Distribution and Abundance of Seabirds Breeding on the California Channel Islands

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INTRODUCTION

The purpose of this paper is to provide an overview of the distribution, abundance, and history of the seabird populations that have bred or currently breed on the Channel Islands of California. Although adjacent to metropolitan Los Angeles and the subject of a large, albeit fragmentary, literature, the marine avifauna of southern California is surprisingly poorly known. Not only are accurate estimates of population size lacking, but often it is difficult to determine whether certain species were breeding or even present on the islands in the past. The recently completed baseline studies of marine birds and mammals of the Southern California Bight, sponsored by the Bureau of Land Management, have provided the first opportunity for a systematic assessment of marine bird populations in this area.

In this paper we (1) provide an update on the status of seabirds nesting in the Southern California Bight; (2) make comparisons of present-day populations with information on prior populations; (3) attempt to assess when and why populations have changed; and (4) discuss some of the interesting zoogeographical aspects of the southern California marine avifauna. It is not our intention that this paper provide the final or complete review of the literature on the history, ecology, or breeding biology of the species in question. Rather, we are providing a synthesis of the results of more detailed studies to be published in the future.

PAST AND PRESENT STATUS OF SEABIRD POPULATIONS

The breeding marine avifauna of the Southern California Bight is surprisingly diverse; 16 species have been recorded nesting there. Two of these species, the Common Murre (*Uria aalge*) and Tufted Puffin (*Lunda cirrhata*), no longer nest on the Channel Islands. Three other species, the Least Tern (*Sterna albifrons*), Elegant Tern (*Thallasseus elegans*), and possibly the Royal Tern (*T. maximus*), nest or have nested at mainland sites but not among the Channel Islands and will not be discussed here. Five families are represented among the marine birds that breed or have bred in recent historical times in the Bight: three storm petrels (Hydrobatidae), three cormorants (Phalacrocoracidae), one Pelican (Pelecanidae), one gull (Laridae), and five alcids (Alcidae).

As seabirds generally restrict their breeding activities to small, isolated islands, colonies are often crowded with thousands, sometimes millions, of birds. However, seabird populations in southern California are relatively small (Table 1); in total, only about 24,000 pairs of marine birds nest on the Channel Islands. Currently, the largest aggregation of nesting seabirds in southern California occurs on San Miguel Island and its two associated islets, Prince Island and Castle Rock (see Figure 1 for place names), where 14,000 to 15,000 pairs of nine species nest. Santa Barbara Island (3,400 pairs, ten species) and Anacapa Island (3,000 pairs, seven species) support the next largest colonies. Other islands support modest populations—San Nicolas (1,200 pairs), Santa Cruz (950 pairs), Santa Rosa (900 pairs)—or miniscule populations—San

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TABLE 1. Estimated numbers of pairs of seabirds breeding in the California Channel Islands, 1975-1977.

Island	Storm Petrels	Brown Pelican	Cormorants	Western Gull	Alcids	Total
San Miguel	400	0	1,450-2,100	580	11,500	14,580
Santa Rosa	?	0	550-750	15	125+	890
Santa Cruz	50+	*0-80	75-150	320	340+	940
Anacapa	-?	*76-417	4-17	2,500	6+	2,940
San Nicolas	-?	0	135-170	900	0	1,170
Santa Barbara	225	0	180-200	800-1,200	1,760	3,385
Santa Catalina	-?	0	0	30	0	30
San Clemente	-?	0	15	60	1+	76

+? - probably present. -? - probably not present.
? - unknown. 0 - not present.
* Data from D.W. Anderson *(in litt.)*, using only high colony counts.

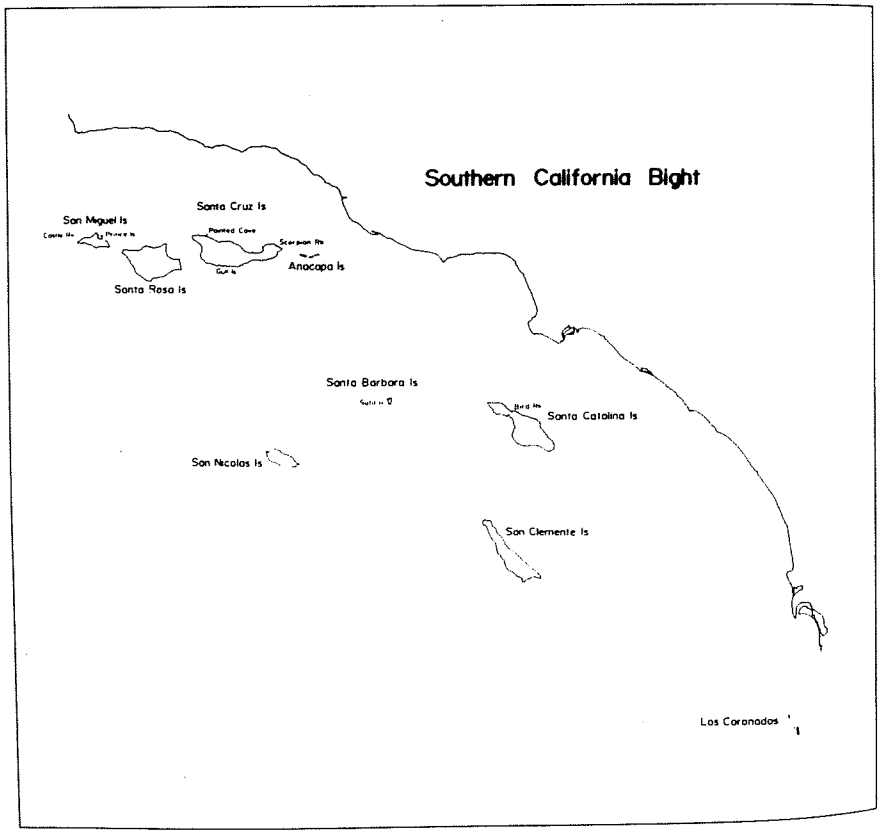

FIGURE 1. *Map of the Southern California Bight.*

TABLE 2. Estimated numbers of pairs of storm petrels breeding in the California Channel Islands, 1975-1977.*

