UNITED STATES DEPARTMENT OF THE INTERIOR
FISHERIES ASSISTANCE OFFICE
U.S. FISH AND WILDLIFE SERVICE
OLYMPIA, WASHINGTON

AN EXAMINATION OF THE FOOD HABITS OF JUVENILE CHUM AND CHINOOK SALMON IN HYLEBOS WATERWAY

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by

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INTRODUCTION

Commencement Bay is a highly developed deep-water port in southern Puget Sound. Major tributaries to the bay include the Puyallup River, Hylebos Creek and Wapato Creek. These streams support runs of Pacific salmon and steelhead of both hatchery and wild origin. Because of its high degree of development and the importance of anadromous fishery resources to the Pacific northwest, the U.S. Fish and Wildlife Service (FWS) has carefully reviewed applications for development permits which entail further losses or degradation of intertidal and shallow subtidal habitat in Commencement Bay. It has been estimated (Bortleson et al, 1980)that approximately 4275 acres of wetlands have been lost from this bay in the last 100 years leaving some 225 acres of remanent wetlands (Shapiro and Associates, Inc., 1980). Shallow estuarine and marine shorelines have been shown to be important feeding areas for juvenile salmonids (Healey, 1979; Fresh et al, 1979; Simenstad et al, 1980) and it is suspected that they provide refuge from predators.

The Port of Tacoma has proposed the development of a marina and marine terminal on 95 acres of tide lands in Hylebos Waterway, which is located in the eastern portion of Commencement Bay. The FWS and Puyallup Tribe opposed these permits because of their probable negative impact on foraging opportunities of anadromous fish. However, little information was available regarding the availability of salmonid prey resources at the Hylebos sites. Therefore, FWS surveyed the epibenthic faunal community at two sites in Hylebos Waterway during 1978 (Meyer and Vogel, 1978). This survey indicated the presence of appreciable quantities of invertebrates which are believed to be salmonid prey. Again, no specific information regarding food habits of juvenile salmonids was available for Commencement Bay or the Hylebos site to confirm the importance of the invertebrates noted.

In order to determine if the invertebrate species detected at the Hylebos sites were being preyed upon and if salmonids were even utilizing the area, additional studies were initiated in 1979 in cooperation with Puyallup Tribal fisheries pesonnel.

METHODS AND MATERIALS

Juvenile salmonids were sampled at six sites in Commencement Bay from mid-May to mid-September, 1979 (Figure 1). Samples were collected with a beach seine which measured 18 meters (60 feet) in length and 2 meters (6 feet) in depth with a mesh size of 3 millimeters (1/8 inch). Use of a beach seine restricted sampling to smooth bottom sites. Seining in Hylebos Waterway was conducted at approximately weekly intervals except during the last

