Stomach Contents of Juvenile Pacific Salmon in Chatham Sound and Adjacent Waters

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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.

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IN CHATHAM SOUND and adjacent waters of northern coastal British Columbia, young Pacific salmon, especially pinks (*Oncorhynchus gorbuscha*) and chums (*O. keta*), are found in varying numbers along the beaches until early summer when they begin to move offshore (Manzer, 1956). This paper describes the diet of young pink, chum, sockeye (*O. nerka*), and coho (*O. kisutch*) salmon during residence in this region from early June to late August in 1955, but mainly during the first half of this period.

Methods — The study was incidental to studies conducted on the distribution and migration of young salmon in Chatham Sound and adjacent waters. Beach sampling locations (Fig. 1) were established in early June on the basis of fishability and were revisited sequentially four times at approximately 2-week intervals. About mid-July when young salmon became scarce along the beaches, fishing operations shifted "offshore" into deeper water.

Young salmon in littoral areas were caught in beach seines (approximately 37 m long, 1.8 m deep), whereas those in deeper water were taken in purse seines (approximately 110 m long, 5.4 m deep). Each type of gear was constructed from 1.9-cm mesh (stretched measure) cotton webbing. Time spent fishing in a particular location ranged from $1\frac{1}{2}$ to $2\frac{1}{2}$ hr. On occasion more than one catch was made, in which case these were combined.

Samples of each species were labelled according to place, date, and time of capture, wrapped in cheese cloth, and preserved in wooden tubs containing 10% formalin. Most fish were sufficiently small that their stomach contents were preserved simply by immersing the fish in the preservative. With relatively large fish, usually cohos, an incision was made in the abdominal wall so that the preservative could enter the body cavity.

In this study, "stomach" is considered to be that portion of the alimentary tract between the oesophagus and intestine. The stomach contents of each fish were identified in the laboratory according to broad taxonomic groups (mainly order) with the aid of a binocular microscope. Contents rendered unrecognizable either through mastication or digestion were classed as "unidentifiable." Stomach parasites were not considered as part of the stomach contents.

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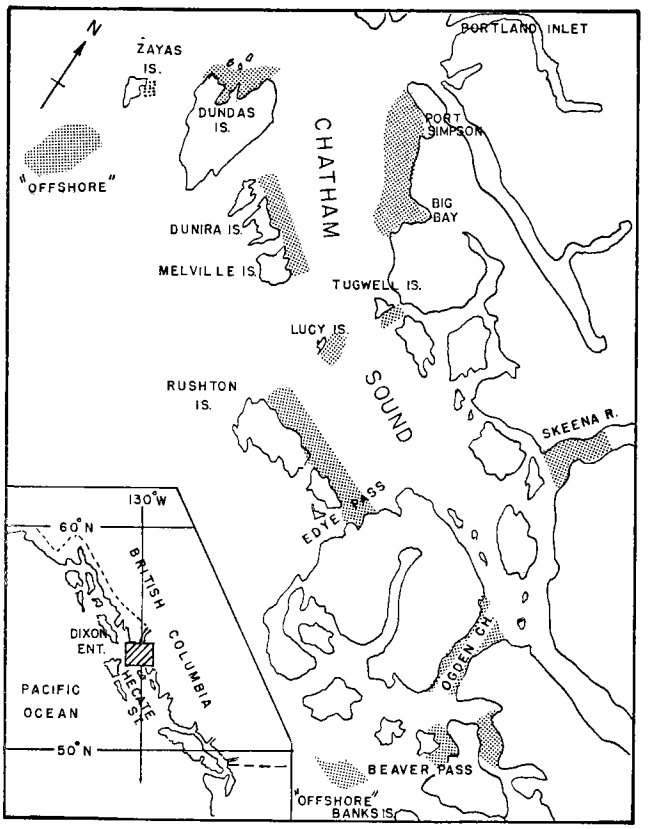

FIG. 1. Chatham Sound in northern British Columbia and sampling localities (shaded areas).

Although fish were not aged, length data recorded at the time of stomach examination indicate that all fish were in their 1st year of ocean life.

The importance of each taxonomic group in a given species' diet was determined from the percentage of stomachs examined that contained organisms of the group (occurrence method) and from the percentage that each kind of organism formed of the total volume of stomach contents of the fish in the sample (volumetric method). Regarding the latter method, initially the percentage for each group was determined from volumetric data based on water displacement. As proficiency in estimating volumes was achieved, volumes of sparsely represented groups were subsequently estimated by eye. The relative merits of using these methods in food studies of fishes have been discussed by Hynes (1950) and Windell (1968).

Results and discussion — For each species a very high proportion of the stomachs examined contained food. The food spectra of pinks, chums, sockeyes, and cohos for the entire study period were reasonably similar, but the degree of importance of each taxonomic group varied (Table 1). In general, pinks and chums were planktophagous, copepods and Larvacea (*Oikopleura* spp.) being most important. Cohos were mainly piscivorous, herring larvae (*Clupea* spp.) and sandlance (*Ammodytidae* spp.) occurring most frequently. Sockeyes overlapped these two groups somewhat in their diet, being mainly planktonic feeders but fish were also important.

TABLE 1. Relative importance of various taxonomic groups consumed by juvenile salmon in Chatham Sound and adjacent waters, early June to late August 1955. F = % occurrence; V = % of volume; + = <0.5%.

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
Cirripedia	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	
% 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	

Examination of the stomach contents of pinks and chums taken in different areas during three sampling circuits from June 8 to July 18, while juveniles were eadily available along the beaches, revealed that for each species the primary food item changed progressively from copepods in the southern areas to Larvacea in the northern areas (Table 2). Since this spatial trend was observed for both pinks and chums, it seems reasonable to think that the phenomenon was the result of differences in the relative contribution of the two kinds of organisms to the local food resource.

The kinds of organisms found in the stomachs of young salmon during this study in general were similar to those reported by earlier investigators working in widely separated areas (Chamberlain, 1907; Fraser, 1946; Foskett, 1951; Synkova, 1951). One outstanding difference, however, is the hitherto unreported large incidence of Larvacea in the diets of pinks and chums.

TABLE 2. 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–July 18, 1955. For each species, only areas are considered that yielded samples in each of the three sampling circuits during this period. See Table 1 for legend. North is Dundas–Zayas Island.

Area	Pinks					Chums				
	No. stomachs examined	Copepods		Larvacea		No. stomachs examined	Copepods		Larvacea	
		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
Melville–Dunira Is.	71	32	22	54	54	41	12	8	71	62
Lucy Is.	–	–	–	–	–	28	18	6	89	76
Edye Pass–Rushton 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

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Effect of the Rate of Storm Growth on Subsequent Surge Elevations

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The surge elevation due to an instantaneously applied generating force over one-half of an infinite rotating sea was given by Crease (Proc. Roy. Soc. London, Ser. A: 233, 1955). This note describes the effect of modifying the applied force to allow it to reach its maximum value over a finite period of time.

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THE SOLUTION FOR the elevation due to the instantaneous application of a given force over one-half of an infinite rotating sea was given by Crease (1955). The mathematical model used was idealistic and several assumptions were made to obtain an analytical solution. However, even simplified models can give useful indications of the dynamics that exist in actual physical systems, and some of the physical characteristics of the surge can be revealed by an investigation of the changes in the analytical solution due to basic modifications in the given conditions. This note describes an interesting result found when the applied force was allowed to grow from zero to its final value over a finite period of time rather than being instantaneously applied at its maximum value. It is shown that the maximum elevation attained by a surge will be

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