FOOD OF THE PACIFIC WHITE-SIDED DOLPHIN, *LAGENORHYNCHUS OBLIQUIDENS*, DALL'S PORPOISE, *PHOCOENOIDES DALLI*, AND NORTHERN FUR SEAL, *CALLORHINUS URSINUS*, OFF CALIFORNIA AND WASHINGTON; WITH APPENDICES ON SIZE AND FOOD OF DALL'S PORPOISE FROM ALASKAN WATERS

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ABSTRACT

The food of the Pacific white-sided dolphin, Lagenorhynchus obliquidens, and Dali's porpoise, Phocoenoides dalli -- collected off California and Washington in 1958-72 -- is compared with food of the northern fur seal, Callorhinus ursinus. The 3 species are opportunistic feeders, preying primarily on small schooling fishes and cephalopods. Species identified for the first time as prey of the Pacific white-sided dolphin are: Pacific lamprey, Entosphenus tridentatus; salmon, Oncorhynchus spp., including pink, 0. gorbuscha, chum, O. keta, and coho, 0. kisutch; California Lanternfish, Symbolophorus californiensis; king-of-the-salmon, Trachipterus altivelis; medusafish, Icichthys lockingtoni; rockfish, Sebastes spp.; Pacific sanddab, Citharichthys sordidus; squids, including Abraliopsis sp., Octopoteuthis sp., Gonatopsis borealis, Onychoteuthis borealijaponicus, Chiroteuthis sp., Cranchidae; and the pelagic octopus, Ocythoe tuberculata. Listed as prey of the Dali's porpoise for the first time are: eulachon, Thaleichthys pacificus; Pacific saury, Cololabis saira; Walleye pollock, Theragra chalcogramma; Pacific sand lance, Ammodytes hexapterus, Pleuronectids; and the squid, Octopoteuthis sp., Berryteuthis magister and Gonatopsis borealis.

INTRODUCTION

Our knowledge of the feeding habits of the Pacific white-sided dolphin, Lagenorhynchus obliquidens, and the Dali'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 dolphin and porpoise by various investigators are listed in Table 1.

This paper documents the stomach contents of 44 white-sided dolphin and 9 Dali's porpoise collected at sea off California and Washington; and food and size of Dali's porpoise taken in Alaskan waters. All animals were collected by the authors during pelagic fur seal studies with the exception of three dolphin 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, Dali'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 refer to the above-named species only unless noted otherwise.

The Pacific white-sided dolphin ranges the eastern North Pacific Ocean, from Baja California northward in the summer to the Gulf of Alaska; they range the western North Pacific Ocean from Japan northward to the Kuril Islands (National Marine Fisheries Service 1978). During pelagic fur seal research voyages off California (1958-66) and Washington (1958-72),

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

Area	Name: Common	Name: Scientific	Reference Source: Pacific white-sided dolphin	Reference Source: Dall's porpoise
California				
	Pacific herring	(Clupea harengus pallasi)		Loeb 1972
	Pacific sardine	(Sardinops sagax)	Higgins 1919	
	Northern anchovy	(Engraulis mordax)	Fitch & Brownell 1968 Norris and Prescott 1961,Brown & Norris 1956, Fiscus & Niggol 1965	Loeb 1972
	Night smelt	(Spirinchus starksi)		Loeb 1972
	California smoothtongue	(Bathylagus stilbius)		Loeb 1972
	Lanternfish	Myctophidae		
	Pinpoint lampfish	(Lampanyctus regalis)		Loeb 1972
	Blue lanternfish	(Tarletonbeania crenularis)		Loeb 1972
	Pacific whiting	(Merluccius productus)	Best 1963, Fitch&Brownell 1968, Fiscus & Niggol 1965	Best 1963, Loeb 1972, Norris & Prescott 1961
	Cusk-eel	(Otophidium taylori)		Loeb 1972
	Eelpouts	Zoarcidae		Loeb 1972
	Grenadier	Macrouridae		Loeb 1972
	Pacific saury	(Cololabis saira)	Houck 1961	
	Jack mackeral	(Trachurus symmetricus)	Norris&Prescott 1961, Houck 1961, Scheffer 1953	Norris&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)	Ridgway 1966, Brown&Norris 1956	Loeb 1972, Norris&Prescott 1961
		(Abraliopsis sp)		Loeb 1972
		(Gonatus sp)	Fiscus&Niggol 1965	Loeb 1972
		(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&Nicholson 1958
	Lanternfish	Myctophidae - Scopelidae	Wilke et al. 1953	Wilke et al. 1953
	Lanternfish	(Notoscopelus sp.)		Wilke&Nicholson 1958
	Lanternfish	(Diaphus sp.)		Wilke&Nicholson 1958
	Lanternfish	(Tarletonbeania taylori)		Wilke&Nicholson 1958
	Lanternfish	(Lampanyctus sp.)		Wilke&Nicholson 1958
	Lanternfish	(Myctophum sp.)		Wilke&Nicholson 1958
	Cod	(Laemonema longipes)		Wilke&Nicholson 1958
	Hake	(Laemonema morsum		Wilke et al. 1953
	Mackerel	(Scomber japonicus)	Wilke et al. 1953	
	Squid	(Watasenia scintillans)	Wilke et al. 1953	
	Squid	(Ommastrephes sloani pacificus)	Hotta et al. 1969	Wilke&Nicholson 1958
Northwestern Pacific and western Bering Sea				
	Sockeye Salmon	(Oncorhynchus nerka)		Mizue et al. 1966
	Unidentified small fish			Koga 1969
	Unidentified fish			Mizue&Yoshida 1965
	Squids			Mizue et al. 1966
				Koga 1969, Mizue&Yoshida 1965
	Shrimp			Mizue et al. 1966
				Koga 1969, Mizue&Yoshida 1965
				Mizue et al. 1966