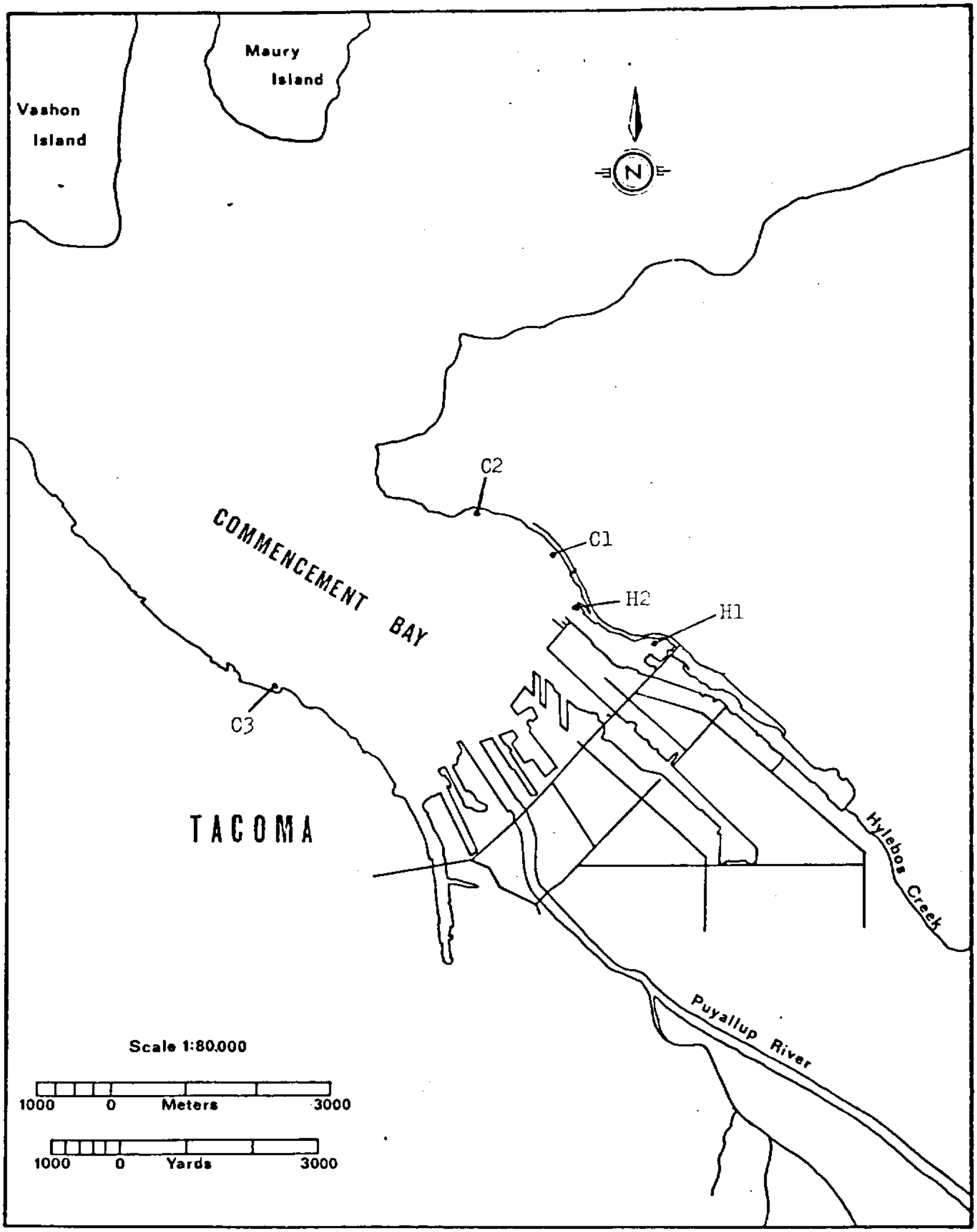

Figure 1. Commencement Bay, Washington and beach seine sampling sites used in 1979.

week in May and first week in June when sampling effort was increased in an attempt to recover florescent pigment, marked chums released by the Puyallup Tribe. Samples were collected at other sites in Commencement Bay irregularly.

A random sample of up to five fish of each salmonid species was retained for stomach analysis and preserved in 10% formalin. Occasionally, potential salmonid predators were also preserved for stomach analysis.

Laboratory procedures consisted of severing the stomach at the esophagus and intestine and removing it from the fish carcass. Adhering tissue was cut away, the stomach botted dry, and weighed to the nearest milligram.. The stomach was then opened and percent fullness estimated. Stomach contents were sorted and identified to the lowest taxonomic category practicable considering the stage of digestion, the state of the taxonomic literature, time constraints, and ease of identification (ie, extensive micro-dissection techniques were not employed). The number, weight and life history stage of the prey in each taxonomic category was recorded. When it was available, a Mettler PC 440 balance was used to determine prey weights in milligrams. At other times, prey weights were not determined. The percent digestion of the stomach contents was also estimated.

Predator and prey information was recorded on key punch forms using the Marine Ecosystems Analysis Program format. Those samples containing prey weight data were then analyzed using the Index of Relative Importance (IRI) developed by Pinkas et al. (1971) and modified by Simenstad and Kinney (1978). IRI diagrams and tables simultaneously display the frequency of occurence of important items, their percent of the total weight, and percentage contribution to the total number of individual items in the diet. IRI figures were computed using a computer program developed by Larry Gales and Charlês Simenstad of the University of Washington, Fisheries Research Institute (FRI).

