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VOLUME III - INVESTIGATORS' REPORTS

Part III. Seabirds - Book II

Reproductive Ecology and Foraging Habits of Breeding Seabirds

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Book II

Reproductive Ecology and Foraging Habits of Breeding Seabirds

A. INTRODUCTION

B. METHODS

A. INTRODUCTION

The purpose of this report is to provide information on the distribution, abundance and reproductive ecology of seabirds breeding in the Southern California Bight (SCB). To this end, we conducted field studies of nesting seabirds, their foods and their foraging distributions during the 1975, 1976 and 1977 breeding seasons. We also conducted a thorough search of all sources of information on the past status of seabird colonies in the Channel Islands in order to provide an estimate of the long-term variability in nesting activity. Although the Channel Islands are close to metropolitan Los Angeles, relatively little was known of the seabirds breeding in this area.

Information on the numbers and reproductive ecology of nesting seabirds is of critical importance in assessing the risks of offshore oil development and for minimizing these potential risks. Knowledge of colony location, numbers and foraging areas is essential to identify areas that will be consistently vulnerable over a period of many years. Data on phenology defines those times of year in which environmental perturbations will have their greatest effect. Using this information, management options can be designed to protect seabird colonies from direct, major impact.

The reproductive success of seabirds is subject to pronounced variations and is often correlated with the availability of specific food resources. Seabirds are long-lived and produce small broods for many years. Thus, the loss of a single year's reproductive output is unlikely to have a major impact. However, a long-term depression of reproductive success may lead to a major, precipitous decline in population size from which populations may not recover. For this reason, it is important to know the food resources upon which the birds depend and the affect that oil development will have on these food stocks. Likewise, a knowledge of "baseline" reproductive rates and continued monitoring of reproductive output throughout the period of oil development and production will provide valuable indicators of the health of these bird populations.

Specifically, sublethal effects of oil may have a profound affect on populations by severly diminishing reproductive output. Hartung (1965) and Grau et al. (1977) have shown that ingested oil may cause cessation of egg laying in waterfowl. Grau et al. (1977) have also found that oil will disrupt yolk structure in Japanese Quail (*Coturnix coturnix*) and Canada Geese (*Anser canadensis*) and will reduce hatchability in the eggs of Japanese Quail. Hatchability may also be reduced when eggs become coated with oil from the soiled plumage of adults (Rittinghaus 1956; Hartung 1965; O'Connor 1967 in Nelson-Smith 1973). Thus, in an oil-related baseline study, it is essential to document normal levels of hatching success. Without such information, it will be extremely difficult to separate preexisting causes of hatching failure from the effects of oil subsequent to commencement of oil recovery operations.

Introduction: (continued)

Seabird reproductive success also provides an inexpensive means of monitoring local marine ecosystems. Since seabirds are top carnivores and are tied to the vicinity of their breeding colonies during the nesting season, their reproductive success and food use will reflect changes in the marine ecosystem on which they depend.

The Seabird Fauna

Upon completion of field work for this study, we knew of eleven species of seabirds nesting in the Channel Islands. Two of these species, Leach's Storm-Petrel (*Oceanodroma leucorhoa*) and Black Storm-Petrel (*O. melania*), were not previously recorded as breeding in the SCB; our records for the Black Storm-Petrel constitute the first breeding records for the United States (Pitman and Speich 1976).

Prior to this study there were considerable data available on the reproductive success of three of the eleven species (Brown Pelican, *Pelcanus occidentalis*; Double-crested Cormorant, *Phalacrocorax auritus*; and Western Gulls, *Larus occidentalis*). In contrast, very little information was available for the remaining eight species (Ashy Storm-Petrel (*O. homochroa*), Leach's Storm-Petrel, Black Storm-Petrel, Pelagic Cormorant, *Phalacrocorax pelagicus*, Brandt's Cormorant, *P. penicillatus*, Pigeon Guillemot, *Cepphus columba*, Xantus' Murrelet, *Endomychura hypoleuca* and Cassin's Auklet, *Ptychoramphus aleuticus*). However, many of these species have been studied elsewhere.

This report has been organized by species and secondarily, under each species, by island. For each species there was generally only one island where we were able to obtain complete information, hence an island-by-island presentation did not appear profitable. Discussions of each area of the SCB on a seasonal basis is reserved for the Volume II synthesis.

For each species we provide a brief synopsis of the world distribution and status, so the significance of the Southern California populations can be seen in perspective. We then provide as complete an account as possible of the past and present status of the species in the Channel Islands. This is followed by a summary of past and present knowledge of reproductive biology, foods used during the breeding season and foraging areas used by island populations.

The Southern California Bight is an important meeting area for breeding species with primarily northern or southern distributions. Northern species are concentrated in the San Miguel Is. area, while more southern species tend to have their major populations at Santa Barbara or Anacapa Islands.

On a finer scale, we find that most colonies of seabirds are on the northern or windward side of islands. It is very likely that

the prevailing oceanographic conditions, and hence food availability, at these northern sites contribute to the birds' reproductive success. Also, although we have not had the opportunity to conduct the necessary critical experiments and observations, it is possible that these northern exposures are used as a means of escaping thermal stress to which the birds would be exposed on the southern sides of the islands. This information may have important management implications. We also find virtually no colonies on sites accessible to large terrestrial vertebrate predators, and human disturbance is another factor which appears to preclude successful breeding at certain sites. Thus, apparently empty available nesting sites may not provide suitable alternate sites for birds displaced by oil contamination or disturbance.

Likewise, our studies of foods and foraging areas provide some insight into the importance of specific ocean areas and specific food resources of breeding species. We find remarkable assymetries in the foraging distributions of birds around their islands. Very preliminary studies of food habits and the distribution of food organisms in the environment suggest that the observed assymetries correlate closely with the abundance of food, again suggesting that the birds may not have suitable alternatives should presently used areas become contaminated.

Finally, our studies of reproductive success and growth rates, in conjunction with historical data on changes in population size, provide a baseline against which to compare reproduction in future years and a gauge of the ability of populations to recover from catastrophic population declines. Several species of breeding seabirds in the SCB have suffered dramatic declines in the past. Some species have failed to recover, others have recovered on one island, but not on others. The ability of populations to recover after declines and the relative importance of the various local populations are critical factors management will need to consider in assessing acceptable levels of risk in planning oil development.

B. METHODS

Our survey was designed to obtain accurate information on six aspects of the reproductive ecology of seabirds in the Southern California Bight (SCB):

1) location of all nesting colonies
2) estimates of breeding population size
3) timing of breeding
4) reproductive success
5) important food organisms
6) important foraging areas

A variety of methods were employed; these are briefly described below. Species-specific details and deviations from standard procedure are described in the individual species' accounts.

1. Survey Schedule

Field surveys of the SCB were conducted from January through August of 1975-1977. Regular ship cruises were scheduled at approximately 3 - 6 week intervals during the breeding seasons (Fig. III-1). At these times, inshore surveys and radial transects were completed, and seabird colonies were visited by research teams on foot. Supplemental trips to infrequently visited sites were performed when necessary.

The amount of time spent at each seabird colony is given in Figs. III-116 to III-118 in Appendix 1. Prince Is. is the largest seabird colony in Southern California and was visited each trip. Other smaller colonies were visited less often; these included Gull Is., Santa Cruz Is., Santa Catalina Is. and San Clemente Island.

Santa Barbara Is. was surveyed during the scheduled cruises, but the majority of the data for this island was obtained by a team of three to eight researchers camped there from 10 April - 28 May 1975, 31 March - 18 July 1976, 6 March - 10 July 1977 and 9 March - 15 July 1978. In 1976 and 1977, this group included both paid and volunteer workers; all their data were made available for this report. The amount of research time spent on Santa Barbara Is. in these two years is presented in Figs. III-119 and III-120. In 1975 and 1978, independent research workers lived on Santa Barbara Is., and, though not supported by the Bureau of Land Management, they have made their data available for inclusion in this report. As a result, the most complete breeding biology data for the Channel Islands came from Santa Barbara Island.

In 1975, San Nicolas Is. was visited by boat at 4 - 6 week intervals. In 1976, a researcher was based on the island from 14 May - 8 July (Fig. III-121). Additional personnel flew out early in the season to check the colony and at other times during the season

Fig. III-1. Schedule of Island Visitation and Inshore Ship Surveys 1975 - 1977

DATES	LOCATION	TRANS-PORTATION
1975		
17 April	Anacapa	Boat
18 April	Santa Rosa, Santa Cruz	Boat
19-21 April	Santa Barbara, San Nicolas	Boat
8 May	San Clemente	Boat
9-10 May	Santa Barbara	Boat
13-14 May	San Miguel	Boat
20-27 May	Santa Barbara	Boat
28 May-3 June	San Nicolas	Boat
7-8 June	Santa Cruz, Anacapa	Boat
11 June	San Nicolas	Boat
16 June	Santa Cruz, Anacapa	Boat
18 June	Santa Barbara	Boat
19 June	San Nicolas	Boat
20 June	Santa Barbara, Santa Catalina	Boat
14-18 July	Interisland	Boat
1976		
14-18 Jan.	Prince Is., Anacapa, Santa Barbara	Boat
11-15 Feb	San Miguel, Santa Cruz, Santa Barbara, Anacapa	Boat
17-21 March	San Miguel, Santa Cruz, Santa Barbara	Boat
6-11 April	Interisland[2]	Boat
27 Apr.-4 May	Interisland[3]	Boat
20-26 May	Interisland[2]	Boat
5-11 June	San Miguel, Santa Rosa, Santa Barbara, Santa Catalina	Boat
15 June	Anacapa	Boat
22-28 June	Interisland[2]	Boat
28-30 July	San Clemente	Airplane
13-19 July	Interisland[3]	Boat
26-28 August	San Miguel, Sutil Is.	Boat
1977		
17-21 Jan.	Interisland[2]	Boat
15-19 Feb.	Interisland[4]	Boat
18-24 March	Interisland[4]	Boat
29 March	San Nicolas	Airplane
12-16 April	San Miguel, Santa Cruz, Anacapa, Santa Barbara	Boat
19 April	San Nicolas	Airplane
26-27 April	San Nicolas	Airplane

continued . . . .

Fig. III-1. (continued)

DATES	LOCATION	TRANS-PORTATION
1977 (cont.)		
2-5 May	San Miguel, Santa Cruz, Santa Barbara	Boat
13-16 May	San Nicolas	Airplane
18-23 May	San Miguel, Santa Cruz, Anacapa, Santa Barbara	Boat
4-8 June	San Miguel, Santa Cruz, Santa Barbara, Santa Catalina	Boat
8 June	San Nicolas	Airplane
10-13 June	San Clemente	Airplane
16 June	Prince Island	Boat
20-24 June	San Miguel, Santa Rosa, Santa Cruz, Anacapa	Boat
28 June	Anacapa	Boat
29-30 June	San Nicolas	Airplane
7-11 July	Santa Barbara, San Miguel, Santa Cruz	Boat
15-17 July	Anacapa	Boat
23-27 July	San Miguel, Santa Cruz	Boat
11-15 August	San Miguel, Santa Barbara	Boat

[1] These visits were for the purpose of radio-tracking and full-time was devoted to that task.

[2] San Nicolas and San Clemente Islands were not included in this trip.

[3] San Nicolas Island was not included in this trip.

[4] San Nicolas, San Clemente and Santa Catalina Islands were not included in this trip.

to assist the resident researcher. In 1977, the colonies were monitored by 1 - 3 day visits at key times in the breeding cycle (egg laying, hatching, fledging).

Because of the endangered status of Brown Pelicans breeding in Southern California and the sensitivity of nesting pelicans to disturbance, observations of West Anacapa Is. were made only from the boat, and BLM researchers did not disembark on West Anacapa Is. to inspect the colony.

Supplemental information for all the Channel Islands (except Anacapa Is.) was obtained from periodic airplane surveys of the Bight (see Vol. III, Part III, Ch 1 of this report). Photographs and counts of nesting colonies and roost areas were made from the plane. These surveys were particularly useful in certain areas (e.g. Pt. Bennett) where the boat could not approach close enough to shore to obtain accurate counts.

2. Distribution and Status of Seabird Colonies

Two major objectives of this project were 1) to identify and describe all nesting colonies for all species of seabirds breeding in the SCB and 2) to provide baseline population estimates for these colonies, which could be used for future comparisons. To accomplish this, every island, islet and offshore rock was surveyed at least once during the study period. Specific census techniques varied with the species concerned, colony size and island terrain. However, in no case did we attempt to get better counts at the risk of disrupting normal colony functions.

Of the eleven species studied, five are extremely conspicuous and were censused by direct counts of active nests or territorial pairs: Brown Pelicans, Pelagic Cormorants, Double-crested Cormorants, Brandt's Cormorants and Western Gulls. The six remaining species, Leach's Storm-Petrel, Ashy Storm-Petrel, Black Storm-Petrel, Pigeon Guillemot, Xantus' Murrelet and Cassin's Auklet, were more difficult to locate and census. For all these species, much of their preferred habitat was inaccessible to humans. In addition, all save one were only nocturnally active. Hence, the status of these birds at prospective colony sites was inferred from 1) careful searches conducted by personnel familiar with their nesting habits, 2) vocalizations and behaviors observed at night and 3) trapping success using mist nets at night. Since total nest counts for these species were not possible, population estimates had to be inferred. Where possible, nest density was estimated by one of two methods. The first consisted of counting every nest within n meters of several line transect through the colony. The second consisted of counting all nests in selected quadrats of predetermined size. In both cases, the average nest density was multiplied by the total colony area to derive the approximate number of breeding pairs present. When these

techniques were not feasible, the estimate was based on the number of nests found in accessible habitat subjectively adjusted for the area which could not be searched. Unfortunately, Pigeon Guillemot nests were so rarely encountered that the number of birds seen on the water below an undisturbed colony was used to estimate the number of breeding pairs present.

3. Breeding Biology

For each species, data on nesting habitat, timing of breeding events and, when possible, reproductive success were obtained.

a. Habitat

Nesting colonies were observed with reference to potentially important environmental factors (i.e. exposure to elements and vegetative cover). The structure and composition of nest sites were also examined and are subjectively reviewed here.

b. Phenology

The timing of breeding events was determined by direct observation of nest contents whenever possible. However, for storm-petrels, cormorants and guillemots, this approach was not always practical due to the inaccessibility of their nests. Although small numbers of storm-petrel nests were located and inspected opportunistically, we often inferred phenology from the brood patch condition of captured birds. Cormorant nest contents could be seen on Prince Is., but on Santa Barbara Is., where much of the data on breeding biology was obtained, observations of courtship behavior and apparent incubation were used in determining when eggs were laid. Similarly, Pigeon Guillemots seen flying with fish were assumed to have chicks.

Since many colonies were visited infrequently, breeding schedules were extrapolated using incubation periods and fledging times reported in the literature. For instance, if eggs were observed from March through June and the species typically incubates for thirty days, then chicks were presumed to be present from at least April through June.

c. Reproductive Success

In order to measure reproductive success, repeated observations on the same nest were required. Therefore, nests were marked with numbered stakes on the first visit to a colony. They were then inspected and their contents recorded on each subsequent visit. Cormorant nests were usually not marked due to potential disturbance

of nesting birds, but the location of individual nests was mapped or photographed. Some cormorant nests on Prince Is., Gull Is. and Santa Cruz Is. were staked before the building season in January of 1976 and 1977. Four standard parameters of reproductive success were calculated for all colonies for which adequate data were obtained. They are:

1) clutch size (total no. of eggs laid/total no. of nests, excluding replacement clutches)
2) hatching success (no. of eggs hatched/no. of eggs laid)
3) fledging success (no. of chicks fledged/no. of chicks hatched)
4) productivity (no. of chicks fledged/no. of nests or no. of chicks fledged/no. of breeding attempts)
5) chick growth rates (grams gained/day)

Throughout, a "nest" was defined strictly as a site at which eggs were eventually laid. Hence, the numerous elaborate scrapes built by Western Gulls prior to laying were not counted as nests. This definition of nest is difficult to apply to cormorants, whose eggs are rarely visible. Hence, productivity for these species was measured as number of chicks fledged/breeding attempt (pairs observed regularly at a probable nest site). Also, since it is difficult to determine the actual time of fledging, fledging success was actually measured using weight or plumage criteria which reflected advanced chick development for that species.

In order to measure chick growth rates, young were individually banded shortly after hatching. Weights were determined using Pesola spring scales; accuracy varied $\pm$ 1 - 25 g, depending upon the capacity of the scale. In all cases, the accuracy of these scales was within the limits of accuracy imposed by the movements of the birds and by the weight of recently injested foods or defecation. Growth rates were calculated as $\frac{\text{weight}_2 - \text{weight}_1}{\text{day}_2 - \text{day}_1}$ for the slope of the straight-line portion of the growth curve. The timing of this linear growth phase is different for each species.

d. Banding

A banding program was initiated in order to trace movements of birds nesting in the Channel Islands and to provide information on normal mortality rates. The information on movements may allow us to determine if individuals shift from one colony to another during their lifespan and also to determine their distribution outside the breeding season. Data on mortality rates are essential for the construction of life tables which will allow an estimation of the ability of a population to recover from a catastrophe. Adult Western Gulls were captured by snaring with a hand-held monofilament loop placed around the nest. Young were hand-caught in their nests or

where they hid in the vegetation. Cassin's Auklets, storm-petrels and Xantus' Murrelets were captured in their burrows or nest crevices and in mist nets placed in front of the nesting areas at night. Captured individuals were banded with standard U. S. Fish and Wildlife Service bands and released after we recorded body weight, brood patch condition, depth of gular pouch (Cassin's Auklet), wing chord length and culmen length (storm-petrels).

The numbers of each species banded during this study are summarized in Fig. III-2. Additionally, Western Gull chicks were color-banded according to natal colony in order to examine juvenile dispersal pattern (Fig. III-3).

4. Food Habits

In order to learn more about the foods taken by nesting marine birds, we analyzed stomach contents of birds collected at sea. We also collected food samples from nestlings (cormorants and gulls) and from adults (auklets) returning with food for young. Most samples were obtained from the birds when they voluntarily regurgitated during handling for banding or weighing; occasionally, samples were extracted by inserting an index finger down the chicks' throats and withdrawing the contents of the proventriculus (Western Gull as in Hunt 1972). In 1975, these samples were placed in 5% buffered formalin and then transferred to 70% ethyl alcohol. Transfer to ethyl alcohol was necessary so that the decalcifying action of the formalin would not damage invertebrates or fish bones and otoliths. In 1976 and 1977, samples were placed directly in ethyl alcohol. In addition, pellets of undigested hard parts of prey were collected near cormorant roosts and nests. These were frozen until the otoliths could be separated and identified. All pellets collected on a given island were combined and treated as one sample.

The numbers of food samples collected from each species from 1975-1977 are presented in Fig. III-4; the numbers of birds collected are presented in Fig. III-5. Detailed accounts of locations where samples were collected and analysis of contents are presented in the accounts of individual species. All samples, thus collected, were analyzed by individuals familiar with the marine fauna of the SCB. Items in each sample were identified to the lowest taxonomic unit feasible given the condition of the material in the sample. Experts in particular taxonomic groups were consulted for verification of identifications when necessary. The composition of these samples was quantified using the following standard measures:

1) Percent Occurrence - defined as the percent of all samples within which a particular organism occurred. This measure may overestimate the importance of organisms with long-lasting hard parts.

Fig.III-2. Numbers of Birds Banded in the Channel Islands 1975-1977

SPECIES	1975	1976	1977	Total
Black-footed Albatross	—	1	—	1
Northern Fulmar	—	1	—	1
Black Storm-Petrel	—	1	27	28
Leach's Storm-Petrel	—	1	2	3
Ashy Storm-Petrel	5	108	178	291
Double-crested Cormorant	—	20	99	119
Brandt's Cormorant	12	38	2	52
Black Oystercatcher	—	—	2	2
Black Turnstone	—	5	34	39
Ruddy Turnstone	—	—	4	4
Western Gull	427	1186	1771*	3384
Heerman's Gull	—	1	—	1
Black-legged Kittiwake	—	—	3	3
Pigeon Guillemot	—	3	2	5
Cassin's Auklet	47	226	218	491
Xantus' Murrelet	58	84	223	365
TOTAL	549	1675	2565	4780

* An additional 37 Western Gull chicks received color-bands only.

Fig. III-3. Numbers of Western Gulls Color-Banded on the Channel Islands 1972 - 1977

ISLAND	1972	1975	1976	1977	TOTAL
Santa Barbara	224	143	452	891	1710
San Nicolas	—	—	446	380	826
San Miguel (Prince Is.)	—	—	113	283	396
Anacapa	—	—	67	137	204
Santa Cruz (Gull Is.)	—	—	15	4	19
(Scorpion Rk.)	—	—	—	106	106
Santa Catalina (Bird Rk.)	—	—	22	7	29
All Channel Islands	224	143	1115	1808	3290

Fig. III-4. Number of Food Samples Collected from Seabirds in the Channel Islands 1975 - 1977

SPECIES	1975	1976	1977	TOTAL
Sooty Shearwater	—	1	—	1
Ashy Storm-Petrel	—	1	—	1
Brown Pelican	—	1	—	1
Double-crested Cormorant	—	7	14	21
Brandt's Cormorant	5	117	250	122
Northern Phalarope	—	—	2	2
Black Oystercatcher	—	1	—	1
Western Gull	86	184	221	491
Heerman's Gull	—	—	1	1
Bonaparte's Gull	—	—	1	1
Common Murre	—	—	2	2
Cassin's Auklet	—	97	114	211
Xantus' Murrelet	—	—	22	22
TOTAL	91	409	627	877

Fig. III-5. Number of Birds Collected from the Channel Islands 1975 - 1977

SPECIES	1975	1976	1977	TOTAL
Eared Grebe	—	—	1	1
Sooty Shearwater	—	—	23	23
Pink-footed Shearwater	—	—	19	19
Ashy Storm-Petrel	—	2	1	3
Leach's Storm-Petrel	—	1	1	2
Western Gull	—	—	3	3
California Gull	—	—	3	3
Black-legged Kittiwake	—	—	1	1
Sabine's Gull	—	—	1	1
Bonaparte's Gull	—	—	1	1
Horned Puffin	—	—	2	2
Rhinocerous Auklet	—	—	5	5
Cassin's Auklet	—	—	44	44
Xantus' Murrelet	—	—	25	25
Northern Phalarope	—	—	7	7
TOTAL	0	3	137	140

Methods: Food Habits (continued)

2) Percent Volume - for each sample, the volumetric contribution of each food type was measured using simple water displacement techniques. The resulting percentages were then averaged.

3) Percent Weight - the total weight for each sample was determined. The weight contribution of each taxon was then measured and converted into a percentage. These percentages were then averaged.

4) Percent of Individuals Present - defined as the number of individuals of a given taxon divided by the total number of individual organisms in a sample. This measure was used for samples consisting predominantly of small planktonic organisms (i.e. from Cassin's Auklets).

5) Number of Prey Items - for organisms identified by otoliths, the number present in each sample was defined as the maximum number of otoliths (either right or left) counted for that taxon.

To complement the information obtained from food samples, a small scale plankton sampling program was initiated in 1977 to study food availability. Figs. III-6 and III-7 list the trawl stations occupied and dates and locations of plankton trawls. Trawling was terminated at Santa Barbara Is. when it was found that our sampling system was not sophisticated enough to capture organisms used by murrelets there. The program at San Miguel Is. would have yielded important information on the distribution of Cassin's Auklets' prey organisms, but inclement weather precluded trawling operations throughout most of the season.

Most trawling operations were conducted aboard the Pacific Clipper. Two additional cruises, 29 January - 6 February and 22 - 23 April, were made aboard the Ellen B. Scripps. A meter bongo net with a 505 mesh was used for the trawls. The net fished along an oblique tow between 50 m and the surface. The samples obtained from each trawl were inspected initially for the presence of rare or infrequently observed organisms. Each sample was then split, and the number of individuals of each taxon within this random sub-sample was recorded.

5. Foraging Areas

Three complementary methods were used to identify the foraging grounds of seabirds breeding on the Channel Islands: Ship surveys, color marking of nesting birds and radiotelemetry of nesting birds. The three methods were needed because of the different problems posed by the various species and islands where they nested. Ship surveys

Fig.III-6. Location of Plankton Stations, Channel Islands, 1977

San Miguel Is.

Station 1	10 mi. out from Prince Is. on heading 180°
Station 2*	4-8 mi. out from Prince Is. on heading 180°
Station 3	2-3 mi. out from Prince Is. on heading 180°
Station 4	10 mi. out from Crook Pt. on heading 180°
Station 5	6 mi. out from Crook Pt. on heading 180°
Station 6	2-3 mi. out from Crook Pt. on heading 180°

Santa Barbara Is.

Station 7	10 mi. out from Webster Pt. on heading 270°
Station 8*	3-6 mi. out from Webster Pt. on heading 270°
Station 9	2-3 mi. out from Webster Pt. on heading 270°
Station 10	10 mi. out from SE tip of Santa Barbara Is. on heading 120°
Station 11	6 mi. out from SE tip of Santa Barbara Is. on heading 120°
Station 12	2-3 mi. out from SE tip of Santa Barbara Is. on heading 120°

* These stations were run where the highest concentration of Xantus' Murrelets/Cassin's Auklets were counted during a radial to the farthest out station.

Fig. III-7. Number of Trawls Completed, Channel Islands, 1977

	18 Jan	19 Jan	21 Jan	15 Feb	18 Feb	21 Mar	22 Mar	23 Mar	24 Mar	Totals
San Miguel Is.										
Station 1	4					1				5
Station 2	4					1				5
Station 3	4					1				5
Station 4		2					1			3
Station 5		2					1			3
Station 6		2					1			3
non-standard*	2			1		2				5
Santa Barbara Is.										
Station 7			2					1		3
Station 8			2					1		3
Station 9			2							2
Station 10					2				1	3
Station 11					2				1	3
Station 12					2				1	3
Totals	14	6	6	1	6	5	3	2	3	46

* non-standard stations were completed at San Miguel Is. in areas with high concentrations of foraging birds.

included inshore surveys, radial transects and travel between islands (island hops). From these surveys, the at-sea distribution could be determined for all species; however, no distinction could be made between breeding and non-breeding birds. Color-marking proved useful only for gulls, which were relatively easy to mark. Finally, radiotelemetry provided a potential method for tracing the daily movement patterns of breeding birds over long distances.

a. Ship Surveys

Inshore Ship Surveys

Whenever possible, the zones around the Channel Islands were surveyed (Fig. III-1). During these surveys, the boat maintained a course just outside the main kelp beds at a constant speed between 11 and 15 km/hr and all birds between the boat and the shore were counted. Few birds in or flying over the water were likely to be overlooked.

Radial Ship Transects

To determine the foraging distribution of seabirds, and particularly of Xantus' Murrelets, Cassin's Auklets and Brandt's Cormorants, around their major breeding colonies (Santa Barbara Is., San Miguel Is. and San Nicolas Is.), radial ship transect surveys were conducted by running straight-line courses out as far as 46.25 km (25NM) from these islands. Radial ship transects were conducted at San Nicolas Is. only on 20 April and 17 July 1975; at Santa Barbara and San Miguel Islands, radial transect programs were initiated in 1975 and expanded in 1976 and 1977 (Fig. III-8). The dates and location of radial transects, 1975-1977 are presented in Figs. III-138 to III-141 and III-175 and III-176.

During radial surveys, the number of observers censusing birds at any time varied between two and four. In 1975, observer height above sea level was variable and ship speed varied between eight and twelve knots. Both these parameters were standardized in 1976 and 1977 by using a single research vessel for all transect surveys (observer height - 15 ft., ship speed - 10kn). All birds sighted on both sides of the ship were counted, identified and observed for interspecific associations, feeding and other aspects of behavior including response to the boat. Sighting distance from the boat was recorded as one of four categories: I=0-50m, II=51-150m, III=151-400m and IV=beyond 400m. Field forms were used to record all shipboard observations (Fig. III-9) which were later transferred into 80-column computer records and entered into the permanent data bank. A detailed account of the radial transect methods and analysis are presented in the individual species accounts.

Fig.III-8. Radial Transect Surveys 1975 - 1977

Santa Barbara	Anacapa(in)	138°	10mi.(18.5 km)	NE point, directly offshore
	Newport Beach(out)	070°	10mi.(18.5 km)	Landing Cove, directly offshore
	Newport Beach(in)	250°	10mi.(18.5 km)	
	Osborn Bank(out)	170°	10mi.(18.5 km)	Cat Canyon, ½ mi. offshore
	Osborn Bank(in)	350°	10mi.(18.5 km)	
	Webster Pt.(out)	270°	10mi.(18.5 km)	
	Webster Pt.(in)	090°	10mi.(18.5 km)	
	Santa Monica(out)	015°	5mi.(9.25 km)	Arch Pt., directly offshore
	Santa Monica(in)	195°	5mi.(9.25 km)	
	*San Clemente(out)	120°	5mi.(9.25 km)	SE tip, ½ mi. offshore
	*San Clemente(in)	300°	5mi.(9.25 km)	
	Sutil Is.(out)	220°	5mi.(9.25 km)	Sutil Is., ½ mi. offshore
	Sutil Is.(in)	040°	5mi.(9.25 km)	
San Miguel	Prince(out)	000°	10mi.(18.5 km)	Prince Is., directly offshore
	Prince(in)	180°	10mi.(18.5 km)	
	Castle/Richardson(out)	295°	10mi.(18.5 km)	W tip Castle Rk., 1 mi. offshore
	Castle/Richardson(in)	115°	10mi.(18.5 km)	
	Pt. Bennet(out)	225°	10mi.(18.5 km)	bouy, 1 mi. offshore
	Pt. Bennet(in)	045°	10mi.(18.5 km)	
	Crook Pt.(out)	180°	10mi.(18.5 km)	Crook Pt., ¼ mi. offshore
	Crook Pt.(in)	360°	10mi.(18.5 km)	
San Nicolas	San Nicolas(out)	069°	25nm.(46.25km)	
	San Nicolas(in)	230°	25nm.(46.25km)	

*The San Clemente Transect of Santa Barbara Is. was lengthened to 18.5 km in 1977.

BIRDS SIGHTING LOG

Page 1 of 1

DATE 8 JAN 76 OBSERVER Lewis SEGMENT NUMBER TC-09

TIME START 1630 TIME STOP 1654 FATIGUE 2 HEIGHT 20 ft
SHIP Kona Pride CRUISE 2-21 WIND DIR/SPEED 315/8 kn
COURSE/SPEED 42/10 °mag/kn AIR TEMP 14 °C VISIBILITY 10 kn
SURFACE TEMP. 55°F °C FOREL # CLOUD COVER (10th's) 1 (¢)
SEA STATE 3 (BEAUFORT) BARO PRESS 1018 mb TREND Steady

Glare 1

TIME	SPECIES: NUMBER/RANGE												REMARKS
START 1630		FN	GUC	KIB	GOU	GOLL	PHAL	AKC	JPO				
1632		2/III											1 (270) DARK
1636			4/III	4/III	3/III	}							1
1639						LC/III							1, 2
1640				1A/III	1A/III								1 (045)
1641		1/III											1 (315)
1642							1/II						1 (180)
1642				3/III									1 (338)
1643								3/III					1 (135)
1644				2/I									1 (270)
1644						150/III							1 LC/DELPH.
	200-300 DELPHINUS LEADING, CHASING ETC @ 400 CD												
	1-2 DALL PORP W/ DELPHINUS												
1645				1A/II									1 (180)
1646				1A/F					2/I				1 JPO-KIB
1648									2/II				2
1650		1/I											1 (045)
1652		1/II											1 (270)
1653									1/II				1 (180)
1654	END SEGMENT												

Figure III-9. Sample of bird sighting log.

Methods: Foraging Areas (continued)

Island Hops

In addition to the inshore surveys and radial transects, we conducted surveys whenever possible along standardized transects running between islands (e.g. from Prince Is. to Santa Barbara Is., Santa Barbara Is. to Santa Catalina Is., etc.). During these "island hops" (IH), sighting and recording procedures were identical to those used on radial ship transects.

b. Color Marking

A second method of tracing movements of nesting birds was to identify residents of particular nesting colonies with dyes and later survey the SCB for color-marked birds. The scheme for color marking adult Western Gulls on the Channel Islands, 1975-1977, was as follows:

	Island	Color	Dye Used
1975	Santa Barbara	Red	Rhodamine Red
	San Miguel (Prince Island)	Yellow/Green	Picric Acid/Victoria Green
1976 & 1977	Santa Barbara	Yellow	Picric Acid
	San Miguel (Prince Island)	Red	Rhodamine Red
	San Nicolas	Green	Victoria Green
	Anacapa	Blue/Purple	Azure Blue/Purple B Concentrate

Crystals of these dyes were sprinkled around the edges of nests containing eggs or very young chicks; the adults were dyed when they resumed incubation or brooding. On Santa Barbara Is. in 1976 and 1977, a mixture of picric acid crystals, vegetable oil, water and a small amount of liquid detergent was applied directly to captured birds. All marking was completed prior to 5 June 1976 on Santa Barbara Island and prior to 24 May on all other islands. In all, 1147 gulls were colormarked, 11.1% of the total breeding population on the four islands monitored. In 1977, all marking was completed prior to 31 May on Santa Barbara Is. and prior to 24 June on all other islands. A total of 1590 gulls (17.1% of the total breeding population) were marked on the islands.

Sighting records of marked birds were obtained from a variety of sources. From 26 May 1976 until 28 August 1976, and from 11 May until 24 June 1977 eight coastal dump sites were regularly surveyed for colormarked gulls (Fig. III-10). Beaches, piers, marinas and sloughs along the Southern California coastline between these sites from Tejiquas (25 miles north of Santa Barbara) to San Diego were also censused. (The schedules of these surveys are in Appendix 4). At each location, the number of gulls present and the number of color-

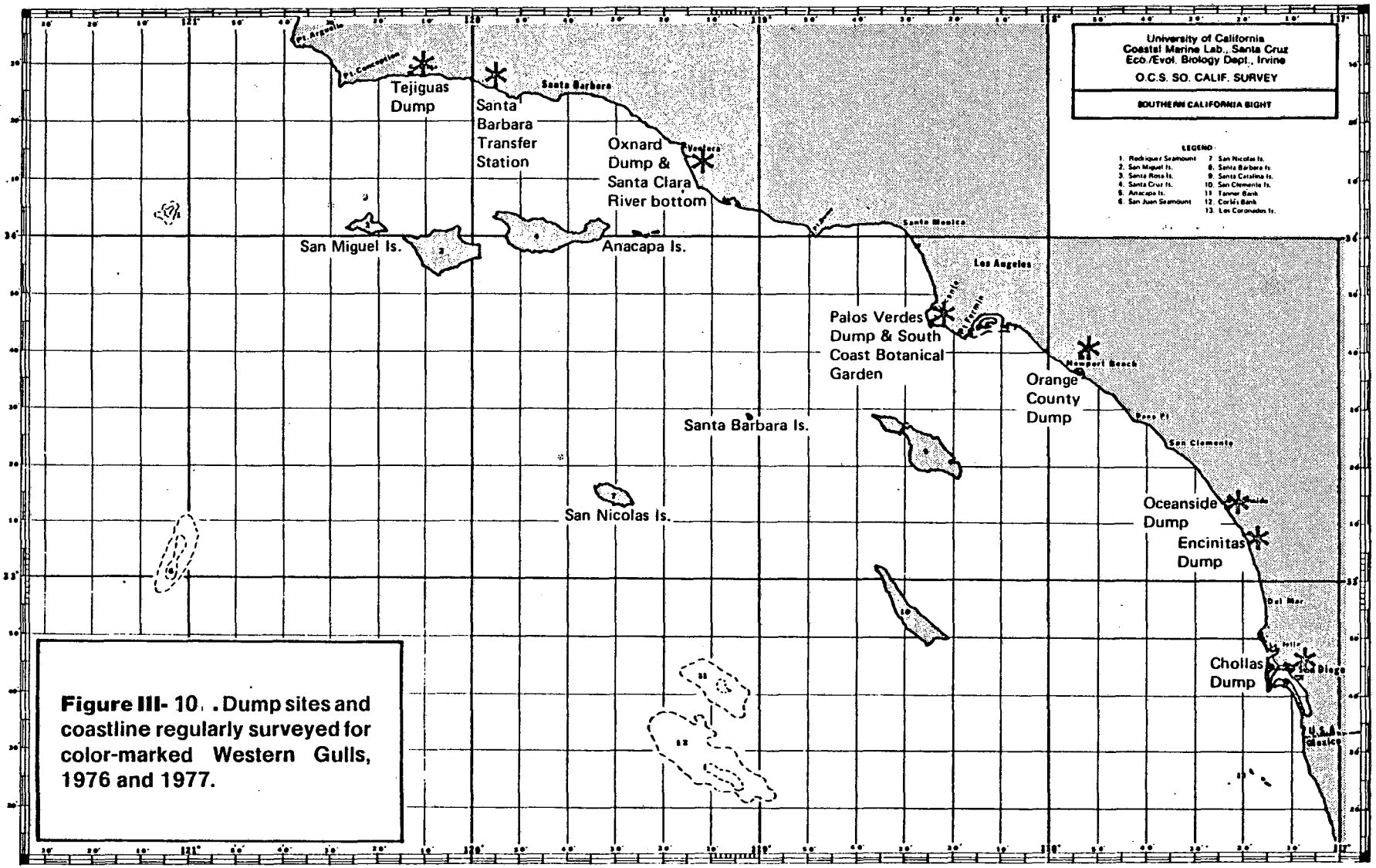


Figure III- 10. . Dump sites and coastline regularly surveyed for color-marked Western Gulls, 1976 and 1977.

marked individuals sighted were noted. To supplement these data, weekly trips on local fishing boats were made, and observations of colormarked gulls were noted during project cruises and project flights in the Bight. In addition, requests for sightings were sent to 132 yacht clubs and were solicited through local newspapers, radio and TV stations. All these sources combined yielded a total of 254 sightings in 1976 and 19 sightings in 1977 (Fig. III-11). Since the public was responsible for less than 5% of the total returns in 1976, the publicity campaign was not repeated in 1977.

We attempted to apply dye (Rhodamine Red in 1975 and picric acid in 1977) directly to adult Xantus' Murrelets while they incubated. The color marking method proved to be impractical for this species. The marks were indistinguishable from a distance, and the marking procedure usually disrupted normal incubation. Cormorants were not color marked due to their dark plumage.

c. Radiotelemetry

Attempts were made to monitor the movements of Western Gulls and Xantus' Murrelets with radio transmitters. All methods and results are presented in Appendix 2.

Fig. III-11. Sources of Colormarked Gull Sightings within the Southern California Bight

Source of Sighting	No. of Gulls Sighted		% of Total Sighted	
	1976	1977	1976	1977
Project Personal	242	17	95.3	89.5
General Public	12	2	4.7	10.5
Total	254	19		

C. RESULTS AND SPECIES ACCOUNTS

Leach's Storm-Petrel (Oceanodroma leucorhoa)

a. Introduction

Leach's Storm-Petrels are by far the most widespread breeding hydrobatid in the Northern Hemisphere. Colonies exist on both sides of the north Atlantic Ocean and in the Pacific Ocean from islands south of Japan north across the Aleutian Islands and down to central Baja California (Palmer 1962). In the eastern Pacific this species breeds commonly from Islas Los Coronados, southward, and from the Farallon Islands, northward, yet it has been curiously absent as a breeding species in the Channel Islands.

Throughout their range in the North Pacific, Leach's Storm-Petrels are quite variable with respect to rump color and mensural characters and have given rise to a plethora of taxonomic comments and revisions (e.g. Emerson 1906; van Rossem 1942; Austin 1952; Crossin 1974). Austin's (op cit) generally accepted interpretation assigns all Leach's Storm-Petrels from southern Alaska to Islas Los Coronados to the race beali Emerson; this would presumably include the Channel Islands.

b. Historical and Present Breeding Status in the Channel Is.

There are no published accounts of Leach's Storm-Petrels breeding in the Channel Islands, although a specimen from Castle Rk. exists (see below). During the 1976 and 1977 field seasons, four Leach's Storm-Petrels were banded and two were collected on Prince Island. This is the only location where they were positively identified.

A summary of our encounters with Leach's Storm-Petrel on Prince Is. is given below:

1976 20 May - One specimen captured, photographed, banded and released.
8 June - None captured.
23 June - Three captured: one banded and released, one collected (SDNHM 39942), and one recaptured and released (the 20 May bird with a clear brood patch).
1977 10 July - One collected (SDNHM).
12 Aug. - Two captured, banded and released.

All specimens had all-white rumps. No intermediately-colored or all-dark rumped birds were noted, though the latter may have been overlooked.

The only other record of Leach's Storm-Petrels on the Channel Islands is a specimen in the National Museum collected on Castle Rk. on 14 May 1968 by POBSP personnel. The rump feathers are brown and concolor with the back, and the measurements are:

wing chord: 142.5 mm, culmen: 13.7 mm, tarsus: 21.8 mm, tail: 79.2 mm (R. B. Clapp, pers. comm.). The specimen was not sexed. Crossin and Brownell (1968) mistook this specimen for an Ashy Storm-Petrel when they collected it. In discussing the "Ashy Storm-Petrels" collected on Castle Rk. on 14 May, they indicated that "four birds were collected in rock crevices" and that all specimens obtained had bare or defeathering brood patches. Although Leach's Storm-Petrels were never actually found nesting in the San Miguel Is. area, we consider the above information conclusive evidence of breeding.

On Santa Barbara Is., workers unfamiliar with this species netted storm-petrels at night where both Black and Ashy Storm-Petrels were commonly encountered. On at least one occasion, a storm-petrel somewhat larger (wing chord a minimum of 150 mm, using non-standard measuring techniques) and with a small amount of white at the base of the rectrices was captured. This individual had a clear brood patch, and it is possible that it was a breeding Leach's Storm-Petrel.

Using similar trapping techniques and intensive searches for nests on every other island and offshore rock in the Bight, we were unable to find evidence of this species elsewhere. Apparently only a very tiny population exists at San Miguel Is. (and possibly Santa Barbara Is.).

c. Breeding Biology

Due to the small numbers breeding and their secretive habits on the colony, no information on the breeding biology of Leach's Storm-Petrels was obtained.

d. Foods and Foraging Areas

No data on foods or foraging areas used by Leach's Storm-Petrels were gathered during this study, except the distributional data obtained during our regular pelagic surveys. According to Ainley et al. (1974), Leach's Storm-Petrels frequent the open ocean, rarely coming close to shore. Most are seen more than 300 km from the mainland coast, and therefore they are primarily found over warm, sub-tropical water west of the California current. Foods taken include fish, molluscs, crustaceans, oily substances and garbage from ships (Palmer 1962). These petrels are often associated with whales, from which they obtain waste food and possibly also feces.

Ashy Storm-Petrel (Oceanodroma homochroa)

a. Introduction

The Pacific coast of the Americas have given rise to a whole host of hydrobatids, some of whose breeding ranges are exceptionally limited. Ashy Storm-Petrels, for example, breed only on the Farallon Islands in central California and in the California Channel Islands (including Islas Los Coronados) in Southern California and extreme northern Baja California. In addition, a few pairs have been found breeding on a rock just north of the Farallons (Ainley and Osborne 1972).

The Farallon Islands undoubtedly host the largest colony of breeding Ashy Storm-Petrels in the world; Ainley and Lewis (1974) estimate the population there to be only about 4000 birds. The entire world population of Ashy Storm-Petrels may number only 10,000-20,000 individuals; probably less.

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

The earliest report of Ashy Storm-Petrels nesting in the Channel Islands comes from Henshaw (in Willet 1912): "An adult from San Miguel Island (now in British Museum), was given to H. W. Henshaw by Captain Forney of the Coast Survey, who stated that the species bred on San Miguel in great numbers." Willet (1910, 1912) spent two weeks on San Miguel Is. in June 1910 and "made particular search" for Ashy Storm-Petrels on the main island, but he failed to find any. He concedes, however, that he may have overlooked them. Willet himself spent only part of one day (9 June) on Prince Is., where he was at least somewhat distracted by more conspicuous nesting species (Willet 1910: 171). One member of the Willet party, O. W. Howard, did spend several nights on Prince Is. but apparently did not find storm-petrels. However, "howling" winds that forced his prolonged stay on the islet may have also deterred storm-petrels from visiting the colony. Four specimens (LACM 20563-20566) were collected on Prince Is. in July 1950, and four more SDNHM 30306-30308; LACM 66099) were collected there on 26 July 1961 by Don Blietz. In early July 1965, Craig and Sheppard (unpubl. notes) found three nests on Prince Is., heard and saw a number of calling birds, and estimated the population to be 400 pairs. Crossin and Brownell (1968) found small numbers of storm-petrels on both Castle Rk. and Prince Is. on 14-15 May 1968. They stated: "On Castle Rock a rough population guess estimate would be several hundred birds." On Prince Is. on the night of 15 May 1968, they heard "only a few calling birds", "but most of the island was not surveyed during nocturnal hours." The storm-petrels collected by Crossin and Brownell (op cit) at Castle Rock all had bare or defeathering brood patches, and four

of their specimens came from rock crevices. (One of these specimens was subsequently identified as a Leach's Storm-Petrel, q.v.) Two weeks after the Crossin and Brownell survey, L. N. Huber (1968) made an eleven day survey of San Miguel Is. and the adjacent islets and rocks (28 May - 7 June 1968). He found a single, well-incubated egg on Castle Rk., which he presumed belonged to this species. During his visit to Prince Is., 17 specimens were collected, and one, possibly two, eggs were found. He estimated the population there to be 50-100 birds.

Present Status - From 1976-77, a total of 161 Ashy Storm-Petrels were banded on Prince Is. (Fig. III-12). Though at times fairly common, this species was by no means abundant; usually less than six or eight birds could be heard calling simultaneously. Fig. III-13 shows the location of the mist net used during both seasons. (Storm-petrels were also occasionally caught in the net used for auklets at the base of the *Opuntia* patch on the SE slope.) The majority of the night work was conducted in the area of the southeast slope, but most other parts of Prince Is. were visited at night at least once during the season. A maximum of five nests were found throughout the survey period, reflecting both the low density of this species on Prince Is. and its very secretive nesting habits. The estimated population at Prince Is. was 300 ± 100 pairs. No night work was done on Castle Rk. during the project, and no signs of nesting storm-petrels were detected during two short, daylight surveys (one day each in 1976 and 1977). However, it is very likely that Ashy Storm-Petrels continued to breed there. Estimating strictly from the amount of habitat available and from Crossin and Brownell's (1968) rough guess, the population at Castle Rk. was believed to be about 100 pairs.

In 1976, evidence was obtained for the occurrence of Ashy Storm-Petrels on San Miguel Is. proper. On 24 June, three Ashy Storm-Petrels were captured in a mist net (one collected, SDNHM 39939) behind a sandy beach on the Harris Pt. side of Cuyler Harbor. All three had clear brood patches. Several others were seen flying and heard calling from the cliff area above the beach. From these observations, we infer a breeding population probably existed on the main island. Suitable habitat also existed north to Harris Pt. and in the cliff area east of Cuyler Harbor. On 25 June 1976, a probable nesting burrow with a very strong storm-petrel odor was detected on Hare Rk., adjacent to Cuyler Harbor.

There appears to have been little change in the overall status of Ashy Storm-Petrels in the San Miguel Is. area in recent historical times (with the exception of Henshaw's (in Willet 1912) second-hand account of "great numbers", which, by nature of the account, requires additional substantiation).

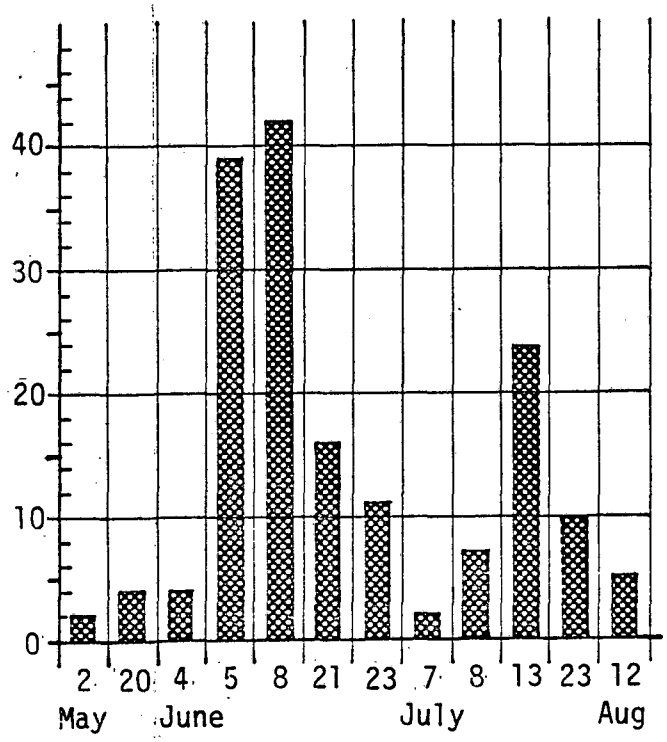
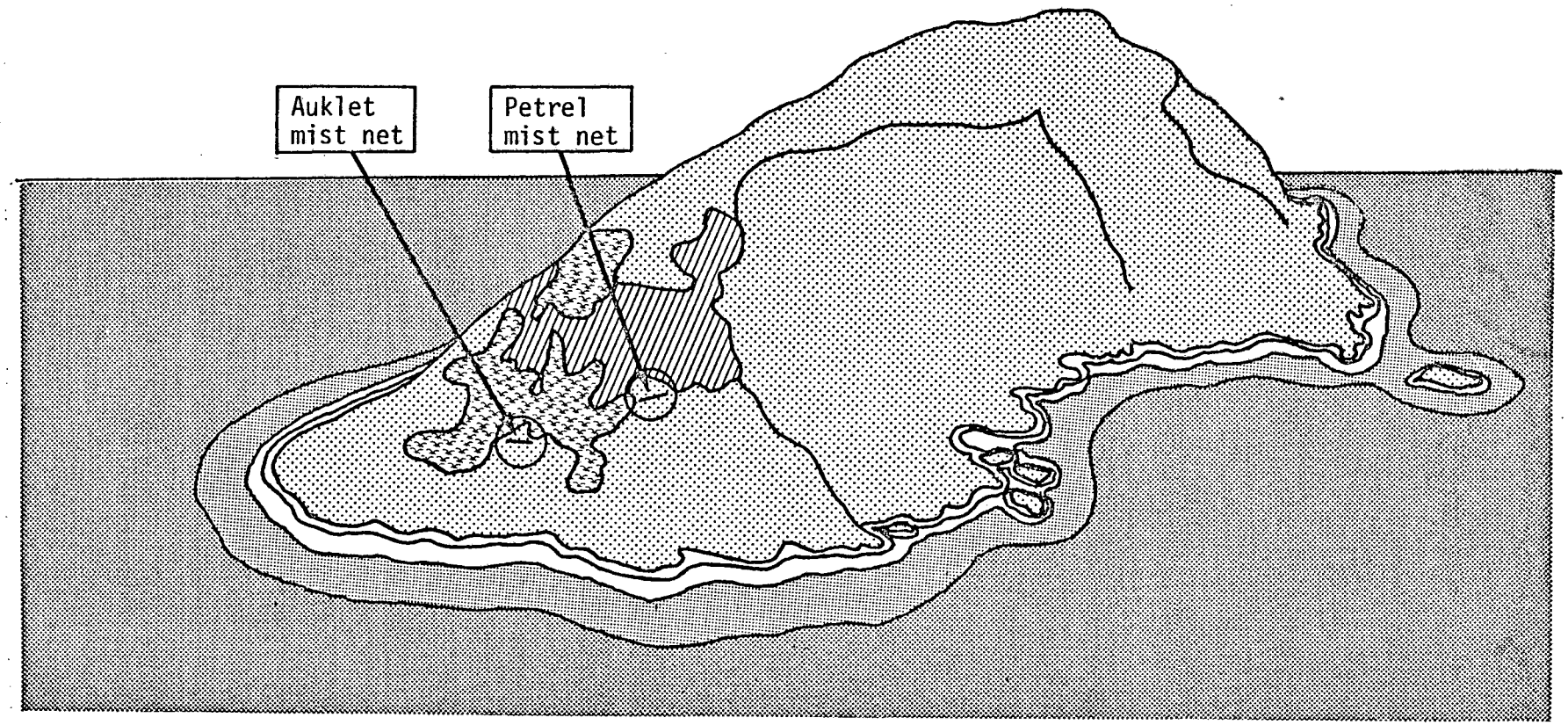


Figure III-12. Dates and numbers of Ashy Storm-Petrels captured in mist nets on Prince Island, 1976 and 1977.

= Opuntia (prickly pear cactus)

= Cliff

Fig. III-13. Prince Island (San Miguel Is.): perspective sketch of SE and NE slopes showing locations of Auklet and Storm-Petrel mist nets.



Santa Rosa Island

There is no historical information concerning Ashy Storm-Petrels breeding at Santa Rosa Is., and no additional information was discovered during the course of our survey work. Santa Rosa Is. has no offshore rocks of sufficient size to support even a small contingent of storm-petrels, though the extent to which the precipitous cliffs along the north side of the island might be used remains unknown.

Santa Cruz Island

Even though the storm-petrel population at Santa Cruz Is. appears to have been quite small, numerous records of storm-petrels exist from there. This is because Santa Cruz Is. was visited frequently by early egg collectors, who only rarely braved the trip to San Miguel Island.

The first record is of a small colony discovered in Painted Cave in 1912 (Wright and Snyder 1913); "four eggs (two WFVZ uncat.) and one small young, together with adults "(SU 9813, 8914) were collected at that time. Another set of eggs was collected there on 23 June 1913 by D. R. Dickey (WFVZ 64273). Pemberton and Peyton collected two sets on 2 June 1928 (WFVZ 2888, 73963) east of Scorpion Harbor, and Paquette (unpubl. notes in WFVZ) took three sets on 19 May 1936 from an offshore rock at Scorpion Harbor. An incubating adult (SDNHM 17248) and ten sets were collected on 17 May 1936 from a "detached rock" at Scorpion Harbor by Stephens and Badger (WFVZ 1384-1386, 27676, 30306, 30307, 30318; WFVZ uncat.; Stevens, unpubl. notes). Sixteen egg sets were taken on 23 May 1937 at Scorpion Harbor and Orizaba Harbor (Painted Cave) (WFVZ 27677, 30319-30323; WFVZ uncat.; SBM uncat.). Nineteen more sets were taken at these two localities on 22 May 1938 (WFVZ 1633-1637, 12099, 54273, 54274; WFVZ uncat.; Stevens, unpubl. notes), eight more sets on 26 May 1940, and three sets at Scorpion Harbor on 25 May 1941 (WFVZ 68360; SBCM 7097-7100; Stevens, unpubl. notes). The last report of Ashy Storm-Petrels breeding at Santa Cruz Is. was in 1949, when Stevens (unpubl. notes) collected three more egg sets (exact locality unknown). Egg collecting activities (though not necessarily nesting activity) were apparently restricted to Scorpion Rk. (just east of Scorpion Harbor) and Painted Cave.

Present Status - During this study, Ashy Storm-Petrels were found breeding on several offshore rocks along the north side of Santa Cruz Island. At Scorpion Rk., on 22 June 1976 an Ashy Storm-Petrel was found incubating an egg under a large overhanging ledge on the south side of the largest rock. This was the only nest found during a 90 min. daylight search. On the night of 25 June 1976

nine Ashy Storm-Petrels were netted, measured, banded and released on the largest rock; six of these had clear brood patches. These birds may have been breeders from the adjacent rock or even the main island. The 22 June bird, still on its egg, was banded on 25 June 1976. In 1977, four nests were found on Scorpion Rk.

On Diablo Rk. immediately west of Diablo Point, the larger of the two rocks was thoroughly surveyed on foot on 15 July 1976. Four storm-petrel nests were located and presumed to belong to this species.

"Sppit" Rock (named by researchers in 1976) is the first rock west of Twin Harbors. It was briefly surveyed on 15 July 1976, and eight nests were found in the "catacombs" under the highest part of the rock. Two or three times this number could have existed there. In 1977, eight nests were found. On Gull Island, a single storm-petrel nest was found on 12 April 1977.

On the main island, two hours were spent exploring Painted Cave on 25 June 1976 with no sign of storm-petrels. It is a little unclear, however, exactly where nesting birds were found here previously (e.g. Bent 1919, refers to "the painted caves" of Santa Cruz Is., suggesting more than one location).

Population estimates for the rocks surveyed were: Scorpion Rk-20 pairs; "Sppit" Rk.-20 pairs; Diablo Rk.-10 pairs; Gull Is.-I pair. If, as the old Painted Cave records suggest, this species can effectively utilize cliff areas along the north side of the island, then a large amount of nesting habitat was not surveyed. We have no information as to how extensively this area was used by this species.

Anacapa Island

There is no direct evidence that storm-petrels ever bred on Anacapa, nor was any evidence obtained during 1975-77.

Santa Barbara Island

Prior to the present study, storm-petrels had never been found nesting at Santa Barbara Island. However, Loye Miller (1936) mentions that while anchored there in late March 1904, "dozens of Ashy Petrels" came on board the boat. Two specimens collected by Miller at Santa Barbara Is. (MVZ 6168 and 45944) are dated 10 April 1904. His notes state: "We were probably quite near a colony preparing to nest." Willet (1912:11) "made a careful search" over all of Santa Barbara Is., including what was probably Sutil Is., in June 1911 and found no trace of breeding storm-petrels. Numerous other researchers have spent nights on Santa Barbara Is. throughout the years and never noticed the presence of storm-petrels, nesting or otherwise (e.g. Grinnell 1897; Wright and Snyder 1913; Sumner 1939; Crossin and Brownell 1968; Hunt and Hunt 1974). DeLong (1967) and

Chandler searched and found no storm-petrels on 20 August 1967, but they state that Don Bleitz had found them there in small numbers. Crossin and Brownell (1968) specifically mention that no storm-petrels were detected in the Landing Cove area on 11 May 1968, an area "where they had previously been recorded" (probably referring to DeLong's (op cit) information).

Present Status - During 1976 and 1977, storm-petrels of two species were found breeding at Santa Barbara Is. (see also Black Storm-Petrel). Ashy Storm-Petrels were recorded breeding on Sutil Is. just off Santa Barbara Is. for the first time in 1976. On 25 May, two nest burrows of unknown contents were located by smell. On 10 June strong petrel odors were detected in several places along the cliffs at the base of the slope on the southwest side, and a nest with an egg was also found. During mist net operations on the night of 27 June, three Ashy Storm-Petrels were captured and several others were heard calling and seen flying. A net casualty was deposited in the San Diego Natural History Museum (SDNHM 39940). On 17 July, six more birds were captured at night using the net at the same site (a pebbly beach at the base of the cliff on the southwest side). The two birds banded on 27 June were recaptured at this time also. In addition, two other individuals were heard singing. Our conservative estimate of the breeding population on Sutil Is. was 20-25 pairs. However, the extent to which the precipitous north face was used was not known.

In 1976 small numbers of storm-petrels were heard throughout the season in the Cat Canyon area, and a single (presumed Ashy) storm-petrel flew on board our boat anchored in Landing Cove on 3 May 1976. It was not until 1977, however, that it was confirmed that Ashy Storm-Petrels breed on Santa Barbara Is. proper. In 1977, 62 Ashy Storm-Petrels were banded at various locations around Santa Barbara Is.; of these, nine were recaptured. Over 90% of the birds captured had brood patches, and although only a single nest was found, it is felt that the net captures are probably indicative of the breeding population there.

In summary, the breeding population at Santa Barbara Is., including Sutil Is., was estimated to be 150 pairs. Nesting density was very low and restricted to the rocky periphery of the island. Many hours of search revealed only one good and one probable nest site on the island, and it is very possible that earlier researchers just overlooked this species.

San Nicolas Island

Grinnell (1897) heard several unidentified storm-petrels and saw one fly by his tent at night in May 1897, but there are no actual breeding records from the island. No evidence of breeding was obtained during 1975-77. In addition, on a survey around the entire

island in 1977, suitable habitat was not seen.

San Clemente Island

On 8 April 1904, L. Miller collected an Ashy Storm-Petrel (MVZ 6167) which came aboard his ship at night while anchored just off the island. Another was collected, also aboard ship, while anchored at night near Pyramid Pt. on 30 August 1935 (Miller 1936: UCLA 32214). Holder (1910:162) says "One night at Mosquito Bay, San Clemente Is. I saw something like a big bat crawling at the entrance of my tent. It proved to be the young of the black (?) petrel, an attractive little creature, which I endeavored to save but it died the following day." There is, however, no firm evidence of Ashy Storm-Petrels ever having bred on San Clemente Island.

Present Status - No Ashy Storm-Petrels were found on San Clemente Is. in 1975-77 either by our personnel or by Public Works personnel working on the island (J. Larson, pers. comm.). Several days were spent in 1976 and 1977 in the area of Seal Cove searching for nest sites and netting and listening at night. This area was felt to contain some of the best habitat for nesting hydrobatids on the island, but no indication of occurrence was found. If any storm-petrels utilized San Clemente Is., their numbers were extremely small.

Santa Catalina Island

There appear to be no records of storm-petrels at Santa Catalina Is. in the past, and none were found during 1975-77.

c. Breeding Biology

The only important studies on the breeding biology of Ashy Storm-Petrels were conducted on the Farallon Islands off San Francisco, where this species is most abundant (Ainley et al. 1974: and references therein). With the general inaccessibility and small size of the Channel Island colonies, it is doubtful that studies of this kind could be successfully undertaken in this area. Hence, no regular program was initiated to study the nesting habits and success of this species. Instead notes on observations, taken opportunistically, are summarized below.

Habitat

Nests were invariably found on the floors of natural cracks and crevices with eggs deposited directly onto the substrate (loose dirt, gravel or solid rock). No nests were found in excavated burrows, although these may have been used to some extent. This is in marked contrast to Leach's Storm-Petrel, which is usually described as a

a burrow excavator (Palmer 1962; Harris 1974).

Phenology

Because of the nocturnal and secretive habits of storm-petrels, information on the timing of major breeding events was extremely difficult to obtain. Therefore, data gathered from all the Channel Islands during 1975-77 were combined to give the best picture of breeding phenology possible.

Individual Ashy Storm-Petrels were present at colonies from at least 17 January (1977), the earliest date that colonies were visited, until 24 August (1976), the latest date colonies were visited. Ainley et al. (1974) found Ashy Storm-Petrels on the Farallon Islands present at the colony the entire year around (though in much reduced numbers in the winter months). This was probably the case in the Channel Islands also.

The seasonal pattern of colony visitation by Ashy Storm-Petrels, as inferred from birds captured in mist nets (Fig. III-14), was somewhat confounded by the fact that the numbers captured depend upon weather conditions at sea (affecting foraging capability) and lunar conditions (a bright moon retarding visitation; see Crossin 1974; Palmer 1962). In both 1976 and 1977, however, prominent peaks of occurrence were recorded in June (8 June 1976 and 5 June 1977), when the highest number of birds were captured in mist nets. Ainley et al. (1974) found Ashy Storm-Petrels were most common on the Farallons in June as well.

Eggs were present from at least 7 June (1977), when a bird with a fully formed egg in its oviduct was captured on Santa Barbara Is., through 15 July (1976). Chicks were found only on 15 July 1976. Brood patch information, however, indicated that the breeding cycle was considerably more protracted than these records suggest. On the night of 17 February 1977, 22 Ashy Storm-Petrels were banded as they flew aboard our vessel, which was anchored at Yellowbanks, Santa Cruz Island. Numerous other individuals were seen but not captured. Only three captured petrels had completely feathered brood patches: the remainder had clear brood patches (eight individuals) or were in various stages of refeathering (nine individuals). Two birds appeared to be in the process of shedding brood patch down. On 22 March 1977, three Ashy Storm-Petrels captured onboard the boat at Santa Barbara Is. all had refeathering brood patches. Ainley et al. (1974) found that brood patches started refeathering two to ten days after eggs hatched. This observation was then useful in determining approximately when eggs were laid. Assuming a 44 day incubation period (Ainley et al. 1974), birds refeathering brood patches at Yellowbanks on 17 February had laid eggs in late December or early January. It is well known that bird populations at lower latitudes tend to have

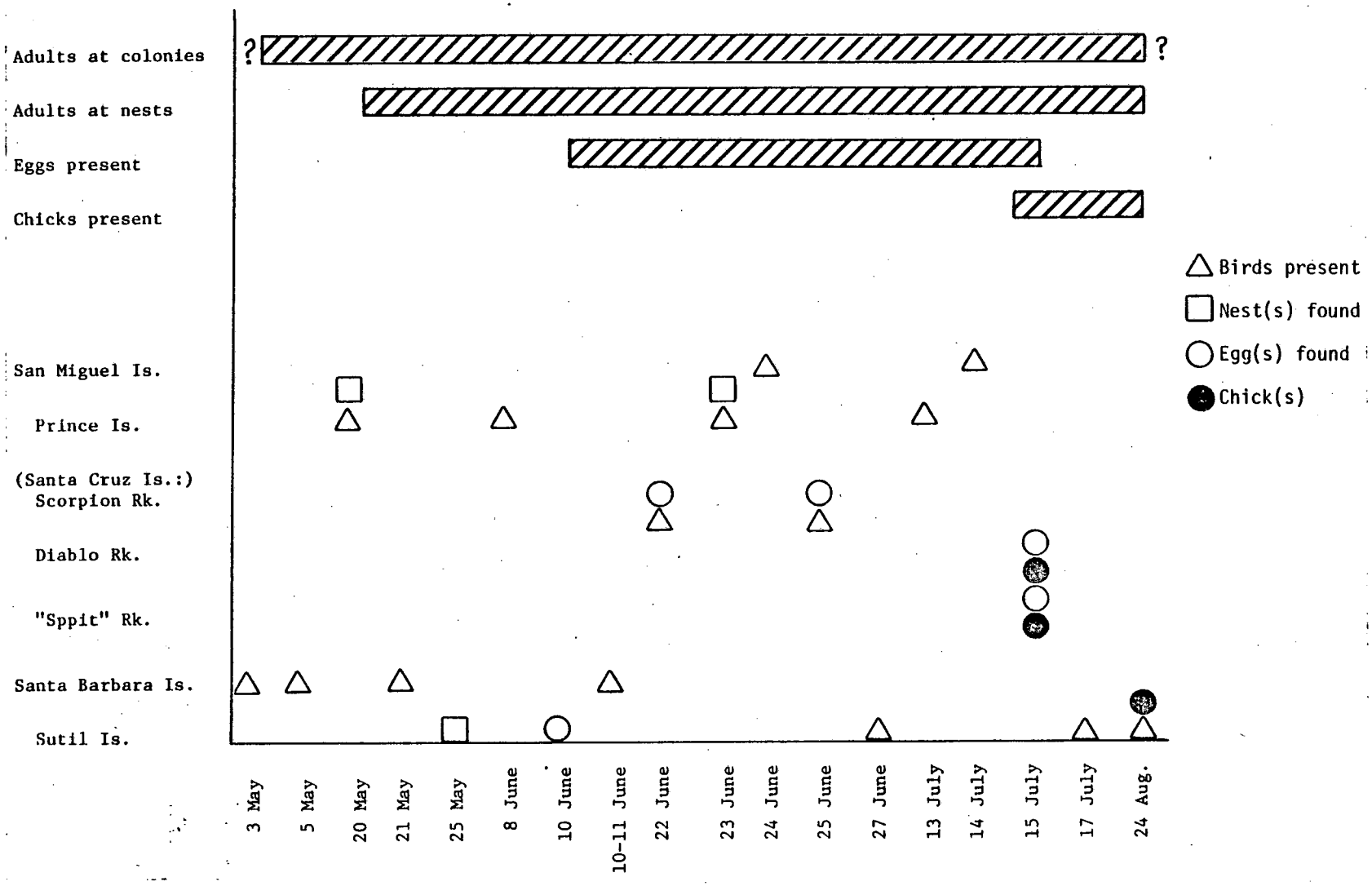


Fig. III-14. Timing of Breeding Events of Ashy Storm-Petrels, Channel Islands, 1976.

longer breeding seasons than conspecifics at higher latitudes. Ainley et al. (1974) have commented on the already extended breeding period of Ashy Storm-Petrels on the Farallon Islands off San Francisco, and it is possible that nesting occurs year-round on the Channel Islands.

d. Food Habits and Foraging Areas

No data on foods or foraging areas used by Ashy Storm-Petrels were gathered during this study, except the distributional data obtained during our regular pelagic surveys. According to Ainley et al. (1974), Ashy Storm-Petrels are confined to waters just seaward of the edge of the continental shelf. They are thus found almost exclusively over the cold waters of the California Current. Foods of Ashy Storm-Petrels include small fish, cephalopods (Ainley et al. 1974) and larval stages of the spiny lobster, Panulirus (Anthony 1898).

Black Storm-Petrel (Oceanodroma melania)

a. Introduction

Prior to this study, breeding Black Storm-Petrels were known only from Mexican waters, where nesting occurs on islands in the Gulf of California and the Pacific Ocean side of the Baja Peninsula (Palmer 1962). Although these populations appear to be quite disjunct, no subspecies have been differentiated.

b. Historical and Present Breeding Status in the Channel Is.

Although Black Storm-Petrels were not known to breed in the Channel Islands prior to this study, Dawson (1923) presaged our findings by stating that this species was "not known to breed in California, but probably does so." Black Storm-Petrels were found breeding on Sutil Is., a tiny islet off Santa Barbara Is., for the first time in 1976 (Pitman and Speich 1976). The population at Sutil Is. at that time was estimated to be no more than 10-15 pairs. This new location is approximately 200 km northwest of Islas Coronados, where this species breeds commonly (Jehl, 1978; DeLong and Crossin ms). During the 1977 field season, 27 Black Storm-Petrels were captured and banded on nearby Santa Barbara Is., including two recaptures. Mist-netting for storm-petrels at Santa Barbara Is. occurred on 18 nights between 28 May and 8 July at several locations around the island. Singing Black Storm-Petrels were heard at Elephant Seal Pt., Lighthouse Pt., and Dragon Cave (between Graveyard and Middle Canyons). Though no nests were actually found on Santa Barbara Is., all petrels captured had defeathered brood patches and were presumed to be breeders. Using the above information, the entire population of Black Storm-Petrels at Santa Barbara Is. (including Sutil Is.) was estimated to be 75 pairs.

During this project two species of storm-petrels were found breeding on Santa Barbara Is., where none had been recorded before: Ashy Storm-Petrel whose breeding metropolis lies to the north and Black Storm-Petrel whose population lies predominantly to the south. It seems unlikely that only recent changes in environmental conditions allowed both these species to expand into this area. More likely, one or both of these storm-petrels were overlooked in the past. Since both species nested in low densities and frequented only the extreme periphery of the island at night, such an oversight is not surprising.

Black Storm-Petrels were not detected on any of the other Channel Islands. Thus Santa Barbara Is. is probably the only breeding site for this species in the United States.

c. Breeding Biology

Habitat

The one nest hole found on Sutil Is. was a natural crevice 20 meters up from a rocky beach along the south side of the islet. The cavity contained egg shell fragments from a Xantus' Murrelet that had hatched earlier in the season. The Black Storm-Petrel found incubating an egg at this site on the night of 16 July 1976 was removed, photographed, banded and released the following morning. Unfortunately, by morning the unattended egg was eaten, undoubtedly by one of the numerous mice (*Peromyscus maniculatus*)that inhabit the islet.

Phenology

As only two nests were found during this study (same site in 1976 and 1977), there is very little information on the phenology of this species from the Channel Islands. Singing birds were heard at night at Santa Barbara Is. from at least 18 May (1977) through 24 August (1976) with most vocalizing occurring in June. Black Storm-Petrels with clear brood patches were captured throughout the mist-netting period (28 May-8 July); however by the first week in June, some individuals brood patches were starting to refeather. Eggs were only seen on 16 July 1976 and 23 June 1977.

The mean weight of 28 Black Storm-Petrels was 65.0 (SD = 9.5, range 53.5 - 93.5). The mean wing chord length for 23 individuals was 171.4 mm (SD = 5.0, range 162 - 180).

Food Habits and Foraging Areas

No data on foods or foraging areas used by Black Storm-Petrels were gathered during this study, except the distributional data obtained during our regular pelagic surveys. These birds forage primarily in warm waters and according to Palmer (1962), they feed on garbage, fish, and squid. In southern California, Anthony (1898) claims the chief food of Black Storm-Petrels is the larval stage of the spiny lobster, *Panuliris*.

Brown Pelican (Pelecanus occidentalis)

a. Introduction

Brown Pelicans are strictly a coastal marine species inhabiting littoral areas throughout the tropical and temperate Americas (Palmer 1962). Along the western coast of the United States, the California Brown Pelican (P. o. californicus) has its northernmost breeding colony in the Channel Islands, though occasionally they have nested as far north as Pt. Lobos (Williams 1927, 1931; Baldridge 1959).

Pelican populations on both coasts of the United States have recently undergone dramatic declines correlated with high concentrations of pesticides in the marine environment and in pelican tissues and eggs. The California Brown Pelican was placed on California's "endangered wildlife" list in 1971 (see Leach 1972:13-14; 1974:19-21). Since that time, practices of discharging DDT contaminants into the marine environment have been discouraged in the Los Angeles area, and a correlated increase in pelican productivity off southern California has given rise to cautious optimism (Anderson et al. 1975).

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

Historically, Brown Pelicans in the San Miguel Is. area have bred only at Prince Island. Streator (1888) mentioned that pelicans were among the water birds "found in breeding season on the island" in July 1886. (Streator mentions two islands off San Miguel, Flea and Gull; he saw the pelicans on Gull Island. From his account and particularly from the abundance of gulls reported, Gull Is. is probably Prince Island). Willet (1910) found "five nests containing young" on Prince Is. on 15 June 1910. O. W. Howard joined Willet's (op cit) party and collected three sets of eggs (WFVZ uncat.), suggesting even more nesting pelicans were present. Wright and Snyder (1913) visited Prince Is. on 12 July 1912; numerous pelicans were present, but nesting was not noted. However, the authors conceded that nesting pelicans may have been overlooked. B. W. Everman collected two sets of eggs on Prince Is. on 19 May 1919 (CAS 1308, 1318). On 31 March 1927, DeGroot (unpubl. notes) recorded a large (breeding?) colony of pelicans present at Prince Island. In the following years, egg sets were taken by J. S. Rowley on 3 June 1928 (WFVZ 26121), L. T. Stevens on 25 May 1929 (SBMNH uncat.), and Stevens again on 24 March 1930. During this last visit, Stevens (unpubl. notes) reported "hundreds of birds nesting on island". Sumner (1939) visited Prince Is. on 18 April 1939 and reported "about 200 nests" on the island. None have been reported there since.

Present Status - No Brown Pelicans were found nesting anywhere in the San Miguel Is. area during 1975-77. However, many roosted at both Prince Is. and Castle Rock.

Santa Rosa Island

There is no evidence that Brown Pelicans ever bred at Santa Rosa Is. nor were any found during this project.

Santa Cruz Island

Blake (1887) does not mention pelicans breeding during his stay in July (1887?). Beck (1899) visited Scorpion Rk. on 5 June 1895; he found cormorants breeding but no pelicans. Wright (in Willet 1912) "found several nests of this species" on Santa Cruz Is. in July 1909. More recently, a small breeding colony was noted on Scorpion Rk. in 1972 and 1974 (Anderson and Anderson 1976).

Present Status - Eighty pairs of Brown Pelicans bred on Scorpion Rk. in 1975 (Anderson et al. 1976). No nesting occurred there in 1976 and 1977. None were recorded breeding anywhere else on Santa Cruz Is. during 1975-77.

Anacapa Island

Pelicans have bred sporadically on West (and formerly East and Middle) Anacapa Is. for quite some time. The first known record is contained in Baird,Brewer and Ridgway (1884): "He (J. G. Cooper) could find no traces of its (Brown Pelicans) nesting in the more southern islands, but was informed that a few of these birds breed on the Island of Anacapa - a locality which he was unable to visit." In 1898, C. F. Holder (1899) found pelicans nesting at the eastern end of the Anacapa Islands. However, the pelicans apparently were not nesting there in June of the following year (Willet 1910). Eleven years later, Willet (1910) found 500 nests with eggs and young on the east island on 5 June 1910. The following year, Peyton (1917) visited the colony (12 March 1911) and found about two hundred pairs of pelicans, only a few of which had started nest building. H. C. Burt (1911) found pelicans mending old nests in May 1911, but no eggs were seen. The next year, Peyton visited the colony in May and estimated the number of pelicans present at 200 pairs (Peyton 1917) and "at least a thousand pairs" (Peyton 1913). Only two (possibly three) nests contained eggs at that time; each had only one egg. When Wright and Snyder (1913) visited the colony two months later (5 July 1912), they found "a large number of birds which apparently were not breeding". Dickey (unpubl. notes) collected an egg set from the north slope of the eastern extremity of the island on 24 May 1913. On 11 June 1914, Peyton (1916, 1917) recorded that the colony had "increased noticeably" since his 1912 visit with "at least a thousand pairs of birds" nesting on the eastern end of the island. Peyton (1917) revisited Anacapa in March of 1916 and 1917, estimated 1500 and 2000 nesting pairs of pelicans, respectively, and commented on the growing prosperity of the colony. Eggs (CAS 1296-1304) and hatched young (Badger, unpubl. notes) were present in April and May 1919. By March 1920, Peyton (in Anderson and Hickey 1970) estimated the colony

size to be 5000+ pairs. On 8 March 1922, a colony of several hundred pelicans were present at Anacapa Is. (Dawson 1923), and at least 53 egg sets were collected (WFVZ 17128; SBMNH uncat.; Peyton, unpubl. notes). DeGroot (unpubl. notes) found a large colony nesting on the seaward side of the north (?) end of Anacapa Is. and estimated 2000 - 3000 pairs breeding on 28 March 1927. However, when DeGroot (unpubl. notes) visited the colony on the following March (5 March 1928) he found only about 500 pairs nesting. Ashworth (unpubl. notes) went to Anacapa Is. on 24 February 1939 and collected at least two egg sets (WFVZ uncat.; MVZ 4561) from a colony recorded for the first time at the west end of the island. Ashworth and Thompson (1930) estimated about 200 nests with eggs and young on 9 March 1930. Stevens (unpubl. notes) collected six egg sets on 10 March 1935, and Bond (1942) reported that in April 1935,pelicans were nesting on the western island in about the same numbers as he saw in 1939, when an estimated 2000 pairs bred at Anacapa Is. (see Sumner 1939). When Stevens and E. N. Harrison traveled to Anacapa the following year (1 March 1936), they independently estimated the pelican population to be two thousand pairs (Stevens, unpubl. notes) and "hundreds of birds" (Harrison, unpubl. notes). They returned on 12 March 1939 and Stevens recorded both a small colony nesting and several hundred pairs nesting on the south side of the west end of the island; it is unclear if these are the same or different colonies. When Sumner (1939) and Bond surveyed the avifauna of Anacapa Is. one month later (16 April 1939), they estimated the population to be "at least 2000 pairs" and breeding successfully. The majority of the pelicans were nesting in colonies of "300 or 400 each" in the ravines and gullies of the westernmost island at that time. Bond (1942) revisited the colony in 1940 and 1941. He found the colony areas had shifted location somewhat, but nesting was still confined to the western island. No significant change in population size was noted.

There were no more pelican nesting reports from Anacapa Is. until 1962, when G. Jensen (unpubl. notes) observed a colony of about 500 pairs with eggs and young on 27 May and collected at least four sets of eggs (WFVZ 33310-33312, 68533). In 1963 and 1964, Banks (1966) saw pelicans nesting on the western island. Though he made no estimate of the population during those years, he mentioned seeing several hundred occupied nests (or "perhaps a thousand", Schreiber and DeLong 1969). Pelicans nested on the western island in 1967 and 1968 with at least some young fledged in the latter year (Schreiber and Delong 1969), though probably very few. Schreiber and DeLong (1969) were fearful at this time that pelicans were being extirpated from Southern California breeding sites because of pesticide residues. In 1969, a minimum of 1272 nests were built with over 75% receiving eggs, but only four young fledged (Risebrough et al. 1971). Gress (1970) reported that of 552 nesting attempts in 1970, only one chick hatched. Reproductive failure in both years was attributed to the collapse of thin-shelled eggs. Anderson and Anderson (1976) report 540 nests on Anacapa Is. in 1971, 261 nests in 1972, 247 nests in 1973 and 416 nests in 1974. (Nest totals for 1972 and 1974 included

some nests on Scorpion Rk. at Santa Cruz Island.)

Present Status - Because of the precariousness of Brown Pelicans breeding in Southern California and the sensitivity of nesting individuals to disturbance, we did not disembark on West Anacapa Is. (1975-1977) or Scorpion Rk. (1975) to inspect colonies there. Instead, we report the findings of Dan Anderson, who has been working with the California Department of Fish and Game for the past several years monitoring the status of Brown Pelicans in California. In 1975, 212 pairs of pelicans nested at Anacapa Island. In 1976, 417 nests were counted. In 1977, only 76 pairs of pelicans nested (Anderson, in lit.). In all three years, nesting was restricted to the West Anacapa Island.

It seems that Brown Pelicans nested almost entirely at the east end of Anacapa until about 1929, when they started nesting at the west end. They have continued there until the present time. Bond (1942) mentions that this shift may have occurred when the lighthouse was established on East Anacapa Island.

Santa Barbara Island

No Brown Pelicans were found breeding at Santa Barbara Is. when Grinnell (1897) spent a week in May 1897, though he saw a few near the island. Willet (1912) found a colony of about 25 pairs breeding on 14 June 1911, and Wright and Snyder (1913) found "between three and four hundred birds" nesting there the following year (2 July 1912). One egg set (WFVZ uncat.) was collected at the time, and at least three sets were taken on 7 May 1914 (Peyton, unpubl. notes). Sumner (1939) and Bond reported seeing 100 pelicans at Santa Barbara Is. on 14 April 1939; thirty of these may have been nesting, but they were not certain. Banks (unpubl. notes) saw "some new nests without eggs", which he believed were pelican nests, on 21 - 23 February 1964. Brown Pelicans nested at Santa Barbara Is. in 1967 (Schreiber and Delong 1969), but none have been reported in the years following (Crossin and Brownell 1968; Hunt and Hunt 1974 (for 1972); Jehl 1974). Remains of old nests can still be seen near the quonset hut on the east side of Santa Barbara Is. and on the south slope of Sutil Island.

Present Status - Though 50 - 100 pelicans roosted on Santa Barbara Is. and its offshore rocks during the breeding season, none nested during 1975-77. Considering the number of human visitors at Santa Barbara Is. each year, it is doubtful that Brown Pelicans will breed on the main island in the future. Sutil Is. remains relatively undisturbed and could conceivably be recolonized.

San Nicolas Island

There are no reliable records of Brown Pelicans breeding on San Nicolas Is. (contra Schreiber and DeLong 1969). Rett (1947) stated that on 27 September 1945 he "found an area where they nested

together with Brandt [sic] and Double-crested Cormorants", but apparently he found all three species roosting in a nesting colony after the breeding season had passed and decided that all three must have bred that year. In 1968, Schreiber (pers. comm.) saw old nests along the western side of the island, which he felt were built by this species. However, no active nests were found in that year.

Present Status - Though Brown Pelicans continued to roost at San Nicolas Is. (particularly in the fall), none bred in 1975-77.

San Clemente Island

There are no records of Brown Pelicans breeding on San Clemente Island. Holder (1910) reported pelicans were rare there and probably did not breed. None were found breeding in 1975 - 1977.

Santa Catalina Island

Schreiber and DeLong (1969) suggested that Brown Pelicans may have nested here irregularly in the ealry 1900's, but there does not appear to be any evidence to support this. None were found breeding in 1975 - 1977.

In summary, the dramatic decline in the numbers of Brown Pelicans breeding on the Channel Islands has been well documented. The colonies in the San Miguel and Santa Barbara Is. areas have been abandoned, and the populations nesting on Scorpion Rk. and Anacapa Is. have been greatly reduced. From 1968 until 1972, marine pollutants were believed to be the major factor depressing this species' reproductive success and hence numbers (Anderson et al. 1975). Though pollutant affects were still evident at the time of this study, pollutant levels have dropped since 1972. Yet the number of Brown Pelicans nesting in the Bight has failed to increase notably since that time. Anderson et al. (1976 ms) argue that the affects of limited food resources on reproductive success may be partially responsible (see Reproductive Success for a more detailed discussion).

c. Breeding Biology

The information below was taken from two reports by Anderson et al. (ms, 1976). These reports incorporate some observations made by personnel of this study during the 1975 - 1977 seasons.

Phenology

Brown Pelicans generally arrived on their colonies and began nest building in January of each year; however, the timing of breeding in this species was highly variable. In 1976, egg laying commenced in late February and continued through early May. Brown

Pelican eggs require approximately 30 days of incubation, so the chicks hatched from late March to June. The young fledge approximately nine weeks after hatching (Palmer 1962), thus most had left the colony by late August.

Reproductive Success

In 1975, the estimated 292 pairs of Brown Pelicans breeding on West Anacapa Is. and Scorpion Rk. successfully raised 256 fledglings, 1.05 young produced per breeding pair. In 1976, productivity dropped to 0.86 young per breeding pair (total: 279 fledglings that year from Anacapa Is. only); only 196 of an estimated 417 breeding pairs successfully fledged young at all. In 1977, only 39 young fledged from the Anacapa Is. colony, which had declined to 76 breeding pairs. This translates into 0.75 young per breeding pair.

Brown Pelicans were still producing thin-shelled eggs in 1978, indicating that pollutant stress continued to depress productivity. In addition, from 1975 - 1978 the decreasing reproductive success of Brown Pelicans in the Bight was correlated with declines in the availability of Northern Anchovies, their major food source during the breeding season. In June and July 1976, personnel of this study found the emaciated bodies of young pelicans, apparently starved to death, floating in the water below the colony. Nest abandonment was also common that year, and anchovy levels were low. These findings suggest that the protection and management of this fishery will have profound affects on the recovery and recolonizing efforts of Brown Pelicans in the Bight.

d. Food Habits

Data on the food habits of Brown Pelicans in Southern California are limited. Anderson et al. (ms) reported "69 banded young on three islands regurgitated 736 fish as follows: Northern anchovy = 87.6 percent occurrence (*n* = 645), Pacific saury (*Cololabis saira*) = 8.8 percent (*n* = 65, all in one day), Pacific mackerel = 3.4 percent (*n* = 25), and blacksmith (*Chromis punctipinnis*) = 0.1 percent (*n* = 1). We have also observed pelicans feeding on California grunion (*Leuresthes tenvis*), but these have not been observed in regurgitations". No data on foods taken by Brown Pelicans were collected during this study.

e. Foraging Areas

Brown Pelicans were generally inshore feeders. They were commonly encountered feeding in the waters adjacent to their breeding colonies and roosting areas, but they probably foraged along the mainland coast as well.

Double-crested Cormorant (Phalacrocorax auritus)

a. Introduction

Double-crested Cormorants are widespread in North America, with four recognized subspecies. Only P. a. albociliatus nests in the Channel Islands. It also nests from Southern British Columbia south along the coast to Baja California, in the Gulf of California (but not the Revillagigedo Islands; see Brattstrom 1956) and in the interior of the Pacific states, Western Nevada and Arizona (A.O.U. 1957). Reilly (in Palmer 1962) describes albociliatus as mostly sedentary with populations moving to lower altitudes during cold seasons and from offshore islands to inshore channels in the non-breeding season.

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

Streator (1888) saw Double-crested Cormorants at San Miguel Is. in July 1886. Appleton (unpubl. notes) reported one colony of 60 - 100 pairs breeding in a cactus patch, and another colony of about "100 others" at Prince Is. on 6 June 1906; thirteen egg sets were collected at that time (incl. WFVZ 63445). Willet (1910) found "quite a large colony" breeding in the cactus patch on the eastern side of Prince Is. on 15 June 1910. Wright and Snyder (1913:91) made a rather hasty survey of Prince Is. on 12 July 1912; they "visited only the west end of the island" and did not find this species. Evermann collected several sets of eggs on 19 May 1919 (CAS 1319-1330); Stevens collected two sets on 25 May 1929 (SBM uncat.); and W. J. Sheffler collected four egg sets there on 11 June 1933 (WFVZ 65933-65936). Sumner (1939) estimated 200 birds (= 100 pairs?) building nests on 18 April 1939. Craig and Sheppard (unpubl. notes) estimated about 350 pairs present on 3 - 5 July 1965. When Crossin and Brownell (1968) visited the island on 15 May 1968, they found a single "colony of about 30 pairs was present on the high bluffs at the SE end". They found no colonies on San Miguel Is. proper. Huber (1968) visited the same area two weeks later and estimated a maximum of 20 active nests on Prince Is. and seven additional nests on San Miguel Is. due south of Prince. Huber's (op cit) estimate of the total population of Prince Is. at that time was 80 - 100 birds. A map appended to the report showed that the Double-crested Cormorant colony on Prince Is. was near the top of the island at the south-east end.

Present Status - In 1976 and 1977, Double-crested Cormorants nested in small, scattered colonies close to the top of the island. Essentially, the same sites were used in both years, and the majority of the nests were located along the south side (Fig. III-15). The main colony (ca. 30 nests) was located amidst Opuntia cactus near the top of the island in the southeast corner; this colony has apparently

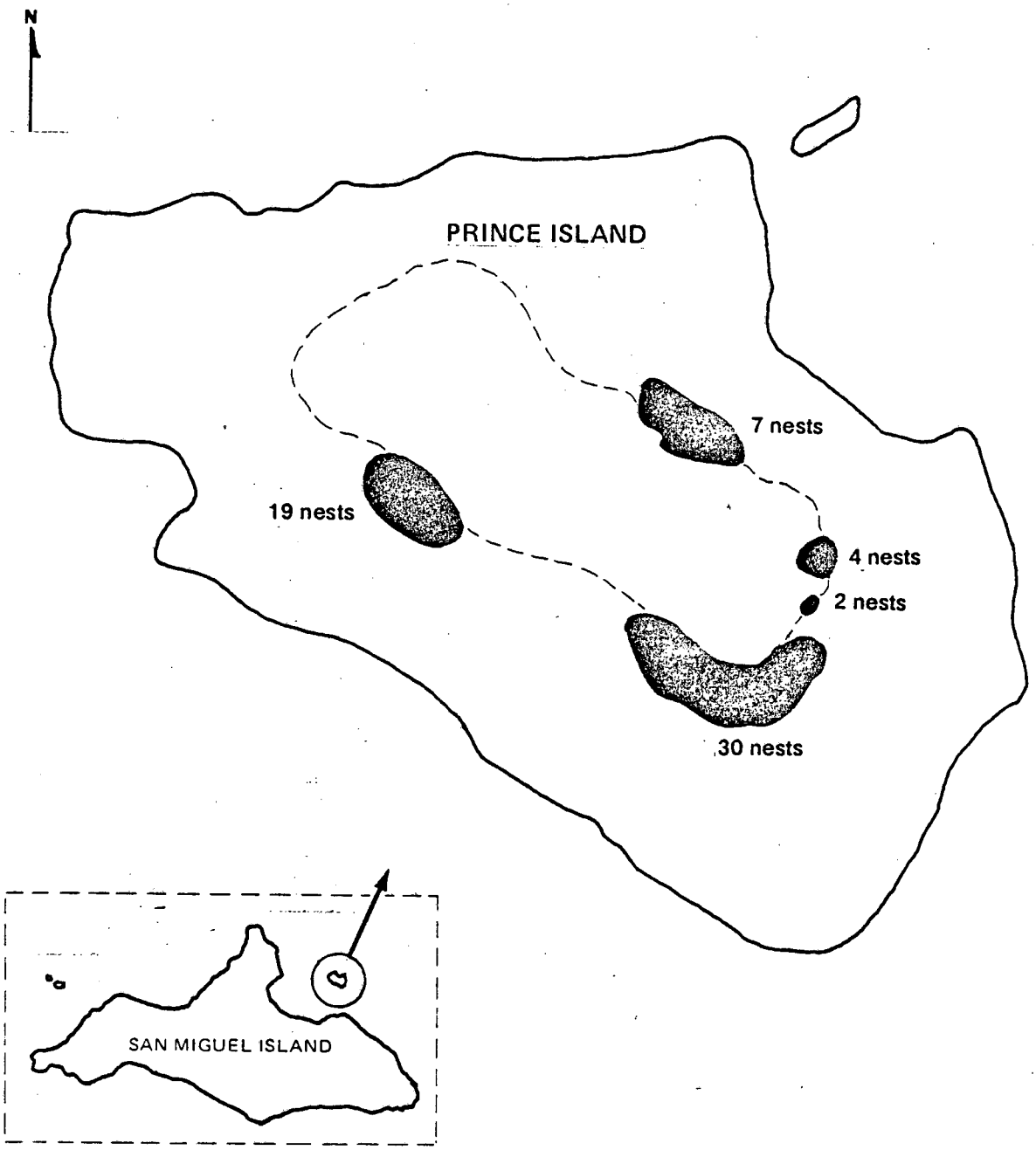


Figure III-15 . Distribution of Double-crested Cormorant nests on Prince Is. (San Miguel Is.), 1976.

persisted since historical times. The breeding population at Prince Is. was estimated in 1976 and 1977 to be about 75 pairs. None were found breeding on either San Miguel Is. proper or nearby Castle Rock.

Santa Rosa Island

There appear to be no records of Double-crested Cormorants breeding at Santa Rosa Is., and none were found nesting there in 1975-77.

Santa Cruz Island

Rollo Beck (1899) reported Double-crested Cormorants breeding on what was undoubtedly Scorpion Rk. on 5 June 1895. This was the only breeding record from this island. Ross (1926) saw them roosting during the breeding season in 1926.

Present Status - No Double-crested Cormorants were found nesting on Santa Cruz Is. proper, Gull Is., Scorpion Rk., or any of the other offshore rocks around the island in 1975 - 1977. However, birds often roosted at some of these locations, particularly Gull Island.

Anacapa Island

Willet (1910) found Double-crested Cormorants breeding on Anacapa Is. on 4 June 1910, and Wright and Snyder (1913) reported a few pairs with recently finished nests on 5 July 1912. Dickey (in Howell 1917) found quite a few breeding there in 1913. DeGroot (unpubl. notes) found "many small colonies" on 28 March 1927. Ashworth and Thompson (unpubl. notes) saw "many birds" in the colony on 15 May 1927 and collected at least one set of eggs (WFVZ 73971); however, they did not report any Double-crested Cormorants in 1930 (Ashworth and Thompson 1930). Badger (unpubl. notes) noted a large colony breeding on 17 May 1936, and collected one egg set (WFVZ uncat.). Bond (Sumner 1939) reported finding about 50 pairs of Brandt's Cormorants nesting on the extreme west end of the western island in April 1934, but historically (and currently) this area has supported a Double-crested Cormorant colony. Hence, Bond's observation may, in fact, refer to Double-crested Cormorants. Sumner's (1939) report of his visit to Anacapa on 16 April 1939 is a little unclear about the status of this species. His account follows: "These birds were very numerous. Some were seen nesting on the south slope near the west end of the west island near a colony of pelicans... Most of the young had hatched and some were nearly half grown. Because of the cactus it was impossible for us to band these young birds." From his statement, it seems that only a small portion of the Double-crested Cormorants present were actually breeding. The nesting area he described may have been the same place where Bond had seen "Brandt's Cormorants" nesting in 1934.

Banks (1966) also mentions the colonies at the west end of West Anacapa Is., but does not identify the species involved. (He seems to imply, however, that they may have been Double-crested Cormorants since he further states that Pelagic Cormorants in their distinct breeding plumage "should be noticed if present" and "Brandt's seem to be the least commonly reported" of the nesting cormorants at Anacapa Is.) His estimate of the numbers breeding in 1964 is also somewhat equivocal; he found that historical "estimates of abundance range from a few pairs to quite a number" and he doubted from his observation "that the overall population has changed much in recent years". Crossin and Brownell (1968) apparently found no Double-crested Cormorants nesting when they visited Anacapa Is. in May 1968.

On 13 May 1969, Kiff (unpubl. notes) collected seventeen eggs (incl. WFVZ 35425-35428) from several nests for pesticide analyses. In the same year, Gress et al. (1973) started closely following the progress of the West Anacapa Is. colony. These surveys were started because Double-crested Cormorants were experiencing the same reproductive failures due to eggshell thinning that Brown Pelicans were demonstrating. In 1968, they reported 76 nesting attempts in two colonies; in 1970 there were 50 nests; in 1971, 48 nests were counted; and in 1972 a boat census recorded only a single colony with a minimum of 14 nests. This colony was later abandoned, and a second colony with eleven "recently active" nests was noted. During the period covered by Gress et al. (1973), reproductive success of Double-crested Cormorants at Anacapa Is. was practically nil. However, in 1972 several young did fledge, and the authors were hopeful that the declining trend had been reversed. In 1973 and 1974, Anderson (in lit.) reported 16 and 29 nesting attempts, respectively, of Double-crested Cormorants at Anacapa Is.; very few young were produced.

Present Status - On 16 June 1975, two Double-crested Cormorant nests were observed on West Anacapa Is., and others were probably present as well. Anderson (in lit.) reported three nests in 1975. In 1976, a minimum of seven nests and nine adults were seen on 26 June in a colony on the north side of the west island. Eleven nests with 16 adults present were seen from the boat on 14 April 1977. On 23 June, 12 nests were counted at the same colony near the western tip of the west island. Anderson (in lit.) counted 15 nests and noted improved productivity in 1977.

Santa Barbara Island

Double-crested Cormorants were formerly very common breeders on Santa Barbara Island. An egg set was collected there by Cooper on 26 May 1863 (MVZ 1952). Grinnell (1897) found them breeding in large numbers on 15 May 1897 and collected two sets of eggs (Willet 1933) and one specimen. Wright and Snyder (1913), without mentioning any numbers, reported that the main colony at Santa Barbara Is. was on a bluff on the northwest part of the island; they collected two

egg sets on 2 July 1912 (WFVZ uncat.). Two sets were taken on 7 May 1914 (Peyton, unpubl. notes), one set was teken by L. Wyman on 31 May 1920 (LACM uncat.), and ten sets were collected on 15 May 1927 (MVZ 3596-3605). Sumner (1939) reported "about 2,000" Double-crested Cormorants on and around Santa Barbara Is. on 14 April 1939, and stated, "They had begun to nest, but the stage of their operations was not determined". Crossin and Brownell (1968) did not see any during their survey of the island in May 1968, but Hunt and Hunt (1974) reported 66 pairs nesting on 2 July 1972. Jehl (1974) saw 14 birds around the island on 11 July 1974, but felt they probably no longer bred there.

Present Status - In 1976, 10 pairs of Double-crested Cormorants bred on Santa Barbara Is. on the sheer cliff adjacent to Shag Rock. An additional 30 pairs nested along the top of the north face of Sutil Is., giving an island total of 40 pairs. In 1977, only 7 pairs nested at the main island site, but 60 pairs bred at the Sutil colony, giving a total of 67 pairs. These colonies were monitored closely enough that the difference between the two years is real.

San Nicolas Island

There is some question as to whether Double-crested Cormorants have ever bred on San Nicolas Island. Grinnell (1897) described this species as "common" but found no evidence of them breeding there in May 1897. On the other hand, Howell (1917) states that "immatures" had been found there, and Rett (1947) says that he found a nesting colony on 27 September 1945. However, this date is extremely late, and Rett presumably based his conclusion on the discovery of some inactive nests which he identified as those of the Double-crested Cormorant. Townsend (1968) described this species as a "breeding resident in small numbers" during 1962-64, but Delong (1967) found none during his visit in July 1967.

Present Status - Double-crested Cormorants did not nest on San Nicolas Is. during 1975-77.

San Clemente Island

There is no good evidence that Double-crested Cormorants ever bred at San Clemente Is., although two sets of eggs taken 3 May 1914 were tentatively identified as belonging to this species (Peyton, unpubl. notes). Double-crested Cormorants did not breed at San Clemente Is. during 1975-77.

Santa Catalina Island

Grinnell (1898) stated that Double-crested Cormorants breed on Santa Catalina Is., and Howell (1917) more specifically claimed this species "breeds on Ship Rock". No evidence of nesting was found in a complete circuit of the island on 9 July 1974 (Jehl 1974), and

Double-crested Cormorants did not breed at Santa Catalina Is. during 1975 - 1977.

Since the turn of the century, Double-crested Cormorants have declined significantly throughout their former breeding range in the Channel Islands. The reasons for this long-term decline are not clear, but Gress et al. (1973) have correlated recent declines in reproductive output with high concentrations of persistent chlorinated hydrocarbon residues (DDE) in yolk lipids from eggs of this species. The resultant pattern of thin eggshells and egg loss was similar to that observed for Brown Pelicans nesting in the Channel Islands and Northwestern Baja California (Jehl 1973). In April 1970, a major source of DDT contamination in the Bight was curtailed; productivity for Brown Pelicans improved in the years following (Anderson et al., 1970). At present, Double-crested Cormorants enjoy moderate to good reproductive success at their colonies in the Bight (Anderson, in lit.; this study) and are probably on the increase. However, this species is notoriously vulnerable to human disturbance. Therefore, it is unlikely there will ever be a large colony nesting on Santa Barbara Is. again, and resumption of breeding at Santa Catalina is doubtful.

c. Breeding Biology

Most of the breeding biology data collected on Double-crested Cormorants during this study were obtained on Santa Barbara Island. Only supplemental information was available from Prince and Anacapa Islands.

Habitat

On Prince Is., Double-crested Cormorant nests were always associated with vegetation (usually *Opuntia*). In the largest colony, nests were interspersed among the *Opuntia* and rocks along the top of the island, extending downhill a short distance and westward along the island's top edge. Nests in this area were low and formed of guano-matted dry vegetation. Double-crested Cormorants consistently nested higher on the island than Brandt's Cormorants.

At the Santa Barbara Is. colonies, the same trends were observed. Double-crested Cormorants nested in high areas, nearly always higher than Brandt's Cormorants. The average height above sea level for 32 Double-crested Cormorant nests was 110 m (range 50-150) compared to a mean height of 21 m (range 7-50) for 46 Brandt's Cormorant nests (estimated heights).

Nests at Santa Barbara Is. were tall, twiggy platforms made of sticks and dry vegetation. Some of the nests had been built up over several years. All the nests were built near or supported by

vegetation; low shrubs were most common (Eriophyllum or Eriogonum). As with Brandt's Cormorants, Double-crested Cormorants nested only along the north sides of the Channel Islands. Because of this species' propensity to nest in vegetated areas, nests were not as densely packed as were those of Brandt's Cormorants.

Phenology

On Santa Barbara Is. in 1976, eggs were first laid during the last week in March (determined by subtracting 25 - 29 days from the date hatchlings first appeared (see Palmer 1962)). Egg laying continued until 13 April on Santa Barbara Is. proper; however, the birds may have continued laying later on Sutil Island. Chicks began hatching around 27 April. Peak hatching, inferred from known hatching dates and relative chick sizes, took place during the last week in April and the beginning of May. Young first fledged from their nests 10 - 16 June. By 11 July, all chicks had fledged with the exception of a single large young on Sutil Is. (Fig. III- 16).

In 1977, egg laying was less synchronous than in 1976 (this may have been due in part to a larger sample size). Clutches were again initiated the last week in March; however, egg laying continued into the middle of June with the peak drawn out from the middle of April to the middle of May (Fig. III- 17). The difference in synchrony between 1976 and 1977 (two-week egg-laying period vs. a two and one-half month period) is not understood. Fig. III- 18 summarizes breeding phenology data for Double-crested Cormorants on Santa Barbara Is. in 1976 and 1977.

At Prince Is., no eggs had been laid by 12 April (1977), though nests were being refurbished. Eggs were present, but most clutches were still incomplete by 29 April (1976). Birds were still incubating until 13 July (1976). Chicks were present from 13 May (1975) until 12 August (1977). By 28 August (1976), no chicks were present in the colony; it was assumed they had fledged. Interestingly, on the night of 13 July (1976), 20 young were found in tight groups away from the immediate nesting areas. These chicks were large with just-errupted to half-grown flight feathers. This information suggests that birds in the Prince Is. colony bred from two to four weeks later than those in the Santa Barbara Is. colony.

At Anacapa Is., chicks were seen from the boat on 26 June and 16 July 1976. Fig. III-19 presents the timing of breeding events for Double-crested Cormorants in the Channel Islands for 1975-77, incorporating all islands.

Reproductive Success

Double-crested Cormorants initiated 42 nests on Santa Barbara and Sutil Islands in 1976. At least 32 (76%) of these eventually contained eggs, as ascertained by incubating birds. The colony on

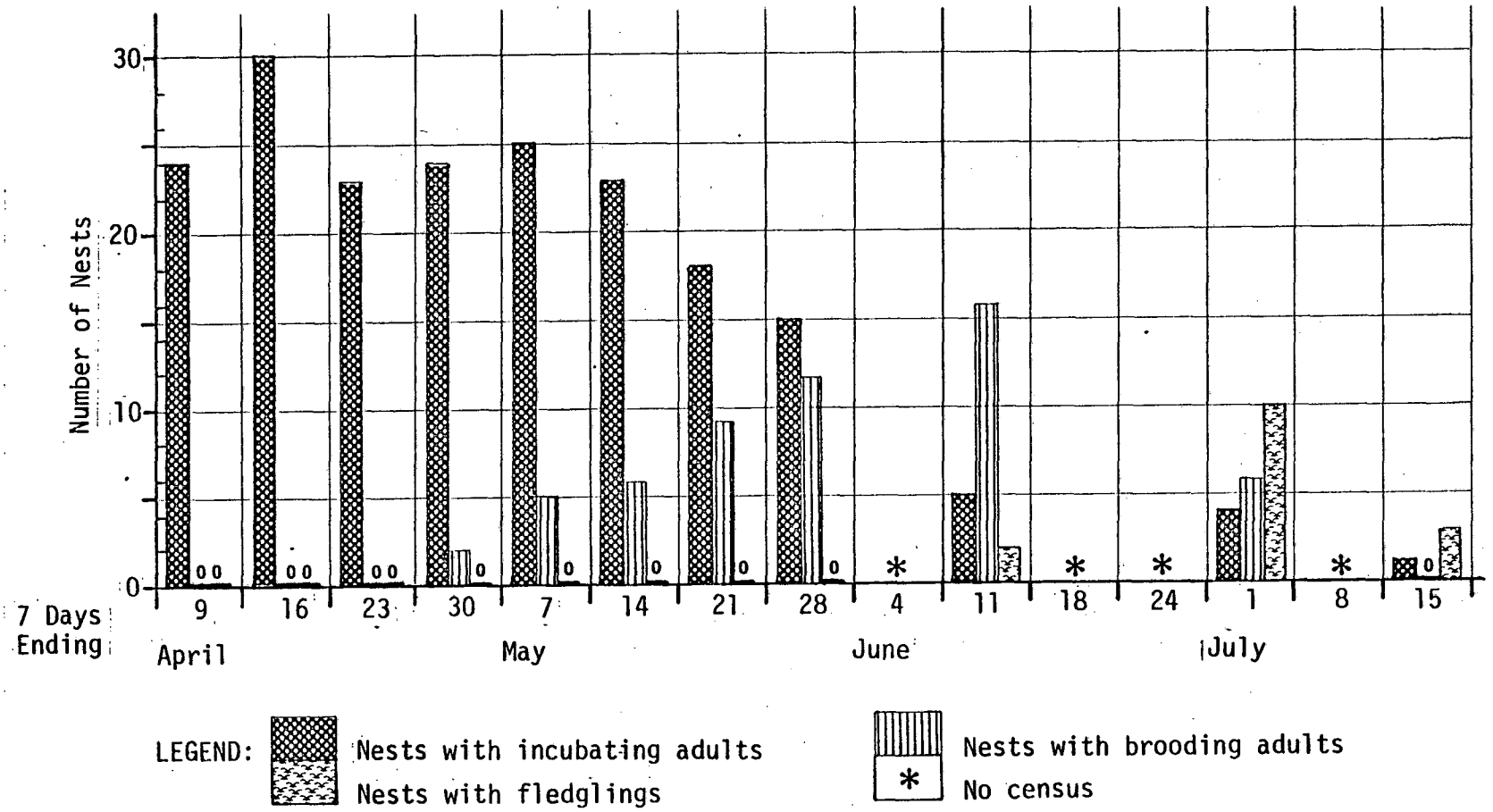


Figure III-16. Timing of breeding activities for Double-crested Cormorants on Santa Barbara Island, 1976. Observations began on 6 April.