Island	Leach's Storm Petrel	Ashy Storm Petrel	Black Storm Petrel
San Miguel	?	+?	0
Castle Rock	+?	100	0
Prince Island	2+	300±100	0
Santa Rosa	?	?	-?
Santa Cruz	?	?	-?
Gull Island	0	1	0
Scorpion Rock	0	20	0
Offshore rocks	0	30+	0
West Anacapa	-?	-?	-?
Middle Anacapa	-?	-?	-?
East Anacapa	-?	-?	-?
San Nicolas	-?	-?	-?
Santa Barbara	+?	125	60
Sutil Island	?	25	15
Shag Rock	?	?	?
Santa Catalina	-?	-?	-?
Bird Rock	0	0	0
San Clemente	-?	-?	-?
Bird Rock	0	0	0

* Symbols as in Table 1.

Clemente (75 pairs), Santa Catalina (30 pairs).

The numerical distribution by species is also uneven; Cassin's Auklet is the most abundant breeding seabird in the Channel Islands with 11,000 pairs, followed by Western Gull (5,600 pairs) and Brandt's Cormorant (3,000 pairs). An additional four species (Leach's and Black Storm Petrels, Double-crested and Pelagic Cormorants) are represented by breeding populations of less than 250 pairs, while the remaining four species (Ashy Storm Petrel, Brown Pelican, Pigeon Guillemot, and Xantus' Murrelet) occur in intermediate numbers.

Species Accounts

Storm Petrels

The distribution and abundance of storm petrels in the Channel Islands remains less well known than for any other group of seabirds (Table 2). Their nocturnal visits to the islands and their distant offshore foraging grounds make detection of the adults difficult, while their nest cavities are inconspicuous and generally inaccessible.

Leach's Storm Petrel (*Oceanodroma leucorhoa*) is the most widespread hydrobatid in the Northern Hemisphere. In the eastern Pacific, it breeds from Alaska south to Islas San Benitos, Baja California, Mexico. Prior to the present study, there were no published reports of Leach's Storm Petrels nesting on the California Channel Islands. In 1976 and 1977, we captured six individuals of this species on Prince Island, one of which was deposited in the San Diego Natural History Museum. One bird caught twice in 1976 had a well-developed brood patch. Upon rechecking storm petrel specimens collected during the Smithsonian Institution's Pacific Ocean Biological Survey Program (POBSP) studies of the Channel Islands, it has been

established that one of the storm petrels collected on Castle Rock, San Miguel Island, 14 May 1968, and originally identified as an Ashy Storm Petrel (*O. homochroa*), was in fact a Leach's Storm Petrel (R. B. Clapp *in litt.*). This bird, representing the first known breeding record for the Channel Islands, was taken from a rock crevice and had a brood patch. Leach's Storm Petrels were captured at Santa Barbara Island for the first time in 1978 and may breed there in small numbers. Thus, although we have now established that Leach's Storm Petrels breed in the Southern California Bight, we are left with the puzzling question of why they are present in such small numbers in a region well within the limits of their range. Possibly these islands are too far from the open ocean foraging areas preferred by this species (Ainley *et al.* 1974).

The Pacific coast of the Americas supports a large number of hydrobatids with breeding ranges that are exceptionally limited. Ashy Storm Petrels, for example, breed only on the Farallon Islands in central California and on the California Channel Islands (including Islas Los Coronados in extreme northern Baja California). 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, although Ainley and Lewis (1974) estimate the population there to be only about 4,000 birds. The entire world population of Ashy Storm Petrels may number only 10,000 to 20,000 individuals.

In the Channel Islands, there are several records for Ashy Storm Petrels breeding on Castle Rock and Prince Island at San Miguel Island and at Painted Cave and Scorpion Harbor, Santa Cruz Island. Although Ashy Storm Petrels have been seen at San Nicolas Island (Grinnell 1897) and collected at Santa Barbara and San Clemente Islands (Miller 1936), there are no historical breeding data for any of the Channel Islands except San Miguel Island, Santa Cruz Island, and their associated rocks and islets.

Field work in 1976-1977 confirmed that Ashy Storm Petrels were scattered in small colonies on many of the offshore rocks along the north side of San Miguel Island and the north side of Santa Cruz Island, and may have nested on San Miguel Island itself. We also captured birds with brood patches and found nests for the first time on both Santa Barbara Island and Sutil Island. The colony at Castle Rock was not inspected closely enough to establish the presence of this species. Instead, an estimate, based on our experience with this species and on Crossin and Brownell's (1968) report, is given in Table 2. On the basis of our present data and data available from the literature and museum records, there is little evidence for any major change in Ashy Storm Petrel population size or distribution within the Bight within historical times.

The Black Storm Petrel (*O. melania*) is another eastern Pacific hydrobatid with a limited breeding range. Before this study, breeding Black Storm Petrels were known only from Mexican islands, where nesting occurs both in the Gulf of California and on the Pacific Ocean side of the Baja California peninsula (Palmer 1962). Dawson (1923) anticipated our findings, however, by stating it was "not known to breed in California, but probably does so." In 1976, Black Storm Petrels were found breeding on Sutil Island, off Santa Barbara Island, for the first time (Pitman and Speich 1976). The population at Sutil Island was estimated at no more than 10 to 15 pairs. This new location is approximately 200 km northwest of Islas Los Coronados, where this species breeds commonly (Crossin 1974). During the 1977 field season, 27 Black Storm Petrels were captured and banded on nearby Santa Barbara Island, including two recaptures. Although no nests were found on Santa Barbara Island, all storm petrels captured had brood patches and were presumed to be breeding there. Using the above information, the entire population of Black Storm Petrels at Santa Barbara Island (including Sutil Island) is estimated to be 75 pairs. Black Storm Petrels were not detected on any of the other Channel Islands. Thus, Santa Barbara Island is probably the only breeding site for this species in the United States.

