

INTERRELATIONSHIPS BETWEEN JUVENILE SALMONIDS AND NONSALMONID FISH IN THE COLUMBIA RIVER ESTUARY

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ABSTRACT

Interrelationships between juvenile salmonids—coho salmon, *Oncorhynchus kisutch*; chinook salmon, *O. tshawytscha*; and steelhead, *Salmo gairdneri*—and nonsalmonid fish were studied in the Columbia River estuary during 1980. Nonsalmonid species were numerically dominant in pelagic and intertidal areas of the lower estuary. In pelagic and intertidal areas of the upper estuary, juvenile salmonids, particularly subyearling chinook salmon were proportionally important. Nonsalmonid species commonly associated with juvenile subyearling chinook salmon included American shad, *Alosa sapidissima*; Pacific herring, *Clupea harengus pallasi*; northern anchovy, *Engraulis mordax*; surf smelt, *Hypomesus pretiosus*; longfin smelt, *Spirinchus thaleichthys*; peamouth, *Mylocheilus caurinus*; threespine stickleback, *Gasterosteus aculeatus*; shiner perch, *Cymatogaster aggregata*; Pacific staghorn sculpin, *Leptocottus armatus*; and starry flounder, *Platichthys stellatus*. Commonly associated species were generally defined only in reference to subyearling chinook salmon because, of all the juvenile salmonids, subyearling chinook salmon were clearly the most abundant and available in sizable numbers for the longest time. Predation on juvenile salmonids by nonsalmonids and other juvenile salmonids was insignificant. Significant diet overlap occurred among subyearling and yearling chinook salmon, coho salmon, and steelhead during the spring. American shad, threespine stickleback, and starry flounder had significant diet overlaps with juvenile salmonids.

The Columbia River system is an important producer of Pacific salmon (*Oncorhynchus* spp.) and steelhead, *Salmo gairdneri*, in North America (Chaney and Perry 1976; Bohn and Stockley 1981). Salmonids (wild and hatchery) originating from the Columbia River system provide fish for both river and ocean fisheries (recreational and commercial). Historically, the world's largest migration of adult chinook salmon, *O. tshawytscha*, occurred in the Columbia River (Van Hynning 1973). Dam construction, poor logging and agricultural practices, overfishing, and pollution have severely reduced adult salmonid returns to the Columbia River system. Efforts to improve the runs, such as large hatchery releases of juveniles, collection and transportation of juveniles at selected dams, and the installation of dam spillway deflectors to reduce nitrogen supersaturation have enhanced adult returns, but failed to increase them to historical levels. There is concern by some resource managers that significant losses of juvenile salmonids may be occurring in the ocean and/or estuary. They feel these losses may be due to predation or competition for the same food organisms by nonsalmonid fish.

No published information is known to exist on the interrelationships between juvenile salmonids and

nonsalmonid fish throughout the Columbia River estuary; this paper helps fill that void. Our objectives were to document the following: 1) The proportional abundance of salmonids and nonsalmonids in various estuarine habitats, 2) the nonsalmonid fish species associated with juvenile salmonids, 3) the length characteristics of nonsalmonids and juvenile salmonids, 4) predation on salmonids, and 5) prey consumption and possible competition between salmonids and nonsalmonids in similar habitats.

METHODS AND MATERIALS

Study Area

The study was carried out in the Columbia River estuary between River Kilometers 3 and 62 (Fig. 1). The estuary is a drowned river mouth with delta islands in the upper portion. Salinity intrusion in the estuary fluctuates considerably because of changing river flows and tide conditions. Vertical salinity gradients exist in parts of the estuary, with the highest salinities in deep water near the bottom (Neal 1972; McConnell et al. 1981).

We divided the estuary into upper and lower areas (Fig. 1); these two areas were further divided into pelagic and intertidal habitats. Pelagic and intertidal areas of the upper estuary were classified as freshwater. The lower estuary was classified as a mixed zone, with salinities ranging from 0 to 33‰ depend-

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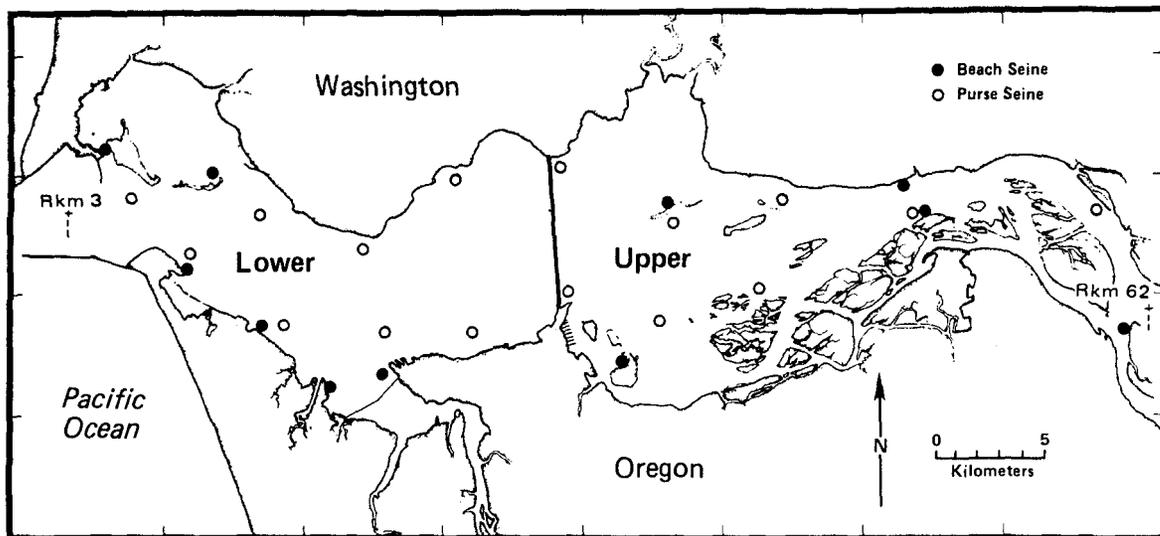


