A COMPARISON OF THE FOOD HABITS OF JUVENILE PACIFIC COD AND WALLEYE POLLOCK IN THE SOUTHEAST BERING SEA

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A

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ABSTRACT

The food habits of juvenile Pacific cod, Gadus macrocephalus, and walleye pollock, Theragra chalcogramma, collected in July and August in 1981 through 1983 in the eastern Bering Sea, were compared in relation to some morphological characteristics.

The fishes° gill rakers were counted, the distances between gill rakers were measured, and the stomach tissue weight was measured. The stomach contents were analysed by occurrence, number and volume. It was found that the fishes° gill structures were related to size-selective predation in both fishes. Pollock utilized small zooplankton and cod large zooplankton.

Food competition was expected when fishes are smaller than 40 mm TL as indicated by high values in proportional similarity. However, food competition decreases as the fishes grow and develop distinct size-selective predation habits. Prey composition in the stomachs reflected the regional differences of local oceanographic environments.

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CHAPTER 1

INTRODUCTION

Distribution of Pacific Cod and Walleye Pollock in the Southeast Bering Sea

Pacific cod, Gadus macrocephalus (Tilesius), and walleye pollock, Theragra chalcogramma (Pallas), are two of the most important demersal fishes in the North Pacific. Adults are typical demersal species inhabiting the continental shelf and slope of subarctic and temperate seas.

Geographically, Pacific cod range from California in North America to the Yellow Sea in Asia, and northwards to the Chukchi Sea (Hart, 1973). In the eastern Bering Sea, Pacific cod are widely distributed over the continental shelf and slope region migrating seasonally between feeding and wintering grounds (Moiseev, 1956). In the Bering Sea during winter, they form dense aggregations where sea surface temperature are 2.5-3.5°C (Teshima, 1983).

Walleye pollock range from the southern Sea of Japan in Asia to Oregon in America, and northwards to the Chukchi Sea (Hart, 1973). Walleye pollock are widely distributed over the continental shelf, slope and Aleutian basin in the Bering Sea, with the highest

densities along the shelf edge (Bakkala et al., 1983). They also exhibit marked seasonal migrations on- and off-shelf. During winter season they tend to aggregate along the outer shelf area (200-500 m depth) where the bottom water temperature is 2.0-4.4°C (Chen, 1983). After spring spawning they disperse over the continental shelf to feed.

Commercial Catch and Fishing Area

Pollock have been exploited commercially since 19th century but were not fully exploited in the North Pacific until the 1960°s. World catches ranged from 3.3 to 6.0 million metric ton in the years 1970-1980. In the eastern Bering Sea, the commercial catch ranged from 0.9 to 1.9 million metric ton in the years 1970-1983. The major fishing ground in the eastern Bering Sea is along the outer continental shelf (Bakkala et al., 1983).

Catches of Pacific cod in the eastern Bering Sea increased from 13 thousand to 70 thousand metric ton between 1964 and 1970. Afterwards the catches varied between 33 thousand and 83 thousand metric ton between 1971 and 1983 (Bakkala and Wespestad, 1984). Pacific cod have been a by-catch in the pollock fishery. Occasionally, however, they have been the target species when dense aggregations have been detected.

Recently, catches of Pacific cod by U.S. fishermen (joint-venture and domestic) contributed 53% of the total Pacific cod catch in the eastern Bering Sea, reaching 43,977 metric ton in 1983 (Bakkala and Wespestad, 1984). Pacific cod catches in the eastern Bering Sea ranged from 2.2% to 7.8% (average 4.0%) of the combined total of cod and pollock catch in the years 1970-1983.

Objectives

In the eastern Bering Sea, the distribution, and spawning grounds and season of adult cod and pollock substantially overlap (Bakkalla, 1981). However, egg and larval stages are spatially segregated. The eggs of Pacific cod are believed to be demersal and slightly adherent (Yamamoto and Nishioka, 1952; Thompson, 1963), whereas eggs of walleye pollock float in the upper surface layer (Yusa, 1954; Nishiyama and Haryu, 1981). However, there is again temporal and spatial overlap during postlarvae and juvenile stages. They are encountered in the mid-layer concurrently (Nishiyama and Haryu, 1981; Nishiyama et al., 1983). Such a concurrence of cod and pollock juveniles in the mid-layer raises questions as to whether they compete for food, or utilize different food organisms.

The literature on food habits of Atlantic cod is extensive (Wiborg, 1948; Marak, 1960; Sysoeva and Degtereva, 1965; Bainbridge and Mckay, 1968; Armstrong, 1982; Klementsen, 1982) with several studies comparing food habits of Atlantic gadid fishes (Last, 1978; Langton and Bowman, 1980). In contrast, the feeding habit studies of Pacific cod are relatively few (Suyehiro, 1942; Forrester, 1969; Mito, 1974; Westrheim,1977; Jewett, 1978; Hunter, 1979; Clausen, 1980).

The feeding habit of young and adult pollock has been extensively studied (Takahashi and Yamaguchi, 1972; Mito, 1974; Smith et al., 1978; Wespestad, 1978; Baily and Dunn, 1979; Dwyer et al., 1983; Maeda, 1983; Yoshida, 1984). Although the food and feeding habits of the larval stage and young-of-the-year juveniles have been reported, available information is limited (Kamba, 1977; Clarke, 1978; Cooney et al., 1980; Nishiyama et al., 1983; Walline, 1983).

No available information, however, exists on the feeding habits of juvenile cod in the southeast Bering Sea. Further, no attempts have been made to compare the feeding habits between juvenile cod and pollock, which co-occur in the same water.

The objective of this study was twofold. First, I examined the types of organisms juvenile cod and pollock consumed to determine if they are partitioning the food resources and therefore avoiding competition. Second, I examined the relationship between the morphological characteristics and the food utilized. Particular attention is paid to the comparisons of stomach tissue weight and gill structure between the two species, as it is known that the feeding behavior of fishes is closely related to such morphological characteristics of each species (Nilsson, 1958; Nikolsky, 1963; Brooks and Dodson, 1965).

CHAPTER 2

MATERIALS AND METHODS

Study Area and Sampling Method

Eighty three stations were established in the eastern Bering Sea, south of St. Lawrence Island and east of 180° W longitude. In addition, there were 5 stations south of Alaska Peninsula. Samples were collected in July and August in 1981 through 1983 aboard R/V Thompson (University of Washington), R/V Alpha Helix (University of Alaska), and T/V Oshoro Maru (Hokkaido University, Japan). Juvenile cod were collected from 24, and pollock from 45 of the 88 stations. No gadoid fish were collected from 38 stations (Fig. 1). A total of 4,689 larvae and juveniles of gadoid fishes were collected from 50 sampling stations. Cod occupied 4.2% (195 fish), and the remaining were pollock. Cod were collected mostly from the edges of continental shelf between Unimak Pass and the Pribilof Islands. To characterize the feeding habits on a regional basis, 4 stations were designated as A, B, C, and D, and 5 stations located near the Pribilof Islands were grouped and designated as E (Table 1).

Four types of sampling gear were used to collect the juveniles from the different depths. A 1.5 m-ring fish larvae net was towed at two knots in the surface

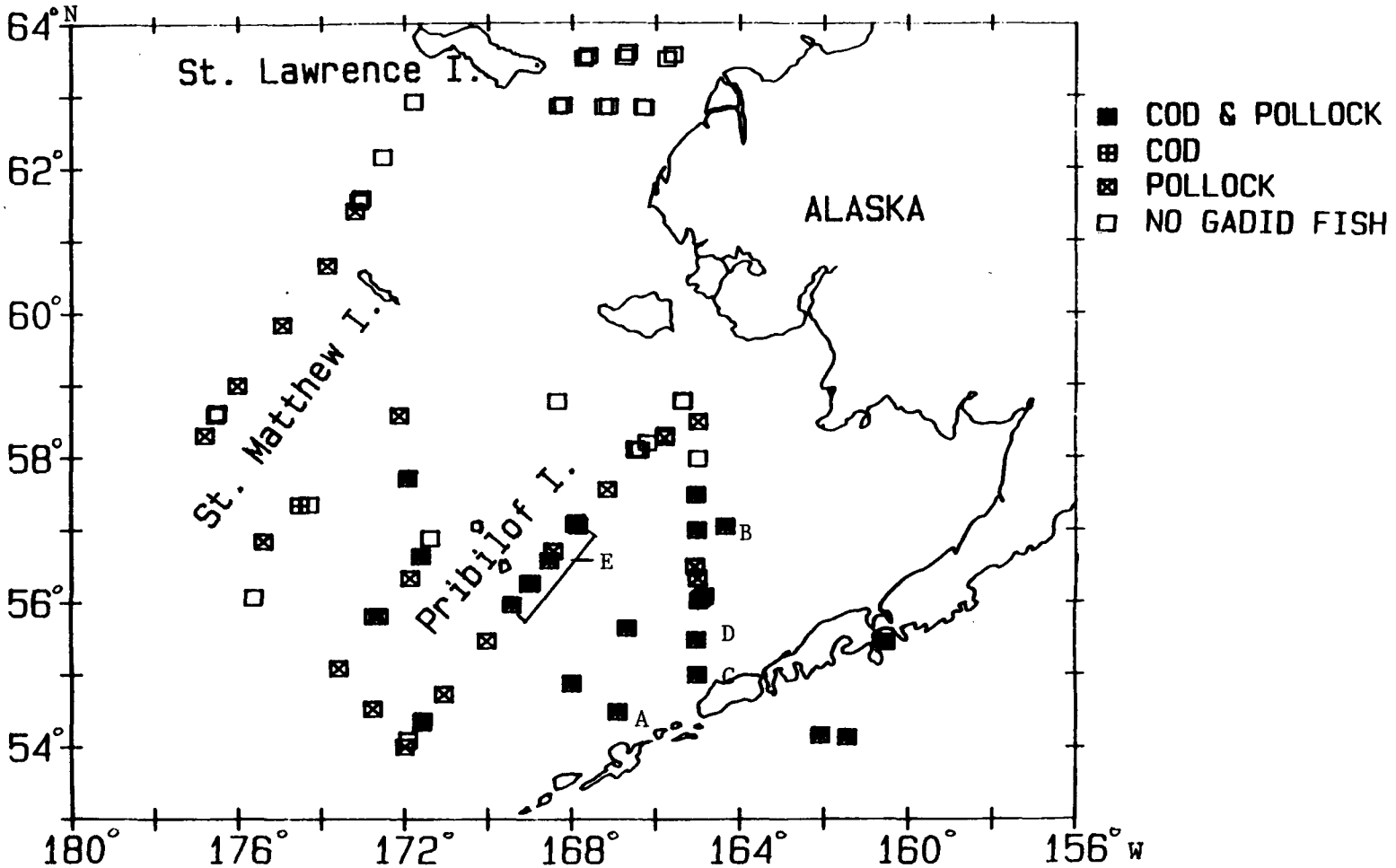

Fig. 1. Study area and the occurrence of larval and juvenile Pacific cod and walleye pollock. The symbols A through E designate the stations which were used for the comparison of regional food characteristics.

Table 1. Station locations used for the comparison of the regional differences in food habits of juvenile Pacific cod and walleye pollock in the southeast Bering Sea.

Station	Date	Location		Sample size	
		Lat. (N)	Long. (W)	Cod	Pollock
A	7-8-81	54° 29.0′	166° 54.0′	48	47
B	7-30-82	57° 01.9′	164° 20.5′	23	30
C	7-18-83	54° 59.5′	165° 00.9′	17	30
D	7-18-83	55° 28.3′	165° 02.3′	43	60
E	7-20-83	57° 02.3′	167° 50.0′	3	5
	7-20-83	56° 33.5′	168° 31.1′	2	5
	7-21-83	56° 15.0′	168° 57.3′	8	24
	7-21-83	55° 56.7′	169° 24.5′	1	5
	7-20-83	56° 14.3′	169° 00.3′	1	1

layer (0 - 1.3 m in depth) for 10 minutes one hour after sunset. Juveniles from mid-water (15 - 70 m) were collected with Mid-water, Issac-Kid Mid-water, and Tucker trawls, and towed at 3 knots for 30 minutes (Table 2). The trawl nets were towed at the depth layer where the thermocline was found.

Length and Weight Measurements of Fishes

The juvenile cod and pollock were picked from the samples aboard the ship, and preserved in a 5% buffered formaldehyde solution. In the laboratory, fishes were blotted with an absorbent paper, and the gross weight was measured to the nearest 1 mg on a Mettler balance. Net weight was derived by subtracting food weight from gross weight. Standard length (SL) was measured to the nearest 0.1 mm under a binocular microscope. Caudal fin length was measured to the fork and the end of the fin under a binocular microscope fitted with an ocular micrometer to the nearest 0.04 mm. Total length (TL) and fork length (FL) were calculated by adding the measurements to the standard length. A maximum subsample of 60 pollock were used for these measurements for any one station.

Table 2. Sampling methods used in collecting larval and juvenile Pacific cod and walleye pollock in the southeast Bering Sea and sample size.

Month year	Cruise No.	Sampling gear	Sampling depth	No. of Station	No. of fish Cod	No. of fish Pollock
July, 1981	R/V Thompson 159	Tucker trawl	50 - 15 m	1	48	48
July & August 1982	R/V Alpha Helix 31	Tucker trawl	50 - 15 m	6	39	1846
June & July 1982	T/V Oshoro Maru 90	Fish larva net	0 - 1.3 m	14	10	88
"	"	IKMT net	50 - 15 m	6	-	-
July, 1983	T/V Oshoro Maru 95	Fish larva net	0 - 1.3 m	18	8	30
"	"	IKMT net	70 - 20 m	12	-	210
"	"	Midwater trawl	70 - 20 m	31	90	2476

Condition Factor

The condition factor (Everhart and Youngs, 1981) of the fishes was calculated from:

$$Cf = \frac{Wt - Wf}{TL^{\wedge}3} \times 1000 \qquad (1)$$

where Cf is the condition factor, Wt is wet body weight in mg, Wf is wet food weight in mg, and TL is the total length in mm. This formula implies that the fish growth is isometric, i.e. the growth rate for length, breadth, and the depth of fish is equal.

Gill Structure

Gill rakers were counted and the interval between gill rakers measured from 40 cod and 42 pollock ranging from 24.0 to 73.7 mm TL. Of the four gill archs, the first was chosen because gill rakers were best developed on this arch. The gill raker interval measurement was standardized as the distance between the 10th and the 15th gill rakers counted from the first gill raker on the upper arch in pollock, and between the 6th and the 10th gill rakers counted from the first gill raker on the upper arch in cod, which intervals were the widest in each species.

Determination of the Weight of Prey

One hundred ninety five cod and 305 pollock stomachs were examined (Table 3). Stomachs were separated by using surgical scissors and blades. Whole stomachs containing food were excised from fish and weighed to the nearest 0.01 mg. Following this, stomach contents were removed, and the stomach tissues weighed separately. The weight of food was calculated by difference. Prey organisms from each stomach were preserved in a 40% isoprophyl alcohol solution, and identified.

Because of the different structure of the various food organisms, they were measured differently. Calanoid and cyclopoid copepods were measured in prosome length. The size of harpacticoid copepods, amphipods, euphausiids, chaetognaths, and fish larvae was represented by the total length. The diameter of pteropods and eggs of zooplankton and fish was measured. The size of the other prey organisms, such as appendicularians and crab zoea or megalopa, were measured following Uye (1982).

To determine length-weight relationships of major prey organisms, zooplankton samples were collected from 2 locations in the southeast Bering Sea (54° 19.8′ N, 171° 34.1′ W, and 63° 30.2′ N, 165° 44.7′ W) in August 1983.

Table 3. Sampling location and number of juvenile Pacific cod and walleye pollock collected and dissected for stomach content examination.

Date	Location		Number of fish			
	Lat. (N)	Long. (W)	Collected		Dissected	
			Cod	Pollock	Cod	Pollock
7-8-81	54° 29.0′	166° 54.0′	48	48	48	47
7-7-82	54° 09.3′	162° 05.3′	6	6	6	6
7-8-82	55° 33.7′	155° 22.0′	3	10	3	10
7-14-82	57° 05.7′	152° 25.7′	1	0	1	0
7-30-82	57° 01.9′	164° 20.5′	23	1,759	23	30
8-6-82	55° 37.9′	166° 39.9′	4	48	4	14
8-8-82	54° 52.2′	167° 59.5′	2	9	2	9
8-8-82	55° 37.9′	166° 39.9′	2	0	2	0
8-11-82	55° 26.9′	160° 32.7′	8	7	8	7
7-17-83	54° 07.8′	161° 26.4′	1	23	1	5
7-18-83	55° 28.3′	165° 02.3′	43	198	43	60
7-18-83	54° 59.9′	165° 00.9′	17	164	17	30
7-18-83	56° 00.6′	164° 58.1′	4	0	4	0
7-19-83	56° 58.8′	165° 00.9′	6	343	6	30
7-19-83	57° 28.2′	165° 02.0′	1	35	1	5
7-20-83	57° 02.3′	167° 50.0′	3	308	3	5
7-20-83	56° 33.5′	168° 31.1′	2	401	2	5
7-20-83	56° 14.3′	169° 00.3′	1	1	1	1
7-21-83	56° 15.0′	168° 57.3′	8	56	8	24
7-21-83	55° 56.7′	169° 24.5′	1	7	1	5
7-21-83	54° 20.7′	171° 33.2′	2	3	2	3
7-24-83	56° 37.3′	171° 35.2′	3	28	3	5
7-25-83	57° 42.2′	170° 54.6′	1	3	1	3
7-26-83	57° 19.5′	174° 29.8′	5	0	5	0
7-26-83	56° 49.6′	175° 22.6′	0	1	0	1

The length and wet weight of 50 to 75 individuals of each species were measured, and length-weight regression equations determined (Table 4).

To determine the weight of each prey organism in fish stomachs, the organisms were measured and the weight determined from the length-weight relationship. The total weight of a prey species in a stomach was calculated from:

$$Wt = \frac{(Wn)}{n} \times N \qquad (2)$$

where Wt is the total weight of a prey species, Wn is the sum of the weight of the prey organisms measured, N is the total number of a prey species, and n is the total number of measured prey organisms. Thus, the estimated total weight of stomach contents in a fish before digestion is calculated from:

$$Ws = \sum_{i=1}^{n} Wti \qquad (3)$$

where Ws is the total weight of stomach contents of a fish, n is the number of prey species, and Wti is the total weight of "i"th prey species.

The specific gravity of seawater 1.025 was used in converting the weight of prey organisms into volume.

Table 4. Length-weight regression of major prey of juvenile Pacific cod and walleye pollock. The equation used was $W=a \times L^b$, where W is wet weight in mg and L is total length or prosome length in mm of the organism. a and b are empirical constants and r^2 is the coefficient of determination.

Prey organism	Sample size	Size range mm	Weight range mg	$a \times 10$	b	r^2
Chaetognath	50	12.7-34.8*	3.27-73.74	0.02	2.993	0.970
C. cristatus	50	6.56-7.60**	11.49-20.62	1.02	2.608	0.619
C. plumchrus	50	3.52-4.20**	2.12-4.00	0.92	2.626	0.529
E. bungii bungii	75	2.56-5.32**	0.20-3.83	0.23	3.001	0.905
Metridia sp.	50	1.36-2.40**	0.07-1.38	0.42	3.923	0.905
Amphipod	50	1.40-8.80*	0.15-35.31	0.62	2.842	0.965
Euphausiid	50	3.20-16.00*	0.47-35.40	0.12	2.930	0.979
Crab zoea	50	1.60-4.80*	1.42-29.05	5.58	2.387	0.964

* total length, ** prosome length

The weight of small prey organisms less than 1 mm in length was estimated following Nishiyama and Hirano (1983).

Feeding Index

Feeding index of individual fish was shown as the percentage of food weight to body weight by:

$$If = \frac{Wf}{Wt - Wf} \times 100 \qquad (4)$$

where If is feeding index, Wt is wet body weight in mg, and Wf is wet food weight in mg.

Index of Relative Importance of Food

Following (Pinkas et al., 1971), the index of relative importance (IRI) was determined from:

$$IRI = \%\ FO\ (\%\ N + \%\ V) \qquad (5)$$

where FO is frequency of occurrence, N is number, and V is volume.

Throughout this study, appendicularians and eggs of zooplankton were excluded from the calculation of percent number and percent volume. The reasons for the exclusion are: the eggs of zooplankton are so numerous that, when

these eggs are included, the percent number of other prey categories approaches zero, and the volume of the eggs occupies only a negligible fraction of food comprising 0.4% in cod and 1.6% in pollock. Appendicularians occupy a substantial fraction in frequency of occurrence in pollock (19.7%) and also seem to have a substantial fraction in volume. The problems in quantifying appendicularians result from the softness of the body tissue. Although the number of appendicularians was enumerated, the number is undoubtedly much smaller than the actual number due to a progressed digestion. Therefore, the calculation of percent number and percent volume of appendicularians would not be accurate.

Proportional Similarity of Food

Following Pielou (1977), proportional similarity (PS) was calculated for prey numbers and volume. Proportional similarity of food is a relative measure of the occurrence of the same food resources between the predators regardless of the food resources abundance in the environment. This was calculated from:

$$PS = 2\sum_{v=1}^{s} \min\left[\frac{Xiv}{Z}, \frac{Xjv}{Z}\right] \qquad (6)$$

where PS is proportional similarity, s is total number of

species, Xiv is the amount of species in identity "i", Xjv is the amount of species in identity "j", and Z is

$$Z = \sum_{v=1}^{s} (Xiv + Xjv) \qquad (7)$$

When the compositions of the two identities are the same, the PS is 1, and when there is no common food resources between the two identities, the PS is 0.

CHAPTER 3

RESULTS

Morphometry

Length-Weight Relationship of Fishes

Total length ranged between 24.6 mm and 73.7 mm in cod, and 19.6 mm and 68.5 mm in pollock (Table 5). The length-weight relationship for both species are well represented by power equations, and "$\hat{r}2$" varied from 0.96 to 0.97 for the three lengths (Tables 6, A-1 and A-2).

The regression equations for the conversion of standard length (SL, mm) to fork length (FL, mm), of standard length to total length (TL, mm) in cod are FL=0.36+1.07xSL and TL=0.72+1.08xSL, respectively. These regression equations in pollock are FL=0.31+1.07xSL and TL=0.42+1.09xSL, respectively. The caudal fins were longer in cod than in pollock until they reach 40.2 mm SL, and thereafter the caudal fins of pollock exceeded that of cod (Table A-3). The bifurcation of the caudal fin became more distinct in pollock than in cod as the fishes grew. As a result, the distance between total length and fork length was longer in cod until the fishes reached 30.0 mm SL, but thereafter it became longer in pollock.

Table 5. Length-frequency of the juvenile Pacific cod and walleye pollock used for the stomach analysis. Years in which samples were obtained are also shown.