During this project, two species of storm petrels were found breeding on Santa Barbara Island and a third species has recently been detected, whereas none had been recorded previously: Ashy Storm Petrel, with the center of its breeding distribution to the north; Black Storm Petrel, with its center to the south; and Leach's Storm Petrel, nesting both north and south of the area. It seems unlikely that any recent change in environmental conditions alone would allow all of these species to expand into the area around Santa Barbara Island unless it is the reduction of predators on the island (see Discussion). Due to the low densities encountered for these species and their habit of frequenting only the extreme periphery of the island at night, it is likely that some or all of these storm petrels were present, but overlooked, in the past.

Brown Pelican and Cormorants

Brown Pelicans (*Pelecanus occidentalis*) breed on both the Atlantic and Pacific coasts of temperate and tropical North and South America. On the Pacific coast, they nest from central South America north to Anacapa Island (Palmer 1962). In former years, Brown Pelicans bred as far north as Bird Island, near Point Lobos, Monterey County, California (Baldridge 1973). The California Brown Pelican (*P. o. californicus*) is presently on California's endangered wildlife list.

The historical record shows that Brown Pelicans have bred, at least intermittently, on Prince Island, Santa Cruz Island (Scorpion Rock), Anacapa Island, and Santa Barbara Island. There is no good evidence of Brown Pelicans having bred on any of the other Channel Islands. At present, varying numbers of pelicans breed regularly on Anacapa Island and occasionally on Scorpion Rock (Gress 1970, Anderson and Hickey 1970, Anderson *in litt.*). Brown Pelicans no longer breed on any of the other Channel Islands. Additionally, their population has declined to perhaps ten per cent of its former maximum in numbers. Since Brown Pelican breeding numbers normally seem to fluctuate in this area at the periphery of their breeding range, it is difficult to know the true extent of their decline. The data available suggest that the major decline occurred in the late 1960s and early 1970s and was accompanied by eggshell thinning and reproductive failure (Gress 1970, Anderson and Hickey 1970, Anderson *in litt.*).

Double-crested Cormorants (*Phalacrocorax auritus*) are widespread as a nesting species in North America, with Pacific coast colonies reported from southwestern Alaska to Baja California (Amer. Ornith. Union 1957). Once a very common breeder in the Channel Islands (Howell 1917), the number of Double-crested Cormorants has decreased over the years until at present only a remnant population persists (Table 3). Gress *et al.* (1973) have presented an overview of the decline of Double-crested Cormorants along the coasts of southern and Baja California. Double-crested Cormorants are still present in small numbers at historically documented colonies (Prince, Anacapa, and Santa Barbara Islands). For example, at Santa Barbara Island in 1939, Sumner (1939) reported approximately 2,000 individuals beginning to nest. In 1977, 67 pairs nested.

The decline probably involves several factors. Grinnell and Miller (1944) commented that the reduction of Double-crested Cormorants in inland California was related to human disturbance (*e.g.*, Willett 1933, Moffitt 1939). Increased human activity in the Channel Islands, including commercial and recreational boating, low-flying private and military aircraft, and increased public access to major colonies, undoubtedly has contributed to what appears to be a long-term decline. Gress *et al.* (1973) documented reproductive failure due to eggshell thinning in the late 1960s in colonies off southern California and in Baja California. This decline in breeding success, correlated with the presence of persistent chlorinated hydrocarbons (DDE) in the ocean environment, apparently caused a recent dramatic, short-term decrease in Double-crested Cormorants. Ainley and Lewis (1974) also suggested that an early beginning of the decline in Double-crested Cormorants may have been related to the disappearence of the fishery-depleted sardine stocks off California.

During 1975-1977, changes in Double-crested Cormorant populations and reproductive

TABLE 3. Estimated numbers of pairs of cormorants breeding in the California Channel Islands, 1975-1977.

Island	Double-crested Cormorant	Brandt's Cormorant	Pelagic Cormorant
San Miguel	0	27-42	100
Castle Rock	0	363-916	15-34
Prince Island	75	860-907	10-20
Santa Rosa	0	500-700	60
Santa Cruz	0	45	4-25
Gull Island	0	23-67	0-4
Scorpion Rock	0	0	0
West Anacapa	3-15	0-1	0-1
Middle Anacapa	0	0-2	0-2
East Anacapa	0	0	0
San Nicolas	0	133-170	0
Santa Barbara	7-10	27-73	0-2
Sutil Island	30-60	70-93	0-2
Shag Rock	0	0	0
Santa Catalina	0	0	0
Bird Rock	0	0	0
San Clemente	0	15	0
Bird Rock	0	0	0

success indicated that this species may be beginning to make a comeback on the four islands (Prince, West Anacapa, Santa Barbara, and Sutil) where it presently nests. Between 1975 and 1977, the number of nests counted on each of these islands increased and adults were successfully fledging young in all colonies. It will be important to monitor these populations carefully to determine if they are in fact beginning to recover their former numbers.

Brandt's Cormorants (*P. penicillatus*) breed along the Pacific coast of North America from Washington south to Baja California (Palmer 1962). They are the most abundant cormorant in the Southern California Bight, where they nest on seven of the eight Channel Islands.