FIGURE 1.—Sampling sites in the upper and lower areas of the Columbia River estuary.

ing upon distance from the river mouth, river flow, and tidal stage. Saline water penetrates along the river channels into sections of the upper estuary at times; however, in most instances, our sampling was associated with fresh water. Habitats we called intertidal often consisted of both intertidal and some subtidal areas.

Sampling

Two beach seines were used to sample in intertidal areas. The seines were 50 m long; one was 4.0 m and the other 3.4 m deep at their deepest points. Both nets contained panels with the following mesh sizes (stretched): 19.0, 12.7, and 9.5 mm. Knotless mesh was used in the bunt to minimize scaling of fish (this was also true in the purse seine). The fishing method was similar to that described by Sims and Johnsen (1974). Beach seining was done at various tide stages.

A 200 m long by 9.8 m deep purse seine was employed to collect pelagic species. Mesh sizes (stretched) in the seine included 19.0 and 12.7 mm. Purse seine sets were made for 5 min in an upstream direction during various stages of the tide.

Collapsible hoop nets and trawl nets were also used, but captured comparatively few salmonids.

Monthly sampling throughout the estuary was performed from February 1980 through January 1981. The effort involved 11 beach seine and 16 purse seine sites (Fig. 1). Five intertidal sampling stations

(beach seine) were in the upper estuary and six in the lower. Eight of the pelagic sampling sites (purse seine) were in the upper estuary and eight in the lower. Before each sampling effort, water temperature, conductivity, and salinity were recorded using a Beckman,² Model RS5-3 salinometer and probe.

Fish were identified and enumerated, and a random subsample of up to 50 fish of each species or stock was measured to the nearest millimeter (total length) and weighed to the nearest gram. Subyearling and yearling chinook salmon were separated using length-frequency histograms. The number and total weight were recorded for those species with over 50 individuals in a single sample effort.

A representative subsample of five individuals of each species was selected from each purse seine and beach seine set for stomach analysis. Fish taken for stomach analysis were injected with a 20% buffered Formalin solution soon after capture to preserve stomach contents. Injected fish were weighed and measured at the laboratory. Stomachs were then removed from the fish and placed in vials containing 70% ethyl alcohol.

Fish stomach contents were examined in a watch glass using a 10× binocular dissecting microscope. Food organisms were identified to the lowest practical taxon and weighed to the nearest 0.0001 g after blotting and air drying for 10 min.

²Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Data Analysis

Because subyearling chinook salmon were the most frequently caught salmonids and were available in sizable numbers from March through September, we chose to compare all other species (including other juvenile salmonid species) in relation to them. We assigned one of three abundance categories: Common, occasional, or uncommon. A common species occurred in 50% or more of the sampling efforts (in which juvenile salmon were captured) and equaled 50% or more of the total number of subyearling chinook salmon captured in that habitat. An occasional species occurred in more than 20% of the sampling efforts and equaled more than 10% of the total number of subyearling chinook salmon. An uncommon species occurred in 20% or less of the sampling efforts and equaled 10% or less of the total number of subyearling chinook salmon. Fish were not separated by age-classes, except yearling and sub-yearling chinook salmon.

Food habit data from April through September were combined into two periods—spring (April through June) and summer (July through September). Diet descriptions and comparisons are not presented for February, March, and October. Principal prey items for each fish species were determined by calculating the Index of Relative Importance (IRI) modified from Pinkas et al. (1971):

$$IRI = (N + W)F$$

where N = numerical percentage of a prey item
 W = weight percentage of a prey item
 F = frequency of occurrence percentage of a prey item.

Any prey item with an IRI value >50 was considered a principal prey for a given species. Digested food was not included in this calculation.

To assess possible food competition, diet overlap of associated species was measured using the formula developed by Morisita (1959) and modified by Horn (1966):

$$\hat{C}_\lambda = \frac{2 \sum_{i=1}^s X_i \cdot Y_i}{\sum_{i=1}^s X_i^2 + \sum_{i=1}^s Y_i^2}$$

where \hat{C}_λ = overlap coefficient
 s = number of food categories
 X_i = proportion of the total diet of fish species X contributed by food category i (by biomass)

Y_i = proportion of the total diet of fish species Y contributed by food category i (by biomass).

