OCCURRENCE PATTERNS AND TRENDS OF CETACEANS RECORDED FROM SOUTHEAST FARALLON ISLAND, CALIFORNIA, 1973 TO 1994

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ABSTRACT—We summarize 22,682 observations of 15 species of cetaceans from Southeast Farallon Island off San Francisco, California, 1973 to 1994. Gray whales (*Eschrichtius robustus*) accounted for 63% of the observations. Most of these were of migrant individuals in the winter and spring, but up to 10 summer/fall residents were also recorded around the island each year. The other 14 species were recorded primarily from July to November. Observations of all cetaceans and of several different species increased significantly during the 22-yr period. These increases may be related to population recoveries due to protection of the large whale species, possible increases or changes in food resources in the Gulf of the Farallones region, possible observer biases, or likely, a combination of these factors. The occurrence of Pacific sardine (*Sardinops sagax*) in the region during the last three years of the study may have resulted in changes in the distributions of several species.

Southeast Farallon Island (SEFI; 37°42'N, 123°00'W), 48 km west of San Francisco, California, is located in a highly-productive, eastern boundary current system (Thompson 1981). The nutrient-rich waters around SEFI host large stocks of zooplankton, krill, and fish (Brinton 1962; Bolin & Abbott 1963; Parrish and others. 1981), which in turn support large numbers of breeding seabirds and pinnipeds on the island (Ainley & Boekelheide 1990; Stewart and others 1994). Whales also have been recorded in the surrounding Gulf of the Farallones, both during migration and while foraging in the area (Pike 1962; Dohl and others 1983; Dohl 1984; Baker and others 1986; Huber and others 1986; Calambokidis and others 1989, 1990). Since 1986, humpback whales (*Megaptera novaeangliae*) and blue whales (*Balaenoptera musculus*) have been surveyed and photographed off California, including the SEFI region, during June through November each year (Calambokidis and others 1990, 1993). Otherwise, little has been published on the year-round occurrence patterns, long-term trends, or biological roles of these and other cetaceans in the Gulf of the Farallones marine ecosystem.

Biologists from the Point Reyes Bird Observatory (PRBO) have been stationed on SEFI continuously since 1968, participating in daily censusing of bird occurrence on the island (Pyle and Henderson 1990). Since 1973, all cetaceans observed from the island also have been recorded on a daily basis. In this paper we summarize occurrence patterns of 15 species of cetaceans in the Gulf of the Farallones, based on our 22-yr survey from SEFI. Seasonal and inter-annual variation of the more abundant species are assessed, along with long-term population trends in the Gulf of the Farallones.

METHODS

Each day from 1973 through 1994, the species and estimated totals of all cetaceans observed from SEFI were recorded by PRBO biologists. All observations included the use of 10× binoculars and 25× telescopes to assist in identification and number counted. Only positive identifications at the species level were recorded, and daily totals were conservatively estimated when large numbers were present or the number observed was debated. Although there were no standardized cetacean observation procedures, seasonally constant numbers (from 3 to 8) of trained personnel on the island consistently scanned sur-

rounding waters during daily censuses of birds and other biological events, and a fairly standardized observer effort can be assumed for most of the period (see DeSante and Ainley 1980 and Ainley et. al. 1985 for further details corroborating a constant effort by SEFI personnel). An exception to this standard protocol occurred during the winter of 1986–1987, when numbers of migrating gray whales were not consistently recorded. Also, from 1987 to 1994, a monitoring program for white sharks (*Carcharodon carcharius*; Klimley et. al. 1992; Pyle and others 1996), during autumn may have resulted in increased observations of certain cetacean species (see Results). For this project, observers scanned surrounding waters for white shark activity, during all daylight hours, visibility permitting, from the lighthouse at an elevation 103 m atop the island. Before 1987, personnel visited the lighthouse less frequently to scan for cetacean activity; effort was not quantified during this period. The area covered for cetaceans ranged to 30 km on very clear days, but on average included the area within 15 km of the island. It is probable that observation skills varied slightly over the 22-yr period due to changes in personnel or possible increases in observer awareness of cetaceans. Such changes cannot be quantified, although we believe that they have had only a minor impact on our data. We use caution, however, in interpreting our data, particularly those of long-term trends. No standardized attempt was made to distinguish individual cetaceans. Thus, statistical analyses for this paper were based on the number of cetaceans observed per day (hereafter "observations"), irrespective of whether the same individuals may have been present on different days. A few individuals of certain species were recognized from day to day or year to year from behavior and unique marks or scars (see Katona & Whitehead 1981); thus, certain residency patterns, particularly of individual gray whales, could be inferred from repeat observations.