RESULTS AND DISCUSSION

Juvenile chum salmon were present in appreciable quantities in Hylebos Waterway on the first sampling date of May 10, declining thereafter through June (Table 1). Chums were captured on eight of 22 sample dates at the inner Hylebos site (H1) and 10 of 23 at the outer site (H2). The overall pattern of declining abundance after the first sampling date probably indicated that sampling started at or after the peak of chum migration through the Hylebos sites. Sampling at other Commencement Bay sites was initiated too late to define any chum timing characteristics.

Juvenile chinook were present in the Hylebos Waterway from mid-May through mid-August (Table 2). They appeared more consistently than chums in Hylebos samples, occurring in 12 of 22 and 15 of 23 sample dates at the inner and outer Hylebos sites, respectively. Besides their longer period of presence in Hylebos and Commencement Bay, they also peaked in abundance at a later date (early June).

Other salmonids captured in this study were cutthroat and rainbow trout, dolly vardon, and coho salmon. These species were captured in much smaller numbers and little can be said regarding their timing or use of the area.

Occasionally, hatchery fish which had been tagged with coded-wire tags and marked by removal of the adipose fin, were included in the subsample preserved for stomach analysis. One coho and 20 marked chinook were captured. Of these, the coho and 13 chinook were released from the Washington Department of Fisheries (WDF) Voights Creek Hatchery, a Puyallup system facility. Six of the remaining chinook had been released from the WDF Sooes Creek Hatchery on the Green River and one originated from the WDF Issaquah Creek Hatchery on Lake Sammamish.

Data from thirty-six chum stomachs included prey biomass, frequency of occurence, and abundance information necessary for computing Index of Relative Importance (IRI) diagrams (Figure 2). Food habits of these fish revealed strong dominance of epibenthic invertebrates, particularly harpacticoid copepods. Epifauna comprised 81% of their total IRI with harpacticoids contributing 64% of this amount and gammarid amphipods comprising another 16%. Pelagic calanoid copepods made up 9% of the IRI and chironomid insects contributed 6%.

The limited comparable data from different sites indicated few obvious diet differences (Table 3). Harpacticoids were very important at all sites. Gammarid amphipods and dipteran insects were also consumed at each site in variable but appreciable quantities.

Thirty-two chinook samples contained data sufficient to compute IRI values. This subsample, which was comprised primarily of fish from sites other than Hylebos, indicated that gammarid amphipods and aphids were consumed most frequently, followed by various stages of decopod crustaceans, and dipterans including nematoceran insects (Figure 3). However, relatively large decapod crustaceans were consumed in greater numbers than any other prey and contributed 53% of the total IRI. Nematoceran insects contributed 15% of the IRI, while contribution of the gammarid amphipod, Calliopius sp. was 7%, various other gammarids 7%, and calanoid copepods 5%.

Too few chinook stomachs from sites C1,C2 and C3 were analyzed to yield information regarding differences in food habits between areas or habitats. However, samples from the Hylebos sites during June and July (the months when they were most prevalent in the study area) indicate heavy usage of dipteran insects and gammarid amphipods (Table 4). Pelagic decapod crustaceans only occurred during the month of June in 18% of the chinook sampled at the outer Hylebos site. Homopteran insects made variable but significant contributions to the diet.

SUMMARY AND CONCLUSIONS

Beach seine sampling during late spring and summer of 1979, confirmed utilization of shallow nearshore areas in Hylebos Waterway by juvenile chum and chinook salmon. Juvenile coho salmon and cutthroat trout were also present in the area, although utilization is probably less frequent. The Hylebos sites appear to be utilized by juvenile salmonids from Commencement Bay tributaries as well as other Puget Sound streams. Our sampling indicated use by fish originating as far away as Issaquah Creek on Lake Sammamish.

Although samples of chum utilizing Hylebos Waterway prior to May 10 were not collected, food habits of fish captured after this date were heavily weighted toward epibenthic invertebrates, particularly harpacticoid copepods. Another important epibenthic prey group was gammarid amphipods. Both these groups are present in the soft mud substrate found at the Hylebos sites. Aquatic and terrestial insects also made significant contributions to the diet. The chironomid insects were of particular importance. These aquatic insects are epibenthic in their larval and pupal stages while the adult form is available during emergence or at the end of the life cycle as it falls back to the water's surface. Although different chironomid species occur in marine, estuarine and freshwaters, we were not able to distinguish which of these forms was occurring in Commencement Bay fish stomachs. Limited sampling at other sites in Commencement Bay indicate a similar prey spectrum among chums.

