THE PINNIPEDS OF THE CALIFORNIA CURRENT

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ABSTRACT

There are six species of pinnipeds—California sea lion, *Zalophus californianus*; northern sea lion, *Eumetopias jubatus*; northern fur seal, *Callorhinus ursinus*; Guadalupe fur seal, *Arctocephalus townsendi*; harbor seal, *Phoca vitulina richardsi*; and northern elephant seal, *Mirounga angustirostris*—that inhabit the study area of the California Cooperative Oceanic Fisheries Investigations (CalCOFI).

The numbers of animals in each population are given; the size, distribution, and seasonal movements are described. The known prey species of the pinnipeds are listed for each species. The otariids, with certain exceptions, consume the same kinds of prey, although in slightly different amounts. In general they feed most commonly on the smaller schooling fishes and squids of the epipelagic zone, and the two sea lion species enter nearshore and estuarine waters to prey on small schooling and anadromous fish. The two phocids, again with certain exceptions, prey on different species. The elephant seal apparently feeds in deeper water than the harbor seal on benthic and demersal species and the harbor seal on nearshore demersal and neretic species, occasionally entering estuarine and river waters to prey on anadromous fish and such small schooling fishes that regularly enter these waters.

RESUMEN

Existen seis especies de pinípedos — el lobo marino de California, *Zalophus californianus*; el lobo marino del norte, *Eumetopias jubatus*; el oso marino austral del norte, *Callorhinus ursinus*; el oso marino austral de Guadalupe, *Arctocephalus townsendi*; la foca peluda, *Phoca vitulina richardsi*; y el elefante marino del norte, *Mirounga angustirostris* — los cuales habitan el área de estudio de California Cooperative Oceanic Fisheries Investigations (CalCOFI).

Se da el número de animales de cada población; se describe el tamaño, la distribución, y sus desplazamientos con la estación. Se ha hecho una lista de las especies que se consideran son presas de cada especie de pinípedo. Los otariídos, con ciertas excepciones, consumen los mismos tipos de presas, aunque en cantidades ligeramente diferentes. En general se alimentan de los peces más pequeños en los cardúmenes y de calamares de la zona epipelágica, y las dos especies de lobo marino entran en la zona cerca de la costa y las aguas estuarinas y engullen los pequeños peces en los cardúmenes y peces anadromos. Los dos fócidos, otra vez con ciertas excepciones, predan especies diferentes. Aparentemente, el elefante marino se alimenta en aguas más profundas que la foca peluda, alimentándose de especies demersales y bénticas, y la foca peluda se alimenta de especies demersales costeras y neríticas, entrando ocasionalmente en ríos y aguas estuarinas haciendo presa de los peces anadromos y otros pequeños peces que entran regularmente en estas aguas.

INTRODUCTION

The California Current, its components, and the California Cooperative Oceanic Fisheries Investigations (CalCOFI) station plan have been described many times in the past and are well known (Kramer et al. 1972). Some portions of this area are inhabited by six species of pinnipeds—the California sea lion, *Zalophus californianus*; the northern sea lion, *Eumetopias jubatus*; the northern fur seal, *Callorhinus ursinus*; and the Guadalupe fur seal, *Arctocephalus townsendi*—and two phocids (earless seals)—the harbor seal, *Phoca vitulina richardsi*; and the northern elephant seal, *Mirounga angustirostris*. These six species are year-round residents, although the northern fur seal is present in large numbers only from January to April, and several others make seasonal migrations throughout the region.

In this paper we present both published and unpublished information on population size, on sightings at sea, and on food and feeding habits of each pinniped species found in the CalCOFI area. Their feeding activities are compared, and predation on commercially valuable fish species is discussed.

SPECIES ACCOUNTS

California Sea Lion, *Zalophus californianus*

Physical Description

The California sea lion is the most commonly observed pinniped in the CalCOFI study area. The species is characterized by relatively short hind flippers and by foreflippers that are haired on the dorsal surface from the insertion of the limb down to the first or second digit. Adult males weigh about 380 kg and measure about 2.2 m in length; their pelage is mostly dark brown with a light (almost white) sagittal crest. Adult females are consider-

ably smaller, weighing about 100 kg and reaching 1.8 m in length; their pelage varies from light brown to straw color. At sea both males and females usually appear dark chocolate-brown to gray. Newborn pups are dark brown, weigh about 9 kg, and measure 65 cm in length.

Distribution and Migration

The California sea lion ranges along the west coast of Mexico from about Latitude 19°N northward to southern British Columbia, Latitude 50°N; its breeding range extends from several Gulf of California islands north to San Miguel Island, California. Some pupping has been reported north to the Farallon Islands, but the overall effect of pupping north of San Miguel on the population is minimal (Ainley 1977; Braham 1974).

During the breeding season (May-July), almost the entire population of 80,000 to 125,000 animals is found south of 34°N Latitude (National Marine Fisheries Service 1978; Le Bouef et al. 1976). Beginning in mid-July, a portion of the male population migrates northward, some reaching waters off Vancouver Island, British Columbia. Mate (1975) estimated that 4,000 males may be found north of California from early fall (September) until spring (May) and the rest of the population remains in California and Mexican waters.

