National Park Service

CHANNEL ISLANDS NATIONAL PARK

TECHNICAL REPORT 98-03

SEABIRD MONITORING
CHANNEL ISLANDS NATIONAL PARK
1993–1996

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ABSTRACT

Channel Islands National Park seabird monitoring staff monitored Western Gulls (*Larus occidentalis*) on Anacapa Island, Cassin's Auklets (*Ptychoramphus aleuticus*) at San Miguel Island, and Western Snowy Plovers (*Charadrius alexandrinus nervosus*) at San Miguel and Santa Rosa Islands between 1993–1996. Monitoring at Santa Barbara Island in 1994–1996 and analysis of 1993 Santa Barbara Island data was carried out by Point Reyes Bird Observatory through cooperative agreement with Channel Islands National Park. Point Reyes Bird Observatory reports to Channel Islands National Park summarize data for monitoring of Double-Crested Cormorant (*Phalacrocorax auritus*), Brandt's Cormorant (*Phalacrocorax pencillatus*), Pelagic Cormorant (*Phalacrocorax pelagicus*), Western Gull (*Larus occidentalis*), Xantus' Murrelet (*Synthliboramphus hypoleuca*), and three species of Storm-Petrel (*Oceanodroma* spp.) on Santa Barbara Island. These reports are included here as Section 2 Section 3 and Section 4 .

There were 25 breeding Snowy Plovers observed at San Miguel Island in 1993. There were 17 in 1994, 9 in 1995, and 3 in 1996. At Santa Rosa Island, 121 adult Snowy Plovers were observed in 1993, 95 in 1994, 71 in 1995, and 83 in 1996. The wintering population at Santa Rosa Island averages about 300 Snowy Plovers near the end of November. Productivity for Cassin's Auklet at Prince Island, San Miguel Island, was 0.80 in 1993, 0.59 in 1993, and 0.83 in 1996. Auklet productivity is unknown for 1995.

Western Gulls at East Anacapa Island produced 1.29 chicks per pair in 1993, 0.72 chicks per pair in 1994, 1.36 chicks per pair in 1995, and 0.97 chicks per pair in 1996. Productivity at Santa Barbara Island was estimated at just under 1 chick per pair for 1993 and 1994, less than 0.5 chicks per pair in 1995, and 0.78 chicks per pair in 1996. The Santa Barbara Island population of Western Gulls was estimated at 4000 breeding pairs in 1994; nearly 2500 breeding pairs in 1995, and over 4100 breeding pairs in 1996. No estimate was made in 1993.

In 1993 and 1994 Double-Crested Cormorants bred in similar numbers (about 250 pairs) at Santa Barbara Island. There were about 180 pairs in 1995 and about 270 pairs in 1996. Productivity was approximately 1 chick per breeding pair in 1993 and 1994, and 0.7 chicks per breeding pair in 1995, and 0.44 chicks per breeding pair in 1996.

Approximately 425 pairs of Brandt's Cormorants bred at Santa Barbara Island in 1993 and 1994. There were about 300 pairs in 1995. In 1996, 415 breeding pairs were monitored while the total population appeared to be about 500 pairs. Productivity was roughly 1.6 chicks fledged per pair in 1993, 1994, and 1995, and 1.85 chicks per pair in 1996.

A small population of Pelagic Cormorants was observed at Santa Barbara Island in 1996. The Pelagic Cormorant population numbered 18 pairs and productivity was 0.83 chicks per pair.

Population size of Xantus' Murrelets was not estimated from 1993–1996 because of difficulties censusing this nocturnal, crevice-nesting species. Murrelet clutch size was similar between 1993 and 1994, but hatching success was much higher in 1993 than 1994. Productivity was roughly 0.8 chicks per pair in 1993 and 0.5 chicks per pair in 1994. Murrelets nested about 6 weeks later than average in 1995 and laid approximately 1.5 eggs per nest and produced an average of 0.8 hatchlings per pair. Murrelets produced an average of 0.86 chicks per pair in 1996.

In 1994 monitoring of Ashy, Leach's, and Black Storm-Petrels was initiated by conducting a mark-recapture study at standardized mist-netting locations. Consistent mark-recapture operations at these locations will provide an index on population trends of these important species in future years. Mist-netting was continued in 1995 and 1996. Storm-petrels were mist-netted on 7 nights in 1994 capturing 67 unbanded birds and 3 previously captured birds. In 1995, 119 unbanded birds and 4 previously banded birds were captured in 9 nights' effort. In 1996, 171 unbanded birds and 9 previously banded birds were captured in 7 nights' effort.

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ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

Summary

This report summarizes data collected by Channel Islands National Park's Seabird Monitoring Program. Some information was originally presented as separate reports summarizing data collected by Point Reyes Bird Observatory through cooperative agreement with Channel Islands National Park. These reports prepared by Jack Feldman, Michael Schultz, Jennifer Roth, William Sydeman,and Shaye Wolf appear as Section 2, Section 3, and Section 4. Information from all volumes of work is presented in this Executive Summary.

Snowy Plover

The number of breeding Snowy Plovers observed has decreased at both San Miguel and Santa Rosa Islands since 1993. Between 1993 and 1996 the number of breeding Snowy Plovers observed at San Miguel Island dropped from 25 to 3. During the same time period, the number of breeding birds at Santa Rosa Island dropped from 121 to 85; the minimum number observed during this time period was 71 (1995).

Instituting fall censuses on Santa Rosa Island in 1993 has shown how important Santa Rosa Island is as a wintering site for Snowy Plovers, as well as a stopover site for other migrating shorebirds of the Pacific Flyway. The average number of Snowy Plovers observed wintering on Santa Rosa Island between 1993 and 1996 was 305 with a trend for decreasing numbers.

Western Gull

Phenology (timing of breeding) has been similar for Western Gulls on Santa Barbara Island and East Anacapa Island. Birds begin laying eggs in late April. The first chicks hatch in late May and peak hatch is early June.

In general, reproductive performance is higher at East Anacapa Island than Santa Barbara Island.

Productivity

Gulls were more successful in 1993, 1995, and 1996 at East Anacapa Island than at Santa Barbara Island. Gulls were more successful at Santa Barbara Island in 1994; mainly because of better hatching success in this year.

Fledging Success

The number of hatched chicks that survive to fledging age is often similar between Santa Barbara and East Anacapa Islands. There were noticeable differences in 1993 when it was higher at Santa Barbara Island, and in 1995, when it was higher at East Anacapa Island.

Clutch Size

In each year, clutch size was larger at East Anacapa Island although these differences do not appear statistically significant.

Hatching Success

Hatching success was almost always higher at Anacapa; it was slightly higher at Santa Barbara Island in 1994.

The gull population on Santa Barbara Island seems to be fluctuating—4,000 breeding pairs in 1994, 2,500 breeding pairs in 1994, and 4,100 breeding pairs in 1996. The trend is that the population is still considerably higher than that reported by Ingram in 1992 and Ingram and Jory-Carter (1997).

Cassin's Auklet

The year 1994 was the only year during the period of this report in which productivity could adequately be determined. Productivity for Cassin's Auklets at Prince Island, San Miguel was 0.80 in 1993, 0.59 in 1994, and 0.83 in 1996. There was insufficient monitoring to determine productivity in 1995.

Xantus' Murrelet

Productivity for Xantus' Murrelets at Santa Barbara Island was similar in 1993, 1995, and 1996 (0.80, 0.80, and 0.86 respectively). Productivity dipped to 0.50 in 1994, which may be attributed to higher predation by deer mice in 1994. Population size has not been estimated because of inherent difficulties censusing Xantus' Murrelets.

Cormorants

Monitoring on Santa Barbara Island continues for Double-Crested Cormorants and Pelagic Cormorants. In 1993, Brandt's Cormorants began nesting routinely on Webster Point at Santa Barbara Island. They were incorporated into the Seabird Monitoring Program and have been monitored annually since 1993.

There were approximately 250 breeding pairs of Double-Crested Cormorants in 1993 and 1994 producing approximately 1 chick per breeding pair in both years. There were only 180 breeding pairs in 1995 producing 0.7 chicks per breeding pair. In 1996, breeding effort was slightly higher (270 breeding pairs) than what was observed in 1993 and 1994. However, productivity was only 0.44 chicks per breeding pair. No explanation can be offered for the decrease in productivity at this time.

The Brandt's Cormorant breeding population on Santa Barbara island has remained fairly constant. There was a decrease in breeding effort in 1995; however, 1996 levels were comparable to 1993 and 1994. Productivity has also remained fairly constant (1.6 in 1993, 1994, and 1995) with a slight increase (1.85) in 1996.

Pelagic Cormorant nesting at Santa Barbara Island is sparse. In 1996, 18 breeding pairs were observed. These nests produced 0.83 chicks per breeding pair.

Cormorants at Anacapa Island are monitored by Frank Gress through the California Institute for Environmental Studies and the University of California, Davis.

Management Recommendations

General

Begin trend analyses on a species-by-species or group-by-group (e.g., Brandt's Cormorants, Western Gulls, etc.) basis. We should continue to investigate ways to reduce human disturbance of breeding seabirds.

Snowy Plover

Census effort at San Miguel Island should be increased to include the beaches on the South side. The Park will be working with National Marine Fisheries Service to obtain necessary permits for encountering pinnipeds on these beaches.

The apparent decline at Santa Rosa Island needs to be investigated. The effect of predation by ravens and foxes on productivity may explain some of this population change. We should consider erecting exclosures around nests to reduce predation.

Since numbers have dropped well below 100, we should also consider comparing what is known about the Snowy Plover's use of other islands in the Santa Barbara Channel as birds may be moving between Santa Rosa, Santa Cruz, San Nicholas, and San Miguel Islands in different years. We recommend censusing Snowy Plovers at Santa Cruz Island, in particular, the Frasier Point area. The proximity of Frasier Point to Skunk Point makes it conceivable that the birds may use both points for breeding and foraging.

Between 1993 and 1996, the censuses have often been conducted under marginal conditions. Snowy Plover censuses should be planned with a backup date *scheduled* to accommodate poor weather conditions. Some flexibility should be built into the census period and transportation.

Western Gull

A population estimate should be obtained for East Anacapa Island. Alternatively, population trends could be assessed by counting birds in certain areas. This could include all areas of the marine terrace and accessible cliff areas.

Cassin's Auklet

The Park should increase monitoring effort of Cassin's Auklet at Prince Island. To date, difficult weather and ocean conditions and limited transportation have restricted access to the point where we are no longer able to gather the information specified in the Channel Islands National Park Seabird Monitoring Handbook.

Xantus' Murrelet

Barn Owls and Peregrine Falcons take adult Xantus' Murrelets. This may have long-term affects on the population. Much more needs to be explored about the interactions between Xantus' Murrelets and deer mice and Xantus' Murrelets and owls and falcons. Population trajectory simulations for Xantus' Murrelets that synthesize demographic information and conservation problems should be further developed. We should investigate the feasibility of using nest boxes as a habitat management tool for Xantus' Murrelets and Storm-Petrels and conduct further studies of population trends by increasing population surveys for certain species (i.e., Xantus' Murrelets and Ashy Storm-Petrels). Nest box monitoring could provide information that is not available from birds nesting in natural crevices.

Section 1

Seabird Monitoring at Anacapa Island, Santa Rosa Island, and San Miguel Island, 1993-1996

ABSTRACT

Channel Islands National Park seabird monitoring staff monitored Western Gulls (Larus occidentalis) on Anacapa Island, Cassin's Auklets (Ptychoramphus aleuticus) at San Miguel Island, and Western Snowy Plovers (Charadrius alexandrinus nervosus) at San Miguel and Santa Rosa Islands between 1993–1996.

There were 25 breeding Snowy Plovers observed at San Miguel Island in 1993. There were 17 in 1994, 9 in 1995, and 3 in 1996. At Santa Rosa Island, 121 adult Snowy Plovers were observed in 1993, 95 in 1994, 71 in 1995, and 85 in 1996. The wintering population at Santa Rosa Island averages about 300 Snowy Plovers at the end of November. Western Gulls at East Anacapa Island produced 1.29 chicks per pair in 1993, 0.72 chicks per pair in 1994, 1.36 chicks per pair in 1995, and 0.97 chicks per pair in 1996. Productivity for Cassin's Auklet at Prince Island, San Miguel Island was 0.80 in 1993, 0.59 in 1994, and 0.83 in 1996. There was insufficient monitoring to determine productivity in 1995.

INTRODUCTION

Seabirds nesting within the boundaries of Channel Island National Park are monitored for two main reasons. The first is to detect changes in population dynamics over time; the second is to establish normal limits of change. Monitoring functions as an early warning to Park managers of threats to seabirds or their environment.

This report summarizes monitoring of Double-Crested Cormorant (*Phalacrocorax auritus*), Brandt's Cormorant (*Phalacrocorax pencillatus*), Pelagic Cormorant (*Phalacrocorax pelagicus*), Western Gull (*Larus occidentalis*), Xantus' Murrelet (*Synthliboramphus hypoleuca*), and 3 species of Storm-Petrel (*Oceanodroma spp.*) on Santa Barbara Island, and Western Gull on Anacapa Island, Cassin's Auklet (*Ptychoramphus aleuticus*) on Prince Island, and Western Snowy Plover (*Charadrius alexandrinus nervosus*) for Santa Rosa Island and San Miguel Island, 1993–1996. Information collected from Brown Pelican monitoring by Channel Islands National Park staff on Santa Barbara Island and on Anacapa Island by Frank Gress will be presented in a separate report. Pelecaniform (pelicans and cormorants) monitoring on the Anacapas continues to be carried out by Frank Gress (California Institute of Environmental Studies, Davis, CA; Department of Wildlife, Fish, and Conservation Biology, University of California, Davis) in conjunction with other research projects. Limited staff, time, and money have prevented Channel Islands National Park staff from monitoring Pelecaniformes at Anacapa Island.

At Santa Barbara Island data were collected by Point Reyes Bird Observatory from 1994–1996. Results from 1993–1994 field data are presented in Section 2 . Results from 1995 and 1996 are presented in Section 3 and Section 4 respectively.

The Channel Islands National Park Seabird Monitoring Handbook outlines the monitored species and provides a synopsis of the methodology used to investigate population size, phenology, and productivity of seabirds in Channel Islands National Park (Lewis et al. 1988). Deviations from methods outlined in the handbook are presented in Methodologies and Results herein. More specific methodologies pertaining to analyses are detailed following each species account.

Previous reports produced by the Channel Islands National Park Seabird Monitoring Program include Lewis (1988), Ingram (1992), and Ingram and Jory-Carter (1997).

Division of Labor

In 1993, all field work was conducted by Channel Islands National Park's Seabird Biologist, a seasonal Park Service Biologist, and a Student Conservation Association volunteer. In 1994, we contracted with Point Reyes Bird Observatory to conduct fieldwork on Santa Barbara Island. A Student Conservation Association volunteer also assisted with data collection on Santa Barbara Island in 1994. In 1995, a cooperative agreement was established allowing Point Reyes Bird Observatory to continue providing monitoring assistance and students began volunteering through Channel Islands National Park's Volunteers In Parks program. Currently, Point Reyes Bird Observatory provides a field supervisor and partial funding for a technician to collect data on 3 species of cormorants, Western Gulls and Xantus' Murrelets at Santa Barbara Island. A Park volunteer also works on Santa Barbara Island to ensure that there are no breaks in data collection efforts. Appendix A summarizes field biologists and assistants for all years included in this report.

Aerial surveys determining cormorant populations and nesting effort were conducted throughout the Channel Islands by Harry Carter and crew under the auspices of the Biological Research Division of U. S. Geological Survey, Dixon Field Station (formerly National Biological Service, formerly US Fish and Wildlife

Service). In addition to aerial surveys, research conducted at Prince Island allowed Biological Research Division personnel to collect information on Cassin's Auklets in 1994 which they provided to Channel Islands National Park. Their analysis and summary of 1994 data is reported in Carter, et. al, 1995.

METHODOLOGY AND RESULTS

Snowy Plover

On San Miguel Island, Snowy Plover breeding censuses have been conducted on beaches on the North side of the island, and, minimally, Cardwell Point. At Santa Rosa Island, the censuses are conducted island-wide on beaches which are likely to have Snowy Plovers, that is, those beaches which have some amount of back dunes and are open allowing birds clear views of approaching predators.

Snowy Plover breeding censuses were conducted in May 1993–1996 on San Miguel Island and Santa Rosa Island and August 1993–1995 on Santa Rosa Island. A census was attempted in August 1995 on Santa Rosa Island; however, exceedingly strong winds caused cancellation. A late fall census was conducted in 1993 to determine the wintering bird population on Santa Rosa Island. In 1993, the breeding survey was conducted and supervised by Gary Page of Point Reyes Bird Observatory. Breeding censuses subsequent to 1993 and Fall censuses were conducted and supervised by Channel Islands National Park staff. Wintering bird (Fall) censuses have been completed in late November, 1993–1996.

Breeding biology of Snowy Plovers at Skunk Point, Santa Rosa Island was monitored in 1993 by Point Reyes Bird Observatory. The results are reported by Stein (1993). Breeding censuses are conducted by having 2–4 people walk spread along the width of the beach and associated dunes to locate nesting birds and chicks. The Fall census is conducted by 1–2 people walking the beach, encountering wintering flocks of birds.

Each bird encountered is examined for leg bands. Each group of birds in a wintering flock is counted multiple times, often from different vantage points, to obtain the most accurate number possible. A large flock may be counted in segments.

The 1996 Snowy Plover census was conducted twice on Santa Rosa Island because of high wind conditions during the scheduled census. Data from the second count were used in 1996 for two reasons: primarily because a new beach was added to the census, but also because there were better census conditions for the second count which occurred in June.

Breeding Population

Total counts of males, females, and unsexed adults are presented in Table 1 and Table 2. Distributions are presented in Figure 1 and Figure 2. Figure 3 is a graphic representation of the annual data.

San Miguel Island. Between 1993 and 1996 the number of birds in breeding plumage observed on San Miguel Island dropped from 25 to 3 (Table 1). However, 14 birds were observed at Crook Point (a known breeding area) in late May 1996 by Vandenburg Air Force Base contract biologists (Stewart et al., 1996). These beaches were not surveyed during the Channel Islands National Park census because of the presence of molting pinnipeds. Brent Stewart later reported this information as spurious (personal communication).

Of the 25 adults observed in 1993, 14 of the birds were observed as male/female pairs (7 pairs). Pairs were not recorded in 1994. One pair was observed in 1995; no pairs were observed in 1996.

One male was observed attending 2 two-week old chicks on Glass Float Beach in 1993 (Tiki Baron's field notes). Two nests were observed on Simonton Beach in 1994. One nest contained 2 eggs and the other nest had 3 newly-hatched young.

Table 1 Mid-breeding season Snowy Plover censuses on San Miguel Island, 1993–1996

Beaches	Date	Males	Females	Unsexed adults / unknown age adult-sized	Total adults
1993					
Bowl Cove	5/18/93	5	4	0	9
Cardwell Point	5/20/93	0	1	0	1
Cuyler Harbor	5/18/93	1	1	0	2
Glass Float Beach	5/20/93	2	0	0	2
Simonton Beach	5/19/93	6	4	0	10
SE Beaches (incl Crook Point)	5/20/93	1	0	0	1
Total		15	10	0	25
1994					
Cardwell Point	5/23/94	no access	no access	no access	
Crook Point	5/21/94	1	1	2	4
Cuyler Harbor	5/21/94	2	2	1	5
Glass Float Beach	5/23/94	no access	no access	no access	
Point Bennett	5/23/94	1	1	0	2
Simonton Beach	5/22/94	3	6	1	10
Total		7	10	4	21
1995					
Bowl Cove	5/24/95	1	1	0	2
Cardwell Point	5/23/95	no access	no access	no access	
Crook Point	5/23/95	no access	no access	no access	
Cuyler Harbor	5/23/95	no access	no access	no access	
Glass Float Beach	5/23/95	no access	no access	no access	
Simonton Beach	5/24/95	0	1	3	4
Total		1	2	3	6
1996					
Bowl Cove	5/22/96	0	0	0	0
Cardwell Point	5/23/96	no access	no access	no access	
Crook Point	5/23/96	no access	no access	no access	
Cuyler Harbor	5/23/96	0	0	0	0
Glass Float Beach	5/23/96	0	0	2	2
Simonton Beach	5/22/96	1	0	0	1
Total		1	0	2	3

Santa Rosa Island. The highest number of adults observed during the spring survey on Santa Rosa Island occurred in 1993 when 121 adults were recorded (Table 2). The number has declined since then with 95 in 1994, 71 in 1995, and 83 in 1996.

The number of pairs observed in 1993 was not available. In 1994, four pairs were observed. Twelve pairs observed in 1995 and 22 pairs observed in 1996.

Five nests were observed in 1993—two at Skunk Point, 1 at Bee Rock, 1 at Sandy Point, and 1 at Arlington. One brood of 1 chick was observed with the male parent at Mud Tank Beach in 1995. The chick was approximately half the size of the adult and no downy feathers were apparent. In 1996, one brood of 2 half-grown chicks was observed with the male parent at Old Ranch House Canyon. A single chick approximately two-thirds adult size was also observed with the male parent on Tecolote Beach in 1996.

Table 2 Mid-breeding season Snowy Plover census on Santa Rosa Island, 1993–1996

Beaches	Date	Males	Females	Unsexed adults / unknown age adult-sized	Total adults
1993					
Abalone Rocks/East of Abalone Rocks	5/18/93	0	0	0	0
Arlington	5/20/93	2	2	0	4
Bee Rock (East and West)	5/19/93	4	7	0	11
China Camp/Cluster Point	5/19/93	13	14	0	27
Marsh	5/18/93	2	6	0	8
Mud Tank	5/19/93	2	2	0	4
Officer's Beach				not checked	
Old Ranch Canyon	5/18/93	11	10	1	22
Old Ranch House Canyon	5/18/93	5	5	1	11
Sandy Point	5/19/93	0	1	0	1
Skunk Point	5/18/93	17	9	2	28
Soledad	5/20/93	0	1	0	1
Southeast Anchorage	5/18/93	1	1	0	2
Tecolote				not checked	
Whetstone Beach	5/19/93	1	1		2
Total		**58**	**59**	**4**	**121**
1994					
Abalone Rocks/East of Abalone Rocks	5/25/94	1	1	0	2
Arlington	5/27/94	4	0	0	4
China Camp/Cluster Point	5/26/94	8	6	7	21
Bee Rock (East and West)	5/26/94	3	2	1	6
Marsh	5/25/94	5	3	4	12
Mud Tank	5/26/94	0	0	0	0
Officer's Beach	5/25/94	0	0	0	0
Old Ranch Canyon	5/25/94	6	5	0	11
Old Ranch House Canyon	5/25/94	14	8	0	22
Sandy Point				not checked	
Skunk Point	5/25/94	9	2	2	13
Soledad	5/27/94	0	0	0	0
Southeast Anchorage	5/25/94	2	1	1	4
Tecolote				not checked	
Whetstone Beach	5/26/94	0	0	0	0
Total		**52**	**28**	**15**	**95**
1995					
Abalone Rocks/East of Abalone Rocks	5/31/95	0	0	0	0
Arlington	5/30/95	2	2	2	6
Bee Rock (East and West)	6/1/95	0	0	1	1
China Camp/Cluster Point	6/1/95	5	4	2	11
Marsh	5/31/95	2	1	0	3
Mud Tank	6/1/95	2	1	0	3
Officer's Beach	6/2/95	0	0	0	0
Old Ranch Canyon	5/31/95	4	6	2	12
Old Ranch House Canyon	5/31/95	4	5	2	11
Sandy Point	6/1/95	0	0	0	0
Skunk Point	5/31/95	9	6	8	23
Soledad	5/30/95	0	0	0	0
Southeast Anchorage	5/31/95	0	1	0	1
Tecolote				not checked	
Whetstone Beach	6/1/95	0	0	0	0
Total		**28**	**26**	**17**	**71**
1996					
Abalone Rocks/East of Abalone Rocks	6/16/96	2	1	0	3
Arlington	6/14/96	0	1	0	1
Bee Rock (East and West)	6/15/96	3	4	0	7
China Camp/Cluster Point	6/15/96	5	3	3	11
Marsh	6/16/96	2	3	0	5
Mud Tank	6/15/96	0	0	0	0
Officer's Beach	6/16/96	0	0	0	0
Old Ranch Canyon	6/16/96	6	8	2	16
Old Ranch House Canyon	6/16/96	5	7	0	12
Sandy Point				not checked	
Skunk Point	6/16/96	8	6	0	14
Soledad	6/14/96	0	0	0	0
Southeast Anchorage	6/16/96	0	0	0	0
Tecolote	6/17/96	8	4	2	14
Whetstone	6/15/96	0	0	0	0
Total		**39**	**37**	**7**	**83**

Table 3 Late fall Snowy Plover census on Santa Rosa Island, 1993–1996

Date	Number Observed
27 Nov–29 Nov 1993	307
29 Nov–2 Dec 1994	323
1 Dec–4 Dec1995	297
29 Nov–3 Dec 1996	291

Winter Population

Santa Rosa Island. The late fall census was conducted on Santa Rosa Island each year between 27 November and 4 December. The total number of Snowy Plovers observed on each census was 307, 323, 297, and 291 in 1993, 1994, 1995, and 1996 respectively (Table 3).

