FOOD HABITS OF THE HARBOR PORPOISE, *PHOCOENA PHOCOENA*, AND DALL'S PORPOISE, *PHOCOENOIDES DALLI*, IN THE INLAND WATERS OF BRITISH COLUMBIA AND WASHINGTON

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Abstract

Stomach contents were analyzed from 22 Dall's porpoise, *Phocoenoides dalli*, and 26 harbor porpoise, *Phocoena phocoena*, collected primarily from single strandings in the inland waters of British Columbia and Washington during the 1990-97 period. Eighteen species of fish and four species of cephalopods were identified from both samples. In the Dall's porpoise sample, fishes comprising nine families were predominant and made up 99.0% of the total number of prey with an occurrence of 95.5%. Two families of cephalopods made up only 0.6% of the total with an occurrence of 13.6%. In the harbor porpoise sample, fishes comprising ten families made up 52.2% of the total number of prey with an occurrence of 88.5%. Three families of cephalopods made up 46.5% of the prey with an occurrence of 15.4%. Juvenile blackbelly eelpout, *Lycodopsis pacifica*, ranging in size from 80-110 mm were the dominant prey by number in both the Dall's (92.2%) and harbor porpoise (49%) samples. Six other prey species, including Pacific herring, *Clupea harengus pallasi*; eulachon, *Thaleichthys pacificus*; walleye pollock, *Theragra chalcogramma*; Pacific hake, *Merluccius productus*; Pacific sandlance, *Ammodytes hexapterus*; and market squid, *Loligo opalescens*, were common to the diets of both species of porpoise. The presence of very large numbers of very small juvenile blackbelly eelpout in both samples has the effect of biasing the importance of other prey in the samples downward. Calculating the contribution by mass for seven prey common to both samples minimizes the exaggerated importance of the blackbelly eelpout and presents a more realistic picture on importance of the other major prey species represented. Using this technique for Dall's porpoise the contribution by total mass index of importance of blackbelly eelpout is 63.0% compared to the 96.6% by number. The contribution by mass for this prey species in the harbor porpoise is 18.8% compared to the 49.6% by number. Differences in the occurrence and numbers of blackbelly eelpout between the

two samples is probably due to temporal differences in the collection of the porpoise samples. Occurrence of juvenile blackbelly eelpout in the study area is seasonal. Juveniles in the 80-110 mm size range occur only in the spring months (March-May). Ninety-five percent of the Dall's and only 61.5% of the harbor porpoise were collected in the spring. In general, the food habits of both species of porpoises is very similar. They differ primarily in the presence of small numbers of lanternfish, family Myctophidae, which occur only in the Dall's porpoise samples. The presence of these mesopelagic species suggests that Dall's porpoise spend some of their time feeding at greater depths than the harbor porpoise.

Introduction

Food habits accounts of Dall's and harbor porpoise off the coast of North America have been largely confined to samples obtained from the outer coast (Cowan 1944, Scheffer and Slipp 1948, Scheffer 1953, Norris and Prescott 1961, Pike and McAskie 1969, Loeb 1972, Morejohn 1979, Jones 1981, Stroud et al. 1981, Gearin and Johnson 1990, Gearin et al. 1994). Little information on the feeding habits of these two species of porpoise is available from the inland nearshore environments of their distribution. Only two accounts of stomach contents of harbor porpoise from the inland waters exist in the literature. Pike and MacAskie (1969) reported on the stomach of one animal incidentally taken in a salmon gillnet in Baynes Sound off the east side of Vancouver Island as " containing only herring". Scheffer and Slipp (1948) reported on the stomach contents of a single animal netted at Samish Flats near Bellingham, Washington as containing "slender, non-armored fish" about 4.5 to 15 cm long. No stomach contents of Dall's porpoise from inland waters have been described in the literature.

This paper constitutes a preliminary report of an on-going study on the food habits of these two species of porpoise. Recently, additional stomach samples have become available but have yet to be examined and included in the database.

