AN ABSTRACT OF THE THESIS OF

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Title: AN INVESTIGATION OF THE UTILIZATION OF FOUR STUDY AREAS IN YAQUINA BAY, OREGON, BY HATCHERY AND WILD JUVENILE SALMONIDS

Abstract approved: Howard F. Horton

Howard F. Horton

Results of a study of spatial and temporal utilization of a tidal river estuary by hatchery and wild juvenile salmonids (Oncorhynchus spp. and Salmo spp.), of overlap in food habits of hatchery and wild juvenile salmonids, and of size and relative abundance of associated fish species are reported in this thesis. The investigation was conducted in Yaquina Bay, Oregon in 1977 and 1978 to provide information for evaluation of concerns over the biological impact of large releases of hatchery salmon on wild fish in the estuary.

A 100- X 3-m beach seine was used to sample four beach study areas from July 1977 through December 1978, and a 222-m lampara net was used to sample two channel study areas from March 1978 through October 1978. Approximately 2.2 million hatchery salmon were released into Yaquina Bay in 1977, and

9.6 million were released in 1978. Tags, fin clips, dye marks, scales, species, release date, external parasites, visceral fat, size, and fin erosion were used to determine hatchery or wild origin of individual salmonids in the catch.

Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon, in decreasing order, were the most abundant wild salmonid species, and coho salmon were the most abundant hatchery species. In 1978 wild populations of chum and coho salmon were present in the estuary for 2-3 mo (March-June), and wild chinook were present during 9 mo (January, April-November). Increase in mean length of wild chum and chinook, and decrease in mean length of wild coho, indicated that wild chum and chinook utilized the estuary as a rearing area, and wild coho did not. Lack of overlap in peak migration periods of wild chum (early April), coho (mid May), and chinook (late July-early August) suggests the need to minimize overlap in utilization of the estuary by hatchery and wild juvenile salmonids. The length of residence of hatchery coho in Yaquina Bay was described by the equation: $N=N_o e^{-kt}$. The "residency half-life" $(\frac{N}{N_o}=\frac{1}{2})$ ranged from 1.7 to 9.0 days for different release groups of hatchery coho in 1977 and 1978. Juvenile hatchery coho that remained for an extended period (1-3 mo) in Yaquina Bay during 1977 increased in mean length from 11.5 cm FL in mid July to 21.0 cm FL in October. Some individuals within summer release groups of hatchery chinook also remained in the estuary for extended periods (> 2 mo). Groups of juvenile hatchery coho and chinook released into Yaquina Bay earlier in the year (June-August) remained in the estuary for longer periods than groups released later in the year (September-October).

Overlap in food habits of hatchery and wild juvenile salmonids in the estuary was often high, although overlap was found to vary with species, time, habitat, space, length of estuarine residence, and prey abundance. In terms of biomass, larval and juvenile fish (Clupeidae, Engraulidae, and Osmeridae) were the most important prey organisms of hatchery and wild coho and chinook salmon in Yaquina Bay. Approximately 58 fish species were captured at the study areas in 1977 and 1978, and 17 were identified in the stomach contents of hatchery and wild salmonids.

Overlap in spatial and temporal utilization and in food habits of hatchery and wild juvenile salmon in the estuary indicates that the potential for competition between these groups does exist, should space or food resources become a limiting factor. To reduce overlap in spatial and temporal utilization, consideration should be given to not releasing hatchery salmon during peak migration periods of wild chum, coho, and chinook salmon. To reduce length of residence of hatchery coho and chinook released after May, mid to late summer releases should be considered.

An Investigation of the Utilization of Four Study Areas in Yaquina Bay, Oregon, by Hatchery and Wild Juvenile Salmonids

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INTRODUCTION

This thesis reports an investigation of the utilization of a coastal river estuary by hatchery and wild juvenile salmonids. The research was initiated to provide biological information needed to evaluate concerns about overlapping use of river estuaries by privately cultured and wild juvenile salmonids. The study was conducted by systematic sampling of specific study areas in Yaquina Bay, Oregon from July 1977 through December 1978.

In 1971 the Oregon Legislature authorized the licensing of private commercial hatcheries to rear, release, and recapture chum salmon (Oncorhynchus keta), in 1973 the law was extended to include coho (O. kisutch) and chinook (O. tshawytscha) salmon, and in 1979 pink salmon (O. gorbuscha) were also authorized for release. To date, the Oregon Department of Fish and Wildlife has issued permits to private commercial operators for the annual release of 100.5 million chum, 42.0 million chinook, and 37.8 million coho salmon, or more than two times the present annual salmon production (72.3 million) of Oregon public hatcheries (Cummings 1979a).

As a result of the issuance of these permits, many biologists, legislators, and fishermen expressed concern about the impact that releases of large numbers of privately cultured salmon may have on populations of wild fish and on salmonids released from public hatcheries (Oreg. Dept. Fish Wildl. 1977b; Goranson 1978; Gunsolus 1978; Kadera 1978; Lichatowich et al. 1978). One specific concern was that privately cultured juvenile salmon released directly into river estuaries might remain for extended periods of time and compete with wild salmonids for food and space (Cummings 1979a; Kadera 1979). These concerns were based, in part, on a lack of knowledge of the importance of estuarine environments to growth and survival of anadromous salmonids (Royal 1972; Iwamoto and Salo 1977), and on the idea that rearing capacities of estuaries for juvenile salmonids are limited (Reimers 1973, 1978; Bailey et al. 1975; Reimers and Concannon 1977; Wilson and Buck 1978).

To provide biological information for the evaluation of these concerns, the objectives of the research reported here were:

1. To determine the spatial and temporal utilization of study areas in Yaquina Bay, Oregon by hatchery and wild juvenile salmonids.
2. To determine the food habits, and extent of overlap in food habits of hatchery and wild juvenile salmonids.
3. To determine the size and relative abundance of other fish species present at the study areas.

Hatchery and Wild Salmonids in Yaquina Bay

Yaquina Bay was chosen as the location for this study because since 1973 it has been the site of one of the release-recapture facilities of the largest private commercial hatchery in Oregon, Oregon Aqua Foods, now a subsidiary of Weyerhaeuser Company. Oregon Aqua Foods has been issued permits for the release of 9.5 million coho, 10.6 million chinook, and 20 million chum salmon into Yaquina Bay annually. However, it may be several years before these production levels are reached.

Oregon Aqua Foods salmon are reared at an inland hatchery at Springfield, Oregon, and trucked to the coastal release-recapture site at Yaquina Bay. After being held in saltwater ponds for 2-3 weeks, the juvenile salmon are released into the estuary at night, at slack high tide.

Juvenile coho salmon released into Yaquina Bay during the period of this study were reared in heated water (11°C) to accelerate their rate of growth. Using this technique coho salmon that normally are reared for 16-18 mo in freshwater to reach migratory size attain a similar size in 5-6 mo. Cummings (1979a) expressed concern that these 0-age coho may remain in the estuary and compete with wild salmonids.

Relatively little is known about wild populations of anadromous salmonids in the Yaquina system. Information is limited primarily to incidental accounts of the occurrence of species, and to brief reports of catch statistics and spawning ground surveys by public resource agencies. In general, however, wild populations of anadromous salmonids in the Yaquina system are considered to be small, and estimates of population size are low when compared to similar estuarine river systems in Oregon (Percy et al. 1974).

Species of anadromous salmonids reported to occur in the Yaquina watershed include fall chinook salmon, coho salmon, chum salmon, pink salmon, winter steelhead trout (Salmo gairdneri), and sea-run cutthroat trout (S. clarki) (Smith 1956; Herrmann 1959; Beardsley 1969; U.S. Army Corps of Engr. 1970; Smith and Lauman 1972; Gaumer et al. 1974).

The Yaquina watershed has 66 tributary streams that are utilized by anadromous salmonids (Smith and Lauman 1972). Smith and Lauman (1972) estimated an annual spawning escapement of approximately 12,600 coho salmon, 7,500 sea-run cutthroat trout, 2,300 winter steelhead trout, and 2,100 fall chinook salmon. If spawning escapement represents a smolt to adult survival rate of at least 1%, then populations of juvenile salmonids either emigrating to the ocean or temporarily utilizing the Yaquina estuary may be as large as 1,260,000 coho salmon, 750,000 sea-run cutthroat trout, 230,000 winter steelhead trout, and 210,000 fall chinook salmon.

