# Roosting Patterns of Brown Pelicans at Mugu Lagoon in June-October 2001

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## INTRODUCTION

In this progress report, we provide an update on the monitoring of California brown pelicans (*Pelecanus occidentalis californicus*) at Mugu Lagoon, California. This work is being conducted by Humboldt State University (HSU) in cooperation with Naval Base Ventura County, Point Mugu (NBVCPM) and the U.S. Geological Survey (USGS; Western Ecological Research Center). The California brown pelican is a U.S. federal and California-state listed endangered subspecies whose current northern breeding limit occurs at Anacapa Island in the Southern California Bight (SCB) (Carter et al. 1992; Gress 1995). The nearest large mainland roost occurs at Mugu Lagoon, located within NBVCPM, approximately 26 km east of Anacapa Island. Ground monitoring of roosting brown pelicans at Mugu Lagoon will be undertaken in 2001-2003 to comply with a U.S. Fish and Wildlife Service programmatic biological opinion related to base activities (USFWS 2001). In addition, aerial photographic surveys of Mugu Lagoon and other pelican roosts throughout the SCB were conducted in January, May and September 1999-2001 as part of a cooperative study between USGS and HSU to examine the at-sea distribution of pelicans and other seabirds throughout the SCB (McChesney et al. 2001). SCB-wide roost surveys also helped us to assess the relative importance of Mugu Lagoon as a roost site within the SCB. We supplemented USGS/HSU roost surveys with: 1) SCB-wide roost surveys in July 2000 and July 2001; and 2) aerial photographic surveys of major roosts near Mugu Lagoon (between Santa Barbara Harbor and Point Dume, including East Anacapa Island) from June 2000 to December 2001 in months when SCB-wide surveys were not flown. Together, these roost surveys will allow a better understanding of roost-use patterns and movements between nearby roosts, especially in the vicinity of Mugu Lagoon.

Numbers of pelicans in the SCB typically increase in late summer and early fall with the influx of large numbers of birds dispersing north from breeding colonies in the Gulf of California, Mexico (GC). These migrants typically return to Mexican colonies in early winter and the lowest numbers of largely resident breeding pelicans in the SCB occur in spring (Anderson and Anderson 1976; Briggs et al. 1981, 1983; Jaques 1994; Jaques et al. 1996). Ground monitoring efforts in 2001 at Mugu Lagoon concentrated on the late summer and early fall period from June to October when large numbers of roosting pelicans are expected from local and Mexican colonies. Our monitoring goals were: 1) to determine seasonal and daily trends in numbers of roosting pelicans; 2) to determine night roosting patterns of pelicans; 3) to determine habitat use patterns by pelicans for roosting and foraging; and 4) to record events of disturbance and potential disturbance to pelicans. Aerial photographic surveys from this period at and near Mugu Lagoon, as well as disturbance observations during waterfowl hunting season in late fall of 2000, are also reported here.

## METHODS

### MUGU LAGOON GROUND SURVEYS

Surveys of brown pelican use of Mugu Lagoon were conducted during the late summer and early fall period on two consecutive days twice per month from mid June to mid September and on one day in early October for a total of 15 survey days. Surveys consisted of hourly counts of pelicans in the central basin from dawn to dusk and disturbance observations during every other hour. Beginning in July, one of the two survey days was modified from hourly observations to focus on three times of day: 1) dawn to two hours after sunrise; 2) two hours surrounding midday; and 3) two hours before sunset to dusk. Disturbance observations were continuous during these periods. Surveys were scheduled so that all days of the week were represented throughout the season.

Pelicans were monitored from the ground or from atop one of the two observation towers in the parking lot near the mouth of the lagoon. Counts of pelicans at each roost location within the central basin were made with a spotting scope with either a 32X or 20-60X zoom eyepiece. Pelicans were aged as either adult or immature. Immatures were birds with all white bellies and either all dark heads or heads with varying amounts of white mottling; this definition includes juveniles to birds over 2 years old (in their third calendar year). Direct counts of roosts were first possible about 15 minutes before sunrise and last possible about 15 minutes after sunset. Pelicans arriving or departing the roost in the low light levels around dawn and dusk could be seen flying low over the water and were added to or subtracted from the most recent direct roost count to determine dawn and dusk counts. Night roosting patterns were determined by comparing dusk and dawn counts. Counts of pelicans utilizing beaches to the east and west of the lagoon mouth and of pelicans in the western arm of the lagoon were made opportunistically when pelicans were present and were not included in counts of pelicans in the central basin. Counts and rough age breakdowns of other species roosting with pelicans were also noted.

All observations of events that flushed pelicans during the designated observation periods were recorded as disturbance. The number of birds that flushed and the numbers that relanded at the same roost, relocated to another roost or departed the lagoon were noted. The source of the disturbance, including aircraft types and altitudes for overflights, was recorded if it could be determined or was otherwise recorded as unknown. Sources of potential disturbance were also noted, including human activities at the parking lot area near the mouth of the lagoon and aircraft overflights that did not flush pelicans.

In November and December 2000, three days of disturbance observations were conducted during waterfowl hunting season. Hunters utilized two blinds located on salt marsh habitat near the edge of the lagoon on the east and west sides of Calleguas Creek. Observations began before first light and were continuous until hunters from both blinds had left the area, typically shortly after noon. Data were recorded in the same manner as for other disturbances noted above.

## AERIAL PHOTOGRAPHIC SURVEYS

Aerial photographic surveys of all pelican roosts within the SCB and adjacent areas from Cambria in San Luis Obispo County south to the U.S.-Mexican border were flown in July 2000 and 2001. Data from these surveys supplement other bight-wide roost and at-sea surveys flown in January, May and September in a concurrent study by USGS and HSU (McChesney et al. 2001). In months when bight-wide surveys were not conducted, aerial photographic surveys of roosts in the vicinity of Mugu Lagoon, (i.e. from Santa Barbara Harbor in the north to Pt. Dume in the south; see Figure 1), were conducted from June 2000 through December 2001. These surveys included roosts at East Anacapa Island, adjacent to the large breeding colony on West Anacapa Island. Large roosts are typically seen on East Anacapa Island and, in 2001, a small nesting effort (<25 nests) also took place near the east end of the island (P. Martin, pers. comm.). Roost data for this local region of the SCB from June to September 2001 are presented in this report. Surveys were flown with pilots from the California Department of Fish and Game and Aspen Helicopters. Photography and counting methods followed those detailed in Carter et al. (1992) and Jaques et al. (1996). As on ground surveys, pelicans were aged as adult or immature in photographs when possible. Immatures may be slightly undercounted in aerial photographs as birds with all white bellies but varying amounts of white in the head were aged as adult when only the head could be seen.

# RESULTS

## MUGU LAGOON GROUND SURVEYS

### *Seasonal Roost Attendance Patterns*

Numbers of pelicans were low and consistent between days in June (high count - 150), increased in July (high count - 310) and peaked in August (high count - 572) before declining in September and October (high count - 162) (Figure 2). Ground counts conducted one to two times daily by Navy biologists at Mugu Lagoon were lower but showed a similar pattern (Appendix 1). Immatures comprised less than 20 percent of the daily high counts in June, between 35 and 57 percent through September, and 31 percent on 5 October (Figure 3) and thus accounted for much of the overall increase in numbers of pelicans. Hatch-year birds, or young of the year, were first seen on 28 June in small numbers. These birds were likely from Anacapa Island, where first fledging dates in 2001 were in mid June (F. Gress, pers. comm.). A random ground count from 2 December of 290 birds was 84 percent adults and likely consisted of birds returning to colonies in Mexico.

A minimum of six banded pelicans were seen during the survey period. Three second year birds with bands were probably from Mexican colonies since pelican chicks have not been banded in the SCB since 1996 (F. Gress, pers. comm.). The three banded adults may have been from SCB or GC colonies. Also, the release of banded rehabilitated birds in recent years may complicate these interpretations if any birds survive for long periods after release (Anderson et al. 1996). In mid August, at least one pelican with a yellow band was seen by PJC and Navy biologists (Appendix 1) and may be a bird that was captured, rehabilitated and released at the Salton Sea (D.W. Anderson, pers. comm.). This sighting is important because it demonstrates that such movements may lead to disease transmission from the Salton Sea to the SCB region.

Double-crested cormorants (*Phalacrocorax auritus*), western gulls (*Larus occidentalis*) and Heermann's gulls (*Larus heermanni*) were also usually present in pelican roosts. The National Park Service bands western gull chicks at Anacapa Island and Santa Barbara Island (P. Martin, pers. comm.) and two juveniles with appropriate color bands were seen at Mugu Lagoon. Black skimmers (*Rhynchops niger*) and tern species (*Sterna sp.*) also roosted nearby, but in distinctly separate areas. Banded skimmers and terns that had moved to Mugu Lagoon from other southern California estuaries were also seen.

*Diurnal Roost Attendance Patterns*

Roost attendance typically increased near sunrise, was steady from late morning to late afternoon and decreased near sunset. While numbers were most consistent from late morning to late afternoon throughout the season, daily high counts occurred in the evening or early morning in June and July and in mid to late afternoon in August to October (Figure 4). Pelicans used Mugu Lagoon as an overnight roost on 17 of 18 evenings from June through August (dawn and dusk counts from 12 survey dates), but ceased night roosting thereafter. Nocturnal movements by pelicans were evident from substantial differences in consecutive dusk and dawn counts (Figure 5) and may be due to disturbance (see below).

*Habitat Use*

The sandbar configuration of the central basin has changed only slightly since 1993, after flooding caused dramatic changes in January 1992 (Jaques et al. 1996). Onuf (1987) stated that the mouth of the lagoon has been known to migrate and slight shifting of the western sandbar at the lagoon mouth was indeed evident in 2001. Pelican activity at Mugu Lagoon was concentrated in the central basin area near the mouth of the lagoon. The main roost areas were along the entire length of the east spit at the mouth of the lagoon and on the mudflats in the central basin just east of a harbor seal (*Phoca vitulina*) haul out area. The sandbar along the west border of the lagoon mouth was used sporadically and typically during low tide. During high tides, the available roosting area on this sandbar is likely too near the human traffic at the parking lot to facilitate use by pelicans. Night roosting occurred only on the mudflats. The central basin waters were used regularly for bathing and foraging. Pelicans also used the beaches to the east and west of the lagoon mouth for roosting. More than 50 birds were seen on the beach to the east toward the firing range twice in August, both times in association with a feeding flock just offshore.

Small numbers of pelicans were routinely seen roosting in the western arm of the lagoon.

Less than 10 pelicans were often seen during low tide on a small mussel shoal about 30 meters west of Laguna Road. Roosting pelicans could also be seen farther west on an arm extending about 50 meters into the lagoon. Navy biologists at Point Mugu began counting this area in September and had a high count of 51 pelicans through October. On several occasions, less than 10 pelicans were seen perched on either side of the culvert (known as the Laguna Road Causeway) connecting the western and eastern arms of the lagoon, perhaps on the lookout for concentrated prey funneling under the causeway.

*Disturbance*

Disturbance events occurred sporadically throughout the 2001 study period and most were due to loud aircraft flying low and directly over the main roost (Table 2). The actual percentage of flights flushing pelicans was quite low however. Raptors including turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*) and peregrine falcon (*Falco peregrinus*) were also noted flushing pelicans. Security vehicle headlights flushed the entire roost on 8 July more than an hour before sunrise and a NBVCPM police officer commented that he often sees pelicans flying over the central basin area in the middle of the night and suspected that his headlights were the cause. Gunshots from the rifle range to the east of the lagoon and human activities on the parking lot near the lagoon mouth were also noted to flush birds on occasion. Terns, gulls, and shorebirds were also seen flushed. No displacement of harbor seals from their haul out areas was seen.

During three waterfowl hunt days in fall 2000, several disturbance events were noted due to gunshots (Table 3). Pelicans did not night roost at Mugu Lagoon prior to any of the hunt days. Bright lights from the set of a movie being filmed in the parking lot near the mouth of the lagoon may have prevented birds from night roosting on the evening of 3 November 2000. Six birds were present 40 minutes after sunset but did not roost overnight.

## AERIAL PHOTOGRAPHIC SURVEYS

Seasonal attendance patterns similar to those at Mugu Lagoon were seen at other nearby roosts from June to September. Total numbers of pelicans at each of these roosts increased in July, peaked in August and declined in September (Table 1). The percentage of immatures at each of these roosts was also greatest in August. In July throughout the SCB, greater total numbers of pelicans and greater percentages of immatures were counted at mainland roosts rather than roosts at the Channel Islands. Of birds aged in photographs, 55 percent were immatures on the mainland versus 31 percent on the islands. Mugu Lagoon was the largest estuarine roost in the SCB in July while the largest individual roost was at Scorpion Rocks at Santa Cruz Island with over 1,000 birds.

## DISCUSSION

*Attendance Patterns*

Patterns of use of Mugu Lagoon by brown pelicans appear largely similar to observations reported by Jaques et al. (1996) from the last detailed censuses during the 1991-1993 period. Total numbers of pelicans in 2001 appear slightly higher however with a high count of 572 on 8 August and may be accounted for by population increases at SCB and GC colonies. Pelican populations in the SCB began increasing in the late 1970s after pollution-related declines in the late 1960s and early 1970s (Anderson and Anderson 1976; Anderson and Gress 1983; Anderson et al. 1975) and populations in the SCB and GC have increased and stabilized since the 1991-1993 period (F. Gress and D.W. Anderson, pers. comm.). Increases in roosting numbers have also been found throughout California, Oregon and Washington over the past two decades (Jaques 1994; D.L. Jaques, pers. comm.). Higher counts at Mugu Lagoon were obtained in 1992, but these resulted from large numbers of failed and nonbreeders during strong El Niño conditions. The breeding season was more successful in 1993 but the Mugu Lagoon high count was 260 birds in June, although no surveys were conducted in August 1993 (Jaques et al. 1996). Seasonal attendance patterns observed in 2001 may more accurately depict the timing of peak numbers of post-breeding pelicans at Mugu Lagoon. However, strong La Niña conditions (Bograd et al. 2000) and good breeding success in 1999-2000 may have influenced the numbers of one- and two-year-old birds present as well as the timing of breeding in 2001.

Other roosts in the vicinity of Mugu Lagoon showed similar seasonal attendance patterns and all but Santa Barbara Harbor also had peak counts in August. East Anacapa Island and Rincon Island both had greater numbers of roosting pelicans than Mugu Lagoon in July to September, but Mugu Lagoon was by far the largest estuarine roost within this region (Table 1). Estuarine habitats are important for pelicans as they provide roosting habitat, foraging opportunties, and brackish waters for bathing all in the same location, an energetically favorable situation (Jaques et al. 1996). Mugu Lagoon was also the largest estuarine roost throughout the SCB in July aerial surveys.

Night roosting patterns suggest that Mugu Lagoon is an important night roost for local SCB breeders from the Anacapa Island or Santa Barbara Island colonies. In June, prior to the arrival of large numbers of birds from colonies in Mexico, the numbers of birds roosting overnight varied little from the numbers of birds using the lagoon during the day (Figure 4). These local birds may also be less susceptible to overnight disturbance events as dawn counts also varied little from the previous night's dusk count. Dawn and dusk counts varied from 8 July to 20 August and night roosting ceased therafter (Figures 4, 5). The large numbers of likely-migrant GC birds seen during the day in July and August may have used Anacapa Island as a night roost as large numbers of birds from Mexico are often seen in July within this colony (F. Gress, pers. comm.). Among other roosts in the vicinity of Mugu Lagoon, Rincon Island was also used as a night roost during the 1991-1993 period (Jaques et al. 1996).

The large increase in numbers of immatures during the June to October period in 2001 was not seen in 1992, a year of poor breeding success for pelicans (Jaques et al. 1996). Percentages of immatures in 2001 were also substantially higher than in 1991-1993. This result may be due in small part to differences in counting methodology; birds with white in the head but with an all white belly (3rd year birds) were considered immature in this study but were lumped with adults by Jaques et al. (1996). However, compared to the poor breeding success in 1992, the high breeding success in 2000 followed by more average breeding success in 2001 in the GC area (D.W. Anderson, pers. comm.) likely accounts for most of this difference. In fact, a count from 8 August of 395 birds consisted of 48 percent immatures, all first or second year birds with completely dark heads.

*Disturbance*

Use of Mugu Lagoon by similar or larger numbers of pelicans compared to the 1991-1993 period suggests that disturbance levels are at a low enough level to allow continued use by pelicans. Continued monitoring and protection of roost areas remains important as human disturbance and habitat alteration may effect long-term use patterns of roost areas by pelicans (Jaques and Anderson 1988). Disturbance from air traffic and waterfowl hunting were the most common sources of disturbance to pelicans at Mugu Lagoon during this study period. Though pelicans may over time become habituated to noise from air traffic, SCB local juveniles or GC migrants unfamilar with Mugu Lagoon will still be sensitive to this disturbance. These birds may flush readily and alarm other birds within the roost causing them to flush as well. This situation was apparently the case on 20 August when a plane flying over the roost caused a small number of birds to flush which in turn caused the entire roost of 365 birds to flush. Disturbance from air traffic thus remains a concern for brown pelicans at Mugu Lagoon.

Jaques et al. (1996) reported human recreational activities on the west spit as the second most common disturbance source, but this area is now closed to the public and patrolled by security personnel regularly. However security vehicle headlights have been documented flushing night roosting pelicans. Circling the parking lot near the mouth of the lagoon in a clockwise direction (i.e., toward the ocean) would likely avoid shining headlights directly on night roosting pelicans. Pelicans use the mudflats in the central basin of the lagoon almost exclusively as their sole night roosting site, so avoiding shining lights on this area should become standard procedure. However, if the parking lot area becomes no longer used, this problem will resolve itself.

## SUMMARY

Mugu Lagoon continues to be the most important estuarine roosting habitat in the SCB for both resident and migrating brown pelicans. Continued monitoring of pelicans at Mugu Lagoon is important because disturbance threats remain and the dynamic nature of the central basin of the lagoon may result in habitat changes over time. Ground surveys of pelican roosting patterns at Mugu Lagoon are planned to continue in 2002-2003 during the late summer and early fall.

## ACKNOWLEDGMENTS

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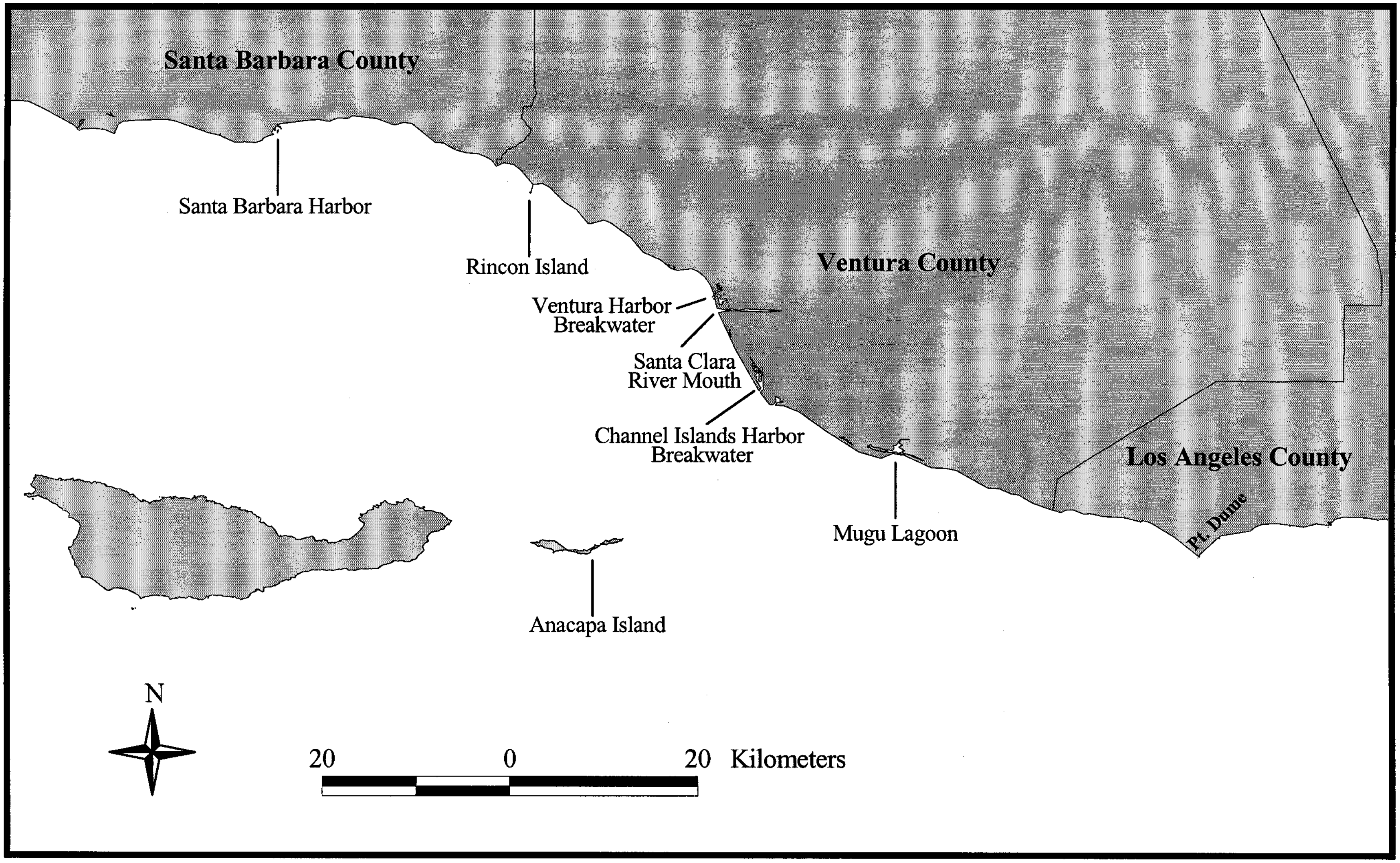


Figure 1. Location of Mugu Lagoon and all other major Brown Pelican roost sites in monthly aerial photographic surveys from Santa Barbara Harbor to Pt. Dume, including Anacapa Island.

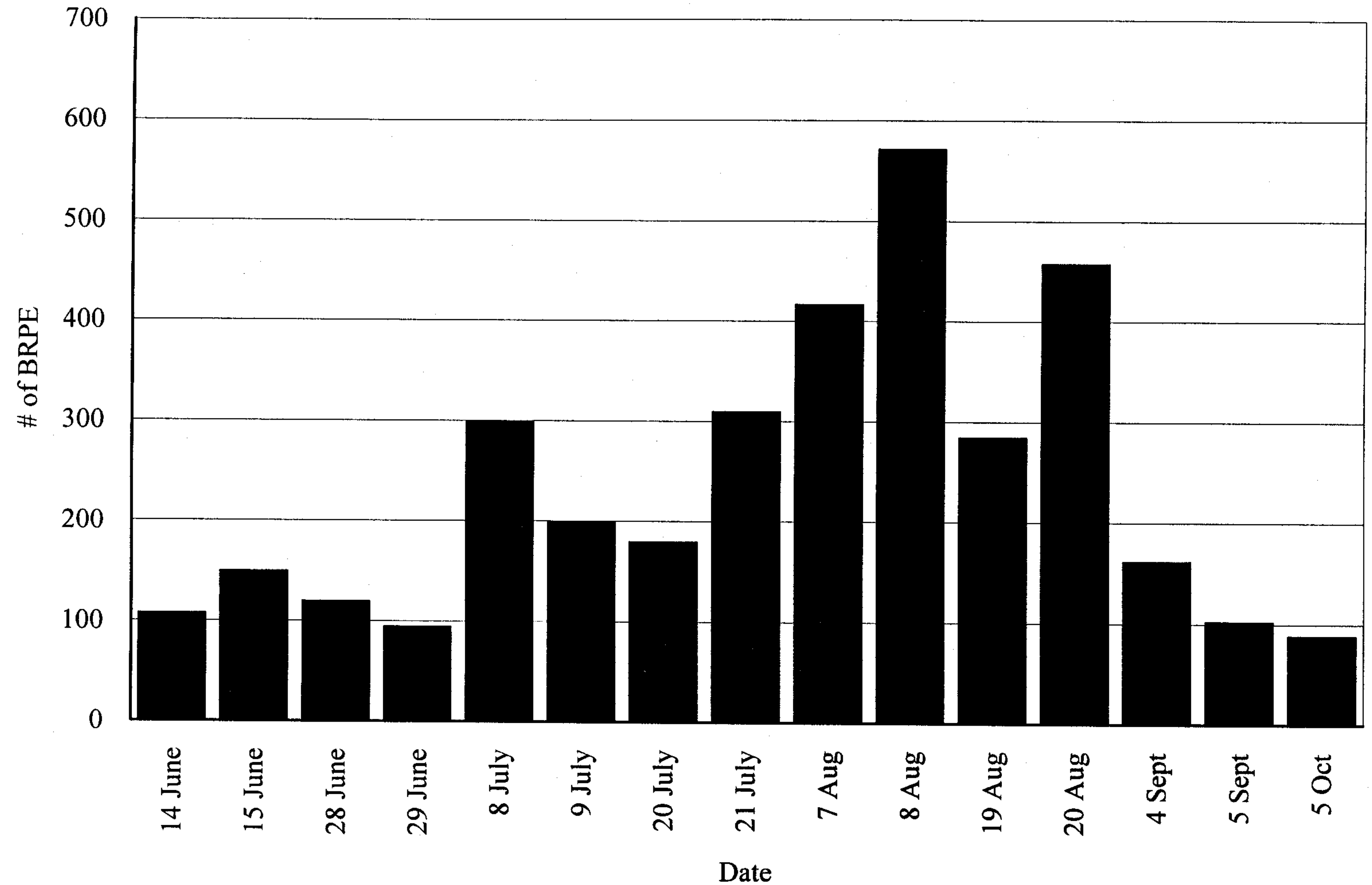


Figure 2. Daily high counts of roosting Brown Pelicans in the Mugu Lagoon central basin, June-October 2001.

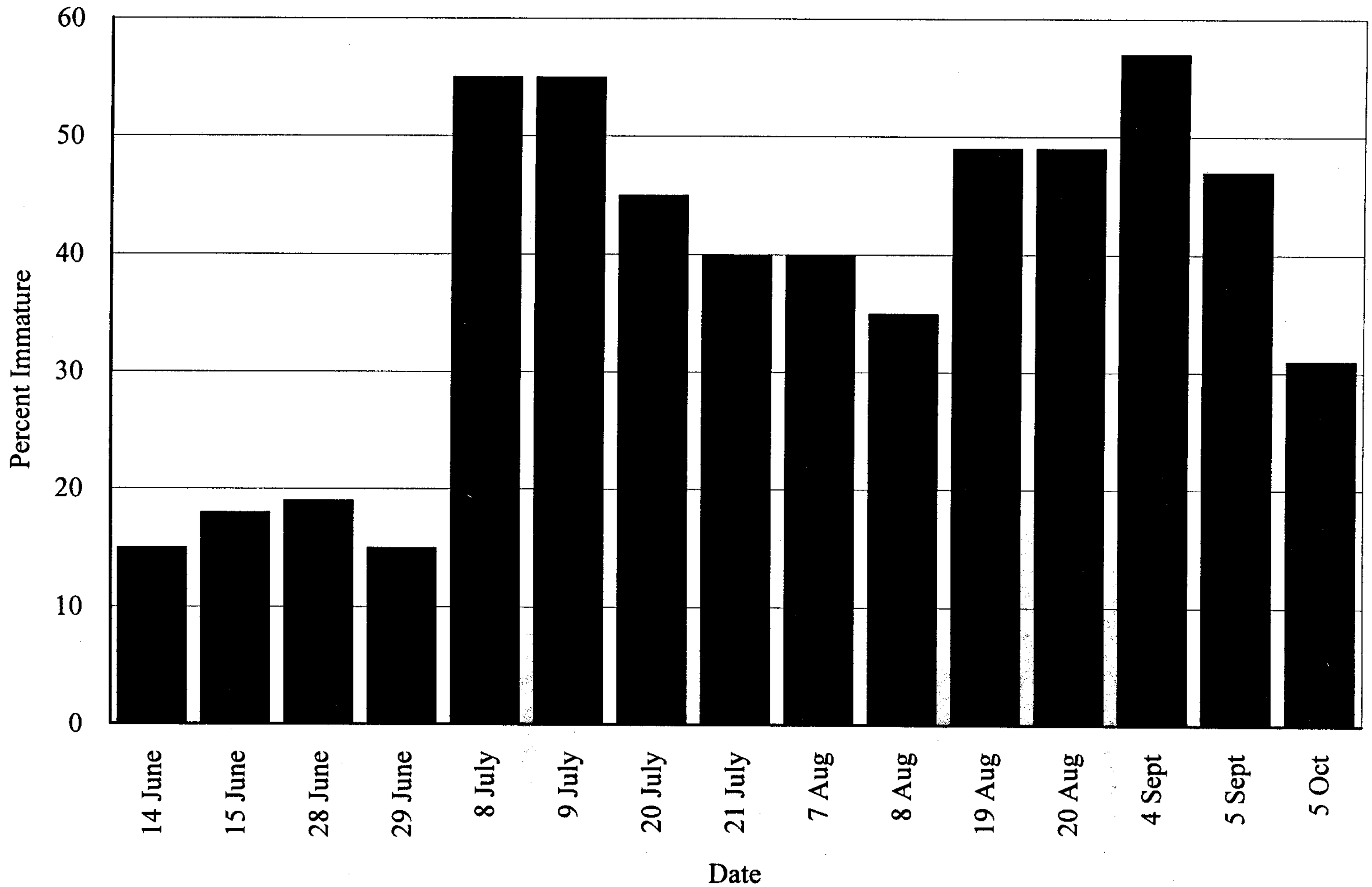


Figure 3. Percentage of immature roosting Brown Pelicans in the daily high counts (see Figure 1) in the Mugu Lagoon central basin, June-October 2001. Immatures include birds with all white bellies and heads that are all brown or brown with white mottling.

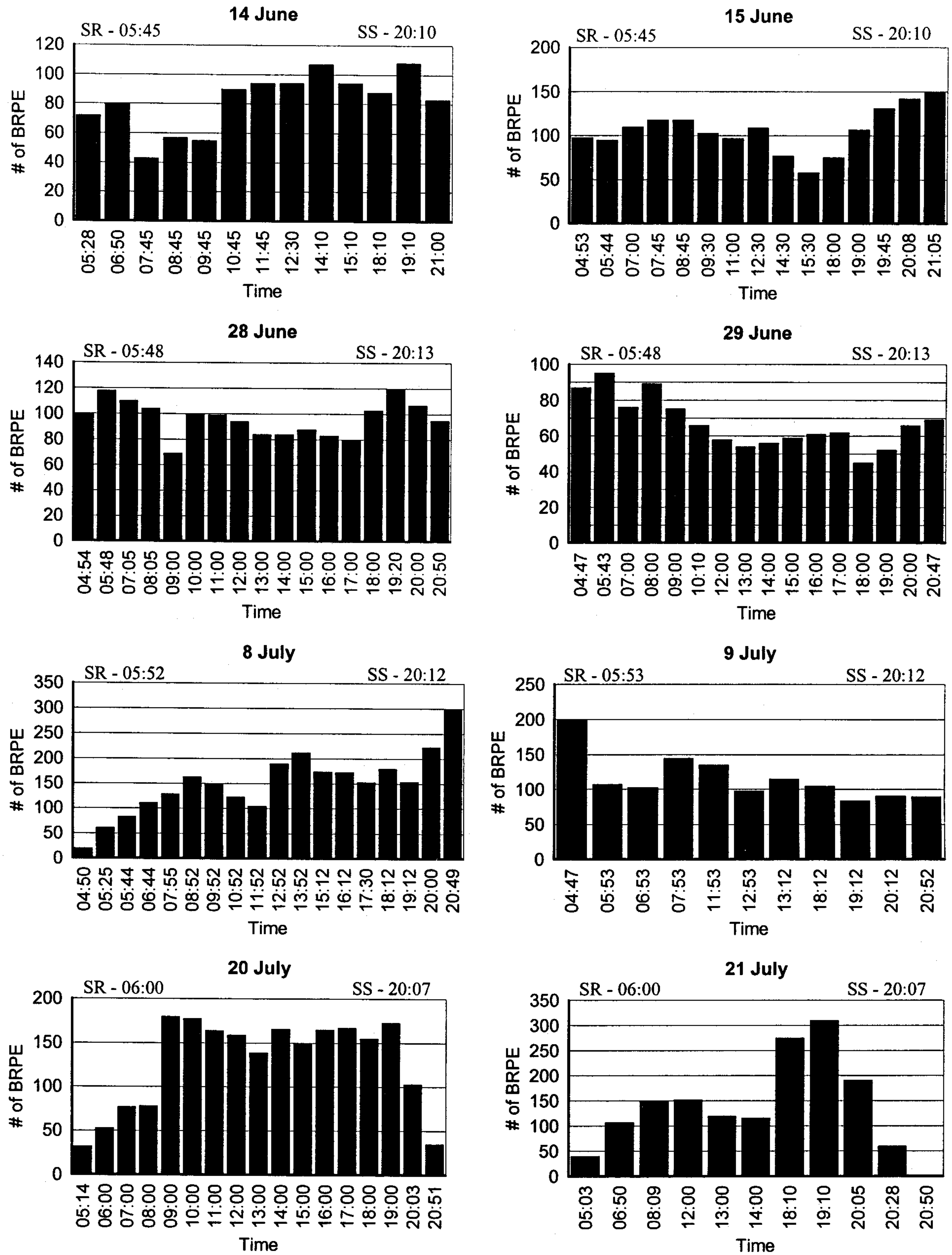


Figure 4. Brown Pelican diurnal roost attendance patterns in the central basin of Mugu Lagoon, California, June-July 2001. SR = sunrise; SS = sunset.

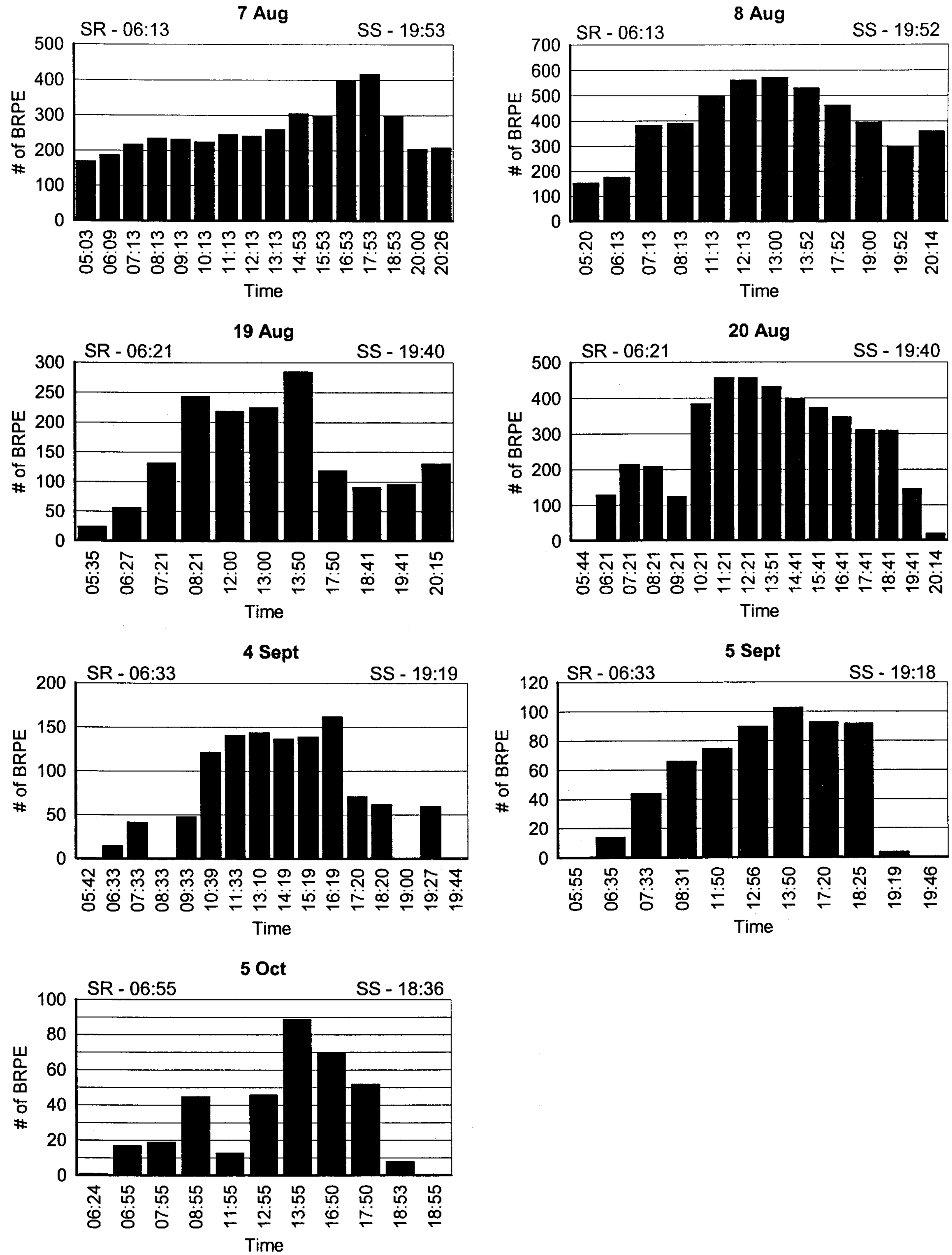


Figure 4 (continued). Brown Pelican diurnal roost attendance patterns in the central basin of Mugu Lagoon, California, August-October 2001. SR = sunrise; SS = sunset.

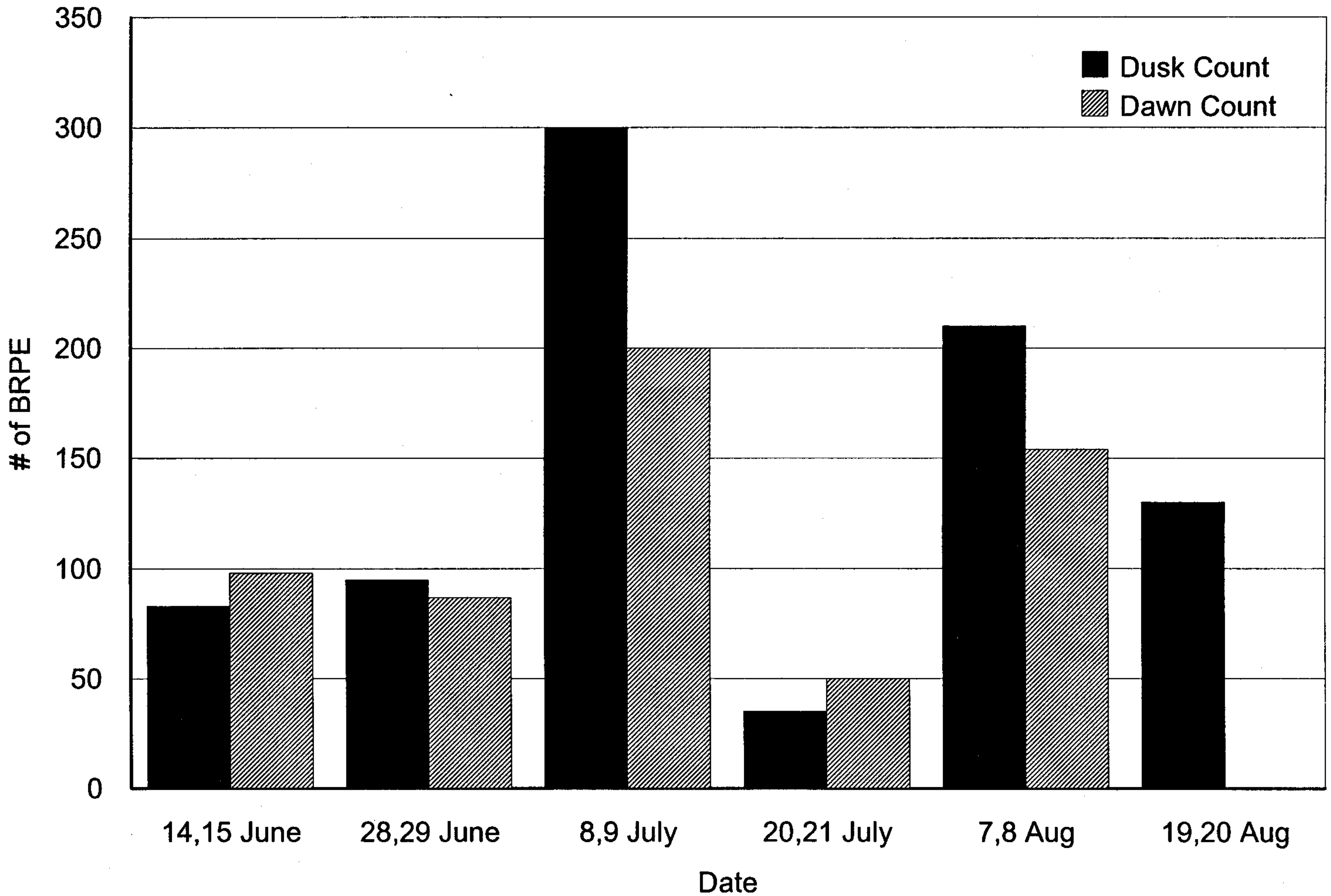


Figure 5. Consecutive dusk and dawn counts of roosting Brown Pelicans in the Mugu Lagoon central basin, June-August 2001. Night roosting by pelicans did not occur on census days in September and October 2001.

