UNIVERSITY OF ALASKA SEA GRANT COLLEGE PROGRAM

A Guide to Marine Prey of Juvenile Salmon

by Judy McDonald Paul

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INTRODUCTION

Salmon ranching is becoming a major component of Alaska's fishing industry. Currently, this endeavor relies on producing as many fry as possible at a hatchery in hopes of producing high numbers of returning fish. As hatcheries become more efficient and numerous, this mass production approach could produce more fish than local food webs are able to successfully support. In the future salmon aquaculturists, like terrestrial ranchers, will have to place limits on the number of animals released into their common property range, the ocean. Ultimately, the ability of food webs to support different numbers and species of salmon near each hatchery will have to be estimated. The first step in determining productivity in an area is to identify the types and abundance of prey eaten by salmon fry. The information currently available on the food of North Pacific salmon fry appears in a variety of scientific publications which are difficult to obtain. The objective of this report is to summarize some of these scientific papers for Alaskan salmon ranchers. The report consists of a compilation of abstracts, or summaries, and data tables from pertinent papers on salmon fry feeding. To facilitate identification of prey species noted in this report, illustrations of the prey types are included.

Bailey, Jack E., Bruce L. Wing, and Chester R. Mattson.

1975. Zooplankton abundance and feeding habits of fry of pink salmon, *Oncorhynchus gorbuscha*, and chum salmon, *Oncorhynchus keta*, in Traitors Cove, Alaska, with speculations on the carrying capacity of the area. *Fishery Bulletin* 73:4:846-861.

ABSTRACT

Juvenile pink salmon, *Oncorhynchus gorbuscha*, and chum salmon, *O. keta*, 28 to 56 mm long (fork length) from Traitors River in southeastern Alaska, fed little in freshwater but fed heavily in the estuary, mainly on pelagic zooplankters. Fry did not feed on cloudy moonless nights. The rate of evacuation of pink salmon stomachs ranged from 6 h at 12.8°C to 16 h at 8.5°C. The abundance of zooplankton ranged from 9 to 154 organisms per liter and quantitatively did not change noticeably while fry were in the estuary. In 1964, 1965, and 1966, the estimated numbers of fry in Traitors Cove were 7, 1, and 4 million, respectively. An attempt was made to estimate the carrying capacity of Traitors Cove, using food consumption and evacuation rates in conjunction with estimates of standing crop of zooplankton. It was concluded that 50 to 100 million additional fry from hatcheries would probably exceed the carrying capacity of the estuary.

Table 1. Zooplankters and other organisms from stomachs of 140 pink salmon fry (length, 28 to 56 mm) collected in daylight and 30 (length 31 to 58 mm) collected at night in Traitors Cove, 1964-66; and percentage relative importance by volume

Item	Collected in daylight: Percentage stomachs containing item	Collected in daylight: Mean items per stomach (Number)	Collected in daylight: Mean items per stomach (Percent)	Collected in daylight: Percentage relative importance by volume[a]	Collected at night: Percentage stomachs containing item	Collected at night: Mean items per stomach (Number)	Collected at night: Mean items per stomach (Percent)	Collected at night: Percentage relative importance by volume[a]
Diatoms	32	3.3	3	+	26	0.4	2	+
Rotifers	15	4.0	3	+	0	0.0	0	0
Bryozoans (cyphonautes)	2	0.0	0	+	0	0.0	0	0
Gastropods (veligers)	12	0.5	0	+	3	0.1	1	+
Pelecypods (veligers)	26	0.9	1	+	6	0.1	1	+
Polychaetes (larvae)	31	1.1	1	1	9	0.3	2	1
Arachnids	2	0.0	0	+	3	0.0	0	+
Cladocerans	56	10.3	8	6	9	0.7	4	3
Copepods	94	70.7	52	77	76	10.7	67	85
Cirripedes (nauplii)	56	18.6	14	6	53	2.1	13	5
Cirripedes (cyprids)	25	1.9	1	2	9	0.4	2	3
Cirripedes (casts)	2	0.1	0	+	9	0.1	1	+
Mysids	4	0.1	0	+	0	0.0	0	0
Cumaceans	3	0.1	0	+	0	0.0	0	0
Isopods	1	0.0	0	+	0	0.0	0	0
Amphipods	4	0.0	0	+	0	0.0	0	0
Euphausiids (larvae)	2	0.1	0	1	0	0.0	0	0
Decapods (zoeae)	9	0.3	0	1	0	0.0	0	0
Unidentified crustaceans*	23	1.4	1	+	9	0.1	1	+
Dipterans (larvae)	3	0.0	0	+	3	0.0	0	+
Dipterans (pupae)	6	0.1	0	+	3	0.0	0	+
Larvaceans	26	1.8	1	3	9	0.2	1	2
Eggs (invertebrates)	49	20.8	15	3	23	0.8	5	1
Fish	4	0.0	0	+	0	0.0	0	0

SOURCE: Bailey, Wing, and Mattson (1975)
NOTE: Original text Table 3.
a
+ indicates less than 0.5%
*
nauplii

Godin, Jean-Guy J.

1981. Daily patterns of feeding behavior, daily rations, and diets of juvenile pink salmon (*Oncorhynchus gorbuscha*) in two marine bays of British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 38:10-15.

ABSTRACT

Stomach analyses showed that pink salmon fry fed mainly during daylight hours in the littoral zone of Departure Bay and Hammond Bay, British Columbia, in May. Although the diurnal feeding patterns of the fish differed slightly between the two bays, maximum mean prey biomass in the fishes' stomachs occurred near or at dusk in both bays. Daily rations consumed by Departure Bay and Hammond Bay fish were estimated to be 13.1 and 6.6 percent of their dry body weight, respectively. The fry consumed similar prey items in both bays, but in differing proportions. Harpacticoid copepods, copepod nauplii, and barnacle larvae comprised numerically 93.1 and 86.2 percent of the diets of Departure Bay and Hammond Bay fish, respectively. About 38 percent of the diet of Departure Bay fish and 51 percent of the diet of Hammond Bay fish comprised epibenthic prey, mainly harpacticoid copepods. The data provide additional support for the importance of the detritus-microbe-consumer type food chain supporting the production of pink salmon during their early period of marine residency.

TABLE 2. Diets of juvenile pink salmon in Departure Bay and Hammond Bay, British Columbia, on May 3 and May 20-21, 1976, respectively

Prey taxon	Departure Bay (N = 78) Occurrence, (Percent)	Departure Bay Prey (Number)	Departure Bay Prey (Percent)	Hammond Bay (N = 87) Occurrence, (Percent)	Hammond Bay Prey (Number)	Hammond Bay Prey (Percent)
Copepoda						
Calanoida	100.0	1 459	5.57	70.1	534	3.87
Cyclopoida	6.4	5	0.02	8.1	7	0.05
Harpacticoida	92.3	9 896	37.81	89.7	6 495	47.03
Monstrilloida	1.3	1	<0.01	4.6	6	0.04
Nauplii larvae[a]	51.3	10 050	38.39	37.9	1 524	11.03
Amphipoda	20.5	32	0.12	56.3	421	3.05
Cirripedia, larvae	76.9	4 430	16.92	78.2	3 885	28.13
Cladocera	9.0	8	0.03	0.0	0	0.00
Cumacea	10.3	8	0.03	17.2	27	0.20
Decapoda, larvae[b]	23.1	29	0.11	18.4	38	0.28
Isopoda	5.2	4	0.02	28.7	36	0.26
Ostracoda	5.1	6	0.02	2.3	2	0.01
Insecta						
Diptera	18.0	19	0.07	26.4	40	0.29
Other	2.6	2	0.01	1.2	1	0.01
Mollusca						
Gastropoda, larvae	44.9	215	0.82	10.3	13	0.09
Bivalvia, larvae	0.0	0	0.00	5.8	12	0.09
Polychaeta	0.0	0	0.00	2.3	2	0.01
Bryozoa, larvae	1.3	1	<0.01	19.5	723	5.23
Teleostei, larvae	3.9	5	0.02	0.0	0	0.00
Invertebrate eggs	2.6	2	0.01	20.7	30	0.22
Unidentified[c]	5.1	4	0.02	29.9	15	0.11
Total		26 176	100.00		13 811	100.00

SOURCE: Godin (1981)
NOTE: Original text Table 2
[a]All copepod nauplii pooled under the same category.
[b]Includes zoea and megalops.
[c]Number of unidentified prey include only intact prey, whereas percentage occurrence of unidentified prey includes fish stomachs containing both intact and fragmented, digested prey.

Healey, M. C.

1980(a). The ecology of juvenile salmon in Georgia Strait, British Columbia. In Salmonid Ecosystems of the North Pacific, eds. D.C. Himsworth and W. McNeil, pp.203-229. Oregon State University Press; Corvallis, Oregon.

Concluding Paragraph

The information summarized in this chapter implies that food shortages may occur in late summer at present population densities of juvenile salmon in Georgia Strait. Salmon enhancement could only aggravate present shortages. Nearshore habitats, with the exception of estuaries, appear least likely to be overloaded. Stomach contents of fish captured in these areas were relatively high and their growth rates during nearshore residence very rapid. Problems appear most likely to rise with pink and chum when they forsake the beaches and begin cropping a declining pelagic food resource. Food shortages at this time could result in premature departure from Georgia Strait or a prolonged period of low rations in June. Sockeye, present at the same time and probably exploiting the same food resource, may experience the same difficulties. For coho and chinook no immediate prediction can be made about a critical period for food limitation. Reduced chinook stocks at present make it unreasonable to expect any obvious food supply problem as long as herring remain abundant. These two species, nevertheless, appear to congregate in regions of best feeding conditions. Therefore, problems with food supply, if coho and chinook numbers increase dramatically, should not be dismissed lightly.