However, spawning ground surveys of tributaries of the Yaquina system have shown that spawning escapement of adult salmonids has declined significantly in recent years (Oreg. Dept. Fish Wildl. 1977a; Scarnecchia 1978; Cummings 1979b).

Commercial net fisheries for salmon have not been allowed in Yaquina Bay since 1956, and the annual sport catch in the Yaquina system has also declined in recent years. In 1972 the annual sport catch was estimated at 2, 800 salmon, 1, 080 cutthroat trout, and 200 winter steelhead trout (Smith and Lauman 1972). Since then, however, the combined annual sport catch of coho and chinook salmon in the Yaquina system has often been less than 1000 fish (Oreg. Dept. Fish Wildl. 1977a).

Early commercial set-net fisheries may have contributed significantly to the depletion of native stocks of anadromous salmonids in the Yaquina system. An early report described an annual catch of 60, 000 adult salmon when commercial set-net fisheries were allowed in the Yaquina River (Oreg. Bd. Fish Comm. 1889). If catches of this size represented smolt to adult survival rates of at least 1%, then populations of juvenile salmonids either emigrating to the ocean or temporarily residing in the Yaquina estuary may have been as large or larger than 6, 000, 000 fish in the late 1800's.

In 1903, a public hatchery located on Elk Creek, the major tributary of the Yaquina River, was completed (Oreg. Dept. Fish.

1905). Hatchery stop-racks were built across the Yaquina River and Elk Creek, and blocked the upstream migration of large numbers of adult salmonids (Oreg. Dept. Fish. 1905, 1913). By 1911 populations of salmonids in the Yaquina system were apparently depleted to the point that eggs were transferred from a hatchery on the Umpqua River "with the view of restocking the waters of Yaquina Bay with chinook salmon" (Oreg. Dept. Fish. 1911).

Although public hatcheries are no longer in operation on the Yaquina, juvenile and adult salmonids reared in public hatcheries located on other river systems have been released into the Yaquina watershed as recently as 1974 (Oreg. Fish Comm. 1974). Present day populations of wild salmonids in the Yaquina system are, most likely, a composite of native Yaquina stocks and stocks originally derived from artificially propagated salmonids.

METHODS

Description of Yaquina Bay

Yaquina Bay (Fig. 1), located 185 km south of the Columbia River, is the fifth largest estuary in Oregon, covering 15.8 km^2 of land at mean high tide (Oreg. Div. State Lands 1973). The river channel and sloughs from the mouth of the bay to the head of tidewater at river mile 26 account for about 65% of the total area, and the remaining 35% of the area is tidelands (Percy et al. 1974). Much of the tideland area is included in two large tidal flats which border the north and south sides of the main channel in the lower estuary (Fig. 1). The narrow entrance of the bay to the ocean is stabilized by two jetties originally constructed in the late 1800's by the U.S. Army Corps of Engineers. The channel is periodically dredged to a depth of 9 m from the mouth of the jetties to the ship turning basin at McLean Point, and to a depth of 3.6 m to the town of Toledo (Fig. 1).

The main source of freshwater in Yaquina Bay is the Yaquina River. The Yaquina River is 94.6 km long and drains 655 km^2 of land (Percy et al. 1974). The average monthly discharge of freshwater from the Yaquina River is 15.8 m^3/s, although discharge can range from 1 m^3/s in August and September to 35 m^3/s in February (U.S. Army Corps Engr. 1970).

Salinities in the estuary range from marine to brackish during

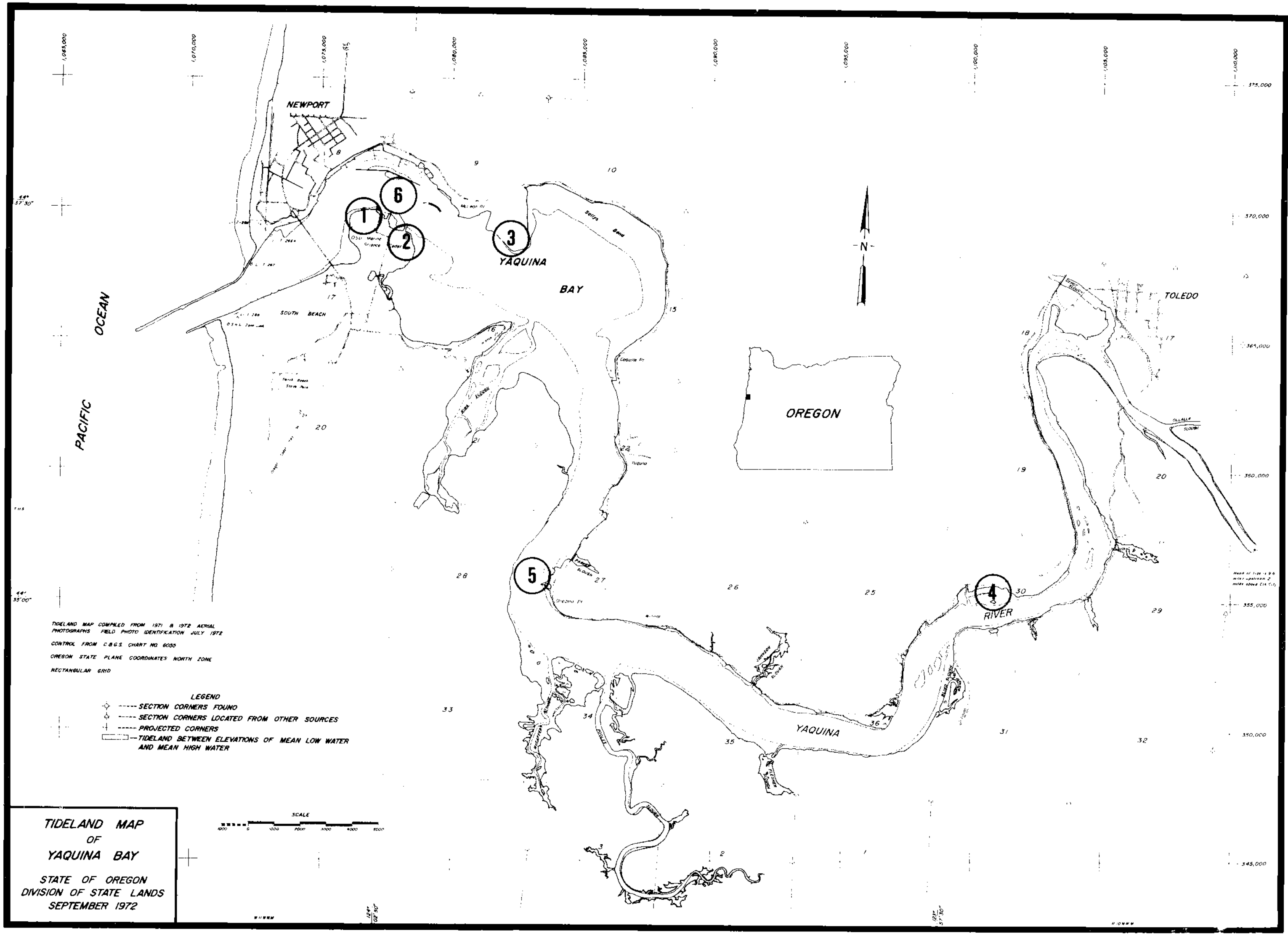

Figure 1. Map of Yaquina Bay, Oregon showing the location of beach study areas 1, 2, 3, and 4 where sampling for juvenile salmonids was conducted by beach seine, and channel study areas 5 and 6 where sampling for juvenile salmonids was conducted by lampara net.

periods of low river discharge, and from brackish to freshwater during periods of high discharge. Kulm and Byrne (1967) described Yaquina Bay as a well mixed estuary from June to October, and a well mixed to partly mixed estuary from November to May.

Water temperatures in the estuary are, generally, cooler than ocean temperatures in the winter, and warmer than ocean temperatures in the summer (Frolander 1964). However, upwelling along the open coast may sometimes cause summer temperatures in the lower estuary to be cooler than winter temperatures. Summer temperatures in the lower reaches of the Yaquina River and upper estuary sometimes exceed the upper limit of temperatures considered suitable for anadromous salmonids (U. S. Army Corps Engr. 1970).