Table 1. Numbers of roosting Brown Pelicans from aerial photographic surveys from Santa Barbara Harbor to Point Dume, California, including East Anacapa Island, June-September 2001.

| Roost | 19 June | 17 July | 10 Aug | 19 Sept |
|---|---|---|---|---|
| East Anacapa Island | 19 | 789 | 1,921 | 70 |
| Santa Barbara Harbor | 67 | 81 | 222 | 251 |
| Rincon Island | 123 | 498 | 986 | 968 |
| Ventura River Mouth | 0 | 2 | 14 | 3 |
| Ventura Harbor Breakwater | 50 | 250 | 782 | 167 |
| Santa Clara River Mouth | 1 | 7 | 402 | 25 |
| Channel Islands Harbor Breakwater | 24 | 41 | 208 | 111 |
| Mugu Lagoon | 164 | 157 | 504 | 181 |
| Other | 0 | 0 | 231 | 17 |
| Total | 448 | 1,828 | 5,270 | 1,793 |

Table 2. Aircraft flyovers causing disturbance to brown pelicans at Mugu Lagoon, California in June-October 2001.

| Aircraft | Date | Time | % Flush | Number of Pelicans | | | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | Flush | Depart | Relocate | Reland | |
| Navy jet | 06/28/01 | 1118 | 4 | 4 | | 4 | | jet did figure 8 over lagoon |
| small helo | 06/28/01 | 1125 | 1 | 1 | | 1 | | |
| Navy radar | 06/28/01 | 1613 | 2 | 2 | | 2 | | |
| Navy cargo | 06/28/01 | 1614 | 2 | 2 | | 1 | 1 | |
| Navy radar | 06/28/01 | 1618 | 1 | 1 | 1 | | | |
| Navy radar | 06/28/01 | 1646 | 4 | 4 | | | 4 | |
| Passenger | 06/29/01 | 1345 | <1 | 1 | 1 | | | |
| Navy jet | 06/29/01 | 1400 | <1 | 1 | 1 | | | 50 Caspian/ Elegant Terns also flush |
| Navy jet | 06/29/01 | 1402 | 5 | 3 | | 3 | | |
| Navy radar | 07/09/00 | 1819 | 8 | 8 | | 8 | | |
| Navy cargo | 07/20/00 | 1451 | 20 | 30 | 2 | | 28 | |
| Navy cargo | 07/20/00 | 1455 | 8 | 12 | | | 12 | |
| Navy cargo | 07/20/00 | 1503 | 8 | 12 | | | 12 | |
| Navy cargo | 07/20/00 | 1612 | 7 | 12 | | | 12 | |
| Navy helo | 08/07/00 | 1319 | <1 | 1 | 1 | | | |
| Navy cargo | 08/07/00 | 1405 | 19 | 50 | 3 | | 47 | |
| Navy jet | 08/07/00 | 1653 | 2 | 7 | | | 7 | |
| Navy helo | 08/08/00 | 1213 | <1 | 7 | | 5 | 2 | |
| small helo | 08/08/00 | 1232 | <1 | 2 | 1 | | 1 | |
| small helo | 08/08/00 | 1240 | <1 | 1 | | | 1 | |
| Navy cargo | 08/20/00 | 1835 | 100 | 365 | 55 | 310 | | |

Table 3. Events causing disturbance to brown pelicans at Mugu Lagoon, California during waterfowl hunt days in November-December 2000.

| Event | Date | Time | % Flush | Number of Pelicans | | | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | Flush | Depart | Relocate | Reland | |
| gunshot | 11/04/00 | 0550 | 100 | 1 | 1 | | | |
| gunshot | 11/04/00 | 0617 | 100 | 4 | | | 4 | foraging birds altered flight, land on water |
| gunshot | 11/04/00 | 0634 | 13 | 1 | | 1 | | |
| gunshot | 11/04/00 | 0934 | 100 | 9 | | 9 | | |
| gunshot | 11/18/00 | 0754 | 100 | 1 | | | 1 | |
| PEFA | 11/18/00 | 0903 | 100 | 2 | 1 | 1 | | |
| unknown | 11/18/00 | 1010 | 25 | 1 | | | 1 | |
| gunshot | 12/02/00 | 0620 | 100 | 23 | 6 | | 17 | reland after circling for 3 minutes |
| unknown | 12/02/00 | 0919 | 100 | 113 | 95 | 18 | | hunters packing decoys |
| unknown | 12/02/00 | 0943 | 100 | 22 | | | 22 | |

Appendix 1. Ground counts of roosting Brown Pelicans at Mugu Lagoon, California, conducted by Navy biologists from Point Mugu in June-October 2001. Central basin counts elsewhere in this report include the areas HSF, PP, SP, EA and SBC. Asterisks for EA, FAM, and OX6 indicate that they were not counted until September.

| Date | Time | HSF | PP | SP | EA | SBC | FAM | WA | OX6 | WC | EC | Total | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/1/2001 | 0720 | 0 | 0 | 113 | * | 0 | * | 0 | * | 0 | 4 | **117** | hsf= harbor seal flats |
| 6/1/2001 | 1605 | 0 | 0 | 86 | * | 0 | * | 0 | * | 0 | 0 | **86** | pp = pelican point |
| 6/4/2001 | 1650 | 0 | 0 | 56 | * | 0 | * | 0 | * | 0 | 0 | **56** | sp= sanderling point |
| 6/5/2001 | 0805 | 5 | 0 | 35 | * | 0 | * | 10 | * | 0 | 0 | **50** | ea= eastern arm |
| 6/5/2001 | 1820 | 0 | 0 | 64 | * | 0 | * | 0 | * | 0 | 0 | **64** | sbc= shorebird cove |
| 6/6/2001 | 0740 | 0 | 0 | 42 | * | 0 | * | 9 | * | 0 | 3 | **54** | fam= family beach |
| 6/7/2001 | 0725 | 0 | 33 | 35 | * | 0 | * | 8 | * | 0 | 0 | **76** | wa = western arm |
| 6/8/2001 | 0613 | 0 | 45 | 44 | * | 0 | * | 1 | * | 0 | 0 | **50** | ox6= ditch 6 into lagoon in western arm |
| 6/11/2001 | 0740 | 38 | 0 | 70 | * | 0 | * | 5 | * | 0 | 0 | **113** | wc= west causeway |
| 6/11/2001 | 1639 | 0 | 0 | 143 | * | 0 | * | 0 | * | 0 | 0 | **143** | ec= eastern causeway |
| 6/12/2001 | 0740 | 74 | 0 | 80 | * | 0 | * | 7 | * | 0 | 0 | **161** | |
| 6/14/2001 | 1655 | 0 | 0 | 78 | * | 0 | * | 0 | * | 0 | 0 | **78** | |
| 6/15/2001 | 0730 | 0 | 0 | 125 | * | 0 | * | 0 | * | 0 | 0 | **125** | |
| 6/15/2001 | 1656 | 0 | 0 | 72 | * | 0 | * | 0 | * | 0 | 0 | **72** | |
| 6/18/2001 | 1730 | 0 | 0 | 121 | * | 0 | * | 0 | * | 0 | 0 | **121** | |
| 6/19/2001 | 1620 | 0 | 0 | 140 | * | 0 | * | 0 | * | 0 | 0 | **140** | |
| 6/20/2001 | 0745 | 0 | 0 | 107 | * | 0 | * | 7 | * | 0 | 0 | **114** | |
| 6/22/2001 | 0755 | 43 | 0 | 57 | * | 0 | * | 6 | * | 0 | 0 | **106** | |
| 6/27/2001 | 0735 | 116 | 0 | 0 | * | 0 | * | 1 | * | 0 | 0 | **117** | |
| 6/27/2001 | 1708 | 0 | 0 | 136 | * | 0 | * | 0 | * | 0 | 0 | **136** | |
| 6/28/2001 | 0725 | 54 | 0 | 46 | * | 0 | * | 0 | * | 0 | 0 | **100** | |
| 6/29/2001 | 0825 | 58 | 0 | 14 | * | 0 | * | 2 | * | 0 | 0 | **74** | |
| 7/2/2001 | 0910 | 0 | 0 | 67 | * | 0 | * | 0 | * | 0 | 2 | **69** | |
| 7/3/2001 | 1549 | 0 | 0 | 70 | * | 0 | * | 0 | * | 0 | 0 | **70** | |
| 7/5/2001 | 0830 | 3 | 0 | 64 | * | 0 | * | 16 | * | 0 | 0 | **83** | |
| 7/9/2001 | 720 | 50 | 24 | 61 | * | 0 | * | 8 | * | 0 | 0 | **143** | |
| 7/9/2001 | 1621 | 19 | 0 | 65 | * | 0 | * | 0 | * | 0 | 0 | **84** | |
| 7/10/2001 | 0830 | 64 | 70 | 0 | * | 0 | * | 5 | * | 0 | 0 | **139** | |
| 7/11/2001 | 0750 | 66 | 40 | 0 | * | 0 | * | 18 | * | 0 | 0 | **124** | |
| 7/11/2001 | 1657 | 0 | 0 | 104 | * | 0 | * | 0 | * | 0 | 0 | **104** | |
| 7/12/2001 | 0735 | 100 | 0 | 42 | * | 0 | * | 3 | * | 0 | 0 | **145** | |
| 7/13/2001 | 0735 | 57 | 0 | 32 | * | 0 | * | 5 | * | 0 | 0 | **94** | |
| 7/16/2001 | 1315 | 0 | 0 | 143 | * | 0 | * | 0 | * | 0 | 0 | **143** | |

Appendix 1. (continued)

| Date | Time | HSF | PP | SP | EA | SBC | FAM | WA | OX6 | WC | EC | Total | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/17/2001 | 0725 | 122 | 0 | 0 | * | 0 | * | 0 | * | 0 | 0 | **122** | |
| 7/17/2001 | 1741 | 0 | 0 | 114 | * | 0 | * | 0 | * | 0 | 0 | **114** | |
| 7/18/2001 | 0800 | 82 | 0 | 21 | * | 0 | * | 0 | * | 0 | 0 | **103** | |
| 7/20/2001 | 0628 | 66 | 0 | 0 | * | 0 | * | 3 | * | 0 | 0 | **69** | |
| 7/23/2001 | 1545 | 0 | 0 | 264 | * | 0 | * | 0 | * | 0 | 0 | **264** | |
| 7/24/2001 | 0725 | 19 | 136 | 0 | * | 0 | * | 11 | * | 0 | 0 | **166** | |
| 7/26/2001 | 0740 | 216 | 0 | 0 | * | 0 | * | 3 | * | 0 | 0 | **219** | |
| 7/30/2001 | 0735 | 141 | 0 | 0 | * | 0 | * | 3 | * | 0 | 0 | **144** | |
| 7/31/2001 | 0730 | 202 | 0 | 0 | * | 0 | * | 0 | * | 0 | 0 | **202** | |
| 7/31/2001 | 0830 | 310 | 0 | 0 | * | 0 | * | 0 | * | 0 | 0 | **310** | |
| 8/1/2001 | 0815 | 205 | 0 | 0 | * | 0 | * | 4 | * | 0 | 0 | **209** | |
| 8/1/2001 | 1646 | 0 | 0 | 150 | * | 0 | * | 0 | * | 0 | 0 | **150** | |
| 8/2/2001 | 0750 | 252 | 0 | 0 | * | 0 | * | 0 | * | 0 | 0 | **252** | dead pelican on SP, maybe one hit |
| 8/6/2001 | 1138 | 23 | 0 | 263 | * | 0 | * | 11 | * | 0 | 0 | **297** | powerline 7/31 |
| 8/6/2001 | 1725 | 0 | 0 | 148 | * | 0 | * | 0 | * | 0 | 0 | **148** | |
| 8/7/2001 | 0740 | 107 | 0 | 100 | * | 0 | * | 8 | * | 0 | 0 | **215** | |
| 8/7/2001 | 1700 | 0 | 0 | 272 | * | 0 | * | 0 | * | 0 | 0 | **272** | |
| 8/8/2001 | 0745 | 95 | 0 | 241 | * | 0 | * | 8 | * | 0 | 0 | **344** | |
| 8/8/2001 | 1718 | 8 | 0 | 490 | * | 0 | * | 0 | * | 0 | 0 | **498** | |
| 8/9/2001 | 0745 | 340 | 0 | 41 | * | 0 | * | 4 | * | 0 | 0 | **385** | |
| 8/10/2001 | 0740 | 232 | 0 | 177 | * | 0 | * | 9 | * | 0 | 0 | **418** | |
| 8/13/2001 | 0735 | 215 | 0 | 0 | * | 0 | * | 7 | * | 0 | 0 | **222** | |
| 8/15/2001 | 0735 | 183 | 0 | 1 | * | 0 | * | 3 | * | 0 | 0 | **187** | |
| 8/17/2001 | 0855 | 109 | 0 | 19 | * | 0 | * | 78 | * | 0 | 0 | **206** | 1 pelican at HSF had a yellow band on rt leg |
| 8/20/2001 | 1649 | 0 | 0 | 316 | * | 0 | * | 11 | * | 0 | 0 | **327** | 18 out in the central basin sand bar |
| 8/22/2001 | 0820 | 0 | 0 | 132 | * | 0 | * | 14 | * | 0 | 0 | **146** | 4 out in the central basin sand bar |
| 8/24/2001 | 0901 | 64 | 0 | 0 | * | 1 | * | 11 | * | 0 | 0 | **76** | 4 out in the central basin sand bar |
| 8/27/2001 | 0954 | 113 | 0 | 69 | * | 0 | * | 6 | * | 0 | 0 | **188** | |
| 8/28/2001 | 1255 | 42 | 0 | 52 | * | 0 | * | 3 | * | 1 | 4 | **102** | |
| 9/4/2001 | 1030 | 115 | 0 | 0 | * | 0 | * | 0 | * | 0 | 0 | **115** | |
| 9/4/2001 | 1655 | 78 | 2 | 4 | * | 0 | * | 9 | * | 0 | 0 | **93** | |
| 9/5/2001 | 0725 | 7 | 0 | 21 | * | 0 | * | 13 | * | 0 | 0 | **41** | |
| 9/5/2001 | 1636 | 22 | 0 | 87 | * | 0 | * | 3 | * | 1 | 2 | **115** | |
| 9/6/2001 | 0725 | 22 | 0 | 18 | * | 0 | * | 8 | * | 0 | 3 | **51** | |
| 9/6/2001 | 1635 | 40 | 5 | 167 | * | 0 | * | 9 | * | 1 | 0 | **222** | |

Appendix 1. (continued)

| Date | Time | HSF | PP | SP | EA | SBC | FAM | WA | OX6 | WC | EC | Total | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/7/2001 | 0730 | 29 | 0 | 28 | * | 0 | * | 7 | * | 0 | 5 | **69** | |
| 9/7/2001 | 1647 | 4 | 0 | 70 | * | 0 | * | 12 | * | 0 | 0 | **86** | |
| 9/10/2001 | 0735 | 89 | 0 | 119 | * | 0 | * | 10 | * | 0 | 0 | **218** | |
| 9/12/2001 | 755 | 78 | 0 | 50 | * | 0 | * | 11 | 37 | 0 | 0 | **176** | Oxnard 6 (O6) now new location |
| 9/12/2001 | 1641 | 0 | 0 | 204 | * | 0 | * | 0 | 0 | 0 | 0 | **204** | |
| 9/13/2001 | 755 | 25 | 0 | 64 | * | 0 | 6 | 0 | 0 | 0 | 1 | **96** | Family beach now new location |
| 9/18/2001 | 805 | 2 | 0 | 0 | * | 0 | 0 | 11 | 0 | 0 | 2 | **15** | |
| 9/19/2001 | 745 | 11 | 0 | 102 | * | 0 | 0 | 13 | 0 | 0 | 0 | **126** | |
| 9/20/2001 | 745 | 16 | 0 | 115 | * | 0 | 0 | 10 | 20 | 0 | 0 | **161** | |
| 9/21/2001 | 835 | 0 | 0 | 92 | * | 0 | 0 | 3 | 0 | 1 | 0 | **96** | |
| 9/24/2001 | 815 | 8 | 0 | 126 | * | 0 | 0 | 5 | 35 | 0 | 0 | **174** | |
| 9/26/2001 | 1430 | 9 | 0 | 88 | * | 0 | 0 | 0 | 16 | 0 | 0 | **113** | |
| 10/1/2001 | 740 | 2 | 0 | 28 | * | 0 | 0 | 0 | 12 | 0 | 0 | **42** | |
| 10/2/2001 | 940 | 0 | 0 | 67 | * | 0 | 48 | 0 | 31 | 0 | 0 | **146** | |
| 10/3/2001 | 1650 | 0 | 10 | 66 | * | 0 | 0 | 3 | 19 | 2 | 0 | **100** | |
| 10/5/2001 | 1535 | 0 | 0 | 82 | * | 0 | 2 | 0 | 25 | 1 | 0 | **110** | |
| 10/8/2001 | 730 | 4 | 0 | 20 | * | 0 | 0 | 6 | 8 | 0 | 2 | **40** | |
| 10/9/2001 | 750 | 3 | 0 | 0 | * | 0 | 0 | 3 | 16 | 0 | 1 | **23** | |
| 10/10/2001 | 1010 | 3 | 0 | 19 | * | 0 | 0 | 0 | 28 | 1 | 0 | **51** | |
| 10/11/2001 | 915 | 2 | 0 | 20 | * | 0 | 2 | 0 | 31 | 0 | 0 | **55** | |
| 10/15/2001 | 750 | 0 | 0 | 1 | 26 | 0 | 0 | 0 | 24 | 0 | 0 | **51** | begin differentiating eastern arm roost |
| 10/16/2001 | 1005 | 0 | 0 | 0 | 42 | 0 | 0 | 0 | 51 | 2 | 0 | **95** | from SP; most pelicans have been there and |
| 10/17/2001 | 1125 | 0 | 0 | 0 | 62 | 0 | 0 | 0 | 38 | 3 | 2 | **105** | not SP last month |
| 10/18/2001 | 1030 | 0 | 0 | 0 | 48 | 0 | 0 | 0 | 51 | 1 | 0 | **100** | |
| 10/18/2001 | 1455 | 10 | 0 | 2 | 68 | 0 | 0 | 0 | 6 | 11 | 2 | **99** | |
| 10/19/2001 | 750 | 38 | 0 | 0 | 0 | 0 | 1 | 2 | 20 | 0 | 2 | **63** | |
| 10/22/2001 | 840 | 0 | 0 | 0 | 47 | 0 | 0 | 16 | 4 | 0 | 1 | **68** | |
| 10/23/2001 | 810 | 15 | 0 | 1 | 12 | 0 | 0 | 0 | 34 | 0 | 0 | **62** | |
| 10/23/2001 | 1435 | 30 | 0 | 0 | 0 | 0 | 0 | 1 | 20 | 4 | 0 | **55** | |
| 10/24/2001 | 815 | 1 | 0 | 0 | 40 | 0 | 1 | 0 | 28 | 1 | 1 | **72** | |
| 10/24/2001 | 1555 | 0 | 0 | 65 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | **86** | |
| 10/25/2001 | 930 | 51 | 0 | 0 | 0 | 0 | 5 | 0 | 50 | 2 | 1 | **109** | |
| 10/29/2001 | 900 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 27 | 5 | 0 | **46** | |
| 10/30/2001 | 815 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | **15** | |
| 10/31/2001 | 1445 | 0 | 50 | 0 | 0 | 0 | 0 | 10 | 9 | 0 | 0 | **69** | |

APPENDIX D: Capitolo, P.J., R.J. Young, H.R. Carter, W.R. McIver, and T.W. Keeney. 2003. Roosting Patterns of Brown Pelicans at Mugu Lagoon, California, and other nearby roosts in 2002. Unpublished report, Humboldt State University, Department of Wildlife, Arcata, California; and Naval Base Ventura County, Natural Resources Management Office, Point Mugu, California.

# Roosting Patterns of Brown Pelicans at Mugu Lagoon, California, and Other Nearby Roosts in 2002

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## INTRODUCTION

In this report, we provide a summary of monitoring activities for California Brown Pelicans (*Pelecanus occidentalis californicus*) (hereafter "pelicans") at Mugu Lagoon, California, in 2002. This work is being conducted by Humboldt State University (HSU; Department of Wildlife) in cooperation with Naval Base Ventura County, Point Mugu (NBVCPM; Natural Resources Management Office) and is a continuation of monitoring work also conducted in 2001 (Capitolo et al. 2002) and 1991-1993 (Jaques et al. 1996). The California Brown Pelican is a U.S. federal and California-state listed endangered subspecies whose current northern breeding limit occurs at Anacapa Island in the Southern California Bight (SCB) (Carter et al. 1992; Gress 1995). The nearest large mainland roost occurs at Mugu Lagoon, located within NBVCPM, approximately 26 km east of Anacapa Island. Disturbance-free terrestrial roosting habitat for pelicans is essential throughout the year (i.e. for drying and maintaining plumage, resting and sleeping, and reducing foraging effort through proximity to prey resources), and roosts near colonies are especially important for breeding populations (Gress and Anderson 1983). Numbers of pelicans in the SCB typically increase in late summer and early fall with the influx of large numbers of birds dispersing north along the coasts of California, Oregon and Washington from breeding colonies in the Gulf of California, Mexico (GC). GC colonies account for approximately two thirds of the breeding population of *P. o. californicus* (Gress and Anderson 1983). These birds typically return to Mexican colonies in early winter and the lowest numbers of largely resident breeding pelicans in the SCB occur in spring (Anderson and Anderson 1976; Briggs et al. 1981, 1983; Jaques 1994; Jaques et al. 1996). Thus, the pelican roost at Mugu Lagoon is important for both local breeders and Mexican migrants.

Ground monitoring of roosting pelicans at Mugu Lagoon has been conducted by HSU and NBVCPM in 2001-2002 to comply with a U.S. Fish and Wildlife Service programmatic biological opinion related to base activities (USFWS 2001). Ground monitoring efforts in 2001 concentrated on late summer and early fall roosting patterns from June to October, when large numbers of pelicans are expected from local and Mexican colonies. In 2002, late summer to early winter roosting patterns were monitored from August to December. Our monitoring goals were: 1) to determine seasonal and daily trends in numbers of roosting pelicans; 2) to determine night roosting patterns of pelicans; 3) to determine habitat use patterns by pelicans for roosting and foraging; and 4) to record events of disturbance and potential disturbance to pelicans. To help evaluate roost-use patterns and disturbance levels at Mugu Lagoon, we also conducted ground surveys at four other roost sites in the vicinity of Mugu Lagoon in 2002.

Monthly aerial photographic surveys of roosting pelicans at Mugu Lagoon and other nearby roosts in the eastern Santa Barbara Channel (i.e., between Santa Barbara Harbor and Point Dume, including East Anacapa Island), were conducted from April 2000 to January 2002 by HSU, in cooperation with U.S. Geological Survey (USGS; Western Ecological Research Center, Dixon, California), Naval Air Warfare Center (NAWC; Point Mugu, California), and California Department of Fish and Game (CDFG; Office of Spill Prevention and Response, Sacramento California). We present the results of these surveys in this report to further evaluate annual patterns of pelican abundance and distribution in the Mugu Lagoon area. Aerial photographic surveys of all pelican roosts in the SCB (including all eight Channel Islands and the mainland coast from the Mexican border to San Luis Obispo County) were conducted by HSU, in cooperation with USGS, NAWC, and CDFG, in: May and September 1999; January, May, July and September 2000; January, May, July and September 2001; and January 2002. These surveys supplemented at-sea aerial surveys of pelicans and other seabirds (McChesney et al. 2001). The results of these surveys will be presented elsewhere.

## METHODS

### GROUND SURVEYS OF MUGU LAGOON

In 2002, surveys of pelican use of Mugu Lagoon were conducted on two consecutive days twice per month from August through October, and on two consecutive days once per month in November and December. The first day of surveys consisted of counts conducted every hour and disturbance observations during every other hour from dawn to dusk. During the second day of surveys, counts and disturbance observations focused on three times of day: 1) from dawn to two hours after sunrise; 2) two hours surrounding midday; and 3) from two hours before sunset to dusk. Surveys were conducted on consecutive days to evaluate night roosting patterns (by comparing dusk and dawn counts). Surveys were scheduled so that all days of the week were represented throughout the season.

Pelicans utilizing the central basin of Mugu Lagoon were monitored from the ground and from atop one of two observation towers in the parking lot near the mouth of the lagoon (Figure 2). These observation towers were removed in January 2003. Counts of roosts were possible as early as 50 minutes before sunrise and as late as 50 minutes after sunset, depending on light conditions (e.g., overcast skies, moonlight). Numbers of pelicans at each roost location within the central basin were recorded separately and totaled. Pelicans were aged as either adult or immature, except during counts in dim light near dawn and dusk. Birds with dark bellies and extensive white in the head and neck were recorded as adults, including birds denoted by Schreiber et al. (1989) as WW2 (birds with a white head but a small amount of white in the belly). Birds with white bellies and either all dark heads or heads with varying amounts of white mottling (WW1) were recorded as immature; this definition includes juveniles, one-year-old birds, and two-year old birds (in their third calendar year). Counts and rough age breakdowns of other species roosting with pelicans were also noted. All counts were made with a spotting scope with a 20-60X zoom eyepiece.

Counts of pelicans utilizing the beach to the east of the lagoon mouth and the western arm of the lagoon were made opportunistically when pelicans were present and were not included in analyses. Counts of the western arm of the lagoon were made at dawn and dusk in December when pelicans were observed night roosting there.

All observations of events that flushed pelicans during the designated observation periods were recorded as disturbance. We noted the number of birds that flushed, relanded at the same roost, relocated to another roost or departed from the lagoon. The horizontal distance of the disturbance source from roosting pelicans, as well as the altitude for aircraft overflights, was estimated. The horizontal distance for aircraft flying directly over a roost was recorded as zero. If the source of the disturbance could not be determined, it was recorded as unknown. We also noted potential sources of disturbance that did not flush pelicans. Events that flushed pelicans from more than one roost site within the central basin were recorded as a single disturbance.

## GROUND SURVEYS OF LOCAL ROOSTS

In 2002, we conducted ground surveys at four other roost sites in the vicinity of Mugu Lagoon (hereafter "local roosts"). Surveys of Rincon Island (RI), Ventura Harbor Breakwater (VHB), Santa Clara River Mouth (SCRM), and Channel Islands Harbor Breakwater (CIHB) (Figure 1) were conducted once per month from August through December. Jetties at VHB and CIHB were also inspected for pelicans. Each survey took place approximately two to three hours prior to sunset until dusk. Counts were conducted once every 30 minutes, and following large fluctuations in numbers caused by disturbances or mass departures. Counts continued until pelicans were no longer visible due to darkness or all birds departed from the roost. Disturbance observations were continuous throughout each survey and were recorded using the same methods used at Mugu Lagoon. All counts were made with a spotting scope with a 20-60X zoom eyepiece.

## DISTURBANCE RATES

We determined the number of disturbance events per hour of observation for Mugu Lagoon and the four monitored local roosts. We also determined rates of disturbance for natural versus human-caused sources. Natural disturbances included those caused by raptors, waves, and disturbances whose cause was unknown. All others were human-caused disturbances. For each of the five roosts, we also calculated a disturbance index (D), developed by Jaques et al. (1996) and modified by Jaques and Strong (2002). The index is intended as a measure of disturbance severity and calculated with the following formula:

$$D = \text{SQR ROOT } \frac{(N*(n\ depart*3)+(n\ relocate*2)+(n\ reland))}{\text{Hours of observation}}$$

where N is the total number of disturbances, and n depart, n relocate or n reland are the number of pelicans showing that response. These data, summarized in Table 4, are useful for comparison to data collected by Jaques and Strong (2002) in southern and central California.

## AERIAL PHOTOGRAPHIC SURVEYS OF LOCAL ROOSTS

Between April 2000 and January 2002, we conducted monthly aerial photographic surveys of roosting pelicans at Mugu Lagoon and other nearby roosts in the eastern Santa Barbara Channel. No survey was conducted in February 2001. These local roost surveys extended from Santa Barbara Harbor in the north to Point Dume in the south, an area described by Gress and Anderson (1983) as having traditional roost sites important to pelicans breeding at Anacapa Island. West Anacapa Island is the largest pelican colony in the SCB (Gress 1995, 2002; Gress and Anderson 1983; Gress and Martin 2000). East Anacapa Island was also included in local roost surveys as a large roost is usually present there during the non-breeding season. Movements between local roosts and the Anacapa colony likely occur within this region.

In late fall 2001, additional local roost surveys were conducted before and after helicopter flights associated with the Black Rat (*Rattus rattus*) eradication program at Anacapa Island (ATTC 2001). These surveys were aimed at assessing if disturbance from helicopter flights affected use of East Anacapa Island roost sites by pelicans and caused movements to mainland roosts, including Mugu Lagoon. Surveys were conducted on 3 and 10 October before and after a simulated eradication helicopter flight. A survey on 29 October was conducted before a planned helicopter flight which was later cancelled. The helicopter flight applying the rodenticide took place on 5 December. Regularly scheduled local roost surveys on 19 November and 10 December served to assess whether the distribution of roosting pelicans in the local survey area was affected over several days by detecting major movements away from Anacapa Island. Short term or smaller movements could not be assessed with our methods.

Most surveys were conducted on the same day between 10:00 and 15:00 h (PDT), with some conducted as early as 09:00 and as late as 18:00. Surveys were generally scheduled for the middle of each month. All local roosts were not photographed on the same day during five surveys (January, March, May, June, and September 2001; Tables 2, 3). Birds foraging on the ocean or in flight over the ocean were not counted during aerial photographic surveys. Surveys were flown at altitudes of 500-800 feet in fixed-wing aircraft operated by the California Department of Fish and Game and Aspen Helicopters. Photography and counting methods followed those detailed in Carter et al. (1992) and Jaques et al. (1996). As on ground surveys, pelicans were aged as adult or immature in photographs when possible. Immatures may be slightly undercounted in aerial photographs as birds with all white bellies but varying amounts of white in the head were aged as adult when only the head could be seen.

## RESULTS

### GROUND SURVEYS OF MUGU LAGOON

#### *Habitat Use*

As in 2001, pelican activity at Mugu Lagoon was concentrated in the central basin area near the mouth of the lagoon (Figure 2). The main roost areas were along the entire length of the east spit, from the lagoon tip to the ocean tip (ESPTLT and ESPTOT), and on the mudflats just east of a Harbor Seal (*Phoca vitulina*) haul out area ("Harbor Seal Flats", HSF). The west spit (WSPT) and a mudflat area north of ESPTLT ("Shorebird Cove", SBC) were used sporadically and typically during low tide. Pelicans used WSPT when a temporary island formed during low tides, and typically as a staging area when pelicans first arrived at the lagoon near sunrise and departed the lagoon near sunset. As the tide rose, pelicans then moved to other roosts in the central basin. During high tides, the available roosting area on this sandbar becomes too near the human traffic at the parking lot for use by pelicans. High tides also inundated HSF leaving only the east spit as roosting habitat. The central basin waters were used regularly for bathing and foraging. Pelicans roosted on the beach to the east toward the firing range on 20 September. A high count of 87 birds occurred in the early afternoon in association with a feeding flock just offshore. Roosting on the beach to the west of the lagoon mouth ("Family Beach"; FAM) was also observed by NBVCPM biologists (Appendix 1).

Pelican use of the western arm of the lagoon appears to have increased since surveys in 1991-1993 by Jaques et al. (1996). In 44 ground surveys of this area in 1991-1993, the highest number of pelicans seen in the lagoon west of Laguna Road was just six. NBVCPM biologists counted more than 50 pelicans in this area three times in August-October 2001 (Capitolo et al. 2002) and twice in October 2002 (Appendix 1). The highest number of pelicans observed using this area during HSU monitoring was 76 on 8 October 2002. A peninsula extending about 50 m into the lagoon along the "Oxnard 6 ditch" (OX6) was the main area used during the day. A sandbar approximately 100 m west of Laguna Road became a temporary island at low tides and was the primary night roosting location in 2002 (see below). A small mussel shoal about 30 m west of Laguna Road was also used by less than 20 pelicans during low tide. On several occasions, less than 10 pelicans were also seen perched on either the west or east side of the culvert (known as the Laguna Road Causeway) connecting the western and eastern arms of the lagoon. Single pelicans were also seen standing in narrow channels adjacent to roads near the central basin.

The sandbar configuration of the central basin has changed only slightly since 1993, after flooding caused dramatic changes in January 1992 (Jaques et al. 1996). Onuf (1987) stated that the mouth of the lagoon has been known to migrate and slight shifting of the western sandbar at the lagoon mouth was evident in 2001. In 2002, ESPTOT also eroded slightly during the survey period.

*Seasonal Roosting Patterns*

Averages of high counts of numbers of pelicans roosting in the central basin of Mugu Lagoon were greatest in August and declined through December (Table 1). The peak daily count of 463 occurred on 20 August (Figure 3). Numbers of immatures were also highest in August and declined through December. Immatures comprised an average of 40% of all roosting pelicans in August, 36% in September, 22% in October, 12% in November, and 4% in December (Figure 5).

Ground counts by NBVCPM biologists were conducted on 164 dates, one to two times daily, in 2002 (Appendix 1). Counts in August-December were lower than counts during HSU surveys, but showed a similar seasonal pattern (Figure 4). Counts of more than 100 pelicans occurred in all months from January-July, with exceptionally high counts of more than 700 birds in early June. These counts indicate the continued importance of Mugu Lagoon to pelicans from SCB colonies during the breeding season.

A minimum of six banded pelicans were observed on ten occasions (Appendix 2). On 10 December, we were able to read a partial band number of an adult pelican with a single aluminum band on its left leg. The partial band number, along with the configuration of the band, allowed determination that the bird was a male banded (# 609-11401) and released as an immature at Terminal Island in San Pedro Bay, California on 25 February 1990, following rehabilitation from oiling during the *American Trader* oil spill (Anderson et al. 1996; D. W. Anderson and F. Gress, pers. comm.). Three other sightings of adults with a single aluminum band on the left leg may or may not have been this same individual. Four pelicans, three immatures and one adult, lacked an aluminum U.S. Fish and Wildlife Service (USFWS) band but had unique color band combinations and may also have once been banded following rehabilitation from oiling along the California coast. These band combinations were not recognizable by researchers banding pelicans at colonies in the SCB or Mexico, or at the Salton Sea. Pelicans banded at these sites always receive an aluminum USFWS band. Pelicans have not been banded at SCB colonies since 1996 (D. W. Anderson and F. Gress, pers. comm.). Rehabilitated and released pelicans banded by the International Bird Rescue Research Center also have only a USFWS aluminum band (J. Holcomb, pers. comm.), and these color bands were instead likely applied by southern California wildlife rehabilitation groups.

Two pelicans were also observed with open wounds on 24 November and 11 December. On both individuals, a defeathered area extended across the breast approximately 6-8" wide and 1-3" high. Both individuals were observed at ESPTLT and roosted apart from the other pelicans. It is unlikely that these were the same individual, as the bird on 11 December appeared to have fresh blood on its lower breast feathers and was unable to fly away from the central basin at dusk (see below). Small numbers of pelicans collide with power lines at NBVCPM (USFWS 2001) and a pelican with a similar wound died after colliding with a power line in January 2003. A pelican with a gunshot wound was also seen in 2002 on Ormond Beach (M. Ruane, pers. comm.).

Other species usually present at pelican roosts included Double-crested Cormorants (*Phalacrocorax auritus*), Western Gulls (*Larus occidentalis*), Ring-billed Gulls (*Larus delawarensis*) and Heermann's Gulls (*Larus heermanni*). On several surveys, approximately 50 Double-crested Cormorants were noted night roosting on power lines above the pipeline in the north central basin. A minimum of eight banded Western Gulls were observed on 14 occasions (Appendix 2) and are likely from colonies at Santa Barbara and Anacapa Islands, where the National Park Service bands Western Gull chicks (P. Martin, pers. comm.). The high count of 72 Heermann's Gulls was recorded on 19 August. This observation coincides with our pelican high count on 20 August, as the timing of dispersal from colonies in Mexico is similar for Heermann's Gulls and pelicans (Briggs et al. 1983). Other species occasionally present at pelican roosts included California Gull (*Larus californicus*), Bonaparte's Gull (*Larus philadelphia*), Herring Gull (*Larus argentatus*), Glaucous-winged Gull (*Larus glaucescens*), and Black Skimmers (*Rhynchops niger*). Several banded skimmers that had moved to Mugu Lagoon from other southern California estuaries were also seen, but we could not determine band combinations. Skimmers do not currently breed at Mugu Lagoon.

*Diurnal and Night Roosting Patterns*

In 2002, pelicans were usually not present in the central basin at dawn, but began to arrive at roosts 10-40 minutes prior to sunrise. Numbers increased through the morning, were highest in mid and late afternoon, and decreased near sunset. High counts occurred in mid to late afternoon on 10 of the 16 surveys. Two high counts occurred within one hour of sunset and four high counts occurred within one hour of midday. Similarly, high counts in August to October 2001 all occurred near midday or later (Capitolo et al. 2002). All pelicans departed the central basin before dusk on 13 of the 16 surveys. The last pelican departed on average 33 minutes after sunset (Figure 6).

Unlike 2001, there was no occasion in 2002 when pelicans were present in the central basin at dusk and again the following dawn. In 2002, pelicans remained in the central basin at dusk on three survey dates in September, but surveys were conducted the following day only once and no birds were present at dawn. These birds may have moved during the night to a different roost within the lagoon, although night roosting in the western arm of the lagoon was not confirmed until December. On 10 December, pelicans departing the central basin were observed flying towards the western arm of the lagoon after sunset. Forty-two pelicans remained roosting on a sandbar in the middle of the western arm that was exposed at low tide. At least 39 pelicans were present at dawn the following morning at the edge of the lagoon just east of the Oxnard 6 ditch, and were likely forced off the sandbar by a high tide over night. On 11 December, approximately 30 pelicans remained at dusk, mostly along the peninsula extending beside the Oxnard 6 ditch. A single pelican remained on the mudflats in the central basin as it could only manage short flights due to injury. The western arm was again inspected on the evenings of 15 December 2002 and 7 January 2003. All 27 and 60 pelicans, respectively, departed the central basin after sunset and remained on the sandbar in the western arm at dusk. Night roosting in the western arm of the lagoon may have occurred earlier in the season undetected. Night roosting in the western arm likely occurred in 2001 as well. Night roosting in the central basin did not occur on surveys after 19 August, but 20-30 pelicans were noted in the western arm at dusk on 20 August and on 4 and 5 September.

On other occasions, pelicans were present in the central basin on our first counts of the morning (Figure 6) but likely did not night roost. On 20 August, pelicans were present 20 minutes before sunrise at the west spit bordering the mouth of the lagoon upon our arrival. It is unlikely that these birds roosted overnight since this area was only exposed during lower tide levels and birds typically gathered at this area only briefly before moving to the more commonly used roost sites within the lagoon. On the mornings of 8 October and 9 and 10 November, pelicans were present in the central basin on the first count of the morning but fog prevented counts until just before sunrise. Given the pattern of pelicans departing the central basin on most evenings, it is unlikely pelicans roosted over night in the central basin before the first counts on these three dates.

*Disturbance*

In 2002, we noted a total of 70 disturbance events during 163.2 hours of observations (Tables 4-7; Figure 7). The overall rate was 0.43 events per hour, nearly identical to the 0.41 rate from observations made in 1991-1993 (Jaques et al. 1996). Aircraft flyovers caused 35.7% of all disturbances in 2002, while waterfowl hunting and human recreation activities on WSPT were the two main disturbance sources in 1991-1993. However, HSU surveys in 2002 were conducted on just one waterfowl hunting day, and WSPT is now less frequently used by pelicans since it was greatly reduced in size after flooding during January 1992. Also, the remaining area of the spit is now closed to the public and regularly patrolled by security personnel. However, the increased percentage of aircraft disturbances may also reflect changes in Navy air operations, such as the recent addition of four E-2 squadrons (USFWS 2001). E-2s were noted causing six disturbances in 2002.

Most of the aircraft disturbances were due to aircraft flying low and over the roost, though disturbances caused by the noise of aircraft from runways and engine testing facilities to the west were also noted. The average estimated height and horizontal distance from roosts for aircraft flyovers that caused disturbances were 424 feet (129 m) and 217 feet (66 m), respectively.

Trespassers were observed twice in 2002 and disturbances to roosting pelicans were noted both times. Two people walking on WSPT flushed pelicans on one occasion and a trespassing surfer flushed pelicans twice. The surfer walked up the beach east of the lagoon and paddled across the mouth. Researchers conducting a bathymetry study from a small boat caused two disturbances and a marsh restoration crew carrying large, white, plastic containers flushed pelicans from as far away as 250 m. Gunshots from the rifle range to the east of the lagoon mouth flushed birds on occasion. No disturbances were noted due to vehicle traffic and training exercises in the parking lot at the mouth of the lagoon. Natural disturbance causes include close flights over roosts by Turkey Vultures (*Cathartes aura*), Northern Harriers (*Circus cyaneus*), and a Great Blue Heron (*Ardea herodias*). Many unknown-cause disturbances may have resulted from flyovers by Peregrine Falcons (*Falco peregrinus*) that we did not detect.

## GROUND SURVEYS OF LOCAL ROOSTS

### *Rincon Island*

Surveys of RI were conducted from the mainland and counts represent only a fraction of the total number of pelicans present. The majority of pelicans seen in aerial surveys roost on the west perimeter of the island and are not visible from mainland vantage points. Our high ground count of 306 occurred in December (Table 1), the same month when highest RI counts from aerial photographic surveys in 2000-2001 also occurred (Tables 2, 3; see below). On all surveys, the first count at 2 hours before sunset was highest (Figure 8). Pelicans did not roost overnight in areas visible from the mainland from August through November, but 53 pelicans remained at dusk on 9 December. On-island surveys are necessary to better evaluate use of RI as a night roost (see also Jaques and Strong 2003, Strong and Jaques 2003). The lowest disturbance rate of our monitored local roosts occurred at RI with just 0.07 events per hour (Table 4). Jaques and Strong (2002) also reported lowest disturbance levels at man-made structures and harbors rather than at estuaries. We observed only one disturbance at RI, perhaps due to a boat checking crab pots. Thirty crab pot floats were counted within 10 m of the island in October, but boats were only briefly observed checking crab pots on two occasions. Since the average estimated distance at which pelicans flush from disturbances caused by boats was 13.75 m for CIHB and VHB combined (see below), disturbances at RI may be more frequent than we detected.