TABLE 3. Diets of juvenile salmon captured by two-boat trawl. Values are estimated percent of stomach contents by volume: Sockeye data are for the Fraser Plume in late April and early May; pink, chum, and coho data are for Saanich Inlet in early June

	Sockeye		Pink		Chum		Coho	
Diet Item	1966	1967	1966	1968	1966	1968	1966	1968
Copepoda	20	32	46	9	37	11	15	<1
Euphausiid	26	0	8	11	2	16	52	52
Amphipoda	<1	3	13	1	4	<1	30	8
Crab larvae	<1	<1	<1	2	<1	2	<1	11
Cladocera	0	10	0	<1	0	<1	0	0
Ostracoda	<1	7	0	0	0	0	<1	0
Insect (adult)	39	21	11	15	7	8	<1	26
Chaetognatha	0	1	10	0	16	<1	0	0
Oikopleura	6	4	11	17	34	40	0	0
Fish larva	9	21	<1	<1	<1	2	2	4
Euphausiid eggs	0	0	0	38	0	16	0	0
Polychaeta	0	0	0	6	0	4	0	0
Barnacle larvae	0	0	0	<1	0	0	0	0
Limacina	0	0	0	0	0	0	1	0

SOURCE: Healy (1980(a))

NOTE: Original text Table 3

TABLE 4. Stomach contents in percent volume of major taxa from samples taken throughout Georgia Strait July to September 1975 and 1976

	Coho		Chinook		Chum		Sockeye		Pink
	1975	1976	1975	1976	1975	1976	1975	1976	1976
Number of fish	482	52	166	37	465	14	26	11	22
Diet item									
Decapoda									
Crab zoea	1.8	0.2	1.4	0	1.6	0	6.1	0	1.5
megalops	26.2	10.9	19.3	16.0	7.5	14.1	9.3	1.4	9.4
juvenile	<0.1	0	0	0	0.3	0	0	0	0
Amphipoda	26.6	40.5	10.0	25.8	41.2	65.6	54.2	66.9	36.9
Caprellid	0.2	1.2	1.2	0	<0.1	0	0	0	0.5
Euphausiid	4.4	0.3	4.0	0.7	13.2	7.2	8.4	0	7.1
Copepoda	0.2	0	0.3	0	7.7	5.6	0.6	7.3	7.8
Shrimp larva	<0.1	1.8	0	0	0	0	0	0	0.2
Limacina	5.3	10.5	0.4	3.4	<0.1	0.8	0	<0.1	1.7
Polychaeta	<0.1	3.6	<0.1	1.2	5.6	3.7	0	0	0.2
Chaetognatha	0	0	0.1	0	2.8	0	<0.1	0	0.7
Ctenophora	0	0	0	0	0.3	0.8	0	13.7	0
Larvacea	0	0	0	0	2.3	0	0	0	0
Insect	0.4	1.6	2.3	24.2	4.3	0	10.9	10.5	32.0
Eggs	0	0	0	0	0.2	<0.1	0	0	0
Herring	13.4	3.6	16.1	8.3	3.1	0	0	0	0
Sandlance	1.3	0	0.2	0	0	0	0	0	0
Fish remains	19.9	25.3	46.8	20.2	9.2	2.1	10.5	0	1.7
All fish	34.6	28.9	63.1	28.5	12.3	2.1	10.5	0	1.7
Stomach contents as percent of body weight	1.15	0.79	0.75	1.13	1.12	0.73			

SOURCE: Healy (1980(a))

NOTE: Original text Table 4

Kaczynski, Victor W., Robert J. Feller, J. Clayton, and R. J. Gerke.

1973. Trophic analysis of juvenile pink and chum salmon (Oncorhynchus gorbuscha and O. keta) in Puget Sound. Journal of the Fisheries Research Board of Canada 30:1003-1008.

ABSTRACT

Pink and chum salmon (Oncorhynchus gorbuscha and O. keta) fry and Clarke-Bumpus plankton tows were collected from three beach areas in Puget Sound in spring of 1970. Chum fry and benthic pump samples were taken in 1971. The diets of the young of the two species were similar. Epibenthic harpacticoid copepods were the chief prey of the chum and pink salmon (57 and 36 percent, respectively, in 1970). Distinct differences were apparent, the more notable being the preference for invertebrate eggs exhibited by the pinks and the higher preferences for small gammarid amphipods and harpacticoids exhibited by the chums. The stomach contents showed no resemblance to the plankton hauls taken in the same area. The onshore stage of development appears to be a distinct ecological stage in the life cycles of these species.

Table 5. Summation of the diets of juvenile pink salmon (*O. gorbuscha*) taken from the same areas and at the same times as the chum salmon in spring, 1970

	Harpacticoids	Barnacle nauplii	Invertebrate eggs	Mysis larvae	Calanoids	Cladocera	Gammarids	Bivalve larvae	Corycaeus	Euphausiids	Calyptopis larvae	Insect adults (Diptera)	Insect larvae	Total
Anderson Island														
(n = 14)														
Percent of diet	95.9	0.5	0.4	0.3	0.7	0	0.1	0	1.3	0	0+	0	0	99.2
SD[a]	3.9	0.8	1.6	0.7	1.4	0	0.2	0	1.4	0	0.1	0	0	
No. prey per fish	195.9	1.0	0.6	0.6	1.7	0	0.1	0	3.1	0	0.1	0	0	203.1
SD	73.5	1.7	2.4	1.2	2.7	0	0.4	0	3.9	0	0.3	0	0	
CV[b] of samples	18.8	89.2	175.0	184.7	136.8	0	175.9	0	124.2	0	172.7	0	0	119.8
No. samples with item	4	2	1	3	2	0	2	0	4	0	1	0	0	19
Dabob Bay														
(n = 16)														
Percent of diet	27.9	6.4	17.9	3.4	20.0	0	4.1	7.9	4.1	3.9	0.2	0	0	95.8
SD	28.5	6.4	30.0	6.7	21.1	0	8.0	13.6	7.2	8.7	1.0	0	0	
No. prey per fish	17.8	4.0	19.5	0.4	14.8	0	0.8	6.9	2.4	0.7	0.2	0	0	67.5
SD	33.6	6.2	47.0	0.9	28.1	0	1.7	13.2	4.3	1.2	1.0	0	0	
CV of samples	53.1	86.7	129.5	133.7	80.0	0	178.1	88.0	168.5	149.6	140.0	0	0	112.5
No. samples with item	5	5	3	2	3	0	3	3	3	3	1	0	0	31
Port Susan														
(n = 23)														
Percent of diet	5.1	30.9	19.7	21.2	4.6	9.7	6.1	0.6	0.1	0	0.5	0.5	0	99.5
SD	5.6	37.6	31.3	28.5	9.0	16.7	10.8	1.7	0.3	0	3.2	1.3	0	
No. prey per fish	8.3	77.2	18.1	9.3	2.3	8.8	10.6	0.5	0.1	0	0.2	1.7	0	137.1
SD	11.9	128.8	35.6	12.0	3.8	18.5	17.2	1.5	0.3	0	0.8	3.2	0	
CV of samples	109.7	80.7	88.6	105.8	129.8	104.8	102.1	116.7	86.6	0	200.0	168.6	0	111.3
No. samples with item	5	5	3	4	4	4	4	1	1	0	1	3	0	35
Total (Weighted)														
(n = 53)														
Percent of diet	36.0	15.5	14.1	10.3	8.2	4.2	3.9	2.7	1.6	1.2	0.3	0.2	0	98.2
No. prey per fish	60.7	35.0	13.9	4.3	5.9	3.8	4.9	2.3	1.6	0.2	0.2	0.7	0	133.5
CV percent	63.5	84.6	118.5	138.3	114.8	104.8	143.8	95.2	136.1	149.6	170.9	168.7	0	113.7
n	14	12	7	9	9	4	9	4	8	3	3	3	0	85

SOURCE: Kaczynski, Feller, Clayton, and Gerke (1973)
NOTE: Original text Table 2

[a] Standard deviation

[b] Coefficient of variation (standard deviation/mean x 100)

Manzer, J. I.

1969. Stomach contents of juvenile Pacific salmon in Chatham and adjacent waters. Journal of the Fisheries Research Board of Canada 26:2219-2223.

ABSTRACT

Stomach contents of young Pacific salmon in Chatham Sound and adjacent waters of northern British Columbia from June through August indicated interspecific differences in the kinds of organisms consumed. Pinks (*Oncorhynchus gorbuscha*) and chums (*O. keta*) were mainly planktophagous, copepods and Larvacea (*Oikopleura* spp.) being most important; cohos (*O. kisutch*) were piscivorous, herring larvae (*Clupea* spp.) and sand lance (*Ammodytidae* spp.) being important; sockeye (*O. nerka*) were mainly planktophagous but fish also were important. With pinks and chums, while they were still relatively abundant along the beaches, the dominant food item progressively changed from copepods in the southern areas to Larvacea in the northern areas.

