$$\log_e F = 9.9713 + 0.3657(A)$$
$$(r^2 = 0.1804,\ s_{y \cdot x} = 0.5466).$$

For fecundity on fork length (Figure 4):

$$\log_e F = -9.8719 + 3.8775(\log_e L)$$
$$(r^2 = 0.6490,\ s_{y \cdot x} = 0.3751).$$

For fecundity on weight:

$$F = 12{,}064.2908 + 374.8848(W)$$
$$(r^2 = 0.4445,\ s_{y \cdot x} = 20{,}427.0752).$$

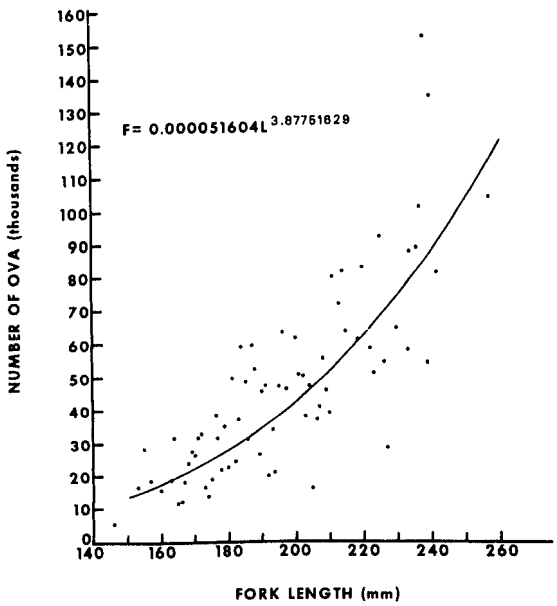

FIGURE 4.—Relation between mean number of maturing ova and fork length for Gulf menhaden.

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FOOD OF THE PACIFIC WHITE-SIDED DOLPHIN, *LAGENORHYNCHUS OBLIQUIDENS*, DALL'S PORPOISE, *PHOCOENOIDES DALLI*, AND NORTHERN FUR SEAL, *CALLORHINUS URSINUS*, OFF CALIFORNIA AND WASHINGTON

Our knowledge of the feeding habits of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, and the Dall's porpoise, *Phocoenoides*

dalli, is based on examination of the stomach contents of stranded animals, animals accidentally taken in commercial fishing gear, those taken in the western Pacific commercial fishery, and animals that died during capture attempts. Of these only a few were normally feeding animals taken at sea, whose stomach contents were thoroughly examined. Fishes and squids previously identified from stomachs of dolphins and porpoises by various investigators are listed in Table 1.

This paper documents the stomach contents of 44 Pacific white-sided dolphin and 9 Dall's porpoise collected at sea off California and Washington. All animals were collected by the authors during pelagic fur seal studies with the exception of three dolphins which were collected by a staff biologist during whale research voyages off California. Comparisons of stomach contents are made between the Pacific white-sided dolphin, Dall's porpoise, and northern fur seal, *Callorhinus ursinus*, collected near the same locations and usually on the same day. Mention of the dolphin, porpoise, and seal in this paper refers to the above-named species only unless noted otherwise.

The Pacific white-sided dolphin ranges the eastern North Pacific Ocean, from Baja California

TABLE 1.—List of fishes and squids previously identified in stomachs of Pacific white-sided dolphin and Dall's porpoise from the North Pacific Ocean by localities.