The present numbers and distribution of Brandt's Cormorants in the Channel Islands are given in Table 3. As with Double-crested Cormorants, major historical colonies are still occupied, but with reduced numbers. Wright and Snyder (1913) reported a colony of about 350 pairs of Brandt's Cormorants and another "fair-sized colony" on Santa Barbara Island in 1912, while Crossin and Brownell (1968) estimated 4,000 pairs of cormorants on Prince Island and Castle Rock as late as 1968. Present numbers on these islands are much lower (Table 3). The reasons for this decline are not known, but two factors may have had overriding effects. The deleterious influence of human activity on cormorant colonies cannot be overstated. Incubating adults are quick to abandon nests, thus exposing eggs or young chicks at the slightest disturbance. Western Gulls are equally quick to find a meal in the momentarily abandoned nests. As an example of this behavior, the following observations were reported by Crossin and Brownell (1968) during a survey that POBSP personnel made of Prince Island on 15 May 1968:

> Nesting [of Brandt's Cormorant] 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.

Huber (1968), also working on the POBSP project, visited Prince Island two weeks after the above survey. Regarding Brandt's Cormorant, he reported, "One nest with a medium downy chick and two with one egg found. No other active nests could be found from at least 1500 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 poorly-timed disturbance) can have disastrous effects, possibly foiling breeding efforts completely for a season.

Another factor that has probably contributed to the decline of Brandt's Cormorants in the Channel Islands is lowered productivity due to eggshell thinning. Because of the attention Brown Pelicans received during the "pesticide period" in southern California, the plight of Double-crested Cormorants, which often nest in the same colonies, also came to light. While eggshell thinning was not extensively investigated in Brandt's Cormorants, R. Lust (*in litt.*) reported thin and collapsed eggshells in the San Nicolas Island colony in the early 1970s. It is likely, then, that this species was also affected by the same environmental pollutants that affected the pelican and Double-crested Cormorants.

The Pelagic Cormorant (*P. pelagicus*) is the smallest of the cormorants that occur in the north Pacific, nesting from Japan through Alaska and south to northern Baja California, Mexico (Palmer 1962). In the eastern Pacific, the Channel Islands are presently the southernmost breeding limit for this species. Nesting may occur on Islas Los Coronados, and possibly on islands further south, but probably not regularly (J. Jehl, pers. comm.). Now, as at the turn of the century (Howell 1917), Pelagic Cormorants are the least numerous of the three species of cormorants which breed in the Bight.

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 such as the storm petrels and alcids. Pelagic Cormorants, in particular, do not occur in large, impressive colonies as do the other species of cormorants, making them even less subject to comment. Early accounts (Willett 1910, Howell 1917) reported Pelagic Cormorants breeding commonly among the northern chain, especially at San Miguel Island, and somewhat sporadically at Anacapa and Santa Barbara Islands. There is little or no indication that they bred on any of the remaining southern islands (San Nicolas, San Clemente, or Santa Catalina).

There seems to have been little change in the overall numbers and even less in the breeding distribution of this species in the Channel Islands (Table 3). As with the other two species of cormorants, Pelagic Cormorant colonies are found only on the northern sides of islands.

Western Gull

The breeding range of Western Gulls (*Larus occidentalis*) extends along the Pacific coast of North America from Washington to Baja California. Western Gulls are strictly coastal, rarely

wandering either far out to sea or inland. In former times they may have nested fairly commonly along the mainland of southern California (Evermann 1886, Miller 1936), but they do not do so now (Small 1974).

Western Gulls are the most widespread breeding marine bird in the Channel Islands, nesting on every island and offshore rock of any size (Table 1). Workers in the past rarely did little more than note their presence around colonies, describing them as "common" or "abundant" (e.g., Grinnell 1897, Willett 1910). There seems, however, to have been no shift in the location of colonies and few, if any, obvious changes in population size since the early 1900s. The Western Gull is probably the only marine bird nesting in the Bight that may be benefiting from the advance of civilization, often using refuse from garbage dumps and offal from fishing vessels to enhance their livelihood. Recently, female-female pairing has been found in this species (Hunt and Hunt 1977), the cause of which is presently unknown.

Murres, Guillemots, Murrelets, Auklets, and Puffins

The Common Murre (*Uria aalge*) is a boreal, low-arctic species that breeds in the north Atlantic and eastern Arctic Oceans; in the north Pacific it breeds from Japan to California, including the Bering Sea (Tuck 1960). Nesting murres formerly occurred as far south as San Miguel Island, but the southernmost colony is presently at the Farallon Islands (Small 1974). Common Murres bred in the Channel Islands until at least 1912 (Wright and Snyder 1913), but have not been recorded breeding there since. Nesting was documented only on Prince Island.

No Common Murres were found breeding at Prince Island 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 on the northwest side of Prince Island. No other sightings of murres associated with islands were made during the course of this study.

The disappearance of nesting Common Murres from the Bight parallels the disappearance of nesting Tufted Puffins, another large alcid that 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 1940s. Since Common Murres were already absent by the late 1920s, other factors were undoubtedly responsible for their disappearance. The tiny colony at Prince Island was approximately 470 km south of the closest murre colony at the Farallon Islands. Egg collectors visiting Prince Island in the early 1900s took at least as many as 50 egg sets in some years (Appleton, unpubl. notes in the Western Foundation of Vertebrate Zoology) from a colony that was never reported to have more than 100 nesting pairs. 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, changes in the marine environment resulting in a reduction in food availability cannot be ruled out.

Pigeon Guillemots (*Cepphus columba*) breed only in the north Pacific, from the Kuril Islands through the Bering Sea region and south to southern California (Udvardy 1963). The southernmost breeding station in the eastern Pacific is in the Channel Islands, at Santa Barbara Island, although individuals have occasionally been seen as far south as Islas Los Coronados, off northern Baja California (Jehl 1977, D. Povey, pers. comm.).