TABLE 6. Relative importance of various taxonomic groups consumed by juvenile salmon in Chatham Sound and adjacent waters, early June to late August 1955 (F = percent occurrence; V = percent of volume; + = <0.5 percent)

Taxonomic group	Pink		Chum		Sockeye		Coho	
	F	V	F	V	F	V	F	V
Chaetognatha	+	+	+	+	-	-	1	+
Cladocera	+	-	-	-	-	-	1	+
Gastropoda	2	+	+	+	2	+	-	-
Polychaeta	-	-	1	+	-	-	-	-
Ostracoda	2	+	3	+	1	1	-	-
Copepoda	48	31	29	19	45	48	7	6
Cirripeda	13	6	5	2	3	1	-	-
Mysidacea	+	+	1	+	-	-	1	+
Cumacea	1	+	2	+	1	+	-	-
Isopoda	1	+	1	+	-	-	1	+
Amphipoda	7	1	8	2	3	3	11	3
Euphausiacea	7	3	7	4	9	1	4	3
Decapoda	14	4	20	5	7	5	14	8
Crustacean remains	-	-	-	-	-	-	4	1
Insecta	8	1	23	5	10	4	19	5
Larvacea	41	40	62	51	25	14	1	+
Fish	2	5	5	4	19	24	53	70
Eggs	1	+	+	+	-	-	-	-
Unidentifiable	18	7	13	4	5	2	8	2
No. stomachs examined	537		410		98		144	
Percent with food	95		95		91		87	
No. fish measured	470		329		50		144	
Size range of fish measured (mm)	35-114		32-106		57-122		62-147	

SOURCE: Manzer (1969)

NOTE: Original text Table 1

TABLE 7. North-south changes in relative importance of copepods and Larvacea in the diet of underyearling pink and chum salmon in Chatham Sound and adjacent waters, June 8 to July 18, 1955 (See Table 6 for legend)

	Pinks					Chums				
	No. stomachs examined	Copepods		Larvacea		No. stomachs examined	Copepods		Larvacea	
Area		F	V	F	V		F	V	F	V
Dundas-Zayas Is.	105	34	20	67	61	42	7	1	76	84
Port Simpson-Big Bay	-	-	-	-	-	68	6	3	75	67
Mevlville-Dunira Is.	71	32	22	54	54	41	12	8	71	62
Lucy Is.	-	-	-	-	-	28	18	6	89	76
Edye Pass-Ruslton Is.	140	71	64	19	9	111	42	26	60	40
Ogden Ch.-Beaver Pass	46	87	76	13	6	77	64	44	39	28

SOURCE: Maizer (1969)

NOTE: For each species, only areas are considered that yielded samples in each of the three sampling circuits during this period. North is Dundas-Zayas Island.

Bailey, Jack E., Bruce L. Wing, and Chester R. Mattson.

1975. Zooplankton abundance and feeding habits of fry of pink salmon, *Oncorhynchus gorbuscha*, and chum salmon, *Oncorhynchus keta*, in Traitors Cove, Alaska, with speculations on the carrying capacity of the area. *Fishery Bulletin Volume* 73:4:846-861.

Abstract appears on page 3 of this report.

Table 8. Zooplankters and other organisms from stomachs of 124 chum salmon fry (length, 32 to 51 mm) collected in daylight and 20 (length, 35 to 43 mm) collected at night in Traitors Cove, 1964-66, and percentage relative importance by volume

Item	Collected in daylight: Percentage stomachs containing item	Collected in daylight: Mean items per stomach Number	Collected in daylight: Mean items per stomach Percent	Collected in daylight: Percentage relative importance by Volume[a]	Collected at night: Percentage stomachs containing item	Collected at night: Mean items per stomach Number	Collected at night: Mean items per stomach Percent	Collected at night: Percentage relative importance by Volume[a]
Diatoms	15	0.4	1	+	4	0.2	5	+
Rotifers	7	0.5	1	+	0	0.0	0	0
Gastropods (veligers)	3	0.2	0	+	0	0.0	0	0
Pelecypods (veligers)	14	0.4	1	+	0	0.0	0	0
Polychaetes (larvae)	21	1.3	2	2	4	0.3	7	6
Arachnids	9	0.1	0	2	0	0.0	0	0
Cladocerans	58	12.9	18	8	0	0.0	0	0
Ostracods	1	0.0	0	+	0	0.0	0	0
Copepods	73	16.3	22	30	39	1.7	41	37
Cirripedes (nauplii)	34	2.3	3	1	29	0.5	12	4
Cirripedes (cyprids)	20	0.6	1	1	14	0.1	2	1
Cirripedes (casts)	1	0.0	0	+	0	0.0	0	0
Cumaceans	6	0.1	0	1	0	0.0	0	0
Isopods	2	0.0	0	+	0	0.0	0	0
Amphipods	3	0.0	0	+	0	0.0	0	0
Euphausiids	1	0.0	0	+	0	0.0	0	0
Decapods (zoeae)	21	0.4	1	2	0	0.0	0	0
Unidentified crustaceans[b]	10	0.8	1	+	4	0.0	0	+
Collembolans	18	0.4	1	1	0	0.0	0	0
Dipterans (larvae)	10	0.2	0	+	9	0.1	2	2
Dipterans (pupae)	51	3.4	5	11	59	1.3	31	50
Dipterans (adults)	4	0.1	0	+	0	0.0	0	0
Unidentified insect remains	6	0.1	0	+	0	0.0	0	0
Larvaceans	54	18.2	25	34	0	0.0	0	0
Eggs (invertebrates)	19	14.0	9	4	4	0.0	0	+
Fish	6	0.1	0	3	0	0.0	0	0

SOURCE: Bailey, Wing, and Mattson (1975)
NOTE: Original text Table 4
a
+ indicates less than 0.5%
b
nauplii

Bakkala, Richard G.

1970. Synopsis of biological data on the chum salmon, *Oncorhynchus keta* (Walbaum) 1792. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries Circular 315: 89 pages.

ABSTRACT

Information presented on the chum salmon includes nomenclature, taxonomy, morphology, distribution, ecology and life history, population dynamics, fishery, and protection and management.

FOOD

The major food of small chum salmon when they enter the sea is zooplankton. Off the British Columbia coast copepods, euphausiids, and tunicates (Larvacea) were main foods. Other food organisms were diatoms, ostracods, cirripedes, mysids, cumaceans, isopods, amphipods, decapods, chaetognaths, and fish larvae. Insects (Diptera) were found in stomach contents frequently. In Traitors Cove, Alaska, young chum and pink salmon ate cladocerans, copepods, barnacle nauplii, and barnacle cyprids. At times Diptera (mostly chironomids) and an intertidal species of the insect order Collembola were also important.

Note: No table on prey species in text.

Feller, Robert J., and Victor W. Kaczynski.

1975. Size selective predation by juvenile chum salmon (Oncorhynchus keta) on epibenthic prey in Puget Sound. Journal of the Fisheries Research Board of Canada 32:1419-1429

ABSTRACT

Analysis of gut contents shows that juvenile (30 to 50 mm) chum salmon (Oncorhynchus keta) in Puget Sound select epibenthic organisms as their primary prey. Harpacticoid copepods numerically comprised over 80 percent of their natural diet in two areas studied, while terrestrial insects and cladocerans were most important in a third area. Calculation of Ivlev electivity coefficients indicated high selectivity factors for harpacticoids at one site (+0.59 to +0.94). Comparison of fish gut contents with quantitative epibenthic pump samples of available prey shows that prey selection was size related, but opposite that currently reported in the literature (Brooks, J.L. and S.I. Dodson, 1965. Predation, body size, and composition of plankton. Science 150:28-35.); that is, the smaller of the available prey was preferred. This was true for both the total available prey size spectrum and the harpacticoid copepod fraction of the prey spectrum. Large numbers of prey eaten per fish suggest that juvenile chum salmon may exert high predation pressure on nearshore epibenthic organisms in Puget Sound during spring.

Table 9. Total number and percentage in composition (italics) of organisms consumed by juvenile chum salmon (Oncorhynchus keta) from three areas of Puget Sound, Washington, in 1971. Prey type in percent is given in the right-hand column.