San Miguel Island. Winter censuses were not conducted on San Miguel Island.

Banded Birds

Santa Rosa Island. Table 4 shows banded bird sightings on Santa Rosa Island between October 1993 and November 1996. These re-sights have been reported to the Bird Banding Lab. Most of these birds were banded as adults in Monterey Bay by Point Reyes Bird Observatory. A female plover banded as a breeder in Monterey Bay has been observed wintering at the same area on Santa Rosa Island 3 times over a 4-year period. There have been no sightings of chicks banded on Santa Rosa Island in 1993 (Stein, 1993).

San Miguel Island. No banded birds have been observed at San Miguel Island.

Additional Species

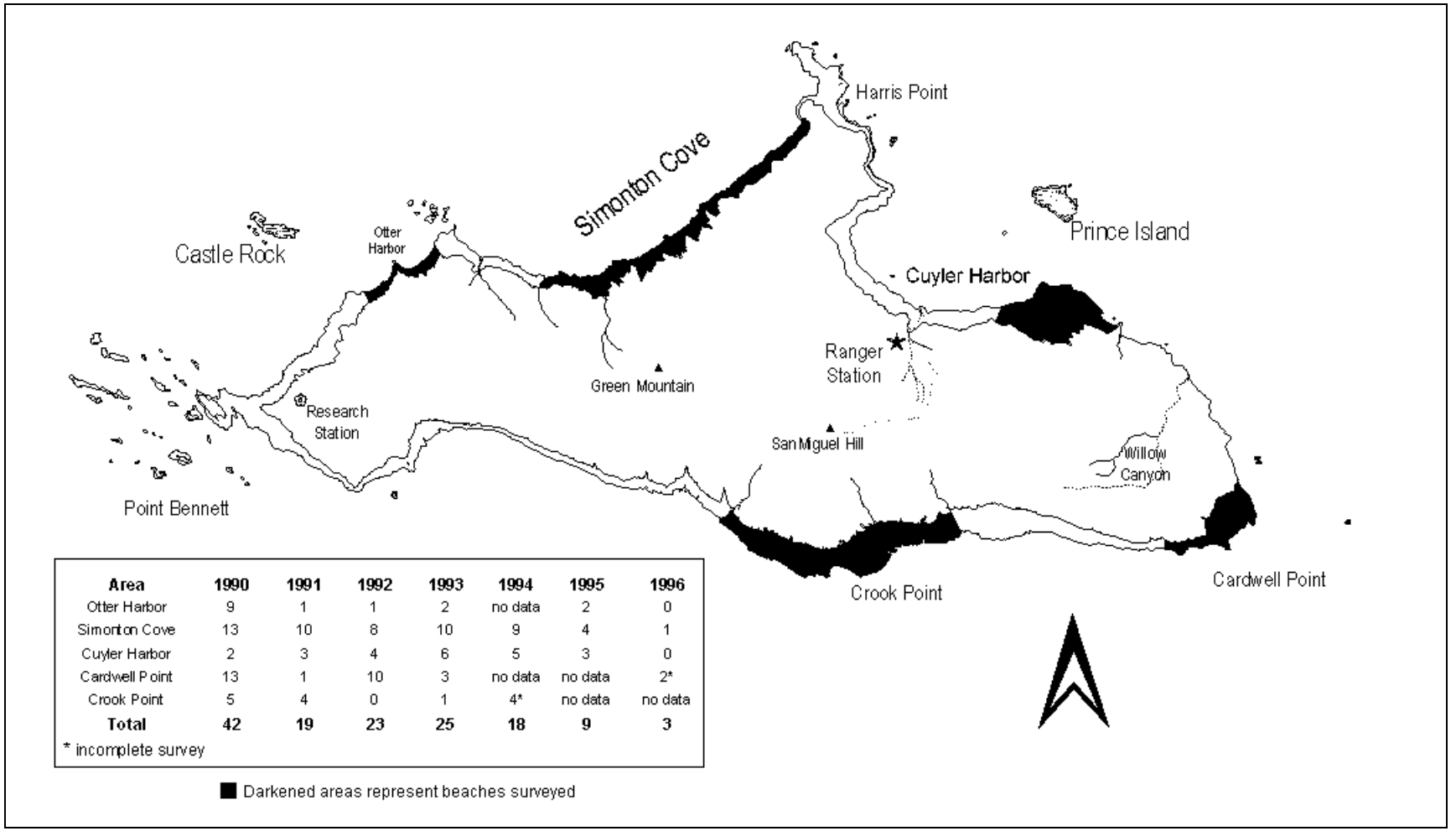
While counting plovers at Santa Rosa Island, moderate effort was made to count cormorants along the census route. Cormorants were routinely encountered at Cluster Point, Dry Canyon Beach and Skunk Point, as well as the vicinity of Officer's Beach. Efforts were always made to estimate numbers of individuals in these flocks.

A bird species list was kept during each plover census. This information is archived at Channel Islands National Park headquarters and is not presented in this report, except to note that the Fall censuses of Santa Rosa Island revealed the island's importance for the Pacific Flyway migration of shorebirds.

Black-Bellied Plover numbers are higher in October than in November, reflecting migration. Usually about 1000 birds were observed.

Table 4 Banded Snowy Plover sightings at Santa Rosa Island

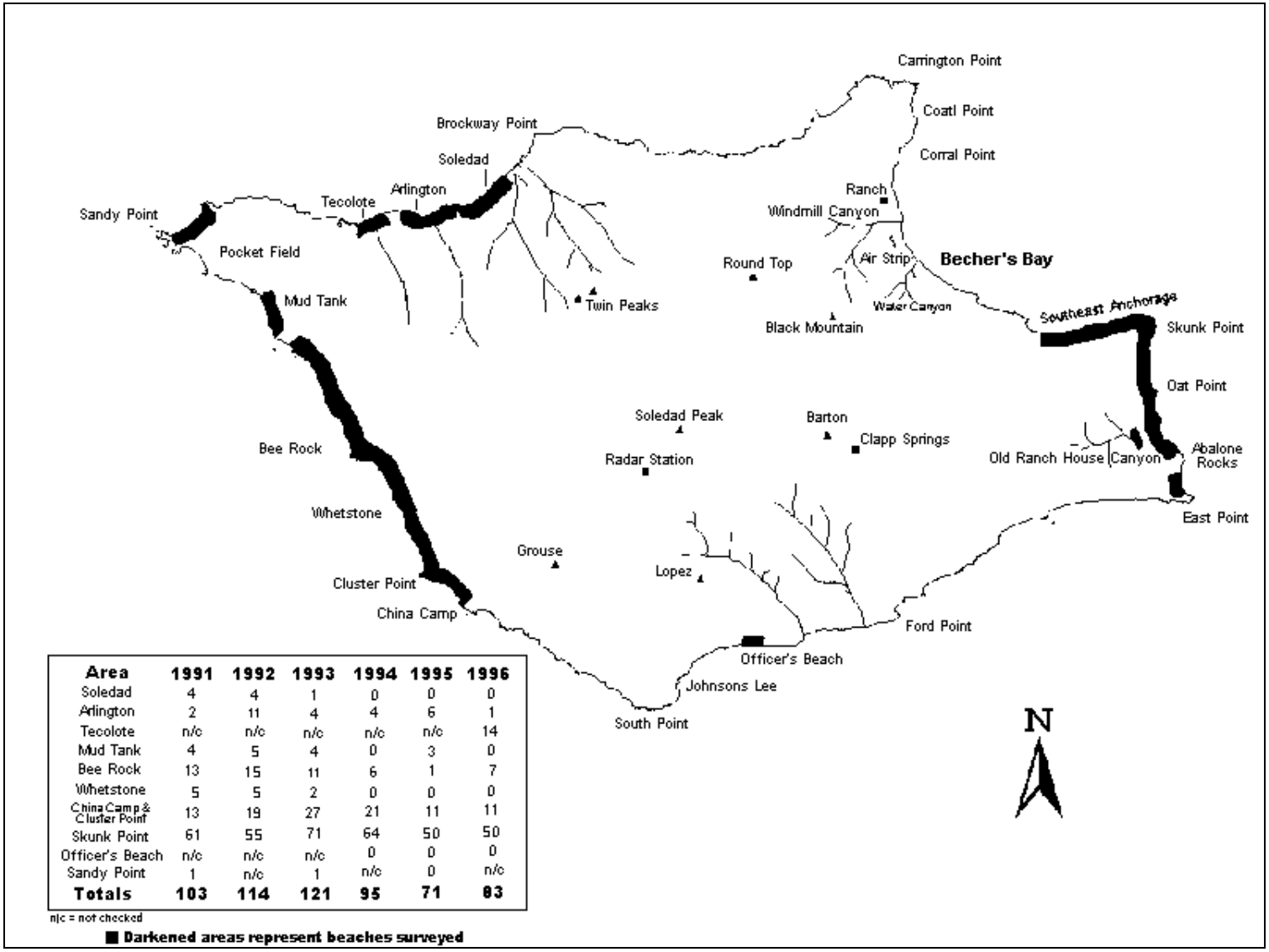
Band combination left leg	Band combination right leg	Date(s) observed	Beach where observed	Total # of birds in flock
aqua over orange	orange over lime	10/31/93	Whetstone	47
aqua over orange	orange over lime	10/27/94	Whetstone	39
aqua over orange	orange over lime	12/1/94	Whetstone	38
aqua over orange	orange over lime	12/1/96	Cluster Point	72
aqua over orange	orange over lime	12/22/96	China Camp	unknown
white	orange-aqua-orange	11/28/93	Skunk Point	94
black over black	blue over white	12/1/94	West Bee Rock	66
white over lime	white over lime	11/4/95	Skunk Point	124
white over lime	white over lime	12/2/95	Skunk Point	70
none	black over orange	11/4/95	Skunk Point	124
orange over white	blue over white	11/5/95	West Bee Rock	21



Area	1990	1991	1992	1993	1994	1995	1996
Otter Harbor	9	1	1	2	no data	2	0
Simonton Cove	13	10	8	10	9	4	1
Cuyler Harbor	2	3	4	6	5	3	0
Cardwell Point	13	1	10	3	no data	no data	2*
Crook Point	5	4	0	1	4*	no data	no data
Total	**42**	**19**	**23**	**25**	**18**	**9**	**3**

* incomplete survey

Figure 1 Breeding Snowy Plover distribution at San Miguel Island, 1990–1996



Area	1991	1992	1993	1994	1995	1996
Soledad	4	4	1	0	0	0
Arlington	2	11	4	4	6	1
Tecolote	n/c	n/c	n/c	n/c	n/c	14
Mud Tank	4	5	4	0	3	0
Bee Rock	13	15	11	6	1	7
Whetstone	5	5	2	0	0	0
China Camp & Cluster Point	13	19	27	21	11	11
Skunk Point	61	55	71	64	50	50
Officer's Beach	n/c	n/c	n/c	0	0	0
Sandy Point	1	n/c	1	n/c	0	n/c
Totals	**103**	**114**	**121**	**95**	**71**	**83**

Figure 2 Breeding Snowy Plover disribution at Santa Rosa Island, 1991–1996

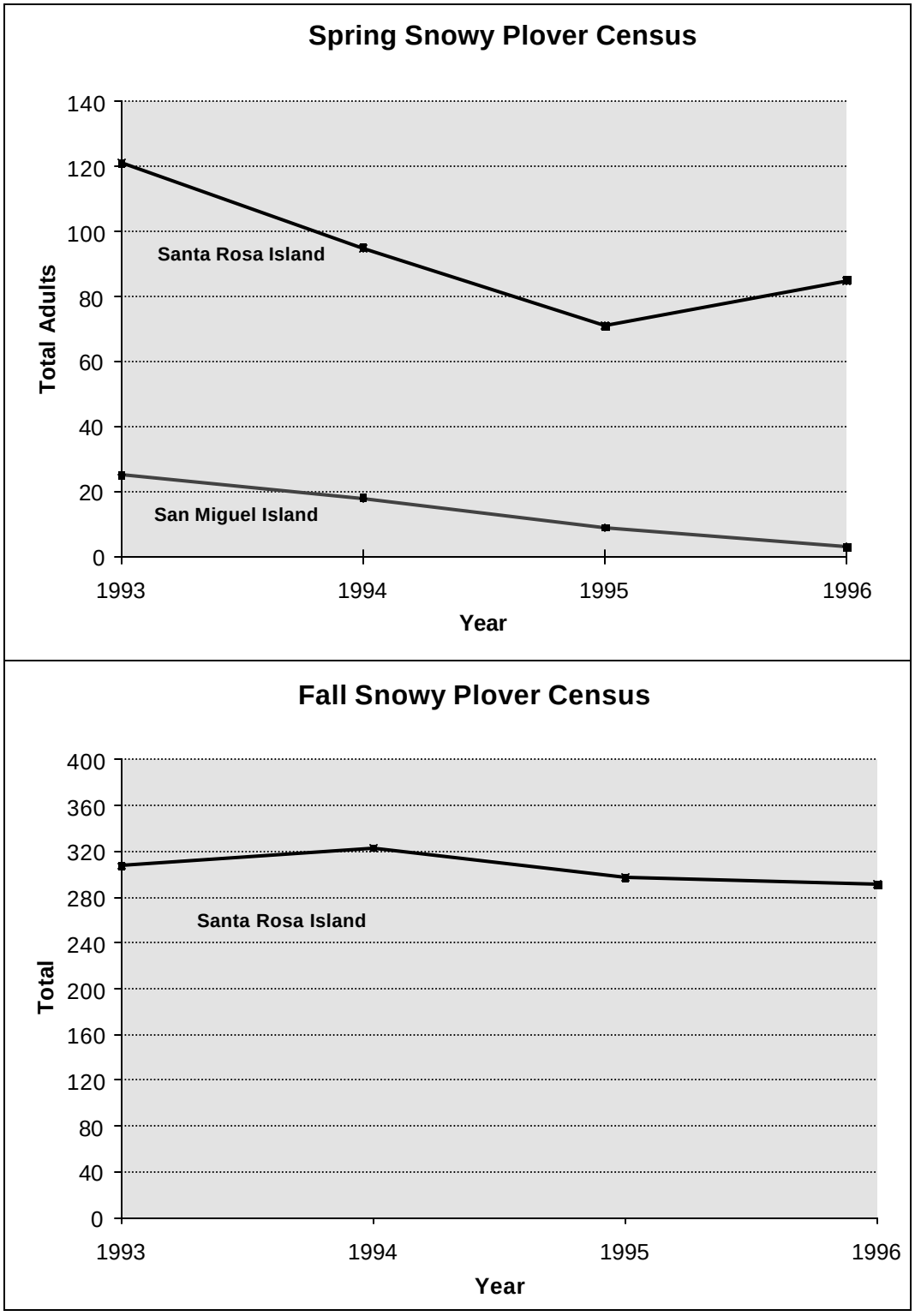


Figure 3 Total numbers of Snowy Plovers observed during spring counts (breeding population) at Santa Rosa Island and San Miguel Island; fall (wintering population) counts at Santa Rosa Island, 1993–1996

Table 5 Phenology of Western Gulls breeding at East Anacapa Island, 1993–1996

Year	First eggs	Peak clutch initiation	First hatched eggs	Peak hatch
1993	late April	early May	late May	1st week of June
1994	late April	early May	late May	late May/early June
1995	late April	early May	3rd week of May	late May/early June
1996	April 19	late April/early May	May 20	late May/early June

Western Gull

Monitoring Western Gulls on East Anacapa Island involved searching two 50x50 meter grids (A and B) for nests with eggs. Once found, nests were marked with an identifying wooden stake and the location was recorded on a map for future reference. Upon subsequent visits, nest contents were verified and monitored. As chicks hatched they were marked and weighed. Individual chicks were followed as long as possible. Survival to 500 gm or fledging was determined based on weight measurements or from observations made of the colony through a spotting scope. Small color markers were attached to the leg until the tarsus was large enough to hold a U.S. Fish and Wildlife Service (USFWS) band.

1993–1995

Nest checks began on 27 April, 30 April, and 25 April in 1993-1995 (respectively). Periods between checks were 8–20 days in 1993, 4–12 days in 1994, and 6–14 days in 1995 .

1996

In 1996 gulls on East Anacapa Island were monitored every 5 days between 25 April and 2 July. The chicks were monitored once a week for the remainder of July.

Accessing Fledging Success

In 1994, we noticed that the monitored sites could be observed from approximately 200 meters away with a spotting scope. Once the majority of chicks reach 500 grams, a great deal of disturbance is caused by persons stepping off the trail and into the colony. Observing the nests from afar appeared to alleviate this problem. This allowed for a secondary observation to determine if missing chicks could be seen at nest sites. We began making observations late in the 1994 season. This proved to be more of a trial run for observing chicks from the Landing Cove. In 1995 and 1996, the nest sites were observed through a spotting scope preceding or following nest checks in the colony.

The Mann-Whitney U-test was used to compare number of eggs laid, number of chicks hatched, and number of chicks fledged between grids. Hatching success was determined by calculating the proportion of eggs hatched per number of eggs laid. Fledging success was determined by calculating the proportion of chicks fledged per number of eggs hatched. Productivity was determined by calculating number of chicks fledged per nest attempt. A nesting attempt is defined as a nest with eggs.

Phenology

Phenology at East Anacapa Island for all 4 years was similar (Table 5). The first eggs were laid in late April, peak clutch initiation occurred in early May, first hatched eggs were observed in late May, and peak hatch occurred in late May/early June. This pattern was similar to that observed at Santa Barbara Island (Figure 5, Section 2; Figure 7, Section 3; Figure 14 and Figure 15, Section 4).

Reproductive Effort

There were no significant differences between grids or between years in average clutch size, number of chicks hatched, or number of chicks fledged. The

Table 6 Number of nest attempts, mean clutch size (± s.d.), chicks hatched, chicks fledged, and other breeding parameters for Western Gulls at East Anacapa Island, 1993–1996

Reproductive success	Grid A	Grid B	Total (A+B)
1993			
Number of Nest Attempts	28	35	63
Clutch Size	2.86 ± .36	2.80 ± .47	2.83 ± .42
Number of Chick Hatched	2.36 ± .87	2.26 ± 1.09	2.30 ± .99
Number of Chicks Fledged	1.29 ± .94	0.89 ± .87	1.06 ± .91
Hatching Success	83%	81%	81%
Fledging Success	55%	39%	46%
1994			
Number of Nest Attempts	36	35	71
Clutch Size	2.53 ± .61	2.83 ± 1.20	2.68 ± .95
Number of Chick Hatched	1.56 ± 1.27	1.94 ± 1.66	1.75 ± 1.48
Number of Chicks Fledged	0.72 ± 1.20	0.94 ± 1.02	0.79 ± 1.10
Hatching Success	62%	69%	65%
Fledging Success	46%	44%	45%
1995			
Number of Nest Attempts	37	30	67
Clutch Size	2.76 ± .44	2.70 ± .53	2.73 ± .48
Number of Chick Hatched	2.70 ± 1.31	2.17 ± .95	2.44 ± 1.17
Number of Chicks Fledged	1.36 ± .93	1.47 ± 1.11	1.41 ± 1.01
Hatching Success	98%	80%	89%
Fledging Success	50%	68%	58%
1996			
Number of Nest Attempts	35	34	69
Clutch Size	2.63 ± .6	2.68 ± .47	2.65 ± .54
Number of Chick Hatched	1.83 ± 1.10	1.74±1.05	1.78 ± 1.07
Number of Chicks Fledged	0.97 ± .92	0.94 ± .92	0.96 ± .91
Hatching Success	70%	65%	67%
Fledging Success	53%	54%	54%

number of nesting attempts, eggs laid, chicks hatched, and chicks fledged (productivity) for each year in each grid is provided in Table 6 Table 7 summarizes other aspects of reproductive effort at East Anacapa Island.

Between-Island Comparisons

Clutch Size

Clutch size was always larger at Anacapa Island than Santa Barbara Island although it does not appear significant (Figure 4, A).

Table 7 Reproductive effort of Western Gulls at East Anacapa Island, 1993–1996

Parameter	1993			1994			1995			1996		
	A	B	Total	A	B	Total	A	B	Total	A	B	Total
Nest Attempts	28	35	63	36	35	71	37	30	67	35	34	69
Eggs Laid (nests)	80(28)	98(35)	178(63)	91(36)	90(35)	181(71)	91(33)	81(30)	172(63)	92(35)	91(34)	183(69)
Chicks Hatched (nests)	66(26)	79(30)	145(56)	56(24)	59(26)	115(50)	82(33)	65(28)	147(61)	64(29)	59(29)	123(58)
Chicks Fledged (nests)	36(21)	31(20)	67(41)	18(12)	33(17)	51(29)	53(31)	44(22)	97(53)	34(23)	32(21)	66(44)

Hatching Success

Hatching succsss was almost always higher at Anacapa Island; it was slightly higher at Santa Barbara Island in 1994 (Figure 4, B).

Fledging Success

Fledging success, a measure of the number of hatched chicks that survive, was similar between islands. There were noticeable differences in 1990 and 1993 when fledging success was higher at Santa Barbara Island, and at East Anacapa Island when it was higher in 1995. In general, all components of productivity were higher at East Anacapa Island in 1995 (Figure 4, C).

Productivity

Productivity is defined as the number of chicks fledged per nest attempt. In general, gulls were more successful in 1991 and 1995 at East Anacapa Island than at Santa Barbara Island. Gulls were more successful at Santa Barbara Island in 1994; indeed this was the only year in which productivity was higher at Santa Barbara Island than East Anacapa Island (Figure 4, D).

Population Size

No population estimates were made for East Anacapa Island. Anecdotal evidence suggests that numbers may have decreased on the East end of the island between 1993 and 1995 (Steve James, Tree Gottshall, personal communications; personal observation).