### *Ventura Harbor Breakwater*

The VHB was under construction in August, preventing use by pelicans. The high count of 460 occurred in November (Table 1). Despite earlier construction, lower numbers in December may have been due to large waves crashing over most of the VHB. During a SCRM survey, pelicans were opportunistically noted roosting on the north jetty in December as waves crashed over most of the breakwater. Numbers of roosting pelicans decreased toward sunset during all surveys, but moderate numbers of pelicans were still present near dusk and some pelicans may have night roosted (Figure 8). Jaques and Strong (2003) also noted night roosting at VHB in July and September 2000. We observed a disturbance rate of 0.53 events per hour (Table 4). Causes of disturbances included fishermen in boats, people walking on the breakwater, and breaking waves. The average estimated distance at which pelicans flushed was 12.5 m for disturbances caused by boats. In November, a fisherman walking on top of the breakwater flushed 79 pelicans. Though public access to the breakwater is not allowed, a harbor patrol boat was observed waving to the fisherman. A few pelicans (< 5) were knocked into the water on 5 December when surprised by a large, crashing wave. Potential sources of disturbance observed included lobster divers shining lights on the breakwater at night and fishermen setting crab pots next to the breakwater and jetty.

### *Santa Clara River Mouth*

Pelicans roosted primarily on sand bars on the inner portion of SCRM when the river flowed freely, but roosted exclusively on the beach outside the mouth when a berm sealed off the river mouth from the ocean. SCRM was blocked by a berm in September and December and open on surveys in August and November. When blocked, water levels rose and covered the sandbars, forcing pelicans to roost on the beach. A high count of 300 pelicans occurred in September (Table 1). On all surveys, the first count at 2 hours before sunset was highest and all pelicans departed the roost before dusk (Figure 8). SCRM was the most disturbed roost site with a disturbance rate of 1.42, nearly twice the rate for the second most disturbed site (Table 4). Thirteen of the 17 observed disturbances occurred when pelicans were roosting on the beach. Disturbance rates are likely even higher at other times as our presence (i.e., conducting research with a spotting scope and clipboard), likely deterred people walking or running on the beach from continuing past the pelican roost. Disturbances caused by people were observed on all five surveys and included people walking on the beach, unleashed dogs, and surfers. Peregrine Falcons, drawn to the estuary by the presence of prey such as shorebirds and waterfowl, were also noted flushing pelicans. The average flushing distance for beach walkers was 25.6 m, while unleashed dogs caused the pelicans to flush at 53.3 m on average. High disturbance rates have previously been reported here (Jaques et al. 1996; Jaques and Strong 2002; Strong and Jaques 2003).

*Channel Islands Harbor Breakwater*

In addition to roosting on the CIHB, pelicans roosted on dredging pipes inside the CIHB that were present October through December. The pipes were the only available roosting habitat in December as large waves crashed over most of the CIHB. Most pelicans also roosted on the pipes in October. The high count of 97 occurred in October (Table 1). Most birds departed the roost, but night roosting may have occurred on all surveys as low numbers of pelicans (<10) were still present near dusk (Figure 8). Night roosting inside the harbor near a bait-holding pen has also been documented (Jaques and Strong 2003; Strong and Jaques 2003). We observed a disturbance rate of 0.68 events per hour (Table 4). Disturbances caused by people were observed on all five surveys and included close passes by boats, jet skis, and surfers. The average estimated distance at which pelicans flushed was 14.2 m for disturbances caused by boats and 40 m for jet skis. Dredging activities next to the harbor caused two of the disturbances when a tug boat moved the dredging pipes on which the pelicans were roosting. All observed disturbances in October through December took place while pelicans were roosting on the pipes. No pelicans were observed roosting on the jetties during the study.

## AERIAL PHOTOGRAPHIC SURVEYS OF LOCAL ROOSTS

*Roost Use*

In addition to Mugu Lagoon, RI, VHB, SCRM, and CIHB, three other sites within the local roost survey area were regularly used by pelicans: Santa Barbara Harbor (SBH), Ventura River Mouth (VRM), and East Anacapa Island (EAI) (Figure 1; Tables 2, 3). EAI was the most important roost location, hosting 39.4% of the total number of roosting pelicans in the eastern

Santa Barbara Channel from all 23 surveys between April 2000 and January 2002. Roosting pelicans were present at EAI on 21 of the 23 surveys. Pelicans were not present on the May and July surveys in 2001, but roosts often form during this time of year within the colony on West Anacapa Island (F. Gress, pers. comm.). At EAI, pelicans roosted extensively on the cliffs and rocks along the south side, on top of the island east of the lighthouse, and on Arch Rock at the east end. Smaller roosts were seen occasionally on the cliffs on the north side.

Roost use at EAI was not affected to a significant extent by helicopter flights in November and December 2001. The numbers of pelicans at EAI on 3 and 10 October (before and after the first helicopter flight) were almost identical. Furthermore, the highest EAI roost count from all 23 surveys occurred on 10 December, five days after the second helicopter flight (Table 3).

RI was the second most important roost, accounting for 29.4% of roosting pelicans in the eastern Santa Barbara Channel and was used on all 23 surveys. Pelicans roost around the perimeter of the island on huge, concrete structures and are protected from waves by the relatively high island perimeter. The VHB and CIHB provide similar roosting habitat to RI, but are lower and more exposed to sea conditions and accounted for 10.3% and 2.1% of all roosting pelicans in the eastern Santa Barbara Channel, respectively. Pelicans roost primarily on the harbor side of the breakwaters and large swells on occasion prevent use of the breakwaters entirely, as in December 2001 when no pelicans were present at CIHB and only small numbers at VHB (Table 3).

Mugu Lagoon was the only other major roost site used on all 23 surveys. It accounted for 6.5% of roosting pelicans in the eastern Santa Barbara Channel and was the largest estuarine roost in the survey area. Numbers fluctuated widely at SCRM, which was used on 20 surveys. High counts of over 400 pelicans occurred in August and December 2001, while fewer than 20 pelicans were present on nine other surveys. The availability of roost habitat varies over time as the river mouth is periodically sealed off from the ocean by a beach berm. VRM was used on only 11 of the 23 surveys and accounted for less than 1% of all roosting pelicans.

At SBH, pelicans roosted on the rooftops along Stearns Wharf, on bait barges inside the harbor, and on beaches to the east and west of the wharf. SBH accounted for 6.5% of roosting pelicans in the eastern Santa Barbara Channel. Other mainland roosts accounted for 1.3% and no other mainland roost site was used on more than three surveys. Other locations where pelican roosts were seen on more than one survey include Carpinteria Marsh, Ormond Lagoon, and Ormond Beach.

*Seasonal Abundance*

In both 2000 and 2001, the total number of roosting pelicans in the eastern Santa Barbara Channel was low in April, increased slightly in May and June, and increased further in July to November. Numbers were low in July 2000, perhaps due to lower photo quality, and the peak fall count in 2001 (5,270 in August) was much higher than in 2000. Numbers peaked in December in both years, and remained high in January 2001 but decreased in January 2002. Most individual roosts showed a similar attendance pattern (Tables 2, 3; Figures 9, 10). VRM was used sporadically with peak counts in May 2000 and June 2001. The high count at SCRM in 2000 also occurred in May. Higher disturbance rates at these habitats compared to VHB and CIHB (Jaques and Strong 2002; this report) likely explain inconsistent roosting patterns at these locations. The highest individual roost counts occurred at EAI (i.e., 2,659 pelicans on 16 January 2001 and 5,600 pelicans on 10 December 2001). The highest mainland roost counts usually occurred at RI, with a peak count of 2,636 pelicans on 6 December 2000.

Percentages of immatures were typically much higher at mainland roosts than at EAI (Tables 2, 3; Figures 11, 12). Immatures were most abundant in early fall, outnumbering adults on the mainland in August and September of both years. At all roosts in the eastern Santa Barbara Channel in both years, the percentage of immatures was low but increased from April to July, peaked in August and September, and decreased in October. Immature numbers remained low through January, but higher than numbers in March and April. Higher immature percentages occurred in small roosts in June at EAI in both years. The percentage of immatures remained high at SBH through both falls.

## DISCUSSION

*Seasonal abundance of roosting pelicans in the eastern Santa Barbara Channel (2000-2001)*

Seasonal movements of Brown Pelicans in California have been described previously through aerial surveys, ship surveys, ground surveys, Christmas Bird Counts, and band recoveries (Anderson and Anderson 1976; Briggs et al. 1981, 1983; Jaques 1994; Jaques et al. 1996). HSU and USGS monthly aerial surveys augmented our understanding of pelican roost-use patterns at Mugu Lagoon and nearby roosts by correlating total numbers of pelicans in the eastern Santa Barbara Channel with breeding phenology at colonies in the SCB and GC.

East Anacapa Island: Few pelicans roosted at EAI in April-July in 2000 and in April-June 2001 when breeders and immatures attended colonies and roosted in loafing groups on West Anacapa Island (F. Gress, pers. comm.). High fall numbers at EAI in September 2000 and August 2001 reflected use of the EAI roost site by SCB adults after leaving breeding colonies plus migrant GC adults arriving from Mexico. However, most immatures used mainland roosts in August and September (see below). Adults continued to roost at EAI in large numbers in the fall. Peaks in January 2001 and December 2001 reflected GC adults returning to Mexico and SCB adults returning to attend colonies. In 2001, egg laying at West Anacapa Island did not begin until mid February (Gress 2002). Numbers at EAI were low in January 2002 when breeding activities at West Anacapa Island began in early January (F. Gress, pers. comm.). This general pattern of pelican movements and EAI roost use was consistent with previous years and studies. Extensive use of the other Channel Islands for fall roosting by pelicans has also been well documented

(Jaques et al. 1996; HSU and USGS, unpublished data).

Mainland Roosts: In both years, small numbers of roosting adults were present in April at mainland roosts, reflecting some use of mainland areas for foraging by local birds from West Anacapa Island and a lack of GC birds in the area. In May-June 2000, an influx of mainly adults occurred at mainland roosts but not at EAI; but by July, numbers were again lower. In 2000 and 2001, the number of nest attempts at West Anacapa Island was approximately 65 percent of the average number of nest attempts in 1994-1999 (excluding 1998 when breeding was reduced due to El Niño) (Gress 2002). The reduced proportion of adults breeding may explain greater use of mainland roosts in May-June 2000, if non-breeding adults foraged closer to the mainland during cold water related to La Niña. However, by July 2000, La Niña conditions had abated substantially and pelicans may have foraged more widely. In 2001, when La Niña conditions no longer occurred, pelicans again foraged more widely and an increase was not seen at mainland roosts in May and June despite the reduced number of nest attempts. An early influx of GC adults into the SCB was noted in June 1992, with increased numbers at mainland roosts, but was related to early colony abandonment in Mexico under strong El Niño conditions (Jaques et al. 1996).

In 2000, numbers at mainland roosts did not increase substantially in July-September. However, the percentage of immatures was much higher (63-67%) in August and September, indicating arrival of GC pelicans and potential movement of SCB immatures to mainland roosts. In 2001, a large increase occurred at mainland roosts in July to September (peaking in August), with large percentages of immatures in August and September (50-61%). This timing and pattern of movement was more typical of other years, with GC adults and immatures dispersing northward together plus SCB adults and immatures moving from colonies to island and mainland roosts. Foraging conditions, disturbance at roost sites, or differing dispersal patterns may explain why this large increase was not seen in July-September 2000. At Mugu Lagoon, we have observed the entire roost departing the lagoon during the day to forage in a feeding flock offshore. Such events before aerial surveys could affect aerial survey numbers.

Fall numbers at mainland roosts were high in both years, indicating extensive use of the eastern Santa Barbara Channel region during the non-breeding season. In 2000, very high numbers in October may have reflected local movements of adults and immatures from the Channel Islands to the mainland; low numbers were seen at the EAI roost at this time. Peak numbers occurred at mainland roosts in December in both 2000 and 2001 and reflected large southward movements of GC birds to Mexico. By late winter, the majority of pelicans in the SCB are from local colonies and pelicans from colonies in Mexico have mostly departed the California coast (Anderson and Anderson 1976; Gress and Anderson 1983). In January 2001, large numbers remained at mainland roosts later than normal but large numbers also attended the EAI roosts, indicating late return to West Anacapa Island.

*Numbers of roosting pelicans at Mugu Lagoon*

Numbers of roosting pelicans at Mugu Lagoon in 2002 were very similar to 2001. The peak high count (463) again occurred in August, although it was lower than in 2001 (572). Daily high counts on the other three August survey dates, however, were nearly identical to counts on the same dates in 2001. Surges in numbers of pelicans roosting at Mugu Lagoon were documented in 1991-1993 (Jaques et al. 1996). October numbers were higher in 2002 than in 2001 likely due to a prolonged breeding season at the Anacapa Island colony. Chicks from a late breeding effort of about 300 nests at West Anacapa Island did not fledge until mid October 2002 (F. Gress, pers. comm.). The mean of all October counts by NBVCPM biologists was 72 in 2001 (Capitolo et al. 2002) and 171 in 2002 (Appendix 1).

Total numbers of pelicans using Mugu Lagoon in 2001 and 2002 appear slightly higher than in 1991-1993 (Jaques et al. 1996). Very high counts were recorded in 1992 (i.e., 1,404 in June), but these resulted from large numbers of failed and non breeding adults from GC arriving early during strong El Niño conditions. In 1993, a successful GC breeding season, the mean daily high count at Mugu Lagoon in June-September was 150 birds with a peak high count of 260 in June, although no surveys were conducted in August. In 2001, omitting August data, the mean daily high count in June-September was 173. The mean daily high count in September 1993 was 137 birds versus 244 in September 2002. Higher numbers of pelicans using Mugu Lagoon in 2001-2002 may also explain increased use of the western arm of the lagoon since 1991-1993, though changes in the configuration of sandbars in the lagoon also may affect use of the western arm.

The slight increase in numbers of pelicans using Mugu Lagoon may be partly accounted for by population growth at SCB and GC colonies. Pelican populations in the SCB began increasing in the late 1970s after pollution-related declines in the late 1960s and early 1970s (Anderson and Anderson 1976; Anderson and Gress 1983; Anderson et al. 1975) and populations in the SCB and GC have increased and stabilized since the 1991-1993 period (Gress 2002; D. W. Anderson, pers. comm.). Increases in roosting numbers have also been found throughout California, Oregon and Washington over the past decade (D. L. Jaques, pers. comm.).

Numbers of pelicans at other roosts in the eastern Santa Barbara Channel also appear to have increased since the 1991-1993 period. In six aerial surveys in 1992-1993, the highest count at VHB was 125 while our mean count from 23 aerials surveys was 205, including a high count of 782. VHB ground counts in 2002 also averaged more than the highest ground count in 1991-1993, 355 versus 190 (Jaques et al. 1996; Tables 1-3). However, various factors affect these comparisons, such as times of day and months of surveys, timing of breeding and dispersal, breeding success (i.e., numbers of juveniles produced), availability of prey in the vicinity of roosts, and human disturbance of roosts. In any case, numbers of roosting pelicans are not declining at Mugu Lagoon or nearby roosts, an encouraging sign for the continued recovery and long-term maintenance of populations of this endangered seabird.

*Night Roosting at Mugu Lagoon and other nearby roosts*

As in 1991-1993, numbers of roosting pelicans at Mugu Lagoon were highest during the day and the lagoon was regularly used as a night roost by lower numbers. Island-like habitat is usually required for night roosting to provide protection from mammalian predators and humans on foot, and pelicans tend to concentrate at fewer, larger night roosts than during the day (Jaques and Strong 2003). In June-August 2001, pelicans night roosted at HSF whether low or high tides occurred overnight. Pelicans did not night roost at HSF after August 2001, nor in August-December 2002. HSF was also the primary night roost site in 1991-1993 and night roosting in the western arm was not observed. At Mugu Lagoon, it is unlikely that pelicans are using different night roosts seasonally since night roosting at HSF was documented in all months in 1991-1993. Habitat changes associated with sedimentary filling of mudflats may have decreased the island barrier at HSF while creating an island sandbar in the western arm. The dynamic nature of the lagoon configuration due to sedimentary filling and winter flooding (Onuf 1987; Jaques et al. 1996) may cause pelicans to select different night roost locations over time as the degree to which mudflats form temporary islands changes. Night roost locations in the western arm may also be less susceptible to disturbance as security vehicle headlights were documented flushing pelicans at HSF in 2001 and in 1991-1993. We recommend that security vehicles patrolling the parking lot at night circle the parking lot in a counterclockwise direction toward the ocean and avoid shining headlights toward HSF. With the dynamic nature of the lagoon, pelicans are likely to utilize HSF as a night roost again in the future. Conducting dusk and dawn surveys regularly throughout the year would allow a better understanding of pelican night roosting patterns and nocturnal movements. Monitoring of pelicans by NBVCPM biologists at Mugu Lagoon could be augmented to include periodic night roost surveys.

Ambient light levels may also affect pelican roosting patterns at night. Pelicans likely prefer night roost locations without bright lights to reduce detection by predators (especially those attracted to lights) and to provide appropriate conditions for resting and sleep. Lights from a movie set illuminated the central basin of Mugu Lagoon in 2000 (Capitolo et al. 2002) and a squid-fishing boat emitted bright lights about one mile offshore of the mouth of Mugu Lagoon in July 2001. Pelicans did not night roost in the central basin on either night. Much concern has been expressed about the potential effects of bright lights from squid-fishing boats on breeding and roosting seabirds in the Channel Islands and along the mainland. Squid-fishing boats emit very bright light close to shorelines which may result in nest failures, increased predation, and reduced use of breeding and roosting sites over time. Squid-fishing lights also occur periodically or sporadically, such that little habituation may develop. Impacts of noise and lights from squid-fishing and other boats on pelicans and other seabirds need to be further evaluated.

Within the eastern Santa Barbara Channel, the only current large night roost occurs at EAI. The large night roost at EAI is not directly illuminated by the beam of light emitted from the lighthouse (F. Gress, pers. comm.). Small numbers of pelicans also night roost at VHB and CIHB. However, large swells frequently wash over VHB and CIHB, preventing pelicans from consistently using them as night roosts. A large night roost was also present in the early 1990s in outer SBH on a temporarily abandoned barge (Jaques et al. 1996). Enhancement of VHB and CIHB by adding rock riprap and the creation of a new floating structure in outer SBH have been proposed as partial restoration for mortality from the *American Trader* oil spill (ATTC 2001; Strong and Jaques 2003; Jaques and Strong 2003). In the future, the west spit and parking lot area east of Family Beach at the mouth of Mugu Lagoon (Figure 2) may also become isolated, island habitat for pelicans. The Mugu Submarine Canyon is moving inland and is expected to breach the lagoon at a point between the mouth and Laguna Road. Buildings and other facilities in this area have been removed and reduced over the past decade in anticipation that the spit will become separated from the mainland and prevent further use for base operations. While this breach may not occur for many years (M. Ruane, pers. comm.), the formation of a large island with little or no human disturbance at the mouth of Mugu Lagoon would provide excellent roosting habitat for large numbers of pelicans both during the day and at night. When island formation occurs, much larger numbers of roosting pelicans can be expected at Mugu Lagoon.

*Disturbance at Mugu Lagoon*

Use of Mugu Lagoon in 2001-2002 by similar or larger numbers of pelicans than in 1991-1993 suggests that disturbance levels are low enough to allow continued use by pelicans. In fact, the disturbance rate in 2002 was nearly identical to the 1991-1993 rate. However, continued monitoring and protection of pelican roost areas remains important as human disturbance and habitat alteration may affect long-term use patterns (Jaques and Anderson 1988). Disturbance from Navy air operations appears to have increased since 1991-1993, apparently due to an increase in aircraft flyovers (e.g., four E-2 squadrons were added in 1999). In particular, flight patterns for touch-and-go practices extend over the central basin and often directly and repeatedly pass over roosting pelicans. Aircraft are recommended to remain above 500 feet (USFWS 2001), but fall below this altitude when approaching runways from the central basin. Sixteen of the 25 disturbances caused by aircraft flyovers in 2002 were by aircraft at altitudes below 500 feet, and at least six of the aircraft causing disturbances flew directly over roosting pelicans (Table 5). Aircraft above 500 feet over the central basin roost areas and those that do not fly directly over the ESPTLT and ESPTOT roosts cause fewer disturbances. Our periodic surveys likely did not detect many disturbances of this kind that undoubtedly occur on a regular basis.

Noise from air traffic also disturbed roosting pelicans. Fighter jets that caused disturbances in 2002 were above 500', but noise from firing afterburners caused pelicans to flush, especially when jets were over the central basin. In fact, engine noise from as far away as the runways flushed pelicans on occasion. Disturbance from helicopter noise also reflected flight paths over roosts at ESPTLT and ESPTOT. As in 1991-1993 (Jaques et al. 1996), helicopters caused the most disturbances among aircraft flyovers in 2002, at an average estimated altitude of 283 feet and an average horizontal distance from the roost of 64 m. At other southern California roosts, Jaques and Strong (2002) found that helicopters flushed pelicans at an average distance of 312 m from the roost, much farther away from the roost than any other disturbance source.

Disturbance events at Mugu Lagoon were observed consistently throughout the survey period, except in December when no disturbances were observed. During December surveys, more than 90% of roosting pelicans were adults and were likely from SCB colonies, as most GC pelicans have returned to colonies in Mexico by early winter (Anderson and Anderson 1976). Local pelicans familiar with Mugu Lagoon, adults in particular, may become habituated to disturbance from aircraft operations at NBVCPM over time. However, Mugu Lagoon is used regularly by immature and migrant GC pelicans (Jaques et al. 1996; Capitolo et al. 2002) which are unlikely to become habituated.

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Table 1. Monthly high counts of numbers of roosting Brown Pelicans from ground monitoring of Mugu Lagoon, California, and other local roosts, August-December 2002. Mugu Lagoon counts are means of the daily high counts for each month.

| Roost | August | September | October | November | December |
|---|---|---|---|---|---|
| Rincon Island[1] | 18 | 226 | 162 | 184 | 306 |
| Ventura Harbor Breakwater | 0[2] | 364 | 436 | 460 | 160 |
| Santa Clara River Mouth | 189 | 300 | 17 | 109 | 123 |
| Channel Islands Harbor Breakwater | 31 | 36 | 97 | 50 | 16 |
| Mugu Lagoon | 361 | 244 | 209 | 206 | 85 |
| Total | 599 | 1,170 | 921 | 1,009 | 690 |

[1]Rincon Island counts are incomplete, since only part of the island is visible from the mainland; [2]Breakwater under construction.

Table 2. Numbers of roosting Brown Pelicans in the eastern Santa Barbara Channel, California, in April 2000-January 2001. The percentage of aged pelicans that were immature appears in parentheses.

| Roost | 18 Apr | 23 May | 13 June | 11 July | 22 Aug | 13 Sept | 18 Oct | 17 Nov | 6 Dec | 16-18 Jan |
|---|---|---|---|---|---|---|---|---|---|---|
| Santa Barbara Harbor | 94 (10) | 79 (18) | 91 (41) | 0 (-) | 148 (99) | 60 (93) | 315 (67) | 171 (70) | 373 (49) | 247 (38) |
| Rincon Island | 43 (16) | 275 (11) | 333 (18) | 38 (0) | 101 (60) | 124 (38) | 961 (26) | 610 (26) | 2,636 (22) | 1,147 (11) |
| Ventura River Mouth | 0 (-) | 40 (0) | 49 (31) | 0 (-) | 4 (100) | 0 (-) | 15 (73) | 0 (-) | 0 (-) | 0 (-) |
| Ventura Harbor Breakwater | 0 (-) | 155 (7) | 194 (11) | 76 (10) | 219 (62) | 99 (56) | 412 (11) | 113 (9) | 453 (13) | 203 (6) |
| Santa Clara River Mouth | 21 (5) | 301 (4) | 180 (19) | 24 (9) | 52 (77) | 56 (91) | 5 (20) | 0 (-) | 15 (0) | 0 (-) |
| Channel Islands Harbor Breakwater | 0 (-) | 13 (0) | 4 (50) | 22 (12) | 44 (47) | 91 (87) | 17[1] (ND) | 15 (7) | 127 (7) | 3 (0) |
| Mugu Lagoon | 26 (8) | 217 (18) | 136 (32) | 288 (43) | 223 (44) | 211 (67) | 19 (32) | 6 (17) | 74 (18) | 125 (4) |
| Other mainland roosts | 0 (-) | 22 (18) | 0 (-) | 0 (-) | 9 (56) | 0 (-) | 16 (50) | 0 (-) | 4 (0) | 61 (8) |
| **Mainland roosts subtotal** | **184 (11)** | **1,102 (10)** | **987[2] (21)** | **448[3] (30)** | **800[4] (63)** | **641[5] (67)** | **1,760[6] (30)** | **915[7] (31)** | **3,682 (23)** | **1,786 (14)** |
| **East Anacapa Island** | **28 (4)** | **0 (-)** | **34 (88)** | **0 (-)** | **496[8] (18)** | **854 (24)** | **413 (3)** | **1,031 (5)** | **653 (11)** | **2,659[9] (6)** |
| **Eastern Santa Barbara Channel** | **212 (10)** | **1,102 (10)** | **1,021 (23)** | **448 (30)** | **1,296 (46)** | **1,495 (42)** | **2,173 (25)** | **1,946 (17)** | **4,335 (21)** | **4,445 (9)** |

[1]ground count (no photos were taken during aerial survey); [2]13 unknown age; [3]207 unknown age; [4]13 unknown; [5]15 unknown age; [6]17 unknown age; [7]8 unknown age; [8]2 unknown age; [9]77 unknown age.

Table 3. Numbers of roosting Brown Pelicans in the eastern Santa Barbara Channel, California, in April 2001-January 2002. The percentage of aged pelicans that were immature appears in parentheses.

| Roost | 30 Mar 6 Apr | 17 Apr | 22-24 May | 18,19 Jun | 17 Jul | 10 Aug | 19,21 Sept | 3 Oct | 10 Oct | 29 Oct | 19 Nov | 10 Dec | 15 Jan |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Santa Barbara Harbor | 39 | 45 | 0 | 67 | 81 | 222 | 251[2] | 212 | 54 | 16 | 99 | 247 | 88 |
| | (31) | (18) | (-) | (37) | (63) | (85) | (63) | (52) | (62) | (56) | (49) | (41) | (45) |
| Rincon Island | 75 | 122 | 165 | 123 | 498 | 986 | 968 | 1,181 | 496 | 469 | 200 | 1,292 | 628 |
| | (15) | (8) | (13) | (22 | (35) | (50) | (39) | (30) | (26) | (22) | (26) | (26) | (17) |
| Ventura River Mouth | 3 | 0 | 30 | 0 | 2 | 14 | 0 | 4 | 0 | 0 | 9 | 0 | 4 |
| | (0) | (-) | (10) | (-) | (0) | (71) | (-) | (50) | (-) | (-) | (44) | (-) | (75) |
| Ventura Harbor Breakwater | 97 | 25 | 68 | 50 | 250 | 782 | 167 | 285 | 446 | 223 | 245 | 79 | 68 |
| | (8) | (8) | (7) | (18) | (29) | (54) | (34) | (23) | (16) | (24) | (33) | (17) | (19) |
| Santa Clara River Mouth | 11 | 19 | 112 | 1 | 7 | 402 | 25 | 5 | 6 | 13 | 185 | 446 | 0 |
| | (0) | (11) | (13) | (0) | (0) | (80) | (32) | (60) | (0) | (31) | (45) | (24) | (-) |
| Channel Islands Harbor Breakwater | 0 | 0 | 29 | 24 | 41 | 208 | 111 | 35 | 26 | 59 | 103 | 0 | 1 |
| | (-) | (-) | (7) | (4) | (56) | (75) | (32) | (31) | (27) | (17) | (38) | (-) | (0) |
| Mugu Lagoon | 23 | 55 | 142 | 164 | 157 | 504 | 181 | 84 | 45 | 4 | 71 | 104 | 119 |
| | (26) | (9) | (39) | (29) | (46) | (56) | (38) | (27) | (36) | (50) | (31) | (31) | (8) |
| Other mainland roosts | 0 | 0 | 0 | 0 | 3 | 231 | 158 | 0 | 5 | 0 | 17 | 12 | 70 |
| | (-) | (-) | (-) | (-) | (67) | (69) | (78) | (-) | (40) | (-) | (47) | (0) | (11) |
| **Mainland roosts subotal** | **248** | **266** | **546** | **429** | **1,039** | **3,349** | **1,861[2]** | **1,806** | **1,078** | **784** | **929** | **2,180** | **978** |
| | **(15)** | **(10)** | **(18)** | **(26)** | **(37)** | **(61)** | **(50)** | **(31)** | **(24)** | **(23)** | **(36)** | **(27)** | **(19)** |
| **East Anacapa Island** | **152** | **75** | **128** | **19** | **789** | **1,921[1]** | **70** | **695** | **692** | **604** | **945** | **5,600** | **215** |
| | **(10)** | **(15)** | **(25)** | **(37)** | **(15)** | **(27)** | **(26)** | **(8)** | **(9)** | **(17)** | **(14)** | **(12)** | **(12)** |
| **Eastern Santa Barbara Channel** | **400** | **341** | **674** | **448** | **1,828** | **5,270** | **1,931** | **2,501** | **1,770** | **1,388** | **1,874** | **7,780** | **1,193** |
| | **(13)** | **(11)** | **(19)** | **(26)** | **(28)** | **(50)** | **(49)** | **(25)** | **(18)** | **(20)** | **(25)** | **(16)** | **(18)** |

[1]317 unknown age; [2]33 unknown age.

Table 4. Summary of Brown Pelican disturbance rates at Mugu Lagoon and nearby roosts, August-December 2002.

| Roost | Total Survey Days | Total Observation Hours | Total Disturbances | Natural Disturbance Rate | Human Caused Disturbance Rate | Total Disturbance Rate | Disturbance Index (D) |
|---|---|---|---|---|---|---|---|
| Mugu Lagoon | 16 | 163.2 | 70 | 0.15 | 0.28 | 0.43 | 53.4 |
| Rincon Island | 5 | 14.3 | 1 | 0.07 | 0 | 0.07 | 5.09 |
| Ventura Harbor Breakwater | 4 | 11.4 | 6 | 0.09 | 0.44 | 0.53 | 19.76 |
| Santa Clara River Mouth | 5 | 11.98 | 17 | 0.42 | 1.00 | 1.42 | 52.90 |
| Channel Islands Harbor Breakwater | 5 | 13.28 | 9 | 0 | 0.68 | 0.68 | 10.35 |

Table 5. Aircraft flyovers and noise from distant aircraft (see text) causing disturbance to roosting Brown Pelicans at Mugu Lagoon, California, in August-December 2002.

| Aircraft | Date | Time | Altitude (feet) | Horizontal Distance (m) | Number of Pelicans | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Flush | Depart | Relocate | Reland |
| Helicopter | 7 Aug. | 11:47 | 500 | ND | 5 | 0 | 0 | 5 |
| Passenger Plane | 7 Aug. | 13:02 | 600 | 0 | 10 | 0 | 6 | 4 |
| Helicopter | 7 Aug. | 15:22 | 400 | 250 | 7 | 0 | 5 | 2 |
| Passenger Plane | 7 Aug. | 15:51 | 550 | 100 | 25 | 25 | 0 | 0 |
| F-14 | 7 Aug. | 16:03 | 700 | ND | 40 | 1 | 0 | 39 |
| Biplane | 7 Aug. | 18:44 | 600 | ND | 5 | 0 | 0 | 5 |
| Biplane | 7 Aug. | 18:44 | 600 | ND | 5 | 0 | 0 | 5 |
| F-14 | 8 Aug. | 12:02 | 700 | ND | 8 | 0 | 6 | 2 |
| F-14 | 8 Aug. | 12:02 | 700 | ND | 4 | 0 | 2 | 2 |
| E-2 | 8 Aug. | 14:20 | 300 | 50 | 10 | 0 | 1 | 9 |
| Cargo Plane | 8 Aug. | 18:19 | 200 | 0 | 30 | 0 | 0 | 30 |
| Aircraft noise | 19 Aug. | 12:33 | ND | ND | 16 | 16 | 0 | 0 |
| Helicopter | 20 Aug. | 8:23 | 100 | 0 | 16 | 3 | 13 | 0 |
| Aircraft noise | 20 Aug. | 17:55 | ND | ND | 24 | 3 | 17 | 4 |
| Helicopter | 6 Sept. | 8:15 | 400 | 100 | 25 | 0 | 0 | 25 |
| Aircraft noise | 6 Sept. | 12:00 | ND | ND | 127 | 7 | 120 | 0 |
| 2 Helicopters | 6 Sept. | 16:58 | 200 | 50 | 160 | 5 | 50 | 105 |
| Sm. Passenger Jet | 7 Sept. | 16:57 | 500 | 0 | 4 | 4 | 0 | 0 |
| Aircraft noise | 19 Sept. | 11:18 | 0 | ND | 8 | 0 | 0 | 8 |
| Helicopter | 19 Sept. | 16:08 | 400 | 25 | 8 | 0 | 0 | 8 |
| Helicopter | 19 Sept. | 16:40 | 150 | 50 | 10 | 0 | 6 | 4 |
| Aircraft noise | 20 Sept. | 13:22 | 0 | ND | 5 | 0 | 5 | 0 |
| Helicopter | 20 Sept. | 14:20 | 200 | 25 | 16 | 0 | 16 | 0 |
| Helicopter | 20 Sept. | 14:20 | 200 | 10 | 20 | 0 | 0 | 20 |
| F-4 | 28 Oct. | 11:59 | 700 | 0 | 4 | 0 | 0 | 4 |
| E-2 | 28 Oct. | 12:57 | 400 | 100 | 1 | 0 | 1 | 0 |
| E-2 | 28 Oct. | 12:58 | 200 | 0 | 7 | 0 | 2 | 5 |
| E-2 | 29 Oct. | 13:11 | 700 | 200 | 1 | 0 | 0 | 1 |
| E-2 | 29 Oct. | 14:58 | 300 | 150 | 2 | 0 | 0 | 2 |
| E-2 | 29 Oct. | 14:59 | 300 | 150 | 4 | 0 | 4 | 0 |
| Aircraft noise | 9 Nov. | 13:00 | ND | ND | 17 | 17 | 0 | 0 |

Table 6. Non-aircraft disturbances of Brown Pelicans at Mugu Lagoon, California, in August-December 2002.

| Disturbance Source | Date | Time | Horizontal Distance (m) | Number of Pelicans | | | |
|---|---|---|---|---|---|---|---|
| | | | | Flush | Depart | Relocate | Reland |
| Firing Range | 7 Aug. | 10:04 | 600 | 209 | 0 | 0 | 209 |
| Unknown | 7 Aug. | 10:39 | Unknown | 25 | 8 | 0 | 17 |
| Unknown | 7 Aug. | 10:40 | Unknown | 80 | 0 | 80 | 0 |
| Firing Range | 7 Aug. | 12:57 | 600 | 2 | 0 | 2 | 0 |
| Unknown | 8 Aug. | 18:53 | Unknown | 27 | 0 | 27 | 0 |
| Unknown | 8 Aug. | 19:33 | Unknown | 160 | 30 | 0 | 130 |
| Unknown | 19 Aug. | 6:17 | Unknown | 37 | 0 | 0 | 37 |
| Raptor | 19 Aug. | 12:44 | Unknown | 200 | 0 | 150 | 50 |
| Raptor | 19 Aug. | 12:47 | Unknown | 35 | 1 | 34 | 0 |
| Unknown | 19 Aug. | 13:52 | Unknown | 139 | 9 | 50 | 80 |
| Unknown | 19 Aug. | 17:33 | Unknown | 100 | 40 | 50 | 10 |
| Unknown | 20 Aug. | 14:06 | Unknown | 40 | 0 | 0 | 40 |
| Surfer | 6 Sept. | 10:51 | 25 | 72 | 0 | 72 | 0 |
| Surfer | 6 Sept. | 11:05 | 40 | 25 | 0 | 7 | 18 |
| Unknown | 7 Sept. | 12:32 | Unknown | 345 | 70 | 257 | 18 |
| Raptor | 19 Sept. | 14:18 | 100 | 160 | 0 | 12 | 148 |
| Unknown | 20 Sept. | 16:06 | Unknown | 140 | 3 | 137 | 0 |
| Raptor | 20 Sept. | 16:58 | 50 | 15 | 0 | 0 | 15 |
| Unknown | 20 Sept. | 17:25 | Unknown | 162 | 0 | 0 | 162 |
| Unknown | 8 Oct. | 9:57 | Unknown | 40 | 20 | 0 | 20 |
| Firing Range | 8 Oct. | 10:02 | 600 | 20 | 8 | 12 | 0 |
| Unknown | 8 Oct. | 10:24 | Unknown | 30 | 7 | 0 | 23 |
| Unknown | 8 Oct. | 11:01 | Unknown | 30 | 8 | 0 | 22 |
| Raptor | 8 Oct. | 15:02 | 50 | 78 | 9 | 50 | 19 |
| Human on Foot | 8 Oct. | 19:06 | 40 | 35 | 35 | 0 | 0 |

Table 6 (continued).

| Disturbance Source | Date | Time | Horizontal Distance (m) | Number of Pelicans Flush | Depart | Relocate | Reland |
|---|---|---|---|---|---|---|---|
| Researchers | 9 Oct. | 11:49 | 60 | 357 | 20 | 337 | 0 |
| Researchers | 9 Oct. | 12:34 | 20 | 376 | 0 | 43 | 333 |
| Unknown | 28 Oct. | 6:11 | Unknown | 10 | 0 | 10 | 0 |
| Researchers | 29 Oct. | 10:15 | 250 | 150 | 125 | 25 | 0 |
| Raptor | 29 Oct. | 11:51 | 20 | 53 | 2 | 0 | 51 |
| Raptor | 29 Oct. | 14:13 | 150 | 7 | 7 | 0 | 0 |
| Researchers | 29 Oct. | 14:20 | 200 | 6 | 4 | 0 | 2 |
| Unknown | 29 Oct. | 16:05 | Unknown | 71 | 10 | 0 | 61 |
| Shots Fired by Hunters | 9 Nov. | 6:28 | Unknown | 1 | 1 | 0 | 0 |
| Shots Fired by Hunters | 9 Nov. | 7:04 | Unknown | 3 | 0 | 3 | 0 |
| Shots Fired by Hunters | 9 Nov. | 11:02 | Unknown | 40 | 0 | 0 | 40 |
| Shots Fired by Hunters | 9 Nov. | 11:36 | Unknown | 3 | 0 | 0 | 3 |
| Unknown | 10 Nov. | 8:20 | Unknown | 63 | 19 | 3 | 41 |
| Great Blue Heron | 10 Nov. | 16:00 | 20 | 30 | 0 | 0 | 30 |

Table 7. Percentages of the total number of disturbance events caused by six general sources in 1991-1993, 2000-2001, and 2002 at Mugu Lagoon, California. Data from 1991-1993 are from Jaques et al. (1996).

| Disturbance Cause | 1991-1993 (*n*=133) | 2000-2001 (*n*=45) | 2002 (*n*=70) |
|---|---|---|---|
| Aircraft | 12.0 | 48.9 | 44.3 |
| Waterfowl Hunting[1] | 24.8 | 13.3 | 5.7 |
| Recreation | 20.3 | 0.0 | 0.0 |
| Trespassing | 10.5 | 0.0 | 4.3 |
| Other Human | 7.5 | 13.3 | 10.0 |
| Natural / Unknown | 24.8 | 24.4 | 35.7 |

[1]Observations during waterfowl hunting took place on nine days in 1991-1993, three days in 2000, and on one day in 2002.

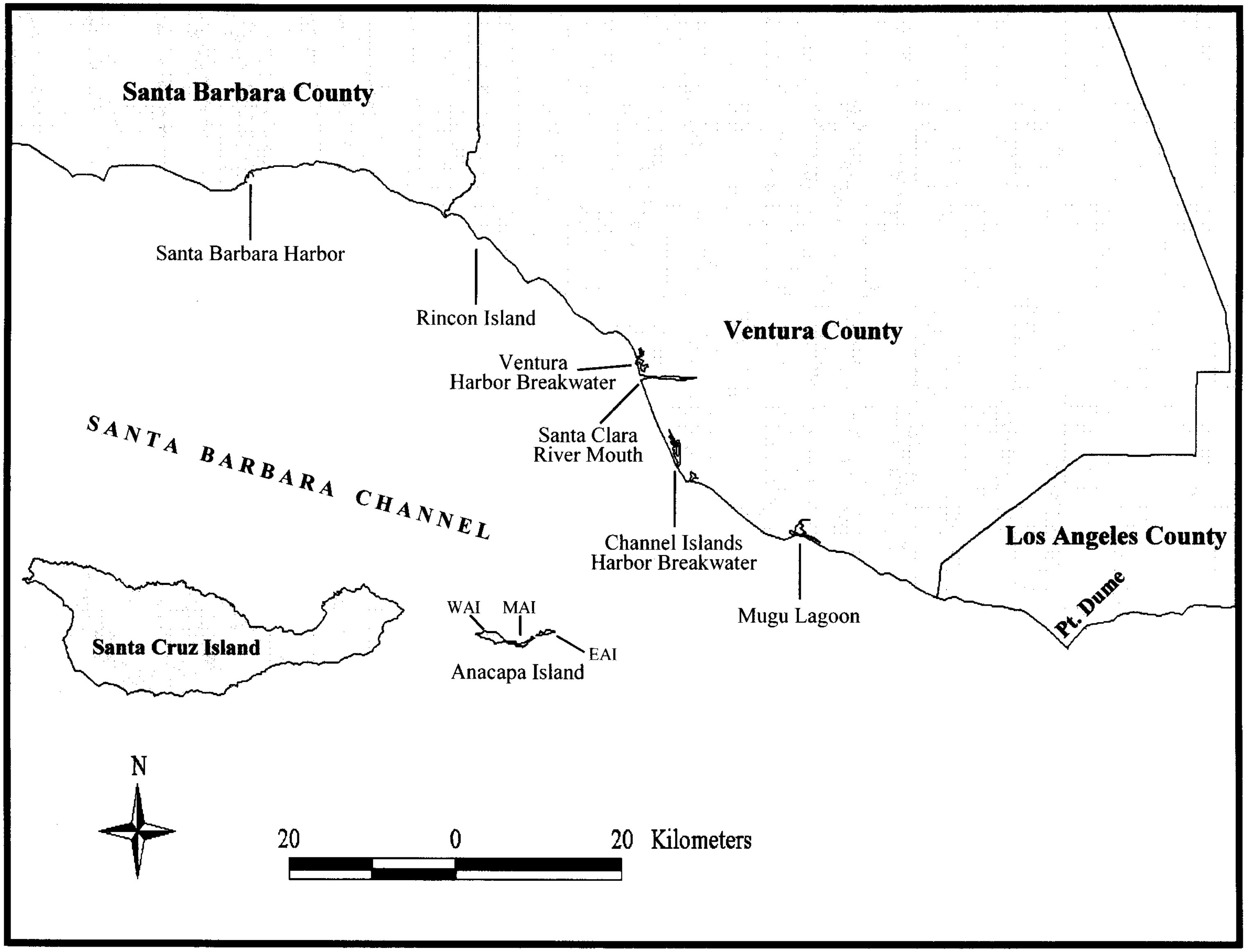


Figure 1. Locations of Mugu Lagoon and all other major Brown Pelican roost sites in the eastern Santa Barbara Channel. At Anacapa Island, East, Middle, and West Islands are indicated as EAI, MAI, and WAI, respectively.