	Calanoid	Harpacticoid	Euphausiid	Gammarid	Hyperiid	Insect	Insect larva	Cyprids	Barn. naup.	Invert. egg	Cumacean	Cladoceran	Zoea	Isopod	Larvacea	Polychaete	Gastropod	$\bar{x}$ no./fish (SD)	$\bar{x}$ Fork length (range) N = 6	% epibenthic	% planktonic	% other
Dabob Bay																						
Apr. 12	11	259	72	33	1	7	1			1								64.2	36.3 mm	*76.2*	*21.9*	*1.9*
	2.9	*67.3*	*18.7*	*8.6*	*0.3*	*1.8*	*0.3*			*0.3*								(43.6)	(33.0–39.0)			
Apr. 21	1	690	1	2		13		1										116.3	37.8 mm	*97.9*	*0.2*	*1.9*
	0.1	*97.5*	*0.1*	*0.3*		*1.8*		*0.1*										(43.1)	(35.5–43.0)			
Apr. 30	1	190	1	2		2	2	1										33.5	36.2 mm	*95.9*	*0.8*	*3.7*
	0.4	*94.5*	*0.4*	*1.0*		*1.0*	*1.0*	*0.4*										(20.8)	(35.0–38.5)			
May 10	12	2568	105	53	3	3		13		3	2	1					3	461.3	41.1 mm	*95.4*	*4.4*	*0.2*
	0.4	*92.9*	*3.8*	*1.9*	*0.1*	*0.1*		*0.4*		*0.1*	*0.1*	*0.1*					*0.1*	(189.4)	(36.5–48.5)			
May 21	59	1139	321	117	45	7	32	7	2								3	289.1	39.1 mm	*73.1*	*24.6*	*2.3*
	3.4	*65.9*	*18.5*	*6.8*	*2.6*	*0.4*	*1.9*	*0.4*	*0.1*								*0.1*	(116.1)	(35.5–42.0)			
$\bar{x}$ no./fish	2.8	161.5	16.6	6.9	1.6	1.0	1.1	0.7	—	—	—	—					—	192.8		*87.7*	*19.3*	*2.0*
$\bar{x}$%	*1.4*	*83.6*	*8.3*	*3.7*	*0.6*	*1.0*	*0.6*	*0.2*	—	—	—	—					—	(179.6)		*(12.0)*	*(11.9)*	*(1.2)*
(SD)	*(1.6)*	*(15.6)*	*(9.5)*	*(3.7)*	*(1.1)*	*(0.8)*	*(0.8)*	*(0.2)*	—	—	—	—					—					
Anderson Island																						
May 6	52	2325	45	4		5		3				2					2	406.3	42.3 mm	*95.6*	*4.0*	*0.4*
	2.1	*95.4*	*1.8*	*0.1*		*0.2*		*0.1*				*0.1*					*0.1*	(163.4)	(38.5–45.0)			
May 17	224	1069	63	6		1	1	13	3		2				2		1	230.8	45.7 mm	*78.7*	*20.9*	*0.4*
	16.2	*77.2*	*4.5*	*0.4*		*0.1*	*0.1*	*0.9*	*0.2*		*0.1*				*0.1*		*0.1*	(93.6)	(36.0–52.5)			
May 26	240	4825	663	50				11		1	2							965.3	42.5 mm	*84.5*	*15.5*	*0*
	4.1	*83.3*	*11.4*	*0.8*				*0.2*		*0.1*	*0.1*							(210.8)	(40.5–4.50)			
$\bar{x}$ no./fish	28.6	456.6	42.8	3.3		0.3	—	1.5	—	—	—	—			—		—	534.1		*86.2*	*13.4*	*0.3*
$\bar{x}$%	*7.4*	*85.3*	*5.9*	*0.4*		*0.1*	—	*0.4*	—	—	—	—			—		—	(383.5)		*(8.6)*	*(8.6)*	*(9.2)*
(SD)	*(7.6)*	*(9.2)*	*(4.9)*	*(0.4)*		*(0.1)*	—	*(0.4)*	—	—	—	—			—		—					
Port Susan																						
Apr. 13	18	2		6		167				1							1	32.5	37.5 mm	*4.6*	*9.2*	*86.1*
	9.2	*1.0*		*3.1*		*85.6*				*0.5*							*0.5*	(10.6)	(36.5–39.5)			
Apr. 23	15	6	2	49		36	6	12	2	47	3	53		1		4		39.5	37.9 mm	*49.3*	*32.3*	*17.7*
	6.3	*2.5*	*0.8*	*20.7*		*15.2*	*2.5*	*5.0*	*0.8*	*19.8*	*1.3*	*22.4*		*0.4*		*1.6*		(22.1)	(35.0–40.0)			
May 3	3	1		5		53	1	9			2	163						39.5	37.3 mm	*7.0*	*70.1*	*22.8*
	1.3	*0.4*		*2.1*		*22.4*	*0.4*	*3.7*			*0.8*	*68.8*						(53.9)	(36.5–38.0)			
May 12	6	8	88	11	2	51		20			4	190					1	63.5	41.0 mm	*11.2*	*75.0*	*13.6*
	1.6	*2.1*	*23.1*	*2.9*	*0.5*	*13.4*		*5.2*			*1.0*	*49.8*					*0.2*	(55.6)	(39.0–45.5)			
May 28	2	147	7	590		34	2	25		21		234						177.0	39.3 mm	*73.8*	*22.9*	*3.4*
	0.2	*13.8*	*0.7*	*55.6*		*3.2*	*0.2*	*2.4*		*2.0*		*22.0*						(74.4)	(37.0–43.5)			
$\bar{x}$ no./fish	1.4	5.4	0.7	22.0	—	11.3	0.3	1.5	—	2.3	0.3	5.2		—		.	.	70.4		*26.2*	*41.9*	*29.7*
$\bar{x}$%	*3.7*	*3.9*	*4.9*	*16.8*	—	*27.9*	*0.6*	*3.2*	—	*8.6*	*0.6*	*32.6*		—		—	—	(60.7)		*(10.8)*	*(29.2)*	*(32.8)*
(SD)	*(3.8)*	*(5.5)*	*(10.1)*	*(23.0)*	—	*(32.9)*	*(1.0)*	*(2.1)*	—	*(4.4)*	*(0.6)*	*(26.8)*		—		—	—					

SOURCE: Feller and Kaczynski (1975)
NOTES: Original text Table 1.
$\bar{x}$ = mean
(SD) = standard deviation

Healey, M. C.

1979. Detritus and juvenile salmon production in the Nanaimo estuary: I. Production and feeding rates of juvenile chum salmon (*Oncorhynchus keta*). *Journal of the Fisheries Research Board of Canada* 36:488-496.

ABSTRACT

Theories of food chain dynamics have important implications for the management of marine resources. As yet, however, there are few empirical studies of the food chain dynamics of resource species against which these theories can be judged. This paper compares the food requirements of juvenile chum salmon (*Oncorhynchus keta*) in the Nanaimo Estuary with the productivity of their principal food species. Chum were present in the estuary from March until June and the estuary population ranged up to 4.1 million in May 1975 and 2.4 million in April 1976. The average weight of chum was 0.66 g in 1975 and 0.65 g in 1976, and their rate of growth averaged 6 percent body weight per day in both years. Food intake estimated by three independent methods ranged 4.4 to 18 percent body weight per day and was assumed to average 15 percent body weight per day. Annual fry production was 2,381 kg in 1975 and 1,122 kg in 1976. Food intake was 6,184 kg in 1975 and 2,815 kg in 1976. The principal dietary item in both years was harpacticoid copepods. In 1975 *Harpacticus uniremis* made up 50 percent of the diet overall, and 80 percent of the diet when fry were most abundant. The seasonal pattern of abundance of fry and *H. uniremis* on the estuary was the same, and the fry consumed most of the estimated production of *H. uniremis*. Juvenile chum production was potentially limited by food supply. Food chain dynamics were, therefore, important in the productivity of the chum population, but since both chum and its chief food were rare and ephemeral elements of the estuarine fauna, their interaction probably had little impact on the dynamics of the estuary as a whole.

TABLE 10. Taxonomic composition of prey in chum salmon fry stomachs taken from Nanaimo Estuary in 1975

	MARCH			APRIL					MAY			
DATE	12	19	26	2	9	16	23	30	7	14	21	28
PREY						PERCENT OF PREY						
Harpacticoids	55	12	54	45	32	37	96	95	83	25	29	34
Shrimp Larvae	4	62	2	32	60	39			14	21		
Miscellaneous Diptera		3	15	10	3	5	2	2		4		
Gammaridae	6	3	1	2	1	11		3	1			
Microcalanus pusilus		14										
Chironomid Larvae	20		4	1	1	1	2			1		
Tanaidaceae	2									1	9	21
Cirripedia Larvae										28		
Caliopiidae											35	45
Others	13	6	24		10	3	7		2	20	27	
Percent Totals	100	100	100	90	107	96	107	100	100	100	100	100

SOURCE: Healey (1979)

NOTE: Numbers were estimated from Figure 5 (Healey, 1979).

Healey, M.C.

1980(a). The ecology of juvenile salmon in Georgia Strait, British Columbia. In Salmonid Ecosystems of the North Pacific, eds. D.C. Himsworth and W. McNeil, pp.203-229. Oregon State University Press:Corvallis, Oregon.

Abstract appears on page 7 of this report.

Tables appear on pages 8 and 9.

Kaczynski, Feller, Clayton, and Gerke.

1973. Trophic analysis of juvenile pink and chum salmon (*Oncorhynchus gorbuscha* and *O. keta*) in Puget Sound. *Journal of the Fisheries Research Board of Canada* 30:1003-1008.

Abstract appears on page 10 of this report.

Table 11. Summation of the diets of juvenile chum salmon (Oncorhynchus keta) from three areas of Puget Sound in spring of 1970

	Harpacticoids	Gammarids	Barnacle nauplii	Mysis larvae	Calanoids	Insects (Diptera)	Bivalve larvae	Corycaeus	Insect larvae	Cladocera	Euphausiids	Invertebrate eggs	Calyptopis larvae	TOTAL
Anderson Island														
(n = 23)														
Percent of diet	89.0	0.5	0.9	0.8	2.8	0.4	0	3.0	2.0	0	0	0	0.1	99.6
SD[a]	17.9	0.7	1.0	2.0	6.3	0.7	0	10.5	4.8	0	0	0	0.1	
Number prey per fish	193.9	1.2	1.2	0.5	2.0	0.5	0	3.6	1.4	0	0	0	0.1	204.4
SD	154.7	1.7	2.2	1.0	3.5	0.8	0	13.8	3.0	0	0	0	0.2	
CV[b] of samples	7.3	105.7	100.6	117.4	111.2	133.7	0	67.3	79.1	0	0	0	161.1	85.4
Number Samples with item	6	4	4	2	3	4	0	4	2	0	0	0	1	30
Dabob Bay														
(n) = 21)														
Percent of diet	34.0	19.6	13.5	7.2	8.5	2.5	4.7	2.8	0	0	1.7	0	0.8	95.3
SD	33.8	28.1	24.1	16.4	11.0	6.7	9.9	6.5	0	0	5.2	0	2.4	
Number prey per fish	24.3	24.4	11.0	3.2	5.9	0.5	8.3	3.7	0	0	0.9	0	0.6	82.8
SD	36.5	45.8	23.2	7.7	15.6	0.9	19.6	9.0	0	0	2.0	0	2.0	
CV of samples	91.0	102.8	152.3	97.2	124.4	183.2	119.2	160.0	0	0	176.1	0	86.8	130.0
Number samples with item	5	5	5	3	5	4	2	2	0	0	3	0	1	35
Port Susan														
(n = 10)														
Percent of diet	31.1	36.5	2.9	10.6	0.4	7.7	4.0	0	0	4.4	0	1.8	0	99.4
SD	27.3	28.4	6.9	22.9	1.3	10.0	12.6	0	0	6.3	0	4.3	0	
Number prey per fish	9.6	13.9	0.7	2.4	0.1	3.3	0.9	0	0	1.6	0	0.7	0	33.2
SD	9.0	12.5	1.6	5.3	0.3	5.2	2.8	0	0	2.5	0	1.9	0	
CV of samples	19.5	34.5	80.0	80.0	325.0	40.4	0	0	0	94.5	0	116.1	0	78.5
Number samples with item	3	2	3	3	1	3	1	0	0	3	0	2	0	20
Total (Weighted)														
(n = 54)														
Percent of diet	56.8	14.6	6.2	5.1	4.6	2.6	2.6	2.4	0.9	0.8	0.7	0.3	0.3	97.3
Number prey per fish	93.8	12.6	4.9	1.9	3.1	1.0	3.3	3.0	0.6	0.3	0.4	0.1	0.3	125.3
CV percent	39.8	91.4	117.0	95.8	142.2	126.2	79.5	98.2	79.1	94.5	176.1	116.1	123.9	100.9
n	14	11	12	8	9	11	3	6	2	3	3	2	2	