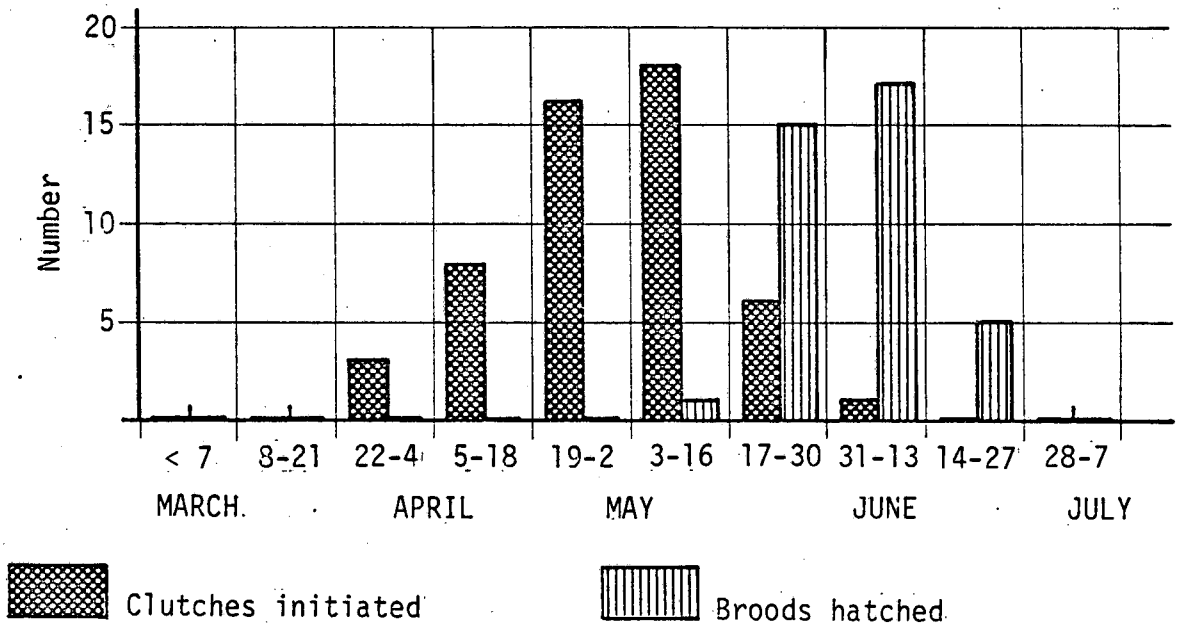


Figure III-17. Timing of breeding events for Double-crested Cormorant, Santa Barbara Is., 1977.

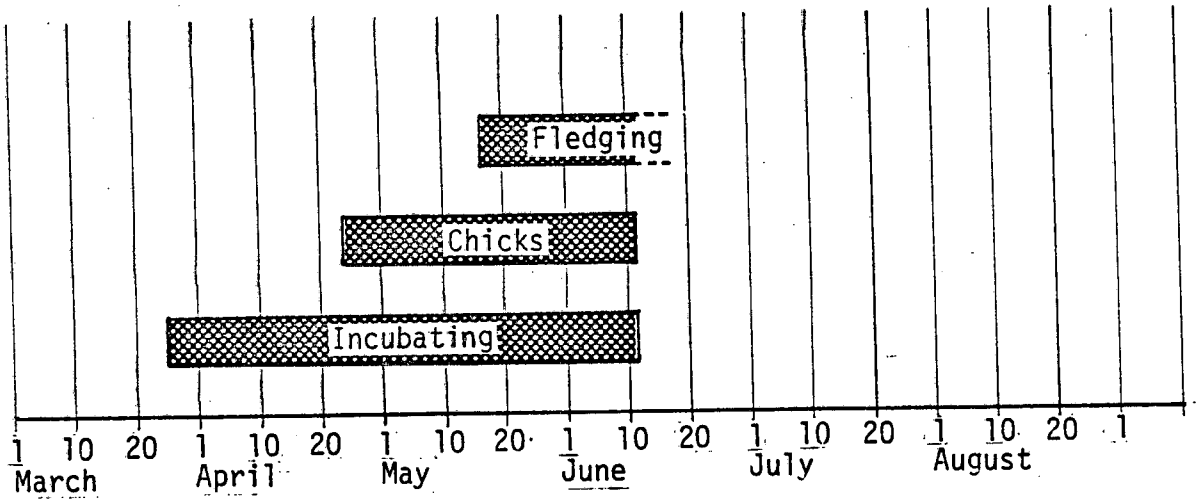


Figure III-18 . Timing of breeding events for Double-crested Cormorant, Santa Barbara Is., 1976-1977.

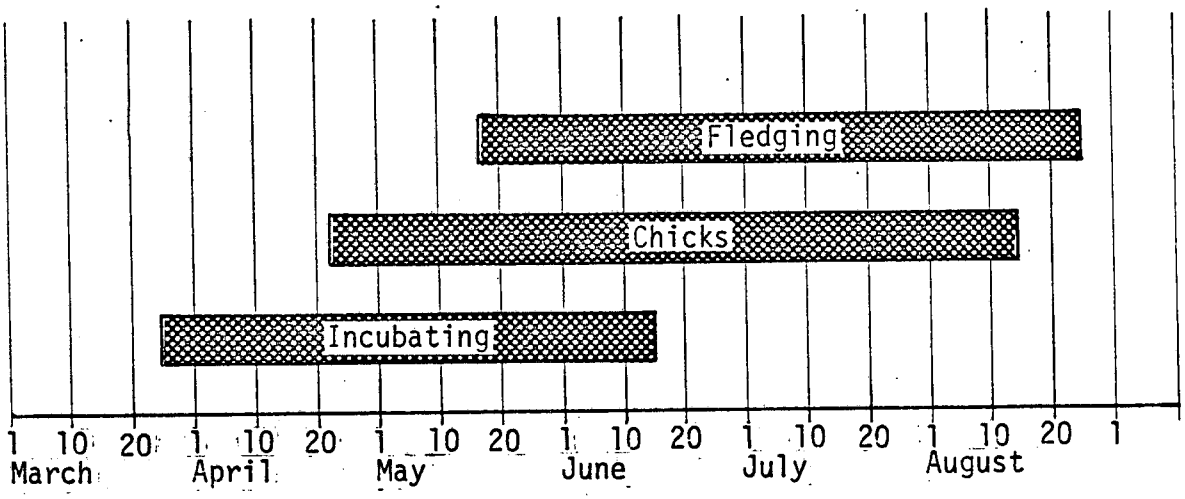


Figure III-19 . Timing of breeding events for Double-crested Cormorant, Channel Islands, 1975-1977.

Santa Barbara Is. (Spire Colony) contained 10 regularly-attended nests. Seven of these nests received eggs, and six of these seven nests produced chicks which eventually fledged. Only two nests were close enough to actually observe nest contents; one received three eggs, the other four. All seven eggs hatched, and the same number of young fledged.

In 1977 at Santa Barbara Is., 27 young successfully fledged from 13 nests where the number of young fledged is known, giving an average of 2.1 fledglings per nest in successful nests. The number of young produced per breeding attempt, however, was considerably lower than this; at least 55% of the active nests in 1977 never fledged young.

The colony on Prince Is. was checked less frequently than the Santa Barbara Is. colonies, but the nests were more accessible. On 23 June 1976, one colony of 20 nests was visited at night. Nests contained both eggs and young.

Nest Contents:	1 egg	2 eggs	3 eggs	1 chick	2 chicks	Total
No. of Nests:	2	2	4	7	5	20 Nests

The average clutch size in these nests was 2.25 eggs per nest.

On 13 July 1976, 19 fledgling-size chicks were found in 12 nests; the average was 1.6 fledglings per nest (range 1-3). At this time, at least 20 additional fledgling-sized young were grouped together, no longer associated with their nests, and six dead chicks were found in the colony. In 1977, 21 nests on Prince Is. contained an average of 2.8 young per brood on 29 July (range 1-7); most were growing their flight feathers. On 12 August, 51 fledgling-size chicks were banded from 31 nests giving a minimum of 1.6 young per brood. However, by this late date, many young had already fledged, and this figure is undoubtedly low. A total of 70 chicks were banded in 1977.

On Anacapa Is., at least two large young were seen in a nest in 1976. In 1977, Anderson (in lit.) found 18 young produced from 15 nests (1.2 young/nest attempt).

d. Food Habits

The food habits of Double-crested Cormorants in North America are well known. They feed on a wide variety of freshwater and marine fish with small amounts of crustaceans and amphibians (Palmer 1962). Considerably fewer data exist for this species in the marine environment of California. Food items recorded include sculpins, sticklebacks, flounders, smelt, pipefish, surfperch, sardines and shrimp (Palmer 1962). Ainley and Lewis (1974) suggested that the failure

of Double-crested Cormorants to maintain their populations along coastal California and Baja Mexico may be due to the depletion of the Pacific Sardine (Sardinops caerulea) stocks.

In 1976, seven regurgitation samples were obtained from large chicks on Prince Island. The samples were composed of Cymatogaster aggregata (21.2% by volume), Sebastes sp. (16.4%), Serranidae (10.8%), Oxyjulis californica (30.4%) and unidentified fish (21.2%). Fourteen regurgitation samples collected from the same colony in 1977 contained a similar variety of fish. Sebastes spp. comprised 87% of the total volume (Fig. III-20).

In summary, these samples contained a common variety of mid-water fish species that inhabit littoral waters particularly in kelp beds. From these data, it appears that the food habits of the Double-crested Cormorants at Prince Is. were similar to those of Brandt's Cormorants.

e. Foraging Areas

Double-crested Cormorants are near-shore feeders. They were usually found within a few miles of their breeding colonies during the breeding season.

Fig. III-20 Food Habits of Double-crested Cormorants, Prince Island, 1977.

Species	Composition of 14 Regurgitation Samples From Chicks	
	Percent Occurrence	Percent Volume
Scorpaeniformes		
Scorpaenidae		
Sebastes spp.	71.4	86.9
Perciformes		
Carangidae		
Trachurus symmetricus	14.2	0.8
Embiotocidae		
Brachyistius frenatus	14.2	0.8
Cymatogaster aggregata	35.7	30.7
Pomacentridae		
Chromis punctipinnis	7.1	6.6

Brandt's Cormorant (Phalacrocorax penicillatus)

a. Introduction

Brandt's Cormorant is a common breeding seabird along the Eastern Pacific Coast from British Columbia to Baja California (Palmer 1962) and in the Gulf of California (Anderson, pers. comm.). This species is strictly a coastal marine inhabitant, rarely wandering from littoral areas.

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

Large numbers of Brandt's Cormorants were reported by most early investigators at San Miguel Is., primarily on Prince Is., but few attempted to estimate their numbers. Streator (1888) commented on the "mass of living gulls and cormorants" on Gull Is. (Prince Is.) that he saw on his 1886 trip to the island. Appleton (unpubl. notes) reported "a large colony breeding" with "100 or more nests on the island" and collected at least 19 egg sets (incl. WFVZ 6363, 21669-21761, 21727, 63450) in June 1906. Willet (1910) found Brandt's "most abundant of the cormorants on Prince Island, breeding in several large rookeries". Later, he mentions one of the colonies had "about a hundred pairs". His party collected a minimum of five egg sets (WFVZ 6363, uncat.). Snyder (unpubl. notes) checked the contents of 500 nests on 12 July 1922 and collected one egg set (WFVZ uncat.). Evermann collected three sets on 19 May 1919 (CAS 1327-1329). Pemberton (1928) found them nesting at San Miguel Is. in 1927, and Peyton collected a single set of eggs on 2 June 1928 (MVZ 4569). Stevens (unpubl. notes) estimated several thousand pairs on Prince Is. and collected two egg sets on 25 May 1929 (SBM). In 1933, Sheffler collected two egg sets on 11 June (WFVZ 65927-65938). Sumner (1939) reported "on Prince Island there were at least 1,000 concentrated particularly on the east and north sides". Many of these birds were actively building nests. Orr (1950) off-handedly mentions cormorants breeding at the west end of Prince Island. In July 1965, Craig and Sheppard (unpubl. notes) stayed on Prince Is. and estimated there were 1,500 pairs of Brandt's Cormorants. Crossin and Brownell (1968) surveyed the area on 14 - 15 May 1968 and estimated the Castle Rk. population to be 3,000 birds and the Prince Is. population to be 5,000 birds; nesting was in progress at both locations. Huber (1968) visited these colonies again two weeks later, 28 May - 7 June. He reported no Brandt's Cormorants nesting on San Miguel Is. and at least 1,200 roosting at Castle Rk., where he made no observations on nesting status. On Prince Is., he found approximately 150 Brandt's Cormorants roosting; the colony had been deserted (see Breeding Biology for discussion). Anderson (in lit.), conducting aerial surveys around Prince Is. and Castle Rk., estimated 1,000 and 500 Brandt's Cormorant nests, respectively, on 27 April 1972.

Brandt's Cormorant: Historical and Present Status (continued)

Present Status - Brandt's Cormorants bred in large numbers on Castle Rk. and Prince Is. and in smaller numbers at Pt. Bennett and Hare Rock. On Castle Rk. in 1975, 216 nests were counted. A more accurate count on 8 June 1976 found 363 nests, and accurate aerial counts in 1977 indicated 916 pairs of nesting Brandt's Cormorants were present. In 1975, an estimated 860 Brandt's Cormorants nested at Prince Is. and a less accurate count in 1976 found a minimum of 590 nests. Excellent surveys in 1977 produced a high count of 907 nests on 21 June. A minimum of 27 nests were seen on Pt. Bennett on 20 July 1977. This was the only colony on the main island. In 1976, five nests were found on Hare Rk. adjacent to Cuyler Harbor. This rock was not checked in 1977. Hence, a total of 1,100 - 2,000 pairs of Brandt's Cormorants nested in the San Miguel Is. area from 1975 - 1977.

On Prince Is., Brandt's Cormorant colonies shifted location from year to year (Fig. III-22). During the 1975 breeding season, Brandt's Cormorants nested along the southern ridge of the islet (facing Cuyler Harbor) and at scattered locations along the north side. In 1976, the bulk of the colony was at the west end of the island on the south side. In 1977, this entire area was abandoned and the main colony was located on the sheer cliffs that face northwest. A similar change in nesting area was noted on Castle Rk. between 1976 and 1977.

The reason for these shifts is not known. However, during a colony visit late in the 1976 season, researchers noted that the area was infested with fleas. When revisited in 1977, the old abandoned nest sites still harbored many fleas. King et al. (1977) and King et al. (1978) discuss the relationship between colony abandonment by Brown Pelicans and infestations of colony sites by ticks (*Ornithodoros* sp.). It seems reasonable that similar factors involving fleas could be responsible for colony site shifts in Brandt's Cormorants. (Fleas from fresh Brandt's Cormorant nests were tentatively identified as *Ceratophyllus pelecani* by Thomas Schwan (in lit.).)

Santa Rosa Island

Howell (1917) felt that Brandt's Cormorants probably bred "on or near Santa Rosa Island". Many were around the island in April 1927, and Pemberton (1928) was certain they nested there. Apparently there are no other published accounts concerning the status of Brandt's Cormorants as a breeding species on this island. During U. S. Fish and Wildlife Service aerial surveys on 27 April 1972, Anderson (in lit.) counted approximately 150 nests, presumably of Brandt's Cormorants, along the north side of Santa Rosa Is.; about 100 of these were in the area of Carrington Pt.

Present Status - Santa Rosa Is. had a large contingent of breeding Brandt's Cormorants. In 1975, incomplete surveys indicated

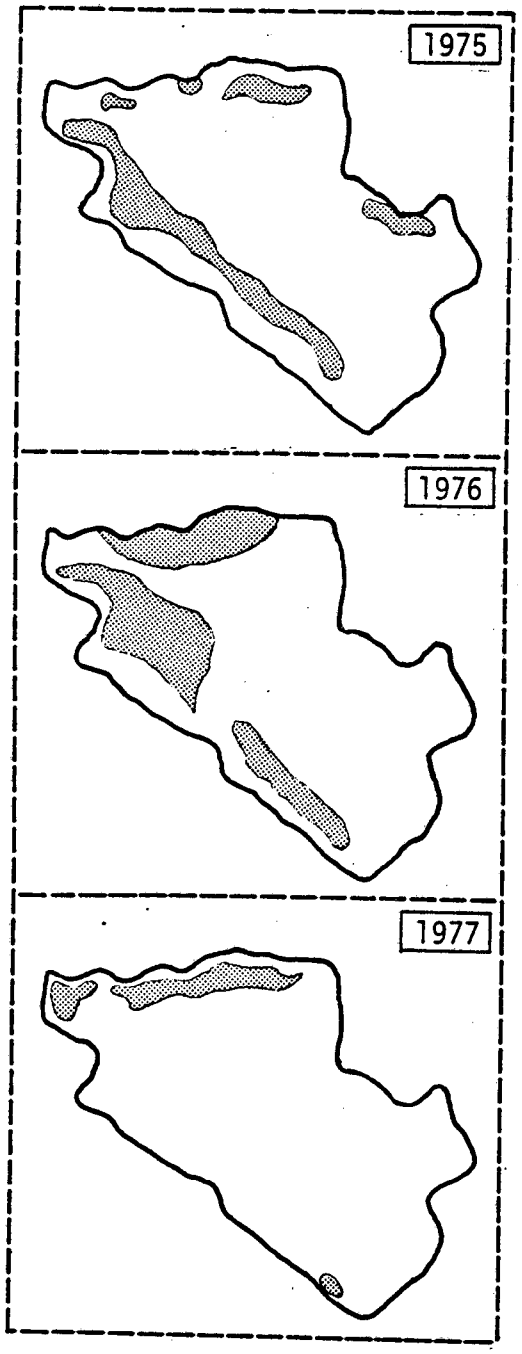


Figure III- 21. Locations of active Brandt's Cormorant colonies on Prince Is. (San Miguel Is.) 1975-1977.

at least 200 pairs of Brandt's Cormorants nested at Carrington Point. In 1976, an estimated 500 pairs nested on the north side of the island between Sandy Pt. and Brockway Point. In June 1977, aerial surveys revealed 352 Brandt's Cormorant nests near Brockway Pt. and a minimum of 250 nests in the Carrington Pt. area, though there may have been as many as 350 nests at the latter site. The total number of Brandt's Cormorants breeding at Santa Rosa Is. was estimated to be 700 pairs in 1977.

These aerial estimates differ markedly with observations made on a 22 June boat trip in 1977: 200 nests were counted at Brockway Pt. and 108 were reported at Carrington Point. These discrepancies illustrate the difficulties of censusing Santa Rosa Is. by boat due to its extremely high cliffs and expansive kelp beds.

Santa Cruz Island

Blake (1887) mentions Brandt's Cormorants breeding on isolated rocks off Santa Cruz Is., and Holder (1910) says he saw many nests of Brandt's Cormorants at Santa Cruz Island. Howell (1917) stated that a small number nested near Scorpion Harbor. Stevens (unpubl. notes) collected four sets of eggs from "Gull Rock" on 9 April 1939. D. W. Anderson (in lit.) saw 25 nests, probably Brandt's Cormorants, during an aerial survey on 27 April 1972.

Present Status - In 1975, at least 23 pairs of Brandt's Cormorants bred at Gull Is.; their status on Santa Cruz Is. proper, however, was not determined. During complete surveys in 1976, 30 Brandt's and 20 unidentified cormorant nests were located along the north side of the island between Fraser Pt. and Profile Pt., and 55 pairs nested at Gull Island. The total breeding population for 1976 was estimated to be 100 pairs. The most complete survey was in 1977; 42 nests were found on Santa Cruz Is. proper, almost all between Fraser Pt. and Profile Pt., and 67 pairs nested on Gull Island. The estimated total breeding population for Brandt's Cormorants at Santa Cruz Is. in 1977 was 115 pairs.

Anacapa Island

Willet (1910) mentioned seeing Pelagic and Double-crested Cormorants, but no Brandt's Cormorants, breeding on the cliffs of Anacapa Is. in June 1910. However, Wright and Snyder (1913) found a few pairs of Brandt's Cormorants nesting on the cliffs in July 1912, and Badger (1917) located a colony in May 1917 and collected an egg set (WFVZ uncat.). Ashworth and Thompson (unpubl. notes) reported finding many nests at the west end of the island on 15 May 1928. A single egg set was collected at that time (WFVZ 73972) and another on 19 April 1931 (WFVZ 27699). Bond (Sumner 1939) observed 50 pairs in April 1934 at the "extreme west end of west island", though he may have confused Double-crested with Brandt's Cormorants (see Double-crested Cormorants, Anacapa Is.). Banks (1966) also reported

cormorant colonies ". . . on the west end of West Island, but which species were involved could not be determined". Crossin and Brownell (1968) were at Anacapa Is. on 12 - 13 May 1968; they saw a few empty nests and estimated the island population to be "ca. 500 birds". (This last figure can be misleading, however. During the current project, we discovered that hundreds of cormorants often roosted and foraged at Anacapa Is., but few actually bred there).

Present Status - A single nest was seen on West Anacapa Island in 1975; none were found in 1976. On 23 June 1977, two nests were found at the east end of Middle Anacapa Island. It is also possible that one or two other nests were overlooked.

Santa Barbara Island

Grinnell (1897) found Brandt's Cormorants "nesting in large rookeries" at Santa Barbara Is. and collected about 30 sets of eggs (incl. MVZ 573) in May 1897. When Howell (1917) visited the island on 1 May 1908, he also found "large rookeries", though he gave no estimates of actual numbers either. Wright and Snyder (1913) found a colony of about 350 Brandt's Cormorants' nests on the north side of the island on 3 July 1912. On a detached rock (Shag?) opposite this colony was another "fair-sized colony". At least four egg sets were taken then (WFVZ uncat.). More than 100 nests were seen (Wyman, unpubl. notes in LACM) and one egg set was taken 30 May 1920 (LACM uncat.). On 27 March 1927, at least four egg sets were taken and 125 nests seen on a rock off the west end of the island (Pemberton 1928, unpubl. notes; WFVZ 2916, 2917, 34459, 34460). During Sumner's (1939) survey in April 1939, he found "A few pairs of these birds were nesting near the northwest corner of the island, while approximately 1,000 apparently were building nests on the two outlying rocks". Crossin and Brownell (1968) reported an estimated 1,000 birds on the northwest end of the island with recently refurbished nests in May 1968. Hunt and Hunt (1974) found one nest in 1972; however, a thorough search was not conducted, and several areas where cormorants breed were not checked. When Anderson (in lit.) conducted an aerial census of the island on 27 April 1972, he reported old, inactive nests from a nearby islet (Sutil?) and 10 active nests on a large southwest cliff of the main island. Jehl (1974) circumnavigated Santa Barbara Is. and its offshore rocks by boat on 11 July 1974 and found 46 nests on the main island and an additional 40 nests on Sutil Island. He estimated the maximum breeding population at 80 pairs.

Present Status - The numbers of Brandt's Cormorants breeding at Santa Barbara Is. during 1975-77 are given below:

	Santa Barbara Is.	Sutil Is.	Total
1975	27	93	120
1976	73	70	143
1977	51	76	127

Colonies on Santa Barbara Is. proper were present at the northeast tip (Lighthouse colony); Elephant Seal Pt.; an isolated location along the west cliffs; and possibly a few nests at Webster Point.

San Nicolas Island

Gaylord (Grinnell 1897) found a small colony of Brandt's Cormorants nesting on the north side of San Nicolas Is. in 1897. Incomplete nests were found by C. B. Linton on 3 April 1910 (Willet 1912). In Rett's (1947) confusing account of the breeding status of Brown Pelicans, Brandt's Cormorants and Double-crested Cormorants on San Nicolas Is. in 1945, he mentioned finding an area where all three species had nested together. (Presumably this conclusion was based on observations of immatures of all three species together in an area with some old nests at the west end of the island in September.) Townsend (1968) found five Brandt's Cormorant rookeries in 1963 but gave no other information. Schreiber (pers. comm.) counted at least 600 nests, none with eggs or chicks, on 17 June 1968 at the northwest end of the island.

During an aerial survey of San Nicolas Is. on 14 June 1972, Anderson (in lit.) reported a large cormorant rookery "1/2 mi. SE of NW pt. on SW side"; he estimated 600 nests were present. He also indicated that in 1973 there were 485 Brandt's Cormorant nests on the island in three separate colonies; an additional three inactive colonies were also found. On 22 May 1974, G. Hunt flew over San Nicolas Is. with Howard Leach of the California Department of Fish and Game and photographed three colonies containing 615 nests. The major colony (415 nests) was the northwestern colony referred to above. The second largest colony (175 nests) was near the major colony, and the smallest colony (25 nests) was on a ledge in a small cave on the southeast corner of the island. Lust (pers. comm.) kept notes on a small nesting colony at the west end of San Nicolas Is. from about 1970 until 1974. This colony was largely unsuccessful in these years because of frequent disturbance by personnel stationed on the island and due to collapse of thin-shelled eggs.

Present Status - On 20 April 1975, 52 active Brandt's Cormorant nests were counted at a colony along the north end of the west side of the island (Colony A). By 11 June, however, all but 18 of these nests had been abandoned and 115 fresh, but unfinished nests were counted in another area about 150 m away. On 19 June, two additional active nests were found 1.5 km away, and the 115 partial nests had been abandoned. Thus, a total of 20 active nests were located in 1975. In May and June, an additional colony (B) was located and photographed by plane 1 km east-southeast of the westernmost point of the island; it contained approximately 230 - 265 active nests. The fate of this colony was not determined.

In 1976, the two cormorant colonies at San Nicolas Is. were located in approximately the same areas as in 1975. "A" colony was

about 300 m southeast of its location in 1975, and it contained approximately 120 active nests. "B" colony never had more than 50 nests, and it eventually failed entirely.

In 1977, 145 active nests were counted in "A" colony in mid-April during aerial surveys. By 14 May, no active nests could be seen although fresh nest material was evident. "B" colony had no active nests (i.e. with eggs) on 13 May, and it is doubtful if any chicks were raised in this area in 1977.

In summary, approximately 150 - 250 pairs of Brandt's Cormorants regularly attempted to breed on San Nicolas Island. However, our observations strongly suggest this population was adversely affected by personnel permanently stationed on the island. A road that runs the perimeter of the island passes within a few yards of both colony areas and undoubtedly accounted for the erratic behavior and limited nesting success of cormorants on the island.

San Clemente Island

Grinnell (1897) apparently did not find Brandt's Cormorants nesting at San Clemente Island. Breninger (1904) mentioned they were present and breeding in 1903 but did not give any indication of how many. Linton (Howell 1917) reported small numbers breeding on the northwest coast of the island in 1907. Leatherwood and Coulombe (unpubl. notes) observed nests with young at Seal Cove on 9 April 1972, and L. Jones noted about 150 birds, some of which appeared to be breeding, near the mouth of Red Rock Canyon on 9 June 1973. Jehl (1973) reported "evidence of 15 nests in Northwest Harbor; one (perhaps six) nests at Castle Rk.; 6 nests at Seal Cove; 10 nests at an unnamed point between Post Pt. and Cove Pt.; and 10 nests one mile south of Northwest Harbor". He estimated no more than 50 pairs nested on the island each year.

Present Status - On 18 July 1975, 12 Brandt's Cormorant nests that had apparently been used earlier in the year were found at Seal Cove; one additional nest was found at Castle Rock. In 1976, fourteen nests were found: Two in Pyramid Cove, three on Seal Cove Rk., four between Mail Pt. and Lost Pt., and five between Wilson Cove and Northwest Harbor. According to Public Works personnel on the island, an additional small colony of about 10 pairs attempted to nest on a small promontory at the south end of Seal Cove but failed completely. The estimated breeding population in 1976 was about 15 pairs. This location was not visited in 1977.

Santa Catalina Island

Howell (1917) stated Brandt's Cormorants bred "in limited numbers on several large detached rocks near Catalina". Willet (1912) took four sets of fresh eggs (incl. WFVZ uncat.) on 11 April 1904; these were from a small island 600 ft. from shore (Bird Rk.?)

where he found five nests together. Jehl (1974) found no evidence of nesting during a complete circuit of the island on 9 July 1974.

Present Status - No Brandt's Cormorants nested at Santa Catalina Is. in 1975 or 1976, and none were detected during partial surveys in 1977.

That Brandt's Cormorants have declined considerably in the Channel Islands since former times seems evident; particularly at Santa Barbara Is. and San Nicolas Is. they have been reduced to 10-50% of their previously known numbers.. (Other colonies were not documented as well historically.) Two other species of Pelicaniformes have also exhibited major population declines off Southern California and Baja California. Their declines were due to breeding failures correlated with pollutants in the marine environment in the sixties and early seventies, and it is very likely that Brandt's Cormorants were affected by the same pollutants. R. Lust's (in lit.) pictures of crushed, thin-shelled eggs in Brandt's Cormorant nests at San Nicolas Is. appear to be the only evidence that this species was affected by DDE-related eggshell thinning, which afflicted Brown Pelicans and Double-crested Cormorants in the Channel Islands so adversely.

Recently, improved reproduction has been noted for Double-crested Cormorants (Anderson, in lit.), and Brandt's Cormorants appeared to be reproducing normally in the Channel Islands during 1975 - 1977. One exception to this was the San Nicolas Is. colony, where human disturbance probably continually hampered breeding attempts.

c. Breeding Biology

Cormorants are notoriously skittish on the breeding colony. Adults are quick to expose eggs or young chicks at the sight of a human being or other disturbance, and Western Gulls are quick to make a meal of the situation. As an example of this behavior, the following observations were reported by Crossin and Brownell (1968) during a survey that Smithsonian Pacific Ocean Biological Survey Program (POBSP) personnel made of Prince Is. on 15 May 1968:

> "Brandt's Cormorants' nesting is still in the egg stage and will likely remain at this stage indefinitely at the rate the eggs are eaten up by Western Gulls. During diurnal survey work on both islets, intensive parasitism was noted. At first sight of the observers, practically every cormorant leaves the colony and lands in the water offshore. Western Gulls then arrive on the scene almost instantaneously from all directions and 'scarf up' the eggs. Many birds were noted swallowing the eggs whole, but the usual method is to slash

> at the egg with the lower mandible and thereby break it open and thus ready to eat. On Castle Rock one newly hatched cormorant was noted, but it also was quickly eaten up by a gull. No cormorant nest was noted with more than two eggs although the species is supposed to lay from four to six eggs. Not only do the cormorants suffer egg and chick loss from the gulls, but when a segment of the colony leaves the area, members of their own species from other segments of the colony rush in and steal nest material from finished nests."

L. N. Huber (1968), also working on the POBSP project, visited Prince Is. two weeks after the above survey. Regarding Brandt's Cormorants he reports, "One nest with a medium downy chick and two with one egg found. No other active nests could be found from at least 1,500 inactive nests on the N and NE slopes (the only place colonies were found)".

From these accounts, it can be seen that repeated disturbance of a cormorant colony (or, as in the above case, one well-timed disturbance) can have disastrous affects. For this reason, cormorant colonies were given a wide berth throughout this project, and minimum disturbance occurred. As a result, the information presented below tends to be general in nature.

Habitat

Brandt's Cormorants invariably nested on the north side of the larger islands and in other locations with exposure to the northwesterly winds which normally prevail during the breeding season (e.g. Pt. Bennett, Gull Is.). Nesting typically occurred in two kinds of habitat. At Prince Is. in 1976, San Nicolas Is. and Castle Rk., colonies were on broad sloping areas or occasionally on flat surfaces. At Prince Is. in 1977, Santa Rosa Is., Gull Is. and Sutil Is., however, nests were crowded on broad ledges on sheer (or near sheer) cliff faces. (A comparison of Brandt's Cormorant and Double-crested Cormorant nesting habits is given in the habitat section for Double-crested Cormorants.)

Nests of Brandt's Cormorants were usually constructed of seaweed, which was brought to the nest site and matted with guano to form a shallow dish. In 1977, late nesting cormorants near the top of Prince Is. made considerable use of the nearby terrestrial vegetation; these nests contained seaweed, large amounts of Mesembryanthemum sp. and several other plant species that were growing within a few meters of these nest sites. These observations suggest that Brandt's Cormorants were somewhat opportunistic with regard to nest material selection.

Brandt's Cormorant: Breeding Biology (continued)

Phenology

Systematic nest observations on Santa Barbara Is. in 1976 and 1977, using telescopes, yielded the best information on timing of breeding for Brandt's Cormorant (Fig. III-22 and III-23).

In 1976, eggs were present from 25 February through 10 June. (A single adult was seen incubating on 25 June and 11 July, but this bird may have been sitting on infertile eggs.) Though the egg-laying period was protracted, 8 (44%) of the 18 clutches were started the first week in April. The first chick hatched during the last week of March, but this was unusually early for the colony as a whole. Most eggs hatched in May and June. By mid-July, when all observations stopped, chicks from all but four nests had fledged.

In 1977, Brandt's Cormorants nested a week to ten days later than in 1976. Clutches were initiated from approximately 8 March until 27 June, with a peak period during the first two weeks in April. Hatching commenced around 8 April and extended into the first week of July. Peak hatching occurred during the first two weeks of May. On a one-day survey on 14 August, several nests with near-fledging size chicks were found.

Two colonies were studied on San Nicolas Is. in 1976. Neither showed any evidence of breeding when checked on 13 April. By 11 May, a minimum of 69 nests were observed in the larger colony (A). Courtship displays and incubating behavior were seen, but nest contents could not be checked. The colony was next checked on 16 June, when young were present in all stages of growth. By 4 July, young were fully grown and nearly ready to fly. At this time, they had left their nests, and were bunched together in creches in different parts of the colony.

In the smaller San Nicolas colony (B), eggs were first seen on 11 May in six nests; three other nests were active and 16 were empty. When checked on 20 and 22 May, all nests had been abandoned. On 8 June, there were 50 new nests at this colony, and three had eggs (one egg each). These nests were abandoned and empty the following day (possibly due to researcher disturbance), and no further breeding attempts were observed.

In 1977, nesting at San Nicolas Is. could not be followed closely but appeared to have been disturbed early in the season. Counts from aerial photographs of "A" colony on 17 April 1977 indicated approximately 145 incubating birds were present. An on-foot survey of this colony on 14 May found no actively nesting cormorants present, though much fairly fresh nesting material was strewn about. An aerial survey of this colony on 3 July found 129 cormorants on nests in what appeared to have been a renesting attempt. Another aerial survey on 28 July counted 161 active nests, suggesting that this renesting attempt may have been successful. No information was

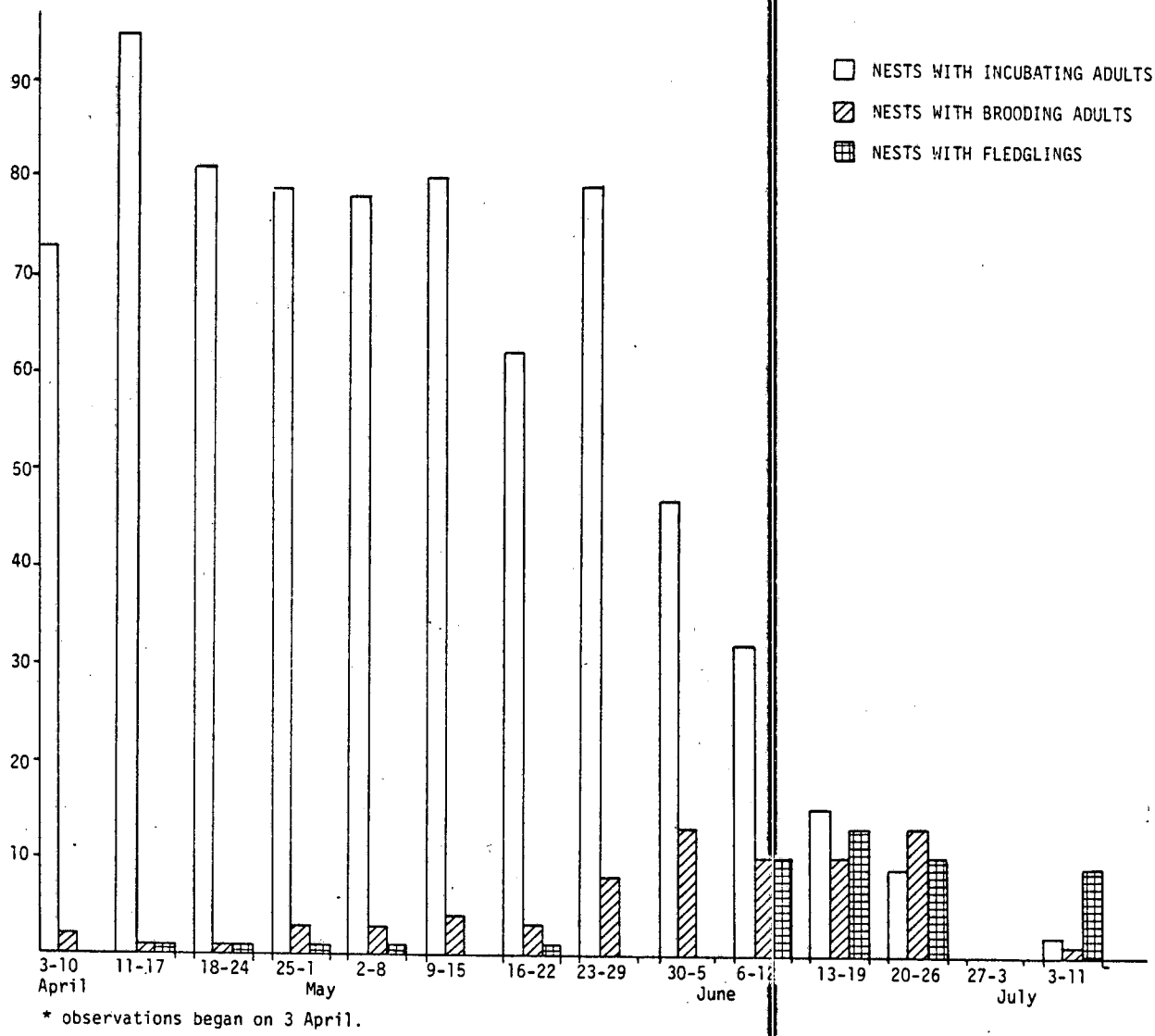


Fig. III-22. Timing of Breeding Events for Brandt's Cormorants, Santa Barbara Is., 1976.

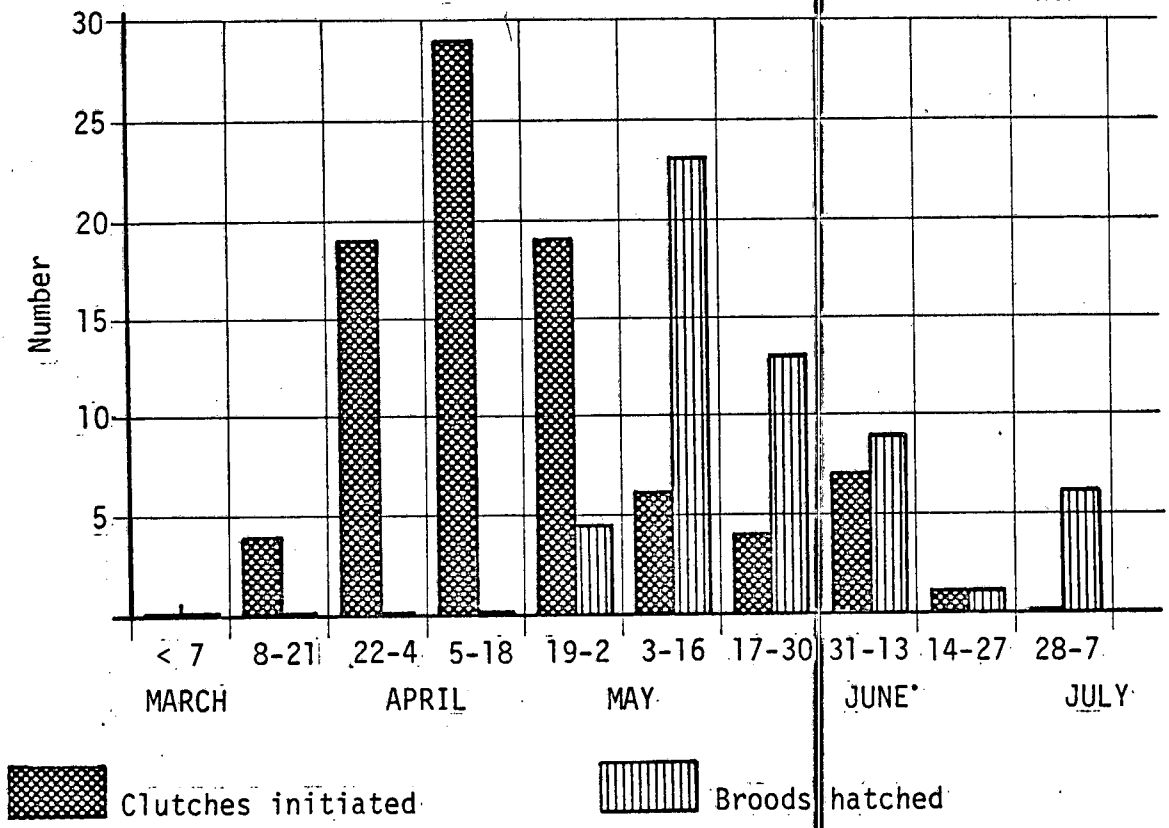


Figure III-23. Timing of breeding events for Brandt's Cormorant, Santa Barbara Is., 1977.

available for "B" colony.

In the San Miguel Is. area, egg laying was just underway at Prince Is. on 29 April 1976, and nests were still being built. Only incubating birds were observed on 20 May, but by 8 June several chicks were seen. Hatching had just begun on Castle Rk. on 8 June, as well. By 23 June, chicks were numerous on Prince Is., and were very large. A night survey on 13 July found many adult-size chicks standing in creches. The majority of these were still downy with flight feathers in all stages of development. By 28 August, essentially all chicks had fledged; a thorough search of the colony on this date revealed only a single large, though still downy chick.

In 1977, seven newly-refurbished nests were found at Prince Is. on 20 March. These nests were not found on subsequent trips, however, and presumably never received eggs. On 13 April, 72 nests were found in what was to become part of the main colony later in the season. These nests all contained fresh nesting material and sitting birds, but no eggs had been laid as yet. By 2 May, 361 nests were counted and several nests contained eggs. Nests continued to be built and eggs laid until at least 16 June, when numerous nests contained large young. On 24 July, a sampling of 35 nests all contained chicks. The timing of the 1977 nesting events agreed fairly well with that observed in the former year.

On Castle Rk., three subcolonies were sampled on 4 June 1977:

	Colony A	Colony B	Colony C
Nests with eggs	8	8	3
Nests with chicks	0	4	5

The sample size was limited by time and the number of birds willing to expose their nest contents. Interestingly, the Castle Rk. cormorants showed the same asynchronous breeding that was seen at Prince Is., Gull Is., and Santa Barbara Is., but their asynchrony was caused by separate subcolonies nesting at different times rather than by individuals within subcolonies nesting at different times.

At Gull Is. in 1976, Brandt's Cormorants were incubating eggs on 9 April and 22 May. Large chicks were present on 22 June, and by 13 July all the chicks observed were at least three-fourths adult size; some were fully fledged. In 1977, single eggs had been laid in only three nests on 12 April, indicating nesting had only recently begun. On 2 May and 20 May, many nests contained eggs. By 4 June, some new clutches had been laid, and several nests had chicks. No eggs were seen in the colony on 23 July, when many chicks were of fledging age. As many nests had eggs (some complete clutches) by 9 April in 1976, it is likely that the Gull Is. Brandt's Cormorant colony was also a week or two later in 1977 than in 1976.

The north side of Santa Rosa Is. was surveyed by boat on 30 April 1976, but no nests were recorded. Birds were first seen incubating there on 20 and 22 May. Since surveys of this island were made by boat, chicks could not be seen until they were quite large. The first chicks were observed on 25 June. At Anacapa Is., two nests had one chick each visible from the boat, on 23 June 1976. Data are not available for either island in 1977.

The timing of the Brandt's Cormorant breeding cycle in the Channel Islands appears rather flexible. Birds nested asynchronously, and each stage was quite protracted (Fig. III-24). In addition, the data from San Nicolas Is. suggest that renesting can be attempted with potential success quite late in the season.

The timing of various breeding events differed by as much as two weeks between 1976 and 1977, on any single island, and even greater variation was evident between islands within each year. Santa Barbara Is. cormorants consistently bred earlier than other colonies. Along the northern chain, cormorants bred later from east to west. The difference between the Santa Barbara Is. and Prince Is. colonies was probably as large as four to six weeks.

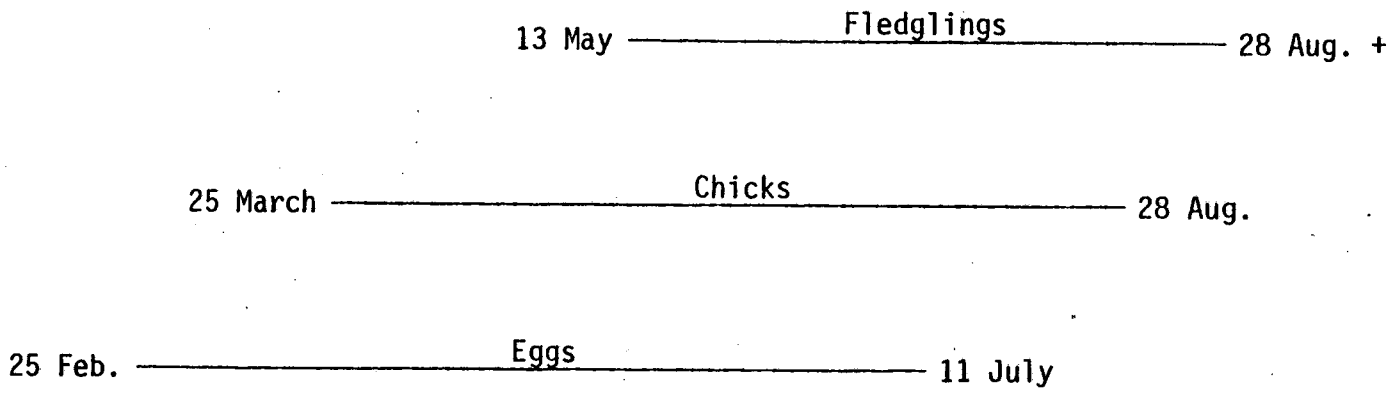
Reproductive Success

Of 143 nests that were active on Santa Barbara Is. during the 1976 season, 102 (71%) eventually received eggs. This was determined by counting incubating birds. Only 28 nests were situated so that nest contents could actually be seen; fifteen (54%) of these 28 nests eventually received eggs. In 13 nests, the exact number of eggs laid was known. (One other nest already had 3 chicks when the study began.) The average clutch size in these 13 nests was 2.4 eggs (SD = 0.9, range 1-4). During the 1976 season, four of these clutches were lost (1, 2, 2, 3 eggs), and eventually 4 new clutches were laid in the same nests (3, 2, 3, 4 eggs, respectively). Replacement clutches were laid 13 - 28 days after the first clutch was lost.

Of 32 eggs laid in 13 clutches, only 9 eggs (28%) hatched. Generally, the entire clutch was lost; single eggs rarely disappeared. Survival of chicks was hard to determine since small chicks could not be seen in distant nests. Of 9 chicks followed from hatching to fledging, 9 (100%) fledged. (In one nest, though, 3 eggs were seen but only 2 large young were recorded. It is not known whether an egg or very small chick was lost.) Overall, reproductive success for Brandt's Cormorants in these nests on Santa Barbara Is. in 1976 was 0.6 fledglings per breeding attempt (n = 14).

In 1977, the average clutch size in six nests was 2.3 eggs (range 1-3). Only six chicks (43%) hatched from 14 eggs laid in these nests (1.0 chicks per nest). In 28 additional nests where chicks could be seen, the average brood was 2.3 young. Overall, at least 71 young fledged from 63 nests that were regularly attended.

Fig. III-24. Timing of Breeding of Brandt's Cormorants in the Channel Islands, 1976-1977.



Therefore, at least 1.1 young fledged per breeding attempt on Santa Barbara Is. in 1977.

On San Nicolas Is., colonies were checked infrequently to minimize disturbance. Since the two colonies had markedly different reproductive success, they were treated separately. The small colony never had more than 9 nests with eggs; these were empty on subsequent visits and may have been lost due to researcher disturbance. In the larger colony, egg counts could not be made without disrupting the colony. Approximately 115 nests were active in the 1976 season; only 75 nests were ever seen with chicks (range: 1-6 young/nest). In a sample of 49 nests, the average brood was 2.4 chicks. During the final visit to this colony on 4 July, 135 fledglings were counted. This indicates a chick survival rate of 77% and a fledging rate of 1.2 fledglings per breeding attempt. However, these figures were probably low, since young which had fledged earlier may no longer have been associated with the colony at the time of this visit.

On Gull Is. and Santa Cruz Is., a minimum of 38 young were counted on 13 July 1976. These were all large and presumably fledged. Using the number of active nests at Gull Is. in 1976 (55), minimum productivity was 0.7 fledglings per breeding attempt on this island. On 23 July 1977, there were a minimum of 38 young Brandt's Cormorants at Gull Is.; almost all were near fledging size and an unknown number had undoubtedly already fledged. Assuming these all fledged, a minimum of 0.6 young were produced per breeding attempt that year.

Brandt's Cormorants at Castle Rk. on 4 June 1977 had an average clutch size of 2.5 eggs per nest (range 1-4, n = 17), and nests with young had an average of 1.6 chicks per nest (range 1-2, n = 7). Because the Prince Is. colony nested almost entirely along the sheer NW face of the island, regular monitoring was impossible in 1977. However, a nest check on 24 July of 35 nests with chicks found an average brood size of 2.1 chicks.

Due to the variety of methods used in collecting these data, comparisons were not possible.

d. Foods

Little information is available on the food habits of Brandt's Cormorant in California. Wright (1913), Bent (1922) and Schorger (in Palmer 1962) have summarized general observations on food items taken by this species, but only Hubbs, Kelly and Limbaugh (1970), Scott (1973) and Baltz and Morejohn (1977) have presented detailed information on the subject.

Hubbs et al. (1970) characterized Brandt's Cormorant as feeding "on diverse assemblages of fish species in a wide variety of

habitats. They feed in dense kelp beds and in open water; in midwater; on the bottom, sometimes rather deep; and near the surface. Both large and small fish are consumed, most of which are of limited commercial significance". Hubbs et al. (1970) based these conclusions on data obtained in part from 14 specimens collected in various habitats. Eight birds collected in kelp beds contained fish that characteristically live in midwater, often almost exclusively among the fronds of Macrocystis pyrifera; Chromis punctipinnis (15% of total individuals) and Oxyjulis californica (64%) composed the bulk of that sample. Two birds collected in sandy bottom habitat off the beach contained mainly Citharichthys stigmaeus (88%). Four birds collected in waters near Islas Coronados contained species typical of kelp beds and one species, Trachurus symmetricus, typical of open water.

Hubbs et al. (1970) also incorporated Martini's (1966) data in their analysis of cormorant food habits; they stated that Martini (1966) "greatly increased the list of fishes that can be regarded with very high probability as items in the diet of Brandt's Cormorant". These fishes were identified from otoliths in the regurgitated pellets ("Gewöller") of Western Gulls, Larus occidentalis. The pellets were collected on the rocky shore in the immediate vicinity of the La Jolla Caves cliffs in Southern California, where Brandt's Cormorants roost and often associate with the Western Gulls. As Martini (1966) suggested,"it may be assumed that the vast majority of the fish species listed had been caught by Brandt's Cormorants. Only a few of the species could conceivably have been captured by the Western Gull, for they live at depths below those available to a feeding gull. The gulls may have robbed the cormorants either on the joint feeding grounds or may have picked up the fish, or even isolated otoliths on the ledges." During the present study, researchers often observed Western Gulls searching cormorant roosts for regurgitated pellets, which they readily consumed. Of the species of fish identified by Martini (1966), the following species were prominently represented: Merluccius productus (16 individuals), Citharichthys sp. (24), Embiotoca sp. (93), Phanerodon furcatus (144), Damalichthys vacca (13), Porichthys notatus (50), Otophidium scrippsi (22) and Chilara taylori (12). The number of regurgitated pellets analyzed was not noted. According to Hubbs et al. (1970), the preceding data demonstrate with certainty, or high probability, that Brandt's Cormorant feed on 35 species of fish that he classed in 31 genera and 18 families in the San Diego area. "These represent a wide variety of the benthic and nektonic fishes that inhabit the littoral waters of the region, on and over the shallower parts of the continental shelf." This information contains some elements of doubt, however, as the actual origin of the otoliths in the gull pellets was unknown. The possibility exists that gulls scavenged some of the fish from fishing boats, pelicans, sea lions or other sources.

Wiens and Scott (1975) presented data on Brandt's Cormorant food habits in Oregon. The dietary composition of an undisclosed number of specimens was reported to be Engraulidae (15% of stomach

volume), Osmeridae (59%), Scorpaenidae (24%), Cottidae (24%) and other fish (32%) (summer and winter percentages averaged). Anchovies were consumed in greater quantities (30% of stomach volume) during the summer months.

Baltz and Morejohn (1977) analyzed the stomach contents of six Brandt's Cormorants taken in the offshore zone ("those waters over the continental shelf out of sight of land") of Monterey Bay. Seven species of fish were reported including Sebastes sp. (25.0% of total individuals), Engraulis mordax (23.4%), and Citharichthys sordidus (12.5%). Two species which had not previously been reported were found: Symphurus atricauda and Medialuna californiensis. Most interesting was the occurrence of the cephalopod, Loligo opalescens, in significant quantities (14% of total individuals). With the exception of a few crustaceans reported by Schorger (in Palmer 1962), invertebrates had not been thought to contribute to the diet of Brandt's Cormorant. However, the small sample size involved (6) may not have been representative of the food habits of this species in central California.

The data for the present study were derived from 5 regurgitated samples collected from chicks on Prince and San Nicolas Islands in 1975 (Fig. III- 25), and 360 cormorant pellets collected at four major roosts in the Channel Islands in 1976 and 1977 (Fig. III-26). The pellets contained otoliths from at least 20,033 individual fish. At least 34 species, 31 genera and 22 families were represented. Considerable variation in the species composition of the fish consumed at each roost was apparent: San Nicolas Is. cormorants fed mainly on Sebastes sp. and Cottidae; birds at San Clemente Is. fed almost exclusively on Chromis punctipinnis; samples from Gull Is. (Santa Cruz Is.) and from Santa Rosa Is. contained mainly Sebastes sp. and Citharichthys sp. These findings are consistent with those reported previously for this species.

e. Foraging Areas

Foraging Brandt's Cormorants were commonly found in or near kelp beds in the vicinity of their breeding colonies. They were almost never encountered more than a few miles from land.

Fig. III-25. Food Habits of Brandt's Cormorants, Channel Islands, 1975.

P.O. = Percent Occurrence
P.W. = Percent Weight

Composition of Regurgitation Samples From Chicks

Species	Prince Island (n=3) P.O.	Prince Island (n=3) P.W.	San Nicolas Island (n=2) P.O.	San Nicolas Island (n=2) P.W.
Scorpaenidae spp.	100.0	-	50.0	25.0
Unknown Fish	66.7	-	100.0	75.0

Fig. III-26. Food Habits of Brandt's Cormorants, Channel Islands, 1976-1977

Composition of Pellet Samples

No. = Number of Prey Items

Percent = Percent of Total Prey Items

	Santa Rosa Is. (50 pellets)		Santa Cruz Is. (107 pellets)		San Nicolas Is. (135 pellets)		San Clemente Is. (75 pellets)	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Atherinidae								
Atherinops sp.					1	0.1	15	3.4
Bathymasteridae								
Rathbunella sp.					2	0.1		
Batrachoididae								
Porichthys notatus	12	0.1	38	0.4				
Bothidae								
Citharichthys sp.	564	6.8	752	7.9	90	5.3		
Brotulidae								
Brosmophycis marginata	1	< 0.1						
Carangidae								
Trachurus symmetricus			2	< 0.1	42	2.5	1	0.2
Clinidae								
Gibbonsia sp.					1	0.1		
Cottidae								
Icelinus tenuis	3	< 0.1						
cottid sp.	13	0.2	7	0.1	161	9.4	1	0.2
Embiotocidae								
Brachyistius frenatus	8	0.1	14	0.3	40	3.5		
Cymatogaster aggregata	32	0.4	93	2.1				
Cymatogaster cf. *gracilis*					51	4.4	1	0.2
Damalichthys vacca			2	< 0.1	44	3.8		
Embiotoca jacksoni					9	0.8	1	0.2
Embiotoca lateralis			6	0.1	4	0.4		

Fig. III- 26. continued	Santa Rosa Is.		Santa Cruz Is.		San Nicolas Is.		San Clemente Is.	
Hyperprosopon argonteum			27	0.6	23	2.0	1	0.2
Hypsurus caryi			3	< 0.1	6	0.5		
Phanerodon atripes	3	< 0.1	10	0.2	1	0.1		
Phanerodon furcatus	5	< 0.1	4	0.1	4	0.4		
Rhacochilis toxotes					1	0.1		
Engraulidae								
Engraulis mordax			151	1.6	2	0.1	15	3.4
Girellidae								
Girella nigricans							1	0.2
Gobiidae								
Coryphopterus nicholsii	22	0.3	7	0.1	6	0.4		
Hexagrammidae								
Oxylebius pictus	3	< 0.1	2	< 0.1	9	0.5		
Hexagrammus sp.	1	< 0.1						
Kyphosidae								
Medialuna californiensis	1	< 0.1	2	< 0.1				
Labridae								
Oxyjulis californica	71	0.8	45	0.5	69	4.0	3	0.7
Pimelometopon pulchrum			1	< 0.1				
Ophiidae								
~~*Chilara taylori*~~	~~3~~	~~< 0.1~~	~~5~~	~~0.1~~				
Pleuronectidae								
Pleuronichthys sp.					1	0.1		
Pomacentridae								
Chromis punctipinnis			30	0.3	77	4.5	386	88.5
Sciaenidae								
Genyonemus lineatus			1	< 0.1				
Scorpaenidae								
Sebastes sp.	7587	90.9	8160	85.4	967	56.8	11	2.5

Fig. III- 26.continued	Santa Rosa Is.	Santa Cruz Is.	San Nicolas Is.		San Clemente Is.
Stichaeidae					
Plagiogrammus hopkinsi			4	0.2	
Zaniolepidae					
Zaniolepis frenata			1	0.1	
TOTAL ITEMS	8343	9551	1703		436

Pelagic Cormorant (Phalacrocorax pelagicus)

a. Introduction

Pelagic Cormorant is the smallest of the cormorants that occur in the North Pacific. They nest from Japan through Alaska and south to Northern Baja California (Palmer 1962). In the eastern Pacific, the Channel Islands are currently the southernmost breeding limit for this species. They may nest on Islas Los Coronados and islands further south but probably not regularly (J. Jehl, pers. comm.).

Of the two named subspecies, only the smaller, resplendens, occurs in the Channel Islands. Now, as at the turn of the century (Howell 1917), Pelagic Cormorants are the least numerous of the three species of cormorants that breed in the Bight.

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

Pelagic Cormorants were noticed by most early investigators at San Miguel Is., but unfortunately the number of birds present was rarely recorded. Streator (1888) reported Pelagic Cormorants at "Gull Is." (this is undoubtedly Prince Is.) during late July 1886. When Appleton visited Prince Is. on 6 June 1906, he found 12 nests and collected three egg sets (WFVZ 63452; unpubl. notes). Willet (1910) found them "breeding commonly on the cliffs everywhere" on San Miguel Is. in June 1910. His party collected one set of eggs each on 11 and 14 June (WFVZ uncat.). Wright and Snyder (1913) visited Prince Is. on 12 July 1912 and did not notice this species. Pemberton (1928:147) saw Pelagic Cormorants nesting at San Miguel Is. in 1927, and on 3 June 1928 he saw several pairs there and took one egg set (WFVZ 65939). In mid-April 1939, Sumner (1939) and Bond observed about 50 individuals on Prince Island. Craig and Sheppard (unpubl. notes) estimated 250 pairs on Prince Is. during a survey on 3 - 5 July 1965. Crossin and Brownell (1968) visited the San Miguel area on 14 - 15 May 1968 and reported "low numbers on Castle Rk. (150 - 200 birds)", while "on the main island of San Miguel adjacent to Prince Islet, about 100 birds were noted in scattered small colonies nesting about shoreline caves". This area was surveyed again by POBSP personnel two weeks later (28 May - 7 June 1968), when Huber (1968) and his party estimated 25 active Pelagic Cormorant nests at Castle Rk., a maximum of five on Prince Is., and 95 on San Miguel Is. proper. This last figure included 55 nests south of Prince Is. (Bay Pt. area) and 40 nests north of Cuyler Harbor (Bat and Nifty Rk. area).

Present Status - The total number of nests found in the San Miguel Is. area in 1975 - 1977 are presented in Fig. III-27. In 1975, less time was spent looking for this species than in 1976 and 1977, so the 1975 nest counts are not comparable to those obtained in the following two years. In 1976 and 1977, the number of Pelagic

Fig.III-27. Pelagic Cormorants Nesting at San Miguel Island, 1975-1977.

	1975	1976	1977
San Miguel Island	31	76	100
Castle Rk.	15	34	25
Prince Island	1	10	20
Total	47	120	145

Cormorant nests in the San Miguel Is. area remained relatively constant. On Prince Is., all nests were found along the precipitous northwest side of the islet. These nests were scattered among the more numerous, but thinly distributed, Brandt's Cormorant nests in this area. This intermingling of nests may account for Craig and Sheppard's (1965) seemingly high estimate of 250 pairs in 1968 (cf Huber's (1968) estimate of 5 pairs for this islet 3 years later).

On Castle Rk., nesting was restricted to the sheer south-facing cliffs. On San Miguel Is., all nesting occurred in three areas: Between Harris Pt. and the north end of Cuyler Harbor (62 nests in 1977), between the east end of Cuyler Harbor and Cardwell Pt. (26 nests in 1977), and in Bouy Cove in the Pt. Bennett area (12 nests in 1977). The estimate for the entire San Miguel Is. area Pelagic Cormorant breeding population was 160 pairs.

Santa Rosa Island

Pemberton (1928) saw "many" Pelagic and Brandt's Cormorants at Santa Rosa Is. in 1927 and stated both species "no doubt were nesting here". Jones (unpubl. notes) observed two active Pelagic Cormorant nests at the mouth of Canada Lobos on 27 April 1974.

Present Status - At Santa Rosa Is., Pelagic Cormorants nest only along the north side. In 1976, 19 nests were found in a small cove at Sandy Pt. at the western tip of the island, and a minimum of five other nests were located between Brockway Pt. and Carrington Point. In 1977, more complete searches revealed 15 nests at the Sandy Pt. colony and a minimum of 21 nests along the sheer cliffs between Brockway Pt. and Carrington Point. In addition, 29 other cormorant nests were recorded between Sandy Pt. and Brockway Pt., but species identification was uncertain. The whole north side of Santa Rosa Is. was difficult to approach by boat and numerous Brandt's Cormorants utilized the cliffs there. As a result, breeding Pelagic Cormorants may have been overlooked. The estimated breeding population of Pelagic Cormorants at Santa Rosa Is. was 60 ± 20 pairs.

Santa Cruz Island

Blake (1887) reported that the Pelagic Cormorant "probably breeds" on Santa Cruz Is.; it was less common than the abundant Brandt's Cormorant there. Rollo Beck (1899) mentioned Pelagic Cormorants breeding on Scorpion Rk. in 1895, and Dawson (1923) described an established colony of this species at the mouth of Painted Cave. These are the only records of Pelagic Cormorants on Santa Cruz Island.

Present Status - No nests were found during an incomplete survey of the main island in 1975; four nests were observed at Gull Island. In 1976, approximately 25 pairs nested at Fraser Pt. (this area may have been overlooked in 1975); none nested at Gull Island.

Only four cormorants were counted at Fraser Pt. in 1977 (presumably this species), and none nested at Gull Island. The Pelagic Cormorant population at Santa Cruz Is. was relatively small and apparently fluctuated considerably in size from year to year.

Anacapa Island

Willet (1912) found Pelagic Cormorants nesting "commonly" on Anacapa Is. in June 1910, and Wright and Snyder (1913) saw several small colonies there on 6 July 1912. Recently, neither Banks (1966) nor Crossin and Brownell (1968) noticed this species breeding there. However, a few pairs have been suspected of nesting on Anacapa Is. in recent years.

Present Status - A single nest thought to be this species was present on West Anacapa Is. in 1975. Pelagic Cormorants were not seen nesting in 1976, but in 1977 two pairs bred at the east end of north Middle Anacapa Island.

Santa Barbara Island

Grinnell (1887) reported that Pelagic Cormorants nested at Santa Barbara Is. in smaller numbers than either Brandt's or Double-crested Cormorants and commented, "Seldom more than two or three nests were seen in any one place". In a later account of the same trip, he described them as "breeding numerously on Santa Barbara Island in May" (Grinnell 1898). On 27 March 1927, Pemberton (1928:147) found them breeding during his one-day stay at the island. Sumner (1939) stated that the species was "present, but in considerably smaller numbers than the preceeding two species" during April 1939. Crossin and Brownell (1968) do not mention them in their report of their May 1968 visit, and in 1972 no nests or individuals were seen (Hunt and Hunt 1974). Jehl (1974) saw no evidence of nesting in July 1974 but felt a few birds could have nested earlier in the year.

Present Status - A single pair nested on the main island in 1975, and none nested there in 1976. In 1977, four pairs attempted to nest: Two on Sutil Is. and two on the mainland in the Webster Pt. area.

San Nicolas Island

Townsend (1868) described this species as a resident on San Nicolas Is.; he observed individuals in breeding plumage in May 1862 and April - May 1863, though none were seen nesting. Pelagic Cormorants have never been known to breed on this island, and none were found during the course of this study.

San Clemente Island

Breninger (1904) states in passing that Pelagic Cormorants

nested on San Clemente Is.; his is the only account of this species having bred there. Linton (1908) saw a few pairs in breeding plumage in March 1907 and secured a specimen there that October. None were found breeding during the course of this study.

Santa Catalina Island

There is no evidence to suggest that Pelagic Cormorants ever bred on Santa Catalina Is., and none were found breeding during 1975 - 1977.

Cormorants as a rule received little attention in early accounts. Like Western Gulls, they were ubiquitous along coastal areas and did not capture the attention of ornithologists and egg collectors as did the more obscure, pelagic species (i.e. storm-petrels and alcids). Pelagic Cormorants, in particular, do not occur in large, impressive colonies, as the other species of cormorants do, lending them even less to comment. However, there seems to have been little change in total numbers and even less change in the breeding distribution of this species in the Channel Islands over the last century. What little discrepancy has been noted can probably be explained by year-to-year fluctuations in individual colony sizes. Like the other predominantly northern species that bred in the Bight, Pelagic Cormorants concentrated in the San Miguel Is. area and radiated south and east to the other islands. Populations at these "fringe" locations tended to be much smaller and more variable on a year-to-year basis.

c. Breeding Biology

Habitat

Pelagic Cormorants nested on high vertical cliff-faces abutting the open ocean. All nesting colonies were on the north sides of the islands (Prince Is. and Castle Rk. are on the north side of San Miguel Is). Scott (1973) found that Pelagic Cormorants in Oregon also utilized only north-facing cliffs, though suitable habitat seemed available on southern cliff faces. This species nested singly or in loose colonies, with nests built in small crevices or on small ledges. The low densities observed at their breeding colonies was probably directly attributable to the kind of nesting habitat this species prefers. Where Pelagic Cormorants nested sympatrically with Brandt's Cormorant (particularly Castle Rk. and Prince Is.), the latter usually nested on rocky slopes or outcroppings conducive to high densities, while the former utilized only sheer cliffs and were thinly distributed. Nests examined were constructed of guano-cemented seaweed.

Phenology

Because of the scattered and inaccessible nature of the nest sites, information on the timing of breeding for Pelagic Cormorants was difficult to obtain. Hence, all available data were pooled to present a generalized picture of this species' phenology.

Adults were paired and on nests as early as 4 April at Prince Is. (1977), though no eggs were present. The earliest record of clutch initiation was 17 - 19 April on Santa Barbara Is. (1977). The incubation stage extended until at least 24 July (1977), when two adults were still incubating (fertile?) eggs at Prince Island. The earliest known hatching date was 19 - 22 May from two nests at Santa Barbara Is. (1977), but hatching extends into June. On Castle Rk., on 8 June 1976, five nests contained eggs; one had two eggs and two recently hatched chicks. By 24 June (1976), both Castle Rk. and San Miguel Is. colonies had chicks large enough to be seen from the boat. On 14 - 15 July (1976), large chicks were present at Prince Is., Santa Rosa Is., and Castle Rock. Adult-sized young were present on San Miguel Is. on 21 July 1977. The earliest calculated fledging date (using a 50-day nestling period, see Robertson 1971) was 11 July (1977), with all birds probably fledging by late August. A trip to Castle Rk. on 28 August 1976 found all nests uninhabited.

Reproductive Success

We have little information on the reproductive output of Pelagic Cormorants in the Channel Islands during 1975-77. Of 12 nests at San Miguel Is. containing young on 24 June and 14 July 1976, eight had two young and four contained one. Of five nests checked at San Miguel Is. on 21 July 1977, one had two and three had one adult-sized young.

d. Food Habits

No information concerning foods of Pelagic Cormorants were obtained during this study. According to Palmer (1962), Pelagic Cormorants feed mainly on fish, but they also take crustaceans and marine worms.

e. Foraging Areas

Pelagic Cormorants foraged mainly in the vicinity of the breeding colonies during the breeding season. Only rarely were they encountered more than a few miles offshore.

Though not included in the survey contract, Black Oystercatchers and Snowy Plovers are intimately associated with the marine environment and breed on the Channel Islands. Both species nest and forage on beaches, and hence both would be highly vulnerable to oil contamination. The information given below was collected only incidentally during regular surveys. Both species probably deserve further study.

Black Oystercatcher (Haematopus bachmani)

a. Introduction

Black Oystercatchers range along the coast from the Western Aleutians, east and south to Central Baja California (A.O.U. 1957). In California, they breed along the mainland as far south as Morro Bay, but farther south they occur regularly only on the Channel Islands and Los Coronados (Small 1974). In former times, they were probably more common along the coast of Southern California (e.g. Gambel 1849).

b. Historical and Present Breeding Status in the Channel Is.

Specimen and/or nesting records exist from the following islands: San Miguel (e.g. Baird 1858; Willet 1910; Crossin and Brownell 1968; 3 egg sets WFVZ; most records from offshore rocks and islets), Santa Rosa (Howell 1917. Howell has apparently transposed the order of "San Miguel and Santa Rosa Islands" in his account. He states oystercatchers were "most plentiful on the last, when G. Willett (14) took five sets of eggs; June 17, 1910", but Willett (1910) was at San Miguel Is. on this date.), Santa Cruz (e.g. Blake 1887; Howell 1917; 7 egg sets WFVZ), Santa Barbara (Baird, Brewer and Ridgeway 1884; Hunt and Hunt 1974), and Santa Catalina (Harper 1971). There apparently are no records from San Nicolas or San Clemente Islands.

Present Status - On 16 - 19 June 1977, approximately 20 oystercatchers were seen during a walk around most of San Miguel Island. One nest was found on Harris Point. During a walk from Pt. Bennett to Cuyler Harbor on 20 - 22 July 1977, a total of 42 oystercatchers were seen. By this late date, this probably included birds of the year. Hence, the breeding population for the main island was estimated to be about 20 pairs. Estimates of offshore rocks are: Prince Is. - three pairs (up to nine individuals seen at one time); Castle Rk. - three pairs; other offshore rocks - two pairs. The resulting total estimate for the entire San Miguel Is. area was 30 pairs.

Santa Rosa Is. has very little to offer in the way of offshore breeding habitat, and foxes abound on the main island. A rough estimate based on limited experiences was 15 - 20 pairs.

Black Oystercatcher: Historical and Present Status (continued)

At Santa Cruz Is., four nests were found on Gull Is. in 1977. One nest each was found on Scorpion Rk. and Diablo Rk. during the study, and three were found on "Sppit" Rock. At this latter location, 15 adults were present on 15 July 1977. In addition, this species does manage to nest on the main island despite the presence of foxes (Anderson, pers. comm.). A reasonable estimate for all of Santa Cruz Is., based upon numbers seen during beach surveys, was 50 pairs.

At Anacapa Is., 18 oystercatchers were seen during a partial survey along the north side on 15 - 17 July 1977. The breeding population was estimated to be a minimum of 10 pairs. Only one nest was found on Santa Barbara Is. proper; an estimate of six pairs was made based on the number of territorial birds observed. Two nests were found in 1976 on Sutil Is., giving a total of eight pairs for Santa Barbara Island.

On a walk around San Nicolas Is. on 13 - 15 May 1977, a single pair of oystercatchers was found in a sandy area above an Elephant Seal rookery on the west side, and two other single individuals at other points around the island. One pair of breeding oystercatchers was estimated for the island.

San Clemente Is., like Santa Rosa and Santa Cruz Islands, was extremely difficult to census for oystercatchers but fortunately numbers were very low there. In 1976 and 1977, a pair nested on a detached rock at the south end of Seal Cove. Single individuals have been encountered elsewhere, so the estimated breeding population was two pairs. A single pair of oystercatchers nested on Bird Rk., off the isthmus at Santa Catalina Is., and the population for the entire island was probably only around two pairs.

Summing these estimates, the number of Black Oystercatchers breeding in the Channel Islands was approximately 115 pairs. In compiling a catalogue of the numbers of marine birds breeding in Northern California, Ainley and Whitt (1973) indicated that only about 35 pairs of oystercatchers occurred from San Francisco to the Oregon border. This figure included 20 pairs (from a population of 50 individuals) from the Farallon Islands (stressing the importance of offshore islands as breeding habitat for this species). Assuming another 15 pairs nested south of the Farallon Islands to Morro Bay, it is clear that a sizeable portion, probably over half, of California's Black Oystercatchers bred in the Channel Islands.

A very small number of American Oystercatchers (Haematopus palliatus) also occur on the Channel Islands. This species occurred irregularly in the area throughout historical times (see Willett 1933; Abbot 1965) and continues to be very rare in the Channel Islands. A single individual has been present at Anacapa Is. for a number of years (McCaskie 1977) and was still present in June 1977. D. B. Lewis (pers. comm.) noticed at least two American Oystercatchers

at Santa Cruz Is. and several apparent *H. palliatus* x *bachmani* hybrids.

c. Breeding Biology

Black Oystercatchers nested on rocky headlands and offshore islets in the Channel Islands. Eggs were deposited in an inconspicuous "nest" consisting of a natural depression in a rock lined with a small amount of gravel and seashell fragments. Eggs were present from at least 4 May (Sutil Is. 1976) until 23 July (San Miguel Is. 1977; two hatchlings were in the nest also). The typical clutch contained two eggs, though one- and three-egg clutches were also seen:

Clutch Size Distribution of Black Oystercatchers, Channel Is.

1976 and 1977

Clutch Size	1	2	3	
Occurrence	4	7	3	Average 1.8

Chicks were present from at least 22 June (Gull Is. 1976) when chicks were approximately one-fourth adult size till 23 July (1977) when two just-hatched chicks were seen at San Miguel. Using a 27-day fledgling period (Webster 1942), the chick period probably extended into at least the third week in August.

d. Food Habits

Cursory inspection of shell mounds left by oystercatchers at several locations in the Channel Islands indicate that their diet is made up almost entirely of mussels (*Mytilus californianus*). Small numbers of limpets and chitons were also present.

Snowy Plover (Charadius alexandrinus)

Snowy Plovers breed the length of California on sandy ocean beaches and also around inland lakes (Small 1974). Like the Least Tern (Sterna albifrons), loss of open beach nesting habitat, due to increased human activity in these areas, has resulted in significant declines in the populations breeding along the California coast.

On a walk around most of San Miguel Is. on 16 - 19 June 1977, one pair of Snowy Plovers was present at Cuyler Harbor, three or four individuals were at Cardwell Pt., a group of four were along the south side, and at least one pair was seen at Simonton Cove. On 20 - 22 July 1977, 13 Snowy Plovers were counted during a walk from Pt. Bennet to Cuyler Harbor through Simonton Cove. This species was not very common considering the amount of available habitat. This was undoubtedly related to the presence of foxes who regularly patrol the island's beaches. The breeding population was estimated to be 25 pairs.

San Nicolas Is. has the most extensive sandy beach habitat of all the Channel Islands, but again foxes kept the plover population at a token level. Using a cumulative total of maximum counts of partial censuses on the island from January through July 1976, we estimated no more than 60 pairs were on the island at any one time.

Western Gull (Larus occidentalis)

a. Introduction

The breeding range of Western Gulls extends along the Pacific Coast of North America from British Columbia to Baja California (Bent 1921). Western Gulls are distinctly coastal, rarely wandering either far to sea or inland. In former times, they may have nested commonly along the mainland of Southern California (see Everman 1886; Miller 1936), but they do not do so now (Small 1974). Only the wymani subspecies breeds in the Bight.

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

Streator (1888) visited San Miguel Is. in July 1886 and wrote that one of the offshore islets there (probably Prince) "appeared one mass of living gulls and cormorants". Hendrick (Peyton, unpubl. notes) took one egg set on 5 June 1906 and reported a colony on the top and sides of the island. On 6 June 1906, J. S. Appleton (unpubl. notes) collected seven sets of eggs (incl WFVZ 63502) and estimated there were 80 - 100 pairs of gulls on the island but very few nests. Willet (1910) found them "breeding commonly on all out-lying rocks and islets" but found none breeding on San Miguel Is. itself during a 14-day stay on the island in June 1910. Members of Willet's party collected at least three egg sets on Prince Is. at that time (WFVZ 34064 and uncat.). Wright and Snyder (1913) mention a colony at Prince Is. in July 1912, but as with most early reporters no indication of numbers is given. Egg sets were collected on Prince Is. on 3 June 1928 (WFVZ 2680), 25 May 1929 (SBM uncat., two sets) and 11 June 1933 (WFVZ 65914-65916). During the 1929 visit, the nesting population was estimated to be 500 - 1,000 pairs. Sumner (1939) reported Western Gulls were abundant and nesting in April 1939. When Craig and Sheppard visited Prince Is. in July 1965, they estimated 2,000 pairs of gulls present. POBSP personnel first visited San Miguel Is. on 14 - 15 May 1968 (Crossin and Brownell 1968) when an estimated 500 individuals of this "obvious species" were utilizing Castle Rk. and 2,000 - 2,500 were on Prince Island. Additional POBSP personnel visited the San Miguel Is. area two weeks later, 28 May - 7 June; they reported that Castle Rk. had 100 - 150 active nesting pairs and Prince Is. had "240 ± 20 active nests with possibly as many as 200 roosting birds" (Huber 1968). On San Miguel Is., Huber (op cit) also noted "50 ± 5 active nests on the grassy slope between the upper and lower cliffs on the point directly south of Prince Islet".

Present Status - The small colony of 50 nests Huber (op cit) noted does not exist anymore. However, small numbers of Western Gulls did nest on the main island. Paul Collins (pers. comm.) found 20 nests on Pt. Bennett on 19 May 1977 and five other nests at isolated

locations in the same area. Other than the seven nests found adjacent to Nifty Rk., no other Western Gulls nested on San Miguel Is. proper. Castle Rk. was surveyed on 8 June 1976, and 50 pairs of gulls were estimated using the rock for nesting. The Western Gull population at Prince Is. nested over the entire top of the island and spilled down the slope on the northwest side. The colony was estimated to be 600 pairs in 1975. Using more precise counts in 1976 and 1977, the population was estimated to be 500 and 480 respectively. In 1976, seven nests were seen on Hare Rk., just north of Cuyler Harbor; this location was not checked in 1977. The entire Western Gull breeding population in the San Miguel Is. area was about 625 pairs.

Santa Rosa Island

There appears to be no specific records of Western Gulls breeding on Santa Rosa Is., and there has probably never been a colony there. Banding recoveries of birds given by Coulter (1967) as having originated from Santa Rosa Is. were undoubtedly from another colony (possibly Prince Is.). W. Abbott and P. Collins (pers. comm.) saw several isolated nests with eggs on sea bluffs on this island in 1974 and 1975.

Present Status - As indicated above, there were no colonies of Western Gulls at Santa Rosa Is.; however, a few scattered pairs bred on sea stacks and inaccessible ledges along the north side. On 25 June 1976, 11 chicks were found between Sandy Pt. and Carrington Pt. on the northern side. In 1977, only two nests and a few "probable nests" were found in the same area. The entire Western Gull breeding population at Santa Rosa Is. was probably around 15 pairs.

Santa Cruz Island

No colonies have ever been reported from Santa Cruz Is. proper, and all records probably pertain to Gull Is., Scorpion Rk., or one of the numerous other offshore rocks. Blake (1887) visited the north side of Santa Cruz Is. and reported that Western Gulls were "extremely abundant; nests on isolated rocks along shore". When Rollo Beck visited Scorpion Harbor in June 1895, he found gulls breeding on a "square-looking rock near Scorpion Harbor (Scorpion Rk.)". Badger (unpubl. notes) found gulls were first beginning to build nests on 8 April 1919 at Santa Cruz Is. (no specific location). Single egg sets were collected on 2 June 1928 (WFVZ 26115) and 19 May 1929 (WFVZ 2681). At least 14 sets were collected 17 May 1936 (WFVZ 1376-1380, 30193, 30196; WFVZ uncat.; SBM uncat.) from a colony of approximately 50 pairs on a small island off the east side of Santa Cruz Is. (Stevens, unpubl. notes; Harrison, unpubl. notes). Stevens (unpubl. notes) took at least 15 sets on 23 May 1937 from a small colony nesting on a small island (WFVZ 30192, 20198; SBM uncat.). One egg set was taken 25 May 1941 (WFVZ 75577). Though we found no records of Western Gulls breeding on Gull Is., it seems likely that, given the island's name, gulls have been associated with the island for

some time (see Howell 1917:11).

Present Status - No colonies of gulls exist on Santa Cruz Is. proper; breeding is restricted to scattered individuals on the mainland (north side only) and small colonies on offshore rocks. In 1977, an estimated 40 pairs of gulls nested between Fraser Pt. and Diablo Pt. along the north side, and an additional 46 pairs nested between Coche and Cavern Points, mostly on offshore rocks. (These numbers are comparable to those obtained from 1976 surveys in the same areas.) In 1976, 125 pairs of Western Gulls were estimated to have bred on Scorpion Rk.; in 1977, 141 nests were counted, and the population was estimated to be 150 pairs. At Gull Is., 85 pairs of gulls were utilizing the main islet and outlying rocks in 1977. The total number of Western Gulls nesting at Santa Cruz Is. was about 325 pairs.

Anacapa Island

Though many early visitors to Anacapa Is. did not report Western Gulls, none specifically stated that this species was not present. At least 90 egg sets have been taken since 1897; a minimum of 14 sets on 2 - 4 June 1899 (WFVZ 21761, 34756, 34757, WFVZ uncat.; Owen, unpubl. notes), two on 5 and 6 June 1910 (WFVZ uncat.), one set on 15 May 1911 (WFVZ uncat.), one on 26 May 1917 (Badger, unpubl. notes), one on 15 May 1919 (CAS 1314); 13 sets on 14 and 15 May 1927 (WFVZ 32118, 32119, 73897, 7021; WFVZ uncat.; SBCM 13652; Peyton, unpubl. notes), six or more sets on 20 May 1928 (WFVZ uncat.; Peyton, unpubl. notes), four sets on 19 and 31 May 1929 (WFVZ 73898; SBM uncat.; Peyton, unpubl. notes), five sets on 11 May 1930 (WFVZ 73899; Peyton, unpubl. notes), 13 sets on 31 May (WFVZ 30183-30188; SBM uncat.), 22 sets on 17 May 1936 WFVZ 1366, 1367, 1368, 1370-1375, 30194, 30196; WFVZ uncat.; SBM uncat.), one set each on 25 May 1941 WFVZ 11959) and 23 May 1949 (WFVZ 21645), three sets on 27 May 1962 (WFVZ 68525-68527) and four sets on 13 May 1969 (WFVZ 35429-35432). Unfortunately, very few investigators commented on colony size. W. L. Chambers (unpubl. notes) reported a colony of 1,000 Western Gull nests during an egg collecting visit to Anacapa Is. in June 1899 (see also Robertson 1903). Thompson and Ashworth (unpubl. notes) estimated 1,000+ (nests or birds, not specified) in a colony they visited in May 1927. In May 1939 they found "hundreds of gulls and pelicans nesting" (Thompson and Ashworth, unpubl. notes). Ashworth and Thompson (1930) found "hundreds of nests" again on 11 May 1930. The only other indication of the size of the gull population at Anacapa Is. was from Crossin and Brownell (1968), who estimated 600 birds. Numerous other authors mention gulls were present but do little more than suggest large numbers. These include: Willet (1910), Bent (1911), Peyton (1913), Wright and Snyder (1913), Badger (1917) and Banks (1966).

Present Status - The Western Gull colony on Anacapa Is. is the largest of all the Channel Islands' colonies. The overwhelming majority of the gulls nest on the north-facing slope, particularly on

the middle and western islands. A few nests were scattered along the south-facing slopes, and some gulls also nested on the flat areas on top of East and Middle Anacapa Island. In 1976, the lighthouse colony on the east end of East Anacapa Is. had 55 pairs, and an additional five pairs nested at the west end of East Anacapa Island. In 1977, 64 nests were found below the lighthouse, but the western colony was apparently abandoned. The entire Western Gull population for East Anacapa Island was estimated to be 100 pairs. West and Middle Anacapa Islands were difficult to census because of their high elevations and dense vegetation. However, based on the numbers of territorial adults present during the breeding season in 1976 - 1977, the breeding population was estimated at about 2,500 pairs. The majority of these occurred on the north side of the middle island, and a smaller number occurred on the north side of the western island. The maximum number of Western Gulls recorded around Anacapa Is. during inshore surveys in the breeding season was 8,583 on 23 June 1977 (includes non-breeding birds).

Santa Barbara Island

When Grinnell (1897) visited the island in 1897, he found Western Gulls breeding in "immense numbers"; "they were nesting on the outer margins of the mesa, nearly the whole way around the island. A good many were nesting on the sides of the hills in the center of the island". He took at least one egg set (MVZ 549). Britton (1897), apparently on the same cruise with Grinnell, also describes "hundreds" of gulls overhead while he was moving through the nesting colonies. Chambers' party estimated 1,000 birds (500 pairs?) on 4 June 1899 (Owen, unpubl. notes) and collected two egg sets (WFVZ uncat.). Willet (unpubl. notes) and party collected at least three sets in June 1911 (WFVZ uncat.). Wright and Snyder (1913) found gulls "breeding in four separate colonies" in July 1912, "all of which contained young"; a single set of eggs was collected at that time (WFVZ uncat.). At least nine sets were collected in May 1914 (Peyton, unpubl. notes; MVZ 5637-5640; WFVZ 27311) and L. Wyman collected eight sets on 29 - 31 May 1920 (LACM uncat.). Eleven sets were collected by A. H. Miller on 15 May 1927 (MVZ 3709-3719) and Pemberton took 23 sets on 6 May 1928 (WFVZ 2657-2679). Sumner (1939) and Bond stated that "approximately 500 Wymani's (Western) Gulls were noted on the mesa toward the southern end of the island and an additional congregation of 1,000 to 1,500, with three other smaller colonies of about 300 to 500 each, was noted on the northwest slope". (Depending upon whether or not one interprets the "additional congregation" as being made up of the three smaller colonies or existing in addition to these, the Santa Barbara Is. population can be estimated from these figures as 1,500 - 2,000 or 2,400 - 3,500 birds.) Crossin and Brownell (1968), reporting on their 11 May 1968 stay at Santa Barbara Is., state, "Nesting concentrations were noted in several places; the largest spread over the W - NW slope between the two high points on the island". They estimated the total island population was 3,000 birds. Hunt and Hunt (1974) report that on 7 July 1972, 1,510 pairs

were counted on territory.

Present Status - In 1975, an estimated 1,162 pairs of Western Gulls nested on Santa Barbara Is. In 1976, 1,120 pairs of Western Gulls bred there, including 1,035 on the main island. In 1977, only 811 pairs bred on the main island and in 1978, only about 425 pairs bred on the main island. Fig. III-28 presents colony sizes at Santa Barbara Is. in 1975-1978. The Western Gull population at Santa Barbara Is. was typically about 1,150 pairs, although the colonies were monitored closely enough that the drop in nesting pairs since 1972 represents a real decline. A large part of this decline may have been related to diminishing food availability (discussed in Food Habits). Other factors that may have contributed to the decline in this breeding population include increased disturbance by park visitors, our research activities, and a long-term degradation of habitat caused by human activities and replacement of native vegetation with iceplant.

San Nicolas Island

A set of Western Gull eggs was collected at San Nicolas Is. on 3 June 1891 (MVZ 2110). Grinnell (1897) noticed a small colony breeding on the island but did not mention where. Rett (1947) stated he found nests in September that had been used the previous spring; these were located "on rocky ledges off the north shore near Thousand Springs". (These may possibly belong to cormorants). During an extended stay on San Nicolas Is., Townsend (1968) found Western Gulls were a "breeding resident, with a single large rookery on the north end of the island. More than 600 downy young were present in 1963". Delong (1967) spent 20-21 July 1967 on San Nicolas Is.; based on the number of fledglings he saw in the area, he estimated that 3,000 pairs of Western Gulls nested on the western end of the island. When Schreiber (1970) studied the breeding biology of Western Gulls nesting there in 1968, he counted 491 nests and estimated the population to be no more than 600 pairs; the nests were located at the northwest end of the island. This colony was also seen by L. Jones in 1974 although no estimate of numbers were made at that time.

Present Status - The only colony on the island is still at the extreme west end. Using a transect method, this colony was estimated to contain 720 and 935 nesting gull pairs in 1975 and 1976, respectively. The colony size was estimated to consist of 1,000 pairs in 1977. One other nest, far removed from the main colony, was found in the sand dunes immediately adjacent to a large *Zalophus* haul-out area along the west facing shore. The difference in the yearly estimates given here may only reflect sampling error; thus, the estimated Western Gull breeding population at San Nicolas Is. was about 900 pairs.

San Clemente Island

Western Gull nesting has been poorly documented at San Clemente Is., suggesting the population there has always been small. Breninger

Fig.III-28. Colony Sizes (in pairs) of Western Gull Breeding at Santa Barbara Is., 1975-1977

Colony:	West side	Southeast	Northeast	Sutil Is.	Shag Rk.	Total
1975	++	+	+	?	?	1162
1976	700	275	60	75	10	1120
1977	594	147	70	(75)*	(10)*	896
1978	275	100	50	?	?	425+

* not actually censused in 1977
\+ present
++ present in large numbers

(1904) mentions Western Gulls breeding on the island and I. D. Nokes collected a set of eggs there on 3 May 1914 (Peyton, unpubl. notes). Jehl (1973) reported 20 adults and six chicks from Bird Rk. in Northwest Harbor, a single nest from Seal Cove, and three pairs from Mail Pt. in July 1973. Jones (unpubl. notes) saw a nest near the mouth of Red Rock Canyon on 19 June 1973 and suspected one or two other pairs were breeding in the vicinity.

Present Status - In 1975, 31 pairs of Western Gulls bred on Bird Rk. in the Northwest Harbor; San Clemente Is. proper was not systematically surveyed. In 1976, 28 pairs of gulls nested on Bird Rk. and 32 pairs nested around the main island, including eleven pairs at Seal Cove Pt., seven on Seal Cove Rk., and ten pairs at Mail Pt. A partial survey in 1977 disclosed two nests on the rock off the northern point of Seal Cove. The entire Western Gull breeding population at San Clemente Is. was about 60 pairs.

Santa Catalina Island

The only Western Gull colony ever recorded from Santa Catalina Is. was at tiny Bird Rk. near the isthmus. Grinnell (1897) was the first to report nests from this location. One egg set was obtained from Catalina by Wright on 12 May 1908 (WFVZ 2654); six sets were collected on 5 May 1914 (Peyton, unpubl. notes); and four sets were collected by Meadows on 27 May 1928 (SBCM4639-4642). No specific collecting locations were given for any of the sets. C. A. Harper studied the breeding biology of Western Gulls on Bird Rk. in 1965 and 1966, when he recorded 24 and 25 nesting pairs, respectively. When Jehl (1974) surveyed the entire island in July 1974, he found none nesting on the main island and estimated 10 pairs breeding on Bird Rock. J. Hand (unpubl. ms) saw 29 pairs nesting there in 1974.

Present Status - The colony at Bird Rk. was estimated to be between 25 and 30 pairs in 1975. In 1976, 26 pairs of gulls bred at Bird Rk., and an additional three pairs were found scattered around the main island during comprehensive inshore surveys. Hence, a total of about 30 pairs of Western Gulls bred at Santa Catalina Island.

Western Gulls are the most widespread breeding marine bird in the Channel Islands, nesting on every island and offshore rock of size. There seems to have been very little change in the location and population sizes of colonies on the islands of the SCB since the turn of the century, though colonies along the coast have disappeared due, undoubtedly, to increased human activity.

c. Breeding Biology

Because gulls nest in highly visible and fairly accessible places, they are easily studied. The breeding biology of Western

Gulls has previously been studied on three of the Channel Islands: San Nicolas Is. (Schreiber 1970); Bird Rk., Santa Catalina Is. (Harper 1971; Hand ms) and Santa Barbara Is. (Hunt and Hunt 1973, 1975, 1977). This study included all of the Channel Islands except Santa Rosa Is., where no sizeable colonies existed.

Methods

To study the breeding biology of Western Gulls on Santa Barbara Is., five 100 m X 100 m quadrats were established (1975 - 1977). On San Nicolas Is. (1976 only) nine 25 m X 25 m quadrats were studied. Individual nests in the quadrats were marked with numbered stakes and followed throughout the season. On Santa Barbara Is., staked nests were checked every few days in 1975, every day in 1976, and every 2 - 4 days in 1977. On San Nicolas Is., nests were checked at least once a week in 1976, when a researcher was on the island. In 1975 and 1977, coverage on San Nicolas Is. was more superficial. On the other islands, nests were individually staked and quadrats were established only when feasible.

Studies of the reproductive success of Western Gulls on San Miguel Is. were limited to Prince Island. Since researchers were not stationed on the island, our results were based on small sample sizes and infrequent nest checks.

For Santa Cruz Is., most of the reproductive data from this study was obtained on Gull Island. Since the endangered Brown Pelican occasionally nests on Scorpion Rk., the gull colony there could not be investigated in 1975. It was visited late in the 1976 and 1977 seasons, when it became apparent that pelicans were not going to be nesting there in those two years.

During the present study, visits to the gull colony on Bird Rk., Santa Catalina Is. were made too infrequently to obtain hatching success data. On Anacapa Is., data were collected on East and Middle Islands. West Island was not examined because of the endangered status of the California Brown Pelican which nests there. Due to the infrequency of visits in all years, the available information is sparse.

In order to calculate average number of fledglings/nest, the number of young surviving to 500 g was used as a criterion for survival and all chicks reaching or exceeding this weight were assumed to have fledged (Hunt, 1972; Hunt and Hunt, 1975). Chick growth rates were calculated using the slope of the straight-line portion of the growth curve (Spaans 1971; Hunt 1972; Hunt and Hunt 1975, 1976a), which occurs when the chick weighs between 125 g and 600 - 700 g. Outside this range, growth is curvilinear.

In order to study juvenile dispersal patterns, chicks were banded on every island except Santa Rosa Island. Initially, small

chicks were banded with numbered plastic bandettes. Once they reached 125 grams, these bandettes were replaced with U.S.F.W.S. metal bands, and each chick was given color bands coded to signify the island and year of hatching (Fig. III-29). In addition, adult Western Gulls were captured and banded for behavior studies. A total of 3,454 Western Gulls were banded from 1975 - 1977.

Habitat

Western Gulls nested in a variety of habitats in the Channel Islands including rocky cliff ledges, iceplant mesas, grass-covered mesas, steep island slopes and barren offshore rocks and stacks. Like cormorants, Western Gulls nested primarily on the exposed north and northwest sides of the islands.

All of the large gull colonies were associated with vegetation. Vegetation is important to the gulls for nest building and ultimately for chick survival. Vegetation serves both as support for nests built on slopes and as lining for the nest. Nearby bushes also offer cover for chicks running to hide, thereby decreasing the chance of chicks crossing territorial boundaries and being killed by neighbors. Generally, gulls are opportunistic and use any vegetated area for nesting purposes. In the Channel Islands, iceplant (Mesembryanthemum crystalinum) and Coreopsis were the predominant vegetation types in gull colonies.

On Santa Barbara Is., the main colony was concentrated on the west side of the island where Suaeda and iceplant were the predominant vegetation types. The density of gull nests in the quadrats established in 1976 and 1977 are given in Fig. III-30. The areas of highest density, Quadrats D and E, were situated on fairly level ground. Quadrat D had sparse Suaeda growth, but contained other forms of cover such as rocks and old pelican or cormorant nests. Quadrat E was heavily vegetated with Suaeda. Quadrats B and C had intermediate densities and were located on slopes where low-lying iceplant was the major ground cover. Quadrat A, with the lowest densities, was the only quadrat on the east side of the island and contained only low-lying vegetation; this quadrat was coursed by deep gullies formed by rain runnoff. Nests on Santa Barbara Is. were constructed with any available vegetation, usually iceplant, Suaeda and grass.

The colony on San Nicolas Is. was located on the northwest tip of the island. This area was characterized by gullies and sand dunes partially stabilized by low-lying vegetation. The vegetation was classified in 1968 by Schreiber (1970) as iceplant, ground heliotrope, sand verbena, beach burr, alkali heath, seablite and lupine. According to Schreiber (op cit), nest depressions were usually made in iceplant or lupine, but beach burr was the only plant found woven into nests.

The gull colony on the top of Prince Is. was covered by iceplant. Most nests were bowls formed in a mat and then lined with

Fig. III-29. Western Gull Colorband Codes*

Code	Color	Natal Colony	Year Fledged
A	Yellow	Santa Barbara Is.	1976
B	White	Gull Rk., Santa Cruz Is.	1977
C	Blue	Anacapa Is.	1978
D	Red	Prince Is., San Miguel Is.	1979
E	Green	San Nicolas Is.	1980
F	Black	Bird Rk., Santa Catalina Is.	1981

*Chicks were banded with colony color on top; fledging year color below on right leg; U.S.F.W.S. band on left leg.

Fig. III-30. Density of Nests in Study Quadrats
Santa Barbara Is., 1976 and 1977

Quadrat	Number of Nests/m^2 1976	1977	Habitat Description
A	.0018	.0014	Wash area; dense but low-lying vegetation in south half of grid, very little vegetation in half-half.
B	.0025	.0028	Located on east to west running slope. Low, sparse vegetation consisting of iceplant, Suaeda, and grass over most of grid.
C	.0026	.0015	On a slope running down from east to west; wide gullies running in the same direction. Vegetation sparse - iceplant and some Suaeda.
D	.0040	.0044	Flat area; vegetation sparse, ground cover is mostly iceplant interspersed with some Suaeda.
E	.0044	.0036	Flat area; dense vegetation consisting mainly of Suaeda; small bare club area.

iceplant. Some nests were depressions in the bare ground, but these were usually associated with rocks or dead branches which served both as support for the nest and cover for the chicks.

The Anacapa Islands are long, narrow and relatively steep. Most of the nests were built on the sloping north sides by Coreopsis bushes and lined with grasses. The Coreopsis often provided a roost above the nest for the non-incubating parent, as well.

Small barren rocks located off of the main islands were used very little by nesting Western Gulls; these included Gull Is. and Scorpion Rk., Santa Cruz Is.; Sutil Is. and Shag Rk., Santa Barbara Is.; Bird Rk., Santa Catalina Is. and Bird Rk., San Clemente Island. These islets had very little vegetation. In many instances, eggs were laid on bare ground, cradled in shallow dirt scrapes. Nests constructed in this manner did not provide good protection against extreme weather conditions.

Phenology

Western Gulls were seen in the vicinity of the islands all year round. Censuses of Santa Barbara Is. showed a steady increase in the number of gulls from January through March (Fig. III-31). The apparent decrease in numbers between 30 March and 20 April 1977 was due to a shift in the daily attendance pattern rather than a decrease in the number of gulls associated with the colony. From January through March, peak numbers of gulls were counted on the colony soon after dawn. This trend gradually shifted in late March and April until, by the end of April, peak numbers of gulls were on the island in the evening. In January 1977, the west side colony on Santa Barbara Is. was monitored from late afternoon until after sunset; no gulls were observed on the colony. However, the next morning approximately 175 gulls were counted. On 27 April 1977, two censuses were taken, one at dawn and one in the evening; twice as many gulls were counted in the evening. The timing of counts is clearly critical for the assessment of the numbers of breeding gulls.

When Santa Barbara Is. and Prince Is. were visited in January 1976 and 1977, gulls were seen actively defending territories. Matings were seen during the first week of study on Santa Barbara Is. in April 1976 and 1977. Western Gulls usually mated on their territories, and copulations occurred for several weeks before eggs were laid. Most courtship behavior and territory defense occurred in the mornings and evenings, when the greatest number of gulls were present on the colony.

Clutch initiation on Santa Barbara Is. began in late April and continued through early June (Fig. III-32). The earliest recorded egg date was 22 April 1976, and the latest date was 7 June 1975.

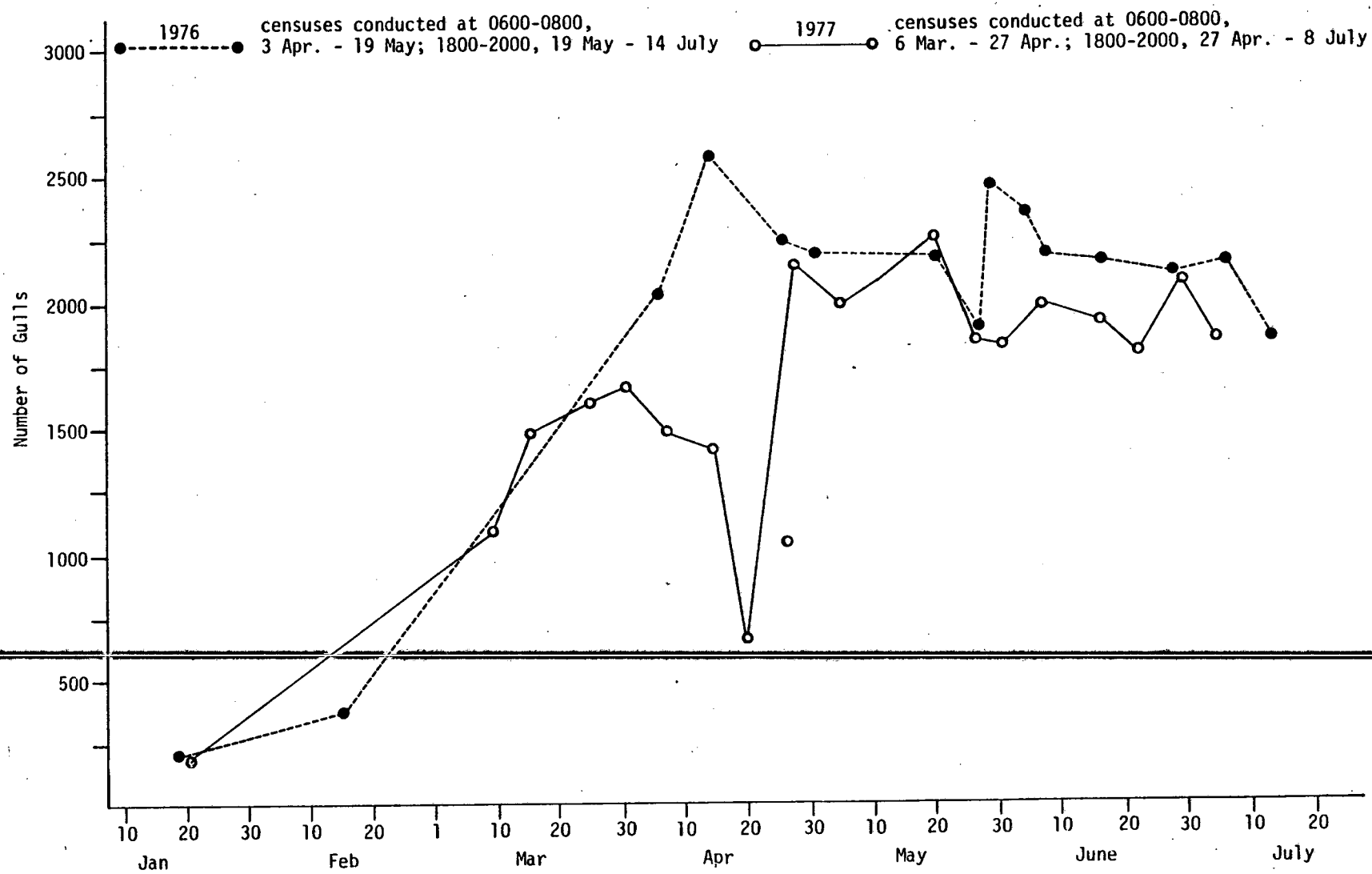


Figure III-31. Results of Western Gull censuses, Santa Barbara Is., 1976-1977.

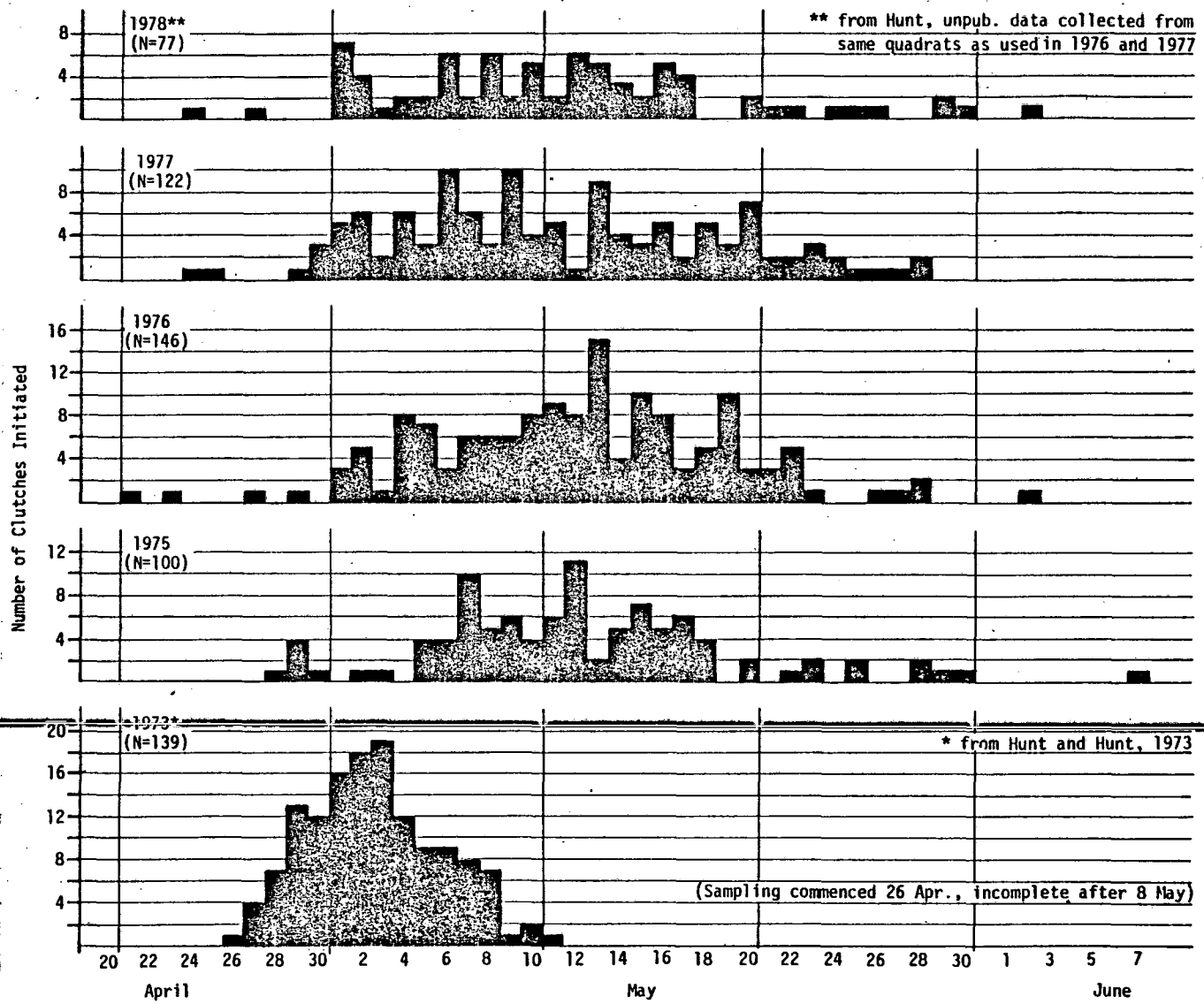


Figure III-32. Clutch initiation of Western Gulls on Santa Barbara Is., 1973*, 1975-1978**

Though not checked frequently, the other islands did provide some phenological data. The birds on Anacapa Is. were the first to lay eggs in both 1976 and 1977. In 1976, 56% of the clutches in the quadrat on Anacapa Is. were initiated before 1 May; 48% were complete clutches (3 eggs) at that time. At Santa Barbara Is., only 3% of the clutches were initiated before 1 May 1976. In 1977, the earliest chick seen on Anacapa Is. hatched around 10 May, indicating egg laying began as early as 12 April.