Values of \hat{C}_λ range from 0 to 1, with 0 indicating no overlap and 1 indicating complete diet overlap. A value of 0.6 is considered significant diet overlap (Zaret and Rand 1971).

RESULTS

Juvenile chinook salmon (subyearling and yearling); coho salmon, *O. kisutch*; and steelhead were the most common salmonids in the estuary (Table 1). Subyearling chinook salmon were the most abundant and were available in quantity for the longest time (March through September). Catches of juvenile chum salmon, *O. keta*; sockeye salmon, *O. nerka*; and cutthroat trout, *S. clarki*, were small; consequently, they will not be included in the analysis of inter-competition. The low incidences of these species indicate their small estuarine populations when compared with steelhead and chinook and coho salmon.

TABLE 1.—Numbers of juvenile salmonids collected in four habitats of the Columbia River estuary from March to September 1980.

Species	Habitat				Total
	Pelagic		Intertidal		
	Upper estuary	Lower estuary	Upper estuary	Lower estuary	
Chum salmon	1	0	16	4	21
Coho salmon	695	617	71	12	1,395
Sockeye salmon	15	14	0	0	29
Chinook salmon					
subyearling	1,858	1,627	1,816	730	6,031
yearling	512	243	29	4	788
Cutthroat trout ¹	16	9	7	0	32
Steelhead	278	253	1	1	533

¹Includes some adults.

Proportional abundances of juvenile chinook salmon (subyearling and yearling), coho salmon, steelhead, and nonsalmonids are shown by month in Figure 2. If fewer than 10 subyearling chinook salmon were collected, then no comparisons were made. In pelagic areas of the upper estuary, juvenile salmonids were numerically important from April through August, with a substantial decline in September. Yearling chinook salmon were an important part of the catch in April and May, coho salmon in May and June, and steelhead in May. Subyearling chinook salmon were important from May through August.

In the pelagic area of the lower estuary, non-salmonids were clearly numerically dominant. Periodically this portion of the estuary contained large schools of marine fish, such as Pacific herring, *Clupea*