Methods

Stomach samples from 22 Dall's porpoise and 26 harbor porpoise were collected during 1990-97 by the Marine Mammal Research Group, Victoria, B.C., Canada, and The Whale Museum, San Juan Island, Washington (Table 1). Most of the samples were collected from stranded animals occurring on the southern tip and eastern side of Vancouver Island, Canada, and the general area around the San Juan Archipelago (Figs.1 and 2). All but five of the samples were obtained from singly stranded animals. The exceptions were four harbor porpoise taken incidentally in local salmon gillnets and one harbor porpoise retrieved from a killer whale attack.

Stomachs were removed intact in the field, tagged with a collection number and placed in frozen storage prior to preliminary sorting and specimen preservation. After removal of the contents the stomach lining was thoroughly rinsed with water in order to collect all otoliths, cephalopod beaks and other small prey items. Stomach contents were then stored in alcohol for later identification, enumeration and measurement. Otolith length and lower rostral length of cephalopod beaks were measured to the nearest 0.05 mm with either vernier calipers or an optical micrometer. Damaged or eroded specimens were not measured. Length measurements of these beaks and otoliths were used to estimate the body lengths and weight of fish and cephalopod prey where supplementary regression data was available.

In most instances, prey length and weight estimates were derived from regression equations presented in Frost and Lowry (1981), Harvey et al. (in press) and Wolff (1984). In those instances where regression data for commonly ingested prey were not available from the literature, prey length and weight estimates were derived from specimens and data available in the food habits reference collection of the National Marine Mammal Laboratory, Seattle, Washington, and the fish collection of the University of Washington, School of Fisheries, Seattle, Washington.

Contribution by mass of commonly ingested fish and cephalopod prey was calculated as: (No. of prey of each species x mean prey weight) ÷ (total mass of prey consumed by each species) × 100 (Recchia and Read 1989, Walker 1996).

There is a strong temporal bias in the seasonal time frame in which the samples were collected. Twenty-one (95.5%) of the Dall's porpoise stomach samples were collected during the spring months (March - May). Over half (61.5%) of the harbor porpoise samples were collected in the spring with the summer months (June - August) accounting for another 31% of the sample.

Results

Dall's Porpoise

All of the 22 stomachs examined contained prey remains. Thirteen species of fish and three species of cephalopods were identified in the sample (Table 2). Fishes comprising nine families were predominant and made up 99.0% of the total number of prey, with an overall occurrence of 95.5%. Two families of cephalopods made up 0.6% of the total number of prey ingested with an overall occurrence of 13.6%. One species of crustacean occurred in trace amounts in one animal and may have been incidentally ingested. Mandibles from the polychaete worm, *Nereis vexillosa*, were a common finding in the samples.

One species of fish was predominant in the sample. The blackbelly eelpout, *Lycodopsis pacifica*, represented 96.2% of the total prey in 81.8% of the stomachs examined. Five other species of fish demonstrated a frequency of occurrence greater than 10%. These were Pacific herring, *Clupea harengus pallasi*; eulachon, *Thaleichthys pacificus;* walleye pollock, *Theragra chalcogramma*; Pacific whiting, *Merluccius productus;* and Pacific sand lance, *Ammodytes hexapterus*. Collectively these five species represented 2.6% of the total prey consumed. Nine other species of fish were taken in small numbers and combined represented less than 0.5% of the total prey. Three species of cephalopods were represented in the sample. These were the market squid, *Loligo opalescens*, and two species of gonatids, *Gonatus berryi* and *G. pyros*. Collectively these three species made up only 0.6% of the total prey.

Composition of the sample by the total mass generally supports the numeric findings on relative prey importance of seven commonly ingested species (Table 3). This index of relative importance is useful in that it minimizes the effect of the upward bias of smaller more numerous prey. This is particularly evident with the large numbers of juvenile blackbelly eelpout for which the calculated total mass is 63% compared to the 96.2% by number.