SOURCE: Kaczynski, Feller, Clayton, and Gerke (1973)
NOTE: Original text Table 1

a Standard deviation

b Coefficient of variation (standard deviation/mean x 100)

LeBrasseur, R. J.

1969. Growth of juvenile chum salmon (*Oncorhynchus keta*) under different feeding regimes. Journal of the Fisheries Research Board of Canada 26:1631-1645.

ABSTRACT

Juvenile chum salmon were fed on six different concentrations of size-selected zooplankton for 8 weeks. Zooplankton were caught daily and sorted through sieves into size-groups roughly as follows: 6 to 20 mm total length, mainly euphausiids; 2.5 to 4.5 mm, mainly copepods; and -1.5 mm, mainly small copepods. The rate of growth in weight of the fish was found to be dependent upon the concentration of the ration. Fish which were offered no food lost weight, and fish which were offered excess food increased in weight by 5.4 percent per day. The mean growth rate of the fish held on fixed rations ranged from 2.2 to 5.7 percent per day and was found to be independent of the type of prey. Electivity experiments showed that all the fish selected copepods 1.6 to 4.5 mm long in proportion to their abundance and rejected copepods -1.5 mm. The euphausiids were selected only by fish which had previously fed on euphausiids. The effect of variations in the availability of prey is discussed.

TABLE 12. Daily rations (as percentages of fish weights)[a] of juvenile chum in the laboratory for various weeks for each of three kinds of prey

	Daily ration (g)					
Week	3.3	6.6	13.2	10.0	16.5	18.5
			Prey mainly *Euphausia pacifica*			
1	3.0(214)	5.1(221)	6.4(172)	10.2(215)	10.4(204)	15.5(190)
2	3.3(164)	6.3(141)	9.2(127)	9.4(165)	13.6(134)	16.5(120)
3	3.4(144)	7.0(121)	9.0(108)	10.8(120)	15.7(91)	17.2(90)
4	2.9(134)	5.9(111)	6.5(98)	9.2(95)	13.9(71)	15.0(70)
5	3.4(94)	5.8(82)	8.3(53)	11.0(55)	16.5(41)	14.2(45)
6	3.2(84)	6.2(55)	8.6(43)	12.6(35)	15.1(36)	16.2(25)
7	3.3(74)	6.7(45)	8.9(33)	13.9(25)	15.9(26)	21.5(15)
8	4.0(64)	7.2(40)	9.6(23)	14.0(20)	15.9(18)	17.9(15)
Mean	3.3	6.2	8.3	11.3	14.0	16.7
			Prey mainly *Calanus plumchrus*			
1[b]	(2.0)(184)	(3.6)(192)	(4.9)(202)	(6.4)(202)	(7.6)(201)	(10.0)(182)
2	3.7(164)	6.8(162)	10.1(167)	13.6(142)	16.8(131)	20.3(112)
3	3.7(144)	6.0(142)	8.9(137)	12.3(112)	16.5(96)	15.6(92)
4	2.9(134)	5.3(112)	7.7(102)	11.6(82)	14.1(71)	13.2(67)
5	2.9(94)	5.0(82)	8.9(62)	11.6(57)	14.7(46)	15.9(37)
6	3.1(64)	6.4(52)	10.0(42)	11.5(42)	13.5(36)	16.3(27)
7	3.4(49)	7.7(37)	8.4(37)	12.8(27)	13.7(26)	19.2(17)
8	3.8(39)	7.2(32)	8.8(27)	11.9(22)	17.7(16)	22.0(12)
Mean(7)	3.3	6.3	8.9	12.1	15.2	17.5
			Prey mainly *Pseudocalanus minutus*			
1	3.3(203)	6.5(200)	9.1(212)	12.0(203)	13.3(217)	14.6(198)
2	3.5(173)	7.7(150)	9.4(162)	12.2(153)	14.2(147)	15.8(128)
3	3.7(153)	6.9(145)	9.8(130)	12.9(113)	15.4(107)	17.6(88)
4	2.9(143)	4.8(135)	8.3(100)	11.8(83)	12.5(87)	14.3(68)
5	2.9(103)	5.4(85)	9.6(60)	10.6(63)	14.3(52)	15.1(43)
6	3.0(83)	6.8(55)	11.6(40)	12.8(43)	16.2(37)	17.6(28)
7	3.3(63)	7.2(45)	10.5(35)	13.5(33)	14.7(32)	16.3(23)
8	3.5(53)	6.9(40)	9.9(30)	11.6(28)	14.7(25)	16.9(18)
Mean	3.2	6.5	9.7	12.1	14.4	16.0

SOURCE: LeBrasseur (1969)

NOTE: Original text Table 1, numbers of salmon in tanks are given in parentheses.

[a]Percent ration = $\frac{\text{Daily Ration}}{\frac{\text{Initial wt + final wt}}{2}} \times 100$

[b]Chum salmon feeding on *C. plumchrus* were on half rations for 1st week.

Manzer, J.I.

1969. Stomach contents of juvenile Pacific salmon in Chatham and adjacent waters. Journal of the Fisheries Research Board of Canada 26:2219-2223.

Abstract appears on page 12 of this report.

Table appears on pages 13 and 14.

Sibert, J. R.

1979. Detritus and juvenile salmon production in the Nanaimo Estuary: II. Meiofauna available as food to juvenile chum salmon (*Oncorhynchus keta*). *Journal of the Fisheries Research Board of Canada* 36:497-503.

ABSTRACT

The meiofauna of the Nanaimo Estuary are briefly described. Nematodes and harpacticoid copepods were the numerically dominant taxa and reached their maximum population densities in late summer. *Harpacticus uniremis* was very important to the early diet of juvenile chum salmon (*Oncorhynchus keta*) but was one of the least common harpacticoid copepods in the estuary. The productivity of *H. uniremis* was found to be only slightly greater than the calculated food requirement of the chum salmon fry; there was close coupling between prey and predator. The role of detritus and bacterially processed carbon in the feeding of *H. uniremis* are discussed.

Note: No table on prey species in text.

Healey, M.C.

1980(a). The ecology of juvenile salmon in Georgia Strait, British Columbia. In Salmonid Ecosystems of the North Pacific, eds. D.C. Himsworth and W. McNeil, pp.203-229. Oregon State University Press:Corvallis, Oregon.

Abstract appears on page 7 of this report.

Tables appear on pages 8 and 9.

Manzer, J.I.

1969. Stomach contents of juvenile Pacific salmon in Chatham and adjacent waters. _Journal of the Fisheries Research Board of Canada_ 26:2219-2223.

Abstract appears on page 12 of this report.

Table appears on page 13.

Carlson, H. Richard

1976. Foods of juvenile sockeye salmon, Oncorhynchus nerka, in the inshore coastal waters of Bristol Bay, Alaska, 1966-1967. Fishery Bulletin Volume 74, Number 2, pages 458-462.

No Abstract

Extracted from Results

In terms of both bulk and frequency of occurrence, copepods were the most important food of juvenile sockeye salmon in inshore Bristol Bay in 1966 and 1967. Fish were second in importance to copepods in terms of weight of food, and over half the bulk of these fish were Pacific sand lance, Ammodytes hexapterus. Larval crustaceans were the only other food of major importance (by bulk) and most of these were anomuran larvae eaten by juveniles in the Ugashik area in July 1966. Other items eaten by juvenile sockeye salmon in significant amounts during their migration out of Bristol Bay were euphausiids, amphipods, and insects. Insects and amphipods occurred frequently in the diet but did not contribute much bulk.

I looked for differences in food selectivity between large and small fish among 144 juveniles (6-13 cm fork length) grouped in 1-cm size categories, but the results were inconclusive.