Length range mm	Pacific cod 1981	1982	1983	Total	Walleye pollock 1981	1982	1983	Total
15.0 - 19.9	-	-	-	-	-	2	-	2
20.0 - 24.9	-	-	1	1	5	4	-	9
25.0 - 29.9	-	4	7	11	4	4	2	10
30.0 - 34.9	4	9	18	31	1	8	15	24
35.0 - 39.9	13	4	22	39	9	20	35	64
40.0 - 44.9	22	6	22	50	12	19	48	79
45.0 - 49.9	6	8	16	30	13	9	40	62
50.0 - 54.9	3	12	8	23	3	7	24	34
55.0 - 59.9	-	6	2	8	-	2	11	13
60.0 - 64.9	-	-	1	1	-	1	6	7
65.0 - 69.9	-	-	-	-	-	-	1	1
70.0 - 74.9	-	-	1	1	-	-	-	-
Total	48	49	98	195	47	76	182	305
Mean	41.5	44.0	40.7	41.7	39.8	39.9	44.7	42.8
SD	4.7	9.6	8.5	8.1	8.4	8.8	7.9	8.5

Table 6. Length-weight relationships for gross (a) and net (b) body weight of juvenile Pacific cod and walleye pollock. See Table 4 for further explanation.

a) Length-gross body weight relationship

Length	Pacific cod				Walleye pollock			
	N	ax10^3	b	$r2$	N	ax10^3	b	r^2
TL	195	3.627	3.182	0.96	305	3.914	3.107	0.97
FL	165	4.860	3.110	0.97	271	4.278	3.095	0.97
SL	165	6.006	3.127	0.96	304	5.651	3.088	0.97

b) Length-net body weight relationship

Length	Pacific cod				Walleye pollock			
	N	ax10^3	b	r^2	N	ax10^3	b	r^2
TL	195	3.801	3.162	0.96	305	3.828	3.106	0.97
FL	165	5.110	3.089	0.97	271	4.189	3.093	0.97
SL	165	6.080	3.115	0.97	304	5.532	3.086	0.97

* TL: total length, FL: fork length, SL: standard length

The results suggest that the morphological changes in body shape and fin occur differently between cod and pollock.

Condition Factor

The condition factor ranged between 4.56 and 9.07 in cod and between 3.10 and 7.30 in pollock. The mean value of condition factor was 6.97 (one standard deviation=0.86) in cod and 5.73 (one standard deviation=0.66) in pollock, indicating that cod are deeper and/or broader for a given body length than pollock (Table 7).

When compared by size range, the condition factor of cod increased significantly from 30.0-34.9 mm TL to 35.0-39.9 mm TL, and from 35.0-39.9 mm TL to 40.0-44.9 mm TL. In contrast, the condition factor did not appreciably increase with fish size in pollock (Table A-4). This means that the body conformation changes with size increase in cod but not in pollock.

Stomach Tissue Weight

Stomach tissue is heavier in cod than in pollock for the same length or weight group (Fig. 2). The difference of stomach tissue weight is greater in the same length group than in the same weight group (Tables A-5 and A-6).

Table 7. Frequency distribution of Condition Factor of juvenile Pacific cod and walleye pollock. SD is one standard deviation.

Range of	Pacific cod			Walleye pollock		
Condition factor	1981	1982	1983	1981	1982	1983
3.00 - 3.99	-	-	-	1	2	-
4.00 - 4.99	-	-	3	2	16	16
5.00 - 5.99	1	-	15	7	53	105
6.00 - 6.99	6	26	54	29	5	61
7.00 - 7.99	20	18	24	8	-	-
8.00 - 8.99	20	5	1	-	-	-
9.00 - 9.99	1	-	1	-	-	-
Total	48	49	98	47	76	182
Mean	7.77	6.97	6.58	6.33	5.29	5.73
SD	0.67	0.67	0.76	0.79	0.55	0.53

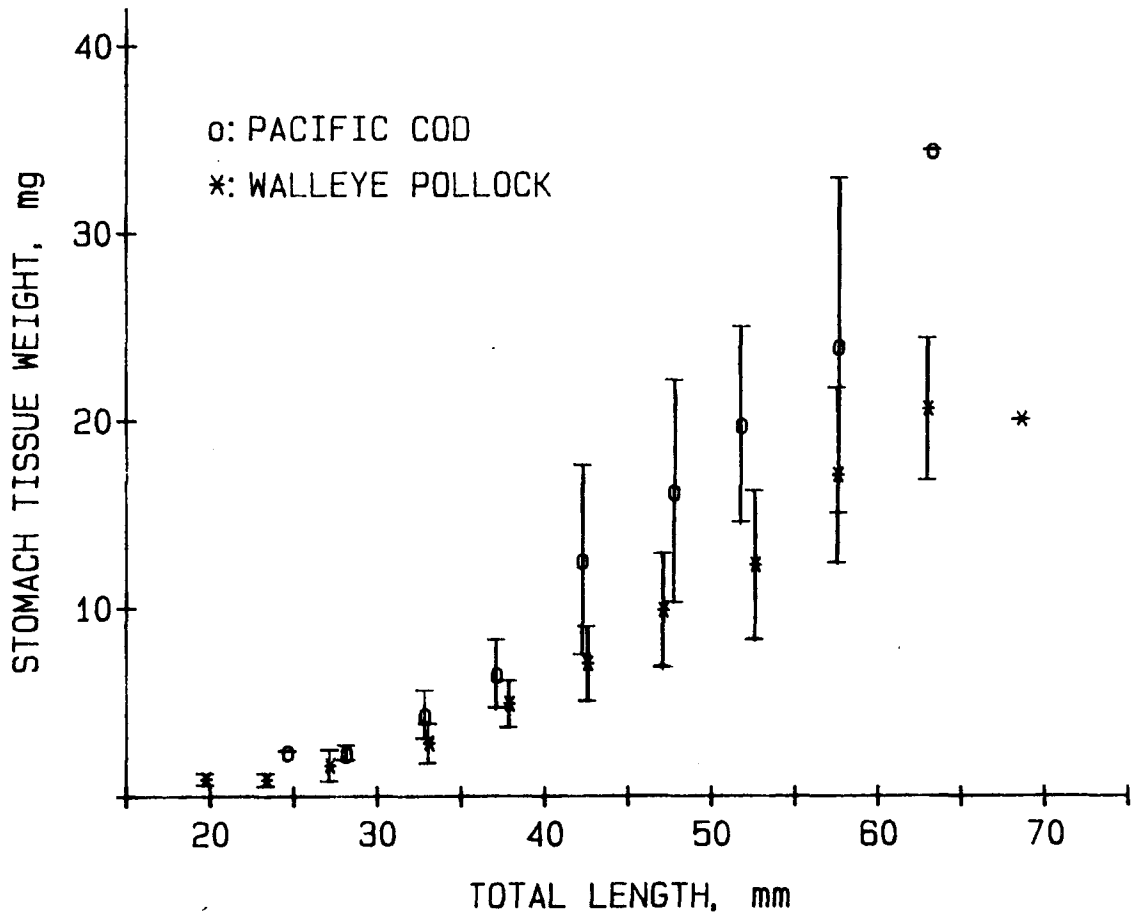

Fig. 2. The relationship between fish size and stomach tissue weight of juvenile Pacific cod and walleye pollock.

Gill Structure

Cod and pollock differ in the number of gill rakers and the distance between gill rakers (Fig. 3). The number of gill rakers ranged from 16 to 24 over 24.6-73.7 mm TL size range for cod, and from 26 to 40 over 24.0-68.4 mm TL size range for pollock (Tables A-7 and A-8). The gill raker interval ranged from 0.14 to 0.43 mm in cod, and from 0.09 to 0.24 mm in pollock. Morphologically, the first gill arch of cod is characterized by few, short and widely-spaced gill rakers, while that of pollock has numerous, long and closely-spaced ones. The interval between the gill rakers was wide in cod, and narrow in pollock. Although there was occasional differences in number and interval of gill rakers between left and right side, the differences were statistically insignificant.

It is evident that in cod the number of gill rakers increased only by 2 as the fish grew from 20 mm TL to 70 mm TL, while in pollock it increased by 10 (Table 8). As a result, the gill raker interval remained narrow in pollock even in large fish.

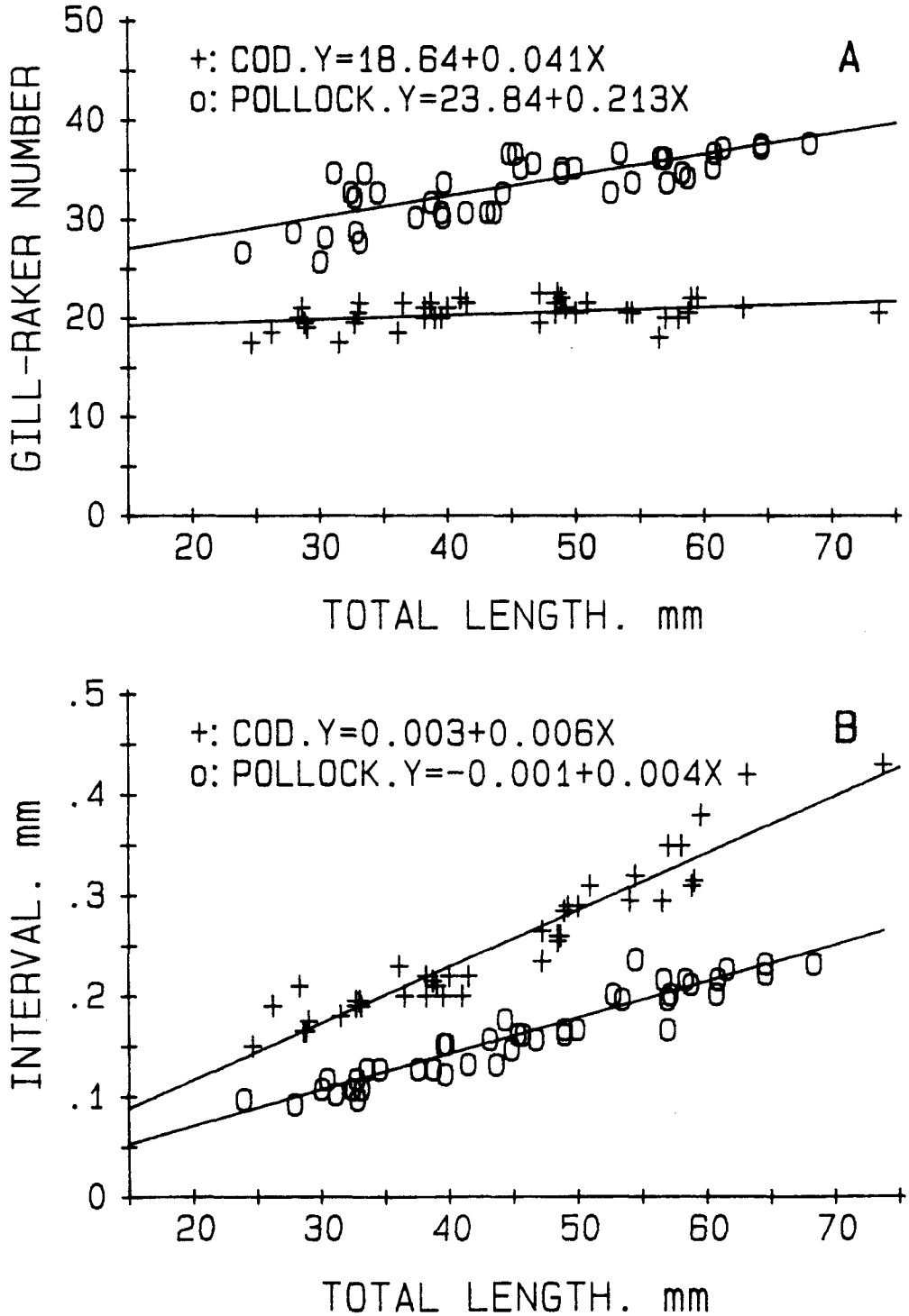

Fig. 3. The relation of gill raker number (A) and spacing between gill rakers (B) of juvenile Pacific cod and walleye pollock.

Table 8. Estimated number and interval between gill rakers in juvenile Pacific cod and walleye pollock. Estimations are based on empirical equations: 1) Y=0.041X+18.64, 2) Y=0.213X+23.84, 3) Y=0.006X+0.003, and 4) Y=0.004X-0.001.

Fish length	Number		Interval, mm	
mm	Cod[1)]	Pollock[2)]	Cod[3)]	Pollock[4)]
15	19	27	0.08	0.05
20	19	28	0.11	0.07
25	19	29	0.14	0.09
30	20	30	0.17	0.11
35	20	31	0.20	0.13
40	20	32	0.23	0.14
45	20	33	0.26	0.16
50	20	34	0.29	0.18
55	21	35	0.31	0.20
60	21	36	0.34	0.22
65	21	37	0.37	0.23
70	21	38	0.40	0.25
75	22	39	0.43	0.27

Food of Juvenile Cod and Pollock

Prey Composition

Prey composition in occurrence, number and volume was related remarkably to fish size (Figs. 4A, 4B and 4C, and Tables A-9 and A-10). Cod smaller than 35 mm TL fed heavily on adult Pseudocalanus sp., cyclopoid copepods (Oithona sp. and Oncaea sp.), A. longiremis and L. helicina while those longer than 50 mm TL preyed on amphipods, calanoid copepods (C. plumchrus, C. cristatus), euphausiids, and fish larvae. Juvenile cod between 35-50 mm TL fed on prey intermediate in size of those fed on by small and large fish.

Pollock smaller than 40 mm TL heavily fed on zooplankton eggs, cyclopoid copepods, A. longiremis, and adult Pseudocalanus sp. Pollock longer than 40 mm TL fed on prey organisms greater than 2 mm in size such as calanoid copepods, amphipods, and euphausiids. However, the above-mentioned prey organisms taken by small pollock §40.0 mm TL remained in a substantial quantity.

Prey composition of pollock changed gradually over the size range examined. In contrast, prey composition in cod appeared to change abruptly at 50 mm TL, being characterized by fish larvae, crab zoea and megalopa, and amphipods.

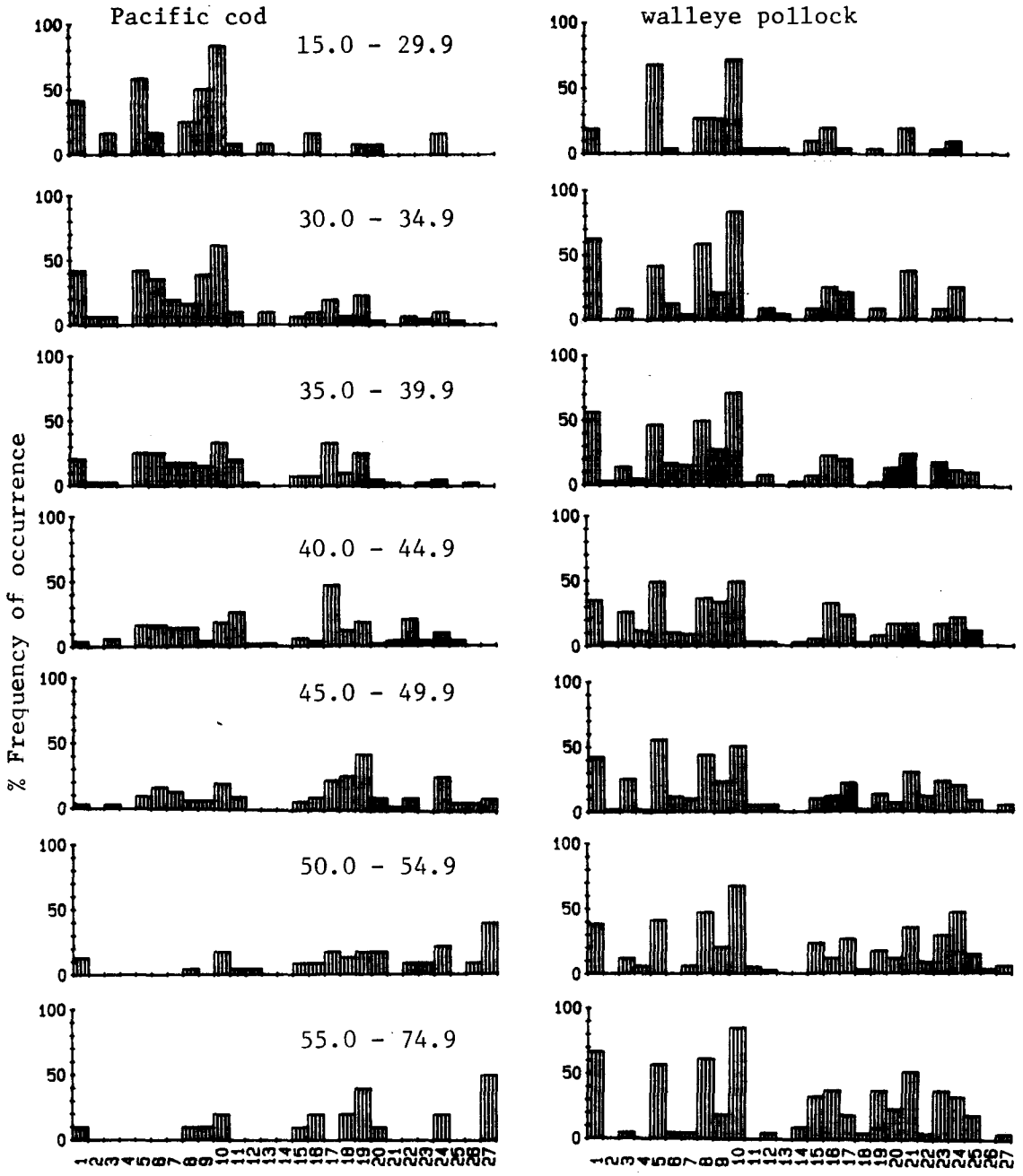

Fig. 4A. Percent frequency of occurrence of prey (in order of increasing size) of juvenile Pacific cod and walleye pollock by fish size (total length, mm).

1:eggs(dia. 0.11mm),2:eggs(dia. 0.20mm),3:eggs(dia. 0.36),4:copepod nauplii, 5:cyclopoid copepods,6:*Limacina helicina*,7:*Balanus* sp.,8:*Pseudocalanus* copepodite,9:*Acartia longiremis*,10:adult *Pseudocalanus* sp.,11:harpacticoid copepods, 12:*A. tumida*,13:*Calanus abdominalis*,14:*Tortanus discaudatus*,15:*Metridia* sp., 16:*C. marshallae*,17:*C. plumchrus*,18:crab zoea and megalopa,19:amphipods, 20:euphausiid furcilia,21:*Eucalanus bungii bungii*,22:*C. cristatus*,23:appendicularians,24:euphausiids(adult and sub-adult),25:chaetognaths,26:shrimp, 27:fish larvae.

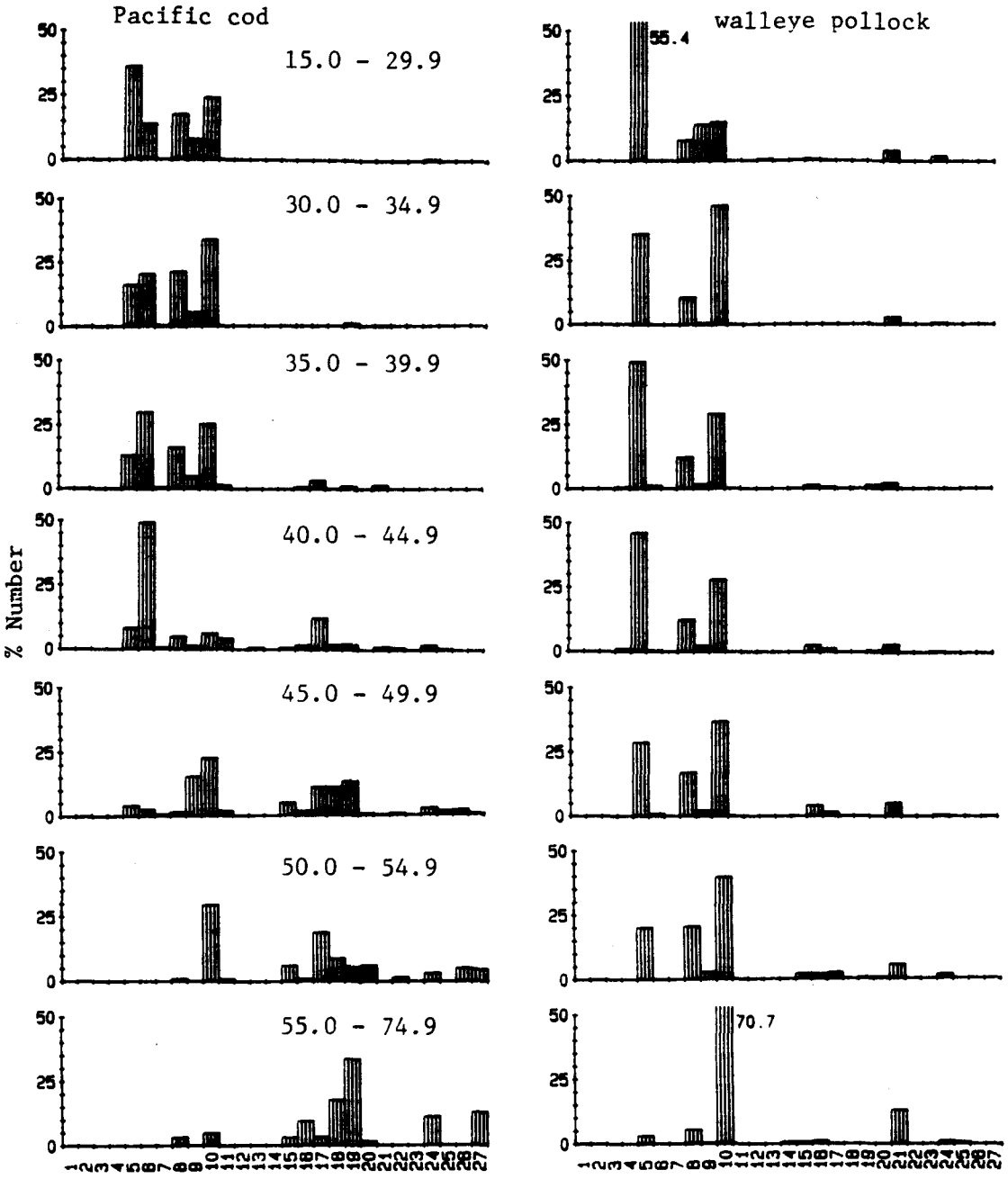

Fig. 4B. Percent number of prey (in order of increasing size) of juvenile Pacific cod and walleye pollock by fish size (total length, mm). See Fig. 4A for denotation of prey organisms.