Le Bouef et al. (1976) carried out surface and aerial surveys of the Southern California Bight in 1975-76 from about Point Conception (34°30'N, 121°10'W) south to 32°20'N. This area included the California Channel Islands and most major banks and ridges. The Southern California Bight includes northern breeding islands that support a population of about 40,000 during the breeding season. Le Bouef concluded that California sea lions are mainly coastal animals that rarely venture more than 50 km from their hauling grounds. In 1965-66, Marine Mammal Division personnel of the NMFS Northwest and Alaska Fisheries Center (hereinafter referred to as MMD) carried out a series of surface transects starting from about 8 to 16 km offshore and extending for 185 to 200 km at intervals of 20' of latitude from 32°N to 38°N. The objective of the survey was to determine the winter distribution of the northern fur seal; however, records were kept of all marine mammals sighted (Fiscus and Kajimura 1967, 1969). In 1976 Le Bouef and his colleagues observed California sea lions along similar transects. The reports from both of these surveys confirmed that this species is a coastal animal rarely venturing seaward off the continental slope. Out of 278 sightings, MMD personnel reported a few sightings of single or, in one instance, two animals sighted over deep water, well offshore: 1) 16 April 1965, one adult male sighted at 37°58'N, 125°25'W, 122 km west of Point Reyes, California; 2) 3 February 1966, one adult male sighted at 33°20'N, 121°33'W, 126 km southwest of San Miguel Island, California; 3) 4 February 1966, a pair and one adult sighted at 34°00'N, 122°14'W, 161 km west of San Miguel Island, California.

Food and Feeding Habits

Known prey species consumed by the California sea lion include: Pacific lamprey, *Entosphenus tridentatus*; Pacific herring, *Clupea harengus pallasi*; northern anchovy, *Engraulis mordax*; salmon, *Oncorhynchus* sp.; plainfin midshipman, *Porichthys notatus*; Pacific hake, *Merluccius productus*; Pacific tomcod, *Microgadus proximus*; jacksmelt, *Atherinopsis californiensis*; white croaker, *Genyonemus lineatus*; jack mackerel, *Trachurus symmetricus*; rockfish, *Sebastes* sp.; rex sole, *Glyptocephalus zachirus*; slender sole, *Lyopsetta exilis*; English sole, *Parophrys vetulus*; and squid, *Loligo opalescens* (Ainley et al. 1977; Best 1963; Briggs and Davis 1972; Fiscus and Baines 1966; Jameson and Kenyon 1977).

Sea lion spewings were examined at Southeast Farallon Island throughout the year when animals were present (Ainley et al. 1977). Investigators discovered Pacific hake to be an important food item, being found almost exclusively in the spewings when the population peaked on its southbound migration in April and May, at the time when hake are beginning to appear on the continental shelf in that vicinity. Sea lion numbers during this peak period in 1974-75 were slightly under 1,400 animals and in 1976 slightly under 1,200.

One of the authors (G.A.A.) collected 50 California sea lion scats from haul sites and rookeries on San Miguel Island in August 1978. Otoliths and cephalopod beaks found in the scat samples were identified by John E. Fitch (California Department of Fish and Game, Terminal Island) and by Clifford H. Fiscus, respectively. Pacific hake (mostly juvenile) occurred in 24 samples; rockfish (mostly juvenile) in 20; northern anchovy in 3; California lanternfish, *Symbolophorus californiensis*, in 1; queenfish, *Seriphus politus*, in 2; pink seaperch, *Zalembius rosaceus*, in 1; Pacific pompano, *Peprilus simillimus*, in 1; *Loligo opalescens* in 30, *Onychoteuthis borealijaponicus* in 6; Gonatidæ in 3; *Histioteuthis* sp. in 1; and Octopoda (mostly very small) in 7.

Fiscus has seen sea lions leave the rookeries and haul sites, form into large groups, and presumably leave for the feeding areas. Large groups of sea lions have been observed feeding in relatively small areas where prey items are highly concentrated; however, the number of sea lions gradually decreases as prey becomes less abundant. The seasonal abundance of schooling fishes such as the northern anchovy, Pacific hake, and the squid, *Loligo opalescens*, in the vicinity of rookeries of the California Channel Islands provides an abundant food supply for this species. California sea lions appear to feed opportunistically on a variety of prey; however, seasonally abun-

dant small schooling fish and squid are common prey species.

Northern Sea Lion, *Eumetopias jubatus*

Physical Description

The northern sea lion is easily distinguished from the California sea lion by its larger size; members of this species are also recognized by their relatively short rear flippers and by a lack of hair on the dorsal surface of the foreflippers below the wrist.

Adult males weigh from 700 to 1,000 kg and reach 3.0 m in length; females weigh from 275 to 450 kg and reach 2.0 m in length (Bonnot 1951; Kenyon and Scheffer 1953). The pelage color in both sexes is blond dorsally and brown ventrally; adult males have a mane of longer hair on neck and shoulders. At sea they appear to be gray or light colored as compared to the darker California sea lion. Newborn pups weigh about 20 kg and are about 1 m in length.