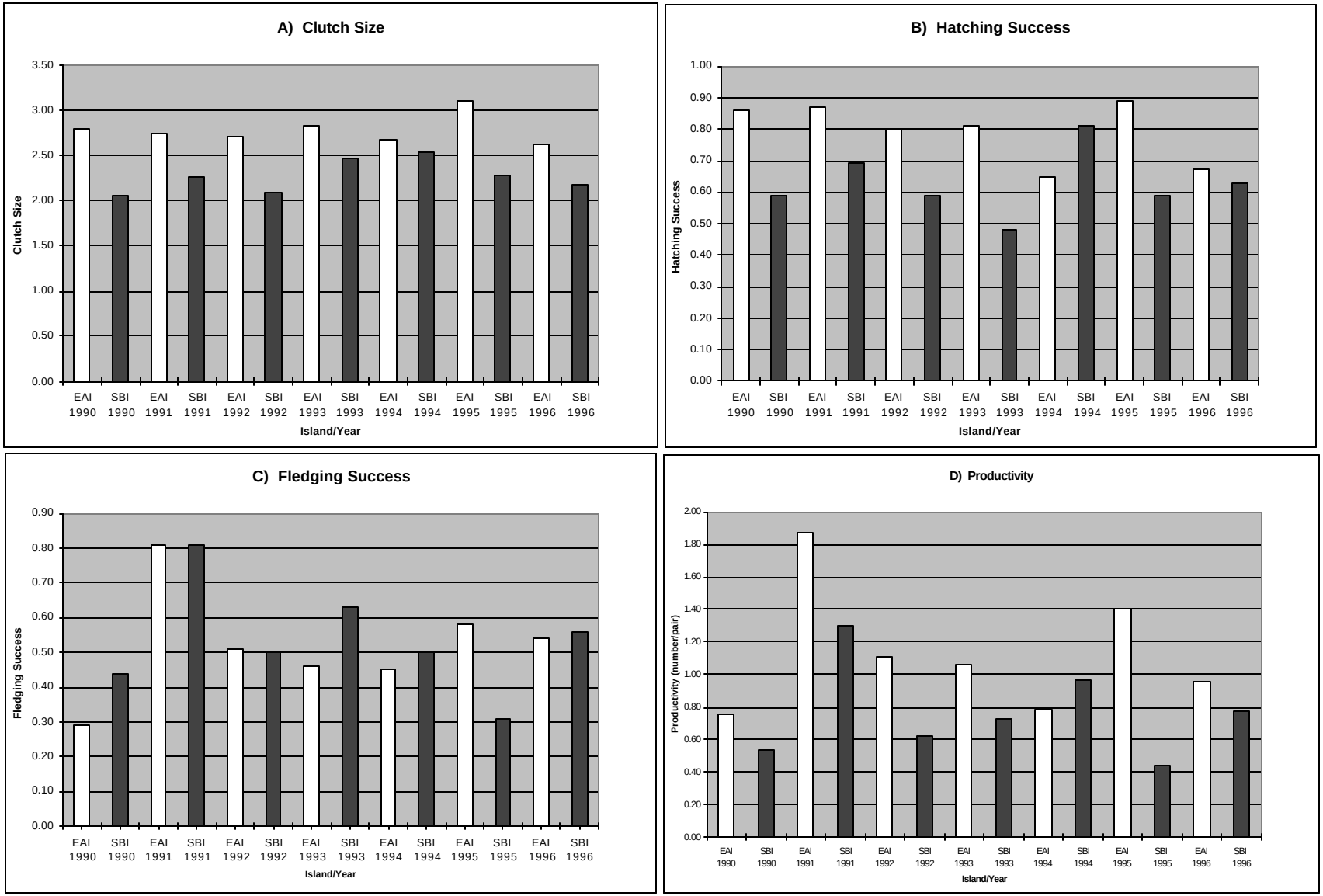


Figure 4 Components of productivity of Western Gulls at East Anacapa Island and Santa Barbara Island, 1990–1996

Table 8 Reproductive effort of Cassin's Auklet on Prince Island, 1993–1996

Year	Hatching success	Fledging success	Productivity
1993	0.95 ± 0.22 (42)	1.00 ± 0.00 (8)	0.80 ± 0.42 (10)
1994	0.85 ± 0.37 (39)	0.83 ± 0.39 (12)	0.59 ± 0.50 (32)
1995	unknown	unknown	unknown
1996	0.88 ± 0.35 (8)	1.00± 0.00 (5)	0.83 ± 0.4135 (6)

Cassin's Auklet

Methods

Monitoring the 50 Cassin's Auklet nest boxes at Prince Island (located within Cuyler Harbor, San Miguel Island) has proven to be a difficult task for Channel Islands National Park staff. Monitoring nest boxes provides an index of productivity, and while the Seabird Monitoring Handbook (Lewis, et al. 1988) calls for checks every 10 days, monitoring has always been hampered by foul weather and logistical problems. Prince Island is 60 miles from Channel Islands National Park headquarters, and its proximity to Point Conception places it within the roughest seas in the Park. Auklets begin nesting in early spring (March) when weather is unpredictable and often causes cancellation of trips which must be scheduled well in advance.

Monitoring in 1993 was completed by Channel Islands National Park staff. Auklet boxes were checked in 1994 by USGS/BRD. Two trips were made by Channel Islands National Park staff in 1996. One of those trips was graciously provided by Channel Islands National Marine Sanctuary.

Results

Seven trips were scheduled before Channel Islands National Park staff made it to Prince Island in 1993. One trip occurred well into the season after most of the chicks had hatched and one at the end of the season after almost all chicks had fledged. From these two trips in 1993 (on 20 May and 8 July), we determined that minimum box occupancy was 84%.

Data for 1993–1996 were summarized by Point Reyes Bird Observatory. Reproductive effort of Cassin's Auklet is presented in Table 8. Hatching success, fledging success, and productivity were lower in 1994 than in 1993 and 1996, but 1994 was the only year with a reasonable sample of nests successfully monitored for productivity. Sample sizes are small because limited visits to the colony within the breeding season resulted in unknown egg and chick fates. No data are available for 1995 because of insufficient sampling effort.

Weight was used as a fledging criteria by Point Reyes Bird Observatory. All chicks last observed at 100 grams or greater were considered to have fledged. Amount of feathering was used as fledging criteria in 1994. All chicks last observed as gawky (small, medium, or large gawky) were considered to have fledged.

In 1994, Auklets began nesting in early March. Data collected in 1994 revealed that nest box occupancy was 80%. Twelve trips were made between 9 March and 7 June.

No data were collected for the 1995 season. The first trip in 1995 was made on 6 April. However, this turned out to be before nest initiation. Our next trip was not made until August by which time all chicks had fledged. Since Auklets did not begin nesting until after our first trip in April, we were only able to determine that nesting began later than normal.

In two trips in 1996 (14 April and 20 June), we estimated that nesting began in early March. We determined that minimum box occupancy at the southeast sites was 80%. The North Auklet sites were not visited at all in 1996. Table 9 shows the

Table 9 Cassin's Auklet nest box check schedule on Prince Island

Year	Dates checked	Checked by
1993	5/20, 7/8	National Park Service
1994	3/10, 3/17, 3/18, 3/21, 3/26, 4/13, 4/25, 4/30, 5/4, 5/13, 5/28, 6/3, 6/4, 6/7	Biological Resources Division (USGS)
1995	Unknown	Biological Resources Division
1996	4/14, 6/20	National Park Service

dates on which nest boxes were checked and which agency checked them.

DISCUSSION

Snowy Plover

Future Snowy Plover (and Cassin's Auklet) censuses should be planned with a *scheduled* backup date to accommodate poor weather conditions. Some flexibility should be built into the census period and transportation as weather conditions in the Spring can vary from calm to 30–40 knot winds—the latter being unacceptable for censusing Snowy Plovers. High winds can cause eggs to be lost if the adults leave the nest unattended because of disturbance.

Declining numbers on the north side of San Miguel Island are cause for great concern. Moreover prohibiting access because of of pinnipeds on the south side of San Miguel Island has left unacceptable gaps in our database. Presently we cannot determine what is happening on San Miguel Island based on observations of the north beaches alone because there are likely differences in population trends between habitats (e.g. pinnipeds may beimpacting the population on the south side). The 1997 Snowy Plover census for the South side of San Miguel Island will be coordinated with censuses conducted by National Marine Fisheries personnel during their work with pinnipeds. The Park will work with National Marine Fisheries to obtain the proper permits necessary for us to access the South side of the island given the sensitive nature of censusing Snowy Plovers in the presence of pinnipeds.

The apparent decline at Santa Rosa Island also needs to be addressed. The number of birds observed in 1993 is probably the most we should expect to see at Santa Rosa Island (G. Page, Point Reyes Bird Observatory, personal communication). Based on the amount of available habitat, the island could support approximately 100 breeding birds. However, since numbers have dropped well below 100 we should consider comparing what is known about plover use of other islands in the Santa Barbara Channel. For instance, birds may be moving between Santa Rosa Island, Santa Cruz Island, San Nicolas Island, and San Miguel Island in different years. Monitoring of Frasier Point at Santa Cruz Island should be initiated. The proximity of Frasier Point to Skunk Point makes it conceivable that the birds may use both points for breeding. We should also determine if predation is affecting productivity.

Western Gull

East Anacapa Island receives the highest public visitation in Channel Islands National Park and provides an excellent opportunity to observe how public access affects wildlife. Gull nest monitoring on East Anacapa Island should continue on a 5-day check schedule to ensure clean, interpretable data.

We should also initiate gull population estimates which could be made by counting from the vantage points available on the island. It is possible to count a large proportion of the population at the

east end from the lighthouse and another large proportion at the West end from the mid-island overlook. There are additional vantage points from which to count smaller segments of the population.

The gull population on Prince Island is no longer monitored because infrequent and unpredictable visits do not allow us to determination of phenology or reproductive success; accurate estimates of phenology are also needed to assess when to conduct population surveys

Cassin's Auklet

A regular schedule should be implemented for auklets at Prince Island. We have not been able to visit Prince Island enough to determine trends in occupancy or productivity on a regular basis. Channel Islands National Park should either invest in making trips to Prince Island a priority or discontinue monitoring this species and site. The best data between 1993 and 1996 was collected by USGS/BRD in 1994. We cannot rely on other organizations to provide this information especially given that this population appears to be declining (Carter et al. 1992).

Since there may be differences between the two sides of the island, we should continue monitoring both sites even though we may not be able to visit both sites at the same time. Furthermore, we should consider installing an additional 25 boxes at the South site to increase the sample size especially for the years when the North side is inaccessible and/or fewer trips are made altogether.

Last, overall our effort should be increased to obtain better information from the nest box colony at Prince Island. Birds at Prince Island, and Cassin's Auklets in particular, may provide valuable information on the marine environment, zooplankton, fishstocks, and fisheries in the Southern California Bight. To facilitate this goal, we should consider staging an inflatable boat at Cuyler Harbor. When weather allows, Channel Islands National Park staff could then fly to San Miguel Island and motor across the harbor to Prince Island.

Section 2

Seabird Monitoring at Santa Barbara Island, 1993-1994

Previously Presented as a Technical Report to
Channel Islands National Park
Ventura, California

POPULATION SIZE, PHENOLOGY, AND PRODUCTIVITY OF SEABIRDS ON SANTA BARBARA ISLAND, 1993–1994

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ABSTRACT

We monitored population size, phenology and productivity of Double-Crested and Brandt's cormorants, Western Gulls, and Xantus' Murrelets on Santa Barbara Island during the 1994 breeding season. In addition, we analyzed Channel Island National Park seabird monitoring data from 1993. Double-Crested Cormorants bred in similar numbers (about 250 pairs) and productivity was approximately 1 chick per breeding pair in both years of the study. Brandt's Cormorants also bred in similar numbers both years (about 425 pairs); productivity was roughly 1.6 chicks fledged per pair in both years. The Western Gull population appears to be growing rapidly with an estimated 1994 size of 4000 breeding pairs; productivity was estimated at just under 1 chick per pair for each year. The population size of Xantus' Murrelets was not estimated for either year due to difficulties with censusing this nocturnal, crevice-nesting species. Murrelet clutch size was similar between years, but hatching success was much higher in 1993 than 1994, presumably due to a higher rate of egg predation by mice in the latter year. Productivity was roughly 0.8 chicks per pair in 1993 and 0.5 chicks per pair in 1994. We also initiated monitoring work on Ashy, Leach's, and Black Storm-Petrels by conducting a mark-recapture study at standardized mist-netting locations. Consistent mark-recapture operations at these locations will provide an index on population trends of these important species in future years. Conservation of seabirds on Santa Barbara Island would be facilitated by: 1) reductions in human disturbance to breeding birds, 2) investigations on the feasibility of using nest boxes as a habitat management tool (Xantus' Murrelet, Storm-Petrels), 3) further studies on population trends by increasing field work on certain species (Xantus' Murrelet and Ashy Storm-Petrel), and 4) development of population trajectory simulations (Xantus' Murrelet) to synthesize information on conservation problems in relation to the current status of populations.

INTRODUCTION

Seabird monitoring is an accumulation of time series data on any aspect of seabird distribution, abundance, demography, or behavior. The value of monitoring seabird populations is twofold. First, wildlife managers and members of the public concerned with particular species or populations that may be affected by human use of coastal or marine resources need these data to document and understand impacts. Second, seabirds respond quickly to environmental perturbations and thus provide real-time information on the abundance of organisms in lower trophic levels in coastal marine ecosystems (Croxall et al. 1988). In short, monitoring seabirds provides important information on both natural and anthropogenic changes in coastal marine environments and provides oceanographers, fisheries biologists, and wildlife managers with timely and accurate information on the status of marine systems of interest.

In recognition of legitimate concerns for the welfare of seabirds in Southern California and the contributions seabirds can make to monitoring marine ecosystems, Channel Islands National Park established a Seabird Monitoring Program in 1985. Important and continuing threats to Channel Islands National Park seabirds include mortality due to the introduction of predators, oil and chemical pollution, and incidental catch in fishing gear. Other aspects of seabird demography (e.g. survival and/or reproduction) may be reduced through alteration of marine food webs by over-exploitation of prey and human disturbance to nesting birds on island colonies.

This report summarizes monitoring of Double-Crested (*Phalacrocorax auritus*) and Brandt's Cormorant (*Phalacrocorax penicillatus*), Western Gull (*Larus occidentalis*) and Xantus' Murrelet (*Synthliboramphus hypoleuca*) on Santa Barbara Island, Channel Islands National Park, in 1993 and 1994. In 1993, data were collected by the Channel Islands National Park Seabird Monitoring Program supervised by Paige Martin; Paige Martin, Jack Feldman, Steve Meyers, Frank Gress, and Tony Flaherty collected data. In 1994, data were collected primarily by Jack Feldman under contract PX8120-94-248 between Point Reyes Bird Observatory and Channel Islands National Park. Paige Martin and Clint Arnett collected data early in the breeding season before the Point Reyes Bird Observatory contract was established. We (Feldman and Sydeman) summarized and analyzed data from both years. The Channel Islands National Park Seabird Monitoring Handbook provides a synopsis of species and parameter selection and the general methodology used to investigate population size, phenology and productivity of seabirds in Channel Islands National Park (Lewis et al. 1988). More specific methodology pertaining to our analyses are detailed below under each species account. This is Point Reyes Bird Observatory contribution no. 674.

METHODOLOGY AND RESULTS

Double-Crested Cormorants

Methodology

Double-Crested Cormorants nested in traditional sites on Santa Barbara Island in 1993 and 1994—North Cliffs, West Cliffs, and Sutil Island (see Figure 11 in Ingram and Jory-Carter in press). In 1993, thirteen land-based censuses were made from various locations on the island throughout the breeding season between 5 May and 31 August. Additionally, a boat-based survey of Santa Barbara Island and Sutil Island was conducted on 18 June, and an aerial survey by the National Biological Survey (NBS) was conducted on 21 June. In 1994, seven land-based censuses were made from various locations on the island between 12 May and 13 August. Additionally, a boat-based survey of Santa

Table 10 Summary of Double-Crested Cormorant population size and reproduction on Santa Barbara Island, 1993

Subcolony	Number of occupied nests [a]	Estimated number of young fledged	Number of abandoned nests [b]
West Clffs 1*	17	19	4
West Clffs 2*	10	10	3
West Clffs 3*	37	40	3
West Clffs 4	64	ND	ND
North Peak 1*	27	14	5
North Peak 2*	15	9	3
North Peak 3*	3	1	2
North Peak 4*	12	8	0
North Peak 5	0	0	0
North Peak 6*	19	23	3
E. of Webster Point	4	ND	ND
Shag Rock*	2	2	0
Sutil Island*	71	29	0
Sample Total [b]	161	155	23
Colony-Wide Total [c]	281	(266)	(40)

[a] Nests with adults in incubation or brooding postures; exact nest contents unknown

[b] Sample data were derived from areas marked with asterisks; on Sutil Island, 19 observable nests were used

[c] Data in parentheses are estimates based on samples. Estimated productivity (chicks fledged/nest) = 155/161=0.96

Barbara Island and Sutil Island was conducted on 16 July. An aerial survey by the NBS was conducted on 15 and 16 May, but those data are not available and are not included in this report.

To estimate productivity, we conducted counts of wandering chicks for each sub-colony late in each breeding season. In 1994, counts were made when many chicks were wandering great distances from nest sites. Therefore, in both years, but particularly in 1994, fledged chicks could have been missed, thus biasing productivity estimates toward low values.

Phenology

In both 1993 and 1994, timing of breeding was similar. In 1993, egg-laying initiated in early May and continued until mid-July with the peak in early to mid-June. The first chick was observed on 21 June. Fledging was completed by mid- to late August. In 1994, egg-laying began in early May and continued until late June with the peak in late May. Peak hatching was between late May and early June, and fledging was completed by mid- to late August.

Population Size and Productivity

In 1993, we estimated 281 breeding pairs of Double-Crested Cormorants on Santa Barbara Island (Table 10). These data represent the peak number of nests observed at each location during land-based surveys. In 1994, we tallied 240 breeding pairs but this estimate does not include NBS aerial survey data (Table 11). In 1993 and 1994, productivity (chicks fledged per breeding pair) was similar: 0.96 (155/161) in 1993 and 0.89 (155/175) in 1994. Nest abandonment in 1993 (14.3%) was higher than in 1994 (6.9%). The estimated number of chicks per successful pair (i.e., excluding nests which were abandoned or where chicks died for various reasons) was 1.76 and 1.88 for 1993 and 1994, respectively.

Table 11 Summary of Double-Crested Cormorant population size and reproduction on Santa Barbara Island, 1994

Subcolony	Number of occupied nests [a]	Estimated number of young fledged	Number of abandoned nests [b]
West Clffs 1*	38	22	1
West Clffs 2*	28	23	0
West Clffs 3*	14	11	2
West Clffs 4	20	ND	ND
North Peak 1*	48	39	5
North Peak 2*	14	10	1
North Peak 3*	6	6	0
North Peak 4*	12	9	0
North Peak 5	0	0	0
North Peak 6*	8	26	1
North Peak 7*	3	8	1
Shag Rock*	4	1	1
Sutil Island*	45	ND	2
Sample Total [b]	**175**	**155**	**12**
Colony-Wide Total [c]	**240**	**(233)**	**(18)**

[a] Nests with adults in incubation or brooding postures; exact nest contents unknown

[b] Sample data were derived from areas marked with asterisks; on Sutil Island, 19 observable nests were used

[c] Data in parentheses are estimates based on samples; estimated productivity (chicks fledged/nest) = 155/175=0.89

Brandt's Cormorant

Methodology

Monitoring of Brandt's Cormorants on Santa Barbara Island was conducted for the first time in 1993 and continued in 1994. In 1993, Brandt's Cormorants nested in large numbers on Webster Point and in smaller numbers along cliff ledges on Sutil Island and the North Peak Cliffs (Table 12). In 1994, Brandt's Cormorants nested almost exclusively on Webster Point except for a very small group at Elephant Seal Cove Point (Table 13). We collected data on 14 dates between early May and mid-September in 1993, and on 8 dates between mid-April and mid-September in 1994. During each survey, we counted the number of nests and wandering chicks. These results may

Table 12 Population size and reproduction of Brandt's Cormorants on Santa Barbara Island, 1993

Subcolony	Number of occupied nests [a]	Estimated number of young fledged	Productivity [b]
Elephant Seal Overlook			
West Cliffs	12	9	
East Cliffs	12	32	
Middle Cliffs	43	60	
Total for Elephant Seal Overlook	76	101	1.51
Webster Point	293	438	1.49
Shag Rock	2	ND	
Sutil Island	45	ND	
Arch Point Cliffs	23	ND	
Total	**430**	**(645)**	**1.50**

[a] Nests with adults in incubation or brooding posture

[b] Estimated number of young fledged/number of occupied nests

Table 13 Population size and reproduction of Brandt's Cormorants on Santa Barbara Island, 1994

Subcolony	Number of occupied nests [a]	Estimated number of young fledged	Productivity [b]
Webster Point	325	563	1.73
Elephant Seal Overlook	10	ND	
Total	**335**	**(580)**	

[a] Nests with adults in incubation or brooding posture

[b] Estimated number of young fledged/number of occupied nests

differ from estimates of population size derived from NBS aerial surveys.

Phenology

In 1993, egg-laying began in mid-April and continued until mid- to late June with 3 distinct periods of nest initiation. In 1994, egg-laying began in early to mid-April and continued until mid- to late May, with 2 distinct periods of nest initiation.

Population Size and Productivity

We estimated 430 and 335 breeding pairs of Brandt's Cormorants in 1993 and 1994, respectively (Table 12 and Table 13). However, in 1994, the colony at Webster Point extended to an area not visible from land; therefore, the breeding population estimate for 1994 is somewhat inaccurate and not strictly comparable with the information for 1993. However, during a boat survey of the section of Webster Point not visible from land conducted on 16 July 1994 we estimated at least another 100 active nests. Therefore, we believe the population to be roughly similar (about 430 pairs) in both 1993 and 1994. Based on data from 2 colonies, Webster Point and Elephant Seal Overlook, productivity was estimated at 1.50 chicks/pair in 1993 and 1.73 chicks/pair for 1994, respectively (Table 12 and Table 13). These data are not biased by the unknown number of nests on the far-side of Webster Point in 1994.

Western Gull

Methodology

We monitored Western Gull breeding phenology, nesting success, and chick growth on Santa Barbara Island in three 1 ha plots in 1993 (see Figure 19 of Ingram and Jory-Carter, 1997). In 1994, however, in addition to grids A and D, we sampled half of grid E due to the growing population and uncertain plot boundaries. We made 9 and 7 visits to the grids in 1993 and 1994, respectively. In 1993, monitoring began on 7 May and continued until 31 August; in 1994, we began nest monitoring 11 May and continued to mid-August.

We sampled growth of Western Gull chicks at approximately 2-week intervals in both years. In 1993, we began to measure chick growth well after chicks had started to hatch. In 1994, we arrived on Santa Barbara Island as eggs were just beginning to hatch and began weighing chicks when they were very young. Consequently, for 1993 our calculations of chick growth are based on chicks which hatched relatively late in the breeding season. For 1994, however, we have calculated chick growth over the entire breeding season. Growth rates for chicks over 800 grams were not used in our calculations or analyses.

Phenology

We estimated phenology based on hatching dates of first chicks (Figure 5). In 1993, hatching began in mid- to late May and through mid-June with a peak in the first week of June. In 1994, a similar pattern was observed. Initial hatching

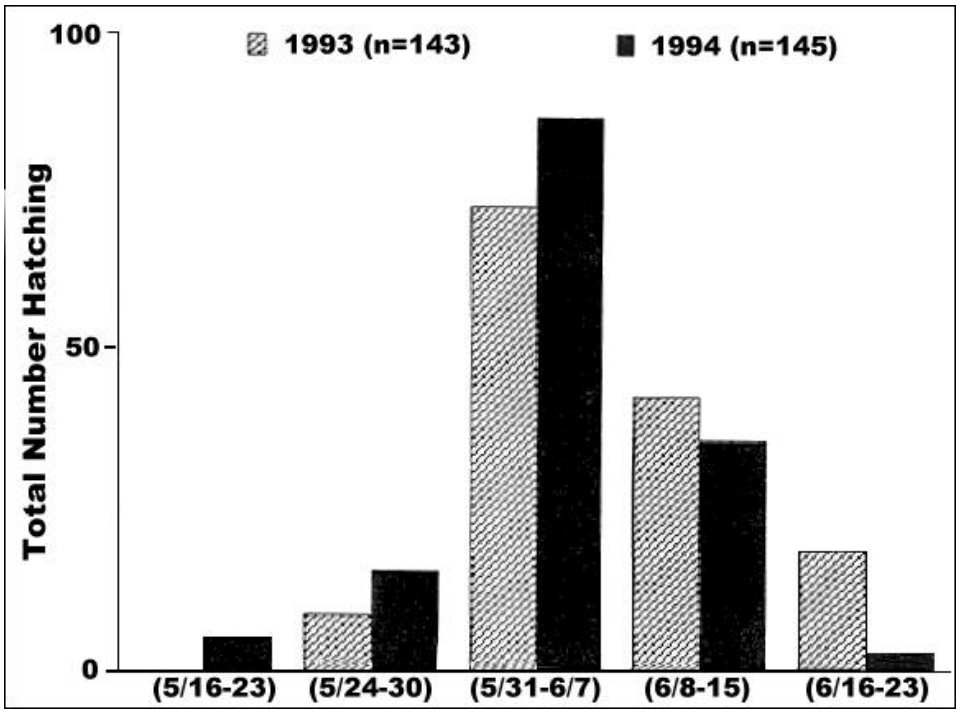

Figure 5 Phenology of first egg hatching dates by week in Western Gulls on Santa Barbara Island, 1993 and 1994

began in mid-May and continued until mid- to late June, with a definite peak during the first week of June.