Prey size estimates were available for seven of the commonly ingested species (Table 3). These data indicate that the porpoise ingested prey ranging in size from 69 mm (*Loligo opalescens*) to as large as 438 mm (*Merluccius productus*).

Harbor Porpoise

All of the 26 stomachs examined contained prey remains. Twelve species of fish and three species of cephalopods were identified in the sample (Table 2). Fishes comprising ten families made up 52.2% of the total number of prey with an overall occurrence of 88.5%. Three families of cephalopods made up slightly more than 46.5% of the prey ingested with an overall occurrence of 15.4%. One species of crustacean occurred in trace amounts. Mandibles from the polychaete worm, *Nereis vexillosa*, were a common finding.

Juveniles of the blackbelly eelpout, *Lycodopsis pacifica*, were also the dominant fish species in the sample and represented 49.6% of the total prey with a frequency of occurrence of 26.9%. Five other species of fish were commonly ingested. These were Pacific herring, *Clupea harengus pallasi*; walleye pollock, *Theragra chalcogramma*; Pacific hake, *Merluccius productus*; eulachon, *Thaleichthys pacificus*; and Pacific sanddab, *Citharichthys sordidus*. Collectively these five species represented 2.4% of the total number of prey. Three species of cephalopods were represented in the sample. The dominant cephalopod, *Loligo opalescens*, represented 46.5% of the total prey in 15.4% of the stomachs. The remaining two species, *Onychoteuthis borealijaponica* and *Gonatus berryi* were found in trace amounts.

Composition of the sample by the estimated total mass generally supports the numeric findings on relative prey importance of seven of the commonly ingested prey (Table 3). The exaggerated importance reflected by the large numbers of juvenile blackbelly eelpout (49.6%) in the sample is reduced in the total mass estimate to 18.8%.

Prey size estimates were available for eight of the commonly ingested species (Table 3). These data indicate that the harbor porpoise ingested prey ranging in size from 58 mm (*Loligo opalescens*) to 371 mm (*Merluccius productus*).

Discussion

The small stomach sample sizes and seasonal bias in the dates of collection of the two samples prevents any detailed statistical analyses of potential differences in the food habits of the Dall's and harbor porpoise at this time. General comparison of the primary prey of these two species of porpoises using the percent by number, frequency of occurrence and estimated total prey mass indices reveals similar food habits for both species of porpoises. However, the complete absence of the lanternfish family, Myctophidae, in the harbor porpoise sample and the greater number and occurrence of gonatid squid in the Dall's porpoise sample (Table 2) indicates that the Dall's porpoise are spending some time feeding deeper in the water column than the harbor porpoise. The size range of the gadid fishes, *Theragra chalcogramma* and *Merluccius productus*, indicated that Dall's porpoise are capable of ingesting larger prey.

Utilizing the contribution by mass index of importance of the blackbelly eelpout, *Lycodopsis pacifica*, presents a more realistic picture on the importance of this species in the diets of the Dall's and harbor porpoise. However, the large numbers and high frequency of occurrence of the blackbelly eelpout in both samples is a seasonal occurrence which biases the importance of the other major prey in the samples downward. In Puget Sound this species of fish spawns during the late fall and early winter (Levings 1969). The 80-110 mm size range for this species found in the porpoise samples is consistent with juveniles from the previous fall-winter spawning period. Additional evidence of the seasonal importance of this species is that all the remains of *L. pacifica* found occurred in samples collected in the spring months (March-May). The differences in the

frequency of blackbelly eelpout between the harbor porpoise (26.9%) and Dall's porpoise (81.8%) samples is probably due, at least in part, to temporal differences between the two samples in that 95.5% of the Dall's porpoise were collected during the spring months and only 61.5% of the harbor porpoise samples were collected during the same period.