767 pods of dolphin totaling 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 in size from 4 to 300 animals.

The Dali'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 the winter months. The porpoise usually occur in smaller groups than do the dolphin. During pelagic fur seal research cruises off California and Washington, 868 pods totaling 3,575 porpoise were sighted (657 pods, 2,845 porpoise and 211 pods, 730 porpoise, respectively). Porpoise pods generally contained less 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 days at sea off California in 1958-66 and 368 days at sea off Washington in 1958-72.

The northern fur seal ranges across the subarctic waters of the North Pacific Ocean and numbers about 1.7 million animals (Lander and Kajimura 1976[2/]. 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, California, population which 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

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1/ NMFS, Nat. Mar. Mammal Lab. 1958-1974. Birds and mammals observed at sea. Unpubl. data listing. Various pagination. Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

2/ Lander, R. H. 1980. A life table and biomass estimate for Alaskan fur seals. In Kajimura et al. Further analysis of pelagic fur seal data collected by the United States and Canada during 1958-74, Part 1. Rep. submitted to the 23rd Annual Meeting of the North Pacific Fur Seal Commission, P. 44-57. (Natl. Mar. Mammal Lab., Natl. Mar. Fish. *Serv., NOAA, 7600* Sand Point Way NE, Seattle, WA 98115).

begin to appear in coastal waters between British Columbia and central California in late November and early December, the pups slightly later in January-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 19.2% 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 to 9 (Marine Mammal Bio,logical Laboratory 1970).

There are no reliable estimates of the numbers of Pacific white-sided dolphin and Dali'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).

MATERIALS-AND METHODS

Hand harpoons or shotguns were used to collect the Pacific white-sided dolphin and Dali's porpoise as they rode the bow wave of the research vessel or dory. The northern fur seal were collected from the vessel or dory with shotguns. The dolphin and porpoise were taken off California l-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[3/] for laboratory examination. The contents of each stomach were gently washed and drained in a small mesh sieve. The stomach rugae 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 to reference specimens and to descriptions in taxonomic keys or other references.

3/ Reference to trade name does not imply endorsement by the National Marine Fisheries Service, NOAA.

The maturity of the dolphin and porpoise was estimated from the length and weight measurements taken from each animal. Tomilin (1957) reported lengths of 180 and 183 cm for female dolphin bearing fetuses. Scheffer and Slipp (1948) recorded a young dolphin, length 124 cm, weight 29.5 kg, whose stomach contained milk. Nishiwaki (1972) did not indicate sexual dimorphism in this species. We assume that those animals in the collection measuring 178 cm or more in length were adults and those measuring less were subadults. None was small enough to be considered juvenile.

Of the 33 dolphin taken off California, 25 were females (9 adult, 15 subadult; no length was available for 1) whose sizes ranged from 159 cm and 65 kg to 191 cm and 101 kg. Eight males (3 adult, 5 subadult) ranged in size from 151 cm and 58 kg to 186 cm and 91 kg. Of 11 specimens taken off Washington, 8 were females (2 adult, 6 subadult) whose size ranged from 165 cm and 67 kg to 179.5 cm and 85 kg, and 3 were males (1 adult, 2 subadult) ranging in size from 152 cm and 59 kg to 179 cm and 97 kg. Detailed morphometric data like those presented for Dali's porpoise (Table 2 and Appendix Table 1) are not presented here as a manuscript on the Pacific white-sided dolphin by W. Walker, S. Leatherwood and R. Stroud is now in preparation and will include these data (pers. commun. R. Stroud, 1980).