Linear trends were estimated from regression analyses on annual observation totals. To reduce skewness and to approximate a normal distribution, yearly totals ($N+0.5$) were log-transformed before regressions were performed. Non-linear trends were estimated by examining effects of quadratic year terms (year^2); a significant positive effect of these terms indicates an accelerating trend, whereas a significant negative effect indicates a decelerating trend. Means + SD are reported in the text. Statistics were performed using the STATA statistical program (Computing Resource Center 1992).

Results and Discussion

From 1973 through 1994, 22,682 observations of 15 species of cetaceans were recorded from SEFI (Table 1). Observations of all cetaceans

TABLE 1. Cetaceans recorded from Southeast Farallon Island, California, 1973–1994. Mean group sizes are for species that occurred in cohesive groups.

Species	Total	Daily group size			Dates observed
		Range	Mean	SD	
Gray whale, *Eschrichtius robustus*	14,192	1–75	—		See text
Blue whale, *Balaenoptera musculus*	894	1–41	—		See text
Fin whale, *B. physalus*	12	1–2	—		Apr–Oct, 1974–1994
Sei whale, *B. borealis*	2	1	—		Jun 1974, Oct 1989
Minke whale, *B. acutorostrata*	116	1–4	—		See text
Humpback whale, *Megaptera novaeangliae*	2504	1–75	—		See text
Sperm whale, *Physeter macrocephalus*	8	1–5	—		Jun 1974, Aug 1988, Nov 1992
Baird's beaked whale, *Berardius bairdii*	15	15	—		Sep 1994
Orca, *Orcinus orca*	97	1–9	3.5	2.8	Feb–Nov, 1973–1992
Pacific white-sided dolphin, *Lagenorhynchus obliquidens*	702	2–150	70	54	Feb, Sep–Nov, 1985–1993
Common dolphin, *Delphinus delphis/capensis*	3294	2–530	235	211	Aug–Nov, 1973; 1985–1994
Risso's dolphin, *Grampus griseus*	440	15–125	49	39	Mar–May, Sep–Nov, 1986–1993
Northern right whale dolphin, *Lissodelphis borealis*	20	10	—		May 1986, Sep 1993
Harbor porpoise, *Phocoena phocoena*	68	1–35	9.7	12.1	Mar–Nov, 1982–1992
Dall's porpoise, *Phocoenoides dalli*	326	1–25	7.8	5.2	See text
Total	22,682				

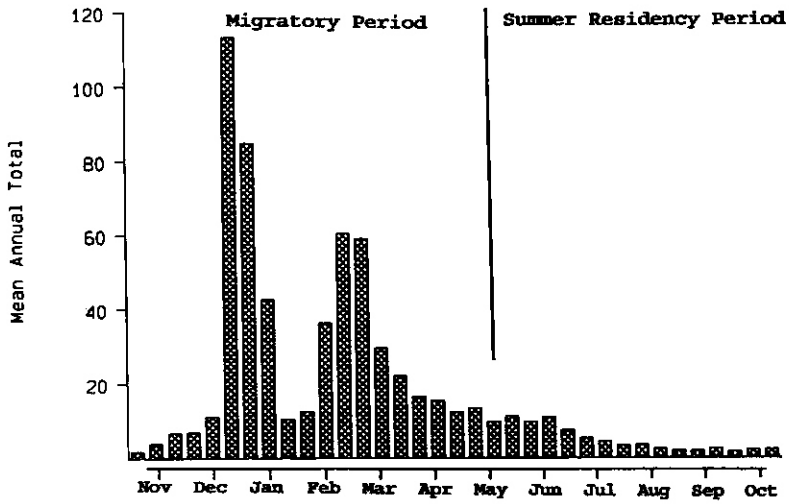

FIGURE 1. Seasonal distribution of gray whales observed from Southeast Farallon Island, California by 10-day period.

