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STUDIES OF MARINE MAMMALS AT THE FARALLON ISLANDS,
CALIFORNIA, 1977-1978

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ABSTRACT

Observations on pinnipeds and cetaceans on or near the South Farallon Islands are reported for the ninth consecutive year, the fourth consecutive year under contract to the Marine Mammal Commission. Five species of pinnipeds and three of cetaceans were censused and observed from 1 September 1977 to 31 August 1978. These islands provide a unique opportunity for comparative studies of colonization by pinnipeds and of long- and short-term fluctuations in offshore pinniped and cetacean populations of the area.

The peak number of gray whales was seen in the second week in January with an average of 18.7 animals per day migrating south. A high count of at least 42 individuals was made on 7 January. Although up to 5 gray whales have been seen summering near the Farallones since 1972, none were observed during 1978. For the second consecutive year humpback whales were sighted during the spring in addition to the usual fall sightings. One recognizable individual was seen in both fall 1977 and spring 1978. A pod of 2 killer whales was seen 2 November 1977 and another pod of 8 or 9 individuals was seen in March 1978.

The 1978 natality rate of Steller sea lions remains low and the pup mortality of 56% was greater than in previous years. Large numbers of pups not born on S. E. Farallon have been seen during fall and winter censuses. For the first time in 4 years no Zalophus pups were observed on the Farallones. Numbers of Zalophus increased dramatically in summer, reaching a peak of 2300 in the fall 1978 (an increase of 45%). The analysis of Zalophus diet by examination of regurgitations showed unusual seasonal diet changes in 1978. Several hypotheses for this diet shift are presented.

Sightings of northern fur seals have increased. A recognizable individual was present in August 1977 and in June and July 1978.

The harbor seal population continued to grow with a high count of 40 animals seen 17 July 1978. This is an increase of 53% over 1977. Only 2 pups were observed during the breeding season.

The elephant seal population also increased (by 40%) during 1978, with a spring peak of 731 animals. During the breeding season 133 pups were born. Pup mortality was 26%, much of it due to severe winter storms. Although much of the Farallon breeding population is still young, it appears to be maturing as more recognizable cows and bulls return year after year. A 3-year-old female born on the Farallones in 1975 returned to pup: she is the first Farallon-born animal to enter the breeding population. The number and percent of copulations by bulls other than the dominant bull increased again in 1978 indicating another step in the change from territoriality to social hierarchy among the breeding bulls. Cows on the Farallones were observed nursing alien pups when their own pups died. Tag returns have given us increased information on immigration to the Farallon colony and interchange between the Farallones and Ano Nuevo Island. An immigrant from Guadalupe Island - a yearling male - was sighted for the first time on the Farallones.

An appendix contains information on censuses of marine mammals in the Gulf of the Farallones from the Golden Gate Bridge to S. E. Farallon Island between 1971 and 1977. Marine mammals were sighted on 56 out of 168 censuses. Five species of cetaceans (killer whale, gray whale, harbor porpoise, Dall's porpoise, white-sided dolphin) and 3 species of pinnipeds (California sea lion, Steller sea lion, northern elephant seal) were seen. The most frequently seen species was the harbor porpoise.

INTRODUCTION

Many reports describing the wildlife of the Farallon Islands, California, have appeared since 1854 (see review by Ainley and Lewis 1974; Ainley et al. 1975), and most have briefly mentioned marine mammals. The first real census work on Farallon pinnipeds was done by Bonnot and is summarized in Bonnot et al. (1938). Little attention has been paid these animals since, yet interesting changes providing insight into their biology and ecology have been occurring in some of the populations and are reported herein, in Le Boeuf et al. (1974), Ainley et al. (1975, 1976, 1977).

Three pinniped species have recently established, or seem to be in the process of establishing, breeding populations at the Farallones. A fourth species which probably was a former breeding species is increasing the frequency of its visits. This provides a unique opportunity to study comparable colonization processes by pinnipeds. A fifth species has been declining rapidly in number, yielding another opportunity to learn about changes in wild populations. Since biologists from the Point Reyes Bird Observatory (PRBO) are present year round on this remote natural laboratory, these opportunities are not being ignored. PRBO looks forward to maintaining a station on Southeast Farallon indefinitely, thus insuring collection of long-term data sorely needed to understand short- and long-term fluctuations in marine mammal populations. Results of studies during our first three Marine Mammal Commission contract years, 1974-75, 1975-76, 1976-77, as well as results from the four years' preceeding Commission support, are reported in Ainley et al. (1975, 1976, 1977). This report presents data collected in 1977-1978 including updates of previous work.

THE FARALLON ISLANDS

Southeast Farallon and West End, shown in Figure 1, compose the South Farallon Islands (or South Farallones which, with several other close by large rocks, comprise about 44 hectares (100 acres). The North Farallones, three large rocks, lie 8 km north. The South Farallones lie 43 km west of San Francisco, California, and 32 km from the closest land, Point Reyes, directly north, and Bolinas Point to the northeast. The islands are on the brink of the continental slope with deep oceanic waters lying immediately westward and shallow inshore waters lying eastward. The islands are positioned at the eastward edge of the cold, productive waters of the California Current.

Few other places in the eastern North Pacific provide habitation for the number and variety of wildlife that occur at the Farallones: twelve breeding species of seabirds with a combined population of over 250,000 constitute the largest seabird breeding colony in the United States outside of Hawaii and Alaska; more than 325 species of birds have visited the islands; and five species of pinnipeds, at least four and perhaps all of which have bred on the islands. Sea otters also are said to have bred at the Farallones.

During the 1800's and through the early 1900's the Farallones were subjected to much disturbance by humans. Sealers exterminated fur seals, elephant seals, and sea otters, and hunted sea lions for food during the early 1800's (Scammon 1874; Riddell 1955; Doughty 1971). In 1854 a lighthouse was established and has been maintained continuously since. For most of that period at least four families, with their associated pets and mules, lived

on the Farallones year round. In 1854 a commercial egg company began an unregulated harvest of seabird eggs that continued until the early 1900's with apparently little regard for other wildlife. During recent years the presence of the U.S. Coast Guard deterred visitors but its present use of helicopters to maintain the automated navigational aids has not been beneficial to wild animals. The Farallones, with the exception of the South Farallones, have been a federal wildlife refuge since 1900. In 1969, the South Farallones were included. Because of the islands' relative remoteness, not much active protection had been practiced until PRBO personnel set up a station in April 1968. When the Coast Guard automated its equipment in 1972, PRBO entered into a cooperative agreement with the U.S. Fish and Wildlife Service whereby, in return for the privilege of working there and aiding in maintenance of facilities, PRBO provided a "presence" and helped coordinate the activities of other persons wishing to conduct studies there. The seabird populations have responded dramatically to the gradually lessening disturbance over the past decade (Ainley and Lewis 1974; PRBO unpubl.).

METHODS

With the exception of elephant seal censuses, little attention was paid the pinnipeds during the first few years of PRBO occupation. In 1971 and 1972 occasional counts of sea lions were made and in mid-1973 regular censuses were started. Since June 1974 censuses have been under contract to the Marine Mammal Commission.

Elephant seals have been counted regularly from blinds or from other points near their preferred haul out areas since 1970, daily during the breeding season and at least once a week during the rest of the year. Beginning in 1976 elephant seals were counted twice/week during the spring molt and fall haul out when the greatest number of animals is present. During the seabird breeding season (from the end of May to 15 August) we counted elephant seals from the lighthouse (elevation 109 m) to minimize disturbance to both birds and seals. The lighthouse census point renders counts slightly low, as portions of the seals' usual hauling out spots are not visible. However, few seals are present during most of that period and we consider the error relatively insignificant. Whenever possible the tag numbers of animals (tagged by PRBO and University of California personnel) were read with binoculars and recorded. Untagged animals were often recognized by individual characteristics (scars, etc.) which are kept on file.

The number of harbor seals hauled out varies greatly from one day to another. Whenever observed, their numbers have been recorded; since 1973 a conscious effort has been made to find them and they are now included in weekly censuses.

Censuses of sea lions were made between 1400 and 1600 hours. Twelve all-day watches in which sea lions were counted revealed that maximum numbers hauled out during these hours. Weekly counts were made from Lighthouse Hill and other vantage points using a 25x spotting scope. These counts included animals in the water.

Northern fur seals were recorded whenever observed.

Beginning in the fall 1970 cetaceans were recorded when sighted. During the course of other activities, the ocean to the south and west of the island was watched intermittently for at least 2 hours daily, weather permitting.

Cetacean sightings made by different observers (with binoculars and/or 25x spotting scopes) were totaled at the end of the day and duplicate sightings eliminated. In November 1977, in addition to continuing daily observations, more systematic watches for cetaceans were begun from Lighthouse Hill which provides an unobstructed 360° view of the ocean. Whales were identified with a 25x spotting scope. Lighthouse "whale watches" ranged in duration from 1 to 15 hours; shifts for each observer last 2 hours. During gray whale migration the number of grays crossing an east-west line and the direction of their travel were also recorded. Observations were stopped if visibility was less than 4 km or if the seas were greater than 2 feet.

CETACEANS

California gray whale (*Eschrichtius robustus*)

The peak number of gray whales was seen in daily observations during the southward migration in December and January (Table 1). The peak daily mean of 18.7 animals occurred in the second week in January; this is a small increase over the 1977 peak of 16.7 animals per day (Fig. 2). The high one-day count of 42 individuals (half as many as in the previous year) was made on 7 January. Our whale watch data from the lighthouse which we began in order to quantify the daily observations indicate that the peak number of gray whales passing the island (about 2/hr.) occurred during this same period (Table 2).

As in past years, the southward migration was quite synchronous; it was essentially over by the last week in January. In that week only 4 grays were seen during the normal daily observations and no grays were seen during a total of 7 hours of observation from the lighthouse.

The first gray whale we saw passing the island travelling north was on 31 January (Table 1). High daily counts during the northward migration were 25 animals on 17 February and 23 animals on both 24 February and 16 March.

Southbound gray whales were observed from the lighthouse to travel directly at a steady speed, with little observed interaction among pod members. The northbound animals observed in February and March however, were frequently observed to change course, stop, or interact with one another as they migrated. Some of this irregular movement was interpreted as feeding. The overall northward progress of individuals was generally slower than for southbound animals. Twice as many southbound grays passed between the island and the mainland as passed on the west side of the island. There was no such apparent preference during the northward migration.

In both lighthouse whale watches and daily censuses the low number of gray whales in the vicinity of the island after March was dramatically obvious (Table 1, Table 2). No gray whales were seen during 117 hours of lighthouse watches between April and August, although five individuals (including an adult with a calf) were observed briefly during the daily observations. Up to 5 animals have been seen summering near the Farallones since 1972 (Ainley et al. 1975, 1976, 1977); none were observed during 1978. This paucity of summering whales seems to reflect the lack of food in the waters around the island in 1978 which in turn appears to be due to poor upwelling and anomalously warm sea temperatures (shown by the water temperatures which we have measured daily since 1972 for Scripps Institution of Oceanography; see also water temperature data in NMFS (1978), which also indicates the warm water anomaly).

Another indication of the lack of food around the island in 1978 is the fact that the breeding productivity of Farallon seabirds was the poorest since we began to monitor it in 1971.

Humpback whale (Megaptera novaeangliae)

Humpback whales are usually seen from the Farallones in the fall during their migration from northern waters to their winter breeding grounds off Mexico (Leatherwood et al. 1972, Kellogg 1929). For the second consecutive year, humpback whales were sighted from the island during the spring in addition to the usual fall observations (Table 3). A high count of 4 individuals was sighted on 1 June 1978. Compared to the fall of 1976, in fall 1977 there were fewer individuals seen on any one day but humpbacks were seen over a longer period of time. One individual, identified by a distinctive notch on its back in front of the dorsal fin, was seen several times in both fall 1977 and spring 1978 (Table 3). Fall 1977 sightings also included an adult with an immature animal.

Robert Casebeer, a former San Francisco whaler, has indicated that humpback whales were "resident" seasonally around the Farallon Islands prior to San Francisco-based commercial whaling in the 1950's (Ronn Storro-Patterson, pers. comm.). If that was so, we may now be seeing a return by this species to the waters near the Farallones.