Pigeon Guillemots are completely absent from the Southern California Bight during the fall and early winter (presumably they disperse northward), but return each spring to breed. Careful estimates of population size have rarely been recorded and, given the secretive nesting habits of Pigeon Guillemots, the available data only give us rough estimates of past abundance. It appears that this species has bred regularly along the northern sides of San Miguel, Santa Rosa, and Santa Cruz Islands, where they nest in damp sea caves. Likewise, Pigeon Guillemots have apparently bred regularly at Santa Barbara Island, having been recorded for at least 11 separate years between 1897 and 1975. Nesting on Anacapa Island seems to have been only sporadic

TABLE 4. Estimated numbers of pairs of alcids breeding in the California Channel Islands, 1975-1977.*

Island	Pigeon Guillemot	Xantus' Murrelet	Cassin's Auklet
San Miguel	200	+?	
Castle Rock	100	+?	10
Prince Island	150	75	1,000+
Santa Rosa	125+	?	10,000
Santa Cruz	200+	?	-?
Gull Island	0	1	-?
Scorpion Rock	4	+?	75
Offshore rocks	?	?	50
West Anacapa	0	?	10
Middle Anacapa	5	?	-?
East Anacapa	0	1+	-?
San Nicolas	0	-?	-?
Santa Barbara	45	1,500	75
Sutil Island	15	75	35
Shag Rock	?	15	0
Santa Catalina	0	0	0
Bird Rock	0	0	0
San Clemente	0	1+	0
Bird Rock	0	0	0

* Symbols as in Table 1.

and apparently they have never bred at San Nicolas, Santa Catalina, or San Clemente Island, despite statements in the literature that they occurred at San Nicolas Island (Evermann 1886).

Estimates of present numbers of breeding Pigeon Guillemots are given in Table 4. As with other primarily northern species, guillemot populations in the California Channel Islands are concentrated in the western portion of the northern islands, with smaller numbers present at Santa Barbara Island. During the present study, no Pigeon Guillemots were found nesting on San Nicolas, Santa Catalina, or San Clemente Island. Despite the somewhat fragmentary nature of the historical record, Pigeon Guillemot numbers and distribution seem to have changed very little in this century.

The entire breeding range of Xantus' Murrelets (*Endomychura hypoleuca*) is restricted to the coast between central Baja California and Point Conception, California (Udvardy 1963); the northernmost colony occurs on San Miguel Island. Jehl and Bond (1975) delimited the breeding ranges of the two well-marked subspecies and suggested they may be acting as distinct species. Generally, only the form *E. h. scrippsi* breeds in the Channel Islands, but a single *E. h. hypoleuca* was recorded nesting on Santa Barbara Island in 1977 and was found in the same nest hole in 1978, paired to a bird intermediate between the *scrippsi* and *hypoleuca* forms (J. Wingfield, pers. comm.) described as typical of San Benitos Island (Jehl and Bond 1975).

Historically, Xantus' Murrelets have been recorded breeding in small numbers on Castle Rock and Prince Island off San Miguel Island and on Scorpion Rock off Santa Cruz Island. They were apparently moderately common at Anacapa Island, with several sets of eggs taken at the beginning of the century. On Santa Barbara Island, early investigators (Cooper 1870,

Grinnell 1897, Wright and Snyder 1913, Sumner 1939) found little or no evidence of this species, suggesting it was very rare there. For the remaining three southern islands (San Nicolas, San Clemente, and Santa Catalina), the only breeding record is on Bird Rock, Santa Catalina Island (D. Bleitz, unpubl. notes 1967).

The present breeding distribution of Xantus' Murrelets in the Channel Islands is similar to that recorded early this century. Small populations persist in the San Miguel Island area and, while only one pair was found on Gull Island, it is likely that a few murrelets may use the cliffs of Santa Cruz Island. The population on Anacapa Island has apparently declined; evidence of but a single pair was found on East Anacapa Island during this study. The presence of introduced rats on Anacapa Island may have been responsible for this drop in numbers. In contrast, the population of murrelets on Santa Barbara Island is probably greater than it has been at any time this century. It is inconceivable that ornithologists exploring the island in the past would not have remarked on the large numbers of birds that visit the island at night and are conspicuous with their loud and frequent calling. On 11 June 1977, a shell of a murrelet egg that had hatched earlier in the season was found in a rocky crevice in the Seal Cove area of San Clemente Island, thereby confirming breeding on this island. However, the almost insignificant murrelet population at San Clemente Island is probably rigorously held in check by the abundant terrestrial predators there and by the lack of offshore rocks. No murrelets were found breeding at San Nicolas or Santa Catalina Island, probably due to the lack of nesting sites safe from terrestrial predators.

Hence, only at Santa Barbara Island have Xantus' Murrelets shown a significant population change since the turn of the century. The dramatic increase recorded there may be related to the disappearance of two predators, one introduced and one natural. According to Howell (1917), cats were introduced on Santa Barbara Island sometime between 1897 and 1908 and subsequently destroyed many of the murrelets. By 1975, when the present study started, the Santa Barbara Island cat population had been substantially reduced, possibly to a single animal, and the Xantus' Murrelet was one of the most abundant breeding birds on the island.

The significant increase in murrelets at Santa Barbara Island in recent years may also be the result of the elimination of the Peregrine Falcon (*Falco peregrinus*). Willett (1933) described the falcon as a "fairly common resident" among the islands, and Howell (1917) indicated they bred on Santa Barbara Island. During 1975-1977, no Peregrine Falcons were definitely known to have bred on the Channel Islands, and certainly none bred at Santa Barbara Island during those years (though single, migratory birds were present there during parts of April and May in 1975 and 1976). In discussing the food preferences of Peregrine Falcons nesting on Langara Island, British Columbia, Nelson and Myers (1976) indicate that Ancient Murrelets were the falcons' major prey species, with a falcon family taking approximately 1,000 murrelets there yearly. Hence, even a single pair of Peregrine Falcons nesting at Santa Barbara Island could exert a tremendous impact on the murrelet population. We suspect that the relatively high number of Xantus' Murralets that now occurs at Santa Barbara Island is a result of the elimination of both cats and falcons from the island.