The frequency of occurrence of the polychaete worm, *Nereis vexillosa*, was high in both the Dall's (59.1%) and harbor porpoise (30.8%) samples. This species of worm reaches up to 30 cm in length and is vulnerable to predation while swimming in open water during its seasonal spawning activity (Johnson 1943, Ricketts and Calvin 1962). While it is possible that the porpoise fed directly on *N. vexillosa* during these spawning events, the possibility that the worm remains were introduced secondarily as prey of larger prey ingested is still being investigated.

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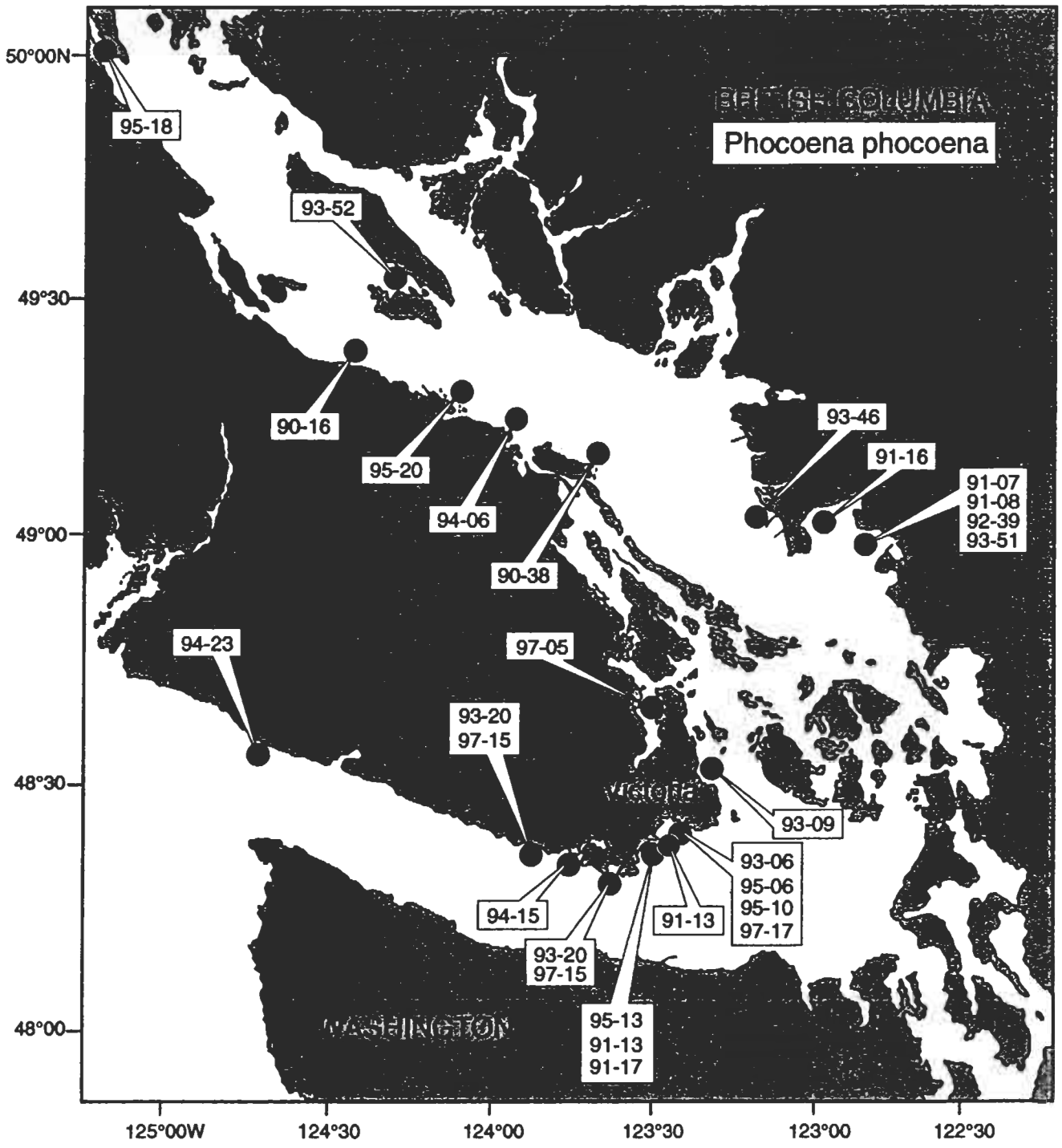