Yaquina Bay experiences mixed semidiurnal tides. The mean tide range in Yaquina Bay is 1. 8 m, and the tidal prism on mean range is $2.36 \times 10^7 m^3$ (Percy et al. 1974). Semidiurnal tidal mixing in Yaquina Bay is responsible for abrupt local changes in temperature and salinity, as well as other physical and biological factors (Frolander 1964).

Study Areas

This project was primarily the investigation of the utilization of four beach or intertidal study areas in Yaquina Bay by hatchery and wild juvenile salmonids. However, in 1978 two study areas in the river channel were also sampled. The location of the four beach (Sites 1-4) and two channel (Sites 5-6) study areas is shown in Figure 1.

Beach Study Areas

Three of the beach study areas were located in the lower estuary (Sites 1-3), and one was located in the upper estuary (Site 4).

Site 1 was a beach on the south side of the estuary, approximately 3.1 river km from the mouth of the bay (end of jetties) (Fig.1). This beach is located between the fish ladder at Oregon Aqua Foods, where juvenile salmon are released into the estuary, and the west jetty of the small boat basin at Southbeach.

Site 2 was a beach on the south side of the estuary, approximately 3.8 river km from the mouth of the bay (Fig. 1). This beach is located adjacent to the Oregon State University Marine Science Center, and immediately to the east of their small boat dock jetty.

Site 3 was a beach on the north side of the estuary, approximately 5.1 river km from the mouth of the bay (Fig. 1). This beach is located immediately to the south of the liquid natural gas storage tank at Newport, and is adjacent to Sallys Bend.

Site 4 was a beach on the north side of the estuary, approximately 16.1 river km from the mouth of the bay (Fig. 1). This beach is located on a small island across the channel from Craigie Point near Channel Marker 38.

Extensive eel grass (Zostera) beds were located off Sites 1-2, and were partially exposed at lower tidal levels. Eel grass beds were also located off Site 3, although they were less extensive and, generally, not exposed except at the lowest tidal levels. No eel grass beds were located as far upbay as Site 4. However, extensive growths of Enteromorpha, a tubular green algae, occurred there during the summer months.

The slopes of the four beach study areas changed considerably depending on the season. In general, Site 2 had the least slope, appearing almost level to the naked eye, while Site 3 had the greatest slope, dropping steeply into the deep water (9 m) of the ship turning basin. Because of the steep slope, the beach at Site 3 was exposed only at tidal levels of approximately 0.3 m or less. The slopes at Sites 1 and 4 were intermediate between these two extremes.

The sediment at Sites 1-3 was composed of sand, grading into a combination of sand, silt, and clay in the eel grass bed areas. The sediment at Site 4 was a combination of sand, silt, and clay.

Because of the similarity in location and habitat, samples taken at Sites 1-3 were sometimes pooled. In this thesis, the "lower estuary" refers to pooled samples taken at Sites 1-3, and the "upper estuary" refers to samples taken at Site 4.

Channel Study Areas

Site 5 was located in the channel area between River Bend Marina (Oneatta Point) and Channel Marker 20, approximately 8.8 river km from the mouth of the bay (Fig. 1).

Site 6 was located in the channel area between the breakwater at the town of Newport and beach sample Sites 1-2, approximately 3.4 river km from the mouth of the bay (Fig. 1).

The locations of the study areas in the channel were not as precise as those of the beach study areas, and sampling in the channel was conducted anywhere within the general area of the locations described above.

Sampling Gear

The beach study areas were sampled with a 100- X 3-m varied mesh beach seine, similar to that described by Sims and Johnsen (1974), except that the anchor wing, bunt, and inner wing sections were all constructed with 0.95-cm stretched knotless nylon mesh.

To set the net it was anchored, stacked on the beach, and attached by a 30-m line to the tow bar on a 6-m dory equipped with a 50-hp outboard motor. The net was towed straight out from the beach until approximately half of the net was in the water, and then towed in a semi-circle with the tidal current until the beach was rejoined. The boat was landed, and the seine was hand hauled with the tow line until the net was closed. The net was then worked along the beach, one person to the float line, and two or more to the lead line until the catch was forced into the bag section.

The two channel study areas were sampled with a 222-m lampara net, constructed of two 102-m lead wings with 10-cm stretched mesh and an 18-m bag having 0.95-cm stretched mesh. The net fished to a depth of approximately 21 m.

To set the lampara net one lead wing was attached by a line and stacked in the stern of an 11-m boat. The bag section and the other lead wing were stacked onto a 3.6-m net barge powered by an outboard motor. The net was then towed away from the boat and set in a circle from the barge until all of the net was in the water and the boat was rejoined. The two lead wings were then hauled in, simultaneously, over a hydraulic block, forcing the fish into the bag section of the net.

Sampling Schedule

The four beach study areas were sampled from July 1977 through December 1978. Biweekly samples were taken during periods of large releases of hatchery fish in July, August, and September of 1977 and 1978. Weekly samples were taken in June 1978 and October 1977 and 1978, and bimonthly samples were taken throughout the remainder of the year. One intensive period of sampling was conducted in July 1977 after the last release of hatchery fish on July 18, during which the four beach sites were sampled once a day for seven consecutive days.

On a particular sample date the beach study areas were sampled by making one set of the net at each site, when tidal levels permitted. Because Site 3 could only be sampled at tidal levels of approximately 0.3 m or less, sampling at this site was not possible on dates when the daytime low tide was above this level. On dates when Site 3 could be sampled, the net was usually set at or within one hour before or after slack low tide. The other three sites could be sampled at all but the highest tidal levels. An occasional sample was missed at these sites because of high tidal levels, damaged netting, or outboard motor problems. All sampling was conducted during daylight hours.

Bimonthly samples were taken at the two channel study areas from March through October 1978. On a particular sample date, one set was made with the lampara net at each site. Sampling had to be conducted at or around slack tide in calm weather, so that tidal currents, or wind and wave action would not collapse the net.

Determination of Species Composition, Number, and Size

The total number of fish of each species, and the standard lengths of up to 20 fish of each species were recorded after every set of the net. When catches were large (> 2000 fish) the total number of all species of salmonids in the catch was counted, and the number of fish in each species in the subsample was assumed to be proportional to the number of fish in each species in the estimated total catch.

Determination of Temperature, Salinity, and Tidal Levels

Data were collected on temperature, surface salinity, and tidal levels at the time of sampling to determine if spatial and temporal utilization of the study areas was related to these factors. Water temperature was measured with a hand held thermometer immediately prior to each set of the net, and a water sample was collected at the same time. Salinity of the water sample was later determined in the laboratory using a refractometer. The time of each set of the net was also noted, and tidal levels were later calculated from tables of hourly tidal heights recorded in Yaquina Bay by the School of Oceanography at the Oregon State University Marine Science Center.

Determination of Food Habits

Food habits of juvenile salmonids were determined by analysis of stomach contents. Samples or subsamples of juvenile salmonids were injected and preserved with 10% buffered Formalin. When catches were small (< 10 fish of each species) all juvenile salmonids in the catch were collected for stomach content analysis; when catches were large (> 10 fish of each species) a randomly selected subsample of at least 10 fish of each species was collected. In the laboratory, the stomach was dissected from each fish, and total wet weight of stomach contents was measured to the nearest .01 g on an electronic balance. The contents were then separated into food categories under a dissecting microscope, and the wet weight of all food categories having a biomass greater than .01 g was measured.

Stomach contents of hatchery and wild juvenile salmonids were compared by means of an empirical measure of overlap. A simplified form of Morisita's index of overlap (Horn 1966), appropriate for proportionalized data, was used. The index, $\hat{C}_\lambda$ is:

$$\hat{C}_\lambda = \frac{2 \sum_{i=1}^{s} x_i y_i}{\sum_{i=1}^{s} x_i^2 + \sum_{i=1}^{s} y_i^2}$$

where x_i and y_i are a measure of the proportion of biomass of all food items in samples x and y that are represented by food item i. This index varies from 0 when samples x and y have no food items in common to 1 when they are the same in terms of proportional composition of stomach contents (Horn 1966).