(species combined) increased over the 22-yr period ($B = 0.092$, SE = 0.013, $t = 7.35$, $p < 0.001$). There was no significant curvilinear effect ($t = -0.98$, $p = 0.341$), indicating that this increase was essentially linear. Similar trends were found when gray whales were excluded from the analyses (linear, $t = 3.30$, $p = 0.004$; curvilinear $t = 1.86$, $p = 0.078$).

The linear increase occurred both before ($t = 4.65$, $p = 0.001$) and after ($t = 4.30$, $p = 0.005$) the initiation of white shark monitoring in 1987. A positive curvilinear increase also occurred before 1987 ($t = 2.97$, $p = 0.013$), but not thereafter ($t = 1.95$, $p = 0.109$). These results are not consistent with those expected by the change in observation procedure at SEFI between 1986 and 1987; had observations increased significantly by the program we would expect a positive curvilinear effect over the entire period. We suspect, however, that totals of certain species, as discussed below, may have been partly augmented by observations during the shark monitoring program. Table 1 summarizes data on all cetaceans recorded from SEFI from 1973 to 1994. Additional data and annotations on several species follow.

Gray Whale

Gray whales (*Eschrichtius robustus*) were the most abundant cetacean recorded from SEFI, accounting for 63% of all cetaceans observed (Table 1). Unlike other cetaceans, the majority of these were seen in the winter and early spring, during their migration (Fig. 1). Small numbers of gray whales were observed feeding around the island during the summer and fall; repeated observations of the same individuals indicated that these were residents of several weeks or more. Based on an examination of the data in Fig. 1, we divided gray whale observations into 2 seasons the migration period (1 November to 15 May) and the summer residency period (16 May to 31 October).

Migrant gray whales occurred in 2 main periods (Fig. 1), southbound migration, from 1 November to 15 February (mean 13 January ± 13.1 days), and northbound migration, from 15 February to 15 May (mean 20 March ± 18.6 days). The extended spring migration in April and May is due to the later migration of adult females with calves, as previously documented (Rice and Wolman 1971; Herzing and Mate 1984; Swartz 1986). This corresponds with our observations of many mothers and calves in April through early May.

Observations of migrant gray whales increased significantly during the 22-yr period (Fig. 2) both without ($t = 6.27$, $p < 0.001$) and with ($t = 4.23$; $p < 0.001$) the inclusion of data from the 1986–1987 season (when numbers were not recorded consistently). The average annual rate of increase between 1973 and 1994 was 4.7% (± 0.68% SE). No significant curvilinear effects were present ($t = -1.74$, $p = 0.099$;

excluding 1986 to 1987), although the negative correlation of this analysis indicates that the increase may have been decelerating (see Fig. 2). These trends reflect the well-documented increase in the gray whale population since the International Convention for the Regulation of Whaling imposed complete protection in 1947 (Reilly 1992; Buckland and others 1993). Our rate of increase was slightly greater than that of 3.29% ± 0.44% (1968 to 1988) calculated by Buckland and others (1993) for gray whales migrating past Monterey County, about 270 km southwest of SEFI. Dohl (1979) provided evidence for an increase in offshore migration routes during the 1970s in the California Bight; it is possible that, if such a shift also occurred in central California, it may have contributed to the increase in numbers observed from SEFI.

The number of gray whales observed during the summer residency period varied both inter-annually and during the course of the summer period. We defined "resident" whales as those observed around the island for at least 2 wks during the residency period. The annual mean number of residents observed during the study period was 3.1 (± 2.3), ranging from none in 1986 to 10 in 1991 (Fig. 2). Most residents departed the island in June and July (Fig. 1) but some remained throughout the fall, until the onset of the southbound migration. Most residents appeared to be smaller animals, yearlings and subadults, although a very old and scarred animal remained around the island for June and July of 1988. One small resident with a unique scar near its blowhole remained throughout both the 1993 and 1994 residency periods. There was no significant trend in numbers of residents observed during the 22-yr period (Fig. 2; $t = 1.04$, $p = 0.310$). Dohl (1979) and Sumich (1984) discuss gray whales south of their normal summering range.