Population Size

Population size in one major colony (Badlands/Cat Canyon) was not determined in 1993 due to consistently poor censusing conditions (fog). Due to the importance of this area to the overall population size, we were unable to estimate the island-wide population in 1993. Available data for 1993 are provided in Table 14. In 1994, we estimated roughly 4000 breeding pairs (Table 15). The population is apparently growing rapidly given estimates of 1800, 2500, and 2100 pairs for 1990, 1991, and 1992, respectively (Ingram 1992, Ingram and Jory-Carter, 1997). In particular, the population appears to be growing in the Badlands/Cat Canyon area(s).

Table 14 Population size of Western Gulls on Santa Barbara Island, 1993

Subcolony area	Subcolony name	Nests[a]	Total birds	Number roosting
1	Landing Cove	138	240	0
2	Arch Point	174	337	40
3	Shag Rock	49	66	0
4/5	Elephant Seal Cove/ North Cliff	138	297	25
6	Webster Point	90	182	0
7/8	A1 Cliff/A1 Area	39	102	0
9	West Colony	270	622	0
10/11	Badlands/Cat Canyon	ND	ND	ND
12	Sea Lion Rookery	186	426	0
Total		**ND**	**ND**	**ND**

[a] **Based on adults sitting on nests**

Table 15 Population size of Western Gulls on Santa Barbara Island, 1994

Subcolony area	Subcolony name	Nests[a]	Total birds[b]	Number roosting
1	Landing Cove	94	205	0
2	Arch Point	184	445	100
3	Shag Rock	51	83	0
4/5	Elephant Seal Cove/ North Cliff	302	391	0
6	Webster Point	189	273	0
7	A1 Cliff	22	70	35
8	A1 Area	153	211	0
9	West Colony	1601	2156	75
10/11	Badlands/Cat Canyon	1047	1465	80
12	Sea Lion Rookery	325	517	0
Total		**3968**	**5816**	**290**

[a] **Based on adults sitting on nests with chicks or showing territorial behavior**

[b] **Total number of adults**

Productivity

The number of nesting attempts, eggs laid, chicks hatched, and chicks fledged for each year in each grid is provided in Table 16 and analyzed in Table 17 and Table 18. We investigated whether breeding parameters differed between years (Table 17) and between grids (Table 18).

Clutch size did not differ significantly between years (Table 8; Oneway ANOVA: F=1.78, df=1,365, P=0.184). Hatching success was significantly lower in 1993 than 1994 (F=60.74, df=1,307, P<0.000). A high number of addled eggs (dead embryos) was found in 1993 probably resulting from high ambient temperatures during peak hatch (early June) in that year. Fledging success, however, was significantly higher in 1993 than 1994 (F=6.25, df=1,232, P=0.013). Chick mortality (the inverse of fledging success) was comparable to the long-term results of monitoring gulls on Southeast Farallon Island, California (Sydeman et al. 1991). Overall productivity was significantly higher in 1994 (F= 6.85, df=1,379, P<0.009) than 1993. In 1993, 44.8% of all pairs fledged at least 1 chick, while in 1994 65.8% of all pairs fledged at least 1 chick. There were no statistical differences

Table 16 Reproductive effort in Western Gulls on Santa Barbara Island, 1993 and 1994

Grid	Nests	Eggs laid (N)	Eggs hatched (N)	Chicks fledged (N)
1993				
A	61	158 (60)	66 (43)	48 (61)
D	69	156 (69)	36 (65)	30 (68)
E	91	217 (87)	115 (79)	81 (91)
Total	**221**	**531 (216)**	**217 (187)**	**160 (220)**
1994				
A	61	144 (57)	122 (55)	65 (61)
D	56	136 (51)	79 (43)	48 (56)
E	44	104 (43)	68 (33)	43 (44)
Total	**161**	**384 (151)**	**269 (131)**	**156 (161)**

Table 17 Reproductive effort of Western Gulls on Santa Barbara Island, 1993 and 1994

Parameter	1993 mean ± s.d. (N)	1994 mean ± s.d. (N)
Clutch Size	2.46 ± 0.61 (216)	2.54 ± 0.59 (151)
Hatching Success	0.48 ± 0.42 (182)	0.81 ± 0.31 (127)
Fledging Success	0.63 ± 0.42 (220)	0.50 ± 0.37 (121)
Productivity [a]	0.73 ± 0.93 (220)	0.97 ± 0.84 (161)
Growth Rates (g/day)	18.04 ± 4.01 (64)	17.68 ± 4.77 (95)

[a] Chicks fledged/breeding pair

in chick growth rates (g/day) between years (F=0.25, df=1,157, P= 0.617).

Breeding performance also varied between grids (study plots). In 1993, clutch size was significantly lower in grid D than in grids A and E (F=6.59, df=2,213, P=0.002).

Hatching success and fledging success were also significantly lower in grid D than grids A and E (hatching success: F=21.53, df=2,179, P<0.001; fledging success: F=5.14, df=2,110, P=0.007). In 1994, we found 1) no difference in clutch size between grids (F=2.16, df=2,148, P=0.119), 2) lower hatching success in grid D (F=4.19, df=2,124, P=0.017), and 3) no difference in fledging success or productivity between grids (fledging success: F=0.36, df=2,118, P=0.696); productivity: F=0.90, df=2,158, P=0.408). The frequency of addled eggs in grid D (1993: 33.1% compared to 9.5% in grids A and E; 1994: 16.2% compared to 7.6% and 3.8%, respectively) explains differences between grids in hatching success. The overall lower productivity of birds in grid D may also be explained by the fact that this plot is located on the periphery of a large colony and may be represented by more inexperienced birds than other plots.

In 1994, we also found a strong relationship between productivity and date of nest initiation (indexed by date of hatching). Productivity declined for pairs nesting later in the breeding season (Figure 6).

Table 18 Reproductive effort of Western Gulls by sample grids on Santa Barbara Island, 1993 and 1994

Grid	Clutch size mean ± s.d. (N)	Brood size mean ± s.d. (N)	Productivity [a] mean ± s.d. (N)
1993			
A	2.63 ± 0.55 (60)	1.53 ± 1.12 (43)	0.79 ± 0.86 (61)
D	2.26 ± 0.59 (69)	0.55 ± 0.94 (65)	0.44 ± 0.87 (68)
E	2.49 ± 0.63(91)	1.46 ± 1.01 (79)	0.90 ± 0.97 (97)
1994			
A	2.52 ± 0.60 (57)	2.22 ± 0.85(55)	1.07 ± 0.85 (61)
D	2.67 ± 0.52 (510	1.84 ± 1.09 (3)	0.86 ± 0.80 (56)
E	2.42 ± 0.63 (43)	2.06 ± 0.79 (33)	0.98 ± 0.88 (44)

[a] Chicks fledged/breeding pair

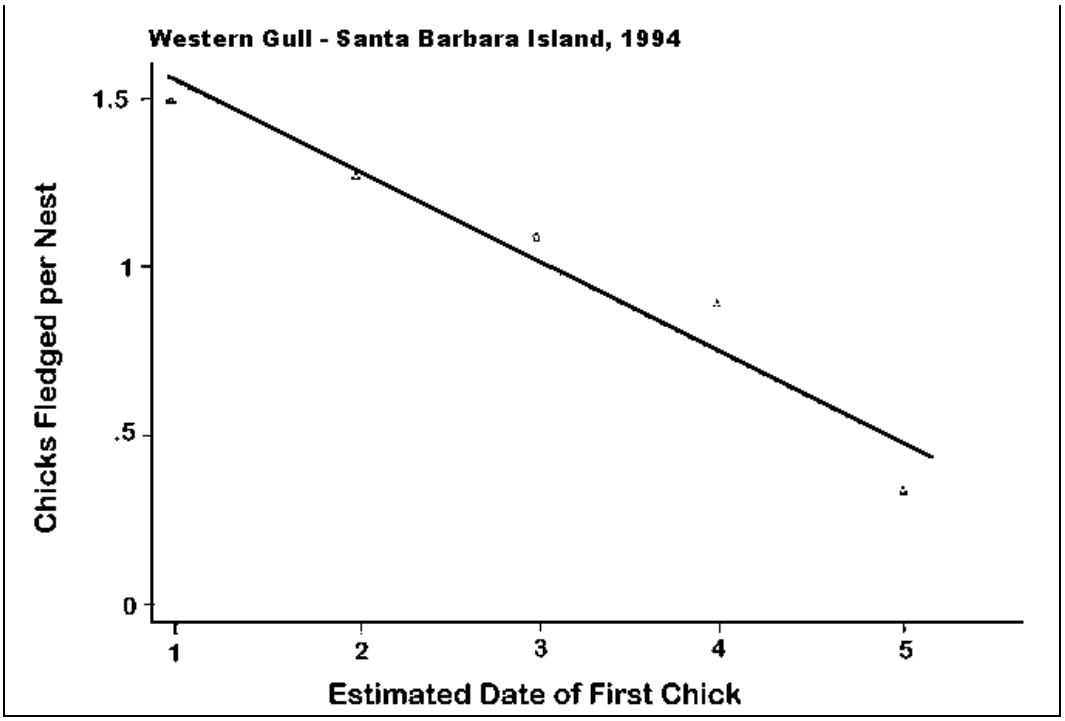

Figure 6 Productivity by date of hatch in Western Gulls on Santa Barbara Island, 1994

Table 19 Reproductive effort of Xantus' Murrelets on Santa Barbara Island, 1993 and 1994

Area	Monitored nest sites	Nest attempts	Eggs laid (N) [a]	Eggs hatched	Eggs broken	Eggs abandoned	Unknown fate
1993							
Nature Trail	56	24	29 (20)	17	3	8	1
Cat Canyon	73	44	59 (44)	35	16	4	4
Total	**129**	**68**	**88 (64)**	**52**	**19**	**12**	**5**
1994							
Nature Trail	59	23	35 (22)	11	19	0	5
Cat Canyon	77	43	59 (43)	25	22	5	7
Total	**136**	**66**	**94 (65)**	**36**	**41**	**5**	**12**

[a] **(N) is the number of nests with known number(s) of eggs laid**

Xantus' Murrelet

Methodology

In 1993, we monitored 129 potential nest sites 17 times between late March and the end of June at 5-day intervals, with 1 gap between 16–29 April. In 1994, 136 nest sites were checked 22 times between mid-March and mid-July, at mostly 5-day intervals. Due to logistical problems with transportation to and from Santa Barbara Island, there were some gaps of 2–10 days in the nest check schedule in 1994.

Phenology

In 1993, Xantus' Murrelets began laying eggs in early April and continued until late May with the peak around mid-April. In 1994, Murrelets began laying eggs at the end of March with peak laying in mid-April and continuing until late May with 1 relay clutch laid in early June.

Population Size

We have no information on the population size of breeding Xantus' Murrelets on Santa Barbara Island in either 1993 or 1994. Indications are that this population is declining (Carter et al. 1992), yet detailed population estimates from Santa Barbara Island, the major colony of this species in California, are currently unavailable for recent years.

Productivity

In 1993, 52.7% of the monitored sites (68/129) were occupied. In 1994, 48.5% of the monitored sites (66/136) were occupied (Table 19). Hatching success (proportion of eggs laid that hatched) was significantly higher in 1993 than 1994 (Table 20, next page). Two-way ANOVA including year and nesting colony [Nature Trail and Cat Canyon]: $F=9.95$, $df=1,126$, $P=0.002$). However, there were no differences between study areas in hatching success ($F=1.50$, $df=1,126$, $P=0.2234$). Productivity (number of chicks hatched per egg-laying pair) was significantly higher in 1993 than 1994 ($F=6.26$, $df=1,131$, $P=0.014$). Egg predation by mice, as indexed by the number of broken eggs, was twice as high in 1994 than 1993 (Table 19). Between study areas, there were no significant differences in productivity ($F=0.25$, $df=1,151$, $P=0.615$).

In addition to the undisturbed Nature Trail and Cat Canyon study sites located around the bunkhouse and Landing Cove areas in 1994. We consider these areas disturbed due to the frequency of human activities near nest sites. In addition, some of the next sites in this areas were man-made (i.e., nests under the bunkhouse) and some nesting birds were subjected to handling and bleeding for studies of baseline blood paramenters (Scott Newman, personal communication). Although these types of effects should be analyzed separately, for the purpose of this analysis,

Table 20 Reproductive effort in Xantus' Murrelets on Santa Barbara Island, 1993 and 1994

Parameter	Nature trail mean ± s.d. (N)	Cat canyon mean ± s.d. (N)
1993		
Nest Attempts/Monitored Site	0.43 ± 0.50 (56)	0.60 ± 0.49 (73)
Clutch Size	1.45 ± 0.51 (20)	1.34 ± 0.48 (44)
Hatching Success	0.60 ± 0.45 (20)	0.65 ± 0.44 (44)
Productivity[a]	0.85 ± 0.67 (20)	0.80 ± 0.55 (44)
1994		
Nest Attempts	0.39 ± 0.49 (59)	0.56 ± 0.50 (77)
Monitored Site		
Clutch Size	1.59 ± 0.50 (22)	1.37 ± 0.49 (43)
Hatching Success	0.30 ± 0.37 (22)	0.44 ± 0.44 (43)
Productivity[a]	0.50 ± 0.60 (22)	0.58 ± 0.54 (43)

[a] **productivity = number of hatched eggs/number of nest attempts**

we consider all man-made (natural crevices but in the region of intense human activity) and manipulated (handled) bird sites to be disturbed. Results show that disturbed nests had a similar clutch size to undisturbed areas (1.50 eggs/clutch) but showed much reduced hatching success (10.0%). We believe that human disturbance is the principal explanation for these results. It has also been suggested that birds recruiting into new man-made structures may be young and inexperienced. Therefore, they may show reduced breeding success simply due to inexperience (see Sydeman et al. 1991 for a review of the literature on this subject).

Although age or inexperience may be a contributing factor in explaining 1994 results, inexperienced birds often lay smaller clutches than experienced ones, which was not found in our analysis. Clearly, efforts to evaluate the effects of human activity on the breeding success and habitat selection of Xantus' Murrelets should be increased.

Ashy, Black, and Leach's Storm-Petrels

Methods and Results

In 1994, we mist-netted storm-petrels on 7 nights on Santa Barbara Island between 16 June and 14 August for a total of 19 net-hours. We caught a total of 67 Storm-Petrels, 3 of which were subsequently recaptured. Ashy Storm-Petrels accounted for the majority of birds caught (76.1%, n=51, including 1 recapture), with lesser numbers of Black Storm-Petrels (13.4%, n=9, no recaptures), and Leach's Storm-Petrels (10.4%, n=7, including 2 recaptures).

In an effort to measure the phenology of Santa Barbara Island Storm-Petrels, we looked for the presence, absence, or re-feathering patterns of the brood patch of the birds. For this analysis, we made 2 groupings—those caught on 3 dates in July and those caught on 3 nights in August. Of 31 Ashy Storm-Petrels caught in July, 17 (55%) had brood patches implying that they were incubating eggs, and 14 (45%) lacked brood patches. Of the 17 Ashy Storm-Petrels caught in August, five (29%) had brood patches while the remaining 12 (71%) had re-feathered brood patches suggesting that most of these birds were now in the chick phase. In July, for Black Storm-Petrels, 2 of the 3 birds had brood patches while in August, 2 had brood patches and 3 had re-feathered brood patches. For Leach's Storm-Petrels, all 3 in July, and all 3 in August had brood patches suggesting that they were all in the incubation stage.

Based on estimates of incubation and nestling periods from the literature, these preliminary analyses suggest a breeding season from June through October for Santa Barbara Island Storm-Petrels.

CONCLUSIONS AND RECOMMENDATIONS

The breeding seasons of 1993 and 1994 on Santa Barbara Island resulted in fairly poor reproductive success (chicks fledged per pair) for Double-Crested Cormorants and Western Gulls. In 1993, reproductive success of Xantus Murrelet was fairly high while in 1994 success was low. Since 1993 was the first year of monitoring Brandt's Cormorant nesting success, we cannot compare results to earlier years. Breeding success between 1993 and 1994 for Brandt's Cormorants was similar.

Breeding success of seabirds in California often correlates with the occurrence of El Niño Southern Oscillation (ENSO) events (Ainley, Sydeman, and Norton 1995). During ENSO-years, prey populations for seabirds may be reduced. A relatively strong ENSO in 1992 and lasting into 1993 probably explains the poor reproductive success of Double-Crested Cormorants and Western Gulls in these years. The fact that reproductive success for these species continued to be poor in 1994 suggests a longer-term effect of the 1992–93 ENSO.

Although reproductive success for Western Gulls in 1993 and 1994 was poor, the population has apparently grown rapidly in the past 3 years. Since 1991 when a population estimate of 2450 pairs was obtained, the population has increased by 62%. This rate of increase is remarkable. Acknowledging that some differences in methodology (and perhaps counting accuracy) exist between the 1991 and 1994 censuses, the population is still considerably larger than previous estimates. Trend analyses (initiated by Ingram and Jory-Carter, 1997) also reveal increasing numbers of Western Gulls over the past two decades.

Unfortunately, as shown at many other locations around the world, as gulls increase, other seabird species generally decline. This is particularly troubling in light of the significant Xantus' Murrelet population on Santa Barbara Island. Notably, 1 of the locations where Western Gulls increased in 1994 is the Cat Canyon area, a location where Xantus' Murrelets nest in concentrated numbers. In future years, the interaction between these species should be evaluated and, if needed, a program of gull control near Xantus' Murrelet nesting habitat should be considered by Channel Islands National Park.

The Double-Crested Cormorant population, although considerably smaller in 1993–1994 than in 1991 when 510 pairs was estimated, is apparently growing and recovering from the 1992–1993 ENSO—in 1992, roughly 195 nesting pairs were estimated. We estimated roughly 280 pairs in 1993 and 240 birds in 1994. The 1994 estimate did not include results of aerial surveys which are likely to document additional nests not visible from land-based censusing locations. Thus the population in 1994 is probably as large or larger than in 1993. We stress, however, that although aerial surveys increase the accuracy of population estimates for surface-nesting seabirds, like ground surveys, this method also misses pairs hidden by rocks or vegetation, on vertical slopes, and in caves. We recommend a combination of land-based and aerial surveys to accurately estimate populations of cormorants on Santa Barbara Island and other Channel Islands National Park islands.

Management Issues

Human disturbance to breeding seabirds on Santa Barbara Island is important. Cormorants (both species), Brown Pelicans, and Xantus' Murrelets are severely influenced by human activity near nest sites. Inadvertent disturbance of

cormorant or pelican colonies may cause birds to flush from their nests thereby exposing eggs and small chicks to predation by Western Gulls. The large colony of nesting Brandt's Cormorants at Webster Point is apparently in danger of disturbance from visitors to Santa Barbara Island. Although we did not document any negative interactions, we recommend that Channel Islands National Park place signs explaining the sensitivity of cormorants to human intrusion at access points to Webster Point and that issues of human disturbance be discussed at the Santa Barbara Island Visitor Center. In addition, the effects of commercial and recreational boating in the vicinity of Webster Point and near other cormorant colonies should be investigated to determine if other problems exist.

Human disturbance to Brown Pelicans along the Sea Lion Rookery/Cat Canyon trail also needs the continued attention of Channel Islands National Park staff. During both breeding seasons, this trail was closed by Santa Barbara Island rangers when disturbance to nesting pelicans was likely. In an effort to minimize the impact of visitors to pelicans yet encourage education and an appreciation of seabirds and the marine environment, we recommend that Channel Islands National Park consider erecting a blind at the Sea Lion Rookery overlook to facilitate observations by visitors to Santa Barbara Island. An educational display exulting the recovery of Brown Pelicans in Channel Islands National Park after the ban on DDT and other organochlorine chemicals could be developed by interpretive staff and placed at this location. This action would help mitigate necessary closures of the Sea Lion Rookery/Cat Canyon trail when large numbers of pelicans nest in the Sea Lion Rookery area.

Finally, there are 2 particularly rare and imperiled seabird species on Santa Barbara Island which require continued attention by Channel Islands National Park staff. These are the Ashy Storm-Petrel and Xantus' Murrelet. Our recommendations for the petrel are simple although difficult—develop and implement a monitoring program for this species using a combination of mark/recapture techniques to estimate population size and trends and deployment of nest boxes in appropriate habitat to monitor breeding biology. Use of sound attractants may be necessary to attract birds to nest boxes.

Xantus' Murrelets, however, deserve more attention than Ashy Storm-Petrels. First, of critical importance is development of up-to-date information on population trends. Development of well-defined study plots in appropriate habitat in which the number of nesting pairs can be determined will help facilitate this goal. In addition to the study areas at the Nature Trail and Cat Canyon, we recommend establishment of study plots between Landing Cove and Arch Rock. The Nature Trail and Cat Canyon study plots which contain approximately 100 breeding pairs would appear to be inadequate for tracking trends of a population that may contain upwards of 5000 pairs. In addition, more effort should be devoted into surveying the existing Nature Trail and Cat Canyon study plots to document occupancy of all *available* nest sites.

Second, habitat enhancement may be accomplished through the deployment of nest boxes. We recommend that at least 30 nest boxes be installed in the vicinity of the Nature Trail to facilitate monitoring and to evaluate the utility of nest boxes for the management and enhancement of murrelet populations. Nest boxes may or may not facilitate mouse predation on murrelet eggs; hence, one of the objectives of the nest box program should be to evaluate the relative effects of predation on murrelet productivity. While nest boxes may enhance reproductive success of the species, we also recommend that Channel Islands National Park investigate the possibility of controlling mouse predation through the use of fencing. This technique has been applied in New Zealand to enhance seabird productivity in regions of excessive mammalian predation. The use of sound attractants in recruiting murrelets

to nest boxes or specific habitat locations should also be investigated.

Third, we advocate hiring experienced seabird biologists for Xantus Murrelet population monitoring. While previous data are useful in understanding the population dynamics of this species, the use of untrained Student Conservation Association volunteers to monitor nest sites adds an element of uncertainty to an already difficult situation for monitoring the species.

Fourth, we believe that sufficient data exist to develop a population viability analysis (PVA) for the Xantus' Murrelet population on Santa Barbara Island. To construct a PVA, one uses modern population modelling techniques such as a stochastic Leslie Projection Matrix (Burgman et al. 1993). The PVA for Xantus Murrelet should incorporate known demographic values (based on previous Channel Islands National Park monitoring of population size and reproductive success), estimates of adult survivorship and juvenile recruitment from the literature on closely related species, and estimated impacts from current threats such as mouse predation and mortality due to oiling, by-catch in commercial fishing gear, and human disturbance. The PVA will enable Channel Islands National Park to investigate the importance of each of these threats and other conservation problems to the Santa Barbara Island Xantus Murrelet population by predicting population size in future years. PVA models may also be used by Channel Islands National Park to choose the most appropriate management schemes (e.g. installation of nest boxes, mouse or gull control, reduction in human disturbance) to ensure the survival of this important population and species.

Section 3

Seabird Monitoring at Santa Barbara Island, 1995

Previously Presented as a Technical Report to
Channel Islands National Park
Ventura, California

POPULATION SIZE, PHENOLOGY, AND PRODUCTIVITY OF SEABIRDS ON SANTA BARBARA ISLAND, 1995

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13 MARCH 1996

ABSTRACT

We monitored population size, phenology and productivity of Double-Crested and Brandt's Cormorants, Western Gulls, and Xantus' Murrelets on Santa Barbara Island during the 1995 breeding season. We also continued a mark-recapture study to assess population trends of Ashy, Leach's, and Black Storm-Petrels. The Double-Crested Cormorant population numbered about 180 pairs and productivity was approximately 0.7 chicks per breeding pair. The Brandt's Cormorants population included approximately 300 pairs and fledged an average of 1.6 chicks per pair. We estimated the Western Gull population at nearly 2500 breeding pairs and productivity of less than 0.5 chicks per pair. Median clutch initiation for Western Gulls was between 5–15 May. We did not estimate the population size of Xantus' Murrelets due to difficulties with censusing this nocturnal, crevice-nesting species. Murrelets laid approximately 1.5 eggs per nest and produced an average of 0.8 hatchlings per pair. Median clutch initiation was between 20–30 May, about 6 weeks later than average. We mist-netted storm petrels on 9 nights, capturing 119 unbanded birds and 4 previously banded birds.Measures that may enhance the conservation of seabirds on Santa Barbara Island are: 1) Reductions in human disturbance of breeding birds. 2) Investigations on the feasibility of using nest boxes as a habitat management tool for Xantus' Murrelet and Storm-Petrels. 3) Further studies of population trends by increasing field-work on certain species (i.e., Xantus' Murrelet and Ashy Storm-Petrel) 4) Development of population trajectory simulations for Xantus' Murrelet that synthesize information regarding conservation problems relative to current population parameters and trends.