After stomach contents of individual fish were sorted into food categories and weighed, a measure of the proportion of the biomass of all stomach contents represented by each food category was calculated by dividing the pooled weights of each food category by the pooled weights of stomach contents of each sample or group of fish to be compared. Food categories representing 1% or more of the total biomass of stomach contents in either group of fish being compared were included in the calculation of the index. Samples containing groups of hatchery and wild fish to be compared were usually pooled over 1 mo intervals. In general, comparisons were not made between hatchery and wild fish when pooled samples contained less than 10 fish of one or both groups.

Determination of Hatchery or Wild Origin

The determination of hatchery or wild origin of individual fish in the catch was determined by a composite technique of differentiation involving examination of the following characteristics:

1. Tags, fin clips, or dye marks
2. Scales
3. Species and release date
4. External parasites
5. Visceral fat
6. Size
7. Fin erosion

Tags, fin clips, or dye marks

Information on tags, fin clips, and dye marks of hatchery fish was obtained from personnel of Oregon Aqua Foods and the Oregon

Department of Fish and Wildlife. The percentages of juvenile hatchery salmon marked with coded wire tags and released into Yaquina Bay during 1977 and 1978 are shown in Table 1.

Hatchery salmon marked with coded wire tags (CWT) were also marked by removal of the adipose fin. The number of juvenile coho and chinook salmon with missing adipose fins was noted; they subsequently were sent to Oregon Aqua Foods, where presence or absence of CWT was determined.

In 1978 about 60% of the CWT coho salmon released into the estuary were part of a genetic experiment conducted by Oregon Aqua Foods. To maximize survival of smolts to adults for this experiment, subsamples were taken when catches of juvenile coho with missing adipose fins were large.

A program of pressure spray marking a percentage of the juvenile hatchery salmon released into Yaquina Bay with fluorescent pigments was initiated by Oregon Aqua Foods in the spring of 1978. The percentages of fluorescent dye marked (FDM) juvenile hatchery salmon released into Yaquina Bay during 1978 are shown in Table 1.

Originally, I planned to check all juvenile coho and chinook salmon taken in samples at the beach study areas for FDM by examining anesthetized fish under a portable ultraviolet light at the study areas. However, because of the large numbers of salmon smolts in the catch during periods of release of juvenile hatchery salmon

Table 1. Total number of juvenile hatchery pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), coho (*O. kisutch*), and chinook (*O. tshawytscha*) salmon released into Yaquina Bay, Oregon during 1977 and 1978, and the percentage marked with coded wire tags and with fluorescent dye.

	Total Number Released*		Tagged and Marked (%)			
			Coded Wire Tag		Fluorescent Dye	
Species	1977	1978	1977	1978	1977	1978
Pink	--	312, 000	--	--	--	--
Chum	15, 000	2, 000	--	--	--	--
Coho	2, 146, 000	8, 898, 000	6. 1	5. 0	--	4. 7
Chinook	42, 000	427, 000	7. 9	10. 9	--	19. 5

*Numbers are rounded to the nearest thousand fish.

in 1978 (often > 500 fish per sample day), the small size of the beach seining crew (usually three persons), and the limited amount of time (1 hr) that could be spent at each study area on a particular sample day, juvenile salmonids in the catch could not be examined for dye marks at the study areas.

Samples or subsamples of juvenile coho and chinook salmon captured at the study areas were preserved in 10% buffered Formalin, and later examined for dye marks under an ultraviolet light in the laboratory. Subsamples of up to 100 juvenile coho from each set of the net were collected for laboratory examination for dye marks. Subsamples of chinook were smaller, usually 10 fish, as chinook were, generally, less abundant than coho in the catch. Approximately 30% of the coho and 35% of the chinook captured in samples taken at the beach study areas in 1978 were examined for dye marks. Storage in preservatives did not appear to have any effect on the visibility of the dye. Dye on marked fish stored in 10% buffered Formalin or 45% isopropanol for over one year was still visible.

Scales

Scales from fish of known origin were examined for structural characteristics that would aid in the determination of origin of individual fish in the catch. Scale samples were taken from hatchery fish prior to their release into Yaquina Bay, from wild fish captured in the Yaquina River, and from fish captured in samples taken in the estuary.

Scales were removed from the first through the third scale rows above the lateral line on the left side of the fish in the area beneath the insertion of the dorsal fin and origin of the adipose fin. Permanent impressions of scales were made on cellulose acetate sheets, heated and pressed at 100°C and 6000 psi for approximately 4 min. Acetate impressions of scales were magnified 80 X using a microprojector. All counts and measurements were made in the anterior field of the scale along a line 10° to the dorsal side of the anterior-posterior axis of the scale.

Nine structural characteristics were examined on the scales of known hatchery and wild coho and chinook salmon (Table 2). My objective was to find a single scale characteristic for which there was little or no overlap between stocks of the same species.

Whereas the majority of wild coho in Oregon migrate to the ocean as yearlings (Reimers 1971), hatchery coho salmon released into Yaquina Bay during this study were grown at an accelerated rate, and were released into the estuary at 8-10 mo of age. The difference in rearing regimes of hatchery and wild coho salmon was reflected in differences in the spacing of circuli formed on their scales during the early period of freshwater growth (Fig. 2).

Of the scale characteristics examined, scales of known

Table 2. Description of structural characteristics measured, counted, or examined on the scales of known hatchery and wild coho (Oncorhynchus kisutch) and chinook (O. tshawytscha) salmon.

Characteristic	Description
1	Radius of the nucleus.
2	Widths of bands of circuli measured from the 1st through the 6th circuli, the 6th through the 11th circuli, and the 1st through the 11th circuli.
3	Radius of the freshwater growth on the scale.
4	Total radius of the scale.
5	Number of freshwater circuli.
6	Number of estuarine circuli.
7	Total number of circuli.
8	Metamorphic checks.
9	Freshwater annuli.

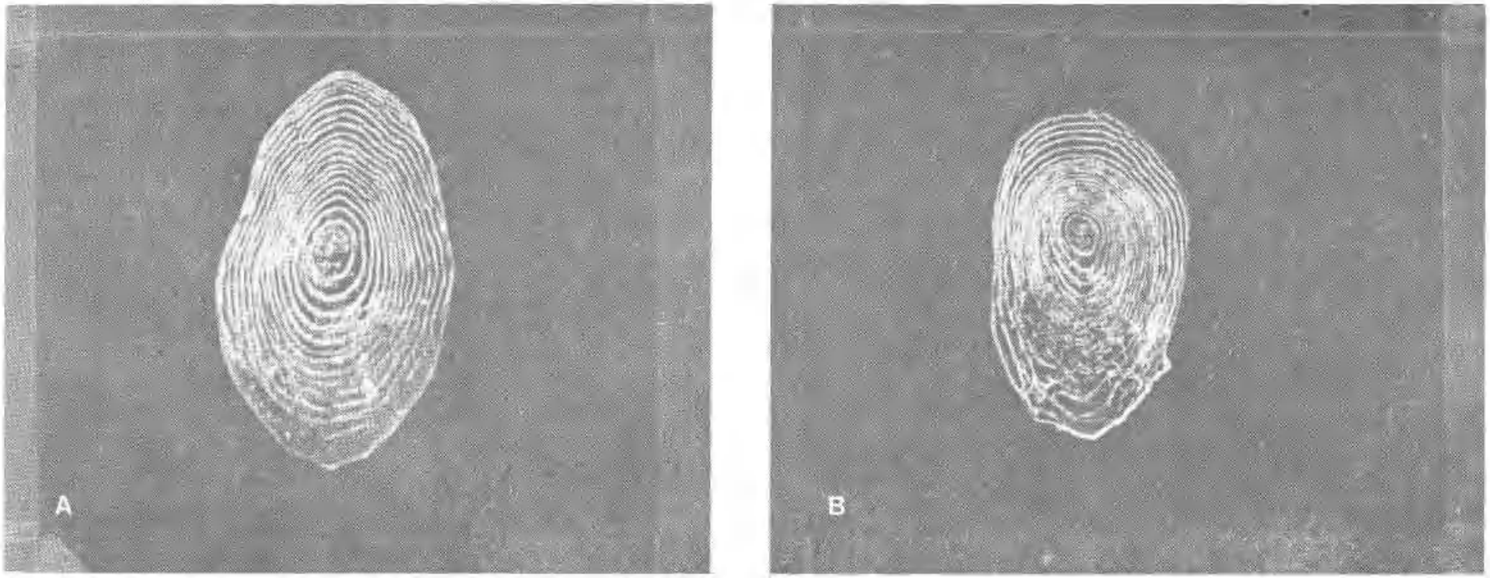

Figure 2. Scales of hatchery and wild coho (Oncorhynchus kisutch) salmon (42X).