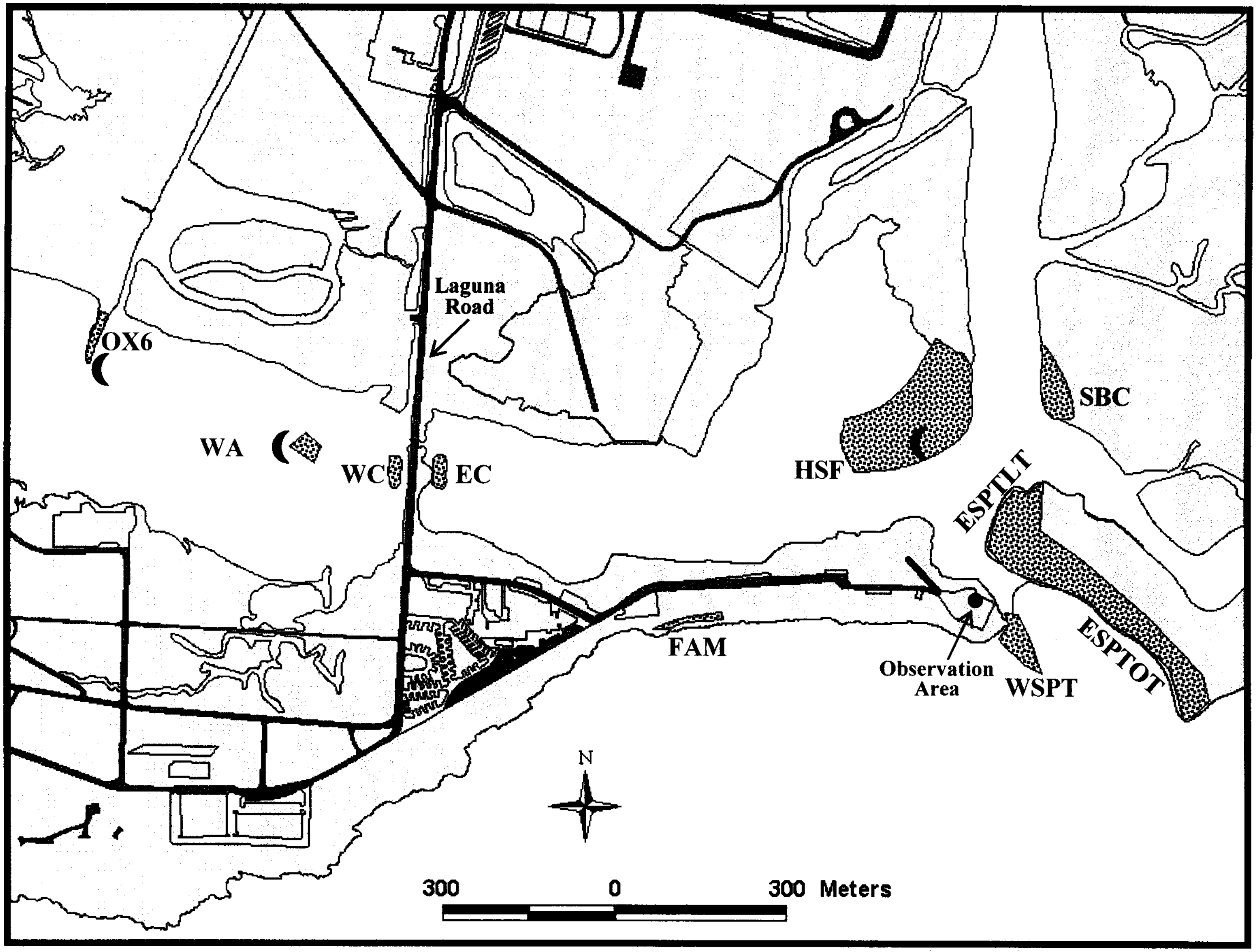


Figure 2. Brown Pelican roost locations at Mugu Lagoon, 2000-2002. Codes are: OX6, Oxnard 6 Ditch; WA, Western Arm; WC, West Causeway; EC, East Causeway; FAM, Family Beach; HSF, Harbor Seal Flats; SBC, Shorebird Cove; ESPTLT, East Spit Lagoon Tip (= SP, Sanderling Point in Appendix 1); ESPTOT, East Spit Ocean Tip (= EA, Eastern Arm in Appendix 1); WSPT, West Spit (= PP, Pelican Point in Appendix 1). Half moon symbols indicate night roosting locations in 2001-2002.

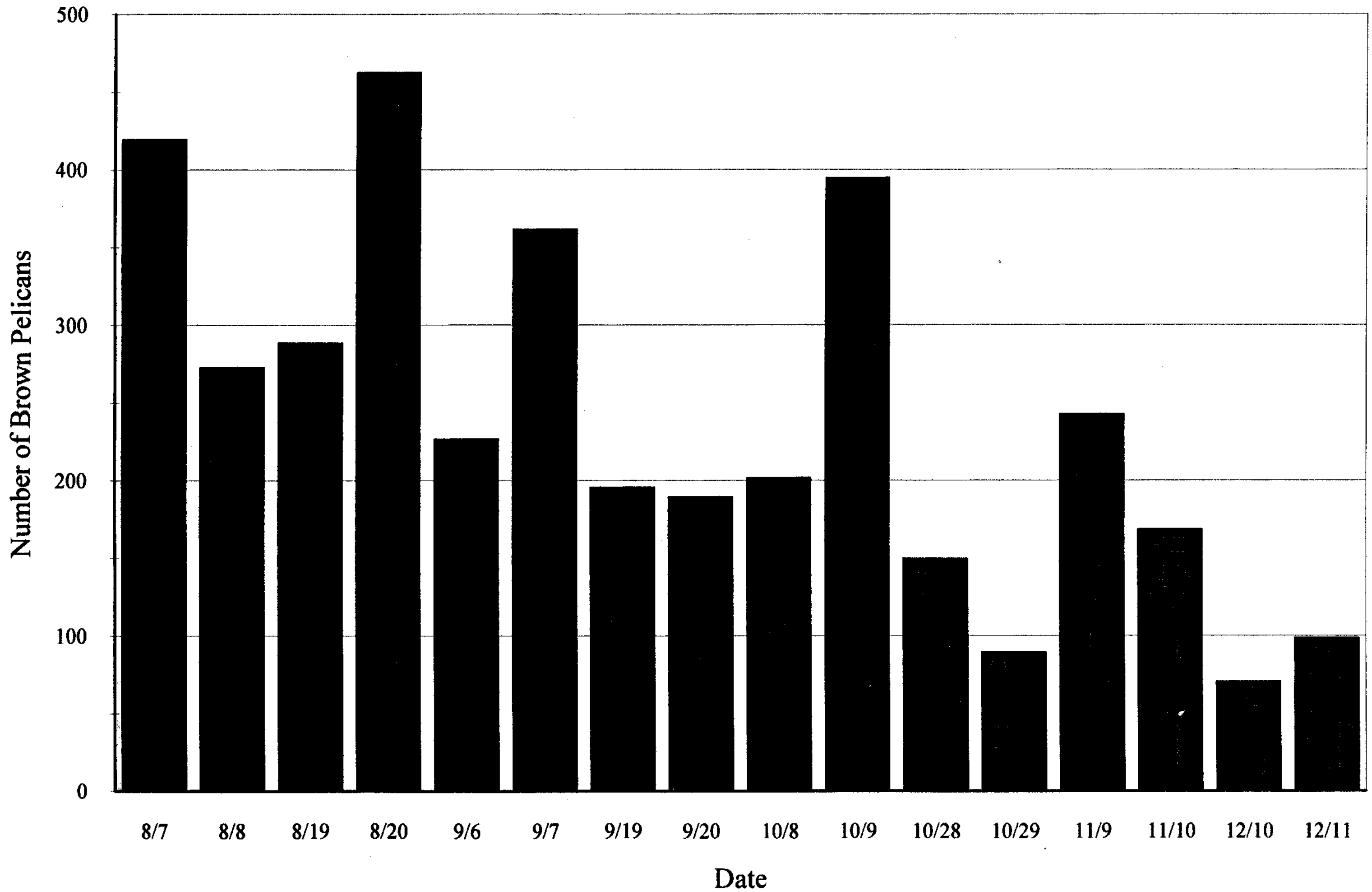


Figure 3. Daily high counts of roosting Brown Pelicans in the Mugu Lagoon central basin, August-December 2002.

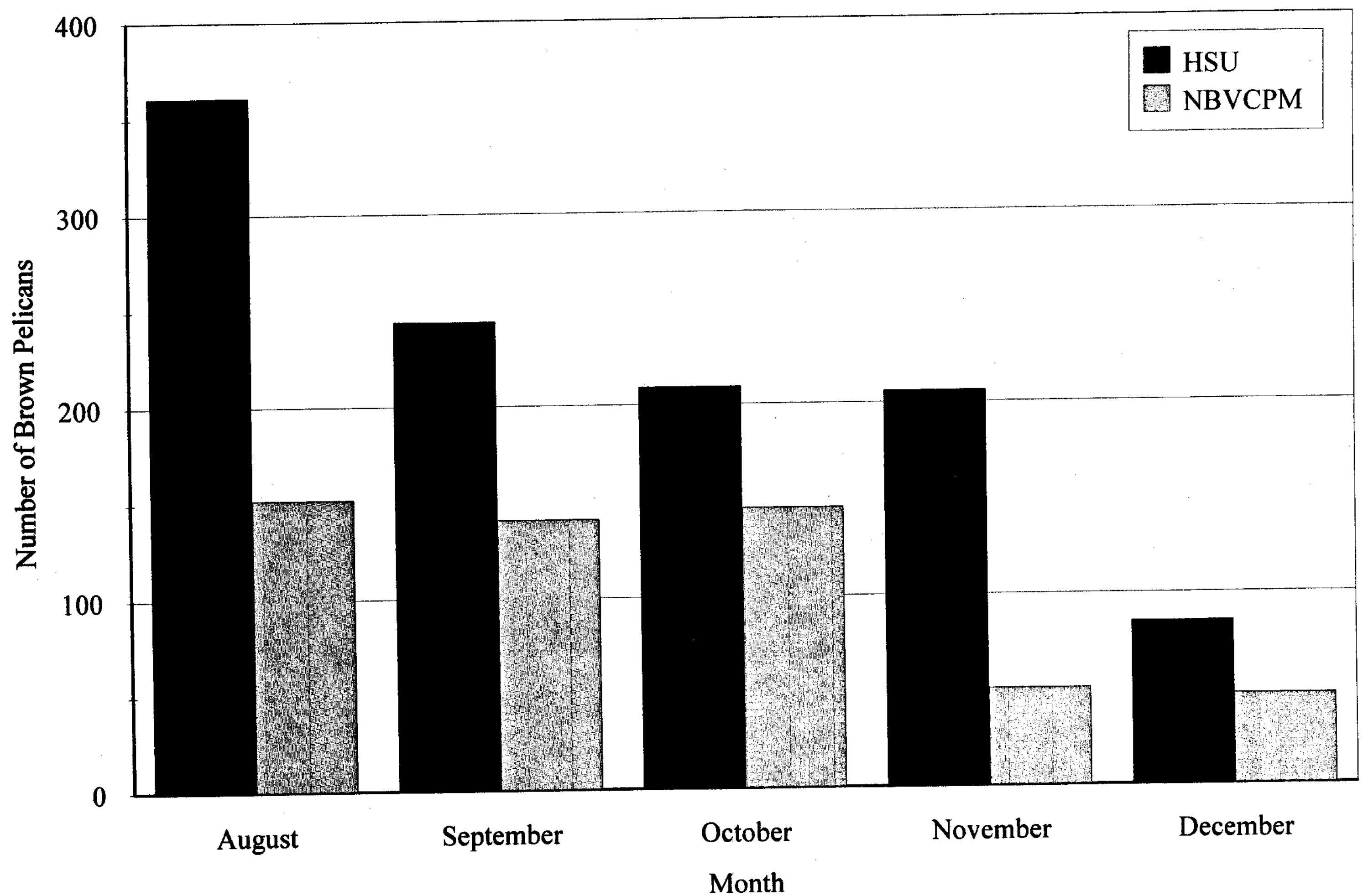


Figure 4. Comparison of HSU and NBVCPM monthly mean counts of roosting Brown Pelicans in the Mugu Lagoon central basin, California, August-December 2002. HSU counts are means of daily high counts and NBVCPM counts are means of all counts (see Appendix 1).

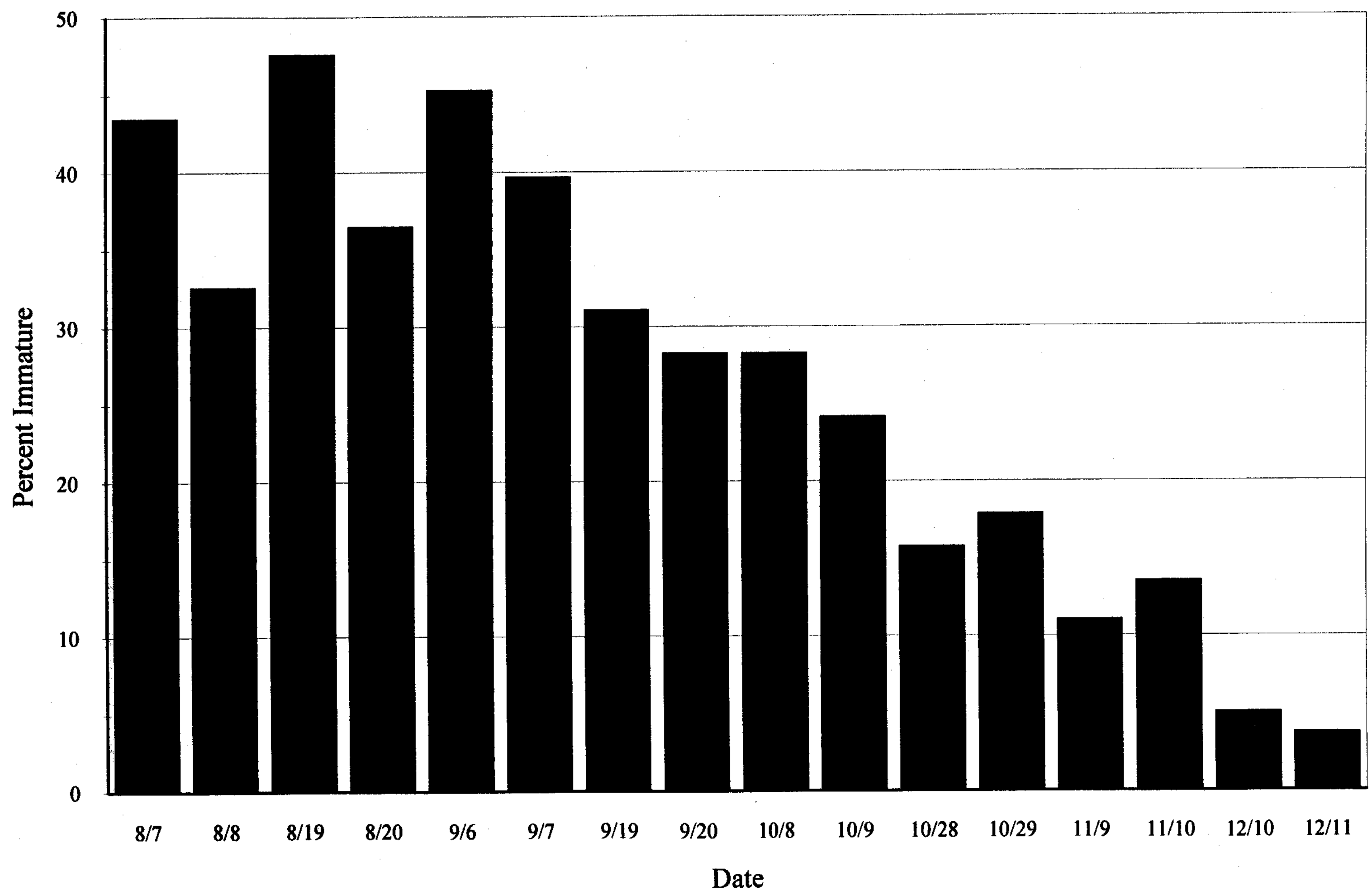


Figure 5. Daily average percentage of immatures among all aged roosting Brown Pelicans in the Mugu Lagoon central basin, August-December 2002.

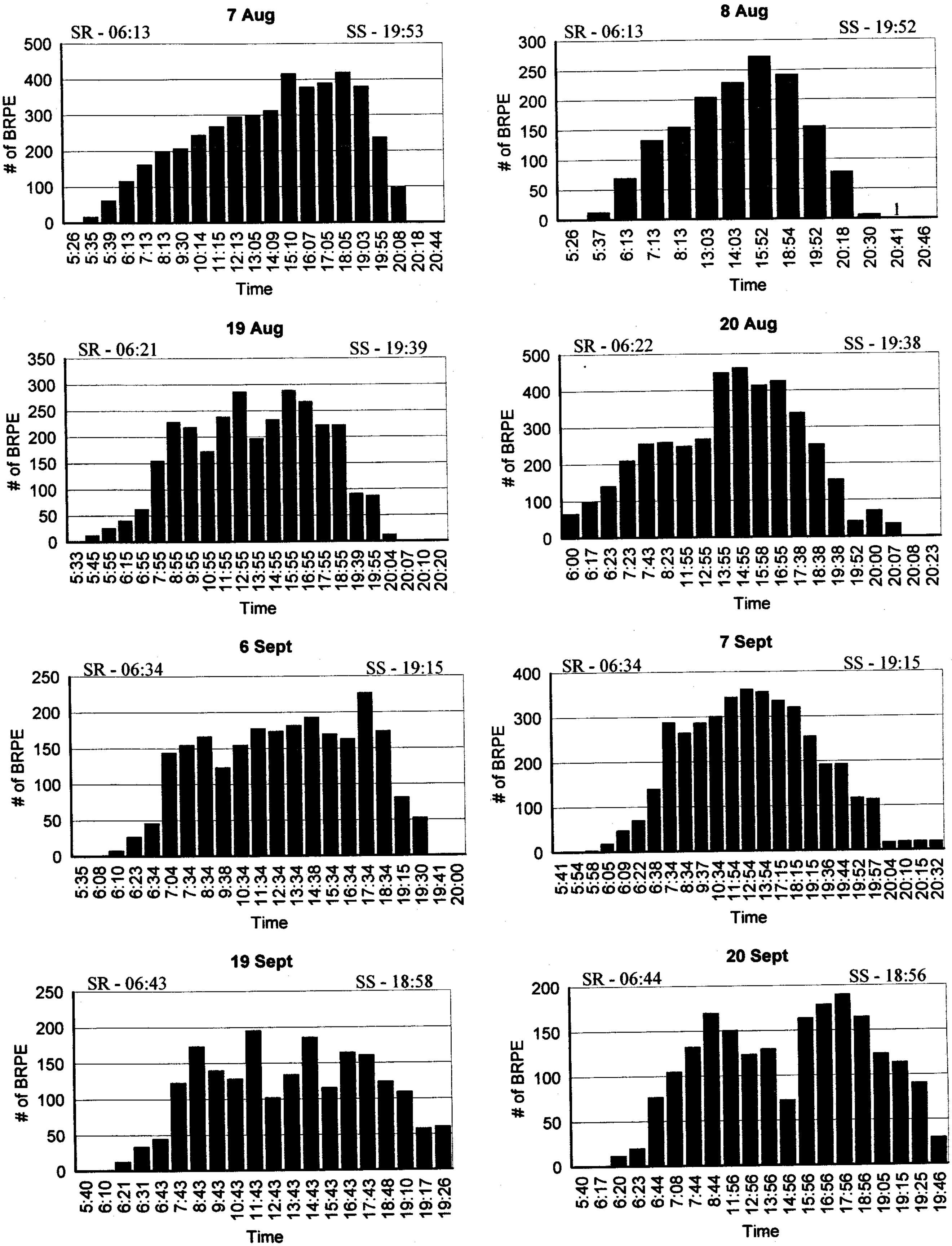


Figure 6a. Brown Pelican diurnal roost attendance patterns in the central basin of Mugu Lagoon, California, August-September 2002. SR = sunrise; SS = sunset.

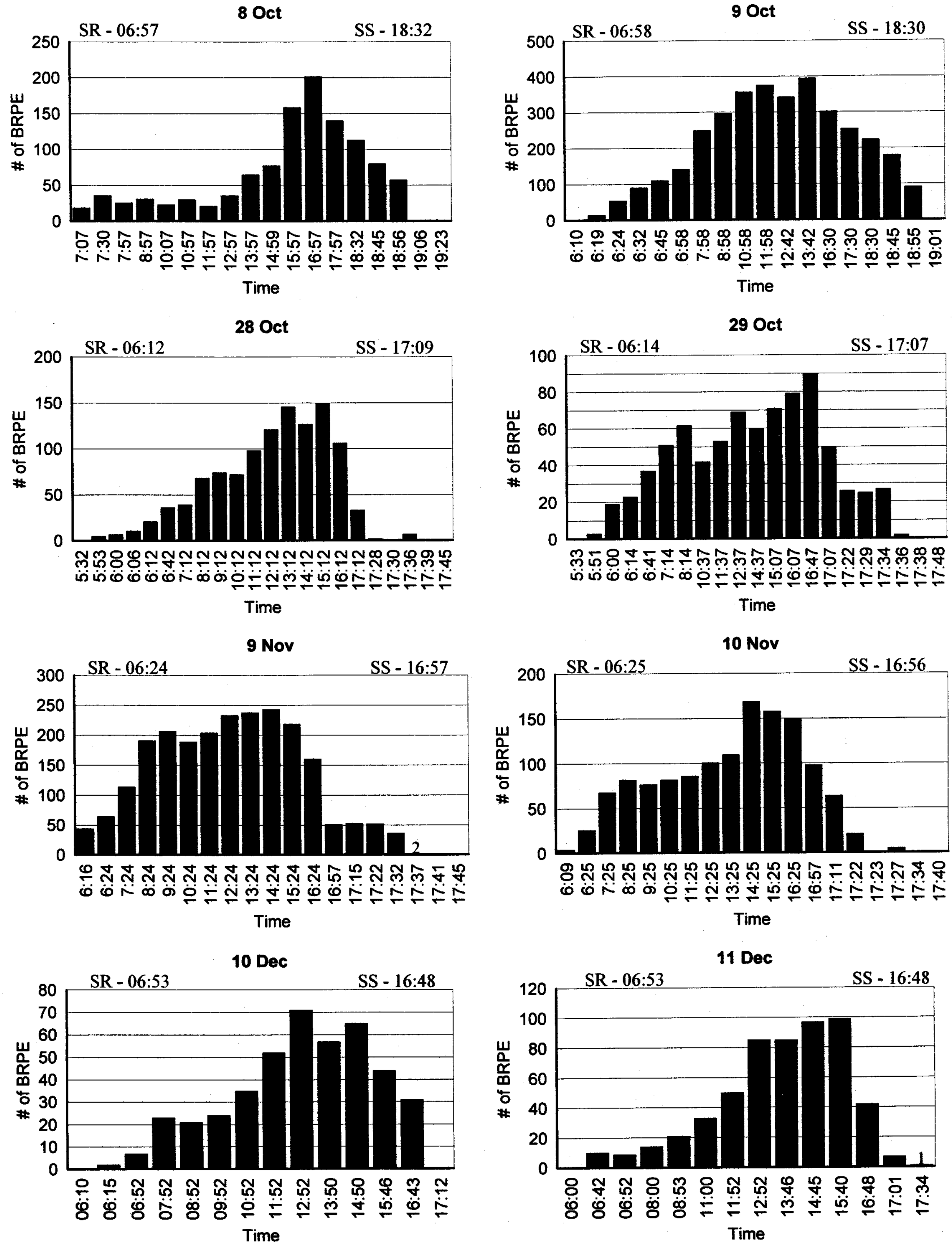


Figure 6b. Brown Pelican diurnal roost attendance patterns in the central basin of Mugu Lagoon, California, October-December 2002. SR = sunrise; SS = sunset.

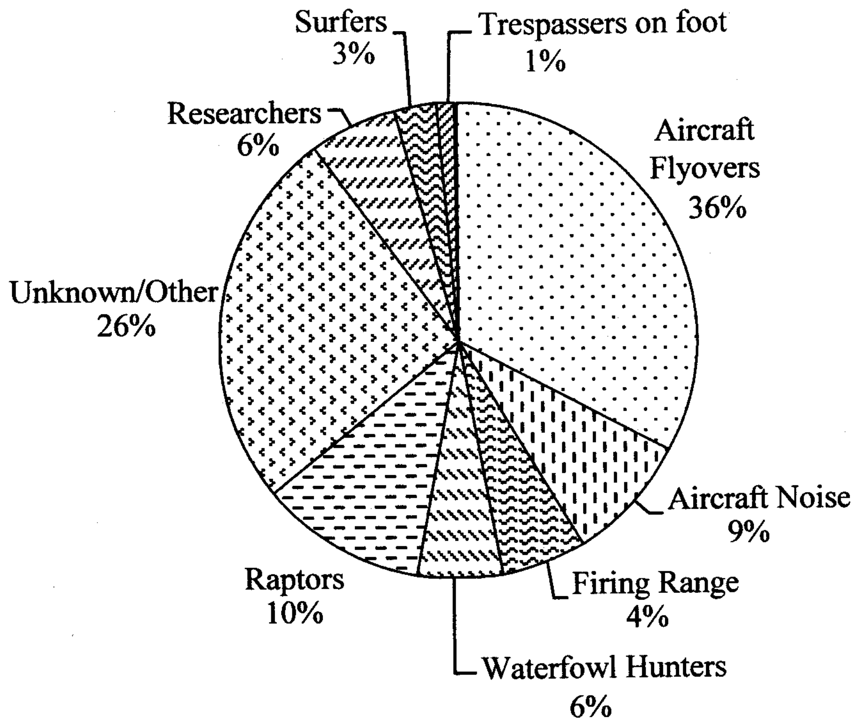


Figure 7a. Sources of disturbance of Brown Pelican roosts at Mugu Lagoon, California, in August-December 2002 (n=70).

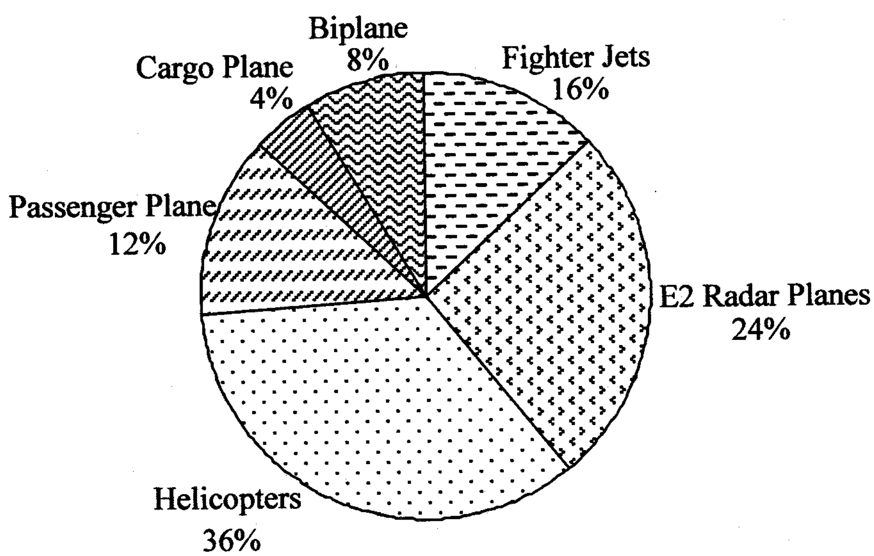


Figure 7b. Percentages of flyover disturbances of Brown Pelican roosts caused by six aircraft types at Mugu Lagoon, California, in August-December 2002 (n=25).

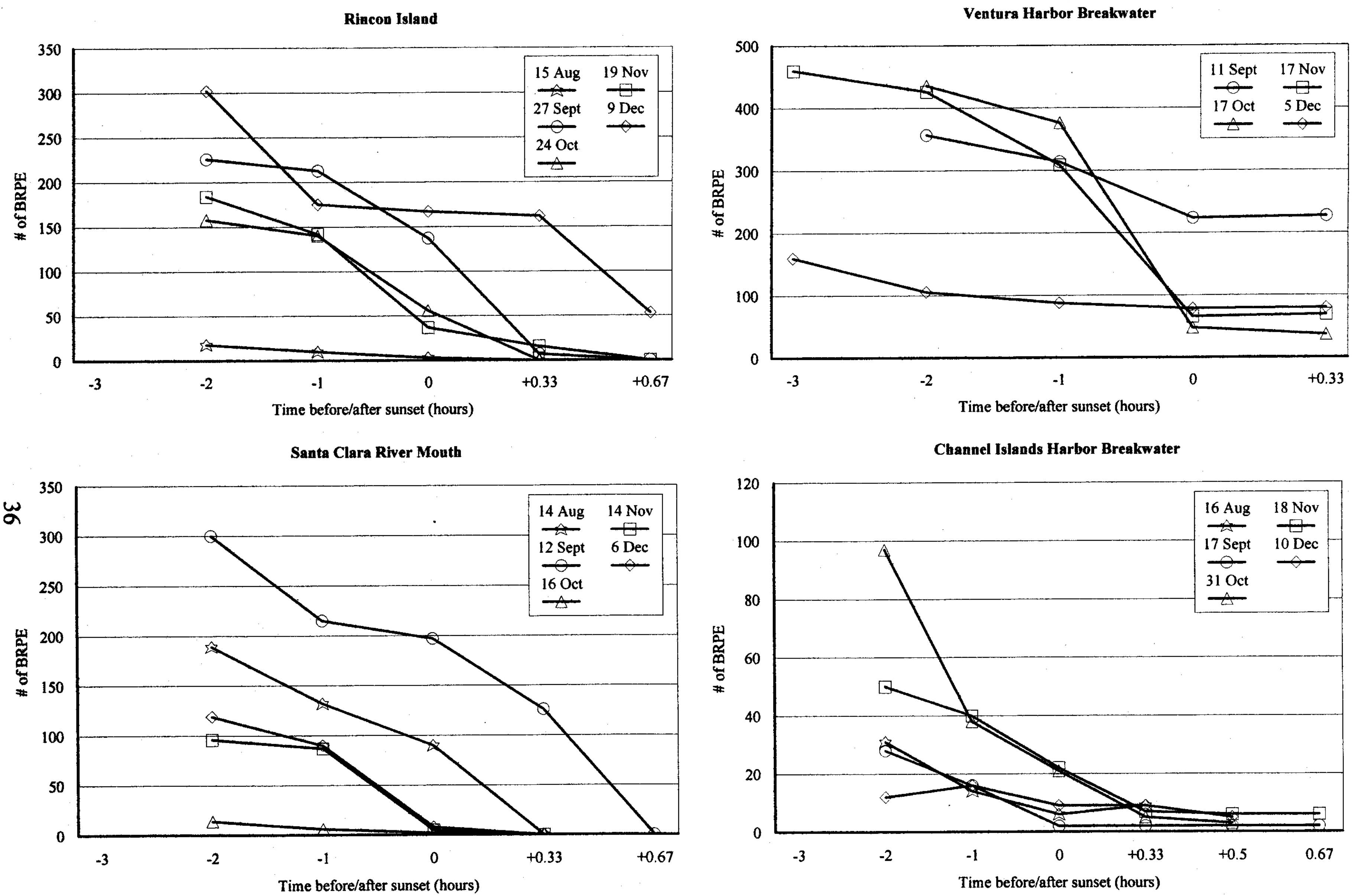


Figure 8. Monthly sunset counts of roosting Brown Pelicans at Rincon Island, Ventura Harbor Breakwater, Santa Clara River Mouth, and Ventura Harbor Breakwater, California, August-December 2002. Times before and after sunset for all counts shown are approximate.

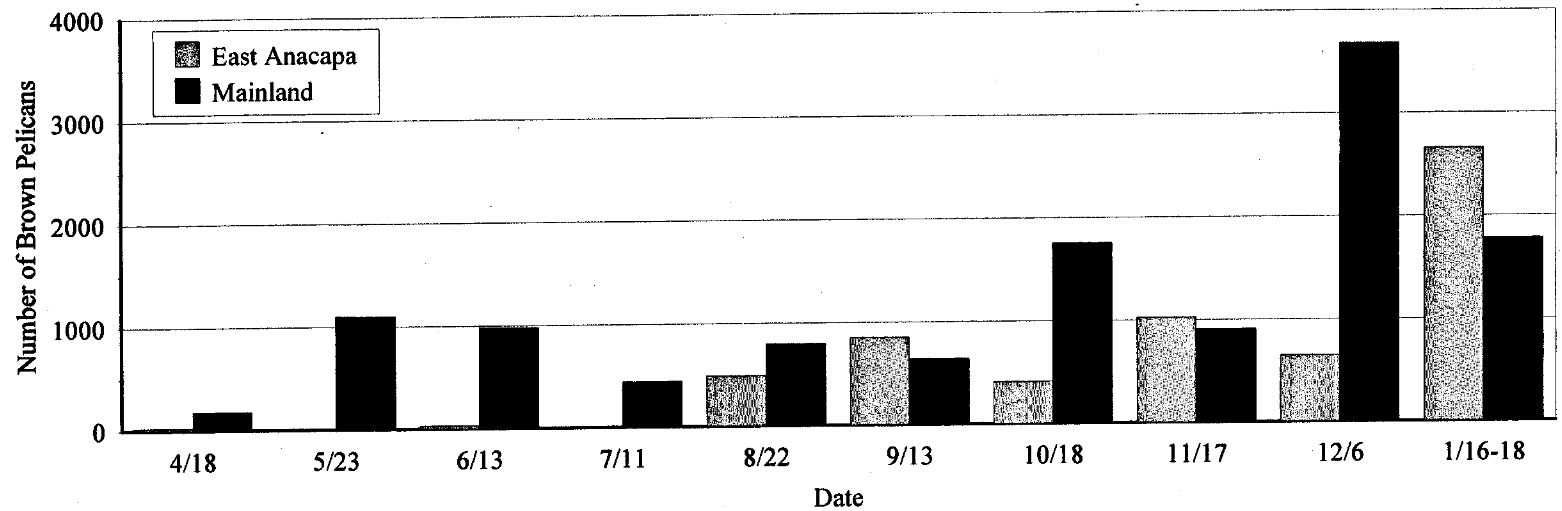


Figure 9. Total number of roosting Brown Pelicans in the eastern Santa Barbara Channel, California, April 2000-January 2001 (see Table 2).

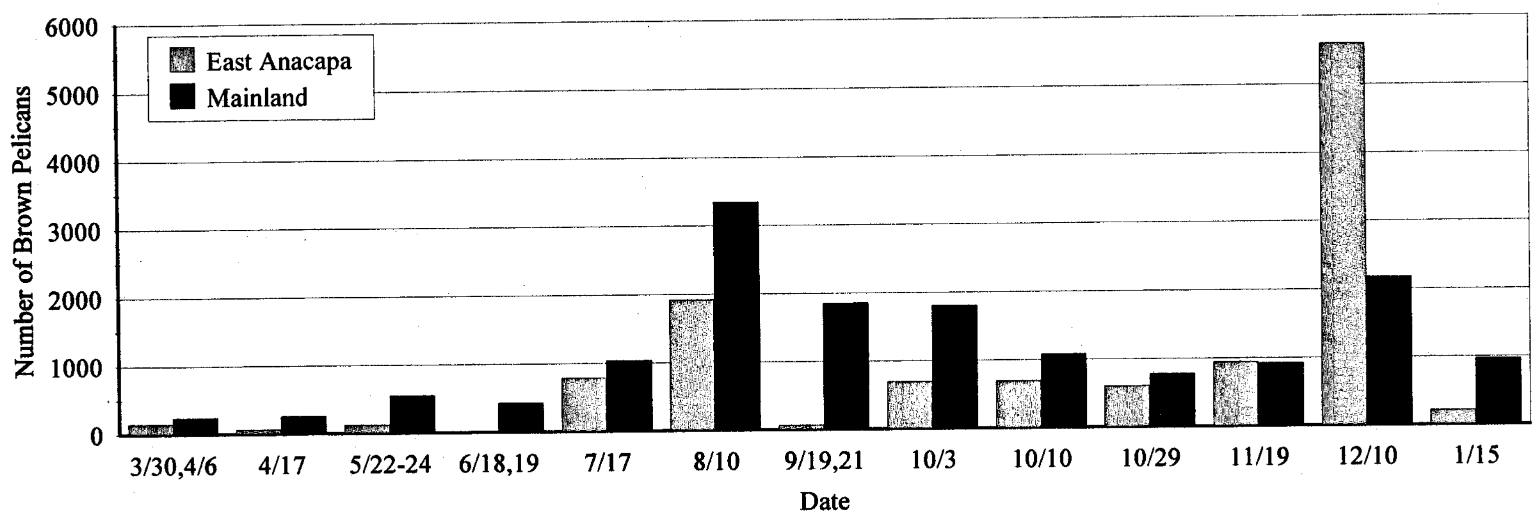


Figure 10. Total number of roosting Brown Pelicans in the eastern Santa Barbara Channel, California, April 2001-January 2002 (see Table 3).

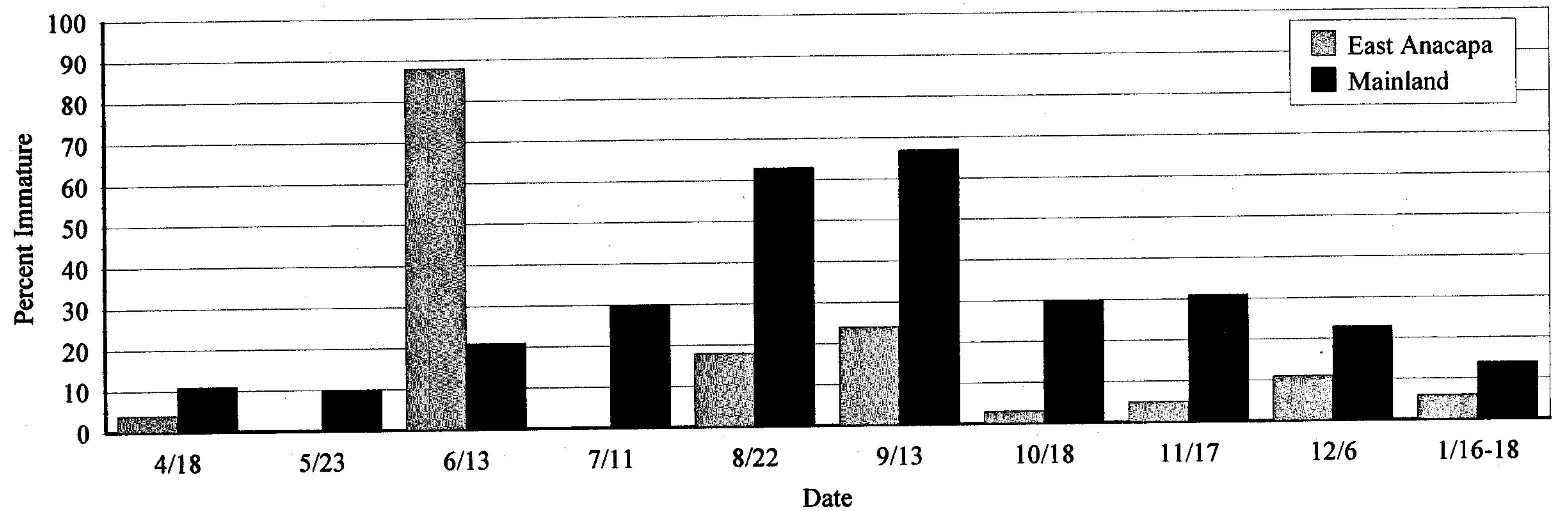


Figure 11. Percentage of immature roosting Brown Pelicans in the eastern Santa Barbara Channel, California, April 2000-January 2001 (see Table 2).