Cassin's Auklet (*Ptychoramphus aleuticus*) has the most extensive breeding range of any alcid in the eastern Pacific, nesting from the Aleutian Islands of Alaska to Isla San Roque off Baja California (Udvardy 1963). It is the most abundant marine bird breeding in the Southern California Bight.

Historically, Cassin's Auklets have had large colonies at Castle Rock and Prince Island off San Miguel Island, at Scorpion Rock off Santa Cruz Island, and at Santa Barbara Island. The Santa Barbara Island population has undergone a major change within historical times. When Grinnell visited the island in 1897, Cassin's Auklets were "breeding in large numbers" (Grinnell 1897), but they had completely abandoned the island by 1908 when Howell (1917) surveyed it. Willett (1912) visited Santa Barbara Island in 1911 and concluded that Cassin's Auklets "had been exterminated by the cats with which the island is infested." Willett (*op. cit.*) also mentions, however, that he found "a colony of about a hundred pairs of Auklets nesting . . . on a detached rocky islet [Sutil] about a quarter of a mile from the main island." This small population was apparently spared the ravages of introduced cats and persists to this day. Sumner (1939) visited Santa Barbara Island 28 years later and wrote that cats were "decidedly abundant." He added, "At one time large colonies of auklets and murrelets were present on the island but none has been recorded in recent years and it is supposed that they have been exterminated by these feral cats." This colony has yet to regain its former numbers despite the reduction in the number of cats on the island.

Populations in 1975-1977 were high at San Miguel Island, especially at Prince Island and Castle Rock, where over 99 per cent of the Channel Islands population occurs. On all the other islands auklet numbers were relatively low (Table 4). It is not known whether the small colony found at Santa Barbara Island in 1977 is the result of a relatively new invasion or a remnant of the old population.

Ainley and Lewis (1974) have discussed periodic upheavals in the Cassin's Auklet population nesting on the Farallon Islands. During periods of unusually strong countercurrent off the California coast, warm water occurs farther north than usual and is associated with decreased upwelling and productivity. Ainley and Lewis (*op. cit.*) attributed an auklet population crash on the Farallons in the mid-1800s to an especially pronounced and prolonged warm-up period. However, declines in the Channel Islands populations (Santa Barbara Island between 1897-1908, Prince Island possibly during 1919 and 1927) do not appear to be correlated with warm-water periods in the Southern California Bight (summarized in Southern California Coastal Water Research Project, 1973), so other factors may be responsible.

Tufted Puffins are primarily residents of 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, nesting on Prince, Santa Cruz, Anacapa, and Santa Barbara Islands (Howell 1917).

Tufted Puffins no longer breed on the Channel Islands, and none were found on or around any of the traditional sites during 1975-1977. At present, they do not breed farther south than the Farallon Islands (Ainley and Lewis 1974).

Formerly, breeding Tufted Puffins were concentrated in the San Miguel Island area, with smaller, more peripheral populations occurring on the remainder of the Northern Channel Islands and Santa Barbara Island. Also, as a corollary, puffins appear to have remained in the San Miguel Island area longer than on other islands in 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. 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 (Baily 1902, Bent [1919] 1946), and nested in relatively inaccessible cliff areas in the Channel Islands (Streator 1888, Wright and Snyder 1913), 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 may well have been responsible for Tufted Puffins abandoning their southernmost breeding stations in the eastern Pacific. Udvardy (1963) has drawn a parallel between the distribution of Tufted Puffins in the north Pacific and the distribution of the Steller's Sea Lion (*Eumatopias jubata*). The southernmost breeding site of the sea lion is presently at San Miguel Island. This population has declined dramatically since the 1930s and also appears to be losing its foothold in the Channel Islands (Bartholomew and Boolootian 1960, Le Boeuf *et al.* 1976, see discussion in Ainley and Lewis 1974).

DISCUSSION

Distributional Patterns

As Hubbs (1967) and many others have pointed out, the Channel Islands provide a meeting ground for northern and southern species of various diverse faunal groups. Forms that typically occur north of the Bight occur most commonly at the west end of the northern chain of islands, while the east end of the northern chain and the southern islands show a predominance of species with southern affinities.

The reasons for these disjunct distributions and the juxtaposition of "antithetical" ecotypes are directly related to the oceanographic features of the Bight (reviewed by Jones 1971). The westernmost Channel Islands, particularly San Miguel Island, are influenced predominantly by the cool, southward-flowing waters of the California Current. During the spring and summer months, upwelled waters bathe the northwestern islands with cold, nutrient-rich water. This effect becomes less pronounced as one travels east along the northern chain and farther south. The southern and eastern islands are influenced to a greater extent by warmer, more tropical water carried north by the California Countercurrent.

As an indication of the abruptness of the change in these oceanographic conditions, seabirds which, because of their vagility, might not be expected to demonstrate clear zoogeographic patterns over such a small range do, in fact, show a striking parallel with the distribution patterns described above. Of the 13 species of seabirds known to have bred in the Channel Islands, five reach their southern breeding limits and three reach their northern limits within the Channel Islands. The remaining five species occur both north and south of the area (Fig. 2). All of the northern species have their greatest numbers in the San Miguel Island area, while southern species occur almost entirely on the islands of Santa Barbara and Anacapa. Species in the middle of their range are, predictably, more widespread in the Channel Islands, although concentrated in the San Miguel Island area.