Food habit data from a subsample of chinook captured in this study revealed substantial utilization of pelagic juvenile stages of decapod crustaceans and terrestial insects. However, examination of chinook stomachs captured at the Hylebos sites indicated much greater utilization of chironomid insects and gammarid amphipods with little predation on pelagic prey. These differences may be attributable to between sample variability or other factors such as differences in the size of chinook captured at the Hylebos site and/or prey availability.

Food habit data presented in this report is very limited in scope. Food habits are known to change with increasing predator size, season, habitat, prey availability and decreasing light intensity. Differences also occur between years. The information available from this survey is sufficient to confirm that juvenile salmonids in Hylebos Waterway do utilize the epibenthic invertebrates found in the soft mud bottom. Detailed studies are needed to describe temporal, spatial, and diet variability in salmonid food habits throughout Commencement Bay.

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Table 1. Mean catch per beach seine set of juvenile chum salmon in Commencement Bay during May-September, 1978.

Date	H1	H2	H3	C1	C2	C3
May 10	-	10.0	-	-	-	-
17	25.0	8.0	5.5	8.0	-	-
21	3.5	6.0	2.0	-	-	-
22	12.5	.6	2.0	-	-	-
24	0	0	0	-	-	-
29	0	0	.3	0	8.6	-
30	7.5	0	2.3	17.0	-	-
31	1.0	1.0	0	0	-	-
Jun 1	.5	.5	2.5	2.0	5.0	-
4	0	1.0	1.0	3.0	50.0	3.0
6	.5	.5	1.0	11.0	0	-
13	0	0	0	7.0	1.0	0
15	0	10.0	65.0	7.0	1.0	2.0
19	1.0	0	0	1.0	0	-
29	0	0	0	0	2.0	-
Jul 3	0	3.0	-	-	0	0
13	0	0	0	0	0	0
17	0	0	-	0	1.0	-
27	0	0	0	0	0	0
Aug 1	0	0	0	0	0	0
13	0	0	0	-	0	-
28	0	0	0	0	0	-
Sep 12	0	0	0	0	0	0

Table 2. Mean Catch per beach seine set of juvenile chinook salmon in Commencement Bay during May - September, 1978.

Date		H1	H2	H3	C1	C2	C3
May	10	-	0	-	-	-	-
	17	0	3.0	0	2.5	-	-
	21	0	2.5	2.0	-	-	-
	22	0	7.5	2.0	-	-	-
	24	0	9.5	3.0	-	-	-
	29	0	4.0	5.0	2.0	.3	-
	30	3.5	9.0	9.3	10.5	-	-
	31	3.3	6.0	1.0	0	-	-
Jun	1	1.5	3.5	3.5	7.6	3.0	-
	4	2.0	5.0	2.0	47.0	250.0	15.0
	6	39.5	15.0	1.0	100.0	32.0	-
	13	7.0	1.0	3.0	63.0	4.0	4.0
	15	2.0	0	4.0	77.0	24.0	31.0
	19	5.0	10.0	9.5	21.0	0	-
	29	1.0	0	7.0	4.0	7.0	-
Jul	3	4.0	6.0	-	-	4.0	1.0
	13	0	1.0	1.0	4.0	7.0	0
	17	3.0	0	-	1.0	4.0	-
	27	0	-	.3	0	0	2.0
Aug	1	2.0	0	.5	5.0	3.0	0
	13	0	1.0	0	-	2.0	-
	0	0	0	0	0	0	-
Sep	0	0	0	0	0	0	0

Table 3. Frequency of occurrance and mean number of five most commonly consumed chum prey species at four sites in Commencement Bay.