Locality and species	Reference source	
	Pacific white-sided dolphin	Dall's porpoise
California:		
Pacific herring, *Clupea harengus pallasi*		Loeb 1972
Pacific sardine, *Sardinops sagax*	Higgins 1919	
Northern anchovy, *Engraulis mordax*	Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965; Fitch and Brownell 1968	Loeb 1972
Night smelt, *Spirinchus starksi*		Loeb 1972
California smoothtongue, *Bathylagus stilbius*		Loeb 1972
Pinpoint lampfish, *Lampanyctus regalis*		Loeb 1972
Blue lanternfish, *Tarletonbeania crenularis*		Loeb 1972
Pacific whiting, *Merluccius productus*	Best 1963; Fiscus and Niggol 1965; Fitch and Brownell 1968	Norris and Prescott 1961; Best 1963; Loeb 1972
Cusk-eel, *Otophidium taylori*		Loeb 1972
Eelpouts, Zoarcidae		Loeb 1972
Grenadier, Macrouridae		Loeb 1972
Pacific saury, *Cololabis saira*	Houck 1961	
Jack mackerel, *Trachurus symmetricus*	Scheffer 1953; Norris and Prescott 1961; Houck 1961	Norris and Prescott 1961
Pacific pompano, *Peprilus simillimus*		Loeb 1972
Rockfish, *Sebastes* spp., juvenile		Loeb 1972
Sablefish, *Anoplopoma fimbria*, juvenile		Loeb 1972
Snailfish, *Liparis* sp.		Loeb 1972
Pacific sanddab, *Citharichthys sordidus*		Loeb 1972
Eels, Anguilliformes		Loeb 1972
Squid, *Loligo opalescens*	Brown and Norris 1956; Ridgway 1966	Norris and Prescott 1961; Loeb 1972
Squid, *Abraliopsis* sp.		Loeb 1972
Squid, *Gonatus* sp.	Fiscus and Niggol 1965	Loeb 1972
Squid, *Onychoteuthis borealijaponicus*		Loeb 1972
Octopus, *Octopus bimaculatus*		Loeb 1972
British Columbia:		
Pacific herring, *Clupea harengus pallasi*		Cowan 1944
Gulf of Alaska:		
Capelin, *Mallotus villosus*		Scheffer 1953
Japan:		
Anchovy, *Engraulis japonica*	Hotta et al. 1969	
Sudidae, *Paralepis* sp.		Wilke and Nicholson 1958
Lanternfish, Myctophidae—Scopelidae	Wilke et al. 1953	Wilke et al. 1953
Lanternfish, *Notoscopelus* sp.		Wilke and Nicholson 1958
Lanternfish, *Diaphus* sp.		Wilke and Nicholson 1958
Lanternfish, *Tarletonbeania taylori*		Wilke and Nicholson 1958
Lanternfish, *Lampanyctus* sp.		Wilke and Nicholson 1958
Lanternfish, *Myctophum* sp.		Wilke and Nicholson 1958
Cod, *Laemonema longipes*		Wilke and Nicholson 1958
Hake, *Laemonema morsum*		Wilke et al. 1953
Mackerel, *Scomber japonicus*	Wilke et al. 1953	
Squid, *Watasenia scintillans*	Wilke et al. 1953	
Squid, *Omnastrephes sloani pacificus*	Hotta et al. 1969	Wilke and Nicholson 1958
Northwestern Pacific and western Bering Sea:		
Sockeye salmon, *Oncorhynchus nerka*		Mizue et al. 1966
Unidentified small fish		Koga 1969
Unidentified fish		Mizue and Yoshida 1965; Mizue et al. 1966
Squids		Mizue and Yoshida 1965; Mizue et al. 1966; Koga 1969
Shrimp		Mizue and Yoshida 1965; Mizue et al. 1966; Koga 1969

northward in the summer to the Gulf of Alaska; it ranges the western North Pacific Ocean, from Japan northward to the Kurile Islands (National Marine Fisheries Service 1978). During pelagic fur seal research voyages off California (1958-66) and Washington (1958-72), 767 pods of dolphin totalling 8,803 animals were sighted[1] (297 pods, 5,555 dolphin, and 490 pods, 3,248 dolphin, respectively). Dolphin pod size ranged from 1 to 1,000+ animals. The dolphin reported here were collected from pods ranging from 4 to 300 animals.

The Dall's porpoise ranges the North Pacific Ocean from northern Baja California and Japan in the south to the Bering and Okhotsk Seas, moving into the southern portion of its range during winter. The porpoise usually occur in smaller groups than do the dolphin. During pelagic fur seal research cruises off California and Washington, 868 pods totalling 3,575 porpoise were sighted (657 pods, 2,845 porpoise, and 211 pods, 730 porpoises, respectively). Porpoise pods generally contained fewer than 20 animals. The porpoise reported here came from pods of three to five animals. Sightings and collections of dolphin and porpoise were obtained during 388 d at sea off California in 1958-66 and 368 d at sea off Washington in 1958-72.

