeding colonies, but more sustained population growth will happen as fish stocks are replenished. However, it is possible for rates of human-caused disturbance to show short-term responses to MPA implementation, especially if targeted outreach efforts are a component of MPA implementation. In the NCCSR, there was a measureable decrease in boat disturbances inside the Egg (Devil's Slide) Rock to Devil's Slide Special Closure (McChesney and Robinette 2013). Though there were no special closures established in the SCSR, the NCCSR nonetheless provide encouraging evidence that rates of human-caused disturbance can be decreased through management actions.

Behavioral parameters for seabirds like foraging rates and distribution may also show short-term responses to MPA implementation. In South Africa, Pichegru et al. (2012) illustrated how a fishing closure can have immediate impacts on African Penguin (Spheniscus demersus) foraging behavior. They found more penguins foraging inside the closed area and an overall decrease in foraging effort by breeding penguins. Similarly, Bertrand et al. (2012) showed seabird behavioral responses to intense localized fishing effort in the Humboldt Current System off Peru. Intense fishing created regional depletion, taking 100 times more than the requirement of breeding seabirds over the same period. With the onset of fishing, breeding seabirds increased their range of daily trips and depths of dives. The more the fishery depleted local prey abundance, the farther the breeding seabirds needed to forage from the colony to obtain food. One main difference between our study and those of Pichegru et al. and Bertrand et al. is that birds in those studies were competing directly with fisheries for prey, whereas the birds we are monitoring are consuming the juvenile age classes of fished species. While we expect our focal species to benefit from decreased fishing inside MPAs, the response will take longer as fishing within the NCCSR does not directly target seabird prey.

<u>Opportunities for Integration</u>

We have identified two opportunities to collaborate with other SCSR baseline monitoring groups. First, we plan to produce a manuscript that investigates the potential of seabird foraging distributions to proxy juvenile fish recruitment inside and outside of SCSR MPAs. We plan to integrate our data on nearshore foraging rates with juvenile fish abundance from kelp forest diver surveys. We will integrate both data sets with regional measures of oceanographic productivity (e.g., upwelling, sea surface temperature) and larval fish abundance to assess seabird responses to spatio-temporal variability in fish recruitment. Second, we plan to investigate relationships between Black Oystercatcher abundance, with rocky intertidal invertebrate abundance and rates of human-caused disturbance. The results of this analysis will help us understand the potential for Black Oystercatchers to breed at mainland sites within the SCSR.

<u>Seabirds as Indicators of Ecosystem Condition</u>

Seabirds have proven to be reliable indicators of change in the marine environment. Seabirds are highly visible and easily enumerated and dietary information can be obtained for many species when conditions allow. Several studies conducted over the past 30 years have shown that seabirds respond predictably to changes in prey abundance and can thus be used as reliable indicators of change in prey populations (see Cairns 1992, Hatch and Sanger 1992). Changes in a variety of seabird demographics and foraging parameters have been successfully used to, among other things, detect changes in prey abundance on several temporal and spatial scales (e.g., Montevecchi and Myers 1995), changes in prey age-class structure (e.g., Sunada et al. 1981, Davoren and Montevecchi 2003), responses of prey populations to climate change (e.g., Miller and Sydeman 2004), and changes in local food-web structure (e.g., Montevecchi and Myers 1996). Thus, studies of seabird ecology can provide timely and important information on local oceanography and marine ecosystem structure that would otherwise be difficult and expensive to obtain. Monitoring seabird ecology can contribute to MPA management in two ways: 1) tracking variability in regional oceanographic conditions and 2) indexing temporal and spatial variability of fish recruitment to nearshore habitats.