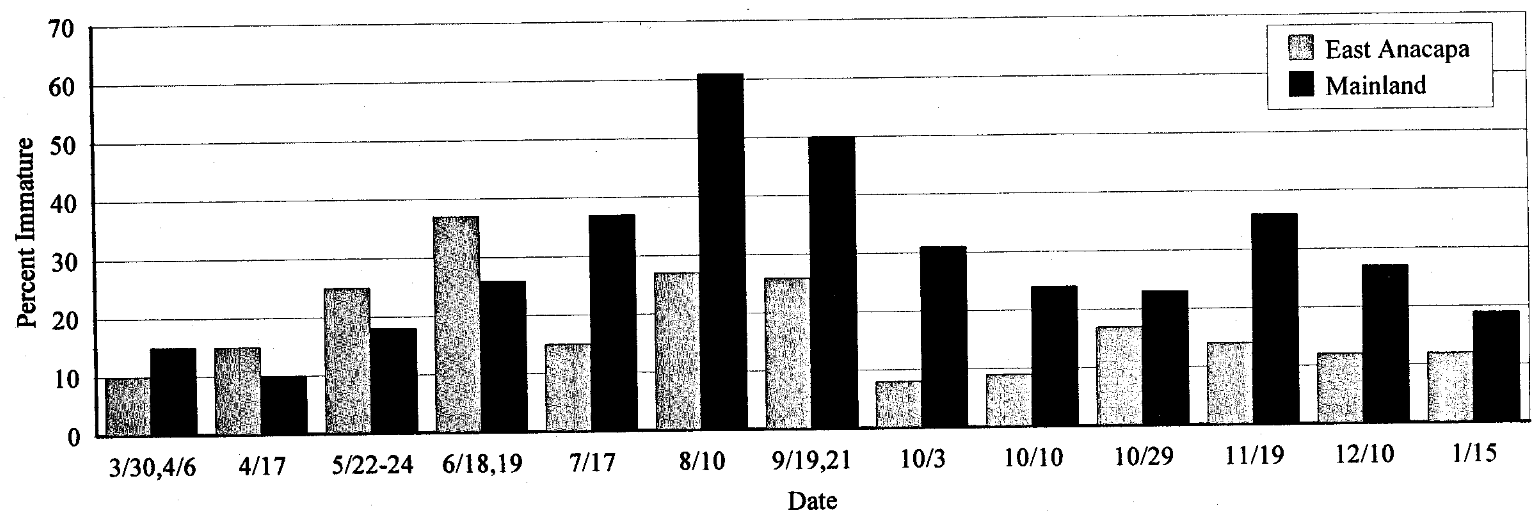


Figure 12. Percentage of immature roosting Brown Pelicans in the eastern Santa Barbara Channel, California, April 2001-January 2002 (see Table 3).

Appendix 1. Ground counts of roosting Brown Pelicans at Mugu Lagoon, California, conducted by NBVCPM biologists in January-December 2002 (see Figure 2 for locations). Codes are: HSF, Harbor Seal Flats; PP, Pelican Point; SP, Sanderling Point; EA, Eastern Arm; SBC, Shorebird Cove; FAM, Family Beach; WA, Western Arm; OX6, Ditch 6 into lagoon in western arm; WC, West Causeway; EC, East Causeway.

| | | Central Basin | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **Time** | **HSF** | **PP** | **SP** | **EA** | **SBC** | **FAM** | **WA** | **OX6** | **WC** | **EC** | **Total** |
| 2-Jan | 1145 | 0 | 0 | 64 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 67 |
| 3-Jan | 825 | 34 | 0 | 0 | 0 | 0 | 8 | 0 | 17 | 0 | 1 | 60 |
| 7-Jan | 1535 | 0 | 58 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 59 |
| 8-Jan | 815 | 0 | 0 | 41 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 42 |
| 9-Jan | 1720 | 0 | 0 | 0 | 10 | 0 | 0 | 18 | 0 | 0 | 0 | 28 |
| 10-Jan | 1645 | 0 | 119 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 126 |
| 11-Jan | 731 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 14-Jan | 848 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 26 |
| 14-Jan | 1420 | 0 | 0 | 6 | 22 | 0 | 0 | 9 | 0 | 0 | 0 | 37 |
| 15-Jan | 1420 | 0 | 0 | 84 | 14 | 0 | 0 | 0 | 1 | 3 | 0 | 102 |
| 16-Jan | 1700 | 0 | 0 | 33 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 40 |
| 17-Jan | 1640 | 0 | 0 | 45 | 4 | 0 | 0 | 8 | 0 | 0 | 0 | 57 |
| 22-Jan | 816 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 22-Jan | 1620 | 10 | 0 | 8 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 50 |
| 23-Jan | 824 | 0 | 0 | 15 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 16 |
| 23-Jan | 1715 | 2 | 0 | 56 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 63 |
| 24-Jan | 1640 | 4 | 11 | 0 | 25 | 0 | 0 | 2 | 0 | 0 | 0 | 42 |
| 25-Jan | 835 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 22 |
| 28-Jan | 1155 | 0 | 0 | 296 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 296 |
| 29-Jan | 845 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 |
| 30-Jan | 755 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 |
| 31-Jan | 1600 | 0 | 1 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 |
| 4-Feb | 800 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| 5-Feb | 904 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| 7-Feb | 830 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8-Feb | 942 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11-Feb | 1338 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12-Feb | 1142 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13-Feb | 1500 | 55 | 0 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 109 |
| 14-Feb | 1533 | 0 | 0 | 57 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 58 |
| 15-Feb | 755 | 0 | 0 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 |
| 18-Feb | 1411 | 20 | 0 | 86 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 107 |
| 19-Feb | 1535 | 30 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 48 |
| 20-Feb | 838 | 77 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 78 |
| 21-Feb | 1434 | 11 | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 68 |
| 25-Feb | 1505 | 0 | 0 | 74 | 14 | 0 | 0 | 3 | 0 | 0 | 0 | 91 |
| 25-Feb | 1707 | 2 | 15 | 16 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 53 |
| 26-Feb | 1459 | 2 | 9 | 85 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 96 |
| 27-Feb | 1636 | 100 | 113 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 252 |
| 28-Feb | 1703 | 5 | 9 | 19 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 34 |
| 4-Mar | 740 | 1 | 0 | 2 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 9 |

Appendix 1 (continued).

| Date | Time | Central Basin HSF | PP | SP | EA | SBC | FAM | WA | OX6 | WC | EC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4-Mar | 1535 | 26 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 34 |
| 5-Mar | 1140 | 0 | 27 | 3 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 37 |
| 6-Mar | 1021 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 4 | 0 | 13 |
| 8-Mar | 1206 | 18 | 0 | 132 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 151 |
| 11-Mar | 1400 | 13 | 11 | 30 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 64 |
| 13-Mar | 1455 | 185 | 11 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 209 |
| 14-Mar | 718 | 0 | 0 | 87 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 90 |
| 14-Mar | 1447 | 138 | 8 | 136 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 286 |
| 18-Mar | 1053 | 23 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 |
| 18-Mar | 1630 | 17 | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 87 |
| 20-Mar | 736 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 20-Mar | 937 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 20-Mar | 1635 | 8 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| 21-Mar | 717 | 1 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 36 |
| 22-Mar | 833 | 38 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 62 |
| 25-Mar | 1632 | 3 | 17 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 21 |
| 26-Mar | 1522 | 5 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 10 |
| 27-Mar | 1637 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 28-Mar | 1244 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 28-Mar | 1640 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 3-Apr | 1542 | 3 | 31 | 89 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 123 |
| 4-Apr | 726 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9-Apr | 1703 | 16 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| 10-Apr | 730 | 0 | 57 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 68 |
| 11-Apr | 1645 | 60 | 42 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 106 |
| 15-Apr | 820 | 5 | 0 | 89 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 97 |
| 16-Apr | 834 | 3 | 96 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 102 |
| 19-Apr | 815 | 32 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| 22-Apr | 1310 | 52 | 260 | 94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 406 |
| 23-Apr | 1145 | 6 | 127 | 125 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 259 |
| 23-Apr | 1708 | 0 | 4 | 201 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 206 |
| 26-Apr | 1355 | 33 | 98 | 47 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 183 |
| 29-Apr | 1400 | 0 | 0 | 69 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 69 |
| 1-May | 1035 | 98 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 106 |
| 2-May | 701 | 5 | 35 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 44 |
| 2-May | 1425 | 0 | 91 | 52 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 148 |
| 7-May | 1145 | 160 | 8 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 173 |
| 7-May | 1708 | 7 | 270 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 282 |
| 8-May | 1345 | 13 | 7 | 93 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 118 |
| 9-May | 705 | 1 | 73 | 25 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 103 |
| 10-May | 815 | 0 | 96 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 96 |
| 13-May | * | 186 | 75 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 274 |
| 16-May | 1320 | 12 | 42 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 3 | 61 |
| 20-May | 1540 | 23 | 102 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 2 | 132 |
| 21-May | 840 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 53 |
| 21-May | 1045 | 47 | 5 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 70 |
| 22-May | 808 | 31 | 0 | 0 | 0 | 0 | 0 | 6 | 4 | 0 | 0 | 41 |

Appendix 1 (continued).

| Date | Time | HSF | PP | SP | EA | SBC | FAM | WA | OX6 | WC | EC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Central Basin | | | | | | | | |
| 28-May | 838 | 21 | 0 | 0 | 192 | 0 | 0 | 4 | 0 | 0 | 0 | 217 |
| 29-May | 900 | 180 | 42 | 0 | 0 | 4 | 0 | 0 | * | 0 | 0 | 226 |
| 30-May | 1015 | 142 | 0 | 0 | 41 | 0 | 0 | 9 | 0 | 0 | 0 | 192 |
| 5-Jun | 720 | 0 | 59 | 473 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 532 |
| 5-Jun | 907 | 0 | 78 | 680 | 0 | 0 | * | * | * | * | * | 758 |
| 6-Jun | 720 | 0 | 0 | 713 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 719 |
| 10-Jun | 1400 | 318 | 0 | 0 | 0 | 0 | 0 | * | * | * | * | 318 |
| 12-Jun | 1710 | 0 | 109 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 157 |
| 13-Jun | 1318 | 128 | 0 | 0 | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 189 |
| 14-Jun | 830 | 28 | 122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150 |
| 18-Jun | 830 | 72 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 172 |
| 28-Jun | 740 | 23 | 123 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 146 |
| 1-Jul | 1450 | 283 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 288 |
| 2-Jul | 730 | 1 | 0 | 0 | 267 | 0 | 0 | 0 | 0 | 0 | 0 | 268 |
| 3-Jul | 832 | * | 203 | * | * | * | * | * | * | * | * | 203 |
| 8-Jul | 1342 | 1 | 174 | 0 | 21 | 0 | 0 | 0 | 2 | 0 | 0 | 198 |
| 9-Jul | 1330 | 24 | 9 | 0 | 115 | 0 | 0 | 0 | 3 | 0 | 0 | 151 |
| 10-Jul | 1638 | 24 | 0 | 0 | 69 | 0 | 0 | 0 | 0 | 0 | 0 | 93 |
| 16-Jul | 725 | 8 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| 22-Jul | 1850 | 0 | 0 | 0 | 84 | 0 | 0 | 0 | * | 0 | 0 | 84 |
| 23-Jul | 953 | 7 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| 24-Jul | 855 | 0 | 0 | 0 | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 49 |
| 24-Jul | 1708 | 0 | 0 | 0 | 69 | 0 | 0 | 0 | 0 | 0 | 0 | 69 |
| 25-Jul | 748 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 38 |
| 25-Jul | 1650 | 1 | 0 | 0 | 120 | 0 | 0 | 0 | 2 | 0 | 0 | 123 |
| 26-Jul | 806 | 0 | 0 | 0 | 40 | 0 | 0 | 2 | 0 | 0 | 0 | 42 |
| 29-Jul | 1115 | 25 | 0 | 4 | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 86 |
| 30-Jul | 745 | 0 | 0 | 0 | 145 | 0 | 0 | 0 | 0 | 0 | 0 | 145 |
| 31-Jul | 810 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 111 |
| 1-Aug | 1712 | 0 | 0 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 130 |
| 5-Aug | 1130 | 26 | 0 | 27 | 119 | 0 | 0 | 0 | 0 | 0 | 0 | 172 |
| 5-Aug | 1630 | 2 | 0 | 167 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 211 |
| 6-Aug | 1005 | 0 | 0 | 81 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 231 |
| 8-Aug | 800 | 0 | 0 | 0 | 155 | 0 | 0 | 14 | 0 | 0 | 0 | 169 |
| 8-Aug | 1735 | 0 | 0 | 84 | 96 | 0 | 0 | 0 | 0 | 0 | 0 | 180 |
| 10-Aug | 810 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 23 |
| 12-Aug | 950 | 13 | 0 | 213 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 229 |
| 12-Aug | 1555 | 0 | 0 | 145 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 145 |
| 14-Aug | 805 | 20 | 0 | 0 | 135 | 0 | 0 | 0 | 0 | 0 | 0 | 155 |
| 15-Aug | 755 | 2 | 0 | 0 | 94 | 0 | 0 | 0 | 0 | 0 | 0 | 96 |
| 15-Aug | 1636 | 0 | 0 | 102 | 52 | 0 | 0 | 0 | 4 | 0 | 0 | 158 |
| 16-Aug | 822 | 50 | 0 | 0 | 128 | 0 | 0 | 2 | 0 | 0 | 0 | 180 |
| 16-Aug | 1630 | 0 | 0 | 102 | 124 | 0 | 0 | 0 | 0 | 0 | 0 | 226 |
| 19-Aug | 950 | 48 | 0 | 0 | 189 | 0 | 0 | 0 | 1 | 0 | 0 | 238 |
| 20-Aug | 910 | 1 | 0 | 0 | 271 | 0 | 0 | 0 | 2 | 0 | 0 | 274 |
| 21-Aug | 804 | 77 | 0 | 0 | 135 | 0 | 0 | 0 | 4 | 0 | 0 | 216 |
| 21-Aug | 1642 | 22 | 0 | 0 | 179 | 0 | 0 | 6 | 0 | 0 | 0 | 207 |

Appendix 1 (continued).

| | | Central Basin | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **Time** | **HSF** | **PP** | **SP** | **EA** | **SBC** | **FAM** | **WA** | **OX6** | **WC** | **EC** | **Total** |
| 22-Aug | 838 | 0 | 0 | 0 | 98 | 0 | 0 | 0 | 4 | 0 | 0 | **102** |
| 22-Aug | 1528 | 0 | 0 | 0 | 204 | 0 | 0 | 0 | 2 | 0 | 0 | **206** |
| 23-Aug | 1649 | 0 | 0 | 1 | 193 | 0 | 0 | 0 | 8 | 0 | 0 | **202** |
| 26-Aug | 900 | 27 | 0 | 0 | 34 | 0 | 0 | 0 | 12 | 0 | 0 | **73** |
| 27-Aug | 715 | 0 | 105 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | **112** |
| 28-Aug | 750 | 0 | 71 | 0 | 25 | 0 | 0 | 2 | 0 | 0 | 0 | **98** |
| 29-Aug | 739 | 14 | 32 | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | **86** |
| 3-Sep | 750 | 55 | 0 | 0 | 150 | 0 | 0 | 0 | 5 | 0 | 0 | **210** |
| 4-Sep | 734 | 18 | 0 | 0 | 95 | 0 | 0 | 47 | 0 | 0 | 0 | **160** |
| 4-Sep | 1755 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | **89** |
| 5-Sep | 1537 | 31 | 0 | 0 | 107 | 0 | 0 | 21 | 18 | 0 | 0 | **177** |
| 9-Sep | 1616 | 0 | 0 | 118 | 10 | 0 | 0 | 0 | 16 | 0 | 0 | **144** |
| 16-Sep | 950 | 110 | 0 | 12 | 27 | 0 | 0 | 0 | 45 | 0 | 0 | **194** |
| 16-Sep | 1625 | 0 | 0 | 172 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | **199** |
| 17-Sep | 1612 | 0 | 0 | 77 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | **87** |
| 18-Sep | 733 | 0 | 0 | 103 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | **105** |
| 18-Sep | 1715 | 0 | 0 | 156 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | **158** |
| 23-Sep | 945 | 0 | 0 | 202 | 0 | 0 | 0 | 0 | 47 | 0 | 0 | **249** |
| 24-Sep | 1406 | 0 | 0 | 149 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **149** |
| 25-Sep | 900 | 0 | 0 | 14 | 32 | 0 | 0 | 0 | 21 | 0 | 0 | **67** |
| 27-Sep | 1639 | 144 | 0 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **178** |
| 30-Sep | 1640 | 0 | 0 | 176 | 0 | 0 | 0 | 0 | 17 | 10 | 3 | **206** |
| 1-Oct | 724 | 136 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | **156** |
| 1-Oct | 1648 | 196 | 0 | 0 | 0 | 0 | 0 | 0 | 52 | 1 | 5 | **254** |
| 2-Oct | 1720 | 169 | 0 | 228 | 0 | 0 | 1 | 0 | 39 | 0 | 5 | **442** |
| 3-Oct | 837 | 146 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 0 | 1 | **198** |
| 8-Oct | 748 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | **57** |
| 10-Oct | 738 | 71 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | **75** |
| 14-Oct | 1145 | 6 | 0 | 175 | 0 | 0 | 0 | 1 | 45 | 1 | 0 | **228** |
| 15-Oct | 1318 | 0 | 0 | 212 | 0 | 0 | 0 | 2 | 29 | 0 | 0 | **243** |
| 16-Oct | 1350 | 1 | 67 | 0 | 0 | 0 | 0 | 0 | 20 | 6 | 0 | **94** |
| 17-Oct | 800 | 118 | 0 | 0 | 0 | 0 | 52 | 0 | 53 | 0 | 5 | **228** |
| 17-Oct | 1450 | 186 | 0 | 0 | 0 | 0 | 1 | 0 | 47 | 0 | 4 | **238** |
| 21-Oct | 835 | * | * | * | * | * | 15 | * | * | * | * | * |
| 21-Oct | 1604 | 0 | 40 | 295 | 0 | 0 | 0 | 0 | 36 | 0 | 0 | **371** |
| 22-Oct | 754 | 7 | 0 | 84 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | **95** |
| 23-Oct | 741 | 0 | 0 | 49 | 0 | 0 | 0 | 0 | 7 | 0 | 2 | **58** |
| 24-Oct | 1328 | 0 | 0 | 107 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **107** |
| 29-Oct | 1654 | 1 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **51** |
| 30-Oct | 1111 | 0 | 0 | 145 | 0 | 0 | 0 | 0 | 23 | 1 | 0 | **169** |
| 31-Oct | 721 | * | * | * | * | * | 15 | * | * | * | * | **15** |
| 4-Nov | 1325 | 0 | 5 | 118 | 0 | 0 | 0 | 0 | 6 | 4 | 0 | **133** |
| 5-Nov | 1500 | 3 | 20 | 52 | 1 | 0 | 0 | 0 | 4 | 1 | 0 | **81** |
| 6-Nov | 1629 | 33 | 19 | 3 | | | | | | | | **55** |
| 12-Nov | 1610 | 140 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | **143** |
| 13-Nov | 724 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 29 | 0 | 0 | **53** |

Appendix 1 (continued).

| | | Central Basin | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date** | **Time** | **HSF** | **PP** | **SP** | **EA** | **SBC** | **FAM** | **WA** | **OX6** | **WC** | **EC** | **Total** |
| 13-Nov | 1636 | 85 | | 8 | | | | | | | | **93** |
| 14-Nov | 720 | 13 | 0 | 55 | 0 | 0 | 1 | 0 | 31 | 0 | 0 | **100** |
| 18-Nov | 820 | 0 | 0 | 31 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | **42** |
| 18-Nov | 1400 | 0 | 0 | 78 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | **82** |
| 20-Nov | 1129 | | | 36 | | | | | 7 | | | **43** |
| 21-Nov | 718 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | **4** |
| 25-Nov | 910 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | **32** |
| 25-Nov | 1638 | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | **62** |
| 26-Nov | 738 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | **13** |
| 27-Nov | 735 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **17** |
| 2-Dec | 1132 | 0 | 8 | 78 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | **90** |
| 2-Dec | 1614 | 4 | 0 | 0 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | **94** |
| 3-Dec | 1645 | 4 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **18** |
| 4-Dec | 1334 | 0 | 2 | 63 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **65** |
| 4-Dec | 1625 | 1 | 27 | 0 | 10 | 0 | 0 | 3 | 1 | 0 | 0 | **42** |
| 5-Dec | 1653 | 4 | 26 | 0 | 3 | 0 | 0 | 1 | 2 | 0 | 0 | **36** |
| 6-Dec | 1605 | 0 | 14 | 50 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | **66** |
| 9-Dec | 820 | 3 | 0 | 21 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | **27** |

Appendix 2. Band combinations of Brown Pelicans (BRPE), Western Gulls (WEGU), and Caspian Terns (CATE) observed at Mugu Lagoon, California, and nearby roosts, in August-December 2002.

| Species | Age | Location | Date | Upper Left Leg | Lower Left Leg | Upper Right Leg | Lower Right Leg |
|---|---|---|---|---|---|---|---|
| BRPE | 2nd Year | Mugu Lagoon | 7 Sept. | None | None | White | None |
| BRPE | Adult | Mugu Lagoon | 7 Sept. | None | None | White | None |
| BRPE | Adult | Mugu Lagoon | 20 Sept. | Aluminum | None | None | None |
| BRPE | Adult | Mugu Lagoon | 9 Oct. | Aluminum | None | None | None |
| BRPE | Adult | Mugu Lagoon | 28 Oct. | None | None | Auminum | None |
| BRPE | Hatch-year | Mugu Lagoon | 28 Oct. | Black | None | Black | None |
| BRPE | Hatch-year | Mugu Lagoon | 28 Oct. | Lavender | None | Light Blue | None |
| BRPE | Adult | Mugu Lagoon | 10 Nov. | Aluminum | None | None | None |
| BRPE | Adult | Mugu Lagoon | 10 Dec. | None | None | Aluminum | None |
| BRPE | Adult | Mugu Lagoon | 10 Dec. | Aluminum | None | None | None |
| CATE | Adult | SCRM | 14 Aug. | Aluminum | Red/White w/Green tinge | Green | Yellow |
| WEGU | Adult | CIHB | 16 Aug. | Aluminum | None | Blue | Yellow |
| WEGU | 2nd Winter | Mugu Lagoon | 19 Aug. | Aluminum | None | White | Black |
| WEGU | 2nd Winter | Mugu Lagoon | 20 Aug. | Aluminum | None | Black | Light Blue |
| WEGU | 2nd Winter | Mugu Lagoon | 6 Sept. | Aluminum | None | White | Black |
| WEGU | 2nd Winter | Mugu Lagoon | 19 Sept. | Aluminum | None | Black | Light Blue |
| WEGU | Hatch-year | Mugu Lagoon | 19 Sept. | Red | Light Green | Aluminum | None |
| WEGU | 2nd Winter | Mugu Lagoon | 19 Sept. | Aluminum | None | White | Black |
| WEGU | 2nd Winter | Mugu Lagoon | 20 Sept. | Aluminum | None | White | Black |
| WEGU | Hatch-year | Mugu Lagoon | 20 Sept. | Red | Light Green | Aluminum | None |
| WEGU | 2nd Winter | Mugu Lagoon | 20 Sept. | Aluminum | None | Black | Light Blue |
| WEGU | Adult | Mugu Lagoon | 8 Oct. | None | None | Aluminum | None |
| WEGU | Adult | Mugu Lagoon | 9 Oct. | Aluminum | None | None | None |
| WEGU | 2nd Winter | Mugu Lagoon | 9 Oct. | Aluminum | None | White | Black |
| WEGU | Hatch-year | Mugu Lagoon | 10 Nov. | Orange | None | Aluminum | None |

APPENDIX E: Capitolo, P.J., J.N. Davis, L.A. Henkel, W.B. Tyler, and H.R. Carter. 2008. Aerial photographic surveys of breeding colonies of Brandt's Double-crested, and Pelagic Cormorants in Southern California, 2005-2007. Unpublished report prepared for California Department of Fish and Game, Office of Spill Prevention and Response Contract #P0475020. University of California, Institute of Marine Sciences, Santa Cruz, California.

# Aerial Photographic Surveys of Breeding Colonies of Brandt's, Double-crested, and Pelagic Cormorants in Southern California, 2005-07


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## EXECUTIVE SUMMARY

Aerial photographic surveys of breeding colonies of Brandt's Cormorants (*Phalacrocorax penicillatus*), Double-crested Cormorants (*P. auritus*), and Common Murres (*Uria aalge*) have been conducted in California since 1979 and annually in southern California since 1991 to assess long-term population trends of these surface-nesting seabird species, using whole-colony counts of birds and nests from photographs. These surveys also have been important in assessing: a) injuries to seabird populations caused by oil spills, gill-net fishing, human disturbance and other anthropogenic factors; b) effects of El Niños, La Niñas, and climate change on seabird populations; and c) opportunities for and effectiveness of seabird restoration projects.

In 2005-07, University of California (Santa Cruz; UCSC), under contract with California Department of Fish and Game (Office of Spill Prevention and Response; CDFG-OSPR), conducted aerial photographic surveys of breeding colonies of Brandt's Cormorants, Double-crested Cormorants, and Pelagic Cormorants (*P. pelagicus*) in coastal southern California. Only a few sample colonies of Pelagic Cormorants were photographed because most require boat surveys for complete colony viewing. One historical murre colony is known for southern California and also was inspected. Aerial surveys also are scheduled for 2008 with CDFG-OSPR funding and support.

In 2005-07, UCSC photographed 36, 7, and 4 breeding colonies of Brandt's, Double-crested and Pelagic Cormorants, respectively. From these photographs, birds and nests were counted for 19, 7, and 2 colonies of Brandt's, Double-crested, and Pelagic Cormorants, respectively. For Brandt's Cormorants, the combined total number of nests for all counted colonies was highest in 2006 (11,818 nests), and 56% and 53% lower in 2005 and 2007, respectively. The largest colony each year was Vizcaino Point South (San Nicolas Island). For Double-crested Cormorants, combined nest totals also were highest in 2006, and 12% and 21% lower in 2005 and 2007, respectively. West Anacapa Island was the largest colony each year, but was surveyed by other researchers. For Pelagic Cormorants, combined nest totals were highest in 2007, and 45% and 15% lower in 2005 and 2006, respectively. Comparison of data from 2005-07 to earlier data indicates the Brandt's Cormorant breeding population size in coastal southern California is stable with much annual variation, but a greater proportion now occurs at the southern Channel Islands and at colonies closer to the mainland among the northern Channel Islands. One new colony was documented on the mainland in 2007. The Double-crested Cormorant population appeared stable in 2005-07 but is possibly declining with emigration to other areas. Little change in Pelagic Cormorant numbers was evident from limited sample colony data.

Brandt's Cormorants successfully nested on all four new, artificial structures at Sandpiper Pier Foundation in 2006-07, a colony along the Santa Barbara County coast that was restored in late 2005. UCSC also discovered, photographed, and counted a breeding colony of California Brown Pelicans (*Pelecanus occidentalis californicus*) at Prince Island (an islet adjacent to San Miguel Island) in 2006. Pelicans had not nested at Prince Island since the early 1960s, and did not nest there in 2005 and 2007.

In 2005-07, UCSC also developed methods for applying digital technology to aerial surveys of seabird colonies in California. Before 2005, surveys had been conducted with slide film, and counts had been made using slide projectors and manual tallying. Use of digital SLR cameras and computer software improved the efficiency of surveys and ease of determining whole-colony counts. Further investigation of possible methods improvements, including use of video cameras and automated features of software, are planned for 2008.

Annual aerial photographic surveys of cormorant and murre colonies throughout coastal California should be continued, with ongoing maintenance of digital images to ensure baseline colony data may be obtained as needed. We also recommend that sample colonies in southern California (or a subset of those listed here) continue to be counted annually, ideally in conjunction with annual sample colony counting for northern and central California, with funding from multiple agencies, and in cooperation with U.S. Fish and Wildlife Service. Oceanographic conditions, prey availability, and anthropogenic impacts may vary widely among the three main regions within and between years, and annual statewide sample colony counting would enable timely detection of seabird responses to these variables. Annual statewide sample colony counting also may reduce the effort required to collect sufficient baseline data needed for assessment of seabird injuries from future oil spills. Periodically (roughly every tenth year), all murre and Brandt's and Double-crested Cormorant colonies in coastal California should be counted to continue decadal comparisons of state-wide breeding distributions, as done for 1975-80, 1989-91, and 2001-04.

# INTRODUCTION

## History of Surveys

Aerial photographic surveys of breeding colonies of Common Murres (*Uria aalge)*, Brandt's Cormorants (*Phalacrocorax penicillatus*), and Double-crested Cormorants (*P. auritus*) have been conducted almost annually in northern and central California since 1979 and annually in southern California since 1991 (Sowls et al. 1980, Carter et al. 1992, 1996, 2001, McChesney et al. 1998a, 2001, 2007, Capitolo et al. 2004, 2006a,b, 2007). Estimates of breeding population size are determined from either raw or adjusted whole-colony counts from aerial photographs, and these estimates can be used to determine long-term population trends. Roosting California Brown Pelicans (*Pelecanus occidentalis californicus*) also have been photographed at murre and cormorant colonies to provide information on use of coastal, terrestrial habitat during the late spring period from April to June (Carter et al. 2000).

From 1979 to 1995, aerial photographic surveys of breeding colonies of murres and cormorants in coastal northern and central California were conducted by U.S. Fish and Wildlife Service (USFWS), Humboldt State University (HSU), and University of California, Santa Cruz (UCSC), with funding and support from several federal and state agencies, including California Department of Fish and Game - Office of Spill Prevention and Response (CDFG-OSPR; Sowls et al. 1980, Briggs et al. 1983, Takekawa et al. 1990, Carter et al. 1992, 1996, 2001). Since 1996, the Common Murre Restoration Project (CMRP) has continued these surveys annually to assess population changes and restoration efforts. CMRP aerial photographic surveys have been conducted cooperatively by USFWS and HSU with funding from the *Apex Houston* Trustee Council (Parker et al. 1997, McChesney et al. 2007).

For coastal southern California, aerial photographic surveys of cormorant breeding colonies were conducted by HSU from 1991 to 2003. Surveys in 1991 were funded by Minerals Management Service in relation to potential offshore oil development, and were part of a large-scale effort to inventory and catalog all seabird colonies in coastal California in 1989-91 through a combination of methods, including aerial, boat, and ground surveys (Carter et al. 1992). In 1992-96, U.S. Navy funded HSU to conduct annual surveys in relation to management responsibilities at San Nicolas Island and for the At-Sea Test Range, with a focus on better understanding population recovery and annual variation (especially effects of the 1992-93 El Niño event; Carter et al. 1996, McChesney 1997). During this same period, CDFG-OSPR funded HSU to develop an annual monitoring program for breeding colonies of Common Murres, and Brandt's and Double-crested Cormorants throughout California using aerial photographic surveys (Carter et al. 1996). All colonies were photographed, and "sample" colonies, considered to be representative of regional populations, were counted for northern and central California. For southern California, sample colonies were not chosen because available U.S. Navy funding allowed all colonies to be counted.

To continue to monitor cormorant population sizes and trends in southern California (especially in relation to at-sea distribution and effects of the 1997-98 El Niño and 1999 La Niña), CDFG-OSPR funded HSU surveys in 1997 (McChesney et al. 1998a), and U.S. Geological Survey and CDFG-OSPR funded HSU surveys in 1998-2002 (McChesney et al.

2001, Mason et al. 2007; H. Carter, unpubl. data). In 2003, as part of an assessment of cormorant populations throughout California, Oregon, and Washington, USFWS and CDFG-OSPR funded southern California surveys (Capitolo et al. 2004). However, funding had not been available to count southern California aerial photographs for 2002-03 (H. Carter, unpubl. data; this report). In 2004, no funding was available to conduct colony surveys in southern California.

**General Results of Past Surveys**

Aerial photographic surveys have detected effects of anthropogenic and natural factors on seabird populations and helped to establish priorities in restoration projects. For Common Murres, comparison of population trends in the 1980s demonstrated dramatic declines in central California but not northern California; this geographic difference clarified that declines were due mainly to significant mortality from local gill-net fishing and oiling, rather than effects from severe El Niños or other large-scale cyclic environmental changes (Takekawa et al. 1990, Carter et al. 2001, 2003a). Loss of the murre colony at Devil's Slide Rock in central California after the 1986 *Apex Houston* oil spill was documented with aerial surveys, providing knowledge that assisted the establishment of the CMRP (Takekawa et al. 1990, Carter et al. 2003a). Murre population decline at Redding Rock in northern California (Carter et al. 2001, Capitolo et al. 2006b) led to a restoration project proposal for the 1999 *Stuyvesant* oil spill (Stuyvesant Trustee Council 2007). Impacts to the murre population in Drake's Bay in central California from mortality due to the 1997-98 Point Reyes Tarball Incidents and the 1998 El Niño were detected in 1998-2000 from aerial photographic surveys (Carter et al. 2003b).

For Brandt's Cormorants, aerial surveys have documented large reductions in breeding population sizes during major El Niño events, followed by significant population increases shortly afterward (Carter et al. 1996, McChesney et al. 1998b, 2001, Capitolo et al. 2006b). Evidence of human disturbance at cormorant and murre colonies detected by aerial surveys (Carter et al. 1998) led to a project in the restoration plan for the 1998 *Command* oil spill to reduce disturbance at seabird colonies (Command Trustee Council 2004). In southern California in 2005, remnants of the Sandpiper Pier Foundation, a Brandt's Cormorant colony discovered during aerial surveys in 1997 (McChesney et al. 1998a), were dismantled and replaced with new structures under advice from CDFG (this report). For Double-crested Cormorants, aerial surveys have generally shown continued population increases in northern and central California, but at a lower rate than other parts of North America, and a possible recent declining trend in southern California (Carter et al. 1995, Capitolo et al. 2004).

**UCSC-OSPR Surveys**

In 2003-04, CDFG-OSPR (P. Kelly) and past HSU Principal Co-Investigator (Carter; now Carter Biological Consulting [CBC]) identified the need to resume aerial photographic surveys of cormorant colonies in southern California, through the development of a new survey team. In late 2004, CDFG-OSPR awarded UCSC a contract to conduct these surveys in 2005-07. UCSC surveys in southern California ensured complete annual photographic coverage of Brandt's and Double-crested Cormorant breeding colonies throughout coastal California, complementing surveys in central and northern California conducted by CMRP. To maintain continuity with past efforts and facilitate future coordination with CMRP efforts, Capitolo joined UCSC to lead 2005-07 surveys in southern California, while continuing as HSU staff on surveys by CMRP. CBC also assisted and supported development of the UCSC aerial survey program for breeding colonies and will continue to cooperate with UCSC and CMRP to interpret long-term trends of cormorants in southern California and throughout California.

CDFG-OSPR is mandated to prevent and minimize the effects of marine oil spills on wildlife resources and take actions to restore resources injured by oil to their baseline conditions. Seabirds generally constitute the single largest category of (observed) wildlife mortality during marine oil spills. Therefore, access to information on the location and abundance of different species of seabirds becomes essential during spill response as well as restoration planning. To this end, aerial photographic surveys are conducted to identify current locations of breeding colonies, collect baseline data, better understand factors affecting populations, and identify opportunities for seabird restoration projects. In this report, we present methods and results of aerial photographic surveys of cormorant colonies in southern California in 2005-07 conducted by UCSC and briefly compare results with data from earlier surveys. We also identify recommendations for future work.

## METHODS

### Aerial Photographic Surveys

*Survey Timing and Colonies Surveyed*

Our objective in each year was to photograph all active Brandt's Cormorant colonies, all active Double-crested Cormorant colonies except those at Anacapa Island (ANI), and four sample Pelagic Cormorant colonies in the Southern California Bight (SCB) between Point Conception and the Mexico border. This region encompasses southern Santa Barbara, Ventura, Los Angeles, Orange and San Diego counties (after Carter et al. 1992; Figures 1,2). We circumnavigated most Channel Islands, but did not inspect most areas of Santa Catalina Island (CAI) or the east side of San Clemente Island (CLI), where no historical colonies had occurred and where little breeding habitat exists. Along the southern California mainland, known colony locations and other small stretches of coastline were inspected, but other potential natural or artificial breeding habitats in harbors or in the airspace of Los Angeles International Airport were not inspected. Following earlier protocols, we scheduled surveys for mid April, mid May and mid June (Table 1) to capture the peak periods of nesting for these species and all colonies. All surveys were conducted between 08:00 and 17:00 h (PDT).

April surveys were designed to focus on certain Brandt's Cormorant colonies where early breeding had been noted in previous years (Carter et al. 1992, 1996, McChesney et al. 1998a). Each year, we photographed colonies at Santa Barbara Island (SBI) and San Nicolas Island (SNI). CLI colonies were photographed in April in 2005 and 2006, but not in 2007 due to U.S. Navy operations restricting airspace around the island. Prince Island (San Miguel Island; SMI) and ANI were surveyed in 2006 and 2007. Sandpiper Pier Foundation was surveyed each month in 2006 to gather additional data on cormorant and pelican use of this site in the first year following its restoration.

In May, we aimed to photograph all active Brandt's Cormorant colonies and all active Double-crested Cormorant colonies except those at ANI. Double-crested Cormorant nesting usually peaks in June, but these colonies were also photographed in May in case certain colonies could not be surveyed in June because of fog or other factors. To avoid possible disturbance to nesting Brown Pelicans, we did not survey Double-crested Cormorants at ANI. California Institute of Environmental Studies (CIES) conducted boat and ground surveys of this Double-crested Cormorant colony annually in 2005-07 (F. Gress, pers. comm.; see Carter et al. 1992, Gress 1995, Capitolo et al. 2004). We also photographed three Pelagic Cormorant colonies at Santa Rosa Island (SRI) which were sample colonies surveyed in previous years (McChesney et al. 1998a, 2001; H. Carter, unpubl. data), and added Prince Island to our list of Pelagic Cormorant sample colonies in 2006. Due to their diffuse colonies and cliffside nesting habits, most Pelagic Cormorant colonies cannot be surveyed completely with aerial photography. Historical cormorant nesting areas at CAI were photographed only in May 2007, but were inspected from the ground in 2005 and 2006 (J. Davis, pers. obs.).

Table 1. Summary of dates and personnel for aerial photographic surveys in southern California in 2005-2007.

| Date | Photographers | Data Recorder | Pilot | Locations Surveyed[1] |
|---|---|---|---|---|
| **2005** | | | | |
| 4/18 | P. Capitolo, J. Davis | L. Henkel | R. Morgan | SBI, SNI, CLI |
| 5/16 | P. Capitolo, L. Henkel | G. McChesney | W. Burnett | SBI, SNI, CLI |
| 5/17 | P. Capitolo, McChesney, Henkel | J. Davis | W. Burnett | SMI, SRI, SZI, ANI, mainland |
| 6/13 | P. Capitolo, J. Davis | L. Henkel | W. Burnett | Prince I., CLI |
| **2006** | | | | |
| 4/25 | P. Capitolo, J. Davis | L. Henkel | W. Burnett | SPF, Prince I., ANI, SBI, SNI, CLI |
| 5/15 | P. Capitolo, L. Henkel | J. Davis | W. Burnett | SBI, SNI, CLI, SD Mainland |
| 5/16 | P. Capitolo, J. Davis | L. Henkel | W. Burnett | SPF, SMI, SRI, SZI, ANI |
| 6/29 | P. Capitolo | P. Capitolo | W. Burnett | SPF, SBI, SNI, Prince I. |
| **2007** | | | | |
| 4/16 | P. Capitolo, J. Davis, L. Henkel | L. Henkel, J. Davis | W. Burnett | Prince I., ANI, SBI, SNI |
| 5/14 | P. Capitolo, J. Davis | L. Henkel | T. Evans | SBI, SNI, CLI, CAI, SD Mainland |
| 5/15 | P. Capitolo, L. Henkel | J. Davis | T. Evans | SPF, SMI, SRI, SZI, ANI |
| 6/12 | P. Capitolo, L. Henkel | L. Henkel | R. Van. | Prince I., Sierra Pablo, SBI, CLI |

[1]Abbreviations: SBI (Santa Barbara Island); SNI (San Nicolas Island); CLI (San Clemente Island); SMI (San Miguel Island); SRI (Santa Rosa Island); SZI (Santa Cruz Island); ANI (Anacapa Island); CAI (Santa Catalina Island); SPF (Sandpiper Pier Foundation)

June surveys were designed to focus primarily on Double-crested Cormorants, which typically breed later than Brandt's Cormorants in southern California (Carter et al. 1996, McChesney et al. 1998a). However, fog prevented surveys of SBI in 2005 and allowed only scattered photographs through patchy breaks in the fog at Prince Island in 2006. All Channel Islands Double-crested Cormorant colonies were surveyed in June 2007. The mainland colony at

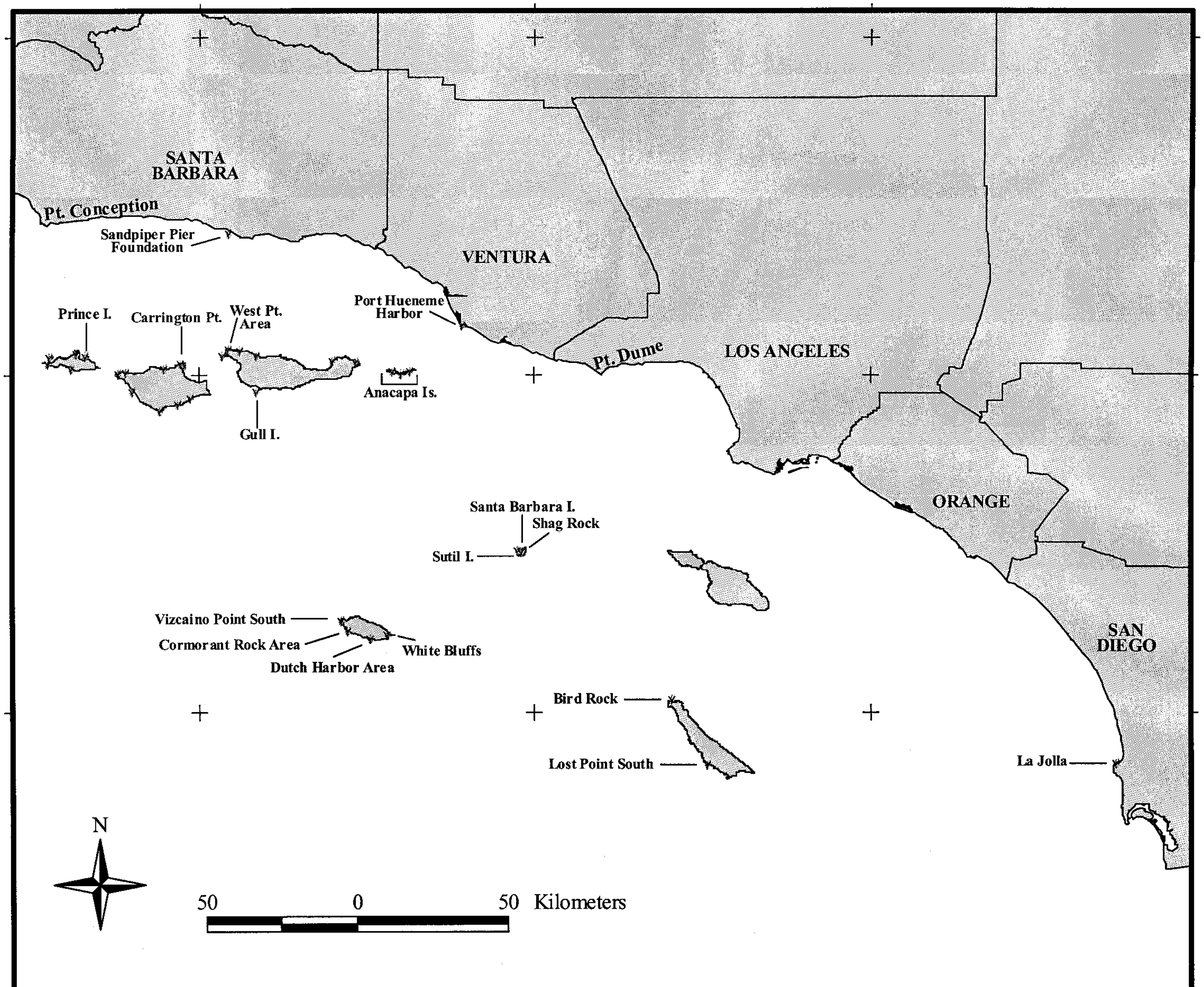


Figure 1. Sample Brandt's Cormorant colonies in southern California in 2005-07. Unlabeled locations indicate non-sample colonies active in one or more years (see Table 2, Carter et al. 1992).

