THIRTY YEARS OF PINNIPED RESEARCH AT SAN MIGUEL ISLAND

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ABSTRACT

We began community ecology and population studies of six pinniped species at San Miguel Island (SMI) in 1969, following the discovery of a small colony of breeding northern fur seals on the island in 1968. During the intervening 30 years, these species have experienced significant population changes. Northern fur seal, California sea lion, harbor seal, and northern elephant seal populations have increased up to three-fold, Steller sea lions have stopped breeding and disappeared from the island, and Guadalupe fur seals may be establishing a breeding colony.

Studies of the pelagic movements and foraging behavior of northern elephant seals, conducted collaboratively with Brent Stewart (Hubbs-Sea World Research Institute), revealed that elephant seal adults undergo two long-distance migrations each year between SMI and oceanic foraging areas, males and females forage in separate areas while at sea, and both sexes dive very deep and for long durations. Long-term population studies of individually marked California sea lions allow construction of the population dynamics of the species and the lifetime reproductive success of individuals. Four El Niño events over the 30-year period have provided insights into how environmental changes may influence pinniped population dynamics at SMI over long time periods.

Keywords: Pinniped populations, northern fur seal, Guadalupe fur seal, California sea lion, northern elephant seal, Steller sea lion, migration, El Niño.

INTRODUCTION

The first systematic pinniped studies in the California Channel Islands were conducted by Paul Bonnot from 1928 through 1947 (Bonnot 1928, 1937; Bonnot and Ripley 1948). Only three species of pinnipeds were noted in small numbers: California sea lions (*Zalophus californianus*), Steller sea lions (*Eumetopias jubatus*), and harbor seals (*Phoca vitulina*). The next systematic survey of the Channel Islands was conducted in 1958, at which time small breeding colonies for the northern elephant seal (*Mirounga angustirostris*) were added to the list of pinniped species using the Channel Islands (Bartholomew and Boolootian 1960). Few pinniped studies were conducted during the 1960s with the exception of the first extensive behavior study of California sea lions conducted by Richard Peterson on San Nicolas Island (Peterson and Bartholomew 1967). In July 1968, a small colony of northern fur seals (*Callorhinus ursinus*) was discovered breeding on San Miguel Island (Peterson et al. 1968). The following year, we established a small research station and began a study of the newly established northern fur seal colony. The studies were sponsored by the Bureau of Commercial Fisheries of the U. S. Fish and Wildlife Service, which later became the National Marine Fisheries Service. The commitment of that federal agency to pinniped studies at San Miguel Island has continued through 1998.

In 1969, six species of pinnipeds occurred at San Miguel Island. California sea lions, Steller sea lions, northern fur seals, harbor seals, and northern elephant seals all had viable breeding populations, and the Guadalupe fur seal *(Arctocephalus townsendi*) was a regular visitant to the island. During the succeeding three decades, four of the species populations experienced substantial population growth, Steller sea lions disappeared from San Miguel Island, and the Guadalupe fur seal still occurs in small numbers.

SPECIES ACCOUNTS

Northern Fur Seal

Northern fur seals appear firmly established at San Miguel Island, which is the southern extent of the species breeding range. Northern fur seals at San Miguel Island have their origin in breeding populations in the North Pacific. Adult females that were tagged as pups on the Pribilof and Commander Islands in the Bering Sea and on Robben Island and the Kurile Islands in the Russian Pacific waters have been observed on San Miguel Island as reproductive animals (Peterson et al. 1968a; DeLong 1982). Thus, the origin and much of the population growth at San Miguel Island has been due to immigration of females from the northern populations. Northern fur seals at San Miguel Island give birth and breed in June and July like their northern relatives, but the reproductive cycle begins about two weeks earlier. The population growth at San Miguel Island, based upon numbers of pups born, has increased exponentially, with severe decreases resulting from the strong El Niño events of

1983 and 1997 (Figure 1). The population numbered approximately 12,000 animals in 1997, based upon a total pup production of approximately 3,000 for the two breeding colonies at Castle Rock and Adams Cove.