The size of Dali's porpoise at maturity is much better documented. Scheffer (1949) listed adult males with lengths between 172 and 184 cm and subadult males between 158 and 167 cm. Based on data of Mizue and Yoshida (1965), we concluded that all Dali's porpoise in the collection were adults. Females ranged in size from 170 cm and 81 kg to 177 cm and 102 kg; males ranged from 170.5 cm and 93 kg to '200 cm and 125 kg. Detailed

morphometric data is given in Table 2. Scientific names of marine mammals follow Marine Mammal Commission (1976)[4]/ 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 fur seal taken in all collection months and across the latitudinal range of the collections off California (Table 3). 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 (hake), (Merluccius productus) was found in 33% (10 occurrences) of the dolphin stomachs and 34% (14 occurrences) of the seal stomachs. 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 Point Reyes contained a greater variety of fishes and squids than those collected in other locations.

4/ Marine Mammal Commission. 1976. Marine mammal names. Unpubl. manuscr., 8 p. Marine Mammal Commission, 1625 Eye St. N.W., Wash. D.C. 20006.

Table 2.--Size of 9 Dali's porpoise collected off California and Washington, 1964-68.

	California					Washington			
Specimen number	3751	3205	3757	3758	3759	3752	3257	3267	3268
Location Lat. N.	35°17'	35°02'	37°20'	37°20'	37°20'	48°08'	48°19'	48°25'	46°19'
Long. W.	121°42'	121°39'	124°42'	124°42'	124°42'	125°05'	125°40'	124°37'	124°25'
Date (day, mo, yr)	14-4-64	14-2-66	21-2-66	21-2-66	21-2-66	1-6-64	7-2-67	14-1-68	23-1-68
Sex	F	M	M	F	F	M	M	F	M
Length (cm)	177.0	200.0	170.5	170.0	171.0	166.0	191.0	174.0	196.0
Weight (kg)	102.0	125.0	93.0	81.0	92.0	80.0	105.0	86.0	135.0
Measurements									
Length (cm)									
Snout to notch of flukes	177.0	200.0	170.5	170.0	171.0	166.0	191.0	174.0	196.0
Snout to tip of dorsal fin	89.0	86.0	90.5	88.0	88.0	89.0	85.0	87.0	77.0
Snout to insertion of flipper	30.0	27.0	30.0	28.0	28.5	25.0	28.0	26.0	30.0
Snout to ear	28.0	25.0	27.5	25.0	26.0	21.5	26.0	24.0	31.5
Snout to center of blowhole	24.0	20.0	22.0	20.0	21.0	20.0	21.0	18.0	25.0
Snout to center of eye	23.0	20.0	21.5	19.0	20.0	16.5	20.0	19.0	25.0
Snout to gape	13.0	10.5	12.0	10.5	11.0	8.0	10.5	11.5	13.0
Notch of flukes to umbilicus	100.0	116.0	99.0	93.5	94.0	94.0	108.0	97.5	110.0
Notch of flukes to genital aperture	60.5	82.0	74.0	--	58.0	69.5	76.0	57.0	75.0
Notch of flukes to anus	54.0	62.0	57.5	55.0	--	52.0	61.0	55.0	57.0
Projection of lower jaw	1.5	1.0	1.0	1.2	1.5	1.0	1.0	1.0	1.0
Girth behind flippers	98.0	100.0	113.5	97.5	99.5	95.0	95.0	89.0	106.5
Maximum girth	122.0	131.0	125.0	115.0	118.5	109.0	115.5	116.5	133.0
Anterior length of flipper	23.0	24.0	22.0	22.0	21.0	19.0	22.5	24.0	24.0
Axillary length of flipper	16.5	16.0	14.0	15.0	14.5	14.0	15.5	17.0	16.0
Maximum width of flipper	10.0	9.5	9.0	10.5	9.5	9.0	10.5	10.5	10.5
Length of base of dorsal fin	33.0	42.0	38.0	33.0	36.5	30.0	42.0	36.0	40.0
Height of dorsal fin	17.0	17.5	18.0	16.0	16.0	17.0	18.0	16.5	18.0
Span of flukes	49.0	54.0	49.5	41.0	49.0	47.0	51.0	49.0	53.5
Width of flukes	13.0	15.0	13.5	14.0	14.0	14.0	14.0	14.0	14.5

Table 3.--Stomach contents of 33 Pacific white-sided dolphin (L) and 41 northern fur seal (C) collected off California, 1964-1968. Fur seal were collected in the same location or in the immediate vicinity at about the same time.