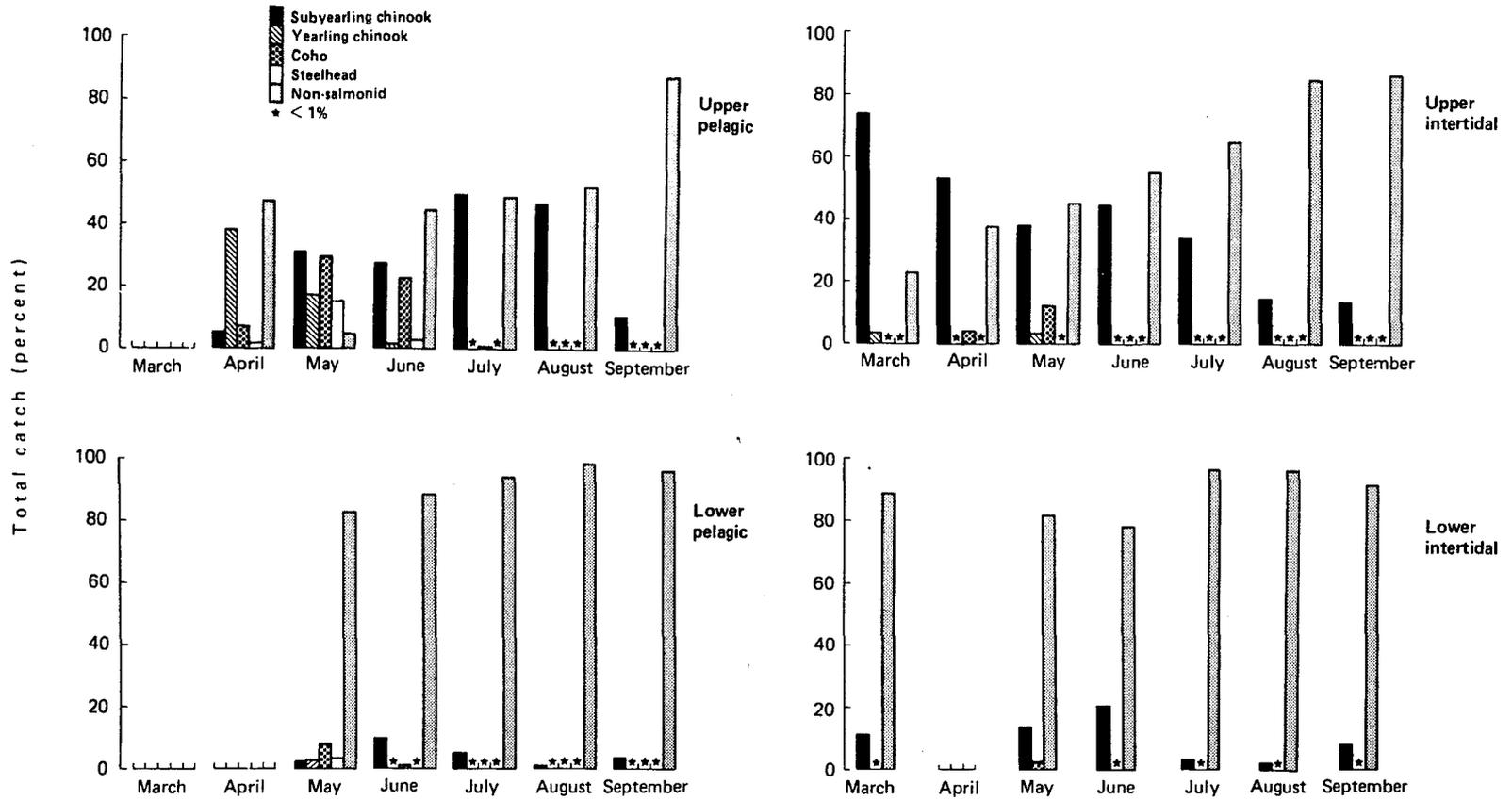


FIGURE 2.—Proportional abundances of fish collected in four habitats of the Columbia River estuary in 1980.

harengus pallasii, and northern anchovy, *Engraulis mordax*.

In intertidal areas of the upper estuary, subyearling chinook salmon was the only abundant salmonid species; its importance was considerably reduced by August.

Catches in intertidal areas of the lower estuary were dominated by nonsalmonids; however, in the intertidal areas, subyearling chinook salmon were more important than in the pelagic zone. Although large numbers of salmonids were captured in the pelagic and intertidal areas of the lower estuary (Table 1), their importance was masked by the large number of marine nonsalmonids.

Thirteen species including yearling chinook salmon were commonly associated with subyearling chinook salmon during at least one of the months in the two seasonal periods in the Columbia River estuary (Table 2).

Juvenile coho salmon were captured primarily in pelagic areas; however, they were occasionally collected in intertidal areas (Table 1). Yearling chinook salmon and steelhead in particular were almost exclusively in pelagic areas.

Length characteristics of subyearling chinook salmon and the commonly associated species are shown in Table 3. Most common species in the pelagic zone of the upper estuary were longer than the subyearling chinook salmon, whereas in the pelagic zone of the lower estuary many of the species were shorter or the same. In the intertidal areas of the upper estuary, only starry flounder, *Platichthys stellatus*; threespine stickleback, *Gasterosteus aculeatus*; peamouth, *Mylocheilus caurinus*; and American shad, *Alosa sapidissima*, were commonly associated with subyearling chinook salmon and all of their mean lengths were shorter. In intertidal areas of the lower estuary, many of the common species were

TABLE 2.—Fish associated with subyearling chinook salmon in the Columbia River estuary from March through September 1980. (C = commonly, O = occasionally, and U = uncommonly associated with subyearlings; * = commonly associated species; J = juveniles; and A = adult.)