In 1976, gulls on Prince Is. were last to begin nesting, lagging behind the other colonies by about one week. In 1977, the birds on San Nicolas Is. started last; they laid eggs about two weeks later than gulls nesting on Santa Barbara Island. All other colonies conformed fairly well to the schedule documented on Santa Barbara (Fig. III-33).

On Santa Barbara Is., the first eggs hatched in late May, and hatching continued into July. A one-week-old chick seen on 18 July 1976 on Bird Rk., San Clemente Is. provided the latest documented hatching date. In both 1976 and 1977, chicks began fledging in mid-July. The earliest chicks to fledge were on Anacapa Island.

In summary, the yearly cycle of the Western Gull consists of: 1) a territorial period beginning at least as early as January; 2) an incubation phase beginning with egg laying during the last ten days of April and extending through the beginning of egg hatching; 3) the chick phase, which begins at the end of May and lasts until most chicks are fledged by 20 - 25 July (Fig. III-34). From the end of May through mid to late June, both incubation and chick rearing are taking place. We know little of the gull's activity patterns from August through January.

Reproductive Success

Clutch size of Western Gulls was documented on Santa Barbara Is. for five years, and on other islands with somewhat lesser accuracy for 1976 and 1977 (Fig. III-35). Average clutch size varied between islands and between years. The typical Western Gull clutch contains three eggs (Bent 1921). However, in the Channel Islands, a variable proportion of the nests contain 4 - 6 eggs (Fig. III-36; see Schreiber 1970; Hunt and Hunt 1973, 1977). These supernormal clutches are the result of female-female pairing (Hunt and Hunt 1977).

On Santa Barbara Is., clutch sizes were consistently high except in 1978, when the average was 2.2 eggs/nest. In 1978, known female-female pairs almost completely failed to produce supernormal clutches. Within the study quadrats, there were no 5- or 6-egg clutches and only 2.5% of the clutches had four eggs. This contrasts with a total of 8.6% and 8.0% supernormal clutches in 1976 and 1977 in the same quadrats. A similar situation was documented on

Fig.III-33. Phenology of Clutch Initiation Western Gulls
Santa Barbara Is.

	1972[1]	1973[2]	1975[3]	1976[4]	1977[4]	1978[5]
Number of Nests Followed	39	139	100	146	122	77
Mean Clutch Initiation Date	∿1 May	∿2 May	12 May	12 May	11 May	11 May
Standard Deviation	—	—	7.01	6.88	7.74	8.08
Mode	—	3 May	13 May	13 May	6-9 May	1 May

1 Estimated from Hunt and Hunt 1976 using hatching dates to estimate laying dates.

2 Hunt, unpublished data; complete data collected only from 26 April - 8 May

3 Individual nests staked throughout colony

4 Nests located in 5 "BLM" quadrats

5 Hunt, unpublished data, collected in a manner comparable to 1975-1977; nests located in 5 "BLM" quadrats

Fig. III-34. Timing of Breeding of Western Gulls - Channel Islands, 1975 - 1977

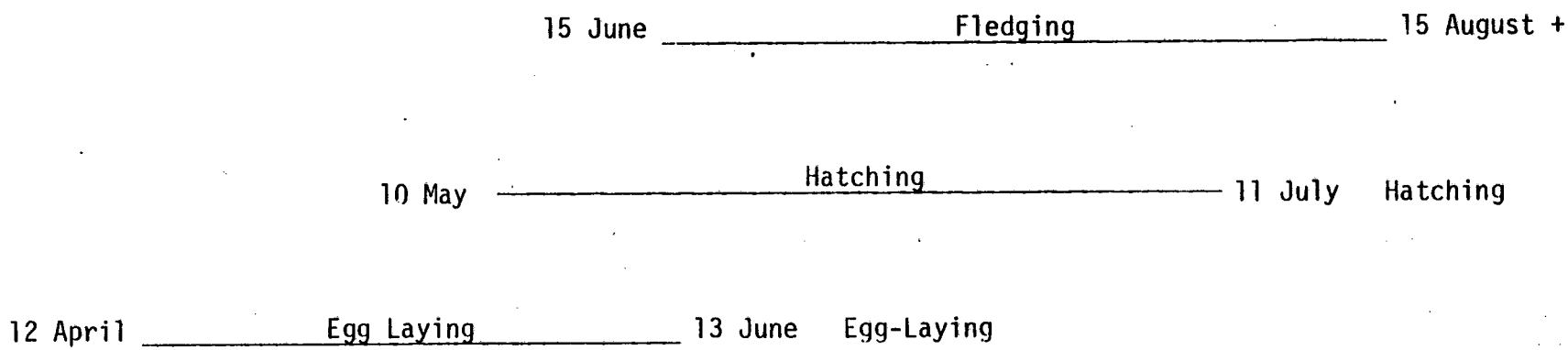


Fig. III-35. Clutch Size of Western Gulls on the Channel Islands

Year	Prince Is. San Miguel	Gull Is. Santa Cruz	Anacapa Is.	San Nicolas Is.	Santa Barbara Is.	Bird Rk. Catalina	Bird Rk. San Clemente
1965[1]						2.4(24)*	
1966[1]						2.5(25)	
1968[2]				2.8(273)			
1972[3]					2.8(63)		
1973[4]					2.9(104)		
1974					2.9(65)[4]	2.8(29)[5]	
1975					3.0(23)		
1976	2.6(211)	2.6(35)	2.9(66)	2.3(46)	2.64(155)	2.8(26)	2.4(21)
1977	2.5(60)	2.6(53)	2.8(99)	2.6(45)	2.8(137)	2.4(12)	
1978[6]					2.2(79)		

*(N=Number of clutches in sample).

[1]From Harper, 1974.

[2]From Schreiber, 1970, using data collected on 22 May 1968.

[3]From Hunt and Hunt, 1973.

[4]Hunt, unpublished data.

[5]From Hand, unpublished data.

[6]Hunt, unpublished data collected in a manner comparable to 1975-1977.

Fig. III-36. Distribution of Clutch Size

Island/Year	N	C/1	C/2	C/3	C/4	C/5	C/6
Bird Rock, Catalina, 1965[1]	24	.25	.13	.58	.04	.00	.00
San Nicolas, 1968[2]	273	.06	.15	.73	.04	.01	.01
Santa Barbara, 1972[3]	63	.08	.19	.62	.06	.05	.00
Santa Barbara, 1973[4]	104	.05	.18	.69	.03	.04	.01
Santa Barbara, 1974[4]	65	.08	.11	.68	.12	.01	.00
Santa Barbara, 1975	23	.04	.13	.70	.09	.04	.00
Santa Barbara, 1976	155	.12	.23	.57	.08	.00	.01
Santa Barbara, 1977	137	.07	.16	.68	.05	.03	.00
Santa Barbara, 1978[4]	79	.24	.33	.41	.03	.00	.00

[1]From Harper, 1971.
[2]From Schreiber, 1970, using May 22, 1968 data.
[3]From Hunt and Hunt, 1973.
[4]Hunt; unpublished data.

San Nicolas Island. In 1968, average clutch size was high (2.8) and 6% of the nests contained supernormal clutches. In 1976, in the established quadrats, no nests had more than 3 eggs and average clutch size was very low (2.3). In contrast, on Anacapa Is., the average clutch size was consistently high in 1976 and 1977 (2.9 and 2.8 respectively), yet supernormal clutches were very rare (one was found in 1976 and none were seen in 1977). The other islands averaged about 2.5 eggs/nest.

On Santa Barbara Is., it was found that the timing of clutch initiation varied with clutch size (Figs. III-37, 38 and 39); small clutches (1 and 2 eggs) and supernormal clutches were laid later in the season than typical three-egg clutches. The smaller, later clutches may have been produced by inexperienced birds breeding for the first time, or they may have been replacement clutches of birds whose first clutch was lost. Supernormal clutches may be laid later in the season because the two females producing the eggs do not benefit from courtship feeding by a mate and, therefore, they may have to spend more time away from their territory foraging (Newman et al., in prep.).

Incubation - Since nests on Santa Barbara Is. were checked every day in 1976, it was possible to calculate how long each egg of a clutch was incubated. Using only nests in which all eggs survived to hatch (n = 117 eggs), the average incubation time was 28.8 days (SD = 1.4, range 25-31). Assuming the first egg laid was the first to hatch, and similarly for the second and third egg, incubation times were calculated for each of the eggs separately (Fig. III-40). Western Gulls usually lay one egg every other day until a clutch of three is complete. Hence, the last egg is laid, on the average, four days after the first, but it hatched only 1.4 days later than the first. This indicates either that Western Gulls did not incubate their eggs continuously until the clutch was complete or that development was accelerated in the last egg laid to enhance synchrony of hatching (Brown 1976).

Hatching Success - Hatching success of eggs is reported in Fig. III-41. Due to the differences in habitat on the islands, changes in the exposure of the colonies to human disturbance and variation in methods of collecting data, it was difficult to compare hatching data on different islands in different years.

Hatching success on all islands was related to clutch size (Fig. III-42). The most successful clutches contained three eggs, while hatching success declined in nests with correspondingly fewer eggs. The extremely low hatching success of supernormal clutches (greater than 3 eggs) was the result of infertility due to female-female pairing described by Hunt and Hunt (1977). On Santa Barbara Is., hatching success fluctuated from 67% in 1972 to 32% in 1975,

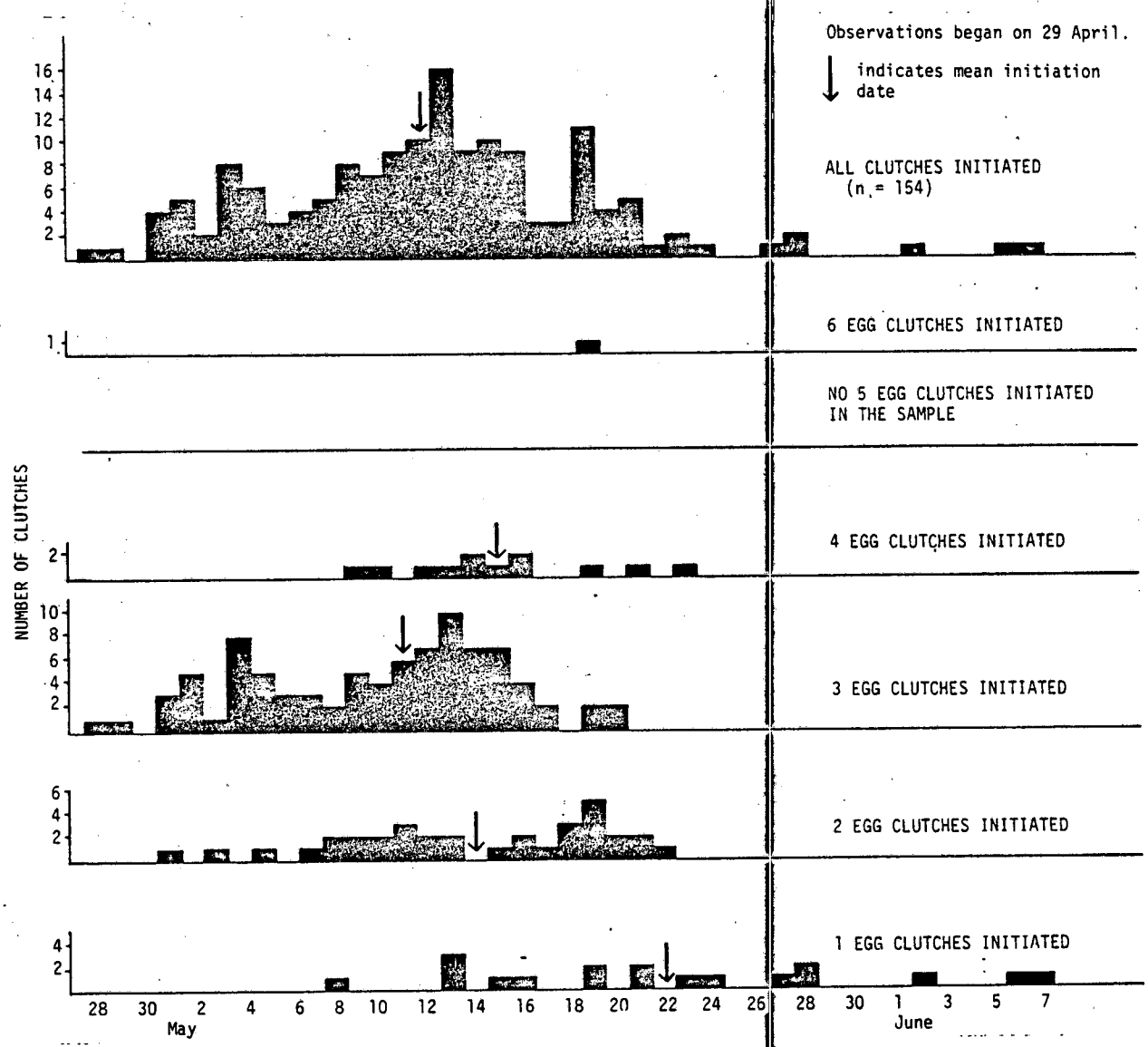


Fig. III-37. Clutch initiation dates and their relation to clutch size in Western Gulls, Santa Barbara Is., 1976.

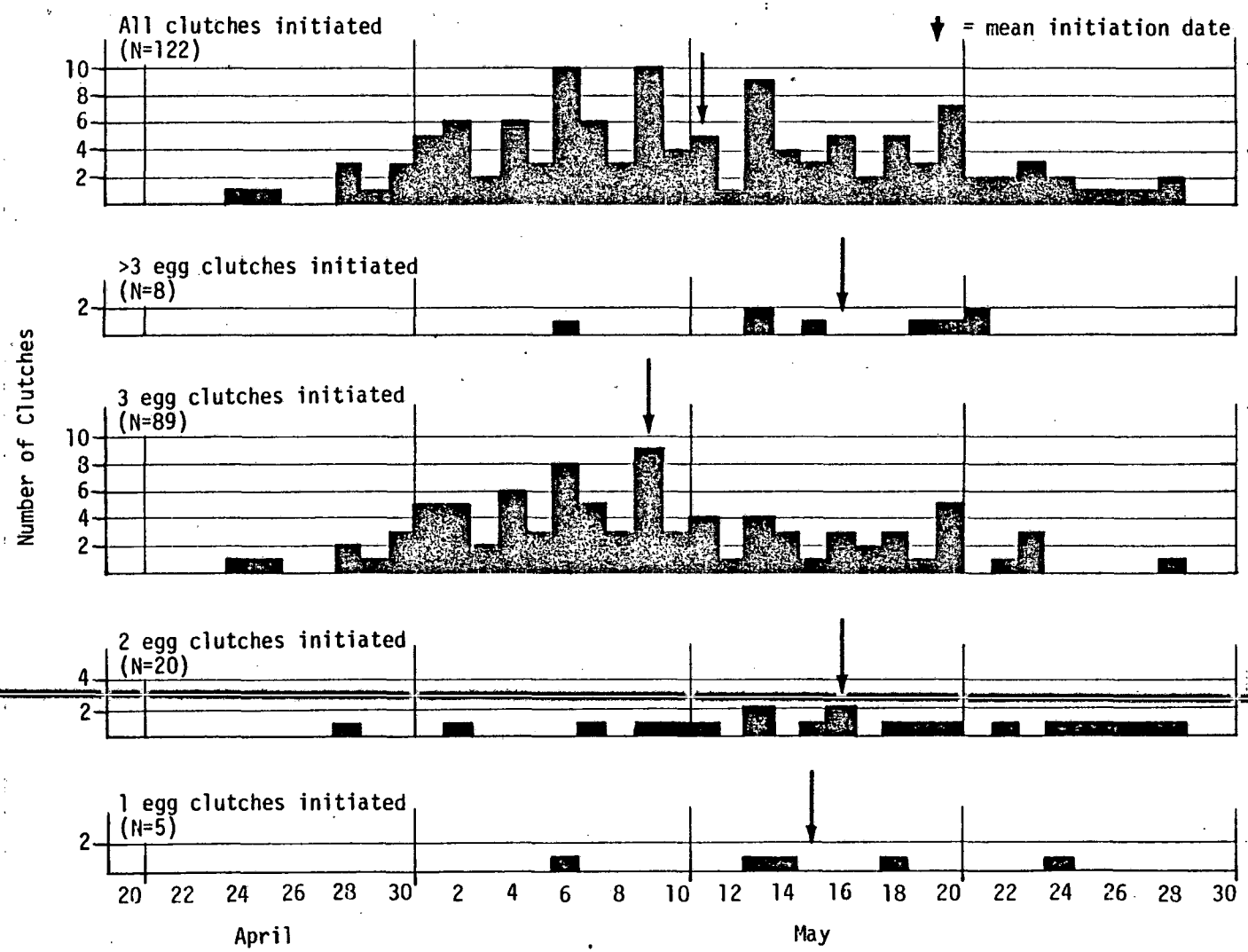


Figure III-38. Clutch initiation dates for Western Gulls and their relation to clutch size, Santa Barbara Is., 1977.

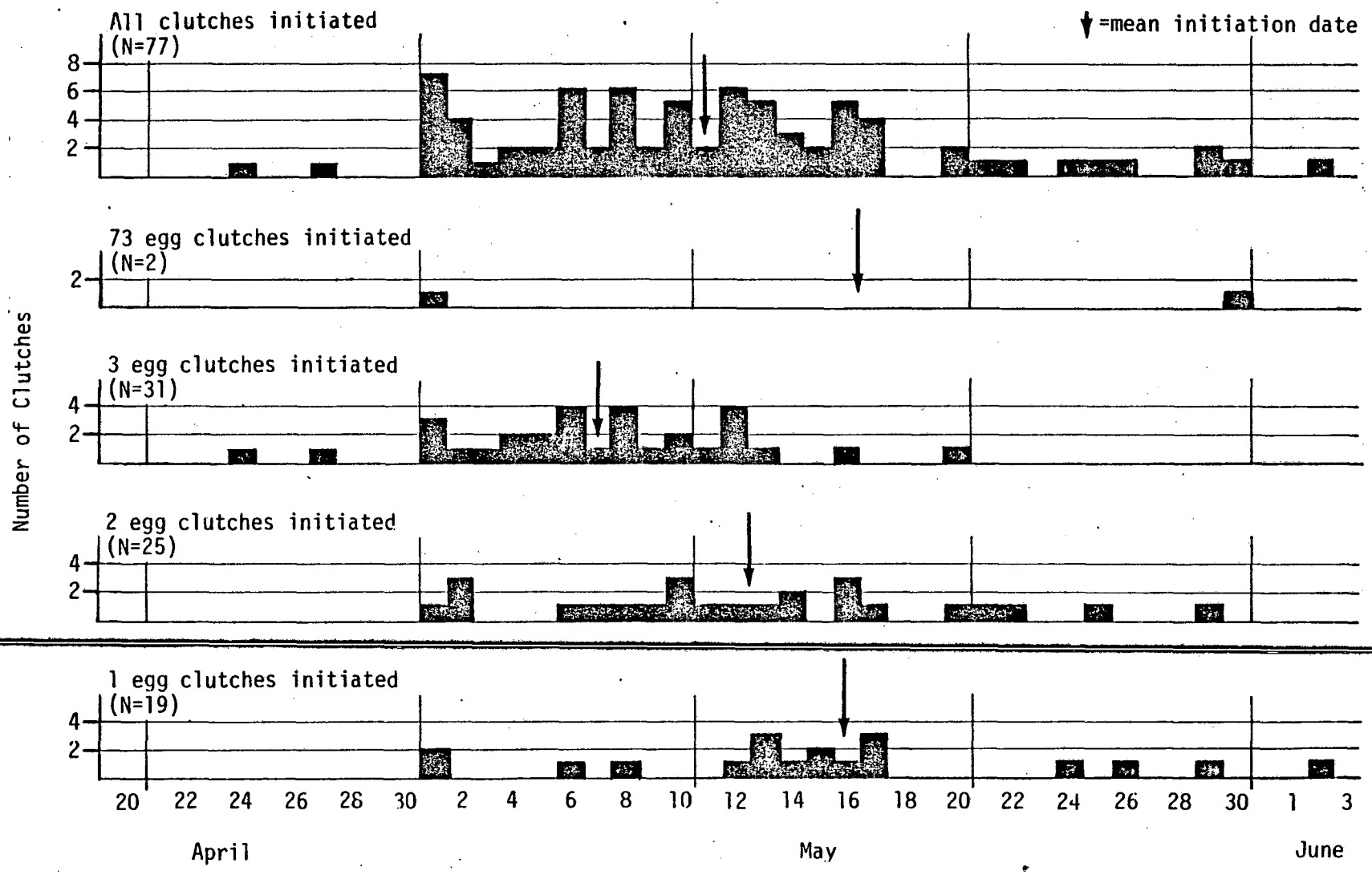


Figure III-39. Clutch initiation dates for Western Gulls and their relation to clutch size, Santa Barbara Is., 1978

Fig.III-40. Incubation Times of Western Gull Eggs, Santa Barbara Is., 1976

	N	Average Incubation Period	Standard Deviation	Range
First Egg	35	29.9	1.0	28-31
Last Egg	35	27.2	0.7	26-28
All Eggs	105	28.5	1.4	26-31

Fig.III-41. Hatching Success of Western Gull Eggs

Year	Prince Is. San Miguel	San Nicolas Island	Santa Barbara Island	Bird Rock Catalina
1965				.76(59)[1,2]
1966				.80(67)[2]
1968		.55(150)[5]		
1972			.67(177)[3]	
1975			.32(68)	
1976	.60(12)	.45(106)	.51(406)	
1977	.70(147)	.48(120)	.53(384)	
1978			.34(175)[4]	

[1](N=number of eggs)
[2]from Harper, 1974
[3]from Hunt and Hunt, 1973
[4]from Hunt, unpublished
[5]from Schreiber, 1970

Fig. III-42. Hatching Success of Western Gull Eggs in Relation to Clutch Size

Island/Year	C/1	C/2	C/3	C/4	C/5	C/6
Bird Rock, Catalina, 1965[1]	.33(6)*	.33(6)	.88(52)	.75(4)	—	—
San Nicolas Is., 1968[2]	.30(10)	.69(48)	.72(297)	.02(48)	.00(20)	.00(6)
Santa Barbara, 1972[3]	.20(5)	.46(24)	.75(117)	.07(72)	.00(30)	—
Santa Barbara Is., 1975	.00(1)	.33(6)	.63(48)	.00(8)	.00(5)	—
Santa Barbara Is., 1976	.10(10)	.46(68)	.64(270)	.04(52)	—	.00(6)
Santa Barbara Is., 1977	.10(10)	.46(44)	.64(282)	.00(28)	.10(20)	—
Santa Barbara Is., 1978[4]	.00(19)	.17(52)	.51(96)	.12(8)	—	—

*(N=number of eggs)

[1] Harper, 1971

[2] Schreiber, 1970

[3] Hunt and Hunt, 1972, 1977

[4] Hunt unpublished

when a larger percentage of supernumerary clutches were followed than in any other year. Hatching success was very similar in 1976 and 1977, but it decreased significantly in 1978 within the study quadrats that were monitored in the two previous years.

On San Nicolas Is., Schreiber (1970) reported that 55% of the eggs hatched in 1968. He also noted that clutches with more than 3 eggs usually failed to hatch. When these were dropped from the calculations, hatching success increased to 70%. During the course of this study, only one supernumerary clutch was found on San Nicolas Is. (5 eggs; 1977), and hatching success was low, similar to that found originally by Schreiber (41% in 1976; 48% in 1977).

During the present study, visits to Santa Catalina Is. were made too infrequently to obtain data on hatching success. However, Harper (1971) tabulated hatching success of different sized clutches on this island. When these were averaged, 76% of the eggs hatched in 1965 and 80% hatched in 1966. Compared to the hatching success of Western Gulls on other islands (approximately 50%), these figures are very high.

Fledging Success - Chick survival and the number of chicks produced per nest fluctuated between islands and from year to year at individual islands (Figs. III-43 and III-44). On Santa Barbara Is., we found an important difference between chick production in 1976 and 1978 versus other years. In 1976, chick survival was markedly reduced as was, to a lesser extent, chick production per nest. In 1978, in spite of high chick survival, the production per nest was greatly reduced due to high egg mortality. These drops in nesting success were partially related to declines in food abundance, especially of Northern Anchovy (*Engraulis mordax*), as will be discussed below. (Our data for other islands were not adequate to make comparisons.)

Egg and Chick Mortality - Factors depressing breeding success include food availability, weather, disturbance and predation; the last two factors were particularly severe problems on San Nicolas Island. Female-female pairing and the associated supernumerary clutches most prevalent on Santa Barbara Is. during the 1970's and earlier on San Nicolas Is. (1968), also contributed to lower hatching success due to the presence of large numbers of infertile eggs (Fig. III-36). However, since 1975, relatively few supernumerary clutches have been found on any of the Channel Islands other than Santa Barbara Island.

In 1977, on Santa Barbara Is., eggs that did not hatch were broken open to determine the cause of mortality (Fig. III-45); the majority of these eggs (63%) showed no apparent development. This phenomenon was widespread, occurring in 41.6% of the clutches laid in the study quadrats (n = 137), and the occurrence of undeveloped eggs was not restricted to supernumerary clutches. While this

Fig. III-43. Proportion Western Gull Chicks Surviving

Year	Island: Anacapa Island	Prince Is. San Miguel	San Nicolas Island	Santa Barbara Island	Bird Rock Catalina
1965					.71(44)[1]
1966					.55(62)
1972				.85(99)[2]	
1975				.91(32)	
1976	.77(17)	≤.56(36)	.83(48)	.70(207)	
1977		.80(48)	≤.91(58)	.96(203)	
1978				.91(59)	

(N=number of chicks hatched)

[1]Harper, 1974

[2]Hunt and Hunt, 1977

Fig.III-44. Western Gull Chicks Produced per Breeding Attempt

Year	Island: Anacapa Island	Prince Is. San Miguel	San Nicolas Island	Santa Barbara Island	Bird Rock Catalina
1965					1.30(24)[1]
1966					.96(25)[1]
1972				1.33(63)[3]	
1974					.59-.69(29)[2]
1975				1.26(23)	1.3-1.8(25-30)
1976	≥1.20(41)	≤ .71(28)	.87(46)	1.00(148)	≥.77(26)
1977	---[5]	≥1.00(35)		1.42(137)	
1978				0.68(79)[4]	

(N=number of nests with eggs laid in them)

[1]Harper, 1974

[2]Hand, J., unpublished data

[3]Hunt and Hunt, 1977

[4]Hunt, unpublished

[5]During a boat survey of the north side of Anacapa Is. on 16-18 July, 1977, at least 1845 large gull chicks were present. Most of these gulls had already fledged; all gulls counted were at least 500 g. The majority of these fledglings were associated with Middle Is.(95 East, 1296 Middle, 453 West). Additional chicks were undoubtedly missed due to their cryptic coloration and other difficulties associated with censusing from a very small inflatable boat.

Fig. III-45. Causes of Egg Mortality in Western Gulls, Santa Barbara Is., 1977

			Proportion of Eggs Lost				
Clutch Size	Number of Nests	Number of Eggs Lost	No Apparent Development	Missing; Presumed Eaten	Died During Hatching	Damaged in Nest	Embryo Died; Cause Unknown
1	10	9	.20	.70	.00	.00	.00
2	22	24	.23	.25	.02	.04	.00
3	94	112	.24	.08	.01	.01	.02
4	7	28	.89	.07	.00	.04	.00
5	4	18	.70	.20	.00	.00	.00
6	0	—	—	—	—	—	—
Total	137	191	.63	.24	.02	.04	.03

phenomenon is not understood, the high proportion of "undeveloped" eggs may be the result of exposure to solar radiation at an early stage of development. Alternatively, the eggs may simply have been infertile. Conspecific predation, especially common in small (one- and two-egg) clutches was the second most important cause of egg mortality. In all, 24% of the eggs laid simply disappeared. Since the only known predator of Western Gull eggs on Santa Barbara Is. was Western Gulls, it was assumed that all eggs that disappeared from the study areas were eaten. Damage to the eggs in the nest, death of well-developed embryos from unknown causes and chicks dying during hatching were also sources of egg mortality. In his study on San Nicolas Is., Schreiber (1970) found the same types of egg mortality in approximately the same proportions.

Weather was also a important factor causing egg mortality. In May 1977, unseasonal rains caused damage to the nests built on sparsely vegetated slopes. These areas were not well represented in the study quadrats on Santa Barbara Is., and thus did not figure very prominently in the mortality figures. In some nests, eggs were washed out of the nest and down to the bottom of the slope. In other nests, mud was deposited in the bottom of the nest cementing the eggs in position. The affects of rain were most pronounced on Scorpion Rk., Santa Cruz Island. On 19 May 1977, the entire rock was surveyed for Western Gull nests. It was estimated that 15 - 20% of the nests contained at least 1 egg covered by mud or cemented to the bottom of the nest. In several nests, the entire clutch of eggs was covered, leaving only the tops of the eggs visible. Therefore, our estimate of eggs lost in this fashion may be low, as some eggs were completely covered.

In 1976, a heat wave coincident with the peak hatching period resulted in the death of several pipping eggs and many chicks. Over the last twenty years (excluding 1976) the average temperature at Avalon Pleasure Pier, Santa Catalina Is. for 21 - 28 June was 69.4^{o}. In 1976, the average was 85.6^{o}, and on four consecutive days (24 - 27 June) temperatures were at or over 90° (climatological data: California U. S. Environmental Service, 1957 thru 1971). During this heat wave, most active nests on Santa Barbara Is. had young chicks, and other nests contained hatching or near-hatching eggs. It is at this time that chicks and embryos are most vulnerable to extremes in weather (Vermeer 1963). Over half (51.6%) of the 62 chicks found dead on this colony in 1976 died during this eight-day period. It is probable that some unhatched eggs were also killed by heat, but no quantitative data were available.

Hence, the heat wave that was recorded on Santa Barbara Is. may have been partly responsible for the lower chick survival in 1976. Since gulls on Prince Island nested slightly later than gulls on Santa Barbara Is., chicks were even smaller and more susceptible to heat during this time.

Low accessible stocks of a major prey item of Western Gulls, Northern Anchovy, was probably another major determinant of the low chick survival rate observed in 1976 (see discussion below). Other causes of chick mortality were predation by island foxes (San Nicolas Is. only) and deformity (one chick was hatched with a stump leg and died within three days), and attacks by neighboring gulls. However, conspecific predation resulted in far less chick loss in Western Gulls in the Channel Islands than is true in most gull species elsewhere. This is probably because many species of gulls nest in much denser colonies than do Western Gulls in the Channel Islands (Hunt and Hunt 1976a, 1976b).

Disturbance - In 1976 and 1977, attempts were made to investigate the affects of research activities (i.e. ground based disturbance) on the reproductive success of the gulls on Santa Barbara Is., because several investigators have shown that chicks disturbed by researchers often run onto neighboring territories and are thus killed by neighbors. (Gillett, Hayward and Stout 1976; Robert and Ralph 1976; Fetterolf, ms.) In 1976, all five quadrats on Santa Barbara Is. were checked daily during incubation. Once chicks started hatching, chicks in three quadrats (A,C,E,) were checked daily and weighed every fifth day. In two quadrats (B,D,), chicks were checked every one to two days but never handled. In 1977, quadrats A and E were less disturbed than B, C and D. The less disturbed grids were checked every 4 days, and the chicks were not handled. The more disturbed quadrats were checked every two days, and young were weighed every fourth day. Unexpectedly, the major affect of researcher disturbance on Santa Barbara Is. occurred during the egg stage and not the chick stage (Fig. III-46). In both years, a higher proportion of eggs hatched in the quadrats which were entered somewhat less frequently and in which chicks were not handled. Chick survival was essentially the same in all quadrats.

As expected, the percentage of eaten eggs and dead eggs with embryos was slightly higher in the more disturbed quadrats. However, the only pronounced difference between the disturbed and less disturbed quadrats was in the number of dead eggs with no apparent development. Hence, although it is evident that disturbance was most detrimental to eggs, the exact way in which the eggs were affected was not clear.

One possible explanation for the high proportion of "undeveloped" eggs in the more disturbed quadrats may be overheating during exposure to solar radiation. In 1978, Winnett and Murray (unpubl. data) found that the air space temperature within some Western Gull eggs exposed to ambient temperature and solar radiation typical of that experienced within an unattended nest exceeded that reported as lethal for chicken embryos of the same age within one hour. Although their sample size was small (12 eggs tested), their evidence seemed to indicate that very young embryos (incubated 1 - 2 days) may be more susceptible to overheating than older embryos. Furthermore,

Fig. III-46. Affect of Research Activity on Western Gull Reproduction, Santa Barbara Island, 1976 and 1977

Treat-Ment	Grid	1976 Number of Eggs	1976 Proportion of Eggs Hatching	1976 Proportion of Chicks Surviving	Grid	1977 Number of Eggs	1977 Proportion of Eggs Hatching	1977 Proportion of Chicks Surviving
Quadrats in which chicks were weighed	A	49	.41	.60	B	66	.47	.97
	C	75	.40	.67	C	44	.52	1.00
	E	122	.43	.74	D	136	.48	.94
TOTAL		246	.42	.69		246	.48	.96
Quadrats in which chicks were not weighed	B	69	.42	.55	A	41	.46	.89
	D	94	.80	.77	E	97	.67	.98
TOTAL		163	.64	.71		138	.61	.96

1976 AND 1977

	"Highly Disturbed"	"Disturbed"
Number of Eggs	492	301
% Eggs Hatching	45	62
% Chicks Surviving	83	82

Winnett (unpubl. MSc. thesis) found that egg mortality, including the occurrence of apparently undeveloped eggs, in Western Gull nests on Santa Barbara Is. was directly related to the amount of time adults spent off of their eggs. Hence, any nest neglect or prolonged disturbance could contribute significantly to egg death.

Growth Rates - Variation in growth rates for Western Gull chicks occurred from one year to another and between islands within years (Fig. III-47). On Santa Barbara Is., where chicks were weighed every 4 - 6 days throughout the season, growth rates were 20% lower in 1976 than in 1975 and 1977. On San Nicolas Is., growth rates were higher than those found on any of the other Channel Islands in the same years. Growth rates of chicks weighed only twice on Prince Is. were the lowest recorded in the Bight in 1975 and 1976, but they increased significantly in 1977. Growth rates obtained from 10 chicks on Bird Rk., Santa Catalina Is. in 1976 were among the highest recorded for the Channel Islands in that year. These high growth rates were probably related to the availability of (human) waste foods nearby from boating activities, Avalon and the settlement at the isthmus.

In past studies, growth rates of young gulls were identified as important predictors of chick survival (Hunt and Hunt 1976). On Santa Barbara Is. (1972 - 1978) growth rates were correlated with Western Gull chick survival ($r^2 = 0.77$, $p < .05$). Reduced growth rates were associated with lower chick survival, but at higher growth rates the correlation between growth rate and chick survival was less tight. Hunt and McLoon (1975) found that gull chicks not fed by their parents became more susceptible to attack by neighboring territory owners than chicks that had been fed. The results of Hunt and Hunt (1976a, 1976b) indicated a threshold above which higher growth rates did not increase chick survival. Thus, any factor requiring gulls to make longer foraging trips, such as flying increased distances for food or having to search for less available food, will likely result in lower chick survival.

Dispersal of Young Gulls

Once young gulls fledge from their island colonies, they disperse along the mainland coast. Since 1972, the dispersal of juvenile Western Gulls from natal colonies has been studied by banding chicks prior to fledging and examining return information. The numbers of gull chicks banded on each island are summarized in Fig. III-48.

The dispersal pattern of these young gulls was determined by analyzing U.S.F.W.S. band returns and sightings of colorbanded gulls reported by our staff and the general public. Special censusing trips to dump sites from San Diego to Tejiquas (34.5°N, 120.1°W) provided much of the data (see Appendix 4 for exact locations and dates). The data presented here include observations and reports from August 1972 to May 1978. Part of this information was previously reported by Hunt and Hunt (1974).

Fig. III-47.Growth Rates of Western Gull Chicks

Year	Island				
	Anacapa Island	Prince Is. San Miguel	San Nicolas Island	Santa Barbara Island	Bird Rock Catalina
1972				26.0(73)[1]	
1975		18.2(3)	31.5(11)	29.0(14)	
1976	24.7(3)	18.7(8)	28.8(42)	22.2(82)	29.4(10)
1977		29.9(54)		29.9(115)	
1978				26.2(20)[2]	

(N=number of chicks on which growth rates in grams/day were measured

[1]from Hunt and Hunt, 1976

[2]Hunt, unpublished

Fig. III-48. Numbers of Western Gull Chicks Color-Banded on the Channel Islands through July 1977

Year	Santa Barbara	San Nicolas	San Miguel (Prince Is.)	Anacapa	Bird Rock Santa Catalina	Santa Cruz Gull Is.	Santa Cruz Scorpion Rk.	TOTAL
1972	224	—	—	—	—	—	—	224
1975	143	—	—	—	—	—	—	143
1976	452	446	113	67	22	15	0	1115
1977	377*	380	283	137	7	4	106	1294
Total Color Banded	1196	826	396	204	29	19	106	2776
% Total Color Banded	43.0	30.0	14.0	7.0	1.0	1.0	4.0	

*An additional 514 adult Western Gulls were color-banded on Santa Barbara Island in 1977

A total of 139 observations of colorbanded juvenile Western Gulls were reported. The overall return rate for U.S.F.W.S. bands from the Channel Islands was 3.0%. The recovery rates for the different breeding colonies are shown in Fig. III-49; they ranged from 0% to 5.3%.

The geographic distribution of the recoveries of bands on 1st-, 2nd- and 3rd-year Western Gulls are shown in Figs. III-50 to III-52. In this study, the "first-year" Western Gulls included birds from time of fledging until the following July, at which time they were designated second-year birds and so on. Since the sightings of the colorbanded juvenile gulls were concentrated along the shores of the Southern California Bight where our observers worked, only recoveries of bands reported to U.S.F.W.S. are presented. And, since the dispersal patterns for the individual island populations showed no colony specific patterns, data for all islands were combined.

All juveniles clearly concentrated along the coast; no birds were sighted more than five miles inland, and only one juvenile was seen in open waters west of the Channel. This strict preference for coastal areas is characteristic of this species of gull (Coulter 1977; Devillers et al. 1971). Along the coast, the returns ranged from Shelter Cove, California in the north to Rosarito, Baja California in the south. The majority of the returns were from the Channel Islands area and from the coastline directly east of the islands between San Clemente (33.5°N; 117.7°W) and Ventura (34.25°N; 119.2°W). This was consistent with Coulter's (1977) finding that gulls from the Channel Islands generally did not disperse great distances. Interestingly, the geographic distribution of the different age classes differed markedly. Bands from first-year birds were recovered from a wide range of localities along the California coast, while the distribution of band recoveries from older age classes were progressively more restricted to the Bight.

d. Food Habits

Western Gulls used a wide variety of foods; a detailed list of our findings is presented in Appendix 3. Fig. III-53 summarizes the most important foods fed to Western Gull chicks on those islands where an adequate number of samples were obtained. Generally, over 70% of the diet consisted of fish. Major components of the diet varied from one island to another; squid was of particular importance at Prince Is., surf perch was prevalent at Anacapa Is., and anchovies and sauries were most important at Santa Barbara Island.

Foods taken at each colony varied from year to year. This is not surprising as an opportunist species such as the Western Gull might be expected to shift the composition of its diet with changes in the availability of prey. However, this flexibility in foraging habits does not apparently enable this species to resist a temporary

Fig. III-49. Western Gull Dispersal Data Base

A. USF & WS Bands Recovered 1972 - May 1978

Age	San Miguel Is.	Santa Cruz Is.	Anacapa Is.	San Nicolas Is.	Santa Barbara Is.	Santa Catalina Is.	San Clemente Is.	TOTAL
1st Yr.	4	2	3	10	26	2	0	47
2nd Yr.	6	1	2	8	24	1	0	42
3rd Yr.	0	0	0	0	6	0	0	6
Total Bands Recovered	10	3	5	18	56	3	0	95
Total Birds Banded	551	97	154	881	1393	57	19	3152
% Re-covered	1.8	3.1	3.3	2.0	4.0	5.3	0	3.0

continued . . .

Fig. III-49. (continued)

B. Color-Band Sightings through August 1977

Age	San Miguel Is.	Santa Cruz Is.	Anacapa Is.	San Nicolas Is.	Santa Barbara Is.	Santa Catalina Is.	San Clemente Is.	TOTAL
1st Yr.	9	2	8	26	41	0	0	86
2nd Yr.	6	1	4	19	15	5	0	50
3rd Yr.	0	0	0	0	3	0	0	3
Total Sighted	15	3	12	45	59	5	0	139
Total Banded	369	125	204	826	972	29	0	2552
% Sighted	3.8	2.4	5.9	5.4	6.1	17.2	0	5.4

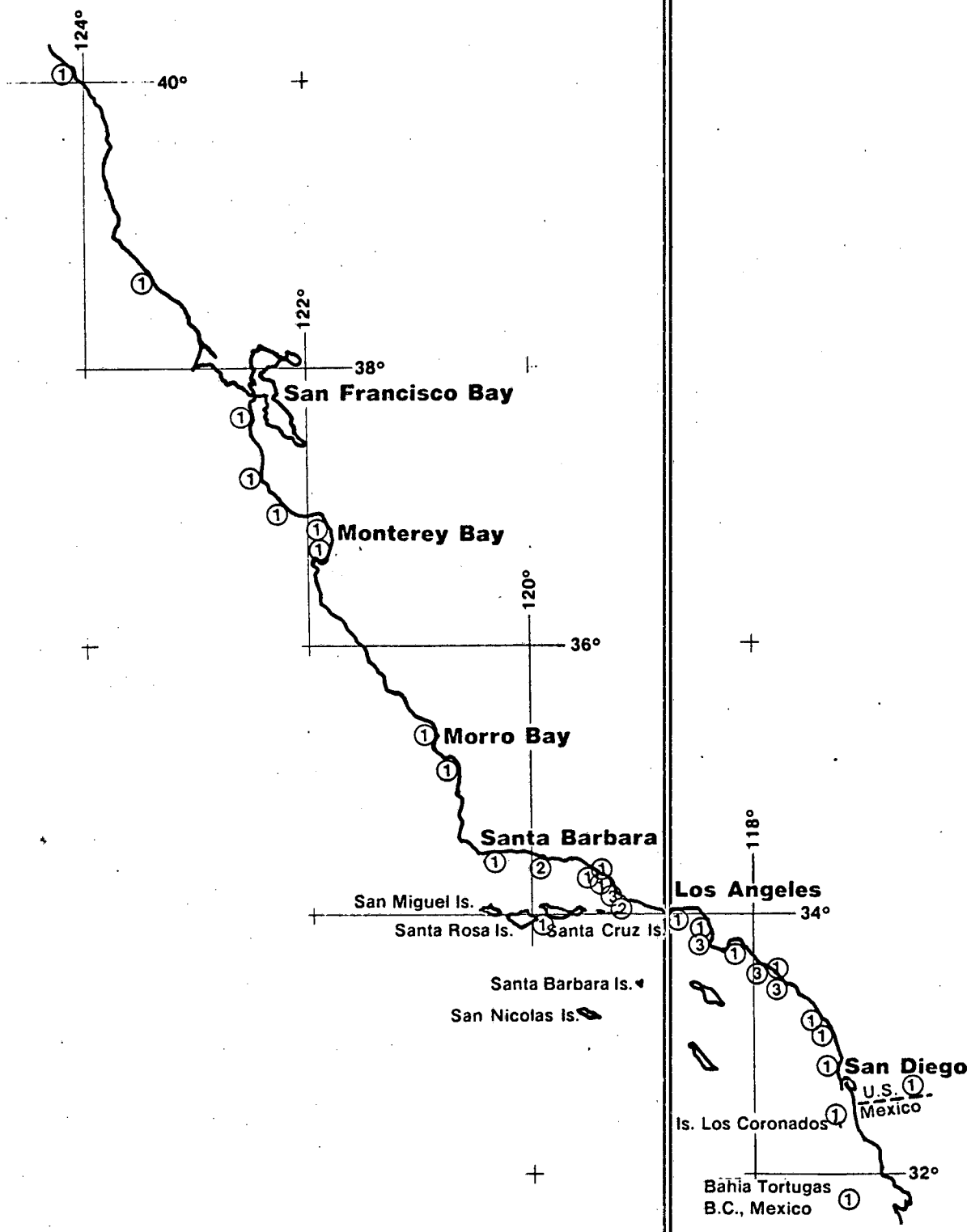


Figure III-50 . Distribution of band recoveries from first year Western Gulls, Channel Islands.

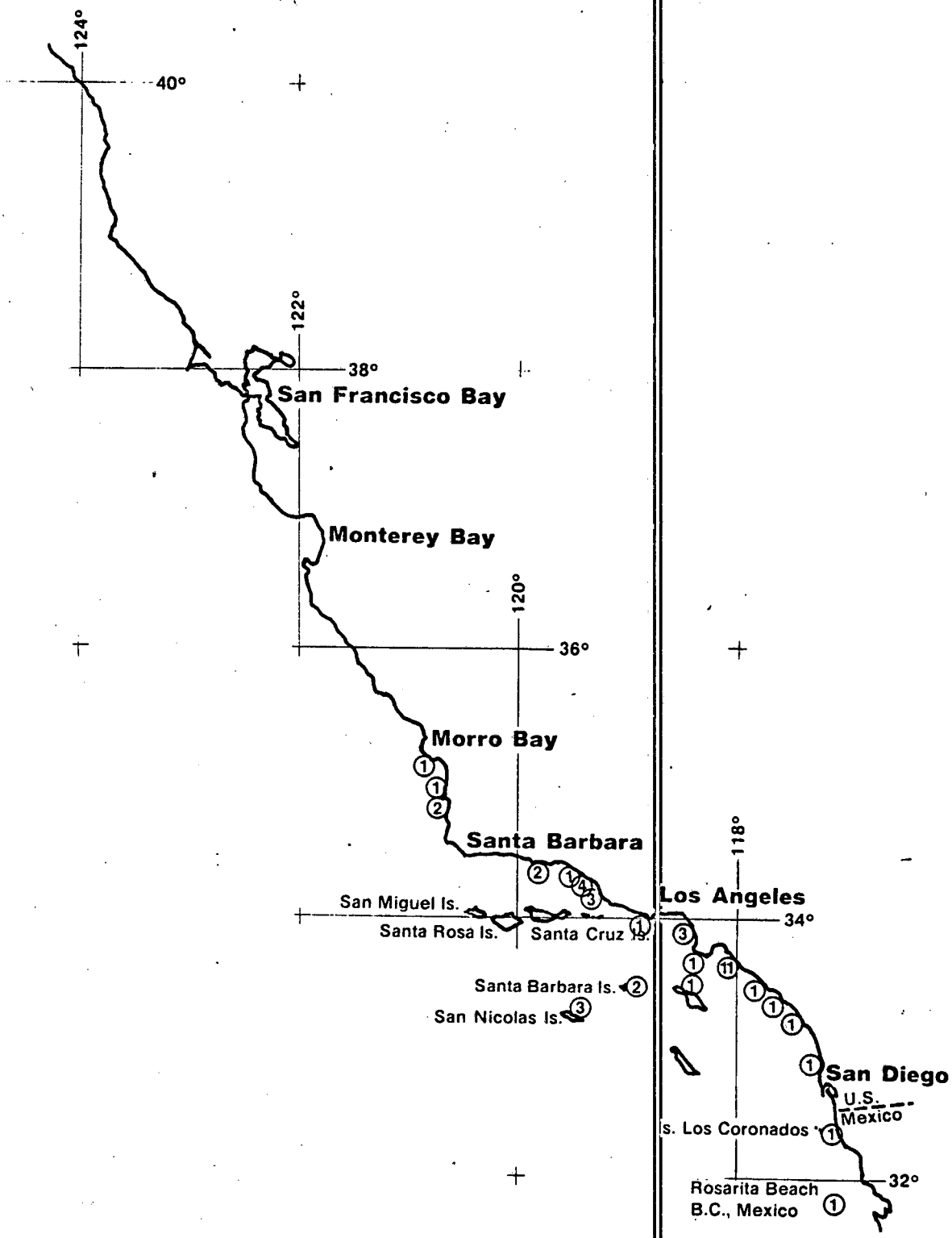


Figure III- 51 . Distribution of band recoveries from second year Western Gulls, Channel Islands.

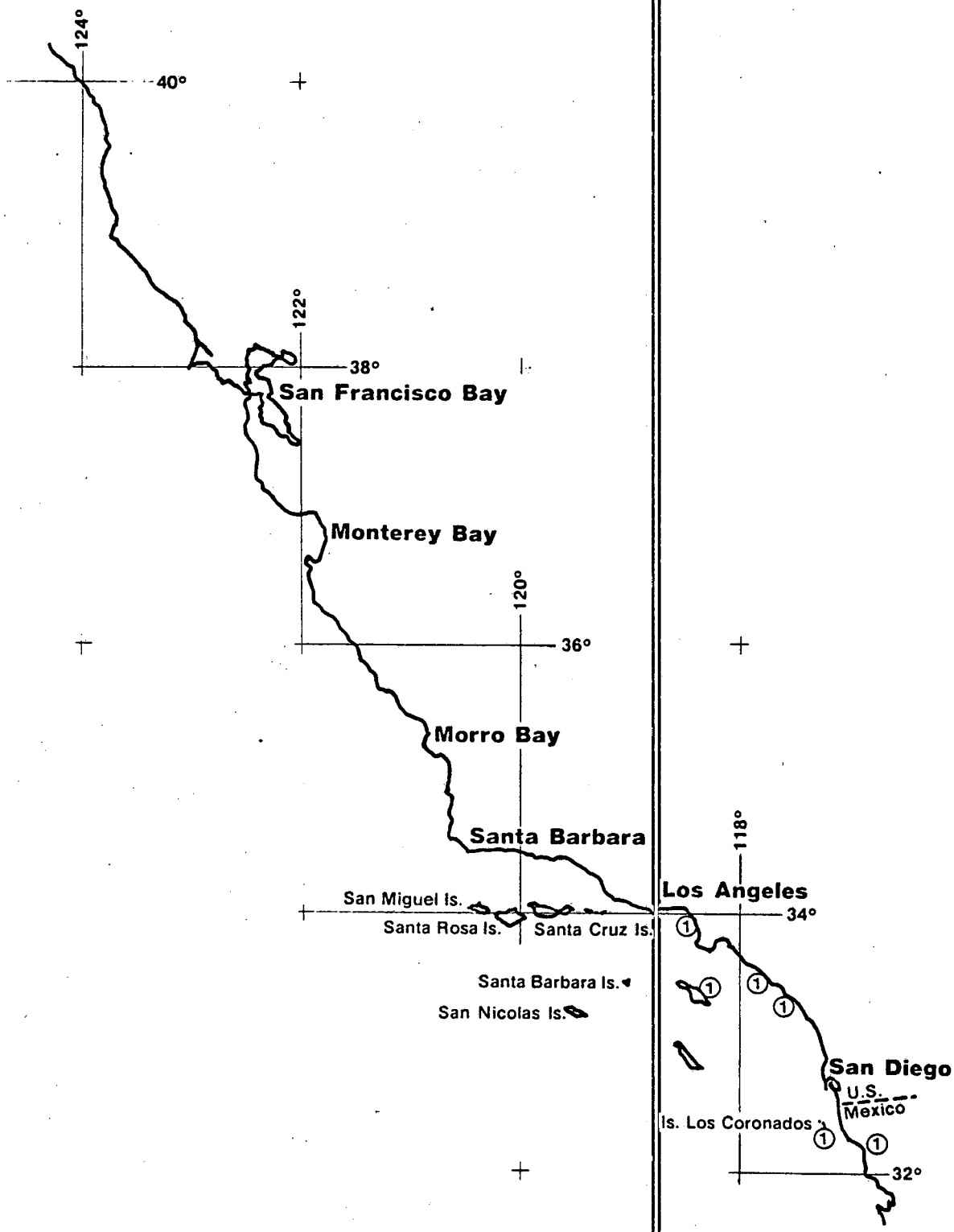


Figure III-52 . Distribution of band recoveries from third year Western Gulls, Channel Islands.

Fig. III-53. Foods Commonly Fed to Western Gull Chicks
1975 - 1977
Percent Occurrence

Island	Prince	San Nicolas	Santa Barbara	Anacapa
N	87	76	250	36
Euphausiacia	0	7	4	0
Cephalopoda	28	16	6	11
Engraulis mordax	5	14	24	11
Cololabis saira	1	1	30	8
Sebastes spp.	14	9	6	17
Perciformes	1	5	2	25
Sea Lion placenta	3	18	4	0
Garbage, offal	7	3	6	14

scarcity in a preferred food. In 1972, Hunt and Hunt found that on days when the percentage of anchovies in the diets of chicks was reduced on Santa Barbara Is., the percentage of empty chicks increased significantly (Hunt and Hunt 1973).

Repeated studies of foods used and of the reproduction effort of gulls on Santa Barbara Is. also demonstrated the linkage between production of young and the availability of a specific food. Fig. III-54 shows the percentage by weight of different kinds of foods used in four years (1978 data are not yet available). In particular, note the steady drop in the use of anchovies, the replacement of anchovies by sauries in 1977, and the reduced use of fish in 1976. The decreased use of anchovies directly parallels a drop in the number of pairs of Western Gulls attempting to breed on Santa Barbara Is. (Fig. III-55). The correlation between numbers of breeding pairs and the percentage of anchovies fed to chicks (an indirect measure of their availability) is statistically significant ($r^2 = 0.987$, $p < 0.01$).

The availability of anchovies, and of fish in general, is correlated with chick growth rates and chick survival, as well. (Fig. III-56; chick survival vs. percent fish, $r^2 = 0.91$, $p < 0.02$; chick growth rates vs. percent fish, $r^2 = 0.95$, $p < 0.01$). Thus, in 1976, when anchovies were not available and there were no sauries to take their place, reproductive success was reduced (also see Reproductive Success for additional affects of weather on chick mortality in 1976). Although data on chick diets for 1978 are not yet available, anchovies, which were scarce early in the season, were reported to be available when chicks were being fed. The relatively high survival and growth rates in 1978 suggest either that fish were not seriously limiting during the chick phase or that survival and growth rates of chicks were high because parents were required to feed, on the average, fewer young (as a result of the widespread hatching failure occurring earlier in the season).

e. Foraging Areas

In order to identify important foraging areas for breeding Western Gulls, an extensive colormarking program was conducted on four of the Channel Islands (Figs. III-57 and III-58; Santa Barbara, San Miguel, San Nicolas and Anacapa Islands). Most of the reported sightings were of gulls colormarked on Santa Barbara Is. or San Miguel Is. (Fig. III-59). The extremely low return rates for San Nicolas Is. and Anacapa Is. were probably due to dyeing difficulties; apparently, the Victoria Green and Azure Blue crystals used on these islands generally failed to penetrate the gull's plumage, and very few birds were permanently marked. The few sightings reported for these islands in 1976 and 1977 are plotted in Figs. III-60 and III-61; no conclusions concerning the foraging patterns of these populations can be made. However, the foraging patterns of breeding Western Gulls from

Fig. III-54. Foods Commonly Fed to Western Gull Chicks
Santa Barbara Island
Percent By Weight

Year	1972	1975	1976	1977
N	157	18	79	153
Loligo opalescens	13	0	4	3
Engraulis mordax	42	32	28	18
Cololabis saira	3	4	7	53
Sebastes spp.	0	0	13	3
All fish	78	81	67	88
Sea Lion placenta	0	4	15	1
Garbage and Offal	0	0	13	3

Fig.55 Number of Western Gull Breeding Pairs on Santa Barbara Island and Percent by Weight Anchovy Fed to Chicks

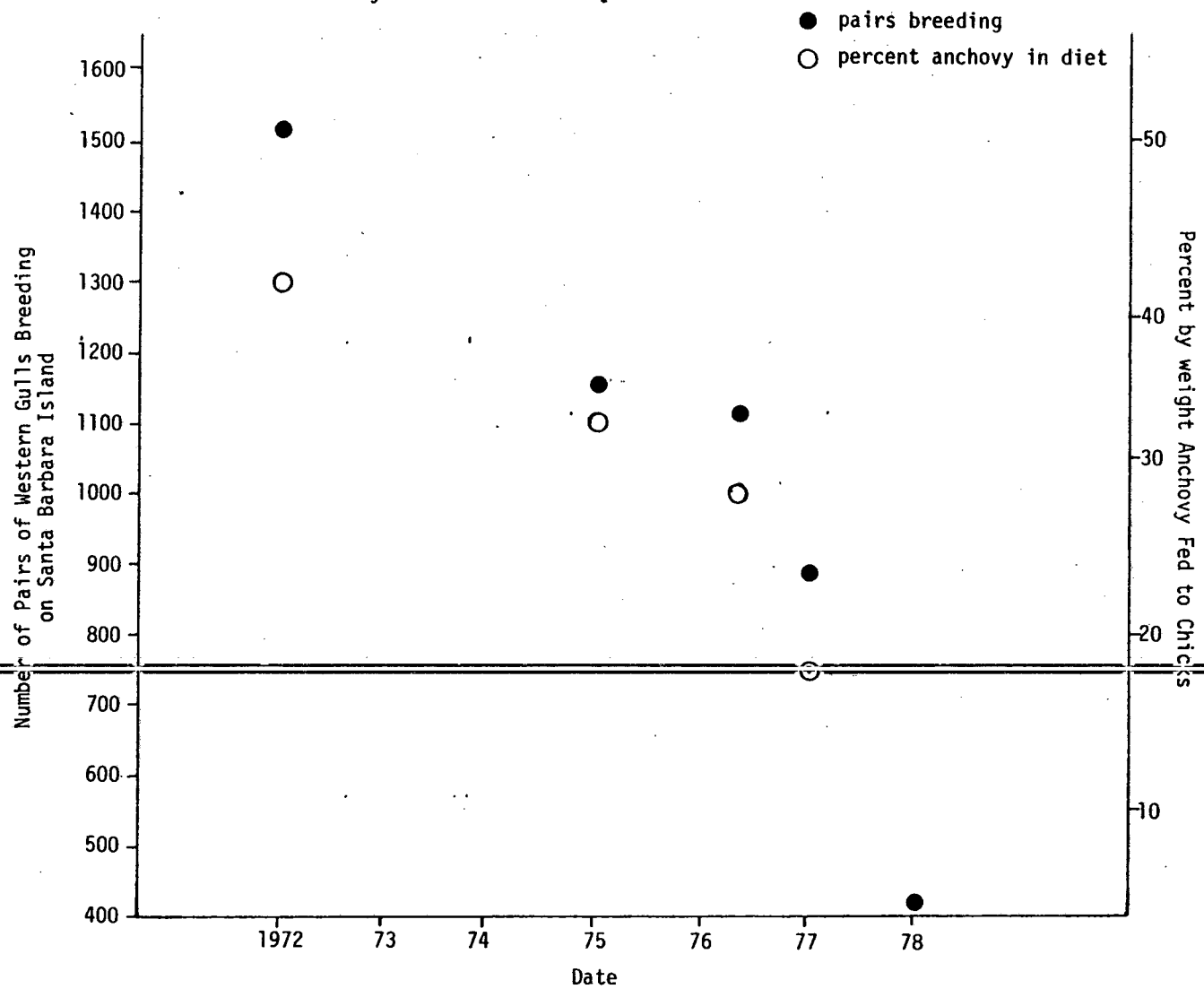


Fig. 56 Relationship of Western Gull Chick Survival and Growth Rates with Percent Fish in the Diets of Chicks; Santa Barbara Island

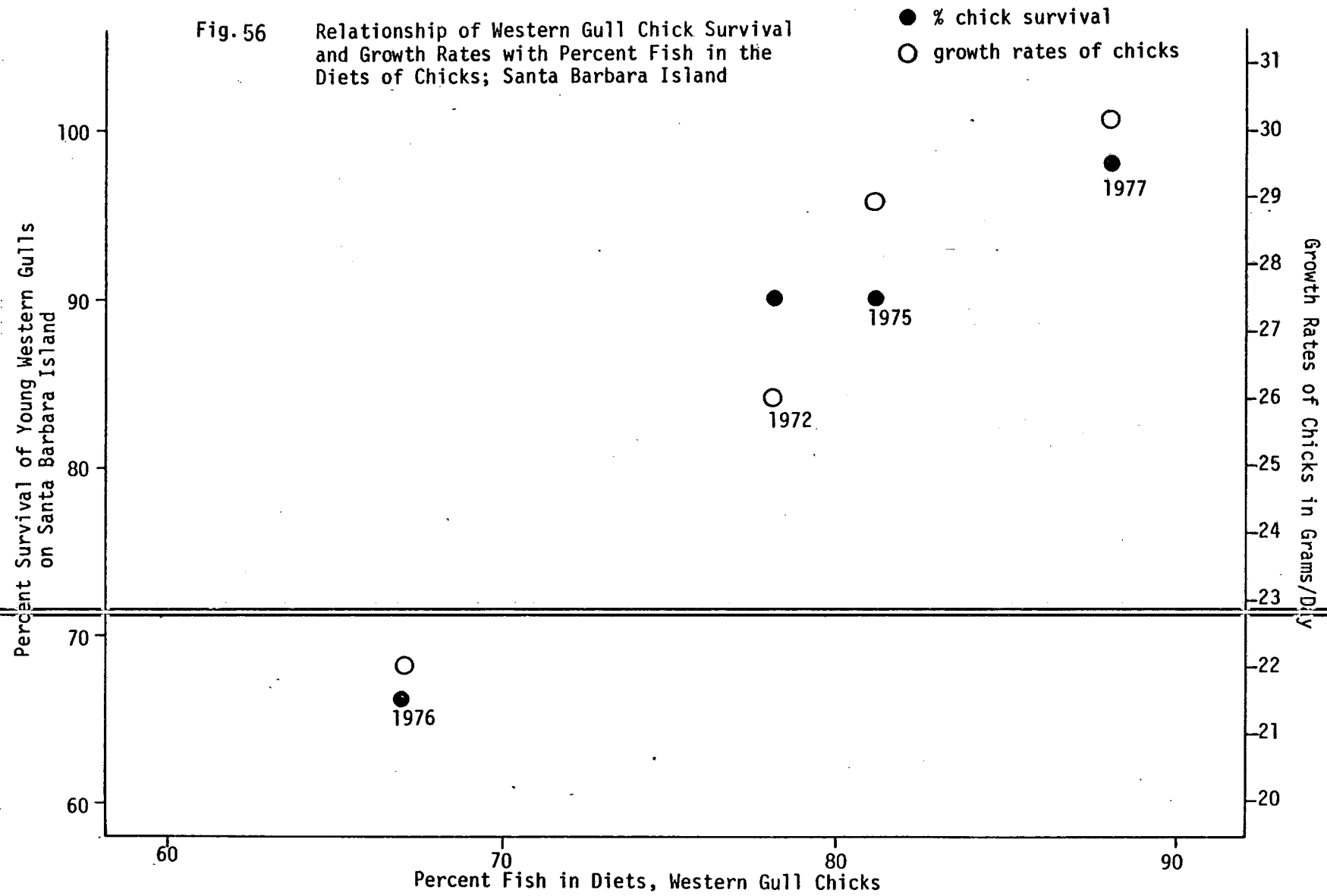


Fig.III-57. Scheme for Color-Marking Adult Western Gulls on the Channel Islands

	Island	Color	Dye Used
1975	Santa Barbara	Red	Rhodamine Red
	San Miguel (Prince Is.)	Yellow/Green	Picric Acid/Victoria Green
1976 and 1977	Santa Barbara	Yellow	Picric Acid
	San Miguel (Prince Is.)	Red	Rhodamine Red
	San Nicolas	Green	Victoria Green
	Anacapa	Blue/Purple	Azure Blue/Purple B Concentrate

Fig. III-58. Numbers of Western Gulls Color-Marked on the Channel Islands, 1975 - 1977

Island	1975 No. of Gulls Dyed	1975 % of Nesting Population Dyed	1976 No. of Gulls Dyed	1976 % of Nesting Population Dyed	1977 No. of Gulls Dyed	1977 % of Nesting Population Dyed
Santa Barbara	850	37.0	423	17.5	304	19.0
San Miguel (Prince)	230	23.0	174	17.4	834	83.4
San Nicolas	0	—	362	19.4	240	13.0
Anacapa	0	—	188	3.8	212	4.0
TOTAL	1080	11.0	1147	11.1	1590	17.0

Fig. III-59. Sighting Rates of Colormarked Western Gulls, Channel Islands, 1976-1977

Island	No. of Gulls Marked	No. of Gulls Sighted	Percent of Marked Population Sighted
1976			
Santa Barbara	423	168	39.7
San Miguel (Prince Island)	174	80	46.0
San Nicolas	362	3	0.8
Anacapa	188	3	1.6
Total	1147	254	22.1
1977			
Santa Barbara	304	5	1.6
San Miguel (Prince Island)	834	14	1.7
San Nicolas	240	0	0.0
Anacapa	212	0	0.0
Total	1590	19	1.2

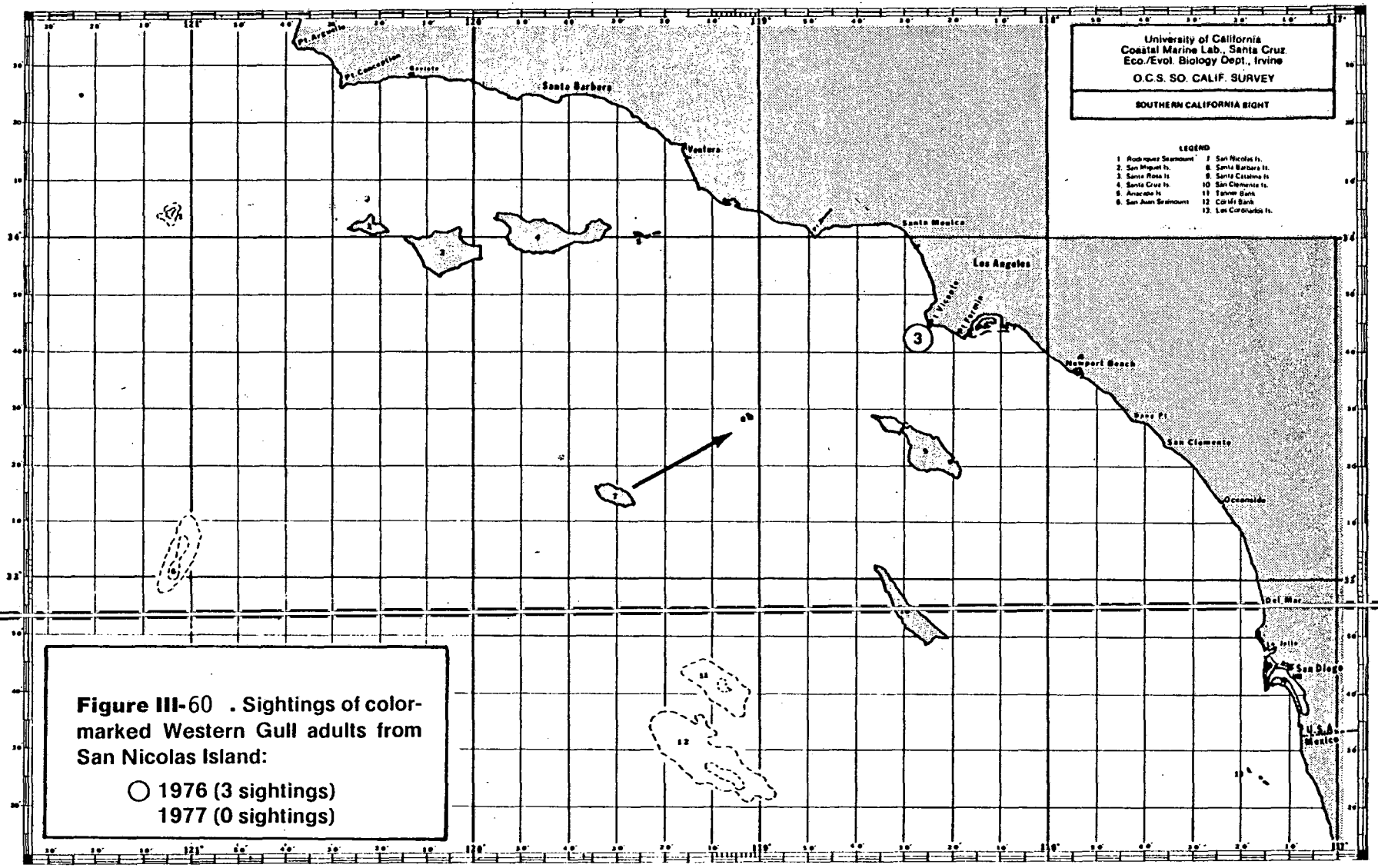


Figure III-60 . Sightings of color-marked Western Gull adults from San Nicolas Island:

○ 1976 (3 sightings)
1977 (0 sightings)

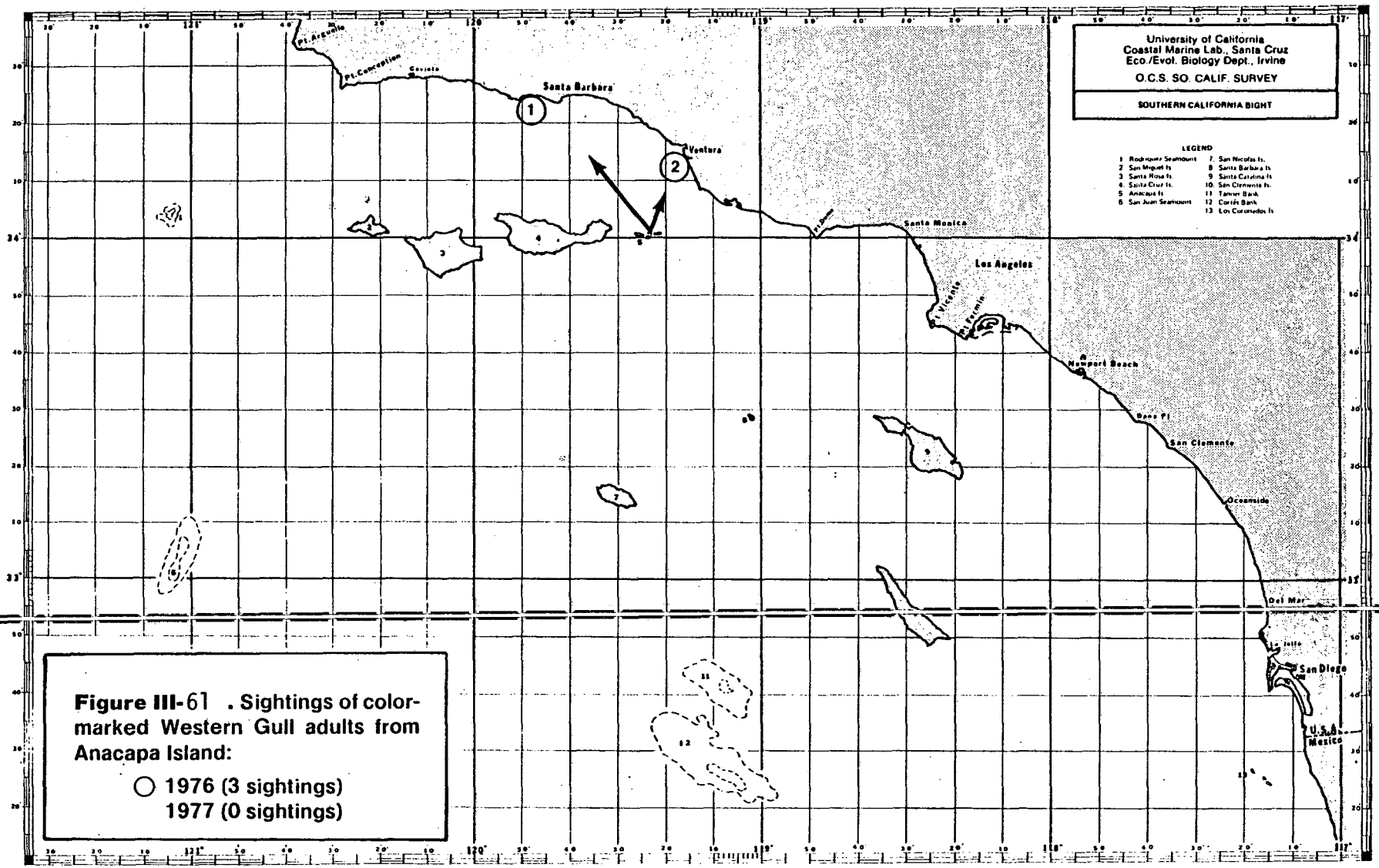


Figure III-61 . Sightings of color-marked Western Gull adults from Anacapa Island:

○ 1976 (3 sightings)
1977 (0 sightings)

Santa Barbara Is. and San Miguel Is., as determined by the distribution of sightings of colormarked individuals, were markedly distinct. Gulls from Santa Barbara Is. foraged and loafed exclusively at the Palos Verdes Dump and the adjacent South Coast Botanic Garden (Fig. III-62). In contrast, the San Miguel Is. gulls dispersed north to the Tejiquas Dump and the Santa Barbara Transfere Station, just north of the city of Santa Barbara (Fig. III-63). Birds from both islands were seen in greatest numbers at coastal dump sites, and both groups preferred the site closest to their nest colony (Fig. III-64). Apparently human refuse sites were a significant coastal resource for nesting Western Gulls in the Channel Islands in 1976; 213 (83.9%) of the 254 colormarked birds seen were observed at dumps. Despite regular censusing, only 22 colormarked gulls were seen at other locations, such as beaches, marinas, piers, harbors, bays or sloughs along the coast in 1976.

In 1977, very few colormarked gulls were sighted on dumps or elsewhere along the mainland coast. As shown by the food samples collected on Santa Barbara Is., sauries were taken in large amounts that year and only a small amount of garbage was used (Fig. III-54). It is likely that gulls foraged on sauries close to the colony in 1977, and few made the long trip to the Palos Verdes Dump.

Interestingly, no colormarked gulls were ever observed south of San Pedro. This may have been due to the limited scope of our effective colormarking program, as large numbers of adult Western Gulls were seen in these southern areas. These areas may have been utilized by breeding birds from islands which we did not mark, such as Santa Catalina, San Nicolas (which was not marked effectively), San Clemente and/or Los Coronados Islands.

The distribution of the colormarked gull sightings in the SCB did not vary throughout the two observation periods (26 May to 28 August 1976 and 11 May to 24 June 1977); the gulls consistently concentrated in the same places. However, the number of colormarked individuals sighted from visit to visit at a given location fluctuated greatly. A decline in the numbers of colormarked gulls was observed towards the end of August 1976. This decline undoubtedly reflected two factors: 1) a decrease in the visibility of the markings as the dye faded and the birds molted, and 2) the dispersal of the birds from the islands.

In 1975, a limited marking effort on Santa Barbara Is. resulted in a modest number of sightings of marked gulls at the South Coast Botanic Garden by the public. The sightings were numerous during the incubation phase but abruptly ceased when chicks began hatching. It is not clear at present whether the shift in foraging activity between the incubation and chick stages in 1975 was related to changing needs of adults switching to feeding young, or if previously unavailable fish stocks became exploitable at this time.

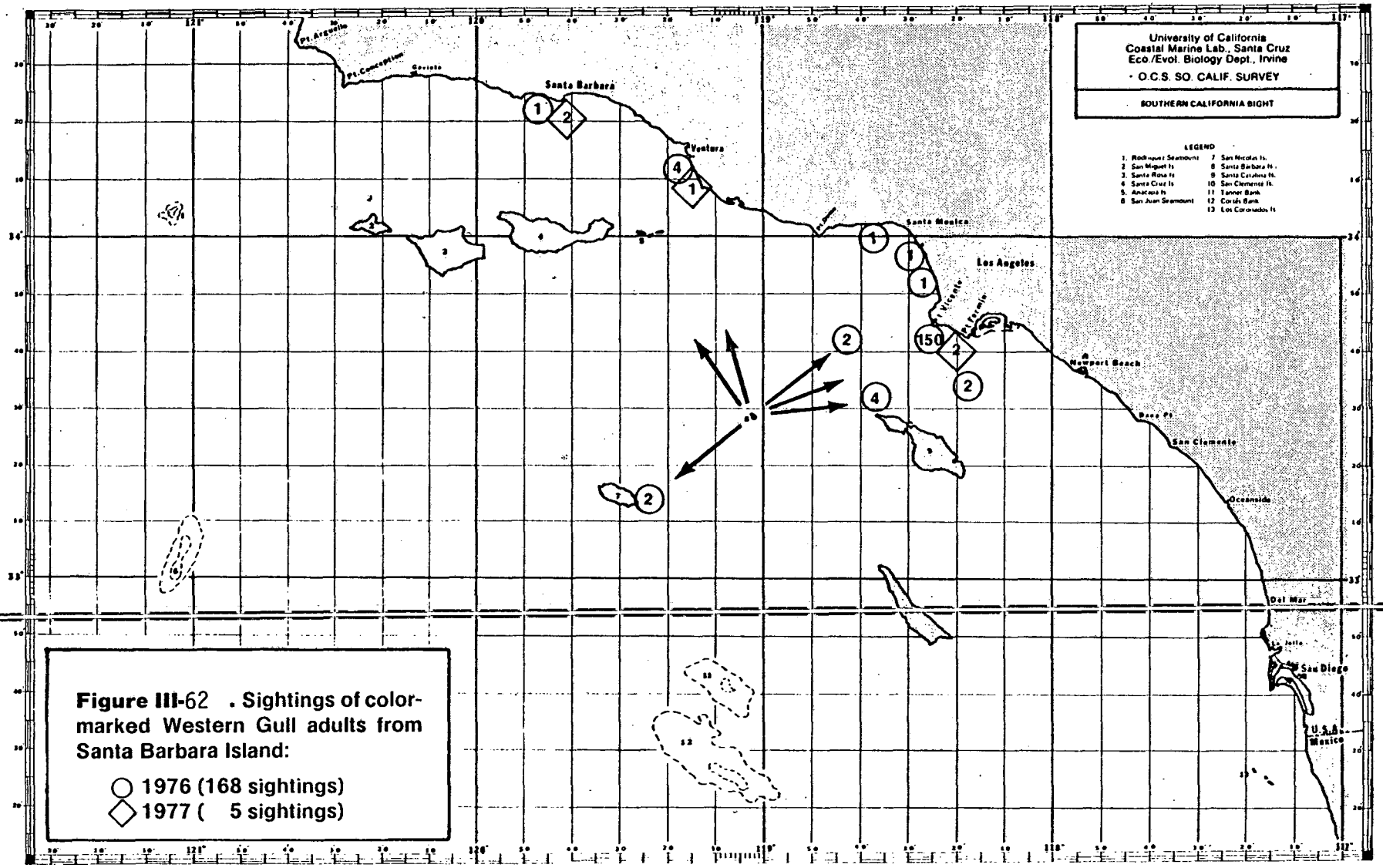


Figure III-62 . Sightings of color-marked Western Gull adults from Santa Barbara Island:

○ 1976 (168 sightings)
◇ 1977 (5 sightings)

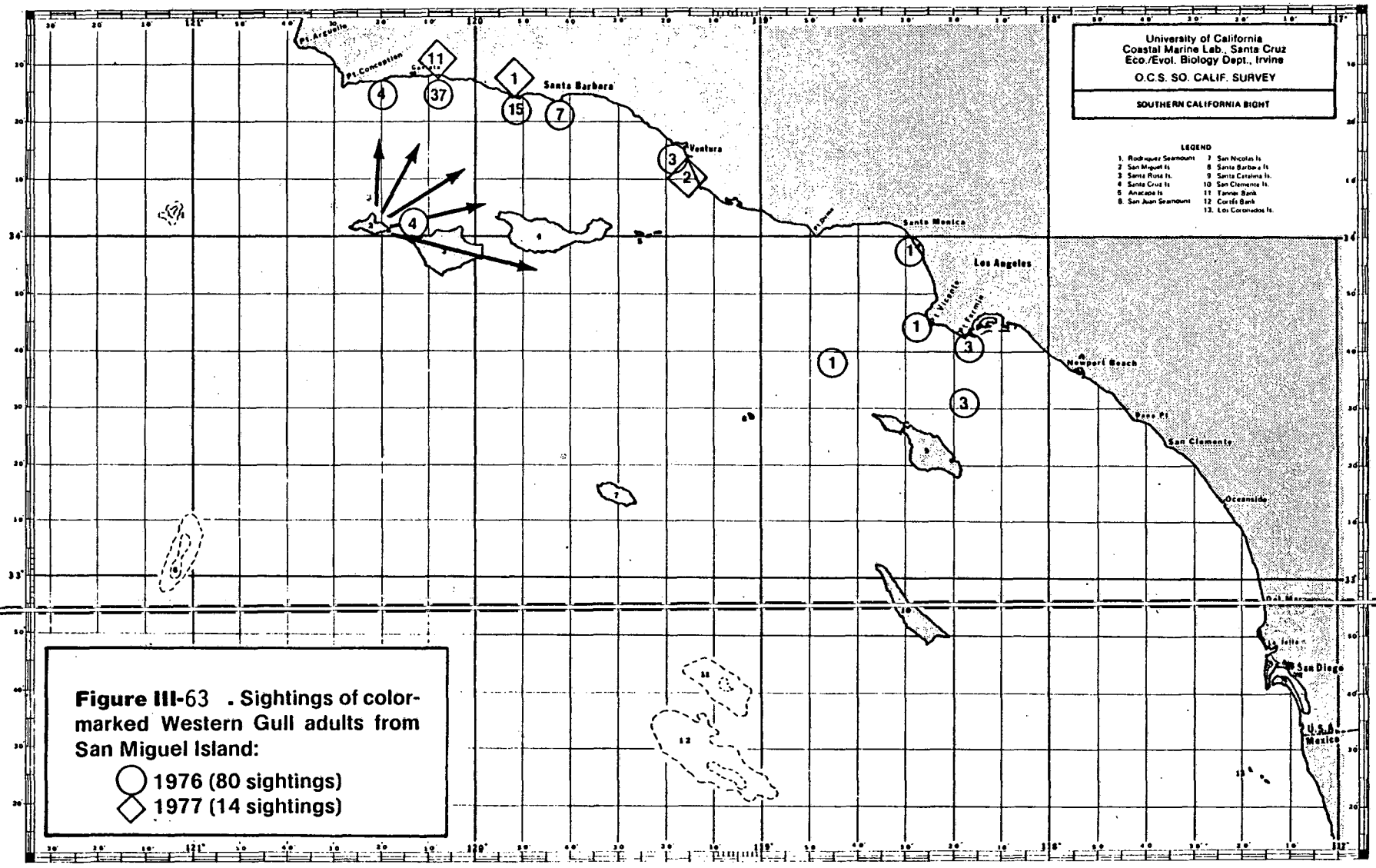


Figure III-63 . Sightings of color-marked Western Gull adults from San Miguel Island:

○ 1976 (80 sightings)
◇ 1977 (14 sightings)

Fig. III-64. Numbers of Colormarked Western Gulls Sighted at Different Coastal Habitats*, Channel Islands, 1976-1977

1976	Number of Gulls Sighted at:				
Island	Closest Dump Site	All Dump Sites	Non-dump Mainland Sites	At Sea/ Near Islands	Total Sighted
Santa Barbara	150 (89.3)	154 (91.7)	4 (2.4)	10 (6.0)	168
San Miguel (Prince Is.)	37 (46.3)	54 (91.7)	17 (21.3)	9 (11.3)	80
San Nicolas	0 (0.0)	3 (100.0)	0 (0.0)	0 (0.0)	3
Anacapa	2 (66.7)	2 (66.7)	1 (33.3)	0 (0.0)	3
Total	189 (74.4)	213 (83.9)	22 (8.7)	19 (7.5)	254
1977					
Santa Barbara	2 (40.0)	3 (60.0)	2 (40.0)	0 (0.0)	5
San Miguel (Prince Is.)	11 (78.6)	11 (78.6)	3 (21.4)	0 (0.0)	14
San Nicolas	0	0	0	0	0
Anacapa	0	0	0	0	0
Total	13 (68.4)	14 (73.7)	5 (26.3)	0 (0.0)	19
Grand Total	202 (74.0)	227 (83.1)	27 (9.9)	19 (7.0)	273

*The numbers in parentheses ( ) are the calculated percents of total sightings from that island.

Western Gull: Foraging Areas (continued)

In addition to the colormarking program, attempts were made to learn more about the foraging patterns of breeding Western Gulls using radiotelemetry (see Appendix 2 for methods and details of results). In total, 20 breeding adults were captured, harnessed with transmitters and released. The data suggested that adult Western Gulls spend a lot of time in the immediate vicinity of the breeding colony and forage in inshore waters. It is felt, however, that the behavior of the harnessed gulls may have been atypical and thus of limited usefulness.

In summary, these data on foods and foraging areas all support the hypothesis that Western Gulls prefer to forage on a variety of fish close to their colonies. They will vary their diet, presumably opportunistically, taking the most available items. Apparently, garbage is not a preferred food type, either because of its low nutritive value relative to fish (Hunt 1972) or because long trips are required to forage at dumps. For Santa Barbara Is., where we have adequate data, reduced availability of preferred food items (especially anchovy and saury) resulted in reduced reproductive success.

Common Murre (*Uria aalge*)

a. Introduction

The Common Murre is a boreal, low-arctic species that nests on sea cliff ledges on islands and coastal headlands. Colonies are found in the north Atlantic, the eastern Arctic and the north Pacific from Japan to California, including the Bering Sea (Tuck 1960). Of eight subspecies listed by Tuck (op cit), only one, *U. a. californica*, breeds in California. Nesting murres formerly occurred as far south as San Miguel Is., but the southernmost colonies are presently Devils Slide, Castle Rk. and Hurricane Pt., near Big Sur (Osborne and Reynolds 1971).

b. Historical and Present Breeding Status in the Channel Is.

Common Murres bred in the Channel Islands until 1912 but have not been recorded breeding there since. Nesting was documented only on Prince Island. The W.C. Bradbury collection contains eight sets of eggs taken on 24 June 1885 (WFVZ 4377-4386). Streator (1888) visited Prince Is. in late July one year later, but murres are conspicuously absent from his apparently complete list of nesting marine birds on the island (nocturnal nesters generally excepted). H.C. Burt (Peyton, unpubl. notes) took at least 13 egg sets on 5 June 1905. Hendrick and Appleton took between 20 and 50 sets in June 1906 (WFVZ 76219-76224; WFVZ uncat.; Appleton, unpubl. notes) and found "two or three colonies of from 5 to 50 each nesting on the island". Willet (1910) found about 100 pairs of murres breeding on a precipitous cliff on Prince Is. on 15 June 1910, and his party collected at least 29 sets of eggs (WFVZ 6172-6174, 32113, 32114, 76217, 76218, WFVZ uncat.; DM 1226, 1231). Wright and Snyder (1913) found "several small colonies of these birds on the high overhanging ledges" on 12 July 1912. "Numerous young" were present at that time, and at least four egg sets were collected (WFVZ uncat.). According to Willet (1933), Pemberton visited the island on numerous occasions in years prior to 1933 but found no murres. He believed they no longer bred there. When Sumner (1939) and Bond surveyed the island on 18 April 1939, they found only one bird on the island but were hopeful a colony still survived. To our knowledge, however no breeding birds have been seen there since.

No Common Murres were found breeding at Prince Is. or any of the other Channel Islands during 1975, 1976 or 1977. On 22 May 1976, an adult murre was seen flying off the precipitous cliffs of the northwest side of Prince Island. However, this individual was not seen on subsequent trips. The only other sighting of a murre associated with the islands was one oiled bird seen on the intertidal rocks of Prince Is. in 1977.

Common Murre: Historical and Present Status (continued)

The disappearance of nesting Common Murres from the Bight parallels the disappearance of the Tufted Puffin, which is another large alcid which once had its southernmost nesting colonies in the Channel Islands. Ainley and Lewis (1974) have attempted to correlate the decline of the Tufted Puffin in California with the demise of the Pacific Sardine during the 1940's. As Common Murres were already absent by the late 1920's, other factors were undoubtedly responsible for their disappearance. Since the tiny colony at Prince Is. was so far south of the nearest murre colony at Big Sur, it seems likely that repeated visits by early egg collectors, coupled with the slim possibility of recruitment from other colonies, could have eliminated murres as a breeding species from the Bight. However, the possibility of climatic changes cannot be discounted.

Pigeon Guillemot (Cepphus columba)

a. Introduction

Pigeon Guillemots breed throughout the Bering Sea region, across the Aleutian chain, and south to Southern California (Udvardy 1963). The southernmost breeding colony in the Eastern Pacific Ocean is at Santa Barbara Is. in the Channel Islands. However, individuals have been seen at least as far south as Islas Los Coronados, off Northern Baja California (Jehl 1977; D. Povey, pers. comm.).

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

Willet (1910) reported guillemots breeding commonly around the San Miguel Is. area in the summer of 1910. At least four egg sets were collected from San Miguel Is. proper by Willet's party between 9 and 23 June (WFVZ 6167; WFVZ uncat.; DM 3399, 3400). Wright and Snyder (1913) merely mention that "numbers were seen entering low caves on Prince Island" on 12 July 1912. Sumner (1939) and Bond saw several off of San Miguel Is. but did not report seeing any at Prince Is. (possible oversight). The first estimates of breeding numbers were provided by Craig and Sheppard (unpubl. notes), who estimated 200 pairs at Prince Is. in 1965. Crossin and Brownell (1968) visited the area on 15 May 1968 and noted small numbers offshore around Prince Is., Castle Rk., and San Miguel Is. adjacent to Prince Island. They also reported a single incubating bird on Castle Rock. Huber (1968) was at San Miguel Is. from 28 May - 7 June 1968. His population estimates were as follows:

San Miguel Is.: 40 ± 5 active nests in the Bay Pt. area (east of Cuyler Harbor) with two nests found. 70 ± 5 active nests between Bat and Hare Rocks.
Prince Is.: Maximum 200 individuals.
Castle Rk.: 30 individuals noted.

Present Status - The secretive nature of guillemot nesting habits made estimation of colony size difficult. As small fluctuations in nesting numbers were almost impossible to detect and since no gross changes in numbers or colony location were noticed during the three years of study, a single estimate of the breeding population at each major colony site is given. On San Miguel Is. proper, approximately 200 pairs nested: 140 from the Bat Rk. area north to Harris Pt. and 60 in the Bay Pt. area east of Cuyler Harbor. At Prince Is., 150 pairs nested, and another 100 pairs bred on Castle Rk. (Fig. III-65). However, wide fluctuations were noted in the number of guillemots that foraged in the waters immediately adjacent to these last two locations. For example, on 22 May 1976, 656 guillemots were recorded during an inshore survey of Prince Is.; on 9 June only 199 were present. The total population of Pigeon

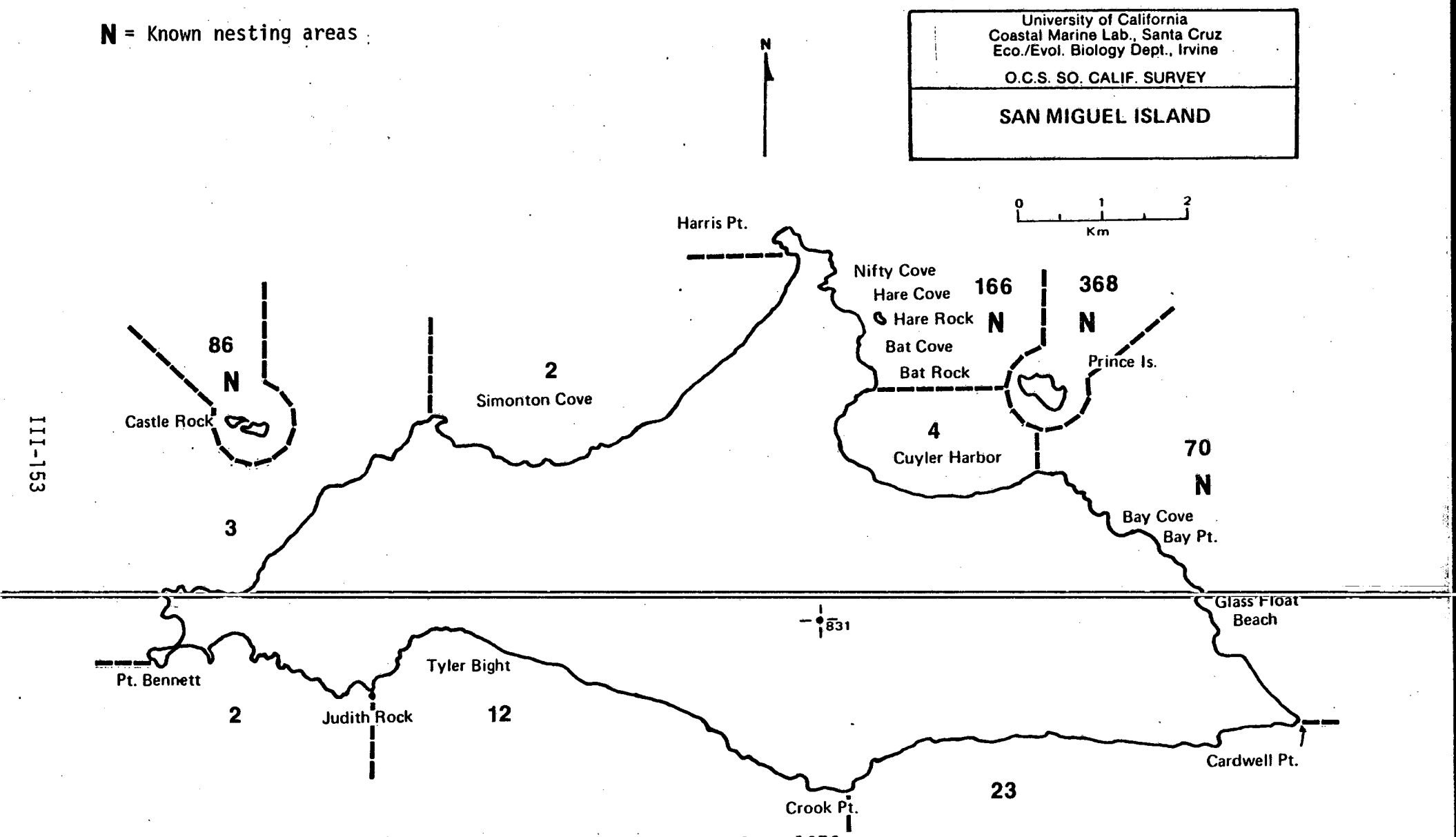


Figure III-65. Pigeon Guillemots at San Miguel Is., May-June 1976.

Guillemots in the San Miguel Is. area was estimated to be 450 pairs.

Santa Rosa Island

Locations and numbers of breeding Pigeon Guillemots have never been clearly defined at Santa Rosa Island. This species was recorded as a "common resident" by Willet (1912). Twelve individuals were seen there between 12 and 15 July 1968 (Diamond, unpubl. notes). Thirty birds were counted in Beechers Bay on 6 August 1973, three were seen at the mouth of Lobo Canyon on 7 August 1973, and four were seen in the same area on 25 April 1974 (Jones, unpubl. notes). However, none of these counts were representative of the island's breeding population; they were surveys of small segments of coastline only.

Present Status - Nesting at Santa Rosa Is. was restricted to the north side and east end of the island with the vast majority of nests occurring between the Sandy Pt. area and Carrington Pt. (Fig. III- 66). The minimum island population was estimated at 125 pairs.

Santa Cruz Island

Streator (1888) visited Santa Cruz Is. in 1886 and collected several Pigeon Guillemots. A year later, Blake (1887) found them common along the rocky shores of the north side of the island and suspected they bred there. Linton (1908) reported that, according to fishermen, guillemots bred at Painted Cave along the northwest coast. Later, Wright and Snyder (1913) found guillemots breeding "in considerable numbers at the Painted Caves at Santa Cruz". During this trip, Snyder collected a single rotten egg (WFVZ uncat.) from the island. Bent (1919) also mentions guillemots breeding at Painted Cave. In March/April 1926, Ross (1926) found guillemots commonly using caves along the north side of the island, and Stevens collected one egg each on 24 June 1945 and 26 May 1946 (SBMNH uncat.) from unspecified locations. More than thirty pairs of guillemots were found nesting in a sea cave in early August 1960 by D. Blietz (Small 1960), and Huber (UA uncat.) collected seven guillemots from a colony of about 25 pairs in a cave along the northeast coast of the island in 1968.

Present Status - Pigeon Guillemot breeding was restricted mainly to the west end of the north side of Santa Cruz Island. They were by far most abundant between Arch Rk. and the Fraser Pt. area. Guillemots also nested fairly commonly at the east end of the island in the area of Scorpion Harbor (Fig. III-67). On 25 June 1976, an hour was spent exploring Painted Cave, on the north side. Numerous guillemots were roosting in the shelf areas inside the cave, but only a single nest was found. Guillemots probably also nested on Scorpion Rk. in all three years (1975-77). The best census was made on 23 June 1977, when a single nest was found and four pairs were estimated for the entire rock. Three additional nests were

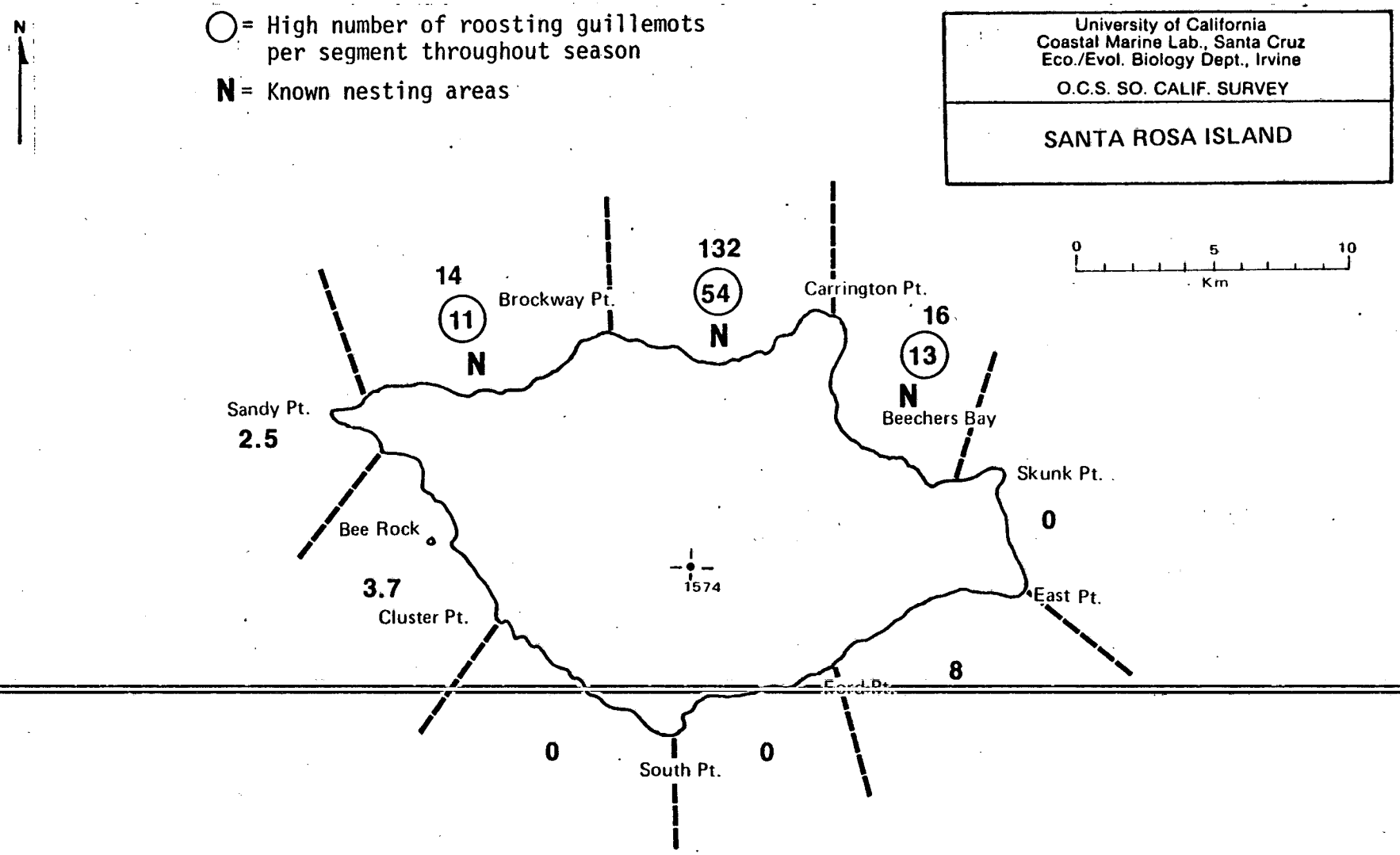


Figure III-66. Pigeon Guillemots at Santa Rosa Island, June-July 1976.

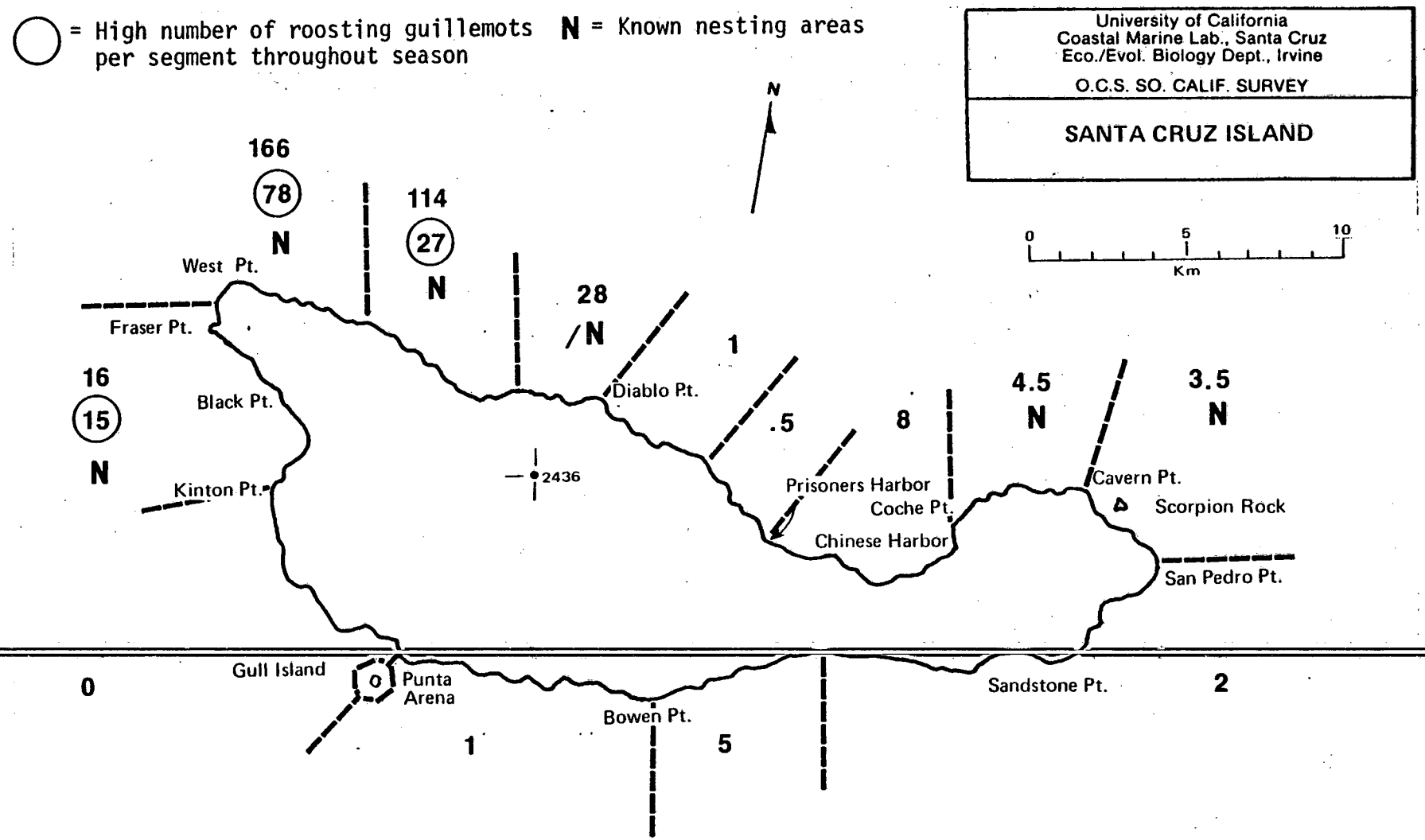


Figure III-67. Pigeon Guillemots at Santa Cruz Is., May-July 1976.

found on the mainland immediately adjacent to Scorpion Rk. on the same day. The entire breeding population of Santa Cruz Is. was estimated to be a minimum of 200 pairs.

Anacapa Island

Pigeon Guillemots have apparently bred only sporadically on Anacapa Island. Evermann (1886) was the first to suggest guillemots were nesting there. When Wright and Snyder (1913) surveyed the birds of Anacapa Is. on 5 - 6 July 1912, they found a pair of guillemots near the east end of the island and three nests in caves at the west end. Dickey (in Howell 1917) found guillemots "nesting in almost every tidal cave" and collected one egg set (WFVZ 63122) on 22 June 1913. Badger (1917), Peyton (unpubl. notes) and Hanna (unpubl. notes) found seven nests (possibly nine) in a cave at the west end on 27 May 1917 and collected two sets of eggs. Badger (unpubl. notes) also took a set (WFVZ uncat.) on 14 May 1927. Sumner (1939) saw several guillemots in April 1939, and twelve birds were reported from the island on 22 May 1944 (Small 1955). However, Banks (1966 and unpubl. notes) saw none in 1963, 1964 or 1965, and Crossin and Brownell (1968) did not mention seeing guillemots in their accounts. Jones (unpubl. notes) felt several pairs were breeding at Anacapa Is. in 1973, but he found only one bird on 26 May 1974.

Present Status - An estimated five pairs of guillemots bred regularly at Anacapa Is., probably along the north side of West Anacapa Island. On 23 June 1977, nine were seen roosting on the north side of the west island; this was the highest number of guillemots seen on land during the three-year study. However, it is still likely that only about five pairs bred here in 1977. During the 1977 season, a guillemot was seen in the middle of the Anacapa passage flying from the direction of Anacapa Is. toward Santa Cruz Is. with a fish in its mouth. This may indicate that some birds nesting on Santa Cruz Is. foraged around the Anacapas.

Santa Barbara Island

Pigeon Guillemots have been recorded for at least 12 separate years on Santa Barbara Is. prior to 1975 and have probably bred there every year. Grinnell (1897) found guillemots common around Santa Barbara Is. in May 1897. Two specimens and four egg sets (incl. MVZ 404) were collected on the north side of the island at that time. Guillemots were collected at Santa Barbara Is. in 1899 (CAS 34682, 38791, 38792); 1909 (UCLA 7694; SU 9037-9040) and 1912 (UCLA 11101). On 3 July 1912, Wright and Snyder (1913) observed birds carrying food into caves on the northern part of the island. Specimens were collected in 1920 (LACM 4599) and 1939 (LACM 50444), and Sumner (1939) saw "several" in April 1939. Guillemots were also present in 1960 (Small 1960), 1967 (DeLong 1967) and 1968 (Diamond, unpubl. notes; Jones, unpubl. notes), though in the latter year Crossin and Brownell (1968) did not mention seeing them during their mid-May

visit. Hunt and Hunt (1974) noted 48 birds on 2 July 1972. On 1 June 1973, Jones (unpubl. notes) counted 50 individuals. He returned the next year and found 60 guillemots on 29 June and 5 July (Jones, unpubl. notes), while Jehl (1974) found 25 pairs of guillemots nesting in July 1974. Apparently few investigators visiting Santa Barbara Is. between March and July have failed to find this species, and the population seems to have remained fairly stable throughout the years.

Present Status - Three areas of Santa Barbara Is. contained the majority of the nesting guillemots: The north side of Sutil Is. (ca. 15 pairs), the Webster Pt. area (ca. 12 pairs), and the Lighthouse area just west of Arch Pt. (ca. 12 pairs). In addition, about 4 pairs bred at Elephant Seal Cove, and 1 - 2 pairs nested in caves just south of Landing Cove. As others were doubtless missed, the breeding population was estimated to be approximately 60 pairs. The highest number of guillemots seen during inshore surveys around the island was 81 birds on 17 July 1976.

San Nicolas Island

Evermann (1886) reported that Pigeon Guillemots were "Rather common about the Santa Barbara Islands; most numerous on San Nicolas, where it breeds". (All his information on the Channel Islands appears to be secondhand, though.) Davie (1898) and Wheelock (1904) both state that guillemots bred at San Nicolas Island. Willet (1912) reported "On June 26, 1911, I saw three birds [guillemots] at San Nicolas Island, where they were probably breeding". Despite these accounts there are no substantiated records of guillemots breeding on San Nicolas Island.