Site	Prey	% Frequency of Occurrence	Mean Number
Inner Hylebos (H1)	Harpacticoids	86	119.0
	Corophium sp.	71	2.7
	Homoptera	43	2.8
	Camella vulgaris	43	.5
	Diptera	29	.5
Outer Hylebos (H2)	Harpacticoids	92	148.3
	Gammarid amphipods	77	23.2
	Chironomids	46	1.2
	Calanoids	31	33.4
	Corophium sp.	23	.7
Tyee Marina (C1)	Harpacticoids	78	15.7
	Corophium sp.	78	1.2
	Nematocera	78	.7
	Chironomids	67	1.4
	Gammarid amphipod	44	.7
Ruston Way (C3)	Harpacticoids	100	101.6
	Chironomids	100	25.2
	Diptera	100	6.6
	Gammarid amphipods	73	3.8
	Allorchestes sp.	55	2.8

Table 4. Frequency of occurrence and mean number of five most commonly consumed chinook prey species at two Hylebos sites in Commencement Bay.

Month	Site	Prey	% Frequency of Occurrence	Mean Number
June	Inner Hylebos (H1)	Chironomids	81	3.1
		Gammarid amphipods	75	2.6
		Diptera	69	7.9
		Corophium sp.	63	5.4
		Cumella vulgaris	56	28.4
June	Outer Hylebos (H2)	Diptera	59	3.4
		Chironomids	50	1.0
		Corophium sp.	32	.7
		Homoptera	27	.7
		Decapoda	18	4.3
July	Inner Hylebos (H1)	Chironomids	71	8.6
		Homoptera	71	8.1
		Corophium sp.	57	8.7
		Diptera	57	2.3
		Gammarid amphipods	43	3.1
July	Outer Hylebos (H2)	Diptera	100	14.1
		Gammarid amphipods	91	13.5
		Harpacticoids	64	3.1
		Homoptera	55	7.5
		Calliopius sp.	45	17.4

PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	75.00	58.53	33.17	6877.5	64.14
GAMMARIDEA	61.11	7.04	14.75	1331.6	12.42
DIPTERA-CHIRONOMIDAE	55.56	5.61	5.34	619.8	5.78
CALANOIDA	38.89	18.34	5.96	945.0	8.81
DIPTERA	33.33	2.09	4.86	231.9	2.16
COROPHIUM SP.	33.33	.36	.77	37.9	.35
NEMATOCERA	30.56	1.90	4.43	193.5	1.80
CUMELLA VULGARIS	25.00	.33	.14	11.6	.11
APHIDIDAE	19.44	.42	.68	21.4	.20
ALLORCHESTES ANGUSTUS	16.67	.59	6.83	123.7	1.15
AMPHIPODA-HYPERIIDEA	16.67	.35	.82	19.4	.18
CALLIOPIUS UNDESCR. SP.	13.89	1.88	16.71	258.2	2.41
COPEPODA	13.89	.40	.08	6.7	.06
COROPHIUM INSIDIOSUM	11.11	.10	.20	3.3	.03
CERCOPIDAE	11.11	.08	.06	1.5	.01
CYCLOPOIDA	8.33	.17	.05	1.8	.02
EOGAMMARUS CONFERVICOLUS	8.33	.06	.19	2.0	.02
CORYCAEUS ANGLICUS	8.33	.08	.05	1.0	.01
HYALE PLUMULOSA	8.33	.08	.34	3.5	.03
AETIDIUS ARMATUS	8.33	.36	.49	7.2	.07
COROPHIUM ASCHERUSICUM	5.56	.06	.63	3.8	.04
PSYLLIDAE	5.56	.06	.31	2.0	.02
PHOTIS BREVIPES	5.56	.04	.03	.4	.00
NEMATODA	5.56	.08	.03	.6	.01
PLEOCYEMATA-CARIDEA	5.56	.08	.03	.6	.01
INSECTA	5.56	.08	.03	.6	.01
OSTEICHTHYES	5.56	.15	2.02	12.1	.11