Killer whale (Orcinus orca)

Killer whales were seen from the island on two occasions during the past year, once in fall and once in spring. The fall sighting, made on 2 November 1977, was of two females or immature males. They were present briefly on the north side of the island. The spring sighting, made on 19 March 1978, was a pod of eight or nine individuals swimming south. That pod was composed of two adult males, at least four females, and two smaller animals. This sighting was nearly one month earlier than the previous earliest spring sighting made on 16 April 1977.

PINNIPEDS

Steller sea lion (Eumetopias jubatus)

As is true at other California offshore islands, the Steller sea lion population on the Farallones is 4 to 6 times lower than it was 40 to 60 years ago (Bonnot et al. 1938, Bartholomew 1967, Ainley et al. 1975). The Farallon population peaks in April and May when migrating animals haul out briefly, but the breeding population (present in June and July) appears to have stabilized at about 130 animals (Fig. 3). Populations studied in Oregon by Mate (1973) are similar to the Farallon population; both of these differ from the Ano Nuevo population which has peak numbers during the June and July breeding season (Orr and Poulter 1967, Gentry 1970).

The number of females present has remained constant since 1974 although the natality rate has varied from 9 to 24% (Table 4). The 1978 natality rate was 17% (18 pups born to 103 females) which is within previous ranges. How-

ever, the pup mortality of 56% (10/18) was greater than in previous years (Table 4). All deaths in 1978 were due to premature pupping which has been the major cause of death in Steller pups since observations began.

Between 11 February and 12 May 1978, 10 Steller sea lion fetuses were observed; three of these were not discovered for a few days, but all others had a female in attendance who was actively defending the fetus from marauding Western Gulls (Larus occidentalis). Only one of the cows (the first) was observed to have a pup of the previous year with her. Three of the fetuses found were collected and frozen immediately. They will be analysed by William Gilmartin of the Naval Oceans Systems Laboratory in San Diego, California for the presence of organochlorine pollutants and disease pathogens such as salmonella bacteria. Organochlorine pollutants are associated with premature pupping in California sea lions (DeLong et al. 1973) and salmonella bacteria is associated with abortions in sea lions (Gilmartin pers. comm.).

All 8 pups born after 21 May survived. Two of these births were observed - both were cephalic presentations and lasted less than 5 minutes. Three of the 8 cows each had a yearling with her as well as a new born pup. One cow also present during the breeding season in 1977 was recognized by a distinctive scar; she did not have a pup with her either year. In the spring of 1978 more cows were identified by distinctive scars and markings so that we can continue to look at the reproductive success of individual Steller cows in order to determine the reason for the low natality rate of Steller sea lions on the Farallones.

Since 1975 when we began to record the presence of Steller sea lions in specific locations on the island, there have been some site changes. For most of the year the Stellers are concentrated at Sea Lion Cove on the windward side of the island. In April and May when the population peaks, the Steller population expands eastward toward the more protected areas of Aulon Peninsula and Fisherman's Bay (Fig. 1). In previous years when pupping began in June most of the breeding population moved to Saddle Rock where the majority of pups were born. For the past 2 years, however, the cows have remained at Sea Lion Cove to pup. One possible explanation is the continued lack of disturbance at the Sea Lion Cove rookery since the departure of Coast Guard personnel in 1972 when PRBO biologists were left as caretakers of the island.

Another change among the Stellers evidenced in the last year is the immigration of pups and cows to S. E. Farallon in the fall and winter. In fall 1977 there were 6 more young of the year present in Sea Lion Cove than survived the previous breeding season. In January 1978, after a severe storm, there was a sharp increase in the number of cows and pups: 17 more pups were censused in Sea Lion Cove than were born on S. E. Farallon. Perhaps coincidentally, 17 is also the number of pups counted on the North Farallons in fall 1977. This information continues to intrigue us in our attempts to find out how much movement there is between the two groups of islands. Unfortunately, because of bad weather and boat limitations we have been unable to census the North Farallones during the breeding season.

California sea lion (Zalophus californianus)

For the first time in 4 years no Zalophus pup was observed on the Farallones during the normal pupping season although a female with a nursing yearling (pup of 1977) was seen at North Landing in March and April 1978 (i.e., just before the pupping season). Whether or not a pregnant female was present

later we cannot say for sure. In previous years almost all Zalophus adult and juvenile males departed in June, making it easy to locate the female. In 1978 more Zalophus remained throughout the summer than ever before (see below).

Since Zalophus censuses began on the Farallones, the outstanding characteristic in yearly fluctuations had been the existence of two peaks, one in late spring and the other in early fall, with the former far exceeding the latter in size (Fig. 4). Between the two peaks, numbers have usually reached close to zero as a result of animals migrating south to major summer breeding sites. The relative size of the two peaks has been opposite to those observed for coastal haul out sites in northern California and Oregon (see Ainley et al. 1977). In 1978, however, after a spring peak that was normal in size but delayed a few weeks, Zalophus remained in unusually high numbers throughout the summer and in August and September reached a number (2300) far exceeding that ever recorded on the Farallones even during the spring.

Based on previous years' work (Ainley et al. 1977) we hypothesized that the large spring peak at the Farallones, compared to the small spring peak at coastal sites, may be a response to the high availability, as prey, of Pacific hake (Merluccius productus) occurring offshore in spring. Comparing 1978 diet samples with 1974-77 samples (Table 5) indicates several interesting facts that may help to explain the differences in 1978 population dynamics. In other years, hake have predominated in the Zalophus diet beginning in April and lasting through August. During the remainder of the year the diet has been diversified. In those years Zalophus numbers showed a tremendous increase in April, reached maximum in early May and fell to near zero by late May. Animals began to reappear in August but numbers never came close to those in spring. Fall and winter numbers remained about the same. In 1978, hake did not predominate in the sea lion diet until May (a difference of one month), fell to very low in June (but were replaced almost completely by Sebastes spp., particularly S. goodei), and regained predominance in July and August. During 1978, hake were much more abundant in September and November diet samples than in other years (although October and November 1978 samples are small). The late spring peak in sea lion numbers during 1978 perhaps relates to what may have been a delayed migration of hake, and the higher fall sea lion numbers in 1978 may be due to hake being more available than in previous fall seasons. The unusual events in Zalophus population dynamics are thus consistent with unusual seasonal diet changes in 1978, and together both tend to support our earlier hypothesis that the availability of hake strongly affects the migration of California sea lions. The delay in hake migration during 1978, as suggested by the sea lion diet analysis, may have resulted from the anomalously high spring and summer sea temperatures in the eastern Pacific (NMFS 1978).

Northern fur seal (Callorhinus ursinus)

Over the last two years sightings of northern fur seals on S. E. Farallon Island have increased dramatically. There were 10 sightings in the year between 19 July 1977 and 3 August 1978, and only 4 sightings in the 8 years before that (Ainley et al. 1975, 1976).

An immature male, recognizable by a broken digit on his left hind flipper, hauled out in Sea Lion Cove on 14 August 1977. This same animal was seen in 1978, in the same place, 27-30 June and 15-20 July. Single immature male fur seals were also sighted at Sea Lion Cove 29 September 1977, 9-10 June and 13 August 1978. It is possible these were also the same individual. Three

other fur seals were seen in the water near the island on 3 and 21 September 1977 and 6 March 1978.

This increase in fur seal sightings combined with the observations of an individual hauling out repeatedly in the same spot may indicate the beginning of recolonization by a probably former breeding species (Peterson and Cooper 1968, Starks 1922). The increase in the sightings of fur seals hauled out in Sea Lion Cove in conjunction with the return of Steller sea lions to pupping in that area is interesting and may be due to the same probable cause - the presence of PRBO biologists on the island which prevents disturbance to the pinnipeds by limiting human traffic past this sensitive area.

Harbor seal (Phoca vitulina)

The harbor seal population on the Farallones continued to increase in 1978 with a high count of 40 animals seen on 17 July 1978 (Fig. 5). This is an increase of 53% over 1977. Only 2 pups were observed during the breeding season; there have been 3 pups seen each year since 1975. Breeding on the Farallones was first observed in 1974.

In order to find out the best time to census harbor seals to get a maximum count, we counted animals at 6 haul out points around the island (Fig. 1) once a week at 90 minute intervals throughout the day. Between March 1977 and September 1978, we did 70 harbor seal censuses. The counts were made simultaneously at all 6 points from the vantage point of the lighthouse. Other data taken included time of day, temperature, wind speed, amount of cloud cover and amount of intertidal area exposed. The intertidal area was divided into 3 zones from the highest to the lowest: the splash, mussel, and algae zones. Each was further divided into an upper, middle and lower portion. The lowest intertidal zone exposed along with the number of animals present was recorded.

Since breeding began in 1974 the harbor seal population on the Farallones fluctuates seasonally (Fig. 5) with low numbers September through February increasing in the spring and peaking in late summer. This follows the pattern of other harbor seal populations along the coast (Johnson and Jeffries 1977, Allen pers. comm.).

Temperature, wind speed and amount of cloud cover seemed to have no bearing on the number of seals hauled out. The amount of intertidal area exposed, which is dependent upon the height of the swell as well as the tide cycle, was the primary factor affecting the haul out pattern, although there were slight morning and noon peaks during the day (Fig. 6). Animals began to haul out when the splash zone was exposed and increased in number until the lowest intertidal zone of the day was reached. The harbor seals remained hauled out as long as possible unless disturbed by an external factor. During several of the census days Coast Guard helicopters flew over Mussel Flat, one of the major haul out areas. The seals immediately went into the water at the sound of the helicopter. They began to haul out again 20 minutes after the disturbance; after 90 minutes all the seals had returned.

We also found some seasonal movement around the island; during July and August most animals were seen on the southwest side of the island at Mussel Flat and Indian Head Beach. In the winter, most of the harbor seals present were found at Shell Beach and Fisherman's Bay, probably because these areas are more sheltered from the southerly winter storms.

Northern elephant seal (*Mirounga angustirostris*)

The most northerly and most recent area of recolonization for the northern elephant seal is the Farallon Islands. The first elephant seal was seen there in 1959 and breeding began in 1972. This rookery presents a unique opportunity to study in detail the recolonization process. The age, birthplace and history of many of the animals on the Farallones are known because of tagging programs for the past several years by B. J. Le Boeuf and associates (including Point Reyes Bird Observatory), and because of intensive observations made by PRBO biologists on the Farallon Islands. The population dynamics of the elephant seal on the Farallones, including events preceding the first birth and details of events occurring during the initial breeding seasons, have been described (Le Boeuf et al. 1974, Ainley et al. 1975, Ainley et al. 1976, Ainley et al. 1977). The population has not yet reached maturity.

Population numbers. The elephant seal population on the Farallones, composed of immigrants from San Miguel, San Nicolas, Ano Nuevo Islands and recently one individual from Guadalupe (see tag return section), continues to increase (Fig. 7). The spring peak of 731 animals on 2 May 1978 represents a 40% increase over the previous year. In 1977 the rate of increase was not as high as in the past (Ainley et al. 1977). In spring and fall 1978, the rate of increase went up again, which may indicate a rising trend also for the 1978-79 breeding season. Apparently the elephant seal population of the Farallones has not yet levelled off.

The age of the members of the Farallon population is still young: the highest proportion of known-age cows are breeding for the first time and the majority of the males are younger than at other colonies (Ainley et al. 1977). Although still young (Tables 6, 7), the Farallon population appears to be maturing as more known cows and bulls return year after year to breed.

At least 40% of the cows breeding in 1978 bred on the Farallones previously and the alpha bull in 1978 was present as a subordinate bull between 1975-1977. In other years the alpha bull had been a more recent immigrant. A 3-year-old female born on the Farallones pupped during the 1978 breeding season, the first Farallon-born animal to enter the breeding population, thus completing another step in the recolonization process. Young males born on the Farallones in 1974 and 1975 are just beginning to reach sexual maturity and should be entering the breeding population in the next few years.

