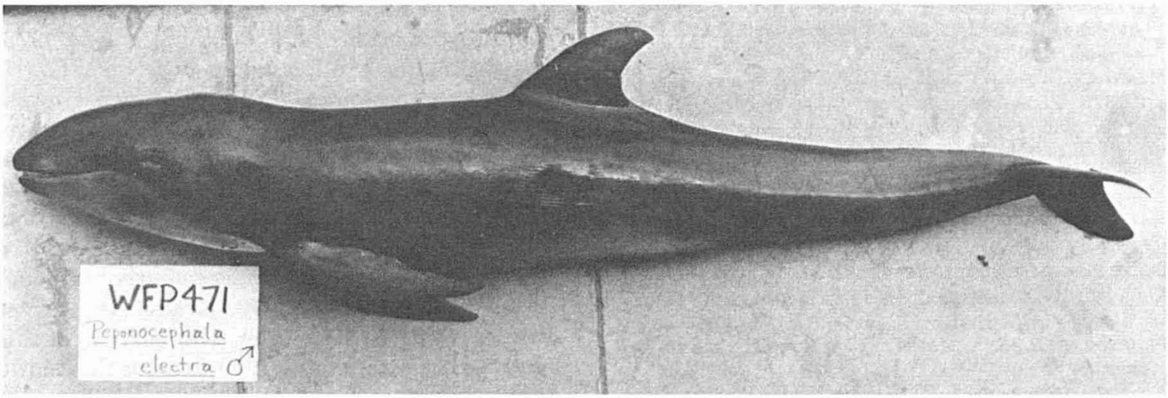

FIGURE 2. — Calf of *Peponocephala electra* collected in eastern tropical Pacific (USNM 504087).

and placed in the marine mammal collection (USNM 504087).

Acknowledgments

I thank Edward Kovalchek and Joseph Madruga for providing the specimen and P. J. H. van Bree for reading the manuscript.

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FOODS OF JUVENILE SOCKEYE SALMON, *ONCORHYNCHUS NERKA*, IN THE INSHORE COASTAL WATERS OF BRISTOL BAY, ALASKA, 1966-67

For most living organisms the early portion of life is most critical in determining survival. Anadromous fishes such as Pacific salmon have two critical periods during early life — development and growth in fresh water and subsequent adaptation to a marine environment. The food of juvenile salmon during the first few months of marine life influences growth and condition, which in turn probably influences parasitism, predation, and other factors which ultimately determine marine survival.

Although the sockeye salmon, *Oncorhynchus nerka* (Walbaum), is one of the most valuable commercial fishes in Alaska and has been the object of extensive research, little is known of its early life in the sea. Straty (1974) and Straty and Jaenicke[1] have made the only comprehensive study of early marine life of the sockeye salmon in Bristol Bay, historically the largest sockeye fishery in the North Pacific. Documented studies of sockeye salmon food habits during this period of life are generally limited to brief accounts of Soviet research in Kamchatka waters (Synkova 1951), a study in British Columbia (Manzer 1969), examination of a few specimens from Aleutian and Kodiak waters (Chamberlain 1907), and 45 specimens taken off Cape Seniavin in lower

[1]Straty, R. R., and H. W. Jaenicke. 1971. Studies of the estuarine and early marine life history of sockeye salmon in Bristol Bay, 1965-67. Unpubl. manuscr., 137 p. Northwest Fish. Cent. Auke Bay Lab., Natl. Mar. Fish. Serv., NOAA, Auke Bay, AK 99821.

Bristol Bay (Dell 1963). Recently, Jaenicke and Bonnett[2] completed an extensive study of the foods of some 1,200 seaward-migrating sockeye salmon in Bristol Bay during 1969 and 1970. Most of their samples were taken over deeper waters farther offshore than mine — particularly those off Port Moller.

The purpose of my study was to document the foods of seaward-migrating sockeye salmon along the main migration route on the north side of the Alaska Peninsula in Bristol Bay, Alaska, during 1966 and 1967. Later studies by Straty and Jaenicke (see footnote 1) and Jaenicke and Bonnett (see footnote 2) show that the areas where I took samples of juvenile sockeye salmon (Kvichak to Port Moller — Figure 1) were indeed along the main migration route in the upper and central parts of the bay (Kvichak to Port Heiden). In lower Bristol Bay, however, my sampling area (Port Moller) was inshore from the usual main migration route. In years when unusually cold seawater temperatures prevail, the main migration route in the lower bay shifts to the warmer inshore waters (Straty 1974). The juvenile sockeye salmon I sampled in the Port Moller area were taken in a year (1967) when normal temperatures prevailed and were presumably inshore from the path followed by most migrants that year. However, the foods found in 1967 in these inshore waters may reflect what is usually available to the main body of outmigrants in colder years when their path is altered.