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

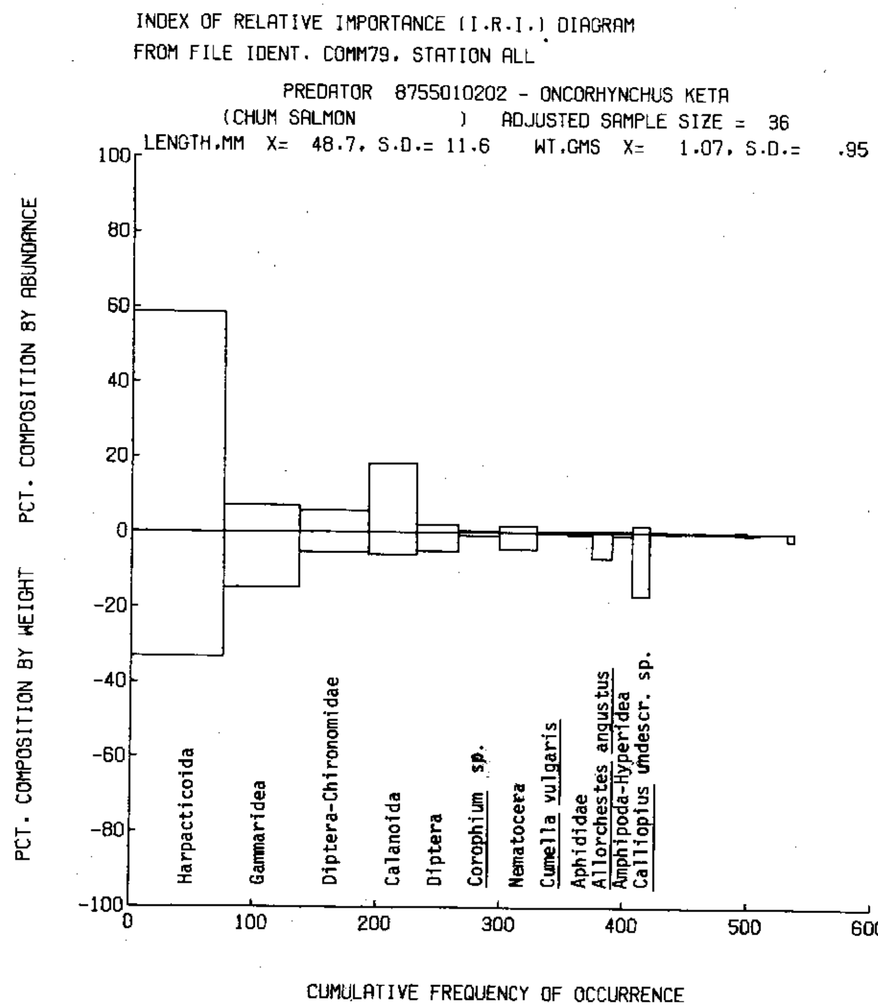

FIGURE 2. IRI diagram and table showing major prey of juvenile chum in Commencement Bay, May - September, 1979.

PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	53.13	6.34	1.85	419.2	6.55
APHIDIDAE	53.13	2.35	1.25	217.7	3.40
DECAPODA	43.75	22.18	55.64	3404.7	53.20
DIPTERA	37.50	2.00	.53	94.6	1.48
NEMATOCERA	37.50	19.34	5.03	932.7	14.57
HARPACTICOIDA	31.25	2.51	.05	79.9	1.25
CALANOIDA	31.25	9.58	1.42	343.7	5.37
DIPTERA-CHIRONOMIDAE	28.13	1.03	.36	39.0	.61
COROPHIUM SP.	21.88	.74	.21	20.9	.33
CALLIOPIUS UNDESCR. SP.	21.88	11.92	7.61	427.0	6.67
COROPHIUM SPINICORNE	15.63	.40	.59	15.4	.24
DECAPODA-BRACHYURA	15.63	3.19	5.63	137.8	2.15
FORMICIDAE	15.63	1.25	1.13	37.3	.58
STAPHYLINIDAE	12.50	.29	.11	4.9	.08
CYCLOPOIDA	12.50	.29	.06	4.4	.07
AMPHIPODA	12.50	.46	.02	5.9	.09
HEMIPTERA	12.50	1.71	2.69	55.0	.86
EPHYDRIDAE	12.50	.29	.20	6.1	.10
EOGAMMARUS CONFERVICOLUS	12.50	.51	1.41	24.1	.38
COPEPODA	9.38	.37	.06	9.6	.15
PAGURIDAE	9.38	.51	.44	9.0	.14
ARANEAE	9.38	.34	.30	6.0	.09
INSECTA	9.38	.29	.11	3.7	.06
CUMELLA VULGARIS	9.38	.29	.01	2.8	.04
DOLICHOPODIDAE	9.38	.23	.78	9.5	.15
CERCOPIDAE	9.38	.17	.01	1.7	.03
PSYLLIDAE	9.38	.34	.15	4.6	.07
ANISOGAMMARUS PUGETTENSIS	6.25	.11	.10	1.3	.02
COROPHIUM INSIDIOSUM	6.25	.11	.10	1.4	.02
HYALE PLUMULOSA	6.25	.34	1.46	11.3	.18
DIPTERA-BRACHYCERA	6.25	.29	.20	3.0	.05
COLEOPTERA	6.25	.11	.15	1.6	.03
COROPHIUM SALMONIS	6.25	.17	.44	3.8	.06
HYMENOPTERA	6.25	.29	.01	1.8	.03
INSECTA-LEPIDOPTERA	6.25	.11	.05	1.0	.02
OSTEICHTHYES	6.25	.11	.15	1.7	.03
HOLMESIELLA ANOMALA	3.13	.06	2.19	7.0	.11
CUMACEA	3.13	2.51	.49	9.4	.15
EUCARIDA-DECAPODA-BRACHYRHYNCH	3.13	2.35	4.73	23.7	.37