Species	March-June 1980				July-September 1980			
	Pelagic		Intertidal		Pelagic		Intertidal	
	Upper estuary	Lower estuary	Upper estuary	Lower estuary	Upper estuary	Lower estuary	Upper estuary	Lower estuary
River lamprey, <i>Lampetra ayresi</i>	—	U	—	—	—	U	—	U
Pacific lamprey, <i>Lampetra tridentata</i>	—	U	—	—	—	U	—	—
White sturgeon, <i>Acipenser transmontanus</i>	—	U	—	U	U	U	—	—
*American shad, <i>Alosa sapidissima</i>	C	C	U	U	C	C	C	U
*Pacific herring, <i>Clupea harengus pallasii</i>	—	C	—	O	O	C	—	C
*Northern anchovy, <i>Engraulis mordax</i>	—	C	—	U	—	C	—	O
Chum salmon (J), <i>Oncorhynchus keta</i>	U	—	U	U	—	—	—	—
*Coho salmon (J), <i>Oncorhynchus kisutch</i>	C	C	O	O	U	U	U	U
Coho salmon (A)	—	—	—	—	U	U	—	—
Sockeye salmon (J), <i>Oncorhynchus nerka</i>	U	U	—	—	—	—	—	—
*Chinook salmon (Yt), <i>Oncorhynchus tshawytscha</i>	C	C	U	U	U	—	U	—
Chinook salmon (A)	—	U	U	—	U	U	—	—
Cutthroat trout, <i>Salmo clarki</i>	U	U	—	—	U	U	U	—
*Steelhead (J), <i>Salmo gairdneri</i>	C	C	U	U	—	U	—	—
Steelhead (A)	—	—	U	—	—	—	U	—
Whitebait smelt, <i>Allosmerus elongatus</i>	—	U	—	—	—	O	—	—
*Surf smelt, <i>Hypomesus pretiosus</i>	U	C	—	C	—	O	—	C
*Longfin smelt, <i>Spirinchus thaleichthys</i>	U	C	—	U	C	C	—	—
Eulachon, <i>Thaleichthys pacificus</i>	—	—	U	O	—	—	—	—
Common carp, <i>Cyprinus carpio</i>	—	—	U	U	U	O	U	—
*Peamouth, <i>Mylocheilus caurinus</i>	C	U	U	U	O	—	C	O
Northern squawfish, <i>Ptychocheilus oregonensis</i>	U	—	U	—	—	—	U	—
Largescale sucker, <i>Catostomus macrocheilus</i>	U	—	U	U	—	—	O	U
Pacific hake, <i>Merluccius productus</i>	—	U	—	—	—	—	—	—
Pacific tomcod, <i>Microgadus proximus</i>	—	U	—	—	U	O	—	U
*Threespine stickleback, <i>Gasterosteus aculeatus</i>	C	O	O	C	O	O	C	O
Yellow perch, <i>Perca flavescens</i>	—	—	—	—	—	—	—	U
Redtail surfperch, <i>Amphistichus rhodotus</i>	—	U	—	—	—	U	—	U
*Shiner perch, <i>Cymatogaster aggregata</i>	—	—	—	C	O	—	O	C
Walleye surfperch, <i>Hyperprosopon argenteum</i>	—	U	—	—	—	—	—	—
Silver surfperch, <i>Hyperprosopon ellipticum</i>	—	U	—	—	—	—	—	U
Pile perch, <i>Rhacochilus vacca</i>	—	—	—	—	—	U	—	—
Pacific sandfish, <i>Trichodon trichodon</i>	—	U	—	—	—	—	—	—
Snake prickleback, <i>Lumpenus sagitta</i>	—	U	—	—	—	U	—	U
Lingcod, <i>Ophiodon elongatus</i>	—	U	—	—	—	—	—	—
Prickly sculpin, <i>Cottus asper</i>	—	U	U	U	U	U	U	U
*Pacific staghorn sculpin, <i>Leptocottus armatus</i>	U	U	O	C	U	O	O	C
Speckled sanddab, <i>Citharichthys stigmaeus</i>	—	—	—	—	—	—	—	U
Butter sole, <i>Isopsetta isolepis</i>	—	—	—	O	—	—	—	—
English sole, <i>Parophrys vetulus</i>	—	—	—	O	—	—	—	O
*Starry flounder, <i>Platichthys stellatus</i>	O	U	C	C	O	O	C	C
Sand sole, <i>Psetichthys melanostictus</i>	—	U	—	U	—	U	—	U

TABLE 3.—Total length (mm) characteristics of subyearling chinook salmon and commonly associated species captured in four habitats of the Columbia River estuary in 1980. *N* = total number captured.

Species	March			April			May			June			July			August			September		
	\bar{X}	2SE	<i>N</i>	\bar{X}	2SE	<i>N</i>	\bar{X}	2SE	<i>N</i>	\bar{X}	2SE	<i>N</i>	\bar{X}	2SE	<i>N</i>	\bar{X}	2SE	<i>N</i>	\bar{X}	2SE	<i>N</i>
Upper pelagic																					
Subyearling chinook				86	2.2	31	100	0.8	493	95	2.0	205	100	1.6	557	128	1.8	366	119	1.6	203
Yearling chinook				178	3.8	210	149	2.6	278												
Coho				139	4.4	41	147	1.6	469	145	2.1	168									
Steelhead							203	4.2	246												
American shad										187	11.8	173			236	10.0	230	186	12.2	260	
Longfin smelt																		97	3.4	710	
Peamouth										194	10.2	108									
Threespine stickleback				55	1.6	177															
Lower Pelagic																					
Subyearling chinook							102	1.6	138	103	1.2	696	104	1.6	444	126	2.4	216	125	2.4	122
Yearling chinook							148	2.4	195												
Coho							149	1.4	509												
Steelhead							207	3.6	234												
American shad							172	7.2	287						239	4.0	567	242	9.6	87	
Pacific herring							152	2.6	4,264	153	4.2	721	114	4.2	944	108	2.8	8,331	107	3.2	1,366
Northern anchovy										149	1.8	4,530				142	3.0	2,357	141	5.2	1,386
Surf smelt							83	5.8	107												
Longfin smelt							100	2.8	245	111	1.6	660	83	2.8	5,164	93	4.2	176			
Shiner perch							105	3.8	150				108	2.4	357	94	4.0	368	78	3.2	83
Upper intertidal																					
Subyearling chinook	69	2.0	214	77	2.6	136	85	2.4	181	75	1.6	709	82	1.4	303	98	1.8	112	125	2.6	161
American shad																			62	1.6	270
Peamouth																71	6.0	242	88	6.2	232
Threespine stickleback																			42	1.6	156
Starry flounder										49	3.6	725	56	5.6	423	57	2.8	237	71	3.8	132
Lower intertidal																					
Subyearling chinook	73	3.0	18				92	2.6	58	75	1.2	405	85	2.2	192	97	4.0	28	120	5.8	25
Pacific herring													74	1.4	569	93	1.6	156			
Surf smelt												86	1.2	428		119	4.6	90			
Threespine stickleback	53	2.8	19				55	1.8	37												
Shiner perch										105	3.8	504	84	3.2	3,960	70	3.0	649	73	1.4	148
Staghorn sculpin	56	10.2	22				58	2.4	186							92	11.0	17	100	4.2	22
Starry flounder	138	14.4	89				118	9.2	89							105	14.2	60	100	5.6	82

shorter, or no longer than, subyearling chinook salmon.