Location				Species		Prey species - frequency of occurrence in stomachs																						
Date collected	Latitude (N)	Longitude (W)	Ocean depth (m)	Lagenorhynchus obliquidens = L Callorhinus ursinus = C	Number specimens	Pod size ( )	Engraulis mordax	Symbolophorus californiensis	Cololabis saira	Merluccius productus	Trachipterus altivelus	Trachurus symmetricus	Sciaenidae	Ichthys lockingtoni	Sebastes spp.	Citharichthys sordidus	Unident. fish	Loligo opalescens	Abraliopsis sp.	Octopoteuthis sp.	Gonatidae	Gonatus sp.	Gonatopsis borealis	Onychoteuthis borealijaponicus	Chiroteuthis sp.	Cranchidae	Unident. squid	Ocythoe tuberculata
8 Jan 1964	34° 07'	120° 46'	786	L	1	(40)											1	1			1						1	
				C	1/																							
19 Jun 1965	36° 25'	122° 31'	2798	L	2	(20)	1*		1	1								1	1		1	2	1	2*				
				C	1 2/																							
				C	1		1*								1													
12 Dec 1965	32° 37'	118° 56'	439	L	1	(100)	1					1				1	1	1	1		1	1		1				1
				C	1/																							
17 Feb 1966	36° 23'	122° 14'	1207	L	1	(15)	1*																					
				C	4 2/																							
				C	2		2*																					
25 Feb 1966	37° 46'	123° 26'	1829	L	9	(+20)	4*	1	5*	1				1	1		1	8*	4	3	3	5	4	7	2	2		
				C	2 2/																							
3 Mar 1966	37° 20'	123° 38'	3292	L	1	(4)	1*		1																			
				C	1								1*					1						1				
5 Mar 1966	36° 29'	122° 30'	2561	L	7	(100+)	6*		2								3	7	5	4	5	6	1	1				
				C	2 2/																							
				C	6		1*										3	1						2			1	
9 Mar 1966	35° 04'	121° 33'	878	L	1	(4)	1*												1			1		1				
				C	7		6*			5*														1				
10 Mar 1966	35° 08'	121° 25'	512	L	3	(25)	2*			3*									2	1	2	3	1	1		1		
				C	3		3*		1*	2*							1*				1							
22 Mar 1966	36° 02'	121° 58'	1170	L	1	(10)	1*			1*																		
				C	1 2/																							
23 Mar 1966	36° 41'	122° 24'	1646	L	1	(4)	1*				1						1			1		1						
				C	1												1											
25 Mar 1966	37° 37'	123° 07'	878	L	1	(30)				1							1											
				C	3					2*							2		1									
25 Mar 1966	37° 40'	123° 08'	457	L	2	(16)				2*								2	2	2	1	2		2				1
				C	4				1*	3*							1					1						
25 Mar 1966	37° 45'	123° 13'	640	L	1	(10)				1										1		1						
				C	3				1*	2*							1					1						
8 Feb 1968	33° 48'	119° 43'	1738	L	1	(15)												1*				1						
				C	1/																							

* Denotes species forming measurable portion of stomach food volume ie, most recent feeding. Trace items ie, fish vertebrae, otoliths, squid beaks (volume ≤ 10 cc) usually indicate an earlier feeding.

1/ No fur seal was collected.

2/ Number of empty stomachs.

The food items consumed by 11 dolphin and 14 seal collected in the same locality off Washington are compared in Table 4. Salmonids, Oncorhynchus spp., comprised most of the stomach contents of 10 dolphin and 12 seal taken 25 and 26 February 1968 over the Astoria Canyon, approximately 37 to 44 km west of the Columbia River (eight occurrences in dolphin, three 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 Dali's porpoise and 17 northern fur seal taken from the same location off California and Washington from 1964 to 1968 were examined. Off California, northern anchovy, Pacific whiting, Pacific saury, and squids, L. opalescens and 0. borealijaponicus, formed major portions of the most recent feedings (Table 5). 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 anchovy but did contain typical 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 0. borealijaponicus were found in stomachs of three porpoise.

TABLE 4.--Stomach contents of 11 Pacific white-sided dolphin (L) and 14 northern fur seal(C) collected off Washington 1968-72. Fur seal were collected in the same location or in the immediate vicinity at about the same time.