INTRODUCTION

Seabird monitoring involves the accumulation of time series data on any aspect of seabird distribution, abundance, demography, diet, or behavior. Seabirds respond quickly to environmental perturbations and provide timely information on the abundance of lower trophic level organisms in marine ecosystems (Croxall et al. 1988). As such these data are useful to resource managers and members of the public for understanding the impacts of human use of coastal or marine resources on particular species or populations.

In recognition of the contributions seabirds can make to monitoring marine ecosystems and specific concern for the welfare of southern California seabirds in light of modern threats, Channel Islands National Park established a Seabird Monitoring Program in 1985. Threats to Channel Islands National Park seabirds include mortality from predators, oil and chemical pollution, human disturbance, and incidental catch in commercial fishing gear. Alterations of marine food webs by the over-exploitation of prey and climate change may also be detrimental to Channel Islands National Park seabird populations.

This report summarizes monitoring of Double-Crested (Phalacrocorax auritus) and Brandt's Cormorants (Phalacrocorax penicillatus), Western Gull (Larus occidentalis), Xantus' Murrelet (Synthliboramphus hypoleuca), and 3 species of Storm-Petrel (Oceanodroma spp.) on Santa Barbara Island, Channel Islands National Park, 1995. Mike Shultz collected the data under contract CA8120-95-003 between Point Reyes Bird Observatory and Channel Islands National Park. Shultz and William Sydeman summarized and analyzed data.

The Channel Islands National Park Seabird Monitoring Handbook provides a synopsis of the methodology used to investigate population size, phenology, and productivity of seabirds in Channel Islands National Park (Lewis et al. 1988). We detailed more specific methodologies pertaining to our analyses following each species account. This is Point Reyes Bird Observatory contribution no. 709.

METHODOLOGY AND RESULTS

Double-Crested Cormorant

Methodology

Double-Crested Cormorants nested on North Cliffs, West Cliffs, and Sutil Island in 1995 (see Figure 11 in Ingram and Jory-Carter, in press). We made 12 land-based censuses from vantage points on the island between 1 April and 4 August. We conducted a boat-based survey of Santa Barbara Island and Sutil Island on 20 July. To estimate productivity, we assessed the total number of nests, the number of nests containing chicks, and the number of large chicks (fledglings) for each sub-colony. Unfortunately, Double-Crested Cormorants bred asynchronously in 1995, making it difficult to accurately determine sub-colony reproductive success. Consequently, productivity estimates may be biased toward lower values.

Phenology

Observations indicated that egg-laying began in late April and continued through mid-July with the peak lay occurring in early June. The period of peak hatch varied between sub-colonies. Peak hatch for North and West Cliffs was in late June, while for Sutil Island the peak occurred from early to mid-July.

Population Size and Productivity

We estimated the breeding population of Double-Crested Cormorants to contain 184 pairs in 1995 (Table 21). These data represent the peak number of nests

Table 21 Summary of Double-Crested Cormorant population size and reproduction on Santa Barbara Island, 1995

Subcolony	Number of occupied nests [a]	Number of nests with chicks	Estimated number of young fledged
West Clffs*	72	32	59
North Peak*	63	22	37
Shag Rock*	1	0	0
Sutil Island*	48	12	Not Determined
Sample Total [b]	**136**	**54**	**96**
Colony-Wide Total [c]	**184**	**66**	**(131)**

[a] Nests with adults in incubation or brooding postures; exact nest contents unknown

[b] Sample data were derived from areas marked with asterisks

[c] Colony-Wide offspring production in parentheses estimated by multiplying the total number of nests (184) by productivity as determined by sample (e.g., 96/136=0.71)

observed during land and boat-based surveys of each sub-colony. We estimated productivity to be 0.71 chicks fledged per pair (96/136). Productivity for successful pairs (i.e., pairs that were observed with large chicks) was 1.86 (96/54) chicks per pair.

Brandt's Cormorant

Methodology

Brandt's cormorants nested exclusively in 1 colony on Webster Point. We collected data for the Webster Point colony on 12 dates between 1 April and 4 August. During each survey, we counted the number of occupied nests and large chicks. We also conducted a boat-based survey of Santa Barbara Island and Sutil Island on 20 July.

Phenology

Egg-laying began in mid-April and continued through late May. Peak laying occurred in early May. We observed the first chicks in early May and the peak hatch took place in late May.

Population Size and Productivity

We estimated 302 breeding pairs of Brandt's Cormorants in the Webster Point colony for 1995 (Table 22). Productivity was 1.64 chicks fledged per pair. In 1994, Brandt's Cormorants nested on the West side of Webster Point, an area not visible from the island. We conducted a boat-based survey late in the breeding season and found no additional nests or chicks. However, it is possible that birds nested in small numbers in this area and the chicks fledged prior to the boat survey.

Western Gull

Methodology

We monitored Western Gull breeding phenology, nesting success, and chick growth in two 1 ha study plots and one 0.5 ha plot (see Figure 19 of Ingram and Jory-Carter in press). Between 1 April and 7 August, we made 18 visits to the plots. We visited the plots at 3-day intervals through the peak egg-laying period. Thereafter, we checked the plots approximately every fifth day. After hatch, we weighed chicks

Table 22 Population size and reproduction of Brandt's Cormorants on Santa Barbara Island, 1995

Subcolony	Number of occupied nests[a]	Estimated number of young fledged	Productivity [b]
Webster Point	325	563	1.73

[a] Nests with adults in incubation or brooding posture; nest contents unknown

[b] Estimated number of young fledged/number of occupied nests

Table 23 Development of the correction factor for converting the number of adult Western Gulls counted into breeding pairs (correction factor = nests x 2/number of adults)

Plot	Number of nests	Number of adults during census	Correction factor
A	62	72	1.72
E	55	62	1.77
Total	**117**	**134**	**1.75**

during each check and used the weights to calculate growth rates.

During the incubation period, we conducted an island-wide count of Western Gull adults (1–3 June). We calculated a correction factor during this census by assessing the number of adults in 2 study plots in which we knew the number of active nests (Table 23). We used this correction factor in conjunction with the actual counts to convert the number of adults to the number of breeding pairs of Western Gulls on Santa Barbara Island.

Phenology

The first eggs were found on 30 April. Peak egg-laying occurred in early May (Figure 7). The first chicks hatched in late May, and peak hatch was in early June.

Population Size

We estimated the population of Western Gulls at nearly 2500 breeding pairs (Table 24). This figure is consistent with previous estimates of 1800, 2500, and 2100 pairs for 1990, 1991, and 1992, respectively (see Ingram 1992, Ingram and Jory-Carter in press) but considerably lower than the 4000 pairs estimated in 1994 (Feldman and Sydeman 1995).

Productivity

Productivity was very low for Western Gulls in 1995 (Table 25). Clutch size was 2.28 eggs per nest compared to 2.46 and 2.54 eggs per nest in 1993 and 1994, respectively. Hatching success (the proportion of eggs laid that hatched) was 0.59. Fledging success (proportion of chicks hatched that fledged) was estimated at 0.31. Overall productivity was 0.44 chicks fledged per breeding pair.

Breeding performance varied between study plots (Table 26 and Table 27). Hatching success and fledging success were significantly lower in plot A than in plots D and E (hatching success: F=3.26,

Table 24 Estimates of population size for Western Gulls on Santa Barbara Island, 1995

Subcolony area	Subcolony name	Total adults counted	Number of roosting birds	Estimated breeding pairs [a]
1	Landing Cove	201	0	100
2	Arch Point	314	74	120
3	Shag Rock	98	0	49
4/5	Elephant Seal Cove/ North Cliff	457	67	195
6	Webster Point	417	77	170
7/8	A1 Cliff/A1 Area	364	42	162
9	West Colony	2102	291	906
10/11	Badlands/Cat Canyon	1325	287	519
12	Sea Lion Rookery	571	18	276
Total		**5849**	**856**	**2497**

[a] **Based on adults sitting on nests with chicks or showing territorial behavior**

Table 25 Reproductive effort of Western Gulls on Santa Barbara Island, 1995

Parameter	Mean ± s.d. (N)
Clutch Size	2.28 ± 0.70 (181)
Hatching Success	0.59 ± 0.42 (179)
Fledging Success	0.31 ± 0.38 (129)
Productivity [a]	0.44 ± 0.69 (181)

[a] Chicks fledged/breeding pair

df=2, 178, P=0.041, Fledging success: F=3.93, df=2, 128, P=0.022). Overall productivity was significantly lower in plot A than in plot D but did not differ significantly from plot E (F=7.36, df=2, 180, P<0.001, Bonferroni test P<0.05). The frequency of addled eggs (i.e., eggs that did not develop or experienced embryo death) in grid A (20.4%) compared to grid D (4.8%) and E (4.1%) explains some of the discrepancy between grids in reproductive effort.

We calculated growth rates using all chick weights and excluding chick weights greater than 800 grams (Table 28). We excluded weights >800g to examine growth during the linear phase of chick development. Using all weights, gull chicks grew at an average of 17.09 grams per day (n=130, sd=6.83). The average growth rate for chicks in plot A was significantly lower than plots D and E (F=6.52, df=2, 129, P=0.002 Bonferroni test P<0.05). Excluding chick weights greater than 800 grams the average growth rate was 16.73 grams per day (n=129, sd=6.76). In this case, the growth rate for plot A was significantly lower than for plot D (F=6.04, df=2, 128, P=0.003); however, plot A did not differ significantly from plot E (Bonferroni test P<0.05).

Xantus' Murrelet

Methodology

We monitored 145 potential nest sites in the Cat Canyon and Nature Trail study areas. We checked sites 21 times at 5-day intervals between late March and mid-July. The Cat Canyon study area has little vegetation and birds nest almost exclusively in rock crevices. In contrast, the Nature Trail study area has few rock crevices and murrelets nest almost entirely under shrubs (*Eriophyllum sp* and *Hemozonia sp*). Additionally, we monitored 11 disturbed nest sites located around the bunkhouse and Landing Cove areas which are exposed to high levels of human activity. Ten of these sites were in man-made structures.

Phenology

Xantus' Murrelets bred very late in 1995. Egg-laying began in mid May and continued until early June with the peak lay occurring in late May (Figure 8). The first chicks hatched in late June with the peak hatch in early July.

Population Size

We have no information on the breeding population size of Xantus' Murrelets on Santa Barbara Island in 1995. Indications are that this population has declined (Carter et al. 1992), yet detailed population estimates from Santa Barbara Island, the major colony of this species in California, are unavailable for recent years.

Table 26 Reproductive effort by Western Gulls in different study plots

Grid	Nests	Eggs laid (N)	Eggs hatched (N)	Chicks fledged (N)
A	62	147 (62)	60 (62)	12 (2)
D	65	145 (65)	99 (63)	42 (650
E	54	121 (54)	81 (54)	26 (540
Total	**181**	**413 (181)**	**240 (179)**	**80 (181)**

Table 27 Reproductive effort of Western Gulls by study plots

Grid	Clutch size mean ± s.d. (N)	Hatching success mean ± s.d. (N)	Fledging success mean ± s.d. (N)	Productivity [a] mean ± s.d. (N)
A	2.37 ± 0.68 (62)	0.49 ± 0.44 (62)	0.17 ± 0.30 (37)	0.19 ± 0.47 (62)
D	2.23 ± 0.77 (65)	0.66 ± 0.39 (63)	0.39 ± 0.41 (50)	0.65 ± 0.82 (65)
E	2.24 ± 0.64 (54)	0.64 ± 0.41 (54)	0.34 ± 0.38 (42)	0.48 ± 0.67 (54)

[a] Chicks fledged/breeding pair

Productivity

Xantus' Murrelets occupied 37.2% of the monitored sites (58/156) in 1995 (Table 29 and Table 30). There were significant differences in occupancy between the Cat Canyon and Nature Trail study areas (Chi square=5.38, df=2, P=0.020). Murrelets nested in 25.8% of the monitored sites (17/66) in the Nature Trail study area and in 44.3% of the sites (35/79) in the Cat Canyon study area. Clutch size varied significantly between study areas (Chi square=7.25, df=2, P=0.027). In Cat Canyon, 40% of pairs laid 2 eggs; whereas in Nature Trail, 80% of birds laid two-egg clutches. For the disturbed sites, 33% of clutches contained 2 eggs. The proportion of eggs laid which hatched was 0.59 for all areas combined. Hatching success was similar for Nature Trail (0.53) and Cat Canyon (0.58). However, factors affecting hatching success were different between the two areas. Egg predation by mice (*Peromyscus maniculatus*) as indicated by the number of broken eggs was 35.7% in Cat Canyon (15/42) and 3.6% for Nature Trail (1/28). In contrast, the proportion of abandoned eggs was 32.1% in Nature Trail (9/28) and 2.4% in Cat Canyon (1/42). Remarkably, hatching success for the disturbed sites was 0.83. Productivity (number of chicks hatched per pair) was 0.84 for all areas combined. Productivity did not vary significantly between study areas, however it was higher for the disturbed sites (1.17 chicks per pair).

Although productivity was higher for birds in disturbed sites, this figure is based on a small sample size (n=6). In 1994, productivity was much lower in these sites than in the other study areas. However, in 1994 biologists handled some of these birds for assessing baseline blood parameters and other activity near nest sites may have been higher. This may explain the discrepancy in results obtained for disturbed sites in 1994 versus 1995.

Ashy, Black and Leach's Storm-Petrels

Methods

We mist-netted storm-petrels during 9 nights on Santa Barbara Island between 4 April and 5 August for a total of 24 net-hours. We conducted mist-netting at standardized locations in proximity to appropriate nesting habitat (Figure 9). To measure the phenology of Santa Barbara Island storm-petrels, we looked for the presence, absence, or re-feathering patterns of brood patches. For this analysis, we made 3 groupings; those

Table 28 Western Gull growth rates for different study plots

Grid	Growth rate (g/day) for weights <801g mean ± s.d. (N)	Growth rate (g/day) for all weights mean ± s.d. (N)
A	13.52 ± 6.36 (29)	13.49 ± 6.26 (29)
D	16.77 ± 7.20 (61)	17.43 ± 7.42 (62)
E	19.06 ± 5.34 (39)	19.21 ± 5.13 (39)
Total	**16.73 ± 6.76 (129)**	**17.09 ± 6.83 (130)**

Table 29 Reproductive effort of Xantus' Murrelets on Santa Barbara Island, 1995

Area	# of sites checked	# of sites occupied	# of eggs laid (sites)	# of eggs hatched	# of eggs broken	# of eggs abandoned	# of unknown eggs
Nature Trail	66	17	28 (15)	14	1	9	5
Cat Canyon	79	35	42 (30)	23	15	1	4
Disturbed	11	6	8 (6)	7	0	1	0
Total	156	58	78 (51)	44	16	11	9

birds caught on 2 nights in April, those caught on 4 nights in June, and those caught on 2 nights in August.

Population

We tallied a total of 123 storm-petrels including new captures and recaptures. Of these birds, 119 were newly banded and 4 were recaptures. All recaptures were banded on Santa Barbara Island. They were originally banded on 13 April 1991, in 1993, 13 May 1994, and 6 June 1995. Ashy Storm-Petrels accounted for the majority of birds caught (74%, n=91, including 2 recaptures), with lesser numbers of Leach's Storm-Petrels (13.8%, n=17, including 2 recaptures), and Black Storm-Petrels (12.2%, n=15, no recaptures). In order to obtain an estimate of the population size of storm-petrels on Santa Barbara Island, additional mark-recapture data are needed.

Phenology

We captured 18 storm-petrels in April (15 Ashy and 3 Black), none of which had brood patches. Of the 49 Ashy Storm-Petrels caught in June, 53.1% (26/49) had brood patches. In August, 55.6% (15/27) had brood patches. For Black Storm-Petrels captured in June, 66.7% (2/3) had brood patches, while in August, 77.8% of birds captured (7/9), had brood patches. For Leach's Storm-Petrels in June, 92.9% (13/14) had brood patches, while in August, 33.3% (1/3) had a brood patch.

We also examined brood patches for evidence of vascularization indicating that the birds were presently incubating eggs. We captured 41 storm-petrels in June with brood patches and 41.5% (17/41) were vascularized. While in August, 69.6% of brood patches (16/23) were vascularized. One bird captured in early August had a re-feathering brood patch suggesting that it was currently in the chick stage.

These data indicate an asynchronous breeding season for storm-petrels on Santa Barbara Island. Leach's Storm-Petrels probably breed earlier than Ashy and Black Storm-Petrels. Storm-Petrels initiated egg-laying in late May to early June, with peak incubation occurring in August. Our analyses suggest a breeding season from late May to October for Santa Barbara Island storm-petrels.

Table 30 Reproductive effort in Xantus' Murrelets on Santa Barbara Island, 1995

Breeding parameter	Nature trail mean ± s.d. (N)	Cat canyon mean ± s.d. (N)	Disturbed mean ± s.d. (N)
Nest Attempts/Monitored Site	0.26 ± 0.44 (66)	0.44 ± 0.50 (79)	0.55 ± 0.52 (11)
Clutch Size	1.80 ± 0.41 (15)	1.40 ± 0.50 (30)	1.33 ± 0.52 (6)
Hatching Success	0.53 ± 0.48 (15)	0.58 ± 0.47 (30)	0.83 ± 0.41 (6)
Productivity [a]	0.87 ± 0.83 (15)	0.76 ± 0.68 (30)	1.17 ± 0.75 (6)

[a] productivity = number of hatched eggs/number of nest attempts

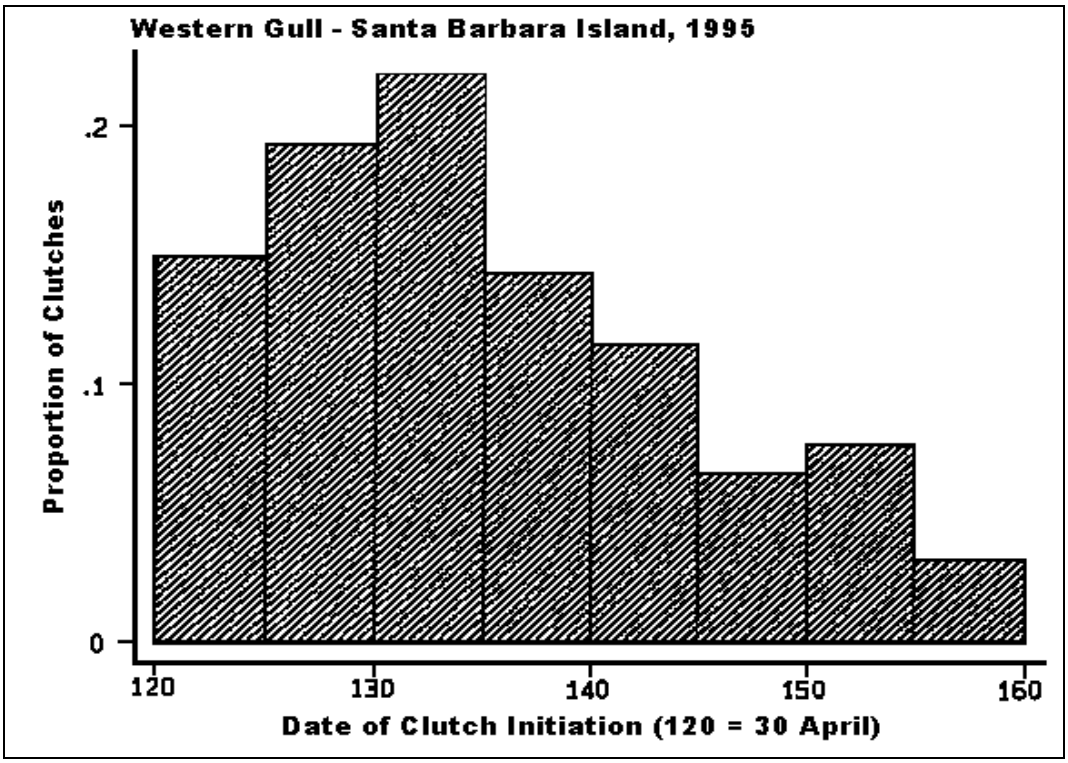

Figure 7 Phenology of clutch initiation for Western Gulls on Santa Barbara Island, 1995

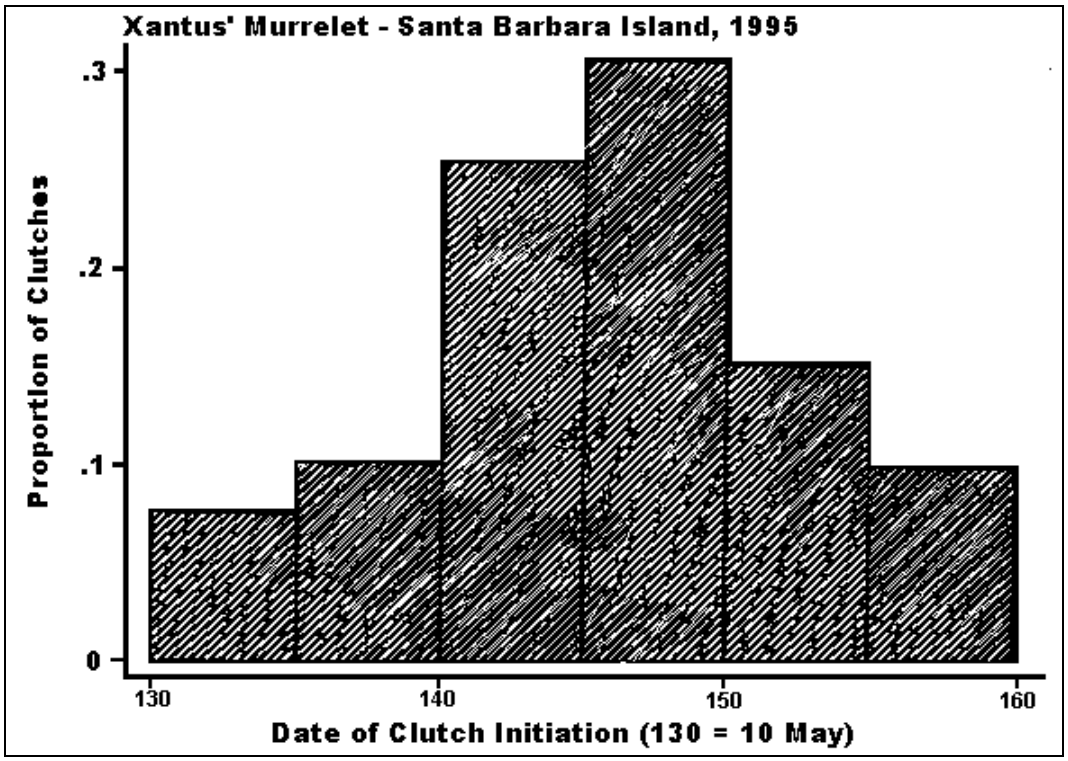

Figure 8 Phenology of clutch initiation for Xantus' Murrelet on Santa Barbara Island, 1995.