Another factor of paramount importance affecting the distribution and numbers of seabirds breeding in the Channel Islands is the presence of the Island Fox (*Urocyon littoralis*) on all the major islands (San Miguel, Santa Rosa, Santa Cruz, San Nicolas, San Clemente, and Santa Catalina). Generally, all of the marine birds breeding in the Bight nest on the small, fox-free islands of Santa Barbara and Anacapa or are crowded onto tiny rocks and islets offshore of the other main islands. A few species that utilize relatively inaccessible habitats do manage to breed on some of the islands despite the foxes. At San Miguel and Santa Rosa Islands, Pigeon Guillemots and Pelagic Cormorants commonly breed in sea caves and on steep sea cliffs, respectively, which offer safety from predators. However, carcasses of guillemots found in fox dens at San Miguel Island suggest that the distributions of these species may also be limited by the foxes. The only island with foxes that supports a sizeable seabird population is San Nicolas Island, where the reason for the persistence of the large gull colony and cormorants breeding at the northwest end is not immediately apparent. The gull colony now appears to be about the largest it has ever been, at a time when Laughrin (1978) reports that the population level for the fox has become "critically low." Seabird populations at San Nicolas Island may fluctuate in response to the fox population, but additional data are needed to determine this.

The most important seabird colonies in southern California are located on three islands. San Miguel Island supports by far the largest and one of the most diverse seabird colonies in southern California, with most of the breeding seabirds concentrated on two small islets: Prince Island and Castle Rock. Sixty per cent of the seabirds nesting in the Channel Islands occur at San Miguel Island and seven of the eleven species that breed in the Bight have their most important colonies there (Leach's and Ashy Storm Petrel, Brandt's, Double-crested, and Pelagic Cormorants, Pigeon Guillemot, and Cassin's Auklet). The largest Xantus' Murrelet

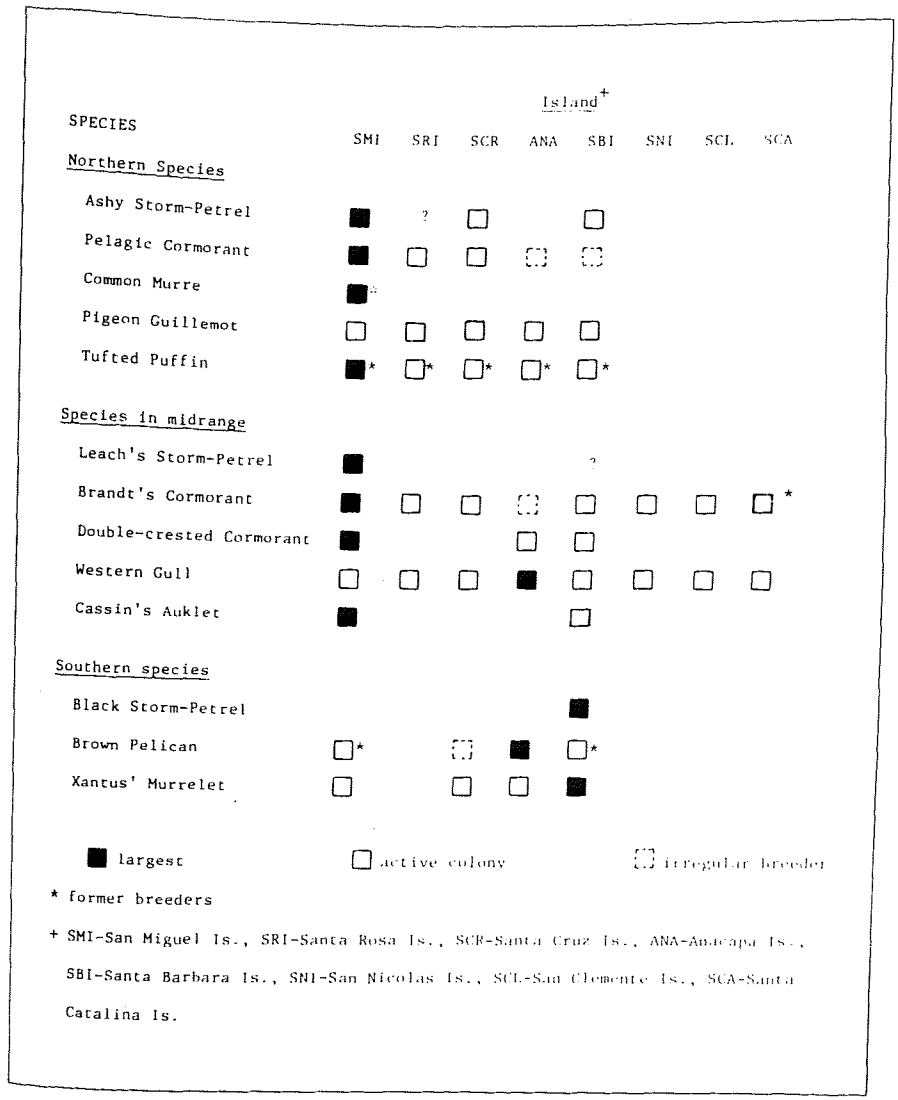

FIGURE 2. *Distribution of seabirds breeding on the Channel Islands, 1975-1977.*

colony in the United States, and possibly the world, occurs on Santa Barbara Island, as does the only colony of Black Storm Petrels in the United States. Anacapa Island is the only place in California where the Brown Pelican breeds regularly and is also the site of the largest Western Gull colony in the Channel Islands. These three islands support the most important seabird colonies in the Southern California Bight.