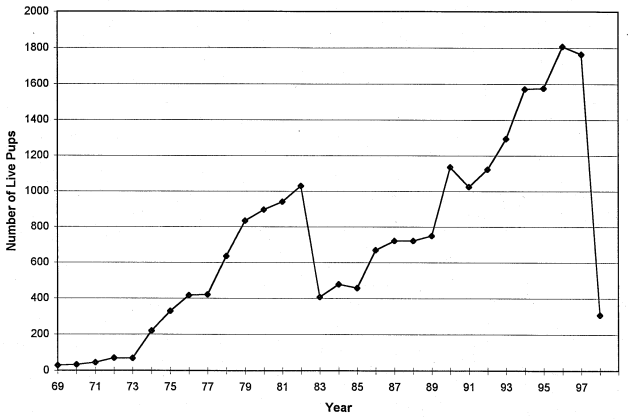

Figure 1. Number of live northern fur seal pups counted on San Miguel Island, California, from 1969 to 1998.

California Sea Lion

California sea lions breed on four islands in the California Channel Islands (Santa Barbara, San Clemente, San Miguel, and San Nicolas), and non-breeding animals haul out on the remaining four islands. The population on San Miguel Island is the largest breeding population (approximately 80,000 animals) within the species range. California sea lions are the most abundant pinniped on San Miguel Island and, over the past two decades, have almost doubled the area occupied for pupping and breeding. Sea lions currently breed on all beaches of the Point Bennett area and along the south coast from Adams Cove eastward through Tyler Bight. Sea lions give birth to pups in May and June and breed in late June and July. Consequently, they share pupping and breeding habitat with the northern fur seal. The California sea lion population has increased exponentially over the past three decades, but has shown decreases in population growth during the El Niño events of 1972, 1983, 1992, and 1997 (Figure 2). In addition to non-density dependent population regulation exerted by El Niños, the population appears to be exhibiting density-dependent increases in pup mortality due to increased incidence of endoparasites (Lyons et al. 1997).

Harbor Seal

Harbor seal populations are found on all the Channel Islands. The species is distributed from central Baja California, Mexico along the Pacific coast of North America to the central Bering Sea. Harbor seals are present year-round at San Miguel Island inhabiting beaches and coves along the island's north and south coasts. These areas are also occupied by northern elephant seals at different times of the year, but are outside most of the California sea lion and northern fur seal breeding and hauling areas. Therefore, harbor seals rarely interact with California sea lions or northern fur seals, but frequently share habitat with northern elephant seals. At San Miguel Island, they give birth to pups and breed during the spring months of March through May. From 1969 through 1986, the population increased steadily, then stabilized at about 1,200 animals through the middle 1990s (Stewart and Yochem 1994). Hanan (1996) has described a more recent decrease in the population of harbor seals at San Miguel Island, which he attributes to their being displaced from the beaches by northern elephant seals.

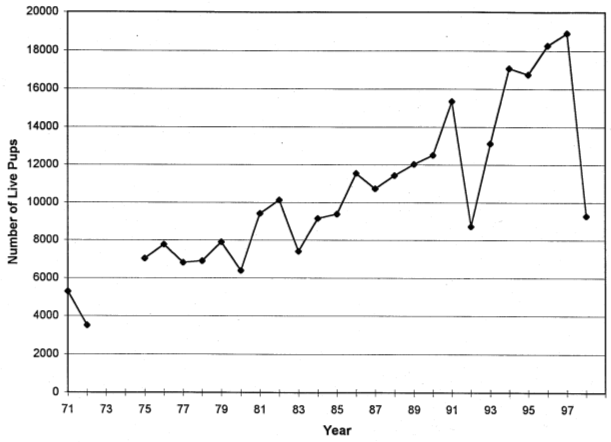

Figure 2. Number of live California sea lion pups counted on San Miguel Island, California, from 1972 to 1998.