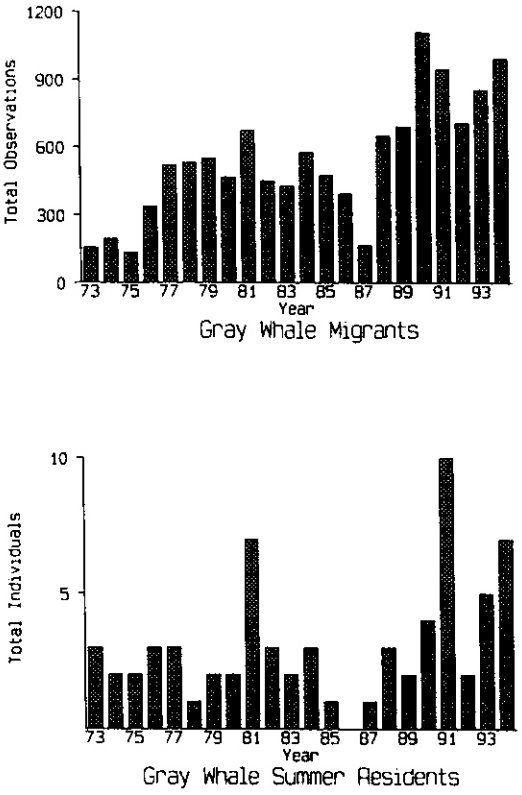

FIGURE 2. Inter-annual distribution and trends of migrant and summer resident gray whales observed from Southeast Farallon Island, California, 1973 through 1994.

Blue Whale

We recorded 894 observations of blue whales (Table 1), although none were observed until 1978. Blue whales have been sighted from SEFI in all months except February to April, with most seen from August to November (Fig. 3). The mean date of occurrence for this period was 19 September ± 15.6 days. Peak counts were 41 on 3 October 1986 and 34 on 11 September 1994. Most blue whales near SEFI are likely part of the over-summering North Pacific population that visits central California from the tip of Baja California (Calambokidis and others 1990; Barlow 1994).

Since 1978, there has been a significant linear increase in sightings of blue whales from the island (Fig. 4; $t = 3.88$, $p = 0.001$; $t = 6.30$, $p < 0.001$ for 1973 to 1994); there was no curvilinear effect (quadratic year term, $t = -0.47$, $p = 0.646$ for 1978 to 1994). Substantial inter-annual variation occurred in numbers recorded (Fig. 4), which likely reflected differences in the distribution of food resources in the area (Calambokidis and others 1989). These data complement the observed increase of this species in the Gulf of the Farallones during the 1980s, attributed to possible increases in the population since protection in 1966 and a shift in the distribution of this species toward the California coast (Calambokidis and others 1990, 1993),

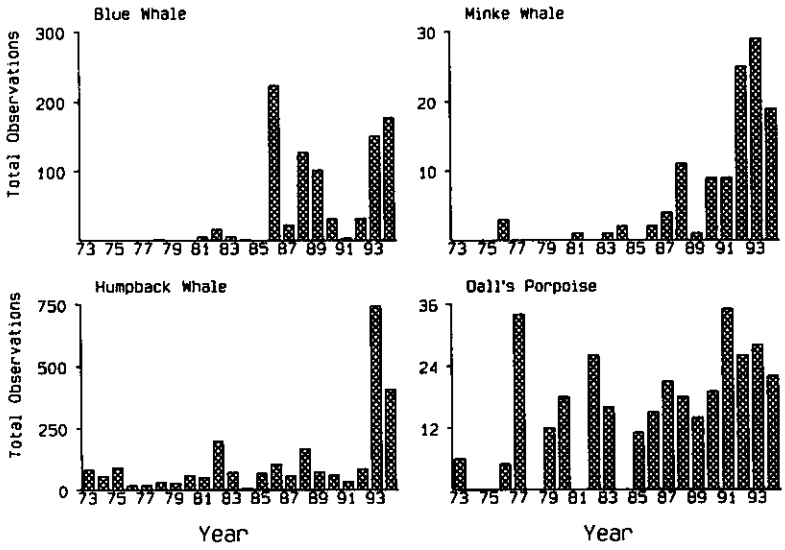

FIGURE 3. Seasonal distribution of four species of cetaceans observed from Southeast Farallon Island, California.

concurrent with a shift away from the Gulf of Alaska (Barlow 1994).