The northern fur seal ranges across the subarctic waters of the North Pacific Ocean and numbers about 1.8 million animals (Lander and Kajimura 1976). Most seal are found near their breeding islands in the Bering and Okhotsk Seas from July into early November except for the very small San Miguel Island, Calif., population that numbers about 2,000 animals. In the eastern North Pacific Ocean few adult males are found south of the Gulf of Alaska. Mature females and immature males and females begin to appear in coastal waters between British Columbia and central California in late November and early December, the pups slightly later in January or February. The movement is generally southward along the continental shelf and slope in January into March with some animals ranging south to about lat. 32° N; however, most of the wintering population can be found between about lat. 35° and 49° N. Some northward migration out of this region may begin as early as March. Most wintering seal are found from over the continental shelf seaward as much as several hundred miles (Fiscus 1978).

Northern fur seal are most frequently observed alone rather than in company with other seal of their species; however, concentrations do occur in areas of abundant food supply. In 1966 (January-March) off California when most of the dolphin and porpoise were collected, 1,441 groups of seal were observed, of which 31% were single animals; 22% were in groups of 2; 16.9% in groups of 3; 10.5% in groups of 4; and 10.2% in groups of 5-20 (Marine Mammal Biological Laboratory 1969).

In 1967-68 (November-February) off Washington, when most of the dolphin and porpoise were collected, 669 groups of seal contained 40.8% single animals; 24.9%, groups of 2; 13.6%, groups of 3; 9.3%, groups of 4; and 14%, groups of 5-9 (Marine Mammal Biological Laboratory 1970).

There are no reliable estimates of the numbers of Pacific white-sided dolphin and Dall's porpoise that inhabit the eastern Pacific offshore waters from California to Washington; however, these two species are the most frequently sighted cetaceans in these waters.The northern fur seal is the only pinniped regularly inhabiting this region. It is a seasonal visitor, from December through May; as many as 500,000 may be here during the peak of the wintering period (Fiscus 1979).

Methods

Hand harpoons or shotguns were used to collect the Pacific white-sided dolphin and Dall's porpoise as they rode the bow wave of the research vessel or dory. Northern fur seal were collected from the vessel or dory with shotguns. The dolphin and porpoise were taken off California, 1-130 km seaward of the continental shelf; those from Washington waters were taken near or over the continental shelf.

Standard measurements and weights of each cetacean and seal were recorded (American Society of Mammalogists, Committee on Marine Mammals 1961, 1967). Reproductive tracts, skulls, stomachs, and tissue samples were collected. Stomachs were tied with string at the esophagus and pyloris and then injected with and preserved in 10% Formalin[2] for laboratory examination. The contents of each stomach were gently washed and drained in a small mesh sieve. The stomach rugae

[1]NMFS, Natl. Mar. Mammal Lab. 1958-74. Birds and mammals observed at sea. Unpubl. data listing, various pagination. Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

were carefully checked for squid beaks, fish otoliths, and other small remains of food items. After excess fluid was drained off, the total weight of stomach contents was recorded and a total volume determined by water displacement. Individual food items were identified, counted, and the percentage of the total volume represented by each type of food item estimated. Fragments of prey species may remain in the stomachs of these animals from 12 to 24 h after feeding; hence hard parts of prey species consumed over the shelf, such as chitinous beaks of squids, fish otoliths, and particularly dense fish bones, may still persist in the stomachs of animals taken well offshore of the shelf. Identification was made by comparison with reference specimens and to descriptions in taxonomic keys or other references.

Of the 33 dolphin taken off California, 25 were females (9 adult, 15 subadult, 1 probably adult) and 8 were males (3 adult, 5 subadult). Of 11 dolphin taken off Washington, 8 were females (2 adult, 6 subadult) and 3 were males (1 adult, 2 subadult). All nine of the Dall's porpoise were adults.