Present Status - No Pigeon Guillemots were found breeding at San Nicolas Is. during this study. None were seen during repeated aerial surveys in 1975-77, and none were seen during a walk of the entire periphery of the island in May 1977. It is very doubtful that any potential nesting sites for guillemots on the island would be safe from the resident foxes.

San Clemente Island

Cooper's (1870) collected specimen is the only known record of this species on San Clemente Island. There are no known records of breeding.

Present Status - Pigeon Guillemots were not found to breed on this island in 1975-77 either by our personnel or by Public Works employees conducting resource management studies on the island (J. Larson, pers. comm.). Three birds in winter plumage were seen off the island on 1 September 1976.

Santa Catalina Island

Grinnell's (1902) casual statement that Pigeon Guillemots breed "at numerous points along the coastline and islands south to Santa Catalina Island" appears to be the only, if somewhat equivocal, indication that guillemots have ever bred there.

Howell (1917) saw them there in April but did not report breeding. No Pigeon Guillemots were seen in the water around Santa Catalina Is. during 1975-77, and undoubtedly they do not breed there.

Despite the somewhat fragmentary nature of the historical record, Pigeon Guillemot numbers and distribution seem to have changed very little in this century. Major colonies persist in San Miguel, Santa Rosa, Santa Cruz and Santa Barbara Is. areas.

c. Breeding Biology

Habitat

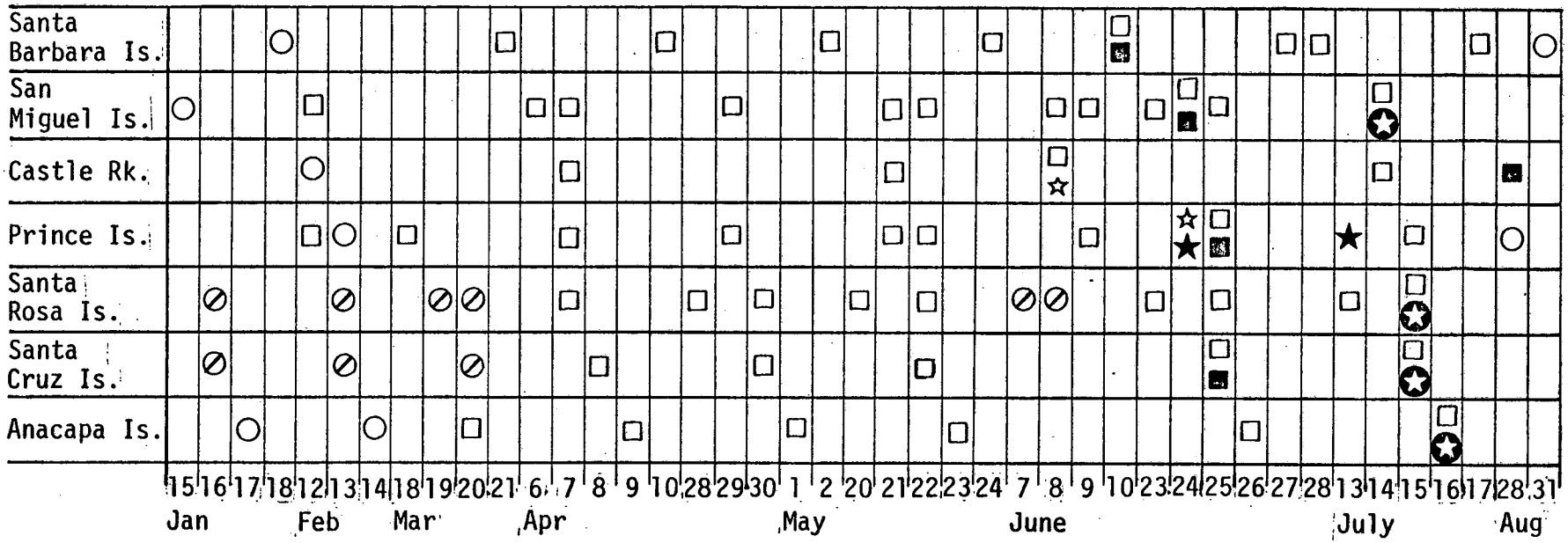
Pigeon Guillemots invariably nested on the northern, exposed sides of islands in sea caves and in grottos often damp with sea spray. Eggs were laid directly in a shallow depression in rocky substrate or loose dirt; occasionally a small amount of gravel was arranged into a nest.

Phenology

Pigeon Guillemots were completely absent from the Southern California Bight during the winter months, but returned in the spring to breed (Fig. III- 68). The first returning guillemots in 1976 were seen at San Miguel Is., in breeding plumage, on 12 February. In 1977, guillemots were first seen on 19 March around the islands of Santa Rosa and Santa Cruz. By the time we arrived at Prince Is. on 21 March, several hundred were present, including some roosting on the island. Courtship behavior was observed on the water at Santa Barbara Is. throughout April and May, with the peak in mid and late April of 1976.

The best information on timing of nesting was obtained on Santa Barbara Is. in 1977; seven nests were followed. Clutches were started between 18 April and 27 June; hatching occurred between 18 May and 27 June. Five of the seven clutches were initiated during the first two weeks of May and hatched in the first two weeks of June. Chicks at two nests examined had full-length wing feathers by 30 - 35 days of age and another brood of two chicks fledged in the same number of days. Thus, peak fledging would have occurred during early and mid-July.

On Prince Is., eggs were present from at least 3 May (1977)



LEGEND:
- ○ None seen--complete survey
- ⊘ None seen--partial survey
- □ Adults present
- ■ Adults carrying food
- ☆ Eggs
- ★ Chicks
- ✪ Fledglings

Figure III-68. Breeding phenology of Pigeon Guillemots in the Channel Islands, 1976.

until 24 June (1976). Chicks were present from at least 5 June until 24 July, when downy young were still at the nest. Peak hatching apparently occured around the middle of June, hence the peak fledging period was in the last half of July (Fig. III- 69).

Observations made at other colonies conformed to the time tables documented on Santa Barbara and Prince Islands. Four nests checked at Castle Rk. on 8 June 1976 had two eggs each. A nest at Scorpion Rk. on 19 May 1977 had two recently hatched chicks. Guillemots near fledging age were seen at Scorpion Rk. on 23 June (1977) and at Painted Cove, Santa Cruz Is. on 25 June (1976). However, chicks were probably still present on Castle Rk. as late as 28 August (1976), for an adult was seen carrying food into a cave at this time. Figure III- 70 summarizes timing of breeding events for Pigeon Guillemots in the Channel Islands for 1976 - 1977.

Reproductive Success

Drent (1965) found that Pigeon Guillemots typically laid two-egg clutches at Mandarte Is., British Columbia, although one-egg clutches occurred about 9% of the time. Of 23 nests checked during 1976 and 1977, 19 (83%) contained two eggs. The remaining four (17%) contained only one egg, but these may have been incomplete clutches, with the second egg either not laid yet or lost.

Eight nests were followed throughout the 1977 season at Santa Barbara Is. to measure reproductive success:

Nests	Eggs	Eggs/Nest	No. Hatched	Hatched/ Nest	No. Fledged	Fledged/ Nest
8	15	1.88	14	1.75	10	1.25

Of the four chicks that died after hatching, one was seen being eaten by mice (Peromyscus maniculatus) shortly after hatching. The chick was alive, and apparently in good health when the mice attacked it. The other three chicks disappeared; cause of death was unknown.

d. Foods

Food species utilized by adult Pigeon Guillemots breeding at other locations have been investigated by Madsen (1957), Belopolski (1961) and Storer (1952). Winn (1950), Thoresen and Booth (1958), and Drent (1965) described the types of food (nearly always fish) brought to chicks in their study areas. No data were collected on foods of Pigeon Guillemots during the course of this study. However, during the breeding season, we often observed adults carrying fish into their nests.

Fig. III-69. Nest Contents of Pigeon Guillemots, Prince Island, 1976, 1977.

	1977 3 May	1977 5 June	1976 29 June	1976 13 July	1977 24 July
Mean Number of Eggs	1.9 n=7 SD=0.3	1.8 n=5 SD=0.4	1.7 n=3 SD=0.6		
Mean Number of Chicks		2.0 n=3 SD=0	1.7 n=6 SD=0.5	2 n=1	1.3 n=6 SD=0.5
Weights of Chicks (g)			121.2 n=10 SD=73.7 range= 40-280		372.0 n=3 SD=143.8 range= 206-460

Fig. III-70. Timing of Breeding Events for Pigeon Guillemots, Southern California Channel Islands, 1976-1977.

Eggs	18 April (SBI)		27 July (SBI calc.)
Chicks		18 May (SBI)	28 Aug. (Castle Rk.)
Fledglings		18 June (SBI)	+?

e. Foraging Areas

Pigeon Guillemots were present in the SCB only during the breeding season (see Phenology). During this time, the majority of the birds foraged in the nearshore waters adjacent to the colonies, and only rarely were birds encountered more than 1 NM offshore.

Xantus' Murrelet (Endomychura hypoleuca)

a. Introduction

The entire breeding range of Xantus' Murrelets lies between central Baja California and Pt. Conception (Udvardy 1963) with the northernmost colony occurring at San Miguel Island. Jehl (1975) delimited the breeding ranges of the two well-marked subspecies and suggested they may be acting as distinct species. In the Channel Islands only the scrippsi form breeds; however, a single hypoleuca was recorded nesting on Santa Barbara Is. in 1977.

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

Xantus' Murrelets were first reported at San Miguel Is. on 18 April 1939, when Sumner (1939) saw one bird a quarter mile off the north end of Prince Island. Breeding, however, was not documented until 1968, when Crossin and Brownell (1968) found a single murrelet on Castle Rk. on 14 May. Huber (1968) found one chick and six broken eggshells on Prince Is. two weeks later. This chick and 12 adults were collected; the majority of the adults were found "in the large rocks at the E and SE ends of the islet". Prior to 1968, numerous other workers visited Prince Is. but did not find murrelets (e.g. Willet 1910; Wright and Snyder 1913; Craig and Sheppard 1965). Despite the presence of ostensibly suitable habitat, this species has never been recorded on San Miguel Is. proper.

Present Status

During the 1976 and 1977 breeding seasons, Xantus' Murrelets were heard singing in Cuyler Harbor, and a few occasionally flew on the boat anchored there. In addition, a researcher on the island heard several murrelets singing close to shore near a rocky cliff area just north of Cuyler Harbor on the night of 21 May 1976. Though murrelets have never been known to breed on the main island, it seems likely that a small number find refuge from the resident foxes in the rocky cliff areas from Bat Rk. to Harris Pt. and possibly in a limited area east of Cuyler Harbor. Brief surveys of Castle Rk. on 8 June 1976 and 4 June 1977 revealed no murrelets, though it is likely a small population persists.

Fig. III-71 summarizes our encounters with Xantus' Murrelets on Prince Is. during 1975-77. The greatest number of birds captured on or near the island on any one night are reported as "High Counts". Despite considerable searching, we found very little evidence of nesting murrelets, indicating that the breeding population on Prince Is. was relatively small. This species may be outcompeted for nest space by the ubiquitous Cassin's Auklet on Prince Island. During the

Fig. III-71. Xantus' Murrelets at Prince Island, 1975-1977

	Number Banded	Nests Found	High Count and Date
1975	0	1	25 - 13 May
1976	10	0	--
1977	8	4	60 - 20 March

breeding season, auklets crowded into almost every crack and crevice typically used for Xantus' Murrelet nest sites at other locations in the Bight. All nests on Prince Is. were found along the southeast portion of the island and were especially concentrated in an area of rocky outcroppings at the north end of the Opuntia patch on this side of the island. However, nocturnal research activity tended to be concentrated in this area, and murrelets may use other areas as well. The total breeding population for the San Miguel Is. complex was estimated at approximately 75 pairs.

Santa Rosa Island

There is no evidence of Xantus' Murrelets nesting on Santa Rosa Is., but it is possible a few pairs bred at isolated locations along the precipitous north side.

Santa Cruz Island

There are no specific references in the literature to Xantus' Murrelets on Santa Cruz Is., but at least 11 egg sets have been collected there. Badger took a set (WFVZ uncat.) at Scorpion Rk. and found several broken eggshells there on 20 May 1928. He obtained another set there on 19 May 1929 (WFVZ uncat.). Stevens, Harrison and Badger visited Scorpion Rk. on 17 May 1936, and each obtained a single egg set (WFVZ 32105, 299 and unpubl. notes, respectively). The same party revisited Scorpion Rk. on 22 May 1938, and each took a single set of eggs (WFVZ 30148, 301 and uncat., respectively). In his unpublished notes of this trip, Stevens describes the site at which his egg set was found as a "nest in hole on face of seventy-five foot cliff", possibly indicating it was from Santa Cruz Is. proper. Stevens obtained two additional sets on 25 May 1941 (SBMNH and unpubl. notes at WFVZ). This is the last record of murrelets nesting at Santa Cruz Island.

Present Status - An unknown number of murrelets may use the cliffs along the north side of Santa Cruz Island. At Gull Is., off the southwest end of Santa Cruz Is., a single pair nested in a rock hole in 1976. This same site was occupied in 1977. No other murrelets were found on this islet despite thorough searching in 1976 and 1977. Murrelets were not found nesting on Scorpion Rk. during 1975-77, despite several thorough searches of the main rock. However, it is possible that some murrelets may have nested on some of the smaller outlying rocks. None were found at Sppit or Diablo Rocks during the study.

Anacapa Island

Willet (1910) first reported Xantus' Murrelets on these islands when he saw two pairs near the east end of East Anacapa Is. in June 1910. He felt the species may occasionally have bred there at that

time. The first egg set was obtained on 15 May 1911 on Cat. Rk. by H. C. Bent (Peyton, unpubl. notes; Willet 1912; Peyton 1913). Two additional sets were taken for Bent on 29 May of the same year at the same locality by H. B. Webster (Willet 1912). Peyton (1913 and unpubl. notes, LACM uncat.) took two sets from Cat Rk. the following year, 11-12 May 1912, and G. A. Snyder took an addled egg 5 July 1912 (WFVZ uncat.). Dickey and A. van Rossem took six sets from widely scattered locations at Anacapa Is. on 21 May 1913 (WFVZ 11324-11329; Howell 1917), and two sets were taken at Cat Rk. 11 June 1915 (Peyton, unpubl. notes; WFVZ uncat.). Badger (1917) found three murrelets nesting on Cat Rk. on 26 May 1912 and collected two egg sets (WFVZ uncat.). He returned to Cat Rk. on 14 May 1927 and took an additional two sets (WFVZ uncat.). Peyton collected a set of eggs from the south side of the main (west) island 20 May 1928, and Steven (unpubl. notes; Harmon, unpubl. notes) took at least two sets 17 May 1936. Three incubating birds were collected on 6 May 1938 (SDNHM 17932-17934). Murrelets were not seen by Sumner in 1939 nor by Banks in 1963, 1964 or 1965. However, about 80 birds were seen "near" the island on 22 May 1955 (Small 1955), suggesting that they may have bred there then. A few murrelets have been seen near the island during the breeding season in recent years as well, but no nests have been reported.

Present Status - On 26 June 1976, an eggshell of a murrelet that had hatched earlier that year was found in a small cave on the north side of East Anacapa Is., just east of the landing cove. On the night of 14 April 1977, our boat was anchored at the landing cove of East Island to listen for singing murrelets; one, possibly two, were heard at that time. Cat Rk. was searched in 1976 and 1977 with no results. A dead rat found there in 1977 suggests that a shore bridge exists during low tides, giving predators access to the rock. A fair amount of good habitat exists on the Anacapas, and despite the presence of introduced rats, a small number of Xantus' Murrelets continued to nest there.

Santa Barbara Island

Xantus' Murrelets were first reported on Santa Barbara Is. by Cooper (1870), who felt it was a rare breeder there in the 1860's. Surprisingly, it was not found by Grinnell (1897) during his six-day visit to the island in May 1897. One nest, containing a cold but "apparently fresh" murrelet egg, was found by Wright and Snyder (1913) on 2 and 3 July 1912; by this late date, however, most of the nesting murrelets would have left the island. Howell (1917) suggested that the species was being threatened by cats on the island. Sumner (1939) found only a pair of murrelet wings on 14 April 1939 and stated, "At one time large colonies of auklets and murrelets were present on the island, but none have been recorded in recent years and it is supposed that they have been exterminated by these feral cats" (p. 5). Numerous nests have been found since 1972 (Jones, unpubl.

notes; Hunt and Hunt 1974).

Present Status - The largest colony of Xantus' Murrelets in the Channel Islands exists at Santa Barbara Island. Nesting occurred around the entire periphery of the main island and on both offshore rocks. On Santa Barbara Is. proper, 212 nests were found in 1977 and workers estimated the breeding population to be between 1,000 and 2,000 pairs. On Sutil Is., 17 nests and seven other very probable nests were found on 10 June 1977; the murrelet population utilizing this islet was estimated to be 75 pairs. On Shag Rk., four good and four probable nests were also found on 10 June, and the breeding population was estimated to be 15 pairs.

The majority of the murrelets nesting in the Bight belong to the scrippsi race. In three years of study, E.h. hypoleuca were encountered only three times and only one bird with a possible intergrade facial pattern was seen (Winnett et al., unpubl. ms; see Jehl (1975) for a discussion of facial patterns). On 26 May 1976, a hypoleuca form of Xantus' Murrelet flew on board a boat anchored at Landing Cove, Santa Barbara Island. It was captured, photographed and subsequently released. During the 1977 field season, a hypoleuca was found incubating an egg at Santa Barbara Island. It is not known whether both members of the nesting pair were hypoleuca birds, but a hypoleuca was always present during five observations at the nest between 21 April and 14 May. If birds of the hypoleuca subspecies do regularly breed on Santa Barbara Is., they comprise less than 1% of the murrelet population. The only other hypoleuca encountered on the Channel Islands during this study was an apparent road kill (!) collected on San Clemente Is. on 30 July 1976 (deposited SDNHM).

San Nicolas Island

There are no records of breeding murrelets at San Nicolas Is. nor were any murrelets found during this study.

San Clemente Island

There is no clear evidence of murrelets breeding on San Clemente Is. in the past. Wright (in Willet 1912) reported seeing them at San Clemente Is. during the summer, and though no nests were found, he believed that they bred there. Howell (1917), however, considered this highly improbable. Two downy chicks with two adults were seen near China Pt. on 27 July 1968 (Jones, unpubl. notes).

Present Status - In 1977, Xantus' Murrelets were heard "twittering" at Seal Cove (2 April) and Wilson Cove (15 April), but no nests were found after fairly thorough searches of accessible areas of China Pt. and Seal Cove in 1976 (G. Kunz, pers. comm.). On 11 June, a shell of a murrelet that had hatched earlier that season was found in a rocky crevice in the Seal Cove area. In addition, the wings and sterna of a fairly freshly killed murrelet and a Cassin's

Auklet were found in a small "den" near this same area; they were apparent victims of a cat or fox. The almost insignificant murrelet population at San Clemente Is. is probably held rigorously in check by the abundant terrestrial predators there.

Santa Catalina Island

D. Bleitz (unpubl. notes) found a pair of Xantus' Murrelets breeding on Bird Rk. near the isthmus in 1967. This is the only record for this island.

Present Status - No murrelets bred at Bird Rk. in 1976 or 1977. On Santa Catalina Is., as on all the larger islands, predators abound. Thus, if murrelets bred there at all, their nest sites were few and scattered far apart. It is likely a very few Xantus' Murrelets nested at Santa Catalina Is., particularly at the west end.

Xantus' Murrelets have apparently never nested in large numbers in the northern chain (Anacapa, Santa Cruz, Santa Rosa and San Miguel Islands), and their present numbers remain low. This species' situation on the southern islands also appears to be unchanged since the last century; a few pairs occasionally bred on San Nicolas, San Clemente and Santa Catalina Islands. The absence of large murrelet colonies on these southern islands was undoubtedly related to the presence of predators (endemic foxes and introduced cats) and to a lack of offshore rocks. Only Santa Barbara Is. has shown a significant population change since the turn of the century. The apparent dramatic increase in Xantus' Murrelets recorded at Santa Barbara Is. appears to have been related to the disappearance of two predators. According to Howell (1917), cats were introduced on Santa Barbara Is. sometime between 1897 and 1908. When Sumner (1939) visited the island in 1939, he noted a decline in the resident alcid populations, and supposed that the "decidedly abundant" feral cats were largely responsible. By 1975, when this project started, the Santa Barbara Is. cat population had been substantially reduced, possibly to a single animal, and Xantus' Murrelets were one of the most abundant breeding birds on the island.

A second factor that undoubtedly contributed to the significant increase in murrelets at Santa Barbara Is. was the elimination of breeding Peregrine Falcons from the Channel Islands. Willet (1933) described the falcon as a "fairly common resident" among the islands, and Howell (1917) indicated they bred on Santa Barbara Island. During 1975-77, no Peregrine Falcons were definitely known to have bred in the Channel Islands. On Santa Barbara Is., single, migratory birds were present during part of April and May in 1975 and 1976, but none bred there during this study. In discussing the food preferences of Peregrines nesting on Langara Is., Nelson and Myers (1976) indicate that Ancient Murrelets were the major prey species of which a falcon family took an estimated 1000 yearly. It can be seen that even a

single pair of Peregrine Falcons nesting at tiny Santa Barbara Is. could exert a tremendous impact on the murrelet population there. Hence, we suspect that the recent increase in the number of Xantus' Murrelets at Santa Barbara Is. was a result of the elimination of both cats and falcons from the island.

c. Breeding Biology

The family Alcidae has received considerable attention in recent years (e.g. Bedard 1968, 1969a, 1969b; Manuwal 1974; Sealy 1973, 1975, 1976). However, other than the taxonomic work of Jehl and Bond (1975) and the preliminary work of DeWeese and Anderson (1976) on the biology of the closely related Craveri's Murrelet, no recent work has been done on Xantus' Murrelets. Hence, this project is the first comprehensive breeding biology study ever undertaken for this species.

Methods

The breeding biology of Xantus' Murrelets was studied on Santa Barbara Is. during 1975, 1976 and 1977. The study periods for these years are given below:

Year	Study Period	Number of Nests Regularly Observed
1975	18 April - 30 May	54
1976	13-22 March, 4 April - 17 July	71
1977	6 March - 7 July	123

During each season, a minimum of two researchers investigated this species. Nests were marked with surveyor's flagging tape and visited regularly, usually every other day. A small number of adults were marked with drops of different colored enamel paint on the top of the head to determine the duration of incubation bouts. Handling an incubating adult usually resulted in flushing it from the nest. This almost always led to abandonment and subsequent egg loss due to mouse predation. As a result, incubating birds were generally not molested, though it was occasionally possible to slip a hand under some birds to determine the number of eggs present.

Habitat

Xantus' Murrelets nested primarily in rock beds and natural crevices around the periphery of nesting islands, though vegetation was used to some extent also. Nests were most concentrated in canyons which contained exposed rocky substrate and were found up to 135 m inland in such areas. Of 212 nests found in 1977, 166 (76.5%) were in small rock holes or rock crevices along cliff edges or a short distance up canyons. The second most common nesting site was in Eriophyllum bushes on cliff slopes; 35 nests (16.1%) were found in

this habitat in 1977. Nine nests (4.1%) were located under artifacts in the quonset hut/camping area, including the quonset hut, boxes and a strip of corrugated metal. An additional four nests (1.8%) were found in abandoned rabbit burrows, and two nests (1.8%) were found under old pelican nests. Use of rocky, cliff habitat was probably underestimated in these figures, as it was the most difficult of all habitats to survey. In other years, a few nests were found in Suaeda, in morning glory, and very rarely in tall grass. In all nest sites, eggs were laid directly on the ground (soil, gravel, hard rock), and no extra material was used to line the nest.

Nesting Density - In 1977, five 20 m X 20 m quadrats were established in murrelet nesting areas. The number of nests found in each quadrat follows:

Quadrat	Location	Nests Found
V	North end of camping area below quonset hut	7
W	South end of camping area below quonset hut	10
X	Mouth of Cave Canyon	9
Y	Western slope of Cat Canyon	9
Z	Western slope of Cat Canyon	5

The average nesting density was 0.02 nests/m^2. These censuses were deliberately conducted in areas of high nesting densities to allow for comparison in future years, and they should not be considered characteristic of the island as a whole.

The number of murrelet nests found in accessible habitat on Santa Barbara Is. in 1977 is given in Fig. III-72. Estimates were based on the number of nests found during reasonably thorough searches of generally accessible areas adjusted for the amount of apparently suitable but inaccessible habitat present in each area. These estimates represent minimum population sizes which will be useful to compare with future findings.

Nest Site Tenacity - A murrelet banded on a nest in 1976 was found incubating at the same nest site in 1977; nothing was known about the mate(s) of this individual. This finding is consistent with that found in other alcids studied (e.g. Sealy 1968; Sealy and Bedard 1973).

Phenology

Xantus' Murrelets were present in the Bight in appreciable numbers only just prior to and during the breeding season (January-July); they were almost completely absent the remainder of the year. Because some murrelets were already incubating eggs when researchers arrived on the island during each year of the study, it was impossible to know when breeding birds started coming onto the island at night. Murrelets were heard singing around Santa Barbara Is. as early as

Fig. III-72. Xantus' Murrelet Nests Found in Accessible Habitat on Santa Barbara Island, 1977

Location	# Nests Found	Estimated # Nests Present	Comments
Arch Pt. to Landing Cove	22	60	
Landing Cove to Cave Cyn.	78	100	
Cave Cyn. to Graveyard Cyn.	12	75	
Graveyard Cyn to Cat Cyn.	1	30	Area not searched extensively.
Cat Cyn. to Signal Peak	74	200	Area west of Cat Cyn. "prime habitat" but not searched.
Signal Peak to West Cliffs	18	100	
Webster Point	1	30	
Elephant Seal Point	3	50	
North Peak to Arch Point	9	50	
Shag Rock	4	15	1976 estimate.
Sutil Island	20	75	
Total	218	785	

6 March (1977), and the earliest egg date was calculated (hatching date minus 41 days) to be 7 March (1976). These data suggest murrelets may have started coming onto the island as early as February.

Almost all breeding activity of Xantus' Murrelets occurred nocturnally; nest site selection, incubation trade-offs at the nest, and visitations all took place at night. During the day, murrelets either incubated or foraged at sea; on only one occasion was an apparently undisturbed bird seen departing the island at mid-morning. Murrelets collected offshore prior to sunset where they were heard singing. However, instead of forming tight groups, as described by Sealy (1976) for Ancient Murrelets, pairs of Xantus' Murrelets and single birds remained more or less spatially segregated. Birds started arriving on the island at dark and continued to do so throughout most of the night. Leaving the island was much more synchronous; peak numbers of murrelets were captured in mist nets at dawn (usually 0500-0530), just as they departed the island.

Egg Laying - The period of egg laying for Xantus' Murrelets on Santa Barbara Is. varied from year to year (Fig. III- 73). In 1975, incubation was well under way when investigators arrived on the island, and laying dates were calculated by subtracting 41 days from known hatching dates. In that year, eggs were laid from about 9 March until at least 24 May. The timing of breeding events was similar in 1976; egg laying began about 7 March and continued through mid-May. In 1977, however, breeding was delayed by more than 2 weeks and egg laying continued through 23 June. In 1976 and 1977, the majority of the eggs were laid in March and April; peak egg laying occurred in early April, and most chicks hatched in late April and throughout May (Fig. III- 74). In 1978, peak egg laying occurred much later, in early to mid-May, and hatching was delayed until late June and July (K. Winnett and K. G. Murray, pers. comm.). Since chicks depart the island with their parents only a few days after hatching, most breeding murrelets and their young were probably distributed well offshore of Santa Barbara Is. by late July of each year.

Xantus' Murrelets developed two lateral brood patches and typically laid two eggs (Fig. III- 75). Average clutch size was 1.9 eggs in 1975, 1.6 eggs in 1976 and 1.7 eggs in 1977; the number of eggs per nest normally ranged from one to two. The seemingly high rate of one-egg clutches was in large part attributable to the loss of first-laid eggs to mouse predation (discussed in "Hatching Success").

The time between the laying of the first and second egg was 6 - 7 days for three nests in 1976. In 1977, approximately 8 days elapsed between layings ($\bar{x}$ = 8.0, SD = 1.1, n = 26). Occasionally, three or four eggs were found in a single nest site. In 1975 and 1976, it was believed these nests contained 3-egg clutches. However, in 1977 we learned that 3- and 4-egg "clutches" could almost always

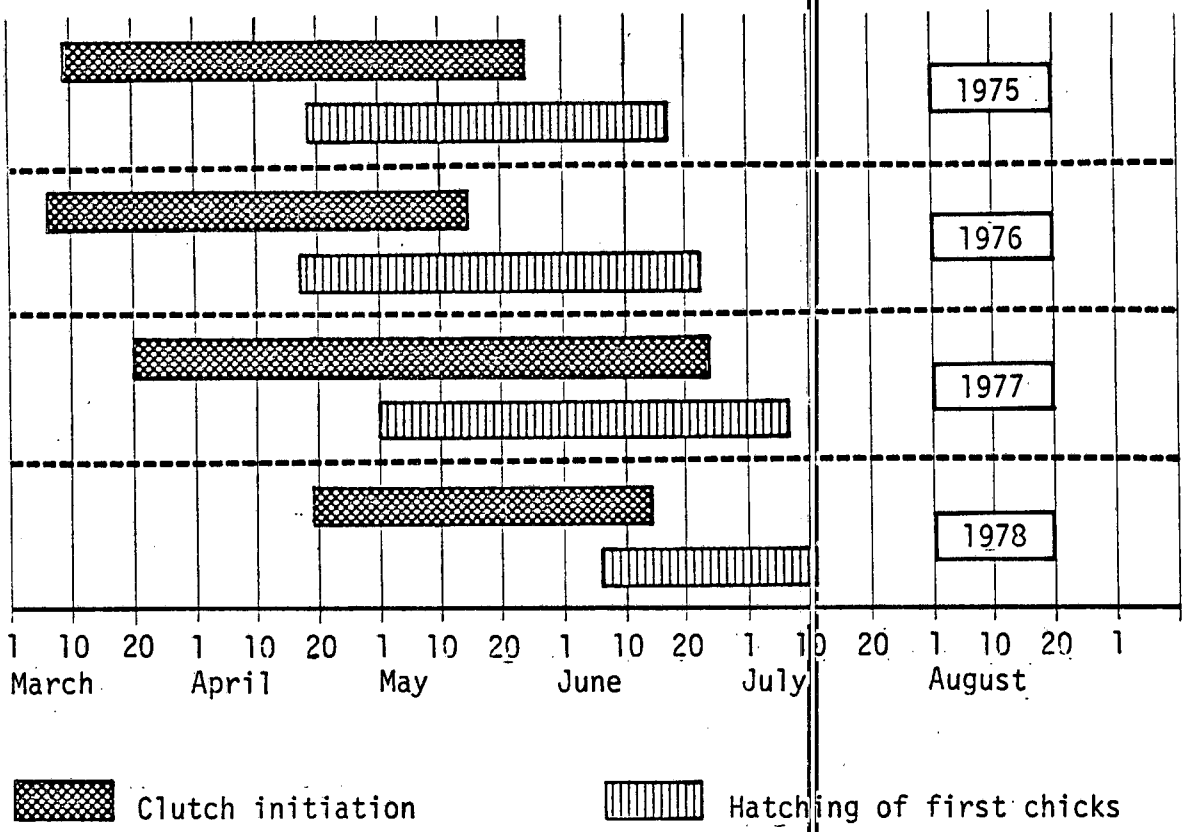


Figure III-73 . Timing of breeding events for Xantus' Murrelet, Santa Barbara Is., 1975-1978.

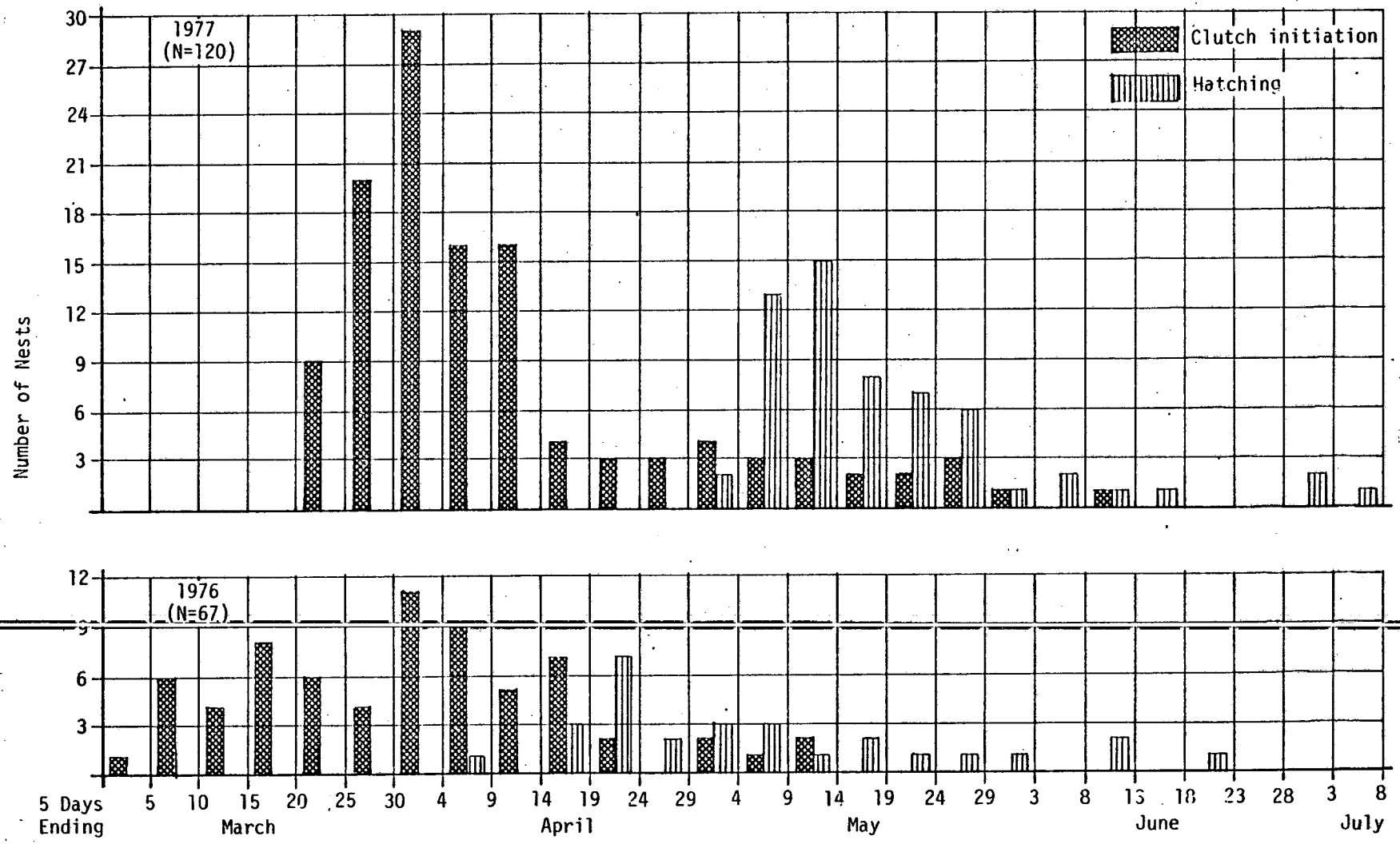


Figure III-74. Timing of breeding events for Xantus'Murrelets on Santa Barbara Is., 1976 and 1977.

Fig. III-75. Distribution of Clutch Sizes, Xantus' Murrelet, Santa Barbara Island, 1975-1977

	Number of Eggs in Clutch			
	1	2	3	$\overline{N}$
1975 (n=45)	5	39	1	1.9
1976 (n=69)	25	44	0	1.6
1977 (n=137)	44	93	0	1.7
Total	74	176	1	1.7
% Total Clutches	29.0	70.0	1.0	

be attributed to the efforts of more than one female. In no case were we able to unquestionably attribute more than two eggs to a single female, but in at least one nest, three eggs were incubated by a single pair. These eggs produced fully-developed chicks; two of these chicks departed, and one died while pipping.

Incubation - Incubation did not begin until the second egg was laid. Prior to that time, the first egg was left unattended.

In 1976, an individual adult incubated for an average of 2.9 days before being relieved by its partner (SD = 1.1, range 1-6, n = 71). Sealy (1976) found that Ancient Murrelets breeding on Langara Is., British Columbia had incubation shifts that were "invariably" three days. Incubation bouts of Xantus' Murrelets at Santa Barbara Is. were more variable, but they normally lasted three days (Fig. III- 76).

The total incubation period for one nest in 1975 was 32 days. In 1976, Xantus' Murrelet eggs required an average 29.8 days of incubation to hatch (SD = 1.3, range 29-32, n = 5). Average incubation time in 1977 for 11 nests was 34.4 days from the day of first incubation until hatching (SD = 2.6, range 32-39). However, it was not uncommon for incubating birds to leave the nest for periods of 1 - 4 days, especially during the early incubation period. For the same 11 nests, the average time of active incubation was 31.3 days (SD = 3.0, range 24-35).

Reproductive Success

Hatching Success - Mortality during the egg period was a major factor affecting the reproductive success of Xantus' Murrelets on Santa Barbara Is. during all three years of this study. Hatching success ranged from 28% to 54% and is summarized in Fig. III-77 .

The primary cause of egg loss was predation by mice (*Peromyscus maniculatus elusus*, a subspecies endemic to Santa Barbara Is.). In 1975, mouse predation was the cause of at least 57% of the egg mortality documented (n = 23). Most mouse predation, and therefore most egg mortality, occurred before the second egg was laid, while the first egg was unattended. Of 113 eggs laid in 1976, 30% were eaten by mice during this time (Fig. III-78). The same type of predation accounted for the loss of 29% of the eggs laid in 1977 (n = 143). An additional 34% of all eggs laid in 1976 (n = 113) and 17% of all eggs laid in 1977 (n = 230) were eaten by mice after incubation had started. In all cases, the nest was unattended. During 1976 and 1977, about half of all murrelet eggs laid were eventually eaten by mice.

Other major causes of egg mortality were abandonment after incubation was initiated and failure to incubate. Together, these accounted for 29% of the total egg mortality in 1976 and 1977 (n = 343). In addition to the loss of eggs after abandonment for no

Fig.III-76. Length of Incubation Bouts of Xantus' Murrelets, Santa Barbara Is., 1976.

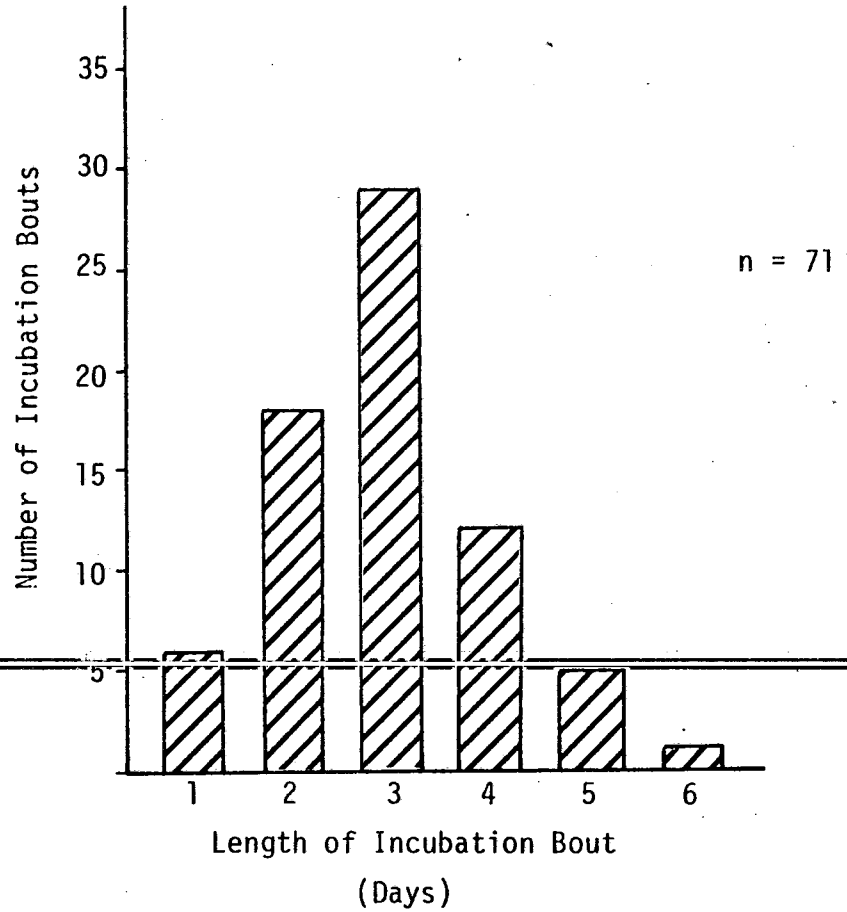


Fig. III-77. Summary of Reproductive Success of Xantus' Murrelet, Santa Barbara Island, 1975, 1976, 1977

	Number of Nests	Number of Eggs	Mean Clutch Size	% of Eggs Hatched	% of Chicks Departed	Chicks Departed Nest	Chicks Departed Egg
1975	28	54	1.9	54	100.0	1.04	0.54
1976	100	155	1.6	28	95.5	0.42	0.27
1977	137	230	1.7	38	99.0	0.63	0.37

Fig. III-78. Causes of Egg Mortality in Xantus' Murrelets, Santa Barbara Island, 1976-1977.

	1976		1977		Total	
	Number	(% Total)	Number	(% Total)	Number	(% Total)
Total Eggs	113		230		343	
Eaten by Mice Before Incubation	34	(30.1)	66	(28.7)	100	(29.2)
Abandoned, Never Incubated	23	(20.3)	13	(5.6)	36	(10.5)
Abandoned After Incubation Commenced	6	(5.3)	28	(12.2)	34	(9.9)
Abandoned or Destroyed by Mice Following Human Disturbance	18	(15.9)	13	(5.6)	31	(9.0)
Other*	2	(1.8)	23	(9.9)	25	(7.3)
Total Lost	83	(73.4)	143	(62.2)	226	(65.9)

*Failure to develop, cracked in nest and unknown causes.

apparent reason, abandonment or destruction of the nest by mice following disturbance by researchers resulted in the loss of 9% of all eggs observed in 1976 and 1977. Most of this research-related mortality occurred in 1976 at nests where murrelets were harnessed with radiotracking devices (see "Radiotelemetry"). Other factors contributing to murrelet egg mortality included failure of eggs to develop although incubated, death of well-developed embryos from unknown causes, and accidental cracking of eggs in the nest either by adults or due to weather-related rock slides.

Replacement Clutches - During the 1977 season, at least one pair of murrelets laid two clutches of eggs at Santa Barbara Island. Both adults were marked with green and red enamel paint while they incubated their first clutch. Later in the season, one of the adults deserted, the eggs were eaten by mice, and the nest was abandoned. Approximately 75 days later, a second clutch was laid by the same marked pair of murrelets. Though this was the only documented case of re-laying, nine other nests received additional clutches during the 1977 season after the first clutch had been destroyed by mice. Replacement of destroyed clutches may be a fairly common occurrence, but there is no evidence to suggest that Xantus' Murrelets raise two broods in a single season as suggested by Bent (1921).

Hatching - Chicks hatched from 29 to 39 days after incubation began. Cracking began from two to five days prior to the chick's emergence. Similar observations have been made by Sealy (1976) for the related Ancient Murrelet.

Description of Chicks - Xantus' Murrelet chicks are precocial and left the nest at one to four days of age. When they quit the nest, the young were still completely downy with the same black-dorsal/white-ventral color pattern of the adults. No development of flight or body feathers was evident before the chicks departed to the sea. At this time, the chick's bill was black with a whitish egg tooth and was much less developed (shorter) than the adults'. The average weight of 14 one- to two-day-old murrelet chicks on Santa Barbara Is. in 1976 was 23.9 g (SD = 2.2, range 20-27), and the average weight of 28 murrelet chicks in 1977 was 24.3 g (SD = 2.9, range 18.0-30.5). Murrelet chicks gained no weight between hatching and leaving the island. Also, chicks weighed every two hours throughout the night showed no weight gain and were successful in leaving the island. On the basis of these data and from observations made at night, it was concluded that Xantus' Murrelets do not feed their young prior to departure from the natal colony.

Departure of Chicks - In the past three years, considerable attention was given to the activities of adult Xantus' Murrelets and their precocial young. Our investigations showed that the chicks depart to sea at approximately two days of age. If there were two chicks at a nest, they departed together the night after the second egg hatched. It is believed they were accompanied out to sea by

their parents. The percentage of chicks departing successfully was 95 - 100% in 1975, 1976 and 1977 (Fig. III-77). As chicks spent only a very short amount of time on the colony before departing to sea, the chances of a mishap occurring were minimal. However mice, which were the major cause of mortality during the egg stage, may occasionally take young murrelets, especially when they are left alone at the nest. In 1975, a mouse killed at the nest of a recently dead chick had chick down in its stomach; whether or not the rodent had dispatched the chick was not known. Cats were probably a serious nuisance in the past, but their numbers have been greatly reduced through Park Service efforts. No signs of predation by cats were found during this study.

Two species of owls were resident on Santa Barbara Is. throughout the study period: 2 - 6 pairs of Burrowing Owls and one or two Barn Owls. Numerous regurgitated pellets of both species were informally inspected during the field season. Burrowing Owls took mostly insects (beetles), mice, and occasionally small passerines. A few pellets contained fragments of murrelet egg shells (the circumstances by which owls obtained these were not determined), but no murrelet remains were ever detected. Barn Owls, however, relied heavily on adult murrelets during the murrelet breeding season. On 2 May 1976, sternums of at least 109 murrelets were found at a Barn Owl roost south of Landing Cove. Though the exposure time of chicks to Barn Owls is much shorter than that of adults, at least a small number of young are probably taken.

Western Gulls may also take some murrelet chicks. Very young chicks, with non-existent or under-developed wing feathers, are incapable of flight. Also, though chicks are proficient divers from the moment they enter the water, they are severely restricted in their mobility. These shortcomings probably make murrelet chicks easy prey for Western Gulls. In 1975, a regurgitated carcass of a young murrelet chick was found in the gull colony. A gull presumably took this chick at sea, as the egg tooth had disappeared. Occasionally a chick was found dead on the island with its egg tooth still present, indicating that at least some chicks left their nests but did not make it to sea.

Dispersal of Young - As with Ancient Murrelets (Sealy 1976), adults and young quickly move far offshore during the first night at sea. Murrelet chicks were rarely encountered during at-sea surveys; in three years, only five sightings of murrelet chicks were made. All were accompanied by two adults. In two cases, the supposed parent-young groups were seen on transect surveys within 18.5 km of Santa Barbara Is.; the other three groups were encountered farther offshore. Because of their proximity to food sources, murrelet chicks probably grow very rapidly and would quickly become difficult to distinguish from adults. It is therefore likely that some parent-young associations were overlooked. However, close groups of three or four murrelets were relatively infrequent (only 6.4% of all sightings 1975-1977). In light of these findings, it is likely that family groups

of Xantus' Murrelets dispersed away from the island quickly, possibly traveling considerable distances in the first night to avoid gull predation upon the chicks. Sealy (1976) mentions that Ancient Murrelet adults with chicks are not found within 10 km of natal colonies by dawn following the night of departure. At present, the distribution and foraging habits of Xantus' Murrelets during this period of the reproductive cycle are unknown.

Adult Weights - Throughout the 1977 breeding season, 179 adult Xantus' Murrelets were captured and weighed on Santa Barbara Island. The mean weight was 166.8 g (SD = 14.3, range 139-230).

d. Food Habits

The food habits of Xantus' Murrelets had not been investigated prior to this study. DeWeese and Anderson (1976) studied the food habits of the closely related Craveri's Murrelet, and Sealy (1975) presented data on foods utilized by another close relative, the Ancient Murrelet.

Stomach samples of 22 murrlets collected offshore of Santa Barbara Is. during the 1977 breeding season indicated that the food items most commonly taken by these birds were larval fish, including Northern anchovies, Pacific sauries and rockfish (Fig. III-79). All of these organisms are important food items for other seabirds breeding in the Bight, also. Larval anchovies comprised almost half of the total sample volume and appeared to be a particularly important food resource for Xantus' Murrelets foraging offshore of Santa Barbara Island. It is worth noting that in early 1978, when the abundance of anchovies in the SCB was reportedly lower than in previous years at the same time (K. Mais, pers. comm.), breeding activities of Xantus' Murrelets were delayed by over a month. Additionally, few pairs bred in areas where large numbers of breeding murrelets had been recorded previously. The availability of Northern anchovies, therefore, may have a dramatic influence on murrelet breeding biology at this location.

e. Foraging Areas.

Due to the potential vulnerability of Xantus' Murrelets to offshore oil development, special studies were conducted to identify the important feeding areas and foraging patterns of this species. During opportunistic surveys in 1975, it was discovered that murrelets tended to forage offshore within the immediate vicinity of breeding islands. In 1976 and 1977, an intensive radial transect survey program was conducted at Santa Barbara Is. in order to document the areal distribution of this species around that island throughout the year. Santa Barbara Is. was chosen because it is by far the most important murrelet colony in the Channel Islands. Prior to this work, the

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Fig. III-79. Food Habits of Xantus' Murrelets
Channel Islands, 1977

	% occurrence (n=22 samples)	% volume (total vol.=66cc)
Osteichthyes		
Salmoniformes		
Engraulidae		
Engraulis mordax	36	48
Atheriniformes		
Scomberesocidae		
Cololabis saira	9	11
Scorpaeniformes		
Scorpaenidae		
Sebastes sp.	9	15
Unidentified Fish	32	25
Empty	14	—

foraging patterns of Xantus' Murrelets had not been examined.

Methods

The distribution of Xantus' Murrelets around Santa Barbara Is. was determined using radial ship transects. General methods will be presented in "Foraging Areas" of Cassin's Auklets. As with the auklets, prior disturbance by the vessel did not affect murrelet numbers ($x = 5$, $n = 11$, $p = 1.00$), so offset and non-offset transects were considered comparable.

In 1975, non-standardized transect surveys were conducted opportunistically from April to July (Fig. III-138). In 1976, seven standard radial transects were established at widely separated points around Santa Barbara Is. (Fig. III-139). These were surveyed regularly in 1976 and 1977 from January through July (Fig. III-140 and III-141).

Data Treatment - Since murrelets are small and inconspicuous diving birds, it was felt that the censusing methods used underestimated the actual density of these alcids around Santa Barbara Island. Therefore, when a radial was performed more than once in a day (e.g. data from both "out" and "in" were collected), the radial with the maximum total number of murrelets was used in calculating all means, densities and distributions. The only exception was the calculation of group size frequencies, in which the sightings from all radials were used.

Due to the small size of Santa Barbara Is. and the relatively large area sampled, it was possible to obtain good estimates of murrelet numbers distributed around the island during 1976 and 1977 using radial transects. Consistently fewer transects were completed in 1977 than in 1976. However, the derived estimates of murrelet numbers are still comparable since the transects were similarly distributed around the island in both years. These numbers were then used to obtain population estimates of the total number of murrelets within an 18.5 km (10 NM) radius of the island by calculating mean densities for 2.0 km rings around the island and multiplying these densities by the area contained within these rings. The area within each ring around the island was approximated by using the area of a circular ring with equivalent inner and outer radii (Fig. III-142).

These population estimates were used to calculate seasonal fluctuations in the overall mean density of murrelets at Santa Barbara Is. (Fig. III-143: Mean density = $\frac{\text{population estimate for month}}{\text{area 0-18.5 km from island}}$). This method of analysis is advantageous because the relative area censused decreased as the boat traveled farther from the island, which results in fewer sightings representing a larger number of birds actually utilizing a given area (e.g. an average of 2 birds/segment in Segment 9 represented 772 murrelets, whereas 2 birds/segment in

Segment 1 represented only 102 murrelets due to the larger area in Ring 9). This method takes these factors into account. All other comparisons were made using standard statistical techniques and are described as they are presented.

In the presentation of all data collected in 1976 and 1977, only sightings from Regions I and II (0-150 m to either side of the ship) were used due to the difficulty of sighting small alcids at greater distances. In 1975, sightings within 300 m of the ship (Regions I, II and III) were recorded cumulatively. Since it was not possible to reliably sight murrelets at distances greater than 150 m, no attempts were made to calculate densities or to compare the information collected in 1975 with that obtained in the two following years.

Results

The total number of Xantus' Murrelets sighted on radial transect surveys at Santa Barbara Is. from 1975 through 1977 are presented in Figs. III- 80 to III- 82. Figs. III- 144 to III- 173 give the distribution of these birds out from the island in NM (1975) or 2-km (1976 and 1977) segments for each set of transects completed.

Seasonal Changes in Foraging Distribution - Xantus' Murrelets were present in appreciable numbers in the vicinity of their nesting colonies only during the breeding season. In both 1976 and 1977, peak murrelet densities were observed from March to late May (Figs. III- 83 and III- 84). This corresponded precisely with the period of maximum nesting activity on the island. According to the transect surveys, the birds were essentially absent from the area prior to (January and February) and immediately after (June through July) the breeding season. However, subsequent observations during 1978 and 1979 indicate that this pattern is subject to substantial yearly variation. During 1978, breeding activities occurred significantly later than in the previous three years, and Xantus' Murrelets were probably foraging offshore of Santa Barbara Is. throughout June and July. Additionally, Xantus' Murrelets were heard singing directly offshore of Santa Barbara Is. on the nights of 4 - 10 January 1979 (A. Newman, pers. comm.), whereas this species was never recorded here this early in the season in past years.

Although the distribution of Xantus' Murrelets from August through December is not known, it is unlikely that they return to the breeding colony at this time. Sightings of Xantus' Murrelets in Northern California, Oregon and Washington during the fall and winter months and the occurrence of southern murrelets (i.e. *E. h. hypoleuca* and *E. craveri*) in the Bight and further north in fall, suggest a general movement northward after the breeding season (see Jehl 1975).

During the 1976 breeding season, the number of murrelets around the island peaked in late May (Fig. III- 83). In 1977, murrelet densities were relatively constant from March through May. The marked

Fig. III-80. Number of Xantus' Murrelets Sighted on Radial Transects, Santa Barbara Island, 1975[1]

Analagous Transect		19-21 Apr.	9-10 May	21-27 May	29 June	16 July
Anacapa	(out)	-	-	-	0	-
	(in)	-	-	-	-	-
Webster	(out)	-	-	80*	-	-
	(in)	58	-	-	-	0
Sutil	(out)***	35	-	-	-	-
	(in)	-	-	-	-	-
Osborne	(out)**	17	-	-	-	-
	(in)**	4	-	-	-	-
San Clemente						
	(out)	-	-	-	-	0
	(in)	-	-	-	-	-
Newport	(out)	25	2*	11	-	-
	(in)	-	-	5	-	-
Santa Monica						
	(out)***	39	6*	-	-	0
	(in)***	42	4*	-	-	-

*Incomplete transect.
**Slightly short transects.
***Extended transects.

[1]Only murrelets sighted within 18.5 km of Santa Barbara Island were included in these totals.
NOTE: These numbers are not directly comparable to 1976 and 1977 figures.

Fig. III-81. Number of Xantus' Murrelets Sighted on Radial Transects, Santa Barbara Island, 1976.

	14-18 Jan.	11-15 Feb.	17-21 Mar.	10-11 Apr.	28 Apr.-4 May	20-26 May	8-11 June	22-28 June	13-17 July	Total
Anacapa (out)	-	-	7	-	-	-	0*	-	-	7
Anacapa (in)	2	-	9	14	84	56	3*	0	0	168
Webster (out)	1	-	32	38	44	132, 201 197, 146*	-	0	0	791
Webster (in)	3	-	38	17	-	237, 70, 64*	0	1	0	430
Sutil (out)	-	-	34	19	96	61, 34	1	-	-	245
Sutil (in)	-	-	23	2	81	30, 22	0	-	-	158
Osborn (out)	4	-	5	6	6	5	1	0	2	29
Osborn (in)	0	-	7	4	14	5	0	0	-	30
San Clemente (out)	-	-	3	1	21	11	-	-	-	36
San Clemente (in)	-	-	2	2	-	6	-	-	-	10
Newport (out)	0	0	6	0	32	2	2	0	0	42
Newport (in)	-	-	-	-	21	-	-	-	0	21
Santa Monica (out)	-	-	2	2	15	15	-	-	-	34
Santa Monica (in)	-	-	6	0	5	8	-	-	-	19
Total	10	-	174	105	419	1302	7	1	2	2020

*Incomplete radials.

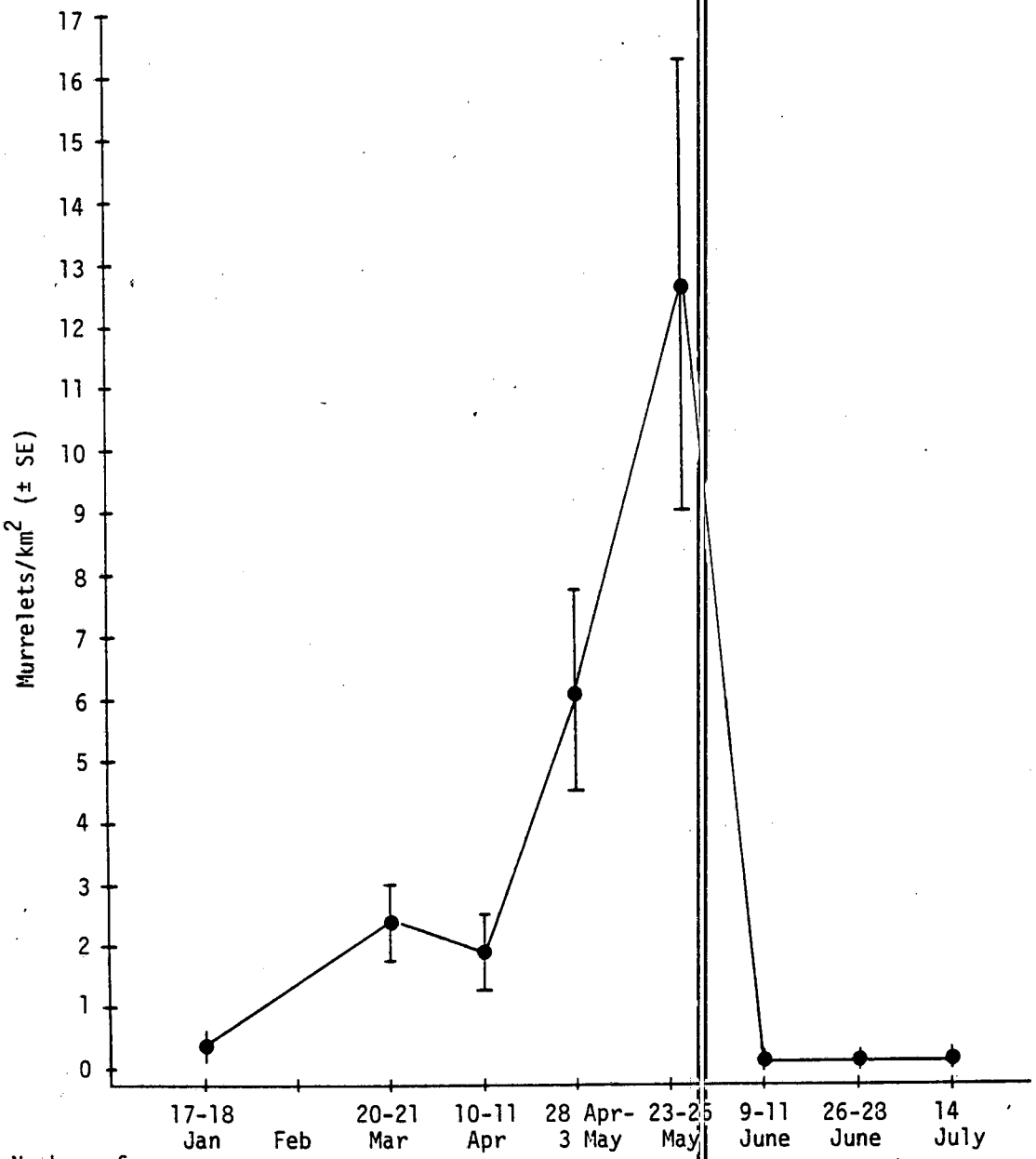
Fig. 82 Total Xantus' Murrelets Seen on Radials Around Santa Barbara Island, 1977

Transect		20-21 Jan.	6 Feb.[1]	18-19 Feb.	22-24 Mar.	12-16 Apr.	23 Apr.[1]	3-5 May	18-19 May	6-7 June	23-24 June	10-11 July	25-27 July	14-15 Aug.
Anacapa	(out)	-	-	-	-	-	-	-	29	-	-	-	-	-
	(in)	0	-	0	-	3**	-	-	-	-	0	-	-	-
Webster	(out)	0	-	1	94**	93,57,62	321,76*	91	40	2	0	-	-	2
	(in)	-	-	0	37	46,56	-	65,32	-	-	0	0	1	-
Sutil	(out)	-	-	-	-	-	-	0	-	-	-	-	1	-
	(in)	-	-	-	-	-	6	-	-	-	-	-	0[a]	-
Osborne	(out)	0	-	0	18	-	-	5	-	0	-	3	1	0
	(in)	0	-	0	11	-	-	1[a]	-	7[a]	-	-	-	0[a]
San Clemente	(out)***	-	0	0	8	15	-	4	-	0	-	-	0	-
	(in)	-	-	-	-	2	-	10[a]	-	0[a]	-	-	0[a]	-
Newport	(out)	0	-	0	42	8	-	0	2	8	0	0	0	0
	(in)	-	-	-	-	-	-	-	24[a]	-	-	-	-	-
Santa Monica	(out)	-	-	-	-	-	-	-	-	-	-	-	-	-
	(in)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		0	0	1	210	342	403	208	95	17	0	3	3	2

*Incomplete transect.
**Slightly short transect.
***Extended transect (see methods).

[a]Special transects, offset 9.25 km (5nm).
[1]Radials performed on the E. B. Scripps with higher viewing platform - accurate censusing in Regions I-III. These numbers are not comparable to surveys from the Pacific Clipper.

Fig. 83 Seasonal Fluctuations in Estimated Density of Xantus' Murrelets, Santa Barbara Is., 1976.



Number of radials used in estimate	3	-	7	7	7	7	5	4	4

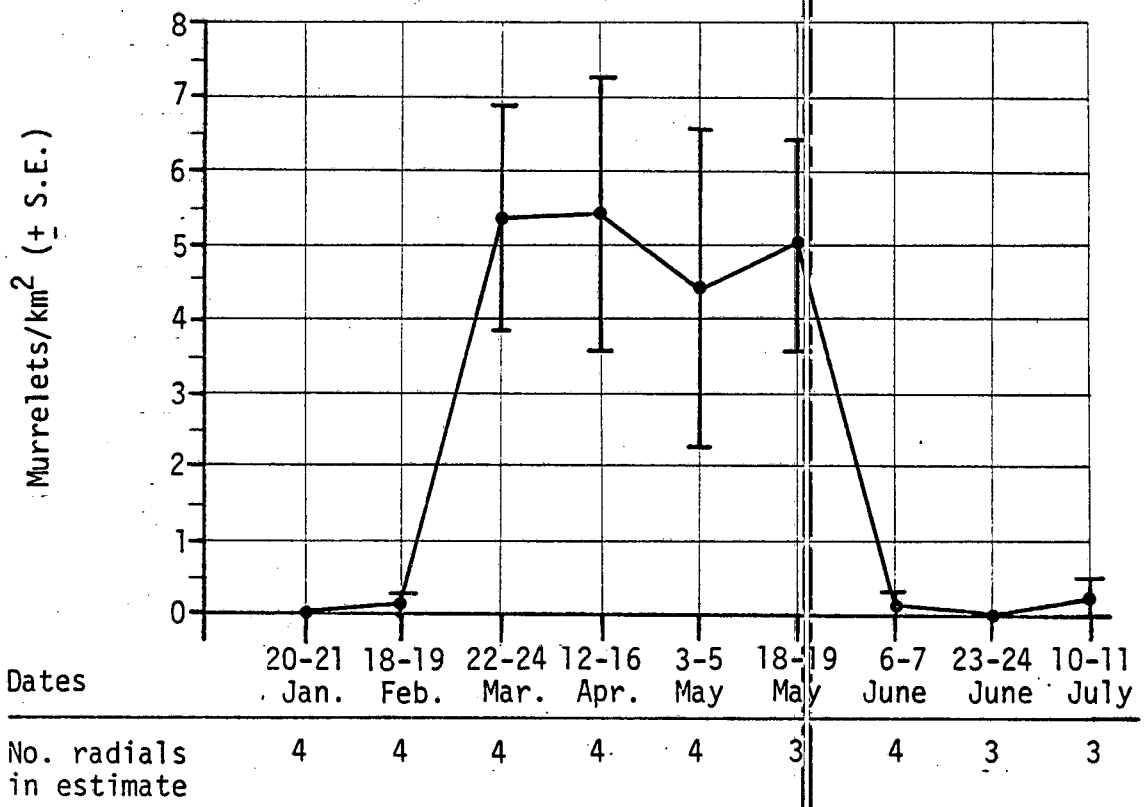


Figure III-84. Seasonal fluctuations in estimated density of Xantus' Murrelet; Santa Barbara Is., 1977.

increase in murrelets noted in late April and May of 1976 is not understood. It is doubtful that this peak represents parents and young that had left the island. Although most chicks hatched and departed in late April or early May of 1976, adults and young move quickly out to sea from natal colonies. This increase in density cannot be explained by a simple shift in the distribution of birds slightly farther out from the island either, as pronounced increases were noted in the absolute number of murrelets seen on six of seven transects in late April and five of seven transects in late May (Fig. III-85). Two possible explanations for the late season surge in murrelet numbers are: 1) a large influx of non-breeding birds late in the season or 2) a change in oceanographic conditions allowing adults to forage closer to the island than they previously had. Since a similar influx was not seen in 1977, the latter explanation seems more probable.

Distribution Around Breeding Colony - On the basis of sightings in the vicinity of Santa Barbara Is., Xantus' Murrelets regularly utilized the western, more oceanic, waters adjacent to their breeding colony most heavily. In 1976, murrelets were invariably more numerous on the three westerly radials (Anacapa, Webster, Sutil) than on any of the three easterly radials (Santa Monica, Newport, San Clemente) throughout the breeding season (Fig. III-86 ; Mann Whitney U, $p = 0.05$ for each set of censuses. A similar pattern was observed in 1977, except the birds' preferred areas appeared even more limited; the vast majority of the murrelets were encountered consistently on the Webster transect (heading 270° mag. (out); Figs. III- 87 and III-88 ; no statistical comparison possible). Murrelets were most abundant west of Santa Barbara Is. on surveys in May of 1975 as well (Fig. III-89). However, in April 1975 the murrelets were dispersed fairly evenly around the island, indicating that this pattern of westerly concentration may be subject to change (Fig. III-90).

All these observations were based on surveys which extended only 18.5 km out from Santa Barbara Island. Censuses conducted during surveys of the waters outside the standard transect area reinforced these conclusions. With one exception, murrelets were notably absent from ten transect surveys extending beyond 18.5 km east of Santa Barbara Is. during the breeding seasons of 1975 through 1977. Conversely, they were encountered regularly on twelve supplemental surveys west of the island during the same period (Fig. III-174; $X^2 = 4.5$, $p < 0.05$). The only exception occurred on 3 May 1976, when appreciable numbers of murrelets were sighted to the southeast between Santa Barbara and San Clemente Islands. Unfortunately, this area was only surveyed once, so the importance of this region to the murrelets remains unclear.

Throughout this study, murrelets seldom occurred in the waters immediately adjacent to the colony. From 1975 through 1977, murrelets were never seen within 0.5 km of shore during radial transect surveys at Santa Barbara Is., and they were only rarely sighted during inshore

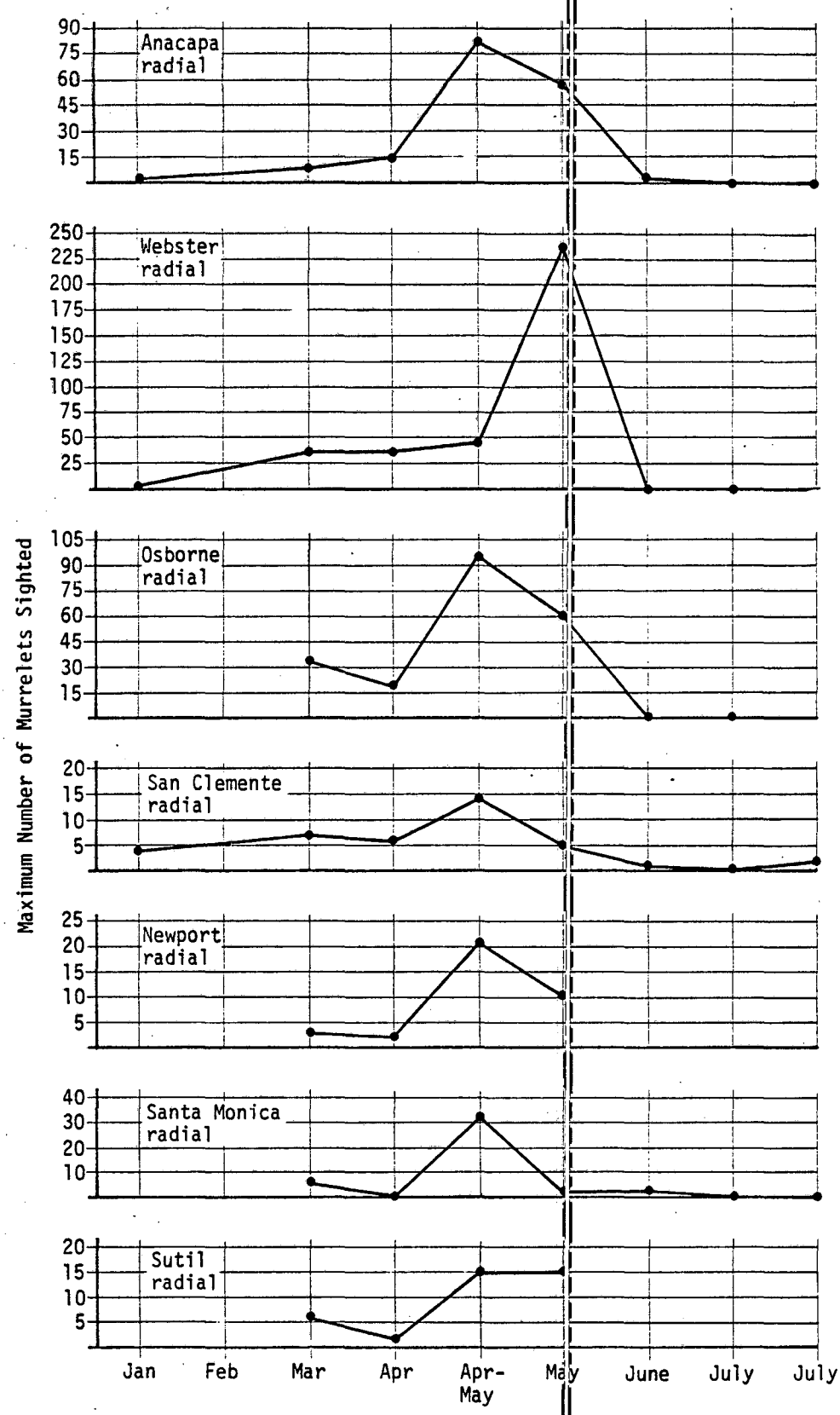
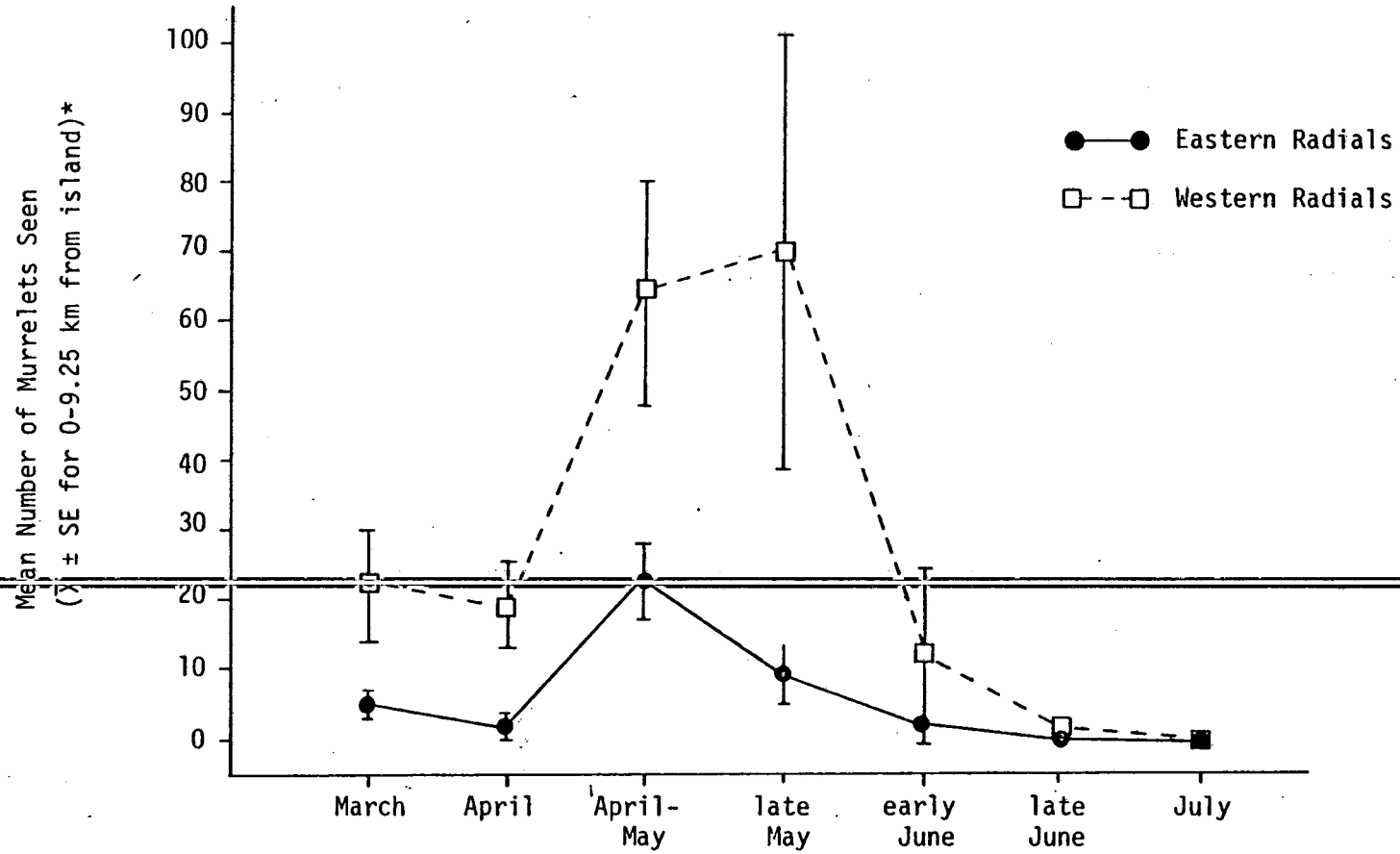


Figure III-85. Xantus' Murrelets sighted on radial transect surveys, Santa Barbara Is., 1976.

Fig.86 Relative Abundance of Xantus' Murrelets on Eastern and Western Radials, Santa Barbara Is., 1976.



*Since the radials differed in length, only the first 5 nm (9.25 km) were used for comparison.

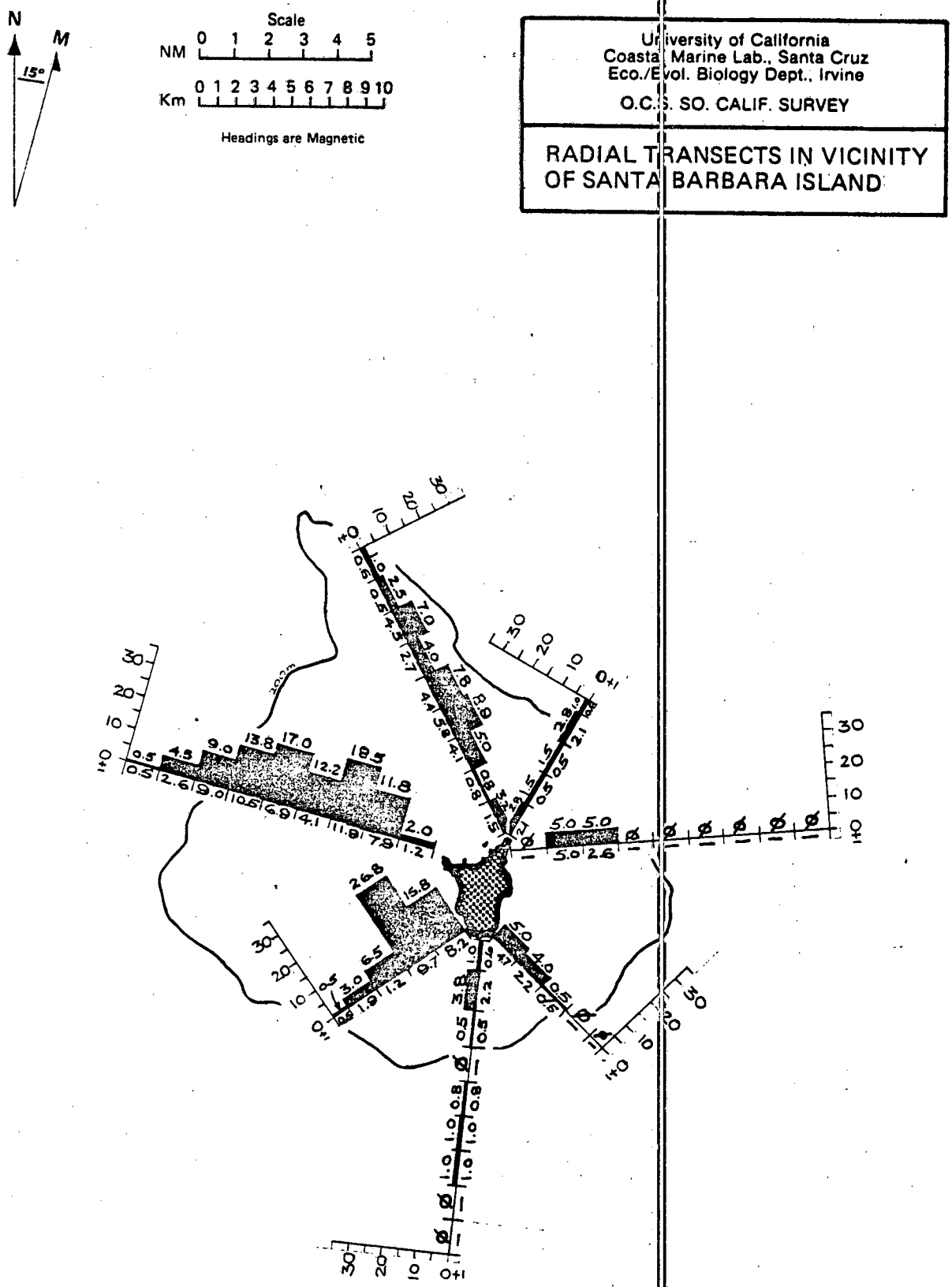


Figure III-87. Mean numbers of Xantus' Murrelets sighted in transect segments, March-May 1976. (N=4 for all radials)

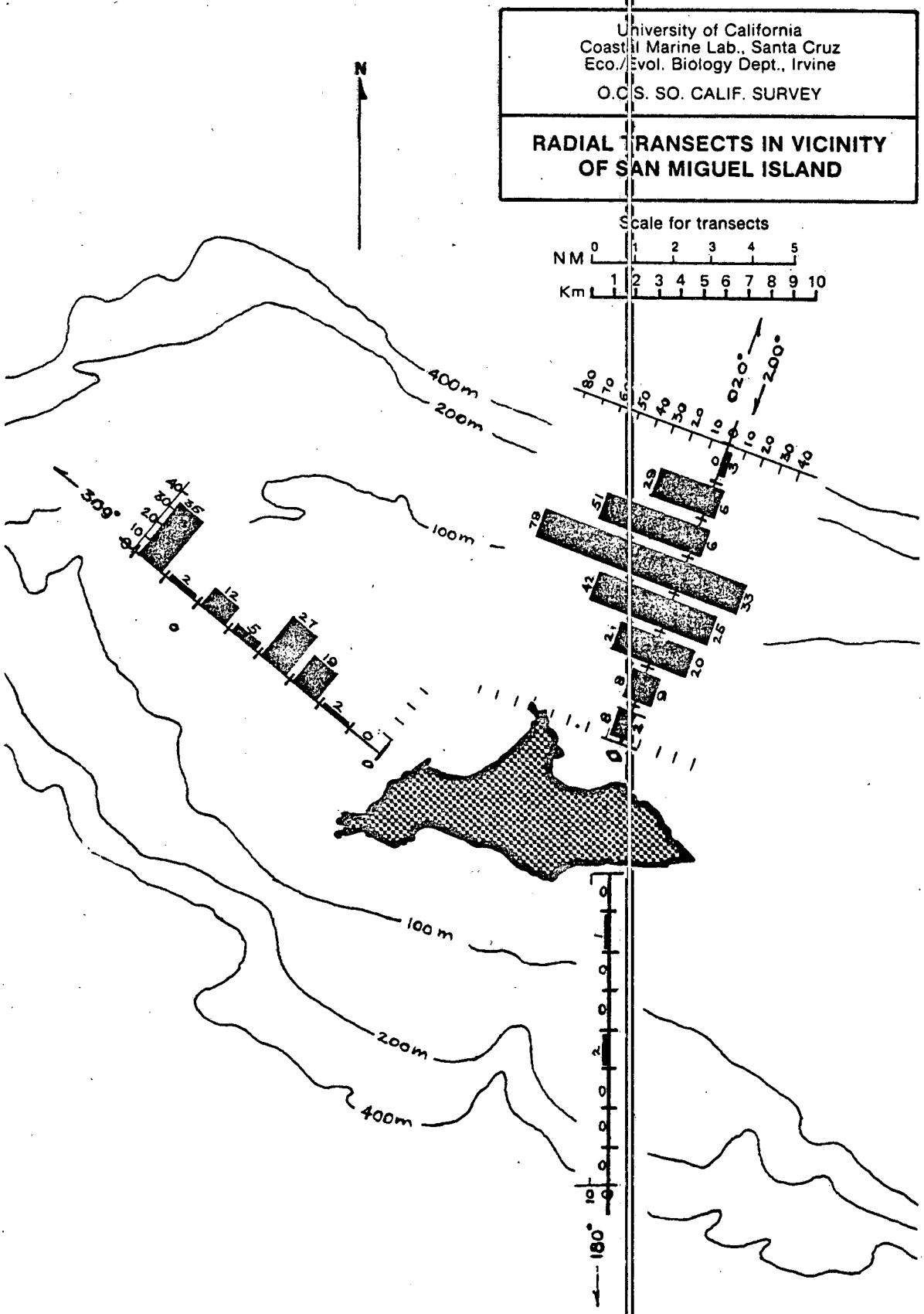


Figure III-89 . Distribution of Cassin's Auklet at sea, May 1975. Numbers of birds sighted per 1.85 km (1 nm) on indicated headings.

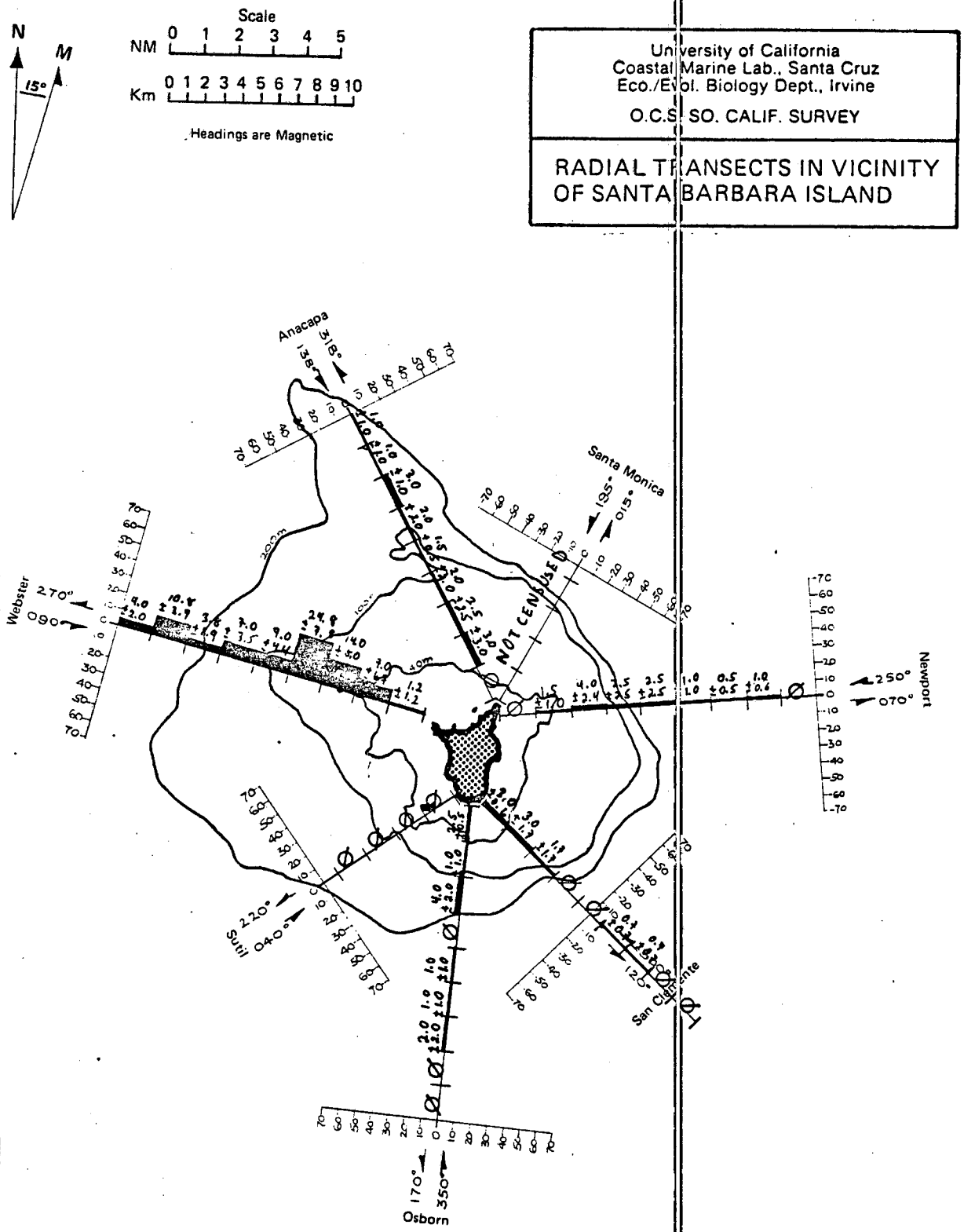


Fig. III-88. Mean numbers of Xantus Murrelets sighted on transect surveys, March - May, 1977, Santa Barbara Is.

surveys. Early in the breeding season, murrelets concentrated in the waters just beyond this inshore area in a band from 0.5 to 10.5 km out from land. In 1975 and 1976, maximum murrelet densities were observed within 6.5 km of shore (Fig. III- 91 and III-92). In 1977, the birds were concentrated slightly farther from the island; maximum densities occurred between 2.5 and 8.5 km from land (Fig. III- 93). This island shelf region may contain prime foraging areas for breeding birds, as the March through early May period encompasses the bulk of the breeding season for Xantus' Murrelets at Santa Barbara Is. during the years 1975-1977. However, the breeding status of murrelets observed near the island remains to be determined, and the distribution of the murrelets' preferred foods is still incompletely known.

Late in the breeding season (late May), the distribution of murrelets out from the island changed. Murrelets were found at greater distances from the island; peak murrelet densities occurred 10.5 to 12.5 km from land in 1976 and 1977. This repeated increase in foraging distance in late May could reflect a seasonal shift in food distribution, or it may represent the onset of the birds' dispersal away from the area at the season's end.

In considering these observed trends, it should be noted that little is known about the abundance of Xantus' Murrelets at distances greater than 18.5 km from Santa Barbara Island. Supplemental surveys indicate that they occasionally dispersed out to approximately 37 km (20 NM) west of this island during the breeding season and may have extended even farther to the southeast. Elsewhere, the limited information available suggests that the majority of the birds were probably contained within an 18.5 km (10 NM) radius of their breeding colony.

At present, there is no clear explanation for the distributional patterns exhibited by Xantus' Murrelets around their breeding islands. A more extensive survey program with concurrent studies of the murrelets and their foods would be very valuable.

Daily Fluctuations and Movements - In order to determine fluctuations in the numbers of murrelets sighted on a transect within a single day, the birds along the Webster transect were counted six times on 24 May 1976; twice each in the morning, mid-afternoon and early evening. There was a sizable variation in the number of murrelets encountered during the afternoon "in and "out" radials (197 vs. 70), but the maximum number of murrelets observed each time a pair of radials was performed remained relatively constant throughout the day (Fig. III- 94). The most marked differences were observed in the distribution of the birds. The murrelets were most abundant near the island in the early morning, but they moved seaward quickly (Fig. III- 94; compare morning "out" and "in"). By noon, they had dispersed almost uniformly between 2.5 and 14.5 km from land. The evening census could not be completed due to rough seas, but the partial survey which was obtained suggested that the murrelets were moving close to shore once again. These observations are consistent

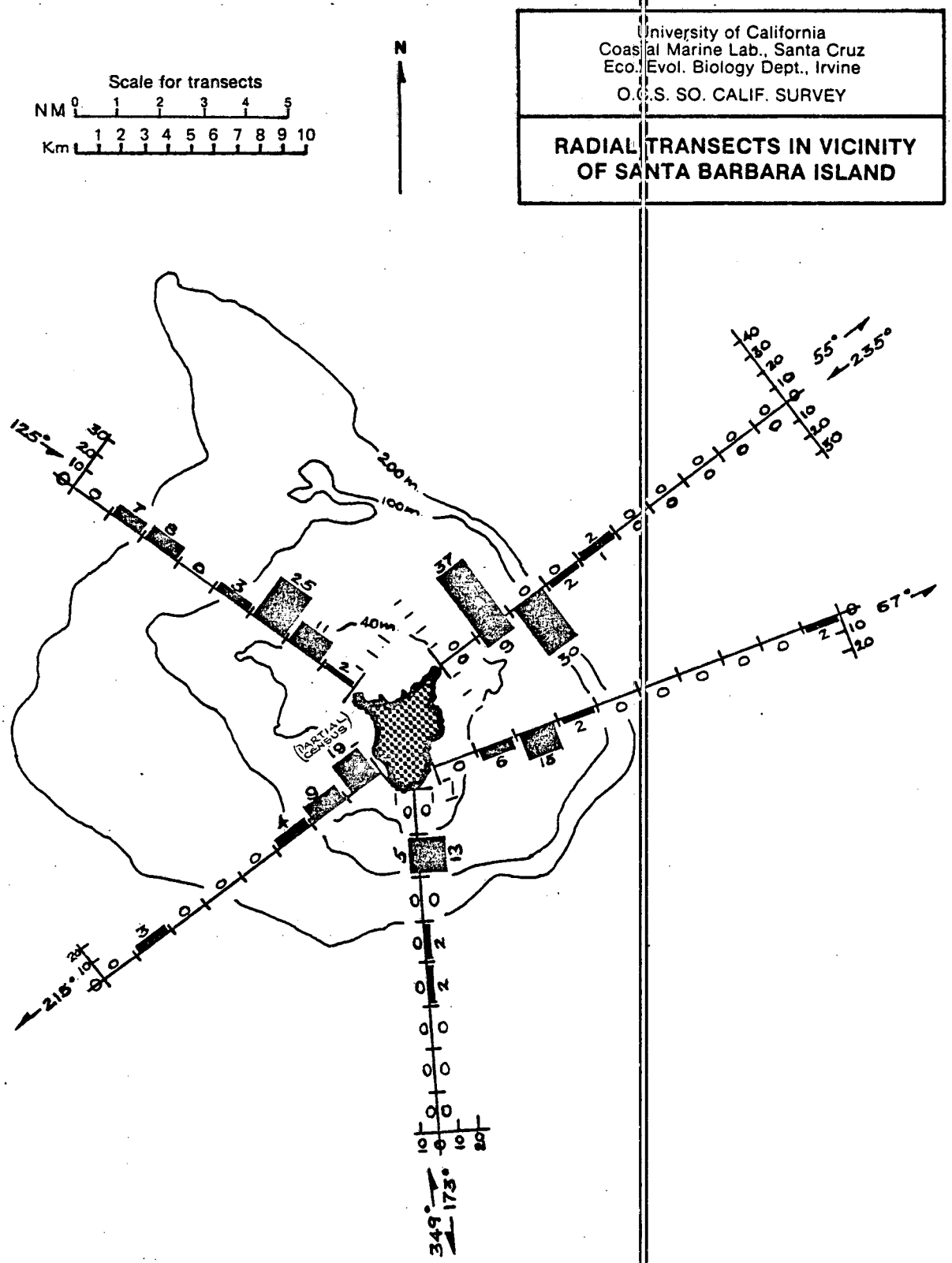


Figure III-90 Distribution of Xantus' Murrelet at sea, April 1975. Numbers of birds sighted per 1.85 km (1 nm) on indicated headings.

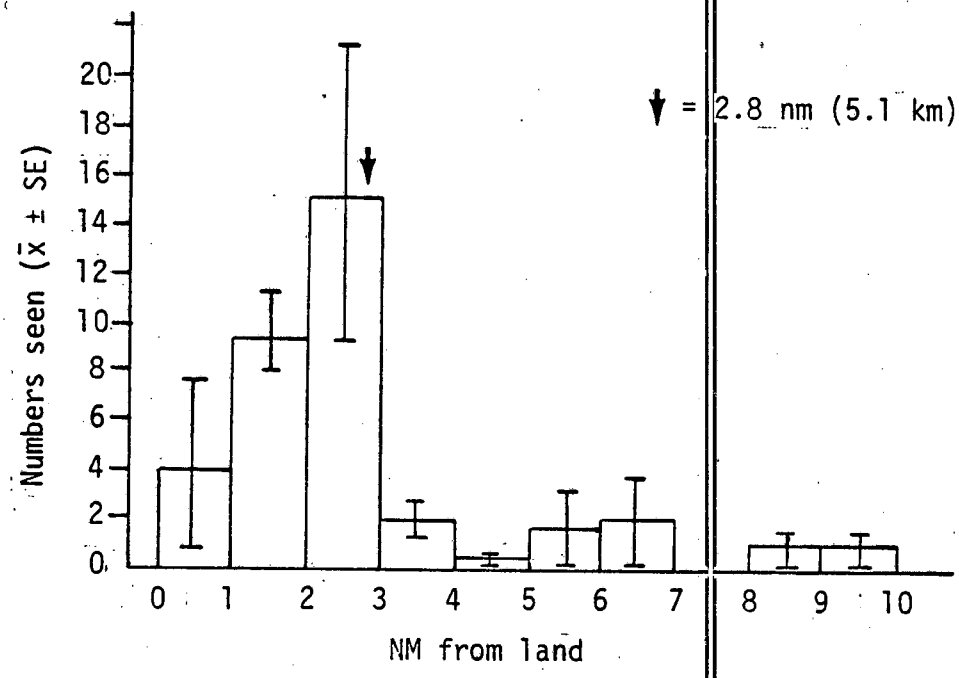
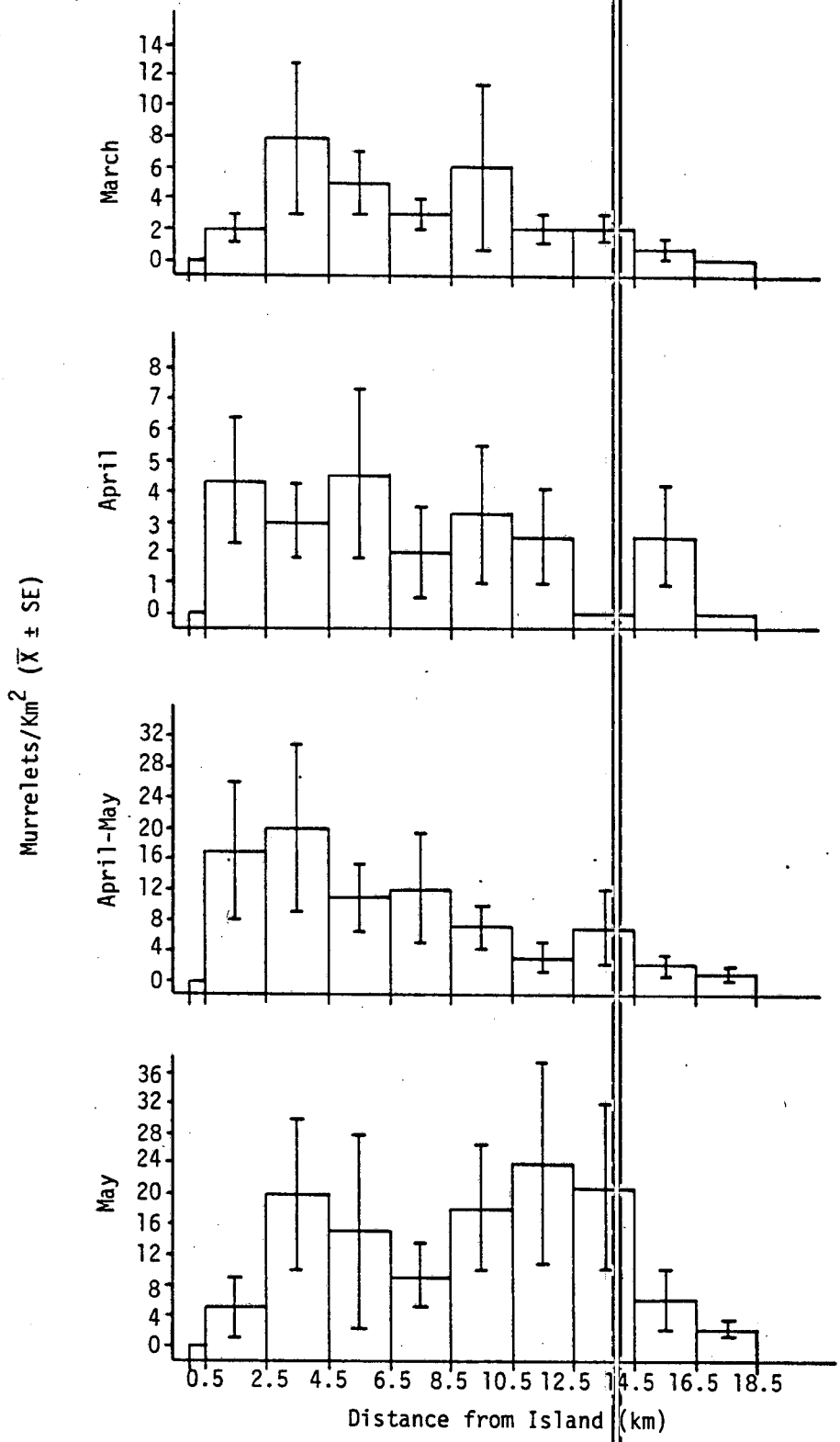


Figure III-91. Distribution of Xantus Murrelets around Santa Barbara Is., April 1975.



* n=7 radials throughout

Figure III-92. Distribution of Xantus' Murrelet densities around Santa Barbara Is., 1976.

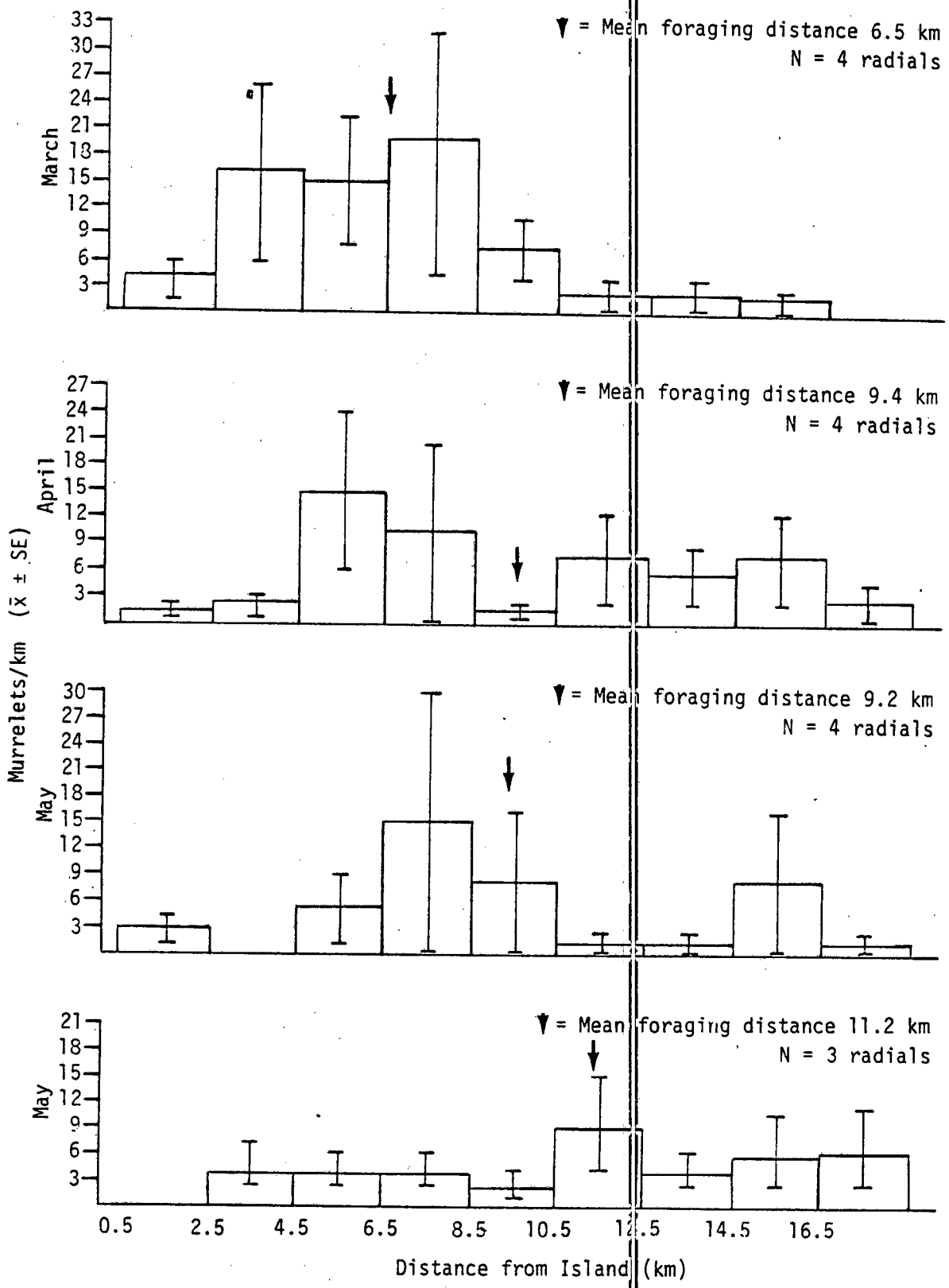
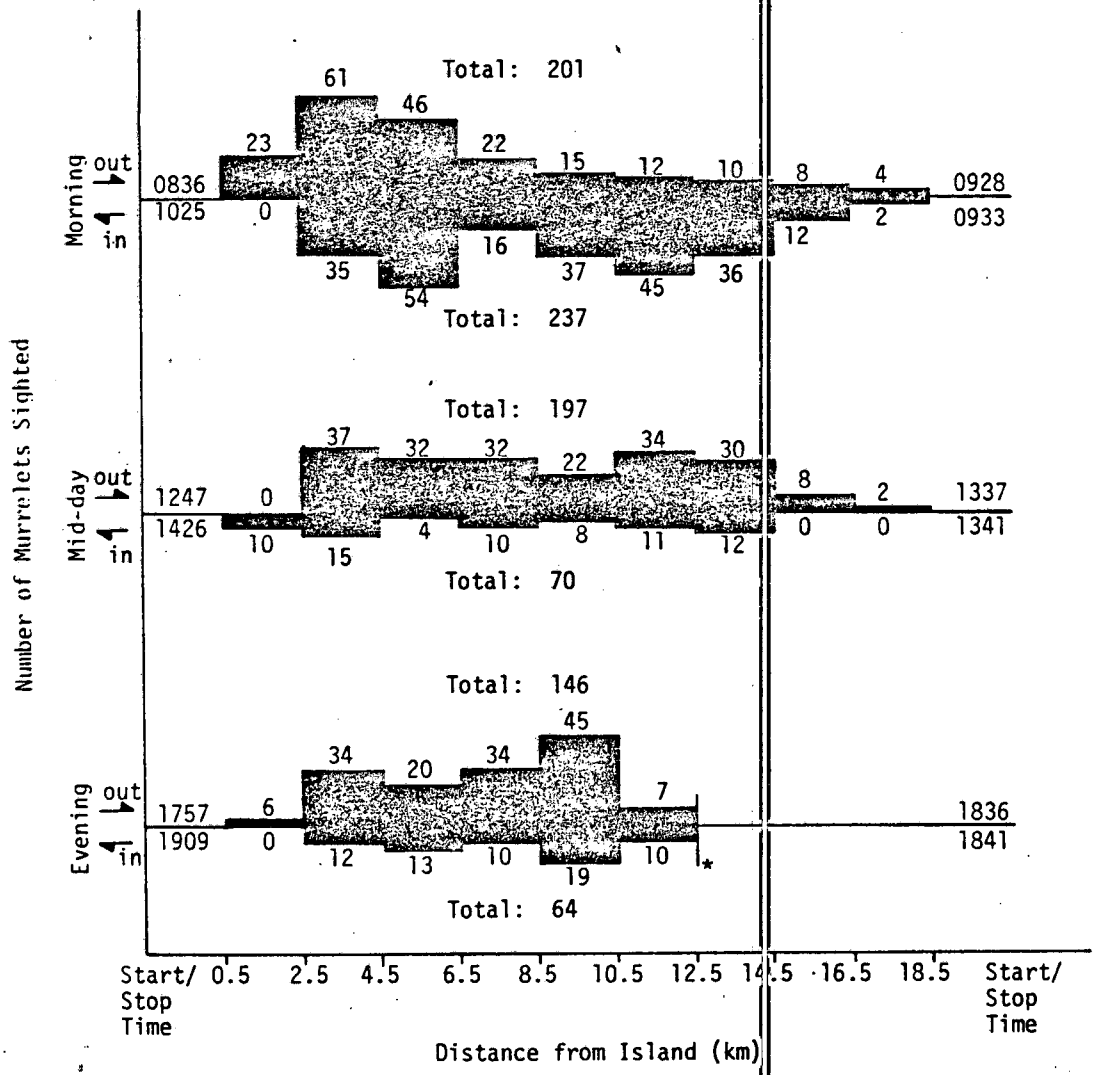


Figure III-93. Distribution of Xantus' Murrelet around Santa Barbara Is., 1977.



* incomplete due to bad weather

Figure III-94. Daily fluctuations in numbers and distribution of Xantus' Murrelets on Webster radial, Santa Barbara Is., 24 May 1976.

with the murrelets' predominantly nocturnal activity pattern discussed previously.

A second assessment of daily intra-radial fluctuations at Santa Barbara Is. was attempted using four murrelet censuses along the shorter Sutil radial (Fig. III- 95). No obvious trends were noted, except the number of murrelets sighted on the noon radials was approximately half that seen during the earliest survey of the day. This could be due to the murrelets dispersing out to sea beyond the terminus of this radial.

Foraging Group Size - Unlike auklets, which forage in large aggregations, murrelets foraged in scattered pairs (Fig. III-96). Overall, more than 80% of all birds were paired. In addition, whenever groups of three or more murrelets were sighted, distinct pair-units were usually discernible. Therefore, the occurrence of pairing is probably even higher than indicated here. Solitary birds were sighted regularly but in very low numbers; large groups of murrelets were never seen.

A perplexing problem is the prevalence of paired birds throughout the entire breeding season (Figs. III-97 and III-98). Since one member of each pair must remain on the nest with the eggs while its partner forages, an increase in the relative number of single birds would be expected during the peak incubation months of April and May. That this was not observed suggests that either 1) a very large paired, but non-breeding, population existed at Santa Barbara Is. or 2) non-incubating, breeding adults paired temporarily at sea, perhaps for foraging efficiency. There is also a possibility that all unpaired non-incubating, breeding adults moved far offshore to feed, but this seems unlikely. Systematic collecting could shed light on this problem.

Several authors have commented on the prevalence of pairing in at-sea sightings of Xantus' Murrelets (e.g. DeWeese and Anderson 1976; Jehl and Bond 1975). Observations of pairs during non-breeding seasons have prompted the speculation that Endomychura murrelets remain paired year-round (e.g. Jehl in DeWeese and Anderson 1976).