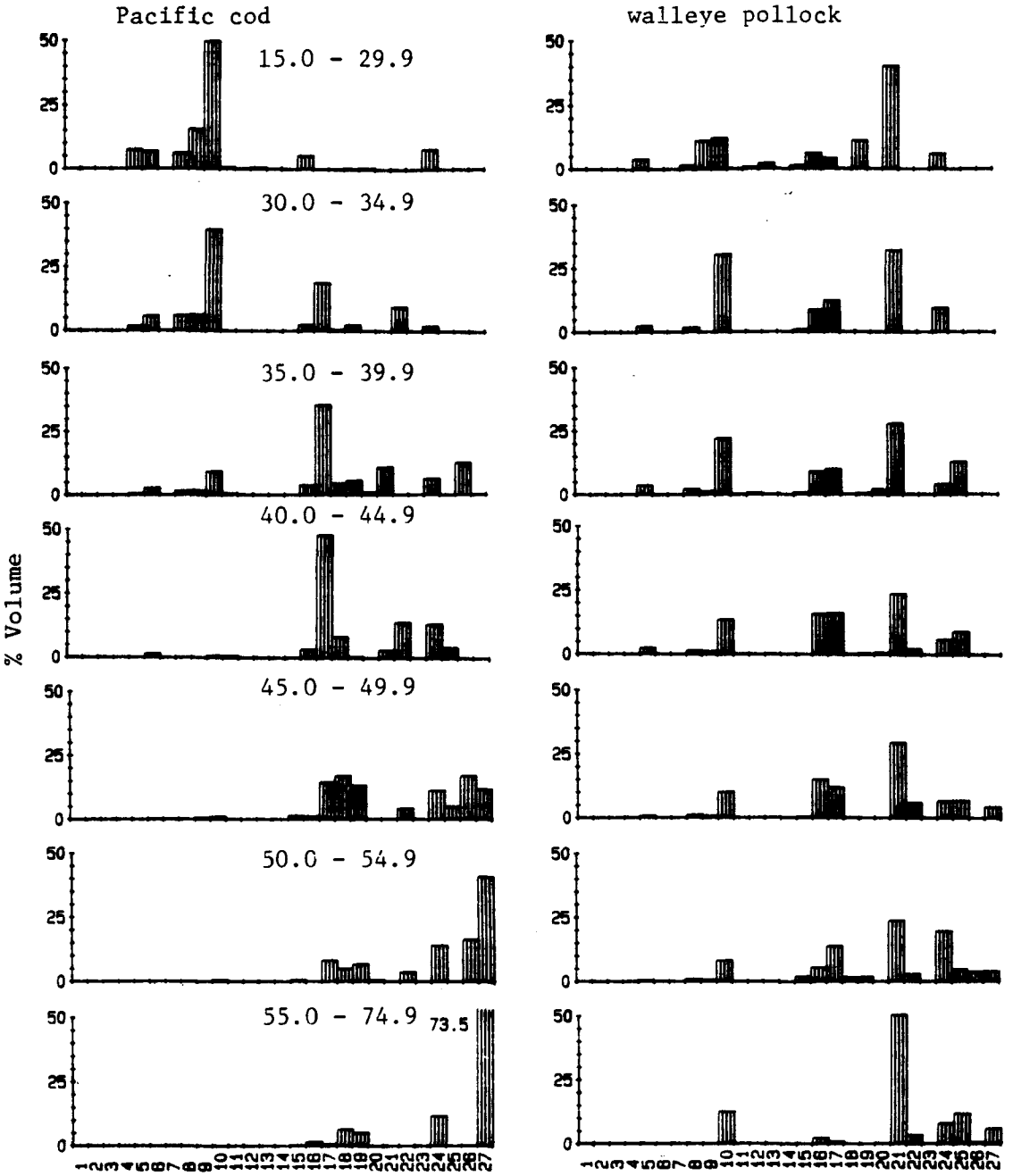

Fig. 4C. Percent volume of prey (in order of increasing size) of juvenile Pacific cod and walleye pollock by fish size (total length, mm). See Fig. 4A for denotation of prey organisms.

This contrasts with pollock which target the calanoid copepods (E. bungii bungii and C. marshallae) and small prey organisms such as cyclopoid copepods and adult Pseudocalanus sp. The differences in prey composition was reflected in the mean number of prey per fish. The mean number of prey tends to decrease in cod, but increase in pollock as the fishes grow (Fig. 5 and Table A-11).

The proportion of prey was relatively similar between cod and pollock. However, crab zoea and megalopa, fish larvae and amphipods occurred more frequently and formed a larger volume in cod. In contrast, appendicularians and E. bungii bungii was higher in pollock.

Prey Size

Prey size varied from 0.11 mm for copepod eggs to 25 mm TL for fish larvae (Fig. 6, and Tables A-12 and A-13). Most prey species had narrow size ranges, but the size of amphipods and euphausiids had a wide size range due to different species and life stages being present. However, the measured prey size is not the best estimate because of the bias caused by the digestion of food. Instead, the mean weight of prey was used in the prey size comparison (Fig. 7, and Tables A-14 and A-15).

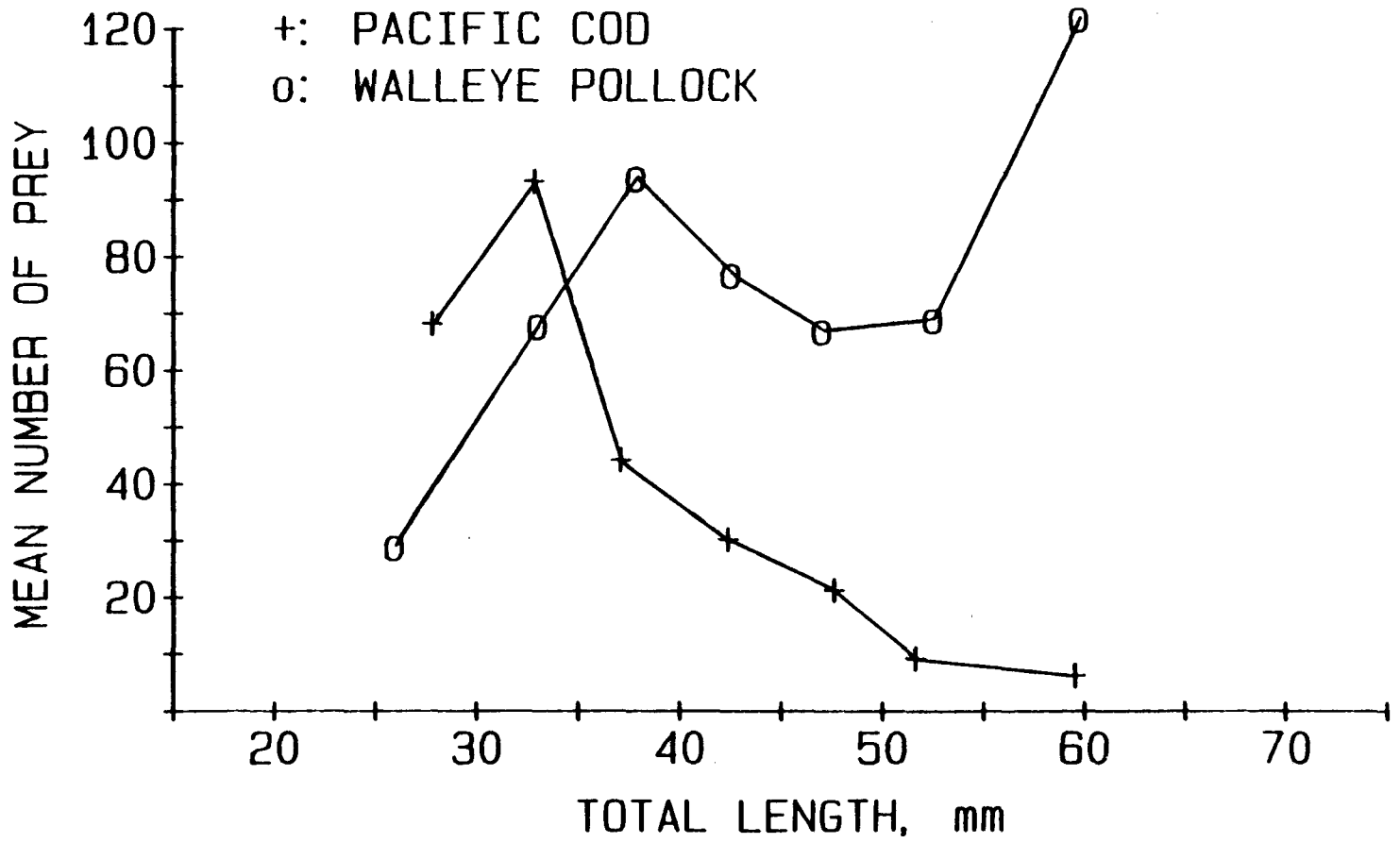

Fig. 5. The relation between fish size and mean number of prey organisms in juvenile Pacific cod and walleye pollock.

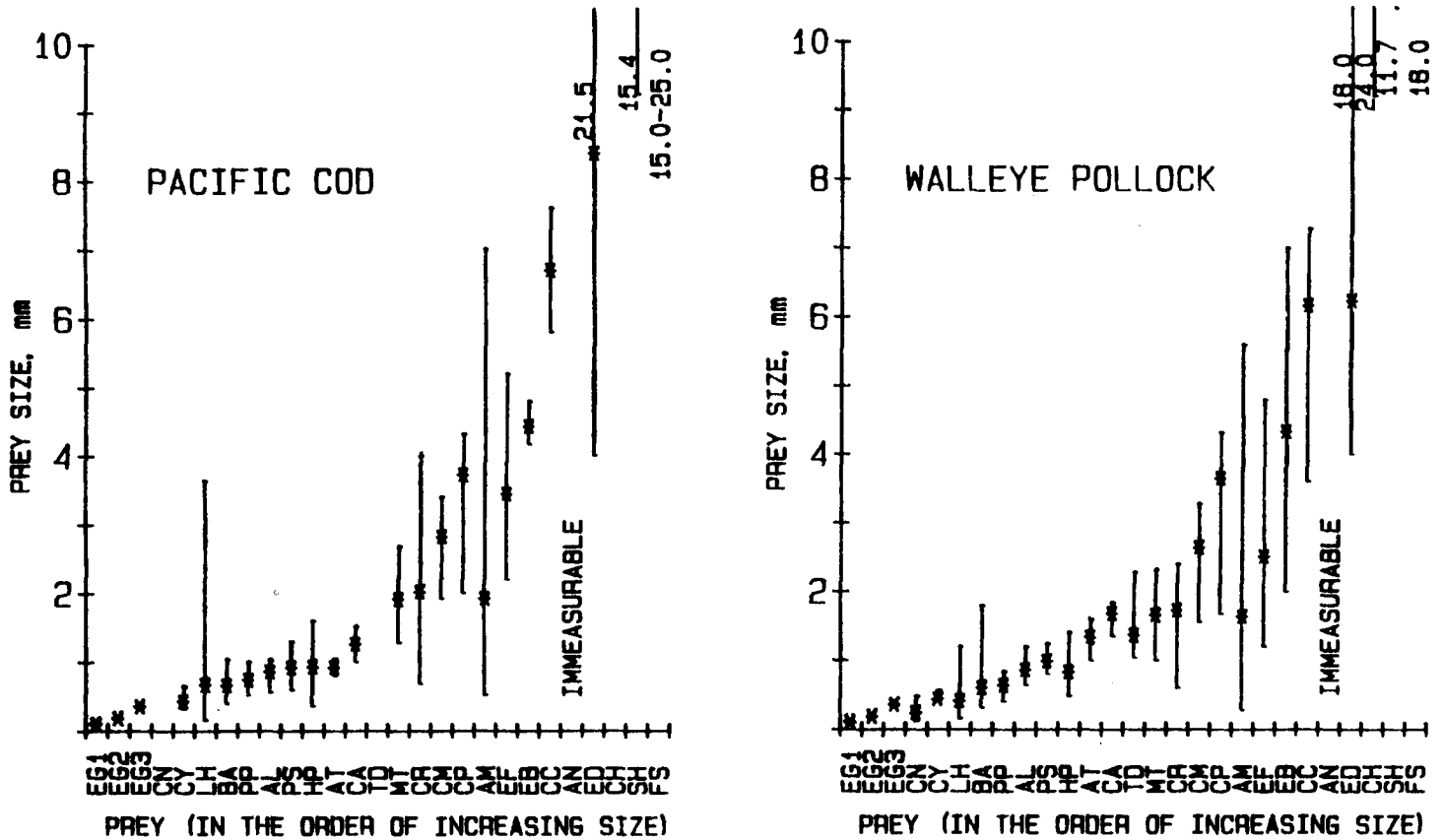

Fig. 6. Prey size of juvenile Pacific cod and walleye pollock.
egl:eggs(dia. 0.11mm),eg2:eggs(dia. 0.20mm), eg3:eggs(dia. 0.36mm),CN:copepod nauplii,CY:cyclopoid copepods, LH:*Limacina helicina*, BA:*Balanus* sp.,PP:*Pseudocalanus* copepodite,AL:*Acartia longiremis*,PS:*Pseudocalanus* sp.(adult),HP:harpacticoid copepods,AT:*A. tumida*,CA:*Calanus abodominalis*,TD:*Tortanus discaudatus*,MT:*Metridia* sp.,CR:crab zoea and megalopa,CM:*C. marshallae*,CP:*C. plumchrus*,AM:amphipods,EF: euphausiid furcilia, EB:*Eucalanus bungii bungii*,CC:*C. cristatus*,AN:appendicularians,ED:euphausiids(adult and sub-adult),CH:chaetognaths,SH:shrimp,FS:fish larvae.

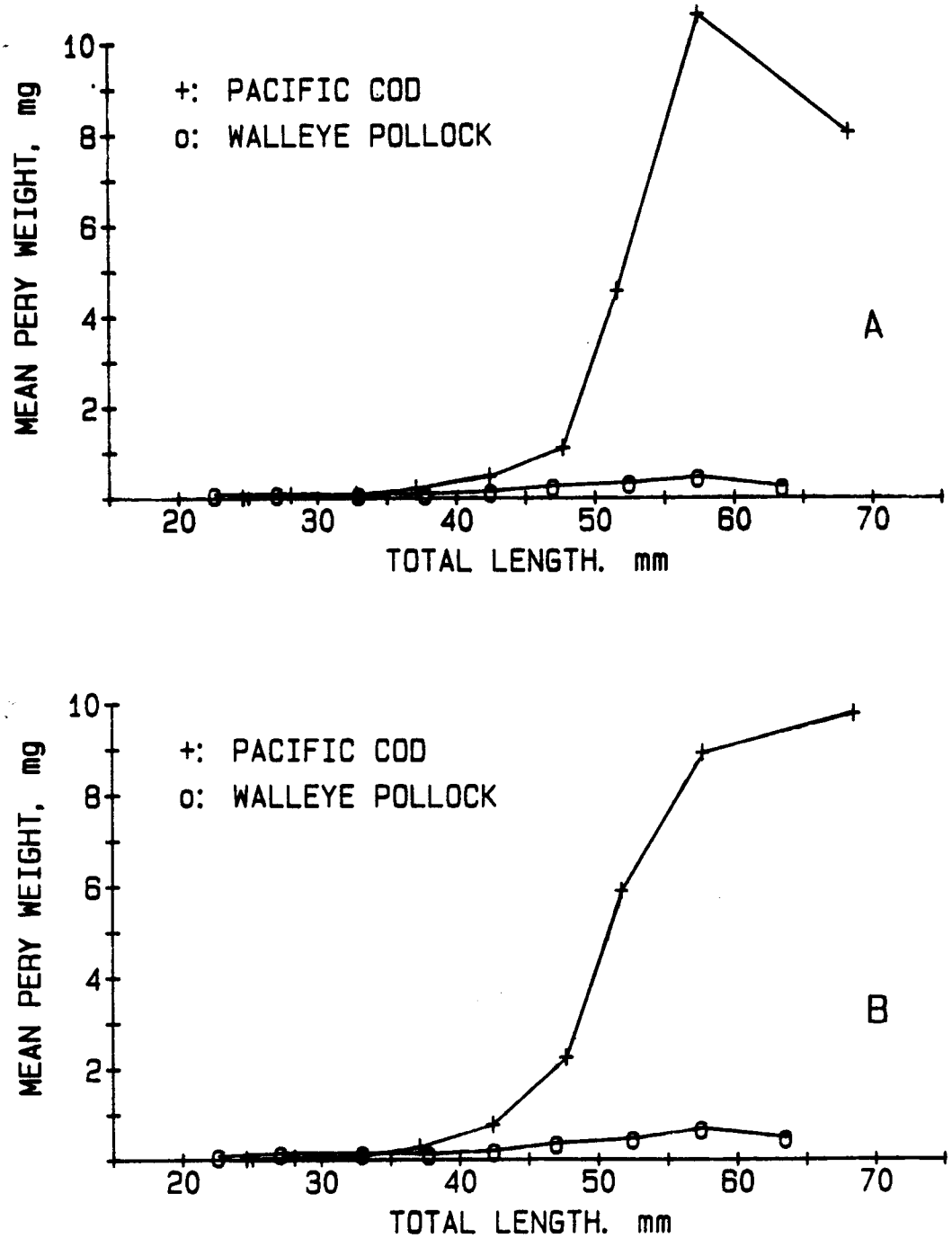

Fig. 7. The relation between mean weight (A, measured and B, estimated) of prey organisms and length of juvenile Pacific cod and walleye pollock.

The mean weight per prey organism is greater in cod than in pollock when the same fish size is compared.

Food Weight and Feeding Index

Mean food weight increased similarly for cod and pollock until they reach 40 mm TL (Table A-16). Thereafter the food weight increased faster in cod than in pollock (Fig. 8a). But the mean food weight relative to fish weight did not differ greatly between the two fish species (Fig. 8b and Table A-17). Although there is no significant disparity in mean food weight between the two fishes at 20.0-40.0 mm TL, the disparity of the mean food weight became greater when the fishes were larger than 40 mm TL.

Feeding index for the overall sample was not statistically different between the two species at 10% significant level (Table 9). The correlation coefficient between total length and feeding index is 0.217 in cod and 0.016 in pollock.

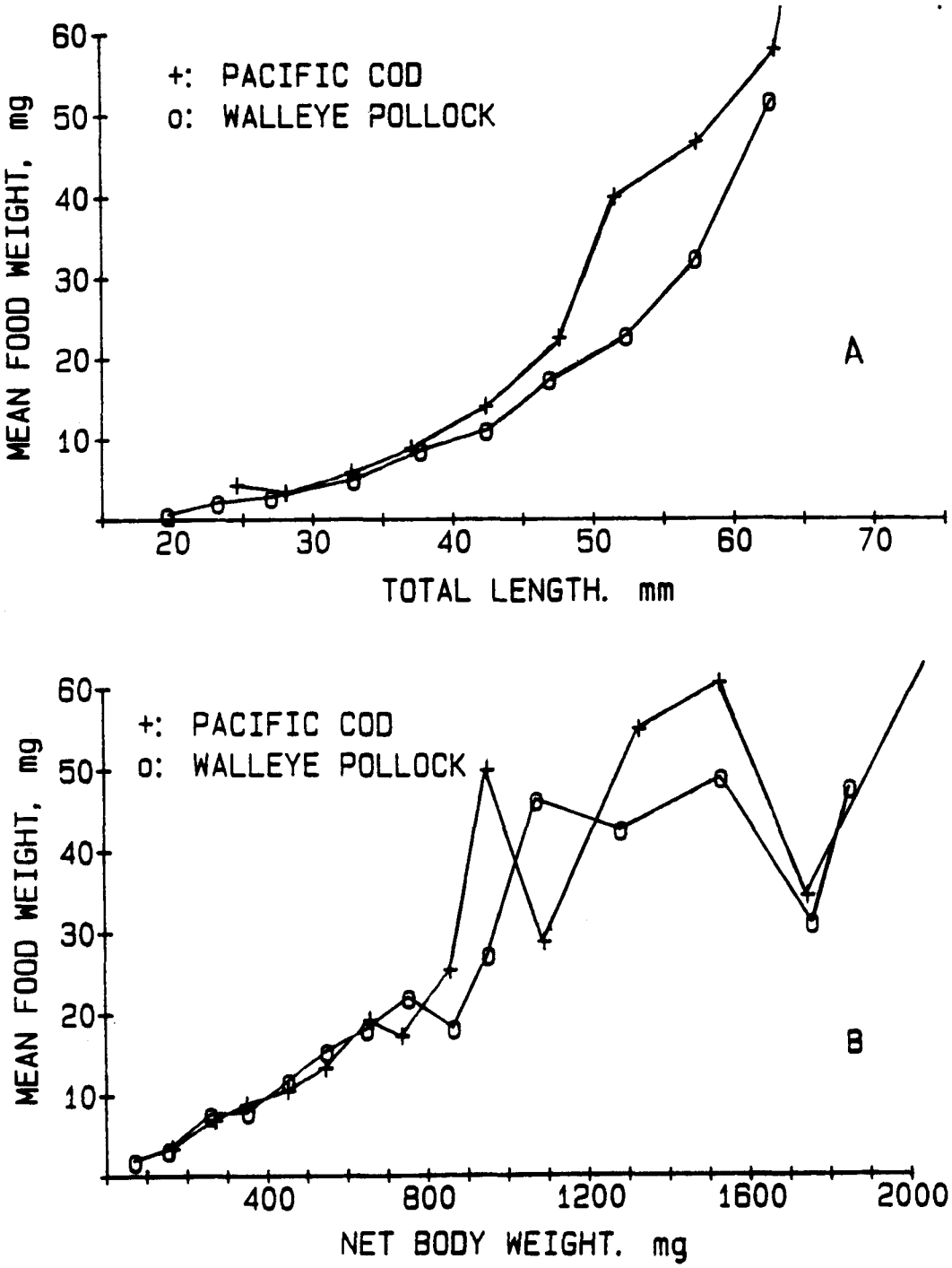

Fig. 8. The relation between mean food weight and fish length (A), and mean food weight and fish weight (B) of juvenile Pacific cod and walleye pollock.

Table 9. Feeding Index of juvenile Pacific cod and walleye pollock. N is the sample size and SD is one standard deviation.

Fish length, mm	Pacific cod			Walleye pollock		
	N	Mean	SD	N	Mean	SD
15.0 - 19.9	-	-	-	2	1.64	0.72
20.0 - 24.9	1	3.89	-	9	3.71	5.18
25.0 - 29.9	11	2.18	0.49	10	2.18	1.83
30.0 - 34.9	31	2.38	1.23	24	2.44	1.51
35.0 - 39.9	39	2.53	1.86	64	2.83	1.82
40.0 - 44.9	50	2.52	1.54	79	2.47	1.64
45.0 - 49.9	30	2.86	2.04	62	2.83	2.01
50.0 - 54.9	23	4.02	3.03	34	2.74	1.80
55.0 - 59.9	8	3.26	3.59	13	2.82	1.93
60.0 - 64.9	1	3.21	-	7	3.39	1.64
65.0 - 69.9	-	-	-	1	1.44	-
70.0 -74.9	1	5.11	-	-	-	-
Total	195	2.77	2.00	305	2.70	1.95

Index of Relative Importance (IRI)

The top 10 IRI ranked prey are listed for each 5 mm size interval in Tables 10 and 11. In cod, adult Pseudocalanus sp. ranked first until the fish were 34.9 mm TL. Between 35.0 mm and 49.9 mm TL, C. plumchrus and amphipods rank first. When cod were larger than 50.0 mm TL, fish larvae ranked first. Between 20.0 mm and 45.0 mm TL, cyclopoid copepods were in the top 5 ranks, but did not appear within the top 10 ranks after 45.0 mm TL. C. plumchrus in the top rank between 35.0 mm and 45.0 mm TL declined to ranks 3-5 in the 45.0 -60.0 mm TL.