TABLE 13. Percentage total dry weight of foods consumed by juvenile sockeye salmon collected at five areas in Bristol Bay, Alaska, 1966 and 1967

Food category	Kvichak N = 50	Egegik N = 23	Ugashik N = 30	Port Heiden N = 9	Port Moller N = 48
Copepods[a]	30.3	8.6	25.4	6.3	71.2
Fish[b]	45.7	4.1	22.6	80.3	11.8
Larval crustaceans	0.1	0.4	44.6	--	5.7
Euphausiids	--	43.1	0.4	--	5.2
Amphipods	0.6	1.0	1.3	4.8	4.7
Insects	18.6	3.9	0.9	0.7	0.8
Miscellaneous crustaceans	2.6	34.9	0.2	0.1	0.5
Zoofauna	2.1	3.3	4.7	6.1	0.2
Other	--	0.8	--	1.8	--

SOURCE: Carlson (1976)
NOTE: Original text Table 1

[a] Copepods - mainly calanoids
[b] Fish - over half the bulk were Pacific sand lance, _Ammodytes hexapterus_

TABLE 14. Summary of foods eaten by juvenile sockeye salmon (N = 160) in all regions of Bristol Bay, Alaska, between June and September 1966 and 1967

Food category	Percentage total dry weight	Percentage occurrence
Copepods[a]	60.4	66.7
Fish[b]	17.4	25.0
Larval crustaceans	9.8	35.4
Euphausiids	4.6	6.3
Amphipods	4.0	29.2
Insects	1.6	41.0
Miscellaneous crustaceans	0.9	22.2
Zoofauna	1.1	18.8
Other	0.1	2.8
Empty stomachs	--	10.0

SOURCE: Carlson (1976)
NOTE: Original text Table 2

[a] Copepods - mainly calanoids
[b] Fish - over half the bulk were Pacific sand lance, _Ammodytes hexapterus_

Healey, M.C.

1980(a). The ecology of juvenile salmon in Georgia Strait, British Columbia. In Salmonid Ecosystems of the North Pacific, eds. D.C. Himsworth and W. McNeil, pp.203-229. Oregon State University Press:Corvallis, Oregon.

Abstract appears on page 7 of this report.

Tables appear on pages 8 and 9.

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Tables appear on page 13.

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1974. Ecology and behavior of juvenile sockeye salmon (*Oncorhynchus nerka*) in Bristol Bay and the eastern Bering Sea. *In* *Oceanography of the Bering Sea With Emphasis on Renewable Resources*, eds., D.W. Hood and E.J. Kelly, pp.285-320. Fairbanks:University of Alaska, Institute of Marine Science, Occasional Publication No. 2, 623 pages.

FOOD HABITS OF SOCKEYE SALMON

In this paper, only those features of feeding behavior which appear to illustrate the influence of environment on the migratory pattern and growth of the sockeye during seaward migration are discussed.

Stomachs from more than 1,200 juvenile sockeye salmon from the purse seine catches in Bristol Bay in 1969 and 1970 were analyzed to determine their contents and degree of fullness. The major food items in order of their relative importance were as follows:

Pacific sand lance, *Ammodytes hexapterus*--larval and young stages
Euphausiids--mainly larval stages
Copepods--all stages
Cladocera, *Podon* sp.
Pteropods
Decapod larvae
Other fish, cods and cottids--larval stages
Eggs, mainly invertebrates
Insects

The dominance of particular organisms varied with the location and time of capture. Limited evidence suggests that the diet of sockeye at any particular location or time reflects the relative abundance of food items available.

Note: No table on prey species in text.

Healey, M.C.

1980(a). The ecology of juvenile salmon in Georgia Strait, British Columbia. In Salmonid Ecosystems of the North Pacific, eds. D.C. Himsworth and W. McNeil, pp.203-229. Oregon State University Press:Corvallis, Oregon.

Abstract appears on page 7 of this report.

Table appears on page 9.

Healey, M. C.

1980(b). Utilization of the Nanaimo River Estuary by juvenile chinook salmon, *Oncorhynchus tshawytscha*. *Fishery Bulletin* 77:3:653-668.

ABSTRACT

Chinook salmon are considered, normally, to spend from a few months to a year rearing in freshwater before migrating to sea. Although large downstream movement of fry, recently emerged from spawning gravels, has been observed in several river systems, it has been suggested that most of these migrant fry are lost to the population. This report describes the fate of downstream migrant chinook salmon fry in the Nanaimo River, British Columbia. In 1975 and 1976 most of the potential fry production from the river system was estimated to have passed by a trapping location near the river mouth. Many of these fry were subsequently found rearing in the intertidal area at the river mouth where salinity was commonly above 20 ppm. Very few chinook salmon fry were captured at other sampling sites within a 10 km radius of the river mouth. Juvenile chinook salmon were present in the intertidal area of the estuary from March to July each year, but peak numbers occurred in April and May. Peak estuary population was estimated to be 40,000 to 50,000 in 1975 and 20,000 to 25,000 in both 1976 and 1977. While in the estuary, chinook salmon grew about 1.32 mm per day or 5.8 percent of their body weight per day. Individual fish probably spent an average of about 25 days rearing in the estuary and left the estuary when about 70 mm fork length. While in the estuary, juvenile chinook salmon fed on harpacticoid copepods, amphipods, insect larvae, decapod larvae, and mysids. After leaving the estuary, they fed mainly on juvenile herring. The stomach content of chinook salmon captured in the estuary averaged 5 percent of body weight or less, and varied seasonally and between years. It appears that in Nanaimo and probably in other systems with well-developed estuaries, that the estuary is an important nursery for chinook salmon fry.

Note: No tables on prey species in text.

TABLE 15. Alphabetical list of juvenile salmon prey

Scientific Name	Common Name	Pages
Amphipods	Amphipods	
Gammaridea	sand fleas	
Callipiidae		
Hyperiidea		
Caprellidea	skeleton shrimp	
Arachnida	Spiders	
Bryozoa	Bryozoans	
cyphonautes - larvae	immature forms	
Cephalopoda	Squid, Octopus	
Chaetognatha	Arrow Worms	
Cirripedia	Barnacles	
nauplii - larvae	immature, free swimming forms	
cyprids	immature, nearing attachment stage	
casts	shed skeletal structure for legs	
Cladocera	Water Fleas	
Pondon sp.		
Copepoda	Copepods	
Calanoida		
Microcalanus pusilus, *Calanus plumchrus*, *Pseudocalanus minutus*		
Cyclopoida		
Corycaeus sp.		
Harpacticoida		
Harpacticus uniremis		
Monstrilloida		
Crustacea	Crustaceans	
nauplii - larvae	immature swimming forms	
anomuran larvae	hermit and king crab immature swimming forms	
Ctenophora	Sea Gooseberry	
Cumacea	Cumaceans	
Decapoda	Decapods, shrimps and crabs	
zoeae - larvae	immature swimming forms	
Crab zoeae - larvae	immature swimming forms	
megalops	immature walking forms	
juveniles	small adult form	
Shrimp zoeae - larvae	immature swimming forms	
Diatom	One cell plants whose cell walls are impregnated with silica	

TABLE 15 (Continued)

Scientific Name	Common Name	Pages
Euphausiacea	Euphausiids, krill	
Calyptopis sp. larvae		
Euphausia pacificia		
larvae	immature forms	
Gastropods	Snails	
veliger	immature swimming forms	
Insecta	Insects	
Collembola	spring tails	
Diptera	flies	
Chironomidae larvae	immature forms	
larvae	immature forms	
pupae	immature forms	
adults	flies	
Isopoda	Isopods	
Tanaidaceae	tanaids	
Larvacea	Larvaceans	
Oikopleura sp.		
Mysidacea	Mysids	
larvae	immature forms	
Nematoda	Round Worms	
Ostracoda	Ostracods	
Pelecypoda	Clams, Mussels, Oysters, Scallops	
veliger	immature swimming forms	
Polychaeta	Segmented Worms	
larvae	immature swimming forms	
Pteropoda	Sea Butterfly	
Limacina sp.		
Rotifera	Rotifers	
Teleostei	Fishes, bony	
Ammodytes hexapterus	sand lance	
Clupeidae	herring	
Cottidae	sculpins	
Gadidae	cod	
Hexagrammidae	greenling	
Myctophidae	lampfish	
Scorpaenidae	rockfish	

Table 16. Habitats and their occupants

Brackish Water[1]	Meroplankton[2]	Holoplankton[3]	Nekton[4]	Benthos & Epibenthos[5]
Arachnida	cyphonautes	Amphipoda	Cephalopoda	Amphipoda
	Bryozoa	Gammaridea	squid	Gammaridea
Cladocera		Hyperiidea		Caprellidea
Pondon sp.	cyprids		Teleostei	
	Cirripedia	Chaetognatha	*Ammodytes hexapterus*	Collembola
			Clupeidae	Copepoda
			Cottidae	Harpacticoida
	larvae	Copepoda	Gadidae	
Diptera	Bryozoa	Calanoida	Hexagrammidae	
Chironomidae	Cirripedia	Cyclopoida	Myctophidae	Cumacea
larvae	Crustacea		Scorpaenidae	males & females
pupae	Decapoda	Ctenophora		
adults	crab			
	shrimp	Cumacea		Decapoda
	Euphausiacea	males		crab, megalops &
	Calyptopis sp.			juveniles
	Mysidacea	Diatoms		
	Polychaeta			
		Euphausiacea		Diatoms
	megalops	*Calyptopis* sp.		
	crab	*Euphausia pacifica*		Isopoda
				Tanaidaceae
		Larvacea		
	nauplii			
	Cirripedia	Ostracoda		Mysidacea
	Copepoda			
	Crustacea	Pteropoda		Nematoda
		Limacina sp.		
				Ostracoda
	veliger	Rotifera		
	Gastropoda			
	Pelecypoda			
	zoeae			
	Decapoda			
	crab			
	shrimp			

[1]Mixture of fresh and salt waters
[2]Larval forms which are in the plankton part of the year
[3]Planktonic organisms which are swimming forms throughout their lives
[4]Active strong swimmers such as fishes
[5]Benthos = creatures which live in the sediment; Epibenthos = creatures which live on the sediment.