Location			Species			Prey species - frequency of occurrence in stomachs															
Date collected	Latitude (N)	Longitude (W)	Ocean depth (m)	Lagenorhynchus obliquidens = L Callorhinus ursinus = C	Number specimens	Pod size ( )	Entosphenus tridentatus	Oncorhynchus spp.	Oncorhynchus keta	Onorhynchus gorbuscha	Onorhynchus kisutch	Pleuronectidae	unidentified fish	Loligo opalescens	Abraliopsis sp.	Octopoteuthis sp.	Gonatidae	Gonatus sp.	Gonatopsis borealis	Onychoteuthis borealijaponicus	Chiroteuthis sp.	Cranchidae
25 Feb 1968	46° 14'	124° 34'	768	L	3	(30)		3*	1		1			1	3	3	3	3	1	3	1	
				C	1	2/																
				C	4				1*			1*	1				1	3				
26 Feb 1968	46° 14'	124° 33'	750	L	4	(1/)	1	3*					1		4	4	4*	4	1	4		2
				C	1	2/																
				C	1													1				
26 Feb 1968	46° 13'	124° 36'	549	L	1	(25)		1*			1			1	1		1	1		1	1	
				C	1	2/																
26 Feb 1968	46° 14'	124° 40'	823	L	2	(1/)		1*					1*	1	2	1	2	2		2	1	1
				C	4			2*		2	2		2									
25 Apr 1972	47° 28'	125° 52'	1600	L	1	(+300)							1		1	1	1	1		1		
				C	2	2/																

* Denotes species forming measurable portion of stomach food volume, ie, most recent feeding. Trace items ie, fish vertebrae, otoliths, squid beaks (volume $\leq$ 10 cc) usually indicate an earlier feeding.

1/ Number of animals recorded as "many".

2/ Number of empty stomachs.

TABLE 5. Stomach contents of 9 Dallas porpoise (p) and 17 northern fur seal (C) collected off California and Washington, 1964-1968.

Fur seal were collected in the same location or in the immediate vicinity at about the same time.

Date Collected	Location: Latitude (N)	Location: Longitude (W)	Ocean depth (m)	Species	Number specimens Pod size ( )	Alosa sapidissima	Engraulis mordax	Mallotus villosus	Thaleichthys pacificus	Columbis saira	Merluccius productus	Sebastes spp.	Anoplopoma fimbria	Pleuronectidae	unident fish	Loligo opalescens	Abraliopsis sp.	Octopoteuthis sp.	Gonatidae	Gonatus sp.	Onychoteuthis borealijaponicus	Cranchidae	Unident squid
California																							
14 Apr 1964	35° 17'	121° 42'	1006	P	1 (5)		1*																
				C	2		1*								1								
14 Feb 1966	35° 02'	121° 39'	1463	P	1 (3)		1*																
				C	4		4*				1*					1*			1				
21 Feb 1966	37° 20'	124° 42'	4024	P	3 (5)					1*	1						3	1	2	1	2	1	1
				C	1 2/																		
				C	3										2				1		1*		
21 Jan 1968	33° 46'	119° 47'	914	P	1 (4)						1*					1*							
				C	1/																		
Washington																							
7 Feb 1967	48° 19'	125° 40'	144	P	1 (5)											1							1
				C	2							1*							1				
14 Jan 1968	48° 25'	124° 37'	148	P	1 (5)			1	1*					1*					1*	1			
				C	1	1																	
23 Jan 1968	46° 19"	124° 25'	128	P	1 (5)														1	1	1		
				C	4				1*			1*	1*		1				1				

* Denotes species forming measurable portion of stomach food volume, i.e., most recent feeding. Trace items i.e., fish vertebrae, otoliths, squid beaks (volume ≤ 10 cc) usually indicate an earlier feeding.

1/ No fur seal was collected.

2/ Number of empty stomachs.

DISCUSSION

Distribution of Prey

Based on identified prey species, it appears that all three of the mammals feed in the epipelagic (O-200 m) and mesopelagic (200-1000 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 less than 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 Dali'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 Onycorhynchus): Because the latter collection was made in a small area over a 3-day 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 bring 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 6. Species identified for the first time as prey of the dolphin are: Pacific lamprey, Entosphenus tridentatus; salmon, Oncorhynchus spp., including pink, 0. gorbuscha, chum, 0. keta, and coho, 0. kisutch; California lanternfish, Symbolophorous californiensis; king-of-the-salmon, Trachipterus altivelis; medusafish, Icichthys lockington; rockfish, Sebastes spp.; Pacific sanddab, Citharichthys sordidus; squids: Abraliopsis sp., Octopoteuthis sp., Gonatopsis borealis, Onychoteuthis borealijaponicus, Chiroteuthis sp., Cranchidae, and the pelagic octopus, Ocythoe tuberculata. Listed as prey of the Dali's porpoise for the first time are: eulachon, Pacific saury, Walleye pollock, Pacific sand lance, Pleuronectidae, and the squid, Octopoteuthis sp., Berryteuthis magister and Gonatopsis borealis. All seal prey species have been previously listed in North Pacific Fur Seal Commission Reports on investigations 1958 to 1961 (1962), 1962-63 (1971), 1964-66 (1969), and 1967-72 (1975).