Figure 1. Approximate locations for harbor porpoise stomach samples collected in the inland waters of British Columbia and Washington.

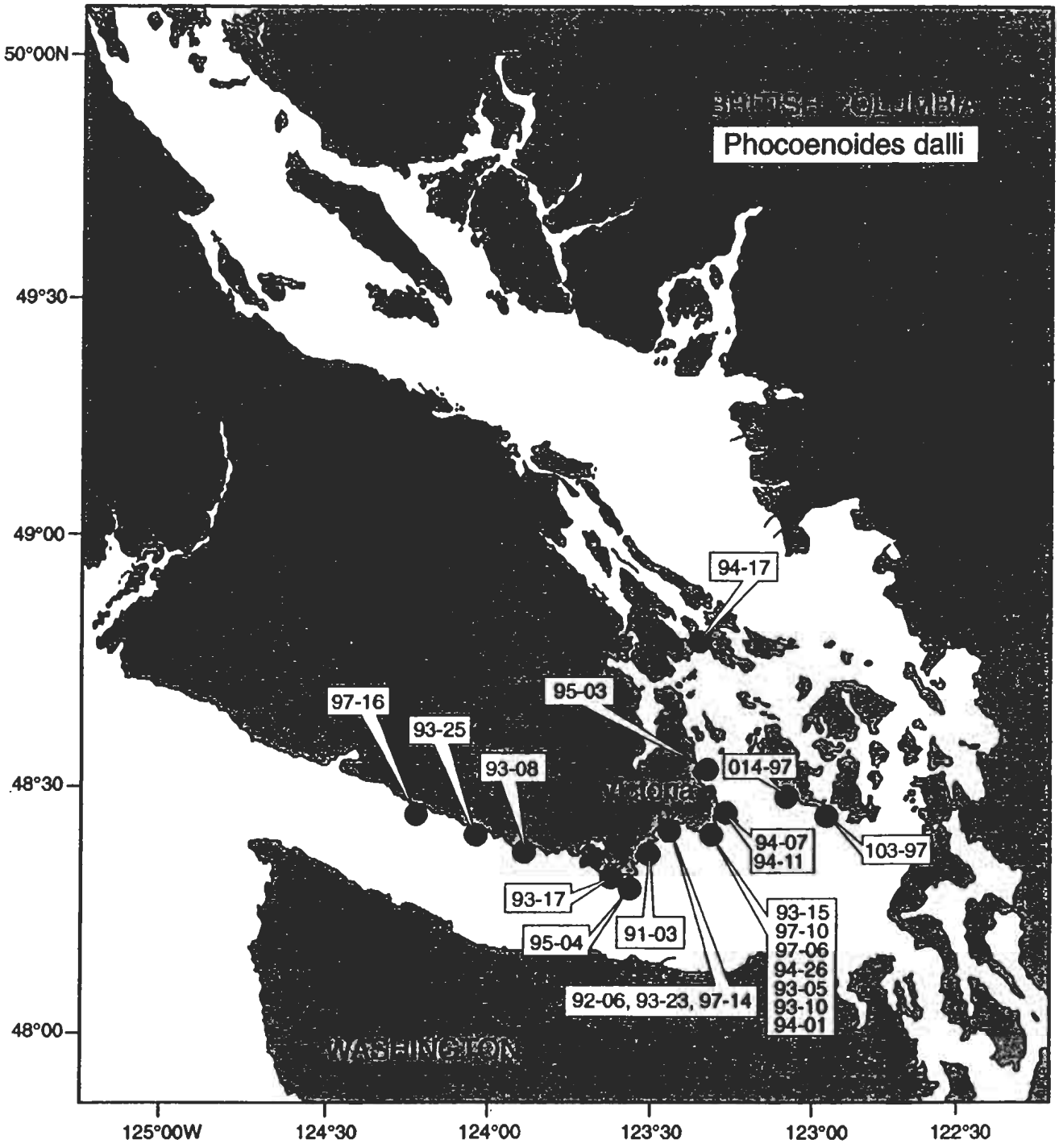

Figure 2. Approximate locations for Dall's porpoise stomach samples collected in the inland waters of British Columbia and Washington.

Table 1. Summary of harbor porpoise and Dall's porpoise included in stomach content samples from the inland waters of British Columbia and Washington.

COLL. NO.	DATE COLL.	LENGTH (cm)	SEX	LOCALITY
		HARBOR PORPOISE		
SWDP 90-16	7/25/90	146	M	Qualicum River, Vancouver Island (salmon gillnet)
SWDP 90-38	12/8/90	190	F	Vance Island
SWDP 91-07	4/16/91	143	F	White Rock, N. Semiahmoo Bay (salmon gillnet)
SWDP 91-08	4/18/91	149	M	White Rock, N. Semiahmoo Bay
SWDP 91-13	5/9/91	121	M	Esquimalt, Vancouver Island
SWDP 91-17	5/15/91	143	F	Saxe Point, Esquimalt, Vancouver Island
SWDP 91-16	5/15/91	159	F	Boundary Bay (salmon gillnet)
SWDP 92-39	9/5/92	131 est.	M	White Rock, N. Semiahmoo Bay
SWDP 93-06	4/22/93	134	F	250 m W. Holland Pt., Victoria, Vancouver Island
SWDP 93-09	4/28/93	146	M	Ten Mile Point, Victoria, Vancouver Island
SWDP 93-20	5/19/93	114	F	Caffrey Point, Becher Bay, Vancouver Island
SWDP 93-00	8/4/93	und.	und.	1 mile north of Fife Sound (killer whale kill)
SWDP 93-46	8/23/93	119	M	Tsawwassen, ferry terminal N. Pt. Roberts
SWDP 93-51	8/28/93	131	M	White Rock, N. Semiahmoo Bay
SWDP 93-52	8/31/93	146	F	Sabine Channel (salmon gillnet)
SWDP 94-06	3/16/94	110	M	Keel Bay, Nanaimo, Vancouver Island
SWDP 94-15	4/26/94	123	M	Sooke Bay, Vancouver Island
SWDP 94-23	5/12/94	111	M	Carmanah Point, Vancouver Island
SWDP 95-06	4/21/95	118	M	Clover Point, Vancouver Island