Radiotelemetry - In 1975 and 1976, attempts were made to supplement the available information on the areal distribution and daily movements of Xantus' Murrelets by tracking individual birds using radiotelemetry. However, due to the range limitations of the system used and the disruptive effect of the harnessing process on the birds' normal behavior, no conclusions could be made (see Appendix 2 for details).

Fig.III-95. Daily Fluctuations in the Numbers and Distribution of Xantus' Murrelets on the Sutil Radial, 24 May, Santa Barbara Is., 1976.

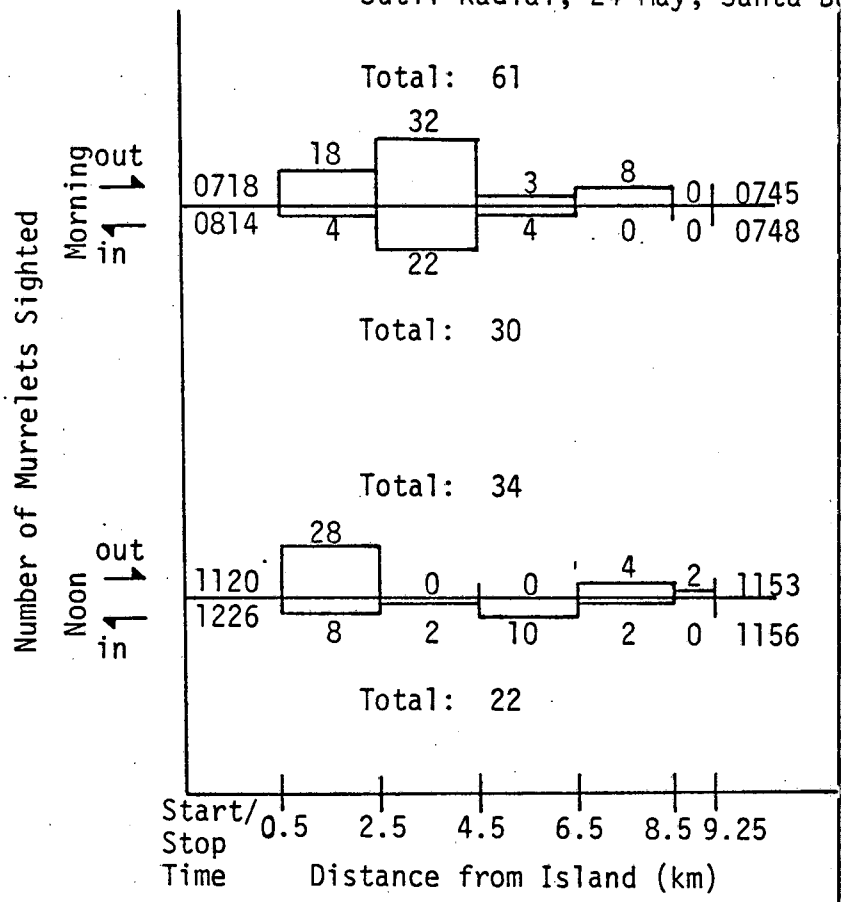


Fig. III-96. Group Size Frequencies of Xantus' Murrelets, 1975-1977

Sightings of Murrelet Groups

Group Size	1975	1976	1977	Total	% of All Sightings
1	32	123	75	230	12.2
2	146	837	545	1528	81.0
3	17	31	21	69	3.7
4	11	26	14	51	2.7
5	2	4	0	6	0.3
6	0	1	0	1	0.1
7	0	0	0	0	0.0
8	1	0	0	1	0.1
Total	209	1022	655	1886	

Number of Birds Seen

No. of Birds in Group	1975	1976	1977	Total	% of Total Birds
1	32	123	75	230	6.1
2	292	1674	1090	3056	81.7
3	51	93	63	207	5.5
4	44	104	56	204	5.5
5	10	20	0	30	0.8
6	0	6	0	6	0.2
7	0	0	0	0	0.0
8	8	0	0	8	0.2
Total	437	2020	1284	3741	

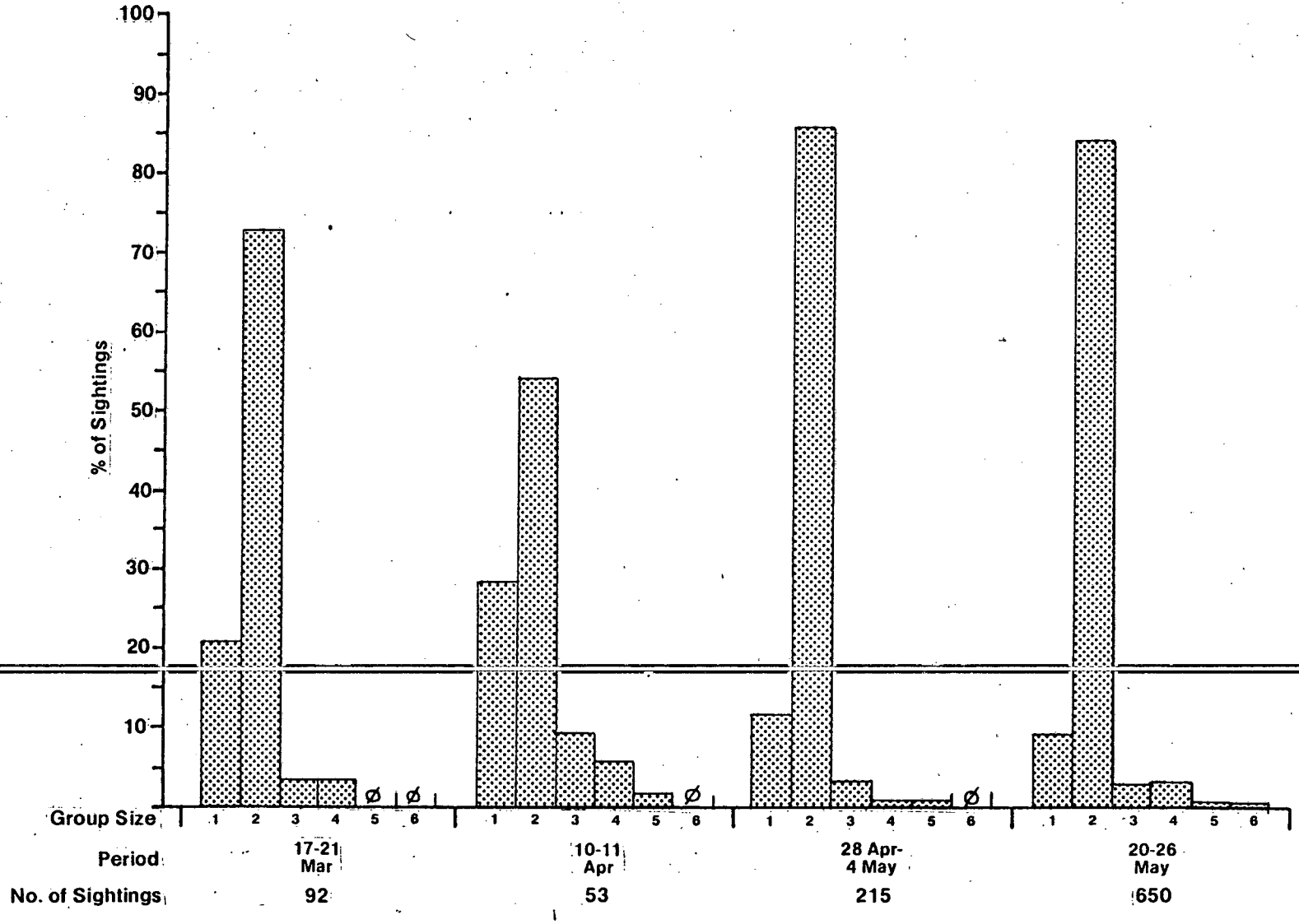


Figure III-97. Relative numbers of birds per sighting, Xantus' Murrelet, Santa Barbara Is., March-May 1976.

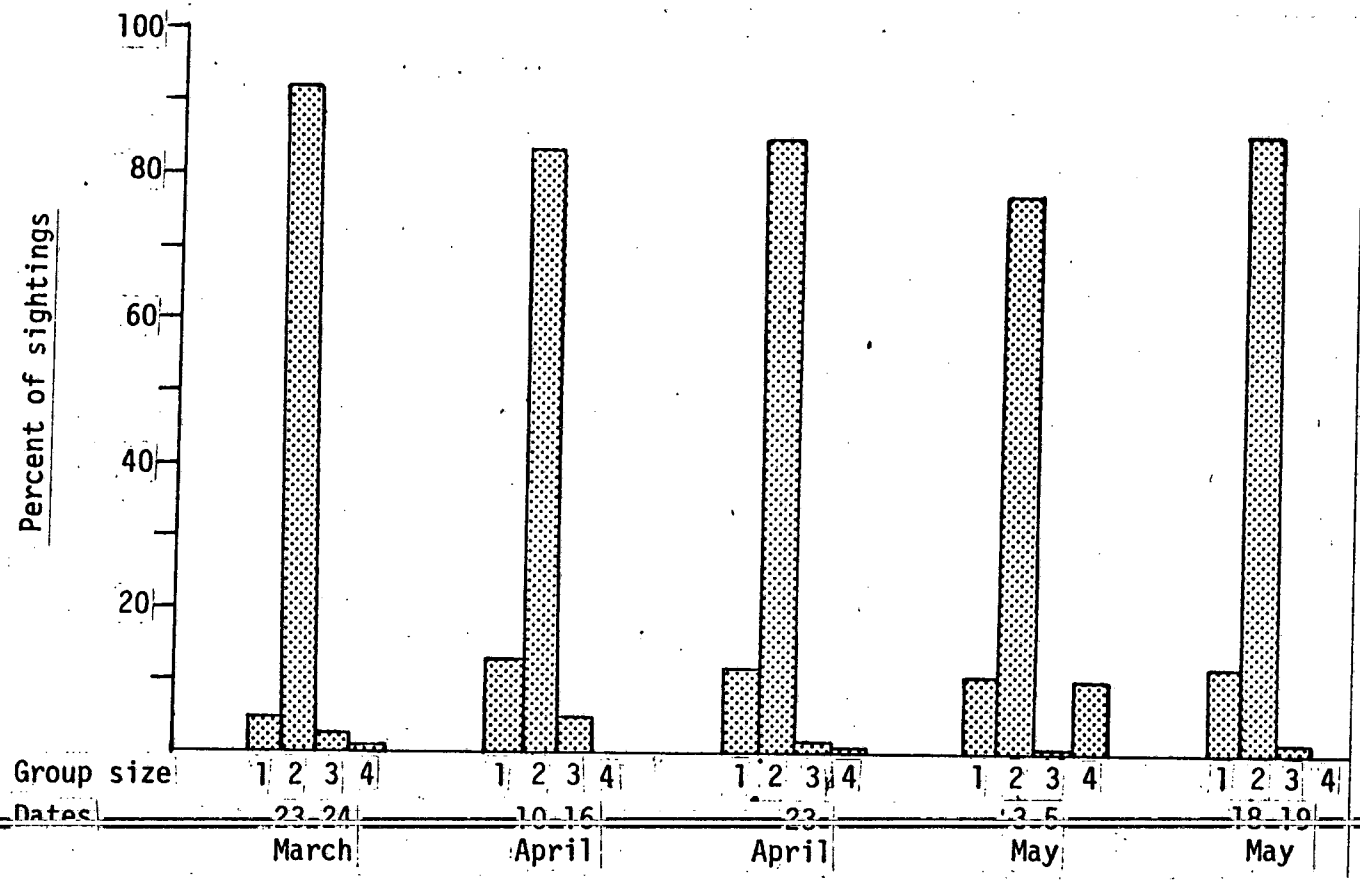


Figure III-98. Relative numbers of Xantus' Murrelets per sighting, Santa Barbara Is., March-May 1977.

Cassin's Auklet (Ptychoramphus aleuticus)

a. Introduction

Cassin's Auklets have the most extensive breeding range of any alcid in the Eastern Pacific, extending from the Aleutian Islands in Alaska to Isla San Rogue off Baja California (Udvardy 1963). They usually nest in dense colonies on offshore islands with soil suitable for burrowing. As with most colonial seabirds, the presence of terrestrial predators usually prevents this species from successfully colonizing large islands.

b. Historical and Present Breeding Status in the Channel Is.

San Miguel Island

The large Cassin's Auklet colony at Prince Is., off San Miguel Is., is quite old, and its history is well documented. The main island and Castle Rk. were surveyed less regularly.

On a visit to Prince Is. in 1886, Streator (1888) commented, "Where there was any soil, it was full of burrows in every direction, made by Cassen's [sic] Auklet". Beck collected one egg set (WFVZ uncat.) on 18 May 1897, possibly on a rock other than Prince Island. When Bent (unpubl. notes) and Appleton (unpubl. notes) traveled to Prince Is. on 6 June 1906, "the island was almost honeycombed by the birds burrows" with "over 1,000 pair nesting on the island". They collected at least four sets of eggs at that time (incl. WFVZ 32104, 76185). In June 1910, a minimum of 10 egg sets were collected (WFVZ 4368, 6154, 76184, uncat.). Willet's (1910) party collected several of these and found "wherever there was soil enough to burrow in, the auklets were nesting, and some nests were found in niches in the rocks". Jay (unpubl. notes) confirms these impressions, remarking that the birds were nesting all over the island. Willet (op cit, see also Willet 1912) also mentions finding "a few nests on a small island off the west end" of San Miguel Is., which was undoubtedly Castle Rock. Wright and Snyder (1913) reported a "very large colony" nesting on the north and northwest slopes of Prince Is. on 12 July 1912. They also stated, "In many places the ground was so undermined by the nesting places of these birds as to render walking difficult".

J. Van Denburgh found only about 100 pairs of Cassin's Auklets (unpubl. notes in WFVZ), from which he collected 11 egg sets, on 19 May 1919. J. R. Pemberton and D. S. DeGroot found only 50 pairs breeding on Prince Is. on 31 March 1927 (DeGroot unpubl. notes); they took 12 egg sets (SBM uncat.; WFVZ 61969-61976, 2600, 2601). Specifically, Pemberton (unpubl. notes) mentions two separate small colonies on the north and west sides of Prince Island. It is unclear from his notes whether his estimates are of numbers of burrows seen, active burrows examined, or some other parameter. Nevertheless,

these figures are far lower than any estimates prior to or since those dates (see Ainley and Lewis 1974 for discussion of dramatic short-term population fluctuations on the Farallon Islands).

Although Sumner (1939) and Bond did not find any auklets on Prince Is. on 18 April 1939, they did find "a considerable number of fresh burrows" and a very large number of old burrows all over the island. When Craig and Sheppard (1965) stayed on Prince Is. 3 - 5 July 1965, they estimated 3,000 pairs of Cassin's Auklets were nesting on the island. On 14 - 15 May 1968, Crossin and Brownell (1968) estimated the Castle Rk. population to be 5,000 (birds, not pairs: Crossin, unpubl. notes, NOF) and "double this on Prince Islet". "Nest sites were usually dug burrows under rocks or cactus (Prince Islet), but occasionally rock crevices were used." Three sets of eggs were collected from Castle Rk. and three sets from Prince Is. (NOF uncat.). Huber (1968) "guestimated" 1,500 pairs of auklets breeding on Prince Is. in May/June 1968. He found them nesting over all but the flat top of the islet.

Present Status - Evidence of Cassin's Auklets breeding on the mainland of San Miguel Is. consists of 8 - 10 auklet burrows found between Pt. Bennett and Adam's Cove by Paul Collins (in lit.) on 19 May 1977 (one egg collected - SBMNH), and a single, shallow burrow located on Pt. Bennett on 30 July 1977 by A. Newman. Because of the inhospitable nature of Castle Rk., very little work was done there, but brief surveys suggest that at least 1,000 pairs of auklets bred at this outpost.

The largest auklet colony in the Bight was at Prince Island. Auklets nested and roosted (at night) over almost every part of the island, particularly in the loose topsoil adjacent to the Opuntia patch at the southeast end of the island. In 1975, an estimated minimum of 9,600 pairs of Cassin's Auklet bred on Prince Is., using a quadrat method for measuring nest densities. Using a similar quadrat system and different personnel in 1976 and 1977, a population estimate of 10,200 pairs of auklets was derived. From the above, the number of Cassin's Auklets regularly nesting at Prince Is. was approximately 10,000 pairs.

Santa Rosa Island

There is no evidence that Cassin's Auklets ever bred on Santa Rosa Is., except for Willet's (1912, 1933) statement that it "probably breeds" there. Santa Rosa Is. has no offshore rocks large enough to support a colony of Cassin's Auklets. Though no time was actually spent on this island looking for nests during this study, it is doubtful that the resident foxes and auklets could co-exist.

Santa Cruz Island

Rollo Beck (1899) was the first to find Cassin's Auklets

breeding at Santa Cruz Is.; on 5 June 1895, he found many occupied burrows on what was undoubtedly Scorpion Rock. Badger (unpubl. notes) took four sets of eggs from Scorpion Rk. on 8 April 1919 (incl. WFVZ uncat.) and an additional set on 20 May 1929. No records of auklets on the main island or other adjacent islets have been found.

Present Status - Cassin's Auklets were found breeding on Gull Is. in the Santa Cruz Is. area in all three years of the study (1975-77). The population was estimated at approximately 75 pairs, with the majority occurring on the main rock. On Scorpion Rk., 15 auklet burrows were found on 22 June 1976; two contained incubating adults. The population for Scorpion Rk. and the smaller adjacent rocks was estimated at 50 pairs. On tiny "Sppit" Rk., off the east end of the north side of Santa Cruz Is., three nests were found on 22 June 1977; the population was estimated at 10 pairs. Suitable habitat also existed on Diablo Rk. and other even smaller rocks along the north side of Santa Cruz Is.; a few pairs of auklets may nest on these islets, as well. The total Cassin's Auklet breeding population for the offshore rocks and islets of Santa Cruz Is. was estimated at approximately 150 pairs.

Anacapa Island

The only evidence of Cassin's Auklets breeding on Anacapa Is. comes from Willet (1910): In June 1910, "Cassin's Auklets were common at night and were undoubtedly breeding somewhere on the island, but we did not locate the nesting colony".

Present Status - No Cassin's Auklets were found breeding on Anacapa Is. in 1975-77. However, West Anacapa Island was not searched, and little time was spent exploring the middle and eastern islands. It is possible, though unlikely, that a small population existed on these islands.

Santa Barbara Island

A Cassin's Auklet egg set (MVZ 1950) was collected by Cooper on Santa Barbara Is. on 26 May 1863. Cooper (in Howell 1917) found auklets numerous on Santa Barbara Is. in 1863, "where they had undermined almost every part of the soft, earthy surface with their burrows". Grinnell (1897) found them breeding in large numbers in 1897: "The southwest side of the mesa from the top of the bluff to the summitt of the hill was crowded with their burrows". One egg set (MVZ 1950) and nineteen specimens were collected during his visit. Britton (1897), apparently on the same cruise with Grinnell, stated, "In a field of malva weed hundreds of burrows contain auklets sitting upon their single white eggs". At least 11 sets of auklet eggs (WFVZ uncat.) were collected by H. Robertson on 9 June 1899. Robertson (1903) examined "a great number of nests and found very few empty ones" at the southern end of the island; he felt that auklets probably nested elsewhere on the island, as well. By May 1908,

when Howell (1917) visited the island, no signs of this species were seen. Willett (1912) found only bones and feathers of auklets all over the island during his trip there in June 1911; he "concluded that they had been exterminated by the cats with which the island is infested". He did find, however, a small colony of about 100 pairs of auklets nesting on an offshore islet (Sutil), where they were safe from the depredations of feral cats. One egg set was collected from this colony on 14 June 1911 (WFVZ 6155). The following year, on 2 - 3 July 1912, Wright and Snyder (1913) undertook a thorough search of the northwest end of the island and found nothing but the remains of auklets, which they felt were attributable to cats also. No Auklets were found by Sumner (1939) and Bond in April 1939, though what may have been some recently worked burrows were seen near the northeast corner of the island. Sumner (1939) also spoke of the "hordes of exotic house cats" that were still on the island. Banks (unpubl. notes) saw a few auklets in the vicinity of the island and heard what he thought were auklets (murrelets?) at night from 21 - 23 February 1964. Hunt and Hunt (1974) saw none in 1972.

Present Status - The Sutil Is. auklet colony still persists. On 27 June 1976, a large downy auklet chick was pulled from a burrow in the loose soil in a saddle area atop Sutil Island. A small number of other burrows were found in the same area and a few were scattered at locations over most of the islet. A total of 35 breeding pairs was estimated for this islet. This is somewhat lower than Willet's (1912) estimate and may indicate a slight decline for this species. There is very little soil on the top of Sutil for burrowing; due to the lack of vegetation, a considerable amount of soil may have eroded away over the years.

On the main island, 42 Cassin's Auklets were banded from a small colony located in a cave near Elephant Seal Pt. in 1977. This colony had an estimated 75 pairs of breeding auklets. In addition, a single pair of nesting auklets was found in Cat Canyon at the opposite end of the island. At this point, there appears to be little to prevent Cassin's Auklets from reoccupying Santa Barbara Is. in their former numbers.

San Nicolas Island

There has never been any indication that auklets ever bred at San Nicolas Island. None were found during 1975-77, and it is very doubtful that any occurred there.

San Clemente Island

No one has ever reported Cassin's Auklets breeding on San Clemente Island. On 11 June 1977, the remains of a recently killed auklet and Xantus' Murrelet were found in a small cave near Seal Cove, the apparent victims of a fox or feral cat; however, no nest sites were found. "Pioneering" individuals may occasionally come into this

island, but these would be held rigidly in check by the land-based predators.

Santa Catalina Island

Cassin's Auklets have never been found breeding at Santa Catalina Island. None were found by this project, and it is extremely doubtful that any occurred there during this study.

c. Breeding Biology

At present, the knowledge of the breeding biology of Cassin's Auklets consists of early anecdotal accounts summarized by Bent (1919) and more recent work focusing on regional aspects (Gabrielson and Lincoln 1959; Jewett et al. 1953), breeding behavior (Thoresen 1964), molt (Payne 1965), and population ecology, food habits and breeding biology (Manuwal 1974). Prior to this project, no rigorous investigations of Cassin's Auklets had been conducted on the Channel Islands. Therefore, a comprehensive study of the breeding biology of this species was conducted.

Methods

The majority of our efforts were concentrated on Prince Is., and all information pertains to this colony unless otherwise stated. The number of breeding pairs (N) was calculated by the following equation:

$$\left(\frac{A}{A + I}\right) \cdot T = N$$

A is the number of burrows known to be active in surveyed quadrats, I is the number of burrows known to be inactive in surveyed quadrats, and T is the total number of burrows estimated for the island. "T" was estimated by calculating the average density in several quadrats and assuming this density for the total area containing burrows.

To gather data on reproductive success, individual nests were staked in February 1976 and January 1977 and checked on each subsequent visit. In 1977, additional nests (Study Area L) were staked later in the season to check the affects of researcher disturbance and to increase the reliability of our data. Nest contents were recorded on each visit. Chick growth rates were calculated in grams/day for birds weighing between 25 and 140 grams. Only weights less than 140 grams were used since Manuwal's (1974) growth curve indicated that the growth rate of auklet chicks was linear up to this weight. After reaching 140 grams, growth was considerably slower.

Habitat

The preferred nesting habitat of Cassin's Auklets in the Channel Islands, as in other parts of its range, was loose topsoil in which this species excavated burrows (Jewett et al. 1953; Gabrielson and Lincoln 1959; Drent and Guiget 1961; Manuwal 1974). Under optimal conditions burrows, each about one meter in length, are closely packed and honeycomb the available topsoil. This extensive tunneling typically undermines the soil structure, but at Prince Is. and Castle Rk., cactus (Opuntia sp.), iceplant (Mesembryanthymum sp.) and other low vegetation helped to stabilize the burrowed soil against collapse and erosion. However, investigators still experienced difficulty in traversing the populous colonies at Prince Is. without breaking through the fragile topsoil and destroying burrows. Therefore, studies were conducted in peripheral or low density areas of the colony, where the investigator's impact could be minimized.

Auklets nested in a variety of habitats on Prince Island. Nests were found in rock crevices everywhere on the island, although the densities in rocky habitat were considerably lower than those in soil-vegetation habitat. Auklets also nested commonly in damp caves and under rocks on the steep northwest face, where they were often found in natural rock crevices similar to and adjacent to those used by Pigeon Guillemots. Overall, the nest sites used on Prince Is. were similar to those reported by Manuwal (1974) on the Farallon Islands.

Burrow densities ranged from 0.1 nest/m^2 in the rocky habitat and in the gull colony on the top of the island to 8.0 nests/m^2 on the periphery of the large cactus patch on the southeast side of the island. Average burrow density in the habitat adjacent to Opuntia averaged 5.4 nests/m^2; this density is considerably higher than the maximum density reported by Manuwal (1974) for the Farallon Islands (1 burrow/m^2). Auklets also nested within the cactus patch, and although we were unable to measure burrow density there, it was probably much less than on the periphery. Auklets nesting within the cactus patch utilized this habitat with relative impunity; only one was found impaled on cactus spines during the breeding season. (It is likely that the cactus provided protection from predators such as Western Gulls.) Generally, the birds arrived at night, flopped onto the ground in adjacent clearings and scurried to their burrows.

The small auklet colony on Santa Barbara Is. was concentrated at Elephant Seal Pt., where auklets burrowed in the soft dirt floor of a large rock crevice. A few nests were also found in natural rock holes, but none were found on the slopes in the gull colony.

Phenology

The timing of the major breeding events for Cassin's Auklets on Prince Is. is shown in Figs. III-99 and III-100. We first

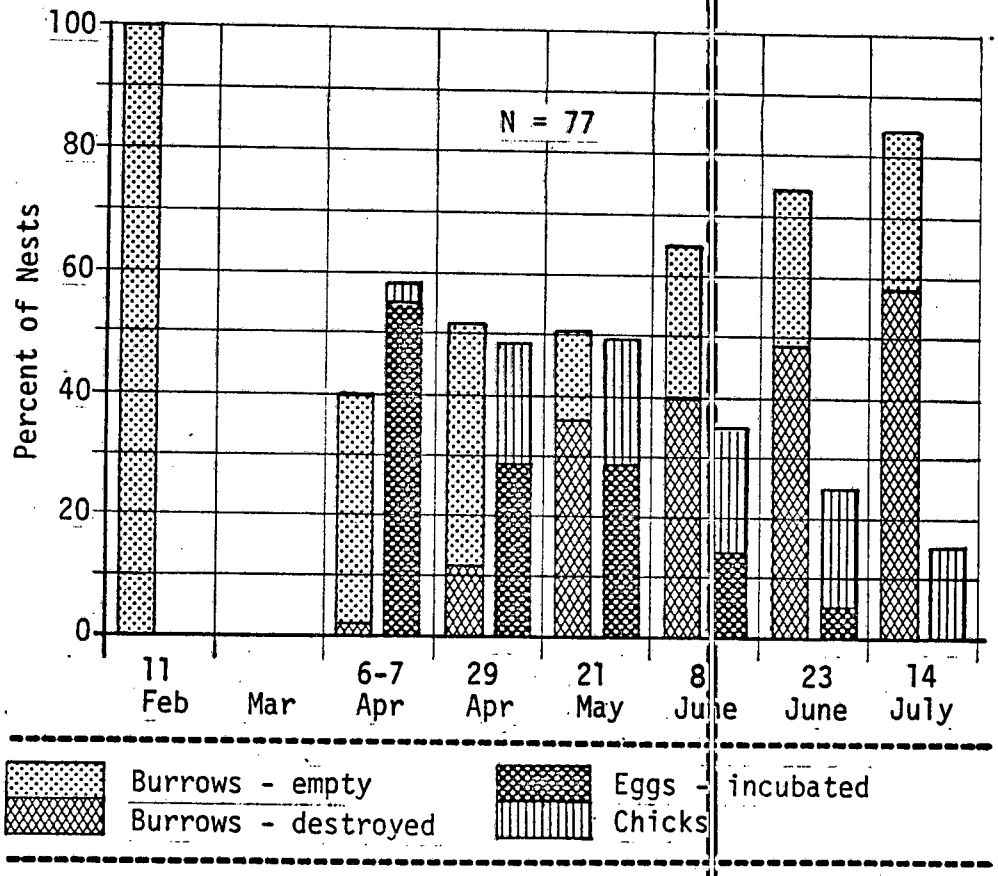


Figure III-99. Timing of breeding events for Cassin's Auklet, Prince Is. (San Miguel Is.), 1976.

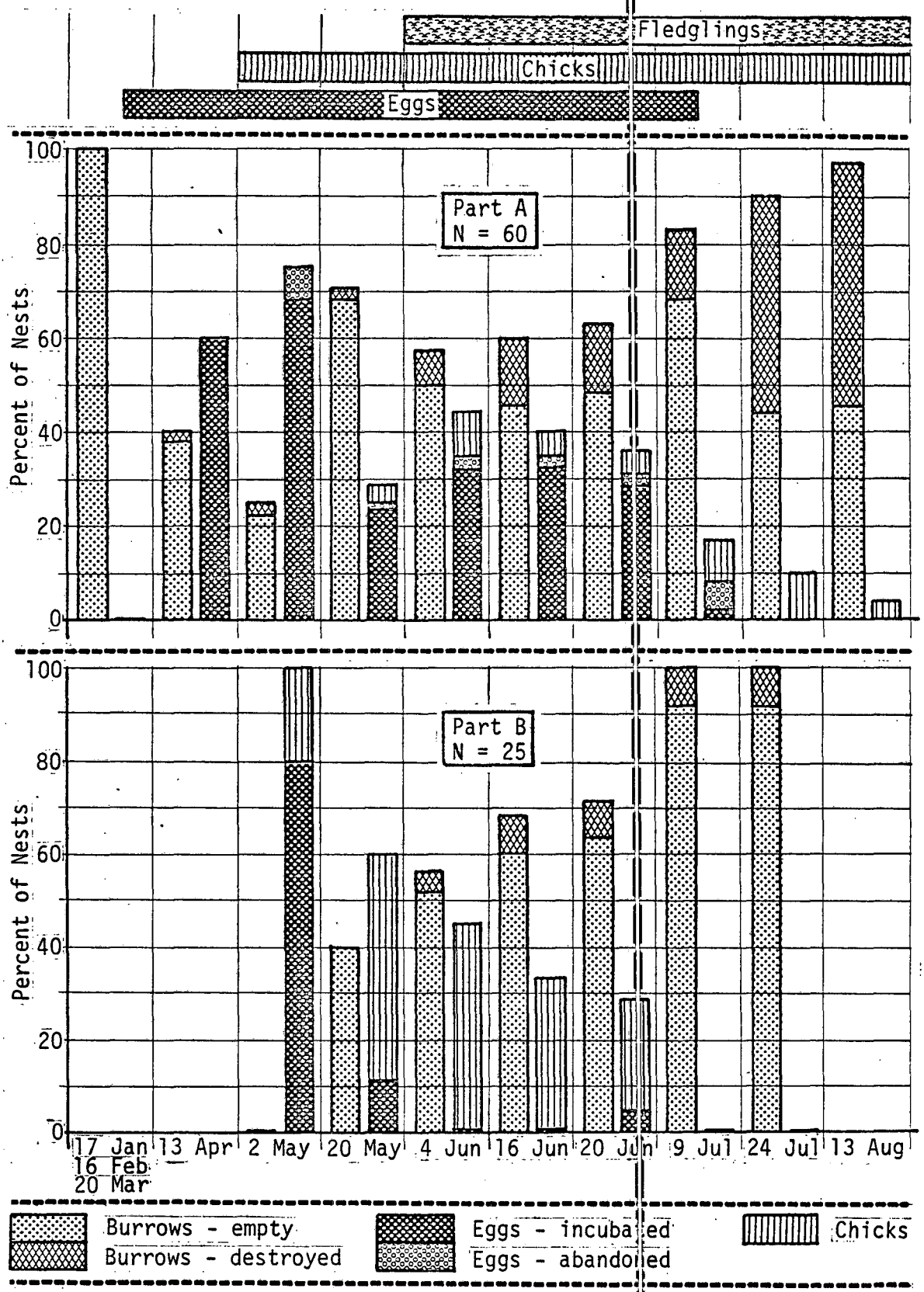


Figure III-100. Timing of breeding events for Cassin's Auklet, Prince Is. (San Miguel Is.), 1977. Part A = phenology for 60 nests followed from 17 January to 13 August; Part B = phenology for 25 nests not checked until later in season, thus less disturbed.

visited Prince Is. in mid-January 1976 and 1977, at which time auklets were actively excavating new burrows and renovating old burrows. (Burrows constructed in soil are altered dramatically by rain, erosion and auklet activity and require rebuilding each breeding season.) Freshly worked burrows checked in mid-February of each year did not yet contain eggs.

The exact date egg laying commenced was difficult to establish due to the infrequency of our visits; however, the first eggs were probably laid in early March in 1976 and late March/early April in 1977. By late March of 1976 and by mid-April of 1977, over half of the burrows examined on Prince Is. had incubating adults. On 6 April 1976, a few burrows contained small chicks and by 28 August all burrows checked were deserted. In 1977, hatching did not commence until shortly before 3 May in the originally established quadrats and some of these burrows still contained chicks on 13 August. The drawn-out incubation period in this study area was attributable to a large amount of re-nesting in late May and June following desertion and destruction of nests that were initiated in April. In contrast, in burrows staked much later in the season, well after incubation had started, all chicks had fledged by early July (Fig. III-100).

During our surveys, breeding activity on Prince Is. was most intense during the evening of 28 April 1976, when auklets were observed singing loudly, engaging in courtship activities and occupying every available crevice and cavity (see Thoresen 1964 for details of this behavior). The birds arrived shortly after dark. Hundreds of birds sat in and above the intertidal area calling, while other birds flew about wildly and flopped clumsily to the ground. The atmosphere was chaotic as mist nets were inundated by incoming auklets. On subsequent visits, investigators found that nocturnal colony activity was less intense, and auklets arrived over a longer period after dark.

On Santa Barbara Is., egg laying commenced on 26 March in 1977, and all of the 8 clutches followed were initiated prior to 11 April. Most chicks hatched between 30 April and 11 May. However, adults carrying food were captured as late as 22 June, suggesting chicks were still present at this time. Fully-fledged juveniles were captured in mist nets adjacent to the Elephant Seal Pt. colony for the first time on 28 May and thereafter until researchers departed the island in mid-July. Peak activity of auklets in this area was observed on the night of 28 May.

Generally, Cassin's Auklets incubate a single egg with two well-developed lateral brood patches for 38 days, followed by a 41- to 45-day nestling period. Fledging occurs when the chicks have attained a weight of about 150 grams (Thoresen 1964; Manuwal 1974). Using these facts, data collected on the weights of chicks on Prince Is., and growth rates developed by Thoresen (1964) and Manuwal (1974), the egg laying period was estimated to extend from late February to early July; the hatching period was estimated to extend from late

March to early August and the fledging period from late April to late August.

Since the auklets at Prince Is. were observed only during the breeding season, a discussion of the information available on this species in other areas throughout the year would be instructive. Thoresen (1964) and Manuwal (1974) found that auklets visited the Farallon Is. colony year round. They suggested that these birds may remain paired all year and possibly for life. Those that had lost mates or were first-time breeders probably acquired mates during the courtship and burrow construction period. On the Farallon Islands, burrows were initiated as early as December, and construction continued until mid-April. The peak in courtship activity occurred from March to April (Manuwal 1974). A few adults continued to feed chicks into August. Generally, auklets appeared to be less numerous in late September and October. It is probable that many birds remained at sea during the remigial molt (September-October) but still visited the island irregularly until the beginning of the breeding season in December (Manuwal 1974).

Reproductive Success

The reproductive success of Cassin's Auklets on Prince Is. was measured in both 1976 and 1977 (Fig. III-101). In 1976, hatching success was similar (∿50%) in both study areas. In 1977, however, there was a marked difference between the hatching success of Study Area 100 (26%) and that of Study Area L (57%).

Study Area 100, which was checked from the beginning of the 1977 season, had an extremely high incidence of egg mortality. 83% of the first eggs laid in this area were lost, and 52% of these burrows eventually received new eggs. Whether these were replacement clutches laid by the same pairs or first eggs laid by new birds is not known. No second clutches were found in burrows where young had fledged. Hatching success was slightly higher for burrows containing these "second" eggs (39%) than it was for burrows in which only one egg was laid. In Study Area L, which was first checked in early May, only one burrow (4%) received a "second" egg. These observations strongly suggest that researcher disturbance was an important factor in the low hatching success documented for Cassin's Auklets.

Unfortunately, it was not possible to measure the relative importance of different sources of chick mortality on Prince Is. in 1976 due to the infrequency of our visits. Chick survival on Prince Is. was quite high in both 1976 and 1977. No actual instances of predation on auklets, either chicks or adults, were observed during this study. However, both owls and gulls prey upon auklets on Prince and Santa Barbara Islands. A Barn Owl roost on the southeast end of Prince Is. contained auklet remains on several occasions. Gulls were often observed "patrolling" auklet colonies, and auklet carcasses were occasionally noted in the gull colony on Prince Island.

Fig. III-101. Summary of Cassin's Auklets Reproductive Success, Prince Island, 1976 and 1977.

	Number of Burrows With Eggs	Total Number of Eggs Laid[1]	Total Number Chicks Hatched	Total Number Young Fledged	Average Clutch Size	Chicks Hatched Per Egg	Number Fledged Per Chick Hatched	Number Fledged Per Egg	Number Fledged Per Nest[2]
1977									
Study Area 100	53	71	18	18	1.0	.25	1.0	.25	.34
Study Area L	20	21	12	10	1.0	.57	.83	.48	.50
Total	73	92	30	28	1.0	.33	.93	.30	.38
1976									
Study Area A	63	76	36	32	1.0	.47	.88	.42	.50
Study Area B	30	46	23	21	1.0	.50	.91	.45	.70
Total	93	122	59	53	1.0	.48	.89	.43	.56
1964									
Thoresen	75	75	31	20	1.0	.41	.65	.27	.27

[1]Number of eggs laid exceeds number of burrows as a result of re-nesting attempts (Thoresen, 1964, did not mention re-nesting).
[2]Nest is defined here as a burrow that eventually received an egg.

Thoresen (1964) reported on the mortality of eggs and young during his extended stay on the Farallon Islands. Of 75 nests observed, only 26.6% raised young to fledging size. Total mortality for eggs and chicks was 73.4%. This included 33% mortality in the early egg state, which he felt was probably due to his intrusion. Thoresen (1964) found that cracked and infertile eggs accounted for 5.3% and collapsed burrows accounted for 12.0% of all mortality. During pipping and hatching, 8.0% died, and 14.8% died or disappeared at later stages of development. Mortality among the chicks which hatched successfully was 35.5%. "Three chicks were seen being devoured by gulls, two died of starvation and six unaccountably disappeared from their burrows before the fledging state." (Thoresen 1964.)

The growth rates for 15 chicks in 1976 and for 12 chicks in 1977 were nearly identical; average rate of chick growth for the two years combined was 4.2 g/day (SD = 1.6, range 1.1-8.0, n = 27). This daily average gain is similar to that reported by Manuwal (1974) for Cassin's Auklets nesting on the Farrallons (3.9 g/day). Manuwal observed that, after reaching a peak weight on about day 37, auklet chicks lost weight until fledging occurred. Such weight loss prior to fledging is common among burrowing alcids (Manuwal 1974) and was also observed in nestlings on Prince Island.

Any attempt to accurately measure natural reproductive success is affected by numerous natural and research-associated variables. Early in the season, the disturbance of incubating adults resulted in the abandonment of eggs, and researcher activity on the colony sometimes inadvertently caused burrows to collapse. Such disturbances would tend to decrease the success estimates below undisturbed, "natural" levels. Also, since the island was visited infrequently, several assumptions had to be made. If a burrow which had an egg on a previous visit was destroyed or empty upon the next encounter, it was assumed that the egg never hatched (an egg mortality). An alternative assumption could have been that the egg hatched, but the chick died (a chick mortality). The use of the former assumption would tend to decrease hatching success estimates. Also, as the chicks grew, some engaged in "burrow switching" during nightly wanderings. This probably resulted in some disappearances and accounts for the unexplained appearance of chicks in certain burrows. Therefore, when small chicks were consistently missing on subsequent nest checks, they were assumed to be dead. However, if the chick was healthy and near fledging on the visit prior to its disappearance, it was assumed to have fledged. These assumptions would have opposing effects on fledging success estimates. Thus, the success rates presented here are only estimates and do not represent absolute reproductive success rates. Comparison of these data with those of Thoresen (1964) or any other study should take these limitations into consideration.

d. Food Habits

Five studies have addressed the food habits of Cassin's Auklets north of Southern California. Carl, Guiget and Hardy (1951) identified a euphausid, Thysanoessa sp., as the main food item of auklets breeding on Vancouver Is. in British Columbia. At the Farallon Islands in Central California, Thoresen (1964) characterized its food in two main types: Euphausids and larval fish, which he referred to as "whitebait". Payne (1965) examined food samples regurgitated by auklets on the Farallon Islands, which consisted mainly of a "pink soupy mass of small crustaceans". He was unable to identify the crustaceans but suspected they were the euphausids Thysanoessa spinifera and Euphausia pacifica. He noted that both species are seasonally abundant in surface waters in Central California. Baltz and Morejohn (1977) mentioned the stomach contents of two wintering Cassin's Auklets taken on Monterey Bay. One contained euphausid parts, and the other contained otoliths representing a minimum of three medusa fish, four flatfish (possibly Citharichthys) and an unidentified crustacean.

Manuwal (1974) has presented the only detailed information on the food habits of Cassin's Auklets to date. Data were obtained from 22 regurgitated samples on the Farrallon Islands while adults were feeding chicks. He found that the main prey items were an euphausid, Thysanoessa spinifera, and an amphipod, Phromema sp. Euphausids dominated samples from four dates until mid-August, when amphipods appeared in large numbers. Prey items of minor importance included squid and fish. Unfortunately neither the species, the percent volume nor the size ranges for any of these food items were noted.

The present study provides the most comprehensive analysis of the food habits of Cassin's Auklets to date. Analyses of 95 samples regurgitated by adults bringing food to young on Prince Is. in 1976 indicated a greater diversity in the species of prey items utilized than had previously been recognized, and an unexpected dominance of larval fish as the major food item (Fig. III-102). Fish comprised 30 percent by volume of the samples, invertebrates (mainly euphausids) 20 percent, and unidentified material 50 percent. Seasonal variations in the species and percentages of food items consumed was evident. Fish and Euphausia were prominent in April, while mainly fish were consumed in May and early June. Fish were still prominent in samples taken in late June with lesser amounts of Acanthomysis and Euphausia. Thysanoessa was prominent in mid-July with smaller amounts of Euphausia and Acanthomysis.

Fish were not consumed in large numbers, but because of their relatively large size they constituted the greatest part of most sample volumes. Mean sizes for food items taken in significant quantities are shown in Fig. III-102. Food items as large as 39 mm and as small as 1.55 mm were consumed. No statistically significant

Fig. III-102. Food Habits of Cassin's Auklet, Prince Island, 1976.

Species	Composition of Regurgitation Samples**		
	Percent Occurrence	Percent Volume	Mean Size of Individual (in mm)
Crustacea	6.3	2.8	
Mysidacea			
Amphipoda			
Lycaeidae			
Tryphana malmi	1.1	0.0	
Pronoidae			
Eupronoe minuta	1.1	0.0	
Vibiliidae			
Vibilia propinqua	1.1	0.0	
Hyperiidae			
Hyperia medusorum	1.1	0.0	
Parathemisto pacifica	1.1	0.0	
Unidentified Amphipoda	3.2	0.0	
Euphausiiacea			
Euphausiidae			
Euphausia pacifica	57.9	7.1	6.09+
Thysanoessa spinifera	50.5	7.7	9.66+
Decapoda			
Albureidae			
Blepharipoda occidentalis	3.2	0.3	
Lophomastix diomediae	* 1.1	0.0	
Alpheidae	* 1.1	0.2	
Canceridae			
Cancer sp.	2.2	0.0	
Crangonidae	1.1	0.0	
Hippolytidae			
Hippolysmata sp.	3.2	0.1	
Maiidae	* 1.1	0.0	
Paguridae	1.1	0.0	
Pandalidae	2.2	0.0	
Caridae	1.1	0.0	
Unidentified Decapoda	3.2	0.2	
Unidentified Crustacea	3.2	0.5	
Mollusca			
Octopoda			
Argonautidae			
Argonauta sp.	* 3.2	0.3	
Enoploteuthidae			
Abraliopsis felis	13.7	1.0	
Unidentified Cephalapoda	4.2	0.2	
Unidentified Invertebrates	3.2	0.5	

Fig.III-102. (Continued) Food Habits of Cassin's Auklet, Prince Island, 1976.

Species	Composition of Regurgitation Samples**		
	Percent Occurrence	Percent Volume	Mean Size of Individual (in mm)
Osteichthyes			
Salmoniformes			
Engraulididae	14.7	0.9	
Engraulis mordax	13.7	0.9	32.94++
Myctophiformes			
Mycotophidae	1.1	0.0	
Atheriniformes			
Atherinidae	* 1.1	0.0	
Scorpaeniformes			
Scorpaenidae			
Sebastes spp.	56.8	12.9	27.03++
Cottidae			
Hemilepidotus sp.	* 4.2	0.1	
Perciformes			
Apogonidae			
Occella verrucosa	1.1	0.1	
Pleuronectiformes			
Bothidae			
Citharichthys spp.	25.3	11.8	18.50++
C. stigmaeus	5.3	1.6	
Unidentified Fish	7.4	1.6	
Unidentified Mush		49.8	

*Identified by non-standard taxonomic characteristics from several to many specimens.
**n = 95 regurgitation samples.

+Carapace length.
++Standard length.

seasonal variation in the sizes of food itmes within species was noted.

Larval Citharichthys sp. was the most important food item consumed by Cassin's Auklets in 1976, comprising 13.4 percent by volume of the samples. Auklets consumed larvae of this species in the 16.5 mm to 19.67 mm size range. These fish would be about 40 days old, having hatched in the spring (E. H. Ahlstrom, pers. comm.). Few conclusions can be drawn about the availability of Citharichthys to the Prince Is. auklets. Ahlstrom and Moser (1975) described the seasonal distribution and abundance of larval flatfish in California; Citharichthys sp. was found to comprise over 87 percent of the flatfish larvae sampled, and the seasonal distribution and abundance was reported to be patchy and varying from year to year. However, the spring hatch would be expected to provide the size range of larvae selected by auklets during the breeding season. A number of other factors may influence the selection of Citharichthys sp. by auklets as well, including: The larvae's abundance and surface dwelling behavior, their long pelagic existance (3 to 4 months), and their large size (30 to 40 mm) (Ahlstrom, pers. comm.).

Sebastes sp. comprised 12.9 percent by volume of the samples. A number of factors may influence the selection of rockfish by auklets, including the fact that the size range consumed (20.0 to 29.5 mm) is abundant near the surface. However, little can be said about the availability or specific identity of the prejuvenile state of rockfish consumed as a number of species have pelagic stages; little is known about their distribution and seasonal abundance; and slow growth, multiple spawnings, and size variability make it difficult to determine age classes for young rockfish. Sebastes diploproa, however, is a likely candidate for the as yet unidentified rockfish under consideration (G. Boelherd, pers. comm.).

The euphausids, Euphausia pacifica and Thysanoessa spinifera, were the only other organisms consumed by auklets in significant quantities. They comprised 7.1 percent and 7.7 percent by volume, respectively, of the samples. E. pacifica and T. spinifera are subartic-transition zone species (Brinton 1962a). Thysanoessa has an affinity for colder waters but inhabits a neritic environment; it is usually restricted to depths of less than 100 meters with little or no vertical migration (Brinton 1962b, 1967). In contrast, Euphausia is more oceanic, deeper, and ranges near shore only in response to cold water (Komaki 1967). Brinton (1967, 1975) described the seasonal distribution and abundance of Euphausia pacifica and Thysanoessa spinifera in the Channel Islands. Both species attain high densities in the spring and summer, particularly in the vicinity of Point Conception and the Northern Channel Islands including Prince Island. Sealy (1975) reviewed the literature on euphausids in his investigation of the food habits of Ancient Murrelets and Marbled Murrelets. He found that only a small proportion of the available zooplankton was taken by feeding Ancient Murrelets and that they fed almost

entirely on E. pacifica until mid-April when T. spinifera began to be taken almost exclusively. He felt that this was probably a result of increasing water temperatures. This shift was not well defined in the present data, but T. spinifera did become more abundant in the July sample.

The size ranges of euphausids consumed by Cassin's Auklets was from 4.78 to 6.68 mm (carapace length) for E. pacifica and 9.27 to 10.76 mm for T. spinifera, indicating that sexually mature (2-year-old) individuals were taken (Brinton, pers. comm.).

In 1977, one hundred and two food samples, including regurgitations collected on the colony at Prince Is. and stomachs from birds collected at sea, were obtained. All samples were combined in the present analysis (Fig. III-103).

The 1977 samples revealed the presence of another species of euphausid, Nyctiphanes difficilis, in significant quantities (14.2% by volume). Only traces of E. pacifica were present, whereas T. spinifera was once again an important component of the diet (32.6%). Larval fish composed a large portion of the diet in 1977, as well (44.3%). The only identifiable genus present in quantity was Sebastes spp. (27.5%).

The 1977 data were consistent with that obtained in 1976; however, some differences were evident which may be due to differences in methods. In 1977, about 90% of the total sample volume was attributed to discrete taxons, whereas in 1976, only about 50% of the total sample volume was thus identified. This discrepancy makes quantitative comparisons difficult.

In summary, although a diverse assemblage of zooplankton of various sizes was consumed by Cassin's Auklets, two species of fish and three species of euphausids constituted the bulk of the food items identified. Although we lack information on the spectrum of foods available to this species, it is likely that size classes and prey species were utilized selectively.

e. Foraging Areas

Very little is known about the foraging patterns of Cassin's Auklets. In a study of alcids breeding on the Olympic Peninsula in Washington, Cody (1973) found that nesting Cassin's Auklets generally foraged farther from land than the other alcids studied, usually at distances greater than 10 km from shore. Thoresen (1964) reported that Cassin's Auklets at the Farallon Islands remained in the vicinity of the breeding colony year-round, but he did not discuss their distribution. No study has examined the at-sea distribution of this species around a nesting colony throughout a breeding season.

Fig. III-103. Food Habits of Cassin's Auklet, San Miguel Island, 1977

Species	Composition of Pouch and Gut Samples (102 samples)	
	Percent Occurrence	Percent Volume
Crustacea		
Amphipoda		
Phronima sedentaria	7	0.6
Phronima sp.	4	-
Vibilia sp.	3	< 1
Unidentified Amphipods	1	
Euphausiacea		
Nyctiphanes simplex	33	14.2
Nematocelis difficilis	4	-
Euphausia pacifica	4	-
Thysanoessa spinifera	28	32.6
Decapoda		
Penaeidae		
Sergestes similis	3	-
Caridae		
family Hippolytidae	6	0.8
Unidentified Carids	2	< 1
Anomura		
Emerita anabia (zoea)	9	< 1
Blepharapoda occidentalis	6	< 1
Brachyura		
family Canaidae		
zoea	6	< 1
megalopa	6	< 1
unidentified Brachyurans	8	-
Cirripeda		
Lepas sp.	2	-
Cephalopoda		
Abraliopsis felis	4	1.9
Loligo opalescens	3	< 1
Gunatus fabrica	4	< 1
Gastropoda		
Carinaria sp.*	5	< 1
Pisces		
Sebastes sp.	19	27.5
Citharichthys sp.	2	1
Engraulis mordax	2	-
Unidentified Fish	12	15.8

*Carinaria sp. identified by radula teeth which were the only undigested portion of the animals.

Cassin's Auklet: Foraging Areas (continued)

Cassin's Auklets are the most abundant marine birds breeding in Southern California, with nesting colonies limited almost exclusively to the San Miguel Is. area. Therefore, as part of the contracted special studies on this species, the waters adjacent to San Miguel Is. were surveyed regularly to learn more about the foraging areas of Cassin's Auklets near their most important nesting colonies in the Bight.

Methods

The distribution of Cassin's Auklets around San Miguel Is. was determined using radial and interisland ship transects. The basic methods of observation and recording used on these transects were the same as those described earlier for shipboard censuses of seabirds in the Bight (see Ship Surveys in Methods).

When the transect program at San Miguel Is. was initiated in 1975, seabird censuses were conducted opportunistically along five radial transect courses extending 14.8 km (8 NM) out from the island. Due to the success of these limited efforts, the program was refined and expanded in 1976 and 1977. Four standard radial transects and one standard interisland transect were used (Fig. III175). All radial transects followed straight line courses extending 18.5 km (10 NM) out from the island; distance was determined using the ship's radar. Data were obtained for the entire length of the Prince, Pt. Bennett and Crook Pt. transects, but only the last 16.0 km of the Castle/ Richardson transect could be accurately censused due to rocks and offshore kelp. The interisland transect ran between offshore islets at San Miguel and Santa Rosa Islands. It surveyed San Miguel Passage and never extended into open waters.

Transects were initially run out from the island on a standard course. At the end of the transect, the boat was turned 180°, and the return ("in") transect was begun immediately. Beginning 21 May 1976, all "in" radials were offset one-half mile counterclockwise around the island from "out" radials to eliminate any possible affect of our passing vessel on subsequent censuses. To determine the extent of the vessel's influence on the number of auklets observed on non-offset return radials, data from "out" and "in" radials performed prior to 21 May 1976 were compared using the sign test (Siegel 1956). Prior disturbance by the vessel had no observable affect on auklet numbers ($x = 4$, $p = 0.55$, $n = 11$); therefore, offset and non-offset radials were considered comparable in all analyses.

Data Treatment

During all transects, sightings were logged in the order of their occurrence, and the time at which each sighting was made was recorded. In order to examine the distribution of auklets at different distances out from land, it was necessary to convert the sighting times to approximate distances. For ease, it was decided

to divide the sightings into 2-km segments. The amount of time required to travel 2 km varied each time a transect was performed and was calculated in the following way:

$$\text{time-equivalent (min) for 2-km segment} = \frac{\text{Total travel time on transect (min)}}{\text{Length of transect (km)}} \times 2 \text{ km}$$

This was considered the most accurate estimate, since the length of the transect was always verified by radar.

Due to the difficulty of sighting small alcids at large distances, especially under rough conditions, only sightings from Regions I and II (0 - 150 m to either side of the ship) were used. Occasionally, a single sighting of large numbers of auklets was recorded cumulatively in Regions "I, II, and III" (Region III extends from 150 - 400 m either side of the ship); such sightings were included in the totals presented.

Because auklets are small and inconspicuous diving birds with a tendency to avoid passing ships, it was felt that the censusing methods used underestimated the actual density of these alcids around San Miguel Island. Therefore, when a transect was performed more than once a day (i.e. data from both "out" and "in" were collected), the survey with the maximum total number of auklets was used in calculating densities and distributions. The selective use of maximum surveys rather than means resulted in higher absolute estimates and higher variance, but it did not influence the general trends observed.

The overall mean density of auklets around San Miguel Is. (presented in Fig. III-108) was calculated by averaging the mean densities (total auklets seen/area censused) for each transect performed for each month. The distribution of the auklets along each standard transect (presented in Figs. III-110 and III-111) was calculated by determining the percent of birds sighted in each segment each month and then averaging these percentages to obtain the mean percent of total auklets sighted a given distance from land (a sample calculation is given in Fig. III-177). Because of the relatively small area sampled at San Miguel Is., no attempt was made to estimate the total Cassin's Auklet population there (cf Xantus' Murrelet at Santa Barbara Is.).

Of the three years in which information was collected, the most complete set of data was obtained in 1976. Fewer radial transects were performed and less frequently in 1977 due to extremely difficult weather conditions. Therefore, the following discussions were based primarily on 1976 data, though, where possible, comparisons were made to the available 1977 data base. Due to the different methods used in 1975 and the small number of transects completed, direct comparisons across all three years were not possible.

Cassin's Auklet: Foraging Areas (continued)

Results

The total numbers of Cassin's Auklets sighted on radial transect surveys around San Miguel Is. from 1975 through 1977 are summarized in Fig. III-104. The distributions of these birds in 1-NM (1975) or 2-km (1976-77) segments along each radial transect can be found in Figs. III-178 to III-200.

Yearly Fluctuations in Numbers

Significantly fewer Cassin's Auklets were observed on radial transects around San Miguel Is. throughout the 1977 season than were seen on equivalent transects the previous year (Wilcoxon Matched Pairs Signed Ranks Test, all radials: $n = 12$, $T = 3$, $p < .01$; Prince transect only: $n = 7$, $T = 0$, $p < .02$). On the average, approximately only 25% of the Cassin's Auklets sighted on 1976 radial transects were seen on comparable surveys in 1977 (Fig. III-105). As there was no evidence of a similar decline in the breeding populations on the colonies, it was assumed that a large portion of the San Miguel Is. auklet population was foraging farther out to sea in 1977, in areas beyond the range of our surveys. The reason for this probable shift in foraging areas is not known. However, it may indicate a decrease in the availability of food for this species.

The data collected in 1975 were too scarce to allow a detailed comparison. However, on the basis of the two sets of transects performed, the general abundance of auklets in the San Miguel Is. area resembled that observed in 1976.

Seasonal Fluctuations in Numbers

In both 1976 and 1977, there were no marked seasonal fluctuations in auklet density (Fig. III-105). Cassin's Auklets were present in the waters adjacent to their breeding colonies in relatively constant numbers from mid-January through mid-July (the census period); the fluctuations observed over the season had no systematic relationship to the breeding cycle. Since auklets foraged in large aggregations, these fluctuations were probably the result of flock movements in and out of the vicinity covered by the standard radial transects as the auklets sought areas of abundant plankton.

According to Thoresen's (1964) and Manuwal's (1974) studies of Cassin's Auklets on the Farallons, it is likely that the birds remain in the vicinity of the breeding colony year round, moving slightly farther offshore during the non-breeding months of October to December. However, large concentrations of auklets have been sighted in the Pacific Ocean from 50 to 250 km from land, suggesting that at least some birds do leave the colony area (see Vol. III, Part III, Book I, Ch. 1).

Fig. III-104. Total Numbers of Cassin's Auklets Sighted on Transect Surveys at San Miguel Island, 1975-1977.

1975	14-19 Jan.	11-16 Feb.	17-22 Mar.	6-7 Apr.	28 Apr.-2 May	13-21 May	4-9 June	19-24 June	8-15 July	23-25 July	12-14 Aug.
Cuyler (out)	-	-	-	-	-	179	-	-	28	-	-
(in)	-	-	-	-	-	51	-	-	-	-	-
Castle Rk. (out)	-	-	-	-	-	103	-	-	-	-	-
Crook Pt. (out)	-	-	-	-	-	3	-	-	446	-	-
Tyler (out)	-	-	-	-	-	0	-	-	-	-	-
Cardwell (out)	-	-	-	-	-	-	-	0	-	-	-
1976											
Prince Is. (out)	110	135	44	41	49	80	19	3	2	-	-
(in)	48	104	127	-	41	126	72	2	4	-	-
Castle Rk. (out)	42	45	-	314	-	293	32	1	80	-	-
(in)	52	67	-	268	-	93	84	-	204	-	-
Pt. Bennett (out)	140	-	-	-	-	6	22	0	0	-	-
(in)	136	-	-	-	-	0	31	0	0	-	-
Crook Pt. (out)	57	3	-	0	1	0	0	7	-	-	-
(in)	12	1	-	1	-	0	-	2	-	-	-
Bee Rk. (out)	-	-	5	-	4	1	0	-	-	-	-

Fig. III-104. Continued. Total Numbers of Cassin's Auklets Sighted on Transect Surveys at San Miguel Island, 1975-1977.

1977	14-19 Jan.	11-16 Feb.	17-22 Mar.	6-7 Apr.	28 Apr.-2 May	13-21 May	4-9 June	19-24 June	8-15 July	23-25 July	12-14 Aug.
Prince Is. (out)	16	35	5	-	22	-	-	0	9	-	3
(in)	-	-	-	-	76[a]	-	-	3	-	-	1
Castle Rk. (out)	20	-	1876	-	-	-	-	-	-	3	30
(in)	3	-	-	-	-	-	-	-	-	2	5[a]
Pt. Bennett (out)	-	-	-	-	-	-	-	-	-	-	6
(in)	-	-	-	-	-	-	-	-	-	-	4
Crook Pt. (out)	0	0	19	-	-	-	-	-	-	-	0
(in)	-	1	-	-	-	-	-	-	-	-	-
Bee Rk. (out)	-	-	-	-	2	-	0	-	-	0	0

[a]Non-standard radial.

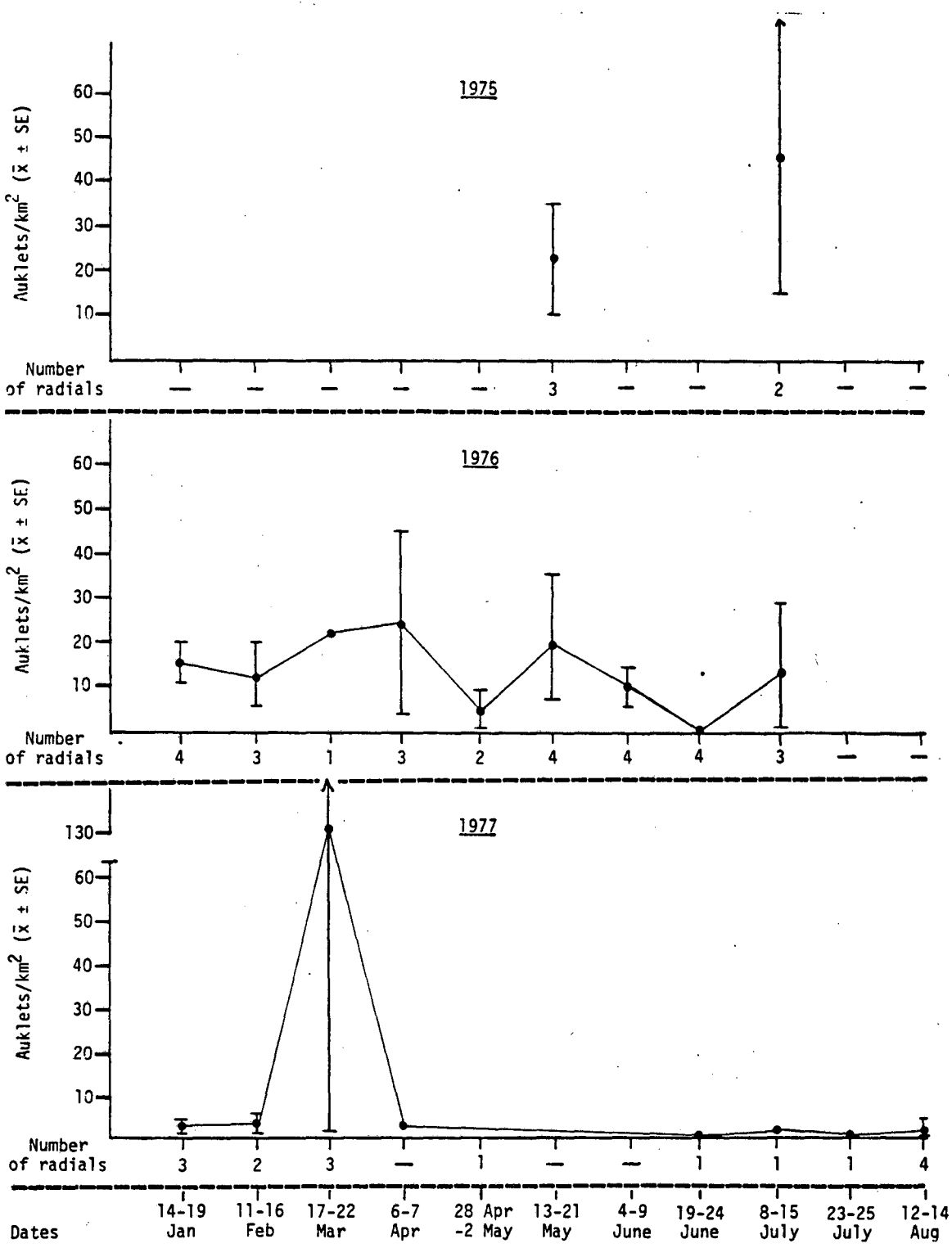


Figure III-105. Seasonal changes in mean densities of Auklets in vicinity of San Miguel Is., 1975-1977.

Cassin's Auklet: Foraging Areas (continued)

Daily Movement Patterns

During the breeding season, Cassin's Auklets leave the breeding colony en masse shortly before dawn, disperse out to sea to forage, and return to land after dark. On the basis of this daily pattern of movements, one would expect the majority of the auklets to be concentrated closer to land in the early morning and early evening than any other time of day. During informal observations in 1976 and 1977, large rafts of auklets were encountered regularly off Prince Is. at sunset, prior to the birds' return to the island, and similar aggregations may form at dawn as the birds fly out to sea. However, with the transect surveys performed, it was not possible to quantitatively document this daily pattern.

Areal Distribution Around the Island

In 1976 and 1977, auklets were most common on the north (Prince) and west (Castle/Richardson) transects (Figs. III-106 and III-107.) These radials are adjacent to the large auklet colonies at Prince Is. and Castle Rk., respectively. In both years, the observed auklet densities north and west of the island were significantly greater than that observed south of the island (Fig. III-108). Very few auklets were encountered east of San Miguel Is. on the interisland transect (Bee Rk. - Prince), and the density of auklets seen to the southwest (Pt. Bennett transect) was generally intermediate to low. However, these areas were not censused often enough to allow direct comparisons.

The small number of radials performed in 1975 makes detailed comparison unfeasible. Nevertheless, the same basic pattern was observed on 13 May when three equivalent transects were performed (Fig. III-109). On 15 July 1975, however, a large concentration of Cassin's Auklets (446 birds) was observed south of Crook Pt., showing that this area is used occasionally by these birds.

Generally, auklets were not seen close to shore, but otherwise they foraged in discrete concentrations at varying distances out from the island (Figs. III-110 and III-111). The location of these concentrations changed each time the birds were surveyed, presumably as the birds congregated in areas of temporary prey abundance. In 1976, the majority of the birds on the Prince and Crook Pt. transects were found between 4.5 km and 18.5 km from shore, but very few auklets were seen within 4.5 km of land (5.6% and 1.8% respectively). Similarly, auklets on the Castle/Richardson radial were distributed in localized concentrations ranging from 2.5 to 18.5 km out. (The segment from 0 - 2.5 km from San Miguel Is. was not systematically censused for this radial, but very few auklets were observed in this area.) Only the Pt. Bennett radial deviated from this general pattern; in this area, over 95% of the auklets were seen within 4.5 km of the island. In 1977, the auklets foraged slightly closer to shore on the Prince and Crook Pt. transects, but otherwise the same

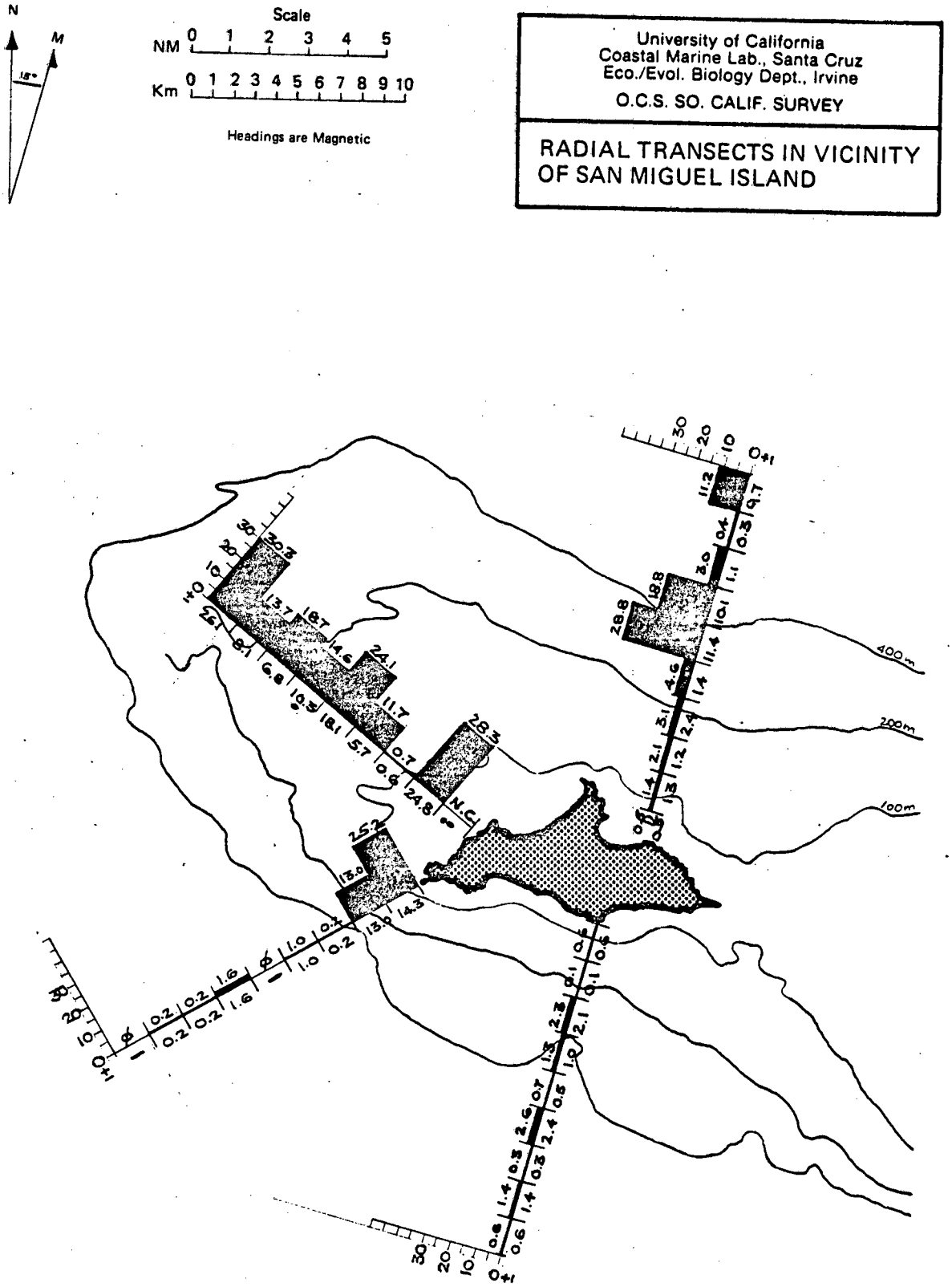


Figure III-106. Average numbers of Cassin's Auklets sighted in transect segments, 1976.

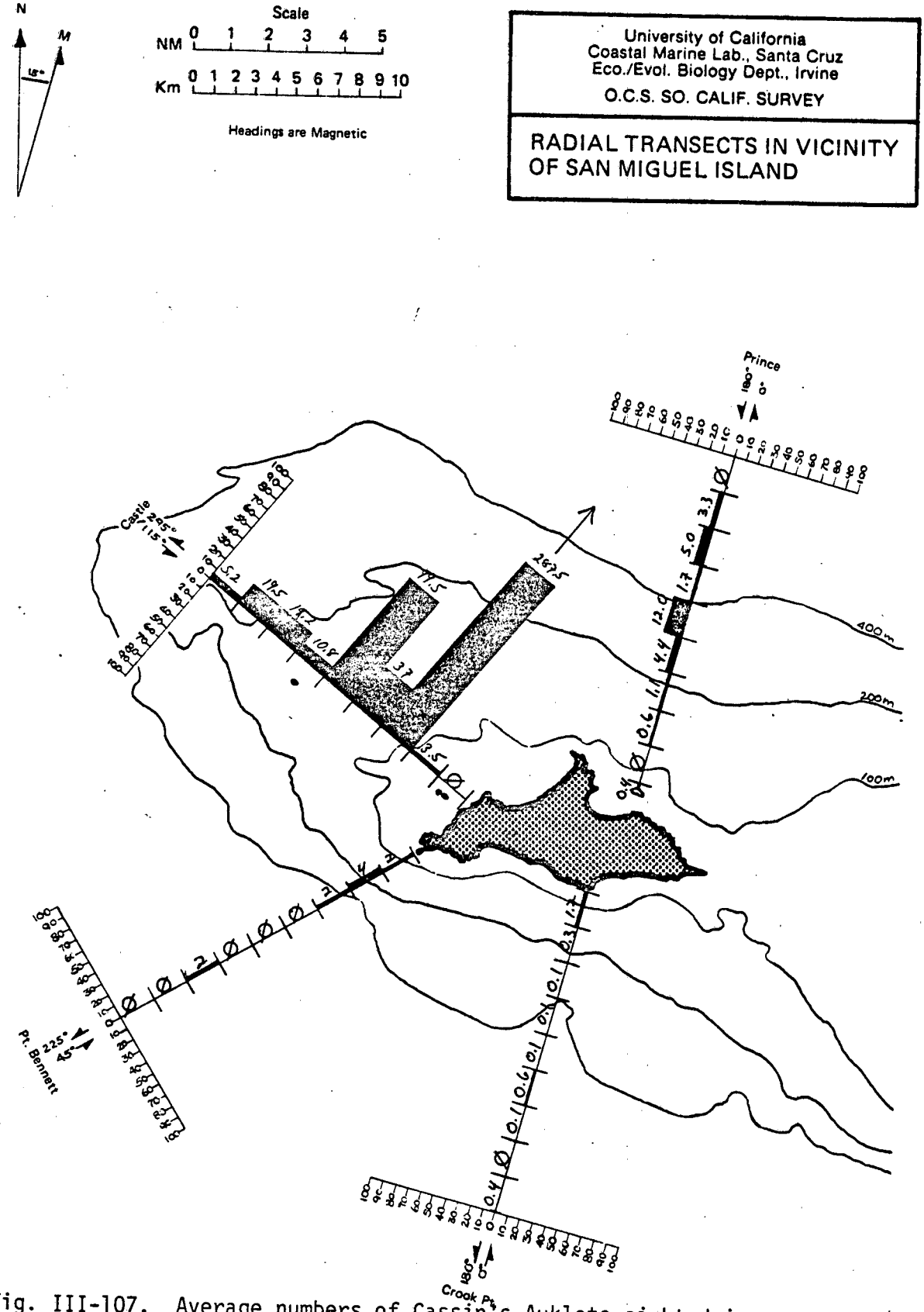


Fig. III-107. Average numbers of Cassin's Auklets sighted in transect segments, 1977.

Fig. III-108. Mean Densities of Cassin's Auklets on Radial Transect Surveys, San Miguel Island, 1975-1977.

1976	14-15 Jan.	11-12 Feb.	17-18 Mar.	6-7 Apr.	28-29 Apr.	20-21 May	8-9 June	23-24 June	14 July	Mean Density ± SE
Prince[a]	19.82	24.32	22.88	7.39	8.83	22.70	12.97	0.54	0.72	13.35 ± 3.16
Castle/Richardson[a]	10.83	13.96	-	65.42	-	61.04	19.38	0.21	42.50	30.48 ± 9.76
Pt. Bennett	24.50	-	-	-	-	1.08	5.59	0	0	6.23 ± 4.68
Crook Pt.[a]	10.27	0.54	-	0.18	0.18	0	0	1.26	-	1.78 ± 1.43
Mean Density	16.36	12.94	22.88	24.33	4.51	21.21	9.49	0.50	14.41	
SD	6.97	11.92	-	35.77	6.12	28.54	8.47	0.55	24.33	
SE	3.49	6.88	-	20.65	4.33	14.27	4.23	0.28	14.05	
n	4	3	1	3	2	4	4	4	3	

1977	17-19 Jan.	15-16 Feb.	21-22 Mar.	Apr.	2 May	21 June	8 July	23-25 July	12-14 Aug.	Mean Density ± SE
Prince[b]	2.88	6.31	0.90	-	3.96	0.54	1.62	-	0.54	2.39 ± 0.81
Castle/Richardson[b]	4.17	-	390.8	-	-	-	-	0.62	6.25	100.46 ± 96.79
Pt. Bennett	-	-	-	-	-	-	-	-	1.08	1.08
Crook Pt.[b]	0	0.18	3.42	-	-	-	-	-	0	0.90 ± 0.84
Mean Density	2.35	3.24	131.71	-	3.96	0.54	1.62	0.62	1.97	
SE	1.23	3.06	129.55	-	-	-	-	-	1.44	
n	3	2	3	-	1	1	1	1	4	

[a,b] Comparison of Prince, Castle/Richardson and Crook Pt. transects.

[a] 1976 - Kruskal Wallis: $H=10.28$; $df=2$; $p<.01$

Prince & Castle/Richardson vs. Crook Pt. - Mann-Whitney U: $U=8.5$; $n_1=7$; $n_2=16$; $p<.001$

[b] 1977 - Kruskal Wallis: $H=5.68$; $df=2$; $p<.05$

Prince & Castle/Richardson vs. Crook Pt. - Mann-Whitney U: $U=6.0$; $n_1=4$; $n_2=11$; $p<.05$

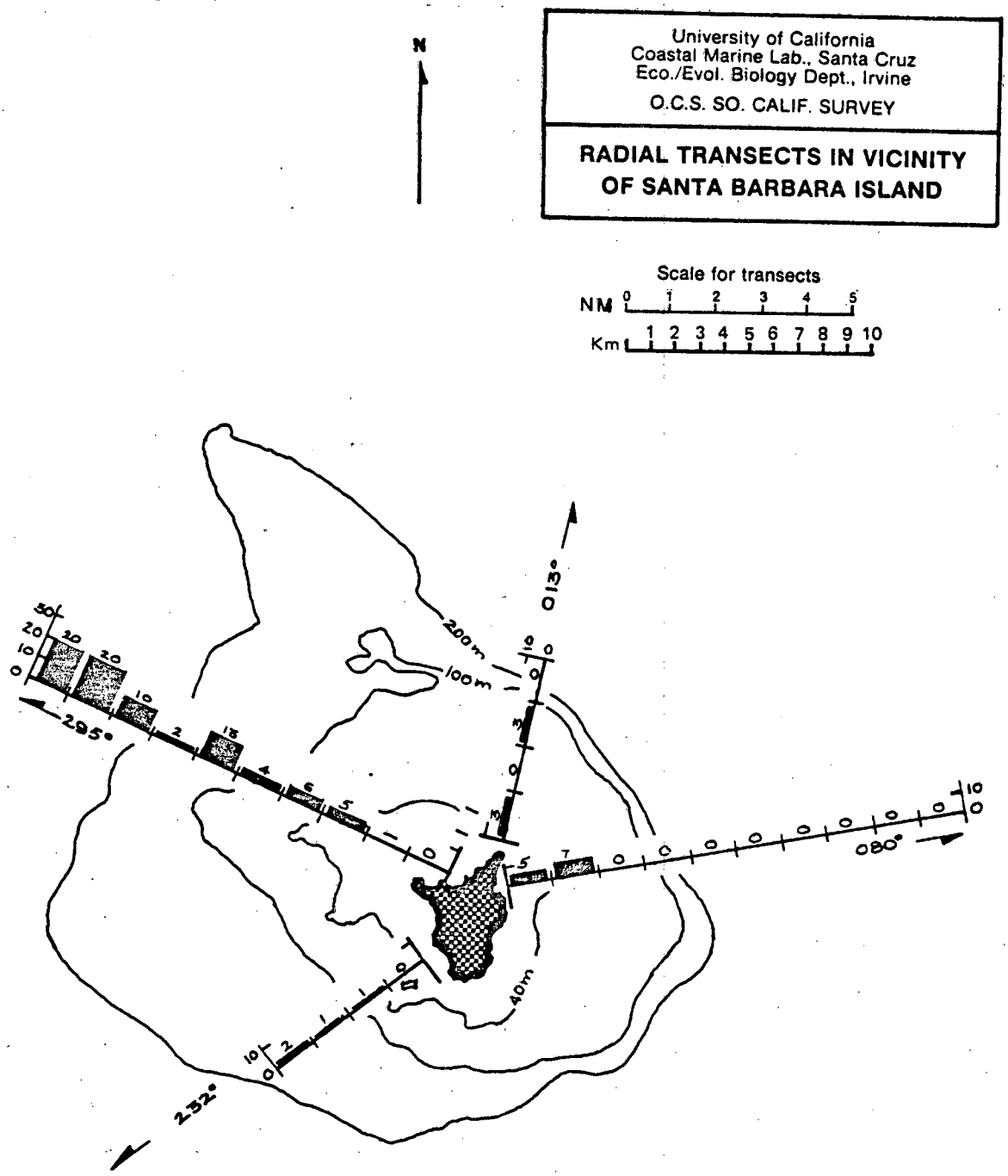
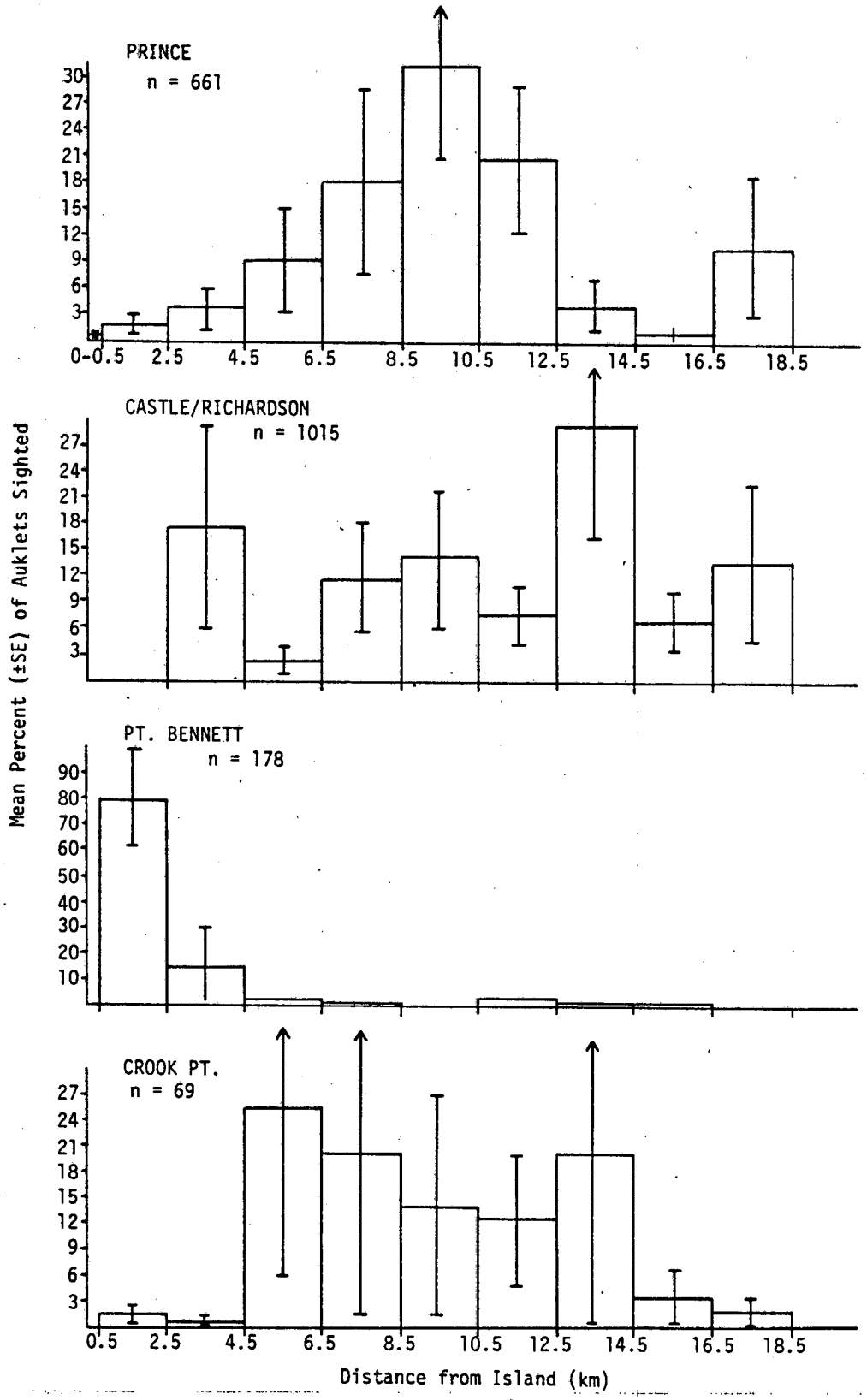


Figure III-109. Distribution of Xantus' Murrelet at sea, May 1975. Numbers of birds sighted per 1.85 km (1 nm) on indicated headings.

Fig. 110. Distribution of Cassin's Auklets on Radial Transect Surveys in the Vicinity of San Miguel Is., 1976.



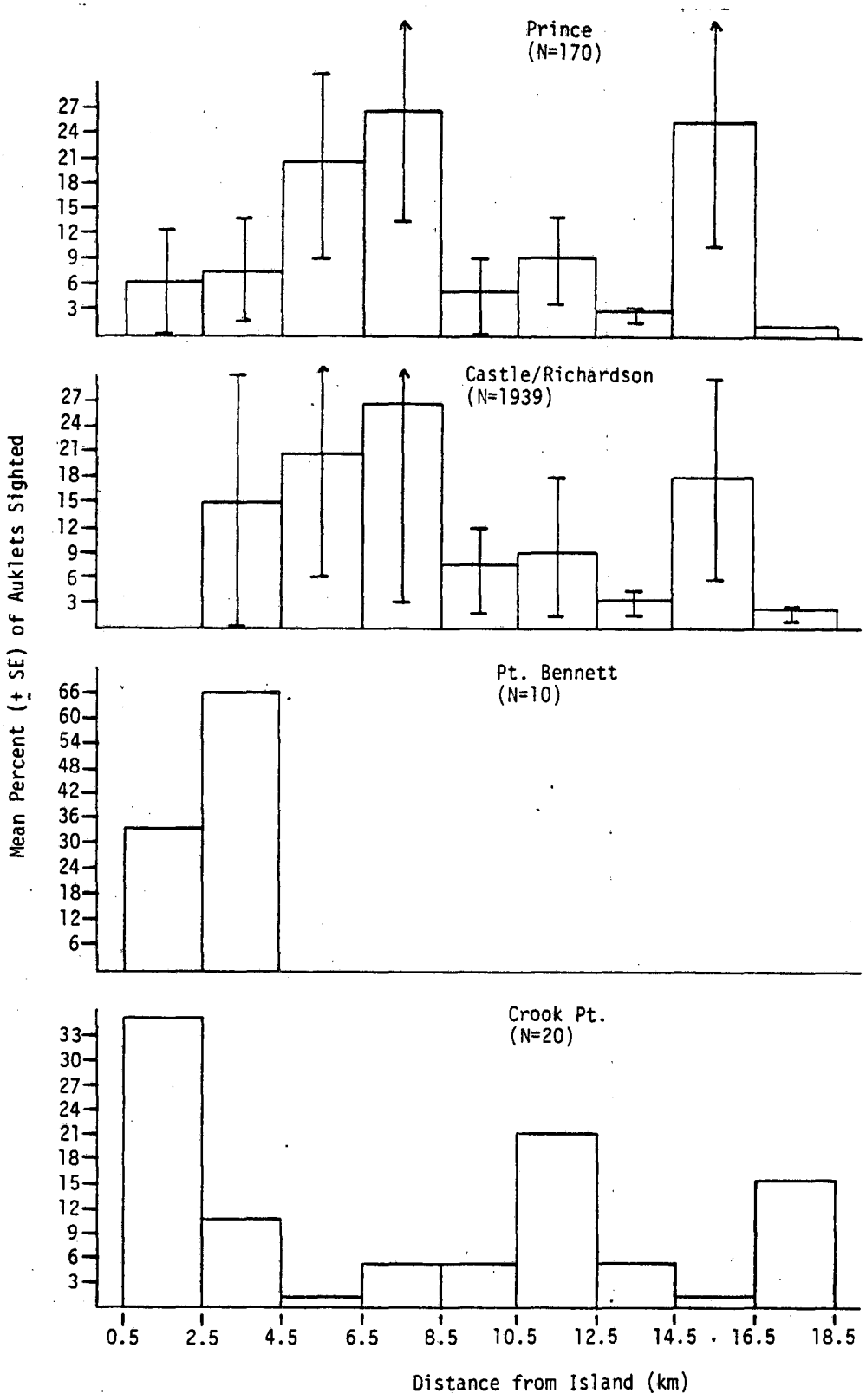


Figure III-111. Distribution of Cassin's Auklets on radial transect surveys in vicinity of San Miguel Is., 1977.

pattern was maintained.

The large variances associated with these data are due to radical monthly changes in the birds' distribution. Such fluctuations suggest that the foraging areas used by Cassin's Auklets off San Miguel Is. varied greatly throughout the season. This extreme variability may simply reflect the naturally patchy distribution of these birds in response to their food resources, or it may indicate that these birds moved freely in and out of our effective censusing area (18.5 km offshore) and possibly foraged regularly at greater distances from land.

On the basis of the available information, the preferred foraging areas of the auklets (indicated by higher observed auklet densities) were not correlated with any obvious parameter of ocean topography (i.e. depth, current). Instead, it appears that the birds avoided inshore areas but otherwise had no preferred water depth or distance from land for foraging. The avoidance of inshore areas may be an adaptation to minimize exposure to gull predation close to land, where the density of gulls moving to and from the colonies is greatest. Otherwise, auklets appeared to disperse directly out to sea from their breeding colonies (which are located north and west of San Miguel Is.) and rarely foraged to the south. Whether or not these distribution patterns reflect the availability of exploitable food resources or some other factors (e.g. accessibility to the breeding colonies) cannot be determined at present. Preliminary examination of plankton trawls, however, suggest that this distribution does reflect, at least in part, the availability of food. Detailed investigations into the productivity of the different areas, especially with respect to the auklets' preferred food populations (euphausids and larval fish) would be necessary before this question could be answered.

Foraging Flocks

Cassin's Auklets were very social at sea and generally foraged in groups during the breeding season. Over 70% of all the auklets sighted on radial transects were in associations of six or more birds (Fig. III-112). The largest single flock encountered contained approximately 300 birds, but Cassin's Auklets often foraged in large, loose, ill-defined groupings of many times this number. The majority of the auklets, however, foraged in groups of 6 to 100 birds with no apparent seasonal changes in the flocking behavior. Large flocks were seen from January through August, and the frequency of flocks of different sizes was quite consistent over the three years of this study. The habit of foraging in large flocks greatly increases the vulnerability of this species to floating oil.

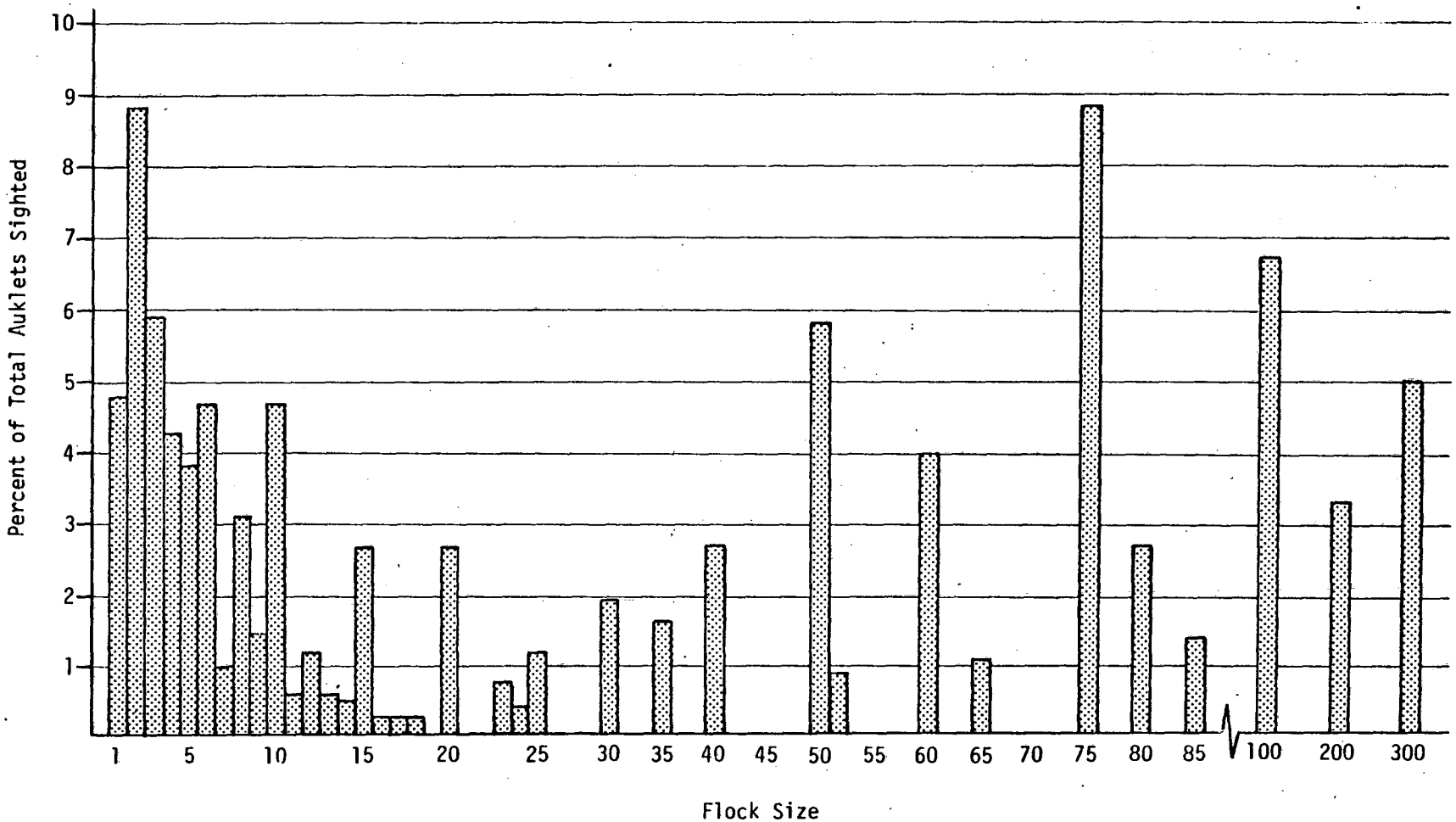


Figure III-112. Percent of Cassin's Auklets sighted in flocks of various sizes, San Miguel Is., 1975-1977.

Tufted Puffin (Lunda cirrhata)

a. Introduction

Tufted Puffins reside primarily in far northern Pacific waters. They breed on rocky coasts and islands of the North Pacific from Japan to California, including the Bering Sea and parts of the Arctic Ocean. Puffins formerly bred in the eastern Pacific as far south as the Channel Islands, but now they do not breed beyond the Farallon Islands off San Francisco. Nests consist of shallow burrows or natural crevices. Except for the northernmost populations which move south, most puffins winter in the area offshore of their breeding grounds (Bent 1919; Gabrielson and Lincoln 1959).

b. Historical and Present Breeding Status in the Channel Is.

Tufted Puffins no longer breed in the Channel Islands, and none were found on or around any of the traditional colonies during 1975-77. Below is an account of this species' breeding history in the Bight.

San Miguel Is.

All records from the San Miguel Is. area only pertain to Prince Island. In 1886, Streator (1888) reported "Dozens of the peculiar birds [Tufted Puffins] sat out upon the ledges of the rocks, while others were flying about in all directions, and crevices in the rocks were filled with eggs". Two sets of eggs were secured by Burt on 5 June 1905 (WFVZ 32098; Peyton, unpubl. notes), and 11 sets were collected on 6 June 1906 by Burt and Appleton (Appleton, unpubl. notes; Willet 1912). Willet (1910) and party visited the island during June 1910 and found puffins "breeding commonly" with eggs and chicks present. Four sets of eggs were collected at this time (WFVZ 4360, 6145; WFVZ uncat.; Willet, unpubl. notes). On 12 July 1912, when Wright and Snyder (1913) visited this colony, they examined "numerous burrows" containing young. After visiting all the northern islands and Santa Barbara Is., they felt that the Prince Is. colony was the largest. This is the last authenticated report of breeding puffins on San Miguel Is. Sumner (1939) and Bond visited the islands of Santa Barbara, Anacapa, Prince and San Miguel in mid-April 1939 but did not mention Tufted Puffins. In their report (Sumner op cit), they mention seeing a single Common Murre on Prince Is. and cite Willet's (1933) belief that the species was extinct there. They express concern for the loss of this breeding species yet do not mention puffins at all, even though Willet (op cit) had stated that puffins were fairly common and breeding on San Miguel, Anacapa and probably Santa Barbara Islands. Whether puffins were not present during their survey or just unwittingly omitted from their accounts is not clear. There is unsubstantiated

evidence that puffins may have nested on Prince Is. as late as the 1950's: Small (1960) says Tufted Puffins "were reported as having nested recently on Prince Is. off Santa Rosa Is. [sic] by Bleitz". Small (op cit) mentions numerous other sightings of puffins around the Channel Islands, which indicates they were considerably more common at that time than they presently are. By 1965, however, no puffins were breeding at Prince Is. (Craig and Sheppard, unpubl. notes), and POBSP personnel failed to find any in 1968 (Crossin and Brownell 1968; Huber 1968).

Santa Rosa Island

Howell's (1917) statement that "definite breeding records are lacking" for puffins at Santa Rosa Is. is the only indication that they may have occurred there. It suggests that this species was suspected of breeding on this island at one time.

Santa Cruz Island

Hewshaw recorded Tufted Puffins nesting at Santa Cruz Is. in the summer of 1875 (Willet 1912), and local fishermen claimed puffins bred regularly at the north [west?] end of the island (Howell and van Rossem 1911). Several were seen by Wright and Snyder (1913) at the west end of the island on 10 July 1912, and Peyton (unpubl. notes) reported "large flocks of Tufted Puffins at the west end of Santa Cruz" on 3 March 1917.

Anacapa Island

The first record of puffins at Anacapa Is. appears to be a specimen collected on 14 August 1909 (UCLA 8946). Willet (1910) saw Tufted Puffins breeding on the cliffs of Anacapa Is. on 5 June 1910. They were "quite numerous on the east end of Anacapa", when Wright and Snyder (1913) saw them on 5 July 1912. Several burrows examined at that time had young or eggshells. Sumner (1939) did not mention seeing this species during his reconnaissance of the island in April 1939 (see discussion), and Banks (1966) did not see any in 1963 or 1964. Banks (op cit) concluded that the colony may no longer have existed by that time, and puffins have not been reported on or around the island since.

Santa Barbara Island

Grinnell (1897) reported "About a dozen of these birds were probably breeding on Santa Barbara Island. They were seen flying about a bluff on the north side of that island on several occasions during our stay there--May 13 to 18, 1897 ." According to Wright and Snyder (1913), burrows that probably belonged to puffins were found "on the

rock on the northeast end of Santa Barbara Island [Shag Rk.]." Five puffins were flushed from the water in the vicinity of the same rock on the next day. Dawson (1923) mentions that puffins were no longer present on Santa Barbara Is., and none have been seen there since.

San Nicolas Island

Willet (1912) reports single puffins seen at San Nicolas Is. in 1910 and 1911. However, there is no evidence that they ever bred there.

San Clemente Island

Wheelock (1904) says Tufted Puffins bred on "San Clementi [sic]" Is. to a limited extent. However, there is no evidence to substantiate this.

Santa Catalina Island

No evidence of breeding.

In summary, breeding Tufted Puffins were concentrated in the San Miguel Is. area, with smaller more peripheral populations occurring on the remainder of the northern Channel Islands and Santa Barbara Island. This distribution pattern is characteristic of marine birds that breed in the Channel Islands whose population centers are decidedly to the north of southern California. (Pelagic Cormorants and Pigeon Guillemots show the exact same pattern). Puffins appear to have remained in the San Miguel Is. area longer than on other islands of the Bight.

Ainley and Lewis (1974) discuss the disappearance of Tufted Puffins from the Channel Islands and their failure to recover from population declines on the Farallon Islands off central California. They suggest these events may have been related to the depletion of sardine stocks off California. As puffins are capable of delivering vicious bites with their enormous bills (Bailey 1902: 13; Bent 1919, 1946) and nest in relatively inaccessable cliff areas (in the Channel Islands: Streator 1888; Wright and Snyder 1913: 88-89), it is very unlikely that early egg collectors were entirely responsible for their extirpation from the Channel Islands. It seems more likely that changes in the marine environment were responsible for Tufted Puffins abandoning their southernmost breeding stations in the eastern Pacific. Udvardy (1963) has paralleled the distribution of Tufted Puffins in the north Pacific with Steller's Sea Lion (*Eumatopias jubata*). The southernmost breeding site of this sea lion is presently at San Miguel Island. Like the Tufted Puffin, Steller Sea Lion populations

have declined dramatically since the 1930's, and this species appears to be loosing its Channel Islands foothold (Bartholomew and Boolootian 1960). The parallel decline of these two apparently unrelated species suggests long term climatic changes, however other data seem to contradict this (see discussion in Ainley and Lewis 1974).

D. DISCUSSION

DISCUSSION

1. Distribution, Abundance and Importance of Local Populations

The California Channel Islands support a diverse mixture of seabirds of northern and southern affinities. Of the eleven species presently breeding on the islands, six have either the northern or southern limits of their range in the Channel Islands or in the nearby Los Coronados Islands (Fig. III-113). Two other species formerly had the southern terminus of their breeding range in the Channel Islands. This zoogeographic diversity in the breeding seabird fauna is of considerable scientific interest, as it provides an opportunity to study the complex interactions determining the distributional limits of species.

The unique composition of the Channel Islands seabird fauna also has important management implications. Specifically, seabird populations that are nesting at the periphery of their species' range may be particularly vulnerable to local extinction. These populations are likely to be subject to marked fluctuations in size, probably in response to natural fluctuations in environmental conditions influencing food availability or other conditions required for successful breeding or survival. In addition, peripheral populations are commonly isolated, meaning that recruitment from nearby colonies is unlikely. Hence, environmental stress related to man's activities may have a more serious impact on these populations than it would on more robust populations at the center of a species' range. The demise of the Common Murre and the Tufted Puffin are examples of this problem, as is the uncertain future of the remnant population of Brown Pelicans on Anacapa Island.

The importance of various colonies or species of seabirds in the Channel Islands depends upon the perspective within which importance is defined. Local populations can be important on a worldwide scale for the preservation of the species or on a regional basis. They may have special scientific or recreational value. Importance of local populations may be independent of the size of those populations, as when the species is rare, restricted in range, or when the local population in question represents the edge of a species' range. It is essential to note that the extripation by man of local populations at the edge of a species distribution cannot be condoned simply because extinctions of populations at the edge of a species' range occasionally occur naturally. The logical conclusion of such a philosophy is the certain eventual extinction of a species as successive peripheral populations are sacrificed.

On a global scale, the Channel Islands support extremely significant populations of Ashy Storm-Petrels and Xantus' Murrelets. Ashy Storm-Petrels have only a small total population restricted to the California coast and the Southern California Bight. The colonies at San Miguel and Santa Barbara Islands may constitute as much as five to ten percent of the world population of this species.

Fig. III-113 Zoogeographic Distribution of Breeding Seabirds of the Southern California Bight

Northern Edge of Range	Midst of Range	Southern Edge of Range
Black Storm-Petrel	Leach's Storm-Petrel	Ashy Storm-Petrel
Brown Pelican	Double-crested Cormorant	Pelagic Cormorant
Xantus' Murrelet	Brandt's Cormorant	Pigeon Guillemot
	Western Gull	Common Murre*
	Cassin's Auklet	Tufted Puffin*

*Formerly bred, no longer nests in the Channel Islands.

Discussion (continued)

The population of Xantus' Murrelets at Santa Barbara Island is the largest known in the world. The presence of nesting Brown Pelicans, an endangered species, at Anacapa Is. (and occasionally at Scorpion Rk.) give these colonies distinction as critical habitats, as well.

In general, the populations of seabirds breeding in the Channel Islands are modest in size (Fig. III-114). Indeed, when compared to the enormous colonies in the Bering Sea or Antarctica, Southern California colonies are quite small. However, the Channel Islands do support over 25,000 pairs of breeding seabirds and constitute the largest aggregation of nesting birds south of the Farallon Islands in the western United States. Thus, on a regional basis, these colonies are very significant.

The three islands supporting the largest colonies are San Miguel (and associated islets), Santa Barbara and Anacapa Islands (Fig. III-114). San Miguel and Santa Barbara Islands also support the most diverse nesting seabird populations. San Miguel and Santa Barbara Islands are important as the northern limits of Xantus' Murrelet and Black Storm Petrel, respectively, while the endangered Brown Pelican reaches the northern extent of its range at Anacapa Island. Pelagic Cormorants and Pigeon Guillemots reach the southern terminus of their ranges at Santa Barbara Island. San Miguel Island's abundant fauna, primarily of northern affinities, is almost certainly the result of this island's location, amidst the cold, rich waters of the California current. In contrast, Santa Barbara Island's large, primarily southern fauna may be related to its proximity to the warmer California countercurrents.

Other colonies in the Bight are of secondary importance when compared to San Miguel, Anacapa or Santa Barbara Islands. However, the large populations of cormorants breeding on the north sides of Santa Rosa and Santa Cruz Islands represent a sizeable fraction of the regional populations of these species. It should be noted that cormorants, particularly Double-crested Cormorants, have suffered recent population declines (Gress et al. 1973) and have only recently begun showing the initial signs of recovery. Therefore, these species require protection, particularly from disturbance, if they are to persist.

In summary, three colonies, (San Miguel, Anacapa and Santa Barbara Islands) are of major regional importance and the same three colonies support populations of species (Ashy Storm-Petrel, Brown Pelicans, Xantus' Murrelets) of worldwide importance. Adequate protection of these colonies will also ensure the preservation of many other seabird species in the SCB. Clearly, the protection of these three islands and their surrounding waters, where their populations forage (see below), should be of the highest management priority.

Fig. III-114. Number of Seabird Pairs Breeding in the Channel Islands, 1975-77.

Island	PTLH	PTAS	PTBL	PELB	COD	COB	COP	GUW	GP	MLX	AKC
1. San Miguel	?	+?	0	0	0	27+	100	30	200	+?	10
Castle Rk.	+?	∿100	0	0	0	363; 916	15-34	50	100	+?	1,000+
Prince Is.	2+	200-900	0	0	75	860; 590+; 907	10; 20	500	150	75	∿10,000
2. Santa Rosa	?	?	-?	0	0	200+; 500; 700	60	15	125+	?	-?
3. Santa Cruz	?	?	-?	0	0	45; 48	25; 4	40	200+	?	-?
Gull Is.	0	1	0	0	0	25+; 55; 67	4; 0; 0;	85	0	1	75
Scorpion Rk.	0	20	0	80; 0; 0	0	0	0	150	4	+?	50
Offshore Rocks	-?	30	0	0	0	0	0	46	?	?	10
4. West Anacapa	-?	-?	-?	212; 417, 76'	3; 7; 15	1; 0; 0	1; 0; 0	2,400		?	?
Middle Anacapa	-?	-?	-?	0	0	0; 0; 2	0; 0; 2		5	?	-?
East Anacapa	-?	-?	-?	0	0	0; 0; 0	0; 0; 0	100		1+	-?
5. San Nicolas	-?	-?	-?	0	0	133; 170; 145	0?	900	0	-?	0

(Continued)

Fig. III-114. Number of Seabird Pairs Breeding in the Channel Islands, 1975-77. (Continued)

Island	PTLH	PTAS	PTBL	PELB	COD	COB	COP	GUW	GP	MLX	AKC
6. Santa Barbara	?	125	60	0	10; 7	27; 73; 51	1; 0; 2	1,162; 1,035; 811	45	1,000-5,000	75
Sutil Is.	?	25	15	0	30; 60	93; 70; 76	0; 0; 2	75	15	75	35
Shag Rk.	?	?	?	0	0	0	0	9	?	15	0
7. Santa Catalina	-?	-?	-?	0	0	0	0	4	0	-?	0
Bird Rk.	0	0	0	0	0	0	0	26	0	0	0
8. San Clemente	-?	-?	-?	0	0	15	0	32	0	1+	0
Bird Rk.	0	0	0	0	0	0	0	28	0	-?	0

NOTE: One number above indicates an estimate based on information from all three years.
Two numbers are from 1976 and 1977, respectively.
Three numbers are from 1975, 1976 and 1977, respectively.
-? Probably not present.
? Status undetermined.
+? Probably present.

Discussion (continued)

2. Colony Site Specificity

It should not be assumed that colonies presently located on San Miguel Is., its surrounding islets, Anacapa Is. or Santa Barbara Is. could successfully shift or be shifted to other locations if disturbance or pollution prevented birds from breeding in their traditional breeding sites. Likewise, the cormorant colonies of importance along the north sides of Santa Rosa and Santa Cruz Islands most likely could not shift elsewhere in the Bight. Four factors suggest that shifts in colony location are unlikely to take place or unlikely to be successful if attempted by artificial means. These factors include the site fidelity of returning birds, the requirement of adequate food resources near the colony, the need for protection from excessive thermal exposure from solar radiation, and the need for protection from terrestrial predators.