The recovery rate of populations released from fishing pressure will be largely determined by the degree to which new individuals recruit to MPAs (Warner and Cowen 2002). Juvenile recruitment in marine organisms is largely dependent on both biophysical processes such as upwelling and the life history strategies of the organisms being considered (Caley et al. 1996). For species with pelagic larval stages, recruitment will be largely dependent on 1) the number of larvae produced in a given year, 2) the survival of those larvae to settlement age, and 3) delivery of those larvae to adult habitat (Jenkins and Black 1994, Levin 1996, Wing et al. 1995a). The first two conditions are greatly affected by regional oceanographic conditions while the third condition is greatly affected by nearshore ocean currents. Robinette et al. (2007) investigated sanddab (Citharichthys spp.) recruitment around the Vandenberg SMR and illustrated how seabird diet can be integrated with estimates of regional larval abundance and upwelling to investigate spatial and temporal variability in recruitment. They found that regional larval sanddab abundance was highest when upwelling was persistent. They also showed that recruitment of sanndabs differed on opposing sides of a coastal promontory, with leeward recruitment strongest during persistent seasonal upwelling and windward recruitment strongest during variable upwelling. Dispersal patterns of planktonic larvae are often influenced by the phasing and amplitude of coastal upwelling, showing offshore transport during periods of persistent upwelling and onshore transport during periods of relaxation (Sakuma and Larson 1995, Sakuma and Ralston 1995, Wing et al. 1995a). However, many studies have provided evidence that localized retention areas prevent the offshore transport off planktonic larvae (Wing et al. 1995b, 1998, Graham and Largier 1997, Mace and Morgan 2006a,b). These studies have found persistent, predictable retention areas in the lee of coastal promontories central California. Robinette et al. (2012) investigated the foraging distribution of multiple seabird species around the Vandenberg SMR and showed that foraging distributions were consistent over a six-year period. Seabirds that feed on juvenile fishes foraged mostly in the lee of the coastal promontory where Robinette et al. (2007) showed fish recruitment should be highest. Together, these studies suggest that the geographic location of an MPA will influence the rate of juvenile recruitment and thus the rate of population and community-level change within MPA boundaries. Furthermore, seabirds can play an important role in identifying areas of high juvenile fish recruitment and tracking variability in recruitment through time.

The success of MPA management will be determined by managers' ability to 1) understand MPA effectiveness and 2) adapt to shortfalls in MPA performance. Both of these will require an understanding of the mechanisms causing change within MPAs. We propose that the best way to understand these mechanisms is to take a two-pronged approach, looking at 1) broad-scale oceanographic conditions to understand variability in regional primary and secondary productivity and 2) fine scale tracking of how regional primary and secondary productivity is delivered to MPAs and areas outside MPA boundaries. Seabirds can provide information for both of these approaches. Monitoring seabird breeding population sizes and reproductive success can complement indices of ocean climate to track interannual variability in ocean productivity while monitoring seabird diet and foraging can provide information on temporal and spatial variability in fish recruitment. Understanding and tracking both of these mechanisms will allow managers to set realistic expectations for how quickly change should occur within individual MPAs and the SCSR as a whole.

Recommendations for Continued Seabird Monitoring

Successful adaptive management of the SCSR network will depend on continued long-term monitoring to inform managers of the network's ongoing status. Long-term monitoring is important due to the highly variable nature of the California Current System. There are two compelling reasons to include seabirds in continued MPA monitoring. First, seabirds are an integral component of nearshore ecosystems and will benefit from MPA protection. However, the benefits of MPAs on coastally breeding seabirds have not been well studied. California's network of MPAs offers a unique opportunity to document these benefits. Second, seabirds are reliable indicators of change within marine ecosystems and can help track the underlying mechanisms governing change within MPA boundaries. Below, we outline seven recommendations for continued seabird monitoring within the SCSR.

1) The SCSR Monitoring Plan should be updated so that individual marine bird species are represented within the appropriate ecosystem feature. The current SCSR Monitoring Plan contains marine birds within some ecosystem features, but we feel many of these species can contribute to more ecosystem features. Specifically, most coastally breeding seabirds are dependent on prey from multiple ecosystem features. By monitoring both the breeding and foraging ecology of these species, it is possible to gain information on multiple ecosystem features without additional surveys. We outlined how seabirds can contribute to SCSR key attributes and indicators in Table 4. We also made recommendations for the use of other marine birds (i.e., shorebirds, waterfowl and other piscivorous birds) within the intertidal and estuary/wetland ecosystem features.

2) The sources and rates of human-caused disturbance should continue to be documented inside and outside of MPAs. MPAs can provide direct benefits to seabird populations, but outreach and enforcement will be a necessary component of their success. Data collected on human-caused disturbance can be used to guide the efforts of MPA Watch and similar groups. Additionally, time spent documenting human-caused disturbance can be used to document illegal fishing as well. Such efforts will reinforce the protection provided by MPAs.

3) Measures of seabird breeding productivity should be integrated with indices of ocean climate and direct measures of ocean productivity. It is important to recognize that much of the change occurring within MPA boundaries will be driven by regional oceanographic conditions governing primary and secondary productivity. Integrating seabird metrics with direct measures of ocean productivity will create a more holistic index of annual oceanographic conditions. Combining this regional approach with the fine scale approach of monitoring inside and outside of individual MPAs will help scientists and resource managers track the mechanisms leading to change within the SCSR network and better interpret the changes observed within individual MPAs.