[2]Jaenicke, H. W., and M. B. Bonnett. Food of sockeye salmon outmigrants in Bristol Bay, Alaska, 1969-70. Unpubl. manuscr., 20 p. Northwest Fish. Cent. Auke Bay Lab., Natl. Mar. Fish. Serv., NOAA, Auke Bay, AK 99821.

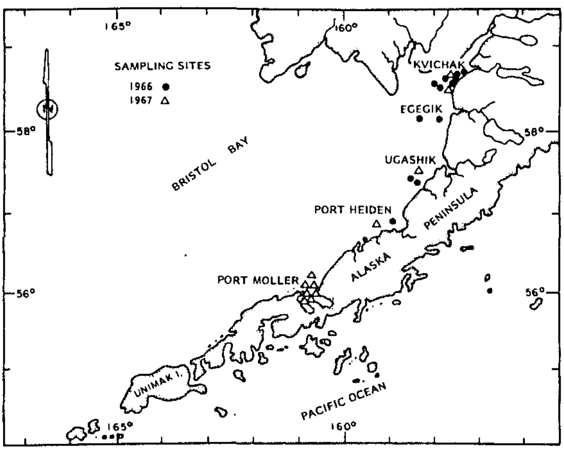

FIGURE 1. — Bristol Bay, Alaska, showing locations where juvenile sockeye salmon were collected in 1966 and 1967 for food habit analyses. Samples in the upper bay (Kvichak and Egegik) were taken in June, and those in the central bay (Ugashik) and lower bay (Port Heiden and Port Moller) were taken from July to September.

Materials and Methods

The samples of juvenile sockeye salmon were collected in 1966 and 1967 in the following areas (Figure 1) and times: Kvichak, June of both years; Egegik, June 1966; Ugashik, July and September 1966 and August 1967; Port Heiden, July 1966 and August 1967; and Port Moller, July and August 1967. All samples were taken during daylight, usually between 1000 and 1900 h.

In 1966, the juvenile sockeye salmon were collected with circular tow nets (2.1 m in diameter) and a small-mesh round haul seine (110 m long by about 7 m deep); in 1967 they were collected in a small-mesh lampara seine (183 m long by about 14 m deep). All sampling was done from the 13-m National Marine Fisheries Service vessel *Sockeye*. Samples were preserved in 10% Formalin[3] solution and processed later.

I analyzed the stomach contents of 160 juvenile sockeye salmon and all but 16 contained food. These 160 fish represented roughly equal numbers of individuals from 1-cm size groups ranging from 6- to 13-cm fork length and were from all five areas of Bristol Bay from Kvichak Bay south to Port Moller — a distance of about 320 km.

The stomach (that portion of the digestive tract from the anterior end of the esophagus to the pylorus) of each specimen was removed, and all food organisms were separated and identified to the lowest taxonomic level practical. All of the food items were air dried overnight at room temperature and weighed to the nearest 0.1 mg the following day.

The eight major categories of food items: copepods, fish, larval crustaceans, euphausiids, amphipods, insects, miscellaneous crustaceans, and zoofauna, are not mutually exclusive. The least specific categories merely reflect the digested condition or incidental importance of a given item, e.g., crustacean remains (recorded as miscellaneous crustaceans) or arachnids (zoofauna), which occurred only once.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

For each sampling area, the weight of each major food category was calculated as the percentage of the total dry weight of all food found. The percentage of occurrences and weights of foods were based only on those specimens containing food.

Results

The foods consumed by seaward-migrating sockeye salmon in Bristol Bay varied in the relative proportion and occurrence of kinds and quantities between months during the summer. The apparent differences between the upper and lower areas of the bay are largely due to date of sampling. The 16 empty stomachs found were collected in June from the upper bay — the Kvichak and Egegik areas.

In early June 1966 in the Kvichak area, 11 of 19 juvenile sockeye salmon contained food. Although fish and insects made up 97% of the bulk (weight), fish occurred in only 5% of the stomachs and insects in 53%. By late June in the same area, 8 of 10 stomachs contained food, most of which was copepods. They made up 89% of the bulk and were found in 70% of the stomachs; miscellaneous crustaceans were found in 60%. In mid-June of the following year (1967), 18 of 21 juvenile sockeye salmon from the Kvichak area contained food. Fish, insects, and copepods made up 93% of the bulk; fish occurred in 19% of the stomachs, insects in 76%, and copepods in 62%.