Scientific names of marine mammals follows Marine Mammal Commission[3]; of fish, Bailey et al. (1970) and Fitch and Lavenberg (1971); of cephalopods, Young (1972).

Results

Pacific White-Sided Dolphin and Northern Fur Seal

Northern anchovy, *Engraulis mordax*, was the most frequently occurring fish in the stomachs of white-sided dolphin and northern fur seal taken in all collection months and across the latitudinal range of the collections off California. Most dolphin were taken off central California between Pt. Conception and Pt. Reyes in the following numbers by month: 1 in January, 11 in February, 18 in March, 2 in June, and 1 in December. Seal used in comparisons were taken in the same localities at the same times. Northern anchovy remains were identified from 58% (19 occurrences) of the dolphin stomachs and 32% (13 occurrences) of seal stomachs collected in the same localities.

Pacific whiting, *Merluccius productus*, was found in 33% (10 occurrences) of the dolphin stomachs and 34% (14 occurrences) of the seal stomachs. Pacific whiting was particularly important in the March 1966 collections at lat. 35° to 38° N (Morro Bay to San Francisco). Pacific saury, *Cololabis saira*, the third ranking fish, was found in 28% (9 occurrences) of the dolphin but in only 7% (3 occurrences) of the seal from the same area.

Squids of the family Gonatidae were the most frequently occurring cephalopods. Both *Loligo opalescens* (64% occurrence) and *Onychoteuthis borealijaponicus* (45% occurrence) were found in the dolphin stomachs in trace amounts only (beaks); however, both species are important seal prey. *Abraliopsis* sp. was identified only once in seal but found in 16 dolphin stomachs from seven collection locations off California. Stomachs of the nine dolphin collected 25 February 1966 off Pt. Reyes contained a greater variety of fishes and squids than those collected in other locations.

The food items consumed by 11 dolphin and 14 seal collected in the same locality off Washington show salmonids, *Oncorhynchus* spp., composed most of the stomach contents of 10 dolphin and 12 seal taken 25 and 26 February 1968 over the Astoria Canyon, approximately 37-44 km west of the Columbia River (8 occurrences in dolphin, 3 in seal). Flatfishes (Pleuronectidae) were present in one seal stomach. Squid beaks representing nine families, genera, or species of squids were identified from the stomachs of dolphin, but these taxa were of minimal importance in the stomachs of seal collected from the same area, occurring in only 4 of 12 stomachs. One dolphin, taken off the continental shelf, 25 April 1972, contained trace amounts of unidentified fishes and squids representing at least five genera. The stomachs of two seal collected in the same area the same day were empty.

Dall's Porpoise and Northern Fur Seal

The stomach contents of 9 Dall's porpoise and 17 northern fur seal taken from the same location off California and Washington from 1964 to 1968 were examined. One porpoise was taken in January off southern California and four were taken in February and one in April off central California. Three were taken off Washington, two in January (one taken in the entrance to the Strait of Juan de Fuca) and one in February. Off California, northern anchovy, Pacific whiting, Pacific saury, and squids, *L. opalescens* and *O. borealijaponicus*, formed major portions of the most recent feedings.

[3]Marine Mammal Commission. 1976. Marine mammal names. Unpubl. manuscr., 8 p. Marine Mammal Commission, 1625 Eye Street, NW., Wash., DC 20006.

Unidentified fishes and six species of squids were also found in trace amounts. The stomachs of three porpoise taken 56 km southwest of Pt. Reyes on 21 February 1966 contained no northern anchovy but did contain typical open ocean dwelling fishes and squids. Off Washington trace amounts of eulachon, *Thaleichthys pacificus*; rockfish, *Sebastes* spp.; sablefish, *Anoplopoma fimbria*; flatfish, Pleuronectidae; American shad, *Alosa sapidissima*; capelin, *Mallotus villosus*; and squids, *L. opalescens*, Gonatidae, *Gonatus* sp., and *O. borealijaponicus*, were found in stomachs of three porpoise.