Minke Whale

Most observations of minke whales (*Balaenoptera acutorostrata*; Table 1) occurred from July through November (Fig. 3), with a mean fall date of 6 October ± 20.8 days. Observations of this species showed an accelerated increase during the 22-yr period (Fig. 4; linear trend, $t = 6.68$, $p < 0.001$; curvilinear trend, $t = 2.73$, $p = 0.013$). A high proportion of observations (92.2%) occurred after 1986, suggesting that the shark monitoring program affected our survey of this species. It is probable that the minke whale's brief and shallow surfacing be-

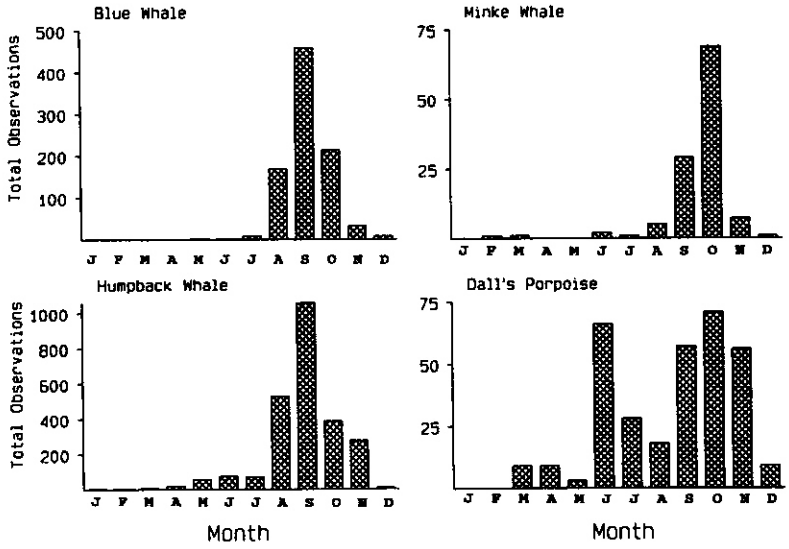

FIGURE 4. Inter-annual distribution and trends of four species of cetaceans observed from Southeast Farallon Island, California, 1973 through 1994.

havior (lacking a visible blow) were more easily seen from the island's peak than its lower portions. Many (30+) observations of minke whales during 1987 to 1994 occurred from the lower portions of the island, however, and the linear increase in numbers during 1987 to 1994 approached significance ($t = 2.38$, $p = 0.055$). These data suggest that a genuine increase in numbers around SEFI was also occurring, perhaps in response to increases in the region of schooling juvenile Pacific sardines (*Sardinops sagax*). Sardines, a probable food resource of the minke whale (Jonsgard 1982; Hoelzel and others 1989), have been recovering from a population crash during the 1940s through the 1960s (Lluch-Belda and others 1992; Wolf 1992), and were first documented in SEFI waters during 1992 (PRBO, unpubl. data). Minke whales were often seen in the vicinity of flocks of seabirds known to be feeding on sardines. Little has been published on trends in minke whale numbers in the Northeastern Pacific (Barlow 1994).

Humpback Whale

Humpback whales were recorded commonly from SEFI (Table 1), with sightings in all months but a high proportion (89.9%) occurring from August through November (Fig. 3). The mean date of occurrence for this fall peak was 17 September ± 30.9 days. An important proportion of the North Pacific humpback population occurs in the Gulf of the Farallones in summer and fall (Dohl and others 1983; Baker and others 1986; Calambokidis and others 1989, 1993), and those recorded are likely part of the Mexican wintering stock that visits central California at this time (Baker et. al. 1986; Barlow 1994). Our total of 2504 observations likely involved no more (and probably much fewer) than the 500 to 600 different individuals estimated off California in 1991 and 1992 through photo-documentation and mark-recapture analyses (Calambokidis 1993). Humpback whales frequently displayed feeding behavior around the island, and the same individuals were likely recorded on multiple days and in separate years.