Changes in use of the island. As the population of elephant seals increases over the years more and more small coves, gulches, and inlets around the island are being used as haul out areas. It is the young animals that make primary use of the peripheral areas, although some of the older animals haul out first in the peripheral areas and then move to join the larger concentrations of animals at the major haul out sites.

The major pupping area is still the Sand Flat (Fig. 1), but there are indications of changes in some of the other pupping areas. During 1978 the Farallones experienced the first severe winter storms since the elephant seal colony became established there. The high tides and swells changed some of the geography, which may have an effect on the cows' choice of pupping areas. There are three approaches to the Sand Flat: one of these, a

gradually sloping sand beach (and a peripheral pupping area), had all the sand washed away, leaving a rocky area with a three-foot drop off to the rocks below. Adult cows now negotiate this area with difficulty, which could discourage many cows from approaching the pupping area.

In spring 1978 immature animals molted on the West End (Fig. 1) for the first time and this may presage an increased use of West End during the breeding season. In past years only a few females (6 in 1978) pupped there, although room for expansion appears to be almost unlimited. Many of the bulls and subadults already use the West End as a hauling out area.

The other potential pupping area, Marine Terrace, is adjacent to the Sand Flat; three cows pupped there in 1978. Space there is also unlimited; however, many of the subordinate bulls use it while waiting for a chance to approach the nearby females in the main pupping area. These males harrassed the females on the Marine Terrace so much that the cows and their pups moved down onto the crowded Sand Flat area under the protection of the dominant bulls. It would require a shift of location by a majority of cows before dominant bulls would move as well.

Tag returns. Since 1972 all pups born on the island that survived to weaning have been tagged. The total tagged is now 273 pups. Since 1975 as many cows, bulls, and immature animals as possible have also been tagged. The total for all animals tagged is 571 (Table 8).

Recent sightings of elephant seals tagged as pups on the Farallones between 1974 and 1977 indicate a slightly higher minimum survival rate of 32% (Table 9) for the first year after weaning as compared to the 26% minimum survival rate previously suggested (Ainley et al. 1977). This is the result of tag sightings of animals not previously reported or of animals not seen for several seasons and presumed dead. Three out of 7 surviving females born in 1975 were sighted during their third year spring molt for the first time since weaning. If this is a pattern among young females, the survival rate may turn out to be even higher than now indicated. The highest mortality for pups is between weaning and the first fall haul out when they are learning to feed and fend for themselves. In all cases these are only minimum survival figures as neither tag loss nor tags overlooked because of crowded censusing conditions has been taken into account. There are no precise figures for tag loss as yet although Le Boeuf (1974) estimates it at less than 5%. The survival rates for males and females appear to be similar.

Of the 60 animals surviving until spring 1978, 10 have been sighted on both the Farallones and Ano Nuevo Island. Most of these animals spent their first winter or spring on Ano Nuevo and have been seen subsequently only on the Farallones. Two animals have been sighted only on Ano Nuevo (89 km south) and two others have been seen only on San Miguel Island (497 km south). One animal from the Farallones has been seen as far north as Cape Arago, Oregon (Ainley et al. 1977).

In the fall of 1977, a yearling male, tagged on Guadalupe Island (1000 km south) as a pup (Le Boeuf, pers. comm.), was observed on the Farallones for nearly a month. This is the first record for a Guadalupe-tagged animal on the Farallones. The same animal returned in the fall of 1978.

Most of the tagged immigrant animals now in the breeding population on the Farallones were sighted in their first fall after weaning. They continued to be seen regularly on the Farallones during the spring and fall haul

outs up to the time they began breeding.

The Farallon population is becoming more stable. No tagged females that have pupped on the Farallones have been known to pup elsewhere previously and only four tagged cows are known to have pupped on Ano Nuevo Island after pupping on the Farallones. Another indication of the increasing maturity of the young Farallon population is the return rate of breeding animals (Table 10). For marked cows pupping in successive years, this rate was high and ranged from at least 63 to 77% between 1975 and 1977.

In the last few years the breeding males have shown increased stability. The dominant bulls in 1972 to 1975 all spent at least part of the breeding season (generally the beginning) at Ano Nuevo Island and did not molt on the Farallones in the summer. During that period there was much more movement of subordinate bulls between the Farallones and Ano Nuevo than is true now. The male breeding population is now composed of animals which first appeared at the Farallones as young subadults or juveniles. The dominant bull in 1978 had been present exclusively on the Farallones during the breeding season since 1975. Because tag loss among males appears greater than among females (many more males have scars from lost tags), it is more difficult to determine the males' rate of return in successive years. However, at least 40% (20/50) of the males present in the 1978 breeding season were present in previous years: three for 4 years, four for 3 years, and thirteen for 2 years.

Other information we have gathered from tag returns concerns the survival of offspring of individual cows. Since 1975 whenever a pup was tagged the natural mother of the pup was also noted. We now have records of the survival of pups of individual cows in successive years. Of 46 cows which pupped 2 or 3 years between 1975 and 1977, only one cow had 3 offspring surviving at least to the second spring. Nine others had 2 offspring surviving and 24 other cows present for 2 or more breeding seasons had 1 pup surviving to at least one year after weaning. Nearly a third (21/67) of the pups surviving to their second spring are offspring of just 10 cows!

Breeding season 1978. The breeding population of the Farallones continues to increase (Table 8). In 1978, 133 pups were born and 98 of them survived to weaning. The chronology of the breeding season is similar to previous years (Table 12), although the arrival of cows and pupping dates are progressively earlier each year.

Of the 133 cows that pupped on the island, 23 were of known age. Two of the oldest, a 6-year-old and a 7-year-old, were born on San Miguel Island. One of the youngest, a 3-year-old, was born on the Farallones. All others (four 6-year-olds; four 5-year-olds; seven 4-year-olds; five 3-year-olds) were born on Ano Nuevo Island. Over half (56%) of these had pupped previously on the Farallones. Ten other cows arrived on the Farallones during the breeding season but did not pup. Six left within a day and four of these were later seen at Ano Nuevo Island. Two females which were 3-year-olds and probably not pregnant left after 3 to 5 days. Of the remaining two (one was a cow with a fresh shark bite), neither gave birth while on the island, but both suckled abandoned pups sporadically. One stayed 18 days, the other 21 days.

The density of the herd at the main pupping area increased in 1978 due only in part to the greater total number of cows present. Also a factor was severe winter storms in January which caused cows to move from the edge of

the herd, where waves were breaking, to the center. In addition, many subordinate males began to use peripheral pupping areas to haul out, causing cows to move into the main pupping area to avoid harassment.

One of the two adult males returning from previous years became the new alpha bull and accomplished 47% of the observed copulations (see male breeding success section). Once again the majority of males were sub-adults 5 to 7 years old (Table 4).

The Farallones rookery still has a higher female to male ratio than other colonies (Le Boeuf and Peterson 1969, Odell 1977). It remains to be seen whether this is characteristic of the Farallon population or just of a young colony.

Breeding success for males. In 1978 the number and percent of copulations by bulls other than the dominant bull increased over previous years (Table 13) and we observed another step in the change from territoriality to social hierarchy (Ainley et al. 1977) described by Odell (1977). In the social hierarchy system of 1978 the dominant bull accomplished a lower percent of copulations (46.9%) than the dominant bull of the previous year (64%), but increased the number of copulations observed by nearly a third. This was a result of the increased number of females in 1978 as compared to 1977. The number of different cows copulated with and the number of first observed copulations was similar for both bulls (Tables 13, 14).

The strategies of the two bulls were very different. In 1977, "Juan" was the dominant bull for the third year in succession. He attempted to control all cows on the Sand Flat despite a 66% increase in females present (from 54 to 90), and to keep all subordinate bulls away from cows as he had in past years. In most colonies the average number of cows under the control of one bull is 50 (Le Boeuf 1974). He spent much of his time chasing off other males and even interrupting his own copulations to do so. At the end of the season he was extremely emaciated; he departed the day before the last cow left. He did not return to molt in the summer.

In 1978 the dominant bull, "Dimple", allowed 3 to 4 other males to remain on the Sand Flat area and in control of small numbers of females on the periphery of the area. These males helped to keep other males off the Sand Flat area and in turn allowed Dimple to accomplish more copulations, probably because he did not have to expend as much energy driving other males off. Dimple remained on the Sand Flat a week after the last cow left and returned in the summer to molt.

At least 4 of the cows that Juan copulated with in 1977 were not pregnant during the 1978 breeding season. Unlike pregnant cows, they were seen hauled out in October and November 1977 with immature animals; at this time they were marked well with dye. They did not appear again until spring molt 1978. All of these cows were first observed copulating with Juan from 1 to 3 times. Only one of these was later observed copulating with another bull. Three of these cows suckled and raised pups successfully and all three of these were experienced cows of 2 of 3 seasons.

It appears that there is a limit to the number of females that a bull can control and also inseminate, and that for a bull to allow subordinate bulls to copulate with a small number of cows actually may increase his reproductive success. It remains to be seen whether these barren cows will return to the breeding cycle or not.

Breeding success for females. There are many factors which contribute to the breeding success of female elephant seals. Choice of pupping area, previous pupping experience, date of pupping and low density at the rookery so that the cow-pup bond can develop are discussed in Ainley et al. (1977).

Since 1975 when we began looking closely at cows and their pups we wondered how a cow that had lost her pup could "recoup her losses" and improve her reproductive success. We found several kinds of relationships in which a cow nursed a pup other than her own: some of these may contribute to breeding success. These abnormal suckling arrangements occurred when a cow lost her own pup because it died, she abandoned it, or it was "stolen" from her. They seemed to fit into 3 categories.

A. A cow "stealing" an alien pup. This occurred only when the cow's natural pup died. The cow aggressively approached another cow (generally a younger, smaller, or injured cow) with a pup less than 3 days old (often newborn), and took control of the alien pup by preventing the natural mother from suckling or even approaching her own pup. This cow then nursed the alien pup exclusively and treated it as if it were her own pup, defending it from other cows and not allowing other alien pups to approach or suckle. These cows had not suckled for from 1 to 8 days between the death of their own pup and the theft of the alien pup. This situation has been observed in 8 cases.

B. A cow "sharing" an alien pup. In 8 cases when a cow lost her pup she approached another cow with a pup from 1 to 11 days old and often through sheer persistence shared the suckling of the alien pup with its natural mother consistently throughout its nursing period. Both these cows would protect the pup from other cows and often fought between themselves over the pup. The pup nursed opportunistically from either cow.

C. A cow "accepting" an alien pup. This was the most common response and occurred in 32 cases. A cow which lost her own pup allowed one or more alien pups or weaners to suckle from her for varying amounts of time ranging from one occurrence to suckling one or more pups throughout the nursing period. This response differed from "stealing" a pup in that the cow did not seek out a pup but rather an abandoned or wandering pup or weaner sought out an accepting cow. These cows less frequently chased and bit pups and weaners than cows raising their own pups or raising one pup exclusively.

Twenty-one of the cows that lost their own pups were never observed to suckle any other pups at all. Although a few approached cows with pups (generally over a week old), they were not successful in either "stealing" or "sharing" an alien pup.

Adoptive suckling in pinnipeds has been documented for several species (Stirling 1975, Smith 1968, Fogden 1968, Burns et al. 1972, Klopfer and Gilbert 1968, Eley 1978, Carrick et al. 1962). Although some examples of adoptive suckling state that it only occurs in colonies disturbed by humans (Fogden 1968), and others simply imply that human stress increases adoptive suckling (Stirling 1975, Smith 1968), we found that adoptive suckling occurred in undisturbed elephant seal colonies and we found some possible explanations for this behavior in observations of a minimally disturbed colony.

We found there were some patterns in the response of the cow depending upon the context in which she had lost her pup. A cow stole another pup only if her pup died, not if she abandoned it or allowed another cow to steal

it. If a pup was abandoned the cow was most likely to accept a wandering pup or weaner indiscriminately, and if a cow had her pup stolen from her she was most likely to share a pup with another cow (Table 15).