In mid-June 1966, 20 of 23 stomachs collected farther seaward at Egegik contained very small amounts of food. Euphausiids and miscellaneous crustaceans made up 78% of the bulk, but euphausiids occurred in only 9% of the stomachs and miscellaneous crustaceans in 13%. Insects occurred in 48% of the stomachs, but made up only 4% of the bulk.

In mid-July 1966 at Ugashik, all 20 stomachs collected contained larval crustaceans (79% by bulk and mostly anomurans). Copepods were insignificant in terms of bulk but occurred in 70% of the stomachs. At Port Heiden (farther seaward) on the same date, fish made up 76% of the bulk of the contents of the seven stomachs collected. Fish occurred in 28% of the stomachs, whereas amphipods occurred in 71% and insects in 57%.

At Port Moller in lower Bristol Bay throughout July and on 1 August 1967, copepods made up 71% of the bulk of food in 48 stomachs and occurred in 85%; larval crustaceans occurred in 58%, amphipods in 50%, and fish in 42%.

By mid-August 1967, when most juvenile sockeye salmon have migrated out of Bristol Bay (Straty 1974), the two juveniles taken at Ugashik contained only copepods and insects and two taken at Port Heiden contained mostly fish.

Only eight juvenile sockeye salmon were taken in September 1966 in the Ugashik area. Copepods and fish accounted for 86% of the stomach contents, but only copepods occurred frequently (100% with copepods vs. 25% with fish).

As the young sockeye salmon migrated seaward over successive months, they ate increasing amounts of food. In the Kvichak and Egegik areas during June, 16 of the 73 stomachs examined were empty and the others had only relatively small amounts of food (average of 3-6 mg). Later in the summer and farther at sea (Ugashik and Port Heiden) the average amount of food per stomach was much greater (20-24 mg), and still later in the summer and farther at sea (Port Moller), the amounts were the highest of all (average of 82 mg).

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 (Tables 1, 2). Two genera of calanoid copepods (*Eurytemora* and *Metridia*) made up 98% of the number of copepods in the stomachs of 50 juveniles taken by Straty and Jaenicke (see footnote 1) in 1967 at Kvichak and

TABLE 1.—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	30.3	8.6	25.4	6.3	71.2
Fish	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	—

TABLE 2. — 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	60.4	66.7
Fish	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

Port Moller. (The 50 specimens were taken at the same time and place as my samples.) 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.

Discussion

The results of this study generally agree with those of other investigators. The importance of copepods in the diet of juvenile sockeye salmon near shore in Bristol Bay is paralleled in coastal waters of British Columbia (Manzer 1969) and is similar to Kamchatka coasts, where copepods and cladocerans were the predominant foods of juvenile sockeye salmon (Synkova 1951). My findings differ from those of Jaenicke and Bonnett (see footnote 2), who sampled mainly over deeper waters of Bristol Bay farther offshore than I did, and Dell (1963), who sampled off Port Moller in Bristol Bay. Jaenicke and Bonnett examined the food of over 1,200 juvenile sockeye salmon captured during the summers of 1969-70 and found that the main items (in bulk) were young and larval sand lance and euphausiids. Similarly, Dell reported that 45 juvenile sockeye salmon taken in late July 1962 contained mostly larval sand lance and euphausiids.

Nearly all of the insects I found were from juvenile sockeye salmon captured in the Kvichak and Egegik areas in June (Table 1). These areas are contiguous to many rivers that form part of a major sockeye salmon reproductive complex of lakes and steams (Figure 1). According to Hartman et al. (1967), most of the migration from freshwater to Bristol Bay takes place in June. Most of the insects were probably ingested in fresh water when the fish were migrating seaward, suggesting that many of the juveniles taken in these areas were recent immigrants from fresh water. The occurrence of the only empty stomachs and small average weight of food per fish at Kvichak and Egegik suggest that the juveniles eat very little when they first enter salt water. Straty (1974) concluded that the young sockeye salmon did not feed when they entered Bristol Bay or that food was scarce. Reduction of feeding could be caused by a number of factors other than lack of food, including the physiological strain of adjusting osmoregulatory function from a freshwater to a marine environment.

The differences I observed in the types, relative proportions, and amounts of food eaten over successive months by the juvenile sockeye salmon as they progressed seaward can be largely attributed to food availability. Near-surface waters in the Kvichak area contained an average of 27 zooplankters per cubic meter in June, while near Port Moller in July the density was 1,400-8,100 (see footnote 1). Straty (1974) compared zooplankton abundance in the inner part of Bristol Bay (above Port Heiden) and the outer part (below Port Heiden) during 1969-71 and concluded that zooplankton was much more abundant as one progressed seaward.