Observations of humpback whales increased during the 22-yr period (Fig. 4; $t = 2.38$, $p = 0.027$). However, the increase can be attributed to large numbers of animals that moved into the region to feed during 1993 and 1994 (Fig. 4); a high count of 75 humpbacks was recorded on 6 September 1993. From 1973 to 1992, there were no linear ($t = 0.90$, $p = 0.383$) or curvilinear ($t = 0.39$, $p = 0.698$) trends. This occurrence pattern emphasizes the influence of food resources on observations of cetaceans from a single location; our observed increase is almost certainly related more to favorable food resources in the area during the latter portion of our study period than to an overall population increase (Calambokidis and others 1989). It is possible that the large aggregations of humpback whales observed in 1993 and 1994 may have responded to recent increases in Pacific sardines in the region (see above). Like Minke whales, humpback whales often were seen near seabird flocks feeding on sardines. Alternatively, the increase we observed could indicate a relative lack of food resources in other parts of the northeastern Pacific during 1993 and 1994.

Orca

Orca (*Orcinus orca*) was the only species to show a general decreasing trend during the 22-yr period, although this trend was not significant ($t = -1.68$, $p = 0.108$). Orca are rare in California waters (Forney 1994). On 18 July 1976 a dead male orca washed up onto the island (California Academy of Sciences specimen 20754). The total length was 7.35 m. The carcass had been scavenged on the ventral surface by white sharks. It washed back out to sea before a necropsy could be performed or cause of death determined.

Pacific White-sided Dolphin

A mostly-leucistic Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*), photographed in a group of 150 white-sided dolphins off SEFI on 16 November 1992, was an animal known from the Monterey Bay area (N. Black pers. comm.).

Risso's Dolphin

Observations of Risso's dolphins (*Grampus griseus*; Table 1) could be categorized into spring and fall periods, 215 animals observed in March to May and 205 animals in late September to November. Most of the observations were made separate from the shark monitoring program, suggesting that the apparent increase of this species near SEFI during the 22-yr period is genuine. The movement pat-

terns of Risso's dolphins are not well understood, but they may migrate south in winter (Dohl et. al. 1983). Our observations are consistent with a migratory pattern in this species. On 20 May 1973 an immature female Risso's dolphin was recovered at SEFI (Museum of Vertebrate Zoology specimen 153257). This and the Orca noted above were the only two cetaceans to strand on SEFI during the 22-yr study period.

Dall's Porpoise

Observations of Dall's Porpoise (*Phocoenoides dalli*; Table 1) were made in all months except January and February, with peaks in June and September through November (Fig. 3). As with other piscivorus cetaceans, numbers of Dall's porpoises increased significantly during the 22-yr period (Fig. 4; $t = 3.03$, $p = 0.007$). The increase was linear (curvilinear effect, $t = -0.03$, $p = 0.981$), suggesting little if any effect of the shark monitoring program on numbers recorded. This cold-water species is relatively common off Central California (Forney 1994).

CONCLUSIONS

Cetaceans recorded from SEFI can be divided into 2 groups, migrant gray whales, which pass the island in winter-spring, and 14 other species which occur primarily in summer and fall and are often seen feeding in the area. A small population of summer resident gray whales also forage around the island in summer and fall. Observations from SEFI of many species of cetaceans increased from 1973 through 1994. Although observer biases, the shark monitoring program, or changes in weather patterns may have partially accounted for the increase in observations, our data indicate that true increases in numbers are also occurring. These increases likely reflect both population recoveries of the larger whales since they were protected from exploitation, and an increase or shift in food resources into the region, especially during the last ten years of our study period. We speculate that some of the species are feeding on Pacific sardines which, during the latter years of our study, were in the process of recovering from a population crash that occurred in the mid-1900s.

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