Some reasons for these behavior patterns might be found in individual differences in the strength of the bond between cow and pup. A cow with a strong bond with her pup is more likely to raise her pup successfully. A cow with a "strong sense" of the cow-pup bond would lose her pup only if it died from uncontrollable causes (e.g. crushed by a bull). She would otherwise attempt to nurse a pup exclusively and exclude all (other) alien pups from her protection. A cow that abandons her own pup probably has a "weak sense" of the cow-pup bond and would permit pups to suckle from her indiscriminately. A cow that has her pup stolen from her, although she may have a "strong sense" of the cow-pup bond, is generally small or weak, and thus would be unable to steal a pup successfully herself, but might through persistence share a pup with another cow.

These responses appear to be three different degrees of the same behavior, ranging from active stealing of a pup from another cow to the passive acceptance of any wandering pup or weaner that wants to suckle. In all cases the adoptive suckling serves the same purpose: to keep the female nursing after she has lost her own pup. This may be a physiological need on the part of the cow to continue nursing. Many cows that suckled an alien pup, and which could be recognized through tags or scars, returned to the rookery pregnant the following year (68% or 11/16). There is no significant difference between the rate of return of these cows and cows that suckled pups normally ($p > 0.01$, χ^2 test). Neither of the marked cows that did not suckle any pup returned for the breeding season the following year, but both pupped the year after that. It would appear that by suckling an alien pup, if she has lost her pup, a cow remains in the breeding cycle rather than skipping a year of reproduction. In that way her reproductive potential is increased.

Thus the adaptive significance of having a strongly developed sense of the cow-pup bond may be that reproductive potential is increased.

Pup mortality. Pup mortality on the Farallones has ranged from 7% to 71% between 1974 and 1978. The average pup mortality on one established rookery is 14% (Le Boeuf et al. 1972). Causes of the highest pup mortality in 1974 have been discussed in previous reports (Ainley et al. 1975, Ainley et al. 1976).

In 1978, 26% (34/133) of the pups died. The causes were similar to previous years (Table 16) (Ainley et al. 1977), although 3 pups, close to weaning (25 to 27 days old), fell off the edge of a 4 m high cliff and were swept away by the tide. Another pup was born with a cleft palate; he died at 8 days.

The pup mortality was not spread evenly throughout the breeding season. As was true in other years, pup mortality was highest (17/34) in the last third of the season when cow density was still high and many males were moving through the herd in an attempt to copulate with cows in estrous. However, the pup mortality in the early third was much higher than usual (10/34) (see discussion in Ainley et al. 1977). This was due to the severe winter storms in the first half of January: waves breaking over the Sand Flat caused confusion among the cows and separated many cows from their pups. Another cause of high mortality in the early part of the season was the presence of a high proportion (13/24) of small-sized cows.

These cows were young (those of known age were all 3-year-olds), most of them probably pregnant for the first time. Three of them abandoned their pups within a few days of birth and 5 were permanently separated from their pups within the first week after birth. In general, smaller cows spent more time separated from their pups than larger cows, and were much less likely to get back to their pups after separation because they were easily intimidated by larger cows.

Future of the Farallon colony. It has been nearly 20 years since the recolonization process began. Breeding began 13 years after the first colonizer was sighted; since then the size of the population has increased nearly eight-fold in five years. The animals that form the colony are still primarily immigrants from other colonies to the south and are, as far as the females are concerned, generally breeding for the first time. And yet every year the percentage of animals pupping on the Farallones for their second, third, fourth or fifth year increases (Table 10). It is now 37%. The male-female ratio is still small in comparison to other colonies, and the number of sub-adult males is large in comparison to the number of adult males present.

As the colony matures there will undoubtedly be a greater number of older breeding animals, both male and female, present. Unlike the first few years of reestablishment, adult males now molt regularly on the island. Immature animals born on the Farallones and elsewhere are seen returning year after year during the spring and fall haul out periods. The first tagged Farallon-born animal to enter the breeding population pupped in 1978.

More female pups born on the island in 1974 and 1975 will be reaching sexual maturity in the next year. We can expect that they too will return to mate, thus completing another step in the progression of recolonization. Since most males do not begin breeding until age 8 or 9, it will be a while longer before males born on the Farallones begin breeding there.

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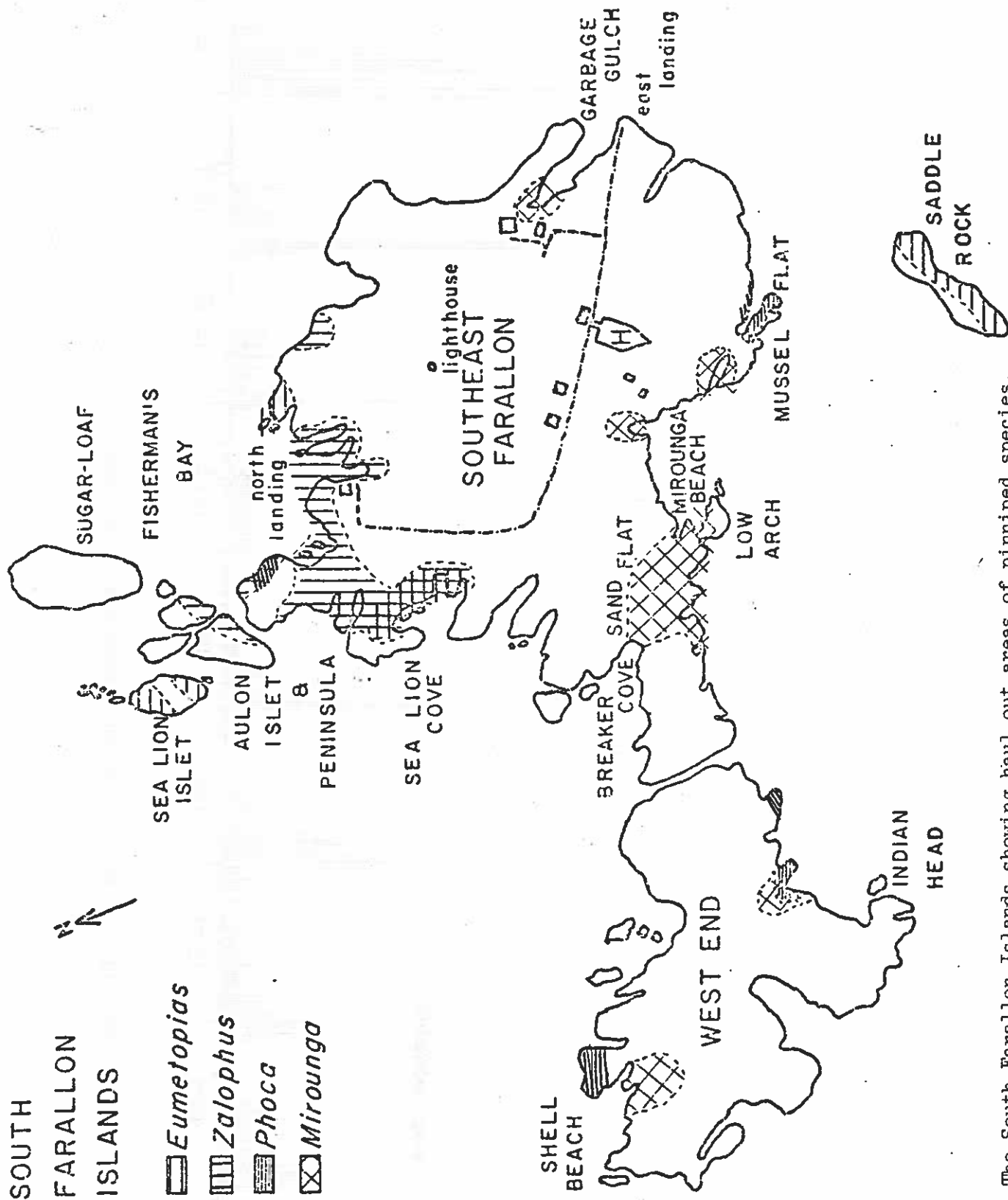


Figure 1. The South Farallon Islands showing haul out areas of pinniped species.

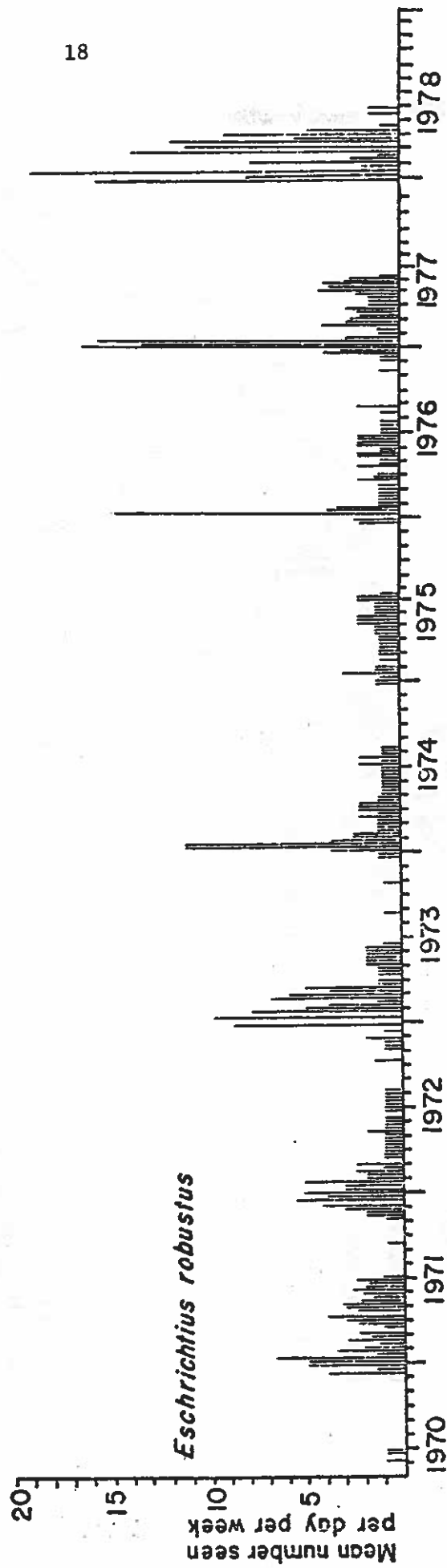


Figure 2. The occurrence of gray whales near the Farallones, 1970-1978.

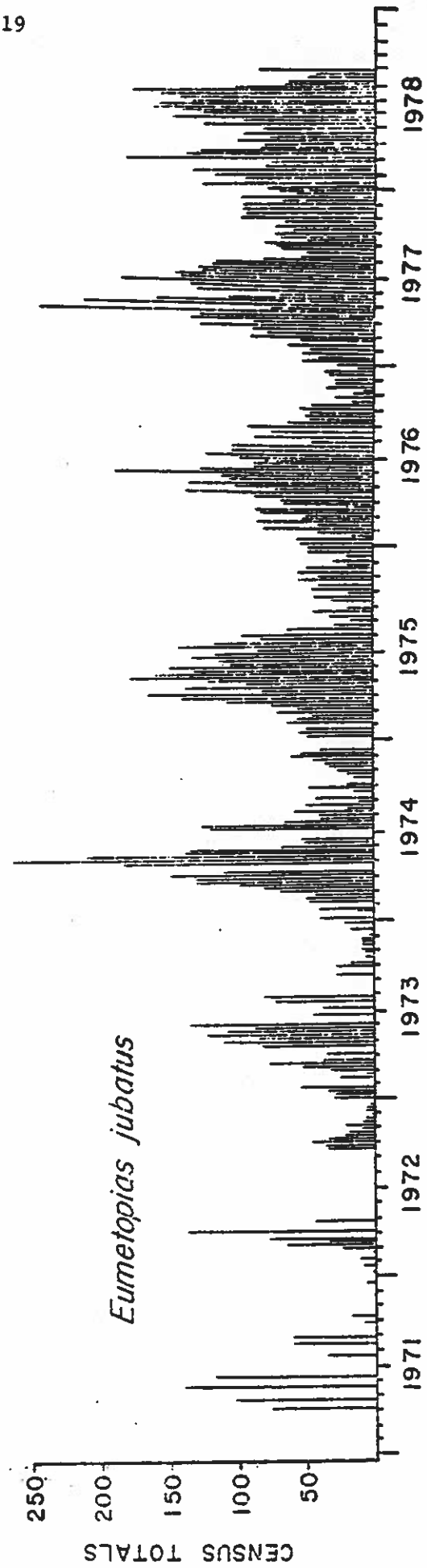


Figure 3. The occurrence of Eumetopias at the Farallones, 1971-1978.