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
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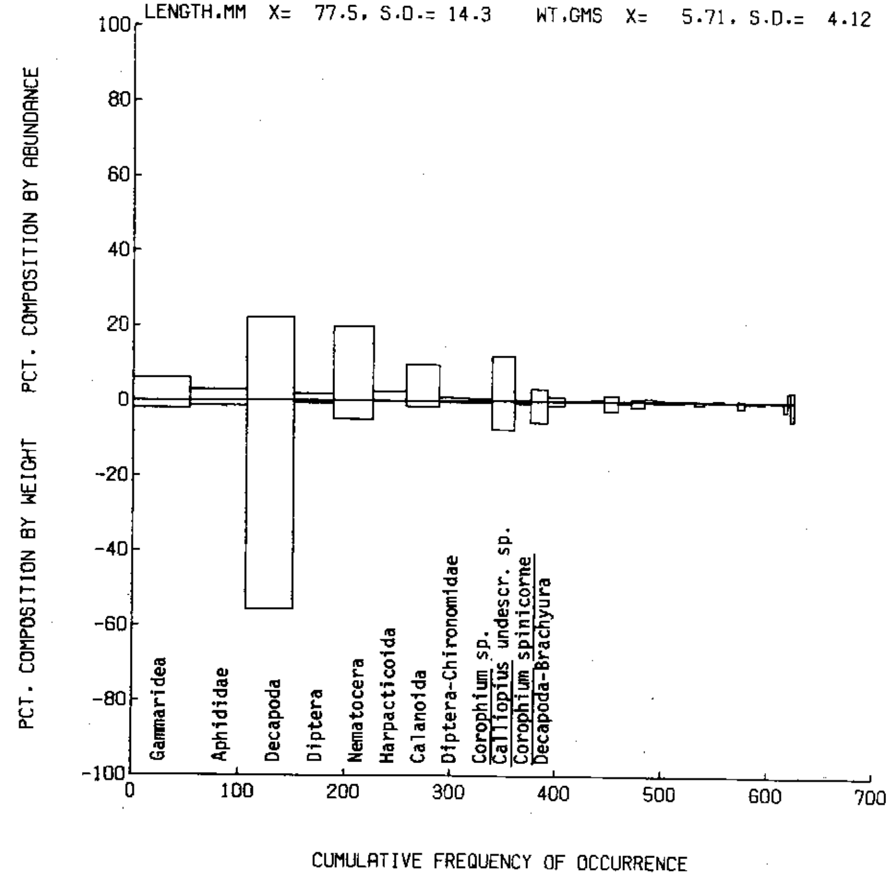

FIGURE 3. IRI diagram and table showing major prey of juvenile chinook in Commencement Bay, May - September, 1979.