It is well known that many species of seabirds show considerable site tenacity or fidelity. Adults frequently return to the same nest or territory used in previous years, and young may return to their natal colony or a nearby colony when they reach breeding age. These phenomena have been documented in storm-petrels (Morse and Buchheister 1977), gulls (Hunt, unpubl.; Tinbergen 1960), and terns (Austin 1949; Haymes and Blockpoel 1978). Fewer data are available for alcids, but observations in Alaska (Hunt, unpubl.) indicate several species of alcids return to the same locality and often the same site to breed year after year. Similarly, Double-crested Cormorant nests are used repeatedly (Hunt, pers obs.; and this study), but it is unknown whether the same pair uses the same nest each year. In contrast, Brandt's Cormorants shift from one colony site to another with great frequency, perhaps to avoid parasites in old nests, but they remain in the same general area. Hence, it is likely that most seabirds nesting in the Channel Islands would attempt to return to traditional nesting sites until forced to move by repeated disturbance and reproductive failure. In addition, breeding seabirds may not be capable of relocating, as other sites may not provide the necessary access to foods or protection. Our observations on foraging distributions and our general knowledge of oceanographic conditions and food distribution suggest that sites on Santa Barbara Is. and on the north sides of the northern islands are closest to rich waters and the major foraging areas of the breeding seabirds. The requirement to travel from sites on the south sides of the northern islands or the more southern islands probably would not fit within the time or energy constraints placed on nesting seabirds feeding young.

Thermal constraints may also be a factor in nest site selection, as the distribution of surface-nesting seabirds indicates a preference for the windward sides of islands and for northern exposures (Appendix III-7). Although we have no direct data on this point, some indirect lines of evidence are suggestive. First, on most small islands, cormorant nests are commonly built on ledges on

Discussion (continued)

the shaded north side and are conspicuously absent from southern exposures, except on the fog-bathed islets at San Miguel Island. These birds gular flutter when exposed to excessive heat, and eggs and young die quickly when exposed to high temperatures. Western Gulls also generally prefer the northern or windward sides of islands (e.g. Santa Barbara Is., Anacapa Is.). The distribution of gulls on these islands cannot be explained by differential access to food. In contrast, burrow and cave nesting species, such as the Xantus' Murrelet, do not show such a strong tendency to avoid southern exposures. Although not conclusive, these observations suggest that surface-nesting birds prefer (and may require) the less thermally demanding colony sites.

The extreme vulnerability of nesting seabirds to terrestrial predators is yet another factor that makes many apparently appropriate alternative colony sites untenable. None of the major seabird colonies are on islands with large populations of the island fox. The only islands where seabirds coexist with foxes are San Nicolas and San Miguel (e.g. Pt. Bennett) Islands. Since in recent years the fox population on San Nicolas Is. has been reduced in size (Laughrin, 1978), it is possible that foxes are presently not sufficiently abundant to have a major impact. However, reproductive success in the gull and cormorant colonies on this island is much lower than elsewhere in the Bight, possibly in part due to foxes. Access to the nesting areas on Pt. Bennett, San Miguel Is., is limited and this may afford breeding seabirds some protection from foxes.

3. Foraging Areas and Food Specificity

As mentioned previously, food availability is likely to profoundly influence the success of nesting seabirds. Foraging areas associated with particular colonies may not only be traditionally used areas, they may also be the only areas appropriate for foraging given the time and energy constraints placed on breeding birds. We have identified two apparently critical foraging habitats: One north and west of Santa Barbara Is. used by Xantus' Murrelets, and the other in the shallow waters north of San Miguel Is. used by Cassin's Auklets. Ashy Storm-Petrels undoubtedly disperse well out to sea to forage over the cold waters of the California current (Ainley et al. 1974; Briggs et al. Chapt. III, this report), and no limited foraging area can be specified for them. Further research is required to define with precision the critical foraging habitat of breeding Brown Pelicans and cormorants.

The shallow shelf waters north of San Miguel Is. are critical foraging habitat for the large numbers of seabirds breeding in that area. We have obtained particularly clear evidence of this for Cassin's Auklets (Appendix 6). These birds were rarely found foraging south or east of San Miguel Island. Inspection of hauls of plankton

Discussion (continued)

in the vicinity of San Miguel Is. suggests that the observed distribution pattern of these birds may be related to the distribution of their primary food resources. Food species were generally rare south of San Miguel Is., and when birds were found there, food was also present. These preliminary findings suggest that birds using the waters north of San Miguel Is. may not have the option of foraging south of the island because of the lack of appropriate food stocks. Confirmation of this hypothesis will require additional data analysis and probably additional field work, as well.

Similarly the assymetrical distribution of Xantus' Murrelets at Santa Barbara Is. may be related to the distribution of plankton around that island. Again, preliminary inspection of samples of zooplankton taken near the island suggest a greater abundance of food west and north of the island than south or east of it.

If further field work and data analysis bear out our hypothesis that alternative foraging areas for these birds are not available in the vicinity of their nesting colonies, then our information on the distribution of foraging seabirds has critical implications for assessing environmental impact in these areas of important foraging habitat. Should these foraging habitats become contaminated by oil spills during the nesting season, breeding adults would be forced either to attempt to forage elsewhere or to continue to forage in the contaminated area and become coated with oil. On the basis of our observations, it is unlikely alternative foraging areas would be found sufficiently close to nesting areas; hence, we predict the first option would lead to complete reproductive failure for that season. Worse, if the birds return to the contaminated traditional foraging area, it is very likely that adult birds would be killed in large numbers. Such losses could severely endanger the future of these populations. It is therefore of the utmost importance that all efforts be made to avoid any chance of oil contamination in critical foraging areas. Of all areas in the SCB, San Miguel Is. and Santa Barbara Is. are the two most sensitive localities in terms of oil contamination and breeding seabirds.

Another point of concern is that many local populations of Southern California seabirds may be dependent on one or a few specific types of prey, even though the species as a whole may use a wide variety of prey items. The sensitivity of the reproductive biology of Western Gulls and Xantus' Murrelets on Santa Barbara Is. to changes in anchovy availability is an example of this dependency. In cases of such specialization, reduction of critical prey species by oil development activities or by fisheries' management policies will have detrimental affects on the seabirds dependent upon these stocks. Therefore, we urgently need more information on the sensitivity of selected prey types to oil contamination, as well as better information on the population dynamics of these organisms. This indirect affect of oil or management on seabirds could have as great or greater impact on the long-term health of seabird populations than massive

Discussion (continued)

die-offs and direct pollution affects. Food habits and growth rates of young are useful indexes of the quality and abundance of seabird food resources, and our data can serve as an important baseline against which future observations can be compared.

4. Impacts of Oil Development on Breeding Seabirds

In addition to the affects of oil contamination on the seabirds and their food resources, spilled oil may directly affect reproductive success and consequently population stability. There is limited evidence (Grau et al. 1977) that ingested oil may affect a bird's ability to lay eggs. In addition, spilled oil contaminating the feathers of birds can be transferred to eggs during incubation. A. O. Gross (1960) used an oil emulsion spray to prevent Herring Gull egg development on the coast of Maine during a gull control program; birds contaminated with oil may have transferred oil to and subsequently killed their own eggs. By these mechanisms, even low levels of chronic oil pollution may have long-term affects. It is possible that populations experiencing such reproductive failure could continue for a number of years with no apparent drop in the number of adult birds and then, in a very short span of time, experience a major population decline (A. MacCall, in prep.). To detect such conditions early, hatching success may be a sensitive indicator of low levels of chronic pollution and can be monitored relatively inexpensively. Once again, this study provides a valuable initial baseline for future comparisons.

Yet another, most damaging, impact that oil development will have on breeding seabirds will be disturbance of colonies. Disturbance will come in many forms. Increased visitation of sensitive colonies during the breeding season will result in increased egg and chick mortality. Surface nesting species, especially cormorants and pelicans, will be very vulnerable to these affects of disturbance: birds flushed from their nests leave their eggs and chicks exposed to predation by gulls; also, eggs left exposed to the sun will be overheated and killed within a few hours.

Most cave nesting species will be less affected by human visitors, but burrow nesting Cassin's Auklets will be very vulnerable to trampling and burrow collapse. There is more than ample evidence that the most careful entry into colonies, even by well-meaning scientists, can and will cause diminution of reproductive success (cormorants: Crossin and Brownell 1968; Huber 1968; Ellison and Cleary 1978. gulls: Hunt 1972; Gillett, Haywood and Stout 1976; Robert and Ralph 1976; Fetterold, ms). Careless entry is certain to result in reproductive failure, and successive reproductive failures will cause desertion of colonies. As discussed above, alternative sites may not be available in the Bight. Hence, colony desertions from disturbance will likely result in overall population declines, not just relocations of breeding sites.

Discussion (continued)

Disturbance, particularly in the San Miguel Is. area, will play a decisive role in the future of Southern California cormorant populations. Cormorants were once numerous at Santa Barbara and Anacapa Islands. Their numbers have been diminished by a combination of disturbance and reproductive failure due to eggshell thinning. If disturbance of the remaining large cormorant colonies increases significantly, these species will almost certainly cease breeding in southern California.

In addition, disturbance does not have to be in the form of colony entry to be damaging. Particularly in the case of pelicans and cormorants, low flying aircraft or boats traveling close by colonies are sufficient to flush birds from their nests. Helicopters, with their loud motors and blade slap are particularly disruptive. Therefore, it is essential that all aircraft and boat traffic associated with oil development operations be required to stay away from the vicinity of breeding colonies. Also, the general public, which will be attracted to the vicinity of oil-related facilities, should be educated and, if necessary, required to keep a safe distance from colonies, as well.

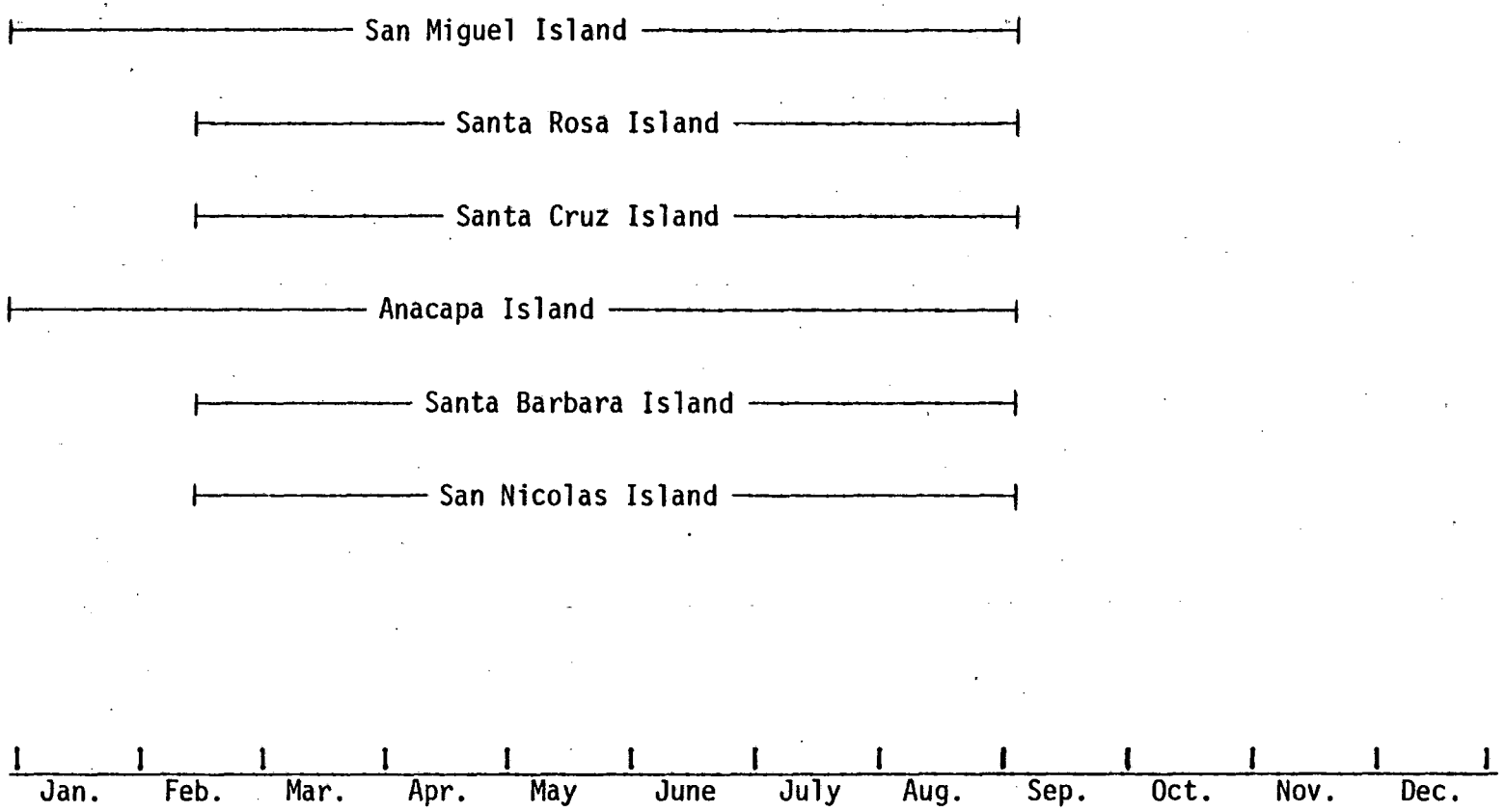
Throughout this discussion, we have stressed the potential impacts of oil development during the birds' breeding seasons (Fig. III-115). This is undoubtedly the most critical period, as the birds are tied to their colonies by the constraints of reproduction. However, it should be noted that many species (e.g. cormorants, gulls, and auklets) remain in the vicinity of their nesting colonies throughout the year, and hence, could be adversely affected by oil contamination and possibly by disruptive activities during the non-breeding season as well.

5. Ability of Seabird Populations to Recover From Declines

A central question in assessing the potential long-term impact of oil development revolves around the resilience of potentially affected populations. Can populations recover from either acute or chronic impacts, and, if so, within what time period? Unfortunately, unequivocable answers to these questions will be hard to obtain. They will require long-term field studies to amass data on life histories and mortality tables. Even thus informed, predictions will be difficult, as the course of events following a major die-off or decline will depend on the portion of the population affected and the speed with which the cause of the decline is corrected.

Historically, some species in the SCB have failed to recover from population declines, while others have apparently recovered and exceeded their former numbers. For example, three species of raptors (Bald Eagle, Osprey and Peregrine Falcon) and two species of alcids (Common Murres and Tufted Puffins) have disappeared from the Bight

Fig. III-115 Season of Maximum Vulnerability of Seabirds Breeding in the Southern California Bight.



Discussion (continued)

as breeding species, having failed to recover after earlier population declines. Similarly, when adult breeding Cassin's Auklets were killed off by cats on Santa Barbara Is., the population failed to return to its former numbers in over 70 years.

In contrast, at Prince Is., Cassin's Auklets have developed a large, healthy breeding population after an apparent severe decline about 1919. Indeed, Ainley and Lewis (1974) document this species' ability for rapid recovery on the Farallon Islands. However, rapid shifts in breeding populations they observed may have been the result of temporary movements in response to food shortages. In such cases, adults were presumably not killed, but rather they temporarily moved away to return when prey populations near traditional breeding sites were again available.

Clearly, the interpretation of the causes and consequences of population fluctuations is not simple. However, based on what we know about the past population histories, the life histories and behavior of the breeding seabirds of southern California, we can make some very general predictions pertinent to the probable impacts of human activities:

1) If large numbers of adults are killed and if there are no nearby sources of colonists that are producing an excess of birds, recovery will probably be very slow. Hence, we would anticipate a slow recovery if the breeding stocks of Ashy Storm-Petrels, Brown Pelicans, Pelagic Cormorants or Pigeon Guillemots were destroyed. It is not clear how rapidly other species would recover.

2) If food resources were destroyed or made unavailable for a long period, we would expect seabirds to leave the affected area and cease breeding in nearby colonies.

3) If food resources became unavailable for a <u>short</u> period, we would anticipate a temporary reproductive failure and possibly temporary desertion of nearby colonies. Colonies would probably be reestablished and nesting resumed in the following breeding season.

4) Repeated failure due either to unavailability of food or disturbance would probably result in permanent colony desertion. Desertion is likely to be particularly rapid if reproductive failure is the result of disturbance.

6. Summary

The studies reported here provide the background information for determining which species of breeding seabirds and which colonies

Discussion (continued)

are most important and most vulnerable to negative impacts from the development of offshore oil fields. We stress the extreme importance and sensitivity of colonies on San Miguel, Anacapa and Santa Barbara Islands and the need to protect, in particular, Ashy Storm-Petrels, Brown Pelicans, and Xantus' Murrelets. The foraging areas on which these species depend during the breeding season should also be preserved. We predict that disturbance, in addition to acute and chronic oil pollution, will pose a major threat to seabirds, particularly surface nesting species such as cormorants and pelicans.

In addition to the obvious need for monitoring total numbers of nesting birds in order to detect desertions or adult die-offs, we recommend regular monitoring of hatching success, growth rates, and foods brought to young. Any adverse physiological affects of contamination on adults or changes in the availability of foods to breeding birds should be reflected in changes in these parameters. Should undesirable changes be found, corrective action could be undertaken.

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APPENDICES

Appendix III-1

SCHEDULES OF ISLAND VISITATION

Fig. III-116. Island Visitation, 1975. The number of hours spent in the field on each island is given in parentheses following the date of visit.

San Miguel	Santa Rosa	Santa Cruz	Anacapa	San Nicolas	Santa Barbara	Santa Catalina	San Clemente
13 May (16)	18 Apr. (2)	18 Apr.(7)	17 Apr.(1)	20 Apr.(5)	19 Apr. (6)	20 June(2)	8 May (4)
14 May (10)	14 July (1)	16 June(4)	16 June(4)	11 June(6)	20 Apr.(12)	17 July(1)	18 July(7)
28 May (11)		14 July(4)	14 July(4)	19 June(7)	21 Apr. (7)		
29 May (12)				17 July(5)	9 May (11)		
30 May (12)					10 May (5)		
31 May (12)					20 May (3)		
1 June (12)					21 May (12)		
2 June (12)					22 May (12)		
3 June (6)					23 May (12)		
18 June (7)					24 May (12)		
14 July (2)					25 May (12)		
15 July(10)					26 May (12)		
					27 May (7)		
					7 June (4)		
					8 June (4)		
					20 June (6)		
					16 July (5)		
Total Hours:							
(122)	(3)	(15)	(9)	(23)	(142)	(3)	(11)

NOTE: The visits of 20 May - 27 May at Santa Barbara Island (82) hours and 28 May - 3 June at San Miguel (77) hours were for the purpose of radio-tracking and full time was devoted to that task.

Fig.III-117.Manhours Spent on Seabird Breeding Colonies, Channel Islands, 1976

	San Miguel Is.	Prince Is.	Castle Rk.	Richardson Rk.	Nifty Rk.	Hare Rk.	Bat Rk.	Santa Rosa Is.	Santa Cruz Is.	Gull Is.	Scorpion Rk.	"Sppit" Rk.	Diablo Rk.	Anacapa Is.	Cat Rk.
14-18 Jan.*		35												4	
11-15 Feb.*	10	12.75								6.75				20.5	
17-21 March*	4	17.25								6					
6-11 April*		30								13.5				13	
27 Apr.-4 May*		67								6				12.5	
20-26 May*		68								10				19	
5-11 June		78.25	2.5	.75											
15 June														4	
22-28 June*	2.5	81							4	13.5	16			19	
13-19 July*	7.5	78.25			.5	.5	.5			11.25		1.5	2	11	.5
28-30 July															
24-28 Aug.		5.5													
Totals	24	473	2.5	.75	.5	.5	.5	0	4	67	16	1.5	2	103	.5

* Regularly scheduled ship cruises
#Time given in Man/Days

Fig.III-117(continued)

	Santa Barbara Is.#	Sutil Is.	Shag Rk.	San Clemente Is.	San Nicolas Is.	Bird Rk.	Seal Rk.	Santa Catalina Is.	Bird Rk.
14-18 Jan.*	26								
11-15 Feb.*	15								
17-21 March*	see fig.119				see fig.121				
6-11 April*									
27 Apr.-4 May*						2			4
20-26 May*		3							1.5
5-11 June		12.5	3.75						5
15 June									
22-28 June*		12							7.5
13-19 July*		10.5				5	1		
28-30 July				4#					
24-28 Aug.		7							
Totals	603#	45	3.75	4#	94#	7	1	0	18

*Regularly scheduled ship cruises
#Time given in Man-Days

Fig.III-118. Breakdown of Man/Hours Spent on Seabird Breeding Colonies, Channel Islands, 1977

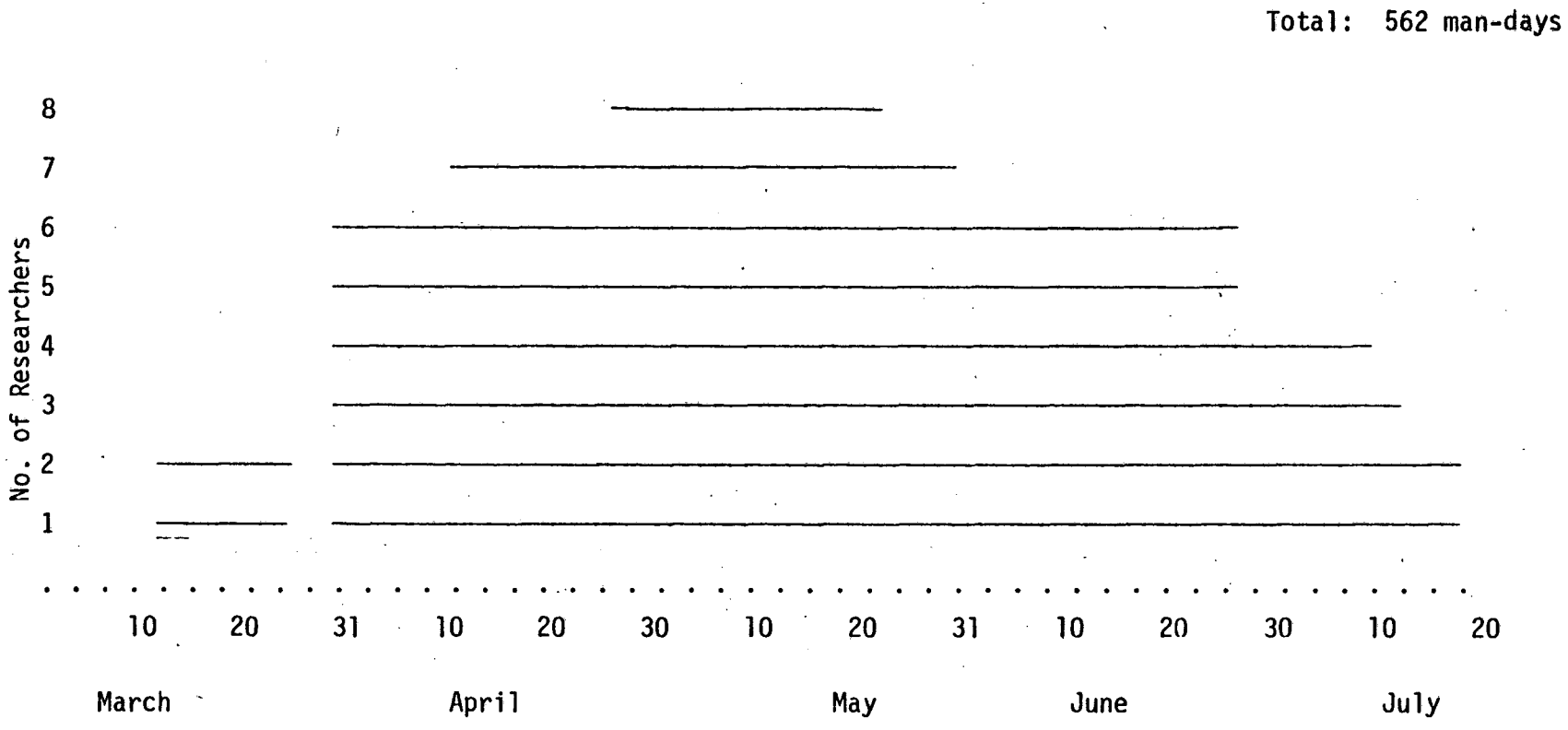
	San Miguel Is.	Prince Is.	Santa Rosa Is.	Santa Cruz Is.	Gull Is.	"Sppit" Rk.	Scorpion Rk.	Anacapa Is.	Santa Barbara Is.*	Sutil Is.	San Nicolas Is.
17-21 Jan.		86			8				4		
15-19 Feb.		58.25			20				3		
18-24 March		33							see Fig. III-120	7	
29 March					2.25	2.5					4
12-16 April		108						6			
19 April											5
26-27 April											17
2-6 May		68.5			2					7.5	
13-16 May											58
18-23 May		54			7.5		9	13		20	
4-8 June		87			8						
8 June											13
10-13 June											
16-20 June	80	50									
20-24 June		76						9		6.25	
28 June								9			
29-30 June											23
7-11 July		39			6					2	
15-17 July								68			
20-23 July	54										
23-27 July		80			9						
11-15 Aug.		50							5		
Total Manhours	134	789.75	0	0	62.75	2.5	9	105	504*	42.75	120

Fig.III-118. (continued)

	San Clemente Is.	Santa Catalina Is.	Bird Rk.
17-21 Jan.			
15-19 Feb			
18-24 March			
29 March			
12-16 April			
19 April			
26-27 April			
2-6 May			
13-16 May			
18-23 May			
4-8 June			7.5
8 June			
10-13 June	63		
16-20 June			
20-24 June			
28 June			
29-30 June			
7-11 July			
15-17 July			
20-23 July			
23-27 July			
11-15 Aug.			
Total Manhours	63	0	7.5

* For Santa Barbara Is. time is given in Man/Days instead of Man/Hours. Fig. 7 summarizes the number of researchers on the island during the breeding season.

Fig. III-119. Breakdown of Researcher Time* Spent on Santa Barbara Is., 1976



* Volunteers and paid BLM personnel

Fig III-120. Breakdown of Researcher Time Spent on Santa Barbara Is., 1977

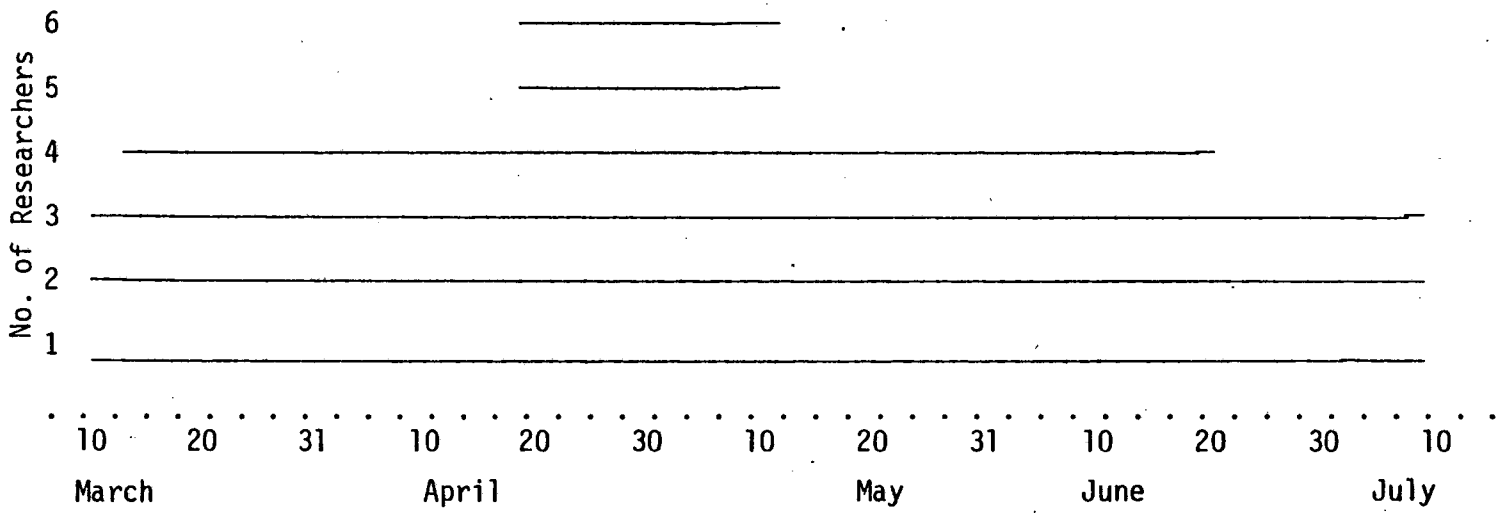
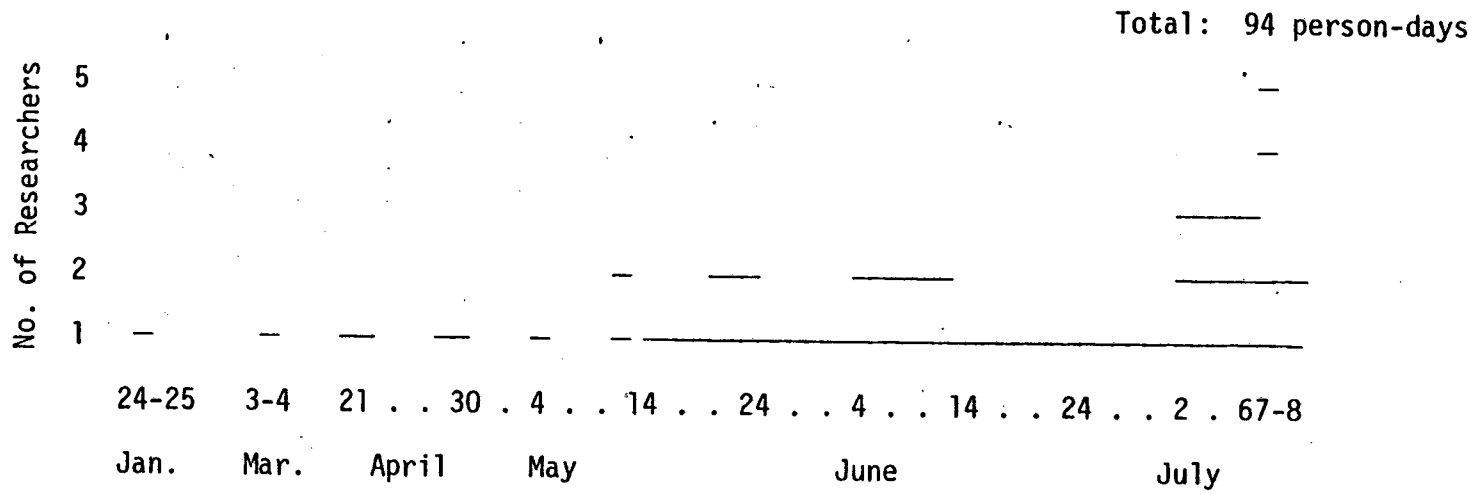


Fig. III-121. Breakdown of Researcher Time* Spent on San Nicolas Is., 1976



* Researcher time presented in person-days

Appendix III-2

RADIOTELEMETRY

APPENDIX III-2. Radiotelemetry

Radiotelemetry was used to monitor the movements of Xantus' Murrelets at Santa Barbara Is. and of Western Gulls at Santa Barbara Is., Prince Is. and San Miguel Island.

a. Methods

Materials and Components

High-VHF range telemetry beacons supplied by AVM Instrument Co., Champaign, Illinois were used. The beacons were of two types: A lightweight, single-stage model for murrelets and a heavier, two-stage unit for gulls. The smaller beacons used an RM-575 mercury cell for power; the larger packages required a 1/2 AA-size lithium cell power source. With power drains typical of the equipment we employed, both types of package had a field life of about 100 days.

Transmitting antennas were stainless steel, 0.043 to 0.060 cm in diameter and 30.6 cm in length. Harnesses were uncoated surgical gut or stainless steel wire enclosed in plastic "shrink-tube". Each had a "weak-link" of dissolvable gut which caused the package to fall off within six to eight weeks (based on laboratory trials). Beacon components were bound and protected in dental acrylic; total package weights (including antenna and harness) averaged 5.7 g for murrelets and 21.2 g for gulls.

To track the signals, 24-channel receivers (LA-12, AVM Instrument Co.) and dual, four-element yagi antennas (Cush Craft) with null-peak attachments were used. These directional receiving antennas were mounted on two-meter high masts that allowed full 360° rotation. A compass was affixed to each antenna mast after the method outlined by Hallberg, Janza and Trapp (1974).

Harnessing and Tracking

Western Gulls were captured by placing an inconspicuous noose of fishing line around nests containing incubated eggs and pulling the noose taut around the birds' feet when they returned to incubate. Gulls were then measured, color marked with dye and/or plastic leg bands and harnessed with a telemetry package. The behavior of birds at the time of release and at all subsequent resightings was noted.

Xantus' Murrelets were either captured by hand on the nest or mist netted as they came onto Santa Barbara Is. at night. We were only certain of the breeding status of the birds captured on the nest. After harnessing, the incubating birds were returned to their nests, where they remained at least until we departed the area. Birds that we caught in mist nets were released near their site of capture.

Four packages were shed by gulls on Santa Barbara Is. as a

result of weak harnesses or biting through the harness material. We modified the harnesses on the remaining gull packages and detected no further self-removals.

We monitored the activities of telemetry subjects from two receiving positions on each island. Receiving positions were selected to maximize elevation and triangulation base and minimize nearby gradients in surface topography. The triangulation base was 1.2 km (0.65 NM) at Santa Barbara Is. and 3.9 km (2.1 NM) at San Miguel Island.

Tracking of the radio-equipped seabirds was conducted from 21 - 24 May 1975 (Santa Barbara Is.), 28 - 29 May 1975 (San Miguel Is.) and 30 April - 8 June 1976 (Santa Barbara Is.).

The receivers were attended at various times of day. Observers attempted to locate each telemetry subject in turn, allowing approximately five minutes for search and localization of each beacon. Hence, "fixes" were obtained every 15 - 60 minutes, depending on the number of units active at that time. Communication between observers was maintained by use of walkie-talkies. Each position record included relative strength of the signal, location of nulls and peaks, and for 103 of the fixes on San Miguel Is., comments on the breadth of the primary signal null. The last notation provided the basis for estimating the potential error in fixes dependent on distance and position of the transmitter relative to the receivers and the length of the triangulation base. The potential for both lateral and distance errors in plotting transmitter positions increased as the distance between the beacon and the triangulation base increased. This was more pronounced at Santa Barbara Is., where the triangulation base was short. Potential distance errors also increased as the direction from the colony to a beacon approached the orientation of the triangulation base (Figs. III-122 to III-124).

In general, our efforts at radiotelemetry were unsuccessful. The birds' behavior was usually affected by the harnessing process, and hence the results are suspect.

b. Western Gull

A total of 20 incubating adult Western Gulls were harnessed with radio transmitters; 13 in 1975 and 7 in 1976. A total of 547 paired signals converged and could be used for triangulation. The location fixes from these signals suggested that adult Western Gulls spent a lot of time in the immediate vicinity of the breeding colony. Overall, nearly 80% of the fixes were located in one of the gull colonies on the island, 46 fixes (8.4%) were obtained from individuals which were just offshore, and only 50 (9.1%) were situated out to sea (Figs. III-125 to III-129).

Fig.III-122. Approximate dimension of "error polygons" in plots of beacon positions as a function of distance and triangulation base. Figures indicate potential errors for fixes at high angle (perpendicular) relative to the triangulation base. Potential distance error is greater on low-angle fixes. Dash indicates that no fixes corresponding to the given distance were encountered in the field.

	San Miguel Island Triangulation base = 3.9 km		Santa Barbara Island Triangulation base = 1.2 km	
Distance between beacon & triangulation base	Potential distance, error (±)	Potential lateral error (±)	Potential distance error (±)	Potential lateral error (±)
0-5 km	1.0 km	0.5 km	1.0 km	0.5 km
5-10 km	1.0	0.8	12	0.9
10-15 km	7.5	1.0	27	1.5
15-20 km	15	1.5	39	2.8
20-25 km	39	2.5	100	2.5
25-30 km	92	2.8	see note a.	
30-35 km	100	3.0	see note a.	
35-40 km	---	---	see note a.	

a. Lines comprising estimate of distance error diverge when beacon is beyond 25 km.

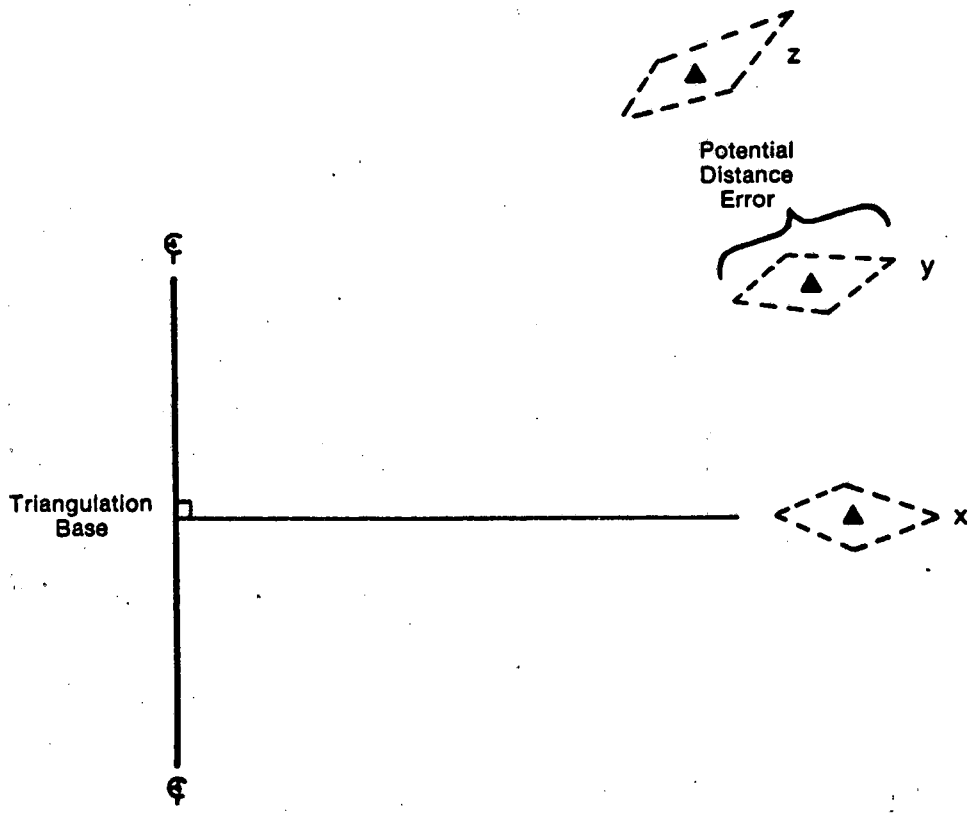


Figure III-123. Effect of beacon position on the dimensions and shape of "error polygons" (beacon positions X, Y, Z are equidistant from the center of the triangulation base). Potential distance error is minimal when a beacon is at a high angle relative to the triangulation base (position X). Increase in distance from receivers or decrease in triangulation base increases potential errors. See preceding Figure for explanation of symbols.

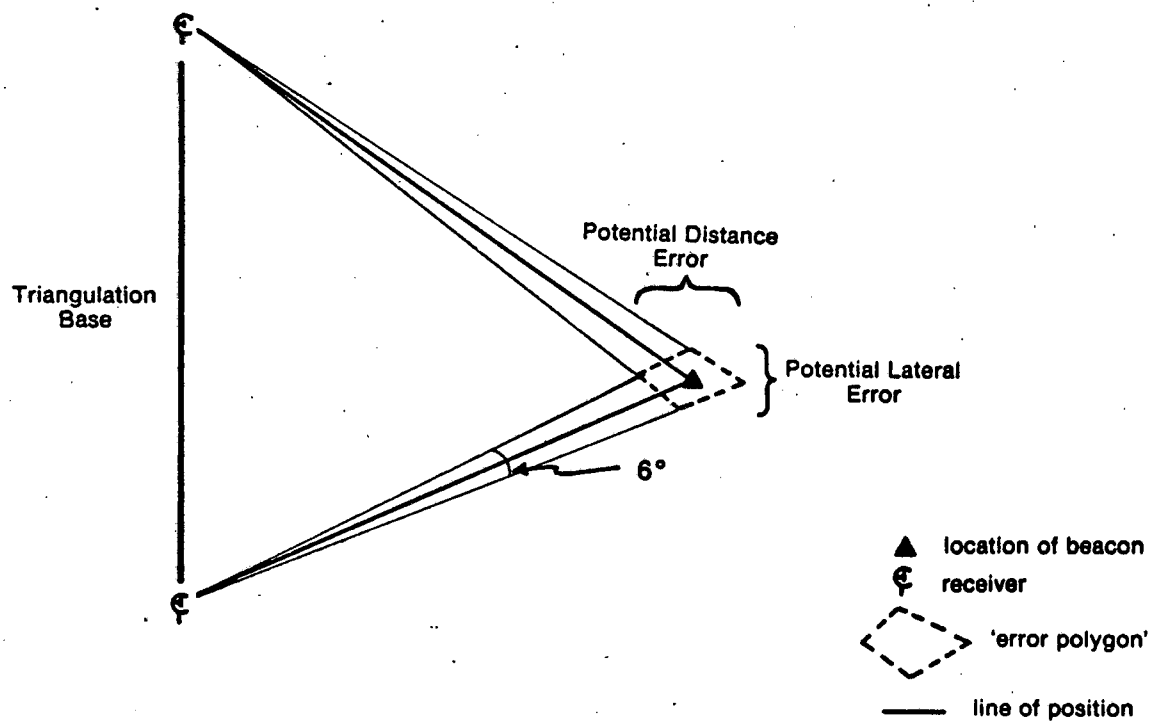


Figure III-124. Schematic of the method used to plot positions of telemetry subjects and limits of potential errors. The intersection of lines of position from each of two receiving stations determines beacon location. An "error polygon," that area enclosing potential distance and lateral errors in plotting beacon position, is drawn by projecting lines 3° on either side of lines of position (corresponding to 6° average breadth of primary signal null).

Fig. III-125 Radiotracking of Adult Western Gulls, 1975.

Location	Number of Gulls Harnessed	Number of Converging Signals Received	Fixes on Colony	Fixes Offshore	Fixes at Sea
Prince Island	9	194	161	15	18
Santa Barbara Island	11	142	98	19	25
Total	20	336	259	34	43

Fig.126 Radiotracking of Adult Western Gulls, 21 May - 5 June, Santa Barbara Is., 1976

Transmitter Number	Probable Sex*	Breeding Status	Response to Harnessing	Number of Days Signals Received after Harnessing	Number of Paired Signals Received	Number of Converging Signals Received	Fixes on Colony	Fixes Offshore	Fixes at Sea
31	Male	Incubating	Probably abandoned; eggs never hatched	3	22	9	8	1	0
32	Male	Incubating	Abandoned; eggs eaten	3	19	18	11	4	3
33	Female	Incubating	Incubated briefly, eggs eaten, then abandoned	7	71	70	68	2	0
34	Female	Incubating	Abandoned	11	28	28	28	0	0
36	Female	Incubating	Probably abandoned	7	18	18	17	1	0
37	Male	Incubating	Abandoned initially; chicks hatched (see text)	4	28	27	23	3	1
39	Female	Incubating	Abandoned	4	25	8	4	1	3
Totals					211	178	159	12	7

* Sex determined by physical measurements

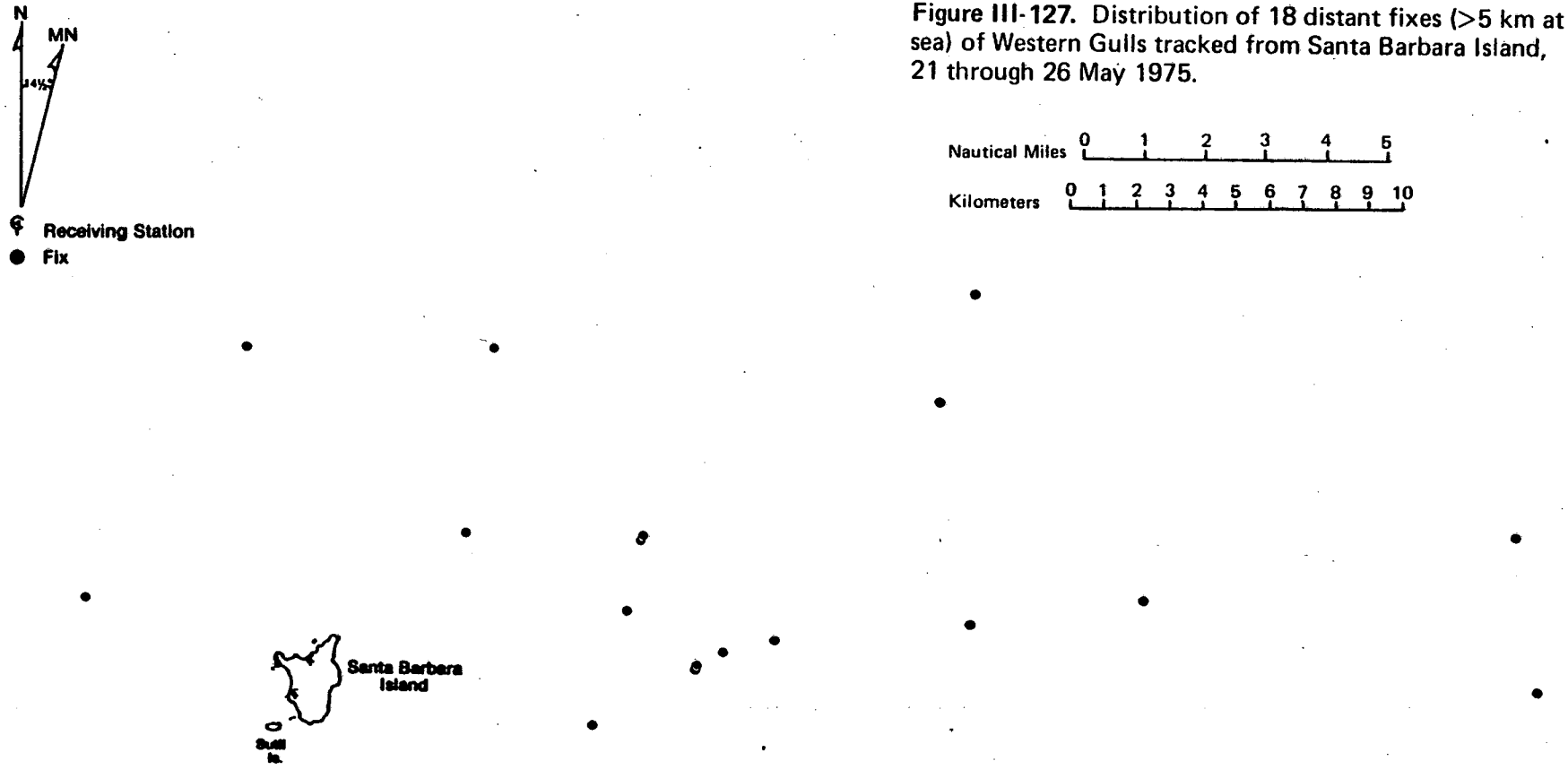
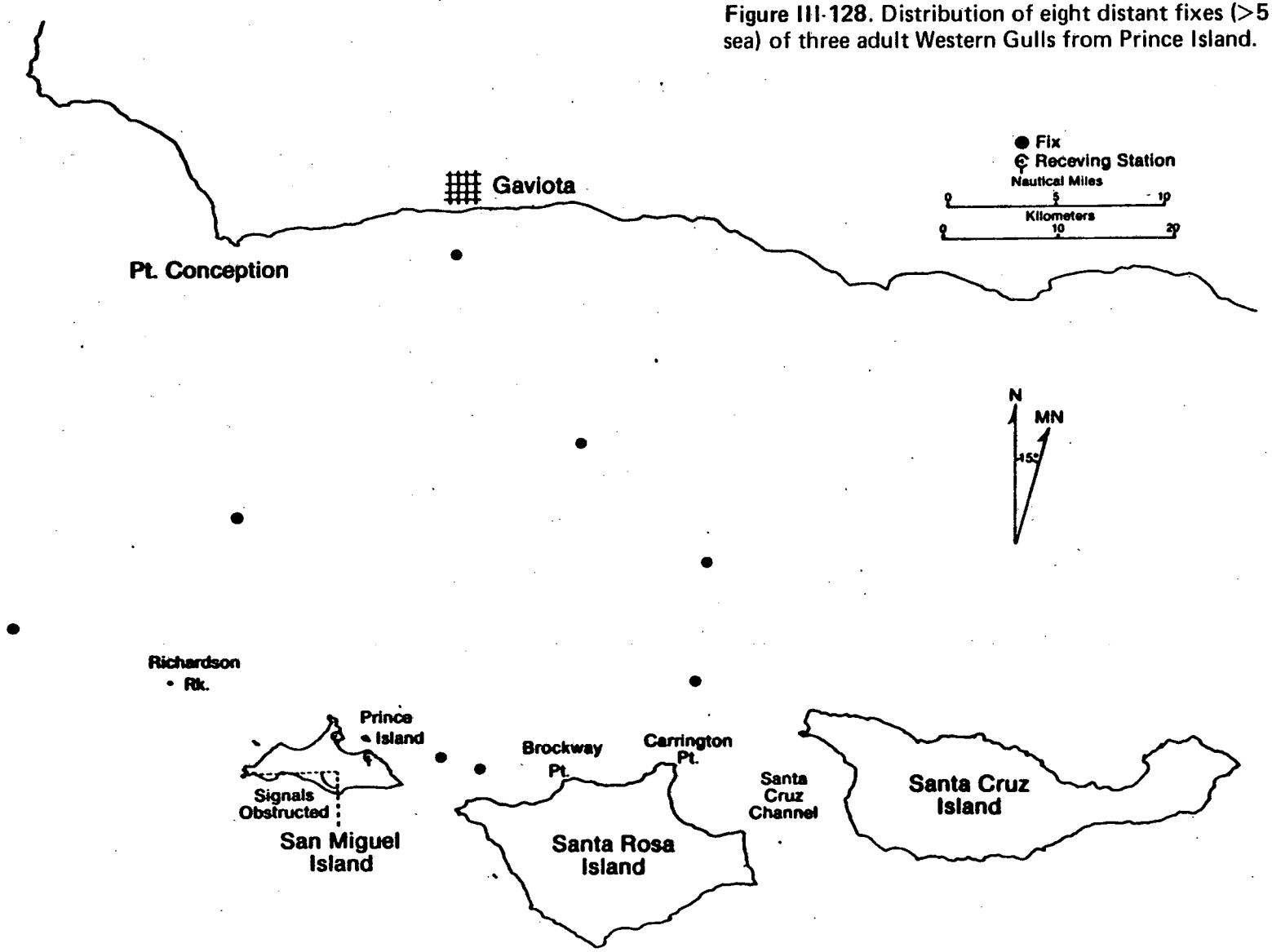


Figure III-127. Distribution of 18 distant fixes (>5 km at sea) of Western Gulls tracked from Santa Barbara Island, 21 through 26 May 1975.

Figure III-128. Distribution of eight distant fixes (>5 km at sea) of three adult Western Gulls from Prince Island.



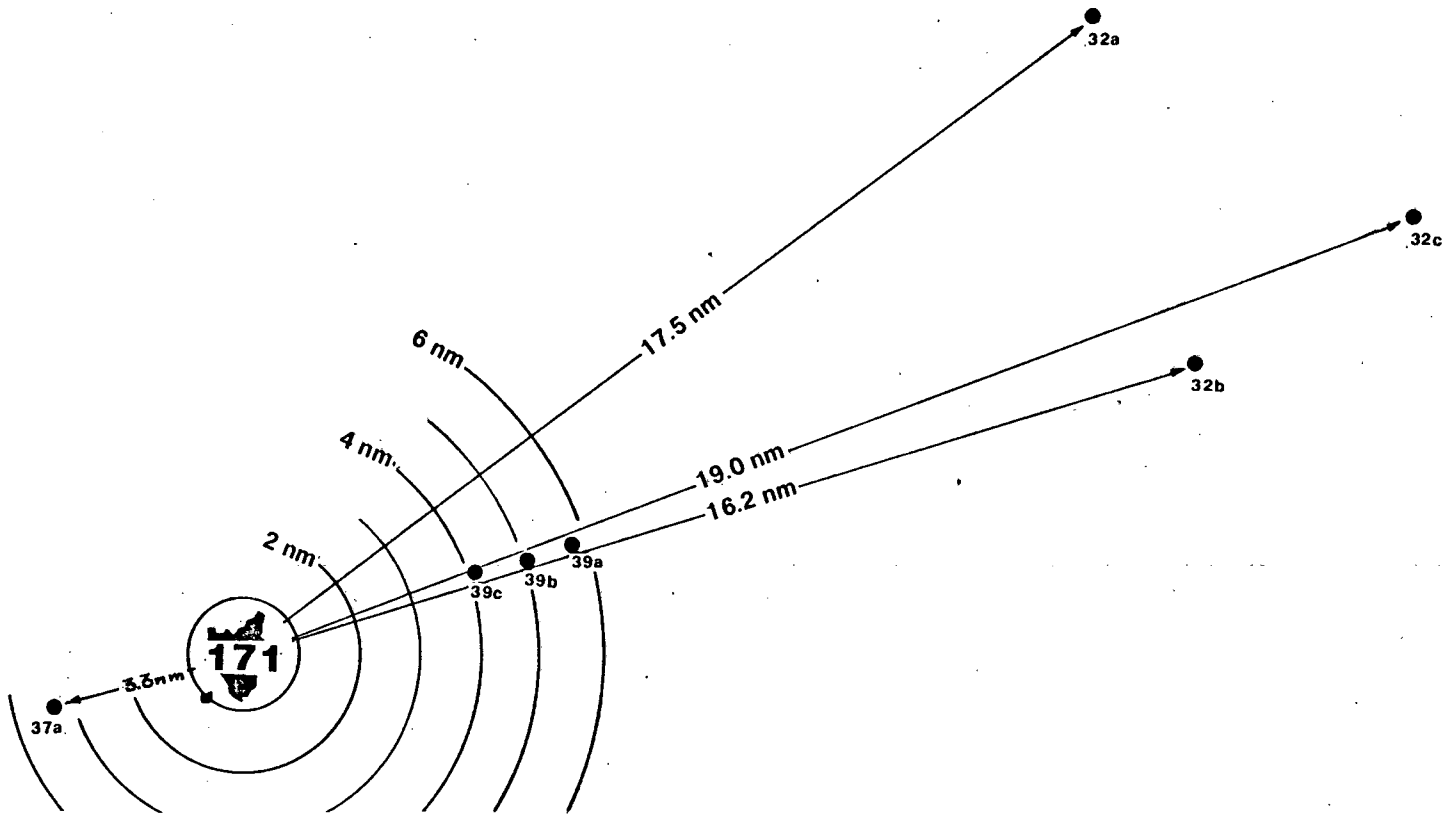


Figure III-129. Distribution of radio telemetry fixes on seven adult Western Gulls, Santa Barbara Is., 1976. Small numbers = individual birds; letters = sequence of fixes.

However, these findings may not be typical of normal breeding Western Gulls. In 1976, all seven radio-harnessed gulls failed to resume incubation of their nests (1975 data not available). Only one of the seven clutches hatched successfully; presumably the harnessed bird's mate was able to complete incubation and fledge two chicks by itself. The other nests were abandoned by both adults, and their eggs were destroyed within three weeks. In addition, the gulls gave many indications of being distressed by the harness, spending much of their time trying to remove it.

c. Xantus' Murrelet

In all, sixteen adult murrelets were harnessed with telemetry beacons; four in 1975 and twelve in 1976. Of these, nine were incubating eggs, one was brooding two chicks, four were non-breeding birds (i.e. without brood patches), and the breeding status of two birds (in 1975) was unknown. The transmitter was removed from one of the incubating adults when the antennas broke off (Fig. III-130).

Triangulation was possible with 23 paired signals in 1975 and with 390 paired signals in 1976. The murrelets were tracked effectively out to approximately five miles east and west of the island and two miles north and south. Although the birds may have moved further out to sea, radio signals did not provide location fixes at greater distances.

The geographical distribution of the radio fixes are presented in Figs. III-131 and III-132. In contrast to observations from ship radial transect surveys, which suggested that Xantus' Murrelets concentrated west of Santa Barbara Is., these data indicated a preference for the waters east of the island. (It should be noted, however, that all the radio-harnessed murrelets were captured on the east side of the island, between Graveyard Canyon and Landing Cove.) These data also indicated that murrelets generally stayed close inshore; 50.6% of the converging signals in 1976 were located in the four one-minute blocks immediately adjacent to the island (approximately one mile offshore). Yet according to radial transect censuses, relatively few murrelets foraged in this range; the majority of the birds were found approximately one to nine miles from the island. Since closer signals were more likely to be received, this discrepancy may reflect a bias in the system used.

In interpreting these data, the disruptive influence of the harnessing process on the murrelets' normal behavior should also be considered. Four of the incubating birds deserted their nests before their mates returned to trade off. Two of the incubating birds traded off normally with their mates, but only one of these two returned to the nest (without its transmitter) and traded off with its mate. The eggs in this nest hatched successfully. The other bird never returned, and its mate deserted the nest four days after the

Fig. III-130. Radiotracking of Adult Xantus' Murrelets, 30 April - 28 May, Santa Barbara Island, 1976.

Transmitter No.	Breeding Status	Response to Harness	No. of Days Signal Received Following Harnessing	No. of Paired Signals Received	No. of Converging Signals Received	No. of Signals Plotted on Map
72	incubating	abandoned immediately	0	0	-	-
73	incubating	abandoned immediately	11	134	124	56
74	incubating	remained on nest, but radio malfunctioned and was removed; deserted later	0	0	-	-
75	non-breeding	stayed in bush, eventually flew off	11	80	65	47
77	incubating	abandoned immediately	11	91	69	52

Fig.III-130. Continued. Radiotracking of Adult Xantus' Murrelets, 30 April - 28 May, Santa Barbara Island, 1976.

Transmitter No.	Breeding Status	Response to Harness	No. of Days Signal Received Following Harnessing	No. of Paired Signals Received	No. of Converging Signals Received	No. of Signals Plotted on Map
79	non-breeding	swam away	2	26	22	20
80	incubating	normal trade-off, returned without transmitter	7	12	12	10
81	brooding	departed with chicks	4	43	16	16
82	incubating	abandoned one day later	4	40	17	11
83	non-breeding	--	6	23	21	11
84	incubating	traded off, but never returned	3	2	2	2
86	non-breeding	flew off	7	63	42	35

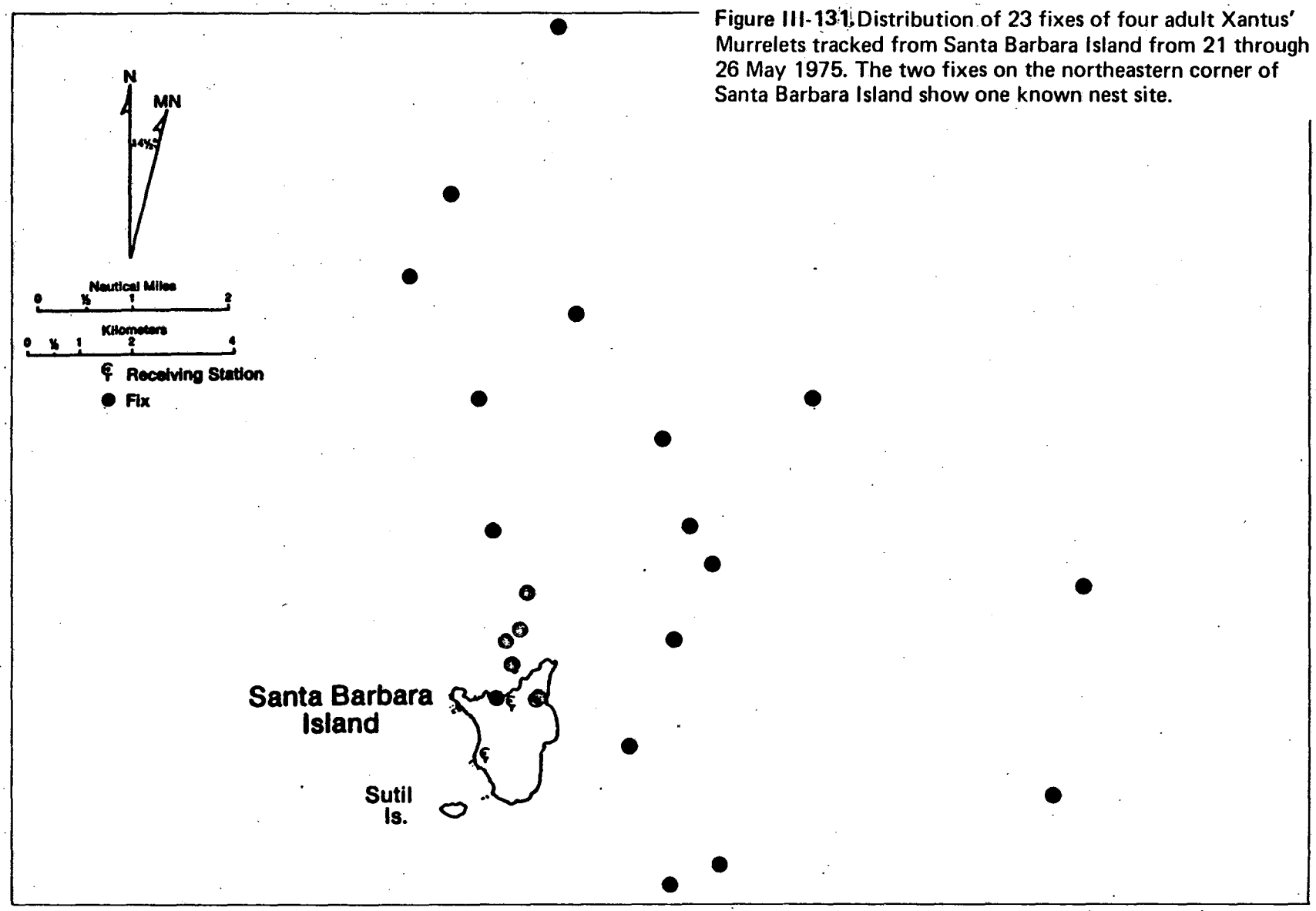


Figure III-131. Distribution of 23 fixes of four adult Xantus' Murrelets tracked from Santa Barbara Island from 21 through 26 May 1975. The two fixes on the northeastern corner of Santa Barbara Island show one known nest site.

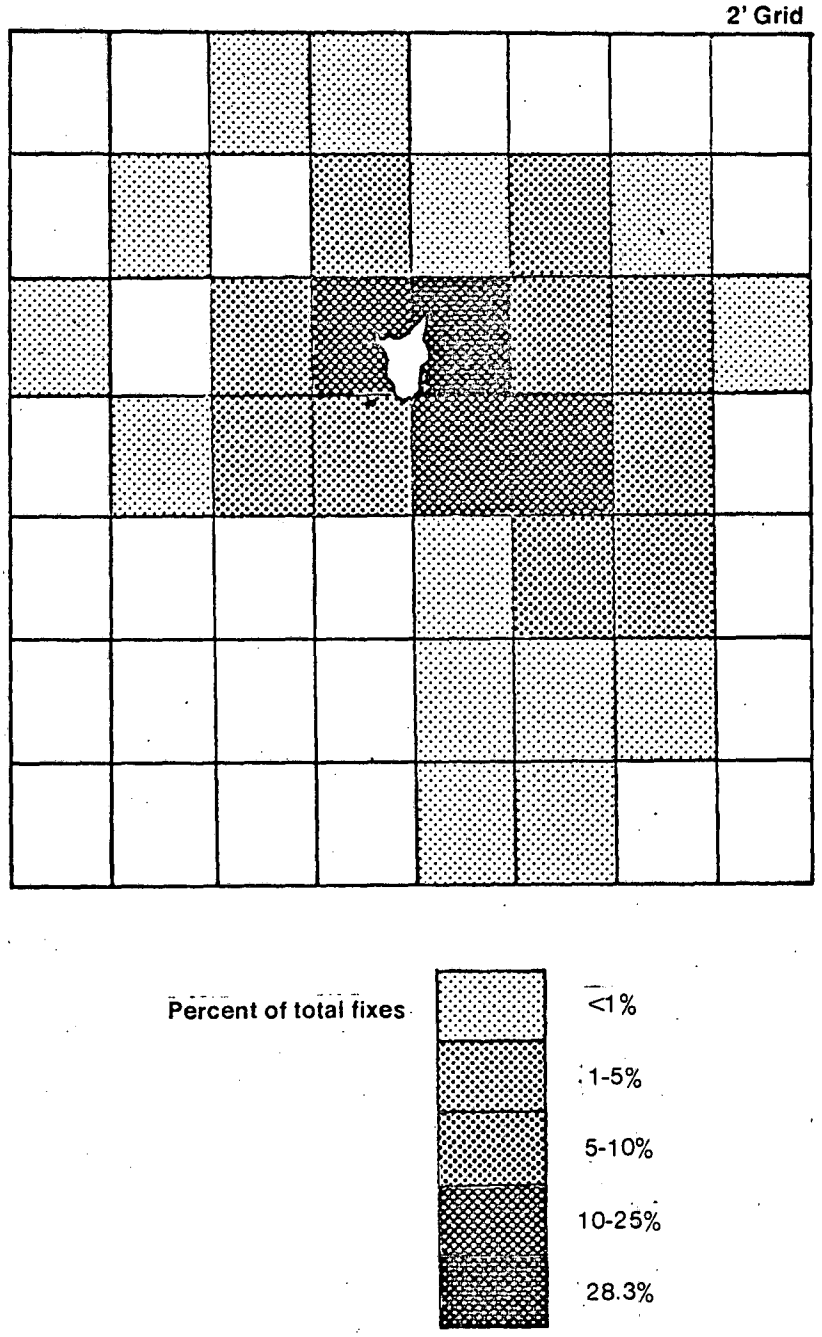


Figure III-132. Distribution of radio telemetry fixes on ten adult Xantus' Murrelets, Santa Barbara Is., 1976.

trade-off. (Follow-up data on the other two incubating birds was not collected.) The one adult harnessed while brooding chicks was seen leaving the nest, leading its chicks to the ocean, shortly before the signal was received from its radio. The four non-breeding and "unknown" birds were released where they were captured; they either flew off, swam away or remained sitting on the ground when released. It is unknown to what extent the apparatus may have interfered with the murrelets' ability to fly, dive, or perform other normal behaviors (another factor that might account for near-shore distribution). Therefore, in light of the observed negative reactions following harnessing and the mentioned discrepancies with the more reliable data gathered during ship surveys, the general usefulness of these data is limited.

Appendix III-3

FOOD HABITS OF WESTERN GULLS

Fig. III-133. Food of Western Gull Chicks, Channel Islands, 1975

Composition of Samples Regurgitated by Chicks

Species (N) = Number of samples	Prince Is. (26)		Anacapa Is. (8)		San Nicolas Is. (21)		Santa Barbara Is. (18)		Bird Rk., Catalina Is. (4)	
	P.O.*	P.W.**	P.O.	P.W.	P.O.	P.W.	P.O.	P.W.	P.O.	P.W.
Gastropoda										
Pellicipes polymerus					5	0.2	11	1.6		
gastropod sp.					5	1.0				
Cephalopoda										
Loligo opalescens	23	58			10	9				
Octopoda sp.							6	8		
Crustacea										
Euphausiid sp.	7.7	0.8			5	0.9				
Pisces										
atherinid fish	3.8	10.7	25	40						
Amphistichus argenteus					10	9				
Sardinops caeruleus	3.8	1.9								
Engraulis mordax					19	16	22	32		
Cololabis saira							6	3.8		
Scorpaenidae sp.					5	3.7				
fish sp.	46	16	50	34	48	46	61	46	75	85
eel sp.	3.8	0.6								
Other										
Sea lion placenta	3.8	3			14	14	6	4		
? striated muscle	7	8								
chicken and bones			37.5	10						
lunchmeat			12.5	15						
Unidentified							6	5	25	15

* P.O. = Percent Occurrence
** P.W. = Percent Weight

Fig. 134 Food Habits of Western Gulls, Channel Islands, 1976.

Composition of Stomach Samples

Island Number of stomach samples P.O. = Percent occurrence P.V. = Percent volume	Prince Is. 27		Santa Barbara Is. 79		Anacapa Is. 16		San Nicolas Is. 40		Gull Is. 12		San Clemente Is. 3		Santa Catalina Is Bird Rk. 7	
	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.
Crustacea														
Euphausiacea														
Euphausicea pacifica							7.5	3.3						
Thysanoessa spinifera							2.5	0.0						
Copepoda														
Cecropidae														
Cecrops latreilli	3.7	1.3												
Cirripeda														
Lepadomorpha														
Lepas anatifera			2.5	0.0										
Unidentified barnacle			1.3	0.0										
Insecta	3.7	0.1			6.3	0.0	2.5	0.0						
Unidentified crustacea														
Mollusca	3.7	0.3	**2.5	0.7										
Octopoda														
Argonautidae														
Arginauta sp.	3.7	0.1												
Teuthoidea														
Loliginidae														
Loligo opalescens	3.7	7.0	2.5	4.2			10.0	18.4	16.6	10.2				
Enoploteuthidae														
Abraliopsis felis	*3.7	1.1	**1.3	1.3										
Pterygioteuthis giardi									*8.3	10.4				
Histioteuthidae														
Histioteuthis sp.			1.3	0.6										
Octopoteuthidae														
Octopoteuthis sicula							*2.5	1.4						
Ommastrephidae														
Dosidicus gigas									8.3	5.2				
Anthopleura xanthogrammica									8.3	1.2				
Unidentified squid							5.0	4.7	8.3	3.1				
Neoloricata														
Mopaliidae														
Amicula stelleri							**2.5	0.2						
Mopalia acuta							*2.5	2.3						
Pelecypoda									**8.3	0.2				

Fig. 134 continued

	Prince Is.		Santa Barbara Is.		Anacapa Is.		San Nicolas Is.		Gull Is.		San Clemente Is.		Santa Catalina Is. Bird Rk.	
Gastropoda														
Calliostomatinae							**5.0	4.3						
Norrisia norrisi							2.5	?						
Turbinidae														
Astraea undosa							2.5	?						
Unidentified gastropod														
Chondrichthyes														
Squaliformes														
Scyliorhinidae														
Parmaturus xaniurus	#3.7	3.4												
Osteichthyes														
Salmoniformes														
Engraulidae														
Engraulis mordax	14.8	21.1	43.0	28.2	25.0	16.3	17.5	22.8	41.6	42.9	66.7	80.5	42.9	10.0
Myctophiformes														
Myctophidae														
Batrachoidiformes														
Batrachoididae														
Porichthys notatus	7.4	16.4					5.0	5.6	25.0	6.2				
Gadiformes							2.5	0.1						
Gadidae														
Merluccius productus	3.7	3.1	3.8	2.1	6.3	5.7								
Atheriniformes														
Scomberesocidae														
Cololabis saira	3.7	2.3	8.9	6.9	18.8	3.5							14.3	4.1
Atherinidae														
Atherinops affinis			2.5	5.8			7.5	12.0					14.3	68.6
Leuresthes tenuis					6.3	5.0								
Gasterosteiformes														
Syngnathidae														
Syngnathus californiensis					6.3	0.6								
Scorpaeniformes	3.7	7.0	1.3	2.3			2.5	0.1					*14.3	6.2
Scorpaenidae														
Sebastes sp.	18.5	12.9	8.9	12.7			12.5	3.0					6.3	0.4
Anoplopomatidae														
Anoplopoma fimbria	7.4	8.9												
Cottidae														
Hemilepidotus sp.														
Scorpaenichthys marmoratus									8.3	10.2				
Perciformes														
Sciaenidae														
Cynoscion nobilis							*2.5	0.7						
Roncador stearnsii							**2.5	1.3						
Umbrina roncador	3.7	4.7	1.3	0.7	37.5	42.4							14.3	5.7
Embiotocidae									**8.3	0.8				
Brachyistius frenatus							**5.0	11.1						
Pomacentridae														
Chromis punctipinnis			2.5	1.7	6.3	0.8			*8.3	3.7				
Stromateidae														
Peprilus semillimus					12.5	24.2								
Unidentified fish	14.8	2.9	12.7	6.2	6.3	0.6	7.5	2.0	8.3	0.2				
Fish guts	**7.4	6.6									**33.3	19.5	**14.3	5.3
Seal placenta	7.4	2.7	*8.9	14.8			25.0	15.3						
Garbage			15.2	13.1	6.3	0.6								

* Identified by non-standard taxonomic characters from several to many specimens.
** Identified by non-standard taxonomic characters from one to few specimens.
\# Probably thrown overboard from a fishing boat.

Fig. 135

Western Gull 1977

Composition of Stomach Samples

Island Number of stomach samples P.O. = Percent occurrence P.V. = Percent volume	Prince Is. n=34		Santa Barbara Is. n=153		Anacapa Is. n=12		San Nicolas Is. n=15		Gull Is. n=12		Scorpion Is. n=12		Santa Catalina Is. Bird Rk. n=1	
	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.	P.O.	P.V.
Crustacea														
Isopoda	2.9	Trace												
Amphipoda			.7	.01										
Euphausiacea														
Euphausicea pacifica			.7	.04										
Thysanoessa spinifera														
Decapoda							3.0	.6						
Copepoda														
Cecropidae														
Cecrops latreilli														
Cirripeda														
Lepadomorpha														
Lepas anatifera														
Unidentified barnacle (Mitella)			3.3	1.1										
Insecta	2.9	Trace	.7	.04										
Unidentified crustacea			.7	.04										
Mollusca														
Octopoda							6.7	2.7						
Argonautidae														
Arginauta sp.														
Teuthoidea														
Loliginidae														
Loligo opalescens	20.6	28.2	5.2	3.1	8.3	2.4	33.3	25.8			8.3	11.3		
Enoploteuthidae														
Abraliopsis felis														
Pterygiotheuthis giardi														
Histioteuthidae														
Histioteuthis														
Octopoteuthidae														
Octopoteuthis sicula														
Ommastrephidae														
Dosidicus gigas														
Anthopleura xanthogrammica														

Fig. 135

Western Gull 1977 - Continued	Prince Is.		Santa Barbara Is.		Anacapa Is.		San Nicolas Is.		Gull Is.	Scorpion Is.		Santa Catalina Is. Bird Rk.
Unidentified squid	11.8	3.9	1.3	.7	25.0	18.0				16.7	6.1	
Neoloricata												
Mopaliidae												
Amicula stelleri												
Mopalia acuta												
Pelecypoda												
Gastropoda												
Calliostomatinae												
Norrisia norrisi												
Turbinidae												
Astraea undosa												
Unidentified gastropod												
Chondrichthyes												
Squaliformes												
Scyliorhinidae												
Parmaturus xaniurus												
Osteichthyes												
Salmoniformes												
Engraulidae												
Engraulis mordax			15.0	17.8						8.3	4.3	
Myctophiformes												
Myctophidae												
Batrachoidiformes												
Batrachoididae												
Porichthys notatus			2.0	3.8	8.3	8.4	6.7	4.1				
Gadiformes												
Gadidae												
Merluccius productus	8.8	18.5	2.6	1.6			6.7	14.4				
Atheriniformes												
Scomberesocidae												
Cololabis saira			44.4	53.1			6.7	6.2				
Atherinidae												
Atherinops affinis							6.7	6.2				
Leuresthes tenuis												
Gasterosteiformes												
Syngnathidae												
Syngnathus californiensis												

Fig.135

Western Gull 1977 - Continued	Prince Is.		Santa Barbara Is.		Anacapa Is.		San Nicolas Is.		Gull Is.	Scorpion Is.		Santa Catalina Is. Bird Rk.	
Scorpaeniformes													
Scorpaenidae													
Sebastes sp.	20.6	8.0	4.6	2.9	50.0	75.5	13.3	2.5		41.7	37.8		
Anoplopomatidae													
Anoplopoma fimbria													
Hexagvammidae													
Ophiodon elongatus													
Cottidae							6.7	12.4					
Hemilepidotus sp.													
Scorpaenichthys marmoratus													
Perciformes													
Carangidae													
Trachurus symmetricus			1.3	1.3									
Sciaenidae										16.7	10.4		
Cynoscion nobilis													
Roncador stearnsii													
Umbrina roncador													
Embiotocidae													
Brachyistius frenatus													
Cymnogaster aggregata			.7	.8									
Pomacentridae													
Chromis punctipinnis													
Stromateidae													
Peprilus semillimus													
Unidentified fish	50.0	24.7	17.0	6.8	16.7	7.2	6.7	1.0		33.3	14.8	100.0	100.0
Fish guts			5.9	.6									
Fish eggs			0.7	1.0			6.7	10.3					
Seal placenta			2.0	2.0			6.7	3.1					
Garbage	5.9	24.7	0.7	1.0			6.7	10.3		16.7	10.9		
Offal			3.3	.7									
Plant Debris			2.0	.6									
Unidentified													

Appendix III-4

SCHEDULE OF COLOR - MARKED
WESTERN GULL SURVEYS

Fig. III-136

Schedule of Colormarked Western Gull Surveys Along the Southern California Coastline

Survey Site	Dates Visited in 1976			
Tejiquas Dump & Slough	27 May	3,11,18,23 June	1,8,16,27 July	6,12,18 August
Santa Barbara Transfere Station	27 May	3,11,18,23 June	1,8,16,27 July	6,12,18 August
Santa Barbara Pier	27 May	3,11,23 June	8 July	6,18 August
Santa Barbara Marina		3,11,23 June	1,8,16,27 July	6,12,18 August
Cabrillo Bird Lagoon		3,11,23 June	1,8,16,27 July	6,12,18 August
Malibu Slough		9,15,22,28 June	1,6,28 July	3,11 August
Ventura County Beach			6 July	11 August
Ventura/Oxnard Dump & Santa Clara River Bottom	31 May	4,9,15,22,28 June	6,16,28 July	3,11,18 August
McGrath State Beach		9,15 June		
Ventura Marina Sportfishing	31 May	4,9,15,22,28 June	6,28 July	3,11,18 August
Channel Is. Marina Sportfishing	31 May	4,9,15,22,28 June	6,28 July	3,11,18 August
Port Hueneme	31 May	9,15,22,28 June	6,28 July	3,11,18 August
Zuma Beach	26 May	22,28 June	6,27,28 July	3 August
Santa Monica Pier	27,31 May	4,9,15,22 June	6,28 July	3,12,18 August
Venice Canal		7,14,30 June	6,7,26 July	2,9,16,23 August
Marina del Rey		7,14,30 June	7,26 July	2,4,9,16,23 August
Playa del Rey		14,25,30 June	7,26 July	2,4,9,16,23 August
King Harbor		7,14,25,30 June	7,26 July	2,9,16,23 August
South Coast Botanic Garden	26,28 May	4,7,14,17,22,25,30 June	7,26 July	2,4,9,16,23 August
Palos Verdes Dump	26 May	7,14,30 June	7,26 July	2,9,16,23 August
Fort McArthur Beach	28 May	17 June		
Santa Ana River Mouth	26 May	14,25,30 June	7,26 July	2,9,16,23 August
Upper Newport Bay	26 May	7,14,25,30 June	7,26 July	2,16,23 August
Orange County Dump	26 May	7,14,30 June	7,26 July	2,16,23 August
Corona del Mar		10,24 June		
Dana Point Harbor		10,24 June	29 July	10,17 August
Oceanside Harbor		10,24 June	29 July	10,17 August

cont...

Fig. III-136. (cont.)

Survey Site	Dates Visited in 1976		
Oceanside Slough	10,24 June	29 July	10,17 August
Oceanside Beach	10,24 June	29 July	10 August
Oceanside Dump	10,24 June	29 July	10,17 August
Encinal Fishing Area Lagoon	10 June		17 August
Encinitas Dump	10,24 June		
Cholla Dump	24 June	29 July	10,17 August

In addition to these sites, the following areas were surveyed once during the 1976 breeding season:

Nicherin Shashu Academy (31 May)
Goleta Beach Slough (11 June)
Santa Barbara Slough (12 August)
Carpinteria State Beach (11 June)
Sycamore Canyon State Park Beach (6 July)
Paradise Cove (9 June)
Malibu Beach (9 June)
"Reef" Beach at Yerba Buena Rd (4 June)
Pt. Mugu State Park, La Jolla Beach (6 July)
Bologna Creek (7 June)
Hyperion Beach (7 June)
Manhattan Beach (4 June)
Hermosa Beach (4 June)
Redondo Beach (4 June)
Cabrillo Beach (28 May)
Bolsa Chica Reserve (26 May)
Huntington State Beach (26 May)
Balboa Pier (26 May)
Doheny State Beach (10 June)
Buena Vista Lagoon (10 June)
Carlsbad State Beach (10 June)
San Marcas Creek (10 June)
San Gabriel River (26 May)
Naval Weapons Stand (26 May)
Long Beach (28 May)

Fig. III-137

Schedule of Colormarked Western Gull Surveys Along the Southern California Coastline

Survey Site	Dates Visited in 1977	
Tejiquas Dump and Slough	19,27 May	2,17,24 June
Santa Barbara Transfere Station	19,27 May	2,17,24 June
Santa Clara Dump	11,19,27 May	2,7,17,24 June
Santa Clara River Bottom	27 May	2,7,17,24 June
McGrath State Beach		2,17,24 June
Ventura Marina Sportfishing		2,17,24 June
Zuma Beach		17,24 June
South Coast Botanic Garden	18,23,30 May	2,10,13,20,24 June
Palos Verdes Dump	19,27 May	2,10,20 June
Huntington Beach	13,17,23,26,30 May	3,7,9,13,16,23 June
Coyote Canyon Dump, Irvine	17,26 May	3,10,23 June
Corona del Mar	17,20,23 May	
Oceanside Dump		15,21 June
Cholla Dump/Cholla Park	25,31 May	15,21 June

In addition to these sites, the following areas were surveyed once during the 1977 breeding season:

Seal Rock, Laguna Beach (26 May)
Miramar Dump (25 May)
Alison Beach (26 May)
Doheny Beach (26 May)
Prima Deschete Dump, Ortega Hwy. (31 May)
Pt. Mugu State Park (2 June)

Appendix III-5

RADIAL TRANSECT SURVEYS IN THE VICINITY OF SANTA BARBARA ISLAND

Fig. III-138. Non-Standard Radial Transect Surveys, Santa Barbara Island, 1975

Survey Date	Heading (° mag.)	Direction	Length (km)	Approximate Analagous Standard Transect
19 April[b]	280°	In	27.75	Webster (in)
20 April[b]	215°	Out	38.85	Sutil (out)
21 April[b]	40°	Out	18.5	Santa Monica (out)
21 April[b]	220°	In	18.5	Santa Monica (in)
21 April[b]	158°	Out	14.8	Osborne (out)
21 April[b]	334°	In	14.8	Osborne (in)
21 April[b-c]	52°	Out	27.75	Newport (out)
9 May[a]	13°	Out	7.4	Santa Monica (out)
9 May[b-c]	205°	In	42.55	Santa Monica (in)
10 May[b]	~60°	Out	12.95	Newport (out)
21 May[a-b]	87°	Out	37.0	Newport (out)
27 May[b]	243°	In	22.2	Newport (in)
27 May[b]	280°	Out	46.25	Webster (out)
29 June[b]	~350°	Out	27.75	Anacapa (out)
16 July[b]	100°	In	46.25	Webster (in)
23 July[b]	25°	Out	44.4	Santa Monica (out)
24 July[b]	119°	Out	11.1	San Clemente (out)

[a]Radial performed between 0600 and 0900.
[b]Radial performed between 0900 and 1700.
[c]Radial performed between 1700 and sunset.

Fig. III-139. Standard Radial Transect Surveys, Santa Barbara Island, 1976-1977

	Heading (°mag.)	Length (km)	Starting or Ending Pt.
Anacapa (out)	318°	18.5	NE point, directly offshore
Anacapa (in)	138°	18.5	
Webster (out)	270°	18.5	Webster Pt., ½ mi. offshore
Webster (in)	090°	18.5	
Sutil (out)	220°	9.5	Sutil Is., ½ mi. offshore
Sutil (in)	040°	9.5	
Osborne (out)	170°	18.5	Cat Canyon, ½ mi. offshore
Osborne (in)	350°	18.5	
San Clemente (out)*	120°	9.5	SE tip, ½ mi. offshore
San Clemente (in)*	300°	9.5	
Newport (out)	070°	18.5	Landing Cove, directly offshore
Newport (in)	250°	18.5	
Santa Monica (out)	015°	9.5	Arch Pt., directly offshore
Santa Monica (in)	195°	9.5	

*San Clemente transect was lengthened to 18.5 km in 1977.

Fig.III-140. Summary of Radial Transect Surveys Completed, Santa Barbara Island, 1976.

	14-18 Jan.	11-15 Feb.	17-21 Mar.	10-11 Apr.	28* Apr.	1-3* May	20* May	23-25 May	9-11 June	26-28 June	16-17 July	Total
Anacapa (out)			1a-b						1a			2
Anacapa (in)	1b		1b-c	1b		1b		1b-c	1a-b	1c	1b	8
Webster Pt. (out)	1a-b		1a	1b	1a		1a	3a-b,b,c		1b	1b	10
Webster Pt. (in)	1b		1a-b	1b				3b,b,c	1c	1b	1b	9
Sutil Is. (out)			1b	1b		1a-b		2a,b	1b			6
Sutil Is. (in)			1b	1b		1b		2a,b	1b			6
Osborn Bank (out)	1b		1b	1a		1b		1a-b	1b	1b	1b	8
Osborn Bank (in)	1b		1b	1a-b		1b		1b	1b	1b		7
San Clemente (out)			1b	1b		1a		1a				4
San Clemente (in)			1b	1b				1a				3
Newport Beach (out)	1b	1b	1b	1b		1b		1b	1b	1a-b	1b	9
Newport Beach (in)						1b-c					1b-c	2
Santa Monica (out)			1b	1b		1b		1c				4
Santa Monica (in)			1b	1b		1b-c		1c				4
Total	6	1	13	12	1	10	1	18	8	6	6	82

*Pacific Daylight Savings Time

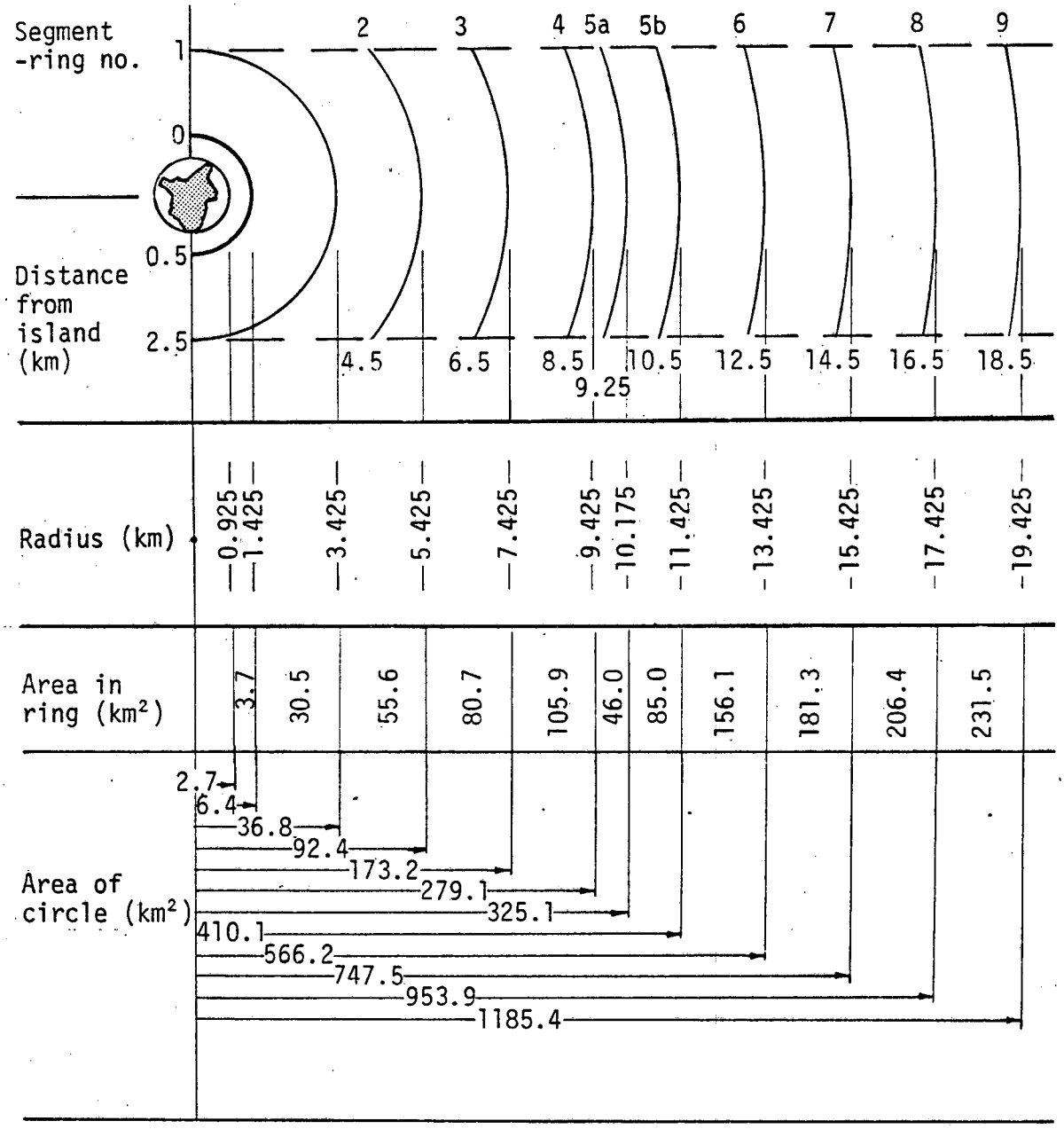
a Radial performed between 0600 and 0900
b Radial performed between 0900 and 1700
c Radial performed between 1700 and sunset

Fig. 141 Xantus' Murrelets: Summary of Radial Transect Surveys Completed, Santa Barbara Island, 1977

Radial		20-21 Jan.	6 Feb.[1]	18-19 Feb.	22-24 Mar.	12-16 Apr.	23 Apr.	3-5 May	18 May	6-7 June	23-24 June	10-11 July	25-27 July	14-15 Aug.	Total
Anacapa	(out)								1[a-b]						1
	(in)	1[b]		1[b]		1[b]					1[b]				4
Webster	(out)	1[a]		1[a]	1[a-b]	3[a-b,b,b]	2[a-b,b*]	1[b]	1[b]		1[a]				11
	(in)			1[a-b]	1[c]	2[b,b]		2[b-c]		1[b-c]	1[b]	1[b]	1[b-c]	1[b]	11
Sutil	(out)							1[b]					1[a-b]		2
	(in)						1[b]						1[b]		2
Osborne	(out)	1[b]		1[b]	1[b]			1[a-b]		1[b]		1[a]	1[b]	1[a]	8
	(in)	1[b-c]		1[b]	1[b]			1[b]		1[b]				1[b]	6
San Clemente	(out)		1[a-b]	1[b]	1[b]	1[b]		1[b]		1[b]			1[b]		7
	(in)					1[b]		1[b]		1[b]			1[b]		4
Newport	(out)	1[b]		1[b]	1[b]	1[b]		1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	11
	(in)								1[b]						1
Santa Monica	(out)														0
	(in)														0
Total		5	1	7	6	9	3	9	4	6	4	3	7	4	68

*Incomplete.

[a]Radial performed between 0600 and 0900.
[b]Radial performed between 0900 and 1700.
[c]Radial performed between 1700 and sunset.
[1]These radial transect surveys were performed on a different vessel, the E. B. Scripps.



Appendix III-42 Areas contained in Segment-rings around Santa Barbara Island.

Fig. 143 Estimate of Xantus' Murrelet Population at Santa Barbara Is., 20-21 March 1976.

Segment Number	0	1	2	3	4	a	5[1] b	6	7	8	9
Distance from island	0-0.5	0.5-2.5	2.5-4.5	4.5-6.5	6.5-8.5	8.5-9.25	9.26-10.5	10.5-12.5	12.5-14.5	14.5-16.5	16.5-18.5
Anacapa	0	4	0	0	3	0	0	0	0	2	0
Webster	0	4	7	3	5	8	7	4	0	0	0
Sutil	0	1	21	8	4	0					
Osborn	0	0	0	0	0	0	3	0	4	0	0
San Clemente	0	0	3	0	0	0					
Newport	0	0	0	6	0	0	0	0	0	0	0
Santa Monica	0	0	2	4	0	0					
Total Murrelets seen	0	9	33	21	12	8	10	4	4	2	0
Mean SD_1	0	1.29±1.89	4.71±7.61	3.00±3.21	1.71±2.21	1.14±3.02	2.50±3.32	1.00±2.00	1.00±2.00	0.50±1.00	0
Est. Density[2] (SD_2) SE	0	2.15±1.19 (3.15)	7.85±4.80 (12.70)	5.00±2.02 (5.35)	2.85±1.39 (3.68)	5.07±5.07 (13.42)	6.67±2.53 (8.85)	1.67±1.26 (3.33)	1.67±1.26 (3.33)	0.83±0.63 (1.67)	0
Area (km^2) (See Fig. 13)	3.69	30.47	55.60	80.74	105.87	46.02	84.98	156.14	181.27	206.38	231.54
Estimated number of murrelets (SD_3) SE	0	66±36 (96)	437±266 (705)	404±163 (432)	302±147 (390)	233±234 (618)	566±285 (752)	260±197 (520)	302±228 (604)	172±130 (344)	0

Estimated Total = $\sum_{\text{Segment}=0}^{9}$ Estimated number of murrelets = 2,741

$$\text{Total Standard Error} = \sqrt{\sum_{\text{Segment}=0}^{9} \frac{(SD_3)^2}{n}}$$

where SD_3 = standard deviation of each estimate

n = the number of radials contributing to the mean

$$= \sqrt{\frac{96^2}{7} + \frac{705^2}{7} + \frac{432^2}{7} + \frac{390^2}{7} + \frac{618^2}{7} + \frac{752^2}{4} + \frac{520^2}{4} + \frac{604^2}{4} + \frac{344^2}{4}} = 711$$

Footnotes on following page

Footnotes for Fig. 143

1 Because some radials were only 9.25 km (5nm) long, segment #5 was divided into two segments, so all the data could be used.

For the distribution plots in Figs. 7 and 8, weighted averages were obtained in the following manner:

$$\text{mean estimated density for segment 5} = \frac{\bar{X}_a + \bar{X}_b}{\text{total area censused}} = \frac{1.14 + 2.50}{0.6} = 6.07$$

$$SE = \sqrt{\frac{(SD_{1a})^2}{n_a} + \frac{(SD_{1b})^2}{n_b}} \Big/ \text{total area censused} = \sqrt{\frac{13.42^2}{7} \quad \frac{8.85^2}{4}} = 5.6$$

total estimated number of murrelets = (estimate for a) + (estimate for b)

$$SE = \sqrt{\frac{(SD_{3a})^2}{n_a} + \frac{(SD_{3b})^2}{n_b}}$$

2 All densities were estimated by the equation: mean murrelets seen/area censused.

area censused = 0.15 km^2 for segment 0
0.225 km^2 for 5a
0.375 km^2 for 5b
0.60 km^2 for all others

units are murrelet/km^2

Fig. III-144. Xantus' Murrelets Sighted on Transect Surveys, Santa Barbara Island, 1975*

Distance From Land (nm):	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
Analagous Standard Transect											
Anacapa:											
29 June (out)	0	0	0	0	0	0	0	0	0	0	0
Webster:											
19 Apr. (in)	2	11	25	3	0	8	7	0	2	0	58
27 May (out)	0	-	5	6	4	13	2	10	20	20	80
16 July (in)	0	0	0	0	0	0	0	0	0	0	0
Sutil:											
20 Apr. (out)	17	9	4	0	0	0	3	0	1	1	35
Osborne:											
21 Apr. (out)	0	13	0	2	2	0	0	0	-	-	17
(in)	0	4	0	0	0	0	0	0	-	-	4
San Clemente:											
24 July (out)	-	-	0	0	0	0	-	-	-	-	0
Newport:											
21 Apr. (out)	0	6	15	2	0	0	0	0	0	2	25
10 May (out)	-	0	2	0	0	-	-	0	0	0	2
21 May (out)	0	4	7	0	0	0	0	0	0	0	11
27 May (in)	0	3	0	0	0	0	0	0	2	0	5
Santa Monica:											
21 Apr. (out)	0	37	0	0	2	0	0	0	0	0	39
(in)	0	9	30	2	1	0	0	0	0	0	42
9 May (in)	0	0	3	3	-	-	-	-	-	-	6
(in)	-	-	-	-	2	-	2	0	0	0	4
23 July (out)	-	-	-	0	0	0	0	0	-	-	0

*Sightings presented in this table include all sightings within 300 m of the ship. They are, therefore, not directly comparable to sightings reported 1976 and 1977 (Fig.

Fig. III-145. Xantus' Murrelets Sighted on Transect Surveys
Anacapa Transect, Santa Barbara Island, 1976-1977

Segment No.:	0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):	0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1976											
17 Jan. (in)	0	0	0	0	0	0	0	2	0	0	2
17 Mar. (out)	0	0	2	5	0	0	0	0	0	0	7
20 Mar. (in)	0	4	0	0	3	0	0	0	2	0	9
10 Apr. (in)	0	7	0	0	2	1	2	0	2	0	14
1 May (in)	0	2	3	17	26	12	2	16	4	2	84
23 May (in)	0	0	0	3	4	18	12	15	2	2	56
11 June (out)	0	2	0	0	1	0*	-	-	-	-	3
(in)	0	0	0	0	0	0*	-	-	-	-	0
26 June (in)	0	0	0	0	0	0	0	0	0	0	0
16 July (in)	0	0	0	0	0	0	0	0	0	0	0
Total	0	15	5	25	36	31	16	33	10	4	175
1977											
20 Jan. (in)	0	0	0	0	0	0	0	0	0	0	0
18 Feb. (in)	0	0	0	0	0	0	0	0	0	0	0
15 Apr. (in)	0	0	0	0	0	1	0	2	0	0**	3
19 May (out)	0	0	6	5	4	2	4	4	2	2	29
23 June (in)	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	6	5	4	3	4	6	2	2	32

*Transect ended 9.25 km (5 NM) from land.
**Incomplete survey of segment.

Fig. III-146. Xantus' Murrelets Sighted on Transect Surveys
Webster Transect, Santa Barbara Island, 1976-1977

Segment No.:		0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):		0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1976												
18 Jan.	(out)	-	1	0	0	0	0	0	0	0	0	1
	(in)	-	0	0	0	3	0	0	0	0	0	3
21 Mar.	(out)	-	2	1	0	6	9	4	4	2	4	32
	(in)	-	4	7	3	5	15	4	0	0	0	38
10 Apr.	(out)	-	4	5	11	6	8	0	0	4	0	38
	(in)	-	1	7	3	0	0	6	0	0	0	17
28 Apr.	(out)	-	0	0	6	22	8	6	0	2	0	44
	(in)	-	-	-	-	-	-	-	-	-	-	-
20 May	(out)	-	0	3	24	20	27	8	12	18	20	132
	(in)	-	-	-	-	-	-	-	-	-	-	-
24 May	(out)	-	23	61	46	22	15	12	10	8	4	201
	(in)	-	0	35	54	16	37	45	36	12	2	237
	(out)	-	0	37	32	32	22	34	30	8	2	197
	(in)	-	10	15	4	10	8	11	12	0	0	70
	(out)	-	6	34	20	34	45	7	-	-	-	146
	(in)	-	0	12	13	10	19	10	-	-	-	64
9 June	(out)	-	-	-	-	-	-	-	-	-	-	-
	(in)	-	0	0	0	0	0	0	0	0	0	0
27 June	(out)	-	0	0	0	0	0	0	0	0	0	0
	(in)	-	0	0	0	0	0	0	0	1	0	1
17 July	(out)	-	0	0	0	0	0	0	0	0	0	0
	(in)	-	0	0	0	0	0	0	0	0	0	0
Total		-	51	217	216	186	213	147	104	55	32	1221

Fig. III-146. Xantus' Murrelets Sighted on Transect Surveys
Webster Transect, Santa Barbara Island, 1976-1977 (Cont'd.)

Segment No.:	0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):	0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1977											
21 Jan. (out)	-	0	0	0	0	0	0	0	0	0	0
19 Feb. (out)	-	1	0	0	0	0	0	0	0	0	1
(in)	-	0	0	0	0	0	0	0	0	0	0
22 Mar. (in)	-	25	4	4	2	2	0	0	0	0	37
23 Mar. (out)	-	5	27	20	36	4	0	0	2	0**	94
12 Apr. (out)	-	0	1	24	24	2	14	9	14	5	93
15 Apr. (out)	-	0	7	2	1	2	11	2	16	16	57
(in)	-	0	4	0	0	0	13	4	4	21	46
16 Apr. (out)	-	0	20	4	4	4	17	4	3	6	62
(in)	-	0	0	4	16	2	20	8	2	4	56
23 Apr. (out)+	-	0	0	33	18	7	0	12	20	2	92
(out)+	-	0	8	23	17	8	0**	-	-	-	56
3 May (in)	-	17	3	0	9	30	0	4	2	0	65
4 May (out)	-	0	0	10	36	20	2	2	19	2	91
(in)	-	0	2	10	12	2	2	4	0	0	32
18 May (out)	-	0	0	2	3	2	12	4	8	9	40
6 June (in)	-	0	2	0	0	0	0	0	0	0	2
24 June (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
10 July (in)	-	0	0	0	0	0	0	0	0	0	0
25 July (in)	-	0	0	0	0	0	0	0	1	0	1
14 Aug. (in)	-	0	0	0	0	2	0	0	0	0	2
Total	-	48	78	136	178	87	91	53	91	65	827

**Incomplete survey of segment.
+Transect performed on the E. B. Scripps.

Fig. III-147. Xantus' Murrelets Sighted on Transect Surveys
Sutil Transect, Santa Barbara Island, 1976-1977

Segment No.:		0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):		0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1976												
21 Mar.	(out)	-	1	21	8	4	0*	-	-	-	-	34
	(in)	-	4	10	9	0	0*	-	-	-	-	23
10 Apr.	(out)	-	6	4	7	0	2*	-	-	-	-	19
	(in)	-	0	2	0	0	0*	-	-	-	-	2
2 May	(out)	-	38	50	8	0	0*	-	-	-	-	96
	(in)	-	31	31	17	2	0*	-	-	-	-	81
24 May	(out)	-	18	32	3	8	0*	-	-	-	-	61
	(in)	-	4	22	4	0	0*	-	-	-	-	30
	(out)	-	28	0	0	4	2*	-	-	-	-	34
	(in)	-	8	2	10	2	0*	-	-	-	-	22
10 June	(out)	-	0	0	0	1	0*	-	-	-	-	1
	(in)	-	0	0	0	0	0*	-	-	-	-	0
Total		-	138	174	66	21	4					403
1977												
23 Apr.	(in)+	-	0	0	0	0	2	0	0	0	0	2
4 May	(out)	-	0	0	0	0	0*	-	-	-	-	0
26 July	(out)	-	0	0	0	1	0	0	0	0	0	1
	(in)	-	0	0	0	0	0	0	0	0	0	0
Total		-	0	0	0	1	2	0	0	0	0	3

*Transect ended 9.25 km (5 NM) from land.
+Transect performed on the E. B. Scripps.

Fig. III-148. Xantus' Murrelets Sighted on Transect Surveys
Osborne Transect, Santa Barbara Island, 1976-1977

Segment No.:	0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):	0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1976											
18 Jan. (out)	-	4	0	0	0	0	0	0	0	0	4
(in)	-	0	0	0	0	0	0	0	0	0	0
21 Mar. (out)	-	0	0	0	0	5	0	0	0	0	5
(in)	-	0	0	0	0	3	0	4	0	0	7
11 Apr. (out)	-	0	2	0	0	0	4	0	0	0	6
(in)	-	0	0	0	0	0	3	0	0	1	4
2 May (out)	-	2	4	0	0	0	0	0	0	0	6
(in)	-	2	10	2	0	0	0	0	0	0	14
25 May (out)	-	2	3	0	0	0	0	0	0	0	5
(in)	-	3	2	0	0	0	0	0	0	0	5
10 June (out)	-	1	0	0	0	0	0	0	0	0	1
(in)	-	0	0	0	0	0	0	0	0	0	0
27 June (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
17 July (out)	-	0	0	0	0	2	0	0	0	0	2
(in)	-	-	-	-	-	-	-	-	-	-	-
Total	-	14	21	2	0	10	7	4	0	1	59

Fig. III-148. Xantus' Murrelets Sighted on Transect Surveys
Osborne Transect, Santa Barbara Island, 1976-1977 (Cont'd.)

Segment No.:	0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):	0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1977											
20 Jan. (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
19 Feb. (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
23 Mar. (out)	-	2	2	6	0	2	2	4	0	0	18
(in)	-	1	6	2	0	2	0	0	0	0	11
5 May (out)	-	3	0	2	0	0	0	0	0	0	5
(in)	-	0	1	0	0	0	0	0	0	0	1
7 June (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	3	4	0	0	0	0	0	0	0	7
11 July (out)	-	0	0	0	0	0	0	0	0	3	3
26 July (out)	-	0	0	0	0	0	0	1	0	0	1
15 Aug. (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
Total	-	9	13	10	0	4	2	5	0	3	46

Fig.III-149. Xantus' Murrelets Sighted on Transect Surveys
San Clemente Transect, Santa Barbara Island, 1976-1977

Segment No.:		0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):		0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1976												
21 Mar.	(out)	-	0	3	0	0	0*	-	-	-	-	3
	(in)	-	0	2	0	0	0*	-	-	-	-	2
10 Apr.	(out)	-	1	0	0	0	0*	-	-	-	-	1
	(in)	-	1	0	1	0	0*	-	-	-	-	2
3 May	(out)	-	19	2	0	0	0	0	0	2	0	23
	(in)	-	-	-	-	-	-	-	-	-	-	-
25 May	(out)	-	0	11	0	0	0*	-	-	-	-	11
	(in)	-	0	0	4	2	0*	-	-	-	-	6
Total		-	20	18	5	2	0	0	0	2	0	48
1977												
6 Feb.+	(out)	-	0	0	0	0	0*	-	-	-	-	0
18 Feb.	(out)	-	0	0	0	0	0*	-	-	-	-	0
24 Mar.	(out)	-	2	6	0	0	0	0	0	0	0	8
16 Apr.	(out)	-	3	3	5	0	0	2	2	0	0	15
	(in)	-	0	0	0	0	0	0	2	0	0	2
5 May	(out)	-	4	0	0	0	0	0	0	0	0	4
	(in)	-	0	0	0	8	2	0	0	0	0	10
7 June	(out)	-	0	0	0	0	0	0	0	0	0	0
	(in)	-	0	0	0	0	0	0	0	0	0	0
27 July	(out)	-	0	0	0	0	0	0	0	0	0	0
	(in)	-	0	0	0	0	0	0	0	0	0	0
Total		-	9	9	5	8	2	2	4	0	0	39

*Transect ended 9.25 km (5nm) from land. +Transect performed on the E. B. Scripps.

Fig. 150 Xantus' Murrelets Sighted on Transect Surveys
Newport Transect, Santa Barbara Island, 1976-1977

Segment No.:	0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):	0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1976											
18 Jan. (out)	0	0	0	0	0	0	0	0	0	0	0
15 Feb. (out)	0	0	0	0	0	0	0	0	0	0	0
21 Mar. (out)	0	0	0	6	0	0	0	0	0	0	6
11 Apr. (out)	0	0	0	0	0	0	0	0	0	0	0
2 May (out)	0	0	20	12	0	0	0	0	0	0	32
(in)	0	2	8	8	0	0	0	0	1	2	21
25 May (out)	0	0	0	2	0	0	0	0	0	0	2
11 June (out)	0	2	0	0	0	0	0	0	0	0	2
28 June (out)	0	0	0	0	0	0	0	0	0	0	0
16 July (out)	0	0	0	0	0	0	0	0	0	0	0
(in)	0	0	0	0	0	0	0	0	0	0	0
Total	0	4	28	28	0	0	0	0	1	2	63
1977											
21 Jan. (out)	0	0	0	0	0	0	0	0	0	0	0
19 Feb. (out)	0	0	0	0	0	0	0	0	0	0	0
24 Mar. (out)	0	0	4	10	10	10	4	2	2	0	42
16 Apr. (out)	0	0	0	6	0	0	0	0	2	0	8
5 May (out)	0	0	0	0	0	0	0	0	0	0	0
18 May (out)	0	0	2	0	0	0	0	0	0	0	2
(in)	0	0	0	0	18	6	0	0	0	0	24
7 June (out)	0	3	5	0	0	0	0	0	0	0	8
24 June (out)	0	0	0	0	0	0	0	0	0	0	0
11 July (out)	0	0	0	0	0	0	0	0	0	0	0
27 July (out)	0	0	0	0	0	0	0	0	0	0	0
15 Aug. (out)	0	0	0	0	0	0	0	0	0	0	0
Total	0	3	11	16	28	16	4	2	4	0	84

Fig. III-151. Xantus' Murrelets Sighted on Transect Surveys
Santa Monica Transect, Santa Barbara Island, 1976-1977

Segment No.:	0	1	2	3	4	5	6	7	8	9	Total
Distance From Land (km):	0.0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	
1976											
21 Mar. (out)	0	0	2	0	0	0					2
(in)	0	0	2	4	0	0					6
10 Apr. (out)	0	0	2	0	0	0					2
(in)	0	0	0	0	0	0					0
1 May (out)	0	9	0	2	2	2					15
(in)	0	1	2	0	0	2					5
23 May (out)	0	2	2	0	9	2					15
(in)	0	4	0	0	4	0					8
Total	0	16	10	6	15	6					53
1977	Not Surveyed.										