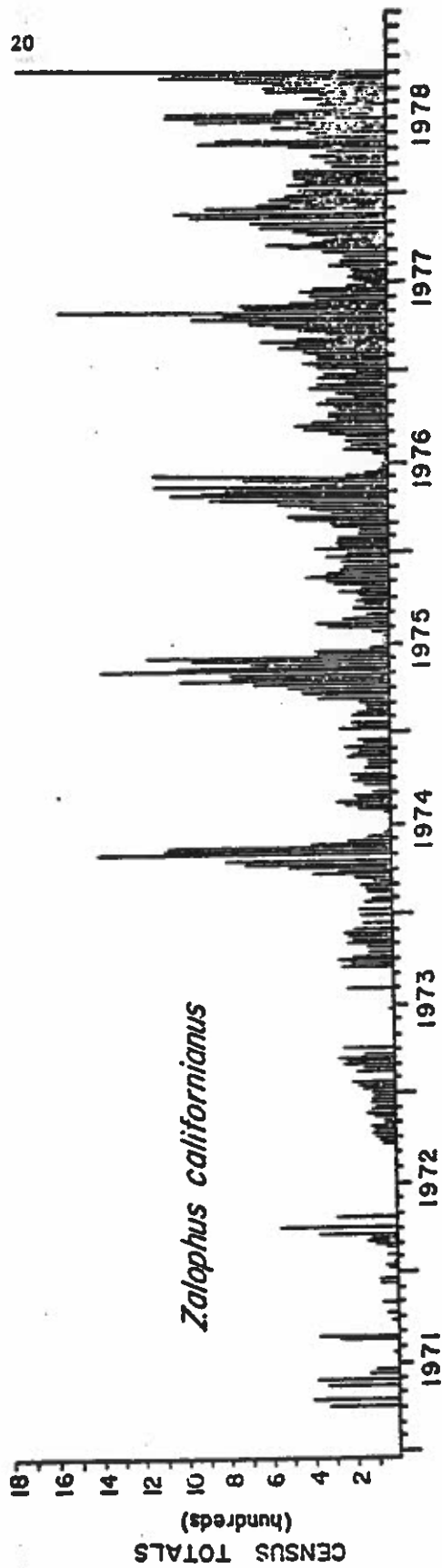


Figure 4. The occurrence of Zalophus at the Farallones, 1971-1978.

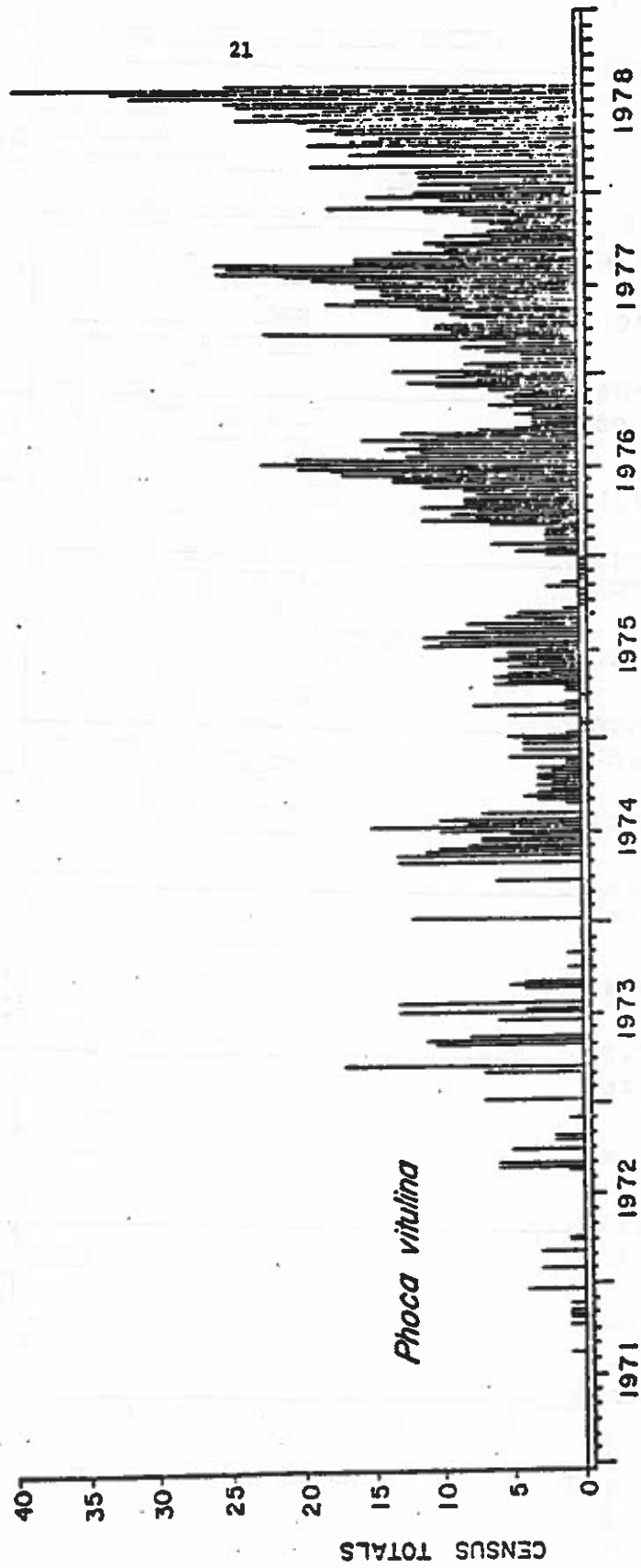
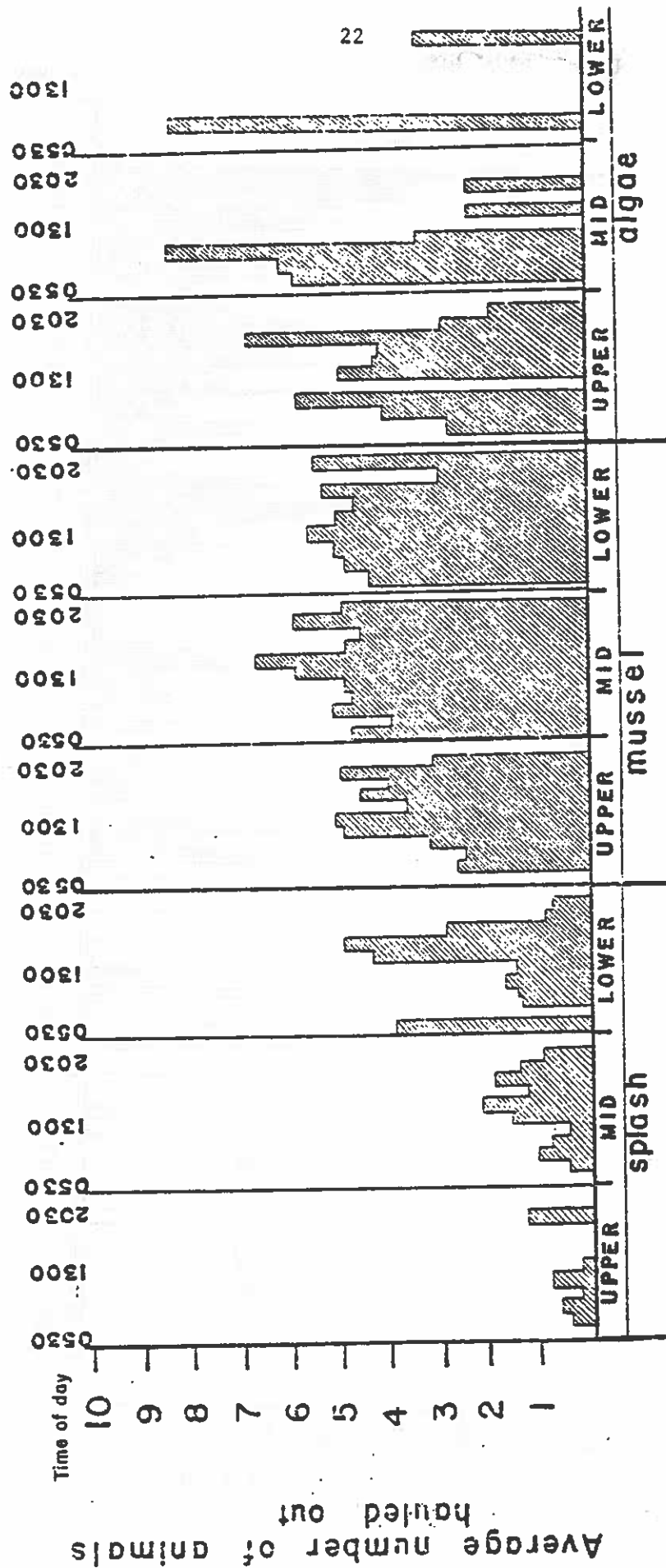


Figure 5. The occurrence of Phoca at the Farallones, 1971-1978.

Phoca vitulina



HIGHEST INTERTIDAL ZONE EXPOSED

Figure 6. Average number of harbor seals hauled out relative to time of day and tidal cycle.

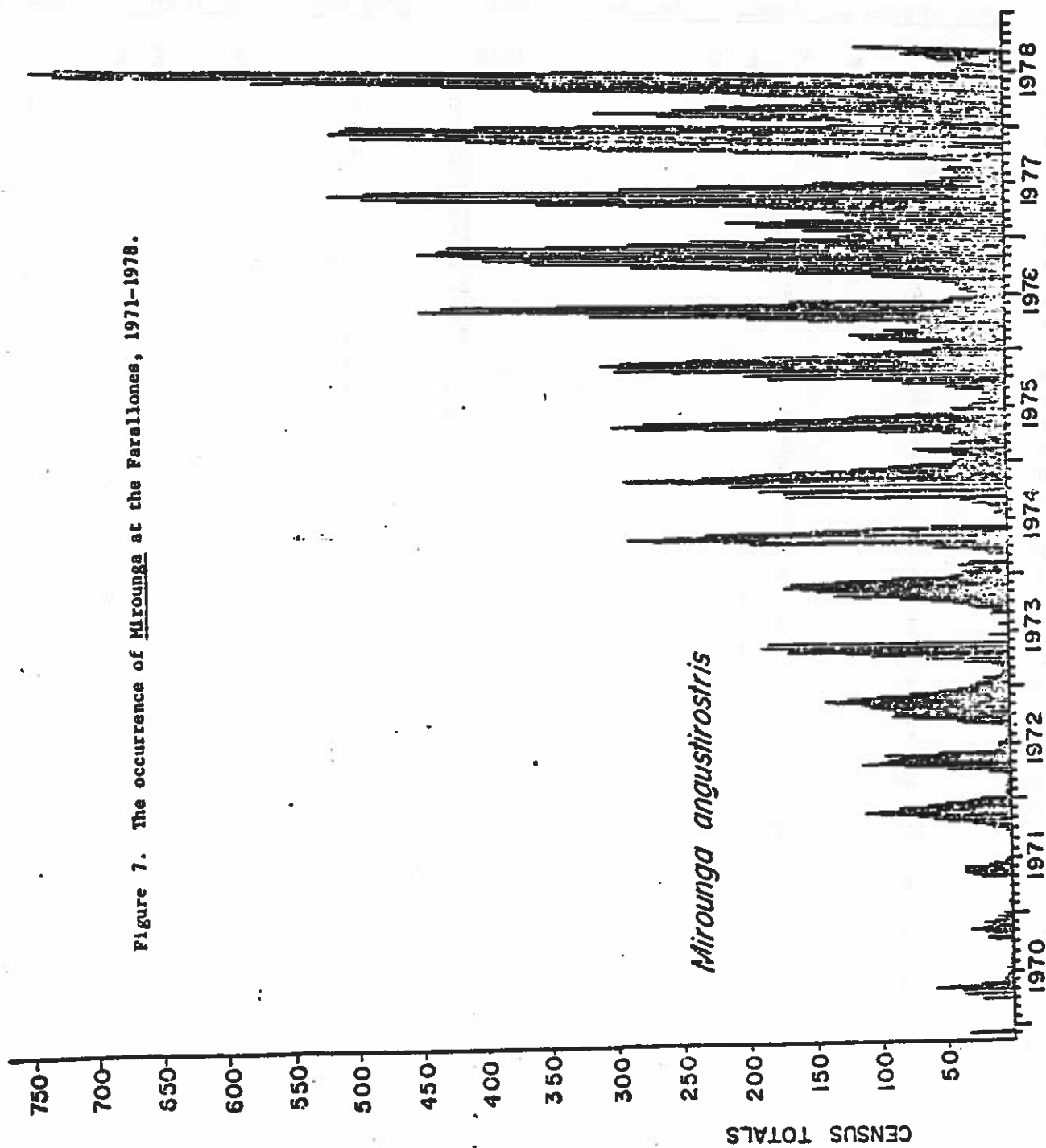


Table 2. Number of gray whales seen and hour effort during Lighthouse Hill whale watches, South Farallon Islands, 1977-1978.