PREY ILLUSTRATIONS

Figure 1. Cladocera.
Size range 1 to 3 mm
(Barnes 1974, p.526)

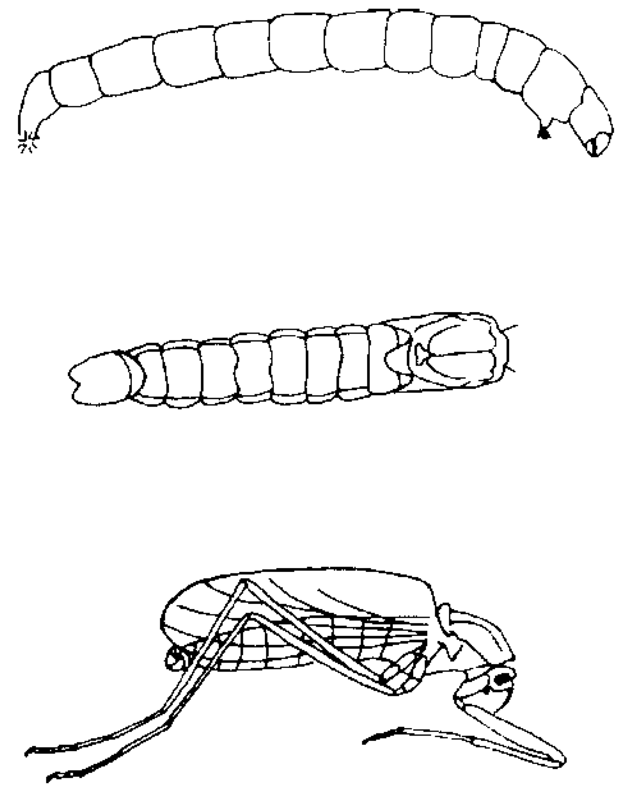


Figure 2. Insecta-Diptera: a. larva; b. pupa; c. adult.
Size range: extreme variability
(Smith and Carlton 1975, p.441)

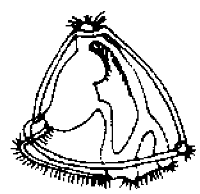


Figure 3. Cyphonautes - Bryozoa - larva.
Size range: 0.5 to 1.0 mm
(Newell and Newell 1963, p.223)

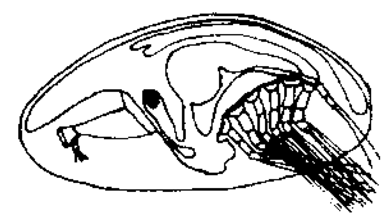


Figure 4. Cyprid - Cirripedia.
Size range: most species 1 to 4 mm
(Barnes 1974, p.551)

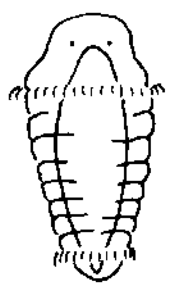


Figure 5. Larvae - Polychaeta.
Size range: 1 to 5 mm
(Newell and Newell 1963, p.207)

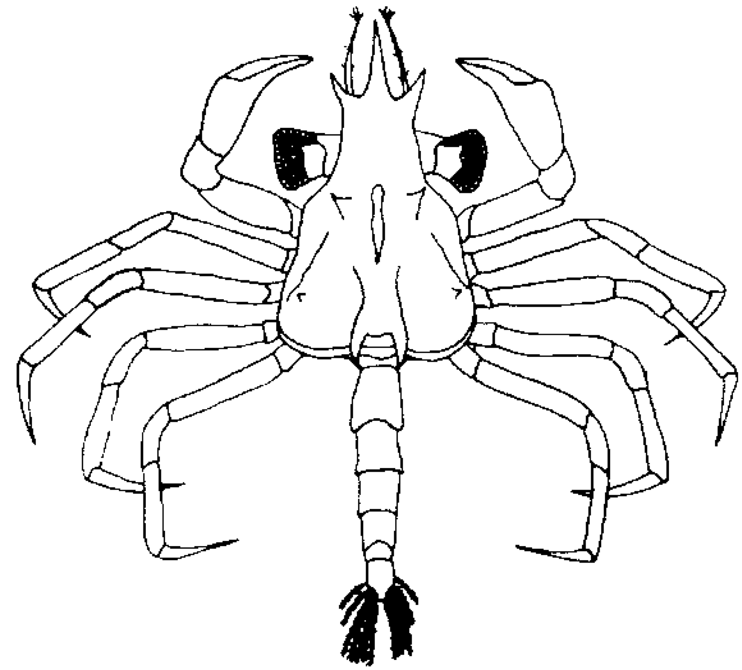


Figure 6. Megalopa - Decapoda - Chionoecetes bairdi
Size range: 4 to 8 mm
(Jewett and Haight 1977, p.461)

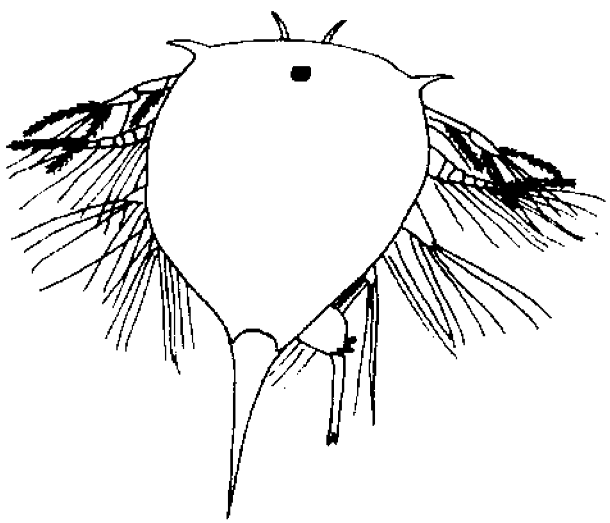


Figure 7. Nauplius - Cirripedia.
Size range: 0.8 to 3.0 mm
(Newell and Newell 1963, p.209)

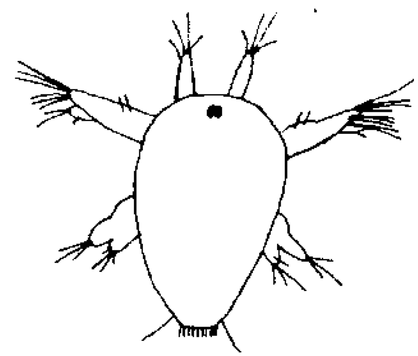


Figure 8. Nauplius - Crustacea.
Size range: most commonly 0.07 to 1.0 mm
(Barnes 1969, p.437)

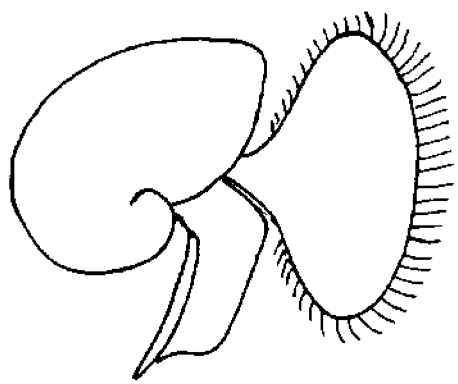


Figure 9. Veliger - Gastropoda.
Size range: most are less than 1 mm
(Barnes 1974, p.364)

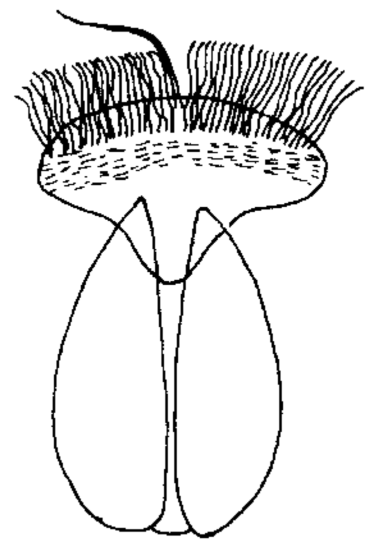


Figure 10. Veliger - Pelecypoda.
Size range: most are less than 1 mm
(Meglitsch 1967, p.544)

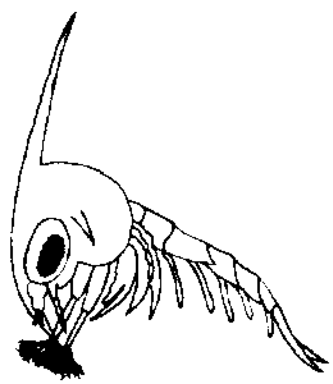


Figure 11. Zoea - Decapoda.
Size range: great variation
1 to 20 mm
(Barnes 1969, p.514)

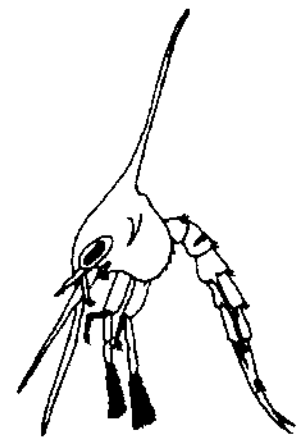


Figure 12. Zoea - Decapoda - *Chionoecetes bairdi*
Size range: 2 to 6 mm
(Haynes 1973, p.772)

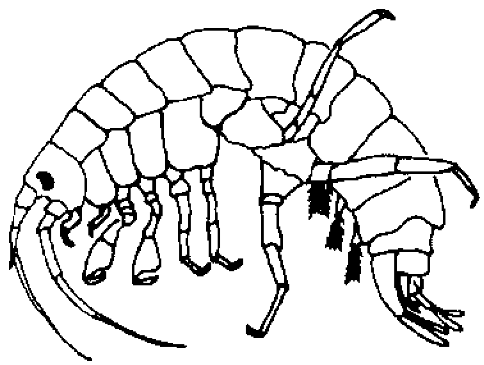


Figure 13. Amphipoda - Gammaridea.
Size range: species dependent, 10 to 60 mm
(Meglitsch 1967, p.788)