Distribution and Migration

The species range extends around the North Pacific Ocean rim from off southern California, to the Bering Sea, to the Kurile Islands and the Okhotsk Sea. The southern limit of the northern sea lions' breeding range in the eastern North Pacific is presently located at San Miguel Island at about Latitude 34°N. In 1977, the breeding population on San Miguel and adjacent Castle Rock was comprised of four adult females, two large males, and three pups born during the season. The breeding colony at Año Nuevo Island at about 37°N numbered about 1,200 animals (Robert Gisiner, University of California Santa Cruz, personal communication), a decline of about 33% from the population described in 1968-69 (Mate 1977; Gentry 1970). The breeding colony at Southeast Farallon Island, at about 38°N Latitude, contains less than 200 animals. Ainley et al. (1977) reported a breeding population there of about 130 animals in 1976. The northern sea lion population on these three breeding areas has declined in numbers since the 1920's and 1930's, as indicated in available census data. The northern sea lion population off California north of 38°N Latitude in July numbers about 800 to 900 animals (Mate 1977); thus the California breeding season population numbers from 2,200 to 2,300 animals.

Most northern sea lions are on or near their breeding islands during May and June. After the breeding season, a general northward movement of male northern sea lions, similar to that which occurs in California sea lions, was proposed by Bonnot (1951) and by Bartholomew and Boolootian (1960). Adult females and young animals apparently stay in the general area of the southern rookeries year-round (Bonnot 1951; Orr and Poulter 1965; Spalding 1964; Le Bouef et al. 1976).

In 1958-61 and 1964-66, MMD personnel recorded 120 northern sea lions at sea. These animals were commonly seen in the nutrient rich waters of the continental shelf and slope in 50 to 200 m of water. There were a few occasions, however, when northern sea lions were observed in water deeper than 200 m.

Single northern sea lions were most commonly observed at sea, although small groups of two to four were occasionally seen. The largest group seen off California (37°09'N, 122°45'W) numbered 20 individuals.

Food and Feeding Habits

Prey species consumed by the northern sea lion in this region include rockfish; sanddab, *Citharichthys* sp.; and turbot, *Pleuronichthys* sp. (Fiscus and Baines 1966). In waters north of the CalCOFI area, prey species include Pacific lamprey: Pacific herring; salmon; smelt, Osmeridæ; Pacific hake; walleye pollock, *Theragra chalcograma*; greenling, Hexagrammidæ; sculpin, Cottidæ, Pacific sandlance, *Ammodytes hexapterus*; arrowtooth flounder, *Atherestes stomias*; flatfish, Pleuronectidæ; ratfish; *Hydrolagus colliei*; spiney dog fish, *Squalus acanthias*; squid; octopus; shellfish; and shrimp (Spalding 1964; Fiscus and Baines 1966).

The food and foraging habits of the northern sea lion are highly variable. Mathisen et al. (1962) and Spalding (1964) have shown that the food of this species varies with season, location, age class, and sex of the animals. In another food study, Fiscus and Baines (1966) suggested that northern sea lions feed in waters of less than 180-m depth. There are, however, offshore sightings of this species in water deeper than 200 m, which suggest that these animals are also epipelagic and mesopelagic feeders.

Northern sea lions presumably feed both nocturnally and diurnally. Several authors (Spalding 1964; Gentry 1970) reported evidence of nocturnal feeding during certain times of the year. Diurnal feeding was reported by Fiscus and Baines (1966).

Northern sea lions usually consume whole small fish and cephalopods below the surface. Large prey are consumed at the surface, where the prey is torn to pieces by a violent shaking motion of the sea lion's head.

Northern Fur Seal, *Callorhinus ursinus*

Physical Description

The northern fur seal is easily distinguished from other otariids by its longer hind flippers, which are about twice the length of sea lion flippers, and by the hair line on the foreflipper which stops abruptly at the wrist line. Adult males weigh from 227 to 318 kg and may reach a length of 2 m, whereas females weigh from 36 to 59 kg and may reach 1.2 m in length (National Marine Fisheries Service 1978). Adult male pelage varies in color from dark brown to dark gray, with a mane of longer hair on the neck

and shoulder areas. Adult female pelage varies from dark brown to light gray brown and is usually lighter ventrally. At sea, fur seals appear black with a lighter muzzle and if startled, they often rear out of the water exposing lighter colored or gray throats. Pups weigh approximately 5.3 kg and measure about 50 cm in length at birth. The black birth coat is retained until fall, when at first molt the pup acquires a silver gray pelage.

Distribution and Migration

The northern fur seal ranges across subarctic waters of the North Pacific Ocean and portions of the Bering and Okhotsk Seas and the Sea of Japan. Its breeding grounds are located in the Pribilof and Commander Islands in the Bering Sea, Robben Island in the Okhotsk Sea, on several of the Kurile Islands in the western Pacific, and on San Miguel Island and adjacent Castle Rock off California in the eastern North Pacific Ocean. A maximum count of 2,388 fur seals was obtained for San Miguel Island and Castle Rock during the 1977 breeding season. Current population estimates of the more northern breeding locations are Pribilof Islands, 1,300,000; Commander Islands, 265,000; Robben Island, 165,000; Kurile Islands, 33,000.

Most fur seals are on or near their breeding islands from July to October. Southbound movements into wintering areas of the North Pacific Ocean and Sea of Japan begin in late October.