SWDP 95-10	5/18/95	125	F	Clover Point,Victoria, Vancouver Island
SWDP 95-13	5/30/95	129	F	Fleming Beach, Victoria, Vancouver Island
SWDP 95-18	7/18/95	159	F	Campbell River, Vancouver Island
SWDP 95-20	7/24/95	149	F	north of Parksville, Vancouver Island
SWDP 97-05	4/30/97	155	M	Patricia Bay, Vancouver Island
SWDP 97-15	5/23/97	136	M	Church Rock, Vancouver Island
SWDP 97-17	6/4/97	131	M	Holland Point, Victoria, Vancouver island
		DALL'S PORPOISE		
SWDP 91-03	3/19/91	160	M	William Head, Vancouver Island
SWDP 92-06	4/30/92	152	M	Esquimalt, Vancouver Island
SWDP 93-05	4/10/93	140	M	McMicking Point, Victoria, Vancouver Island
SWDP 93-08	4/23/93	160	M	Church Point, Vancouver Island
SWDP 93-10	5/4/93	160	M	300 m W.Clover Point,Victoria, Vancouver Island
SWDP 93-15	5/14/93	179	F	East side Ross Bay, Vancouver Island
SWDP 93-17	5/17/93	162	M	S. Crekye Point, Vancouver Island
SWDP 93-23	5/26/93	147	F	Albert Head, Vancouver Island
SWDP 93-25	5/27/93	152	F	1 km E.Tugwell Creek, Vancouver Island
SWDP 94-01	1/7/94	133	M	Ross Bay, Victoria, Vancouver Island
SWDP 94-07	3/25/94	152	F	N.E. shore Discovery Island
SWDP 94-11	4/15/94	190	F	Ten mile Point, Victoria, Vancouver Island
SWDP 94-17	4/29/94	206	F	Stanley point, North Pender Island
SWDP 94-26	5/15/94	169	M	Ross Bay,Victoria, Vancouver Island
SWDP 95-03	4/7/95	188	M	Island View Beach, Vancouver Island
SWDP 95-04	4/9/95	141	F	Race Rocks
SWDP 97-06	5/1/97	140	F	Ross Bay, Vancouver Island
SWDP 97-10	5/15/97	140	F	Clover Point, Vancouver Island
SWDP 97-14	5/20/97	175	M	Albert Head, Vancouver Island
SWDP 97-16	5/24/97	153	F	French Beach, Vancouver Island
SJ103-97	4/10/97	164	M	Cattle Point Lighthouse, San Juan Island.
SJ014-97	5/8/97	184	F	Edward's Point, San Juan Island.