Northern Elephant Seal

Northern elephant seals currently breed on islands from central Baja California, Mexico north to the Farallon Islands in central California and on mainland sites from Cape San Martin in central California north to Cape Arago in central Oregon. Unlike the other pinnipeds at San Miguel Island, northern elephant seals give birth to pups and breed during the winter months from December through February, utilizing rookery habitat which is occupied for breeding by California sea lions and northern fur seals during the summer. The population at San Miguel Island reestablished in the 1950s and has since increased exponentially. It has become the largest breeding population for the species, numbering some 50,000 animals (Stewart 1989; Stewart et al. 1993). This population continues to grow, and although pup mortality is higher during El Niño events due to high surf during storms, there is less evidence of adult mortality or depressed natality than is seen among the otariid species (Figure 3).

Steller Sea Lion

The Steller sea lion was reportedly more abundant than California sea lions at San Miguel Island from 1927 through 1947 (Bonnot and Ripley 1948). In 1958, Steller sea lions were reported to breed on three rocky points at San Miguel Island (Bartholomew and Boolootian 1960). By 1969, when we began studying at San Miguel Island, Steller sea lions

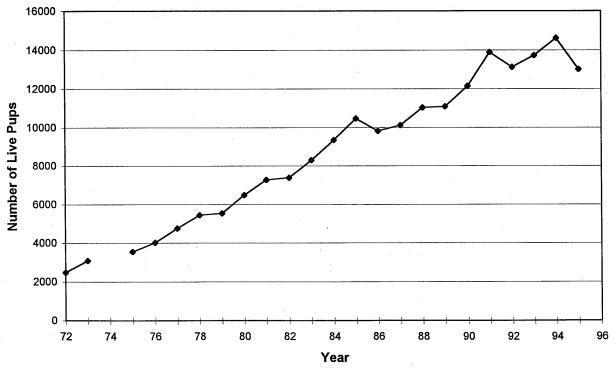

Figure 3. Number of live northern elephant seal pups counted on San Miguel Island, California, from 1972 to 1998. (Data sources: 1972 to 1991 from Stewart et al. 1994, and 1992 to 1995 from Lowry et al. 1996)

bred only on Northwest Point in the Point Bennett region. In that year, there were two territorial males with females and 13 pups counted during the breeding season. The numbers of animals ashore during the breeding season gradually declined until the last pup was born in 1981, and the last animal of breeding age was seen ashore during the breeding season of 1983. The disappearance of Steller sea lions from San Miguel Island, which was the southern extent of the breeding range, occurred at a time when the species was declining in numerical abundance throughout the range of the species (Loughlin et al. 1984). It also occurred during a time when the ocean temperatures increased along the Pacific Coast in what has become regarded as a decadal shift in oceanic temperatures (Trenberth and Hurrell 1994; McGowan et al. 1998). Although the causes of the disappearance of Steller sea lions from San Miguel Island are unknown, competition with California sea lions for breeding habitat or changes in the marine foraging environment due to interannual variations and interdecadal shifts in oceanic conditions (McGowan et al. 1998) are possibilities.

Guadalupe Fur Seal

Guadalupe fur seals breed at Isla de Guadalupe (Peterson et al. 1968b) and Islas San Benito (Maravilla-Chavez and Lowry 1999), and adult males and juveniles haul out on the Channel Islands (Stewart et al. 1993). At San Miguel Island, one or more adult males have been seen annually since 1969, and juvenile animals of both sexes have been seen occasionally over the years (Stewart et al. 1987). Single males have been observed with established territories among California sea lions in rocky habitats, effectively excluding breeding sea lions. The first adult female at San Miguel Island was seen in 1997. In June 1997, she gave birth to a pup in rocky habitat along the south side of the island and, over the next year, reared the pup to weaning age (Melin and DeLong, In press). This was apparently the first pup born in the California Channel Islands in at least 150 years. With the continued expansion of the breeding population on Isla de Guadalupe (Gallo-Reynoso 1994) and new establishment of a breeding population on Islas San Benito (Maravilla-Chavez and Lowry 1999), it is probable that Guadalupe fur seals will continue to establish new breeding colonies and that the Channel Islands will be recolonized.