About 1,000,000 fur seals winter in the eastern North Pacific, from the Aleutian Islands eastward and south to about 32°N Latitude (Fiscus et al. 1977). In the offshore waters of California, the first seals begin to arrive in late November, generally moving south over waters of the continental shelf and slope with maximum numbers occurring from January to March from about 34°N to 42°N Latitudes. The northward migration begins in March and most seals have left the offshore area by early June with the exception of the San Miguel-Castle Rock population.

The fur seal wintering range extends south to about 32°N, although there have been verified sightings farther south. Most fur seals wintering in California waters are females of all age classes and young males 2-4 years old.

Fur seals seldom approach land during the winter months although there are a few exceptions. In 1965-66 off California, transects were run from near shore over the continental shelf and slope seaward over deep water. Seals were seldom seen within 18 to 28 km of shore, being most numerous along the continental slope and those areas where bottom topography caused upwellings of nutrient rich water (Fiscus and Kajimura 1967, 1969).

Fur seals are usually alone at sea, although pairs and groups of three are fairly common. The largest group seen during 15 years of ocean research numbered about 100 animals, its members feeding on a large school of anchovies off the Farallon Islands, California. Fur seal densities are quite variable, ranging from 0 to 20 per km^2.

Food and Feeding Habits

Fur seals congregate in areas of abundant food supply, even though they usually remain in small separate groups of two to three animals. On occasion larger groups of seals are formed but these probably disperse after the prey schools have broken up. Most feeding is done at night, although daytime feeding may occur when schools of prey are located near the surface. Fur seals are able to swallow whole fish or squid up to 25 cm in length but usually surface and break up larger prey there before eating it.

During pelagic studies of the northern fur seal off California from 1958 to 1966, 3,595 seals were taken, of which the stomachs of 2,516 contained food. Among the prey items identified were 26 species of fish and 9 cephalopods. Species of prey that formed a major portion of the fur seals' diet off California are listed in Table 1.

TABLE 1
Principal Prey from the Stomachs of Northern Fur Seals Collected off California[1].

	Year and Month of Collection					
	1958	1959	1960	1964	1965	1966
Species	Feb. Mar. Apr.	Jan. Feb. Mar. Apr.	Dec. Jan. Feb. Mar. Apr.	Apr. May	Apr.May June	Jan. Feb. Mar.
	Percentage of Volume					
Engraulis mordax	14.3	58.9	29.7	2.1	15.0	74.4
Merluccius productus	17.0	24.4	7.1	73.8	36.7	19.8
Cololabis saira	20.7	3.5	13.4	0.4	3.0	2.8
Onychoteuthis borealijaponicus	.6	.6	27.2	2.4	2.6	1.0
Loligo opalescens	7.9	2.0	11.4	12.9	24.0	.5
Sebastes sp.	—	—	—	—	11.6	—
Trachurus symmetricus	5.1	2.4	—	—	3.3	—
Anoplopoma fimbria	—	—	—	7.5	—	—
Number of stomachs with food	323	893	565	228	226	331

[1]Data from North Pacific Fur Seal Commission 1965, 1969.
Note: Does not include all food items listed.

Guadalupe Fur Seal, *Arctocephalus townsendi*

Physical Description

The Guadalupe fur seal can be distinguished from the other otariids by the distinctive feature of having hair on the dorsum of the foreflipper that extends past the wrist line. Their rear flippers are relatively small and similar to those of the sea lions. Adult males grow to a weight of

about 170 kg and may reach 2.0 m in length. Females weigh over 50 kg and may reach 1.7 m in length. Their general overall color is dark brown with lighter shading on the chest. In addition to the obvious size difference, males have a mane of longer hair which also distinguishes them from females. At sea, both sexes appear black under most conditions. Newborn pups are probably about the same size and color as northern fur seal pups.

Distribution and Migration

The former range of the Guadalupe fur seal may have extended from about 18°N, Isla Socorro, northward to the Santa Barbara, California, Channel Islands to about 34°N, and there is some evidence from the bones of Guadalupe fur seals found in Indian kitchen middens that breeding colonies existed as far north as these islands (Repenning et al. 1971).

The Guadalupe fur seal breeds only on Guadalupe Island. Once thought extinct, an adult male was seen on San Nicolas Island in 1947, and breeding animals were rediscovered on Guadalupe Island in November of 1954 by Dr. Carl L. Hubbs (1956). Hubbs returned in June 1955 and counted more than 30 seals. Since 1955, counts of this species have been made periodically, and increasing numbers of animals have been found. The most recent counts were made in July and July 1977 by Fleischer (1978), who counted a total of 1,073 animals. Fleischer calculated that the population ashore in 1977 was made up of 30% mature males, 38% mature females, 19% pups, 7% juveniles, 2% subadults, and 4% uncategorized seals.

Recently, individual animals have been seen at Isla Cedros, Baja California (National Marine Fisheries Service 1978), and on San Clemente Island (Le Bouef et al. 1976). Robert DeLong and one of us (G.A.A.) both of the Marine Mammal Division, have observed one or more subadult or adult males at San Miguel Island each year since 1968. DeLong, Fiscus, and Karl Kenyon observed a juvenile female on San Miguel Island in 1971. On 25 April 1977, a young Guadalupe fur seal was found on a beach in Monterey Bay, California (M. Webber, personal communication).