In pollock, adult Pseudocalanus sp. and cyclopoid copepods ranked first or second throughout the whole size range. E. bungii bungii were also important, varying between the second and the fifth ranks.

In cod, the IRI of cyclopoid copepods, adult Pseudocalanus sp. and Pseudocalanus copepodite were relatively high among the fish smaller than 40.0 mm TL, but became negligible at 45.0 mm TL (Fig. 9). In contrast, the IRIs of these prey in pollock showed consistently high values beyond 45.0 mm TL. C. marshallae and E. bungii bungii exhibited substantial values for the overall samples in pollock, while these were negligible in cod.

Table 10. Index of Relative Importance rank of major prey organisms found in the stomach of juvenile Pacific cod.

Prey species	Fish size										
	20.0 -24.9	25.0 -29.9	30.0 -34.9	35.0 -39.9	40.0 -44.9	45.0 -49.9	50.0 -54.9	55.0 -59.9	60.0 -64.9	70.0 -74.9	Total
Calanoida											
C. cristatus	-	-	8	-	3	9	-	-	-	-	-
C. marshallae	-	7	9	-	-	-	-	4	-	-	-
C. plumchrus	-	-	6	1	1	3	3	5	-	-	2
Pseudocalanus sp.											
adult	1	1	1	2	7	4	2	8	4	-	1
copepodite	2	5	5	5	9	-	-	6	-	-	7
C. abdominalis	-	10	-	-	-	-	-	-	-	-	-
Metridia sp.	-	-	-	-	-	10	10	-	3	-	-
A. longiremis	3	3	4	7	-	8	-	-	-	-	10
A. tumida	-	8	-	-	-	-	-	-	-	-	-
Cyclopoid copepods	4	2	2	4	5	-	-	-	-	-	4
Harpacticoid copepods	-	9	-	9	6	-	-	-	-	-	-
Amphipods	-	-	7	6	10	1	5	3	5	2	5
Euphausiids											
adult and juvenile	-	6	10	-	4	5	4	2	-	-	6
furcilia	5	-	-	-	-	-	9	7	-	-	-
Crab zoea and megalopa	-	-	-	8	8	2	8	-	2	3	9
Shrimp	-	-	-	-	-	6	7	-	-	-	-
Pteropoda											
Limacina helicina	-	4	3	3	2	-	-	-	-	-	3
Fish larvae	-	-	-	-	-	7	1	1	1	1	8

Table 11. Index of Relative Importance rank of major prey organisms found in the stomach of juvenile walleye pollock.

Prey species	Fish size										
	15.0 -19.9	20.0 -24.9	25.0 -29.9	30.0 -34.9	35.0 -39.9	40.0 -44.9	45.0 -49.9	50.0 -54.9	55.0 -59.9	60.0 -64.9	Total
Chaetognaths	-	-	-	-	7	9	-	9	-	3	8
Calanoida											
C. cristatus	-	-	-	-	-	-	9	-	9	-	-
C. marshallae	-	7	7	7	5	4	6	8	6	8	5
C. plumchrus	-	-	8	5	6	6	5	6	10	-	6
E. bungii bungii	-	3	3	3	3	5	3	2	2	2	3
Pseudocalanus sp.											
adult	2	2	2	1	1	2	1	1	1	1	1
copepodite	3	4	6	4	4	3	4	4	3	4	4
C. abdominalis	-	-	9	-	-	-	-	-	-	-	-
Metridia sp.	-	8	10	9	-	-	-	7	8	-	-
A. longiremis	1	6	4	8	8	8	10	10	-	-	9
A. tumida	-	9	-	-	-	-	-	-	-	-	-
T. discaudatus	-	-	-	-	-	-	-	-	-	9	-
Cyclopoid copepods	4	1	1	2	2	1	2	5	5	6	2
Amphipods	-	5	-	-	-	-	-	-	-	-	-
Euphausiids											
adult and juvenile	-	-	5	6	9	7	8	3	4	5	7
furcilia	-	-	-	-	10	-	-	-	-	7	-
calyptopis	-	-	-	-	-	-	-	-	-	10	-
Fish larvae	-	-	-	-	-	-	-	-	7	-	-

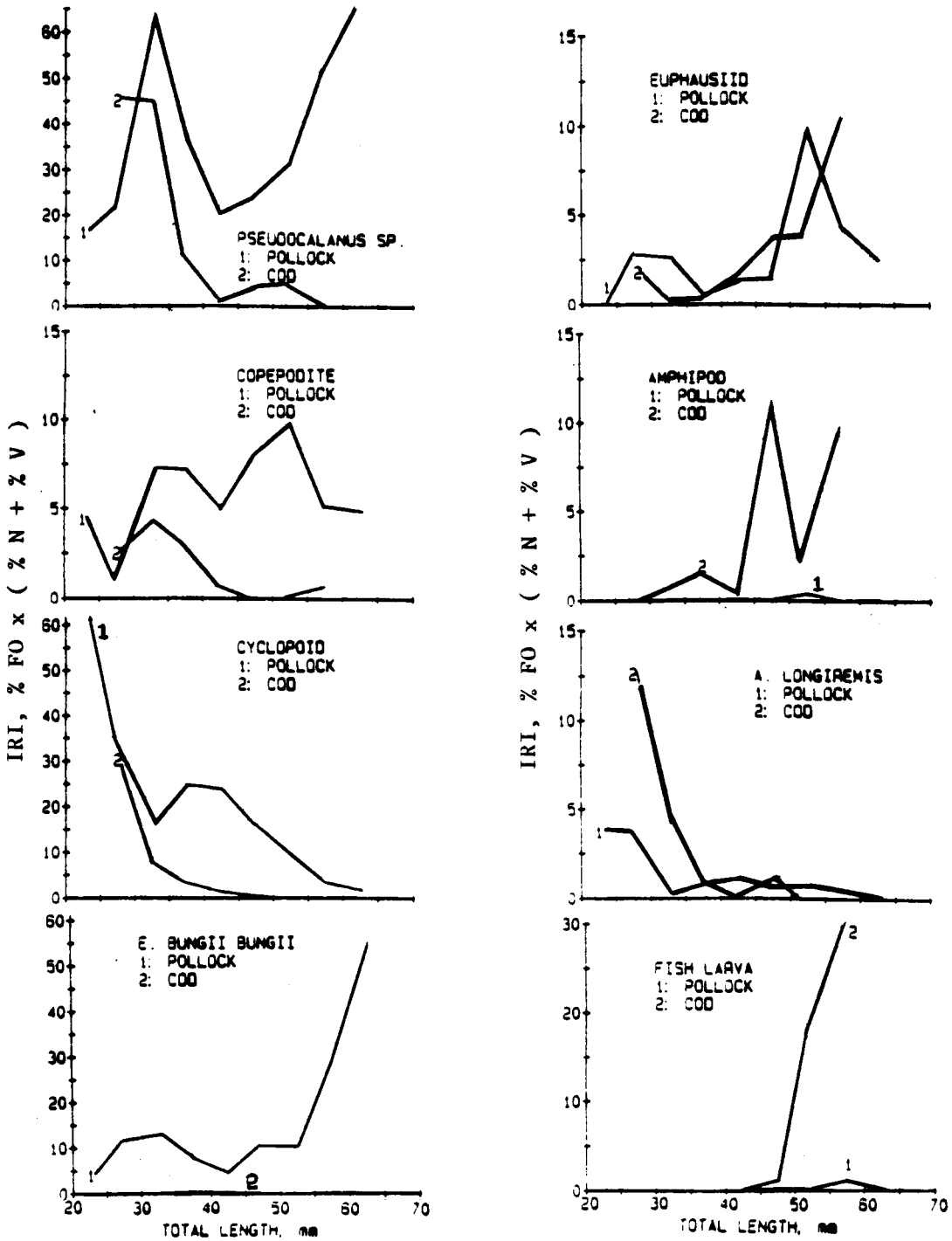

Fig. 9. The relation between Index of Relative Importance and fish length of major prey organisms in juvenile Pacific cod and walleye pollock.

Metridia sp. and euphausiids showed a similar tendency in both fishes over all fish size ranges. When the fishes became larger than 45.0 mm TL, amphipods and fish larvae exhibited high IRI values in cod, but were negligible in pollock.

Proportional Similarity (PS)

The PS of food between cod and pollock decreases steadily both in number and volume as the fishes grow (Fig. 10). The PS in number was 0.55 at 15.0-29.9 mm TL, peaked as 0.69 at 30.0-34.9 mm TL, and declined to 0.04 at 55.0-74.9 mm TL. The PS in volume shows a similar trend: 0.42 at 15.0-29.9 mm TL, 0.58 at 30.0-34.9 mm TL, and 0.20 at 60 mm TL (Table A-18).

There was a difference in the feeding habits of the fishes based on PS (Fig. 11, and Tables A-19 and A-20). The values of PS-length difference of fish in cod was generally low when compared to those in pollock. In cod, the PS decreases steadily both in number and volume as the length difference becomes greater. But in pollock, the PS in number doesn°t decrease until the length difference becomes 25.0 mm. The PS in volume decreases more slowly in pollock than in cod.

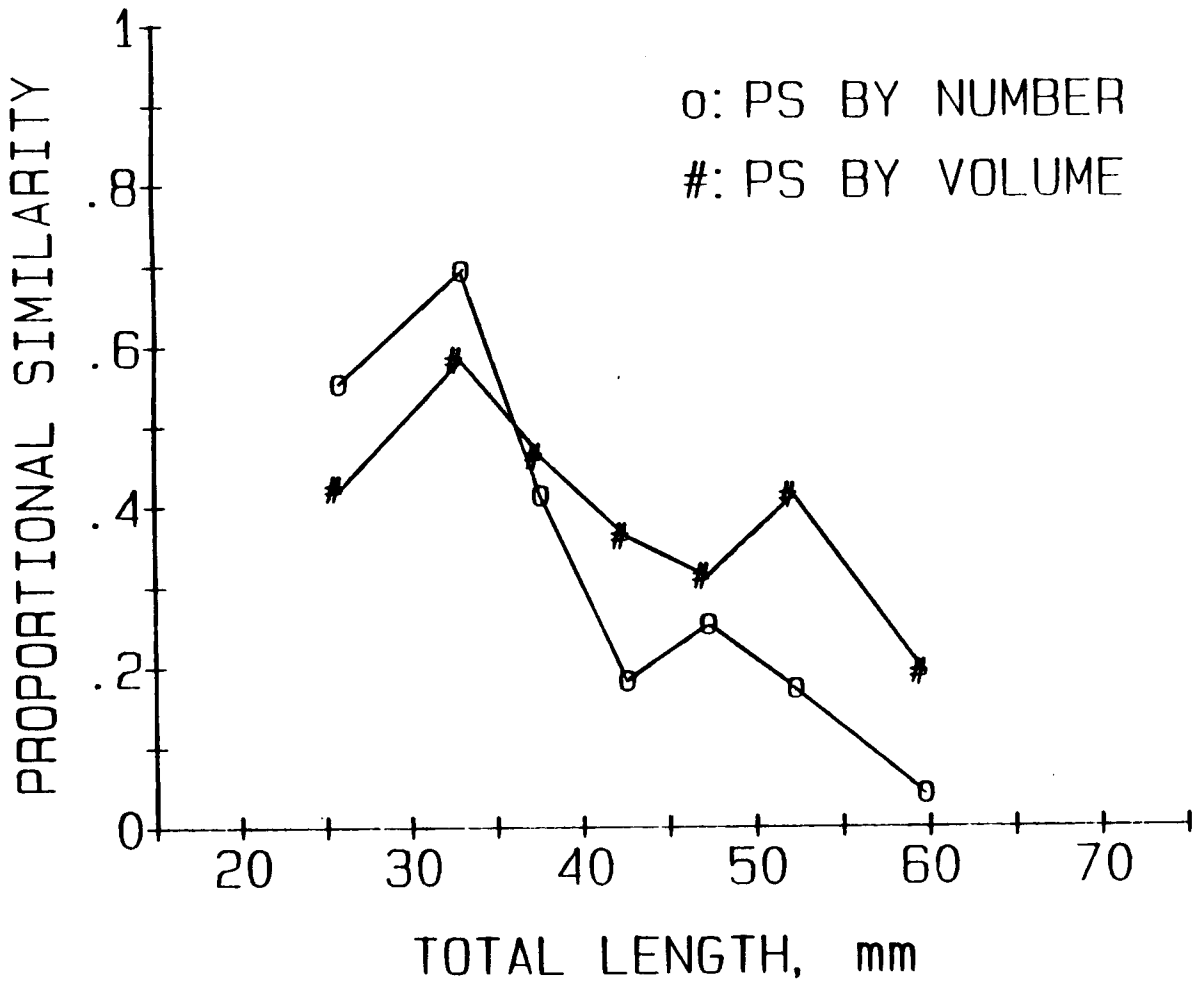

Fig. 10. The relation between the Proportional Similarity of food (number and volume) and size of juvenile Pacific cod and walleye pollock.

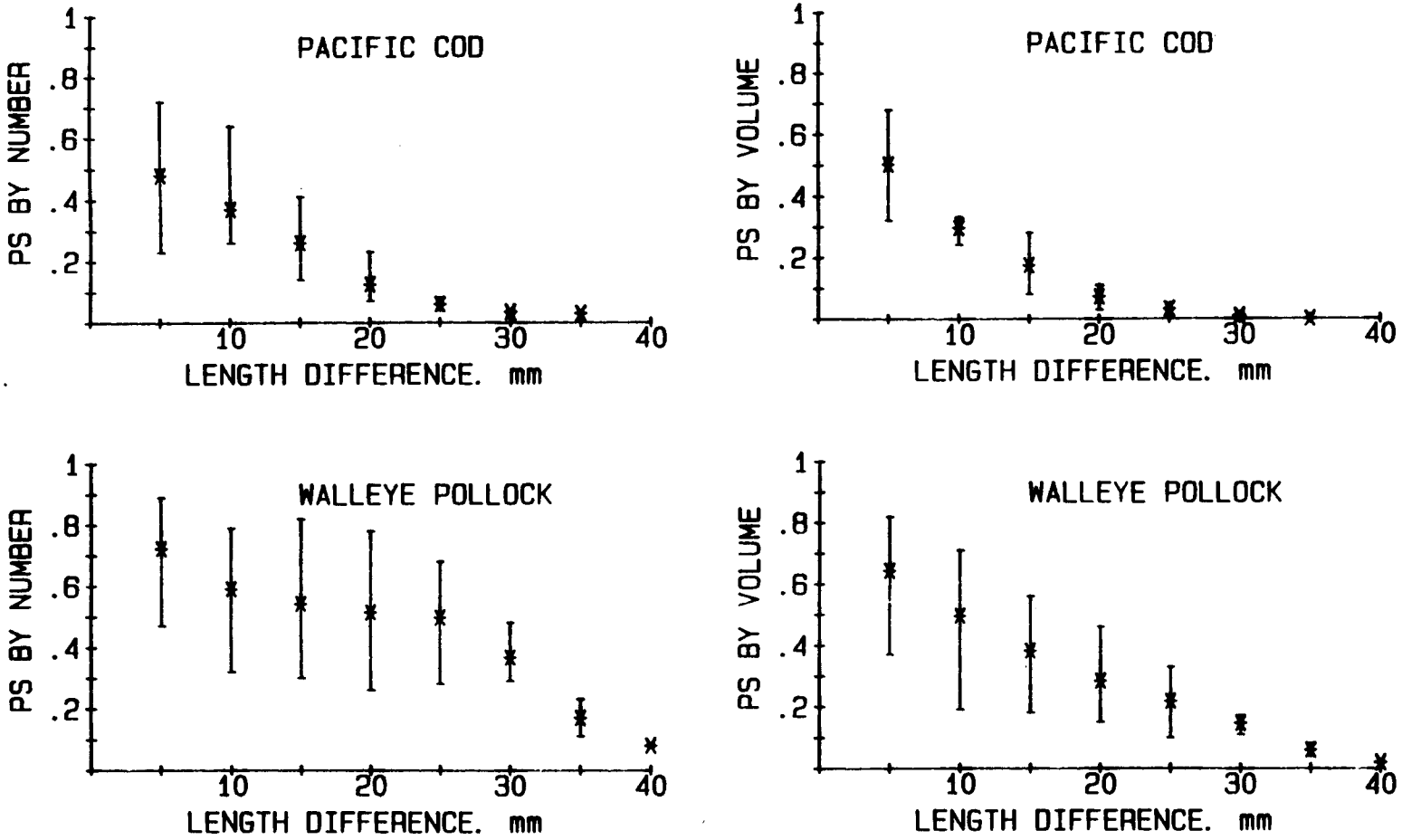

Fig. 11. The relationship between the Proportional Similarity of food (number and volume) and unit length difference (5 mm interval) of juvenile Pacific cod and walleye pollock.

High numerical PS between cod and pollock were observed at stations C and E, and in volume at stations A and C. The high PS in volume was caused by C. plumchrus at station A, and adult Pseudocalanus sp. at station C. Cyclopoid copepods accounted for the high PS in number at station E (Fig. 12).

The PS between stations is lower in cod than in pollock (Table 12). The PS between the same fish species from different stations was lower than that between the different species from the same stations.

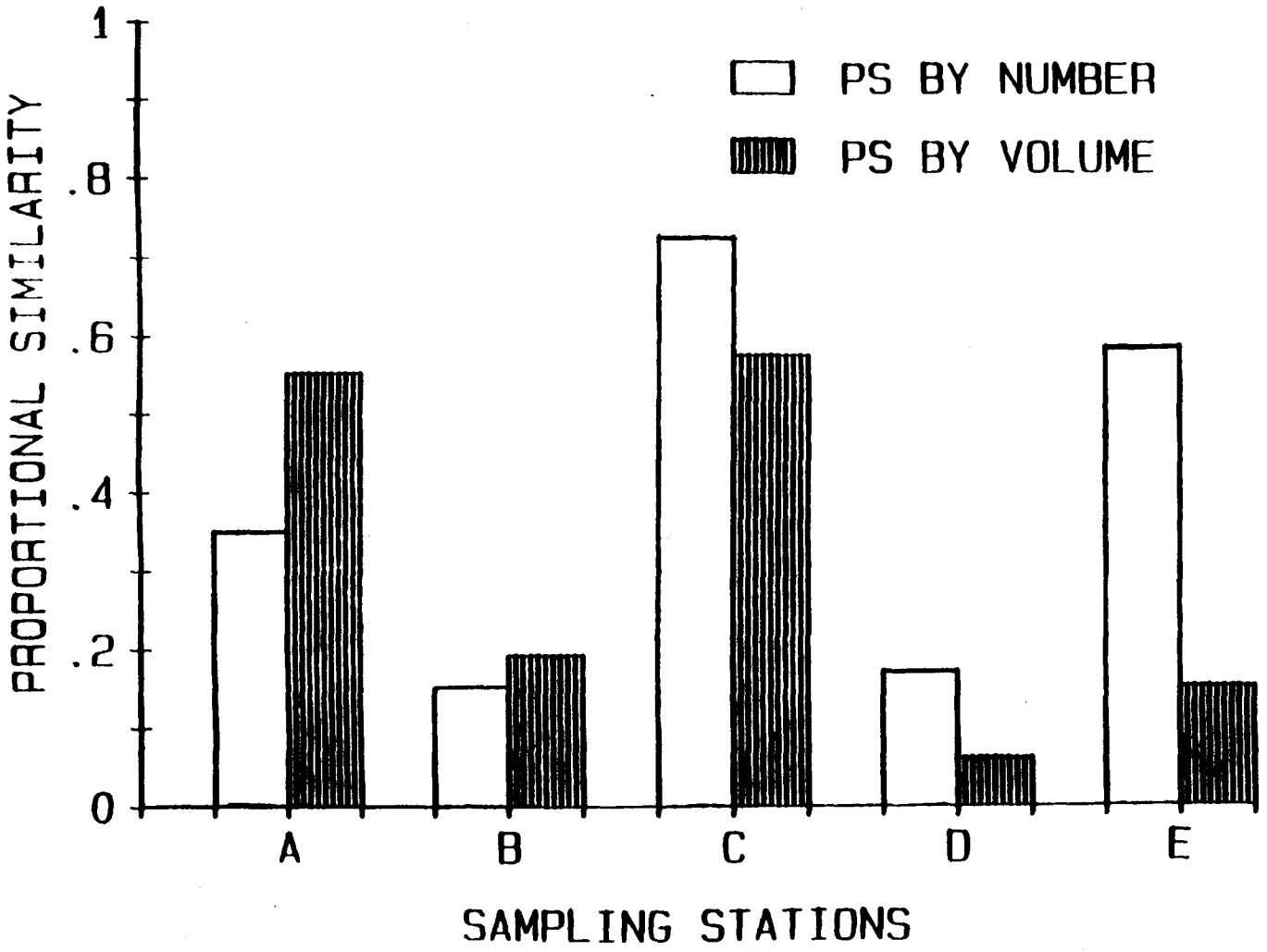

Fig. 12. The Proportional Similarity of food (number and volume) between juvenile Pacific cod and walleye pollock at five designated stations.

Table 12. The Proportional Similarity of food in number and volume between five designated sampling stations in juvenile Pacific cod and walleye pollock.

A) Pacific cod

PS by number

	A	B	C	D	E
A		0.02	0.01	0.01	0.02
B	0		0.01	0.03	0.06
C	0	0.03		0.07	0.06
D	0	0.14	0.08		0.41
E	0.02	0.34	0.08	0.36	

PS by volume

B) Walleye pollock

PS by number

	A	B	C	D	E
A		0.14	0.07	0.09	0.20
B	0.03		0.10	0.08	0.10
C	0.06	0.07		0.59	0.08
D	0.11	0.12	0.73		0.53
E	0.33	0.28	0.13	0.21	

PS by volume

Regional Characteristics in Food Habits

The prey composition for the 5 sampling stations are shown in Fig. 13 and 14. The occurrence of prey organisms varied by station and by fish species, suggesting the differences in the feeding behavior and the surrounding planktonic communities (Tables A-21 and A-22). C. plumchrus and C. cristatus were predominant at station A, fish larvae and C. marshallae at station B, Pseudocalanus sp. and cyclopoid copepods at stations C and D, and euphausiids, amphipods and Metridia sp. at station E. There were some nearshore community organisms such as C. abdominalis and T. discaudatus at station C. Prey organisms were relatively diverse at stations C and D, and simple at stations A and B.

At station A, the prey composition in cod was simple. The major prey organisms at station A were C. plumchrus (100%), harpacticoid copepods (54.2%), and C. cristatus (35.4%) by frequency of occurrence. Similarly C. plumchrus (65.8%) was abundant in number, followed by harpacticoid copepods (19.6%) and C. cristatus (3.6%). In volume, C. plumchrus (73.6%) and C. cristatus (20.2%) constituted about 94%.