DISCUSSION

Community Ecology

We have studied interactions between these pinniped species for food and rookery space. Many of these data are yet to be analyzed and published, but a few of the published studies give examples of the nature of competition on the community level. Northern fur seals and California sea lions breed at the same time and actively compete for breeding space (DeLong 1982) resulting in the displacement of California sea lions from breeding habitat. California sea lions and northern fur seals compete for food, having many of the same prey species in their diets, but appear to minimize competition by foraging in different areas (Antonelis et al. 1990). Northern elephant seals minimize competition with other species in the pinniped community, first by breeding in a different season, and second, having dramatically different foraging behavior (DeLong and Stewart 1991; Stewart and DeLong 1995). At some times of the year, harbor seals and northern elephant seals use the same beaches for pupping, breeding, or hauling out. It appears that during the elephant seal breeding season, harbor seals are displaced from some of their preferred beaches. It is also probable, but as yet not well documented, that molting female elephant seals are actively displacing harbor seals from their preferred pupping beaches, causing the decline in harbor seal numbers reported by Hanan (1996).

Northern Elephant Seal Diving Study

We conducted diving and foraging behavior studies collaboratively with Brent Stewart of Hubbs-Sea World Research Institute in the late 1980s and early 1990s. Working collaboratively with Roger and Susan Hill of Wildlife Computers, we developed a microprocessor-controlled recorder that recorded depth, light level, and sea surface temperature. With the records of light levels, we were able to make one estimate of the animals' location each day (DeLong et al. 1992). We deployed the instruments on adult male elephant seals at the end of the breeding season and recovered the instruments when males returned to molt about four months later during July. To our amazement, the bulls from San Miguel Island dived continuously to average depths of 425 m and traveled to the Gulf of Alaska and the eastern Aleutian Islands, where they established foraging areas. They remained in these foraging areas for up to 40 days, diving continuously, before returning to San Miguel Island to molt (DeLong et al. 1992; Stewart and DeLong 1995). During the two migrations, males traveled at least 21,000 km in a year (Stewart and DeLong 1995). We expanded the study to include the foraging behavior of adult females and found that they migrated to a different area between 42 and 48

degrees north and ranged offshore throughout the eastern Pacific, traveling at least 18,000 km annually during the two migrations (Stewart and DeLong 1995). It became apparent that adult males and females utilized different foraging areas and did not mix at sea, and that adults of both sexes conducted two separate migrations from San Miguel Island to foraging areas in the North Pacific, one between the breeding season and the molt and a second between the molt and the next pupping/breeding season (Stewart and DeLong 1995).

California Sea Lion Branding Study

In 1975, we began tagging California sea lion pups with the objective of assessing vital rates (survival and natality rates and age of first reproduction) for the species and monitoring changes in vital rates with population fluctuations. After several years, it became apparent that, because sea lions spend so much time ashore, the numbers on plastic tags wore off within a few years of application. Consequently, tags were unreliable for assessing the population parameters we wished to measure. We evaluated a few more tag types, all with the same disappointing results. In 1987, we began a pilot study, in collaboration with biologists from the Southwest Fisheries Center of the National Marine Fisheries Service, using hot brands to permanently and individually mark a sample of pups from each of three successive cohorts. During that three-year period, we evaluated the impacts of branding on weight gain of pups and assessed first-year survival. The evaluations indicated that weight gain and survival were not significantly impacted by branding. In 1990, we began a long-term branding program, marking a sample of 500 pups from each cohort. Since the beginning of the branding program, we have branded over 5,000 pups from 12 cohorts. Estimates of survival, recruitment, and natality rates will be presented elsewhere, but it is sufficient to report here that resighting probabilities are high, 50 to 60% for animals older than two years and 30 to 40% for animals up to two years old. These resighting probabilities provide adequate data to estimate population parameters with high precision. In addition, we currently have over 170 adult females for which we will annually document reproductive activity to assess their lifetime reproductive contribution to the population.