Acknowledgements

I thank Walter R. Whitworth, Professor of Fisheries of the University of Connecticut, for his advice and help with this manuscript, which in more inclusive form was accepted as an M.S. thesis (1968) at the University of Connecticut, Storrs, and also thank my colleagues at the Northwest Fisheries Center Auke Bay Laboratory, National Marine Fisheries Service, NOAA, particularly Richard R. Straty and Herbert W. Jaenicke for their assistance and advice throughout the study.

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OCCURRENCE OF TWO GALATHEID CRUSTACEANS, *MUNIDA FORCEPS* AND *MUNIDOPSIS BERMUDEZI*, IN THE CHESAPEAKE BIGHT OF THE WESTERN NORTH ATLANTIC OCEAN[1,2]

Living male specimens of *Munida forceps* A. Milne-Edwards and *Munidopsis bermudezi* Chace (Table 1) were collected on the continental slope and rise south of Norfolk Canyon off the coast of Virginia on 18-19 November 1974. An ovigerous female *M. bermudezi* was also collected on 14 September 1975 in the Norfolk Canyon. They were taken with a 15-m shrimp trawl (12-mm stretch mesh inner liner) towed from the RV *James M. Gillis* (University of Miami, Florida).

Munida forceps has been reported from 80 to 338 m within the Gulf of Mexico and in the southwestern Atlantic between lat. 22°46.5′ and 26°37.0′N (Chace 1940, 1942; Springer and Bullis 1956; Bullis and Thompson 1965). Our find is consistent with the previously reported depth range, but it extends the geographic range of the species northward by 10° latitude.

Munidopsis bermudezi has been reported from the coast of Cuba (lat. 21°19′N, long. 76°05′W) at a depth of 2,654 m (Chace 1940, 1942), the Gulf of Mexico (lat. 25°50.5′N, long. 94°27′W) at 3,294 m (Pequegnat and Pequegnat 1970), and north of the Azores (lat. 45°26′N, long. 25°45′W) at 3,171 m (Sivertsen and Holthuis 1956).

The *Munida forceps* sample also included the galatheids *M. iris* A. Milne-Edwards and *M. longipes* A. Milne-Edwards and other decapods including *Bathynectes superbus* (Costa), *Cancer borealis* Stimpson, *C. irroratus* Say, *Homarus americanus* H. Milne Edwards, and penaeidean and caridean shrimps. The association of *M. forceps* with *M. iris* and *M. longipes* in our sample is previously unreported. Some previous records have shown associations with *M. stimpsoni* A. Milne-Edwards (Chace 1942) and with *M. flinti* Benedict and *M. irrasa* A. Milne-Edwards (Milne-Edwards 1880 from Pequegnat and Pequegnat 1970). Others (Benedict 1902; Bullis and Thompson 1965; Pequegnat and Pequegnat 1970) have not specified association of *M. forceps* with other galatheids.

TABLE 1.—Station and morphometric data for *Munida forceps* and *Munidopsis bermudezi* captured near Norfolk Canyon off the coast of Virginia. Length and width measurements in millimeters.

Item	*Munida forceps*	*Munidopsis bermudezi*	
	Male	Male	Female
Station	79	86	35
Collection	C74-499	C74-506	C74-168
Location, lat.	36°43.2′N	36°41.6′N	36°57.9′N
long.	74°38.0′W	73°47.0′W	73°21.5′W
Date of collection	Nov. 1974	Nov. 1974	Sept. 1975
Depth (m)	220-310	2,620-2,650	2,915-2,955
Bottom temperature (°C)	10.6	3.0	2.3
Bottom salinity (‰)	—	34.82	35.11
Total length (rostral tip to posterior margin of telson)	34	81.4	83.2
Carapace width, anterior	7.9	28.4	28.8
posterior	10.4	31.0	31.5
Carapace length (orbit to posterior margin)	13.5	33.5	33.5
Carapace length (including rostrum)	18.5	44.8	43.8
Cheliped (right) length	45	42.4	40.8
Carpus length	4.0	8.5	7.5
Merus length	15.2	14.5	13.0
Propodus length	25.6	19.3	14.3
Propodus width	4.5	8.8	8.0
Dactylus length	15.1	10.5	8.3
Second left pereopod length	28.8	48.7	46.5

[1]Research supported by National Science Foundation Grant GA-37561, J. A. Musick, Principal Investigator and by U.S. Department of Commerce, National Marine Fisheries Service Contract No. 03-4-043-353 for C.E.L. and P.A.H. participation.
[2]Contribution No. 717, Virginia Institute of Marine Science.