Discussion

Distribution of Prey

Based on identified prey species, it appears that all three of the mammals feed in the epipelagic (0-200 m) and mesopelagic (200-1,000 m) zones of the ocean and that over the continental shelf, they may descend to the bottom (200 m or less) on occasion as demonstrated by the presence of demersal species in their stomachs. Many of the fishes and squids rise to or toward the surface at night, thereby becoming more readily available and perhaps ruling out the necessity for long, deep dives. Kooyman et al. (1976), reporting on fur seal diving behavior, indicated that dives between the surface and 20 m lasting <1 min may be for shallow feeding or travel and that dives between 20 and 140 m of 3.3-3.4 min duration may be hunting and feeding dives. They reported dives deeper than 140 m; the deepest reported dive lasted 5.4 min and reached 190 m. A study of blood oxygen levels of three genera of porpoise by Ridgway and Johnston (1966) reported that the Pacific white-sided dolphin cannot swim as fast and probably cannot dive as deep as the Dall's porpoise.

Prey Species

Off the California coast all three of the mammals feed primarily on small schooling fishes and cephalopods, including the northern anchovy, Pacific saury, and Pacific whiting. Other species of fish were probably taken as the opportunity arose. The primary fish species in dolphin collected off the Washington coast were salmonids (genus *Oncorhynchus*). Because the latter collection was made in a small area over a 3-d period, the taking of salmonids may have been opportunistic and short term rather than typical of more routine feeding. This sample is too small to conclude that a major predator-prey relationship exists between the Pacific white-sided dolphin and the salmonids.

Cephalopods are probably more important as prey species than indicated by the relative volume of stomach contents in the collection. Except for the chitinous beaks, cephalopods are probably more rapidly digested than fish. Marine mammals are more likely to feed on squids during the night because the vertical migration of many species brings them closer to the surface waters (Roper and Young 1975; Pearcy et al. 1977). Collection of dolphin during the day would give adequate time for digestion of fleshy parts, thus leaving the large numbers of indigestible chitinous beaks often found in stomachs.

The fishes and squids identified in the stomachs of the dolphin, porpoise, and seal taken during this study are presented in Table 2.

Stomach Capacity of Predators

The 44 Pacific white-sided dolphin were all adult or subadult animals, presumably with stomachs of maximum size. Eleven stomachs contained only trace amounts of food, and 33 contained food contents varying from 10 to 3,490 cm^3 (10-3,745 g).

The dolphin whose stomach contained the most food from California waters had eaten 68 anchovy (1,770 cm^3 or 1,895 g). Anchovy grow to 18-20 cm and may weight 57 g (Fitch and Lavenberg 1971).

Off Washington, the largest dolphin stomach examined contained the remains of nine salmon (including identifiable remains of four coho salmon and two pink salmon) which measured 26.0, 27.0, 31.0, 31.5, 31.5, 33.0, 33.0, 33.0, and 33.5 cm. The full stomach measured 40 cm long and 24 cm at the widest point (outside stomach dimensions), and the stomach contents represented 4.4% (3,490 cm^3 or 3,745 g) of the total body weight of the animal.

The largest stomach content from a Dall's porpoise off California contained 58 northern anchovy (1,000 cm^3 or 1,090 g). Off Washington, the largest stomach content contained fragments of five capelin, four eulachon, one flatfish (family Pleuronectidae), and trace amounts of squids (*Gonatus* sp. and Gonatidae) (130 cm^3 or 125 g). Five stomachs contained food volumes varying from 5 to 1,000 cm^3 (5-1,090 g) whereas four stomachs contained only trace amounts of food. Except for occasional

TABLE 2.—Size of fish and frequency of occurrence of fishes and cephalopods found in the stomachs of Pacific white-sided dolphin, Dall's porpoise, and northern fur seal[1] collected off California and Washington, 1964-72.