Impacts of El Niño

There have been four strong El Niño events in the past 30 years that have had measurable impacts on pinnipeds at San Miguel Island and other Channel Islands. The impacts of the El Niños of 1972, 1983, 1992, and 1997 have been most clearly documented in annual production, pup mortality, pup growth, and population recovery of California sea lions and northern fur seals and, to a lesser extent, northern elephant seals. The 1983 El Niño has been regarded as the most powerful such event recorded in California. On San Miguel Island in 1983, numbers of northern fur seal and California sea lion pups born declined 60% and 30%, respectively, from previous years (DeLong and Antonelis 1991; DeLong et al. 1991). Similar impacts were reported on California sea lions on all rookery islands in the Channel Islands, where pup production declined 30 to 71% in 1983 (DeLong et al. 1991). It is also apparent that significant increases in juvenile and adult female mortality occurred during the El Niño year because it required six years for sea lions and eight years for fur seals in the Channel Islands to again reach pup production levels of 1982 (Figures 1 and 2) (DeLong and Antonelis 1991; Barlow et al. 1995).

The 1992 El Niño significantly affected only California sea lions. Pup production declined 43% for sea lions and the observed pup mortality of 33% was more than double that of the previous year. California sea lions rebounded quickly and, by 1994, were at record high production levels, indicating that adult survival was not dramatically impacted during this event.

The 1997 El Niño had its onset in southern California in May, shortly before sea lion and fur seal pupping began. Record numbers of northern fur seal and California sea lion pups were born at San Miguel Island in 1997, but during the pupping and breeding season adult females of both species became food stressed. Consequently, mortality of fur seal pups reached 75% before survivors of the cohort departed the island in October and November, and mortality of California sea lion pups up to four months of age was more than 24%. It is unlikely that any pups of the 1997 northern fur seal cohort survived, and California sea lion pups probably suffered additional mortality before weaning at 11 months. Pup production for both species crashed in 1998; northern fur seals declined 82% and sea lions declined 51% from 1997 levels. Levels of pup mortality were also high during 1998, with northern fur seals exceeding 50% mortality and California sea lions exceeding 40% mortality in the first few months of life. It is probable that few northern fur seals and greatly reduced numbers of sea lions from the 1998 cohorts will survive. The cumulative effects of two years of high pup mortality and one year of extremely low production for both species will create significant changes in the age distribution of these populations, which will result in slower population growth in the future. If pup production remains at or slightly above the 1998 level for northern fur seals over the next few years, the population level will have been reduced, by one short-term environmental perturbation, to population levels observed more than 20 years ago (Figure 1).

El Niño conditions impact fur seals and sea lions by decreasing the availability of prey, thereby exposing animals to nutritional stress that results in reduced reproductive rates and survival. Northern elephant seals seem to be impacted primarily by increases in pup mortality caused by flooding of the breeding beaches due to higher sea levels and increased surf height related to increased storm intensity.

Although both northern fur seals and California sea lions have experienced rapid population growth at San Miguel Island, their pup production and juvenile survival are dramatically impacted by the changes in food availability associated with El Niño conditions, such that the

population levels can be set back six or more years on the population growth curves. Northern fur seals suffer greater impacts from severe El Niño events than California sea lions. If El Niño events become more frequent or severe, it is possible that the northern fur seal population at San Miguel will enter a sustained period of population decline. Rather than being regulated by interspecific competition or intraspecific density dependent factors, the fur seal population may be regulated primarily by non-density-dependent environmental factors. In contrast, California sea lion, northern elephant seal, and harbor seal populations will likely be regulated by a combination of density-dependent and environmental factors.

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