A. The scale of a 0-age hatchery coho salmon captured in Yaquina Bay, Oregon on July 1, 1977. Note the wide spacing between circuli, with the exception of several circuli with narrow spacing at the outer edge of the scale.

B. The scale of a yearling wild coho salmon captured in the Yaquina River above the town of Nashville, Oregon on April 28, 1978. Note the narrow spacing between circuli, with the exception of several circuli with wide spacing at the outer edge of the scale.

hatchery and wild coho could successfully be distinguished by measuring the width of a band of circuli from the outer edge of the 1st circulus after the center plate (nucleus) to the outer edge of the 11th circulus. Figure 3 shows the percent frequency of occurrence of the width of this band of circuli on the scales of yearling wild coho collected in the Yaquina River above the town of Nashville on April 28, 1978 and 0-age hatchery coho collected from Oregon Aqua Foods prior to release into the estuary in 1977. There was no overlap in the frequency distributions for this characteristic on the scales of hatchery and wild coho of known origin (Fig. 3). Coho of unknown origin for which the width of the band formed by the first 11 circuli was greater than 17 mm (magnified 80X) were considered to be of hatchery origin, whereas coho for which this measurement was less than 16 mm (magnified 80X) were considered to be of wild origin. Coho for which the width of this band of circuli measured 16 or 17 mm were considered to be of unknown origin, and were separated by other techniques. Because of the small number of wild coho used to develop this criterion, the range of values for the width of the band formed by the first 11 circuli was probably greater for the real population of wild coho than for those in my sample. Therefore, the number of wild coho in samples taken at the study areas may have been underestimated by using this technique.

Scales of zero-age hatchery coho were distinguished from those

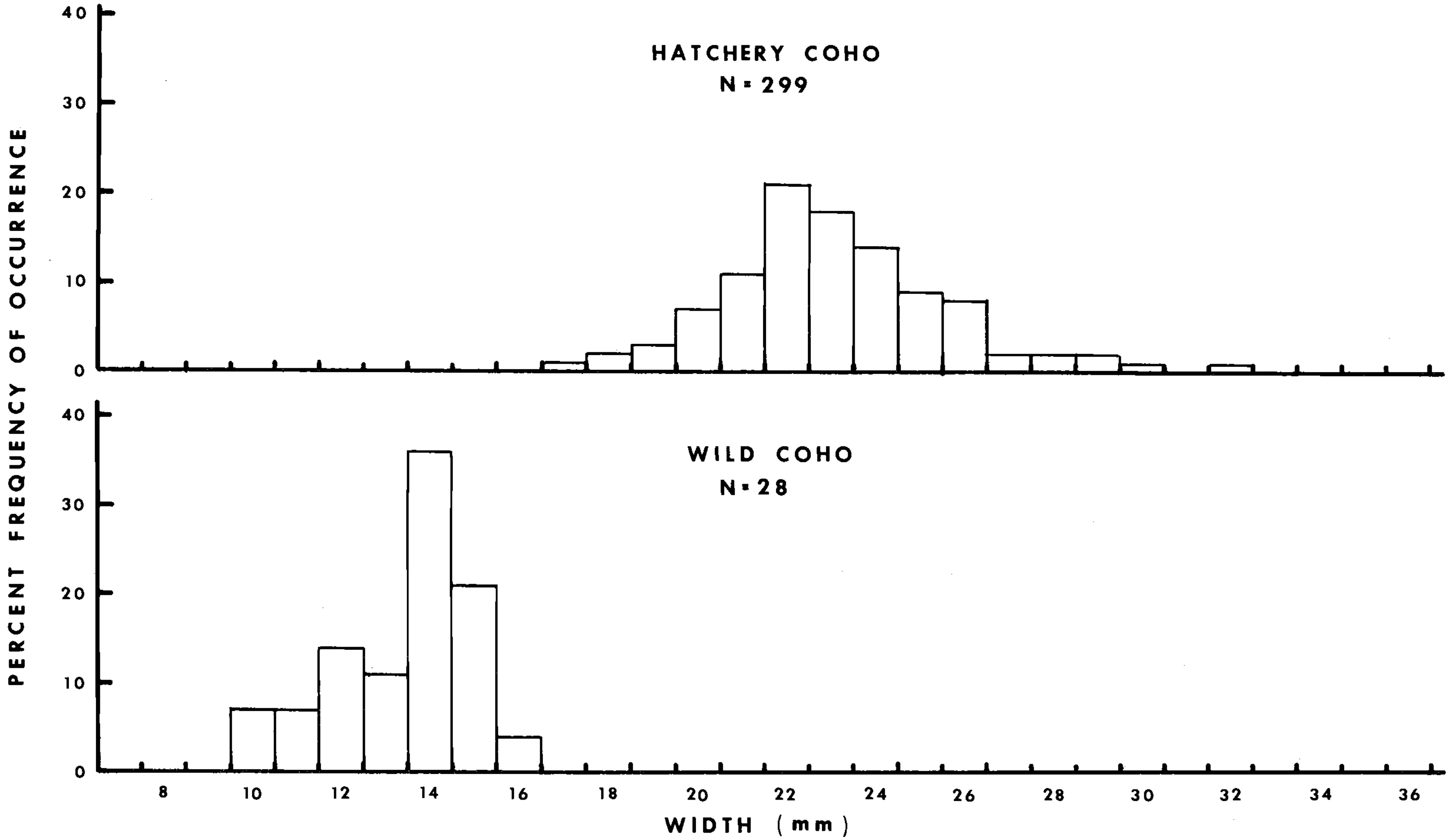

Figure 3. Percent frequency of occurrence of the width of a band of circuli measured from the outer edge of the 1st circulus to the outer edge of the 11th circulus on the magnified (80X) scales of 0-age hatchery coho salmon (Oncorhynchus kisutch) and yearling wild coho salmon.

of yearling wild coho by examining the scale for the presence or absence of a freshwater annulus (Fig. 2). This technique, however, was more subjective. Checks in scale growth, characterized by a distinct narrowing of the space between circuli, may be formed at the outer edge of the scales of 0-age hatchery coho as they experience the abrupt change from the hatchery to a natural environment (Fig. 2A). Other checks in scale growth may occur with changes in rearing regime while the fish is still in the hatchery environment or as the fish undergoes the process of smoltification. These checks in scale growth might be misinterpreted as freshwater annuli.

Scales of wild fall chinook captured in the estuary prior to the first release of hatchery chinook in 1977 and 1978 were compared to the scales of hatchery chinook collected at Oregon Aqua Foods prior to release, as well as scales of tagged or marked hatchery chinook recaptured in the estuary. None of the scale characteristics examined were sufficient to distinguish hatchery chinook released in June and July from wild chinook juveniles. The scales of hatchery chinook released in the fall could be distinguished from scales of wild chinook captured in the estuary at the same time.

Scales from a group of FDM hatchery chinook released on October 7, 1978 and recaptured one week later in the estuary were distinguished from scales of wild chinook captured in the estuary at the same time on the basis of the number of "freshwater" circuli. For this procedure, "freshwater" circuli were identified as thin, closely spaced circuli occurring concentrically after the center plate (nucleus) of the scale, and sometimes preceding thicker, more widely spaced "estuarine" circuli. The terms "freshwater" and "estuarine" refer only to the relative thickness and spacing of the circuli on individual scales, and not to the environment in which they were formed on the scale. For example, the scale in Figure 2B has a band of approximately 17 "freshwater" circuli followed by a band of 6 "estuarine" circuli, even though all the circuli were formed in freshwater.

Figure 4 shows the percent frequency of occurrence of the number of freshwater circuli on the scales of hatchery and wild chinook captured at the study areas in October of 1978. On this basis, chinook with 24 or more freshwater circuli were considered to be of hatchery origin. Because the scales of a small percentage of the wild chinook present in the estuary at this time had 24 or more freshwater circuli (Fig. 4), the number of hatchery chinook may have been overestimated using this technique. However, wild chinook with scales of this type were usually readily identified by the presence of freshwater parasites or lack of fin erosion (see below).