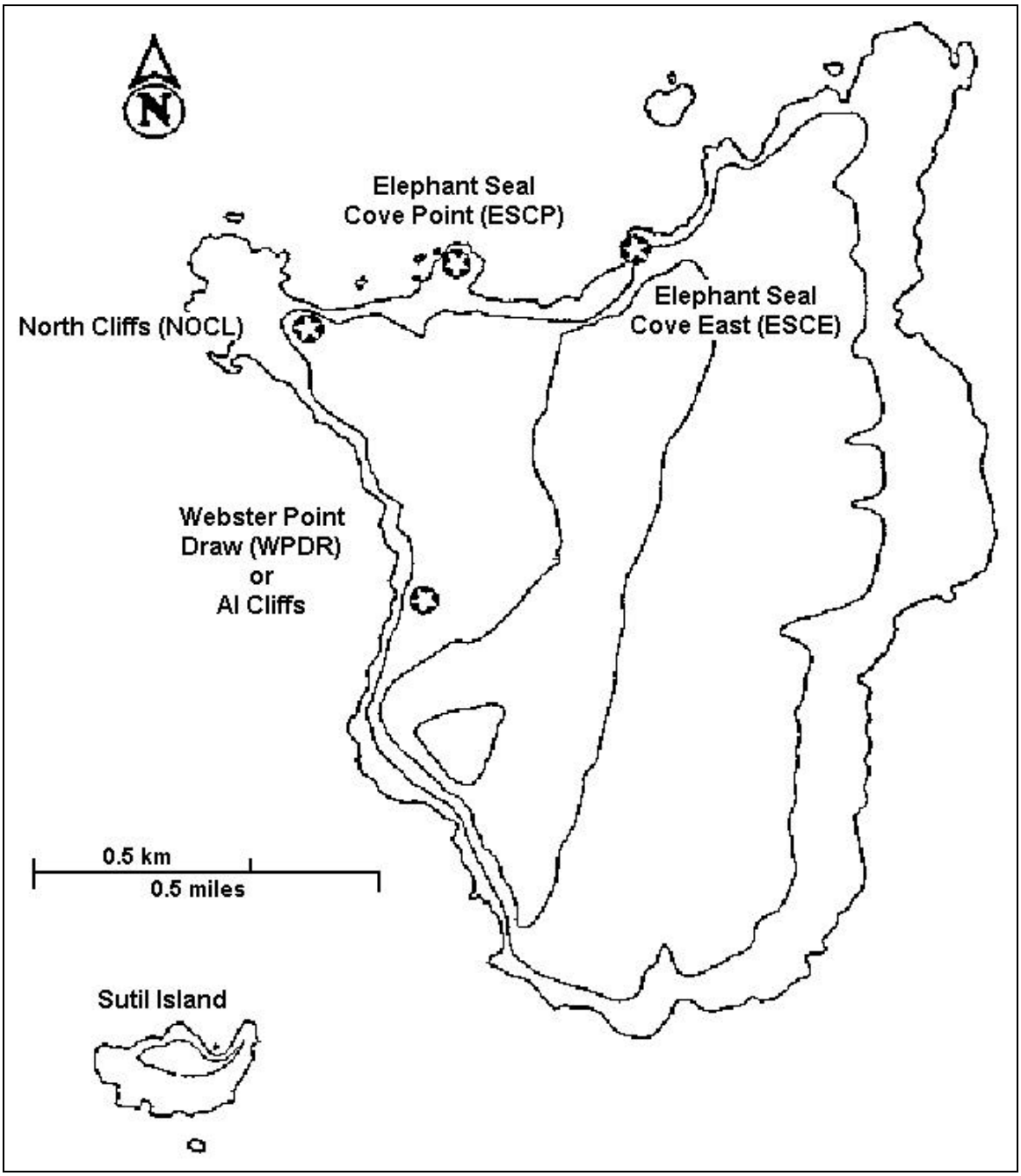

Figure 9 Storm-Petrel mist-netting locations on Santa Barbara Island, 1995

DISCUSSION

The 1995 breeding season on Santa Barbara Island resulted in poor reproductive success for Western Gulls and Double-Crested Cormorants. Productivity of Xantus' Murrelets was similar to other years, however, the number of nest attempts declined. Brandt's Cormorant nesting success was similar to estimates for previous years.

Although reproductive success for Western Gulls in 1995 was poor, the population appears to be stable. Since 1990, population estimates have fluctuated between 2000–2500 breeding pairs. This year's estimate of 2500 pairs is slightly higher than the 1991 estimate of 2450 pairs but lower than the 1994 estimate of 4000 breeding pairs. Population estimates from additional seasons are necessary to determine if the population of Santa Barbara Island Western Gulls is stable or increasing.

Analyses reveal a general trend of increasing numbers of Western Gulls on Santa Barbara Island over the past two decades. At many other locations around the world, as gull populations increase, other seabird species generally decline. This is cause for concern on Santa Barbara Island given the significant and apparently declining Xantus' Murrelet population. This season there were 2 instances of Western Gulls constructing nests near murrelet breeding sites which ultimately resulted in the eviction and death of the adult murrelets. In future years, the gull population should be monitored carefully to elucidate any significant trends. Also, interactions between Xantus' Murrelet and Western Gulls should be evaluated to determine if a program of gull control near murrelet nesting habitat is warranted.

Xantus' Murrelets began laying eggs over a month later in 1995 than they did in 1993 and 1994. Moreover, the number of occupied nest sites in the study plots declined from 68 in 1993 and 66 in 1994, to 52 in 1995. Murrelets also abandoned 32% of eggs laid in the Nature Trail study area. Severe storms that occurred in March of 1995 may have reduced prey availability during the critical period just prior to nesting. This may have caused a decline in physiological condition that resulted in delayed breeding, low occupancy of nest sites, and a high proportion of abandoned eggs. Cassin's Auklets on Southeast Farallon Island in 1995 exhibited a similar pattern (Point Reyes Bird Observatory unpubl. data). This suggests that both species which feed on similar prey items (zooplankton and larval fish) may have experienced a period of low food availability early in the breeding season.

We estimated the Double-Crested Cormorant population at 184 pair in 1995 which was considerably lower than other population estimates. In 1991, 510 pairs were estimated, but during the 1992 ENSO period, the estimate was 195 pairs. The 1995 estimate is based almost entirely on land-based surveys. The boat survey which we conducted on 20 July was late in the breeding season and therefore it is possible that some breeding pairs may have been missed. Additionally, the 1995 estimate does not include results of aerial surveys which document additional nests not visible from land-based censusing locations. Given the limitations of our censusing technique, the population in 1995 may be somewhat larger than our reported estimate. We recommend a combination of land-based, boat-based, and aerial surveys to accurately estimate populations of cormorants on Santa Barbara Island.

The reproductive success of Double-Crested Cormorants has also recently declined. Birds produced 0.96 chicks per pair in 1993, 0.89 per pair in 1994, and 0.71 chicks per pair in 1995. This downward trend deserves close attention.

MANAGEMENT RECOMMENDATIONS

Human disturbance is an important factor that may influence breeding seabirds on Santa Barbara Island. Cormorants and Brown Pelicans can be severely impacted by human activity near nest sites. Inadvertent disturbance of cormorant or pelican colonies may cause birds to flush from their nests, thereby exposing eggs and small chicks to predation by Western Gulls. The large colony of Brandt's Cormorants nesting at Webster Point appears to be in danger of disturbance from visitors to Santa Barbara Island. We recommend that Channel Islands National Park place signs explaining the sensitivity of cormorants to human intrusion at access points to Webster Point, and that issues of human disturbance be discussed at the Santa Barbara Island Visitor Center. In addition, the effects of commercial and recreational boating in the vicinity of cormorant colonies should be investigated to determine if other problems exist.

Human disturbance to Brown Pelicans along the Sea Lion Rookery/Cat Canyon trail needs to be continually assessed. In past breeding seasons, Santa Barbara Island rangers closed this trail when disturbance to nesting pelicans was likely. This did not occur in 1995 but may be necessary in the future. If a detour route around Graveyard Canyon is planned, tourists would not be inconvienced by a Channel Islands National Park policy to minimize disturbance to breeding pelicans. To mitigate the loss of certain portions of the Cat Canyon Trail to visitors, we also recommend that a blind be placed at the Sea Lion Rookery overlook. This would provide visitors with views of breeding pelicans without disturbing nesting birds and promote education. A display describing the recovery of Brown Pelicans after the ban on DDT in the early 1970s could be placed at this location. This action would help to reduce necessary closures of the Sea Lion Rookery/Cat Canyon trail as pelicans continue to recover from environmental contamination and expand present breeding colony.

Additionally, visitors to Santa Barbara Island have the potential to substantially impact breeding Western Gulls. The Elephant Seal Cove trail and the trail through the Badlands bisect the 2 largest gull colonies on the island. Visitors may leave the trail to observe chicks, thereby preventing adults from sitting on nests. The presence of visitors in these areas in times of high ambient temperatures can cause large numbers of eggs and small chicks to overheat and die. Visitors to Santa Barbara Island should be informed about the sensitivity of these birds to heat stress from human disturbance.

We recommend that additional research and conservation efforts be devoted to the study of Ashy Storm-Petrels and Xantus' Murrelets. For Ashy Storm-Petrels a monitoring program that uses a combination of mark/recapture techniques and nest boxes should be implemented to monitor phenology, population size, and population trends. The deployment of nest boxes would facilitate the monitoring of storm-petrel breeding biology. Sound attractants may be necessary to bring birds to the nest boxes.

Xantus' murrelets also require intensified study efforts. It is critically important to develop up-to-date information on murrelet population trends. The establishment of well-defined study plots in appropriate habitats would facilitate the calculation of nesting density and help monitor population fluctuations. In addition to the Nature Trail and Cat Canyon study areas, we recommend establishment of study plots between Landing Cove and Arch Rock. The Nature Trail and Cat Canyon study plots which contain approximately 100 breeding pairs are inadequate for tracking trends of a population that may contain upwards of 5000 pairs. In addition, more effort should be devoted into surveying the existing

Nature Trail and Cat Canyon study plots to document occupancy of all nest sites.Nest boxes also may be a valuable habitat enhancement tool for Xantus' Murrelets on Santa Barbara Island. We recommend that 30 nest boxes be installed in the vicinity of the Nature Trail. This would facilitate the monitoring of murrelet breeding biology and enable biologists to evaluate the utility of nest boxes for the management and enhancement of murrelet populations. One of the objectives of the nest box program should be to evaluate the relative effects of predation on murrelet productivity. We also recommend that Channel Islands National Park investigate controlling mouse predation through the use of fencing. This technique has been applied in New Zealand to enhance seabird productivity in regions of excessive mammalian predation. The use of sound attractants in recruiting murrelets to nest boxes or specific habitat locations should also be tested.

We believe that sufficient data exist to develop a population viability analysis (PVA) for the Xantus' Murrelets on Santa Barbara Island. To construct a PVA, one uses modern population modeling techniques such as a stochastic Leslie Projection Matrix (Burgman et al. 1993). The PVA for Xantus' Murrelet should incorporate known demographic values, estimates of adult survivorship and juvenile recruitment from the literature on closely related species, and estimated impacts from current threats such as mouse predation and mortality due to oiling, by-catch in commercial fishing gear, and human disturbance. The PVA will enable Channel Islands National Park to investigate the importance of individual threats and conservation problems to the Santa Barbara Island Xantus' Murrelet population by predicting population size in future years. Population viability models may also be used to choose the most appropriate management schemes (e.g., installation of nest boxes, mouse or gull control, reduction in human disturbance) to ensure the survival of this important population and species.Lastly, educational materials that explain the importance of Santa Barbara Island as habitat for breeding seabirds should be developed. Pamphlets that describe the seabird demography of the island, human/seabird interactions, and that provide maps of viewing locations should be made available in the visitor center. This would increase visitor awareness of seabirds on Santa Barbara Island as well as enhance their experience of visiting the park.

Section 4

Seabird Monitoring at Santa Barbara Island, 1996

Previously Presented as a Technical Report to
Channel Islands National Park
Ventura, California

POPULATION SIZE, PHENOLOGY, AND PRODUCTIVITY OF SEABIRDS ON SANTA BARBARA ISLAND, 1996

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ABSTRACT

We monitored population size, phenology, and productivity of Double-Crested Cormorants, Brandt's Cormorants, Pelagic Cormorants, Western Gulls, and Xantus' Murrelets on Santa Barbara Island during the 1996 breeding season. We also continued a mark-recapture study to assess population trends of Ashy Storm Petrels, Leach's Storm Petrels, and Black Storm-Petrels. The Double-Crested Cormorant population numbered about 270 pairs and fledged approximately 0.44 chicks per breeding pair. The Brandt's Cormorant population included 415 monitored pairs and productivity was 1.85 chicks per pair. The total Brandt's Cormorant population was approximately 500 pairs. A small population of Pelagic Cormorants was also monitored this year. The Pelagic Cormorant population numbered 18 pairs and productivity was 0.83 chicks per pair. We estimated the Western Gull population at over 4100 breeding pairs. Western Gull productivity was 0.78 chicks per pair. We did not estimate the population size of Xantus' Murrelets due to difficulties with censusing this nocturnal, crevice-nesting species. Murrelets produced an average of 0.86 chicks per pair. We mist-netted storm-petrels on 7 nights, capturing 171 unbanded birds and 9 previously banded birds.

INTRODUCTION

Seabird monitoring is the accumulation of time series data on any aspect of seabird distribution, abundance, demography, or behavior. Seabird monitoring has the potential to provide useful information to marine resource managers for a variety of reasons. Seabirds respond quickly to environmental perturbations and, therefore, provide timely information on the abundance of lower trophic level organisms (e.g. zooplankton and demersal fishes) in marine ecosystems (Croxall et al. 1988). These data are particularly useful to wildlife managers and members of the public for understanding the impacts of human use of coastal or marine resources on particular species or populations. In 1985, Channel Islands National Park established a Seabird Monitoring Program out of concern for the welfare of Southern California seabirds and in recognition of the contributions seabirds can make to monitoring marine ecosystems. Threats to Channel Islands National Park seabirds include mortality from native and introduced predators, oil and chemical pollution, and incidental take (i.e., bycatch) by commercial fisheries. Alterations of marine food webs by the over-exploitation of prey and climate change may also be detrimental to populations of seabirds in Southern California.

This report summarizes monitoring of Double-Crested Cormorant (*Phalacrocorax auritus*), Brandt's Cormorant (*Phalacrocorax penicillatus*), Pelagic Cormorant (*Phalacrocorax pelagicus*), Western Gull (*Larus occidentalis*), Xantus' Murrelet (*Synthliboramphus hypoleuca*), and 3 species of storm-petrel (*Oceanodroma homochroa, Oceanodroma melania*, and *Oceanodroma leucorhoa*) on Santa Barbara Island, Channel Islands National Park, 1996. Jennifer Roth and Shaye Wolf collected the data under contract CA8120-95-003 between Point Reyes Bird Observatory and Channel Islands National Park. Roth and William Sydeman summarized and analyzed data. The Channel Islands National Park Seabird Monitoring Handbook provides a synopsis of the methodology used to investigate population size, phenology, and productivity of seabirds in Channel Islands National Park (Lewis et al. 1988). We provide more specific methodologies pertaining to our analyses in each species account. This is Point Reyes Bird Observatory contribution no. 737.

METHODOLOGY AND RESULTS

Double-Crested Cormorant

Methodology

Double-Crested Cormorants nested on North Peak Cliffs, West Cliffs, Sutil Island, and the south slope of Signal Peak in 1996. We made 24 land-based censuses from vantage points on the island between 7 April and 14 August. Data are contained in the file *DCCO96SM* (see Appendix B for file structure). To estimate productivity, we assessed the total number of nests, the number of nests containing chicks, and the number of large chicks (fledglings) for each sub-colony. The Signal Peak sub-colony was first observed on 12 June, well after the initiation of nests at this location. The number of nests (i.e., breeding birds) estimated for that colony was taken from the first observation which represented the peak number of nests observed. However, it is possible that a higher number may have been obtained if sampling this location had occurred earlier in the season. In addition, another portion of North Peak Cliffs was colonized this year and is referred to in the data as “np7”. Boat-census data for Double-Crested Cormorants were not available, so population estimates may be biased towards low values.

Phenology

Observations indicated that egg-laying began in late April with peak lay occurring

in mid-June (Figure 11). Chicks began to hatch in late May with peak hatch occurring in mid-July. We estimated the hatch dates by assuming that chicks were already approximately 10 days old when we first observed them. The period of both peak-lay and peak-hatch varied between sub-colonies.

Population Size and Productivity

We estimated the breeding population of Double-Crested Cormorants to contain 270 pairs in 1996 (Table 31). These data represent the peak number of nests observed during land-based surveys of each sub-colony. We estimated productivity to be 0.44 chicks fledged per pair (120/270).

Brandt's Cormorant

Methodology

Brandt's Cormorants nested on Webster Point, Webster Cove Cliffs, and Arch Point. We collected data on 18 dates between 7 April and 1 July. The Brandt's Cormorant colonies were already well-established when we began monitoring at the beginning of April. We monitored the colonies until it was impossible to distinguish between adults and chicks. Data are contained in file *BRCO96SM* (see Appendix B for file structure). During each survey, we counted the number of occupied nests, nests with chicks, and large chicks. We also conducted a boat-based survey of Sutil Island and Santa Barbara Island on 30 April and 2 May (Figure 12).

Phenology

We estimated that egg-laying began in late March. Peak lay occured in late April (Figure 13). We also estimated that chicks began hatching in late April with peak hatch occuring in late May. We arrived at these estimates by assuming that eggs were laid approximately 30 days before chicks hatched and by assuming that chicks were approximately 10 days old when they were first observed.

Table 31 Double-Crested Cormorant population size and reproduction on Santa Barbara Island, 1996

Subcolony	Number of occupied nests [a]	Number of nests with chicks	Estimated number of young fledged [b]
Sutil Island	37	13	11
Signal Peak	34	12	11
West Cliff 1	19	3	5
West Cliff 2	12	2	4
West Cliff 3	41	12	15
North Peak 1	44	15	34
North Peak 2	6	0	2
North Peak 3	8	4	5
North Peak 4	17	5	9
North Peak 5	7	0	0
North Peak 6	17	6	9
North Peak 7	28	11	15
Total	270	83	120

[a] Nests with adults in incubation or brooding postures; exact nest contents unknown

[b] Number of big chicks seen in nest

Table 32 Population size and reproductive success for Brandt's Cormorants on Santa Barbara Island, 1996, based on land-based surveys

Subcolony	Number of occupied nests [a]	Estimated number of fledged young [b]	Productivity [c]
Webster Point	385	731	1.9
Webster Cove Cliffs	12	18	1.5
Arch Point	18	20	1.11
Total	415	769	1.85

[a] Nests with adults in incubation or brooding postures; nest contents unknown

[b] Number of big chicks seen in nest

[c] Estimated number of young fledged/number of occupied nests

Population Size and Productivity

Based on land-based surveys, we estimate 415 breeding pairs of Brandt's Cormorants on Santa Barbara Island in 1996 (Table 32). Productivity was 1.85 chicks fledged per pair. We found an additional 93 nests on Santa Barbara Island during the boat census, bringing the total population estimate up to 508 breeding pairs. No information on fledging was available from these additional nests.

Pelagic Cormorant

Methodology

Pelagic Cormorants nested exclusively on Webster Cove Cliffs. We collected data on 18 dates between 7 April and 1 July. Data are contained in file *PECO96SM* (see Appendix B for file structure). During each survey, we counted the number of occupied nests, nests with chicks, and large chicks. We also conducted a boat-based survey of Santa Barbara Island on 2 May.

Phenology

We estimated that Pelagic Cormorants began laying eggs in early April, with peak lay in early May (Figure 14). We also estimated that the first chicks hatched in early May and that peak hatch was in early June. We arrived at these estimates by assuming that eggs were laid approximately 30 days before chicks hatched and by assuming that chicks were approximately 10 days old when they were first observed.

Population Size and Productivity

There were 18 breeding pairs of Pelagic Cormorants on Santa Barbara Island in 1996 (Table 33). Productivity was 0.83 chicks per pair. No additional nests were seen during the boat census.

Western Gull

Methodology

We monitored Western Gull breeding phenology, nesting success, and chick growth in three 1 ha study plots (Lewis et al. 1988). Between 21 April and 25 July,

Table 33 Population size and reproductive success for Pelagic Cormorants on Santa Barbara Island, 1996, based on land-based surveys

Subcolony	Number of occupied nests [a]	Estimated number of fledged young [b]	Productivity [c]
Webster Cove Cliffs	18	15	0.83

[a] Nests with adults in incubation or brooding postures; nest contents unknown

[b] Number of big chicks seen in nest

[c] Estimated number of young fledged/number of occupied nests

Table 34 Development of the k correction factor used for converting the number of adult Western Gulls counted into breeding pairs (correction factor = nests x 2/number of adults)

Plot	Number of nests	Number of adults during census	Correction factor
A	67	71	1.89
E	96	134	1.43
Average [a]			1.66

[a] Average correction factor was used to estimate population size

we made 20 visits to the plots. Summary data are contained in file WG96SM (see Appendix B for file structure).We visited the plots at 5-day intervals throughout the breeding season. After hatch, we weighed chicks during each check to ascertain growth rates.

From 23 May and 25 May, during the peak of the incubation period, we conducted an island-wide census of Western Gull adults. To convert the number of adults counted to an estimate of total breeding population size, we developed a ***k*** correction factor by assessing the number of adults in 2 study plots in which we knew the number of active nests as well.

Phenology

First eggs were found in late April. Peak egg-laying occurred in mid-May (Figure 15 and Figure 16). The first chicks hatched in late May and peak hatch was in early June.

Population Size

We estimated the breeding population of Western Gulls at over 4100 breeding pairs (Table 34 and Table 35). This figure is considerably higher than the 1995 estimate of nearly 2500 pairs, but it is consistent with the 1994 estimate of 4000 pairs. The 1990, 1991, and 1992 estimates were 1800, 2500, and 2100 pairs respectively. The population has apparently increased since the early 1990's, especially in the A1, West, and Sea Lion Rookery sub- colonies.

Productivity

Clutch size was 2.18 eggs per nest (Table 36). There were no significant

Table 35 Estimates of population size for Western Gulls on Santa Barbara Island, 1996

Subcolony area	Subcolony name	Total adults counted	Number of roosting birds	Estimated breeding pairs [a]
1	Landing Cove	160	3	130
2	Arch Point	327	48	232
3	Shag Rock	82	1	67
4, 5	Elephant Seal Cove/ North Cliff	329	66	218
6	Webster Point	341	17	269
7	A1 Cliff	30	5	21
8	A1Area	508	0	422
9	West Colony	1367	133	1024
10, 11	Badlands/Cat Canyon	1489	105	1149
12	Sea Lion Rookery	846	81	635
Total		5470	459	4167

[a] Estimated by subtracting the number of roosting birds from the total number of adults counted, multiplying this estimate by the *k* correction factor, then dividing this product by 2 to estimate breeding pairs

Table 36 Reproductive effort of Western Gulls on Santa Barbara Island, 1996

Breeding parameter	Mean ± s.d. (N)
Clutch Size	2.179 ± 0.694(223)
Hatching Success	0.629 ± 0.398(223)
Fledging Success	0.561 ± 0.428(174)
Productivity [a]	0.780 ± 0.839(223)

[a] **Chicks fledged/breeding pair**

differences in clutch size between grids (Table 37 and Table 38, F=1.90, df=2, p=0.152). Hatching success (the proportion of eggs laid that hatched) was 0.63. Hatching success varied by grid (F=3.84, df=2, p=0.023); Grid D was significantly lower than Grid A (Bonferroni test, p=0.020). Fledging success (proportion of chicks hatched that fledged) was estimated at 0.56. There were marginally significant differences between grids in fledging success (F=2.96, df=2, p=0.055), with higher fledging in Grid D over Grid A (Bonferroni test, p=0.058). Productivity was 0.78 chicks fledged per breeding pair (Table 36, Table 37, and Table 38). There were no significant differences in productivity between study plots (F=0.16, df=2, p=0.852).

We calculated chick growth rates using from 3–5 weights per chick during the linear phase of growth (i.e., between 100 and 600 grams). Data are contained in the file *WGCKWT96* (see Appendix B for file structure). The average growth rate for chicks on Santa Barbara Island was 25.76 □ 5.96(160) grams per day. The average growth rate for chicks that fledged was 26.25 □ 5.65(143) grams per day and 21.65 □ 7.03(17) grams per day for chicks that did not fledge. Growth rates did not vary significantly between plots (F=.23, df=2,157, p=0.79).