The appearance of this species on islands in its former range, the midden records, Webber's record from Monterey Bay, and one sighting of a seal at sea in the Southern California Bight (Le Bouef et al. 1976) may indicate a breeding season movement of a few subadult and adult males and a northward post-breeding season movement of juveniles. Best and Shaughnessy (1975), in describing pup behavior of the Cape fur seal, *Arctocephalus pusillus pusillus*, report that pups begin to enter the water at about 4 and 5 months after birth; by 7 months of age they may stay away from land for 2 to 3 days at a time; and after that some may go to sea at age 7 months and by the 10th month the seaward dispersal is quite evident. Should a similar pattern occur in the Guadalupe fur seal, most pups could be expected to be at sea from about February to April/May. The southern species of this genus does not migrate great distances from the rookery islands and spends more time on land or in the sea relatively near its regular haul sites. This same behavioral trait may also occur in the Guadalupe Fur Seal.

Food and Feeding Habits

We have no information on the prey species or feeding habits of the species. Shaughnessy (1976a) records the food of the Cape fur seal as 50% fish, 37% cephalopods, and 13% crustaceans. Of the fish, pilchards, anchovy, and hake were identified. Shaughnessy (1976b) listed fish, cephalopods, and euphausiids as prey of the Amsterdam Island fur seal, *Arctocephalus tropicalis*. Raul Vas-Ferreira (1976) recorded fish, cephalopods, and crustaceans as food of the South American fur seal, *Arctocephalus australis*, and Bonner (1976) listed krill, *Euphausia* sp., as the principal food of the Antarctic fur seal, *Arctocephalus gazella*.

Nurtient-rich waters surrounding Guadalupe Island support an abundant supply of small schooling fishes belonging to the same families as those utilized by their southern counterparts; squids of several species are plentiful in the area, and we can probably assume that anchovy, Pacific hake, jack mackerel, and other small schooling fishes and squid form a large portion of the Guadalupe fur seal's diet. Only one of the southern species existed principally on crustaceans; therefore, it is possible that if present in sufficient numbers, crustaceans may be utilized by the Guadalupe fur seal.

Harbor Seal, *Phoca vitulina richardsi*

Physical Description

The harbor seal is the smallest pinniped found in the CalCOFI study area. All flippers are relatively small and completely haired. Adults of both sexes generally weigh from 65 to 105 kg and reach from 1.2 to 1.8 m in length. Females usually weigh only about three-fourths the weight of males (Sheffer and Slipp 1944). The pelage of both sexes is spotted or mottled, and their general overall color ranges from silver gray to dark brown or black. At sea, they usually appear dark gray-brown or black with lighter mottling or spots. Most often, only the head is visible. The pelage of newborn pups is similar to that of the adults; however, there are rare occasions in California when they are born with a white lanugo coat (usually shed in utero). At birth, the pups weigh about 11 kg and measure 75 cm in length.

Distribution and Migration

Five subspecies of harbor seals are distributed along the coastline and offshore islands of the North Pacific Ocean, the North Atlantic Ocean, and contiguous seas. *Phoca vitulina richardsi* is the subspecies that inhabits the CalCOFI area (Shaughnessy and Fay 1977). It ranges from about 65°N Latitude southward along the coasts of Alaska, Canada, Washington, Oregon, California, and Baja California to Isla San Martin, 30°29'N, 116°07'W (Shaughnessy and Fay 1977; Scheffer 1974).

Harbor seals usually haul out on secluded beaches, rocky intertidal areas, or mud flats in bays and estuaries. There is no obvious segregation by sex or age class in these areas, although it is believed that some beaches are preferred for pupping (Houck 1975, personal communicattion; Le Bouef et al. 1976). Both Houck and Le Bouef report that in the spring, when the breeding season begins, the numbers of adults and newborn pups increase steadily. The population then reaches an annual high in early summer, then again declining to the lowest numbers ashore in mid-winter.

In 1976 Mate (1976) conducted an aerial census from British Columbia southward to the Gulf of California between 17 June and 1 July. He reported a harbor seal count of 7,517 for Washington, Oregon, California, and Mexico, including a CalCOFI area count of 3,127 animals.

There is little evidence of seasonal migrations in harbor seals, although seasonal changes in numbers in Humboldt Bay (Houck 1975, personal communication) and in the Southern California Bight (Le Bouef et al. 1976) suggest that some form of predictable haulout pattern may exist. It is not known if the smaller population observed during the non-breeding season represents a change in haulout behavior, or increased time spent at sea. There is evidence that harbor seals in the northeastern North Pacific Ocean are more pelagic during their foraging activities than previously suspected (Pitcher and Calkins 1978). In California waters, harbor seals have seldom been reported from water deeper than 90 m.

Food and Feeding Habits

Little is known about the food consumed by the harbor seals off California and Baja California. In one study, two harbor seals were collected by Bob DeLong at San Miguel Island on 2 June 1971. One harbor seal stomach contained otoliths from plainfin midshipman and pileperch, *Rhacochilus (Damalilicthys) vacca*, whereas the other contained pileperch and an unidentified species of octopus. There are, however, several other studies of harbor seals in more northern waters that can also be used to generally describe harbor seal feeding habits. This species is believed to be an opportunistic feeder, preying on seasonally abundant species (Scheffer and Sperry 1931; Scheffer and Slipp 1944; Spalding 1964; Calambokidis et al. 1978). All of these authors reported a wide variety of food items including Pacific hake; plainfin midshipman; walleye pollock; Pacific tomcod; Pacific staghorn sculpin, *Leptocottus armatus*; starry flounder, *Platichthys stellatus*; Pacific herring; rockfish; salmon; and a few species of squid, octopus, crustacea, and bivalve mollusc.