Species and release date

The determination of hatchery or wild origin was made on the basis of species present or of release date of hatchery fish. All juvenile steelhead and cutthroat trout in samples taken at the study

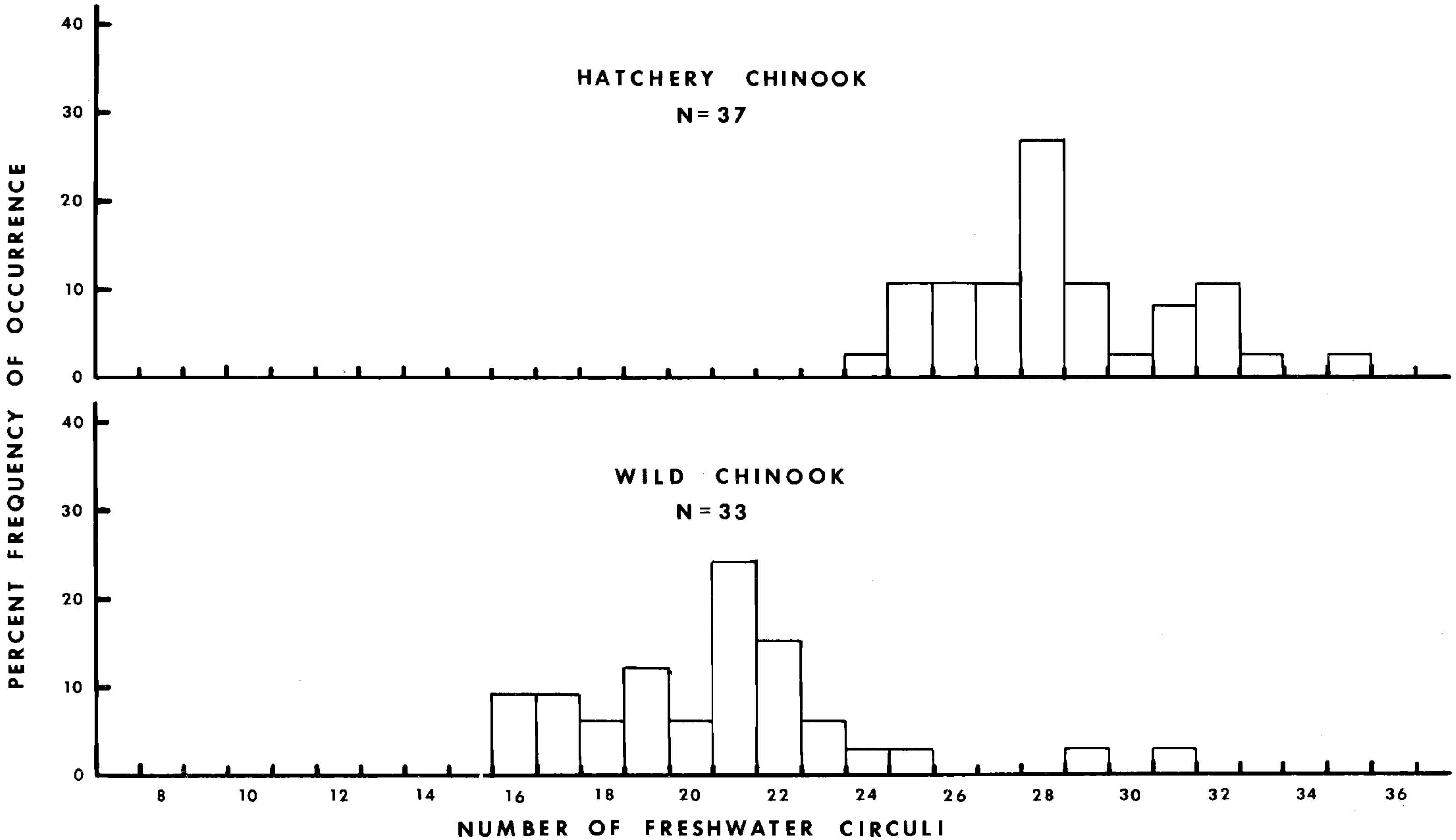

Figure 4. Percent frequency of occurrence of the number of freshwater circuli on the scales of hatchery and wild juvenile chinook salmon (Oncorhynchus tshawytscha) captured in Yaquina Bay, Oregon in October 1978.

areas were assumed to be of wild origin, because no hatchery steelhead or cutthroat trout were released into the estuary during this study. Juvenile chum salmon captured at the beach study areas in 1978 were also assumed to be of wild origin, because they were captured prior to the only release of hatchery chum salmon on June 5, 1978. In addition, 87 juvenile chinook salmon captured in samples prior to the first release of hatchery chinook in 1977 and 1978 were assumed to be of wild origin. The number of wild fish of these species may have been overestimated if straying of juvenile hatchery fish from other estuaries occurred, or if hatchery fish were able to escape into the estuary from holding ponds at Oregon Aqua Foods facilities prior to the "official" date of release.

External parasites

Fish of known hatchery or wild origin were examined in the laboratory for the presence of external parasites that might aid in the determination of hatchery or wild origin. The fins, gills, and skin of fish were examined for parasites, both with the naked eye and with the aid of a binocular microscope. Identification of parasites was confirmed by parasitologists at Oregon State University.

A significant number of wild coho and chinook salmon were parasitized by the metacercarial larvae of an unknown species of digenetic trematode of the order Strigeoidea. The infestation was characterized by small (< 1 mm), clear, round cysts embedded in the hypodermis of the fish, and surrounded by black pigmentation (Fig. 5). Even when parasites were already dead or resorbed, the pigmentation remained, leaving scars that give the fish the appearance of being covered by black spots.

Approximately 78% of the fish in a sample of 28 wild coho taken in the Yaquina River above the town of Nashville, Oregon on April 28, 2978, and 82% of the fish in a sample of 87 wild chinook captured in the Yaquina estuary prior to the release of hatchery chinook in 1977 and 1978 were infested with Strigeoid trematode metacercaria. No metacercarial larvae or pigment scars from metacercarial larvae were found on the skin of over 1, 500 tagged or marked hatchery coho and chinook salmon juveniles recaptured in the estuary. Therefore, coho and chinook juveniles with metacercarial larvae or pigment scars of strigeoid trematodes were considered to be of wild origin.

Visceral fat

During the initial stages of stomach content analysis, I found that the pyloric caeca, stomach, intestine, and spleen of many fish in the samples were surrounded or completely obscured from view by the presence of large amounts of visceral fat. This characteristic was examined to determine if it would be useful in the differentiation

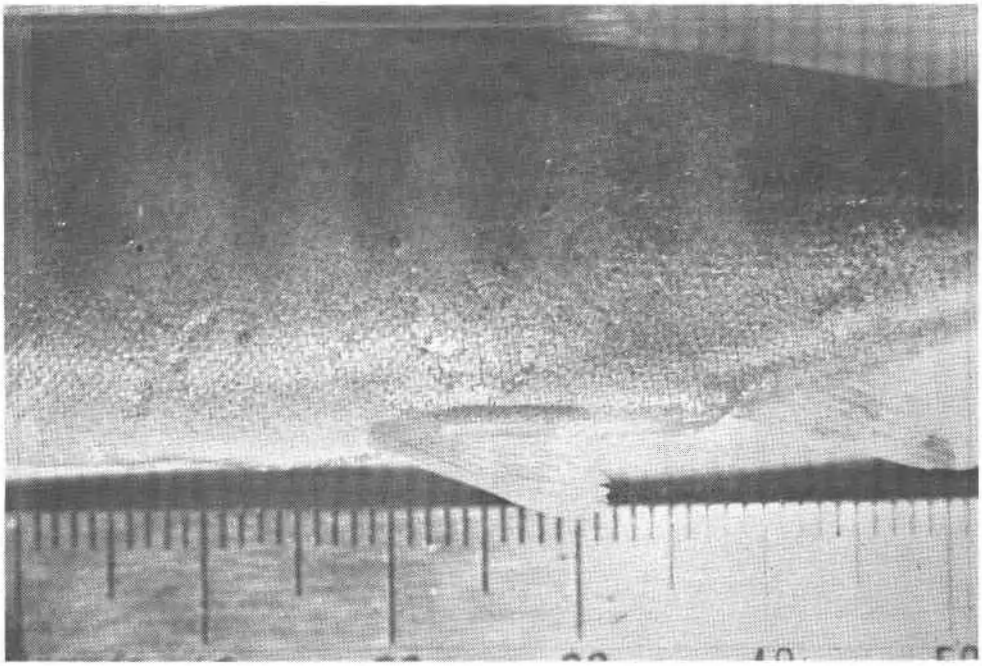

Figure 5. A yearling wild coho salmon (Oncorhynchus kisutch) captured in the Yaquina River above the town of Nashville, Oregon on April 28, 1978, showing the appearance of metacercarial larvae of digenetic trematodes of the order Strigeoidea embedded in the skin.

of hatchery and wild fish.