Table 37 Reproductive effort of Western Gulls in different study plots

Grid	Nests	Eggs laid (nests)	Eggs hatched (nests)	Chicks fledged (nests)
A	68	156(68)	112(59)	51(35)
D	57	117(57)	64(38)	43(29)
E	98	213(98)	139(77)	80(56)
Total	223	486(223)	315(174)	174(120)

Xantus' Murrelet

Methodology

We monitored 150 potential nest sites in the Cat Canyon and Nature Trail study areas. We checked sites 24 times at 5 day intervals between 8 March and 4 July. Summary data are contained in file *XAMU96SM* (see Appendix B for file structure). The Cat Canyon study area has little vegetation and birds nested almost exclusively in rock crevices. In contrast, the Nature Trail study area has few rock crevices and murrelets nest almost entirely under shrubs (*Eriophyllum* spp and *Hemizonia* spp). Additionally, we monitored 17 disturbed nest sites located around the bunk-house and dock areas which are exposed to high levels of human activity. All of these sites were associated with man-made structures. Disturbed sites and new sites (i.e., those not monitored in 1995) found in Cat Canyon and Nature Trail were excluded from calculations of occupancy but were included in other estimates of breeding parameters. All sites with unknown egg fates were excluded from estimates of breeding parameters. Second attempts were also excluded from our estimates.

Phenology

Egg-laying began in early April with peak lay occurring in mid-April (Figure 17**)**. Clutch initiation dates were similar between Nature Trail and Cat Canyon. The first chicks hatched in late May with peak hatch in early June.

Population Size

We have no information on the breeding population size of Xantus' Murrelets on Santa Barbara Island in 1996. Indications are that this population has declined (Carter et al. 1992, Sydeman et al. in prep.), yet detailed population estimates from Santa Barbara Island, the major colony of this species in California, are unavailable for recent years.

Table 38 Reproductive effort of Western Gulls by study plots

Grid	Clutch size mean ± s.d. (N)	Hatching success mean ± s.d. (N)	Fledging success mean ± s.d. (N)	Productivity [a] mean ± s.d. (N)
A	2.294 ± 0.671(68)	0.708 ± 0.359(68)	0.463 ± 0.435(59)	0.750 ± 0853(68)
D	2.053 ± 0.717(57)	0.515 ± 0.428(57)	0.671 ± 0.418(38)	0.754 ± 0.872(57)
E	2.174 ± 0.689(98)	0.641 ± 0.395(98)	0.582 ± 0.417(77)	0.816 ± 0.817(98)

[a] Chicks fledged/breeding pair

Productivity

Xantus' Murrelets occupied 40% of the monitored sites in 1996. Murrelets nested in 35% of the monitored sites in the Nature Trail =1, p=0.061). The proportion of eggs laid which hatched was 0.45 □ 0.46(56) for all areas combined. Hatching success was 0.37 □ 0.46(14) for Nature Trail and 0.56 □ 0.45(30) for Cat Canyon. Hatching success was 0.25 □ 0.40(12) for the disturbed sites (Table 39).

Egg predation by deer mice (*Peromyscus maniculatus*), as indicated by the number of broken eggs, was 48% in Nature Trail and 37% in Cat Canyon. The proportion of abandoned eggs was 14% in Nature Trail and 3% in Cat Canyon. In the disturbed areas, egg predation was 50%, and 25% of the eggs were abandoned. There were not any significant differences in predation or abandonment between study areas. Productivity (number of chicks hatched per pair) was 0.86 □ 0.86(56) for all areas combined (Table 40). There were no significant differences in productivity between the Cat Canyon and Nature Trail sites (Pearson chi^2=1.6315, df=2, p=0.442).

Ashy, Black, and Leach's Storm-Petrels

Methods

We mist-netted storm-petrels during 7 nights on Santa Barbara Island between 6 June and 15 August for a total of 24 net-hours (Figure 17). We were unable to mist-net in April or May due to high winds. Data are compiled in file ASSP96 (see Appendix B for file structure). We conducted mist-netting at standardized locations in proximity to appropriate nesting habitat. To measure the phenology of Santa Barbara Island storm-petrels, we looked for the presence or absence of brood patches. For this analysis, we grouped storm-petrels into those captured during 4 nights in June, 2 nights in July, and 1 night in August.

Population

We tallied a total of 180 storm-petrels including new captures and recaptures. Of these birds, 171 were newly banded and 9 were recaptures. Ashy Storm-Petrels accounted for the majority of birds caught (89%, n=161, including 9 recaptures), with lesser numbers of Black Storm-Petrels (9%, n=16, no recaptures), and Leach's Storm-Petrels (2%, n=3, no recaptures). Five of the recaptures were originally banded on Santa Barbara Island. They

Table 39 Reproductive effort of Xantus' Murrelets on Santa Barbara Island, 1996

Area	# of sites checked	# of sites occupied	# of eggs laid (sites)	# of eggs hatched	# of eggs broken	# of eggs abandoned	# of unknown eggs
Cat Canyon	76	34	54	31	19	2	2
Nature Trail	57	23	34	10	11	2	11
Disturbed	17	17	23	7	9	4	3
Total	150	74	111	48	39	8	16

Table 40 Reproductive effort in Xantus' Murrelets on Santa Barbara Island, 1996

Breeding Parameter	Nature trail mean ± s.d. (N)	Cat canyon mean ± s.d. (N)	Disturbed mean ± s.d. (N)
Occupancy [a]	0.26 ± 0.44 (66)	0.44 ± 0.50 (79)	0.55 ± 0.52 (11)
Clutch Size	1.80 ± 0.41 (15)	1.40 ± 0.50 (30)	1.33 ± 0.52 (6)
Hatching Success [b]	0.53 ± 0.48 (15)	0.58 ± 0.47 (30)	0.83 ± 0.41 (6)
Productivity [c]	0.87 ± 0.83 (15)	0.76 ± 0.68 (30)	1.17 ± 0.75 (6)

[a] Productivity = number of hatched eggs/number of nest attempts

[b] Sites with unknown egg fates were not included

[c] Productivity = number of hatched eggs/number of nest sites (results from first and apparent second attempts were added; sites with unknown egg fates were not included)

were banded on 13 April 1991, 16 July 1991, 13 May 1994, 9 August 1994, and 3 August 1995. Two of the recaptures were originally banded on a boat in Orizaba Anchorage, Santa Cruz Island on 7 June 1996. The remaining recaptures were caught in Scorpion Anchorage, Santa Cruz Island on 10 July 1994 and at Prince Island, off of San Miguel Island, on 4 May 1995.

Phenology

Of the 98 Ashy Storm-Petrels captured in June, 55% (54/98) had brood patches. In July, 58% (33/57) had brood patches and 57% (4/7) had brood patches in August. For Black Storm-Petrels 100% (2/2) in June, 78% (7/9) in July, and 60% (3/5) in August had brood patches. We captured 2 Leach's Storm-Petrels in June and 1 in August, all of which had brood patches.

Discussion

The 1996 breeding season resulted in poor reproductive success for Double-Crested Cormorants, which is consistent with the decline in productivity observed over the past few years. Double-Crested Cormorants fledged, on average, 0.96 chicks per pair in 1993, 0.89 chicks per pair in 1994, 0.71 chicks per pair in 1995, and 0.44 chicks per pair in 1996. The decrease in productivity in 1996 may be due to a high abandonment rate, but data on the number of nests abandoned was not available. Though productivity has decreased the breeding population appears to be stable. The population estimate for 1996 was higher than the estimate for 1995 but consistent with estimates for 1993 and 1994. We recommend combining our estimates with the available aerial survey data to get a better idea of how the Double-Crested Cormorant population has varied.

Xantus' Murrelets began breeding approximately a month earlier than last year, consistent with observations made in 1993 and 1994. Reproductive success in Xantus' Murrelets is consistent with estimates from last year. The murrelets fledged approximately 0.83 chicks per pair in 1993, 0.54 chicks per pair in 1994, 0.84 chicks per pair in 1995, and 0.86 chicks per pair in 1996. Hatching success and predation have fluctuated over the past 4 years. Hatching success was approximately 0.59 in 1993, compared to 0.38 in 1994, 0.56 in 1995, and 0.45 in 1996. The proportion of eggs depredated in 1993 was 0.22, compared to 0.44 in 1994, 0.21 in 1995, and 0.45 in 1996.

Observations indicate that Brandt's Cormorant productivity has been increasing over the last several years, reaching their highest levels in 1996. Productivity estimates were 1.50 in 1993, 1.73 in 1994, 1.64 in 1995, and 1.85 in 1996. Population levels were considerably higher in 1996 than in previous years, though the inclusion of census data gathered during the boat counts may account for some of the differences.

Pelagic Cormorants were monitored for the first time this year, making any comparisons of population size or productivity impossible. Though the population is small, it would be worth

monitoring this species in the future to measure any increases in their abundance.

Western Gulls exibited increased productivity in 1996, though productivity estimates have fluctuated over the past 4 years. Productivity was estimated at 0.72 chicks per pair in 1993, 0.97 chicks per pair in 1994, 0.44 chicks per pair in 1995, and 0.78 chicks per pair in 1996. The chick growth rate was considerably higher in 1996 than in previous years. Estimates of Western Gull population size have also varied considerably. The 1996 estimate of greater than 4100 breeding pairs was much higher than the 1995 estimate of nearly 2500 pairs but close to the 1994 figure of approximately 4000 pairs. Island-wide population data was not available for 1993.

MONITORING AND MANGEMENT RECOMMENDATIONS

Cormorants

The Double-Crested Cormorant population appears to be expanding into areas that have not been colonized in the last few years. In 1996, Double-Crested Cormorants colonized an additional section of North Peak Cliffs and the southwest slope of Signal Peak. It is possible to see into the nests of the Signal Peak sub-colony from a vantage point along the Signal Peak Trail. We recommend increased monitoring of this sub-colony to provide more detailed information concerning chronology and reproductive effort, in addition to gathering similar data from the vantage point along North Peak.

Brandt's and Pelagic Cormorants nested earlier in the season than expected. Colonies were already well-established by early April in 1996 (Figure 13 and Figure 14). Brandt's Cormorants nested on Arch Point and both Brandt's and Pelagic Cormorants nested on Webster Cove Cliffs in 1996. We recommend earlier and continuing monitoring of these areas, paying particular attention to Pelagic Cormorants to determine whether or not their numbers are increasing on Santa Barbara Island. It is also important to continually assess the impact of commercial and recreational boaters and aircraft on cormorant and pelican colonies. While no disturbance was noted in 1996, any undue disturbance near nesting sites could cause birds to abandon their nests, thereby subjecting eggs and chicks to Western Gull predation. We recommend enforcement of a 1000' altitude limit when flying over or near the island to protect nesting seabirds.

Xantus' Murrelet

We recommend that significantly more effort be devoted to the study of the population ecology of Xantus' Murrelets (see also Sydeman et al. in prep). It is especially important to obtain an accurate assessment of occupancy of potential nest sites on Santa Barbara Island to aid in estimating population size. This could be accomplished by defining boundaries around the Cat Canyon and Nature Trail study areas or establishing new study plots in which all potential Xantus' Murrelet nest sites are studied for occupancy. Establishing formal plots would allow for more rigorous searching of additional sites than has been done in the past. Sites within these defined areas (i.e. not just monitored sites) should be checked for occupancy at the peak of the incubation period. Including the additional sites in occupancy calculations would give a less biased estimate of occupancy values than data provided by monitored sites in Cat Canyon and Nature Trail alone. We also recommend investigations into the characteristics of suitable Xantus' Murrelet sites. Knowledge of the size and configuration of sites occupied by murrelets could be used in estimates of the number of available sites in defined areas and in the design of artificial habitat (if

desirable) to promote population growth and/or protection.

There were 3 changes in the breeding parameters of Xantus' Murrelets in 1996 that are particularly noteworthy. First, there were fewer two-egg clutches in Nature Trail than in Cat Canyon, which was only seen in two of the previous 13 years. Second, egg predation was higher in Nature Trail than in Cat Canyon. Higher rates of predation in Nature Trail were also seen in just two of the previous 13 years. Third, occupancy at both Cat Canyon and Nature trail, but particularly at Nature Trail, was very low. These patterns are opposite the general patterns established in previous years and remain largely unexplained. It is possible, however, that recent research conducted by the National Biological Service (NBS) may have had an effect on Xantus' Murrelet reproductive effort. NBS researchers worked near Santa Barbara Island for 5 days in April and 5 days in May during 1996. Their visits corresponded to times of peak lay and to dark phases of the moon when murrelets were more likely to be near the island. These researchers handled birds for morphometric analysis, sampled blood parameters, and placed approximately 50 radio transmitters on individuals. Birds were captured from staging areas below the Nature Trail study site and elsewhere along the east side of Santa Barbara Island. This disturbance may have caused a reduction in breeding effort, thereby influencing occupancy rates, or a reduction in nest attentiveness throughout the incubation period, thereby allowing mice access to eggs which would normally be protected by breeding birds. Results from the terrestrial program have shown that there were very high numbers of mice in 1996. Given concern for this species (it is considered a species of special concern under the Endangered Species Act of 1973) this warrants additional investigation and discussion prior to February 1997 when the NBS project enters its third year.

To mitigate any detrimental effects on Xantus' Murrelets nesting in disturbed areas on Santa Barbara Island we recommend reducing the movement of construction materials and supplies during the breeding season as much as possible. Murrelets readily nest under boards, coils of rope, and other similar materials. Removing these materials during the breeding season leaves murrelet eggs open to predation by gulls and causes birds to abandon sites. In addition, it may be possible to enhance available habitat away from disturbed areas by installing nest boxes on Santa Barbara Island. Nest boxes would provide murrelets with additional nesting sites, facilitate the monitoring of murrelet demography, and protect birds in areas of high levels of human disturbance (e.g. Landing Dock).

Western Gulls

We recommend reducing effort that is currently devoted to monitoring Western Gulls. This could be accomplished by dropping Grid D or half of Grid E, as was done in 1995, and monitoring the grids on different days. These changes would reduce the amount of time researchers are in the grids, thereby reducing the impact of predation and heat stress on eggs and chicks. Changes would also allow more time for monitoring species facing conservation problems (i.e., Xantus' Murrelets). We also recommend careful assessment of Western Gull population changes. The population has grown considerably through time. If this pattern continues, it might cause problems for other species on Santa Barbara Island (murrelets, auklets, and storm-petrels) as gulls are known to be voracious predators on other seabirds, though there was no evidence of this type of predation during the 1996 season.

Storm-Petrels

Due to Ashy Storm-Petrels status as a species of special concern under the Endangered Species Act, we recommend continuing standardized mark-recapture studies to estimate population size and establish population status and trends.

General

Having two researchers involved with monitoring this year allowed for uninterrupted data collection and, therefore, the most complete data set on seabird population size, chronology, and reproductive effort (i.e., the objectives of the Channel Islands National Park Seabird Monitoring Program) collected to date.

Interaction and overlap on Santa Barbara Island between seabird researchers is essential to ensure consistency in data collection and efficiency (i.e., that a minimum amount of time is spent collecting the maximum amount of data). We strongly recommend that Channel Islands National Park continue to support two people to accomplish seabird monitoring on Santa Barbara Island. Problems with earlier data could be alleviated given additional personnel and time to conduct studies in a thorough manner.

Last, in order to provide maximum protection to nesting seabirds and increase and enhance visitor awareness and enjoyment of Santa Barbara Island, we recommend that a more extensive display on seabirds and the effects of human disturbance is developed and placed in the Santa Barbara Island visitor center. The display should include an explanation of the risks of predation and heat stress to Western Gull eggs and young chicks when nests are exposed, and the likelihood of abandonment when cormorants and pelicans are flushed from nests. The display should also include the fact that Xantus' Murrelets are considered a *species of special concern* by the U.S. government under the Endangered Species Act.

Visitors should be informed about how to reduce their impacts on breeding birds (e.g., by staying on the not trails and not lingering too long in areas populated by Western Gulls).

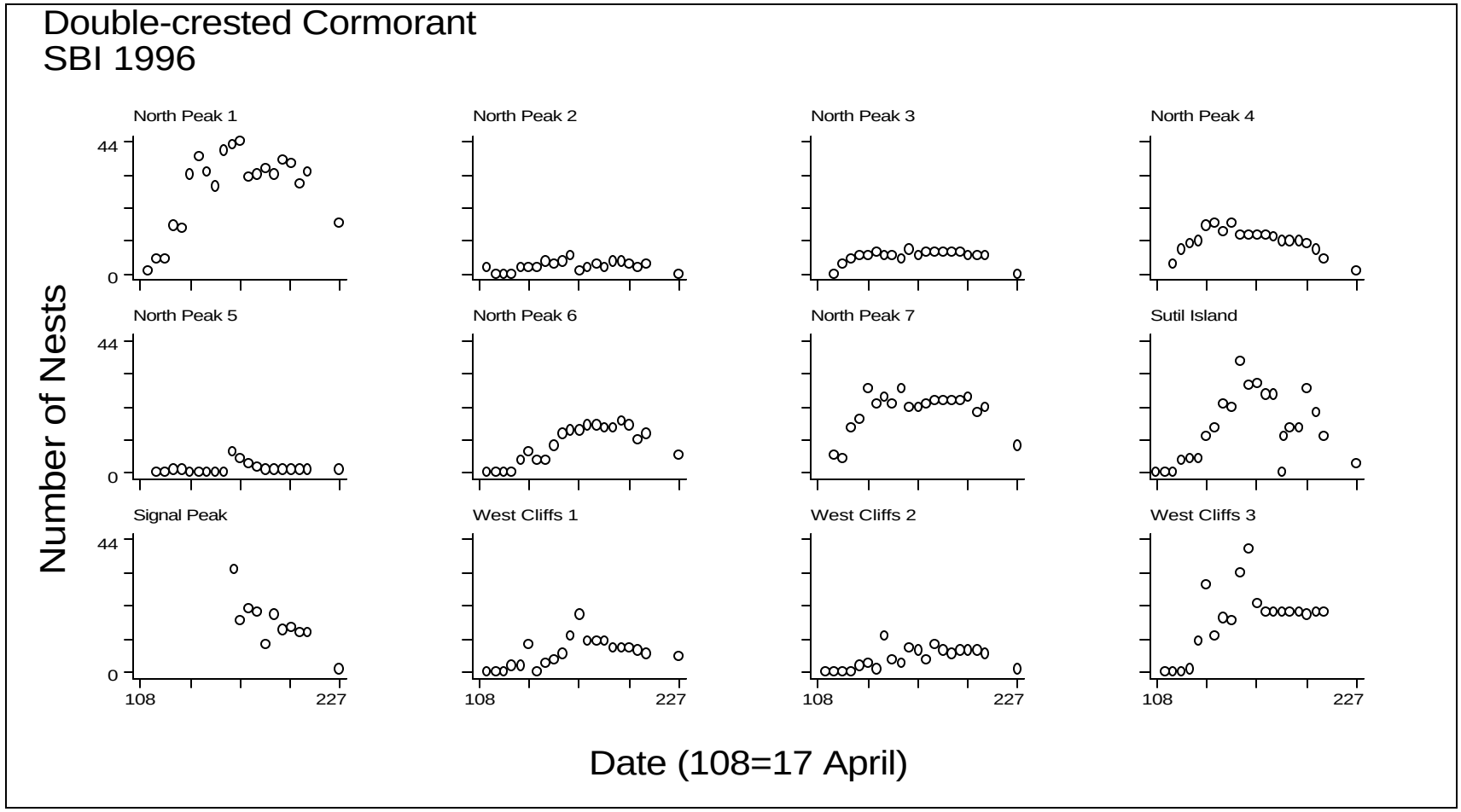

Figure 10 Chronology of colony formation for Double-Crested Cormorants on Santa Barbara Island, 1996

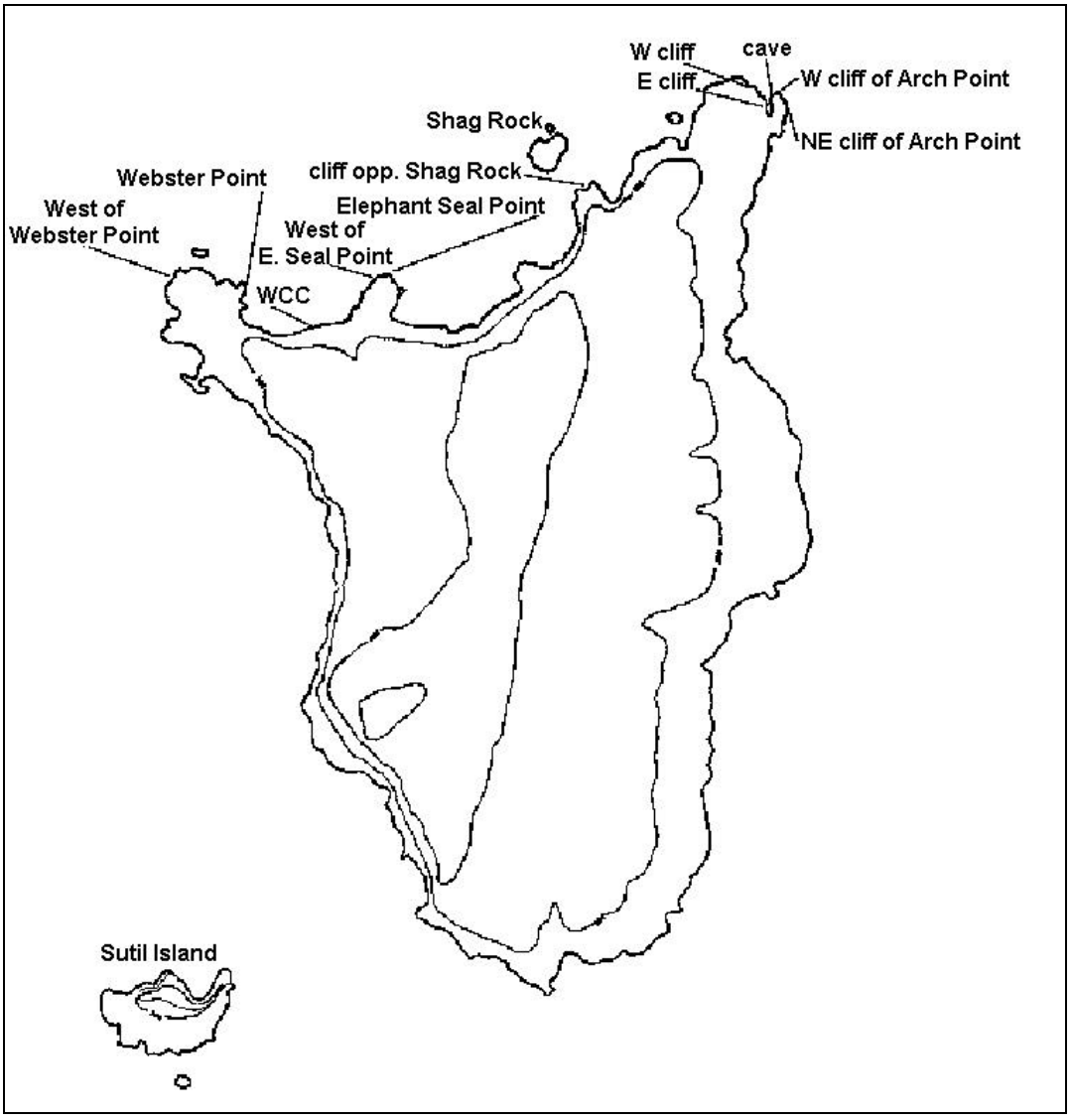

Figure 11 Brandt's and Pelegic Cormorant nesting sites surveyed during the boat censuses of Santa Barbara Island, Sutil Island, and Shag Rock, 1996