Harbor seals are believed to be late afternoon feeders (Spalding 1964), although movement to the water is also related to tidal changes and changes in the diel photoperiod (Woodhouse personal communication; Kenyon 1965; Spalding 1964). Typically, large prey are consumed at the surface, whereas smaller prey are eaten underwater. Bivalve molluscs are brought to the surface, crushed, and opened in the mouth before consumption (personal observation G.A.A.).

Northern Elephant Seal, *Mirounga angustirostris*

Physical Description

The northern elephant seal is the largest pinniped found in the CalCOFI study area. All flippers are relatively small and completely haired. Adult males grow to a weight of about 2,700 kg and a length of 5.0 m. They can be easily distinguished from females by their long proboscis and thickly wrinkled neck shields. Adult females may weigh 900 kg and reach a length of about 3.4 m. The color of the pelage of both sexes ranges from silver-gray to light brown. At sea their pelage varies in color from gray-black to black. Newborn pups have a black pelage and may weigh 35 kg and reach about 1.0 m in length.

Distribution and Migration

The population has recovered from an estimated low of 100 in 1890 to its present high of about 60,000 (Le Bouef and Bonnell in press). This species ranges along the west coast of Baja California northward into the Gulf of Alaska and breeds from Isla Natividad, Mexico, north to the Farallon Islands, California. Breeding rookeries are located on Isla Natividad, Isla Cedros, Islas San Benito, Isla Guadalupe, Isla San Martin, and Islas Los Coronados in Mexico, San Miguel Island, Año Nuevo Island, Point Año Nuevo, and Southeast Farallon Island off California (National Marine Fisheries Service 1978; Le Bouef and Panken 1977; Le Bouef and Mate 1978). There are three records of elephant seals from the eastern Aleutian Islands in 1977-78 (David Withrow, personal communication) and two records from Midway Atoll, northwestern Hawaiian Islands in 1978 (John Naughton, personal communication).

The portions of the elephant seal population at sea varies according to season. Le Bouef et al. (1976) describe the periods ashore for the islands of the Southern California Bight. During the breeding season (from about

December to 15 March), breeding-age males, adult females, and newborn pups are ashore; during the spring season (from about mid-March to early June), adult females and juveniles molt and the pups begin to go out to sea; during the summer (from early June through August), subadult and adult males are molting; during the fall (from September through November), yearlings and juveniles 2 to 5 years haul out. Thus the entire population is not at sea at any given time as is the case of the northern fur seal. During fur seal research cruises off California between 1958 and 1966 (388 sea days), MMD personnel sighted 51 elephant seals, all solitary animals. During the period 9 May 1975 to 15 March 1976, Le Bouef et al. (1976) sighted 28 animals in the Southern California Bight, most of which were individual animals. Our sightings were made over the continental shelf and slope. Scheffer (1964) records the taking of three young elephant seals from a depth of 180 m (100 fathoms) on longline gear set for sablefish, *Anoplopoma fimbria*, about 26 August 1963 off Florence, Oregon. The largest animal, estimated to be 2-3 years old, from cranial characters and teeth, was dead; the two smaller seals were still alive and were released by the fisherman. This report is our only record of three seals being in the same area at the same time at sea and represents the only depth of dive records. The MMD has several reports of this species from seaward of the continental shelf over deep water from fishermen and from recent Alaskan and Midway Atoll sightings which indicate that some offshore movements must occur.

Food and Feeding Habits

Information on the food and feeding habits of the northern elephant seal are scanty. Anthony (1925) mentions that of the seals (seven) taken in 1892 on Isla Guadalupe, the stomach of one contained a fish, *Sebastes* sp., and a few fragments of kelp, and the other stomachs were found to be empty. Townsend (1912) mentioned that Harris found small sardines, not more than 2 inches long, in the stomach of an elephant seal he took in 1907. Huey (1930) reports that the stomach of the large adult male taken about 40 miles (74 km) off Point Loma, California, on 20 September 1929, contained seven ratfish; one spiney dogfish; one swell shark, *Cephaloscyllium ventriosum*; three skate, *Raja* sp.; and four squid, *Loligo opalescens*. Cowan and Guiguet (1965) wrote that the stomach of a seal taken at Ucluelet, British Columbia, contained only eggs of Pacific hagfish, *Eptatretus stouti*, and a vertebral column, also possibly from a hagfish.

Brown and Norris (1956) reported seeing adult elephant seals on three occasions with groups of Pacific whiteside dolphin, *Lagenorhynchus obliquidens*, and California sea lions, all apparently feeding on the same northern anchovy school. Morejohn and Baltz (1970) examined the stomach contents of a subadult male found dead on a Monterey Bay beach on 20 December 1968 and from otoliths determined that the animal had eaten about 50 spotted cusk-eels, *Otophidium taylori*; 35 plainfin midshipmen; 10 rockfish; one flatfish; and two brown catsharks, *Apristurus brunneus*. The stomach also contained some unidentifiable teleost bones and an elasmobranch veterbral column.