SWDP = Stranded Whale and Dolphin Program, B. C., Canada; SJ = Record numbers of the San Juan County Marine Mammal Stranding Network, The Whale Museum, Friday Harbor, Washington

Table 2. **Number and frequency of occurrence for prey recovered from Dall's porpoise, *Phocoenoides dalli*, and harbor porpoise, *Phocoena phocoena*, from the inland waters of British Columbia and Washington.**

	DALL'S PORPOISE (n=22)				HARBOR PORPOISE (n= 26)			
	Number		Frequency of occurrence		Number		Frequency of occurrence	
	No.	%	No.	%	No.	%	No.	%
Total Prey	10581				3602			
FISHES	10473	99.0	21	95.5	1891	52.5	23	88.5
Clupeidae								
Clupea harengus pallasi	66	0.6	10	45.5	53	1.5	8	30.8
Osmeridae								
Thaleichthys pacificus	21	0.2	4	18.2	3	0.1	1	3.9
Myctophidae	18	0.2	2	9.1	0	-	0	-
Stenobrachius leucopsaurus	12	0.1	2	9.1	0	-	0	-
Lampanyctus ritteri	2	< 0.1	1	4.5	0	-	0	-
Diaphus theta	3	< 0.1	1	4.5	0	-	0	-
Protomyctophum sp.	1	< 0.1	1	4.5	0	-	0	-
Batrachoididae								
Porichthys notatus	0	-	0	-	1	< 0.1	1	3.9
Gadidae	120	1.1	13	59.0	18	0.5	2	7.7
Theragra chalcogramma	113	1.1	15	68.2	3	0.1	2	7.7
Merluccius productus	7	0.1	3	13.6	15	0.4	2	7.7
Zoarcidae								
Lycodopsis pacifica	10175	96.2	18	81.8	1786	49.6	7	26.9
Ammodytidae								
Ammodytes hexapterus	61	0.6	6	27.3	2	< 0.1	2	7.7
Embiotocidae								
Cymatogaster aggregata	0	-	0	-	5	0.1	2	7.7
Scorpaenidae								
Sebastes sp. (juv.)	0	-	0	-	1	< 0.1	1	3.9
Cottidae	3	< 0.1	2	9.1				
Icelinus borealis	2	< 0.1	1	4.5	8	0.2	2	7.7
unident. cottid	1	< 0.1	1	4.5				

Table 2. Continued.