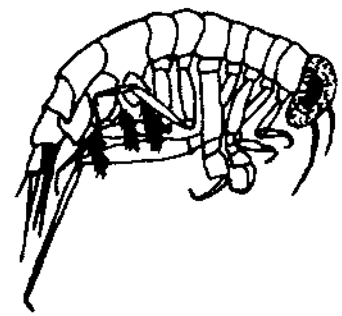


Figure 14. Amphipoda - Hyperiidea - *Parathemisto* sp.
Size range: reaches 30 mm
(Newell and Newell 1963, p.200)

Figure 15. Chaetognatha.
Size range: 20 to 60 mm
(Newell and Newell 1963, p.192)

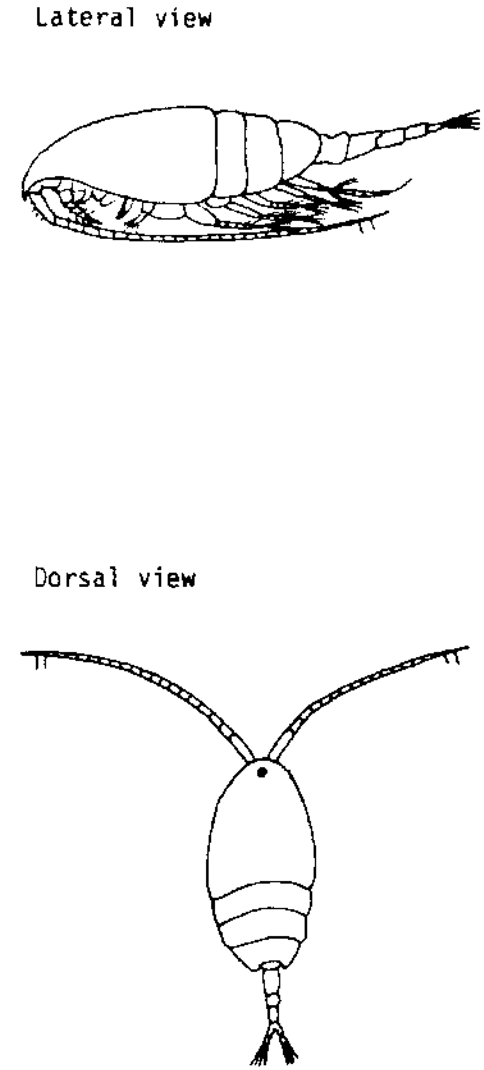


Figure 16. Copepoda - Calanoida.
Size range: species dependent, 0.9 to 11 mm
(Newell and Newell 1963, p.195)

Figure 17. Ctenophora.
Size range: great variation
(Barnes 1974, p.138)

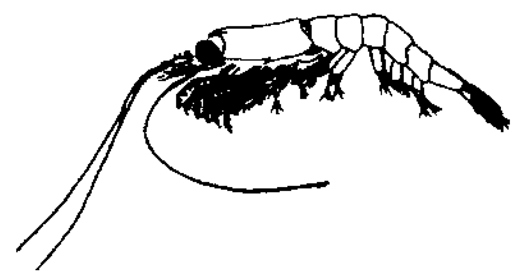


Figure 18. Euphausiacea - Euphausia pacifica.
Size range: reaches 25 mm
(Smith and Carlton 1975, p.249)

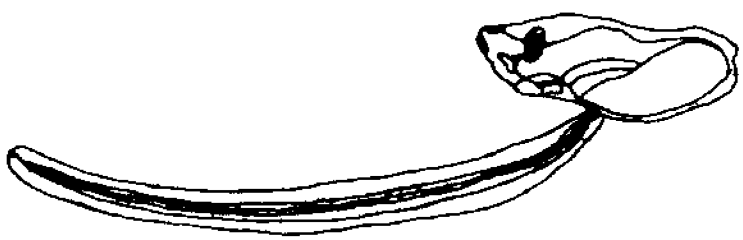


Figure 19. Larvacea - Oikpleura sp.
Size range: reaches 15 to 20 mm
(Newell and Newell 1963, p.206)

Figure 20. Ostracoda.
Size range: most common genus Conchoecia 1 to 6 mm
(Smith and Carlton 1975, p.249)

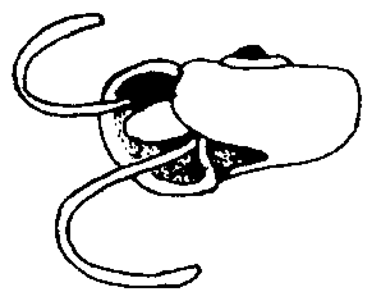


Figure 21. Pteropoda - Limacina sp.
Size range: reaches 10 mm in diameter
(Barnes 1974, p. 342)

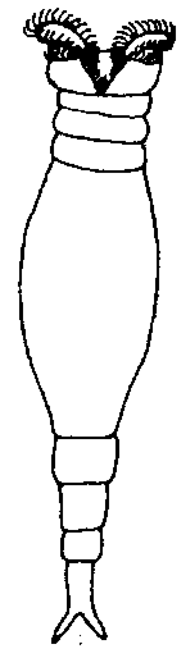


Figure 22. Rotifera.
Size range: most species less than 1 mm
(Meglitsch 1967, p. 258)

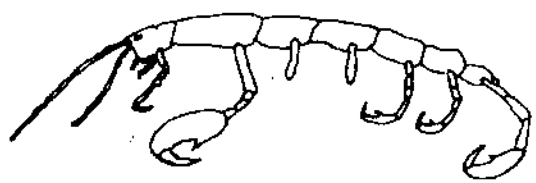


Figure 23. Amphipoda - Caprellidea.
Size range: averages 5 to 15 mm
(Meglitsch 1967, p. 798)

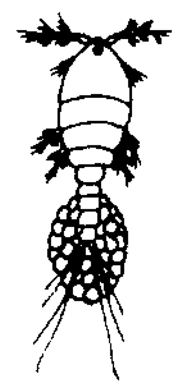


Figure 24. Copepoda - Harpacticoida.
Size range: reaches 1.5 mm
(Smith and Carlton 1975, p. 254)

Figure 25. Cumacea.
Size range: largest species reaches 28 mm
(Newell and Newell 1963, p. 202)

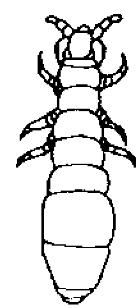
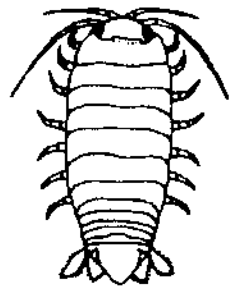
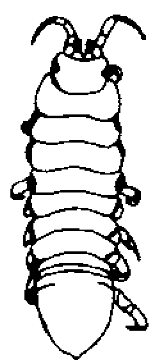


Figure 26. Insecta - Collembola.
Size range: less than 1.5 mm
(Smith and Carlton 1975, p. 435)

a.



b.



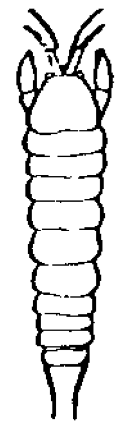


Figure 27. Isopoda
a. Isopoda, Size range: reaches 60 mm
b. *Idothea wosnesenski*, Size range: reaches 32 mm
(Meglitsch 1967 (Isopoda), p.794; Ricketts and Calvin 1968 (*Idothea wosnesenski*) p.197)

Figure 28. Isopoda - Tanaidaceae.
Size range: most species 1 to 2 mm
(Richardson 1905, p.10)

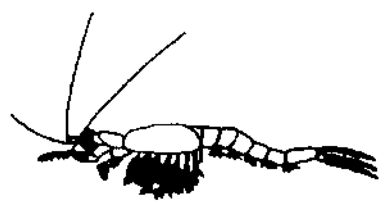


Figure 29. Mysidacea.
Size range: largest species reaches 35 mm
(Smith and Carlton 1975, p.249)

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Smith, Deboyd L. 1977. A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae. Kendall/Hunt Publishing Company: Dubuque, Iowa. 161 pages.

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Alaska Sea Grant College Program

NEW PUBLICATION

TITLE: A Literature Review: Guide to Marine Prey of Juvenile Salmon (Marine Advisory Bulletin No. 12)

AUTHOR: Judy McDonald Paul
TOPIC AREA: Aquaculture
PAGES: 40
PUBLISHED: May 1982
PRICE: $5.00

DESCRIPTION

Salmon ranching is becoming a major component of Alaska's fishing industry. Currently, this endeavor relies on producing as many fry as possible at a hatchery in hopes of producing high numbers of returning fish. As hatcheries become more efficient and numerous, this mass production approach could produce more fish than local food webs are able to successfully support. In the future salmon aquaculturists, like terrestrial ranchers, will have to place limits on the number of animals released into their common property range, the ocean. Ultimately, the ability of food webs to support different numbers and species of salmon near each hatchery will have to be estimated. The first step in determining productivity in an area is to identify the types and abundance of prey eaten by salmon fry. The information currently available on the food of North Pacific salmon fry appears in a variety of scientific publications which are difficult to obtain. The objective of this report is to summarize some of these scientific papers for Alaskan salmon ranchers. The report consists of a compilation of abstracts, or summaries, and data tables from pertinent papers on salmon fry feeding. To facilitate identification of prey species noted in this report, illustrations of the prey types are included.

To order, detach and return this section to Alaska Sea Grant, University of Alaska, Bunnell Building, Room 3, 303 Tanana Drive, Fairbanks, Alaska 99701.

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