About 5,000 stomachs from 50 species of fish collected from February through October 1980 were analyzed. There were only two predations on juvenile salmonids—two yearling chinook salmon each ate a subyearling chinook salmon. Juvenile subyearling chinook salmon preyed on nonsalmonid fish, chiefly in the lower estuary. Nonsalmonid fish consumed by subyearlings included Pacific sand lance, *Ammodytes hexapterus*; northern anchovy; longfin smelt, *Spirinchus thaleichthys*; and whitebait smelt, *Allosmerus elongatus*. Principal prey items accounted for an average of 93% of the diet biomass for all fish species with a range of 53-100%. Principal prey items of juvenile salmonids and commonly associated nonsalmonids were invertebrates, chiefly crustaceans (Figs. 3, 4); fish were eaten but they were never the only prey.

Figures 5 and 6 show the degree of diet overlap between salmonids and commonly associated species. In the pelagic areas during spring, all the salmonids except steelhead (upper pelagic) had significant diet overlap values (≥ 0.6). Salmonid species had significant diet overlap values with American shad in the lower estuary and threespine stickleback in the up-

per estuary. In the intertidal areas during spring, significant diet overlap occurred only between subyearling chinook salmon and starry flounder. Significant diet overlap in the spring was primarily due to the importance of *Corophium salmonis* and *C. spinicorne* as prey items. In summer there was no significant fish diet overlap.

On 18 May 1980, Mount St. Helens erupted and deposited large amounts of volcanic ash and sediments into the Columbia River, thereby increasing the turbidity of the estuary. For a short time, the increased sediment loads and high turbidities reduced the amount and variety of food items eaten. By July 1980, turbidities returned to lower levels.

DISCUSSION

Some of the same species associated with juvenile chinook salmon in the Columbia River estuary were found in similar associations in other Pacific Northwest estuaries. Conley (1977), working in Everett Bay in Puget Sound, Wash., caught many shiner perch, *Cymatogaster aggregata*; Pacific staghorn sculpin, *Leptocottus armatus*; and starry flounder in intertidal areas along with juvenile chinook salmon. Myers (1980), working in Yaquina Bay,

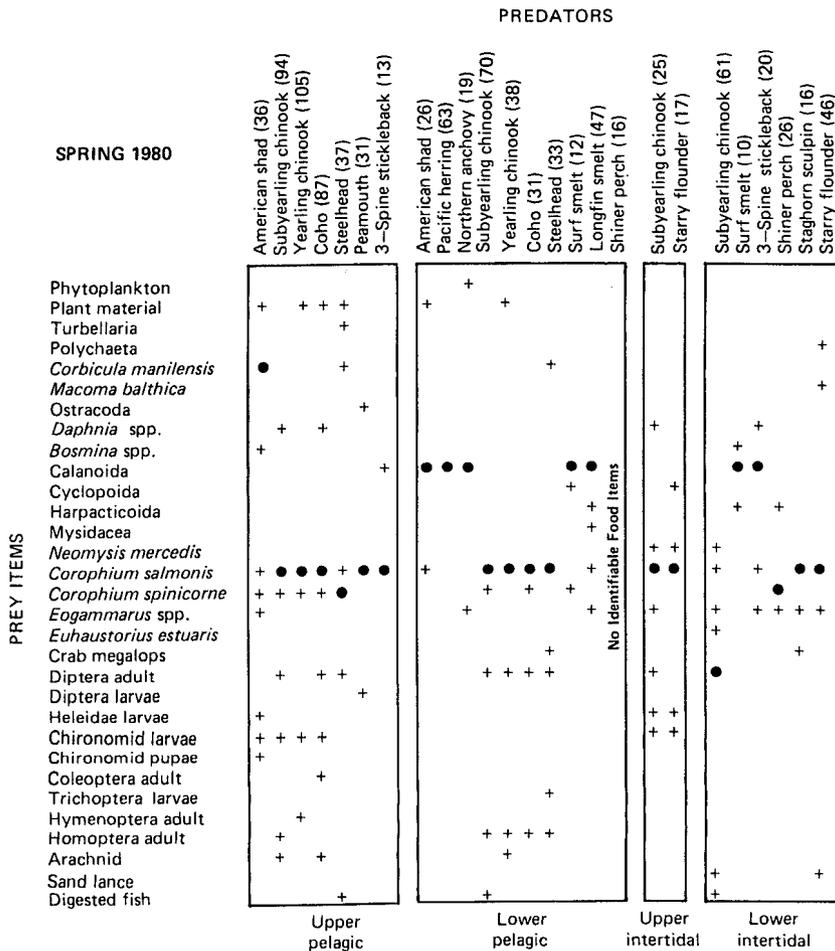


FIGURE 3.—Principal prey items of juvenile salmonids and commonly associated nonsalmonids captured in four habitats of the Columbia River estuary during spring 1980. A principal prey item has an IRI value >50; the prey item with the highest IRI value for each species is indicated by a solid circle. Number of stomachs examined is shown in parentheses.