	Number		Frequency of occurrence		Number		Frequency of occurrence	
	No.	%	No.	%	No.	%	No.	%
Bothidae								
Citharichthys sordidus	1	< 0.1	1	4.5	10	0.3	2	7.7
Pleuronectidae	5	< 0.1	2	9.1	0	-	0	-
Glyptocephalus zachirus	1	< 0.1	1	4.5	0	-	0	-
Isopsetta isolepis	1	< 0.1	1	4.5	0	-	0	-
Parophrys vetulus	1	< 0.1	1	4.5	0	-	0	-
unidentifiable pleuronectid	2	< 0.1	1	4.5	0	-	0	-
unidentifiable teleosts	3	< 0.1	2	9.1	4	0.1	4	15.4
INVERTEBRATES	108	1.0	14	63.6	1711	47.5	13	50.0
Cephalopoda	66	0.6	3	13.6	1677	46.6	5	19.2
Loliginidae								
Loligo opalescens	44	0.4	2	9.1	1673	46.5	4	15.4
Onychoteuthidae								
Onychoteuthis borealijaponica	0		0	-	2	< 0.1	1	3.9
Gonatidae	22	0.2	2	9.1			1	3.9
Gonatus berryi	20	0.2	2	9.1	2	< 0.1	1	3.9
Gonatus pyros	2	< 0.1	1	4.5	0	-	0	-
Crustacea	3	< 0.1	1	4.5	1	< 0.1	1	3.9
Crangonidae								
Crago sp.	3	< 0.1	1	4.5	0	-	0	-
Penaeidae								
Sergestes sp.	0	-	0	-	1	< 0.1	1	3.9
Polychaeta								
Nereidae								
Nereis vexillosa	39	0.4	13	59.1	33	0.9	8	30.8

Table 3. Summary of size, weight estimates and indices of importance for seven commonly ingested prey of Dall's and harbor porpoise collected in the inland waters of British Columbia and Washington.

	DALL'S PORPOISE						HARBOR PORPOISE					
Prey species	Length range (mm)	Mean length (mm)	Mean weight (gms)	% Total mass *	% No.	% Freq.	Length range (mm)	Mean length (mm)	Mean weight (gms)	% Total mass *	% No.	% Freq.
FISHES				98.8	98.8	95.5				45.2	51.8	88.5
Clupea harengus pallasi	102 - 217	151.0	67.3	7.1	0.6	45.5	123 - 228	178.6	88.2	12.0	1.5	30.8
Thaleichthys pacificus	128 - 176	158.0	37.8	1.3	0.2	18.2	124 - 181	153.0	33.8	0.3	0.1	3.9
Theragra chalcogramma	127 - 363	259.0	118.0	21.1	1.1	68.2	185 - 188	186.4	34.7	0.3	0.1	7.7
Merluccius productus	397 - 438	417.5	521.0	5.7	0.1	13.6	338 - 371	353.0	316.9	12.2	0.4	7.7
Lycodopsis pacifica	80 - 105	95.0	3.9	63.0	96.2	81.8	80 - 110	104.3	4.1	18.8	49.6	26.9
Ammodytes hexapterus	93 - 133	109.0	6.0	0.6	0.6	27.3	undet.	157.0	10.0	0.1	< 0.1	7.7
Citharichthys sordidus	-	-	-	-	-	0	125 - 176	152.0	57.7	1.5	0.3	7.7
CEPHALOPODS				1.2	0.6	13.6				54.8	46.6	19.2
Loligo opalescens	69 - 127	95.2	19.6	1.2	0.4	9.1	58 - 125	81.4	12.7	54.8	46.5	15.4

* Calculation of the total mass percentages is based only on the cumulative contribution of these seven prey species.

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