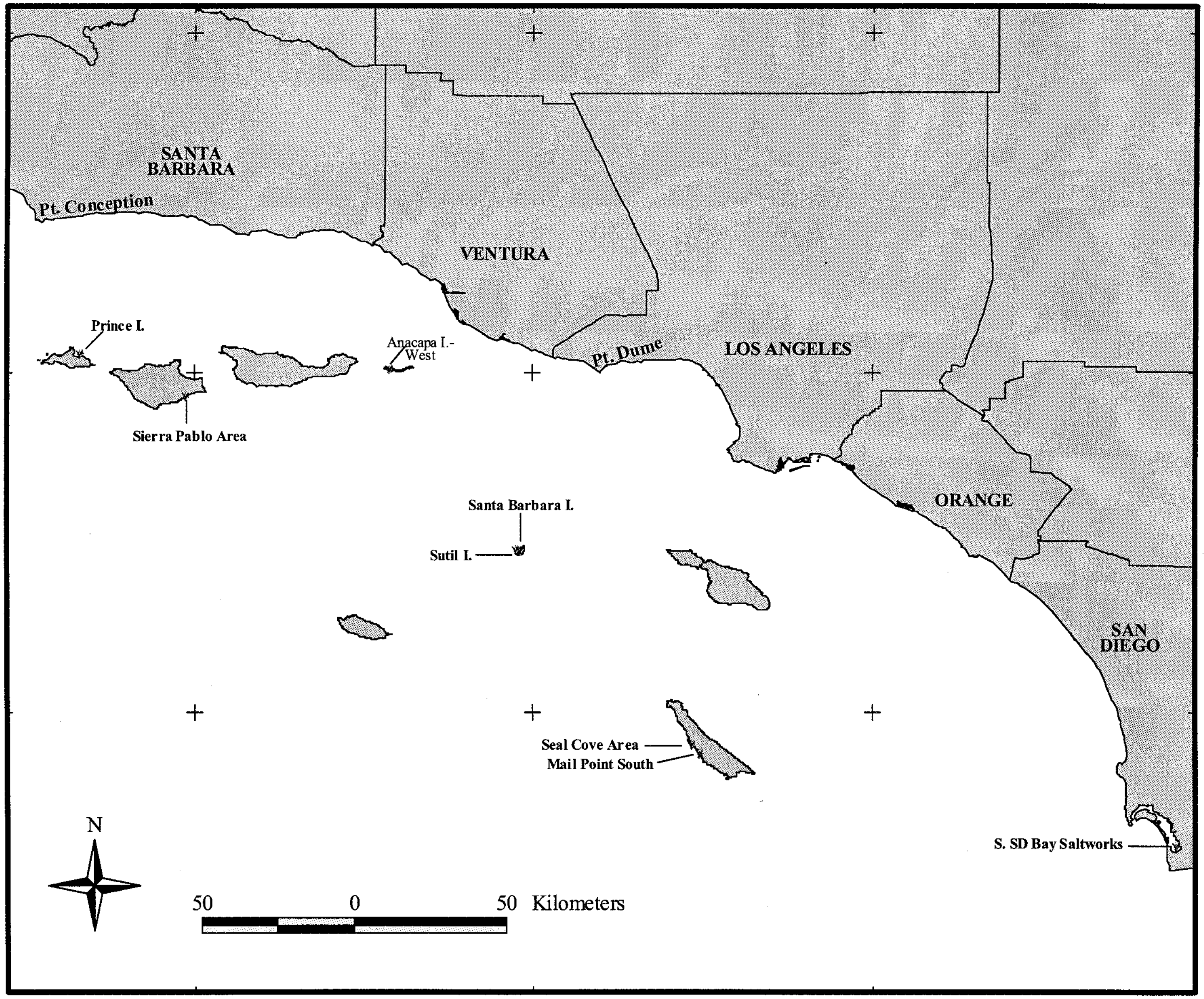


Figure 2. Active Double-crested Cormorant colonies in coastal southern California in 2005-07. Bold indicates sample colonies.

South San Diego Bay Saltworks was surveyed only in May each year. We also photographed Brown Pelicans roosting at cormorant colonies on all surveys.

*Photographic Techniques*

All surveys were conducted from a CDFG, twin-engine Partenavia aircraft, at altitudes of 500-1200 feet (150-365 m), and all photographs were taken with Canon EOS 20D digital SLR cameras (8.2 megapixels). UCSC surveys in 2005-07 marked the first large-scale use of digital photography for aerial surveys of seabird colonies in California (Capitolo et al. 2006a). Oblique photographs were taken through side windows during April and May surveys. Two observers photographed each colony, while a third crew member recorded data. The lead photographer directed the pilot and took close-up photographs with a 200mm telephoto lens through an open port in the side window. The back-up photographer took overview photographs of all colonies and close-up photographs at certain colonies with a 70-200mm zoom lens through the back-seat plexiglass window. The effective focal length of lenses on the digital SLR camera body is 1.6 times greater than on a 35mm film camera; thus, the 200mm telephoto lens was equivalent to a 320mm lens on a 35mm film camera. Multiple photographs and sometimes several passes were needed to ensure complete coverage of nesting areas.

In June 2006, we tested the suitability of vertical photography through a port in the bottom ("belly") of the aircraft for surveying Double-crested Cormorant colonies. Vertical photography of southern California cormorant colonies had been tested in the late 1990s (H. Carter, unpubl. data), but proved inefficient for many Brandt's Cormorant colonies that occur on low cliffs, including at sea cave entrances, and are best seen from an oblique perspective. Brandt's Cormorants also shift nesting locations between years, and the vertical perspective through the belly port limits observers' ability to search for nesting birds. In contrast, southern California Double-crested Cormorant colonies occur mostly high on broad slopes of islands and their locations vary little between years. Colonies were inspected obliquely to identify all nesting areas and explain preferred flight paths to the pilot. Colonies were then photographed by approaching them perpendicularly (i.e., flying toward the island slope rather than parallel to shore) at sufficient altitudes to remain 500-600' above ground level when flying over the tops of islands. Vertical photography also was successfully used in June 2007.

Following surveys, photographs were downloaded from memory cards to a laptop computer and stored in folders of 100 photographs. Each photograph used approximately 4.5 MB of memory; all photographs combined totaled about 13 GB of memory in 2005 and 18 GB in 2006 and 2007. At the end of each day, photographs on the laptop were copied to an external hard drive. Survey date and time of day were automatically stored with each photograph.

*2006 Central California Surveys*

In 2006, Brandt's and Double-crested Cormorant colonies from Point Conception north to Point Piedras Blancas were surveyed with digital photography during surveys conducted by the CMRP to facilitate a possible objective at that time (if time and funding allowed) to assess cormorant population trends from Point Piedras Blancas to the Mexico border from 1979-2007 (Capitolo et al. 2007). Capitolo, as part of the CMRP survey team, took close-up photographs using a UCSC digital camera while G. McChesney (CMRP) took overview and backup photographs with slide film. Digital photographs were archived by UCSC and slides by the CMRP.

## Photograph Counting

### *Colonies Counted*

We selected sample Brandt's Cormorant colonies to be counted (Figure 1) that were representative of regional populations based on data available from surveys in 1991-2001 (Carter et al. 1992, 1996, McChesney et al. 1998a, 2001; H. Carter, unpubl. data). To maintain wide geographic coverage, sample colonies were selected from each of the seven Channel Islands with current breeding colonies. For ANI, SBI, SNI, and CLI, we selected all colonies because the islands represent distinct areas of the SCB and because many colonies are relatively small and easily counted. However, only certain colonies were selected for SMI, SRI, and Santa Cruz Island (SZI) because of geographic proximity of the islands and larger colony sizes. Few, small colonies occur on the mainland and all were selected. The number of sample colonies varied each year because certain colonies at ANI, SBI and SNI were not active annually and one new mainland colony formed. For Double-crested Cormorants, we counted all colonies surveyed (see above) because only a small number of colonies occur in coastal southern California (Figure 2). No active Brandt's or Double-crested Cormorant colonies occur at CAI. For Pelagic Cormorants, we counted two colonies that occurred adjacent to sample Brandt's Cormorant colonies, Prince Island (SMI) and Carrington Point (SRI). Sample colonies for Brandt's and Double-crested Cormorants are listed in Table 2.

### *Dotting*

Since 1985, standardized counting methods had involved projecting selected slides onto 2'x3' white paper; marking (or "dotting") each bird, nest, and site with a felt pen; and calculating totals for each category (Takekawa et al. 1990, Carter et al. 1992, 1996, 1998, 2000, 2001, 2003b, Sydeman et al. 1997, McChesney et al. 1998a,b, 1999, 2001, 2007, Capitolo et al. 2003, 2004, 2006b). Having switched to digital photography in 2005, we purchased Image-Pro Express, image-analysis software developed by Media Cybernetics, to allow implementation of standardized counting methods with computers (Capitolo et al. 2006a).

For each sample colony, we counted the number of nests, territorial sites, and birds at specific subcolonies and summed these to determine whole-colony totals. Subcolonies are distinct geographic areas within colonies, previously defined by Carter et al. (1992, 1996). Brandt's Cormorant colonies that were photographed in April and May in 2005 were counted for both surveys and highest monthly subcolony counts were summed to determine whole-colony counts. For these colonies in 2006 and 2007, we visually inspected photographs from both surveys to determine which survey was most appropriate for counting for each subcolony. For Double-crested Cormorant colonies, we counted photographs only from June if a colony was surveyed in both May and June. Only the small colonies at SRI and CLI were counted for both May and June to allow some comparison of the increase in nest totals between months.

Nests were categorized by their stage of development following the standardized HSU protocol described in McChesney et al. (1998a,b, 1999). Nest categories and codes are: "well-built nest" (X); "nest with chicks" (C); "poorly-built nest" (P); "abandoned nest" (A; without attending adult); "empty nest" (E; with attending adult); and "brood" (B; chicks without attending adult and not obviously associated with a nest structure). Nest totals in this report include all of these categories. We also counted territorial sites (Z), locations with little or no nesting material that were attended and apparently defended (based on spacing) by one adult. Sites can indicate impending additional nest building, but this is unusual later in the breeding season. Total numbers of birds include any roosting cormorants within or immediately adjacent to breeding areas. Roosting birds not immediately adjacent to nesting areas may have included birds of more than one cormorant species and were considered unidentified. Brown Pelicans were aged as adult (at least some white in head) or immature (dark head). Among pelican nests at Prince Island, only "well-built nests" (X) and "nests with chicks" were detected.

*2002-03 Slides*

Prior to conducting surveys in 2005, we labeled aerial photographs (slides) from 2002 surveys conducted by HSU. Funding was available to conduct surveys in 2002, but not to label or count photographs. HSU and CMRP had stored these photos in the interim. We also completed counting of sample colonies for 2002, but not 2003. Data for 2002 are provided (Appendixes 1-3), but are not discussed further in this report.

**Data Archiving**

After counting nests, birds, and sites from a particular image, dotting effort was archived in one of two ways using Image-Pro Express. In some cases, object data were saved as .tag files, such that data from an image can be re-inspected in the future by opening the image in Image-Pro software and loading the corresponding .tag file. In other cases, we saved a Screen Capture of the image that included all dotting information including all dotting symbols as well as total counts for each category. Screen Captures were saved as .jpeg files to be readily viewable for future reference, but object data can only be manipulated at a future time by saving the .tag file and with access to Image-Pro software. Future counting effort using Image-Pro software should include saving Screen Captures and .tag files as standardized archival procedures.

Count data for individual images were saved to Microsoft Excel spreadsheet files. Totals for subcolonies were entered into Microsoft Access database with a structure adapted from previous versions of aerial photographic survey databases (e.g., Carter et al. 2000) and the database currently being developed by USFWS (Migratory Birds and Habitat Programs, Portland, Oregon) for seabird colony data from California, Oregon, and Washington (USFWS 2005). Eventually, these data will be retrievable on-line, along with colony and subcolony maps. However, the USFWS database structure does not represent all data collected during counting of aerial photographs.

Table 2. Known breeding colonies of Brandt's Cormorants and Double-crested Cormorants in southern California, and sample colonies counted for 2005-07 (bold). Codes are: CCN = California Colony Number; USFWSCN = USFWS Colony Number; Y = nests photographed; N = no nests detected; H = confirmed breeding prior to 1991 only; ND = no data; Dash (-) = breeding has not been documented.

| | | | Brandt's Cormorant | | | Double-crested Cormorant | | |
|---|---|---|---|---|---|---|---|---|
| COLONY | CCN | USFWSCN | 2005 | 2006 | 2007 | 2005 | 2006 | 2007 |
| MAINLAND-SANTA BARBARA CO. | | | | | | | | |
| **Sandpiper Pier Foundation** | **SB-342-07** | **502-029** | **Y** | **Y** | **Y** | - | - | - |
| SAN MIGUEL ISLAND | | | | | | | | |
| Point Bennett | SB-SMI-01 | 501-014 | Y | Y | Y | - | - | - |
| Castle Rock | SB-SMI-02 | 501-005 | Y | Y | Y | - | - | - |
| Richardson Rock | SB-SMI-03 | 501-026 | N | N | N | - | - | - |
| Northwest San Miguel Island | SB-SMI-04 | 501-027 | N | N | N | - | - | - |
| Harris Point-Cuyler Harbor | SB-SMI-06 | 501-015 | Y | Y | N | - | - | - |
| **Prince Island** | **SB-SMI-07** | **501-004** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| Hoffman Point Area | SB-SMI-08 | 501-029 | N | N | N | - | - | - |
| Bay Point Area | SB-SMI-09 | 501-016 | N | N | N | - | - | - |
| Crook Point-Tyler Bight | SB-SMI-11 | 501-031 | Y | Y | Y | - | - | - |
| SANTA ROSA ISLAND | | | | | | | | |
| Sandy Point | SB-SRI-01 | 501-033 | Y | Y | Y | - | - | - |
| Northwest Santa Rosa Island | SB-SRI-02 | 501-034 | Y | Y | Y | - | - | - |
| Brockway Point Area | SB-SRI-03 | 501-035 | H, N | H, N | H, N | - | - | - |
| Cañada Verde-Santa Rosa I West Base | SB-SRI-04 | 501-035 | Y | Y | Y | - | - | - |
| **Carrington Point** | **SB-SRI-05** | **501-037** | **Y** | **Y** | **Y** | - | - | - |
| North Becher's Bay | SB-SRI-06 | 501-038 | Y | Y | Y | - | - | - |
| Sierra Pablo Area[1] | SB-SRI-09 | 501-040 | Y | Y | Y | **ND** | **ND** | **Y** |
| Ford Point-Wreck Canyon | SB-SRI-10 | 501-041 | - | - | Y | - | - | - |
| South Point Area | SB-SRI-11 | 501-042 | Y | Y | Y | - | - | - |
| Bee Rock Mainland Area | SB-SRI-13 | 501-044 | N | N | Y | - | - | - |
| SANTA CRUZ ISLAND | | | | | | | | |
| Fraser Point | SB-SZI-01 | 502-015 | N | N | Y | - | - | - |
| **West Point Area** | **SB-SZI-02** | **502-016** | **Y** | **Y** | **Y** | - | - | - |
| Profile Point Area | SB-SZI-03 | 502-017 | Y | Y | N | - | - | - |
| Cueva Valdaze Area | SB-SZI-04 | 502-018 | N | Y | N | - | - | - |
| Coche Point Northeast | SB-SZI-11 | 502-024 | N | N | Y | - | - | - |
| Cavern Point Area | SB-SZI-12 | 502-025 | N | N | N | - | - | - |
| Scorpion Anchorage | SB-SZI-13 | 502-026 | N | N | N | - | - | - |
| Scorpion Rocks | SB-SZI-14 | 502-010 | - | - | - | H, N | H, N | H, N |

Table 2 (continued).

| COLONY | CCN | USFWSCN | Brandt's Cormorant | | | Double-crested Cormorant | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2005 | 2006 | 2007 | 2005 | 2006 | 2007 |
| San Pedro Point Area | SB-SZI-15 | 502-027 | Y | Y | Y | - | - | - |
| **Gull Island** | **SB-SZI-22** | **524-001** | **Y** | **Y** | **Y** | - | - | - |
| **MAINLAND-VENTURA COUNTY** | | | | | | | | |
| **Port Hueneme Harbor** | **VE-340-01** | **502-030** | - | - | **Y** | - | - | - |
| **ANACAPA ISLAND** | | | | | | | | |
| **Anacapa Island – West** | **VE-ANI-01** | **502-007** | **Y** | **Y** | **Y** | **ND** | **ND** | **ND** |
| **Anacapa Island – Middle** | **VE-ANI-02** | **502-008** | **N** | **N** | **Y** | - | - | - |
| **Anacapa Island – East** | **VE-ANI-03** | **502-009** | **Y** | **Y** | **Y** | - | - | - |
| **SANTA BARBARA ISLAND** | | | | | | | | |
| **Shag Rock** | **SB-SBI-01** | **524-007** | **N** | **Y** | **Y** | **N** | **N** | **N** |
| **Santa Barbara Island** | **SB-SBI-02** | **524-008** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| **Sutil Island** | **SB-SBI-03** | **524-009** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| **SAN NICOLAS ISLAND** | | | | | | | | |
| **Vizcaino Point South** | **VE-SNI-01** | **524-022** | **Y** | **Y** | **Y** | - | - | - |
| **Vizcaino Point East** | **VE-SNI-02** | **524-023** | **N** | **N** | **N** | - | - | - |
| **Dutch Harbor Area** | **VE-SNI-05** | **524-026** | **Y** | **Y** | **Y** | - | - | - |
| **Cormorant Rock Area** | **VE-SNI-07** | **524-028** | **Y** | **Y** | **Y** | - | - | - |
| **White Bluffs** | **VE-SNI-08** | **524-068** | **N** | **N** | **Y** | | | - |
| **SAN CLEMENTE ISLAND** | | | | | | | | |
| Castle Rock | LA-CLI-01 | 524-029 | H, N | H, N | H, N | - | - | - |
| **Bird Rock** | **LA-CLI-02** | **524-030** | **Y** | **Y** | **Y** | - | - | - |
| Northwest Harbor to Wilson Cove | LA-CLI-03 | 524-031 | H, N | H, N | H, N | - | - | - |
| Pyramid Cove | LA-CLI-04 | 524-032 | H, N | H, N | H, N | - | - | - |
| **Lost Point South** | **LA-CLI-06** | **524-034** | **Y** | **Y** | **Y** | - | - | - |
| **Mail Point South** | **LA-CLI-07** | **524-035** | **H, N** | **H, N** | **H, N** | **N** | **N** | **Y** |
| **Seal Cove Area** | **LA-CLI-08** | **524-036** | **N** | **N** | **N** | **Y** | **Y** | **Y** |
| **SANTA CATALINA ISLAND** | | | | | | | | |
| Ship Rock | LA-CAI-03 | 524-039 | H, N | H, N | H, N | H, N | H, N | H, N |
| Bird Rock | LA-CAI-04 | 524-010 | H, N | H, N | H, N | - | - | - |
| **MAINLAND-SAN DIEGO COUNTY** | | | | | | | | |
| **La Jolla** | **SD-324-04** | **545-009** | **Y** | **Y** | **Y** | - | - | - |
| **South San Diego Bay Saltworks** | **SD-322-04** | **545-027** | - | - | - | **Y** | **Y** | **Y** |

[1]Sierra Pablo Area was a sample colony only for Double-crested Cormorants.

## RESULTS

### Brandt's Cormorant

Thirty-six Brandt's Cormorant colonies were active in one or more years in 2005-07. Of these, 24 were active each year, three were active in two years, and nine were active in just one year (Table 2). However, some small colonies on cliffs on the north side of SZI may not always have been detected. The total number of nests at sample colonies (Tables 3-5, Figure 3) was highest in 2006 (11,818 nests) and 56% and 53% lower in 2005 (7,563 nests) and 2007 (7,713 nests), respectively. If nests and territorial sites are combined, the total was highest in 2006 (12,457 nests and sites) and 33% and 14% lower in 2005 (8,313 nests and sites) and 2007 (10,655 nests and sites), respectively.

The largest colony occurred at Vizcaino Point South each year (SNI; range: 1,871-3,154 nests). Other colonies with more than 1,000 nests in one or more years were Dutch Harbor Area (SNI), Prince Island (SMI), Santa Barbara Island, Gull Island (SZI), and West Anacapa Island. In 2006, nest totals for most colonies were substantially higher than in 2005; however, the Gull Island (SZI) nest total was very similar (-2%). In 2007, nest totals for many colonies were substantially lower than in 2006. However, a substantially higher nest total in 2007 at Carrington Point (SRI; +23%) may reflect movements of birds from other nearby colonies, especially Gull Island (SZI) where the nest total in 2007 was more than 60% lower than in both previous years. Similarly, a higher nest total at Sutil Island in 2007 compared to 2006 (+414%) likely reflects movements of birds from adjacent Santa Barbara Island. Non-sample (i.e., not counted) colonies of several hundred nests were active at SMI and SRI (Tables 2,6, Figure 1).

Breeding phenology in the SCB was asynchronous, but appeared substantially earlier in 2006 at SBI, SNI, and sample colonies along the north side of SMI, SRI, and SZI (Appendix 1). At SBI in April 2006, chicks were visible in 62% of nests at Webster Point and Elephant Seal Point combined. In contrast, just 8% and 13% of nests at these two areas had visible chicks in April 2005 and April 2007, respectively, and Webster Point was not active until May in 2007. Similarly, 12% of nests at SNI in May 2006 had visible chicks compared to just 1% in May 2005 and 0.1% in May 2007. At Prince Island (SMI) and Carrington Point (SRI), colonies closest to the upwelling center off Point Conception, chicks were visible in 64% and 68% of nests, respectively, in May 2006 compared to 0% and 15% in May 2005 and 0% at both colonies in May 2007. On the north side of SZI, breeding phenology at West Point Area also was earliest in 2006.

On the south side of SZI however, breeding phenology at Gull Island was earliest in 2005 when 19% of nests in May had visible chicks, compared to zero in May 2006 and May 2007. A similar pattern occurred at Anacapa Island-East. Phenology patterns were mostly similar each year at Anacapa Island-West, CLI, and the small mainland colonies at Sandpiper Pier Foundation and La Jolla. Asynchronous breeding also was noted within colonies at Anacapa Island-West and SBI (Capitolo et al. 2006, 2007; also see Boekelheide et al. 1990, Carter et al. 1996, McChesney et al. 1998a). Small numbers of nest initiations also may have occurred after our surveys. Active nests were reported at Vizcaino Point South (SNI) in late August 2005

Table 3. Whole-colony counts of nests, sites and birds for Brandt's, Double-crested, and Pelagic Cormorants at sample colonies in southern California, April-June 2005. Dash (-) = breeding has not been documented.

| | | | Brandt's Cormorant | | | Double-crested Cormorant | | | Pelagic Cormorant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Colony** | **USFWSCN** | **Date** | **Nests** | **Sites** | **Birds** | **Nests** | **Sites** | **Birds** | **Nests** | **Sites** | **Birds** |
| Sandpiper Pier | 502-029 | 5/17 | 96 | 0 | 262 | - | - | - | - | - | - |
| Prince Island | 501-004 | 5/17, 6/13[1] | 796 | 47 | 960 | 174 | 0 | 189 | 9 | 2 | 11 |
| Carrington Point | 501-037 | 5/17 | 323 | 0 | 516[a] | - | - | - | 13[f] | 0[f] | 13[f] |
| West Point Area | 502-016 | 5/17 | 377 | 26 | 520 | - | - | - | ND | ND | ND |
| Gull Island | 524-001 | 5/17 | 1,180 | 0 | 2,378[b] | - | - | - | ND | ND | ND |
| Anacapa I. – West | 502-007 | 5/17 | 437 | 31 | 505 | ND | ND | ND | ND | ND | ND |
| Anacapa I. – East | 502-009 | 5/17 | 48 | 0 | 85 | - | - | - | ND | ND | ND |
| Santa Barbara I. | 524-008 | 4/18, 5/16[1,2] | 501 | 88 | 741[c] | 75 | 9 | 88 | ND | ND | ND |
| Sutil Island | 524-009 | 4/18, 5/16[1] | 37 | 4 | 45 | 50 | 2 | 57 | - | - | - |
| Vizcaino Point South | 524-022 | 5/16 | 1,871 | 354 | 3,074 | - | - | - | - | - | - |
| Dutch Harbor Area | 524-026 | 5/16 | 1,066 | 146 | 1,432 | - | - | - | - | - | - |
| Cormorant Rock Area | 524-028 | 5/16 | 248 | 7 | 260 | - | - | - | - | - | - |
| Bird Rock | 524-030 | 5/16 | 530 | 46 | 777[d] | - | - | - | - | - | - |
| Lost Point South | 524-034 | 5/16 | 31 | 0 | 44 | - | - | - | - | - | - |
| Seal Cove Area | 524-036 | 5/16, 6/13[1] | 0 | 0 | 0 | 35 | 0 | 44 | - | - | - |
| La Jolla | 545-009 | 5/17 | 22 | 1 | 43 | - | - | - | - | - | - |
| S. SD Bay Saltworks | 545-027 | 5/17 | - | - | - | 77[g] | 0[g] | 66[g] | - | - | - |
| **Total[3]** | | | **7,563** | **750** | **11,636[e]** | **411** | **11** | **444** | **22** | **2** | **24** |

**Numeric Footnotes:** [1]Second date is survey date for Double-crested Cormorant; [2]Brandt's Cormorant totals include data from both survey dates (see text, Appendix 1); [3]Note that totals are for sample colonies only and are not totals for all of southern California. **Alphabetic Footnotes:** [a]Includes 22 roosting birds; [b]Includes 615 roosting birds; [c]Includes 19 roosting birds at Webster Point; [d]Includes 40 roosting birds; [e]Includes 696 roosting birds; [f]SC 04 only; [g]Nest total is USFWS ground count, and bird count is aerial count for dredge barge only (see text; Appendix 1).

Table 4. Whole-colony counts of nests, sites and birds for Brandt's, Double-crested, and Pelagic Cormorants at sample colonies in southern California, April-June 2006. Dash (-) = breeding has not been documented.

| | | | Brandt's Cormorant | | | Double-crested Cormorant | | | Pelagic Cormorant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Colony** | **USFWSCN** | **Date** | **Nests** | **Sites** | **Birds** | **Nests** | **Sites** | **Birds** | **Nests** | **Sites** | **Birds** |
| Sandpiper Pier | 502-029 | 4/25, 5/16[1] | 82 | 7 | 147 | - | - | - | - | - | - |
| Prince Island | 501-004 | 5/16 | 1,265 | 17 | 1,316 | 186 | 4 | 193 | 8 | 0 | 10 |
| Carrington Point | 501-037 | 5/16 | 444 | 8 | 536 | - | - | - | 26[a] | 0[a] | 33[a] |
| West Point Area | 502-016 | 5/16 | 402 | 5 | 442 | - | - | - | ND | ND | ND |
| Gull Island | 524-001 | 5/16 | 1,158 | 10 | 1,208 | - | - | - | ND | ND | ND |
| Anacapa I. – West | 502-007 | 4/25, 5/16[1] | 1,033 | 122 | 1,409 | ND | ND | ND | ND | ND | ND |
| Anacapa I. – East | 502-009 | 5/16 | 12 | 3 | 57 | - | - | - | ND | ND | ND |
| Shag Rock | 524-007 | 5/15 | 228 | 28 | 283 | 0 | 0 | 0 | 0 | 0 | 0 |
| Santa Barbara I. | 524-008 | 4/25, 6/29[2] | 1,135 | 35 | 2,040 | 109 | 1 | 113 | ND | ND | ND |
| Sutil Island | 524-009 | 4/25, 6/29[2] | 35 | 4 | 55 | 48 | 0 | 58 | - | - | - |
| Vizcaino Point South | 524-022 | 5/15 | 3,154 | 259 | 4,482 | - | - | - | - | - | - |
| Dutch Harbor Area | 524-026 | 5/15 | 1,488 | 35 | 1,716[b] | - | - | - | - | - | - |
| Cormorant Rock Area | 524-028 | 5/15 | 408 | 32 | 633 | - | - | - | - | - | - |
| Bird Rock | 524-030 | 5/15 | 868 | 74 | 1368 | - | - | - | - | - | - |
| Lost Point South | 524-034 | 5/15 | 74 | 0 | 107 | - | - | - | - | - | - |
| Seal Cove Area | 524-036 | 5/15 | 0 | 0 | 0 | 45 | 0 | 58 | - | - | - |
| La Jolla | 545-009 | 5/15 | 32 | 0 | 167 | - | - | - | - | - | - |
| S. SD Bay Saltworks | 545-027 | 5/15 | - | - | - | 74 | 2 | 87 | - | - | - |
| **Total[3]** | | | **11,818** | **639** | **15,966** | **462** | **5** | **509** | **34** | **0** | **43** |

**Numeric Footnotes:** [1]Brandt's Cormorant totals include data from both survey dates (see text, Appendix 1); [2]Second date is survey date for Double-crested Cormorant; [3]Note that totals are for sample colonies only and are not totals for all of southern California. **Alphabetic Footnotes:** [a]SC 04 only; [b]Includes 26 roosting birds.

Table 5. Whole-colony counts of nests, sites and birds for Brandt's, Double-crested, and Pelagic Cormorants at sample colonies in southern California, April-June 2007. Dash (-) = breeding has not been documented.

| | | | Brandt's Cormorant | | | Double-crested Cormorant | | | Pelagic Cormorant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Colony** | **USFWSCN** | **Date** | **Nests** | **Sites** | **Birds** | **Nests** | **Sites** | **Birds** | **Nests** | **Sites** | **Birds** |
| Sandpiper Pier | 502-029 | 5/15 | 95 | 39 | 202 | - | - | - | - | - | - |
| Port Hueneme Harbor | 502-030 | 6/12[1] | 8 | ND | ND | - | - | - | - | - | - |
| Prince Island | 501-004 | 5/15, 6/12[2] | 567 | 331 | 1,192 | 123 | 0 | 143 | 14 | 2 | 17 |
| Carrington Point | 501-037 | 5/15 | 547 | 293 | 1,388[a] | - | - | - | 26[b] | 13[b] | 47[b] |
| Sierra Pablo Area | 501-040 | 6/12 | ND | ND | ND | 20 | 0 | 27 | ND | ND | ND |
| West Point Area | 502-016 | 5/15 | 301 | 178 | 659[c] | - | - | - | ND | ND | ND |
| Gull Island | 524-001 | 5/16 | 462 | 256 | 1,530[d] | - | - | - | ND | ND | ND |
| Anacapa I. – West | 502-007 | 5/15 | 478 | 26 | 724 | ND | ND | ND | ND | ND | ND |
| Anacapa I. – Middle | 502-008 | 5/15 | 15 | 15 | 40 | - | - | - | ND | ND | ND |
| Anacapa I. – East | 502-009 | 5/16 | 33 | 12 | 66 | - | - | - | ND | ND | ND |
| Shag Rock | 524-007 | 4/16 | 245 | 24 | 283 | 0 | 0 | 0 | 0 | 0 | 0 |
| Santa Barbara I. | 524-008 | 4/25, 5/14, 6/12[2,3] | 556 | 255 | 995[e] | 77 | 0 | 80 | ND | ND | ND |
| Sutil Island | 524-009 | 4/25, 5/14, 6/12[2,3] | 180 | 12 | 201 | 30 | 0 | 33 | - | - | - |
| Vizcaino Point South | 524-022 | 5/14 | 3,329 | 1,183 | 5,811 | - | - | - | - | - | - |
| Dutch Harbor Area | 524-026 | 5/14 | 0[f] | 0[f] | 0[f] | - | - | - | - | - | - |
| Cormorant Rock Area | 524-028 | 5/14 | 278 | 89 | 449 | - | - | - | - | - | - |
| White Bluffs | 524-068 | 5/14 | 56 | 19 | 313[g] | - | - | - | - | - | - |
| Bird Rock | 524-030 | 5/14 | 532 | 198 | 838[h] | - | - | - | - | - | - |
| Lost Point South | 524-034 | 5/14 | 5 | 12 | 26 | - | - | - | - | - | - |
| Mail Point South | 524-035 | 5/14 | 0 | 0 | 0 | 3 | 0 | 3 | - | - | - |
| Seal Cove Area | 524-036 | 6/12 | 0 | 0 | 0 | 45 | 0 | 45 | - | - | - |
| La Jolla | 545-009 | 5/14 | 26 | 0 | 53 | - | - | - | - | - | - |
| S. SD Bay Saltworks | 545-027 | 5/14 | - | - | - | 86 | 11 | 150 | - | - | - |
| **Total[4]** | | | **7,713** | **2,942** | **14,770** | **384** | **11** | **481** | **40** | **15** | **64** |

**Numeric Footnotes:** [1]Data from ground survey (see text); [2]Double-crested Cormorant data is from June date; [3]Brandt's Cormorant totals include data from April and May (see text, Appendix 1); [4]Note that totals are for sample colonies only and are not totals for all of southern California. **Alphabetic Footnotes:** [a]Includes 88 roosting birds; [b]SC 04 only; [c]Includes 8 roosting birds; [d]Includes 413 roosting birds; [e]Includes 12 roosting birds; [f]Colony was active in April but abandoned by May - April totals not included here due to possible movement to Vizcaino Point South by May (see Appendix 1); [g]Includes 202 roosting birds; [h]Includes 45 roosting birds.

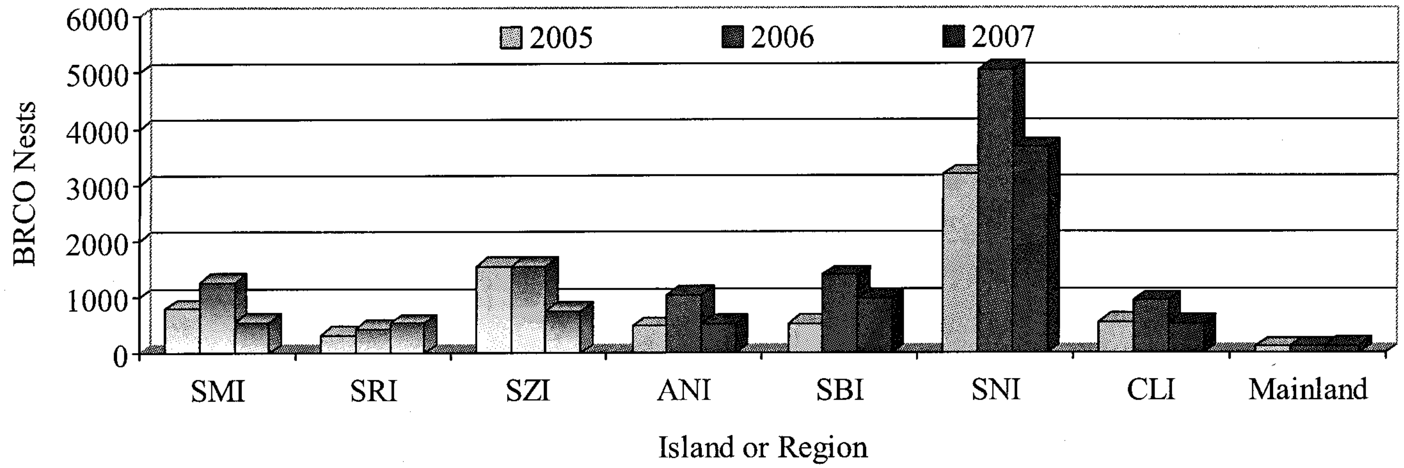


Figure 3a. Island and mainland total numbers of Brandt's Cormorant nests counted at southern California sample colonies in 2005-2007. Bars with gradient fill patterns indicate that sample colonies do not include all active colonies for that island.

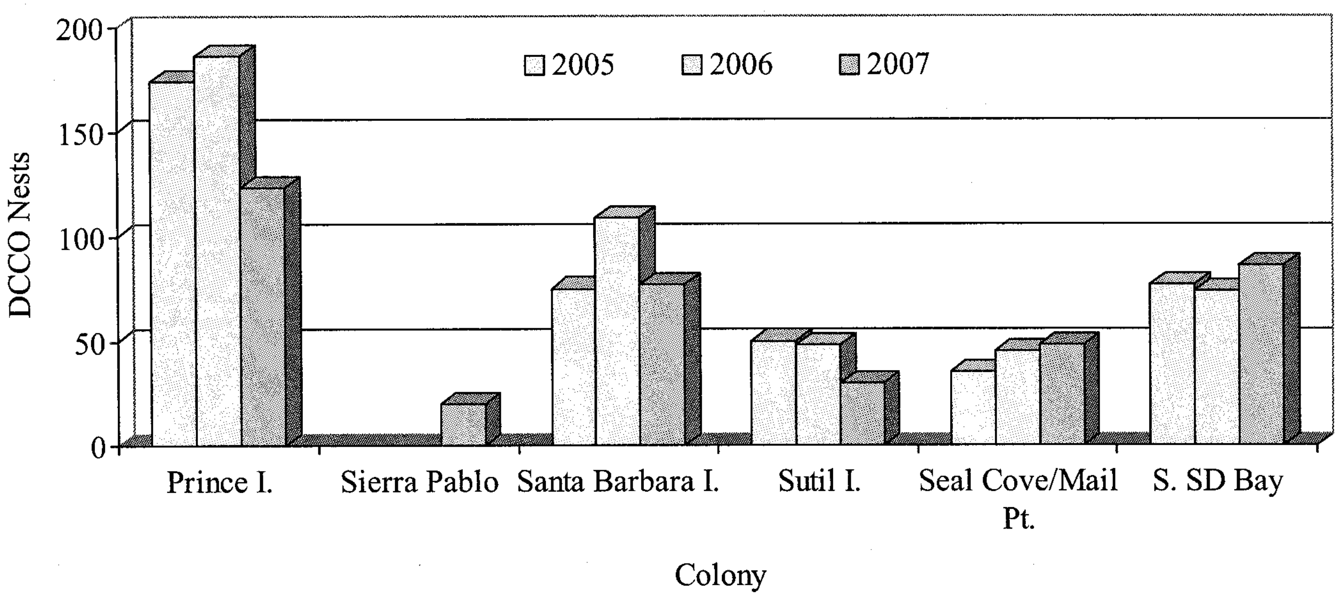


Figure 3b. Total numbers of Double-crested Cormorant nests counted at southern California sample colonies in 2005-2007.

(G. Smith, pers. comm.), and three new breeding groups formed between May and June 2006 at SBI (Capitolo et al. 2007).

Substantial nest abandonments were noted at certain colonies in 2005 and 2007. At Prince Island in June 2006, more than 100 abandoned nests were evenly distributed through all nesting areas, and few nests with visible chicks were detected. Smaller numbers of abandoned nests occurred at Cormorant Rock Area in 2006. In 2007, Dutch Harbor Area (SNI) was attended by hundreds of cormorants in April (198 nests; Appendix 1) but was completely abandoned by May. Nest abandonment also occurred at SMI colonies in 2007 (see below). No substantial nest abandonments were noted at any colony in 2006. In September 2006, approximately 13,000 roosting cormorants estimated at SNI likely included thousands of recently-fledged Brandt's Cormorants (Capitolo et al. 2008), suggesting high breeding success at SNI (and perhaps other SCB colonies) in 2006.

*Sandpiper Pier Foundation – Restoration Site*

Since 1997, Sandpiper Pier Foundation had been one of only two Brandt's Cormorant colonies along the southern California mainland coast south of Point Conception (a third occurred in 2007; see below). Nesting was first noted on deteriorating pier remnants during HSU surveys in 1997 (McChesney et al. 1998a). By December 2005, to comply with state and county regulations to remove the decommissioned structure, the owners of the pier (Atlantic Richfield Corporation) had dismantled pier remnants and (under advice from CDFG) constructed new structures for use by nesting cormorants and roosting cormorants, Brown Pelicans and other seabirds. Also, pieces of the demolished concrete support columns were left on the ocean floor and augmented with rip-rap for maintenance of the artificial reef, which had developed over several decades.