TABLE 6.--Size and frequency of occurrence of fishes and cephalopods found in the stomachs of Dall's porpoise, Pacific white-sided dolphin and northern fur seal[9] collected off California and Washington, 1964-1972.

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

1/ A complete list of prey species of northern fur seal appears in North Pacific Seal Commission Reports on Investigations, 1962, 1969, 1975.

2/ Length measurement of chinook salmon and sablefish is standard length, other measurements are total length. The numbers in parenthesis 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.

Stomach Capacity of Predators

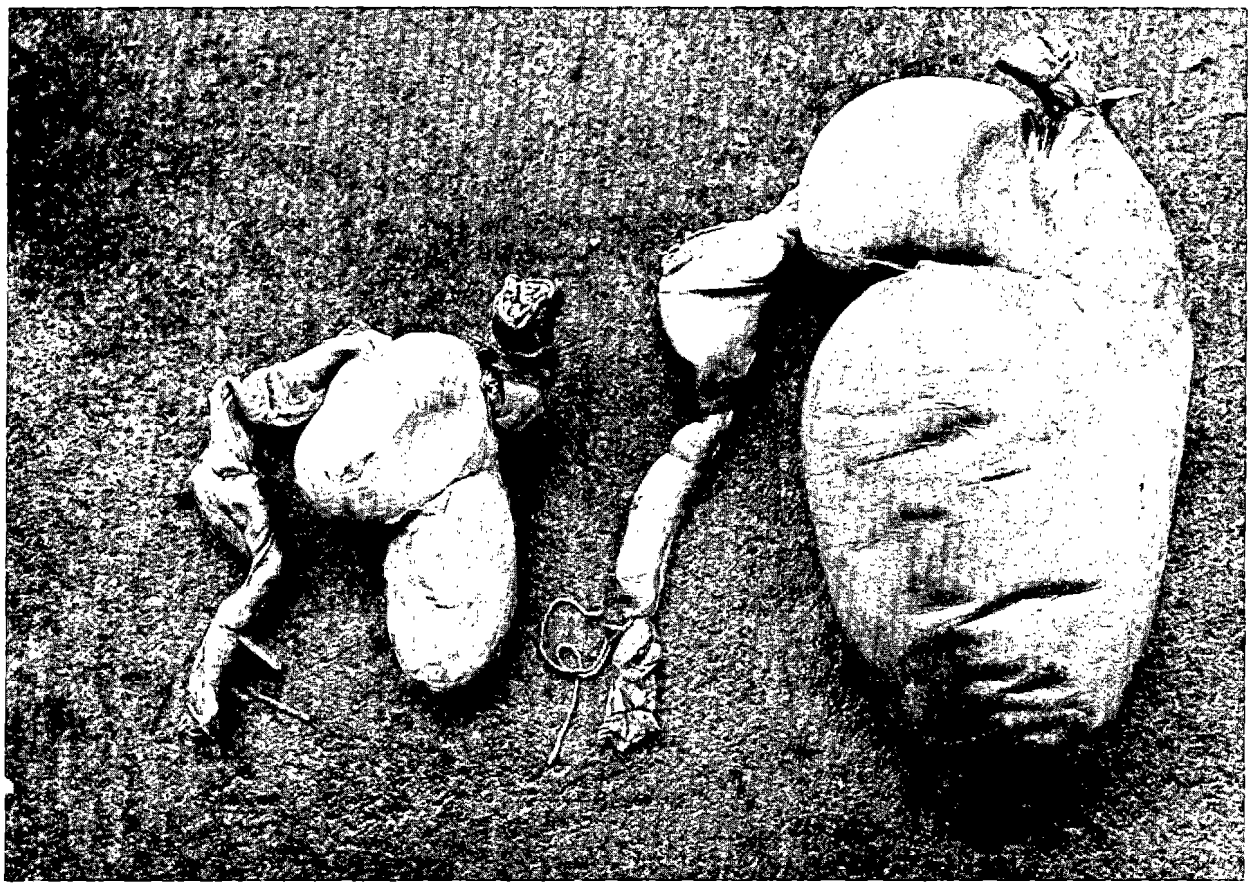
The 44 Pacific white-sided dolphin were all adult or subadult animals, presumably with stomachs of maximum size. Eleven stomachs contained only trace amounts of food, and 33 contained food contents varying from 10 to 3,490 cc (l0-3,745 g).