The prey composition in pollock at station A were similar to that of cod. In frequency of occurrence, C. plumchrus (78.7%) was very common, followed by adult

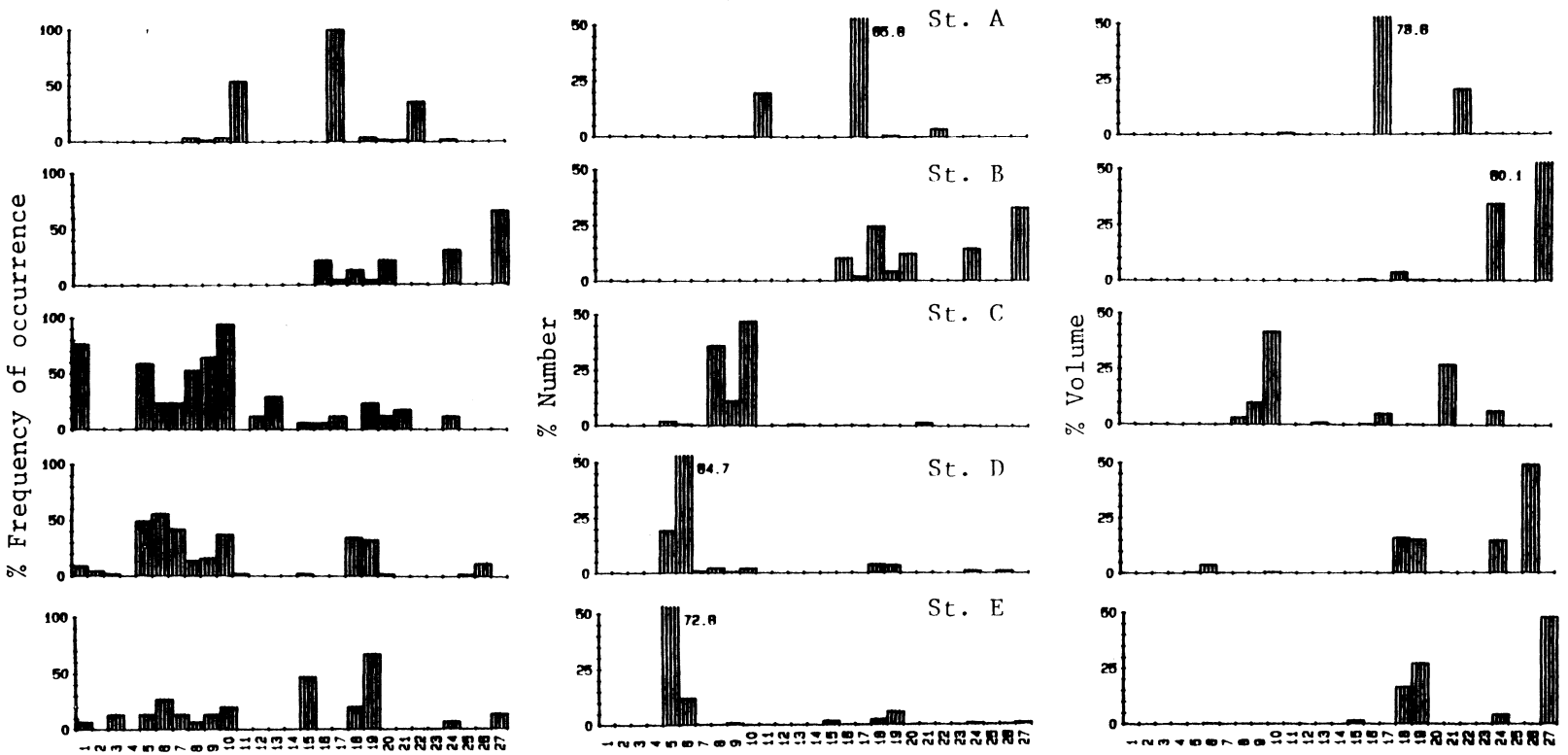

Fig. 13A. Percent frequency of occurrence, percent number and precent volume of the food of juvenile Pacific cod from five sampling stations (St.). Pery are numbered in order of increasing size.

1:eggs(dia. 0.11mm),2:eggs(dia. 0.20mm),3:eggs(dia. 0.36mm),4:copepod nauplii,5:cyclopoid copepods,6:*Limacina helicina*,7:*Balanus* sp.,8:*Pseudocalanus* copepodite,9:*Acartia longiremis*,10: adult *Pseudocalanus* sp.,11:harpacticoid copepods,12:*A. tumida*,13:*Calanus abdominalis*,14:*Tortanus discaudatus*,15:*Metridia* sp.,16:*C. marshallae*,17:*C. plumchrus*,18:crab zoea and megalopa,19:amphipods,20:euphausiid furcilia, 21:*Eucalanus bungii bungii*,22:*C. cristatus*,23:appendicularians, 24:euphausiids(adult and sub-adult),25:chaetognaths,26:shrimp,27:fish larvae.

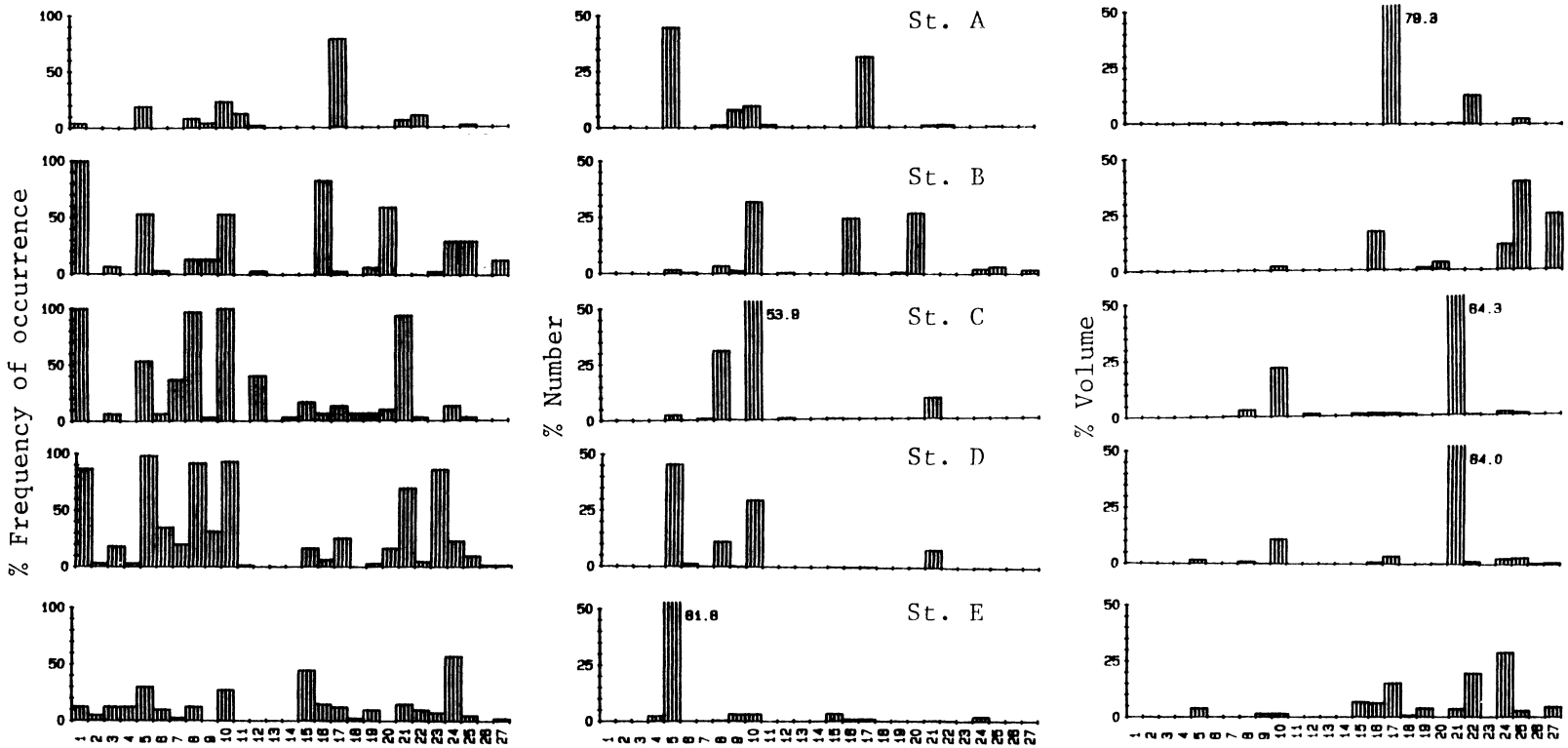

Fig. 13B. Percent frequency of occurrence, precent number and percent volume of the food of juvenile walleye pollock from five sampling stations (St.). See Fig. 13A for denotation of prey organisms.

Pseudocalanus sp. (23.4%), cyclopoid copepods (19.1%), C. cristatus (10.6%), and Pseudocalanus copepodite (8.5%). In number, cyclopoid copepods (44.7%) ranked first, followed by C. plumchrus (31.5%), adult Pseudocalanus sp. (9.7%), and A. longiremis (7.9%). In volume, C. plumchrus (79.3%) and C. cristatus (12.9%) were dominant, followed by chaetognaths (2.5%).

For both fish species, C. plumchrus was the dominant prey organism. Cod had a relatively large fraction of C. cristatus and harpacticoid copepods, while cyclopoid copepods and adult Pseudocalanus sp. occupied a large fraction in pollock.

The food of cod at station B was also characterized by the simple prey composition. Fish larvae (65.2%) were the most common, followed by euphausiids (adult and juvenile) (30.4%), C. marshallae (21.7%), euphausiid furcilia (21.7%), and crab zoea & megalopa (13.0%) by frequency of occurrence. Similarly, the numerical composition indicated the dominance of fish larvae (32.7%), euphausiids (adult and juvenile) (14.3%), euphausiid furcilia (12.2%), and C. marshallae (10.2%). In addition, crab zoea and megalopa also showed a substantial fraction (24.5%). In volume, fish larvae (60.1%) and euphausiids (adult and juvenile) (34.5%) composed almost 95%.

Crab zoea and megalopa were 3.9% in volume.

Unlike cod, the prey composition in pollock were complicated at station B. The fraction of fish larvae was relatively small , while that of megazooplankton was large. In frequency occurrence, C. marshallae (83.3%) was the most common, followed by euphausiid furcilia (60.0%), adult Pseudocalanus sp. (53.3%), chaetognaths (30.0%), and adult and juvenile euphausiids (30.0%). In number, adult Pseudocalanus sp. (32.2%), euphausiid furcilia (27.1%) and C. marshallae (24.8%) were abundant. In volume, chaetognaths (39.3%), fish larvae (24.8%), C. marshallae (17.4%), and adult and juvenile euphausiids (11.4%).

At station C, the prey compositions were considerably diverse both in cod and pollock. Pseudocalanus sp. (adult and copepodite) and calanoid eggs (diameter 0.11 mm) were very common in both fish species.

The prey composition in cod at station C is characterized by the predominance of adult Pseudocalanus sp. and A. longiremis. In frequency of occurrence, adult Pseudocalanus sp. (94.1%), A. longiremis (64.7%), cyclopoid copepods (56.8%), and Pseudocalanus copepodite (52.9%) were the common species. In number, adult Pseudocalanus sp. (47.0%), Pseudocalanus copepodite

(35.9%) and A. longiremis (11.0%) were the major components. Cyclopoid copepods (2.0%) and E. bungii bungii (1.5%) were the minor components. In volume, adult Pseudocalanus sp. (41.9%) and E. bungii bungii (27.3%) occupied 69%. A. longiremis (9.8%), adult and juvenile euphausiids (6.5%), and C. plumchrus (5.1%) showed also a minor fraction.

The food of pollock at station C was composed of mostly Pseudocalanus sp. and E. bungii bungii. Adult Pseudocalanus sp. (100%), Pseudocalanus copepodite (96.7%) and E. bungii bungii (93.3%) were found in most of the fish. Cyclopoid copepods occurred in more than half of the fish (53.3%). In number, adult Pseudocalanus sp. (53.9%) and Pseudocalanus copepodite (31.0%) were predominant, accompanied by E. bungii bungii (9.3%) and cyclopoid copepods (2.5%) as subordinate components. In volume, 85% of the food was composed of E. bungii bungii (64.3%) and adult Pseudocalanus sp. (21.8%).

At station D, the food of cod consisted of a variety of prey organisms. Those five prey species as L. helicina (55.8%), cyclopoid copepods (48.8%) Balanus sp. (41.9%), adult Pseudocalanus sp. (37.2%), and crab zoea & megalopa (34.9%) were commonly found to occur. However, L. helicina (64.7%) and cyclopoid copepods (19.2%) were numerically abundant, whereas crab zoea and megalopa

(3.9%), amphipods (3.5%), and Pseudocalanus copepodite (2.3%) were fewer. However, despite the insignificance in number, shrimp (48.7%), crab zoea & megalopa (15.8%), amphipods (15.1%), and adult and juvenile euphausiids (14.6%) were the substantial components by volume. L. helicina occupied only 3.9% of the volume despite its high frequency and number.

The food of pollock at station D is characterised by the dominance of cyclopoid copepods and Pseudocalanus sp. In frequency of occurrence, cyclopoid copepods (98.3%), adult Pseudocalanus sp. (93.3%), Pseudocalanus copepodite (91.7%), appendicularians (86.7%), and eggs (93.3%), (diameter 0.11, 86.7%) were common prey species. In number, cyclopoid copepods (45.7%), adult Pseudocalanus sp. (29.9%) and Pseudocalanus copepodite (11.3%) were abundant. E. bungii bungii were relatively numerous (8.1%). In volume, E. bungii bungii (64.0%) were predominant, followed by adult Pseudocalanus sp. (11.1%). C. plumchrus (3.6%), chaetognaths (3.1%) and euphausiids (adult and juvenile) (2.7%) did not occupy a substantial fraction in volume. Although the number and volume of appendicularians seemed to be substantial at this station, the quantification was not possible due to partial digestion.

At station E, the food of cod was characterized by the common occurrence of amphipods (66.7%) and Metridia sp. (46.7%). Subordinately, L. helicina (26.7%), adult Pseudocalanus sp. (20.0%), and crab zoea & megalopa (20.0%) were also taken. Unlikely, the numerical occurrence showed that cyclopoid copepods (72.8%) were very abundant, followed by L. helicina (12.0%), amphipods (5.8%) and crab zoea & megalopa (2.3%). In contrast to the high occurrence, Metridia sp. showed only 1.7% in number. It is noticeable that fish larvae (47.8%) ranked first in volume. Amphipods (27.3%) and crab zoea & megalopa (16.5%) occupied a considerable volume. Euphausiids (adult and juvenile) (4.2%) and Metridia sp. (1.6%) were less than 6% in volume.

The food of pollock at station E is characterized by the common occurrence of euphausiids and Metridia sp. In frequency of occurrence, adult and juvenile euphausiids (57.5%), Metridia sp. (45.0%), cyclopoid copepods (30.0%), and adult Pseudocalanus sp. (27.5%) were the most common prey species. In number, cyclopoid copepods (81.8%) were exclusively abundant with a minor portion of Metridia sp. (3.4%), adult Pseudocalanus sp. (3.3%), A. longiremis (3.2%) and copepod nauplii (2.5%).

In volume, euphausiids (adult and juvenile) (28.8%), C. cristatus (19.5%) and C. plumchrus (15.2%) were important.

Feeding index fluctuated from station to station (Table 13). Feeding index was large at stations B and C in cod, at stations C and D in pollock. In both fish species, the feeding index was small at station E. The feeding index in cod was statistically different at the 5% level between stations A and E, between B and D, and between B and E. The feeding index in pollock was significantly different among all the stations except between stations A and E. The feeding index was significantly different between cod and pollock at all stations except station C.

The IRI rank of prey was different from station to station (Table 14). In cod, C. plumchrus and harpacticoid copepods were the important top two at station A. At station B, fish larvae and euphausiids (adult and juvenile) were important. Small prey such as Pseudocalanus sp., L. helicina, A. longiremis, and cyclopoid copepods were important at stations C and D. Amphipods were important at station E.

In pollock, C. plumchrus and cyclopoid copepods were important at station A. At station B, C. marshallae and euphausiid furcilid were important.

Table 13. Condition Factor and Feeding Index of juvenile Pacific cod and walleye pollock at five designated sampling stations. N is the sample size and SD is one standard deviation.

Station	Fish species	No. of fish	Body length Mean (mm)	Body length SD	Condition factor Mean	Condition factor SD	Feeding index Mean	Feeding index SD
A	Cod	48	41.5	4.7	7.77	0.67	2.67	1.17
	Pollock	47	39.8	8.4	6.33	0.79	1.91	0.99
B	Cod	23	51.2	4.5	7.37	0.92	4.37	3.81
	Pollock	30	41.7	4.3	5.22	0.49	2.73	2.02
C	Cod	17	34.8	5.6	6.86	0.51	3.32	1.82
	Pollock	30	40.8	6.9	5.87	0.34	3.57	1.25
D	Cod	43	41.2	6.8	6.76	0.51	2.46	1.89
	Pollock	60	46.1	8.8	6.16	0.39	4.19	1.75
E	Cod	15	42.1	12.6	6.63	0.91	2.52	1.38
	Pollock	40	44.2	7.8	5.24	0.46	1.73*	1.65*
Total	Cod	146	42.4	7.8	7.19	0.79	2.94	2.16
	Pollock	207	42.9	8.1	5.84	0.70	2.92*	1.86*

* : Three empty stomachs were excluded from the calculation.

Table 14. Index of Relative Importance rank of major prey organisms in juvenile Pacific cod and walleye pollock at five designated sampling stations.

a) Pacific cod

Prey species	Station				
	A	B	C	D	E
Calanoida					
C. cristatus	3	-	-	-	-
C. marshallae	-	4	-	-	-
C. plumchrus	1	7	7	-	-
E. bungii bungii	10	-	4	-	-
Pseudocalanus sp.					
adult	6	-	1	7	10
copepodite	7	-	-	9	-
C. abdominalis	-	-	8	-	-
Metridia sp.	-	-	-	-	6
A. longiremis	-	-	2	-	9
E. amphitrites	8	-	-	-	-
Cyclopoid copepods					
Oithona sp. and *Oncaea* sp.	-	-	5	2	2
Harpacticoid copepods	2	-	3	10	-
Amphipods	5	6	-	4	1
Euphausiids					
adult and juvenile	9	2	6	6	8
furcilia	-	5	-	-	-
Balanus sp.	-	-	-	8	-
Shrimp	-	-	-	5	-
Crab zoea and megalopa	-	3	-	3	4
Pteropoda					
Limacina helicina	-	-	10	1	5
Fish larvae	-	1	-	-	3

Table 14. continued.

b) Walleye pollock

Prey species	Station				
	A	B	C	D	E
Chaetognaths	10	4	-	9	-
Calanoida					
C. cristatus	4	-	-	-	5
C. marshallae	-	1	-	-	7
C. plumchrus	1	-	8	6	4
E. bungii bungii	9	-	2	1	9
Pseudocalanus sp.					
adult	3	3	1	3	6
copepodite	8	7	3	4	-
Metridia sp.	-	-	10	-	-
A. longiremis	5	9	-	10	8
A. tumida	-	-	5	-	-
Cyclopoid copepods					
Oithona sp. and *Oncaea* sp.	2	8	4	2	1
Harpacticoid copepods	7	-	-	-	-
Amphipods	-	10	-	-	10
Euphausiids					
adult and juvenile	-	5	7	7	2
furcilia	-	2	-	-	-
Balanus sp.	-	-	6	-	-
Pteropoda					
Limacina helicina	-	-	-	8	-
Fish larvae	-	6	-	-	-

E. bungii bungii and *Pseudocalanus* sp. were important both at stations C and D. Cyclopoid copepods and euphausiids (adult and juvenile) were important at station E.

CHAPTER 4

DISCUSSION

There were distinct differences in the structure and the development of gill rakers in Pacific cod and walleye pollock. There were relatively few gill rakers in cod and the gill rakers were short and stout with wide intervals. In contrast, gill rakers of pollock were relatively numerous, long and thin with narrow intervals. The increase of the number of gill rakers with fish size is quite remarkable in pollock. The narrow gill raker spacing in pollock was largely attributed to the increase in gill raker number with the growth of the fish. In cod, the gill raker number did not increase with fish size, resulting in the pronounced wide interval. Okada and Kobayashi (1968) reported the gill raker number to be 19-21 in adult cod, and 34-40 in adult pollock. Similarly, Yoshida (1984) reported that adult pollock had 34-45 gill rakers and the interval was 1.5-2.0 mm in 40 cm long fish. These observations were similar to those observed in juveniles in the present study (16-24 in cod, 26-40 in pollock).

The numerous, long and closely-spaced gill rakers in pollock are advantageous in preventing the escape of small prey organisms more effectively than the few, short

and widely-spaced gill rakers in cod. This advantage in pollock is supported by the evidence that relatively numerous and small prey organisms, particularly calanoid eggs and cyclopoid copepods (Oithona sp. and Oncaea sp.), were found in the stomachs of the pollock.

Stomach size is generally large in fish which feed on large prey (Nikolsky, 1963) because not only does such a fish need the capacity for the large prey volume, but also it has to kill the prey in the stomach. In this study, the stomach tissue weight was measured instead of stomach volume, assuming that the stomach size is proportional to the stomach tissue weight. The data demonstrate clearly that the stomach tissue of cod is heavier than that of pollock, when same size range of fish is compared. Therefore, I think that cod have more expandable and/or thicker stomachs than pollock. Such a heavy stomach enables cod to take large prey more effectively than pollock. This is reflected in food organisms present; pollock stomachs contained numerous and small prey organisms while those of cod contained few larger ones. Also the mean weight of prey organisms remained nearly constant in pollock over the fish size range while it increased steadily as cod became larger. These facts support Nikolsky°s statement.

In examining the gut contents of juvenile pollock from Uchiura Bay, Hokkaido, Kamba (1977) found that the maximum size of prey organisms was nearly the same among the juvenile pollock of 30-70 mm in length, but it increased suddenly in the 70-80 mm long fish. Cooney et al. (1980) confirmed in pollock from the eastern Bering Sea that there was a distinct difference in the food composition between 20-60 mm long fish (mainly Pseudocalanus sp.) and 60-100 mm long fish (large calanoid copepods). These observations suggest that in pollock, regardless of geographical difference, a critical length exists around 60-80 mm at which the size of prey organisms changes sharply. The change in food habit was indistinct in pollock of 15-70 mm TL in the present study. On the contrary, a remarkable change of prey weight was observed to occur in cod at 40.0-44.9 mm TL (Fig. 8). The change of food was also indicated by the low values of the PS-length difference of fish (Fig. 11). Therefore, this size range can be regarded as the critical length of food change in cod. Cod begin to take large prey, including fish larvae, when the fish reach 40 mm TL. This size range corresponds with the time when cod turn from planktivorous feeding to piscivorous feeding. Consequently, at approximately half the size that pollock do, cod begin to change their food resources.