Although the amount of visceral fat was not quantified, amounts of fat sufficient to obscure the pyloric caeca, stomach, spleen, and intestine from view (Fig. 6A) were present in marked or tagged hatchery coho and chinook for a period of about 2 wk after release into the estuary. In addition, although not sufficient to obscure the viscera entirely from view, visceral fat in reduced amounts was present in many marked or tagged hatchery fish recaptured in the estuary up to 2 mo after release. None of the fish in a sample of 28 wild coho taken in the Yaquina River above the town of Nashville, Oregon on April 28, 1978 (Fig. 6B), or fish in a sample of 87 wild chinook captured in the estuary prior to the first release of hatchery chinook in 1977 and 1978 had any visible visceral fat in the body cavity. Therefore, juvenile coho and chinook salmon in which the pyloric caeca, stomach, intestine, or spleen were either wholly or partially obscured from view by the presence of visceral fat were considered to be of hatchery origin.

Size

Size was seldom used as a method of differentiation between hatchery and wild fish, because hatchery and wild salmonids of the same species were usually in the same general size categories. However, length was used to separate large yearling hatchery coho

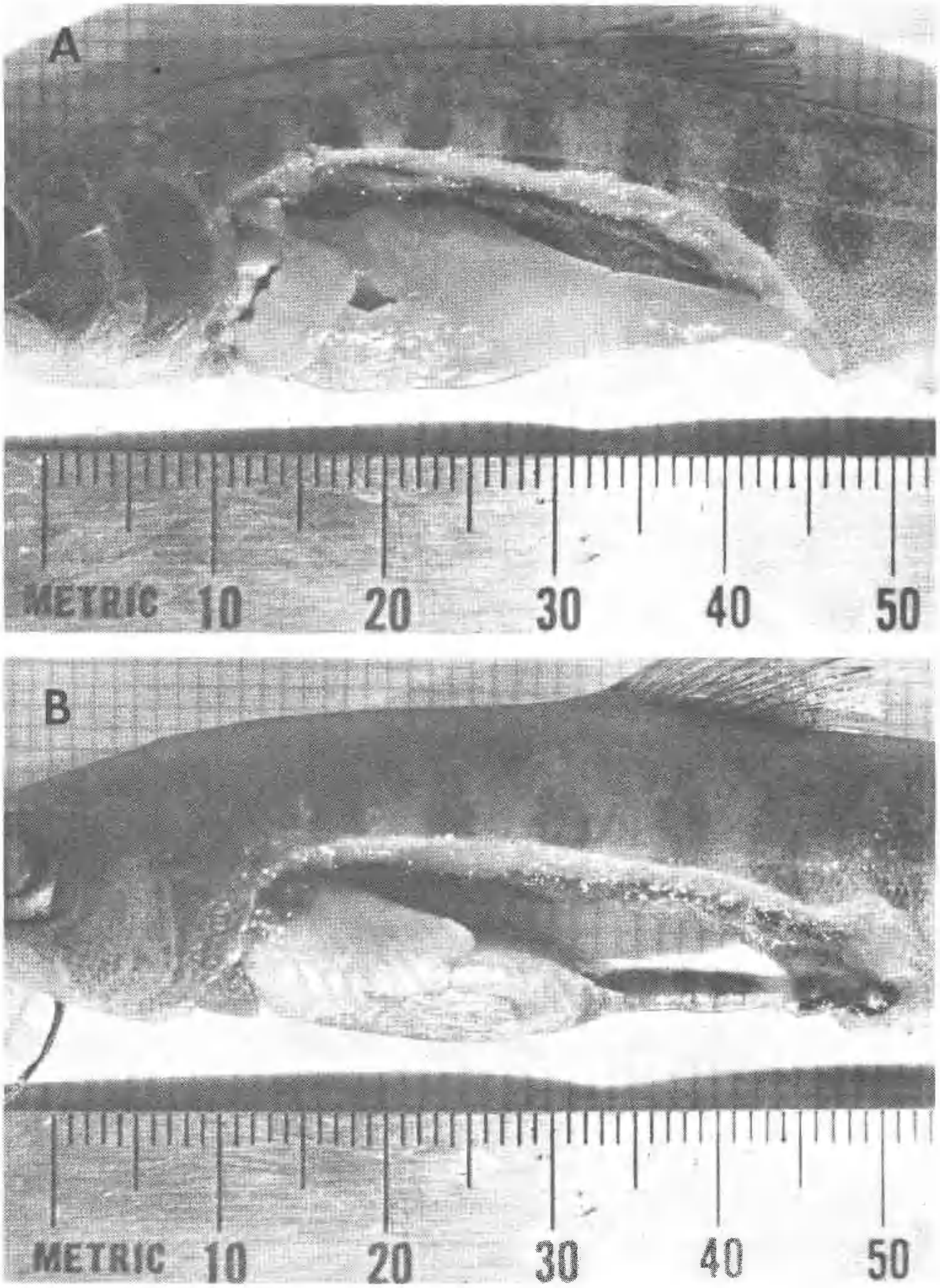

Figure 6. The viscera of juvenile coho salmon (Oncorhynchus kisutch) captured in the Yaquina River system in 1978.

A. The viscera of a hatchery coho. The pyloric caeca, stomach, intestine, and spleen are obscured by large amounts of visceral fat.

B. The viscera of a wild coho.

from yearling wild coho captured in the estuary at the same time.

FDM fish from a group of yearling hatchery coho released into the estuary on April 6, 1978 and recaptured at the study areas in April and May ranged in fork length from 11.4 to 30.0 cm (n=20; $\overline{X}$=18.3 cm), but fish from a group of wild yearling coho captured in the Yaquina River on April 28, 1978 ranged in fork length from 7.8 to 11.8 cm (n=28; $\overline{X}$=9.8 cm). Therefore, coho of unknown origin captured in samples taken at the study areas during April and May with fork lengths greater than or equal to 18 cm were considered to be of hatchery origin.

Fin erosion

Rays in the fins of fish that have been reared in the close confinement of hatchery troughs, raceways, and holding ponds often have a deformed, eroded, or clubbed appearance because of contact with the walls of these structures or with other fish. For example, approximately 98% of the chinook in a sample of 97 FDM chinook recaptured at the study areas in October and November had substantial erosion or deformation of the caudal fin (Fig. 7A), but none of the caudal fins of a sample of 112 wild chinook (identified by the presence of trematode parasites) captured in the estuary at the same time were eroded (Fig. 7B). Therefore, chinook with eroded caudal fins were considered to be of hatchery origin. The number of hatchery chinook