The dolphin whose stomach contained the most food from California waters had eaten 68 anchovy (1,770 cc and 1,895 g). Anchovy *grow* to 18-20 cm and may weigh 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 and two pink: which measured 26.0, 27.0, 31.0, 31.5, 31.5, 33.0, 33.0, 33.0, 33.5 cm, respectively. The full stomach (Fig. 1) measured 40 cm in length and 24 cm at the widest point (outside stomach dimensions) and the stomach contents represented 4.4% (3,480 cc or 3,745 g) of the total body weight of the animal.

The largest stomach content from a Dali's porpoise off California contained 58 anchovy (1,000 cc and 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 cc or 125 g). Five stomachs contained food volumes *varying* from 5 cc to 1,000 cc (5-1,090 g) whereas four stomachs contained only trace amounts of food. Except for occasional 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 fore-stomach. Stomach volumes were highly variable depending on the time of day the animal was collected and the digestibility of the

FIGURE 1.--An empty stomach (left), and a full stomach (right) from Pacific white-sided dolphin. The full stomach, 40 cm long and 24 cm in circumference at the widest point contained 3.7 kg (3.5 liters) of food.



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-year-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 cc volume representing 7.2% of body weight) with walleye pollock comprising 80% (7,340 cc) of the total stomach volume. The stomach of an adult female fur seal contained food weighing 5.9 kg (5,565 cc volume representing 13.1% of body weight). This 15-year-old animal was collected at 0645 h on 19 April 1964 off California and had fed on 31 Pacific whiting, Merluccius productus.

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/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) reports food requirements in captive animals equalled 7-8% of body weight/day for dolphin and lo-12% for porpoise. The species fed to these captive animals were not identified.

Size of Prey

Pacific White-Sided Dolphin

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 to 50 cm long, and 14 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 6). All salmon consumed by dolphin were generally immature, showing O-age ocean growth, although a few showed 1, 2, and 3 ocean annuli.

Dali's Porpoise

Scheffer (1953) reported on stomach contents of two Dali'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, 0. nerka, from stomachs of 148 porpoise taken in conjunction with the high-seas salmon gillnet 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 (William Gilmartin, Naval Ocean Systems, San Diego, California, Pers. commun. 1978). The teeth, jaw structure,' and relative neck mobility of the

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 Dali's, porpoise. The maximum size of prey eaten is apparently limited by the predator's ability to capture and swallow whole fish.

Northern Fur Seal

The sizes of prey listed in Table 6 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.

CONCLUSIONS

The Pacific white-sided dolphin and the Dali'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 the squid, Loligo opalescens. Meaningful estimates of dolphin and porpoise populations are unavilable, 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, Baines, and Wilke 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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APPENDIX: THE SIZE AND FOOD OF DALL'S PORPOISE TAKEN IN ALASKAN WATERS, 1958-68.

To meet the increasing need for information on this species, morphometric and feeding data is presented for 9 Dall's porpoise taken during the course of pelagic sealing voyages in Alaskan waters. Morphometric data given in Appendix Table 1 indicate that of the 2 females and 7 males taken, 1 (a female) can be considered a subadult and the other 8 (1 female and 7 males) can be considered adults based on data of Mizue and Yoshida (1965).

The stomach contents (Appendix Table 2) of the Dall's porpoise taken in Alaskan waters contained only small schooling fishes and squids. Fur seals collected in the same location or in the immediate vicinity at about the same time were eating the same prey species. Prey species reported as food for the first time for Dall's porpoise are: walleye pollock, Theragra chalcograrmna, Pacific sand lance, Ammodytes hexapterus, and the squid, Berryteuthis magister, and Gonatopsis borealis.

Appendix Table l.--Size of 9 Dali's porpoise collected in Alaskan waters, 1958-68.