Taxon	Measurable length of fish in stomachs[2] (cm)	California			Washington		
		White-sided dolphin (33 coll.)	Dall's porpoise (6 coll.)	Northern fur seal ([3]4[4]10 coll.)	White-sided dolphin (11 coll.)	Dall's porpoise (13 coll.)	Northern fur seal ([3]1[4]7 coll.)
Fish:							
Pacific lamprey, *Entosphenus tridentatus*[5]	—	—	—	—	1	—	—
American shad, *Alosa sapidissima*	—	—	—	—	—	—	1
Pacific herring, *Clupea harengus pallasi*	28.5-31.3 (11)	—	—	—	—	—	—
Northern anchovy, *Engraulis mordax*	14.5-17.8 (19)	19	2	[3]13[4]5	—	—	—
Salmon, *Oncorhynchus* spp.[5]	—	—	—	—	8	—	2
Pink salmon, *O. gorbuscha*[5]	25.0-40.5 (3)	—	—	—	—	—	2
Chum salmon, *O. keta*[5]	—	—	—	—	1	—	1
Coho salmon, *O. kisutch*[5]	21.0-33.0 (5)	—	—	—	2	—	2
Chinook salmon, *O. tshawytscha*[5]	21.0-24.5 (2)	—	—	—	—	—	—
Capelin, *Mallotus villosus*	10.9-15.5 (26)	—	—	—	—	1	—
Eulachon, *Thaleichthys pacificus*[6]	15.3-20.5 (4)	—	—	—	—	1	1
California lanternfish, *Symbolophorus californiensis*[5]	—	1	—	—	—	—	—
Pacific saury, *Cololabis saira*[6]	—	9	1	3	—	—	—
Pacific whiting, *Merluccius productus*	—	10	2	[3]1[4]41	—	—	—
King-of-the-salmon, *Trachipterus altivelis*[5]	—	1	—	—	—	—	—
Jack mackerel, *Trachurus symmetricus*	—	1	—	—	—	—	—
Drum, *Sciaenidae*	—	—	—	1	—	—	—
Medusafish, *Icichthys lockingtoni*[5]	—	1	—	—	—	—	—
Rockfish, *Sebastes* spp.[5]	—	1	—	1	—	—	2
Sablefish, *Anoplopoma fimbria*	25.0 (1)	—	—	—	—	—	1
Pacific sanddab, *Citharichthys sordidus*[5]	—	1	—	—	—	—	—
Righteye flounder, Pleuronectidae[6]	—	—	—	—	—	1	1
Cephalopods:							
Squid, *Loligo opalescens*		21	1	[3]2[4]1	3	1	
Squid, *Abraliopsis* sp.[5]		16	3	1	11	—	—
Squid, *Octopoteuthis* sp.[5,6]		12	1	—	9	—	—
Squid, Gonatidae		14	2	[3]1[4]2	11	2	[3]1[4]2
Squid, *Gonatus* sp.		23	1	2	11	2	3
Squid, *Gonatopsis borealis*[5]		7	—	—	2	—	—
Squid, *Onychoteuthis borealijaponicus*[5]		15	2	4 1	11		1
Squid, *Chiroteuthis* sp.[5]		2	—	—	3	—	—
Squid, *Cranchiidae*[5]		3	1	—	3	—	—
Pelagic octopus, *Ocythoe tuberculata*[5]		2	—	—	—	—	—

[1]A complete list of prey species of the northern fur seal appears in North Pacific Fur Seal Commission Reports on Investigations, 1962, 1969, 1971, 1975.
[2]Length measurement of chinook salmon and sablefish is standard length, other measurements are total length. The numbers in parentheses indicate sample size.
[3]Northern fur seal in association with Pacific white-sided dolphin.
[4]Northern fur seal in association with Dall's porpoise.
[5]Identified for the first time as prey of the Pacific white-sided dolphin.
[6]Identified for the first time as prey of the Dall's porpoise.

squid beaks, bone fragments, and otoliths, which were found in the fundic (or pyloric) stomach and the duodenal ampulla, all undigested or semidigested food items were found in the forestomach. Stomach volumes were highly variable depending on the time of day the animal was collected and the digestibility of the species of fish or squid ingested. Of 30 dolphin taken off California, those taken before 1000 h averaged more than twice the volume of food in their stomachs than those taken after 1000 h.