DATE	Time		Total # hours watched	Total # gray whales seen	# of gray whales crossing east-west line:	
	Start	Stop			Total # (# per hour)	
					Going North	Going South
1977						
24 Nov	1100	1200	1	0		
8 Dec	1030	1200	1.5	0		
31	1400	1500	1	6		1 (1)
1978						
1 Jan	0730	0930	2	2		2 (1)
6	0730	1700	9.5	18		15 (1.6)
9	1340	1700	3.3	7		7 (2.1)
20	0730	1730	10	11		11 (1.1)
24	1200	1700	5	15		7 (1.4)
26	0700	1300	6	0		
31	1010	1110	1	0		
2 Feb	0730	1745	10.3	3		
9	0745	1500	7.3	1		
16	0715	1430	7.3	13	2 (0.3)	
7 Mar	1015	1200	1.8	5		
11	0730	1100	3.5	9	7 (2)	
16	0730	1800	10.5	23	8 (0.8)	2 (0.2)
30	0715	1800	10.8	0		
7 Apr	1345	1545	2	0		
9	1520	1735	2.3	0		
13	0630	1030	4	0		
7 May	0540	1930	13.8	0		
11	0605	1500	9	0		
14	1700	1900	2	0		
15	0825	0935	1.2	0		
18	0630	2015	13.8	0		
25	0530	2030	15	0		
1 June	0530	1730	12	0		
18	1835	1930	1	0		
20	0700	0945	2.8	0		
23	0530	1600	10.5	0		
29	0530	1200	6.5	0		
25 July	0730	1730	10	0		
23 Aug	1820	2000	1.7	0		
24	1130	2015	8.8	0		

Table 3. Sighting of Humpback whales around South Farallon Islands 1977-1978.

<u>DATE</u>	<u>Total # of Whales</u>	<u>Remarks</u>
1977 Sept 17	2	1 adult, imm. (adult w/ distinctive notch in front of dorsal fin
18	2	" " " (same as 17 Sept)
Nov 3	2	2 adults: remained in same area 1 1/2 hours feeding(?)
24	3	travelling north
27	2	travelling south
1978 Apr 9	1	travelling south
May 11	3	north of island from 0615 to 1345; 1 animal w/ distinctive notch
		(same as 17 Sept)
14	1	moving NW
25	2-3	one animal w/ distinctive notch in fin (same as 17 Sept)
June 1	4	2 travelling south, 2 travelling north

Table 4. Reproductive success of female Eumetopias on S. E. Farallon Island, 1973-1978.

<u>YEAR</u>	<u>Highest number of females present</u>	<u>Number of pups born</u>	<u>Percent natality</u>	<u>Number of premature and still births</u>	<u>Pup death other causes</u>	<u>Percent mortality</u>
1973	73	9	12	3	-	33
1974	110	10	9	4	-	40
1975	98	19	19	4	5	47
1976	98	14	14	5	1	43
1977	111	27	24	11	-	41
1978	103	18	17	10	-	56

Table 5. Seasonal change in the diet of California sea lions at the Farallon Islands. Data are based on otoliths and squid beaks regurgitated by sea lions and collected by us at haul out sites.

PREY	MONTHS ¹											
	J	F	M	A	M	J	J	A	S	O	N	D
SQUID		1/0	9/0					1/0	2/22			
FISH												
<u>Merluccius productus</u>	54/0	38/33	6/57	93/59	93/86	94/16	100/95	81/85	33/47	42/75	26/67	30/0
<u>Sebastes spp.</u>	45/0	27/33	81/30	5/41	7/13	1/84	0/3	11/12	32/20	15/25	70/33	30/0
<u>Porichthys notatus</u>		1/0	0/14	1/0	0/1	1/0		1/3	1/4	33/0	1/0	
<u>Engraulis mordax</u>		21/0						1/0	0/4		1/0	
<u>Glyptocephalus zachirus</u>		1/0							11/2			
<u>Chilara taylori</u>		8/0				3/0			10/4	1/0	2/0	40/0
<u>Parophrys velutus</u>		1/33						1/0	3/4			
<u>Genyonemus lineatus</u>						1/0		1/0	2/0	2/0		
<u>Citharichthys sordidus</u>		1/0						1/0	2/1	3/0		
<u>Microgadus proximus</u>		1/0	3/0					1/0	1/4			
<u>Atherinopsis californiensis</u>								1/0	1/0			
<u>Leptocottus armatus</u>									+0	2/0		
<u>Zalemblus rosaceus</u>									+0	2/0		
<u>Microstomus pacificus</u>									+0			
<u>Trachurus symmetricus</u>							0/2	1/0	+0			
<u>Clupea pallasii</u>								1/0				
<u>Lyopsetta exilis</u>									+0			
TOTAL ITEMS	11/0	140/3	32/23	450/103	969/123	111/181	5/40	553/28	243/258	98/4	137/3	10/0
(1974-77, 1978)												

¹The left column under each month gives the proportion of the total for that month during 1974-77; the right column represents the proportion for that month during 1978. Total number of items for each month are given at the bottom of each column.

⁺Less than 1% of total.

Table 6. Known-age elephant seal cows breeding on the Farallones, 1975 - 1978.

AGE	1975	1976	1977	1978
3-year-old	1	0	3	6
4-year-old	4	6	5	7
5-year-old	1	2	4	4
6-year-old	0	1	2	5
7-year-old	<u>0</u>	<u>0</u>	<u>1</u>	<u>1</u>
Total	6	9	15	23

Table 7. Age classes of male elephant seals South Farallon Islands 1976-1978.

AGE	1976	1977	1978
Bull (8+ years)	6	2	2
Subadult ⁴ (7-8 years)	0	1	4
Subadult ³ (6-7 years)	6	15	16
Subadult ² (5 years)	<u>10</u>	<u>18</u>	<u>26</u>
TOTAL	22	36	48

Table 8. Number of elephant seals tagged on South Farallon Islands, 1972-1978.

YEAR	Bull	SA ⁴	SA ³	SA ²	SA ¹	Adult female	Immature	Pup	Total number of animals tagged
1972								1	1
1973								2	2
1974			1					5	6
1975	2		7	5		11		28	53
1976			2	3		16		56	77
1977			7	21	10	49	11	83	181
1978		2	13	22	20	62	34	98	251
TOTAL	2	2	30	51	30	138	45	273	571

Table 9. Resighting of elephant seals tagged as pups on the Farallon Islands, 1974-1977.

	<u>1974</u>			<u>1975</u>			<u>1976</u>			<u>1977</u>			<u>1978</u>							
Number of pups born	17			35			60			104			216							
Pups surviving to weaning* (first spring)	2	3	5	29%	18	10	28	80%	27	29	56	93%	35	49	84	81%	82	91	173	80%
First fall	1	2	3	18%	9	5	14	40%	13	11	24	40%	19	22	41	39%	42	40	82	38%
Second spring	1	2	3	18%	9	4	13	37%	9	11	20	33%	17	17	34	33%	36	34	70	32%
Second fall	1	2	3	18%	8	4	12	34%	7	10	17	28%								
Third spring	1	2	3	18%	7	4	11	31%	5	7	12	20%								
Third fall	1	2	3	18%	7	4	11	31%												
Fourth spring	1	2	3	18%	7	4	11	31%												
Fourth fall	1	2	3	18%																
Fifth spring	1	2	3	18%																

* all pups surviving to weaning were tagged

Table 10. Number of adult female elephant seals present during the breeding season in successive years on the Farallones from observations begun in 1974.

<u>YEAR</u>	<u># of adult females pre-sent 2 years</u>	<u># of adult females pre-sent 3 years</u>	<u># of adult females pre-sent 4 years</u>	<u># of adult females pre-sent 5 years</u>	<u>Total # cows returning to breed</u>
1975	2	-	-	-	2
1976	12	2	-	-	14
1977	18	8	2	-	28
1978	30	14	5	2	51

Table 11. A summary of animals involved in elephant seal breeding seasons on the South Farallon Islands, 1972-1978.

<u>YEAR</u>	<u>Number of bulls¹</u>	<u>Number of breeding males</u>	<u>Number of breeding females</u>	<u>Pups born</u>	<u>Pups weaned</u>
1972	1	1	1	1	1
1973	4	1	2	2	2
1974	7	1	17	17	5
1975	8	3	35	35	28
1976	6	5	60	60	56
1977	2	10	104	104	84
1978	2	18	133	133	98

¹ as defined in Table 7.

Table 12. Breeding season chronology for elephant seals on South Farallon Islands, 1972-1978.

YEAR	BULLS		COWS		PUPPING
	Arrival	Departure	Arrival	Departure	
1972	6 Feb	16 Feb	20 Jan	12 Feb	20 Jan
1973	13 Jan	16 Feb	13-14 Jan	10-12 Feb	17-19 Jan
1974	27 Nov - 18 Jan	28 Jan - 23 Mar	8-28 Jan	9 Feb - 16 Mar	15 Jan - 6 Feb
1975	26 Nov - 17 Jan	13 Feb - 15 Mar	25 Dec - 4 Feb	27 Jan - 11 Mar	31 Dec - 10 Feb
1976	1-22 Dec	24 Feb - 11 Mar	20 Dec - 4 Feb	21 Jan - 7 Mar	28 Dec - 10 Feb
1977	19-27 Dec	10-13 Mar	20 Dec - 17 Feb	18 Jan - 14 Mar	25 Dec - 18 Feb
1978	6-23 Dec	10-21 Mar	19 Dec - 12 Feb	18 Jan - 13 Mar	23 Dec - 15 Feb

Table 13. Breeding success of male elephant seals on South Farallon Islands in 1978.

<u>Name</u>	<u>Age¹</u>	<u>Copulations observed</u>	<u>Different cows bred</u>	<u>First obser- ved breedings for individual females during season</u>	<u>Percent of total copulations observed</u>	<u>Periods of copulations</u>
Dimple	Bull	121	57	51	46.9%	Jan 16-Mar 12
Bill	Bull	46	32	18	18.6%	Jan 30-Mar 8
Pismo	SA ⁴	27	18	9	10.9%	Jan 26-Mar 2
Gash	SA ⁴	12	10	2	4.9%	Jan 28-Feb 26
Cal	SA ³	7	6	0	2.8%	Feb 15-Mar 8
406	SA ³	5	3	1	2.0%	Jan 28-Feb 18
Sarge	SA ³	4	3	2	1.6%	Feb 2-Feb 23
Trotsky	SA ²	4	2	0	1.6%	Jan 31-Feb 1
409	SA ²	4	4	0	1.6%	Feb 14-Feb 23
214	SA ²	3	3	0	1.2%	Jan 31-Feb 17
Whitey	SA ²	3	3	1	1.2%	Feb 14-Feb 21
Lonely	SA ³	2	2	0	.8%	Feb 13-Feb 17
Frank	SA ³	2	2	0	.8%	Feb 23-Mar 13
Al	SA ³	1	1	1	.4%	Feb 17
Urt	SA ⁴	1	1	0	.4%	Feb 24
Jake	SA ²	1	1	1	.4%	Feb 11
Don	SA ³	1	1	1	.4%	Feb 8
Rolfe	SA ²	1	1	0	.4%	Feb 2

¹ as defined in Table 7.