*Transect ended 9.25 km (5nm) from land.

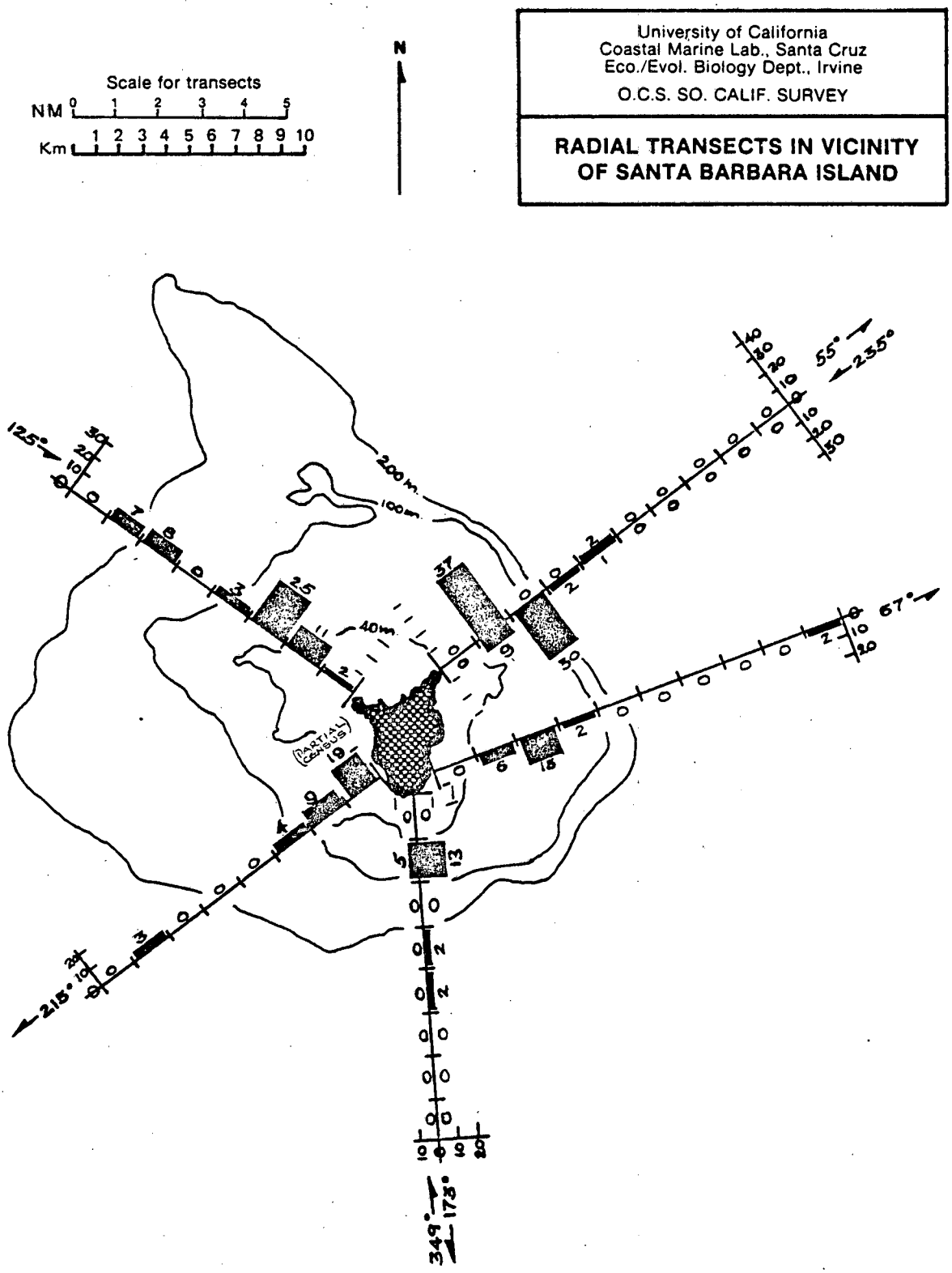


Figure III-152 Distribution of Xantus' Murrelet at sea, April 1975. Numbers of birds sighted per 1.85 km (1 nm) on indicated headings.

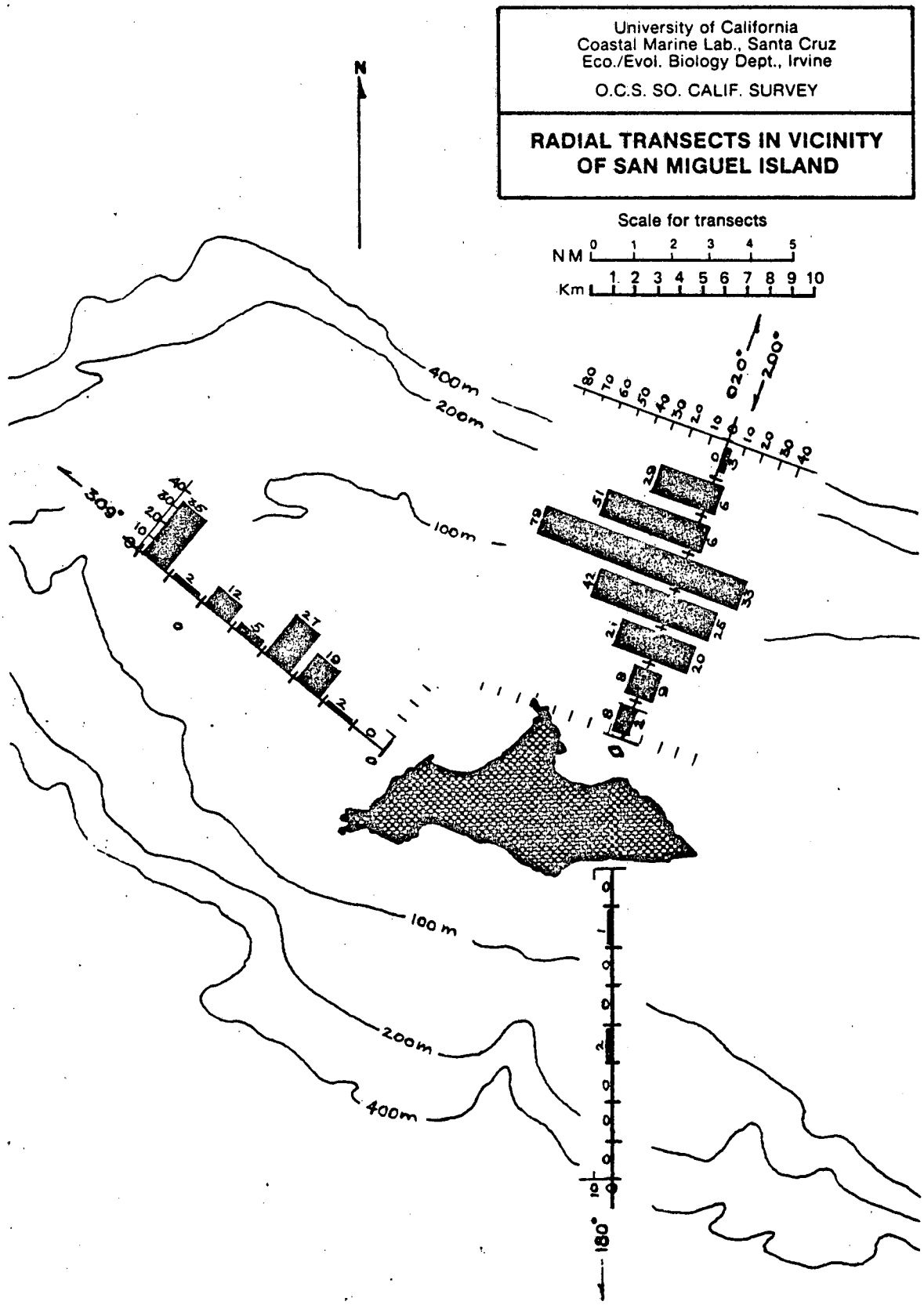


Figure III-153. Distribution of Cassin's Auklet at sea, May 1975. Numbers of birds sighted per 1.85 km (1 nm) on indicated headings.

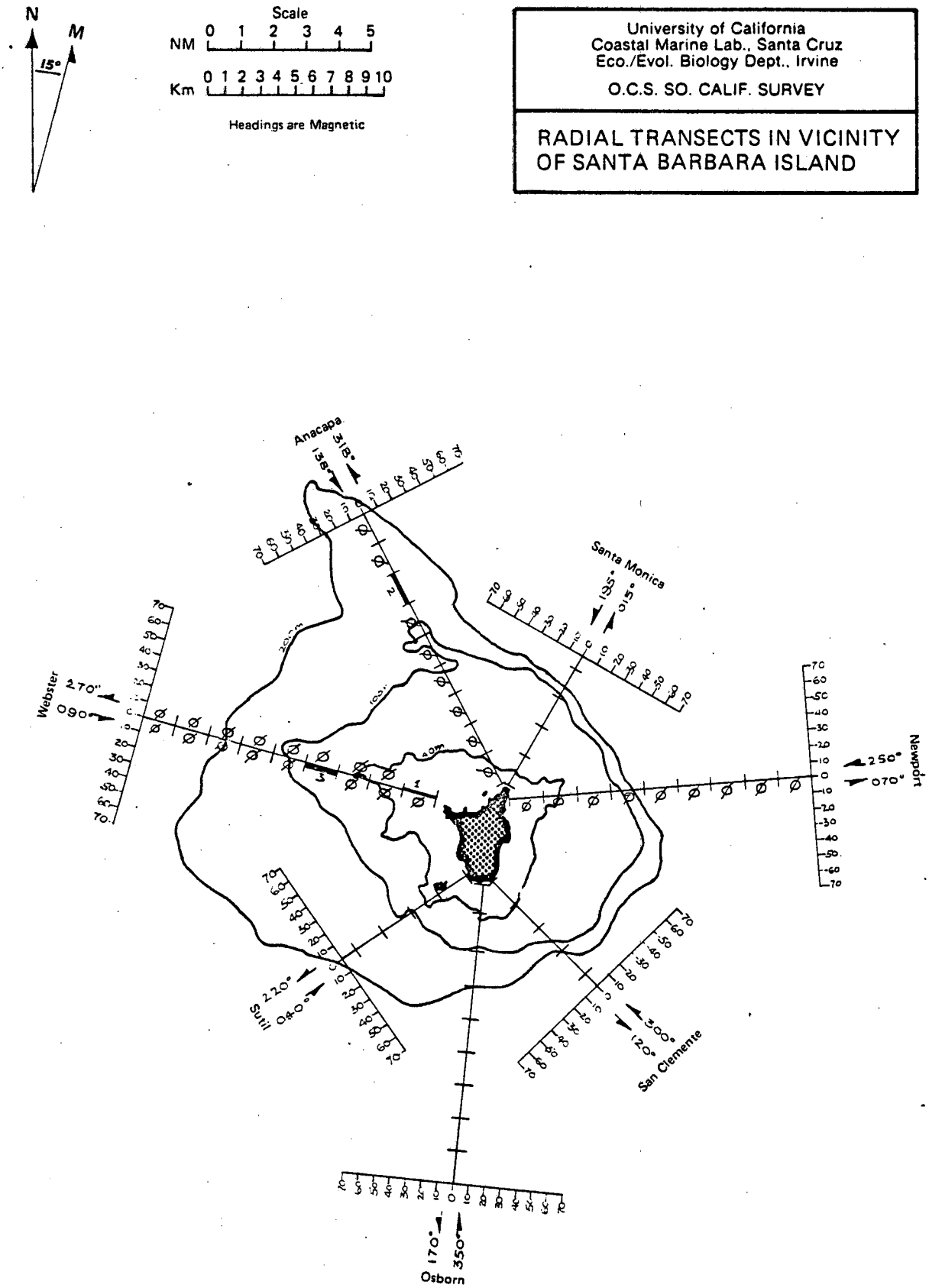


Figure III-154. Numbers of Xantus' Murrelets sighted in transect segments, January 1976.

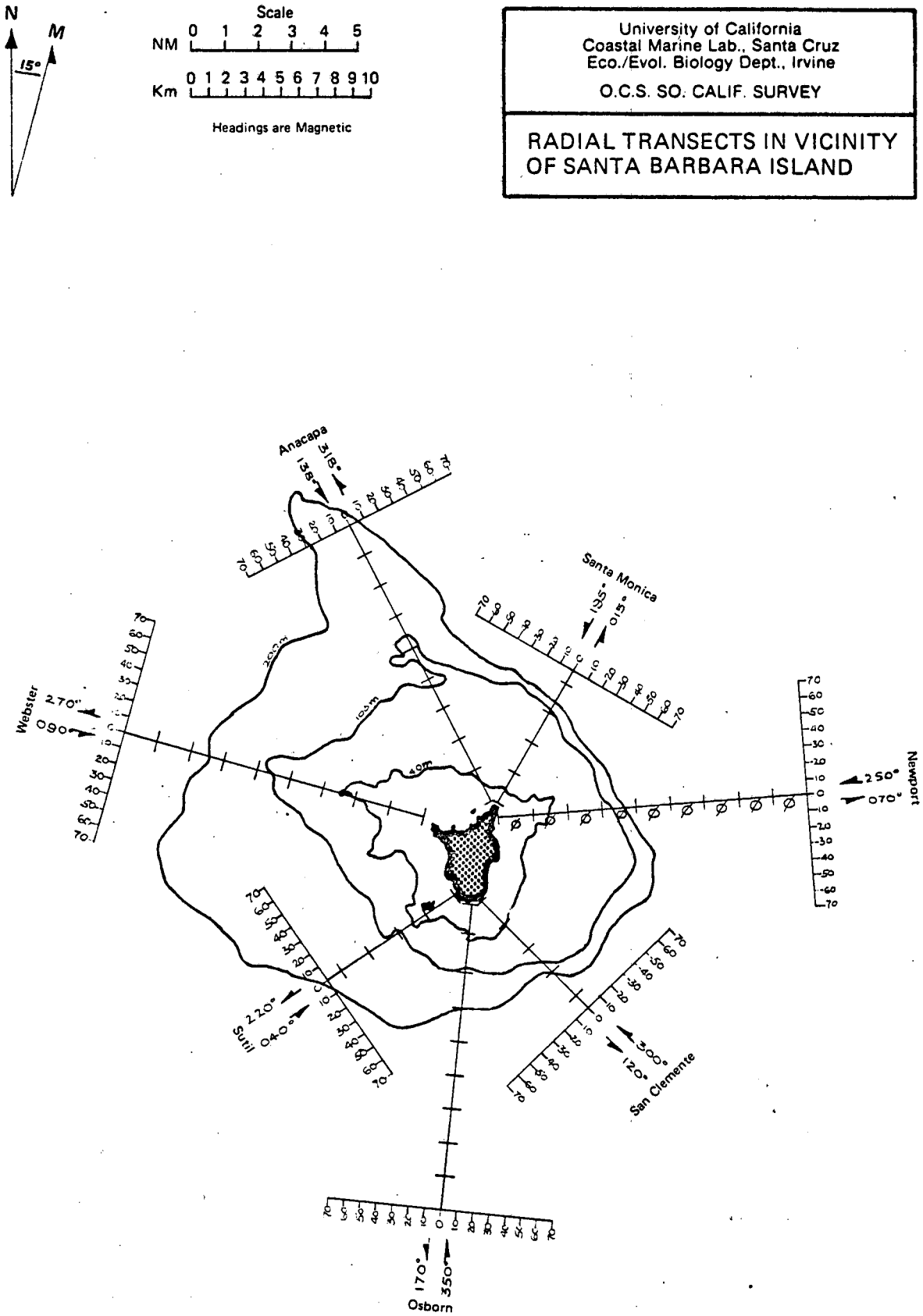


Figure III-155. Numbers of Xantus' Murrelets sighted in transect segments, February 1976.

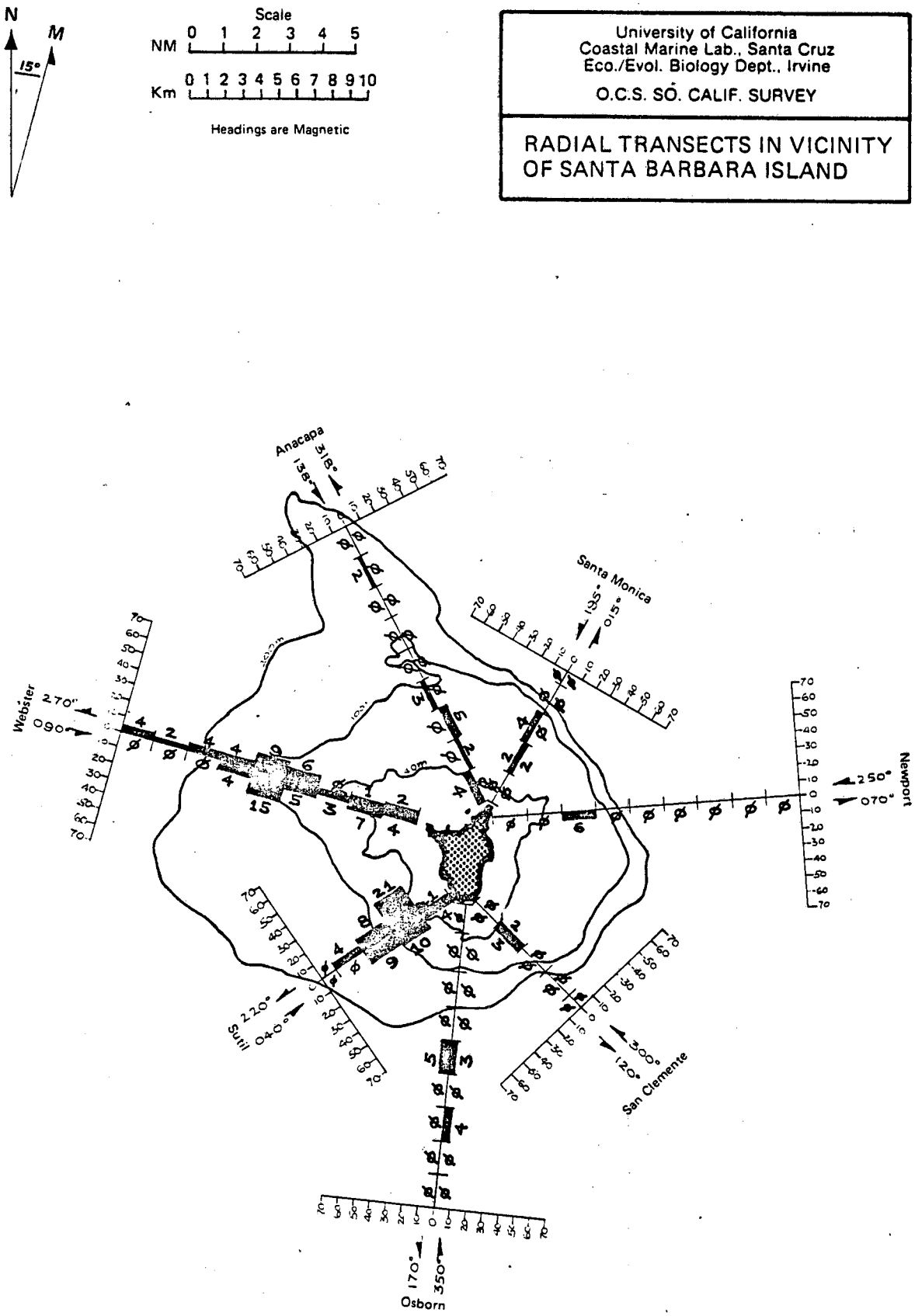


Figure III-156. Numbers of Xantus' Murrelets sighted in transect segments, March 1976.

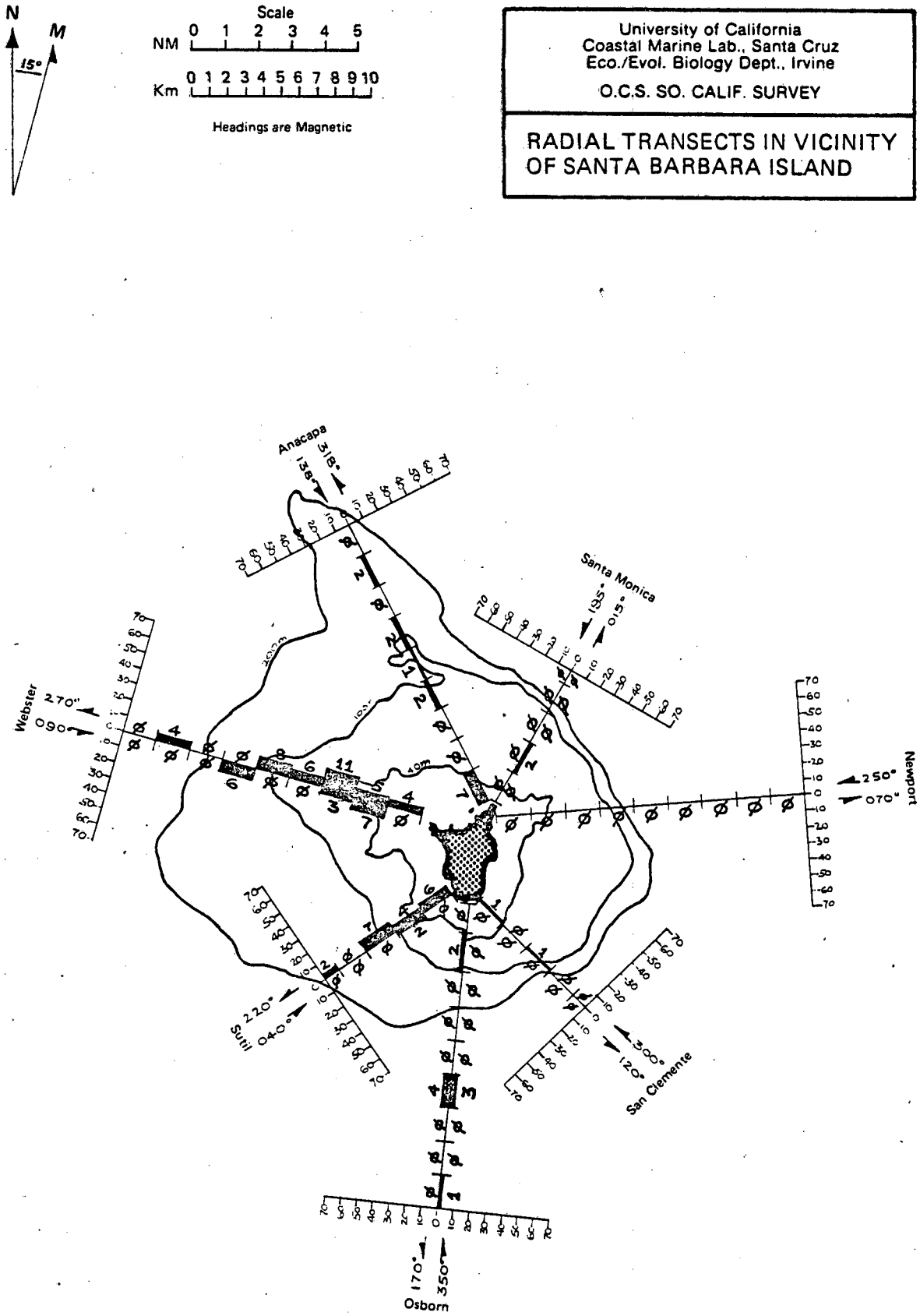


Figure III-157. Numbers of Xantus' Murrelets sighted in transect segments, 10-11 April 1976.

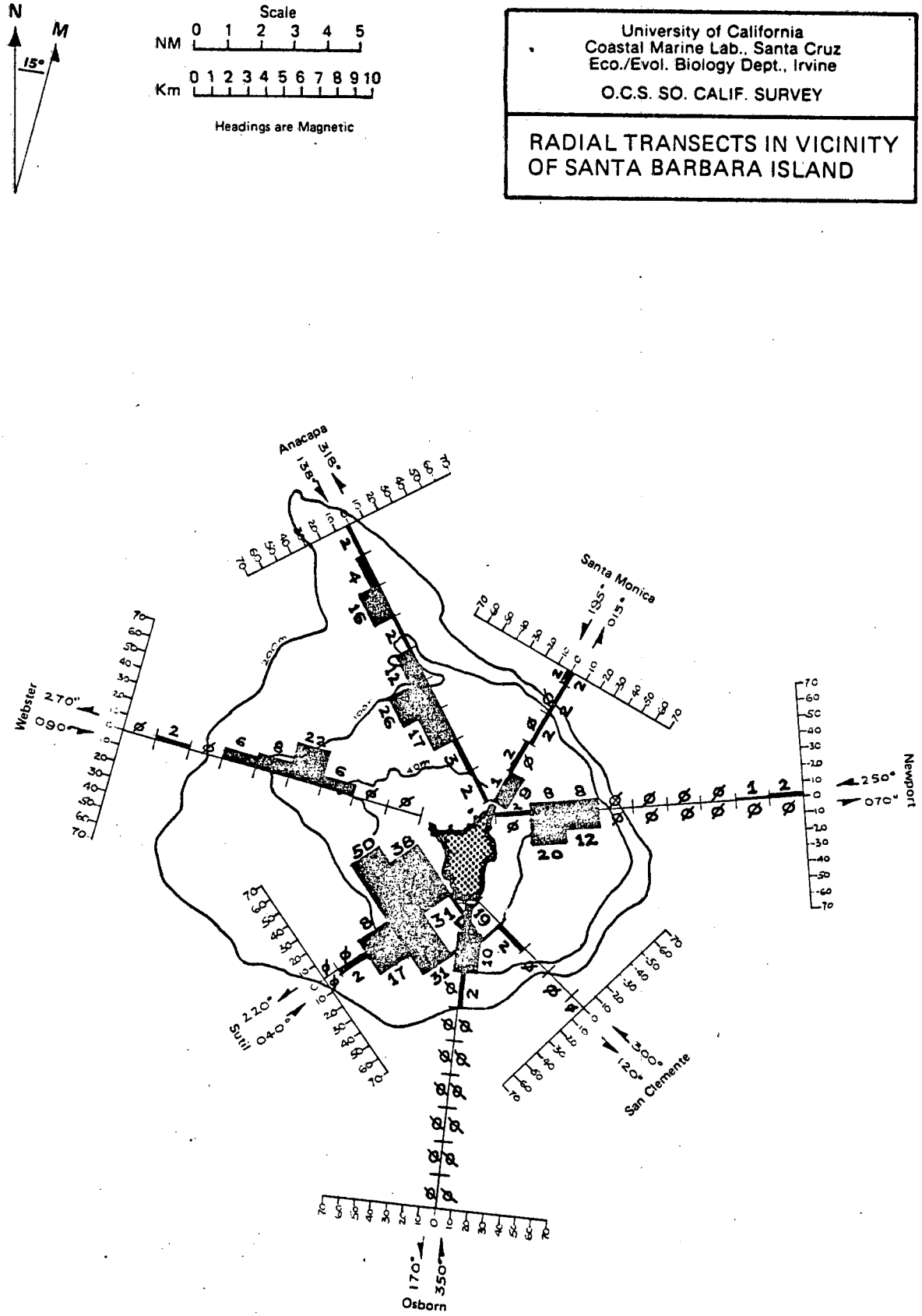


Figure III-158. Numbers of Xantus' Murrelets sighted in transect segments, 28 April-3 May 1976.

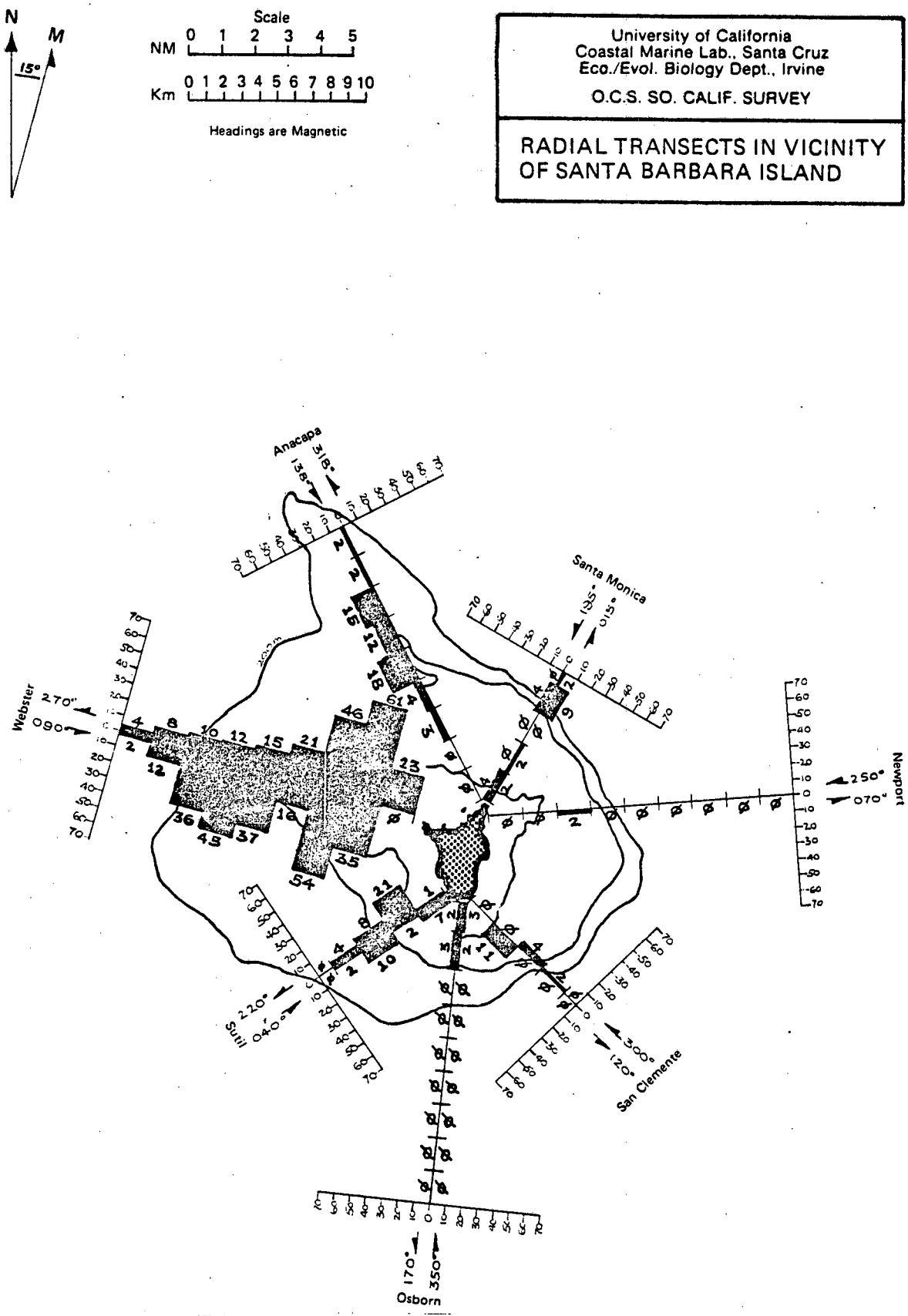


Figure III-159. Numbers of Xantus' Murrelets sighted in transect segments, 24-25 May 1976.

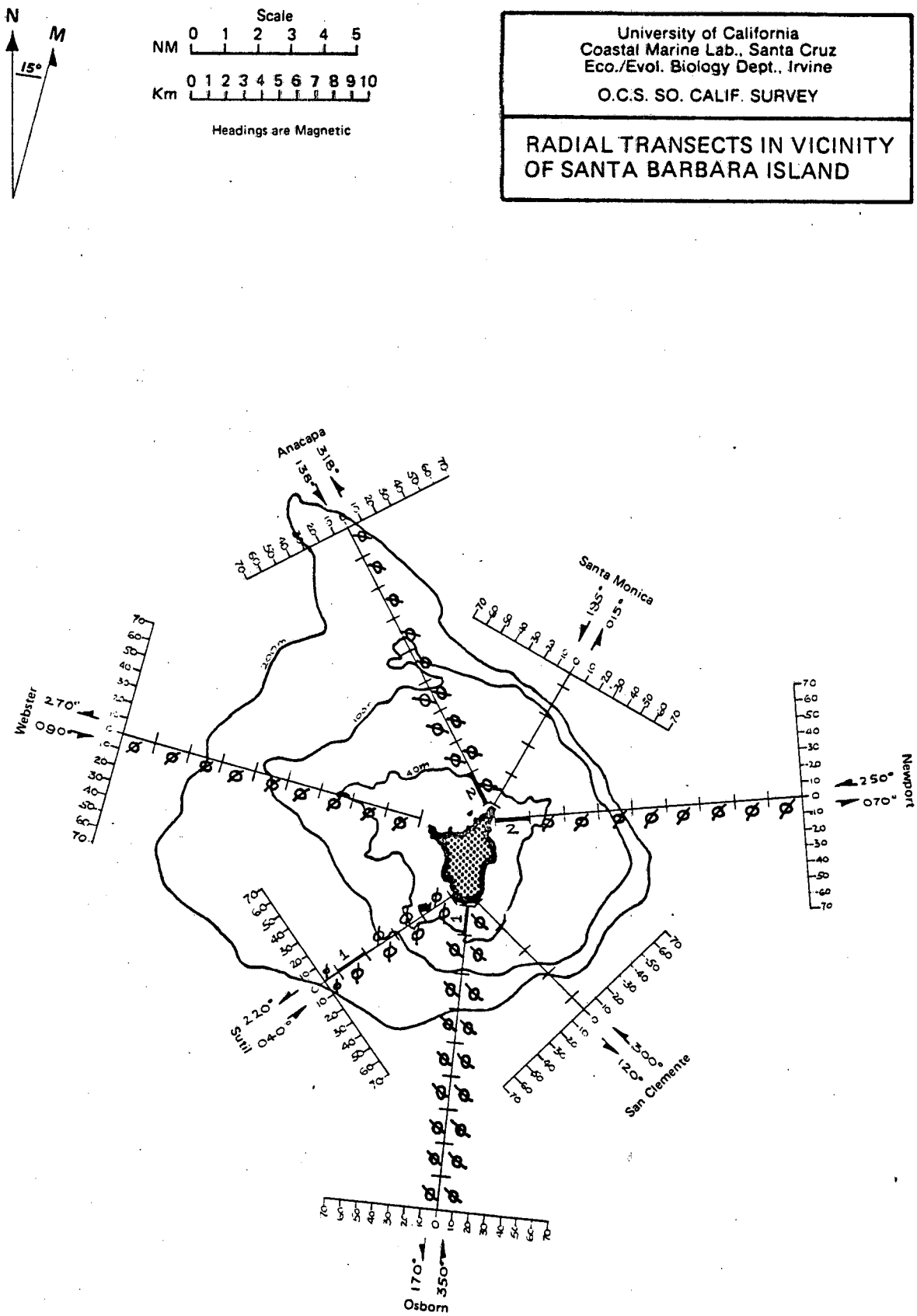


Figure III-160. Numbers of Xantus' Murrelets sighted in transect segments, 9-11 June 1976.

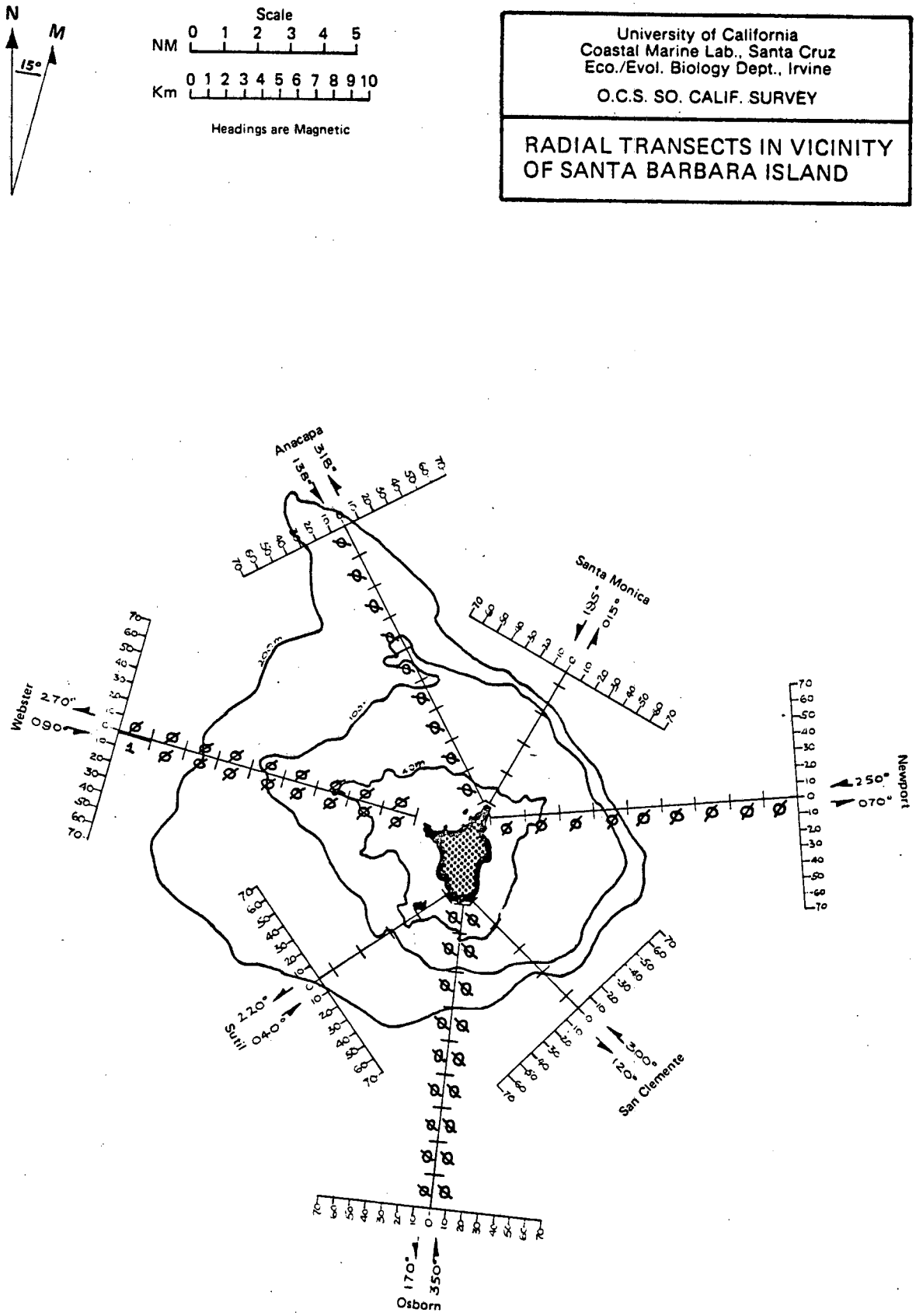


Figure III-161. Numbers of Xantus' Murrelets sighted in transect segments, 26-28 June 1976.

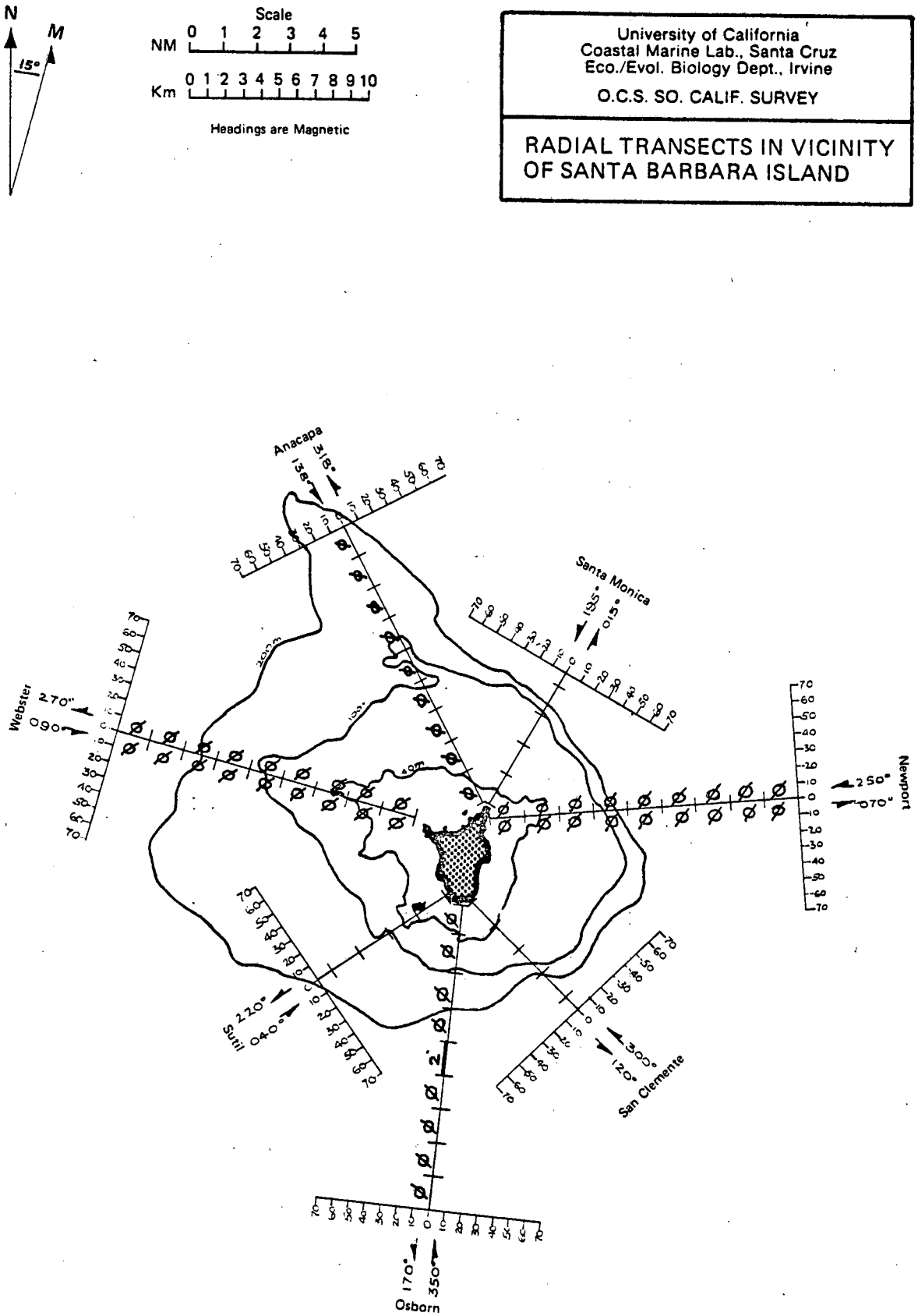


Figure III-162. Numbers of Xantus' Murrelets sighted in transect segments, July 1976.

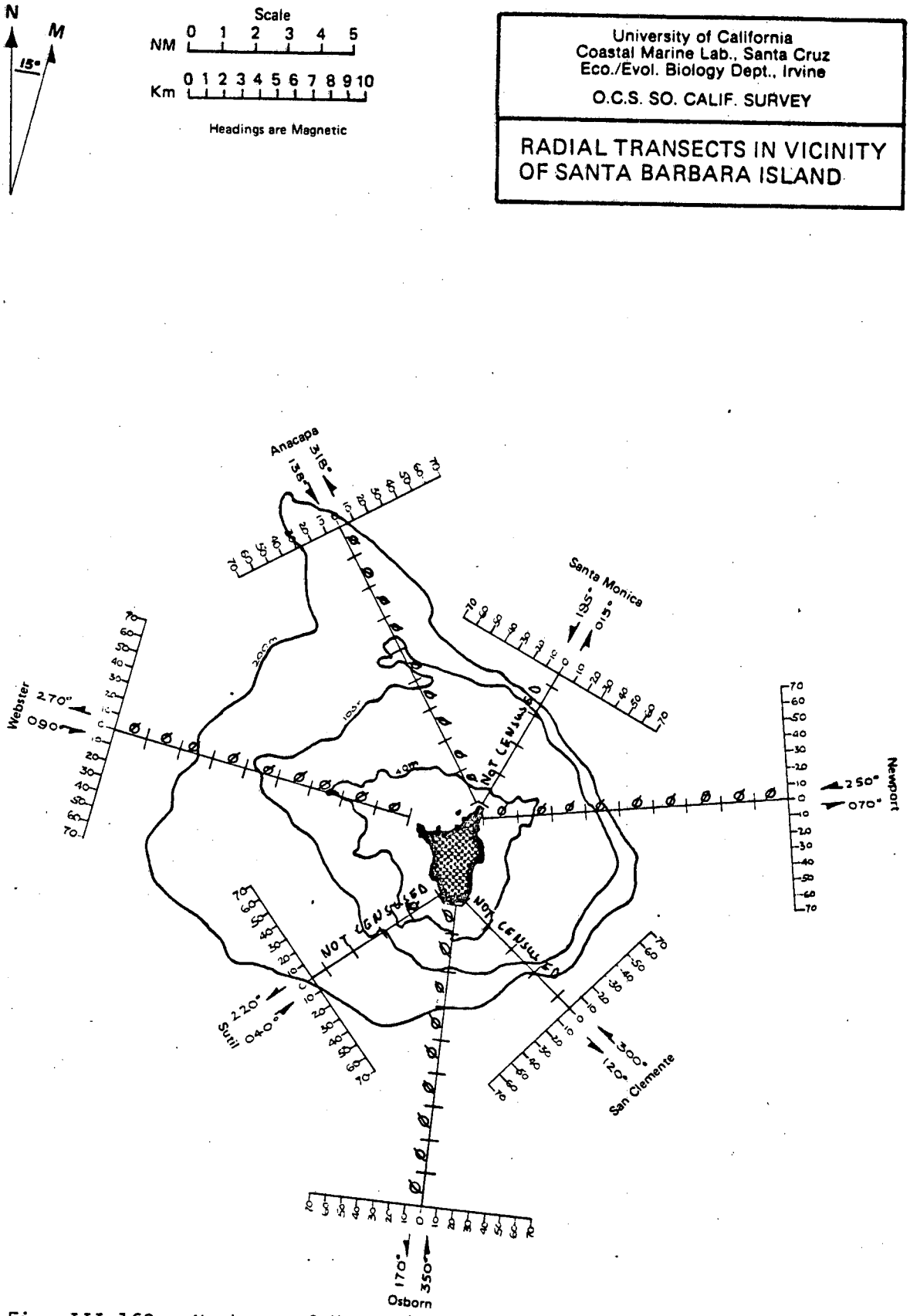


Fig. III-163. Numbers of Xantus' Murrelets sighted in transect segments 20-21 January 1977.

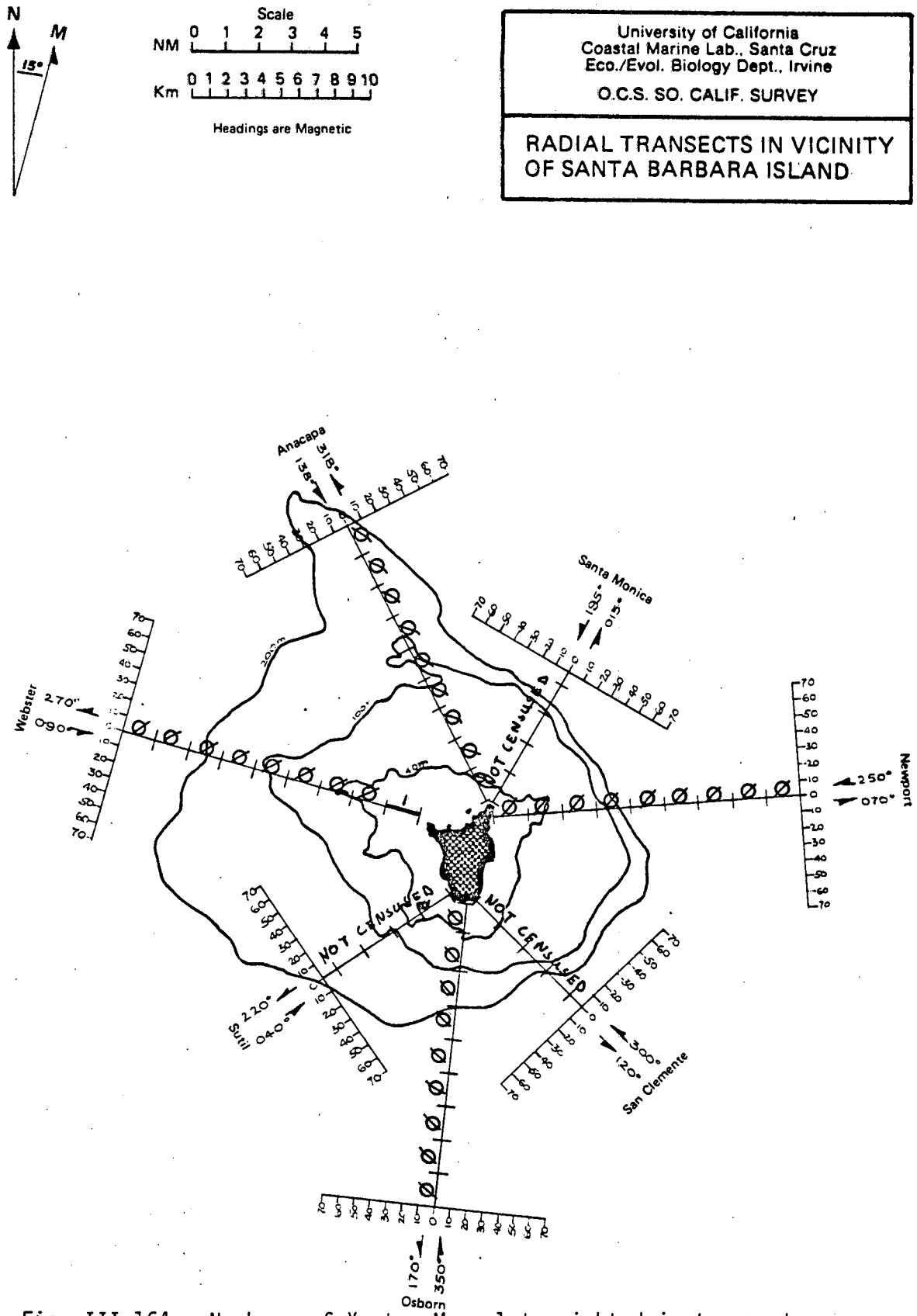


Fig. III-164. Numbers of Xantus Murrelets sighted in transect segments 18-19 February 1977.

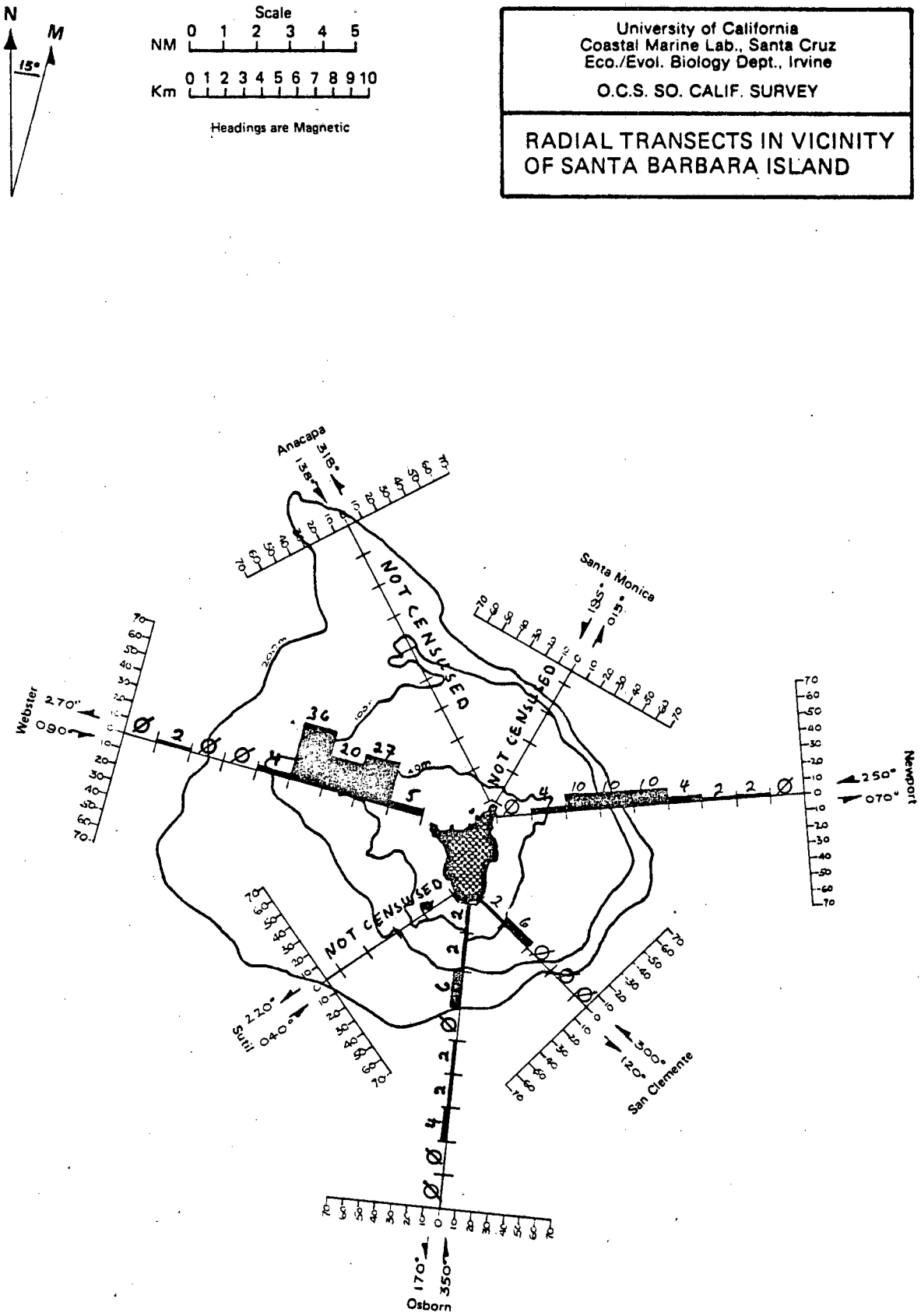


Fig. III-165. Numbers of Xantus Murrelets sighted in transect segments 22-24 March 1977.

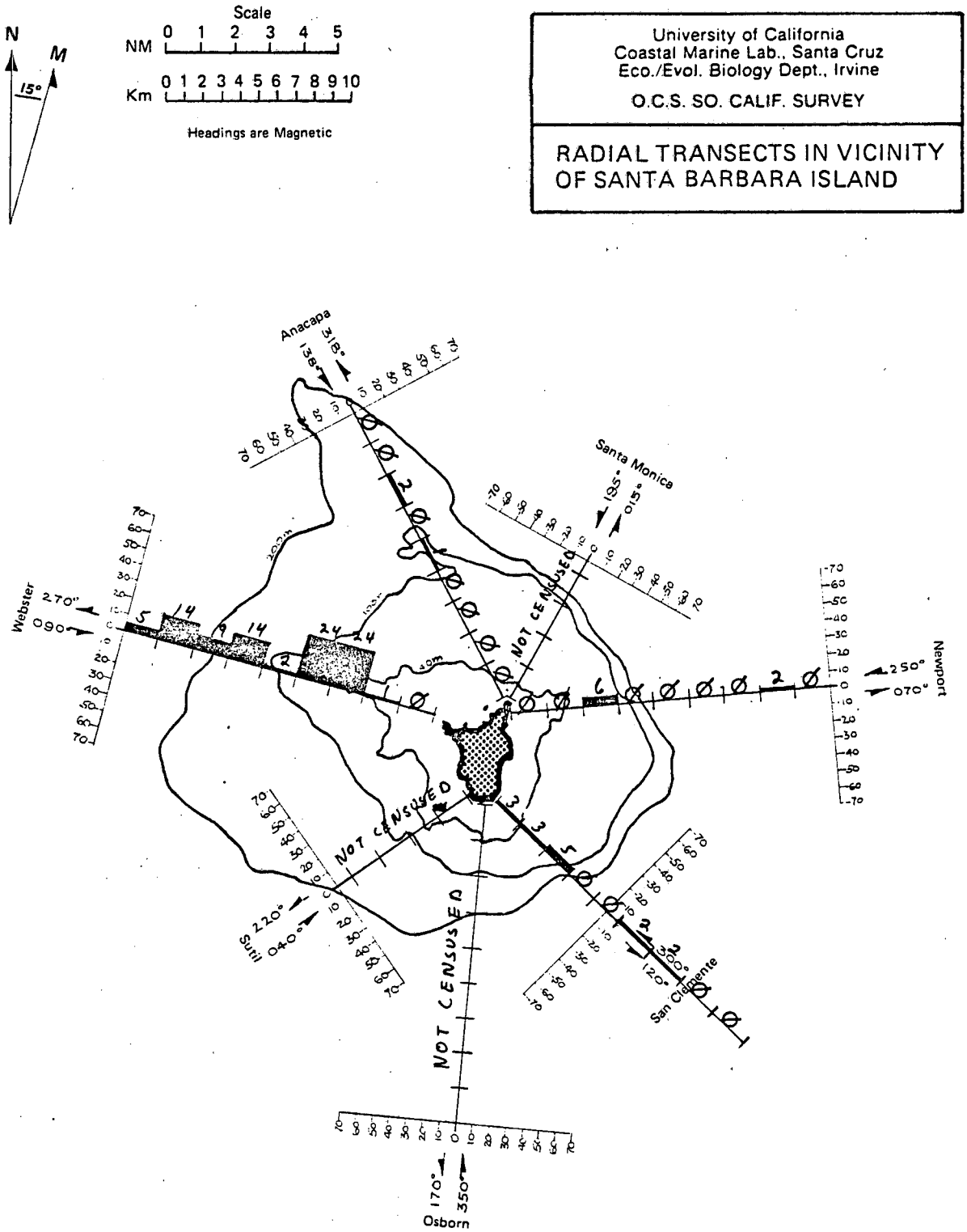


Fig. III-166. Number of Xantus Murrelets sighted in transect segments 12-16 April 1977.

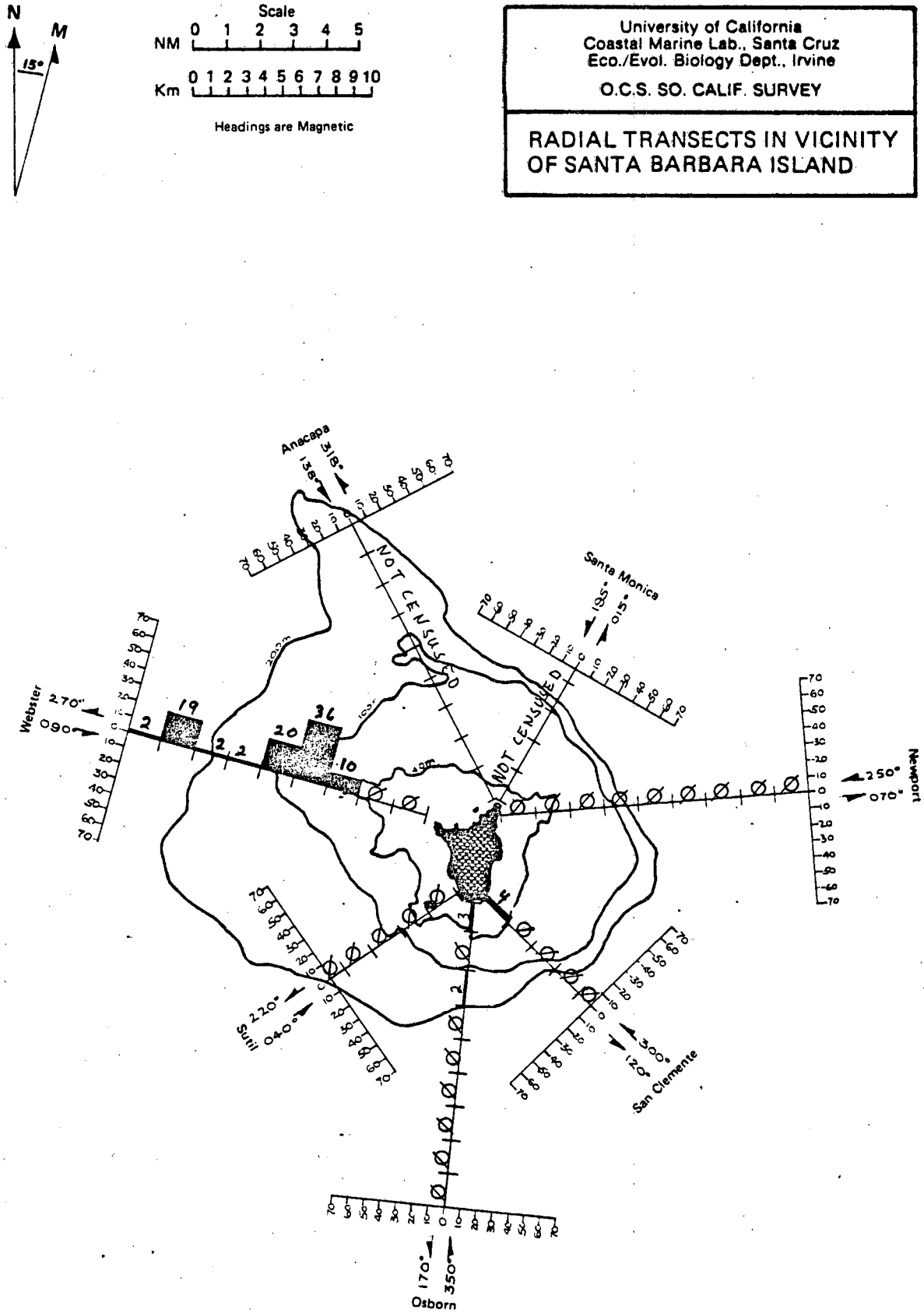


Fig. III-167. Number of Xantus' Murrelets sighted in transect segments 3-5 May 1977.

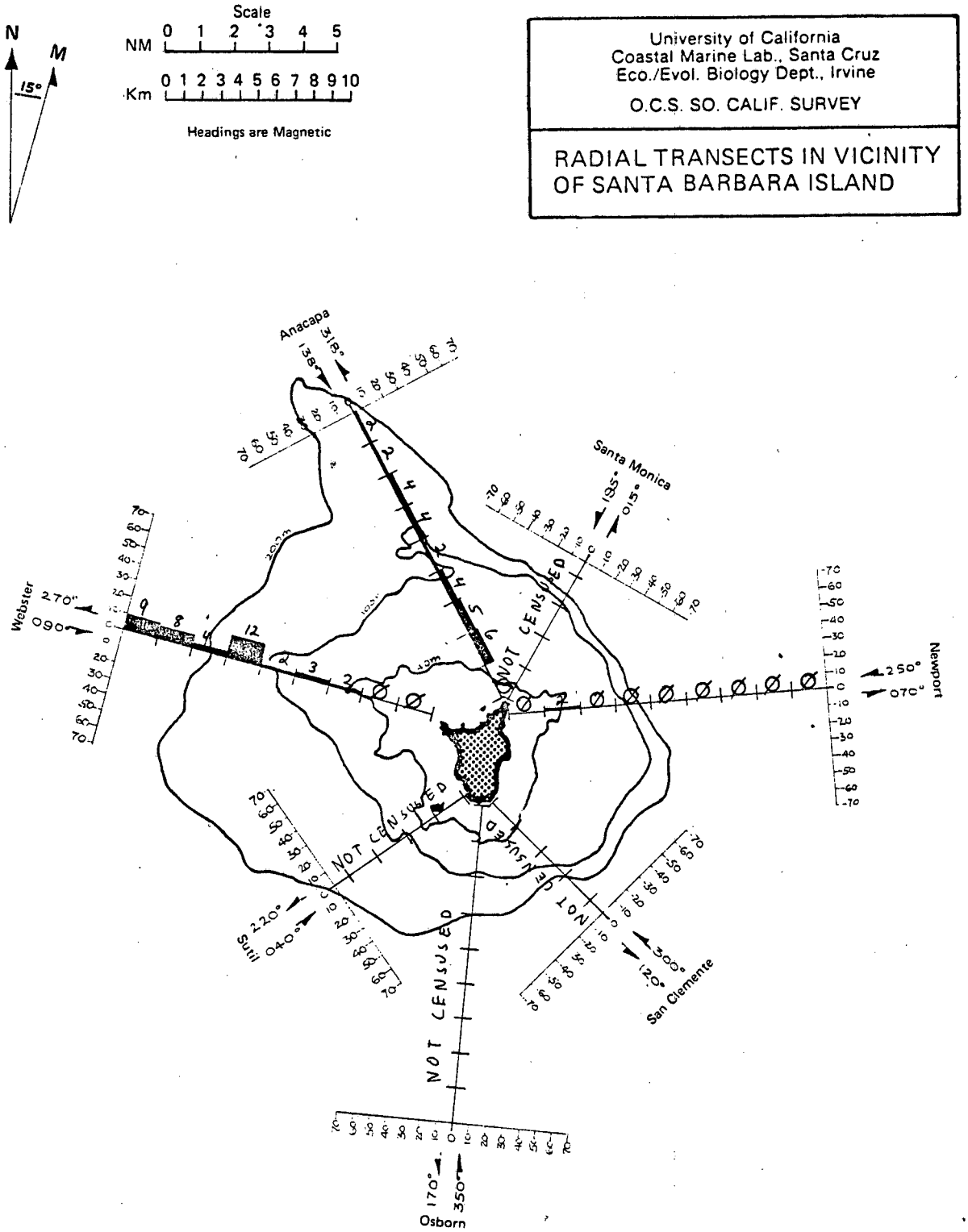


Fig. III-168. Number of Xantus' Murrelets sighted in transect segments 18-19 May 1977.

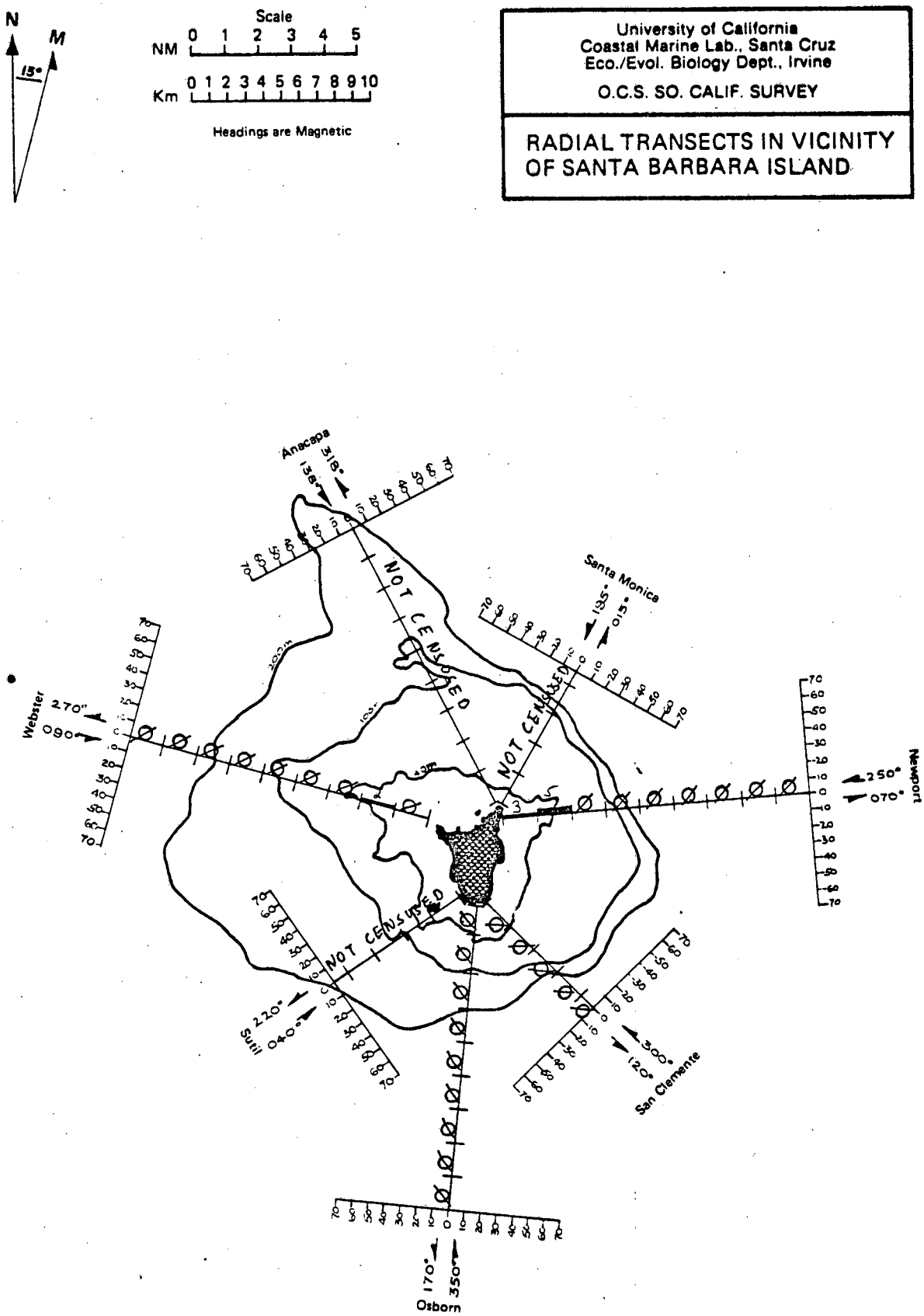


Fig. III-169. Number of Xantus' Murrelets sighted in transect segments 6-7 June 1977.

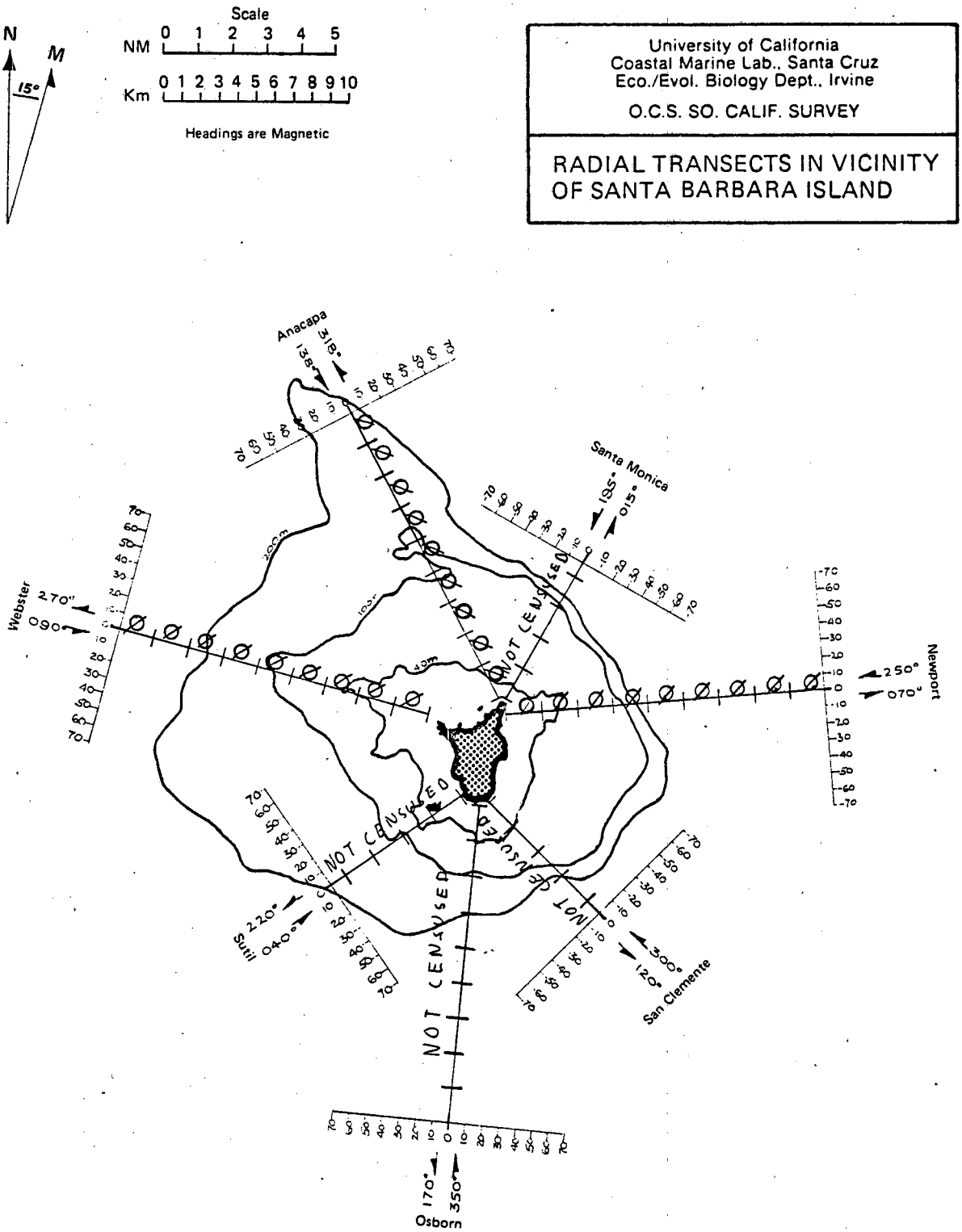


Fig. III-170. Number of Xantus' Murrelets sighted in transect segments 23-24 June 1977.

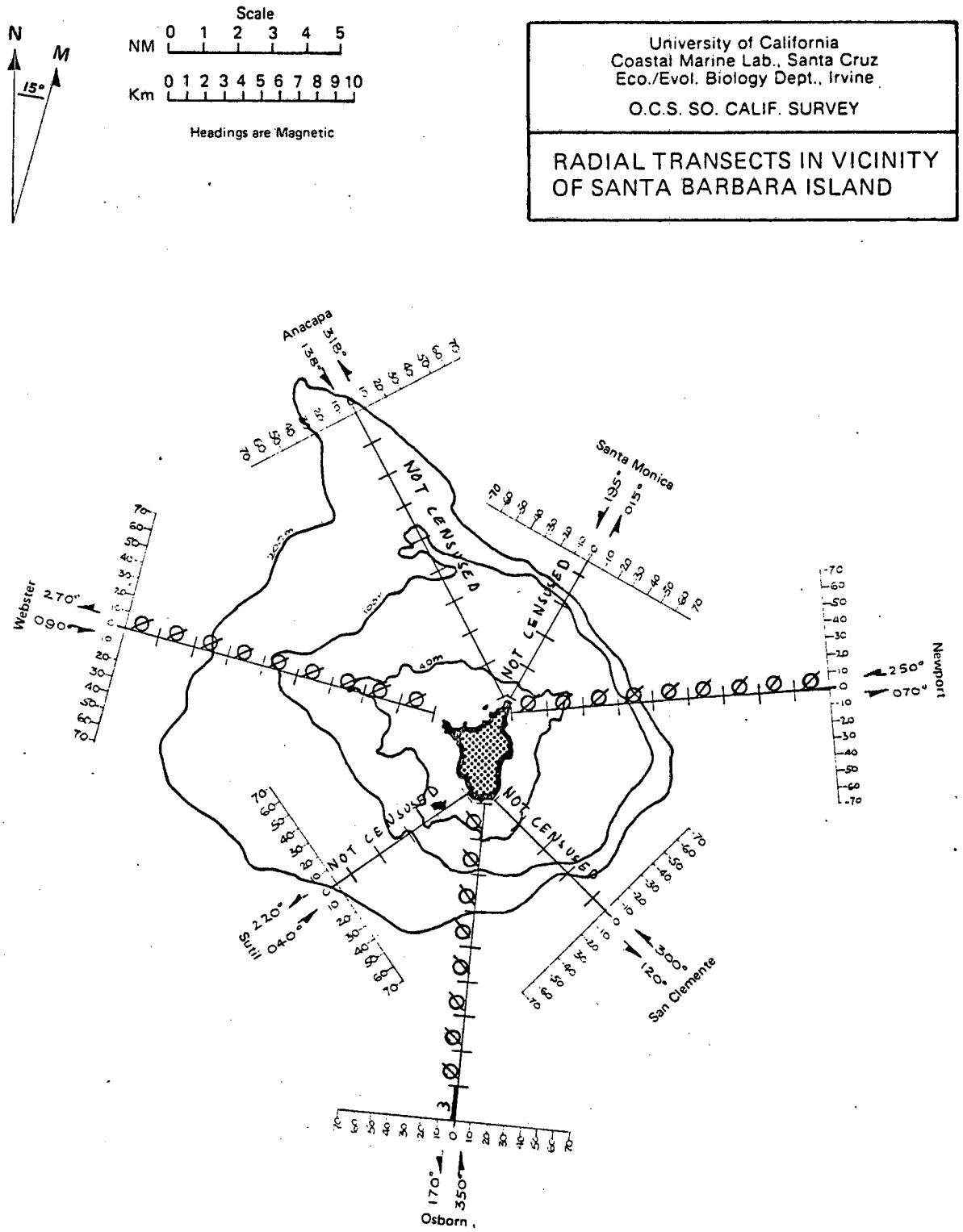


Fig. III-171. Number of Xantus' Murrelets sighted in transect segments 10-11 July 1977.

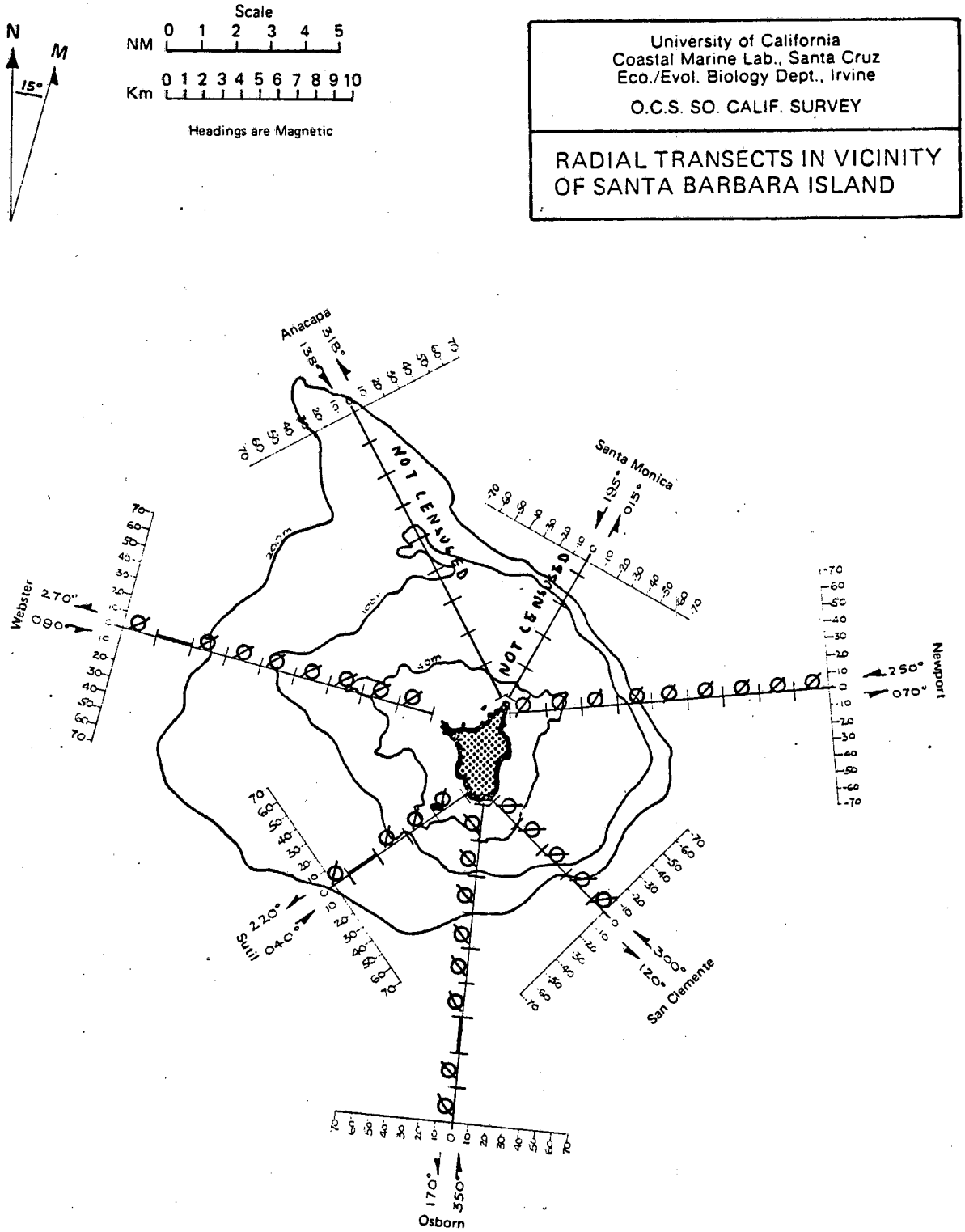


Fig. III-172. Number of Xantus' Murrelets sighted in transect segments 25-27 July 1977.

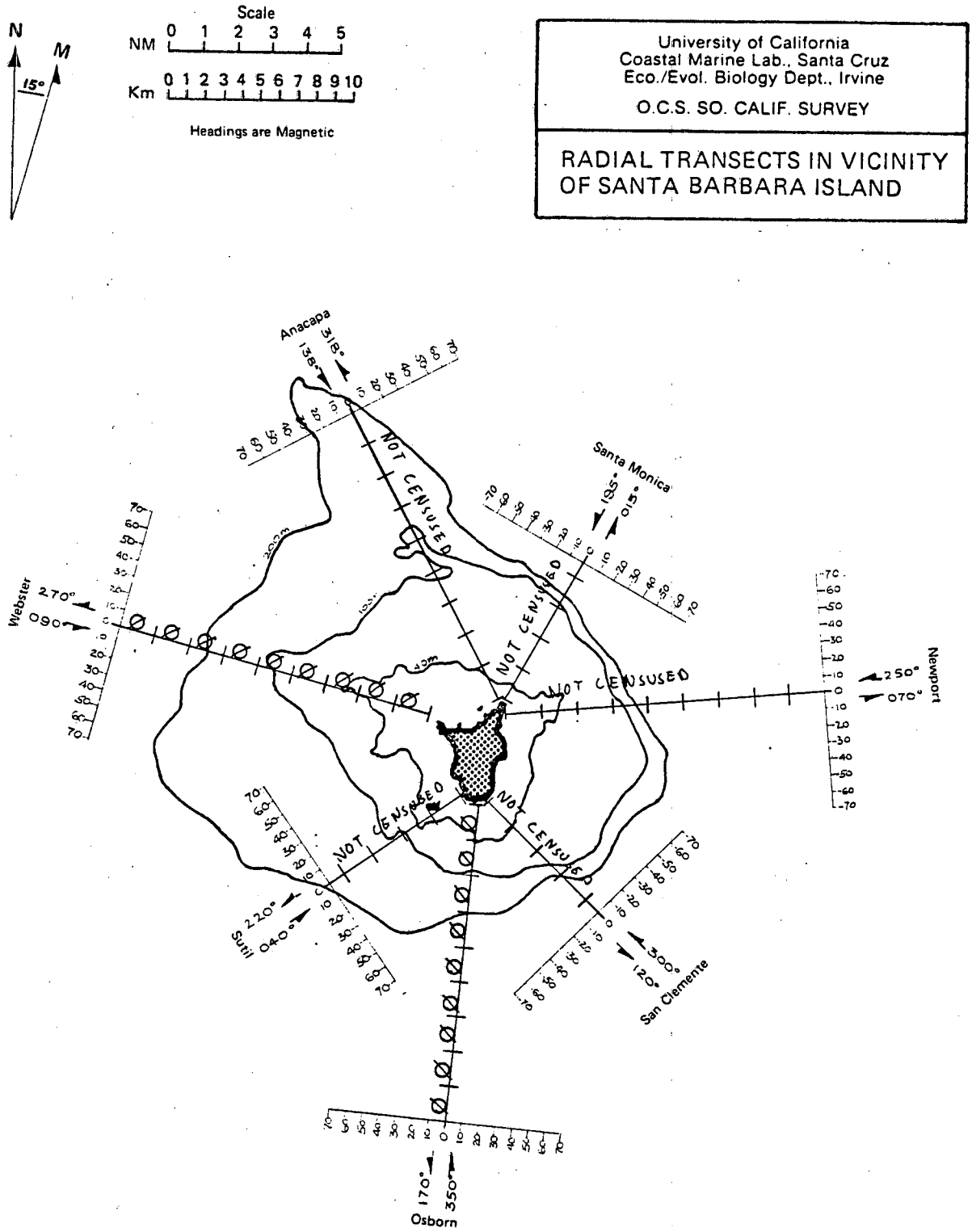


Fig. III-173. Number of Xantus' Murrelets sighted in transect segments 14-15 August 1977.

Fig. III-174. Supplemental Transect Surveys of Xantus' Murrelets During the Breeding Season, Santa Barbara Island, 1975-1977

Date	Number Sighted Within 18.5 km of Land	Number Sighted Beyond 18.5 km of Land	Distance of Last Sighting (km)	Distance Surveyed (km)
Western Transects				
Anacapa:				
10 Apr. 76	14	0	16.5	34.5
1 May 76*	84	0	18.5	36.5
23 May 76	56	2	22.5	38.5
15 Apr. 77*	3	0	14.5	27.75
19 May 77*	29	6	∿20.5	27.75
Webster:				
19 Apr. 75	58	6	27.75	27.75
27 May 75	80	65	37.0	46.25
22 Mar. 77	37	4	58.5	58.5
12 Apr. 77	93	12	24.5	∿34.5
15 Apr. 77	46	38	20.5	20.5
15 Apr. 77	57	18	20.5	20.5
Sutil:				
20 Apr. 75	35	38	38.85	38.85
Eastern Transects				
San Clemente:				
3 May 76	21	14	42.5	42.5**
Santa Monica/Newport:				
21 Apr. 75	25	0	18.5	27.75
9 May 75*	4	0	12.95	42.55
21 May 75	11	0	7.4	∿37.0
27 May 75	5	0	16.65	22.2
11 Apr. 76	0	0	-	40.5
25 May 76	2	0	6.5	38.5
24 Mar. 77	42	2	20.5	29.6+
16 Apr. 77	8	0	16.5	29.6+
5 May 77	0	0	-	29.6+

*Non-continuous transect - periodic segments surveyed.
**Transect ended 18.5 km from San Clemente Island.

Appendix III-6

RADIAL TRANSECT SURVEYS IN THE VICINITY OF SAN MIGUEL ISLAND

Fig. III-175. Standard Transect Surveys, San Miguel Island, 1975-1977.

Transect	Heading (°m)	Maximum Distance From Land km	NM	Origin/Terminus
1975				
Cuyler (out)	000-005	14.8	8	
Cuyler (in)	185	14.8	8	
Castle Rk. (out)	294	14.8	8	
Crook Pt. (out)	160-165	14.8[a]	8[a]	Crook Pt., ¼ mi. offshore
Tyler (out)	150	14.8	8	Tyler Bight
Cardwell Pt. (out)	125	14.8	8	Cardwell Pt.
1976-1977				
Prince (out)	000	18.5	10	Prince Is., Directly offshore
Prince (in)	180	18.5	10	
Castle/Richardson (out)	295	18.5	10	W. tip Castle Rk. 1 mi. offshore
Castle/Richardson (in)	115	18.5	10	
Pt. Bennett (out)	225	18.5	10	Bouy, 1 mi. offshore
Pt. Bennett (in)	045	18.5	10	
Crook Pt. (out)	180	18.5	10	Crook Pt., ¼ mi. offshore
Crook Pt. (in)	360	18.5	10	
Bee Rk. (out)	305	2.75	1.5	From Bee Rk., Santa Rosa Is. ¼ mi. offshore to Prince Is., San Miguel Is. directly offshore

[a]When performed on 15 July 1975, this radial extended 16.5 (9 NM) from land.

Fig. III-176. Summary of Radial Transects Completed, San Miguel Island, 1975-1977.

1975	13-14 May*	19 June	15 July	Total Completed
Cuyler (out)	1[b]	-	1[b]	2
Cuyler (in)	1[b]	-	-	1
Castle Rk. (out)	1[b]	-	-	1
Crook Pt. (out)	1[b]	-	1[b]	2
Tyler (out)	1[b]	-	-	1
Cardwell (out)	-	1[a]	-	1
Total Completed	5	1	2	8

1976	14-15 Jan.	11-12 Feb.	17-18 Mar.	6-7 Apr.	28-29 Apr.*	20-21 May*	8-9 June*	23-24 June*	14 July*	Total Completed
Prince (out)	1[b]	1[a]	1[a-b]	1[b]	1[b]	1[b-c]	1[a-b]	1[a-b]	1[b-c]	9
Prince (in)	1[b]	1[a-b]	1[b]	1[b]	1[b-c]	1[c]	1[b]	1[b]	1[c]	9
Castle/Richardson (out)	1[a-b]	1[b]	-	1[a-b]	-	1[a-b]	1[b]	1[b]	1[b]	7
Castle/Richardson (in)	1[b]	1[b]	-	1[b]	-	1[b]	1[b]	1	1[b]	6
Pt. Bennett (out)	1[b]	1	-	1	-	1[b]	1[b-c]	-	1[b]	5
Pt. Bennett (in)	1[b]	-	-	-	-	1[b]	1[c]	1[b]	1[b]	5
Crook Pt. (out)	1[b]	-	-	-	-	1[b]	1[b]	1[b-c]	1[b]	5
Crook Pt. (in)	1[b]	1[b]	-	1[b]	1[b]	1[b]	1	1[c]	-	7
Bee Rk. (out)	1	1[b]	-	1	-	1[b-c]	-	-	-	5
	-	-	1[b]	-	1[b]	1[b]	1[a]	-	-	4
Total Completed	8	6	3	6	4	9	8	7	6	57

(Continued)

Fig. III-176. Summary of Radial Transects Completed, San Miguel Island, 1975-1977.
(Continued)

1977	17-19 Jan.	15-16 Feb.	21-22 Mar.	Apr.	2 May*	18-21 May*	4-7 June*	21 June*	8 July*	23-25 July*	12-14 Aug.*	Total Completed
Prince (out)	1[a-b]	1[b]	1[b]	-	1[b]	-	-	1[b]	1[b]	-	1[b]	7
Prince (in)	-	-	-	-	1[b]	-	-	1[b-c]	-	-	1[b]	3
Castle/ Richardson (out)	1[b]	-	1[b]	-	-	-	-	-	-	1[b]	1[b]	4
Castle/ Richardson (in)	1[b]	-	-	-	-	-	-	-	-	1[b-c]	1[b]	3
Pt. Bennett (out)	-	-	-	-	-	-	-	-	-	-	1[b]	1
Pt. Bennett (in)	-	-	-	-	-	-	-	-	-	-	1[b]	1
Crook Pt. (out)	1[a-b]	1[b]	1[b]	-	-	-	-	-	-	-	1[a-b]	4
Crook Pt. (in)	-	1[b]	-	-	-	-	-	-	-	-	-	1
Bee Rk. (out)	-	-	-	-	1[b]	-	1[b]	-	-	1[b]	1[b]	4
Total Completed	4	3	3	0	3	0	1	2	1	3	8	28

*Pacific Daylight Savings Time.

[a]Radial performed between 0600 and 0900.
[b]Radial performed between 0900 and 1700.
[c]Radial performed between 1700 and sunset.

Fig. III-177. Sample Calculation of Mean Percent of Auklets Sighted in Each Segment of a Radial Transect Survey, Prince Radial, San Miguel Island, 1976.

	Percent of Total Auklets Seen in Each Segment									
Segment No.	0	1	2	3	4	5	6	7	8	9
Distance from Land	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5
Jan.	0	0	0	0	1.8	77.3	20.9	0	0	0
Feb.	0	0	0	0	5.2	54.8	34.8	5.2	0	0
March	0	0	0.8	3.9	2.4	22.0	69.3	1.6	0	0
Apr.	0	0	9.8	53.7	36.6	0	0	0	0	0
Apr.	0	2.0	22.4	0	6.1	18.4	4.1	14.3	6.1	26.5
May	4.8	9.5	2.4	0	2.4	4.0	3.2	4.0	0	69.8
June	0	0	0	0	6.9	79.2	4.2	8.3	1.4	0
June	0	0	0	0	100.00	0	0	0	0	0
July	0	0	0	25.0	0	25.0	50.0	0	0	0
Mean Percent	0.5	1.7	3.9	9.2	17.9	31.2	20.7	3.7	0.8	10.7
SD	1.6	3.2	7.6	18.6	32.7	31.5	25.3	4.9	2.0	23.8
SE	0.5	1.1	2.5	6.2	10.9	10.5	8.4	1.6	0.7	7.9

Fig. III-178. Cassin's Auklets Sighted on Transect Surveys, San Miguel Island, 1975.

Distance From Land (NM)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
Cuyler											
13 May (out)	8	8	11	10	62	51	29	0	-	-	179
13 May (in)	2	9	13	8	9	1	6	3	-	-	51
15 July (out)	0	0	0	0	2	21	3	0	0	2	28
Castle Rk.											
13 May (out)	0	2	19	27	5	13	2	35	-	-	103
Crook Pt.											
13 May (out)	0	1	0	0	2	0	0	0	-	-	3
15 July (in)	0	0	14	115+	235+	70	12	0	0	-	446+
Tyler											
14 May (out)	0	0	0	0	0	0	0	0	-	-	0
Cardwell											
19 June (out)	0	0	0	0	0	0	0	0	-	-	0

Fig. III-179. Cassin's Auklets Sighted on Transect Surveys, Prince Transect, San Miguel Island, 1976-1977.

Segment No.	0	1	2	3	4	5	6	7	8	9	
Distance From Land (km)	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	Total
1976											
14 Jan. (out)	0	0	0	0	2	85	23	0	0	0	110
(in)	0	2	4	6	21	13	0	2	0	0	48
12 Feb. (out)	0	0	0	0	7	74	47	7	0	0	135
(in)	0	0	0	4	10	27	49	12	2	0	104
18 Mar. (out)	0	0	0	0	0	33	11	0	0	0	44
(in)	0	0	1	5	3	28	88	2	0	0	127
7 Apr. (out)	0	0	4	22	15	0	0	0	0	0	41
(in)	-	-	-	-	-	-	0	0	1	0	1
28 Apr. (out)	0	1	11	0	3	9	2	7	3	13	49
(in)	0	0	10	16	7	1	6	0	0	1	41
20 May (out)	0	0	0	0	2	0	12	2	0	64	80
(in)	6	12	3	0	3	5	4	5	0	88	126
9 June (out)	0	0	0	0	4	14	1	0	0	0	19
(in)	0	0	0	0	5	57	3	6	1	0	72
24 June (out)	0	0	0	0	3	0	0	0	0	0	3
(in)	0	0	0	0	0	1	1	0	0	0	2
14 July (out)	0	0	0	0	2	0	0	0	0	0	2
(in)	0	0	0	1	0	1	2	0	0	0	4
Total	6	15	33	54	87	348	249	43	7	166	1008

Fig. III-179. Continued. Cassin's Auklets Sighted on Transect Surveys, Prince Transect, San Miguel Island, 1976-1977.

Segment No.	0	1	2	3	4	5	6	7	8	9	
Distance From Land (km)	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	Total
1977											
18 Jan. (out)	0	0	0	0	15	0	0	1	0	0	16
(in)	-	-	-	-	-	-	-	-	-	-	-
15 Feb. (out)	3	0	1	2	14	11	4	0	0	0	35
(in)	-	-	-	-	-	-	-	-	-	-	-
21 Mar. (out)	0	0	0	3	2	0	0	0	0	0	5
(in)	-	-	-	-	-	-	-	-	-	-	-
2 May (out)	0	0	0	14	2	0	4	1	1	0	22
(in)	0	0	4	2	0	13	7	32	18	0	76
21 June (out)	0	0	0	0	0	0	0	0	0	0	0
(in)	0	0	0	0	0	0	0	0	3	0	3
8 July (out)	0	4	4	1	0	0	0	0	0	0	9
(in)	-	-	-	-	-	-	-	-	-	-	-
12 Aug. (out)	0	0	0	0	0	0	1	0	2	0	3
(in)	0	0	0	0	0	1	0	0	0	0	1
Total	3	4	9	22	33	25	16	34	24	0	170

Fig. III-180. Cassin's Auklets Sighted on Transect Surveys, Castle/Richardson Transect, San Miguel Island, 1976-1977.

Segment No.	0	1	2	3	4	5	6	7	8	9	
Distance From Land (km)	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	Total
1976											
15 Jan. (out)	-	-	0	0	2	6	2	0	13	19	42
(in)	-	-	12	1	12	2	6	17	0	2	52
11 Feb. (out)	-	-	0	10	6	22	0	0	4	3	45
(in)	-	-	2	4	26	34	0	1	0	0	67
7 Apr. (out)	-	-	0	0	38	129	76	42	25	4	314
(in)	-	-	2	3	83	29	33	102	16	0	268
21 May (out)	-	-	0	0	6	2	10	32	57	186	293
(in)	-	-	0	3	0	1	3	41	39	6	93
8 June (out)	-	-	1	0	2	4	6	6	11	2	32
(in)	-	-	7	0	0	0	7	36	14	20	84
24 June (out)	-	-	0	0	0	0	0	1	0	0	1
(in)	-	-	-	-	-	-	-	-	-	-	-
14 July (out)	-	-	0	76	0	0	1	0	1	4	82
(in)	-	-	177	20	0	2	3	2	0	0	204
Total	-	-	201	117	175	231	147	280	180	246	1577

Fig. III-180. Cassin's Auklets Sighted on Transect Surveys, Castle/Richardson Transect, San Miguel Island, 1976-1977.
Continued.

Segment No.	0	1	2	3	4	5	6	7	8	9	
Distance From Land (km)	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	Total
1977											
17 Jan. (out)	-	-	12	4	0	0	0	1	3	0	20
(in)	-	-	0	2	0	0	0	1	0	0	3
21 Mar. (out)	-	0	2	1146	145	396	33	75	59	20	1876
(in)	-	-	-	-	-	-	-	-	-	-	-
23 July (out)	-	0	0	0	3	0	0	0	0	0	3
(in)	-	1	0	0	0	0	0	0	0	1	2
12 Aug. (out)	-	0	0	0	0	2	10	1	16	1	30
(in)	-	0	0	0	3	2	0	0	0	0	5
Total	-	1	14	1152	151	400	43	78	78	22	1939

Fig. III-181. Cassin's Auklets Sighted on Transect Surveys, Pt. Bennett Transect, San Miguel Island, 1976-1977.

Segment No.	0	1	2	3	4	5	6	7	8	9	
Distance From Land (km)	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	Total
1976											
15 Jan. (out)	-	60	65	0	5	0	8	1	1	0	140
(in)	-	80	52	3	1	0	0	0	0	0	136
21 May (out)	-	6	0	0	0	0	0	0	0	0	6
(in)	-	0	0	0	0	0	0	0	0	0	0
8 June (out)	-	10	2	10	0	0	0	0	0	0	22
(in)	-	30	0	1	0	0	0	0	0	0	31
23 June (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
14 July (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
Total	-	186	119	14	6	0	8	1	1	0	335
1977											
13 Aug. (out)	-	2	4	0	0	0	0	0	0	0	6
(in)	-	0	0	2	0	0	0	2	0	0	4
Total	-	2	4	2	0	0	0	2	0	0	10

Fig.III-182. Cassin's Auklets Sighted on Transect Surveys, Crook Point Transect, San Miguel Island, 1976-1977.

Segment No.	0	1	2	3	4	5	6	7	8	9	
Distance From Land (km)	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	Total
1976											
15 Jan. (out)	-	4	1	15	2	3	17	1	10	4	57
(in)	-	2	2	0	0	0	0	5	3	0	12
12 Feb. (out)	-	0	0	0	0	2	1	0	0	0	3
(in)	-	0	0	0	0	0	0	0	1	0	1
6 Apr. (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	1	0	0	1
29 Apr. (out)	-	0	1	0	0	0	0	0	0	0	1
(in)	-	-	-	-	-	-	-	-	-	-	-
21 May (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	0	0	0	0	0	0	0	0
9 June (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	-	-	-	-	-	-	-	-	-	-
23 June (out)	-	0	0	0	7	0	0	0	0	0	7
(in)	-	0	0	2	0	0	0	0	0	0	2
Total	-	6	4	17	9	5	18	7	14	4	84

Fig. III-182. Continued. Cassin's Auklets Sighted on Transect Surveys, Crook Point Transect, San Miguel Island, 1976-1977.

Segment No.	0	1	2	3	4	5	6	7	8	9	
Distance From Land (km)	0-0.5	0.6-2.5	2.6-4.5	4.6-6.5	6.6-8.5	8.6-10.5	10.6-12.5	12.6-14.5	14.6-16.5	16.6-18.5	Total
1977											
19 Jan. (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	-	-	-	-	-	+	-	-	-	-
16 Feb. (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	0	0	1	0	0	0	0	0	0	1
22 Mar. (out)	-	7	2	0	1	1	4	1	0	3	19
(in)	-	-	-	-	-	-	-	-	-	-	-
14 Aug. (out)	-	0	0	0	0	0	0	0	0	0	0
(in)	-	-	-	-	-	-	-	-	-	-	-
Total	-	7	2	1	1	1	4	1	0	3	20

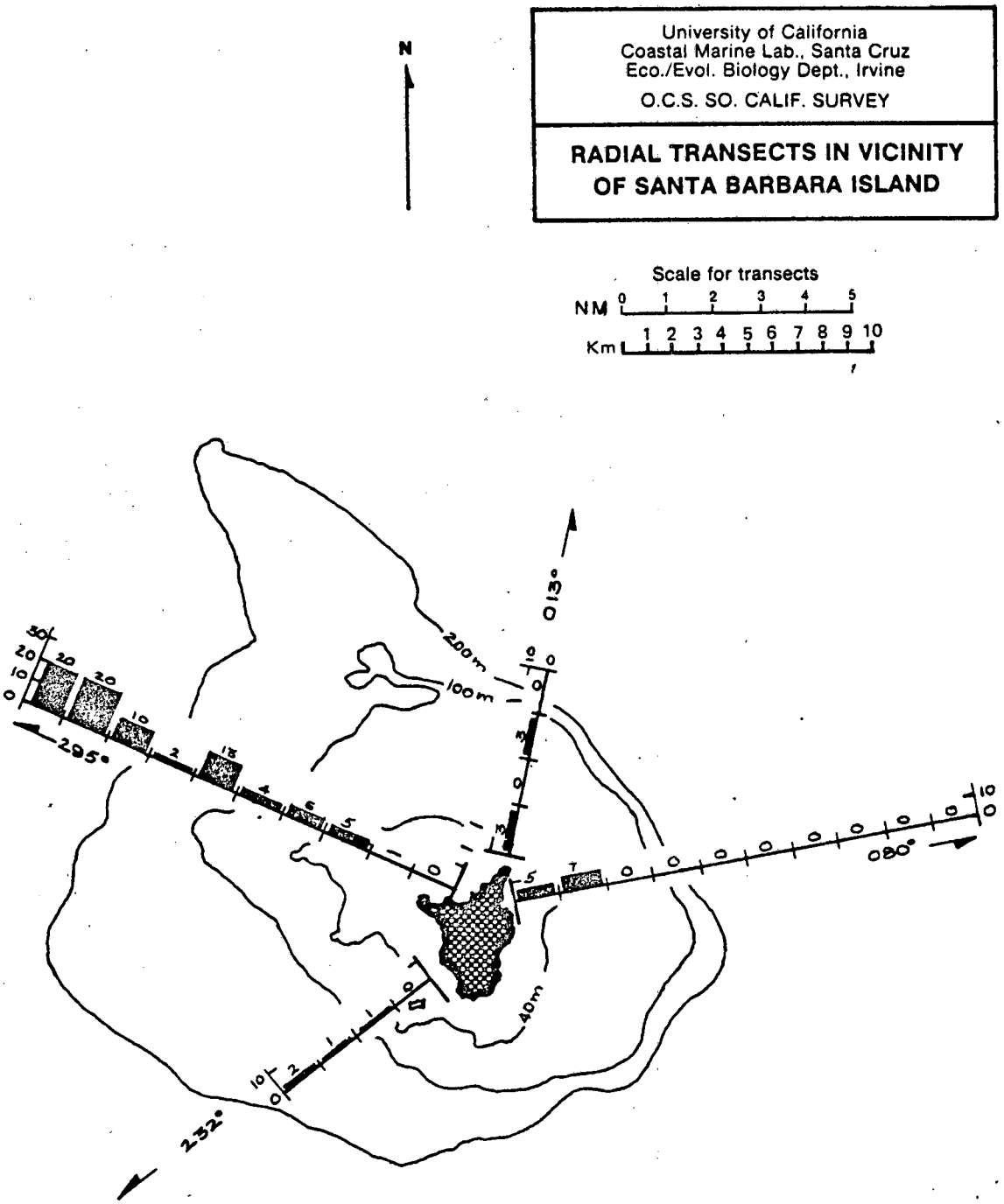


Figure III-183. Distribution of Xantus' Murrelet at sea, May 1975. Numbers of birds sighted per 1.85 km (1 nm) on indicated headings.

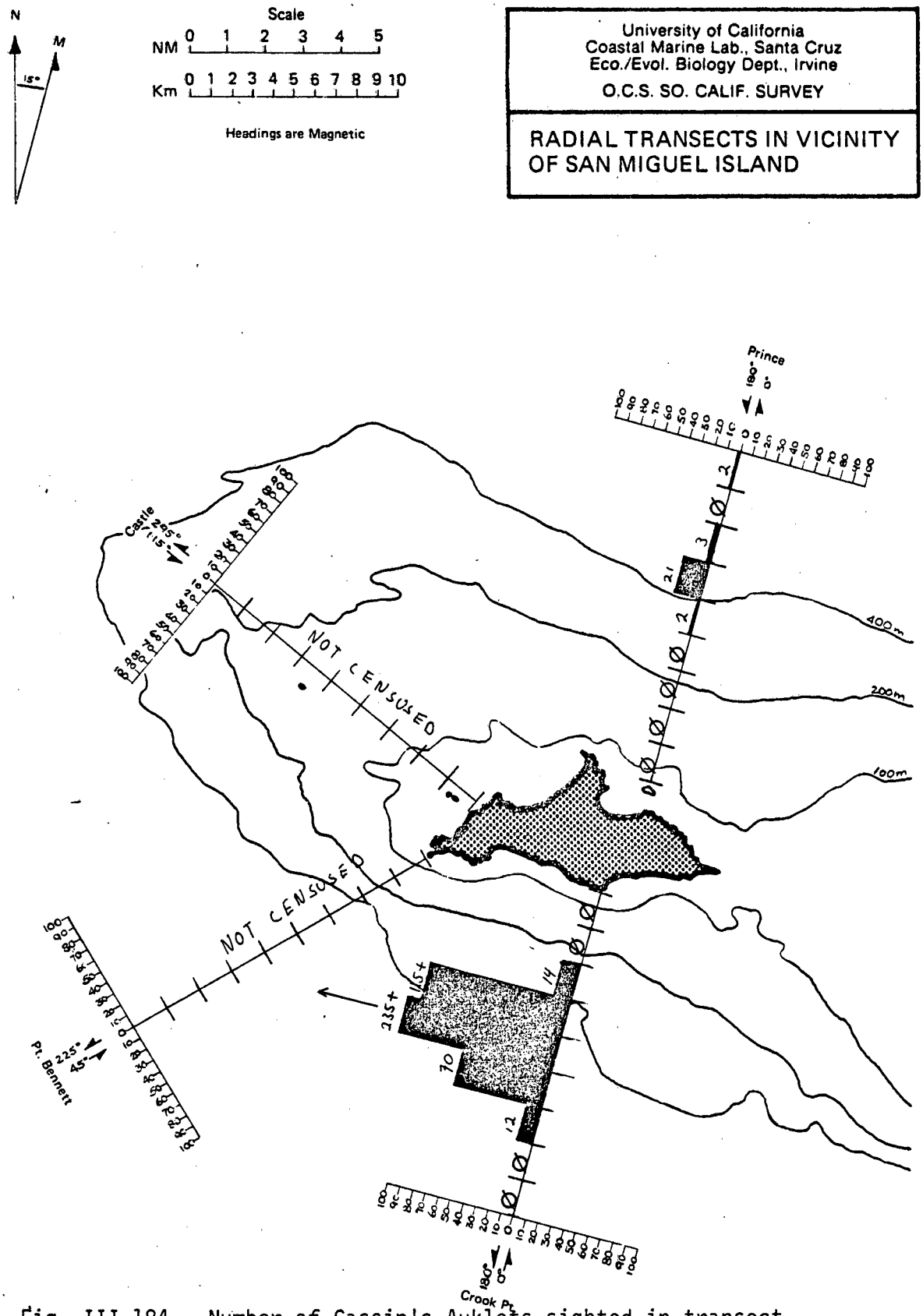


Fig. III-184. Number of Cassin's Auklets sighted in transect segments 15 July 1975.