Fiscus examined the stomach contents of four elephant seals found dead on Oregon beaches in 1973 for R. Stroud, School of Veterinary Medicine, Oregon State University, Corvallis, and identified the following species of cephalopods: Gonatidæ, 2 *Gonatus* sp., *Gonatopsis borealis, Chiroteuthis* sp., *Octopoteuthis* sp., *Onychoteuthis borealijaponicus, Rossia pacifica* and *Octopus* sp. In addition to the squids, the Pacific lamprey was found in two stomachs, and two species of flatfishes, Pacific sanddab, *Citharichthys sordidus*, and rex sole, were found in one stomach. From these records, it would appear that the elephant seal feeds principally on benthic neritic and demersal prey but does prey to some extent on epipelagic and mesopelagic species.

Identified prey species and pinniped population estimates are summarized in Table 2.

PREDATORS ON PINNIPEDS

Suspected predators of these pinnipeds are sharks of several species and killer whales. Rice (1968) listed the remains of California sea lions, northern sea lions, and northern elephant seals from the stomachs of killer whales, *Orcinus orca*. Kenyon (1959) identified the remains of California sea lions from the stomach of a white shark, *Carcharodon carcharias*.

DISCUSSION

Comparatively little is known about pinniped movements and feeding habits at sea, with the exception of the northern fur seal. We can, however, make some generalizations about feeding activites and foraging strategies of these six species by using available data.

In California waters, the schooling fishes and squid (Pacific hake, northern anchovy, jack mackerel, and the squid *Loligo*) are all commonly preyed on by otariids. We can assume that epipelagic and mesopelagic foraging is usual among otariids from what is known about the movement of these species both in coastal and offshore waters. Feeding in the epipelagic and mesopelagic zones is particularly true for the wintering northern fur seal when it arrives in California waters in December (from the northern rookeries) until it departs again in spring (Fiscus and Kajimura 1967, 1969).

The northern fur seal is the most pelagic of the four otariid species and seldom approaches land, whereas the two sea lion species do feed in the nearshore areas and to

TABLE 2

Summary of Prey Species and Pinniped Population Estimates in the CalCOFI Study Area.

Scientific name	Common name	Pinniped species and population estimate: *Zalophus californianus* (80,000 to 125,000)	*Eumetopias jubatus* (2,300)	*Callorhinus ursinus* 2,388 residents,[1] unknown number of winter migrants	*Arctocephalus townsendi* (2,000)	*Phoca vitulina richardii* (3,127)[1]	*Mirounga angustirostris* (60,000)
		Prey species[2]					
Eptatretus stouti	Pacific hagfish						C
Entosphenus tridentatus	Pacific lamprey	C	N	C			
Cephaloscyllium ventriosum	swell shark						
Apristurus brunneus	brown catshark						C
Squalus acanthias	spiny dogfish		N				C
Raja sp.	skate						C
Hydrolagus colliei	ratfish		N				C
Clupea harengus pallasi	Pacific herring	C	N	C		N	
Alosa sapidissima	American shad			C			
Sardinops sagax	Pacific sardine						C
Engraulis mordax	Northern anchovy	C		C			C
Oncorhynchus sp.	salmon	C	N	C		N	
Osmeridæ	smelt		N				
Hypomesus pretiosus	surf smelt			C			
Thaleichthys pacificus	eulachon			C			
Tactostoma macropus	longfin dragonfish			C			
Myctophidæ	lanternfish	C		C			
Paralepis atlantica	barracudinas			C			
Tarletonbeania crenularis	blue lanternfish			C			
Porichthys notatus	plainfin midshiman	C		C		C	C
Merluccius productus	Pacific hake	C	N	C		N	
Microgadus proximus	Pacific tomcod	C				N	
Theragra chalcogramma	walleye pollock		N			N	
Otophidium taylori	spotted cusk-eels						C
Cololabis saira	Pacific saury			C			
Antherinopsis californiensis	jacksmelt	C		C			
Trachipeterus altivelis	king-of-the-salmon			C			
Syngnathus californiensis	kelp pipefish			C			
Trachurus symmetricus	jack mackerel	C		C			
Scomber japonicus	chub mackerel			C			
Genyonemus lineatus	white croaker	C		C			
Seriphus politus	queenfish			C			
Rhacochilus vacca	pile perch					C	
Zalembius rosaceus	pink sea perch	C					
Ammodytes hexapterus	Pacific sandlance		N				
Peprilus simillimus	Pacific pompano	C					
Sebastes sp.	rockfish	C	C	C		N	C
Anoplopoma fimbria	sablefish			C			
Brama japonica	Pacific pomfret			C			
Medialuna californiensis	halfmoon			C			
Hexagrammidæ	greenling		N				
Cottidæ	sculpin		N				
Leptocottus armatus	Pacific staghorn sculpin					N	
Citharichthys sp.	flounder		C	C			
Citharichthys sordidus	Pacific sanddab						C
Pleuronectidæ	flatfish		N	C			C
Atheresthes stomias	arrowtooth flounder		N				
Glyptocephalus zachirus	rex sole	C					
Lyopsetta exilis	slender sole	C		C			
Parophrys ventulus	English sole	C					
Platichthys stellatus	starry flounder					N	
Pleuronichthys sp.	turbot		C				
Decapoda	squid		N			N	
Rossia pacifica	squid						N
Loligo opalescens	squid	C		C			C
Octopoteuthis sp.	squid			C			N
Onychoteuthis borealijaponicus	squid	C		C			N
Moroteuthis robusta	squid			C			
Gonatidæ	squid	C					N
Berryteuthis magister	squid			C			
Gonatus sp.	squid			C			N
Gonatopsis borealis	squid			C			N
Histioteuthis sp.	squid	C					
Dosidicus gigas	squid			C			
Chiroteuthis sp.	squid						N
Abraliopsis sp.	squid			C			
Octopoda	octopus	C	N	C		C	N
Pelecypoda	shellfish		N			N	
Crustacea	crab and shrimp		N			N	