Table 14. Breeding success of male elephant seals on South Farallon Islands in 1977.

<u>Name</u>	<u>Age¹</u>	<u>Copulations observed</u>	<u>Different cows bred</u>	<u>First obser- ved breedings for individual females during season</u>	<u>Percent of total copulations observed</u>	<u>Periods of copulations</u>
Juan	bull	92	59	53	64%	14 Jan-3 Mar
Dimple	bull	17	12	8	12%	21 Jan-2 Mar
Bill	SA ⁴	9	8	3	6%	3 Feb-2 Mar
Sarge	SA ³	9	8	4	6%	2 Feb-14 Feb
Hank	SA ³	6	5	3	4%	28 Jan-21 Feb
76	SA ³	5	4	1	3%	6 Feb-19 Feb
Rog	SA ³	3	3	0	2%	17 Feb-13 Mar
Yellow	SA ³	2	2	1	1%	Feb 7-10
Spot	SA ³	1	1	0	1%	12 Feb
Norton	SA ¹	1	1	1	1%	7 Feb

¹ as defined in Table 7.

Table 15. Response of female elephant seals to losing pups on South Farallon Islands, 1975-1978.

A = stole a pup; B = shared a pup; C = accepted 1 or more pups or weaners; D = never suckled. See text for discussion.

<u>Context</u>	<u>Pup died</u>				<u>Pup abandoned</u>				<u>Pup stolen</u>			
Response	A	B	C	D	A	B	C	D	A	B	C	D
YEAR												
1975	1	2	0	3	0	0	0	0	0	0	0	1
1976	1	1	1	1	0	1	2	1	0	1	0	0
1977	2	4	9	3	0	2	3	3	0	1	0	1
1978	<u>4</u>	<u>1</u>	<u>9</u>	<u>6</u>	<u>0</u>	<u>2</u>	<u>8</u>	<u>2</u>	<u>0</u>	<u>3</u>	<u>0</u>	<u>1</u>
TOTAL	8	8	19	13	0	5	13	5	0	5	0	3

Table 16. Elephant seal pup mortality 1974-1978 on South Farallon Islands.

YEAR	Number of pups died	Washed away by high tides	Separated from cow (starved or bitten)	Crushed by male	Fell off cliff	Stillborn	Weak- never suckled	Unknown
1974	12	2	8			1	1	
1975	7	3		2		1	1	
1976	4	1	1	1		1		
1977	20	6	7	5		2		
1978	34	9	7	7	3	1	2	5
Total	77	21	23	15	3	6	4	5

APPENDIX

SUMMARY OF SIGHTINGS OF MARINE MAMMALS ALONG A TRANSECT BETWEEN THE GOLDEN GATE BRIDGE AND S. E. FARALLON ISLANDS 1971-1977.

INTRODUCTION

Many observations of marine mammals have been contributed by those persons who "happened to be there", primarily fishermen or whalers. Recently many trained observers, looking specifically for marine mammals, have been placed on vessels. As a result more and more information is being gathered on the distribution and abundance of marine mammals. Many of these "ships of opportunity" are only available seasonally and do not regularly follow the same path, and thus the information is often sketchy and not comparable from year to year. From 1971 to 1977 biologists from Point Reyes Bird Observatory have censused marine birds and mammals along a fixed transect in the gulf of the Farallones, providing some information on the occurrence of 8 species of marine mammals and an analysis of some of the problems of interpretation of data gathered on "ships of opportunity".

METHODS AND STUDY AREA

All marine mammals observed along a transect line between the Golden Gate Bridge and S. E. Farallon Island were censused by PRBO biologists from April 1971 to November 1977. One hundred sixty-eight censuses were conducted irregularly during all months of the year (Table I) and under various weather conditions using power and sailboats provided by the U.S. Coast Guard and the Oceanic Society. On 56 of these, marine mammals were observed.

The study area (Fig. I) is divided into two distinct sections by the San Francisco Bay plume. This is marked by a distinct change in water color near the San Francisco Bay Entrance Buoy (approximately 21 km west of the Golden Gate Bridge) which varies from about 1 km east of the buoy (with an incoming tide) to about 1 km west of the buoy (on an outgoing tide). East of this line lie shallow waters heavily influenced by run-off from San Francisco Bay. To the west lie deeper (15 to 30 fathoms) waters influenced by the productive California current and relatively free of shipping traffic.

Harbor porpoise (Phocaena phocaena)

The harbor porpoise ranges from Morro Bay, California north to Pt. Barrow, Alaska (Leatherwood et al. 1972) but it is uncommon south of Monterey Bay (Norris and Prescott 1961). Little is known of the population size or of breeding areas in California at present, although Morejohn indicates that parturition occurs from January through July (Winzler and Kelley 1977).

Past reports of the harbor porpoise in the Gulf of the Farallones are also sketchy: Scammon (1874) recorded that harbor porpoises were occasionally caught by fishermen inside San Francisco Bay. More recently, Brownell (1964) reported that the harbor porpoise was "not common" in the Bay and suggested that it might be becoming less abundant there because of pollution and boat traffic. Between 1971 and 1977, we saw only one harbor porpoise inside San

Francisco Bay, although it was the most frequently sighted marine mammal on our transects outside the bay.

We made 32 sightings of harbor porpoise between April and September each year (Table II) in groups that ranged in size from 1 to 15 animals (average pod size was 2-3 animals). More than a third of the sightings (13/32) occurred in 1977. Most were in the deeper water between San Francisco Bay Entrance Buoy and S.E. Farallon Island. A third of the sightings were just east of the San Francisco Bay Entrance Buoy. Other researchers described the harbor porpoise as "common" east of the San Francisco Bay Entrance Buoy between 1958 and 1963 (Fiscus and Niggol 1965; Brownell 1964).

It is hard to assess even the relative abundance of the harbor porpoise. They are difficult to observe at sea, as they do not approach boats or ride the bow wave as many other small cetaceans do, nor do they have the conspicuous blows of the large cetaceans, nor do they spend much time at the surface. They also tend to travel alone or in small inconspicuous pods.

Gray Whale (Eschrichtius robustus)

Gray whales range from their winter breeding grounds in Baja California north to their summer feeding areas in northern waters. They are commonly observed along the California coast during both north and southward migrations.

Gray whales were seen 11 times on Gulf of the Farallones transects (Table III) primarily in December and January during their southward migration and in March during the northerly migration. The sighting in late June 1976 may have been an animal summering in the area. Several gray whales have spent at least part of the summer feeding near the Farallones since 1974 rather than returning immediately to their Arctic feeding grounds (Ainley et al. 1975).

All gray whales seen were west of the San Francisco Bay Entrance Buoy, travelling in a north-south direction. All gray whales seen were single animals or in small pods of 2 to 5 animals (average pod size was 2).

Killer whale (Orcinus orca)

Killer whales are found in all oceans (Rice 1977); they probably breed throughout their range in the Pacific Ocean (Winzler and Kelly 1977). There were 2 sightings of killer whales during our censuses (Table IV). Two whales on 21 August 1971 were seen feeding on a seal between S.E. Farallon and the San Francisco Bay Entrance Buoy, and another individual was seen 28 June 1972 6 km east of S. E. Farallon.

Whale sp.

There were 3 observations of "whale sp.", all seen between the San Francisco Bay Entrance Buoy and the island (Table V). They were most probably gray whales, as the sightings occurred during the time of gray whale migrations. The whale seen 13 March 1976 was headed south.

Dall's porpoise (Phocoenoides dalli)

Dall's porpoise are found in the Pacific coastal waters from Alaska south to Baja California (Leatherwood et al. 1972). They have been seen in central California waters throughout the year (Winzler and Kelley 1977), although a large part of the population moves south in the winter and north in the summer (Leatherwood et al. 1972).

These porpoises are generally found in deep waters: Brownell (1964) found 91% (10/11) of sightings of Dall's porpoise outside of the 50 fathom line and Fiscus and Niggol (1965) found few Dall's porpoise inside the 100 fathom curve except in the vicinity of the Farallones.

Since hake is one of the common prey of the Dall's porpoise (Fiscus 1978, Norris and Prescott 1961, Scheffer 1953), it is possible that they are attracted to the Farallones in order to take advantage of the abundance of hake found there, as do the California sea lions (Ainley et al. 1976).

All our censuses were inside the 30 fathom line and almost all our sightings were in the relatively deeper waters (15 to 30 fathoms) between the San Francisco Bay Entrance Buoy and S. E. Farallon. One sighting was on a transect close to shore where 10 Dall's porpoises were observed 4-5 km west of the mainland at Duxbury Reef.

There were 15 sightings of Dall's porpoise (Table VI), most of these in June and July. After the harbor porpoise, this species was the most frequently sighted marine mammal in our transects. The Dall's porpoise was seen in groups of from 1 to 15 animals (average pod size was 7).

Pacific White-sided dolphin (Lagenorhynchus obliquidens)

A pod of 6 white-sided dolphins was sighted on 9 June 1974, 8 km west of the San Francisco Bay Entrance Buoy.

Porpoise sp.

There were 14 sightings of unidentified porpoise (Table VII). The 3 sightings east of the San Francisco Bay Entrance Buoy were probably all harbor porpoise because of the tendency of that species to inhabit shallower water. The sighting of a group of from 25+ to 100 animals in March was probably not harbor porpoises, because they do not gather in such large groups (Winzler and Kelley 1977, Norris and Prescott 1961). These sightings were scattered throughout the year with the majority of sightings in the summer.

California sea lion (Zalophus californianus)

The California sea lion breeds in the eastern Pacific from the Farallon Islands (Ainley et al. 1975) south to the islands off Baja California, in the Gulf of California, and along the west coast of Mexico (King 1964). Breeding males and subadults move as far north as British Columbia in the fall, returning to southern rookeries in the spring. The females and young remain near the breeding grounds and some even move south in the winter (Peterson and Bartholomew 1967).

During transects Zalophus were seen on 14 occasions; in all but one instance single animals were seen (Table VIII). Most of them were seen between the Golden Gate Bridge and the San Francisco Bay Entrance Buoy, and are probably from the population at Seal Rock. The two sightings within 8 km of S.E. Farallon are probably from the Farallon population. Most of the California sea lions were seen April to June, which is when peak numbers are seen at the Farallon Islands but not at other coastal areas. Four individuals were seen eating fish; one of the fish was identified as a flat fish.

Steller sea lion (Eumetopias jubatus)

There was one observation of a Steller sea lion on 25 July 1976, 19 km west of the San Francisco Bay Entrance Buoy. It was probably part of the Farallon Island population. A dead Steller sea lion was seen on 16 August 1976 floating in the water 18 km west of the Golden Gate Bridge.

Sea lion sp.

There were 4 sightings of "sea lion sp." in January, May and December (Table IX). The January and May sightings near Pt. Bonita were probably Zalophus californianus and probably from the population at Seal Rock.

Northern elephant seal (Mirounga angustirostris)

A single elephant seal, an immature animal, was seen 6 September 1975 between the Golden Gate Bridge and Pt. Bonita. This was during the time of year when many immature animals are returning to rookeries for the fall haul out.

DISCUSSION

To interpret the results of these censuses several factors must be taken into account. Since these censuses were taken incidentally to the main purpose of the trip, which was transportation to and from the S.E. Farallon Island field station for PRBO biologists, trips were made in all weather conditions on whatever vessel was available. When we analyzed all censuses according to wind speed and marine mammal sightings, we found a significant difference in the number of marine mammals sighted under low, moderate, and high wind conditions ($p < 0.05$). The higher the wind speed, the larger the seas and the more visibility along the water surface is obscured. Higher winds also rapidly disperse the blows of cetaceans.