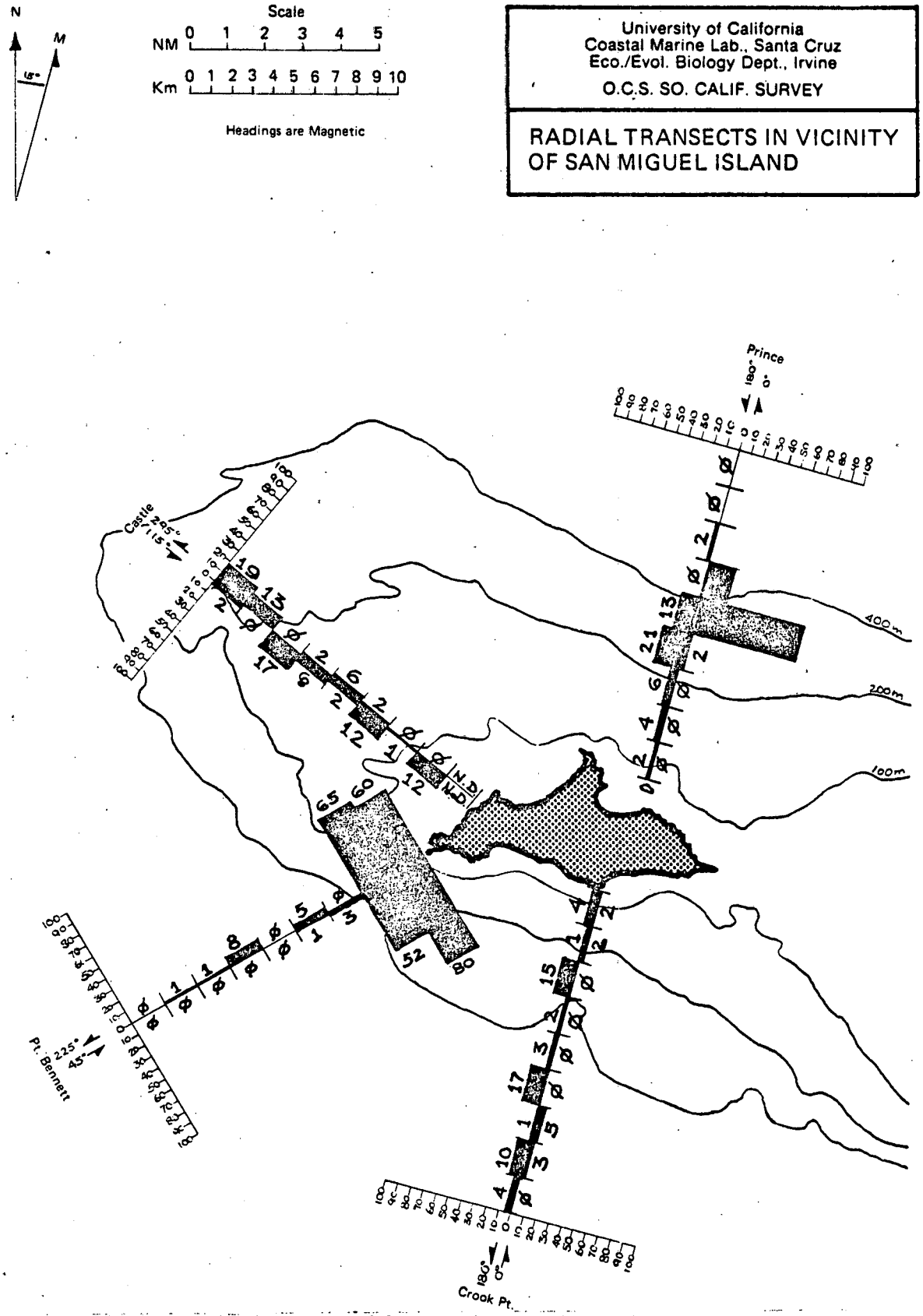


Figure III-185. Numbers of Cassin's Auklets sighted in transect segments, 14-15 January 1976.

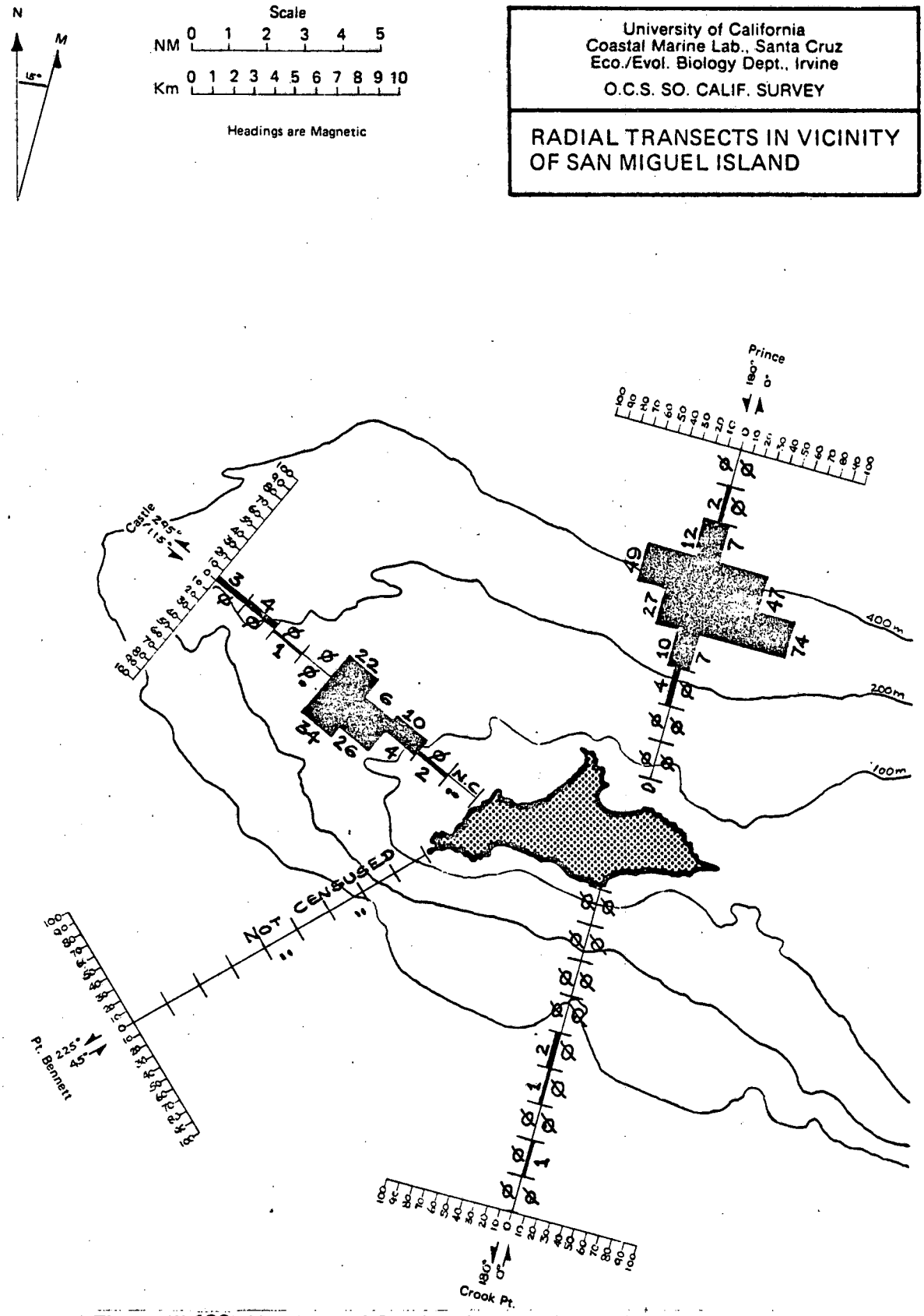


Figure III-186. Numbers of Cassin's Auklets sighted in transect segments, 11-12 February 1976.

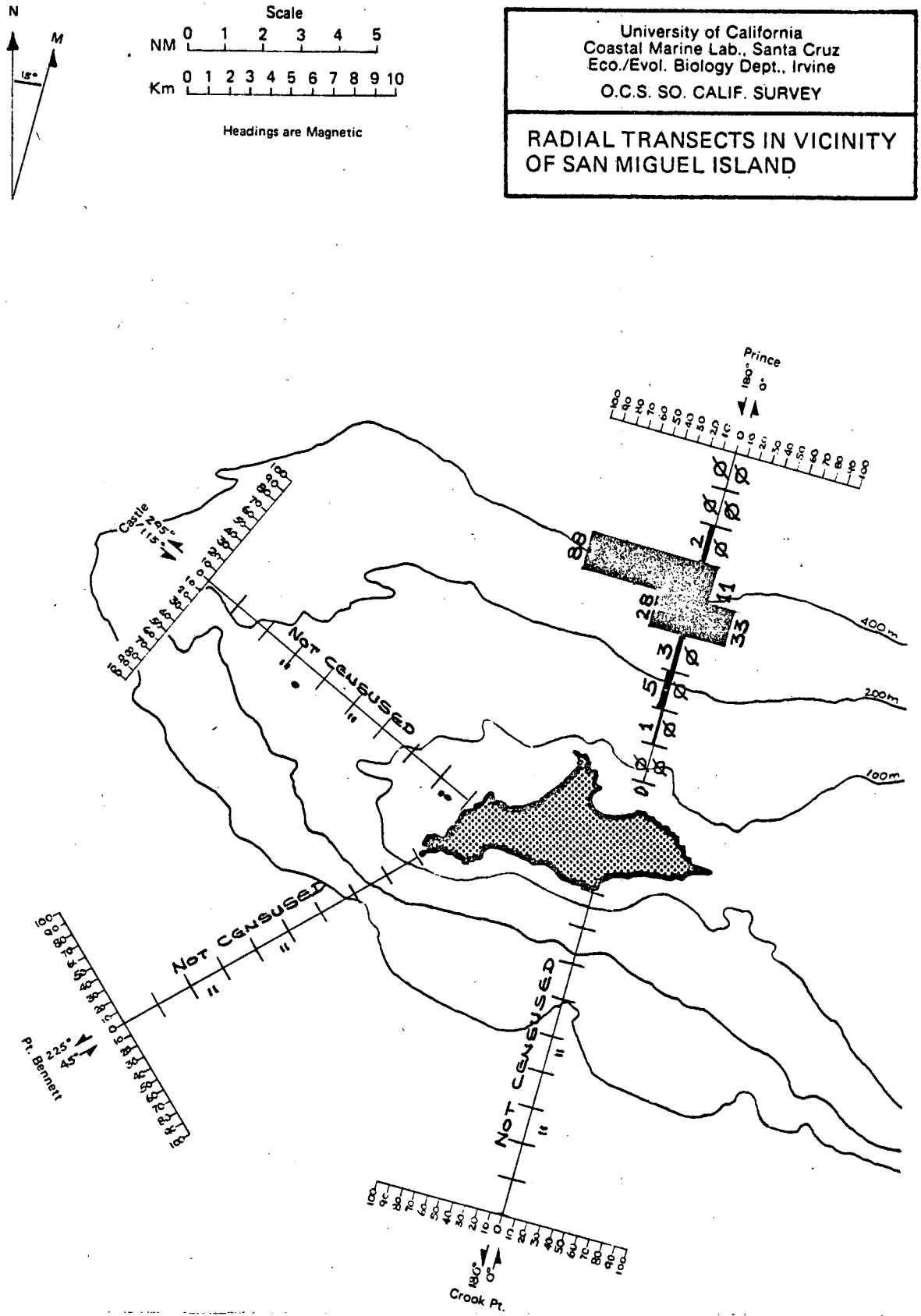


Figure III-187. Numbers of Cassin's Auklets sighted in transect segments, 17-18 March 1976.

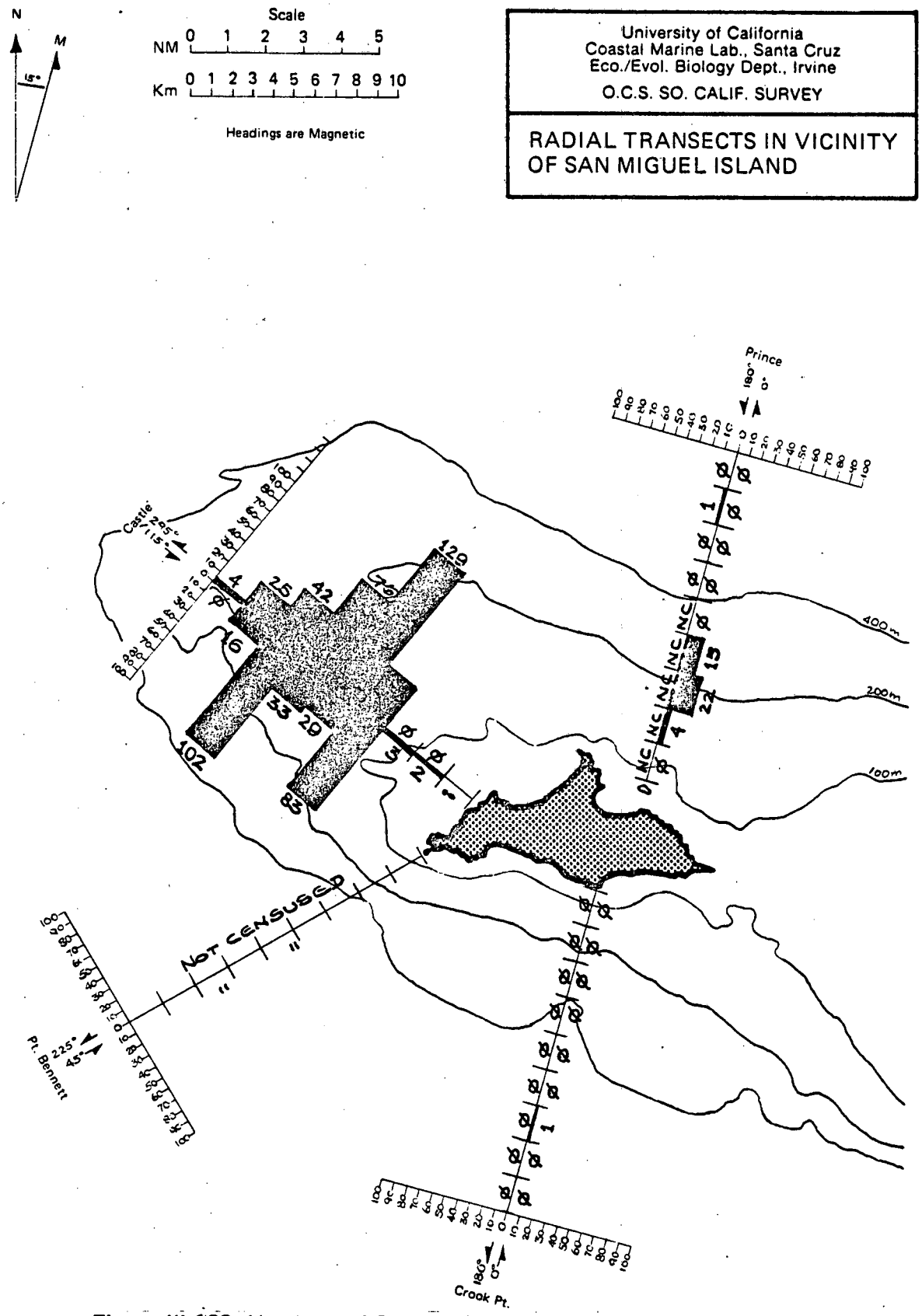


Figure III-188. Numbers of Cassin's Auklets sighted in transect segments, 6-7 April 1976.

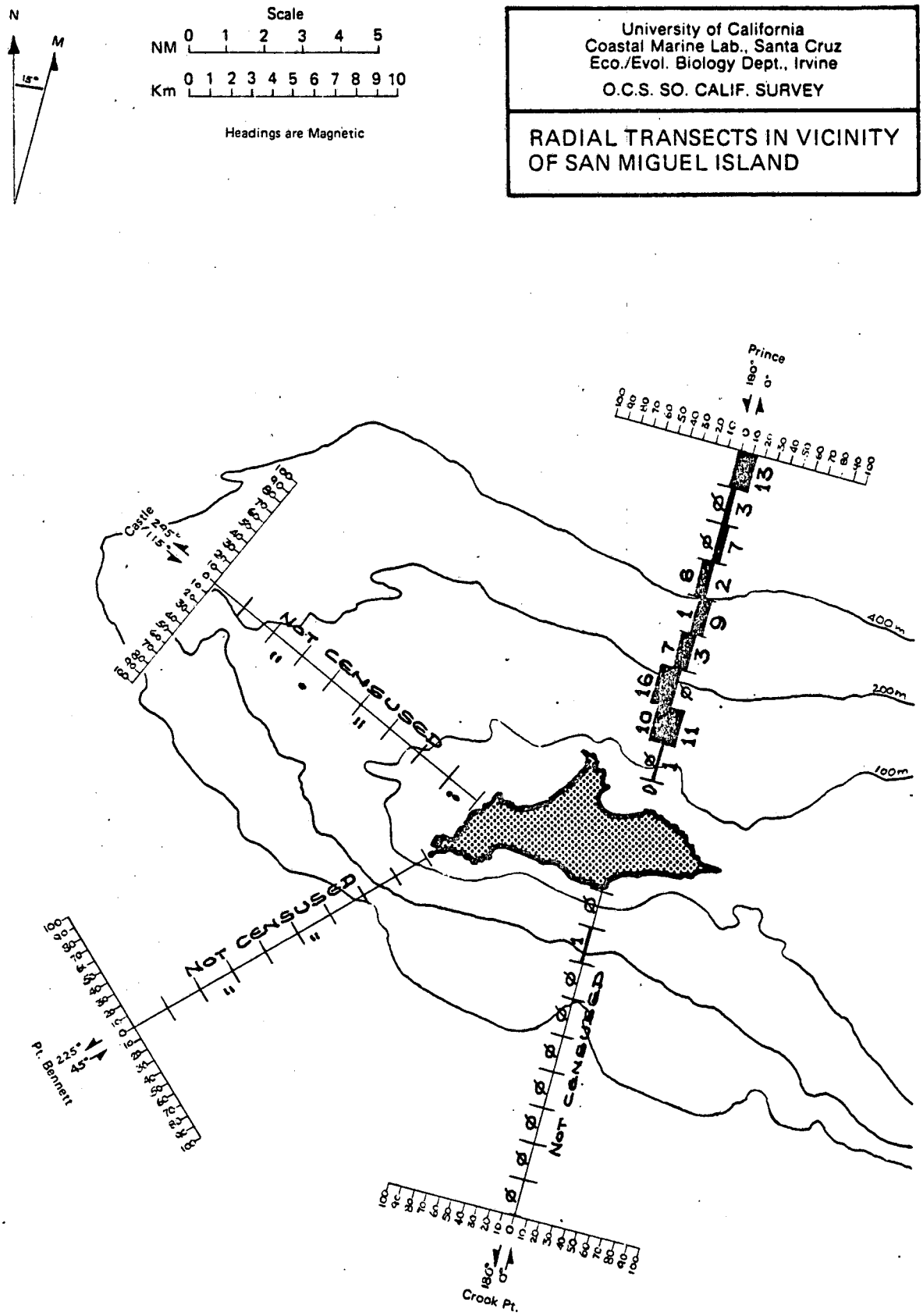


Figure III-189. Numbers of Cassin's Auklets sighted in transect segments, 28-29 April 1976.

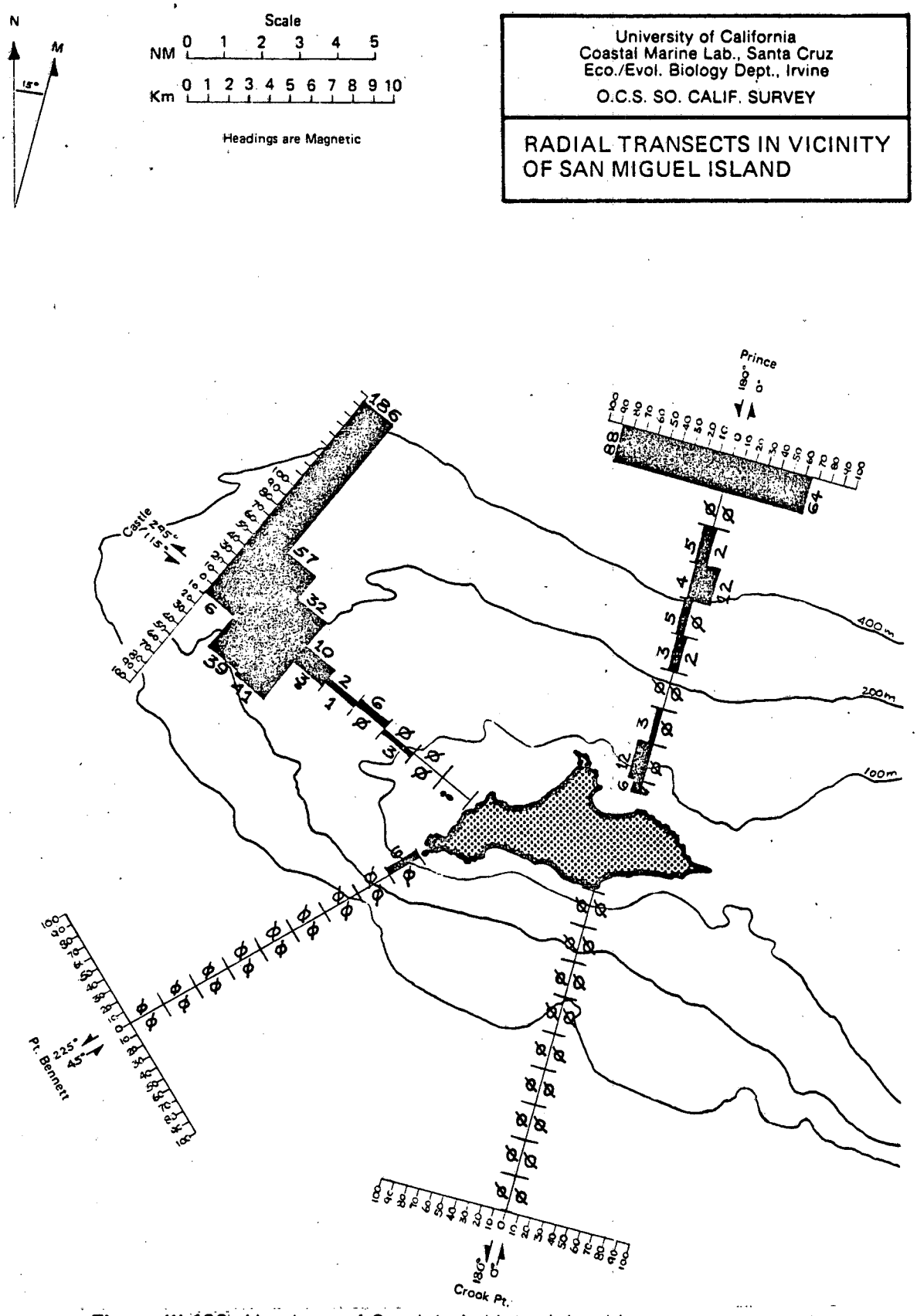


Figure III-190. Numbers of Cassin's Auklets sighted in transect segments, 20-21 May 1976.

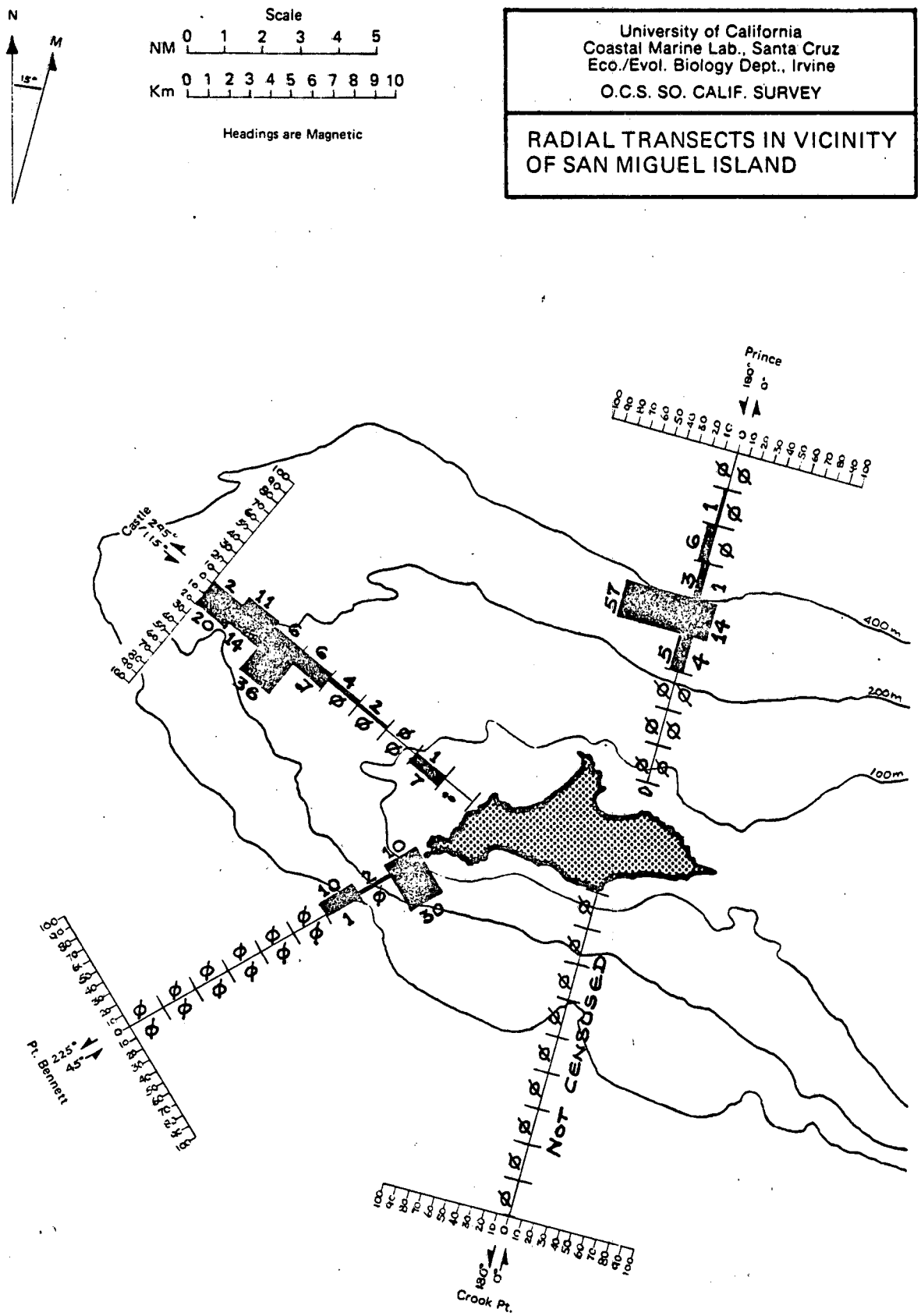


Figure III-191. Numbers of Cassin's Auklets sighted in transect segments, 8-9 June 1976.

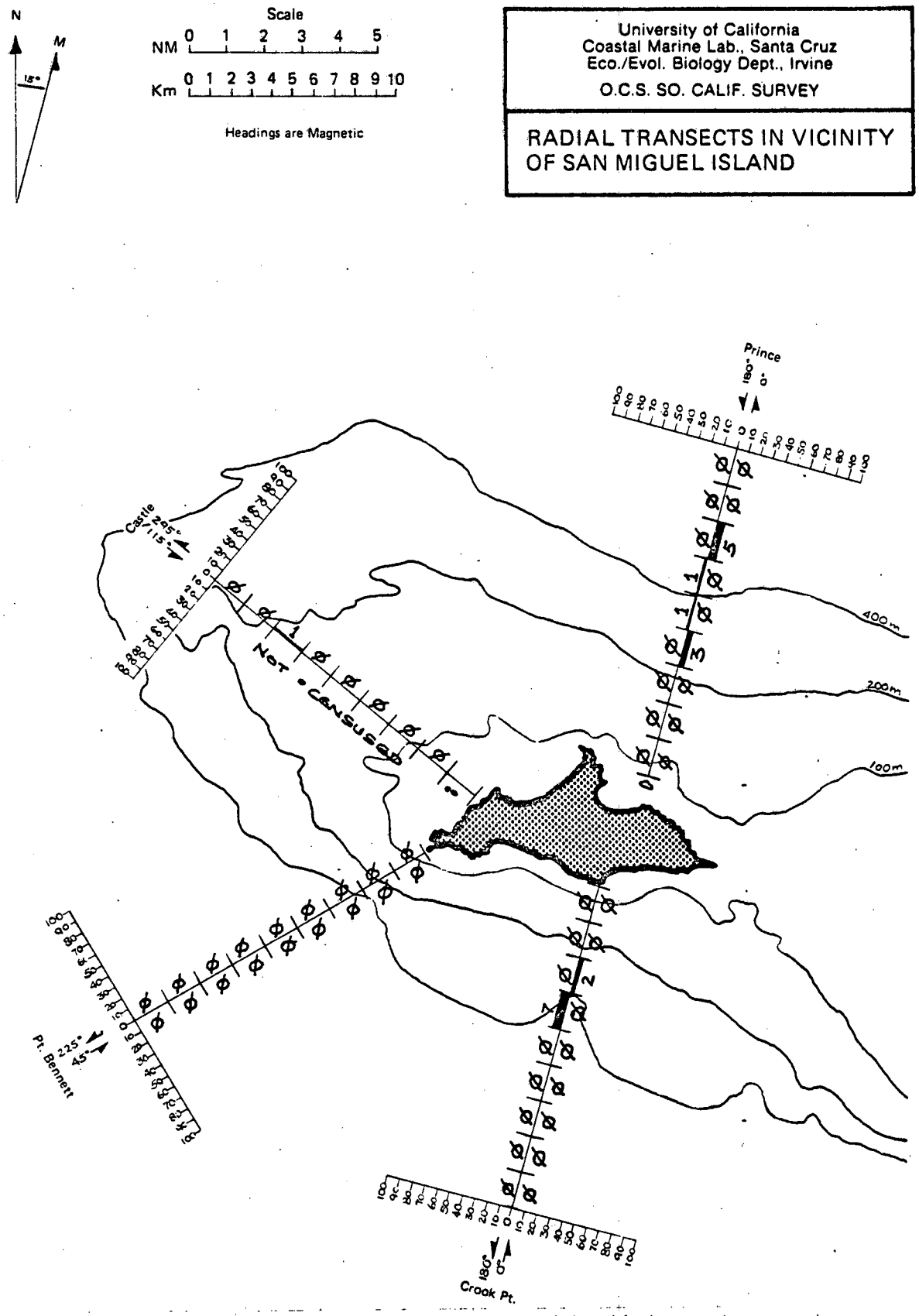


Figure III-192. Numbers of Cassin's Auklets sighted in transect segments, 23-24 June 1976.

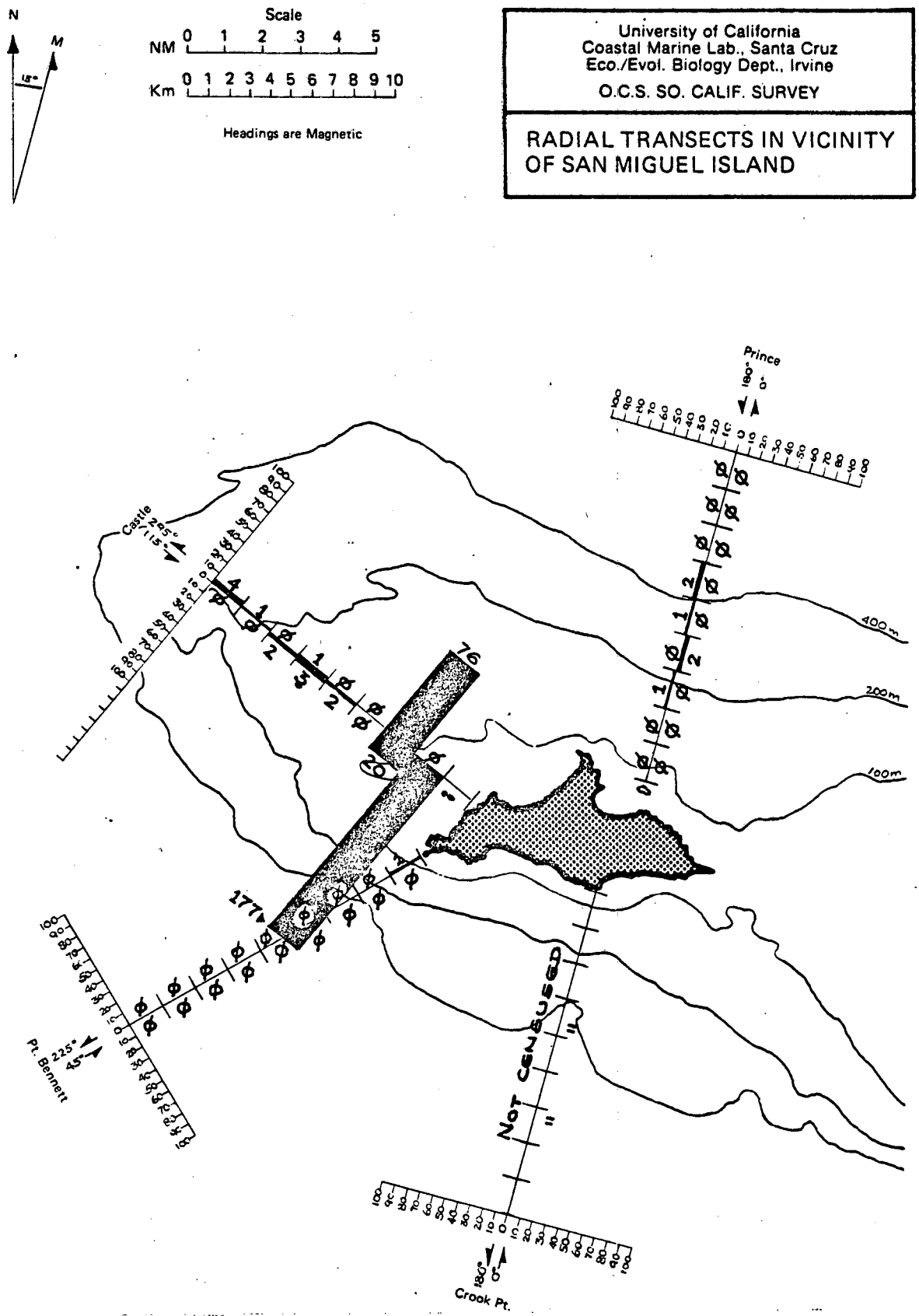


Figure III-193. Numbers of Cassin's Auklets sighted in transect segments, 14 July 1976.

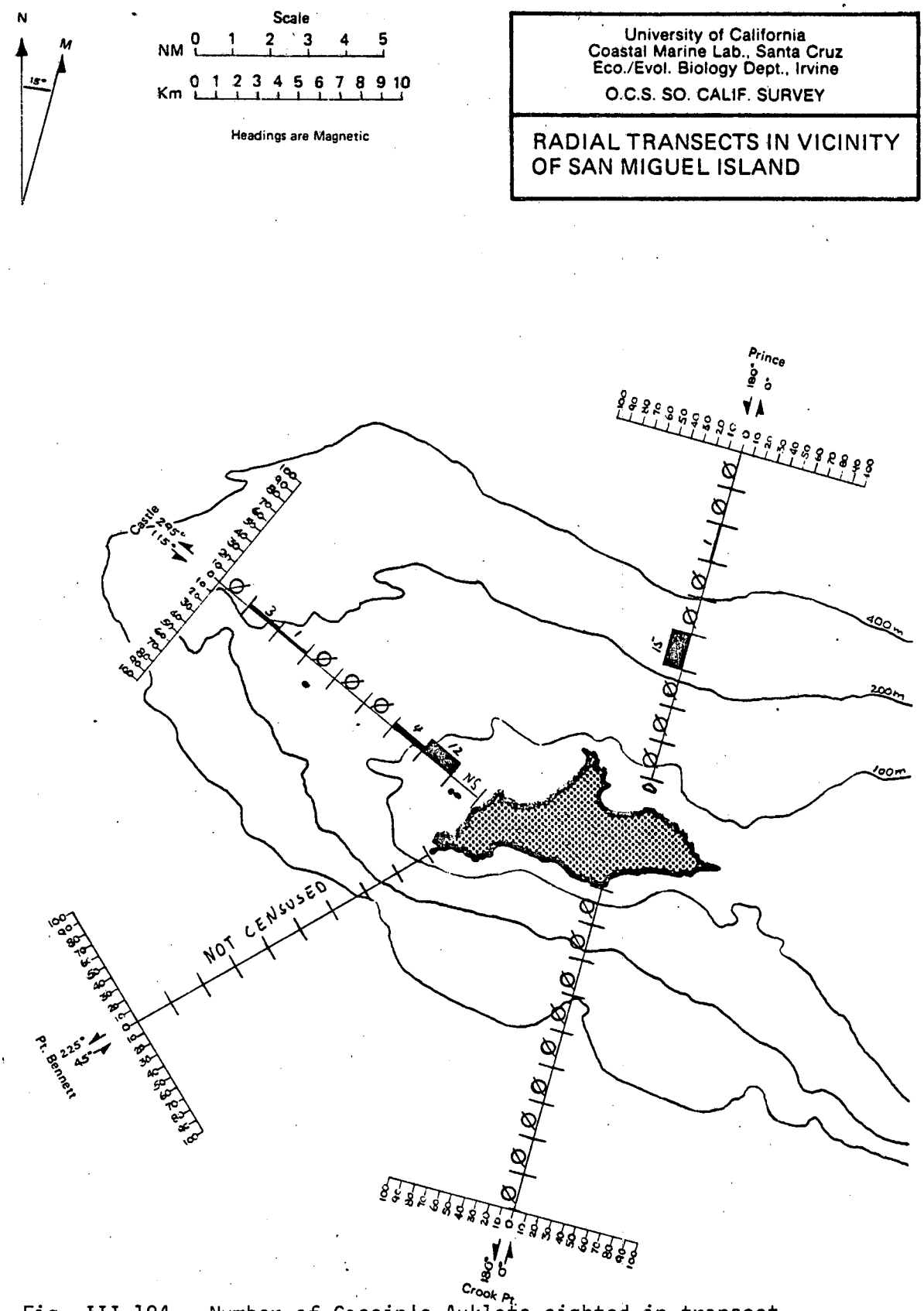


Fig. III-194. Number of Cassin's Auklets sighted in transect segments 17-19 January 1977.

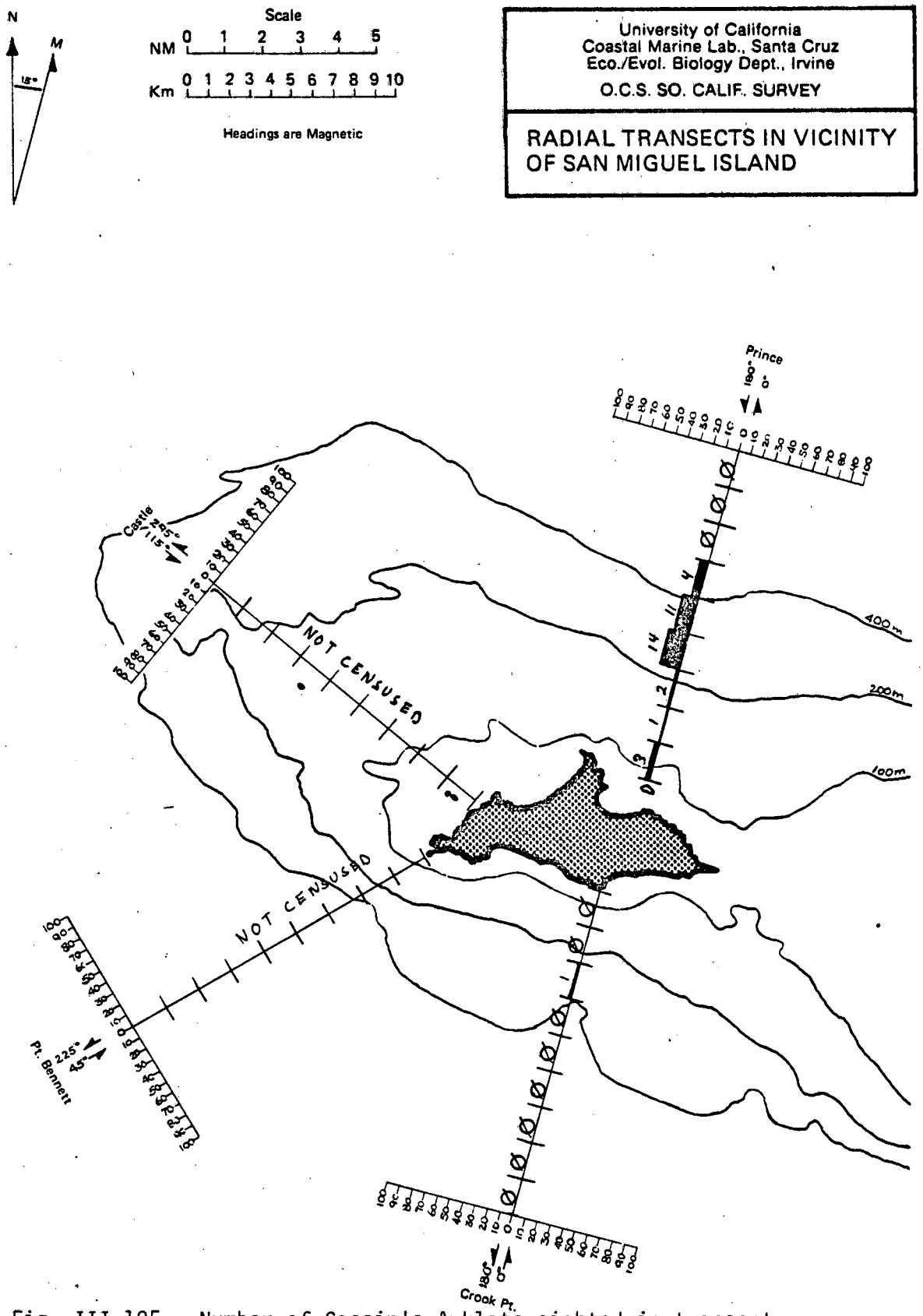


Fig. III-195. Number of Cassin's Auklets sighted in transect segments 15-16 February 1977.

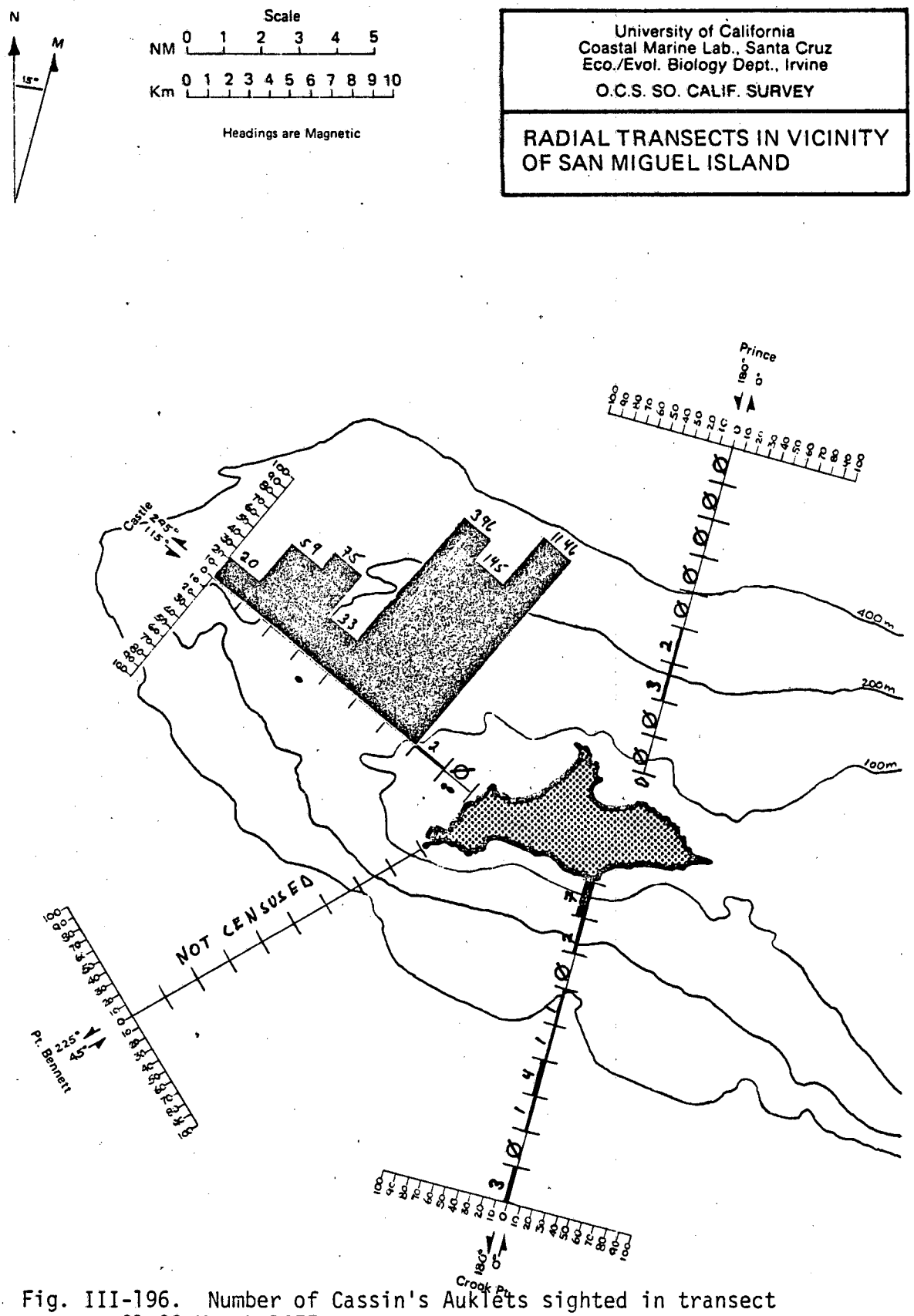


Fig. III-196. Number of Cassin's Auklets sighted in transect surveys 21-22 March 1977.

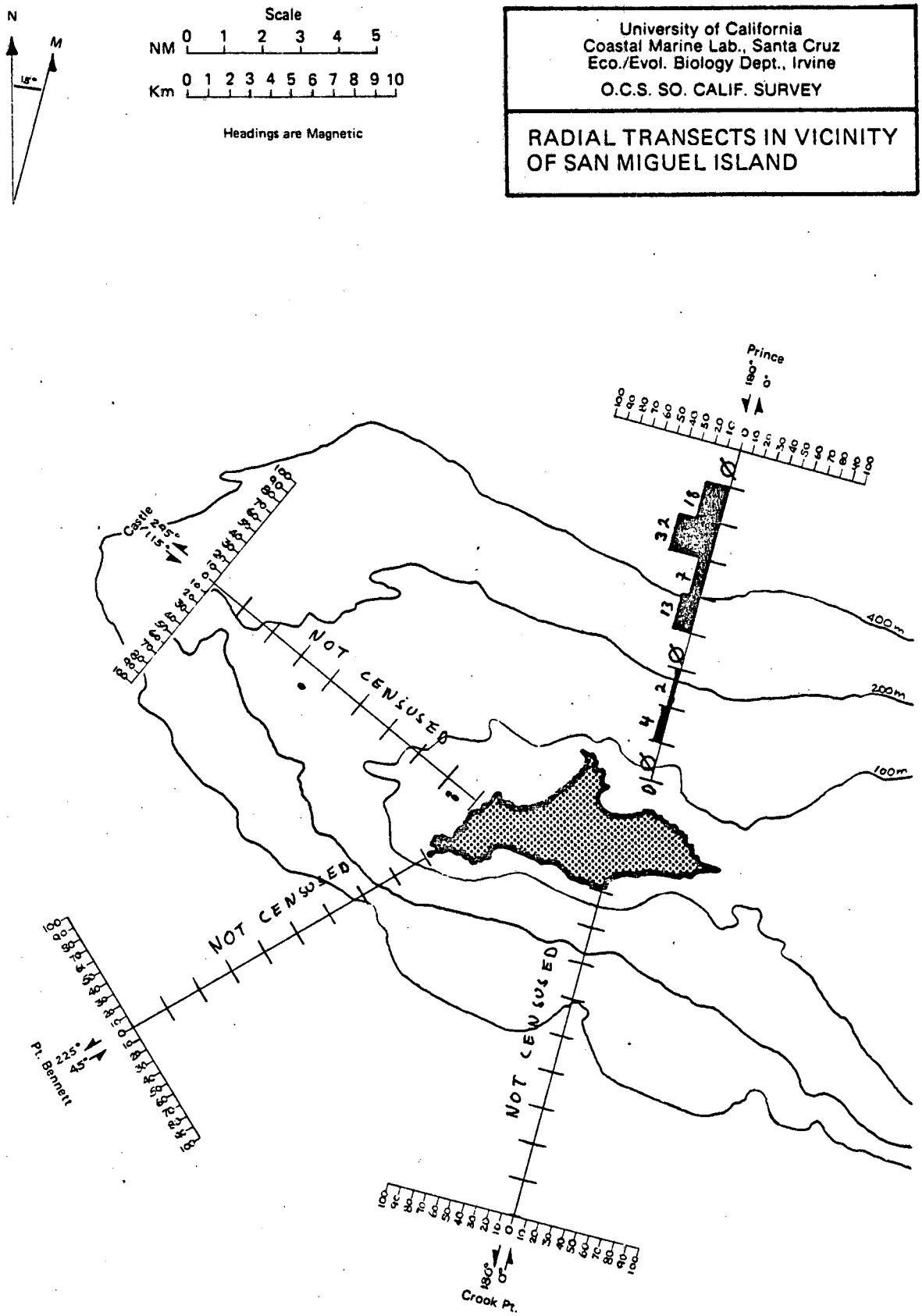


Fig. III-197. Number of Cassin's Auklets sighted in transect segments 2 May 1977.

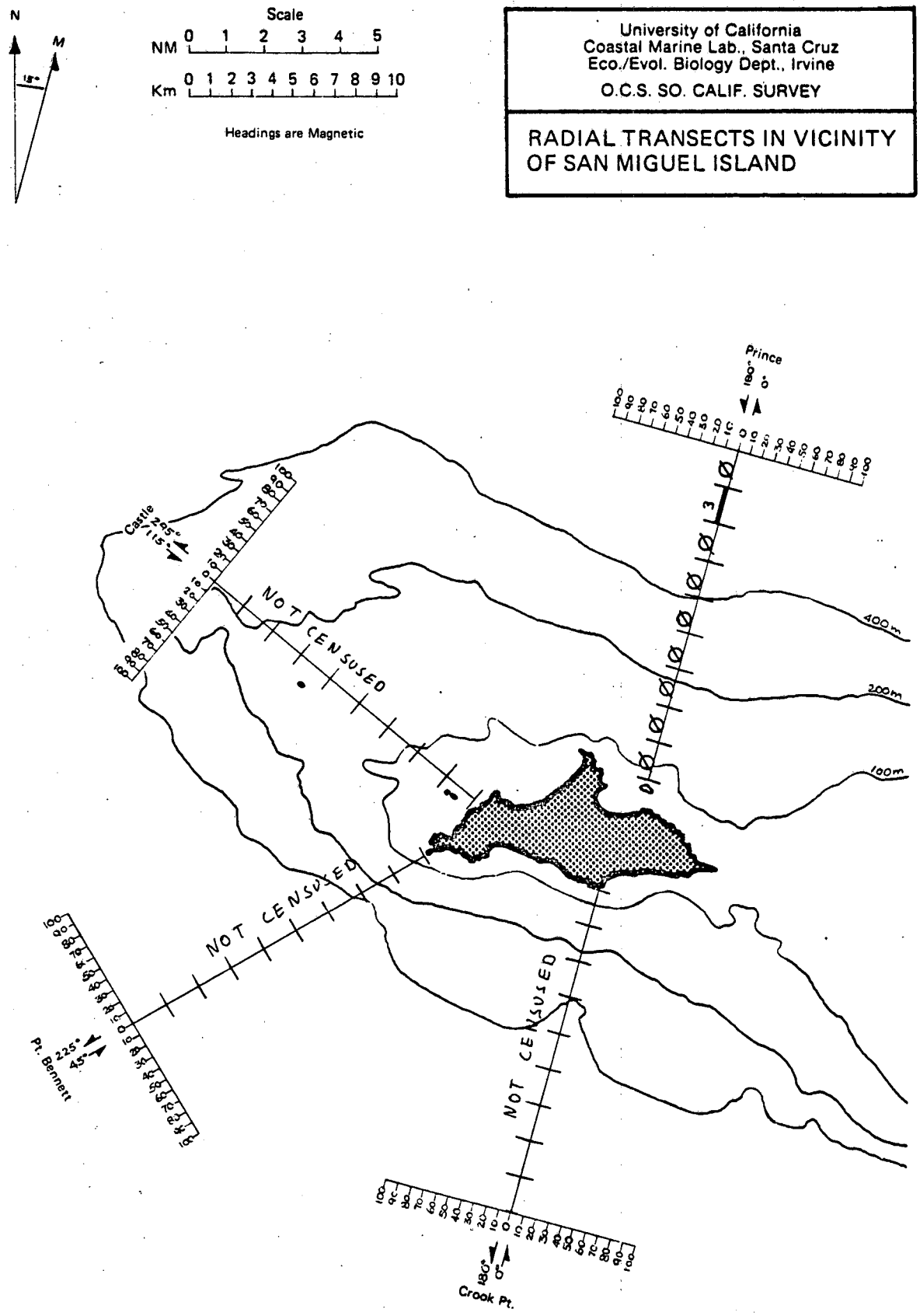


Fig. III-198. Number of Cassin's Auklets sighted in transect segments 21 June 1977.

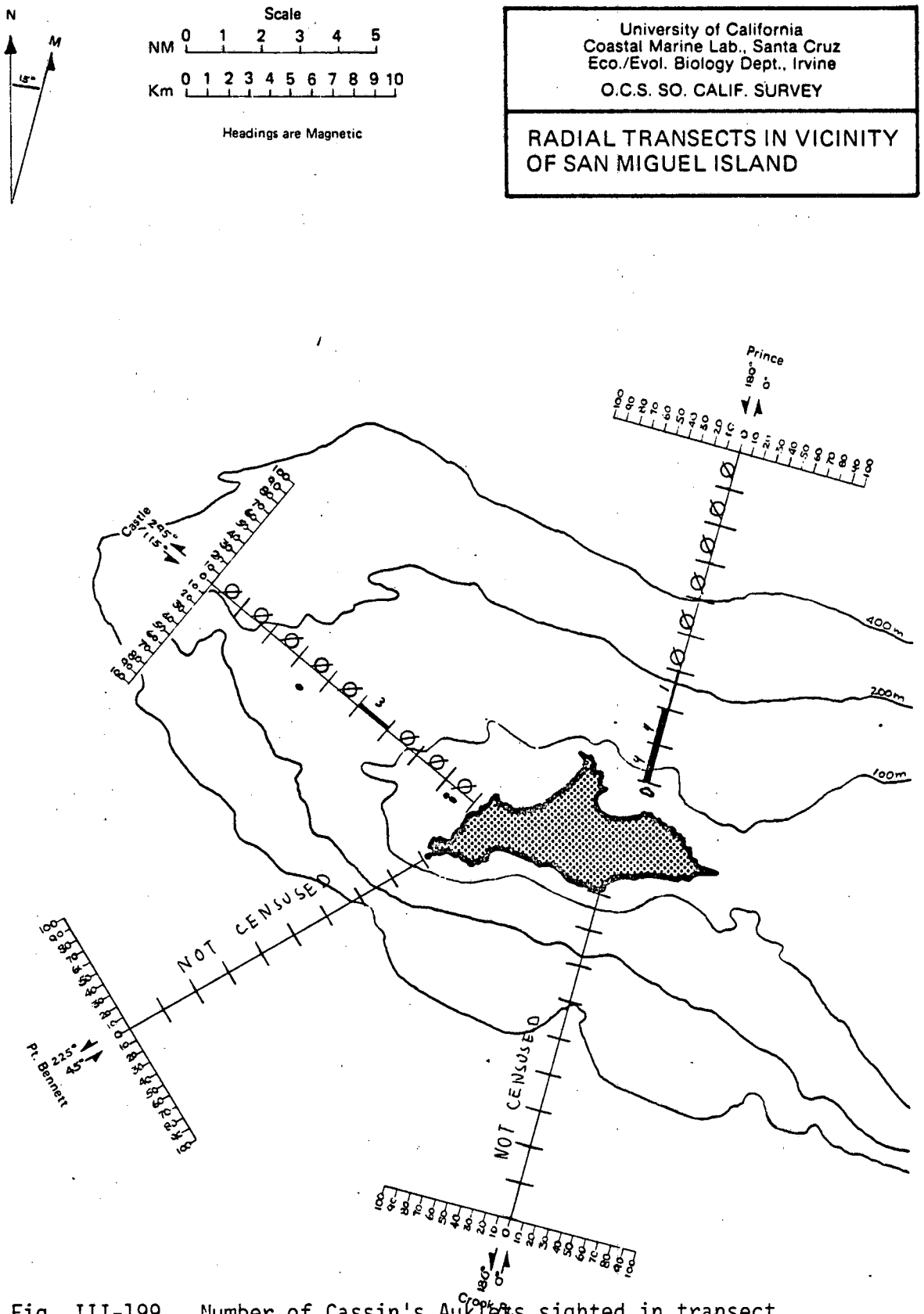


Fig. III-199. Number of Cassin's Auklets sighted in transect segments 8 (Prince) and 23 (Castle) July 1977.

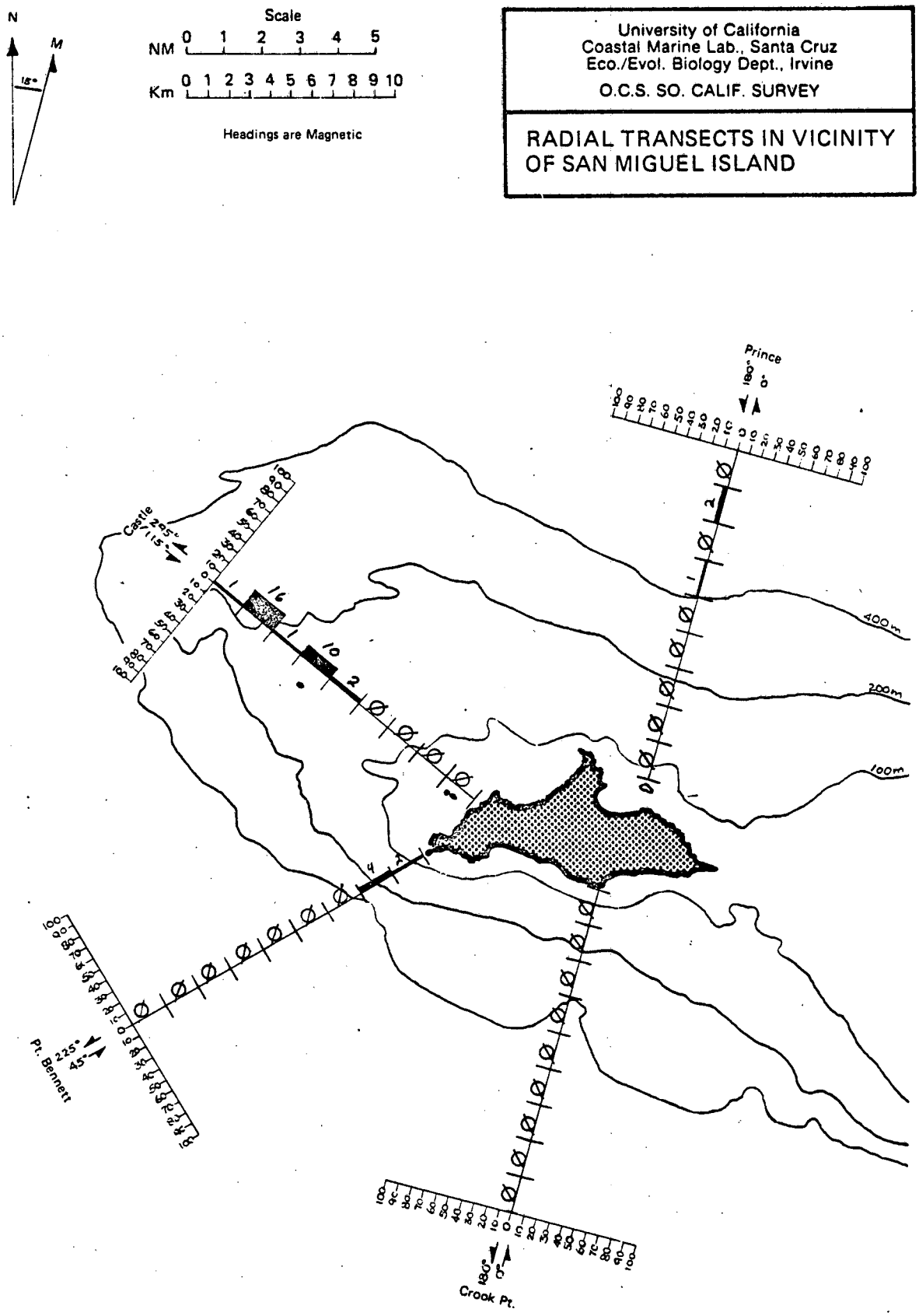


Fig. III-200. Number of Cassin's Auklets sighted in transect segments 12-14 August 1977.

Appendix III-7

LOCATION OF SEABIRD COLONIES IN THE SOUTHERN CALIFORNIA BIGHT

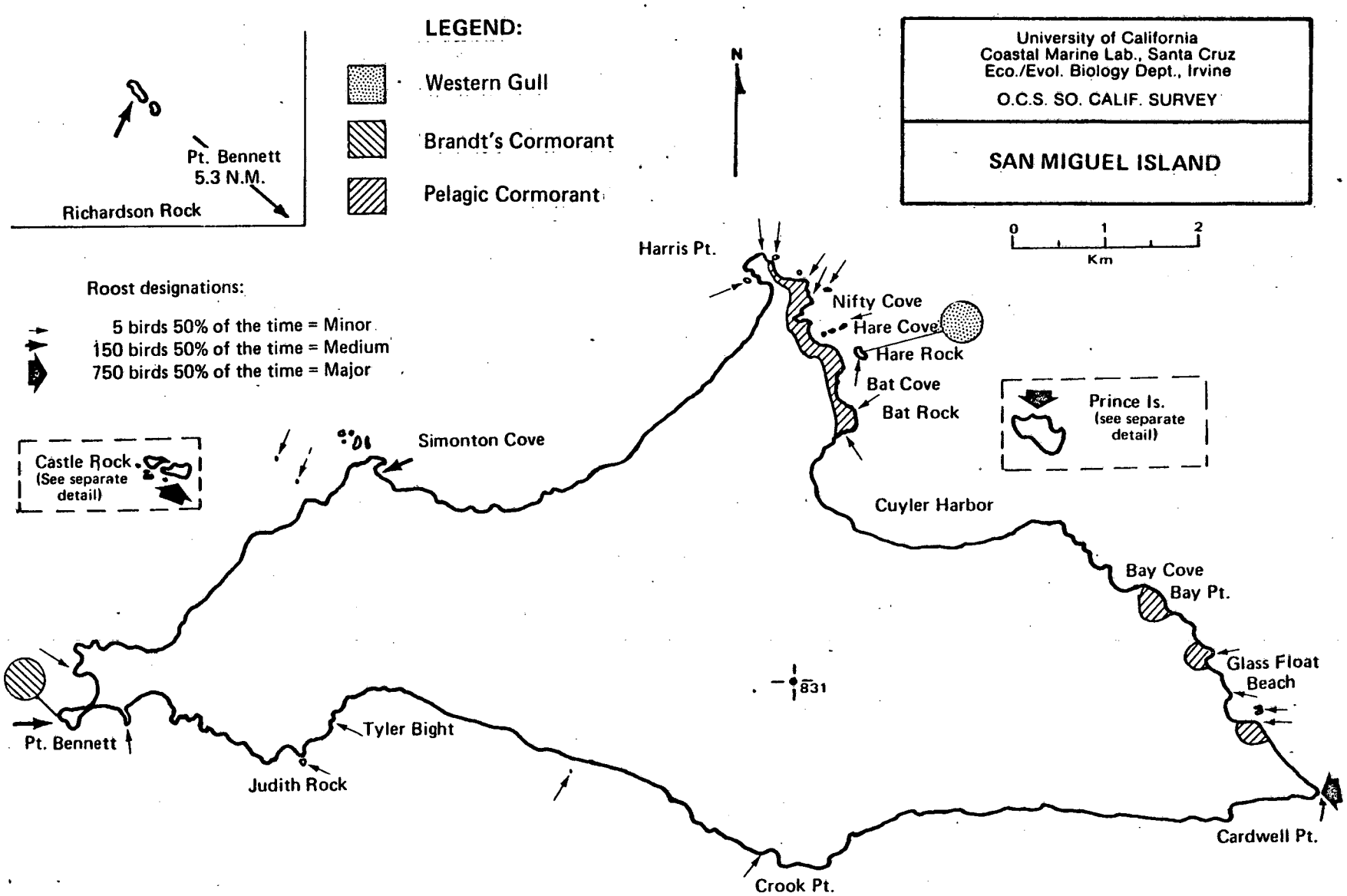


Figure III-201. Seabird colonies on San Miguel Is.

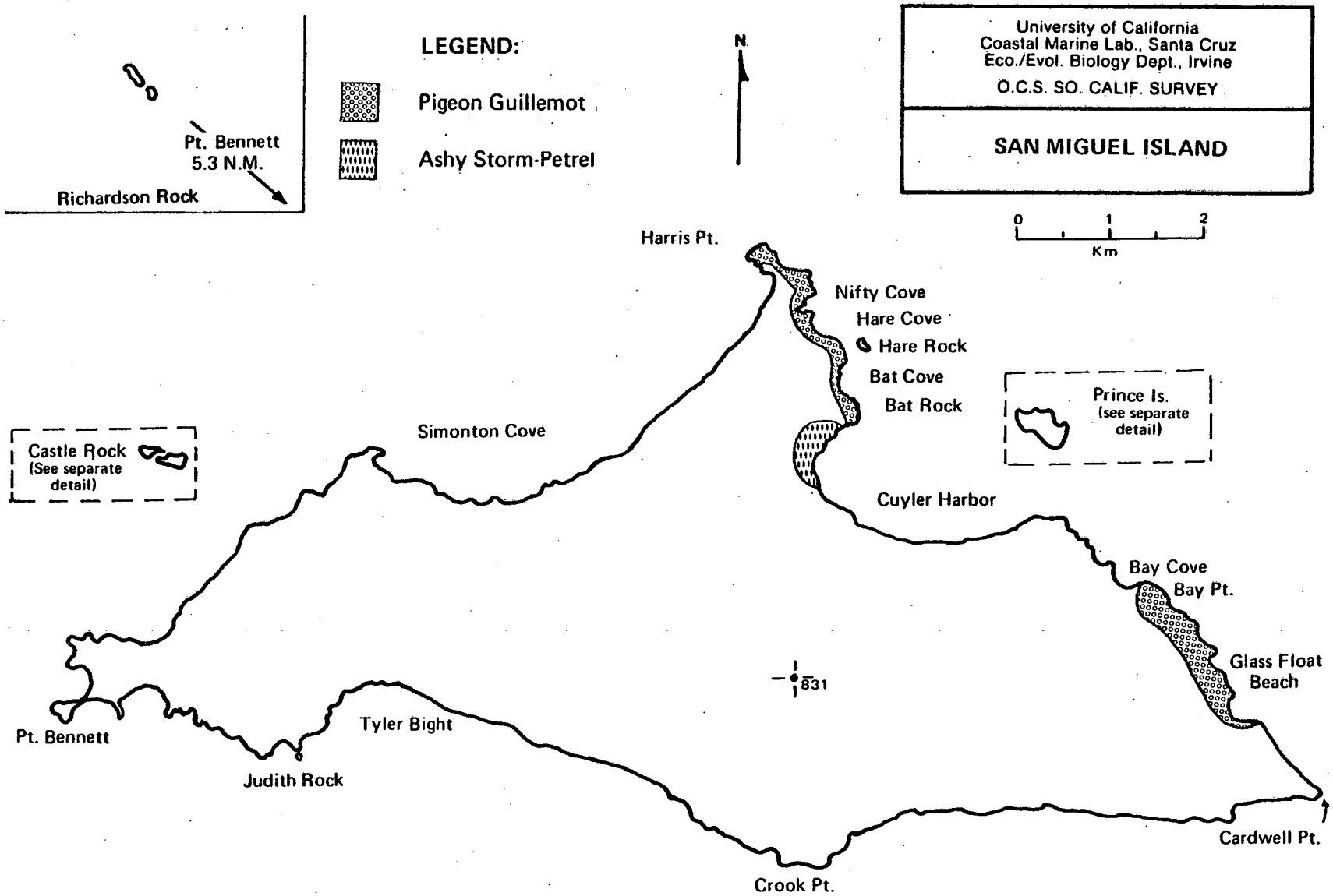


Figure III-202. Seabird colonies on San Miguel Is.

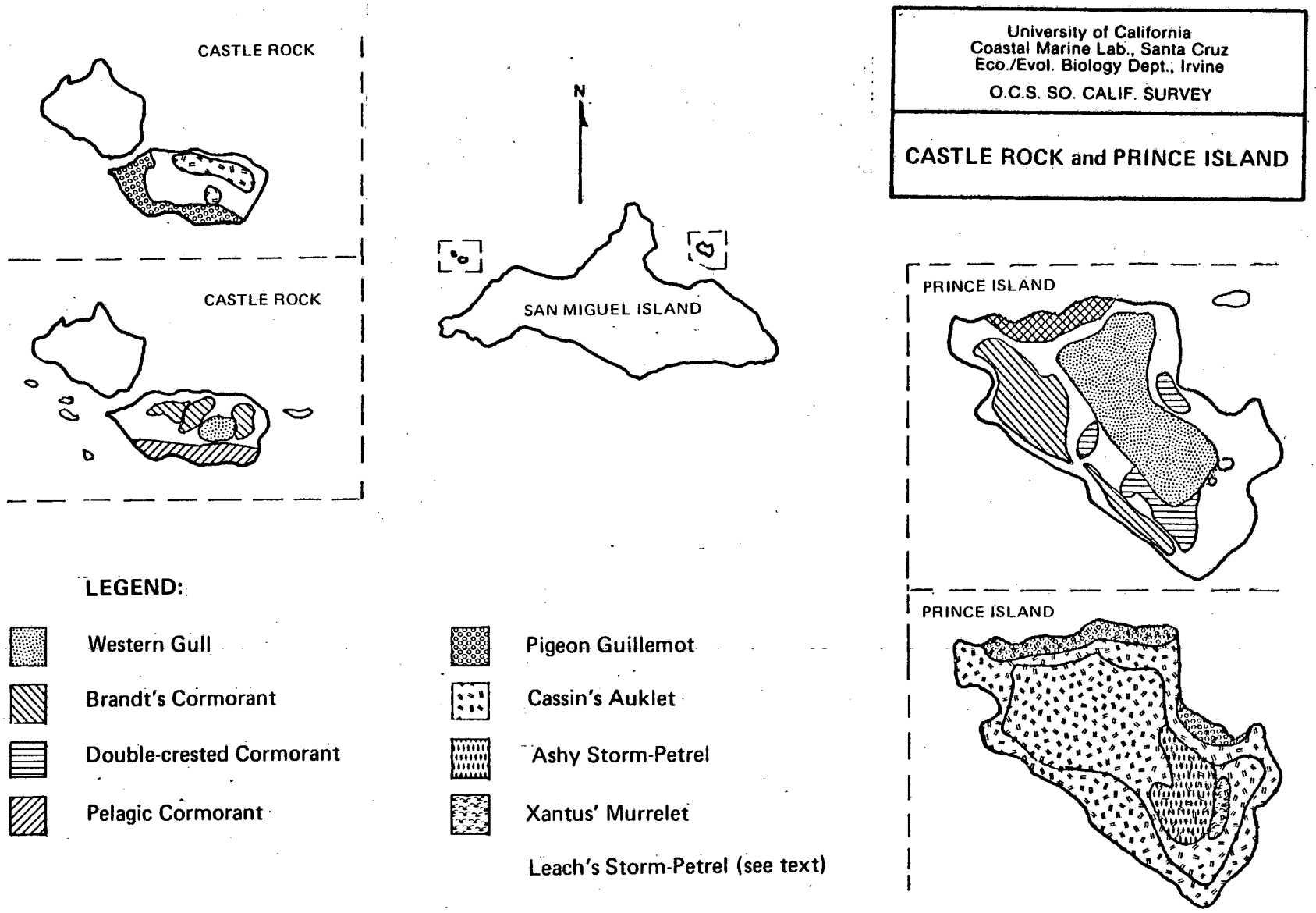


Figure III-203. Seabird colonies on Castle Rock and Prince Is. (SMI).

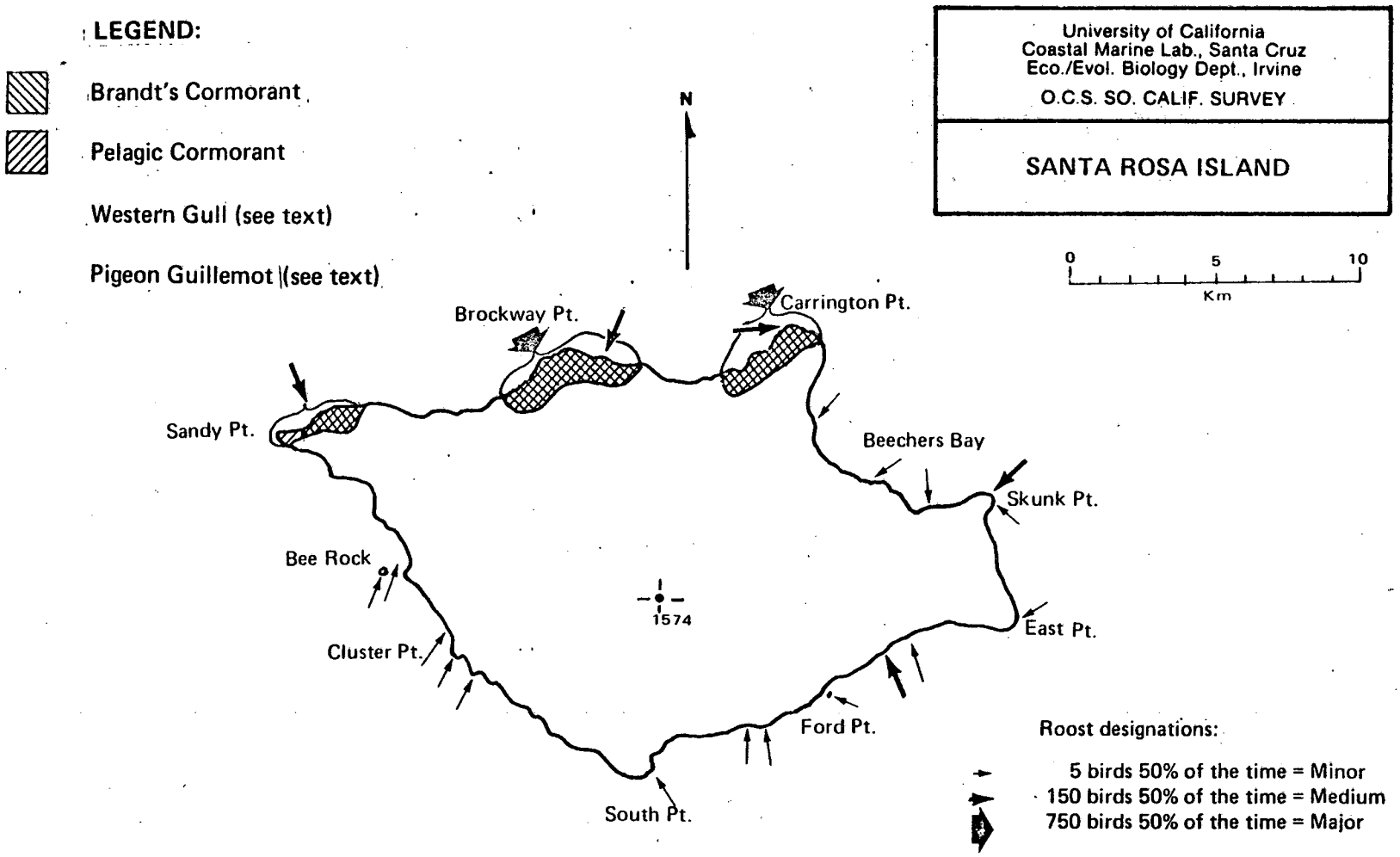


Figure III-204. Seabird colonies on Santa Rosa Is.

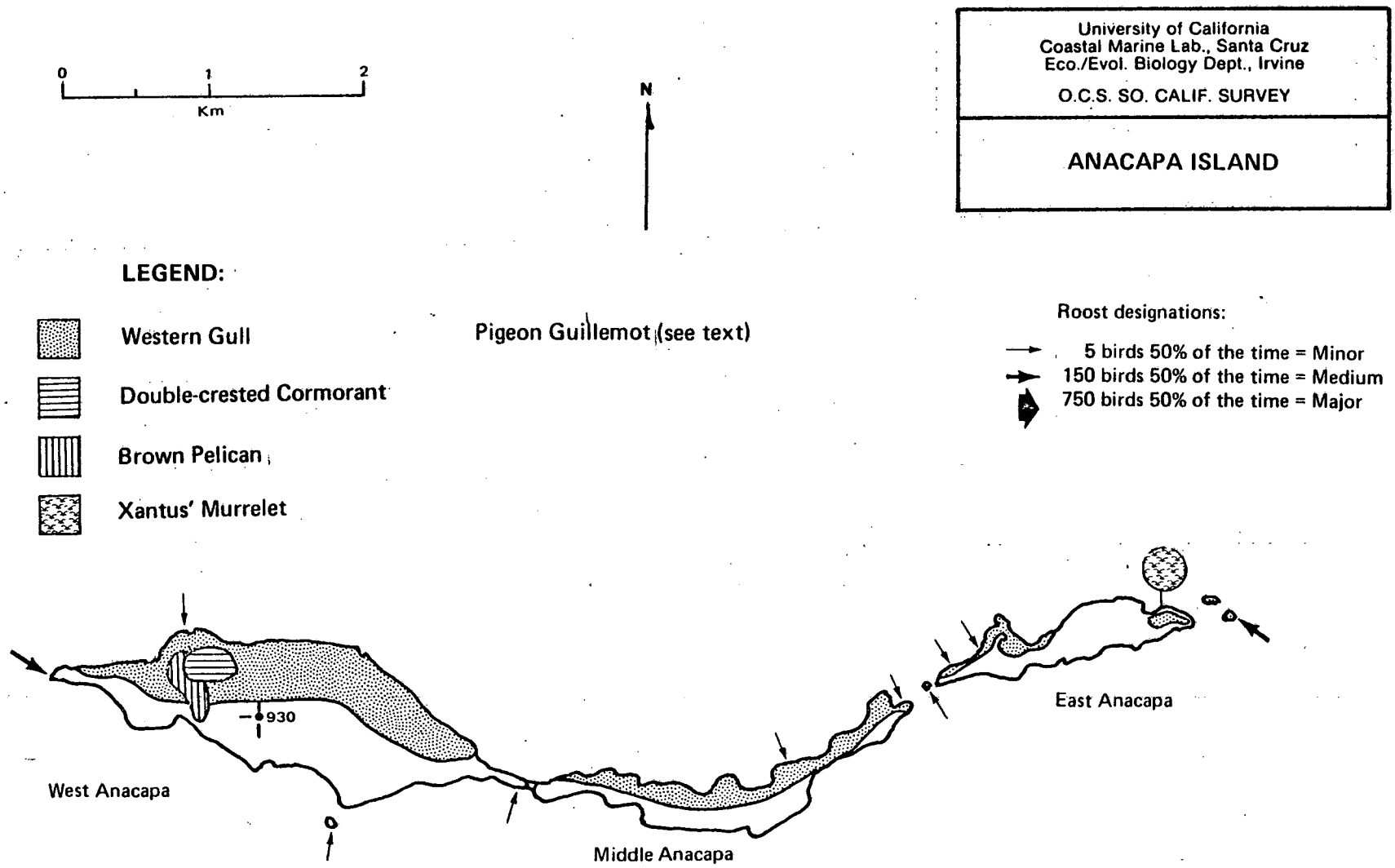


Figure III-205. Seabird colonies on Anacapa Is.

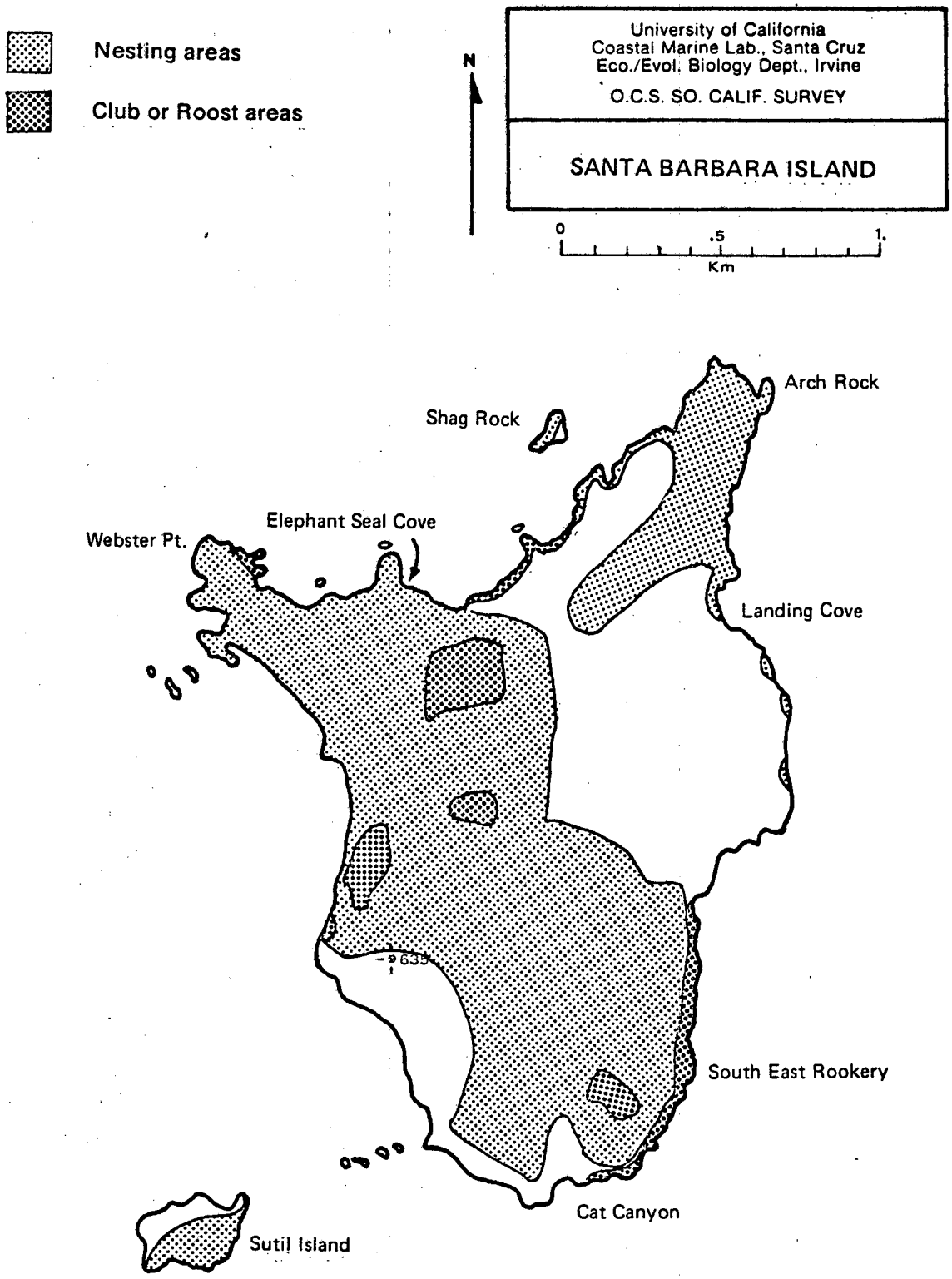


Figure III-206. Western Gull: location of breeding colonies and "club" areas.

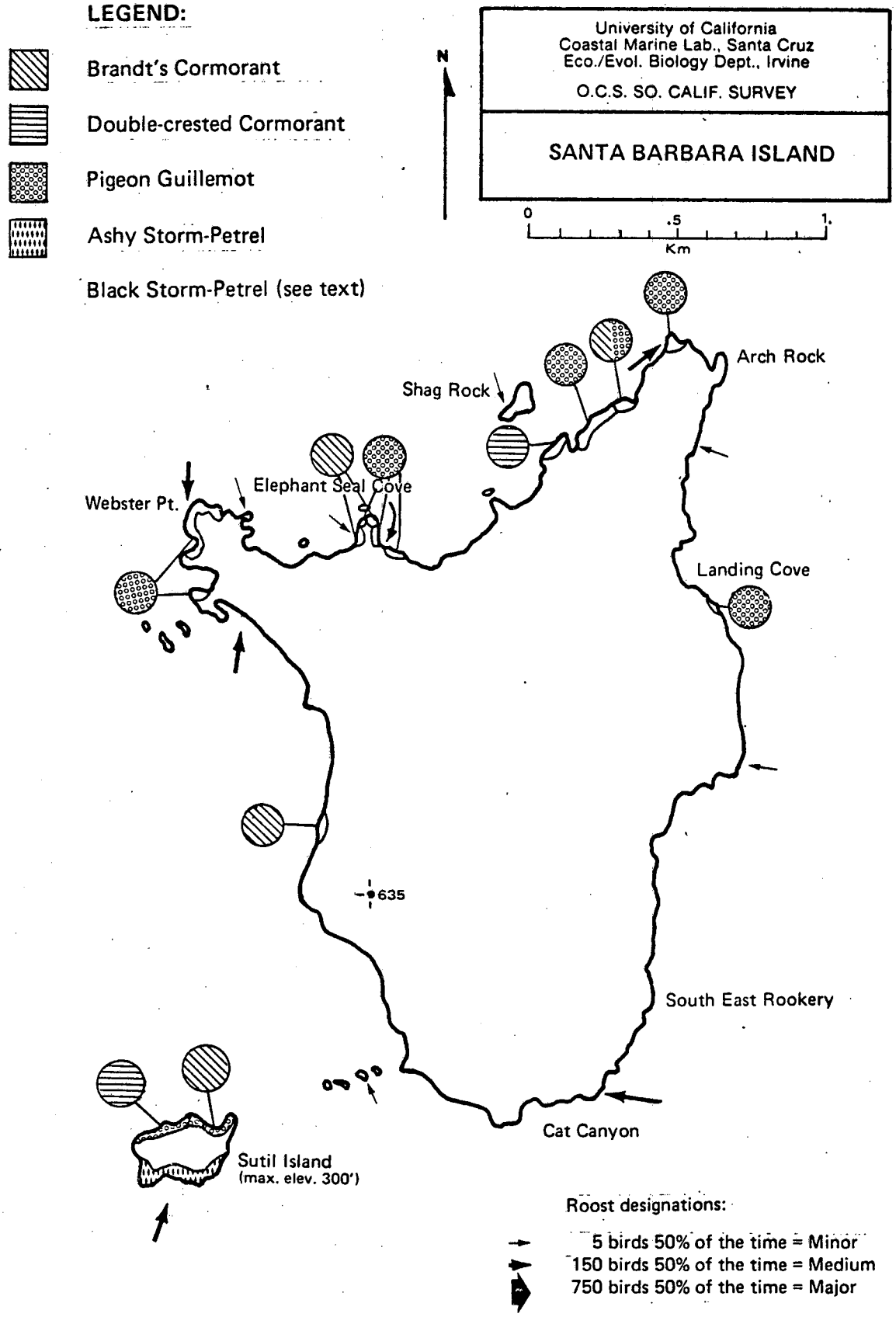


Figure III-207. Seabird colonies on Santa Barbara Is.

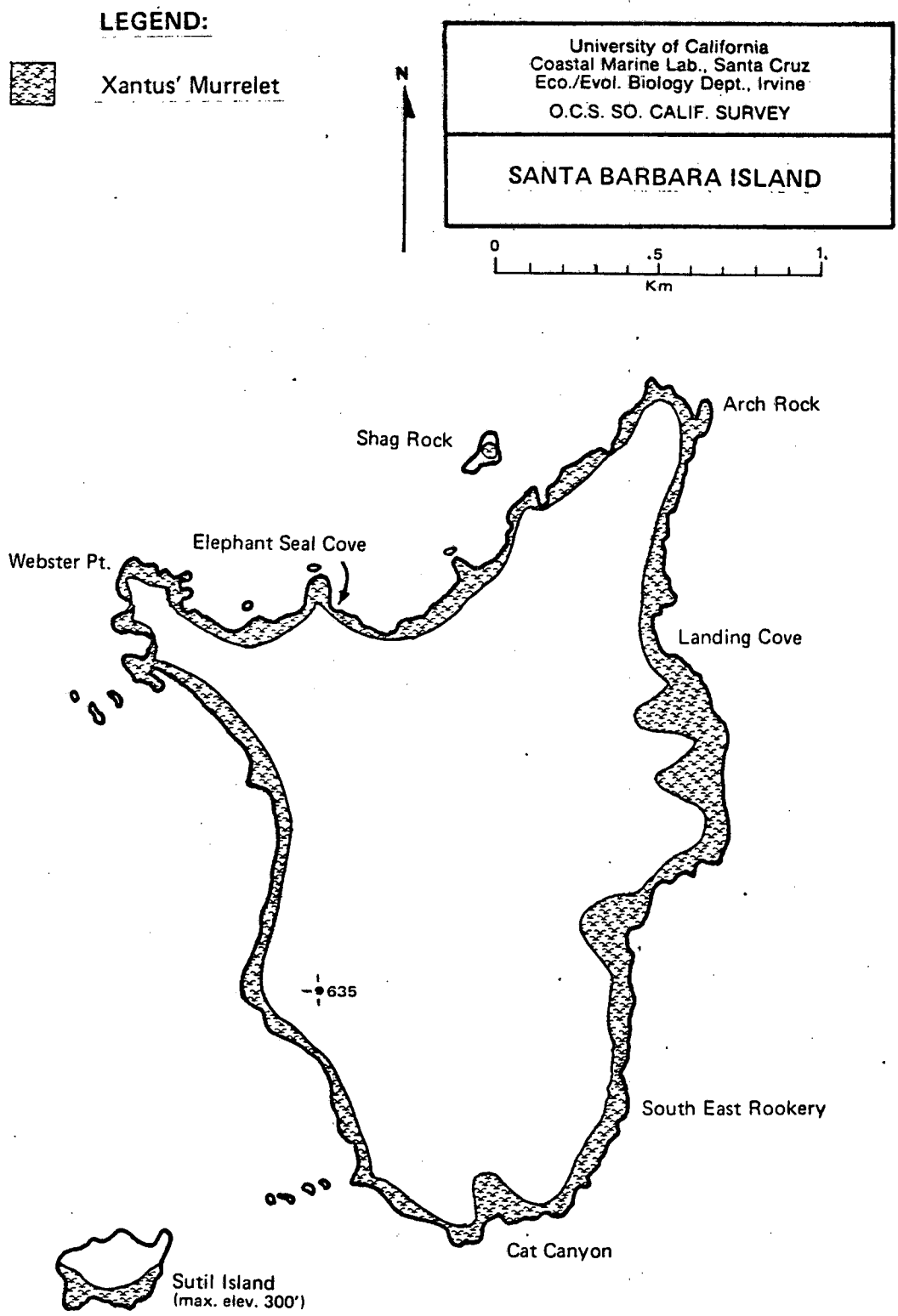


Figure III-208. Xantus' Murrelet colonies on Santa Barbara Is.

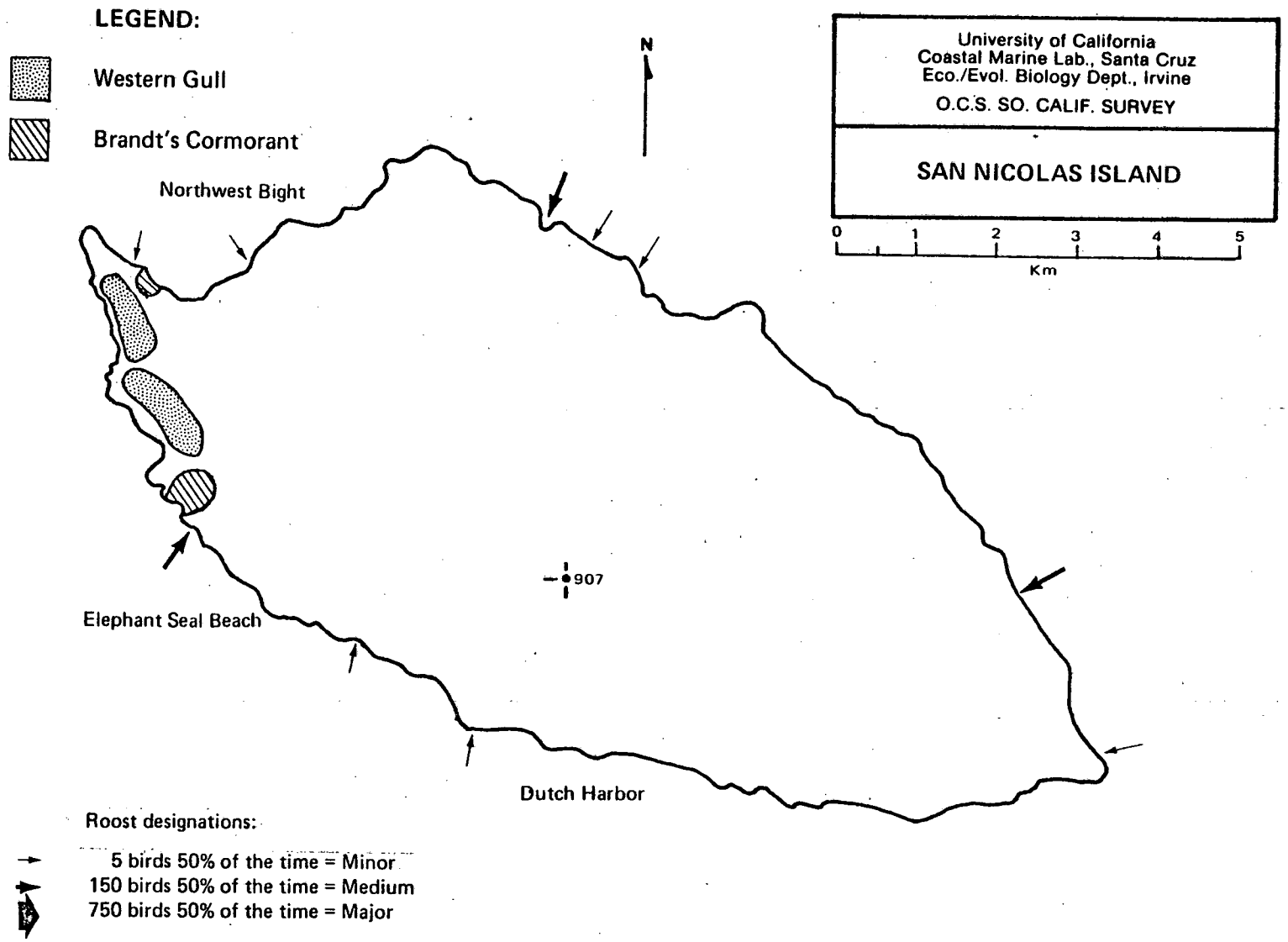


Figure III-209. Seabird colonies on San Nicolas Is.

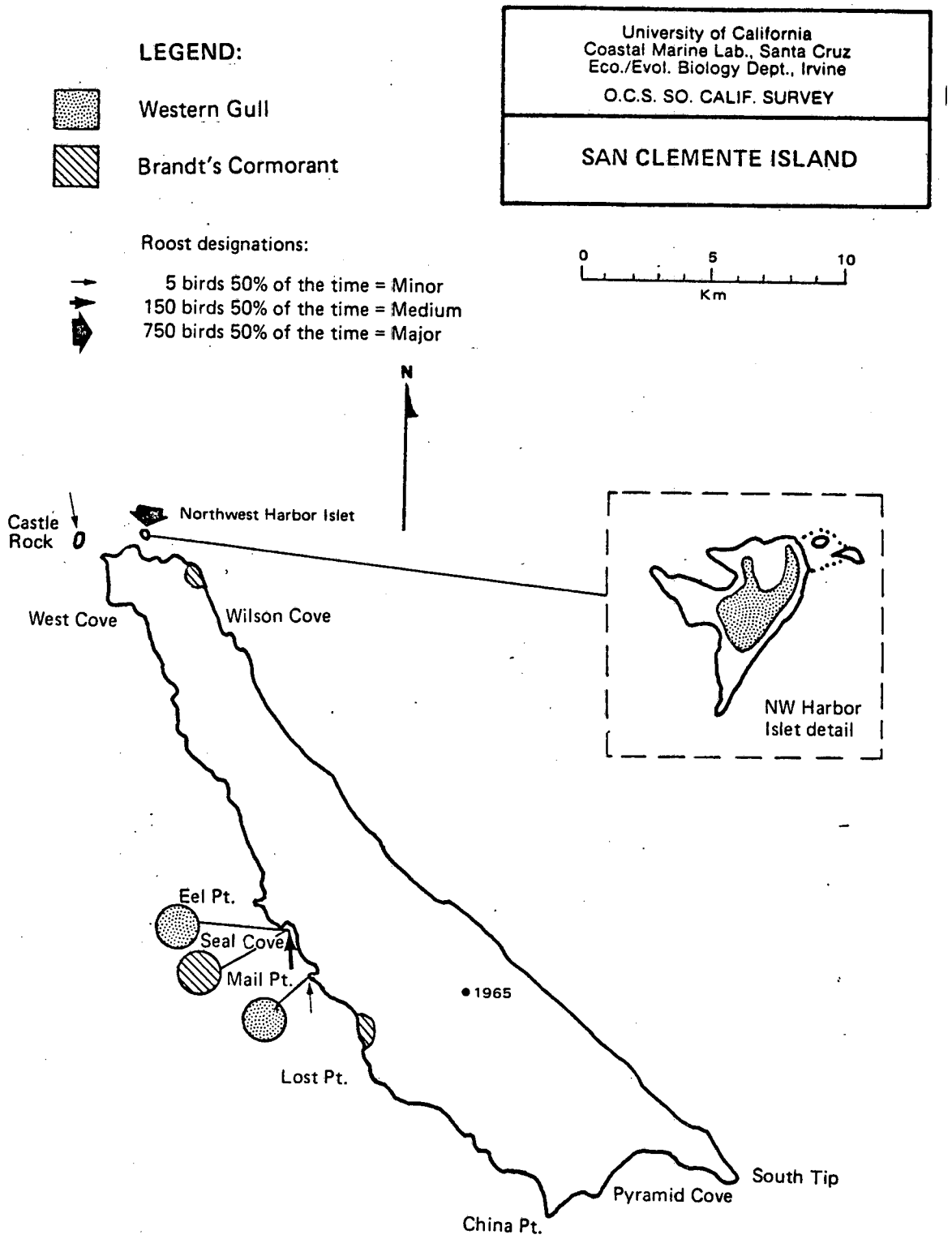


Figure III-210. Seabird colonies on San Clemente Is.

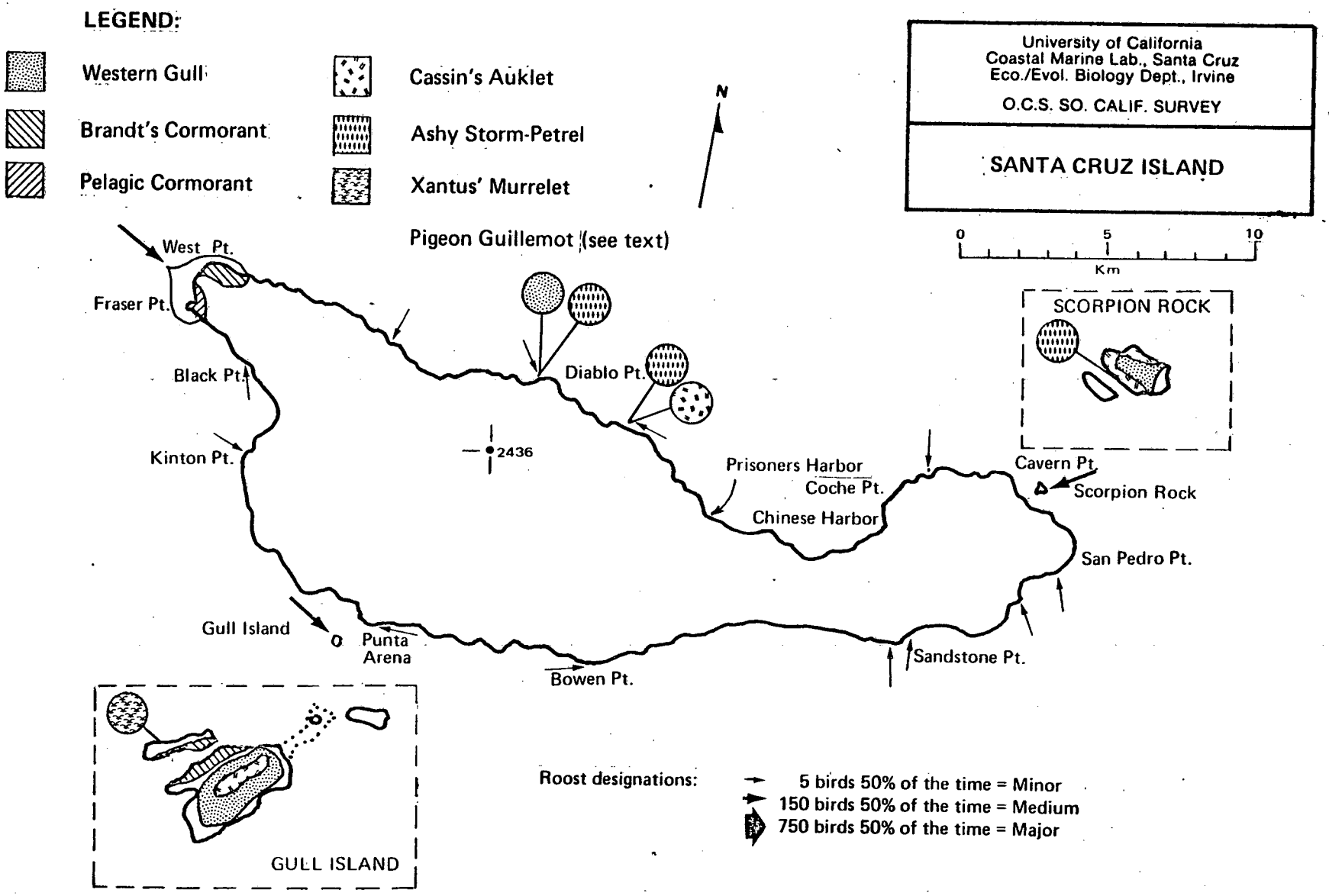


Figure III-211. Seabird colonies on Santa Cruz Is.

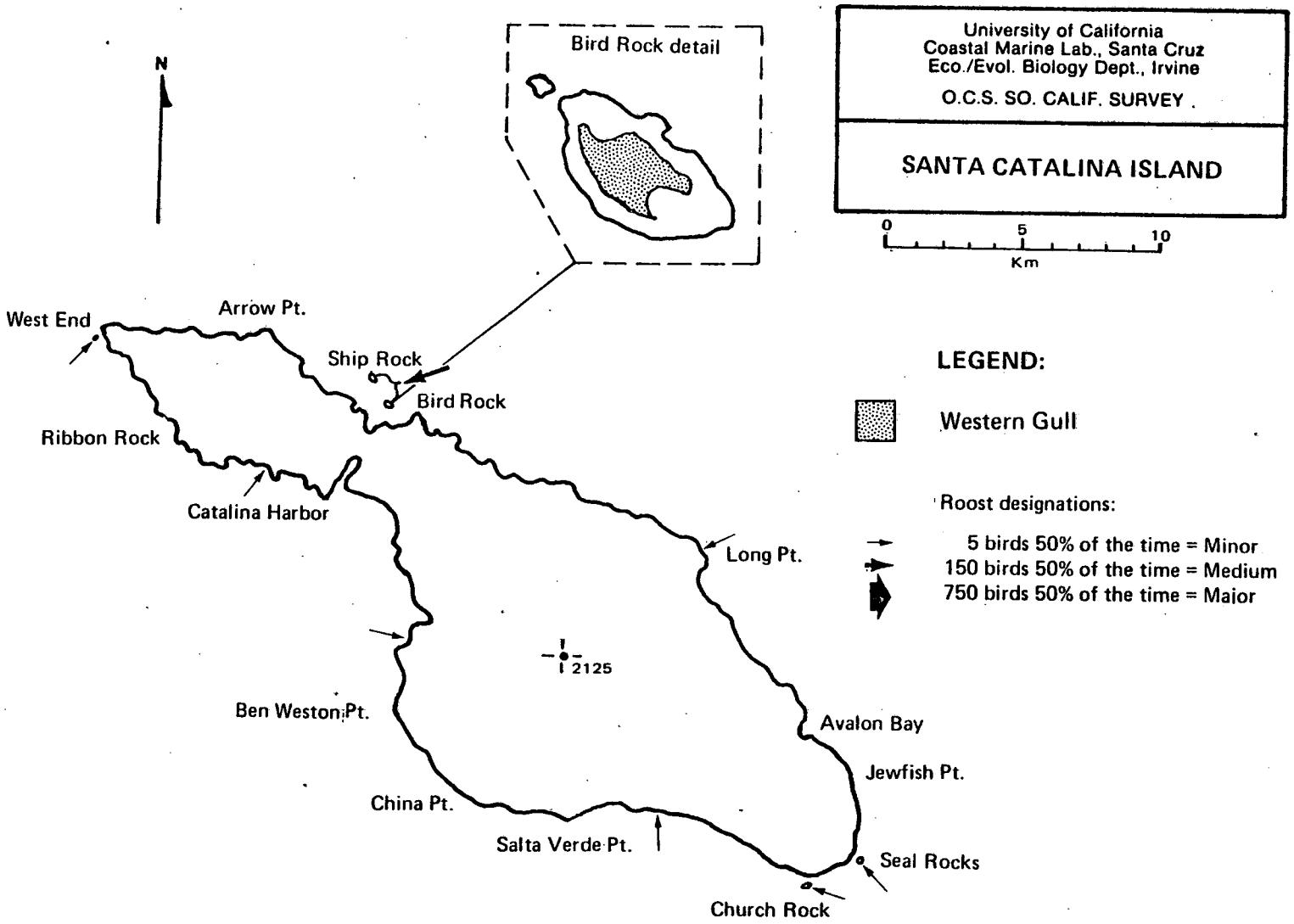


Figure III-212. Seabird colonies on Santa Catalina Is.

Appendix III-8

ABBREVIATIONS USED IN THE TEXT

Fig. III-213. Abbreviations used for species during this study.

PTLH = Leach's Storm-Petrel

PTBL = Black Storm-Petrel

PTAS = Ashy Storm-Petrel (*Oceanodroma homochroa*)

PELB = Brown Pelican (*Pelecanus occidentalis*)

COD = Double-crested Cormorant (*Phalacrocorax auritus*)

COB = Brandt's Cormorant (*P. penicillatus*)

COP = Pelagic Cormorant (*P. pelagicus*)

GUW = Western Gull (*Larus occidentalis*)

GP = Pigeon Guillemot (*Cepphus columba*)

MLX = Xantus' Murrelet (*Endomychura hypoleuca*)

AKC = Cassin's Auklet (*Ptychoramphus aleuticus*)

Fig. III-214. Museum Abbreviations

CAS	California Academy of Sciences Museum
DM	Denver Museum
LACM	Los Angeles County Museum of Natural History
MVZ	Museum of Vertebrate Zoology, Berkeley
NOF	Neotropical Orinithological Foundation
SBCM	San Bernardino County Museum
SBM	Santa Barbara Museum of Natural History
SDNHM	San Diego Natural History Museum
SU	Stanford University (Collection presently at CAS)
UCLA	University of California at Los Angeles
WFVZ	Western Foundation of Vertebrate Zoology