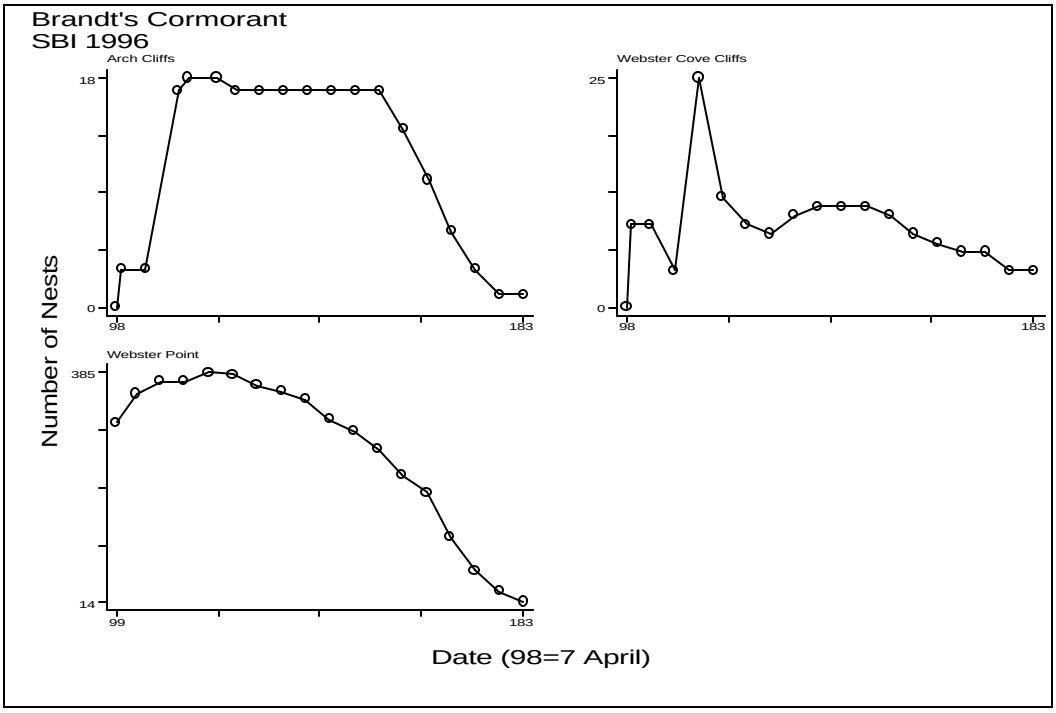

Figure 12 Chronology of colony formation for Brandt's Cormorants on Santa Barbara Island, 1996

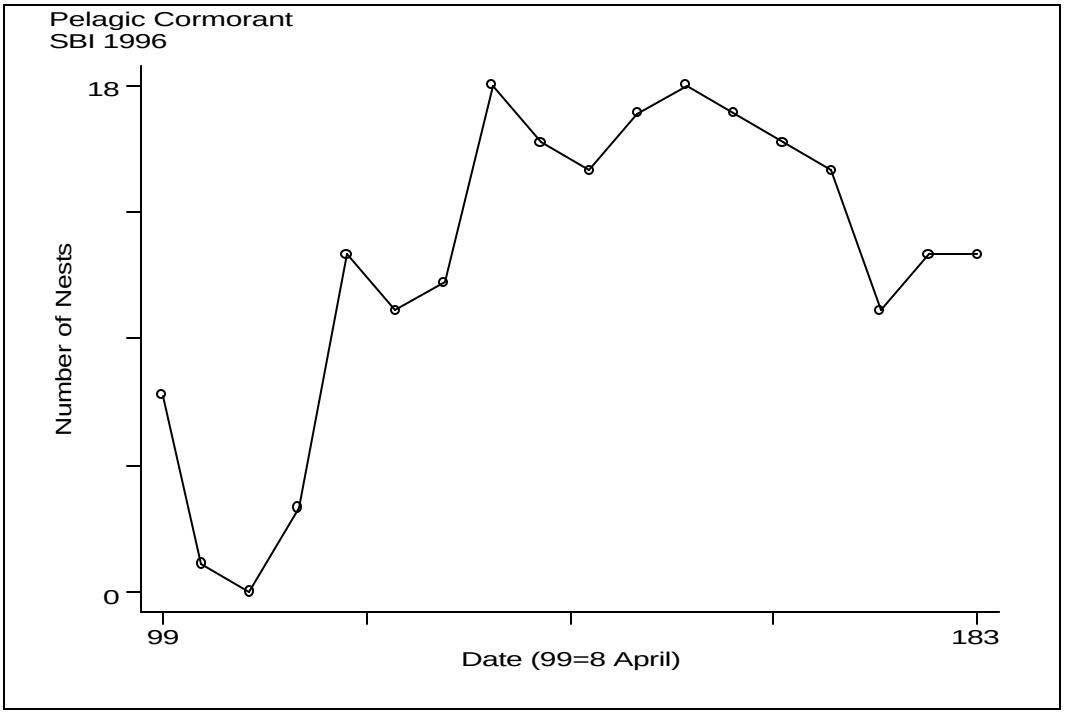

Figure 13 Chronology of colony formation for Pelagic Cormorants on Santa Barbara Island, 1996

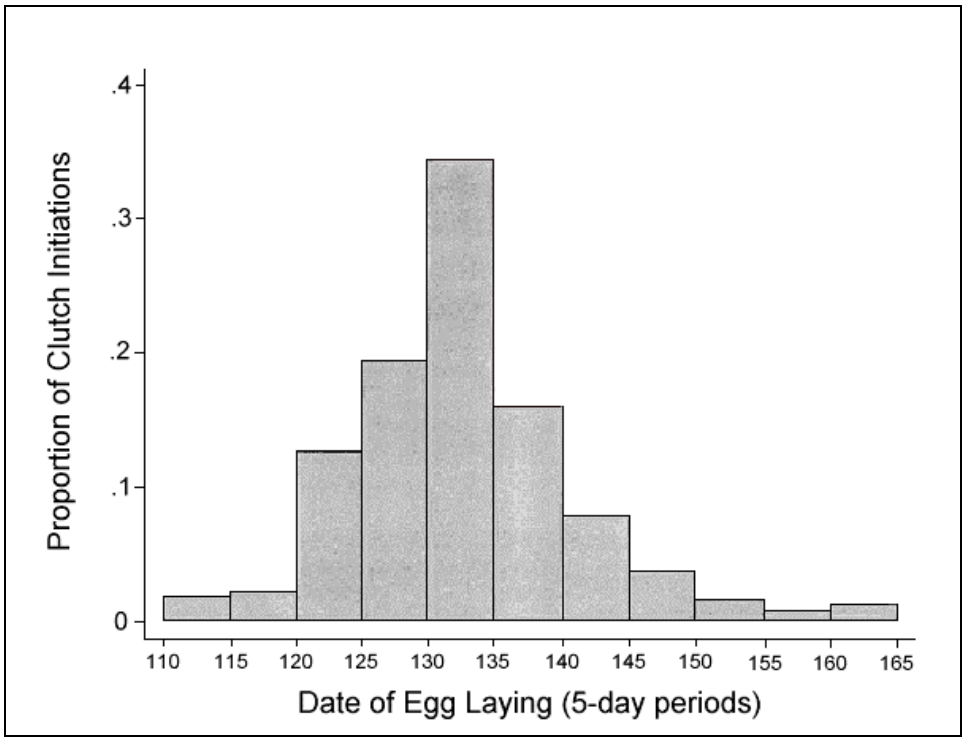

Figure 14 Chronology of clutch initiation for Western Gulls on Santa Barbara Island, 1996

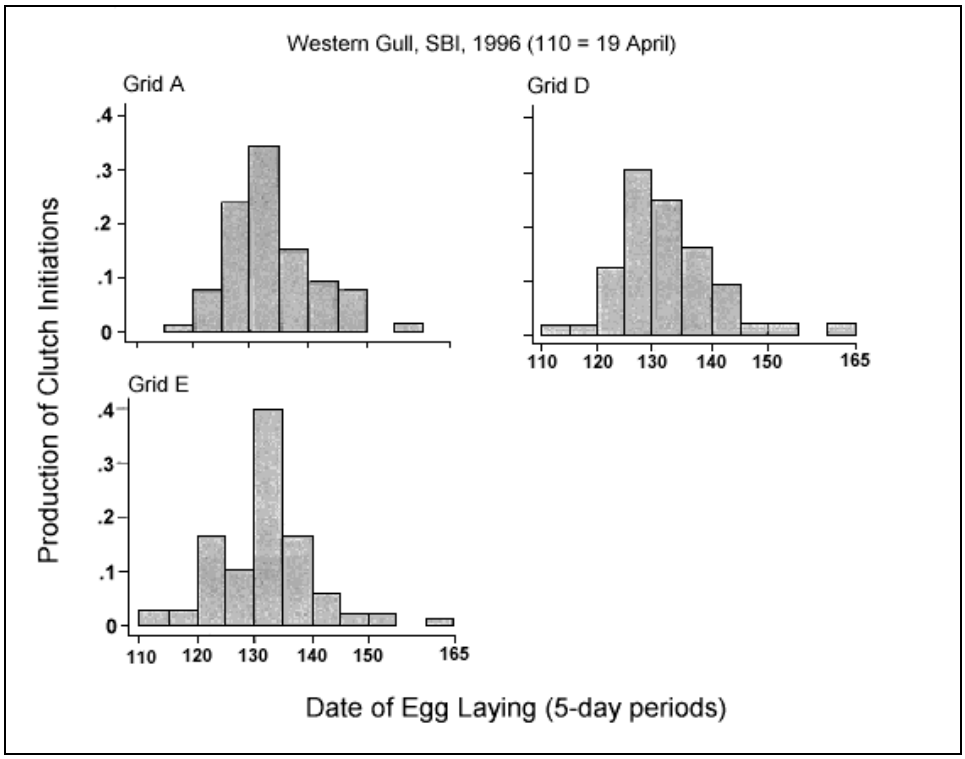

Figure 15 Chronology of clutch initiation by grid for Western Gulls on Santa Barbara Island, 1996

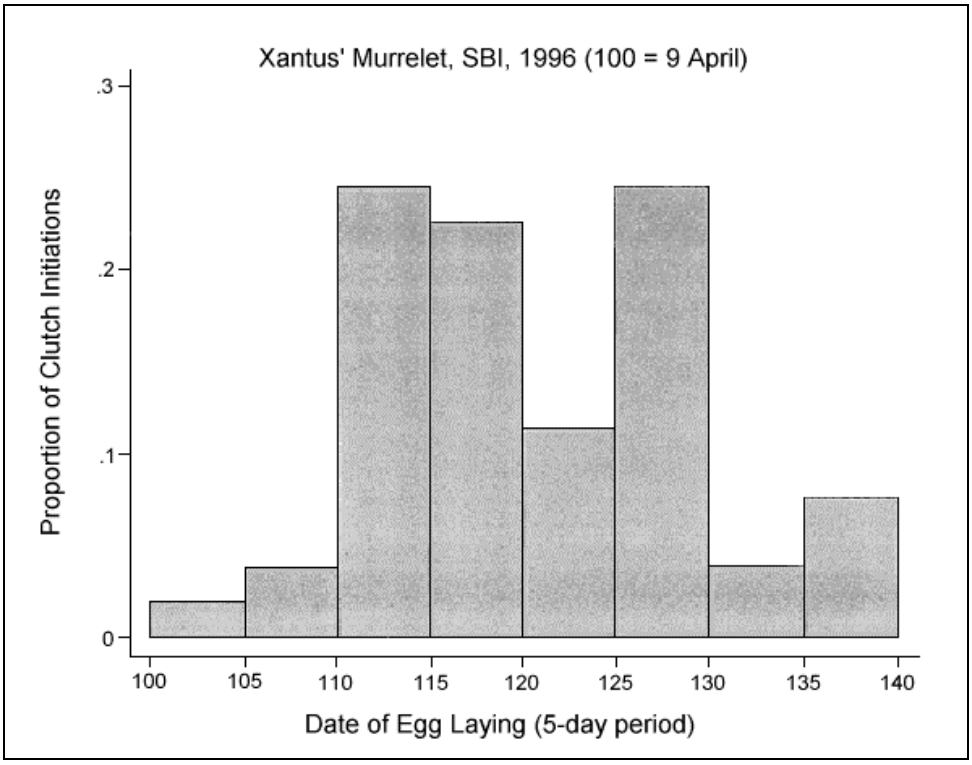

Figure 16 Chronology of clutch initiation for Xantus' Murrelets on Santa Barbara Island, 1996

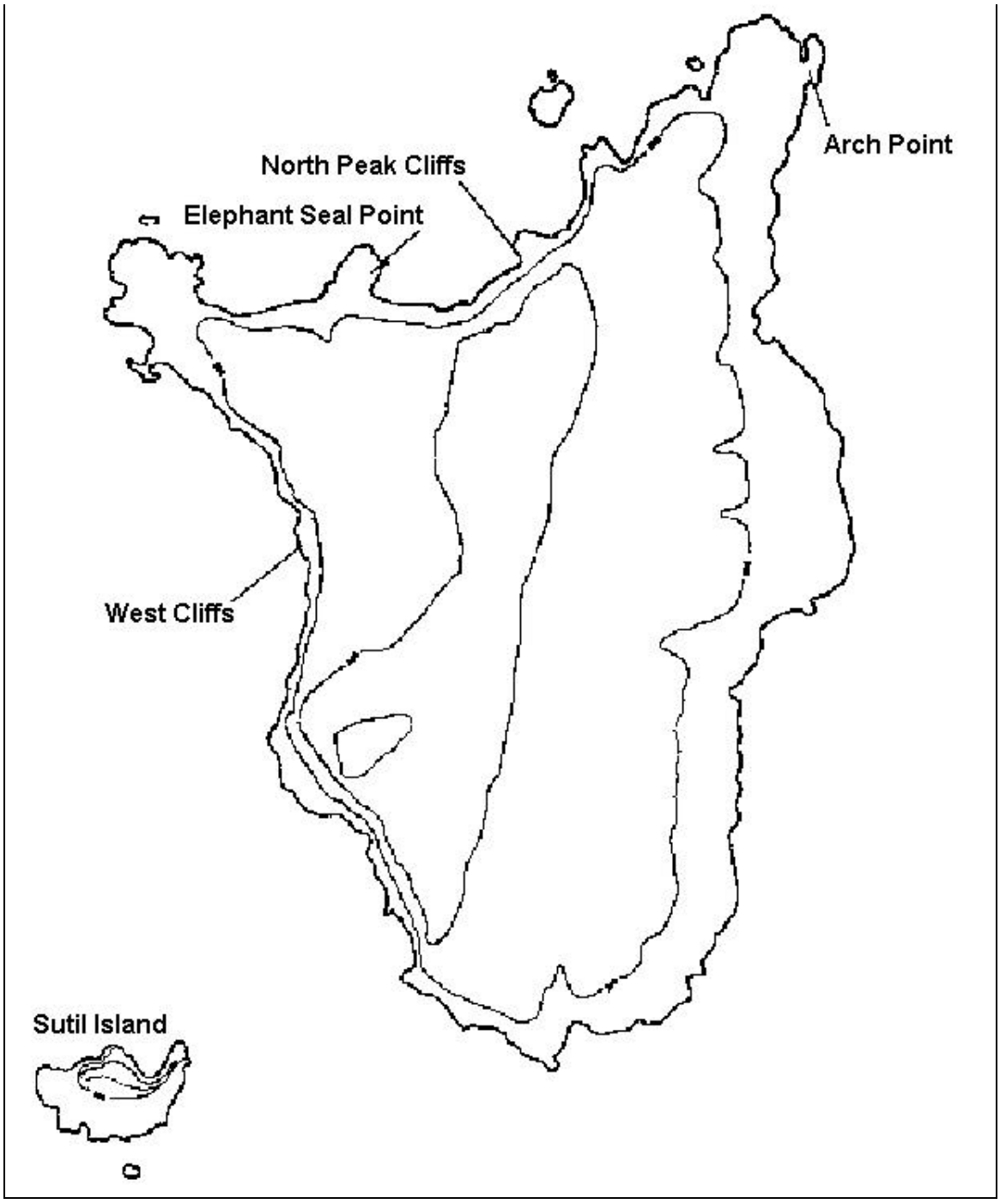

Figure 17 Storm-Petrel mist-netting locations on Santa Barbara Island, 1996

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APPENDIX A

Data Collected by the Channel Islands National Park Seabird Monitoring Program and Point Reyes Bird Observatory

Santa Barbara Island

1993 Paige Martin (Channel Islands National Park), Steve Myers (Student Conservation Association) and Jack Feldman (Channel Islands National Park) collected the data on Santa Barbara Island. Feldman and William Sydeman (Point Reyes Bird Observatory) summarized and analyzed the data under Contract No. 1443CA8120-93-003. Point Reyes Bird Observatory contribution no. 674.

1994 Jack Feldman (Point Reyes Bird Observatory), Clint Arnett (Student Conservation Association), and Tony Flaherty (Channel Islands National Park-Volunteers in Parks) collected the data. Feldman and William Sydeman summarized and analyzed the data under Contract No. 1443CA8120-93-003. Point Reyes Bird Observatory contribution no. 674.

1995 Mike Shultz (Point Reyes Bird Observatory) and Sarah Sturges (Channel Islands National Park-Volunteers in Parks) collected the data under Cooperative Agreement No. 1443CA8120-95-003 between Point Reyes Bird Observatory and Channel Islands National Park. Shultz and William Sydeman summarized and analyzed the data. Point Reyes Bird Observatory contribution no. 709.

1996 Jennifer Roth (Point Reyes Bird Observatory) and Shaye Wolf (Channel Islands National Park) collected the data under Cooperative Agreement No. 1443CA8120-95-003. Roth and William Sydeman summarized and analyzed the data. Point Reyes Bird Observatory contribution no. 737.

East Anacapa Island

1993 Paige Martin (Channel Islands National Park).

1994 Paige Martin.

1995 Paige Martin, Derek Lerma (Channel Islands National Park).

1996 Paige Martin, Derek Lerma.

San Miguel Island

1993 Walter Wehtje and Tiki Baron (Western Foundation of Vertebrate Zoolgy, under the auspices of Point Reyes Bird Observatory).

1994 Paige Martin, Ian Williams (Channel Islands National Park).

1995 Ian Williams, Derek Lerma.

1996 Paige Martin, Ian Williams, Eric Davis (Channel Islands National Park –Volunteers in Parks).

Santa Rosa Island

1993 Rob Stein (Point Reyes Bird Observatory), Gary Page (Point Reyes Bird Observatory), Paige Martin, Cece Sellgren (Channel Islands National Park).

1994 Paige Martin, Jim Hutton (Channel Islands National Park), Walter Wehtje.

1995 Paige Martin, Derek Lerma.

1996 Paige Martin, Derek Lerma, Bonnie Peterson (USN, civilian employee), Lauren Johnson (Channel Islands National Park).

Volunteer Field Assistants at East Anacapa Island

1993 Dana Smith (Channel Islands National Park), Tracy Miner.

1994 Dana Smith, Wither Bonin (Channel Islands National Park).

1995 Holly Snyder (IPCO).

1996 Holly Snyder, Derek Lohuis (Channel Islands National Park), Jeff Mondragon (Channel Islands National Park), Jennifer Morgan (Channel Islands National Park), Tom Dore (Channel Islands National Park), Shaye Wolf, Kim Goe, Ann Goe, Steve Tucker.

APPENDIX B

Santa Barbara Island 1996 Database Documentation

FILENAME: DCCO96SM

DOUBLE-CRESTED CORMORANT POPULATION AND PRODUCTIVITY DATA

FIELD	DESCRIPTION
DATE	Date of observation
WC1–WC3	WC1=Section 1 of West Cliffs sub-colony, WC2=Section 2 of West Cliffs sub-colony, WC3=Section 3 of West Cliffs sub-colony
NP1–NP7	NP1=Section 1 of North Peak sub-colony, NP2=Section 2 of North Peak sub-colony, NP3=Section 3 of North Peak sub-colony, etc.
Sutil Island	Sutil Island sub-colony
TOTAD	Total number of adults
NESTS	Total number of well-built nests, nests with incubating or brooding birds, or nest with chicks
NWCKS	Total number of nests observed with chicks
BGCKS	Total number of big chicks observed

FILENAME: BRCO96SM

BRANDT'S CORMORANT POPULATION AND PRODUCTIVITY DATA

FIELD	DESCRIPTION
DATE	Date of observation
WP	Webster Point
WCC	Webster Cove Cliffs
AP	Arch Point
TOTAD	Total number of adults
NESTS	Total number of well-built nests
NSTCKS	Total number of nests observed with chicks
BGCKS	Total number of big chicks observed

FILENAME: PECO96SM

PELAGIC CORMORANT POPULATION AND PRODUCTIVITY DATA

FIELD	DESCRIPTION
DATE	Date of observation
WCC	Webster Cove Cliffs
SR	Shag Rock
TOTAD	Total number of adults
NESTS	Total number of well-built nests
NSTCKS	Total number of nests observed with chicks
BGCKS	Total number of big chicks observed

FILENAME: WG96SM

WESTERN GULL PRODUCTIVITY DATA ARE SUMMARIZED FOR GRIDS A, D, AND E

FIELD	DESCRIPTION
GRID	A, D, or E
GRIDNO	A=1, D=2, E=3
NEST	Nest number
CS	Clutch size (number of eggs laid)
CH	Brood size (number of chicks hatched)
CF	Number of chicks fledged
DE	Dead eggs (unhatched eggs—addled, dead, or broken)
DC	Dead chicks (found)
LD1	Date that first egg was found

FILENAME: WGCKWT96

WESTERN GULL CHICK WEIGHT DATA AND CHICK FATES

FIELD	DESCRIPTION
GRID	A, D, or E
GRIDNO	A=1, D=2, E=3
NEST	Nest number
BAND	Last 5 digits of band number (966–XXXXX)
D1W–D8W	Date of first weight, date of second weight, etc.
WT1–WT8	First weight, second weight, etc.
FATE	Chick fate: 0=Never hatched 1=Disappeared at hatch 2=Stolen 3=Stolen after banding 4=Dead before banding, unknown cause 5=Dead after banding, unknown cause 6=Dead before banding, pecked in head 7=Dead after banding, pecked in head 8=Disappeared before banding 9=Disappeared after banding 10=Fledged (seen fully-feathered) 11=Never laid 12=Assumed fledged (seen mostly-feathered) 13=Unknown, not banded 14=Assumed fledged (see gawky-downy) 16=Dead (see Notes) 17=Deformed or injured, no fledge 19=Unknown fate 20=Dead after fledging, pecked in head 21=Dead after fledging, not pecked in head 22=No data after chick banding

FILENAME: XAMU96SM

XANTUS' MURRELET PRODUCTIVITY AND PHENOLOGY DATA ARE SUMMARIZED BY AREA

FIELD	DESCRIPTION
AREA	CC=Cat Canyon, NT=Nature Trail, H=House Sites, D=Dock Sites
NEST	Nest number
EL	Number of eggs laid in first clutch
E1L	Estimated lay date of first egg (within 5-day check period; (first clutch)
E2L	Estimated lay date of second egg (within 5-day check period; (first clutch)
HE	Humber of hatched eggs (first clutch)
BE	Number of broken eggs (first clutch)
ABE	Number of abandoned eggs (first clutch)
UKE	Number of unknown eggs (first clutch)
DC	Number of dead chicks (first clutch)
REL	Number of eggs laid (relay clutch)
RELD	Estimated lay date of first egg (within 5-day check period; relay clutch)
RHE	Number of hatched eggs (relay clutch)
RBE	Number of broken eggs (relay clutch)
RABE	Number of abandoned eggs (relay clutch)
RUKE	Number of unknown eggs (relay clutch)
RDC	Number of dead chicks (relay clutch)

FILENAME: ASSP96

STORM-PETREL MARK-RECAPTURE DATA FOR 1996 **(includes wing chord and brood patch measurements)**

FIELD	DESCRIPTION
SITE	Location of mist-netting—AP=Arch Point, WC=West Cliffs, ESP=Elephant Seal Point, NPC=North Peak Cliffs
DATE	Date of netting session
TIME	Time of capture
CODE	1=New Capture, 2=Recapture
BNDPRE	Band prefix=first 3 or 4 digits of band number
BAND	Last 5 or 6 digits of band number
RECAP	Band number of recaptured bird
SPCODE	AOU species code
AGE	1=adult
WING	Wing cord measurement in millimeters
BP	Brood patch—D=Downy, no brood patch, PD=Partially downy, B=Bare
BDR	Bander initials—FG=Frank Gress, DL=Derek Lohuis, PM=Paige Martin, JR=Jennifer Roth, SW=Shaye Wolf