As the planktivorous feeding in pollock up to 70 mm in length can be explained by the increased number and narrow interval of gill rakers, the change in feeding habit around 40 mm TL in cod can be explained by the structure of widening gill raker intervals. Moreover, it is noteworthy that the significant condition factor increase coincides with the change of feeding habit in cod, compared with the insignificant change of condition factor and the feeding habit in pollock.

From the results observed, it is surmised that in nature competition for food will occur in different ways depending upon the combination of different size ranges between cod and pollock. The feeding intensity on adult Pseudocalanus sp. (0.60-1.30 mm in length) exemplifies the feeding relationship between cod and pollock. Although adult Pseudocalanus sp. were taken commonly by cod and pollock, the predation by cod decreased sharply when cod reached 30.0-34.9 mm TL. Contrarily, the predation on adult Pseudocalanus sp. was intensified by pollock after 30.0-34.9 mm TL. Similar trends were apparent for cyclopoid copepods and Pseudocalanus copepodites.

From these results, it is concluded that the competition will be weak between cod and pollock of the same size range.

However, the intensity of competition for food differs for fishes of different size ranges. A strong competition for food will occur between cod and pollock when the fishes are smaller than 40.0 mm TL, because these fishes share common prey organisms. When both fish species are larger than 40.0 mm TL, there will be a moderate competition for food because pollock tend to take small prey organisms while cod take larger ones. The food competition will be also moderate when large pollock and small cod coexist. The competition will be the weakest between large cod and small pollock; however, there will be predation pressure of large cod on pollock larvae.

Food weight of cod was heavier than that of pollock when the fishes of the same length were compared. However, when the fishes of the same weight were compared, there was no significant difference in the food weight. Thus, the results lead to the conclusion that cod and pollock are capable of taking the same amount of food relative to the body weight, which will result in the same growth rate in terms of weight, if the energy values of food and assimilation rate of the two fish species are the same. Therefore, it is likely that cod are older than pollock when they have the same length. Walline (1983) reported that the growth of larval cod was slower than

that of pollock in terms of length.

The differences in regional food habits indicate the prey compositions and the prey size vary considerably from station to station. It is likely that the variability in prey composition and prey size reflects the differences in planktonic communities in the different areas.

The eastern Bering Sea is a relatively unique ocean area: 1) it has a wide continental shelf area, 2) it is partly isolated from the North Pacific by the Aleutian Ridge, 3) sea ice covers most of the continental shelf from mid-December to March (Favorite et al., 1976), 4) the freshwater discharges from rivers are enormous, 5) the mean flow over the outer shelf is sluggish (1 cm/second) and parallels the bathymetry in a slow, northward drift, 6) and the predominant sources of mixing energy over the shelf are only wind and tidal energy. As a result, the differences of the mixing energy across the shelf lead to frontal formations. These fronts divide the area into four regions: the oceanic domain, the outer shelf domain, the inner shelf domain, and the coastal domain (Kinder and Schumacher, 1981). Because of the absence of the advective flow across the shelf, the seasonally abundant zooplankton are unable to move across the fronts.

Cooney (1981) defined three distinct planktonic communities in the eastern Bering Sea: oceanic outershelf community, coastal and middle shelf community, and nearshore community. Each is represented by typical component zooplankters.

At stations A and B, the prey composition was simple. The common and dominant occurrence of C. plumchrus, C. cristatus, and adult Pseudocalanus sp. in both fish species exhibits the characteristics of the oceanic outershelf community. At station B, where fish larvae and euphausiids dominate cod prey, and euphausiids, adult Pseudocalanus sp. and C. marshallae dominate in pollock. The food organisms then reflect the characteristics of the coastal and middle shelf community in which the fishes were sampled.

At stations C, D and E, the prey compositions were diverse showing the traits of the mixed community (Motoda and Minoda, 1974; Cooney, 1981) between the oceanic outershelf community and the coastal and middle shelf community. At stations C and D, E. bungii bungii, adult Pseudocalanus sp., Pseudocalanus copepodite, cyclopoid copepods and calanoid eggs were the common and abundant prey species. At station E, amphipods, cyclopoid copepods and Metridia sp. prevailed as prey in both fishes.

Consequently, the species-selective predation by the fish species is unlikely, despite the size-selective preference associated with the structure of the gill rakers. The results lead to the conclusion that cod and pollock are basically opportunistic in their feeding behavior, although food availability and the prey size seem to be the major limiting factors in determining the actual acquisition of food. The opportunistic feeding behavior is also substantiated by the fact that the proportional similarity (PS) between cod and pollock is higher at the same station than that between the same fish species at different stations.

CHAPTER 5

SUMMARY

1. The food and feeding habit of juveniles of Pacific cod and Walleye pollock were studied in relation to some morphological differences between the two species. Samples were collected in the southeast Bering Sea in 1981 through 1983. Examination of stomach contents was done for 195 cod and 305 pollock. The body length ranged between 24.6 mm TL and 73.7 mm TL in cod, and between 19.5 mm TL and 68.4 mm TL in pollock.
2. The length-weight relationship was established as $W=3.627 \times TL^{3.182}$ in cod, and $W=3.914 \times TL^{3.107}$ in pollock.
3. The caudal fin was longer in cod than in pollock until they reached 40.2 mm SL, and afterwards pollock°s caudal fin exceeded that of cod. As the fish grew, the bifurcation of caudal fin became distinct in pollock.
4. The condition factor ranged between 3.56 and 9.07 with a mean of 6.97 (one standard deviation=0.86) in cod, and between 3.10 and 7.30 with a mean of 5.73 (one standard deviation=0.66) in pollock. The condition factor did not increase with growth in

pollock over the size range examined, but increased significantly in cod at the 30.0-44.9 mm TL range.

5. The mean stomach tissue weight was 2.52% of the body weight in cod, and 2.00% in pollock. The difference between the two species was statistically significant ($P \leq 0.001$).

6. Cod had short and stout gill rakers while pollock had long and fine ones. The interval of gill rakers was wide in cod (0.14-0.43 mm), but narrow in pollock (0.09-0.24 mm). The number of gill rakers did not increase remarkably with growth in cod (19 gill rakers in 20 mm TL fish and 21 gill rakers in 70 mm TL fish), but increased by 10 in pollock as the fishes grew from 20 mm to 70 mm TL (28- 38 gill rakers).

7. The size of prey varied from 0.11 mm TL in copepod eggs to 25.0 mm TL in fish larvae. The percentage of the food weight per body weight remained the same between the fish species. As the fishes grew, pollock took numerous small prey organisms while cod took voluminous prey organisms in fewer numbers. As a result, the mean weight of prey organisms did not increase greatly in pollock, but it increased abruptly at 40-50 mm TL in cod.

8. The food weight fell within the range of 10 mg in wet weight. The food weight was greater in cod than in pollock when fishes of the same length were compared, but it was the same when fishes of same weight were compared. Hence, the feeding indices were the same in cod and pollock.
9. The prey composition differed from station to station reflecting the planktonic communities of the surrounding water. The prey composition was diverse in the boundary area between different planktonic communities, and homogeneous in the areas where typical component plankters of a community prevail. The feeding index and condition factor also differed among stations. The PS (proportional similarity) of food between cod and pollock at the same sampling station was higher than that between the same fish species among different stations.
10. Pseudocalanus sp. was the most important prey organism in IRI (index of relative importance) rank for the overall samples of cod and pollock. However, Pseudocalanus sp. was the most important until 34.9 mm TL in cod, and its importance continued until 65.0 mm TL in pollock.

11. The PS of food between cod and pollock decreased as the fishes grew. The mean PS by number over all the size was 0.45, and was 0.37 by volume. The PS by number decreased from 0.55 at 15.0-29.9 mm TL to 0.04 at 55.0-74.9 mm TL. The PS by volume declined from 0.42 at 15.0-29.9 mm TL to 0.19 at 55.0-74.9 mm TL. The PS between cod and pollock was high at stations A and C, and was low at stations B, D and E.
12. Cod had less common food between different size groups than pollock did. The PS between different size groups remained constant in pollock regardless of length difference, but it decreased in cod. It is concluded that food change with growth is faster in cod than in pollock. The critical size of prey change occurred at 40.0-50.0 mm TL in cod, where cod start to prey on fish larvae.
13. There is a potential of strong food competition between cod and pollock when the fishes are smaller than 40 mm TL. When both fish species are larger than 40 mm TL, there will be weak food competition.

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APPENDIX

Table A-1. Wet body weight of juvenile Pacific cod and walleye pollock in mg.

Length (mm)	Pacific cod			Walleye pollock		
	N	Mean	SD	N	Mean	SD
15.0 - 19.9	-	-	-	2	43.5	3.5
20.0 - 24.9	1	110.0	-	9	67.7	22.1
25.0 - 29.9	11	154.5	24.6	10	119.9	26.9
30.0 - 34.9	31	242.4	47.7	24	204.9	39.9
35.0 - 39.9	39	350.9	58.7	64	318.8	47.0
40.0 - 44.9	50	560.9	98.4	79	452.0	64.6
45.0 - 49.9	30	802.5	135.9	62	627.2	93.4
50.0 - 54.9	23	1039.5	111.3	34	839.2	111.7
55.0 - 59.9	8	1447.1	251.9	13	1155.1	144.5
60.0 - 64.9	1	1803.0	-	7	1628.6	198.3
65.0 - 69.9	-	-	-	1	1909.0	-
70.0 - 74.9	1	3270.0	-	-	-	-

N : sample size.
SD : one standard deviation.

Table A-2. Wet net body weight of juvenile Pacific cod and walleye pollock in mg.

Length (mm)	Pacific cod			Walleye pollock		
	N	Mean	SD	N	Mean	SD
15.0 - 19.9	-	-	-	2	42.8	3.2
20.0 - 24.9	1	105.7	-	9	65.4	22.2
25.0 - 29.9	11	151.2	24.0	10	117.0	24.2
30.0 - 34.9	31	236.6	45.8	24	199.9	38.1
35.0 - 39.9	39	342.2	56.3	64	310.2	46.4
40.0 - 44.9	50	547.0	94.4	79	440.9	61.4
45.0 - 49.9	30	780.1	130.1	62	609.8	89.0
50.0 - 54.9	23	999.7	107.9	34	816.5	104.3
55.0 - 59.9	8	1400.6	236.6	13	1122.8	135.0
60.0 - 64.9	1	1745.0	-	7	1577.0	206.1
65.0 - 69.9	-	-	-	1	1881.5	-
70.0 - 74.9	1	3102.0	-	-	-	-

Wet net body weight=wet body weight-wet food weight.
N : sample size.
SD : one standard deviation.

Table A-3. Measurement of caudal fin in juvenile Pacific cod and walleye pollock; standard length (SL), fork length (FL), and total length (TL).

a) Pacific cod

Fish size (TL, mm)	N	Measurement (mm) SL	TL-SL	TL-FL	FL-SL
20.0 - 29.9	26	26.86	2.87	0.54	2.33
30.0 - 39.9	78	34.23	3.56	0.67	2.89
40.0 - 49.9	51	44.55	4.35	0.73	3.62
50.0 - 59.9	9	53.03	5.07	0.85	4.22
60.0 - 69.9	1	67.50	6.20	0.80	5.40

b) Walleye pollock

Fish size (TL, mm)	N	Measurement (mm) SL	TL-SL	TL-FL	FL-SL
10.0 - 19.9	1	19.00	1.70	0.20	1.50
20.0 - 29.9	26	25.04	2.54	0.46	2.08
30.0 - 39.9	128	35.48	3.63	0.74	2.89
40.0 - 49.9	94	44.01	4.39	0.87	3.52
50.0 - 59.9	21	53.95	5.10	0.93	4.17
60.0 - 69.9	1	62.80	5.60	1.00	4.60

N: sample size

Table A-4. Condition Factor of juvenile Pacific cod and walleye pollock.

Fish length	Pacific cod			Walleye pollock		
TL, mm	N	Mean	SD	N	Mean	SD
15.0 - 29.9	-	-	-	2	5.64	0.23
20.0 -24.9	1	7.39	-	9	5.04	1.19
25.0 - 29.9	11	6.77	0.57	10	5.85	0.76
30.0 - 34.9	31	6.62	0.74	24	5.50	0.60
35.0 -39.9	39	6.68	0.75	64	5.74	0.74
40.0 - 44.9	50	7.14	0.97	79	5.72	0.62
45.0 - 49.9	30	7.16	0.94	62	5.82	0.59
50.0 - 54.9	23	7.26	0.79	34	5.62	0.50
55.0 - 59.9	8	7.32	0.78	13	5.93	0.59
60.0 - 64.9	1	7.18	-	7	6.34	0.55
65.0 - 69.9	-	-	-	1	5.97	-
70.0 - 74.9	1	8.17	-	-	-	-

N : sample size.
SD : one standard deviation.

Table A-5. Stomach tissue weight of juvenile Pacific cod and walleye pollock; body length vs. stomach tissue weight in mg.

Size range	Pacific cod				Walleye pollock			
	Sample size	Mean length	STW Mean	SD	Sample size	Mean length	STW Mean	SD
15.0-19.9	-	-	-	-	2	19.7	0.92	0.31
20.0-24.9	1	24.6	2.42	-	9	23.3	0.89	0.34
25.0-29.9	11	28.1	2.33	0.39	10	27.1	1.65	0.83
30.0-34.9	31	32.8	4.36	1.28	24	33.0	2.82	1.04
35.0-39.9	39	37.1	6.52	1.81	64	37.8	4.91	1.24
40.0-44.9	50	42.2	12.60	5.05	79	42.5	7.06	1.99
45.0-49.9	30	47.7	16.25	5.93	62	47.0	9.89	3.04
50.0-54.9	23	51.7	19.82	5.22	34	52.5	12.30	3.97
55.0-59.9	8	57.5	24.01	8.94	13	57.4	17.10	4.68
60.0-64.9	1	63.1	34.47	-	7	62.8	20.63	3.79
65.0-69.9	-	-	-	-	1	68.4	20.07	-
70.0-74.9	1	73.7	54.60	-	-	-	-	-

STW: stomach tissue weight.
SD : one standard deviation.

Table A-6. Stomach tissue weight of juvenile Pacific cod and walleye pollock; body weight vs. stomach tissue weight in mg.

	Pacific cod				Walleye pollock			
Body weight range	Sample size	Mean weight	STW Mean	STW SD	Sample size	Mean weight	STW Mean	STW SD
0 - 99.99	-	-	-	-	14	68.61	0.99	0.47
100 - 199.99	21	160.26	2.76	0.60	19	151.69	2.12	0.72
200 - 299.99	32	266.26	5.05	1.50	39	257.62	4.05	1.07
300 - 399.99	23	344.38	6.20	1.29	58	350.75	5.38	1.08
400 - 499.99	23	447.09	8.99	2.66	52	450.69	7.28	1.69
500 - 599.99	21	541.99	11.36	3.00	35	546.24	8.39	2.34
600 - 699.99	15	652.54	16.29	5.23	28	647.62	10.75	2.75
700 - 799.99	15	732.93	16.39	4.59	21	751.96	11.52	2.68
800 - 899.99	10	854.45	17.76	6.16	11	863.17	13.72	4.49
900 - 999.99	14	947.79	19.92	4.66	9	950.16	13.81	3.20
1000 - 1199.99	12	1087.76	19.66	6.45	6	1071.47	16.32	1.18
1200 - 1399.99	3	1324.40	25.62	3.43	7	1280.69	20.62	3.38
1400 - 1599.99	3	1523.07	28.81	6.21	2	1527.50	23.19	1.75
1600 - 1799.99	2	1740.05	32.02	3.46	2	1753.30	17.91	5.00
1800 - 1999.99	-	-	-	-	2	1848.75	22.48	3.40
2000 -	1	3102.80	54.60	-	-	-	-	-

STW: stomach tissue weight.
SD : one standard deviation.

Table A-7. The interval and number of gill rakers in juvenile Pacific cod.

Fish No.	Fish length, mm	Gill raker Number		Gill raker Interval, mm	
		Left	Right	Left	Right
1	24.6	17	16	0.14	0.16
2	26.2	17	20	0.19	0.19
3	28.3	20	20	0.21	0.21
4	28.6	21	21	0.16	0.17
5	28.8	20	19	0.14	0.19
6	29.0	19	19	0.16	0.19
7	31.5	17	18	0.17	0.19
8	32.7	17	22	0.19	0.19
9	32.7	19	20	0.19	0.20
10	33.0	22	19	0.19	0.20
11	33.1	22	21	0.19	0.19
12	36.1	18	19	0.23	0.23
13	36.5	22	21	0.19	0.21
14	38.2	19	21	0.21	0.23
15	38.2	22	20	0.20	0.20
16	38.7	22	21	0.20	0.23
17	39.0	20	20	0.21	0.21
18	39.5	20	20	0.20	0.20
19	40.0	22	20	0.21	0.23
20	41.0	23	21	0.20	0.20
21	41.5	22	21	0.24	0.20
22	47.2	20	19	0.26	0.27
23	47.2	24	21	0.21	0.26
24	48.4	22	19	0.24	0.27
25	48.4	22	21	0.26	0.26
26	48.6	24	21	0.23	0.29
27	48.9	22	22	0.27	0.30
28	49.2	21	21	0.29	0.29
29	50.0	20	21	0.24	0.34
30	50.9	22	21	0.31	0.31
31	54.0	21	19	0.29	0.30
32	54.4	21	20	0.31	0.33
33	56.5	18	18	0.29	0.30
34	57.0	20	20	0.34	0.36
35	58.0	20	20	0.37	0.33
36	58.8	21	20	0.31	0.31
37	59.0	23	21	0.29	0.34
38	59.5	22	22	0.39	0.37
39	63.1	21	21	0.40	0.44
40	73.7	21	20	0.43	0.43

Table A-8. The interval and number of gill rakers in juvenile walleye pollock.

Fish No.	Fish length, mm	Gill raker Number		Gill raker Interval, mm	
		Left	Right	Left	Right
1	24.0	27	27	0.10	0.10
2	28.0	27	31	0.10	0.09
3	30.1	26	26	0.11	0.11
4	30.5	28	29	0.11	0.13
5	31.2	34	36	0.10	0.11
6	32.5	33	33	0.11	0.11
7	32.8	33	32	0.11	0.13
8	32.9	27	31	0.10	0.10
9	33.2	28	28	0.11	0.11
10	33.6	35	35	0.13	0.13
11	34.6	33	33	0.13	0.13
12	37.6	30	31	0.13	0.13
13	38.8	32	32	0.13	0.13
14	39.6	31	31	0.17	0.14
15	39.7	29	32	0.14	0.11
16	39.8	34	34	0.17	0.14
17	41.5	31	31	0.14	0.13
18	43.2	30	32	0.16	0.16
19	43.7	32	30	0.11	0.16
20	44.4	34	32	0.17	0.19
21	44.9	37	37	0.14	0.16
22	45.4	39	35	0.16	0.17
23	45.8	35	36	0.16	0.17
24	46.8	35	37	0.16	0.16
25	49.0	36	35	0.17	0.17
26	49.0	34	36	0.16	0.19
27	50.0	35	36	0.17	0.17
28	52.8	32	34	0.20	0.21
29	53.5	37	37	0.20	0.20
30	54.5	35	33	0.24	0.24
31	56.7	36	37	0.23	0.21
32	57.0	37	36	0.20	0.20
33	57.0	37	36	0.17	0.17
34	57.2	34	34	0.21	0.20
35	58.4	35	35	0.23	0.21
36	58.8	34	35	0.23	0.20
37	60.8	36	35	0.21	0.20
38	60.9	38	36	0.21	0.23
39	61.6	38	37	0.23	0.23
40	64.6	40	35	0.21	0.24
41	64.6	37	38	0.24	0.23
42	68.4	38	38	0.24	0.23

Table A-9. Stomach contents of juvenile Pacific cod; number of fish (n), frequency of occurrence (FO), number of prey (N), volume of prey (V), and ranks in Index of Relative Importance (IRI).

Size range 20.0-24.9 mm TL, n=1, length 24.6 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
Pseudocalanus sp.							
adult			79	46.7	7.71	84.3	1
copepodite			79	46.7	0.92	10.1	2
A. longiremis			4	2.4	0.25	2.8	3
Cyclopoid copepods			6	3.6	0.06	0.6	4
Euphausiids							
furcilia			1	0.6	0.20	2.2	5
Egg (dia. 0.11mm)			212				
Total			169				

Table A-9. continued.

Size range 25.0-29.9 mm TL, n=11, mean length 28.1 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. marshallae	2	18.2	2	0.3	2.05	6.8	7
Pseudocalanus sp.							
adult	9	81.8	117	17.9	11.41	37.9	1
copepodite	2	18.2	63	9.7	1.48	4.9	5
C. abdominalis	1	9.1	1	0.2	0.20	0.6	10
A. longiremis	5	45.5	59	9.0	5.76	19.1	3
A. tumida	1	9.1	1	0.2	0.39	1.3	8
Cyclopoid copepods	6	54.5	289	44.3	2.82	9.4	2
Harpacticoid copepods							
adult	1	9.1	2	0.3	0.20	0.6	9
Amphipods	1	9.1	1	0.2	0.10	0.3	11
Euphausiids							
adult & juvenile	2	18.2	5	0.8	3.04	10.1	6
Pteropoda							
Limacina helicina	2	18.2	112	17.2	2.62	8.7	4
Egg (dia. 0.11mm)	4	36.4	157				
" (dia. 0.32-0.40mm)	2	18.2	5				
Total			652				

Table A-9. continued.

Size range 30.0-34.9 mm TL, n=31, mean length 32.8 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	1	3.2					
Calanoida							
C. cristatus	2	6.5	2	0.07	22.34	9.4	8
C. marshallae	3	9.7	5	0.2	5.81	2.4	9
C. plumchrus	6	19.4	16	0.6	45.09	18.9	6
Pseudocalanus sp.							
adult	19	61.3	972	33.5	94.83	39.8	1
copepodite	5	16.1	613	21.2	14.35	6.0	5
C. abdominalis	3	9.7	7	0.2	1.16	0.5	13
Metridia sp.	2	6.5	2	0.07	0.74	0.3	16
A. longiremis	12	38.7	153	5.3	14.93	6.3	4
Calanus sp. *	2	6.5	3	0.1	7.27	3.0	11
Cyclopoid copepods	13	41.9	468	16.2	4.57	1.9	2
Harpacticoid copepods							
adult	3	9.7	4	0.1	0.39	0.2	15
eggsac	2	6.5	2	0.07			
Amphipods	7	22.6	31	1.1	5.49	2.3	7
Euphausiids							
adult & juvenile	3	9.7	10	0.3	4.82	2.0	10
furcilia	1	3.2	1	0.03	0.28	0.1	17
nauplius	1	3.2	1				
Balanidae							
Balanus sp.	6	19.4	10	0.3	0.98	0.4	12
Crab zoea & megalopa	2	6.5	4	0.1	1.28	0.5	14
Mollusca							
snail	1	3.2	2	0.07			
Pteropoda							
L. helicina	11	35.5	592	20.4	13.86	5.8	3
Appendicularians	1	3.2					
Egg (dia. 0.11 mm)	13	41.9	1,103				
" (dia. 0.19-0.20 mm)	2	6.5	7				
" (dia. 0.32-0.40 mm)	2	6.5	6				
Digested unidentifiable food	2	6.5					
Total			2,898				

* : unidentified

Table A-9. continued.