Population Changes

The populations of a number of seabirds nesting in the Southern California Bight have changed remarkably during historical times. Some of these species, such as the Common Murre and the Tufted Puffin, were northern species at the southern edge of their range. Their demise may have been the result of natural, random fluctuations in a peripheral population, or a response to human disturbance at the colony (in the case of murres) or to diminished food resources (in the case of puffins, see Ainley and Lewis 1974).

Major declines in the Brown Pelican, Double-crested Cormorant, and Brandt's Cormorant undoubtedly find a common cause in their sensitivity to disturbance on the nesting grounds and in reproductive failure due to ingestion of chlorinated hydrocarbons. With the apparent decrease in eggshell thinning following the reduction of environmental pollution by chlorinated hydrocarbons (Anderson *et al.* 1975), these species now have a reasonable chance of regaining their former numbers if their nesting areas are left free of further disturbance.

Major changes in the populations of Xantus' Murrelets and Cassin's Auklets on Santa Barbara Island appear to have been influenced by a combination of changes in predation pressure, particularly the introduction and eventual removal of terrestrial predators and the disappearance of the Peregrine Falcon as a breeding species in the Channel Islands. The causes of apparently large fluctuations in the auklet population at Prince Island, as suggested by the historical record, are not known, however.

It is not at all clear why the murrelets have expanded their population at Santa Barbara Island more rapidly than have the auklets. It is possible that the tendency of Xantus' Murrelets to remain paired throughout the year preadapts them for colonizing an area rapidly; auklets, however, are also capable of rapid recolonization (*cf.* Prince Island with Farallon Island; Ainley and Lewis 1974). It would be most interesting to know the circumstances under which these species managed to reinvade and expand populations on islands from which they were once extirpated. Such information would be valuable for the long-term conservation of seabirds in the Southern California Bight and elsewhere.

Probably by far the greatest single agent of change affecting seabird populations in southern California has been the activities of man. Almost nothing is known about the prehistory of the Channel Islands marine bird populations. However, for thousands of years prior to the earliest Spanish explorations in the area, native California Indians lived on all the larger Channel Islands. In their search for food they undoubtedly used nesting seabird populations, although whether they made regular sorties to the offshore colonies is not known. With the advent of European exploration, starting with the "discovery" of the Channel Islands by Juan Cabrillo in 1542, the seabird fauna of the islands has endured much hardship in its association with man. Prominent in a list of misdeeds has been the introduction of exotic animals. Introduced predators, such as cats and rats, have found easy prey among the seabirds that have little or no defense against terrestrial predators. The numerous herbivores left behind by settlers (*e.g.*, sheep, goats, mules, rabbits) have altered, in some cases radically, the environments of the islands through overgrazing, causing habitat destabilization and loss through erosion.

During the earlier part of this century, numerous egg and specimen collectors made dozens of visits to the colonies during the height of the breeding season to further their avocations. Often colonies were disturbed year after year and declines in some seabird populations were no doubt the result of these activities.

From 1942 until 1965, San Miguel Island was used as an aerial bombing range and missile target area by the U.S. Navy. D. Bleitz (pers. comm.), who visited the area in the 1950s and 1960s, reported seeing the top of Prince Island cindered after one of these exercises. Since 1965, however, the island has not been used as an impact area (Kolipinski 1976). The northwest end of San Nicolas Island has also been used as a target zone.

Adverse impact on the Channel Islands seabird colonies has prevailed even into the present time where applied technology has broadened the effects man is having on his environment. Chemical pollution of ocean waters has threatened the existence of several species nesting on the islands. Oil spills and contamination are ever-present and increasing hazards. Short-sighted fishery policies, which have led to disastrous effects in some parts of the world (*e.g.*, the anchovy fishery of Peru), could, if repeated, have the potential of damaging marine bird populations in the Bight by disrupting food cycles. Increased human activity in the Bight in the form of boat and air traffic has added to the amount of disturbance in the colonies (*e.g.*, foot traffic, shooting, sonic booms).

It is possible now, though, with the three most important seabird colonies in the Bight finally under the protection of the U.S. National Park Service, that these populations will be able to maintain or increase their numbers. Only with adequate protective measures, backed by effective monitoring, can we retain a healthy and diverse marine avifauna in the Channel Islands.

SUMMARY

The Channel Islands of the Southern California Bight presently support breeding colonies of 11 species of primarily marine birds: Leach's Storm Petrel (two or more pairs), Ashy Storm Petrel (600 ±100 pairs), Black Storm Petrel (*ca.* 75 pairs), Brown Pelican (75 to 400 pairs), Double-crested Cormorant (115 to 160 pairs), Brandt's Cormorant (2,075 to 3,025 pairs), Pelagic Cormorant (190 to 250 pairs), Western Gull (2,400 to 2,800 pairs), Pigeon Guillemot (*ca.* 850 pairs), Xantus' Murrelet (*ca.* 1,650 pairs), and Cassin's Auklet (*ca.* 11,150 pairs).

The largest populations of nesting seabirds occur at San Miguel Island (14,000 to 15,000 pairs), with smaller populations on Santa Barbara Island (3,400 pairs) and Anacapa Island (3,000 pairs). In contrast, San Clemente Island and Santa Catalina Island support but 75 pairs and 30 pairs, respectively. Populations of breeding seabirds are generally greatest on the small, fox-free islands and offshore rocks; with the exception of San Nicolas Island, large islands with populations of the Island Fox support few nesting seabirds. The westernmost of the northern islands support many species at or near the southern limits of their range, while species with more southern affinities, except for the pelican, have but small populations north of Santa Barbara Island.

Populations have changed for several species of seabirds in southern California during historical times. Common Murres and Tufted Puffins used to nest on the islands but no longer do so. Numbers of pelicans, cormorants, and Cassin's Auklets have decreased, while numbers of Xantus' Murrelets have increased. Many of these changes can be directly or indirectly linked to the activities of man.

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