Oreg., found that Pacific herring, shiner perch, northern anchovy, and surf smelt, *Hypomesus pretiosus*, were abundant at her beach seine sites. Durkin et al.³ found that shiner perch, Pacific herring, surf smelt, and northern anchovy were commonly associated with subyearling chinook salmon in intertidal areas of the lower Columbia River estuary.

Considering the nonsalmonid species commonly associated with subyearling chinook salmon and their size characteristics, nonsalmonid predation on

subyearlings in the Columbia River estuary should be minimal. American shad, Pacific herring, surf smelt, longfin smelt, peamouth, threespine stickleback, and shiner perch are essentially invertebrate and/or plant eaters. Large Pacific staghorn sculpins and starry flounder could eat subyearling chinook salmon; however, the large individuals of these species are usually not found in intertidal areas of the estuary. Normally the large sculpins and flounders are found in deep demersal habitats of the Columbia River estuary. Although many researchers have studied the use of the estuarine areas as nursery and feeding areas for salmonids (Mason 1974; Levy and Levings 1978; Reimers et al 1978; Sibert 1979; Healey 1980; Myers 1980), few have documented the food habits of associated nonsalmonid estuarine fish

³Durkin, J. T., S. J. Lipovsky, G. R. Snyder, and M. E. Tuttle. 1977. Environmental studies of three Columbia River estuarine beaches. Unpubl. manusc., 78 p. Northwest and Alaska Fisheries Center Hammond Field Station, National Marine Fisheries Service, NOAA, P.O. Box 155, Hammond, OR 97121.

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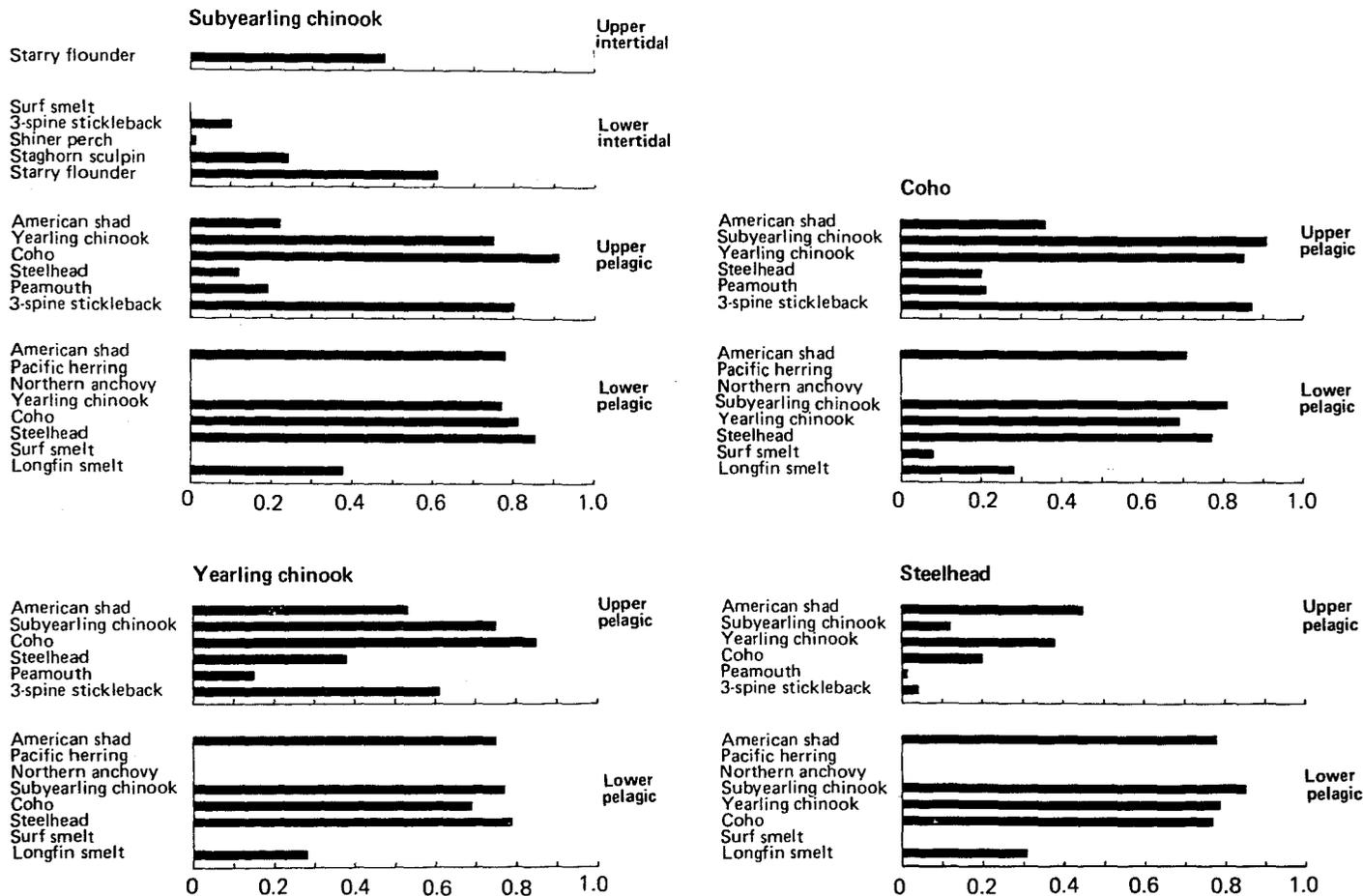