During the course of pelagic fur seal research, thousands of seal stomachs have been examined by the authors. The stomach containing the most food was from a 17-yr-old male collected in the eastern Bering Sea at 1330 h, 9 August 1968. The animal had consumed 13 walleye pollock, *Theragra chalcogramma*, and 4 squid, *Berryteuthis magister*. The contents weighed 9.8 kg (9,175 cm^3 volume representing 7.2% of body weight) with walleye pollock composing 80% (7,340 cm^3) of the total stomach volume. The stomach of an adult female fur seal contained food weighing 5.9 kg (5,565 cm^3 volume representing 13.1% of body weight). This 15-yr-old animal was collected at 0645 h on 19 April 1964 off California and had fed on 31 Pacific whiting.

The energy requirements of the northern fur seal are poorly known. Keyes (1968) reported that seal and other pinnipeds kept in captivity subsisted well on 6-12% of body weight daily, with vitamin supplements. Studies indicate possibly higher daily consumption rates among growing immature animals. Sergeant (1969) summarized the feeding rates per day of several captive cetaceans including two dolphin which consumed 7.9% of their body weight in herring and mackerel and a porpoise that consumed 11.3% of its body weight of mackerel. Ridgway (1972) reported food requirements in captive animals equalled 7-8% of body

weight/d for dolphin and 10-12% for porpoise. The species fed to these captive animals were not identified.

Size of Prey

Higgins (1919) mentioned a stomach containing six large Pacific sardine, *Sardinops sagax*, each about 30 cm long. Houck (1961) reported a dolphin with a stomach full of Pacific saury and with a 33 cm jack mackerel, *Trachurus symmetricus*, wedged in its throat. Unfortunately, no count of the Pacific saury was given. Fitch and Brownell (1968) reported that otoliths representing 29 Pacific whiting 40-50 cm long and 14 Pacific whiting about 20 cm long were recovered from a dolphin stomach. The sizes of fish in stomach contents were measured only from whole or nearly whole specimens or those with complete vertebral columns (Table 2). All salmon consumed by dolphin were generally immature, showing 0-age ocean growth, although a few showed 1, 2, and 3 ocean annuli.

Scheffer (1953) reported on stomach contents of two Dall's porpoise taken off Oregon, each of which contained four Pacific whiting about 45 cm long. These records represent the largest fish recovered from porpoise stomachs. Mizue et al. (1966) reported only one occurrence of sockeye salmon, *O. nerka*, from stomachs of 148 porpoise taken in conjunction with the high-seas salmon gill net fishery. No mention was made of the size of this fish, although they did state that adult salmon are probably not taken by animals of this species.

In our collections, there was no evidence of large fish being broken up prior to ingestion by either dolphin or porpoise. Captive bottlenose dolphin, *Tursiops truncatus*, have been observed to break up food species.[4] The teeth, jaw structure, and relative neck mobility of the white-sided dolphin are similar to those of the bottlenose dolphin and would allow such behavior in this species more so than in the Dall's porpoise. The maximum size of prey eaten is apparently limited by the predator's ability to capture and swallow whole fish.

The size of prey listed in Table 2 does not necessarily indicate that these fish are the largest consumed by the seal. Seal generally swallow smaller fish and squid whole below the surface whereas larger fish are brought to the surface and broken into smaller pieces by grasping them with their teeth and shaking them violently from side to side. The largest fish we have seen taken by a seal was a king-of-the-salmon (length 170 cm) which we took away from the animal as it attempted to break the fish into smaller pieces at the surface.

[4]William Gilmartin, Naval Ocean Systems, San Diego, Calif., pers. commun. 1978.

Conclusions

The Pacific white-sided dolphin and the Dall's porpoise feed primarily on small schooling fishes and cephalopods. They, like the northern fur seal, are opportunistic feeders, preying on available species, including some that are commercially important such as salmon, anchovy, jack mackerel, and *Loligo opalescens*. Meaningful estimates of the dolphin and porpoise populations are unavailable, and too few stomachs have been examined to make any estimate of the percentage of commercially important fishes included in the diet.

Regardless of the time of day collected, stomachs may contain undigested fish indicative of recent feeding. Based on stomach content volume and time of collection, large stomach volumes were most often observed in animals collected before 1000 h in the morning, indicating that most feeding is done at night or in the morning.