Marine mammals were sighted on only 2 transects (2/18) when winds were more than 15 knots and were seen on less than a third (22/72) of the transects under moderate (8 to 15 knot) wind conditions. As expected, the highest number of transects on which marine mammals were observed were those with low wind and calm sea conditions. Another factor affecting the number of marine mammals observed was the type of vessel and its speed. This varied from census to census. In 1971 and 1972 almost all censuses were from U.S. Coast Guard Search and Rescue cutters travelling at 15 knots. This high speed, rather than an absence of animals, may account for the low number of marine mammals seen during this period (Table I). Conversely, the increased number of sailboats and slower powerboats travelling at 5 to 10 knots may account for increased number of sightings after 1973.

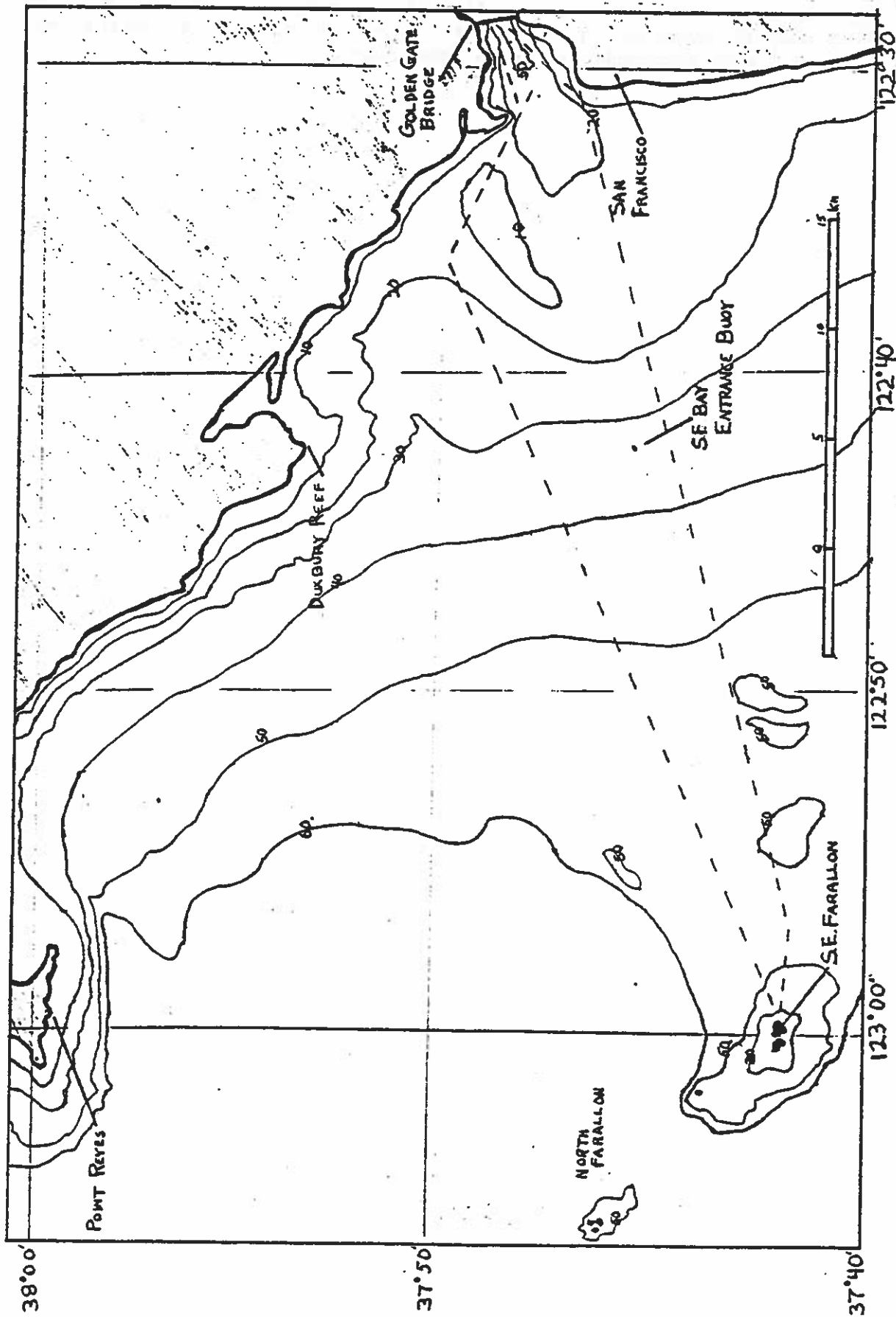
Under low wind conditions (0 to 7 knots) an observer was more likely to see marine mammals from a sailboat travelling at 4 to 7 knots than from a powerboat travelling 10 knots. The difference, however, was not statistically significant.

In general, only pinnipeds and the harbor porpoise were seen east of the San Francisco Bay Entrance Buoy. The majority (70%) of mammal observations were between the San Francisco Bay Entrance Buoy and S.E. Farallon Island, and most of these (50%) were between 10 and 18 km west of the San Francisco Bay Entrance Buoy. The harbor porpoise was found in deeper waters

than generally assumed and the Dall's porpoise closer to shore.

Most marine mammals were sighted during June, July and August (Table I); however this does not necessarily reflect seasonal abundance but possibly only the increased number of transects made during that period combined with more favorable censusing conditions.

Appendix Figure 1. The gulf of the Farallones: study area for transects between S. E. Farallon Island and the Golden Gate Bridge is marked by dotted lines. Depth of water is shown in meters (2 meters = 1 fathom).



Appendix Table I. Number of transects between Golden Gate Bridge and S. E. Farallon Island, 1971-1977.
(Number of transects on which marine mammals were sighted / total number of transects).
Each transect approximately 4 hours long.

YEAR	MONTHS												Total Number of Transects
	J	F	M	A	M	J	J	A	S	O	N	D	
1971				0/1	0/3	0/2	0/2	1/1	0/2	1/1	0/1	0/1	16
1972	2/2	0/2	0/3	0/1	0/5	3/2	2/3	0/4	0/4	0/3	0/2	NT*	38
1973	0/2	0/2	2/0	0/2	0/2	1/1	2/1	2/1	2/1	NT	NT	0/2	23
1974	NT	1/0	1/0	1/1	0/3	1/1	0/1	NT	0/2	NT	NT	NT	12
1975	NT	NT	NT	0/2	1/0	2/1	1/3	1/3	1/1	1/2	NT	0/1	20
1976	NT	NT	2/1	0/2	3/2	2/2	3/2	1/2	1/4	0/2	0/1	1/2	33
1977	2/0	NT	0/1	2/0	1/1	2/1	1/1	3/3	2/2	0/1	1/2	NT	26
Total/ Month	4/4	1/4	5/5	3/9	5/16	11/10	9/13	8/14	6/16	2/9	1/6	1/6	

* NT indicates no transects made during that month.

Appendix Table II. Sightings of harbor porpoise in the Gulf of the Farallones.

DATE	LOCATION (km W. of Golden Gate Bridge)	NUMBER OF ANIMALS
12 May 1973	41 km	2
3 June 1973	27.5-34 km	1
1 July 1973	15.5-21 km	1
18 August 1973	30.5-47 km	2
9 September 1973	31.4-36.6 km	5
29 September 1973	15.5-21 km	2
8 December 1973	11-15.5 km	3
9 June 1974	29 km	15
4 May 1975	22-27.5 km	3
7 June 1975	15.5-21 km	1
	26.2-31.4 km	3
12 July 1975	15.5-21 km	1
	4.5-11 km	2
27 July 1975	1 km inside N. Tower Golden Gate Bridge	1
27 August 1975	24-30.5 km	5
8 May 1976	21.4-26.6 km	3+
31 July 1976	29.6-38.2 km	4
4 September 1976	29.6-38.2 km	2
	22-29.6 km	3
	11-15.5 km	2
23 April 1977	22-27.5 km	1
	24-30.5 km	2
29 June 1977 (west)	22-29.6 km	1
	28.2-47 km	2
29 June 1977 (east)	11-15.5 km	2
17 July 1977	11-15.5 km	1
	11-15.5 km	3
	15.5-21 km	2
14 August 1977	29.6-38.2 km	1
	38.2-47 km	2
3 September 1977	4.5-11 km	1
10 September 1977	29.6-38.2 km	2
	38.2-47 km	2

Appendix Table III. Sightings of gray whales in the Gulf of the Farallones.

<u>DATE</u>	<u>LOCATION</u> <u>(km W. of Golden Gate Bridge)</u>	<u>NUMBER OF</u> <u>ANIMALS</u>
18 January 1972	26.2-31.4 km	2
18 March 1972	34-40.5 km	4
9 March 1974	31.4-36.6 km	2
24 April 1974	22-27.5 km	1
29 March 1976	26.2-31.4 km	1
22 May 1976	34-40.5 km	1
19 June 1976	25.3-29.6 km	1
18 December 1976	34-40.5 km	3
9 January 1977	27.5-34 km	3
	34-40.5 km	3
	40.5-47 km	5+

Appendix Table IV. Sightings of killer whales in the Gulf of the Farallones.

<u>DATE</u>	<u>LOCATION</u> <u>(km W. of Golden Gate Bridge)</u>	<u>NUMBER OF</u> <u>ANIMALS</u>
25 August	22-48 km	2
28 June 1972	30.5-46 km	1

Appendix Table V. Sightings of whale sp. in the Gulf of the Farallones.

<u>DATE</u>	<u>LOCATION</u> <u>(km W. of Golden Gate Bridge)</u>	<u>NUMBER OF</u> <u>ANIMALS</u>
5 January 1972	26.6-41.2 km	2
29 March 1973	34-40.5 km	1
13 March 1976	25.3-29.6 km	1

Appendix Table VI. Sightings of Dall's porpoise in the Gulf of the Farallones.

DATE	LOCATION (km W. of Golden Gate Bridge)	NUMBER OF ANIMALS
28 October 1971	4 km W. of Duxbury Reef	10
7 June 1972	21.4-36.6 km	3
5 July 1972	29-38.2 km	8
20 July 1973	26.6-40 km	15
6 August 1973	27.5-34 km	1
	34-40.5 km	1
8 December 1973	33.9-38.2 km	3
9 February 1974	31.4-36.6 km	8
12 July 1975	26.6-40 km	2
	31.4-36.6 km	5
19 June 1976	38.2-42.5 km	5
26 June 1976	22-29.5 km	7
29 June 1977 (east)	38.2-47 km	14
29 June 1977 (west)	34-40.5 km	14
17 July 1977	40.5-47 km	12

Appendix Table VII. Sightings of porpoise sp. in the Gulf of the Farallones.

DATE	LOCATION (km W. of Golden Gate Bridge)	NUMBER OF ANIMALS
28 June 1972 (west)	27.5-34 km	10 [±] (3-5,2,3)
28 June 1972 (east)	34-40.5 km	2
	40.5-47 km	7
12 July 1972	25.3-29.6 km	1
	15.5-21 km	1
29 March 1973	27.5-34 km	25 - 100
15 June 1975	11-15.5 km	1
18 October 1975	11-15.5 km	4
22 May 1976	40.5-47 km	4
19 June 1976	25.3-29.6 km	3
	42.5-47 km	12
9 January 1977	34-40.5 km	2
2 August 1977	3 km SW of "C" buoy	10 [±]
14 August 1977	21-48 km	3

Appendix Table VIII. Sightings of California sea lions in the Gulf of the Farallones.

DATE	LOCATION (km W. of Golden Gate Bridge)	NUMBER OF ANIMALS
7 June 1975	15.5-21 km	2
15 June 1975	43-48 km	1 subadult
10 July 1976	0-4.5 km	1 ♂
18 December 1976	11-15.5 km	1
	22-23 km	1 ♂
9 January 1977	0-4.5 km	1
9 April 1977	0-4.5 km	1 ♂
23 April 1977	4.5-11 km	1
	15.5-21 km	1
	21-27 km	1
1 May 1977	0-4.5 km	1
29 June 1977	11-15.5 km	1 immature
	39-47 km	1
26 November 1977	11-15.5 km	1

Appendix Table IX. Sightings of sea lion sp. in the Gulf of the Farallones.

DATE	LOCATION (km W. of Golden Gate Bridge)	NUMBER OF ANIMALS
15 May 1976	4.5-11 km	2
	0-4.5 km	1
18 December 1976	15.5-21 km	1
9 January 1977	0-4.5 km	1

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