FIGURE 5.—Diet overlaps between juvenile salmonids and commonly associated species in the Columbia River estuary during spring 1980. Overlap values were calculated using Morisita's (1959) equation modified by Horn (1966).

SUMMER 1980

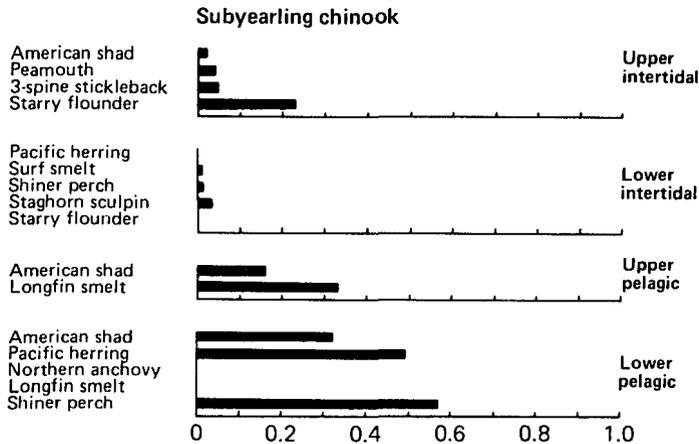


FIGURE 6.—Diet overlaps between subyearling chinook salmon and commonly associated species in the Columbia River estuary during summer 1980. Overlap values were calculated using Morisita's (1959) equation modified by Horn (1966).

spiniorne and *C. salmonis* were found to be important prey for juvenile chinook salmon (Reimers et al. 1978). Although the principal prey items differ in each estuary, the estuaries do provide important feeding habitat. Estuarine feeding and growth play an important role in salmonid and nonsalmonid life histories (McHugh 1967; Mason 1974; Levy and Levings 1978; Healey 1980).

Research indicates that at low prey abundances various prey sizes are eaten as encountered, but at higher densities larger prey are selected by predators (Ivlev 1961; Werner and Hall 1974). We believe the high diet overlap between fish in the spring is related to the occurrence of an abundant food resource (principally *C. salmonis*). In the summer when *Corophium* abundance apparently was lower, predators shifted to feeding primarily on zooplankton and diversified their diets, thus keeping diet overlap at a minimum. McConnell et al. (1978) also noted reduced abundance of *C. salmonis* in the diets of subyearling chinook salmon in the upper Columbia River estuary during the summer.

Information explaining why *C. salmonis* was an important prey in spring and not in summer is lacking. It was apparent that migrating salmonids and many nonsalmonids were intensely harvesting this food resource. This predation may have affected *Corophium* abundance. Levings and Levy (1977) and Nelson (1979) showed that fish predators could be a controlling factor in estuarine amphipod populations. Also, the huge deposition of sediment that resulted from the eruption of Mount St. Helens prob-

ably reduced *C. salmonis* populations in the Columbia River estuary (Emmett 1982).

Juvenile salmonids and nonsalmonids share the same habitats. Both nonsalmonids and subyearling chinook salmon utilize intertidal areas of the estuary as feeding and resting areas. Undoubtedly the estuary serves as a sanctuary for many juvenile nonsalmonids as well as for juvenile salmon. Intertidal shallow areas of the estuary typically support rich populations of benthic invertebrates, which are important prey items.

Like the intertidal areas, the pelagic sections of the estuary are utilized by juvenile salmonids and nonsalmonids as feeding places. Many of the juvenile salmonids in the pelagic areas are probably migrating actively to the ocean. Myers (1980) found that the mean length of wild juvenile chinook salmon captured in the channel areas was greater than that of those collected along the shoreline. Gear selectivity may have caused this anomaly; however, if it did not, then Myers (1980) felt that the small juvenile chinook salmon may be rearing along the beaches, then migrating into channel areas at a larger size.

The interrelationships of various species in estuarine habitats will probably change from year to year. Yet we feel the general picture of the fish communities in the estuary in regards to juvenile salmonids will remain virtually unchanged, unless detrimental artificial alterations are made. This estuary serves as a sanctuary (from other fish predators) for juvenile salmonids, along with being an important feeding area for some subyearling chinook

salmon. The juvenile salmonids share the same estuarine habitats with many other species, both freshwater and marine.

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