Size range 35.0-39.9 mm TL, n=39, mean length 37.1 mm

Calanoida							
C. marshallae	3	7.7	13	0.8	17.13	3.7	11
C. plumchrus	13	33.3	56	3.3	161.41	39.2	1
E. bungii bungii	1	2.6	25	1.5	48.44	10.6	14
Pseudocalanus sp.							
adult	13	33.3	430	25.1	41.95	9.1	2
copepodite	7	17.9	276	16.1	6.46	1.4	5
Metridia sp.	3	7.7	4	0.2	1.78	0.4	17
A. longiremis	6	15.4	81	4.7	7.90	1.7	7
A. tumida	1	2.6	2	0.1	0.39	0.08	18
Calanus sp. *	3	7.7	8	0.5	20.70	4.5	10
Cyclopoid copepods	10	25.6	225	13.2	2.20	0.5	4
Harpacticoid copepods							
adult	8	20.5	24	1.4	2.34	0.5	9
eggsac	4	10.3	7	0.4			
Amphipods	10	25.6	18	1.0	24.54	5.4	6
Euphausiids							
adult & juvenile	2	5.1	3	0.2	28.52	6.2	13
furcilia	2	5.1	6	0.3	3.86	0.8	16
calyptopis	1	2.6	1	0.06			
Balanidae							
Balanus sp.	7	17.9	10	0.6	0.98	0.2	15
Shrimp	1	2.6	3	0.2	57.60	12.6	12
Crab zoea & megalopa	4	10.3	6	0.3	20.30	4.4	8
Mollusca							
bivalve	1	2.6	1	0.06			
Pteropoda							
L. helicina	10	25.6	512	29.9	11.99	2.6	3
Appendicularians	1	2.6					
Egg (dia. 0.11 mm)	8	20.5	466				
" (dia. 0.19-0.20 mm)	1	2.6	2				
" (dia. 0.32-0.40 mm)	1	2.6	18				
" (dia. 0.63 mm)	1	2.6	3				
Digested unidentifiable food	5	12.8					
Total			1,711				

* : unidentified

Table A-9. continued.

Size range 40.0-44.9 mm TL, n=50, mean length 42.4 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	2	4.1	7	0.5	42.26	4.1	12
Calanoida							
C. cristatus	10	20.4	10	0.7	155.77	13.9	3
C. marshallae	2	4.1	27	1.8	38.53	3.4	11
C. plumchrus	23	46.9	182	12.2	538.42	48.0	1
E. bungii bungii	2	4.1	18	1.2	34.88	3.1	13
Pseudocalanus sp.							
adult	9	18.4	93	6.2	9.07	0.8	7
copepodite	7	14.3	73	4.9	1.71	0.2	9
C. abdominalis	1	2.0	10	0.7	1.66	0.1	19
Metridia sp.	3	6.1	11	0.7	5.59	0.5	16
A. longiremis	2	4.1	20	1.3	1.95	0.2	17
A. tumida	1	2.0	2	0.1	0.78	0.07	21
E. amphitrites	1	2.0	1	0.1	2.84	0.3	20
Calanus sp. *	3	6.1	4	0.3	11.04	1.0	15
Cyclopoid copepods	8	16.3	124	8.3	1.21	0.1	5
Harpactcoid copepods							
adult	13	26.5	64	4.3	6.24	0.6	6
larva	1	2.0	1	0.1			
egg sac	6	12.2	10	0.7			
Amphpods	9	18.4	30	2.0	5.39	0.5	10
Euphausiids							
adult & juvenile	5	10.2	28	1.9	149.32	13.3	4
furcilia	1	2.0	1	0.1	0.48	0.04	22
Balanidae							
Balanus sp.	7	14.3	9	0.6	0.88	0.08	14
Crab zoea & megaloba	6	12.2	27	1.8	91.37	8.2	8
Mollusca							
bivalve	3	6.1	5	0.3	0.12	0.01	18
snail	1	2.0	2	0.1			
Pteropoda							
L. helicina	8	16.3	732	49.1	17.14	1.5	2
Appendicularians	2	4.1	30+?				
Egg (dia. 0.11 mm)	2	4.1	7				
" (dia. 0.32-0.40 mm)	3	6.1	405				
Digested unidentifiable food	8	16.3					
Total			1,491				

* : unidentified

Table A-9. continued.

Size range 45.0-49.9 mm TL, n=30, mean length 47.7 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	2	6.7	10	1.6	66.09	4.9	10
Calanoida							
C. cristatus	3	10.0	4	0.6	54.98	4.1	9
C. marshallae	3	10.0	10	1.6	14.27	1.1	14
C. plumchrus	7	23.3	67	10.9	191.74	14.1	3
E. bungii bungii	1	3.3	1	0.2	2.19	0.2	20
Pseudocalanus sp.							
adult	6	20.0	138	22.4	13.46	1.0	4
copepodite	2	6.7	9	1.5	0.21	0.02	17
Metridia sp.	2	6.7	31	5.0	20.73	1.5	10
A. longiremis	2	6.7	94	15.2	9.17	0.7	8
Calanus sp. *	2	6.7	11	1.8	29.43	2.2	15
Cyclopoid copepods	3	10.0	25	4.1	0.24	0.02	12
Harpacticoid copepods							
adult	3	10.0	12	1.9	1.17	0.09	16
larva	1	3.3	1	0.2			
egg sac	3	10.0	3	0.5			
Amphipods	13	43.3	81	13.3	177.65	13.1	1
Euphausiids							
adult & juvenile	8	26.7	16	2.6	152.08	11.2	5
furcilia	3	10.0	3	0.5	2.27	0.2	19
Balanidae							
Balanus sp.	4	13.3	4	0.6	0.39	0.03	18
Shrimp	2	6.7	12	1.9	230.40	17.0	6
Crab zoea & megalopa	8	26.7	66	10.7	230.49	17.0	2
Pteropoda							
L. helicina	5	16.7	15	2.4	0.35	0.03	13
Fish larvae	3	10.0	3	0.5	158.16	11.7	7
Egg (dia. 0.11mm)	1	3.3	86				
" (dia. 0.32-0.40mm)	1	3.3	191				
Digested unidentifiable food	1	3.3					
Total			616				

* : unidentified

Tabel A-9. continued.

Size range 50.0-54.9 mm TL, n=23, mean length 51.7 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. cristatus	2	8.7	3	1.5	42.92	3.7	11
C. marshallae	2	8.7	2	1.0	2.85	0.2	12
C. plumchrus	4	17.4	37	18.9	96.29	8.3	3
Pseudocalanus sp.							
adult	4	17.4	58	29.6	5.66	0.5	2
copepodite	1	4.3	2	1.0	0.05		14
Metridia sp.	2	8.7	12	6.1	8.03	0.7	10
A. tumida	1	4.3	1	0.5	0.39	0.03	15
Calanus sp. *	5	21.7	12	6.1	30.51	2.6	6
Harpacticoid copepods							
adult	1	4.3	2	1.0	0.20	0.02	13
eggsac	1	4.3					
Amphipods	4	17.4	11	5.6	79.40	6.8	5
Euphausiids							
adult & juvenile	5	21.7	6	3.1	164.85	14.2	4
furcilia	4	17.4	12	6.1	5.80	0.5	9
Mysids	1	4.3	2	1.0			
Shrimp	2	8.7	10	5.1	192.00	16.5	7
Crab zoea & megalopa	3	13.0	22	8.7	58.03	5.0	8
Appendicularians	2	8.7					
Fish larvae	9	39.1	9	4.6	474.48	40.9	1
Egg (dia. 0.11 mm)	3	13.0	96				
Digested unidentifiable food	3	13.0					
Total			201				

* : unidentified

Table A-9. continued.

Size range 55.0-59.9 mm TL, n=8, mean length 57.5 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. marshallae	2	25.0	6	17.1	9.91	3.2	4
C. plumchrus	1	12.5	2	5.7	4.96	1.6	5
Pseudocalanus sp.							
adult	1	12.5	1	2.9	0.1	0.03	8
copepodite	1	12.5	2	5.7	0.05	0.02	6
A. longiremis	1	12.5					
Amphipods	2	25.0	12	34.3	12.70	4.2	3
Euphausiids							
adult & juvenile	2	25.0	7	20.0	66.54	21.8	2
furcilia	1	12.5	1	2.9	0.48	0.2	7
Fish larvae	3	37.5	4	11.4	210.88	69.0	1
Egg (dia. 0.11 mm)	1	12.5	7				
Digested unidentifiable food	3	37.5					
Total			35				

Table A-9. continued

Size range 60.0-64.9 mm TL, n=1, length 63.1 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
Pseudocalanus sp.							
adult			2	18.1	0.20	0.3	4
Metridia sp.			2	18.1	2.17	3.0	3
Amphipods			1	9.1	1.15	1.6	5
Crab zoea & megalopa			5	45.5	16.92	23.1	2
Fish larvae			1	9.1	52.72	72.1	1
Total			11				

Table A-9. continued.

Size range 70.0-74.9 mm TL, n=1, length 73.7 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Amphipods			8	47.1	15.73	8.1	2
Crab zoea & megalopa			6	35.3	20.94	10.7	3
Fish larvae			3	17.6	158.16	81.2	1
Total			17				

Table A-10. Stomach contents of juvenile walleye pollock; number of fish (n), frequency of occurrence (FO), number of prey (N), volume of prey (V), and ranks in Index of Relative Importance (IRI).

Size range 15.0-19.9 mm TL, n=2, mean length 19.7 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
Pseudocalanus sp.							
adult	1	50.0	3	9.4	0.29	9.9	2
copepodite	1	50.0	1	3.1	0.02	0.8	3
A. longiremis	2	100.0	27	84.4	2.63	89.0	1
Cyclopoid copepods	1	50.0	1	3.1		0.3	4
Total			32				

Table A-10. continued.

Size range 20.0-24.9 mm TL, n=9, mean length 23.3 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. marshallae	2	25.0	18	7.5	1.75	8.0	7
E. bungii bungii	2	25.0	2	0.8	3.89	17.7	3
Pseudocalanus sp.							
adult	7	87.5	23	9.0	2.24	10.2	2
copepodite	2	25.0	35	14.6	0.82	3.7	4
A. longiremis	2	25.0	18	7.5	1.76	8.0	6
Metridia sp.	1	12.5	1	0.4	0.41	1.9	8
A. tumida	1	12.5	1	0.4	0.39	1.8	9
Cyclopoid copepods	7	87.5	154	64.4	1.50	6.8	1
Amphipods	1	12.5	2	0.8	8.28	37.6	5
Egg (dia. 0.11mm)	1	12.5	2				
Total			239				

Table A-10. continued.

Size range 25.0-29.9 mm TL, n=10, mean length 27.1 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. marshallae	2	20.0	2	0.6	1.77	3.7	7
C. plumchrus	1	10.0	1	0.3	2.59	5.4	8
E. bungii bungii	2	20.0	14	4.5	26.13	53.9	3
Pseudocalanus sp.							
adult	7	70.0	60	19.4	5.85	12.1	2
copepodite	3	30.0	11	3.5	0.26	0.5	6
Metridia sp.	1	10.0	1	0.3	0.39	0.8	10
A. longiremis	2	20.0	36	11.6	3.51	7.2	4
C. abdominalis	1	10.0	4	1.3	1.56	3.2	9
Cyclopoid copepods	6	60.0	167	53.9	1.63	3.4	1
Harpacticoid copepods	1	10.0	1	0.3	0.09	0.2	11
Euphausiids							
adult & juvenile	2	20.0	13	4.2	4.64	9.6	5
Pteropoda							
L. helicina	1	10.0					
Appendicularians	1	10.0					
Egg (dia. 0.11 mm)	3	30.0	71				
Digested unidentifiable food	1	10.0					
Total			310				

Table A-10. continued.

Size range 30.0-34.9 mm TL, n=24, mean length 33.0 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. marshallae	6	25.0	17	1.0	21.04	8.6	7
C. plumchrus	5	20.8	11	0.7	29.67	12.1	5
E. bungii bungii	9	37.5	45	2.8	78.59	32.1	3
Pseudocalanus sp.							
adult	20	83.3	760	46.9	74.15	30.3	1
copepodite	14	58.3	175	10.8	4.10	1.7	4
C. abdominalis	1	4.2	1	0.06	0.39	0.2	13
Metridia sp.	2	8.3	5	0.3	1.96	0.8	9
A. longiremis	5	20.8	8	0.5	0.78	0.3	8
A. tumida	2	8.3	2	0.2	0.78	0.3	11
Calanus sp. *	1	4.2	2	0.1	3.62	1.5	10
Cyclopoid copepods	10	41.7	582	35.9	5.68	2.3	2
Amphipods	2	8.3	3	0.2	0.31	0.1	12
Euphausiids							
adult & juvenile	6	25.0	9	0.6	23.61	9.6	6
calyptopis	1	4.2	1	0.06			
Pteropoda							
L. helicina	3	12.5	1+?	0.06			
Appendicularians	2	8.3					
Egg (dia. 0.11mm)	15	62.5	754				
" (dia. 0.32-0.40mm)	2	8.3	2				
Total			1,623				

* : unidentified

Table A-10. continued.

Size range 35.0-39.9 mm TL, n=64, mean length 37.8 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	7	10.9	10	0.2	99.42	12.8	7
Calanoida							
C. marshallae	15	23.4	68	1.1	68.48	8.9	5
C. plumchrus	13	20.3	26	0.4	76.43	9.8	6
E. bungii bungii	16	25.0	122	2.0	215.77	27.8	3
Pseudocalanus sp.							
adult	46	71.9	1,761	29.1	171.80	22.1	1
copepodite	32	50.0	729	12.1	17.07	2.2	4
Metridia sp.	5	7.8	12	0.2	3.63	0.5	14
A. longiremis	18	28.1	97	1.6	9.46	1.2	8
A. tumida	5	7.8	9	0.1	3.51	0.5	15
T. discaudatus	2	3.1	7	0.1	1.37	0.2	18
Calanus sp. *	5	7.8	16	0.3	26.79	3.4	11
Cyclopoid copepods	30	46.9	2,977	49.3	29.04	3.7	2
Harpacticoid copepods							
adult	1	1.6	1	0.02	0.09	0.01	19
Amphipods	2	3.1	2	0.03	3.26	0.4	17
Euphausiids							
adult & juvenile	8	12.5	11	0.2	30.79	4.0	9
furcilia	9	14.1	77	1.3	16.25	2.1	10
Balanidae							
Balanus sp.	10	15.6	13	0.2	1.27	0.2	13
Pteropoda							
L. helicina	11	17.2	64	1.1	1.50	0.2	12
Appendicularians	12	18.8	43+?				
Copepod nauplii	3	4.7	41	0.7	0.12	0.02	16
Egg (dia. 0.11mm)	36	56.3	2,151				
" (dia. 0.19-0.20mm)	2	3.1	4				
" (dia. 0.32-0.40mm)	9	14.1	172				
" (dia. 0.06mm)	2	3.1	37				
Digested unidentifiable food	2	3.1					
Total			6,043				

* : unidentified

Table A-10. continued.

Size range 40.0-44.9 mm TL, n=79, mean length 42.5 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	9	11.7	11	0.2	109.37	9.0	9
Calanoida							
C. cristatus	2	2.6	2	0.03	25.77	2.1	14
C. marshallae	25	32.5	157	2.6	193.33	15.8	4
C. plumchrus	18	23.4	70	1.2	197.03	16.1	6
E. bungii bungii	13	16.9	177	2.9	288.64	23.7	5
Pseudocalanus sp.							
adult	38	49.4	1,693	27.8	165.17	13.5	2
copepodite	28	36.4	757	12.4	17.72	1.5	3
Metridia sp.	4	5.2	9	0.1	2.15	0.2	17
A. longiremis	26	33.8	137	2.3	13.37	1.1	8
A. tumida	2	2.6	3	0.04	1.17	0.1	19
T. discaudatus	2	2.6	13	0.2	2.54	0.2	18
Calanus sp. *	8	10.4	51	0.8	85.72	7.0	10
Cyclopoid copepods	38	49.4	2,815	46.3	27.46	2.3	1
Harpacticoid copepods							
adult	3	3.9	3	0.04	0.29	0.02	20
Amphipods	6	7.8	10	0.1	5.49	0.4	15
Euphausiids							
adult & juvenile	17	22.1	28	0.5	73.45	6.0	7
furcilia	13	16.9	37	0.6	8.77	0.7	11
calyptopis	1	1.3	2	0.03			
nauplius	1	1.3	1	0.01			
Balanidae							
Balanus sp.	7	9.1	13	0.2	1.27	0.1	16
Crab zoea & megalopa	2	2.6	2	0.03	0.68	0.06	20
Pteropoda							
L. helicina	8	10.4	32	0.5	0.75	0.06	13
Appendicularians	13	16.9	79+?				
Copepod nauplii	9	11.7	65	1.1	0.19	0.02	12
Egg (dia.0.11mm)	27	35.1	2,957				
" (dia.0.19-0.20mm)	2	2.6	2				
" (dia.0.32-0.40mm)	20	26.0	1,888				
" (dia.0.06mm)	3	3.9	209				
Digested unidentifiable food	1	1.3					
Total			6,088				

* : unidentified

Table A-10. continued.

Size range 45.0-49.9 mm TL, n=62, mean length 47.1 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	5	8.5	10	0.2	99.42	6.8	11
Calanoida							
C. cristatus	7	11.9	7	0.2	87.01	5.9	9
C. marshallae	13	22.0	169	4.1	219.36	14.9	6
C. plumchrus	20	33.9	64	1.5	174.35	11.9	5
E. bungii bungii	18	30.5	214	5.2	430.20	29.2	3
Pseudocalanus sp.							
adult	30	50.8	1,525	36.8	148.78	10.1	1
copepodite	26	44.1	707	17.1	16.55	1.1	4
Metridia sp.	6	10.2	14	0.3	6.58	0.4	14
A. longiremis	14	23.7	87	2.1	8.49	0.6	10
A. tumida	3	5.1	5	0.1	1.95	0.1	18
Calanus sp. *	15	25.4	52	1.3	95.84	6.5	7
Cyclopoid copepods	33	55.9	1,192	28.8	11.63	0.8	2
Harpacticoid copepods	3	5.1	4	0.1	0.39	0.02	19
Amphipods	8	13.6	11	0.3	0.88	0.06	15
Euphausiids							
adult & juvenile	12	20.3	22	0.5	97.85	6.7	8
furcilia	4	6.8	5	0.1	1.29	0.09	17
Balanidae							
Balanus sp.	6	10.1	11	0.3	1.07	0.07	16
Crab zoea & megalopa	1	1.7	1	0.02	3.68	0.2	20
Pteropoda							
L. helicina	7	11.9	42	1.0	0.98	0.07	13
Fish larvae	3	5.1	3	0.1	64.87	4.4	12
Appendicularians	14	23.7	270+?				
Copepod nauplii	1	1.7	1	0.02			
Egg (dia.0.11mm)	25	42.4	2,103				
" (dia.0.19-0.20mm)	1	1.7	3				
" (dia.0.32-0.40mm)	15	25.4	1,122				
Total			4,146				

* :unidentified

Table A-10. continued.

Size range 50.0-54.9 mm TL, n=34, mean length 52.5 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	5	14.7	5	0.2	49.71	4.6	9
Calanoida							
C. cristatus	3	8.8	3	0.1	30.74	2.9	13
C. marshallae	4	11.8	40	1.7	58.90	5.5	8
C. plumchrus	9	26.5	54	2.3	149.16	13.9	6
E. bungii bungii	12	35.3	126	5.4	256.63	23.8	2
Pseudocalanus sp.							
adult	23	67.6	902	38.5	88.00	8.2	1
copepodite	16	47.1	468	20.0	10.96	1.0	4
Metridia sp.	8	23.5	48	2.0	21.63	2.0	7
A. longiremis	7	20.6	61	2.6	5.95	0.6	10
A. tumida	1	2.9	5	0.2	1.95	0.2	19
Calanus sp. *	3	8.8	30	1.3	63.37	5.9	11
Cyclopoid copepods	14	41.2	523	22.3	5.10	0.5	5
Harpacticoid copepods	2	5.9	4	0.2	0.39	0.04	18
Amphipods	6	17.6	11	0.5	18.14	1.7	12
Euphausiids							
adult & juvenile	16	47.1	38	1.6	211.16	19.6	3
furcilia	4	11.8	6	0.3	2.31	0.2	16
Balanidae							
Balanus sp.	2	5.9	2	0.08	0.2	0.02	20
Shrimp	1	2.9	3	0.1	40.68	3.8	15
Crab zoea & megalopa	1	2.9	5	0.2	18.38	1.7	17
Appendicularians	10	29.4	186+?				
Fish larvae	2	5.9	2	0.08	42.25	4.0	14
Copepod nauplii	2	5.9	3	0.1			
Ostracods	1	2.9	1	0.04			
Egg (dia. 0.11mm)	13	38.2	923				
" (dia. 0.32-0.40mm)	4	11.8	279				
Digested unidentifiable food	1	2.9					
Total			2,340				

* : unidentified

Table A-10. continued.

Size range 55.0-59.9 mm TL, n=13, mean length 57.4 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. cristatus	1	7.7	4	0.4	46.46	7.5	9
C. marshallae	5	38.5	22	2.4	25.40	4.1	6
C. plumchrus	3	23.1	6	0.7	11.07	1.8	10
E. bungii bungii	6	46.2	136	14.8	301.11	48.4	2
Pseudocalanus sp.							
adult	10	76.9	556	60.3	54.24	8.7	1
copepodite	7	53.8	86	9.4	2.01	0.3	3
Metridia sp.	5	38.5	17	1.2	6.01	1.0	8
A. longiremis	4	30.8	8	0.9	0.78	0.1	12
Calanus sp. *	3	23.1	4	0.4	8.23	1.3	11
Cyclopoid copepods	7	53.8	57	6.2	0.56	0.09	5
Euphausiids							
adult & juvenile	5	38.5	12	1.3	63.20	10.2	4
furcilia	1	7.7	1	0.1	1.12	0.2	16
Balanidae							
Balanus sp.	1	7.7	1	0.1	0.09	0.02	17
Shrimp	1	7.7	1	0.1	11.82	1.9	13
Crab zoea & megalopa	1	7.7	1	0.1	3.57	0.6	15
Fish larvae	1	7.7	4	0.4	86.50	13.9	7
Pteropoda							
L. helicina	1	7.7	6	0.7	0.14	0.02	14
Appendicularians	4	30.8	39+?				
Egg (dia. 0.11mm)	8	61.5	922				
" (dia. 0.32-0.40mm)	1	7.7	329				
Total			922				

* : unidentified

Table A-10. continued.