4) Seabird foraging rates should continue to be monitored inside and outside of

MPAs in order to 1) better interpret annual variability in breeding population size and breeding productivity by documenting annual variability in prey distribution and 2) track where fish recruitment is likely occurring within nearshore habitats. Data on foraging rates can be integrated with indices of ocean climate, estimates of regional larval abundance, and fine-scale maps of nearsurface currents to investigate both temporal and spatial variability in the ocean conditions affecting fish recruitment. Understanding annual variability in fish recruitment for individual MPAs will help managers interpret the changes observed within these MPAs and establish realistic expectations for their performance. Furthermore, it will help managers determine if MPA boundaries need to be moved to increase the effectiveness of a given MPA.

Table 4. Recommended inclusion of marine birds as indicators/focal species for future monitoring efforts within the SCSR.

<table>
<tr><th>Ecosystem Feature</th><th>Key Attribute</th><th>Indicator/Focal Species</th></tr>
<tr><td rowspan="9">Kelp and Shallow (0-30m) Rock</td><td rowspan="7">Primary: Seabird Breeding & Foraging Ecology</td><td>Pelagic Cormorant Breeding Population Size & Fledging Rate</td></tr>
<tr><td>Brandt's Cormorant Breeding Population Size & Fledging Rate</td></tr>
<tr><td>Pigeon Guillemot Breeding Population Size</td></tr>
<tr><td>Pelagic Cormorant Foraging Rates</td></tr>
<tr><td>Brandt's Cormorant Foraging Rates</td></tr>
<tr><td>Pigeon Guillemot Foraging Rates</td></tr>
<tr><td>Least Tern Diet</td></tr>
<tr><td rowspan="2">Optional: Seabird Diet</td><td>Pigeon Guillemot Diet</td></tr>
<tr><td>Brandt's Cormorant Diet</td></tr>
<tr><td rowspan="6">Mid-Depth (30-100m) Rock</td><td rowspan="4">Primary: Seabird Breeding & Foraging Ecology</td><td>Brandt's Cormorant Breeding Population Size & Fledging Rate</td></tr>
<tr><td>Pigeon Guillemot Breeding Population Size</td></tr>
<tr><td>Brandt's Cormorant Foraging Rates</td></tr>
<tr><td>Pigeon Guillemot Foraging Rates</td></tr>
<tr><td rowspan="2">Optional: Seabird Diet</td><td>Brandt's Cormorant Diet</td></tr>
<tr><td>Pigeon Guillemot Diet</td></tr>
</table>

Table 4 continued.

Ecosystem Feature	Key Attribute	Indicator/Focal Species
Rocky Intertidal	Primary: Black Oystercatcher Breeding & Foraging Ecology	Black Oystercatcher Breeding Population Size & Fledging Rate
		Black Oystercatcher Foraging Rates
		Black Oystercatcher Diet
	Optional: Predatory Marine Birds	Abundance of Shorebirds & Piscivorous Birds
		Diversity of Shorebirds & Piscivorous Birds
		Abundance of Black Oystercatchers
Soft-Bottom Subtidal (0-100m)	Primary: Seabird Breeding & Foraging Ecology	Brandt's Cormorant Breeding Population Size & Fledging Rate
		Pigeon Guillemot Breeding Population Size
		Brandt's Cormorant Foraging Rates
		Pigeon Guillemot Foraging Rates
		Least Tern Diet
	Optional: Seabird Diet	Brandt's Cormorant Diet
		Pigeon Guillemot Diet
Estuary& Wetland	Primary: Waterbird Habitat Use	Abundance of Shorebirds, Waterfowl, and Piscivorous Birds
		Diversity of Shorebirds, Waterfowl, and Piscivorous Birds
		Least Tern Diet
	Optional: Predatory Marine Bird Foraging	Foraging Rates of Piscivorous Birds
Soft-Bottom Intertidal & Beach	Primary: Predatory Marine Birds	Abundance of Shorebirds
		Diversity of Shorebirds
	Optional: Western Snowy Plover Breeding	Western Snowy Plover Breeding Population Size & Fledging Rate

Table 4 continued.

Ecosystem Feature	Key Attribute	Indicator/Focal Species
Nearshore Pelagic	Primary: Seabird Breeding Ecology	Brandt's Cormorant Breeding Population Size & Fledging Rate
		Brown Pelican Breeding Population Size & Fledging Rate
	Optional: Seabird Diet	Brandt's Cormorant Diet
		Brown Pelican Diet
		Cassin's Auklet Breeding Population Size and Fledging Rate

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