	Gulf of Alaska		Unimak Pass and Bering Sea						
Specimen number	1	2	3727	3737	3740	3741	807	3750	3773
Location Lat. N.	58°35'	58°10'	56°31'	54°19'	54°24'	54°21'	54°24'	54°41'	55°02'
Long. W.	149°16'	150°57'	171°47'	165°28'	165°10'	165°19'	165°20'	167°24'	167°05'
Date (day, mo, yr)	8-5-58	25-5-60	15-8-60	15-6-62	12-7-62	12-8-62	4-10-62	5-9-63	25-7-68
Sex	F	M	F	M	M	M	M	M	M
Length (cm)	154.0	175.0	180.0	184.0	175.0	175.0	185.0	179.0	178.0
Weight (kg)	72.5	99.0	103.0	105.0	89.5	--	102.8	93.0	100.0
Measurements									
Length (cm)									
Snout to notch of flukes	154.0	175.0	180.0	184.0	175.0	175.0	185.0	179.0	178.0
Snout to tip of dorsal fin	--	78.0	90.0	87.0	84.0	83.0	86.0	86.0	82.0
Snout to insertion of flipper	--	30.0	29.0	28.0	25.0	29.0	29.0	29.0	26.0
Snout to ear	--	28.0	29.0	26.0	27.0	28.0	30.5	25.5	25.0
Snout to center of blowhole	--	21.0	22.0	19.0	22.0	21.0	19.5	20.0	21.5
Snout to center of eye	--	22.0	23.0	21.0	22.0	21.5	19.0	18.5	18.5
Snout to gape	--	12.0	12.5	11.0	11.0	10.5	10.0	11.0	9.0
Notch of flukes to umbilicus	--	98.0	100.0	102.0	102.0	102.0	107.0	99.0	95.0
Notch of flukes to genital aperture	--	71.0	60.0	71.0	76.0	71.0	75.0	75.0	73.0
Notch of flukes to anus	-	57.0	54.0	55.0	56.0	53.0	55.0	56.0	56.0
Projection of lower jaw	--	--	--	1.5	1.5	0.5	--	1.0	1.0
Girth behind flippers	--	--	--	105.0	100.0	97.0	101.5	98.0	95.0
Maximum girth	--	126.0	126.0	122.0	125.0	123.0	124.5	124.0	121.0
Anterior length of flipper	--	21.0	23.0	20.5	20.0	21.5	21.5	21.0	21.0
Axillary length of flipper	--	15.5	16.0	15.5	15.0	15.5	16.5	15.5	15.5
Maximum width of flipper	--	10.0	11.0	10.0	9.0	10.0	10.5	9.5	10.0
Length of base of dorsal fin	--	35.0	32.0	33.0	34.0	31.0	32.0	32.0	36.0
Height of dorsal fin	--	16.0	17.0	19.0	18.0	15.0	19.5	17.5	15.0
Span of flukes	39.5	50.0	47.0	48.0	48.5	46.5	53.0	46.5	49.0
Width of flukes	--	16.0	14.0	15.0	15.0	14.5	15.0	15.0	13.0

Appendix Table 2.--Stomach contents of 9 Dali's porpoise (P) and 43 northern fur seal (C) collected in Alaskan waters 1958-68. Fur seal were collected in the same location or in the immediate vicinity at about the same time.

Location				Species			Prey species - frequency of occurrence in stomachs										
Date collected	Latitude (N)	Longitude (W)	Ocean depth (m)	Phocoenoides dalli = P Callorhinus ursinus = C	Number specimens	Pod size ( )	Mallotus villosus	Theragra chalcogramma 1/	Gadidae	Pleurogrammus monopterygius	Ammodytes hexapterus 1/	Unident. fish	Gonatidae 1/	Gonatus sp.	Berryteuthis magister 1/	Gonatopsis borealis 1/	Unident. squid
Gulf of Alaska																	
8 May 1958	58° 35'	149° 16'	128	P	1 2/	(20-50)	1*										
				C	6 2/												
25 May 1960	58° 10'	150° 57'	146	P	1	(2)					1*						
				C	5						5*						
Unimak Pass & Bering Sea																	
15 Aug 1960	56° 31'	171° 47'	146	P	1 2/	(12)											1
				C	2 2/												
				C	5			4*									2
15 Jun 1962	54° 19'	165° 28'	71	P	1 2/	(5)											
				C	2 2/												
				C	1		1*				1*						
12 Jul 1962	54° 24'	165° 10'	174	P	1 2/	(5)	1										
				C	4 2/												
				C	2		2*										
12 Aug 1962	54° 21'	165° 19'	137	P	1 2/	(6)	1*										
				C	3 2/												
				C	1												1
4 Oct 1962	54° 24'	165° 20'	165	P	1	(8)	1*										
				C	5		5*				3*						
5 Sep 1963	54° 41'	167° 24'	549	P	1	(4)							1*	1*	1*	1*	
				C	3					2*		1	3*	1*	1*	3*	
25 Jul 1968	55° 02'	167° 05'	165	P	1 2/	(5)		1					1*		1*		
				C	1 2/												
				C	3			2*	1				1				

* Denotes species forming measurable portion of stomach food volume, i.e., most recent feeding. Trace items, i.e., fish vertebrae, otoliths, squid beaks (volume ≤ 10 cc) usually indicate an earlier feeding.

1/ Prey not previously reported as food of Dall's porpoise.

2/ Number of empty stomachs.