Northern fur seal tend to congregate in areas of abundant food supply and usually feed at night, probably because most prey species rise toward the surface after dark and are more readily available (Fiscus et al. 1964). Food species consumed by the seal vary by area, but the important food in the diet of this mammal in a given area, based on percentage of stomach content volume, generally does not change—only ranking by volume changes. The animals collected on the continental shelf appear to feed on fishes, whereas those taken beyond the shelf feed primarily on squids.

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SPAWN AND LARVAE OF THE PACIFIC SANDFISH, *TRICHODON TRICHODON*

Little is known about the biology of the Pacific sandfish, *Trichodon trichodon*, other than that the adults are characteristic of inshore, sand-gravel communities (Isakson et al. 1971); they occur from San Francisco, Calif., to Kamchatka, USSR (Hart 1973); and they burrow into a sandy substrate (Clemens and Wilby 1961). Clemens and Wilby reported that a mature female taken on Long Beach, Vancouver Island, Canada, extruded mature eggs (upon disturbance) in February.

The first discovery of natural spawn of *T. trichodon* and subsequent rearing of larvae through metamorphosis at the Vancouver Public Aquarium has provided information about the reproduction and early life history of this species. In addition to life history notes, this paper presents a description of larvae of *T. trichodon*.

Methods

A portion of an egg mass was collected at lat. 48°56′ N, long. 125°43′ W, 16 km southeast of Long Beach, Vancouver Island, on 12 June 1976 and transported in a plastic bag with oxygen and seawater to the Vancouver Aquarium, where it was incubated in an aerated aquarium with seawater (25-29‰, 8°-13° C) provided at an inflow rate exceeding 100 tank volumes/d. The seawater temperature changed seasonally with changes in average ambient seawater surface temperatures, so that the salinity/temperature regime was comparable with that which the eggs would have encountered intertidally. The eggs were fixed in a bag of nylon mesh in front of the inlet pipe. In October, December, and January, embryos were excised from a few of the eggs to determine whether development was continuing. About once per month egg membranes were scrubbed with a bottle brush to remove diatom growth.

As they hatched the larvae were collected with a beaker and transferred to a 1,000 l rearing tank (ca. 1 m depth × 1 m in diameter) with seawater (25-27‰, 10°-12° C) inflow at a rate exceeding one tank volume per day and a light cycle of 14 h light and 10 h dark, including simulated twilight periods. Larvae were provided brine shrimp, *Artemia salina*, nauplii daily in excess quantities. Debris was siphoned from the tank bottom daily and examined for dead fish larvae. Juveniles were placed in a tank with a sand bottom and flow-through seawater and were fed frozen euphausiids and frozen brine shrimp.

At various ages specimens were preserved in 3% Formalin[1] in seawater, with borax and Ionol. Freshly killed specimens were measured to the nearest 0.5 mm standard length (SL), then measured again 1 yr after preservation, to determine shrinkage. Line drawings, morphometric data, and meristic characters were based on preserved specimens.

Life History Notes

The egg mass was found in a surge channel on a rocky shoreline between 0.6 and 1.0 m tide levels. The mass was visually estimated to have about 1,000 eggs, was irregularly shaped, and adhered firmly to the rock surface.

Adults of this species are known to inhabit sandy beaches, whereas the egg mass is suited only to rocky substrate to which it can adhere. Presuming an incubation period of about 1 yr as discussed below, most plant substrates would be too ephemeral for an egg deposition site and bedrock on sand beaches could be covered by seasonal shifting of sand. Rocky shoreline removed from sandy areas would therefore provide the most stable substrate for the adhesive eggs. The precise location on the wall of a fully exposed surge channel might provide a refuge from egg predation as well as high flow velocities for gas exchange. The rocky intertidal area in which this egg mass occurred is located 8 km from the nearest sandy intertidal area. Thus, a limited spawning movement along the shore must occur.

[1]Reference to trade names does not imply endorsement by the Vancouver Aquarium or by the National Marine Fisheries Service, NOAA.