Brandt's Cormorants successfully nested in 2006 and 2007 on each of four new, artificial structures (Figure 4). In 2006, we counted 77, 79, and 61 nests in April, May, and June, respectively. We numbered the four structures from north to south as Subcolonies 01-04. Highest subcolony counts of 27 nests occurred in April and May on Subcolonies 01 and 03, respectively; Subcolonies 02 and 04 had high counts of 13 and 15 nests, respectively, in May (Appendix 1). Including the higher Subcolony 01 count from April, the 2006 nest total (82 nests; Table 4) was 15% lower than the 2005 nest total (96 nests; Table 3), which was the highest total ever recorded. Increased use of Subcolonies 02 and 04 occurred in 2007 when we counted 25 nests on Subcolonies 01, 03, and 04, and 20 nests on Subcolony 02. The nest total in 2007 (95 nests) was similar to the total in 2005 prior to restoration.

*New or Irregularly Attended Colonies and Subcolonies*

Two new Brandt's Cormorant colonies were detected in 2007. A small colony atop a concrete wall within Port Hueneme Harbor was first noted from ground observations on 12 June and was occasionally observed through July (M. Ruane, pers. comm.; Figure 5). Eight nests were counted on 12 June, and 7 well-built nests and 3 poorly-built nests were counted on 21 June. Seven nests remained on 12 July, including some with 3 chicks and one apparently still in the incubation stage; a total of 13 chicks were counted, some fledgling-sized. By 30 July, 11

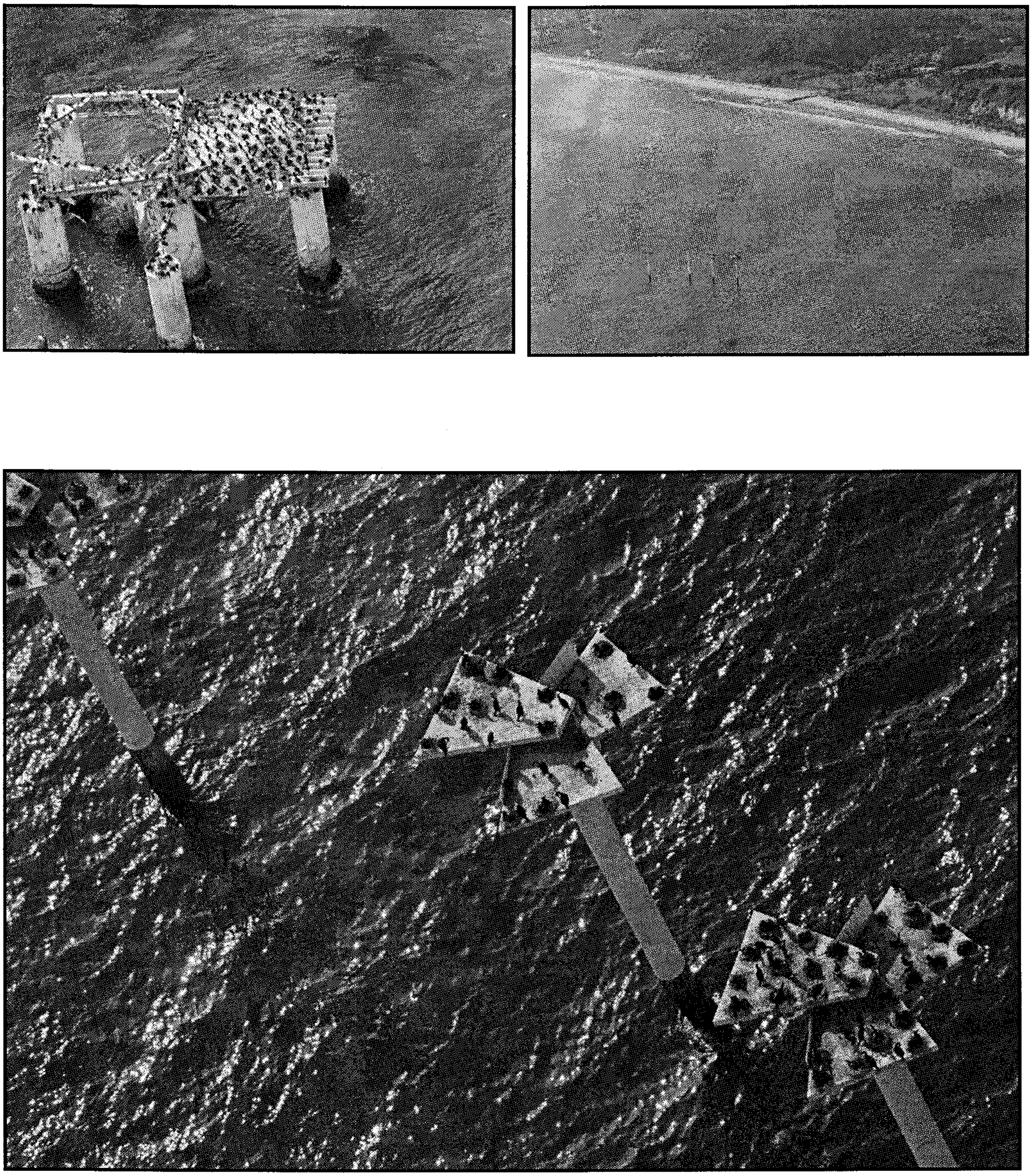

Figure 4. Sandpiper Pier Foundation, Santa Barbara County, California, prior to restoration (top left) on 17 May 2005 and after restoration (top right and bottom) on 16 May 2006.

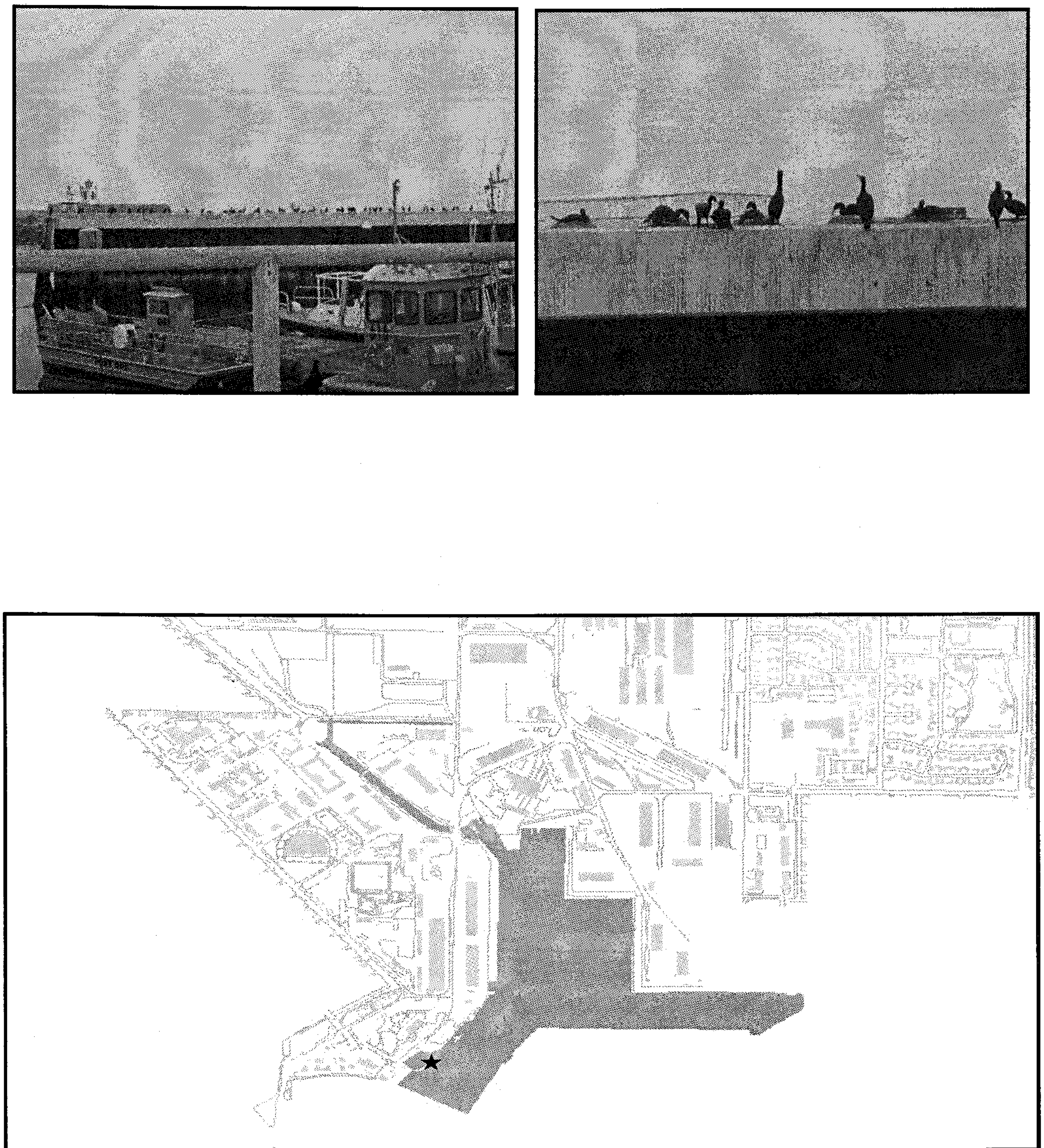

Figure 5. Location of nesting Brandt's Cormorants at Port Hueneme Harbor, Ventura County, California, 12 June 2007. Star symbol on map indicates location of colony within the harbor. Images and map by M. Ruane.

chicks remained, eight very close to fledging. Most egg-laying likely occurred in mid May if chicks seen on 12 July are assumed to be on average roughly 2 weeks old. Port Hueneme Harbor is only the third known location of Brandt's Cormorant nesting along the southern California mainland. At Ford Point-Wreck Canyon on the south side of SRI, nesting by Pelagic Cormorants and Double-crested Cormorants had previously been noted (Carter et al. 1992, McChesney et al. 1998a), but 2007 was the first year in which nesting Brandt's Cormorants were noted. Six nests and one site on a low ledge within Subcolony 01 were photographed on 15 May. Other nesting cormorants in adjacent areas of Subcolony 01 were only photographed with overviews and could not be identified to species. These were likely Pelagic Cormorants, but may have included some Brandt's Cormorants.

Of the nine colonies active in only one year in 2005-07; six were active in 2007. Also in 2007, we noted cormorants nesting at certain subcolonies where they either irregularly nest or had not been previously documented nesting. At SBI, for example, nesting typically occurs along the length of the north shore but also occurred at Subcolony 12 (93 nests) on the east side of the island for the first time and record high numbers occurred at adjacent Sutil Island. One new subcolony (06) also was named in 2007 at Crook Point-Tyler Bight (SMI; see below). Vizcaino Point South, where Brandt's Cormorants previously nested in two distinct subcolonies (01 and 03), was considered one subcolony (01) in 2005-07 due to recent colony growth and merging of nesting areas.

*San Miguel Island Non-sample Colonies in 2007*

For May 2007, non-sample Brandt's Cormorant colonies at SMI also were counted pro bono by Capitolo to assist an assessment of the status of breeding seabirds at SMI by CBC and CIES for the *Montrose* Trustee Council (Table 6, Appendix 1; Carter et al., in prep.). A total of 1,338 nests was determined for all colonies combined. However, much nest abandonment and variable phenology was evident at all colonies, as well as possible older nests from 2006, requiring careful consideration of data and re-inspection of 2006 digital images in determining colony totals. At Subcolony 01 of Crook Point-Tyler Bight, abandoned nests remained well-built, without flattened or scattered nesting material, and remaining active nests were widely distributed. These observations suggest abandoned nests were from 2007 (rather than from the previous year) and that they did not reflect earlier, successful breeding. Abandoned nests were not included in the colony total because nests and sites in early breeding stages at a new subcolony (06) east of Crook Point may have been birds that had abandoned Subcolony 01. Abandonment may have been due to poor marine conditions or disturbance by mammalian predators such as Island Foxes (*Urocyon littoralis*) or Black Rats (*Rattus rattus*). Abandoned nests also were noted at Prince Island, Point Bennett (224 nests) and Castle Rock, but were included in colony totals only for Point Bennett (51% of total). At Point Bennett, the presence of a few large, wandering chicks combined with flattened, scattered nesting material at abandoned nests suggests some early breeding may have occurred. However, no group of roosting fledged birds was present anywhere at SMI and abandonment may instead have been due to poor marine conditions with few pairs still attending nests and chicks by May. Only Prince Island was also photographed (but not counted) in April. Inspection of April photographs revealed two areas on the west side of the island with about 50 nests attended by adults in incubation posture (some with eggs visible) that were abandoned by May. Other nests in these areas in April apparently had already been abandoned. Due to increased nesting at other areas of Prince Island by May, abandoned nests in areas on the west side of the island were not included in colony totals. At Castle Rock, abandoned nests noted in May were considered to be leftover from 2006. However, some may have been from 2007 and the nest total may therefore be an underestimate.

Table 6. Whole-colony counts of nests, sites and birds for all active Brandt's Cormorant colonies at San Miguel Island, California, May 2007.

| | | | Brandt's Cormorant | | |
|---|---|---|---|---|---|
| **Colony** | **USFWSCN** | **Date** | **Nests** | **Sites** | **Birds** |
| Point Bennett | 502-014 | 5/15 | 438 | 45 | 348 |
| Prince Island | 501-004 | 5/15 | 567 | 331 | 1,192 |
| Castle Rock | 501-005 | 5/15 | 133 | 93 | 355 |
| Crook Point-Tyler Bight | 501-031 | 5/15 | 200 | 115 | 407 |
| **Total** | | | **1,338** | **584** | **2,302** |

## Double-crested Cormorant

In coastal southern California, Double-crested Cormorants nest regularly at six Channel Islands colonies and one coastal mainland colony in South San Diego Bay (Figure 2). The largest colony (> 300 nests) occurs at West Anacapa Island (Carter et al. 1992, 1995, Capitolo et al. 2004), and nesting recently also occurred on Middle Anacapa Island (F. Gress, pers. comm.). In 2005-07, we photographed and counted all colonies except those at ANI, which were surveyed by CIES using boat and ground counts (F. Gress, unpubl. data).

Total numbers of nests at sample colonies (Tables 3-5, Figure 3) were highest in 2006 (462 nests). Prince Island (SMI) was the largest sample colony each year. Reduced nesting effort in 2007 was evident at Prince Island, SBI, and Sutil Island, while totals at CLI and South San Diego Bay Saltworks were similar all three years. The 2007 total also includes 20 nests at Sierra Pablo Area (SRI), where similar numbers likely nested in 2005 and 2006 but were not detected during aerial surveys (see below). Not counting Sierra Pablo Area, the total number of nests at sample colonies in 2005 and 2007 was 12% and 21% lower than in 2006, respectively.

The nest totals for Seal Cove Area (CLI) in 2006 and 2007 (45 nests) were 29% higher than the 2005 total, and the highest recorded for this colony since its discovery in 1999 (McChesney et al. 2001). Nest counts at South San Diego Bay Saltworks were similar each year (range: 74-86 nests) if a ground count of 77 nests by USFWS is used for 2005 (USFWS 2006), when we did not detect cormorants nesting on levees. Nesting occurred on an abandoned dredge barge each year (range: 35-50 nests) and on 1-3 levees each year (Appendix 2).

Double-crested Cormorant breeding phenology was mostly similar each year, but apparently earlier at the northern islands than at the southern islands in 2007 (Appendix 2). At Prince Island, 56% and 33% of nests had visible chicks in June 2005 and 2007, respectively. In 2006, Prince Island was not surveyed in June, but some chick-nests were noted by May. Also, 67% of nests at SBI had visible chicks in June 2006. In June 2007 however, obvious chicks were noted in many nests at Prince Island (33%) and Sierra Pablo Area (SRI; 85%), but in only one nest at SBI and none at CLI. South San Diego Bay Saltworks was only surveyed in May and showed similar phenology each year.

*New or Irregularly Attended Colonies and Subcolonies*

No new Double-crested Cormorant colonies were detected in 2005-07, but nesting occurred in 2007 at two colonies that had previously been noted only in one or two years. Small numbers of nests at Sierra Pablo Area (SRI) were noted from boat in 1994 and 1995 (H. Carter, unpubl. data; McChesney et al. 1998a), but nesting was not noted in 1996-2005. In 2007, 20 nests occurred high on cliffs slightly east of the Subcolony 03 boundary. Overview photographs from 2006 also show less than 20 nests that may have been Double-crested Cormorant nests, but no close-up images were taken. This colony may not have been readily detectable during aerial surveys in 1996-2006 due to small numbers of nests on steep cliffs. Also, the south side of SRI typically was not surveyed in June, when numbers of Double-crested Cormorant nests peak. Along with increased numbers of nests by 2007, detection of the colony was aided by much guano accumulation on the cliffs by May due to early phenology (many nests in 2007 had obvious chicks in May; Appendix 2). At Mail Point South (SNI), the only previous record of nesting by Double-crested Cormorants was 3 nests on 20 May 2003 (H. Carter, unpubl. data). Three nests again occurred there on 14 May 2007. Mail Point South is adjacent to the Seal Cove Area colony. In May 2008, just prior to completion of this report, local observers in Santa Barbara County reported a new mainland colony in *Eucalyptus* trees along Goleta Slough, where small numbers of cormorants were nesting along side Great Blue Herons (*Ardea herodias*) and Great Egrets (*Ardea alba*).

**Pelagic Cormorant**

For SRI, we photographed three sample subcolonies and counted the sample subcolony at Carrington Point. The nest total for this subcolony was identical in 2006 and 2007 (26 nests) and was twice as large as the 2005 total (Tables 3-5), but similar to the 1991 count (25 nests; Carter et al. 1992). Reduced nesting effort and much nest abandonment also was noted in central California in 2005 (and 2006) (Goericke et al. 2007; G. McChesney, pers. comm.).

In 2006, we added Prince Island (SMI) to our list of Pelagic Cormorant sample colonies to photograph and count. Nest totals were similar in 2005-07 (range: 8-14 nests; Tables 3-5). This colony can be completely counted with aerial photographs because all areas of Prince Island are typically photographed in the course of obtaining complete coverage of Brandt's and Double-crested Cormorant nesting areas. Pelagic Cormorants have only been noted on the north cliffs, usually easily distinguished from adjacent Brandt's Cormorants by experienced observers. From boat surveys in 2007, Carter et al. (in prep.) recorded similar maximum counts of 11 nests and 21 birds on 23 May and 24 April, respectively, and noted little change in numbers since 1977. Boat surveys are necessary to completely survey Pelagic Cormorants on the main island of SMI. No chicks were visible in nests at Carrington Point or Prince Island in any year, indicating breeding phenology later than for the other two cormorant species.

## Other Species

### *Brown Pelican*

A highlight of surveys in 2005-07 was the discovery of nesting Brown Pelicans at Prince Island on 16 May 2006 (Figure 6). Brown Pelicans were last noted nesting at Prince Island in the early 1960s (D. Bleitz, unpubl. data; G. McChesney, pers. comm.), during a period when the southern California population was undergoing dramatic declines related to organochlorine contamination. These declines eventually led to the species being federally-listed as endangered by the USFWS in 1970, and state-listed as endangered by the California Fish and Game Commission in 1971. Prior to the early 1960s, the last record of pelicans nesting at Prince Island is from 1939. However, few if any surveys of Prince Island occurred during the 1940s and 1950s. While it was not clearly documented how often pelicans nested there, Prince Island may have been a significant colony (Gress and Anderson 1983). Prince Island is located about 83 km west of the large West Anacapa Island colony. At other southern California colonies in 2006, CIES biologists noted the first-known nesting at Middle Anacapa Island, small numbers breeding on East Anacapa Island, and an expanded distribution of pelican nesting at Santa Barbara Island (F. Gress, pers. comm.).

We counted 102 nests at Prince Island, including 43 on a smooth slope on top of the island at the north end, and 59 nests in a steeper, cliff area at the top of the island at the southeast end, adjacent to nesting Double-crested Cormorants. A large number of roosting birds also occurred amid the north nesting area, as well as lower on the south side of the island. Roosting birds drew our attention to the north nesting area, and in fact we did not positively identify the pelican nests in either nesting area until examining the photographs after the survey. Additional nests may have been present in April and abandoned by May, but Double-crested Cormorant nesting areas were not photographed and incomplete photo coverage resulted for upper areas of Prince Island in April. In June, a low, patchy fog blanketed Prince Island throughout the survey day, allowing usable photographs for only about one half of the north nesting area. However, from this partial photographic coverage, we counted five adults and ten chicks at six nests, including three chicks at one nest. Two of the ten chicks were not obviously attended by an adult. Chicks appeared large, about one-half to three-fourths of adult size. Chick plumage was mostly white, with beginnings of black primaries evident on some individuals. Black primaries are not present on chicks at 3 weeks of age and are 1"-2" long after 4 weeks, chicks are brooded less after four weeks, and fledge at 13-14 weeks (F. Gress, pers. comm.). Thus, most chicks were likely 3-4 weeks old, most hatching apparently occurred in late May or early June, and fledging of all chicks would have not been completed until late August or September. Many nests counted in May were likely abandoned by June; no abandoned nests could be seen (perhaps due in part to limited photographic coverage), but a few, exact locations where nests with an incubating adult were present in May were empty on 29 June. Pelicans did not nest at Prince Island in 2005 and 2007.

The largest pelican roost among our sample cormorant colonies occurred on the mainland at La Jolla in May 2006 (724 birds; Appendix 3). Large roosts also occurred at Prince Island and Gull Island. Roosting Brown Pelicans occurred at few sample colonies, but were also

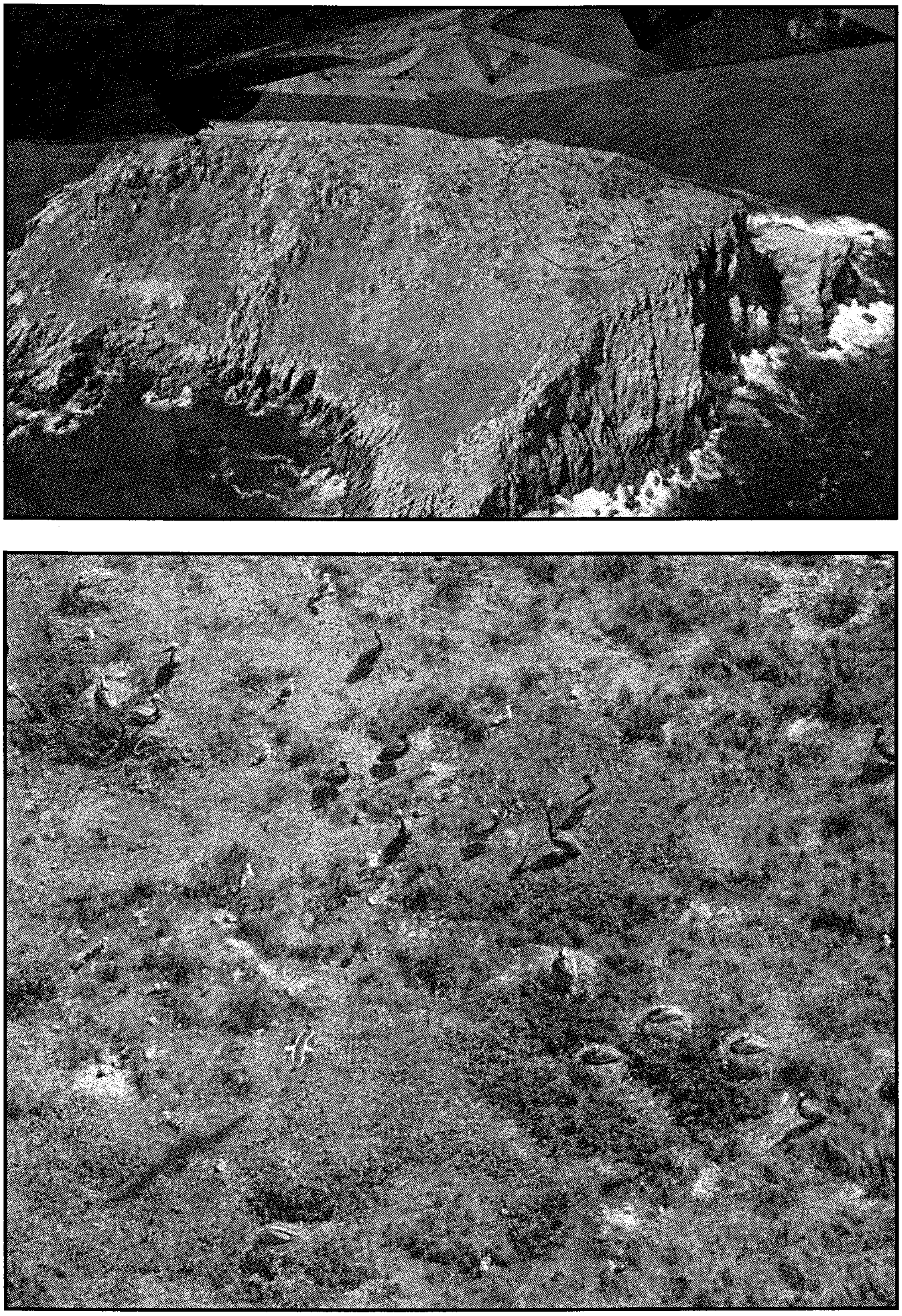

Figure 6. Overview image (from 2005, without pelicans) and close-up image of Prince Island, San Miguel Island, showing locations of Brown Pelican nests in 2006 (overview), and pelican nests in the north nesting area on 16 May 2006 (close-up).

photographed at other non-sample colonies that we did not count. At Sandpiper Pier Foundation, roosting Brown Pelicans were present on our surveys only in 2005, prior to restoration (see Brandt's Cormorant above).

*Common Murre*

In 2005-07, no Common Murres were detected in aerial photographs of the northwest cliffs of Prince Island, the only location in southern California where murres bred historically (recorded between 1885 and 1912; Carter et al. 2001). From boat surveys, however, fewer than 20 murres were noted standing on a ledge in August 2005 (J. Adams, unpubl. data), and increased attendance was noted during morning hours in May-June 2007 (Carter et al. 2008). Murres also were noted attending Prince Island in 1939, 1976, and 1999 (Carter et al. 2001). Prospecting behavior by murres could lead to future recolonization (Carter et al. 2001, Carter 2004, Capitolo et al. 2005).

We also conducted a preliminary test of the appropriateness of the Image-Pro Express software program (which we currently use for southern California cormorant colonies) for use in dotting large, dense murre colonies. Murre colonies in California had previously been counted only with traditional methods using slide film and projectors. Capitolo, as part of the CMRP survey team conducting aerial surveys in central and northern California, opportunistically took several digital photographs of certain northern California murre colonies in 2006. One photograph of the dense, central portion of the Green Rock murre colony was opened in Image-Pro Express and dotted by Capitolo. Encouraged by the high quality of these digital images, the flexibility to easily zoom images and adjust contrast and brightness settings, and the efficiency of automatic tabulation of all object classes in Image-Pro Express, the CMRP switched to using digital cameras for aerial photographic surveys of all murre and cormorant colonies in central and northern California in 2007 (McChesney et al. 2007). Since then, the CMRP also has successfully used Image-Pro Express to dot large murre colonies and has begun initial testing of automated features of Image-Pro (the advanced version of the software; USFWS, unpubl. data). Further testing of these automated features will be done in 2008 by UCSC and the CMRP.

## DISCUSSION

### Brandt's Cormorant

By 1991, when annual aerial photographic surveys in southern California began, the Brandt's Cormorant had recovered substantially from previous declines to become the most abundant breeding seabird species in the SCB (Hunt et al. 1980, Sowls et al. 1980, Carter et al. 1992). Breeding population size in 1991 also was higher than in any subsequent year through 2003 (Carter et al. 1992, 1996, McChesney et al. 1998a, 2001, Capitolo et al. 2004, H. Carter unpubl. data), and apparently reflected eight years of population recovery following effects of severe El Niño conditions in 1983. Similarly, reduced cormorant breeding after 1991 probably was related to severe El Niño conditions in 1992-93 and 1998, with the 2006 peak in breeding population size also reflecting eight years of population recovery. Oceanographic conditions in the SCB in 2005-07 were characteristic of neither strong El Niño nor strong La Niña episodes.

Upwelling-favorable winds were weak or delayed in 2005 and 2006, but apparently with minor biological consequences in the SCB (Goericke et al. 2007). Thus, general comparisons of SCB breeding population sizes and distributions in 1991 and 2006 are appropriate to make. However, further comparison and regression analyses of annual data since 1991 are necessary to best describe population changes over time.

We counted 11,818 nests at sample colonies in 2006 compared to 13,130 nests counted at all colonies in 1991 (Carter et al. 1992). Considering non-sample colonies, which include some colonies (about 5 or 6) of several hundred nests at SMI and SRI, the total breeding population size in 2006 likely was slightly greater than in 1991. Large breeding population sizes in 2006 also were apparent from central and northern California aerial photographic surveys. The 2006 estimate for the South Farallon Islands (the largest Brandt's Cormorant colony throughout the species' range) was near the all-time high (McChesney et al. 2007, Boekelheide et al. 1990).

However, some shifting of the population within the SCB has apparently occurred since 1991. The 2006 nest total for sample colonies was much higher (93%) than the 1991 total for these colonies. Although non-sample colonies at SMI (the westernmost of the northern Channel Islands) were not counted for 2006, total numbers of nests at SMI clearly remained substantially lower than in 1991. In contrast, whole-island nest totals in 2006 for ANI (the most nearshore of the northern Channel Islands) and the southern Channel Islands (SBI, SNI, CLI) were dramatically higher compared to 1991. Additionally, the new colony at Port Hueneme Harbor in 2007 further indicates an expanding nearshore population. However, suitable disturbance-free breeding habitat is limited along the southern California mainland.

Population growth at certain colonies also may have been facilitated by disturbance reduction. At SNI, Vizcaino Point has in effect become a wilderness area following U.S. Navy road closures and strict limitations of personnel and researcher access that were implemented in the mid 1990s. Increased roost use by Brown Pelicans further indicates the beneficial effects of reduced disturbance at Vizcaino Point to seabirds (Capitolo et al. 2008). Restoration efforts to eradicate Black Rats from ANI in 2001 and 2002 have benefited nocturnal, crevice-nesting seabirds (Whitworth et al. 2005) and may also have contributed to ANI cormorant population increases. However, there is no evidence of past predation of cormorant eggs by rats. Restoration of Sandpiper Pier Foundation ensured continued availability of a small amount of artificial breeding habitat nearshore.

The apparent partial shift of the SCB breeding population to areas of warmer sea surface temperatures may reflect changes in prey availability. Rockfish (*Sebastes sp.*) were the majority of diet items in Brandt's Cormorant pellets collected after the breeding season at five Channel Islands in 1976-78, but diets also were diverse with 37 families of prey species represented (Ainley et al. 1981), suggesting Brandt's Cormorant diets are flexible in response to changing prey resources. In fact, breeding success at the South Farallon Islands in 2005 and 2006 was at average levels despite extremely low juvenile rockfish abundance and reproductive failures of other seabird species (Peterson et al. 2006, Goericke et al. 2007; also see Sydeman et al. 2001). Additionally, Ainley et al. (1990) found differences in prey item percentages prior to egg laying compared to during the chick rearing period at the South Farallon Islands in 1977. Northern Anchovies (*Engraulis mordax*) comprised 29% of diet samples prior to egg laying and rockfish

99% of diet samples during chick rearing. Thus, timing and location of anchovy abundance in the SCB may influence Brandt's Cormorant breeding distribution and phenology. Increased breeding effort by Brown Pelicans in the SCB in 2006 also may be partly explained by possible localized increases in anchovies, the major food source of breeding pelicans (Anderson et al. 1982). Anchovies apparently were abundant near SMI in April-May 2006 (Goericke et al. 2007) when pelicans nested at Prince Island for the first time since the 1960s.

Substantial increases in Brandt's Cormorant nest totals from 2005 to 2006 likely indicate high recruitment in 2006 due to high juvenile survival in recent years. Most Brandt's Cormorants first breed when 3-4 years old, but some two-year-olds may breed when prey is abundant (Boekelheide and Ainley 1989). Fewer adults skipping breeding in 2006 because of abundant prey resources may also have contributed to increases. Early Brandt's Cormorant breeding phenology, as evidenced by the high percentages of nests with visible chicks, may indicate that prey availability was favorable enough for most adults in the population to attempt breeding (Boekelheide et al. 1990, Nur and Sydeman 1999).

In addition to high breeding population size in 2006, breeding success in the SCB also may have been highest in 2006 considering more nest abandonment was seen in 2005 and 2007. Thousands of roosting juveniles in September 2006 at SNI also suggested high breeding success. Significant seabird mortality in 2005 was noted in central and northern California due to reduced prey availability (Nevins et al. 2005) that may also have led to nest abandonment in southern California, especially at SMI and SRI, where prey availability is most related to upwelling conditions, as in central and northern California. Disturbance or nest predation by Island Foxes and/or feral cats may have caused nest abandonments each year at SNI. Significant fox predation of cormorant and Western Gull (*Larus occidentalis*) eggs was noted in 1992-96 at SNI (McChesney 1997; H. Carter, unpubl. data), where the fox population remains relatively large and stable (Schmidt et al. 2007). Increased use of Vizcaino Point by cormorants has occurred in recent years and may be associated with relatively low use of the area by foxes. The width of the island narrows substantially at Vizcaino Point, and only 3 or 4 fox territories occur adjacent to the point, with territorial behavior likely preventing other foxes from accessing the point (G. Schmidt pers. comm.). Cormorant nesting at the point also occurs in many, widely-distributed groups, which may offer protection from island fox or feral cat disturbance causing complete colony abandonment. Eradication of feral cats at SNI is being planned by the *Montrose* Trustee Council (MSRP 2005). Disturbance by Island Foxes also may have occurred at SMI at Crook Point-Tyler Bight in 2007. Reintroduction of foxes at SMI began in 2003, after the few remaining individuals were removed from the island in 1999 to protect them from predation by Golden eagles (*Aquila chrysaetos*) and to begin captive breeding (Coonan and Schwemm 2008). Disturbance by marine mammal researchers also may have occurred at certain colonies in 2007 (Carter et al., in prep.). Domoic acid poisoning caused the deaths of many Brandt's Cormorants, pelicans, and other seabirds in southern California in March-April 2007, and later in central California, but the impact on cormorant breeding in the SCB in 2007 is unknown.

**Double-crested Cormorant**

The Double-crested Cormorant population in the SCB also had increased by 1991 following population declines due to organochlorine contamination (Gress et al. 1973, Carter et al. 1992, 1995), but since 1991 it has apparently declined and may have undergone a slight geographic shift with possible emigration to other areas. Data collected annually by CIES boat and ground surveys for the large ANI colony are needed to fully assess changes in breeding population sizes and distribution in the SCB. These data have not been collated since 2001 due to lack of funding (Capitolo et al. 2004; F. Gress, pers. comm.). Also, further comparison and regression analyses of annual data for all colonies since 1991 are needed to best describe SCB population changes over time. Further comparison of annual data will need to carefully consider survey dates for available data. Double-crested Cormorant nest totals in southern California typically peak in June, but fog in the SCB in June is often lower and more persistent than in April or May, such that in some years June surveys were incomplete or prevented entirely.

Through 2001, breeding population size at ANI had apparently changed little since 1991 (Gress 1995, Carter et al 1992, 1995, 1996, Capitolo et al. 2004), and recent nesting at Middle Anacapa Island (F. Gress, unpubl. data) suggests a possible increase. However, the highest combined nest total for all other colonies in 2005-07 (462 nests in 2006) was 39% lower than in 1991 (753 nests). In 2001, the total for all other colonies was 52% lower than in 1991 (Capitolo et al. 2004). Decline is most evident at SBI (including Sutil Island). The highest combined nest total for SBI and Sutil Island in 2005-07 (157 nests in 2006) was 68% lower than the 1991 total (492 nests; Carter et al. 1992), but similar to totals since 1999 (McChesney et al. 2001, Capitolo et al. 2004, H. Carter, unpubl. data), suggesting possible emigration of some birds to other islands or interior areas of mainland southern California following severe El Niño conditions in 1998. Small colonies have formed at SRI and CLI since 1991, but combined nest totals for these would account for only about 20% of reduced numbers at SBI. Record numbers of nesting Brandt's Cormorants and Brown Pelicans at SBI in 2006 suggest that there was no shortage of prey. Reduced numbers also are evident but less pronounced at Prince Island. The highest nest total in 2005-07 (186 nests in 2006) was 19% lower than the 1991 nest total (Carter et al. 1992, 1996), but higher than the most recent available nest total (140 nests in 2001; Capitolo et al. 2004). Nesting at the historical colony at Santa Catalina Island is likely still prevented by continuing high levels of human activity near Two Harbors.

Compared to Brandt's Cormorants, Double-crested Cormorants in coastal California show less annual variation in breeding population size and less-marked reductions of breeding effort during El Niño conditions. In northern and central California, most foraging occurs in estuarine waters that are less affected by annual variation in oceanographic conditions and periodic El Niño conditions. Double-crested Cormorants at Prince Island in 1976-78 fed chicks mostly rockfish and anchovies, suggesting greater dietary overlap of Brandt's and Double-crested Cormorants in the Channel Islands than in northern and central California (Ainley et al. 1981), possibly due to greater distance to mainland estuaries. Birds feeding chicks at the South Farallon Islands travel daily round-trips of at least 70 km to nearshore and estuarine foraging areas in central California (Ainley et al. 1990), but a similar commute distance among southern California colonies is only possible at ANI. Round-trip distances to and from mainland estuaries would be 120 km or more for birds nesting at Prince Island or SBI, and more than 180 km for CLI birds. Additional research on diets of cormorants in southern California is needed.

Breeding phenology and success of Double-crested Cormorants was not obviously different between years in 2005-07 based on interpretation of aerial photographs. No large-scale nest abandonments were noted, and nests with visible chicks occurred at most colonies, often with multiple, large chicks in many nests. Thus, although numbers of nesting birds were lower compared to 1991, breeding success may have been near average in 2005-07.

## RECOMMENDATIONS FOR FUTURE WORK

### Northern, Central, and Southern California

1) *Continue to conduct annual aerial photographic surveys of Common Murre and Brandt's and Double-crested Cormorant breeding colonies throughout coastal California, in collaboration with various state and federal trustee agencies(hereafter "Seabird Trustees".* Beginning in 2008, UCSC will conduct aerial photographic surveys of seabird colonies in northern and central California, as well as in southern California. Surveys in central and northern California will be conducted in collaboration with Seabird Trustees (i.e., the CMRP) to ensure adequate personnel with expertise in surveying California seabird colonies are available. Aerial photographic survey personnel that have expert familiarity with California seabird colonies are essential so that colonies are photographed completely and in a manner that will not compromise data comparability between years. Collaboration with Seabird Trustees also is important to assist with ongoing restoration efforts (McChesney et al. 2007, NOAA 2006).

Annual aerial surveys will ensure that baseline data of seabird colonies are obtained as needed for assessing seabird injuries from oil spills, human disturbance, or other anthropogenic impacts, and for long-term monitoring and determination of statistical population trends. Annual surveys also allow detection of new colony formations or re-colonizations of historic nesting areas (e.g., Brown Pelicans at Prince Island in 2006; this report).

2) *Archive and maintain all digital images from aerial photographic surveys.* Archival of digital images will require continued maintenance to prevent loss of data from possible computer hardware failure or software incompatibilities, and to ensure images are archived in the most efficient manner as computer technology changes. Archival of images is necessary to maintain a photographic record of all colonies over time, and because not all colonies are counted annually.

3) *Conduct annual statewide counting of photographs of sample colonies in collaboration with Seabird Trustees and other experts, with the aim to maintain and enhance long-term monitoring of murre and cormorant colonies throughout California (see Carter et al. 1996).* Collaboration with Seabird Trustees and other experts will facilitate future counting efforts, and ensure that the most appropriate sample colonies are selected for future counting. Statewide sample colony counting conducted annually is preferred over periodic, regional, sample colony counting to allow for all regions: 1) documentation of general trends in annual variability of murre and cormorant breeding populations, which are good indicators of oceanographic conditions and prey availability that affect all seabirds but are regionally variable; 2) determination of statistical rates of population change over time - use of sample colonies to represent population trends already has been implemented by USFWS in Oregon (Carter et al. 2001); 3) timely detection of regionally variable impacts of El Niño conditions, human disturbance, and oil spills on breeding population sizes; 4) assessment of seabird use of

restoration sites and artificial habitat; and 5) reduction of future effort needed to collect sufficient baseline data for assessment of seabird injuries cause by oil spills.

Collaboration for statewide monitoring also will accomplish the California portion of the National Waterbird Monitoring Program for these species, and assist with the natural resource management responsibilities of several land and ocean management agencies, including California Department of Fish and Game, U.S. Fish and Wildlife Service, National Park Service, National Oceanic and Atmospheric Administration, U.S. Bureau of Land Management, U.S. Army, U.S. Navy, Minerals Management Service, Nature Conservancy, and Catalina Island Conservancy. Ideally, statewide sample colony counting should be conducted with funding from multiple agencies.

4) *Periodically conduct photograph counting of all Common Murre, Brandt's Cormorant, and coastal Double-crested Cormorant colonies in California for the same year.* We recommend that all Common Murre, Brandt's Cormorant and coastal Double-crested Cormorant colonies in California should be counted for the same year at least every 10 years, with consideration of annual variability of oceanographic conditions to determine the most appropriate year (see Sowls et al. 1980, Carter et al. 1992, Capitolo et al 2004, 2006b). The next 10-year census should be targeted for about 2011-13. Boat surveys will be required for certain Double-crested Cormorant colonies in San Francisco Bay.