Size range 60.0-64.9 mm TL, n=7, mean length 62.8 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Chaetognaths	4	57.1	17	1.7	169.02	23.4	3
Calanoida							
C. marshallae	2	28.6	7	0.7	7.93	1.1	8
C. plumchrus	1	14.3	1	0.1	2.23	0.3	15
E. bungii bungii	5	71.4	201	20.6	408.94	56.7	2
Pseudocalanus sp.							
adult	7	100.0	597	61.1	58.24	8.1	1
copepodite	6	85.7	54	5.5	1.26	0.2	4
Metridia sp.	2	28.6	4	0.4	0.97	0.1	12
A. tumida	1	14.3	3	0.3	1.17	0.2	14
T. discaudatus	1	14.3	18	1.8	3.51	0.5	9
Calanus sp. *	1	14.3	5	0.5	10.03	1.4	11
Cyclopoid copepods	5	71.4	22	2.3	0.21	0.03	6
Amphipods	2	28.6	2	0.2	1.03	0.1	13
Euphausiids							
adult& juvenile	2	28.6	16	1.6	51.02	7.1	5
furcilia	3	42.9	11	1.1	3.69	0.5	7
calyptopis	1	14.3	19	1.9	1.85	0.3	10
Appendicularians	4	57.1	80+?				
Egg (dia. 0.11 mm)	5	71.4	730				
Total			977				

* : unidentified

Table A-10. continued.

Size range 65.0-69.9 mm TL, n=1, length 68.4 mm

Prey	FO	% FO	N	% N	V	% V	IRI
Calanoida							
C. marshallae			1	0.1	0.55	0.8	3
Pseudocalanus sp. adult			663	99.1	68.68	98.1	1
T. discaudatus			3	0.4	0.59	0.9	2
Euphausiids furcilia			2	0.3	0.11	0.2	4
Egg (dia. 0.11 mm)			1,265				
Total			669				

Table A-11. Mean number of prey in juvenile Pacific cod and walleye pollock.

Fish size (TL, mm)	Pacific cod			Walleye pollock		
	No. of prey	No. of fish	No. of prey per fish	No. of prey	No. of fish	No. of prey per fish
15.0 - 29.9	821	12	68	581	20	29
30.0 - 34.9	2898	31	93	1623	24	68
35.0 - 39.9	1711	39	44	6043	64	94
40.0 - 44.9	1491	50	30	6088	79	77
45.0 - 49.9	616	30	21	4146	62	67
50.0 - 54.9	201	23	9	2340	34	69
55.0 - 74.9	63	10	6	2568	21	122

Table A-12. Prey size of juvenile Pacific cod.

Prey	No. of measured prey	Mean	SD	Size range	Measuring part
Calanoida					
C. cristatus	16	6.69	0.50	5.80-7.60	P
C. marshallae	27	2.82	0.34	1.92-3.40	P
C. plumchrus	167	3.72	0.30	2.00-4.32	P
E. bungii bungii	6	4.43	0.27	4.17-4.80	P
Pseudocalanus adult	53	0.92	0.13	0.60-1.30	P
Pseudocalanus copepodite	25	0.74	0.15	0.52-1.00	P
C. abdominalis	4	1.26	0.22	1.00-1.52	P
Metridia sp.	16	1.91	0.42	1.28-2.68	P
A. longiremis	29	0.86	0.11	0.56-1.04	P
A. tumida	2	0.92	0.17	0.80-1.04	P
Cyclopoid	43	0.43	0.07	0.32-0.65	P
Harpacticoid	87	0.93	0.29	0.36-1.60	T
Amphipoda	55	1.92	1.76	0.52-7.00	T
Euphausiid					
juvenile and adult	29	8.38	6.76	4.00-21.50	T
furcilia	14	3.44	1.06	2.20-5.20	T
Balanidae					
Balanus sp.	31	0.66	0.17	0.40-1.04	T
Shrimp	4	11.55	2.69	9.25-15.40	T
Crab zoea	34	2.02	0.86	0.68-4.00	T
Mollusca					
bivalve	5	0.31	0.05	0.26-0.38	T
snail	4	0.63	0.41	0.36-1.24	D
Pteropoda					
L. helicina	85	0.67	0.46	0.16-3.64	D
Fish larva	9	20.9	3.9	15.0-25.0	T
Egg 1				0.11	D
" 2				0.32-0.40	D
" 3				0.19-0.20	D
" 4				0.63	D

* P: prosome length, T: total length, D: diameter

Table A-13. Prey size of juvenile walleye pollock

Prey	No. of measured prey	Mean	SD	Size range	Measuring part
Chaetognath	9	17.8	4.2	9.2-24.0	T
Calanoida					
C. cristatus	12	6.16	0.98	3.60-7.28	P
C. marshallae	214	2.64	0.35	1.56-3.28	P
C. plumchrus	142	3.65	0.40	1.68-4.32	P
E. bungii bungii	296	4.33	0.65	2.00-7.00	P
Pseudocalanus adult	183	0.99	0.10	0.80-1.24	P
Pseudocalanus copepodite	137	0.64	0.07	0.40-0.84	P
C. abdominalis	3	1.68	0.28	1.35-1.84	P
Metridia sp.	51	1.66	0.39	1.00-2.32	P
A. longiremis	113	0.86	0.11	0.64-1.20	P
A. tumida	20	1.34	0.15	1.00-1.60	P
T. discaudatus	8	1.37	0.41	1.04-2.28	P
Cyclopoid	148	0.44	0.01	0.40-0.56	P
Harpacticoid	9	0.83	0.28	0.48-1.40	T
Amphipoda	39	1.64	1.40	0.28-5.60	T
juvenile and adult	51	6.23	2.32	4.00-16.00	T
furcilia	53	2.51	0.79	1.20-4.80	T
calyptopis	4	1.15	0.19	1.00-1.40	T
Balanidae					
Balanus sp.	38	0.61	0.23	0.32-1.80	T
Shrimp	3	10.92	0.66	10.48-11.68	T
Crab zoea	3	1.73	0.99	0.60-2.40	T
Pteropoda					
L. helicina	107	0.41	0.17	0.16-1.20	D
Fish larva	2	16.0		16.0	T
Egg 1				0.11	D
" 2				0.32-0.40	D
" 3				0.19-0.20	D
" 4				0.06	D
Copepod nauplius	15	0.24	0.09	0.12-0.48	T

* P: prosome length, T: total length, D: diameter

Table A-14. Mean weight of prey organism in juvenile Pacific cod and walleye pollock.

Fish size (TL, mm)	Preditor number		Prey number		Food weight		Mean prey weight	
	Cod	Pollock	Cod	Pollock	Cod	Pollock	Cod	Pollock
15.0 - 24.9	1	11	169	271	4.28	21.62	0.008	0.080
25.0 - 29.9	11	10	652	310	36.34	28.62	0.056	0.092
30.0 - 34.9	31	24	2898	1623	179.43	120.22	0.062	0.074
35.0 - 39.9	39	64	1711	6043	341.89	550.35	0.200	0.091
40.0 - 44.9	50	79	1491	6088	696.97	875.26	0.467	0.144
45.0 - 49.9	30	62	616	4146	671.93	1079.30	1.091	0.260
50.0 - 54.9	23	34	201	2340	915.05	773.58	4.552	0.333
55.0 - 59.9	8	13	35	922	372.21	419.23	10.635	0.455
60.0 - 74.9	2	8	28	1646	225.12	388.78	8.040	0.236
Total	195	305	7801	23389	3443.22	4256.96	0.441	0.182

* weight in (mg)

Table A-15. Estimated mean weight of prey organism before digestion in juvenile Pacific cod and walleye pollock.

Fish size (TL, mm)	Preditor number		Prey number		Estimated food weight		Estimated mean prey weight	
	Cod	Pollock	Cod	Pollock	Cod	Pollock	Cod	Pollock
15.0 - 24.9	1	11	169	271	9.37	25.60	0.017	0.094
25.0 - 29.9	11	10	652	310	30.81	49.66	0.047	0.160
30.0 - 34.9	31	24	2898	1623	241.14	250.91	0.083	0.155
35.0 - 39.9	39	64	1711	6043	469.96	796.51	0.275	0.132
40.0 - 44.9	50	79	1491	6088	1148.67	1250.83	0.770	0.205
45.0 - 49.9	30	62	616	4146	1389.90	1507.96	2.256	0.364
50.0 - 54.9	23	34	201	2340	1190.49	1103.53	5.923	0.472
55.0 - 59.9	8	13	35	922	313.26	637.88	8.950	0.692
60.0 - 74.9	2	8	28	1646	274.68	806.74	9.809	0.490
Total	195	305	7801	23389	5176.67	6200.24	0.664	0.265

* Weight in mg

Table A-16. Food weight of juvenile Pacific cod and walleye pollock; body length vs. food weight in mg.

Fish size (TL, mm)	Pacific cod			Walleye pollock		
	N	Food weight (mg)		N	Food weight (mg)	
		Mean	SD		Mean	SD
15.0 - 19.9	-	-	-	2	0.72	0.36
20.0 - 24.9	1	4.28	-	9	2.24	2.91
25.0 - 29.9	11	3.30	0.92	10	2.86	3.11
30.0 - 34.9	31	5.79	3.49	24	5.01	3.48
35.0 - 39.9	39	8.77	6.39	64	8.60	5.38
40.0 - 44.9	50	13.94	9.16	79	11.08	7.65
45.0 - 49.9	30	22.40	16.41	62	17.41	13.07
50.0 - 54.9	23	39.78	29.61	34	22.75	16.25
55.0 - 59.9	8	46.53	54.52	13	32.25	22.49
60.0 - 64.9	1	57.87	-	7	51.60	21.92
65.0 - 69.9	-	-	-	1	27.58	-
70.0 - 74.9	1	167.25	-	-	-	-
Total	195	17.66	23.50	305	13.96	14.05

Table A-17. Food weight of juvenile Pacific cod and walleye pollock; body weight vs. food weight in mg.

Body weight	Pacific cod				Walleye pollock			
	N	Mean fish weight	Food weight Mean	SD	N	Mean fish weight	Food weight Mean	SD
0 - 99	-	-	-	-	14	68.61	1.96	2.37
100 - 199	21	160.26	3.40	1.21	19	151.69	3.31	2.65
200 - 299	32	266.26	6.89	4.89	39	257.62	7.64	5.30
300 - 399	23	344.39	8.83	5.94	58	350.75	8.01	5.02
400 - 499	23	447.09	10.52	7.06	52	450.69	11.77	8.20
500 - 599	21	541.99	13.29	7.94	35	546.24	15.44	9.57
600 - 699	15	652.54	19.19	13.09	28	647.62	18.20	12.05
700 - 799	15	732.93	17.20	12.93	21	751.96	22.04	14.48
800 - 899	10	854.45	25.35	11.64	11	863.17	18.28	11.78
900 - 999	14	947.79	49.92	33.42	9	950.16	27.28	23.85
1000 - 1199	12	1087.76	28.82	17.63	6	1071.47	46.38	21.82
1200 - 1399	3	1324.40	54.97	40.52	7	1280.69	42.62	22.73
1400 - 1599	3	1523.07	60.62	84.42	2	1527.50	49.01	31.49
1600 - 1799	2	1740.05	34.46	33.11	2	1753.30	31.18	14.55
1800 - 1999	-	-	-	-	2	1848.75	47.73	28.50
2000 - 4000	1	3102.80	167.25	-	-	-	-	-

Table A-18. Proportional Similarity of food between juvenile Pacific cod and walleye pollock.

a) Proportional similarity of food by size group

Fish size (TL, mm)	Sample size		PS by number	PS by volume
	Cod	Pollock		
15.0-29.9	12	21	0.55	0.42
30.0-34.9	31	24	0.69	0.58
35.0-39.9	39	64	0.41	0.46
40.0-44.9	50	79	0.18	0.36
45.0-49.9	30	62	0.25	0.31
50.0-54.9	23	34	0.17	0.41
55.0-74.9	10	21	0.04	0.19
Total	195	305	0.45	0.37

b) Proportional similarity of food by station

Station	Sample size		PS by number	PS by volume
	Cod	Pollock		
A	48	47	0.35	0.55
B	23	30	0.15	0.19
C	17	30	0.72	0.57
D	43	60	0.17	0.06
E	15	40	0.58	0.15

Table A-19. Proportional Similarity of food between the fishes of different size ranges in juvenile Pacific cod.

PS by volume

Fish size (TL, mm)	Fish size (TL, mm)							
	20.0-29.9	30.0-34.9	35.0-39.9	40.0-44.9	45.0-49.9	50.0-54.9	55.0-59.9	60.0-74.9
20.0-29.9		0.55	0.29	0.08	0.05	0.03	0.02	0
30.0-34.9	0.72		0.42	0.24	0.14	0.11	0.05	0
35.0-39.9	0.64	0.60		0.44	0.33	0.28	0.10	0.02
40.0-44.9	0.34	0.38	0.63		0.45	0.32	0.15	0.03
45.0-49.9	0.23	0.21	0.37	0.37		0.66	0.31	0.22
50.0-54.9	0.08	0.09	0.21	0.29	0.53		0.68	0.29
55.0-59.9	0.03	0.04	0.07	0.14	0.26	0.28		0.32
60.0-74.9	0.03	0.04	0.06	0.11	0.41	0.29	0.23	

Fish size (TL, mm)

PS by number

Table A-20. Proportional Similarity of food between the fishes of different size ranges in juvenile walleye pollock.

PS by volume

Fish size (TL, mm)	15.0-24.9	25.0-29.9	30.0-34.9	35.0-39.9	40.0-44.9	45.0-49.9	50.0-54.9	55.0-59.9	60.0-64.9
15.0-24.9		0.37	0.19	0.18	0.15	0.10	0.11	0.04	0.02
25.0-29.9	0.78		0.58	0.53	0.44	0.31	0.25	0.16	0.08
30.0-34.9	0.45	0.53		0.82	0.71	0.56	0.46	0.33	0.17
35.0-39.9	0.37	0.44	0.78		0.80	0.63	0.52	0.31	0.19
40.0-44.9	0.44	0.51	0.79	0.86		0.77	0.61	0.34	0.19
45.0-49.9	0.48	0.56	0.82	0.77	0.82		0.77	0.48	0.25
50.0-54.9	0.48	0.55	0.78	0.73	0.74	0.89		0.56	0.32
55.0-59.9	0.23	0.29	0.68	0.53	0.52	0.63	0.66		0.47
60.0-69.9	0.08	0.11	0.33	0.28	0.26	0.30	0.32	0.47	

Fish size (TL, mm)

PS by number

Table A-21. Prey of juvenile Pacific cod at five designated sampling stations; percent frequency of occurrence (%FO), percent number (%N), and percent volume (%V).

	% FO				
Station	A	B	C	D	E
Sample size	48	23	17	43	15
Chaetognaths	-	-	-	2.3	-
Calanoida					
C. cristatus	35.4	-	-	-	-
C. marshallae	-	21.7	5.9	-	-
C. plumchrus	100.0	4.3	11.8	-	-
E. bungii bungii	2.1	-	17.6	-	-
Pseudocalanus sp.					
adult	4.2	-	94.1	37.2	20.0
copepodite	4.2	-	52.9	14.0	6.7
C. abdominalis	-	-	29.4	-	-
Metridia sp.	-	-	5.9	2.3	46.7
A. longiremis	2.1	-	64.7	16.3	13.3
Cyclopoid copepods	-	-	58.8	48.8	13.3
Harpacticoid copepods	54.2	-	-	2.3	-
Amphipods	4.2	4.3	23.5	32.6	66.7
Euphausiids					
juvenile and adult	2.1	30.4	11.8	-	-
furcilia	2.1	21.7	11.8	2.3	-

-- continued --

Table A-21. (continued).

	% FO				
Station	A	B	C	D	E
Sample size	48	23	17	43	15
Balanidae					
Balanus sp.	-	-	23.5	41.9	13.3
Shrimp	-	-	-	11.6	-
Crab zoea/megalopa	-	13.0	-	34.9	20.0
Pteropoda					
L. helicina	-	-	23.5	55.8	26.7
Fish larvae	-	65.2	-	-	13.3
Egg 1 (dia. 0.11 mm)	-	-	76.5	9.3	6.7
" 2 (dia. 0.19-0.20 mm)	-	-	-	4.7	-
" 3 (dia. 0.32-0.40 mm)	-	-	-	2.3	13.3

Table A-21. (continued).

	% N				
Station	A	B	C	D	E
Sample size	48	23	17	43	15
Calanoida					
C. cristatus	3.6	-	-	-	-
C. marshallae	-	10.2	0.04	-	-
C. plumchrus	65.8	2.0	0.2	-	-
E. bungii bungii	0.2	-	1.5	-	-
Pseudocalanus sp.					
adult	0.4	-	47.0	2.2	-
copepodite	0.4	-	35.9	2.3	0.2
C. abdominalis	-	-	0.6	-	-
Metridia sp.	-	-	0.04	0.04	1.7
A. longiremis	0.2	-	11.0	0.6	0.8
Cyclopoid copepods	-	-	2.0	19.2	72.8
Harpacticoid copepods	19.6	-	-	0.04	-
Amphipods	0.6	4.1	0.1	3.5	5.8
Euphausiids					
juvenile and adult	0.2	14.3	0.3	1.1	0.6
furcilia	0.2	12.2	0.07	0.04	-
Balanidae					
Balanus sp.	-	-	0.2	1.0	0.4
Shrimp	-	-	-	1.0	-
Crab zoea/megalopa	-	24.5	-	3.9	2.3
Pteropoda					
L. helicina	-	-	0.6	64.7	12.0
Fish larvae	-	32.7	-	-	0.8

Table A-21. (continued)

	% V				
Station	A	B	C	D	E
Sample size	48	23	17	43	15
Calanoida					
C. cristatus	20.25	-	-	-	-
C. marshallae	-	0.6	0.4	-	-
C. plumchrus	73.64	0.1	5.1	-	-
E. bungii bungii	0.16	-	27.3	-	-
Pseudocalanus sp.					
adult	0.02	-	41.9	0.6	0.1
copepodite	0.004	-	3.2	0.1	0.006
C. abdominalis	-	-	1.0	-	-
Metridia sp.	-	-	0.07	0.05	1.6
A. longiremis	0.007	-	9.8	0.1	0.2
Cyclopoid copepods	-	-	0.2	0.5	0.1
Harpacticoid copepods	0.75	-	-	-	-
Amphipods	0.07	0.5	0.4	15.1	27.3
Euphausiids					
juvenile and adult	0.17	34.5	6.5	14.6	4.2
furcilia	0.08	0.3	0.2	0.02	-
Balanidae					
Balanus sp.	-	-	0.2	0.2	0.05
Shrimp	-	-	-	48.7	-
Crabzoea/megalopa	-	3.9	-	15.8	16.5
Pteropoda					
L. helicina	-	-	0.1	3.9	0.4
Fish larvae	-	60.1	-	-	47.8

Table A-22. Prey of juvenile walleye pollock at five designated sampling stations; percent frequency of occurrence (%FO), percent number (%N), and percent volume (%V).

	% FO				
Station	A	B	C	D	E
Sample size	47	30	30	60	40
Chaetognaths	2.1	30.0	3.3	10.0	5.0
Calanoida					
C. cristatus	10.6	-	3.3	5.0	10.0
C. marshallae	-	83.3	6.7	6.7	15.0
C. plumchrus	78.7	3.3	13.3	25.5	12.5
E. bungii bungii	6.4	-	93.3	70.0	15.0
Pseudocalanus sp.					
adult	23.4	53.3	100.0	93.3	27.5
copepodite	8.5	13.3	96.7	91.7	12.5
Metridia sp.	-	-	10.0	16.7	45.0
T. discaudatus	-	-	3.3	-	-
A. longiremis	4.3	13.3	3.3	31.7	-
A. tumida	2.1	3.3	40.0	-	-
Copepod nauplii	-	-	-	3.3	12.5
Cyclopoid copepods	19.1	16.7	53.3	98.3	30.0
Amphipods	-	6.7	6.7	3.3	10.0
Euphausiids					
juvenile and adult	-	30.0	13.3	23.3	57.5
furcilia	-	60.0	10.0	16.7	-

-- continued --

Table A-22. (continued).

% FO

Station	A	B	C
Sample size	47	30	30
Balanidae			
Balanus sp.	-	-	36.7
Pteropoda			
L. helicina	-	3.3	6.7
Appendicularians	-	3.3	-
Fish larvae	-	13.3	-
0.11 mm)	4.3	13.3	100.0
0.19-0.20 mm)	-	3.3	-
0.32-0.40 mm)	-	-	6.7

D	E
60	40
20.0	2.5
35.0	10.0
86.7	7.5
1.7	2.5
86.7	12.5
3.3	5.0
18.3	12.5

Table A-22. (continued).

	% N				
Station	A	B	C	D	E
Sample size	47	30	30	60	40
Chaetognaths	0.4	3.3	0.03	0.06	0.08
Calanoida					
C. cristatus	1.1	-	0.03	0.03	0.3
C. marshallae	-	24.8	0.2	0.3	1.0
C. plumchrus	31.5	0.5	0.2	0.4	1.1
E. bungii bungii	0.9	-	9.3	8.1	0.4
Pseudocalanus sp.					
adult	9.7	32.2	53.9	29.9	3.3
copepodite	1.1	3.5	31.0	11.3	0.4
Metridia sp.	-	-	0.4	0.2	3.4
T. discaudatus	-	-	0.1	-	-
A. longiremis	7.9	1.5	0.03	0.4	3.2
A. tumida	0.2	0.6	0.7	-	-
Cyclopoid copepods	44.7	1.8	2.5	45.7	81.8
Amphipods	-	0.8	0.06	0.03	0.2
Euphausiids					
juvenile and adult	-	2.3	0.2	0.3	2.1
furcilia	-	27.1	0.2	0.2	-
Balanidae					
Balanus sp.	-	-	0.7	0.2	0.04
Pteropoda					
L. helicina	-	0.6	0.06	1.4	0.04
Fish larvae	-	1.8	-	0.01	0.04

Table A-22. (continued).

Station	A	B
Sample size	47	30
Chaetognaths	2.5	39.3
Calanoida		
C. cristatus	12.9	-
C. marshallae	-	17.4
C. plumchrus	79.3	0.2
E. bungii bungii	0.5	-
Pseudocalanus sp.		
adult	0.8	2.0
copepodite	0.02	0.05
Metridia sp.	-	-
T. discaudatus	-	-
A. longiremis	0.7	0.01
A. tumida	0.07	0.06
Cyclopoid copepods	0.4	0.01
Amphipods	-	1.2
Euphausiids		
juvenile and adult	-	11.4
furcilia	-	3.5
Balanidae		
Balanus sp.	-	-
Pteropoda		
L. helicina	-	0.02
Fish larvae	-	24.9

% V		
C	D	E
30	60	40
0.9	3.1	2.9
0.4	1.4	19.5
1.4	1.0	6.3
1.2	3.6	15.2
64.3	64.0	3.7
21.8	11.1	1.6
3.0	1.0	0.04
1.1	0.1	6.8
0.1	-	-
0.01	0.2	1.6
1.2	-	-
0.1	1.7	4.0
0.05	0.01	4.0
1.5	2.7	28.8
0.3	0.3	-
0.3	0.07	0.02
0.006	0.1	0.005
-	1.0	4.5