[1] Actual count
[2] C=known prey in CalCOFI area. N=known prey north of the CalCOFI area.
[3] No prey species identified to date.

some extent in estuarine waters on seasonally abundant anadromous species of fish Fiscus (in press). Both species of sea lions and the northern fur seal apparently feed opportunistically on a variety of different prey. Some of these prey species are frequently preyed upon when they become more abundant during their seasonal migrations into nearshore waters and over the continental shelf and slope. Opportunistic feeding is substantiated by several reports on seasonal variations in feeding behavior of California sea lions (Ainley et al. 1977), northern fur seals (Fiscus and Kajimura 1967, 1979), and northern sea lions (Spalding 1964). We assume that Guadalupe fur seals exhibit feeding behavior similar to that of the other otariids, although studies of the food of this species have not been carried out.

Unlike the otariids, harbor seals and northern elephant seals most commonly feed on demersal prey species, although in different zones. Harbor seals probably forage near shore in less than 80 m of water, since flounder, sculpin, octopus, crustaceans, and bivalve mollusc are common food items (all from northern population; Spalding 1964 and Calambokidis et al. 1978). Harbor seals also feed opportunistically on seasonally abundant small schooling fishes that migrate near shore. Spalding (1964) reported relatively high consumption of salmon by harbor seals only during the fall migratory season in nearshore and estuarine waters.

The northern elephant seal feeds on several demersal and benthic species commonly found in water to 180 m (Huey 1930; Morejohn and Baltz 1970). Prey records of this species by Anthony (1925), by Townsend (1912), by Brown and Norris (1956), and the results of this study indicate that epipelagic and mesopelagic foraging also occurs when prey are abundant.

We assume that opportunistic feeding on a variety of prey species is common among these pinnipeds, and that during times of abundant food supply, foraging areas of different species overlap. One of us (C.H.F.) has personally observed California sea lions, northern fur seals, the saddleback dolphin, *Delphinus delphis*, and the Pacific whiteside dolphin all actively feeding on a single school of anchovies. When prey concentrations disperse, overlapping and competition in foraging areas declines. Thus, during a period of low prey abundance, one might expect to see the greatest degree of species separation as foraging occurs in the epipelagic and mesopelagic zones (>150 m) for northern fur seals, the neritic zone for both species of sea lion, the nearshore area for harbor seals, and the offshore demersal and benthic zone for northern elephant seals. During these same periods, we will also see a greater variety of prey species consumed.

The Guadalupe fur seal population is so small (a total population of probably no more than 2,000) that it could not significantly affect the abundance of fish and cephalopod resources of the region. The other three species of otariids (California sea lion, northern sea lion, and the northern fur seal) have populations that are large and are known to feed on a variety of commercially important fish and squids, including northern anchovy, salmon, Pacific hake, jack mackerel, and squid. The degree of pinniped predation on these species, however, is impossible to determine at this time since so little is known about the foraging behavior of these animals.

Information about the feeding habits of the two species of phocids (harbor seal and northern elephant seal) that inhabit the California Current region is extremely scarce. It is possible, however, that both species may affect the abundance of nearshore schooling fishes and squids, such as northern anchovy and *Loligo*. Furthermore, when elephant seals feed in deeper water there is a potential for competition with certain fisheries, such as longline fisheries for bottom fish.

It is possible that all fish species taken in the commercial fisheries might be potential food of these pinnipeds because of their opportunistic feeding behavior. At the present time, however, the effect of pinniped predation on the major commercial fisheries in the CalCOFI area cannot be determined. The establishment of the Fishery Conservation and Management Act of 1976, and the possibility of increased commercial fishing activities in pinniped foraging areas, could be of major concern in the future.

In addition to their potential impact on valuable commercial stocks, pinnipeds at times interact directly with commercial fishing operations. Briggs and Davis (1972) reported on damage caused by California sea lions in the sport and commercial troll fishery for salmon in Monterey Bay. Interactions between pinnipeds and other fisheries such as the purse seine fishery for anchovy and squid occur. California coastal marine mammal-fishery interaction studies are presently being implemented by the National Marine Fisheries Service through contract with the California Department of Fish and Game.

It is apparent that because of our general lack of knowledge of pinniped foraging habits, a great deal of research must be completed before we will be able to evaluate the impact of these marine mammals on commercially valuable marine resources. Preferred foraging habitats, distribution at sea, and seasonal feeding habits of different age groups and sexes are all topics that must be addressed in order to better understand predator-prey relationships.

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