6) *Continue to refine and evaluate aerial photographic survey and counting techniques, in collaboration with Seabird Trustees and other researchers.* Digital photography and counting techniques developed in 2005-07 have improved the efficiency of aerial photographic surveys. In 2008, with funding from CDFG-OSPR's Scientific Study and Evaluation Program, we will test the use of high-definition digital video cameras. Use of video cameras may increase the efficiency of both survey and counting effort, especially for large murre colonies where more than 100 photographs are typically counted to obtain complete coverage of nesting areas (e.g., Farallon Islands, Castle Rock NWR). Also, we will conduct initial investigations and assessments of software with features that may enable automated counting of birds and nests from digital images. Collaboration with Seabird Trustees and other experts is important in considering comparability of data generated from automated methods with past data.

**Southern California**

1) *Analyze and summarize southern California colony and subcolony cormorant counts to assess population trends for 1991-2007.* All colonies south of Point Conception have been counted for 1991-2001, and sample colonies have been counted for 2005-07 and 2002 (this report). Trend analyses should be examined for the 1992-97, 1998-2007, and 1991-2007 periods. The two former periods start with El Niño years when breeding populations were greatly reduced. Completion of sample colony counting for 2003 is needed.

2) *Aid assessment of restoration efforts to eradicate introduced mammalian predators from SMI and SNI by analyzing and summarizing cormorant population trends and counting all cormorant colonies at both islands in years prior to and following restoration.*

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Appendix 1. Subcolony counts of Brandt's Cormorant nests, sites and birds at southern California sample colonies, April-June 2002 and 2005-07. See text for nest category definitions.

| | | | | | Nest Categories | | | | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colony | USFWSCN | SC # | Date | Time | X | C | P | A | E | B | Nests | Sites | Birds |
| **Santa Barbara Mainland** | | | | | | | | | | | | | |
| Sandpiper Pier | 502-029 | 99 | 5/21/02 | 1540 | 49 | 0 | 0 | 0 | 0 | 0 | **49** | **0** | **139** |
| Sandpiper Pier | 502-029 | 99 | 5/17/05 | 0847 | 83 | 13 | 0 | 0 | 0 | 0 | **96** | **0** | **262** |
| Sandpiper Pier | 502-029 | 01 | 4/25/06 | 1115 | 22 | 3 | 2 | 0 | 0 | 0 | **27** | **0** | **37** |
| Sandpiper Pier | 502-029 | 02 | 4/25/06 | 1115 | 9 | 0 | 1 | 0 | 0 | 0 | **10** | **11** | **25** |
| Sandpiper Pier | 502-029 | 03 | 4/25/06 | 1115 | 21 | 0 | 4 | 0 | 0 | 0 | **25** | **2** | **38** |
| Sandpiper Pier | 502-029 | 04 | 4/25/06 | 1115 | 13 | 0 | 2 | 0 | 0 | 0 | **15** | **1** | **33** |
| Sandpiper Pier | 502-029 | 01 | 5/16/06 | 1729 | 15 | 9 | 0 | 0 | 0 | 0 | **24** | **0** | **41** |
| Sandpiper Pier | 502-029 | 02 | 5/16/06 | 1729 | 11 | 2 | 0 | 0 | 0 | 0 | **13** | **0** | **31** |
| Sandpiper Pier | 502-029 | 03 | 5/16/06 | 1729 | 24 | 3 | 0 | 0 | 0 | 0 | **27** | **7** | **44** |
| Sandpiper Pier | 502-029 | 04 | 5/16/06 | 1729 | 8 | 7 | 0 | 0 | 0 | 0 | **15** | **0** | **35** |
| Sandpiper Pier | 502-029 | 01 | 6/29/06 | 1235 | 4 | 6 | 3 | 0 | 0 | 4 | **17** | **5** | **49** |
| Sandpiper Pier | 502-029 | 02 | 6/29/06 | 1235 | 3 | 8 | 0 | 0 | 0 | 0 | **11** | **0** | **36** |
| Sandpiper Pier | 502-029 | 03 | 6/29/06 | 1235 | 2 | 15 | 2 | 0 | 0 | 1 | **20** | **0** | **37** |
| Sandpiper Pier | 502-029 | 04 | 6/29/06 | 1235 | 1 | 11 | 0 | 0 | 0 | 1 | **13** | **0** | **34** |
| Sandpiper Pier | 502-029 | 01 | 5/15/07 | 1634 | 19 | 6 | 0 | 0 | 0 | 0 | **25** | **8** | **57** |
| Sandpiper Pier | 502-029 | 02 | 5/15/07 | 1634 | 20 | 0 | 0 | 0 | 0 | 0 | **20** | **16** | **54** |
| Sandpiper Pier | 502-029 | 03 | 5/15/07 | 1634 | 17 | 3 | 5 | 0 | 0 | 0 | **25** | **5** | **44** |
| Sandpiper Pier | 502-029 | 04 | 5/15/07 | 1634 | 22 | 1 | 2 | 0 | 0 | 0 | **25** | **10** | **47** |
| **San Miguel Island** | | | | | | | | | | | | | |
| Prince Island | 501-004 | 01 | 5/21/02 | 1515 | 402 | 0 | 24 | 0 | 0 | 0 | **426** | **20** | **490** |
| Prince Island | 501-004 | 01 | 5/17/05 | 1213 | 754 | 0 | 42 | 0 | 0 | 0 | **796** | **47** | **960** |
| Prince Island | 501-004 | 01 | 6/13/05 | 1511 | 484 | 10 | 1 | 128 | 13 | 0 | **636** | **0** | **575** |
| Prince Island | 501-004 | 01 | 5/16/06 | 1557 | 426 | 814 | 21 | 0 | 4 | 0 | **1,265** | **17** | **1,316** |
| Prince Island | 501-004 | 01 | 5/15/07 | 1359 | 231 | 0 | 336 | 0 | 0 | 0 | **567** | **331** | **1,192** |
| Point Bennett | 501-014 | 04 | 5/15/07 | 1334 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **7** |
| Point Bennett | 501-014 | 05 | 5/15/07 | 1334 | 97 | 3 | 87 | 41 | 12 | 0 | **240** | **45** | **324** |

Appendix 1 (continued).

| Colony | USFWSCN | SC # | Date | Time | Nest Categories X | C | P | A | E | B | Totals Nests | Sites | Birds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Bennett | 501-014 | 07 | 5/15/07 | 1334 | 1 | 0 | 0 | 86 | 0 | 0 | **87** | **0** | **1** |
| Point Bennett | 501-014 | 08 | 5/15/07 | 1334 | 4 | 9 | 0 | 97 | 1 | 0 | **111** | **0** | **16** |
| Castle Rock | 501-005 | 01 | 5/15/07 | 1340 | 56 | 21 | 23 | 0 | 9 | 0 | **109** | **59** | **263** |
| Castle Rock | 501-005 | 02 | 5/15/07 | 1340 | 6 | 0 | 18 | 0 | 0 | 0 | **24** | **34** | **92** |
| Crook Pt.-Tyler Bight | 501-031 | 01 | 5/15/07 | 1324 | 18 | 14 | 0 | 0 | 4 | 0 | **36** | **0** | **41** |
| Crook Pt.-Tyler Bight | 501-031 | 02 | 5/15/07 | 1324 | 11 | 0 | 33 | 0 | 0 | 0 | **44** | **29** | **91** |
| Crook Pt.-Tyler Bight | 501-031 | 06 | 5/15/07 | 1324 | 46 | 0 | 74 | 0 | 0 | 0 | **120** | **86** | **275** |
| **Santa Rosa Island** | | | | | | | | | | | | | |
| Carrington Point | 501-037 | 02 | 5/22/02 | 1015 | 194 | 4 | 4 | 0 | 0 | 0 | **202** | **2** | **221** |
| Carrington Point | 501-037 | 03 | 5/22/02 | 1015 | 11 | 0 | 1 | 0 | 0 | 0 | **12** | **0** | **13** |
| Carrington Point | 501-037 | 02 | 5/17/05 | 1054 | 227 | 39 | 0 | 0 | 0 | 0 | **266** | **0** | **432** |
| Carrington Point | 501-037 | 03 | 5/17/05 | 1054 | 46 | 10 | 1 | 0 | 0 | 0 | **57** | **0** | **84** |
| Carrington Point | 501-037 | 02 | 5/16/06 | 1633 | 99 | 231 | 0 | 0 | 0 | 0 | **330** | **6** | **403** |
| Carrington Point | 501-037 | 03 | 5/16/06 | 1633 | 41 | 73 | 0 | 0 | 0 | 0 | **114** | **2** | **133** |
| Carrington Point | 501-037 | 02 | 5/15/07 | 1441 | 173 | 0 | 228 | 0 | 0 | 0 | **401** | **158** | **877** |
| Carrington Point | 501-037 | 03 | 5/15/07 | 1441 | 0 | 0 | 25 | 0 | 0 | 0 | **25** | **34** | **93** |
| Carrington Point | 501-037 | 07 | 5/15/07 | 1441 | 13 | 0 | 108 | 0 | 0 | 0 | **121** | **101** | **418** |
| **Santa Cruz Island** | | | | | | | | | | | | | |
| West Point Area | 502-016 | 04 | 5/23/02 | 0911 | 16 | 2 | 0 | 0 | 0 | 0 | **18** | **0** | **25** |
| West Point Area | 502-016 | 06 | 5/23/02 | 0911 | 61 | 0 | 0 | 0 | 0 | 0 | **61** | **0** | **70** |
| West Point Area | 502-016 | 07 | 5/23/02 | 0911 | 34 | 0 | 1 | 0 | 0 | 0 | **35** | **13** | **49** |
| West Point Area | 502-016 | 09 | 5/23/02 | 0911 | 46 | 0 | 3 | 0 | 1 | 0 | **50** | **0** | **53** |
| West Point Area | 502-016 | 13 | 5/23/02 | 0911 | 74 | 0 | 3 | 0 | 0 | 0 | **77** | **8** | **87** |
| West Point Area | 502-016 | 14 | 5/23/02 | 0911 | 10 | 0 | 1 | 0 | 0 | 0 | **11** | **0** | **12** |
| West Point Area | 502-016 | 15 | 5/23/02 | 0911 | 7 | 0 | 0 | 0 | 0 | 0 | **7** | **0** | **8** |
| West Point Area | 502-016 | 19 | 5/23/02 | 0911 | 7 | 0 | 0 | 0 | 0 | 0 | **7** | **0** | **11** |
| West Point Area | 502-016 | 20 | 5/23/02 | 0911 | 2 | 0 | 0 | 0 | 0 | 0 | **2** | **0** | **3** |
| West Point Area | 502-016 | 21 | 5/23/02 | 0911 | 12 | 0 | 1 | 0 | 0 | 0 | **13** | **0** | **14** |

Appendix 1 (continued).

| | | | | | | | Nest Categories | | | | | Totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colony | USFWSCN | SC # | Date | Time | X | C | P | A | E | B | Nests | Sites | Birds |
| West Point Area | 502-016 | 06 | 5/17/05 | 1138 | 24 | 0 | 2 | 0 | 0 | 0 | **26** | **11** | **47** |
| West Point Area | 502-016 | 07 | 5/17/05 | 1138 | 58 | 0 | 0 | 0 | 0 | 0 | **58** | **0** | **74** |
| West Point Area | 502-016 | 09 | 5/17/05 | 1138 | 229 | 2 | 18 | 0 | 0 | 0 | **249** | **15** | **343** |
| West Point Area | 502-016 | 19 | 5/17/05 | 1138 | 9 | 0 | 0 | 0 | 0 | 0 | **9** | **0** | **11** |
| West Point Area | 502-016 | 21 | 5/17/05 | 1138 | 35 | 0 | 0 | 0 | 0 | 0 | **35** | **0** | **45** |
| West Point Area | 502-016 | 04 | 5/16/06 | 1653 | 43 | 20 | 0 | 0 | 0 | 0 | **63** | **3** | **72** |
| West Point Area | 502-016 | 05 | 5/16/06 | 1653 | 13 | 9 | 0 | 0 | 0 | 0 | **22** | **0** | **23** |
| West Point Area | 502-016 | 06 | 5/16/06 | 1653 | 52 | 28 | 2 | 0 | 10 | 0 | **92** | **0** | **100** |
| West Point Area | 502-016 | 07 | 5/16/06 | 1653 | 4 | 0 | 0 | 0 | 0 | 0 | **4** | **0** | **4** |
| West Point Area | 502-016 | 08 | 5/16/06 | 1653 | 8 | 0 | 0 | 0 | 0 | 0 | **8** | **0** | **8** |
| West Point Area | 502-016 | 09 | 5/16/06 | 1653 | 76 | 26 | 1 | 0 | 0 | 0 | **103** | **0** | **114** |
| West Point Area | 502-016 | 16 | 5/16/06 | 1653 | 94 | 8 | 0 | 0 | 0 | 0 | **102** | **0** | **107** |
| West Point Area | 502-016 | 17 | 5/16/06 | 1653 | 8 | 0 | 0 | 0 | 0 | 0 | **8** | **2** | **14** |
| West Point Area | 502-016 | 13 | 5/15/07 | 1502 | 44 | 0 | 147 | 0 | 0 | 0 | **191** | **132** | **452** |
| West Point Area | 502-016 | 14 | 5/15/07 | 1502 | 44 | 0 | 39 | 0 | 0 | 0 | **83** | **42** | **169** |
| West Point Area | 502-016 | 17 | 5/15/07 | 1502 | 11 | 0 | 5 | 0 | 0 | 0 | **16** | **3** | **26** |
| West Point Area | 502-016 | 23 | 5/15/07 | 1502 | 6 | 0 | 5 | 0 | 0 | 0 | **11** | **1** | **12** |
| Gull Island | 524-001 | 01 | 5/21/02 | 1207 | 337 | 27 | 5 | 0 | 1 | 0 | **370** | **16** | **426** |
| Gull Island | 524-001 | 02 | 5/21/02 | 1207 | 11 | 0 | 17 | 0 | 0 | 0 | **28** | **18** | **52** |
| Gull Island | 524-001 | 01 | 5/17/05 | 1214 | 940 | 227 | 13 | 0 | 0 | 0 | **1,180** | **46** | **1,869** |
| Gull Island | 524-001 | 02 | 5/17/05 | 1214 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **268** |
| Gull Island | 524-001 | 03 | 5/17/05 | 1214 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **241** |
| Gull Island | 524-001 | 01 | 5/16/06 | 1449 | 1,114 | 0 | 17 | 27 | 0 | 0 | **1,158** | **10** | **1,208** |
| Gull Island | 524-001 | 01 | 5/15/07 | 1242 | 2 | 0 | 18 | 0 | 0 | 0 | **20** | **96** | **135** |
| Gull Island | 524-001 | 02 | 5/15/07 | 1242 | 193 | 0 | 248 | 0 | 0 | 0 | **441** | **159** | **1,088** |
| Gull Island | 524-001 | 03 | 5/15/07 | 1242 | 0 | 0 | 1 | 0 | 0 | 0 | **1** | **1** | **307** |
| **Anacapa Island** | | | | | | | | | | | | | |
| Anacapa I.-West | 502-007 | 02 | 5/23/02 | 0955 | 64 | 0 | 4 | 0 | 0 | 0 | **68** | **2** | **71** |

Appendix 1 (continued).

| Colony | USFWSCN | SC # | Date | Time | X | C | P | A | E | B | Nests | Sites | Birds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Nest Categories | | | | | Totals | |
| Anacapa I.-West | 502-007 | 03 | 5/23/02 | 0955 | 39 | 2 | 0 | 0 | 0 | 0 | **41** | **3** | **47** |
| Anacapa I.-West | 502-007 | 08 | 5/23/02 | 0955 | 55 | 0 | 3 | 0 | 0 | 0 | **58** | **7** | **70** |
| Anacapa I.-West | 502-007 | 09 | 5/23/02 | 0955 | 28 | 0 | 2 | 0 | 0 | 0 | **30** | **3** | **38** |
| Anacapa I.-West | 502-007 | 10 | 5/23/02 | 0955 | 36 | 2 | 10 | 0 | 0 | 0 | **48** | **42** | **108** |
| Anacapa I.-West | 502-007 | 01 | 5/17/05 | 1232 | 163 | 37 | 13 | 0 | 0 | 0 | **213** | **8** | **248** |
| Anacapa I.-West | 502-007 | 02 | 5/17/05 | 1232 | 13 | 208 | 0 | 2 | 0 | 1 | **224** | **23** | **257** |
| Anacapa I.-West | 502-007 | 01 | 5/16/06 | 1425 | 169 | 84 | 2 | 0 | 0 | 0 | **255** | **4** | **315** |
| Anacapa I.-West | 502-007 | 02 | 4/25/06 | 1205 | 255 | 25 | 33 | 0 | 0 | 0 | **313** | **72** | **455** |
| Anacapa I.-West | 502-007 | 03 | 4/25, 5/16 | - | 26 | 1 | 0 | 0 | 0 | 0 | **27** | **0** | **35** |
| Anacapa I.-West | 502-007 | 07 | 4/25, 5/16 | - | 30 | 22 | 0 | 0 | 5 | 0 | **57** | **0** | **96** |
| Anacapa I.-West | 502-007 | 10 | 4/25, 5/16 | - | 346 | 9 | 26 | 0 | 0 | 0 | **381** | **46** | **505** |
| Anacapa I.-West | 502-007 | 02 | 5/15/07 | 1531 | 62 | 121 | 18 | 0 | 0 | 0 | **201** | **10** | **323** |
| Anacapa I.-West | 502-007 | 03 | 5/15/07 | 1531 | 132 | 19 | 25 | 0 | 0 | 0 | **176** | **9** | **261** |
| Anacapa I.-West | 502-007 | 06 | 5/15/07 | 1531 | 17 | 3 | 6 | 0 | 0 | 0 | **26** | **6** | **41** |
| Anacapa I.-West | 502-007 | 10 | 5/15/07 | 1531 | 49 | 19 | 2 | 0 | 0 | 0 | **70** | **1** | **93** |
| Anacapa I.-West | 502-007 | 11 | 5/15/07 | 1531 | 4 | 0 | 1 | 0 | 0 | 0 | **5** | **0** | **6** |
| Anacapa I.-Middle | 502-008 | 13 | 5/23/02 | 0955 | 0 | 5 | 0 | 0 | 0 | 0 | **5** | **0** | **7** |
| Anacapa I.-Middle | 502-008 | 09 | 5/15/07 | 1534 | 15 | 0 | 0 | 0 | 0 | 0 | **15** | **15** | **40** |
| Anacapa I.-East | 502-009 | 11 | 5/17/05 | 1240 | 29 | 19 | 0 | 0 | 0 | 0 | **48** | **0** | **85** |
| Anacapa I.-East | 502-009 | 11 | 5/16/06 | 1433 | 10 | 0 | 0 | 0 | 2 | 0 | **12** | **3** | **57** |
| Anacapa I.-East | 502-009 | 07 | 5/15/07 | 1536 | 27 | 0 | 6 | 0 | 0 | 0 | **33** | **12** | **66** |
| **Santa Barbara Island** | | | | | | | | | | | | | |
| Shag Rock | 524-007 | 01 | 4/25/06 | 1510 | 7 | 0 | 63 | 0 | 0 | 0 | **70** | **122** | **252** |
| Shag Rock | 524-007 | 01 | 5/15/06 | 1358 | 118 | 2 | 107 | 1 | 0 | 0 | **228** | **28** | **283** |
| Shag Rock | 524-007 | 01 | 4/16/07 | 1214 | 229 | 0 | 16 | 0 | 0 | 0 | **245** | **24** | **283** |
| Santa Barbara Island | 524-008 | 02 | 5/22/02 | 1547 | 10 | 0 | 0 | 0 | 0 | 0 | **10** | **0** | **35** |
| Santa Barbara Island | 524-008 | 03a[1] | 4/22/02 | 1224 | 209 | 0 | 2 | 0 | 1 | 0 | **212** | **11** | **265** |
| Santa Barbara Island | 524-008 | 08 | 4/22/02 | 1224 | 4 | 0 | 0 | 0 | 0 | 0 | **4** | **0** | **5** |

Appendix 1 (continued).

| | | | | | Nest Categories | | | | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colony | USFWSCN | SC # | Date | Time | X | C | P | A | E | B | Nests | Sites | Birds |
| Santa Barbara Island | 524-008 | 22 | 4/22/02 | 1224 | 139 | 0 | 12 | 0 | 1 | 0 | **152** | **15** | **216** |
| Santa Barbara Island | 524-008 | 01 | 4/18/05 | 1350 | 263 | 4 | 46 | 1 | 0 | 0 | **314** | **45** | **469** |
| Santa Barbara Island | 524-008 | 01 | 5/16/05 | 1602 | 56 | 109 | 0 | 22 | 0 | 14 | **201** | **0** | **264** |
| Santa Barbara Island | 524-008 | 02 | 5/16/05 | 1603 | 7 | 3 | 0 | 0 | 0 | 0 | **10** | **0** | **18** |
| Santa Barbara Island | 524-008 | 03a[1] | 4/18/05 | 1355 | 97 | 33 | 5 | 0 | 0 | 0 | **135** | **3** | **158** |
| Santa Barbara Island | 524-008 | 03b[2] | 5/16/05 | 1613 | 23 | 2 | 2 | 0 | 0 | 0 | **27** | **39** | **78** |
| Santa Barbara Island | 524-008 | 04 | 5/16/05 | 1615 | 11 | 0 | 3 | 0 | 1 | 0 | **15** | **1** | **18** |
| Santa Barbara Island | 524-008 | 01 | 4/25/06 | 1510 | 138 | 176 | 13 | 0 | 0 | 0 | **327** | **13** | **602** |
| Santa Barbara Island | 524-008 | 03a[1] | 4/25/06 | 1510 | 75 | 217 | 0 | 0 | 5 | 0 | **297** | **3** | **794** |
| Santa Barbara Island | 524-008 | 03b[2] | 4/25/06 | 1510 | 12 | 21 | 0 | 0 | 0 | 0 | **33** | **3** | **61** |
| Santa Barbara Island | 524-008 | 03b[2] | 5/15/06 | 1358 | 4 | 10 | 0 | 0 | 0 | 0 | **14** | **0** | **25** |
| Santa Barbara Island | 524-008 | 04 | 4/25/06 | 1510 | 283 | 34 | 23 | 0 | 0 | 0 | **340** | **3** | **398** |
| Santa Barbara Island | 524-008 | 04 | 5/15/06 | 1358 | 282 | 32 | 4 | 0 | 0 | 0 | **318** | **5** | **358** |
| Santa Barbara Island | 524-008 | 06 | 4/25/06 | 1510 | 4 | 7 | 0 | 0 | 0 | 0 | **11** | **0** | **11** |
| Santa Barbara Island | 524-008 | 22 | 4/25/06 | 1510 | 96 | 16 | 15 | 0 | 0 | 0 | **127** | **13** | **174** |
| Santa Barbara Island | 524-008 | 01 | 5/14/07 | 1153 | 41 | 0 | 141 | 0 | 0 | 0 | **182** | **161** | **453** |
| Santa Barbara Island | 524-008 | 02 | 5/14/07 | 1153 | 15 | 13 | 4 | 0 | 0 | 0 | **32** | **10** | **52** |
| Santa Barbara Island | 524-008 | 03a[1] | 4/16/07 | 1217 | 77 | 13 | 4 | 0 | 0 | 0 | **94** | **4** | **118** |
| Santa Barbara Island | 524-008 | 04 | 4/16/07 | 1217 | 96 | 0 | 24 | 1 | 0 | 0 | **121** | **57** | **205** |
| Santa Barbara Island | 524-008 | 05 | 4/16/07 | 1217 | 27 | 0 | 7 | 0 | 0 | 0 | **34** | **2** | **40** |
| Santa Barbara Island | 524-008 | 12 | 4/16/07 | 1217 | 79 | 9 | 5 | 0 | 0 | 0 | **93** | **21** | **127** |
| Sutil Island | 524-009 | 01 | 4/22/02 | 1234 | 31 | 0 | 0 | 0 | 1 | 0 | **32** | **0** | **41** |
| Sutil Island | 524-009 | 01 | 5/15/06 | 1456 | 6 | 3 | 1 | 0 | 0 | 0 | **10** | **0** | **24** |
| Sutil Island | 524-009 | 01 | 4/25/06 | 1343 | 11 | 24 | 0 | 0 | 0 | 0 | **35** | **0** | **55** |
| Sutil Island | 524-009 | 01 | 4/16/07, 5/14/07 | 1200, 1126 | 176 | 1 | 3 | 0 | 0 | 0 | **180** | **12** | **201** |
| **San Nicolas Island** | | | | | | | | | | | | | |
| Vizcaino Point South | 325-048 | 01 | 5/22/02 | 1116 | 635 | 91 | 69 | 0 | 0 | 0 | **795** | **419** | **1,328** |
| Vizcaino Point South | 325-048 | 01 | 4/18/05 | 1428 | 315 | 0 | 476 | 0 | 0 | 0 | **791** | **578** | **1,576** |

Appendix 1 (continued).

| | | | | | Nest Categories | | | | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colony | USFWSCN | SC # | Date | Time | X | C | P | A | E | B | Nests | Sites | Birds |
| Vizcaino Point South | 325-048 | 01 | 5/16/05 | 1314 | 1,607 | 14 | 249 | 0 | 1 | 0 | **1,871** | **354** | **3,074** |
| Vizcaino Point South | 325-048 | 01 | 5/15/06 | 1320 | 1,052 | 234 | 17 | 0 | 0 | 0 | **3,154** | **259** | **4,482** |
| Vizcaino Point South | 325-048 | 01 | 5/14/07 | 1315 | 1,916 | 4 | 1,409 | 0 | 0 | 0 | **3,329** | **1,183** | **5,811** |
| Dutch Harbor Area | 524-026 | 01 | 5/22/02 | 1055 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** |
| Dutch Harbor Area | 524-026 | 01 | 4/18/05 | 1418 | 90 | 0 | 357 | 0 | 0 | 0 | **447** | **216** | **852** |
| Dutch Harbor Area | 524-026 | 01 | 5/16/05 | 1302 | 936 | 11 | 119 | 0 | 0 | 0 | **1,066** | **146** | **1,432** |
| Dutch Harbor Area | 524-026 | 01 | 5/15/06 | 1306 | 1,367 | 77 | 44 | 0 | 0 | 0 | **1,488** | **35** | **1,716** |
| Dutch Harbor Area | 524-026 | 01 | 4/16/07 | 1110 | 198 | 0 | 16 | 0 | 0 | 0 | **214** | **38** | **364** |
| Dutch Harbor Area | 524-026 | 01 | 5/14/07 | 1257 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** |
| Cormorant Rock Area | 524-028 | 04 | 5/22/02 | 1103 | 49 | 0 | 4 | 0 | 4 | 0 | **57** | **3** | **61** |
| Cormorant Rock Area | 524-028 | 05 | 5/22/02 | 1103 | 171 | 62 | 1 | 0 | 4 | 0 | **238** | **11** | **299** |
| Cormorant Rock Area | 524-028 | 06 | 5/22/02 | 1103 | 7 | 0 | 0 | 0 | 0 | 0 | **7** | **0** | **7** |
| Cormorant Rock Area | 524-028 | 04 | 4/18/05 | 1424 | 7 | 0 | 0 | 40 | 0 | 0 | **47** | **0** | **9** |
| Cormorant Rock Area | 524-028 | 05 | 4/18/05 | 1424 | 2 | 0 | 0 | 14 | 0 | 0 | **16** | **0** | **2** |
| Cormorant Rock Area | 524-028 | 06 | 4/18/05 | 1424 | 25 | 0 | 50 | 0 | 0 | 0 | **75** | **50** | **147** |
| Cormorant Rock Area | 524-028 | 04 | 5/16/05 | 1307 | 3 | 0 | 0 | 35 | 0 | 0 | **38** | **0** | **8** |
| Cormorant Rock Area | 524-028 | 05 | 5/16/05 | 1307 | 26 | 4 | 5 | 17 | 0 | 0 | **52** | **3** | **54** |
| Cormorant Rock Area | 524-028 | 06 | 5/16/05 | 1307 | 147 | 3 | 8 | 0 | 0 | 0 | **158** | **4** | **198** |
| Cormorant Rock Area | 524-028 | 04 | 5/15/06 | 1310 | 47 | 43 | 0 | 0 | 0 | 0 | **90** | **0** | **115** |
| Cormorant Rock Area | 524-028 | 05 | 5/15/06 | 1310 | 72 | 88 | 2 | 0 | 0 | 0 | **162** | **32** | **315** |
| Cormorant Rock Area | 524-028 | 06 | 5/15/06 | 1310 | 115 | 39 | 0 | 0 | 2 | 0 | **156** | **0** | **203** |
| Cormorant Rock Area | 524-028 | 05 | 5/14/07 | 1304 | 128 | 0 | 19 | 0 | 0 | 0 | **147** | **57** | **252** |
| Cormorant Rock Area | 524-028 | 06 | 5/14/07 | 1304 | 107 | 0 | 24 | 0 | 0 | 0 | **131** | **32** | **197** |
| White Bluffs | 524-068 | 01 | 5/14/07 | 1252 | 50 | 0 | 6 | 0 | 0 | 0 | **56** | **19** | **313** |
| **San Clemente Island** | | | | | | | | | | | | | |
| Bird Rock | 524-030 | 01 | 5/22/02 | 1218 | 262 | 2 | 12 | 0 | 0 | 0 | **276** | **20** | **450** |
| Bird Rock | 524-030 | 01 | 4/18/05 | 1522 | 374 | 0 | 98 | 0 | 0 | 0 | **472** | **81** | **1,048** |
| Bird Rock | 524-030 | 01 | 5/16/05 | 1344 | 360 | 146 | 24 | 0 | 0 | 0 | **530** | **46** | **777** |

Appendix 1 (continued).

| | | | | | Nest Categories | | | | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colony | USFWSCN | SC # | Date | Time | X | C | P | A | E | B | Nests | Sites | Birds |
| Bird Rock | 524-030 | 01 | 5/15/06 | 1453 | 392 | 437 | 3 | 0 | 36 | 0 | **868** | **74** | **1,368** |
| Bird Rock | 524-030 | 01 | 5/14/07 | 1350 | 272 | 238 | 16 | 6 | 0 | 0 | **532** | **198** | **838** |
| Lost Point South | 524-034 | 01 | 5/22/02 | 1156 | 25 | 0 | 0 | 0 | 0 | 0 | **25** | **0** | **44** |
| Lost Point South | 524-034 | 01 | 5/16/05 | 1413 | 6 | 20 | 2 | 0 | 3 | 0 | **31** | **0** | **44** |
| Lost Point South | 524-034 | 01 | 5/15/06 | 1438 | 2 | 11 | 1 | 0 | 6 | 0 | **20** | **0** | **34** |
| Lost Point South | 524-034 | 04 | 5/15/06 | 1438 | 24 | 27 | 1 | 0 | 2 | 0 | **54** | **0** | **73** |
| Lost Point South | 524-034 | 03 | 5/14/07 | 1403 | 5 | 0 | 0 | 0 | 0 | 0 | **5** | **12** | **26** |
| Seal Cove Area | 524-036 | 04 | 5/22/02 | 1205 | 28 | 0 | 2 | 0 | 0 | 0 | **30** | **1** | **63** |
| **San Diego Mainland** | | | | | | | | | | | | | |
| La Jolla | 545-009 | 01 | 5/22/02 | 1435 | 21 | 0 | 0 | 0 | 0 | 0 | **21** | **0** | **42** |
| La Jolla | 545-009 | 01 | 5/17/05 | 1636 | 14 | 8 | 0 | 0 | 0 | 0 | **22** | **1** | **43** |
| La Jolla | 545-009 | 01 | 5/15/06 | 1548 | 23 | 7 | 2 | 0 | 0 | 0 | **32** | **0** | **167** |
| La Jolla | 545-009 | 01 | 5/14/07 | 1506 | 21 | 5 | 0 | 0 | 0 | 0 | **26** | **0** | **53** |

**Numeric Footnotes:** [1]Elephant Seal Point area of SC 03; [2]North Point area of SC 03.

Appendix 2. Subcolony counts of Double-crested Cormorant nests, sites and birds at southern California sample colonies, April-June 2002 and 2005-07. See text for nest category definitions.

| | | | | | Nest Categories | | | | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colony | USFWSCN | SC # | Date | Time | X | C | P | A | E | B | Nests | Sites | Birds |
| **San Miguel Island** | | | | | | | | | | | | | |
| Prince Island | 501-004 | 01 | 6/17/02 | 1409 | 110 | 0 | 0 | 0 | 0 | 0 | **110** | **3** | **146** |
| Prince Island | 501-004 | 01 | 6/13/05 | 1511 | 76 | 98 | 0 | 0 | 0 | 0 | **174** | **0** | **189** |
| Prince Island | 501-004 | 01 | 5/16/06 | 1557 | 153 | 3 | 30 | 0 | 0 | 0 | **186** | **4** | **193** |
| Prince Island | 501-004 | 01 | 6/12/07 | 1154 | 82 | 41 | 0 | 0 | 0 | 0 | **123** | **0** | **143** |
| **Santa Rosa Island** | | | | | | | | | | | | | |
| Sierra Pablo Area | 501-040 | 03 | 5/15/07 | 1252 | 9 | 7 | 0 | 0 | 0 | 0 | **16** | **0** | **17** |
| Sierra Pablo Area | 501-040 | 03 | 6/12/07 | 1219 | 3 | 17 | 0 | 0 | 0 | 0 | **20** | **0** | **27** |
| **Santa Barbara Island** | | | | | | | | | | | | | |
| Santa Barbara Island | 524-008 | 03 | 6/17/02 | 1237 | 25 | 0 | 0 | 0 | 0 | 0 | **25** | **0** | **26** |
| Santa Barbara Island | 524-008 | 04 | 6/17/02 | 1237 | 3 | 0 | 0 | 0 | 0 | 0 | **3** | **0** | **3** |
| Santa Barbara Island | 524-008 | 18 | 6/17/02 | 1237 | 34 | 0 | 0 | 0 | 0 | 0 | **34** | **0** | **35** |
| Santa Barbara Island | 524-008 | 03 | 5/16/05 | 1613 | 12 | 0 | 9 | 0 | 0 | 0 | **21** | **5** | **28** |
| Santa Barbara Island | 524-008 | 04 | 5/16/05 | 1613 | 7 | 0 | 0 | 0 | 0 | 0 | **7** | **0** | **7** |
| Santa Barbara Island | 524-008 | 18 | 5/16/05 | 1613 | 28 | 0 | 18 | 0 | 1 | 0 | **47** | **4** | **52** |
| Santa Barbara Island | 524-008 | 03 | 6/29/06 | 1435 | 20 | 37 | 0 | 0 | 6 | 0 | **63** | **1** | **67** |
| Santa Barbara Island | 524-008 | 18 | 6/29/06 | 1420 | 21 | 24 | 0 | 0 | 1 | 0 | **46** | **0** | **46** |
| Santa Barbara Island | 524-008 | 03 | 6/12/07 | 1331 | 39 | 0 | 0 | 0 | 0 | 0 | **39** | **0** | **40** |
| Santa Barbara Island | 524-008 | 18 | 6/12/07 | 1331 | 30 | 1 | 7 | 0 | 0 | 0 | **38** | **0** | **40** |
| Sutil Island | 524-009 | 01 | 6/17/02 | 1219 | 43 | 0 | 0 | 0 | 0 | 0 | **43** | **0** | **46** |
| Sutil Island | 524-009 | 01 | 5/16/05 | 1549 | 39 | 0 | 11 | 0 | 0 | 0 | **50** | **2** | **57** |
| Sutil Island | 524-009 | 01 | 6/29/06 | 1415 | 15 | 33 | 0 | 0 | 0 | 0 | **48** | **0** | **58** |
| Sutil Island | 524-009 | 01 | 6/12/07 | 1308 | 30 | 0 | 0 | 0 | 0 | 0 | **30** | **0** | **33** |
| **San Clemente Island** | | | | | | | | | | | | | |
| Mail Point South | 524-035 | 02 | 5/14/07 | 1405 | 3 | 0 | 0 | 0 | 0 | 0 | **3** | **0** | **3** |
| Seal Cove Area | 524-036 | 03 | 5/22/02 | 1205 | 15 | 0 | 0 | 0 | 0 | 0 | **15** | **0** | **15** |
| Seal Cove Area | 524-036 | 03 | 5/16/05 | 1401 | 25 | 2 | 2 | 0 | 0 | 0 | **29** | **1** | **35** |

Appendix 2 (continued).

| Colony | USFWSCN | SC # | Date | Time | X | C | Nest Categories P | A | E | B | Nests | Totals Sites | Birds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seal Cove Area | 524-036 | 03 | 6/13/05 | 1638 | 24 | 11 | 0 | 0 | 0 | 0 | **35** | **0** | **44** |
| Seal Cove Area | 524-036 | 03 | 5/15/06 | 1444 | 44 | 1 | 0 | 0 | 0 | 0 | **45** | **0** | **58** |
| Seal Cove Area | 524-036 | 03 | 5/14/07 | 1409 | 27 | 0 | 10 | 0 | 0 | 0 | **37** | **2** | **41** |
| Seal Cove Area | 524-036 | 03 | 6/12/07 | 1410 | 44 | 0 | 0 | 1 | 0 | 0 | **45** | **0** | **45** |
| **San Diego Mainland** | | | | | | | | | | | | | |
| S. SD Bay Saltworks | 545-027 | 07 | 5/22/02 | 1410 | 39 | 4 | 1 | 0 | 0 | 0 | **44** | **0** | **68** |
| S. SD Bay Saltworks | 545-027 | 07 | 5/17/05 | 1619 | 36 | 1 | 1 | 0 | 0 | 0 | **38** | **0** | **66** |
| S. SD Bay Saltworks | 545-027 | 07 | 5/15/06 | 1534 | 41 | 5 | 4 | 0 | 0 | 0 | **50** | **2** | **59** |
| S. SD Bay Saltworks | 545-027 | 03 | 5/15/06 | 1534 | 24 | 0 | 0 | 0 | 0 | 0 | **24** | **0** | **28** |
| S. SD Bay Saltworks | 545-027 | 02 | 5/14/07 | 1451 | 4 | 0 | 0 | 0 | 0 | 0 | **4** | **0** | **6** |
| S. SD Bay Saltworks | 545-027 | 03 | 5/14/07 | 1451 | 6 | 0 | 0 | 0 | 0 | 0 | **6** | **0** | **9** |
| S. SD Bay Saltworks | 545-027 | 05 | 5/14/07 | 1451 | 27 | 0 | 14 | 0 | 0 | 0 | **41** | **11** | **79** |
| S. SD Bay Saltworks | 545-027 | 07 | 5/14/07 | 1451 | 34 | 1 | 0 | 0 | 0 | 0 | **35** | **0** | **56** |

Appendix 3. Numbers of roosting unidentified cormorants (UNCO) and Brown Pelicans (BRPE) counted at sample cormorant colonies in southern California, April-June 2002 and 2005-07.

| | | | | | | | BRPE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Colony** | **CCN** | **USFWSCN** | **SC #** | **Date** | **Time** | **UNCO** | **Adult** | **Imm.** | **Unk.** | **Total** |
| Sandpiper Pier | SB-342-07 | 502-029 | 01 | 5/17/05 | 0847 | 0 | 8 | 26 | 0 | 34 |
| Prince Island | SB-SMI-07 | 501-004 | 01 | 6/13/05 | 1511 | 0 | 28 | 20 | 0 | 48 |
| Prince Island | SB-SMI-07 | 501-004 | 01 | 5/16/06 | 1557 | 0 | 236 | 165 | 0 | 401[a] |
| Prince Island | SB-SMI-07 | 501-004 | 01 | 5/15/07 | 1359 | 85 | 357 | 296 | 0 | 653 |
| Carrington Point | SB-SRI-05 | 501-037 | 02 | 5/15/07 | 1441 | 0 | 6 | 8 | 0 | 14 |
| Gull Island | SB-SZI-22 | 524-001 | 03 | 5/17/05 | 1214 | 0 | 0 | 0 | 15 | 15 |
| Gull Island | SB-SZI-22 | 524-001 | 02 | 5/15/07 | 1242 | 0 | 9 | 19 | 0 | 25 |
| Gull Island | SB-SZI-22 | 524-001 | 03 | 5/15/07 | 1242 | 0 | 172 | 193 | 0 | 365 |
| Santa Barbara Island | SB-SBI-02 | 524-008 | 04 | 5/16/05 | 1615 | 4 | 0 | 0 | 0 | 0 |
| Sutil Island | SB-SBI-03 | 524-009 | 01 | 5/16/05 | 1549 | 21 | 0 | 0 | 0 | 0 |
| Sutil Island | SB-SBI-03 | 524-009 | 01 | 4/25/06 | 1456 | 29 | 0 | 0 | 0 | 0 |
| West Point Area | SB-SZI-02 | 502-016 | 10 | 5/16/06 | 1653 | 24 | 16 | 20 | 0 | 36 |
| West Point Area | SB-SZI-02 | 502-016 | 10 | 5/15/07 | 1502 | 0 | 30 | 7 | 8 | 45 |
| Bird Rock | LA-CLI-02 | 524-030 | 01 | 5/22/02 | 1218 | 0 | nd | nd | 152 | 152 |
| Castle Rock | LA-CLI-01 | 524-029 | 01 | 5/16/05 | 1346 | 49 | 0 | 0 | 0 | 0 |
| La Jolla | SD-324-04 | 545-009 | 99 | 5/17/05 | 1636 | 162 | 13 | 2 | 6 | 21 |
| La Jolla | SD-324-04 | 545-009 | 99 | 5/15/06 | 1548 | 87 | 393 | 331 | 0 | 724 |
| La Jolla | SD-324-04 | 545-009 | 99 | 5/14/07 | 1506 | 87 | 148 | 9 | 0 | 157 |

[a]An additional 216 pelicans (including some roosting birds) were present in nesting areas.