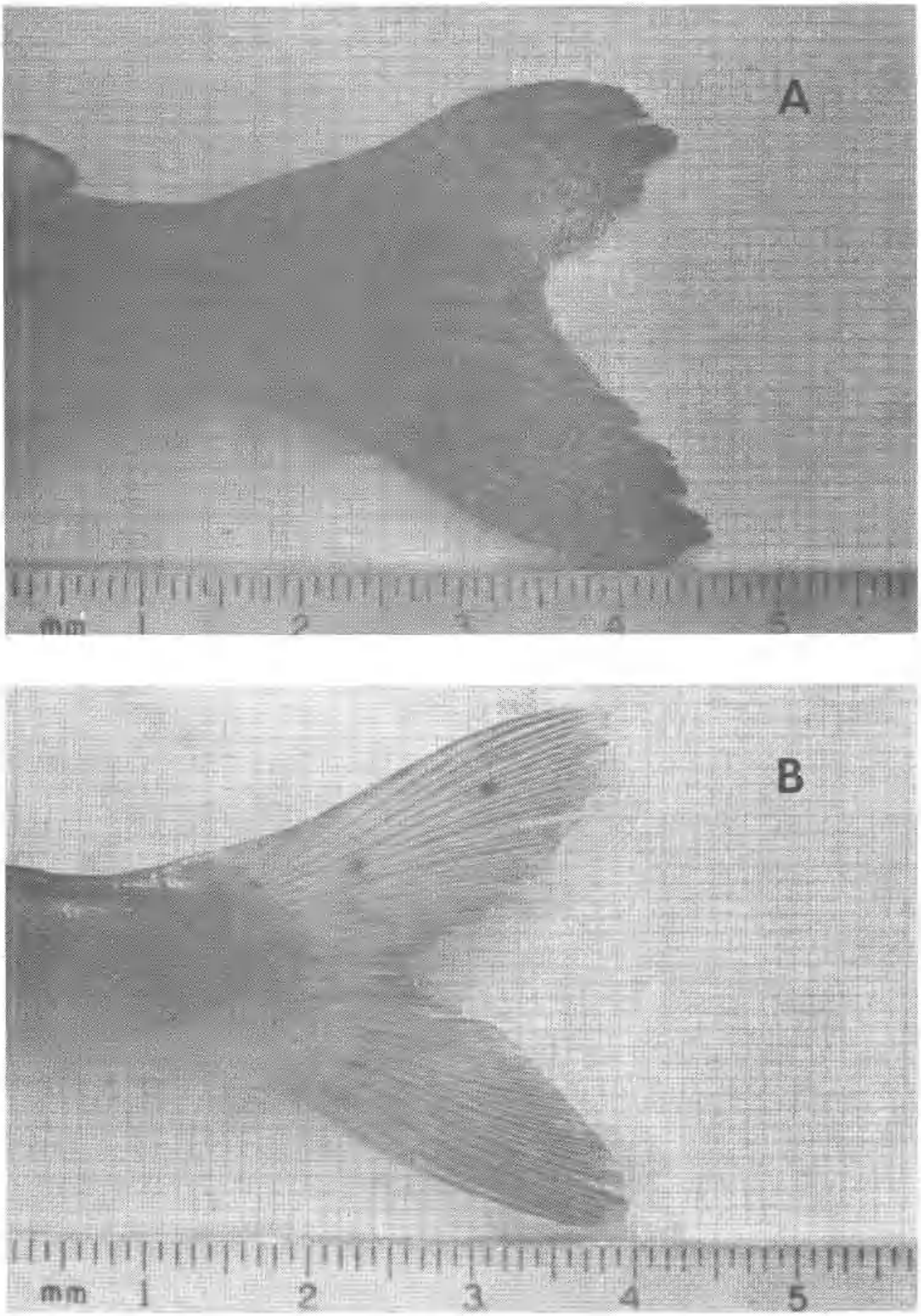

Figure 7. The caudal fins of juvenile chinook salmon (Oncorhynchus tshawytscha) captured in Yaquina Bay, Oregon in October 1978.

A. The fin of a hatchery chinook, showing erosion.

B. The fin of a wild chinook.

may have been underestimated by using this technique, because a small percentage of the hatchery chinook examined did not have eroded caudal fins.

RESULTS

Spatial and Temporal Utilization

Relative abundance of wild juvenile salmonids

Five species of wild juvenile salmonids were captured in the combined samples taken at the beach and channel study areas during this study: steelhead trout, cutthroat trout, chum salmon, coho salmon, and chinook salmon. Of these the beach study areas were utilized primarily by chum, coho, and chinook salmon, and the channel study areas were utilized primarily by chinook salmon. During this 18 mo study, only one juvenile steelhead trout and seven juvenile cutthroat trout were captured in samples taken at the beach study areas. And during the 8 mo that the channel study areas were sampled, only five wild juvenile coho salmon, three juvenile steelhead trout, and one juvenile cutthroat trout were captured.

Relative abundance of wild chum, coho, and chinook juveniles captured at the beach and channel study areas during 1978 are shown in Figures 8 and 9. In Figure 8 the plot for the upper estuary represents catch data collected at Site 4, and the plot for the lower estuary represents pooled catch data from samples collected at Sites 1-3. The catch per unit effort (CPUE) is the pooled catch of each species during 2 wk (bimonthly) intervals, divided by the number of sets of

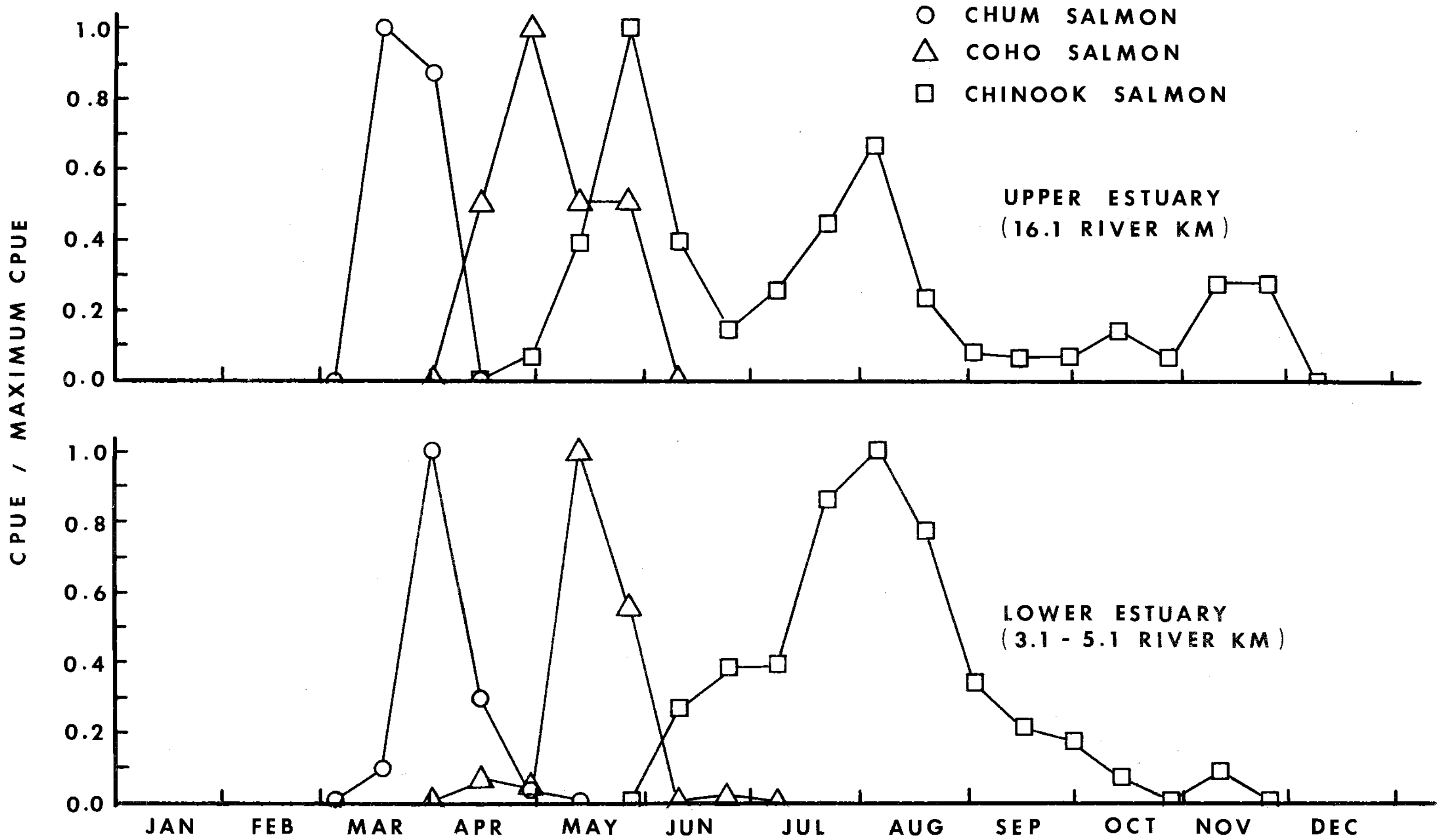

Figure 8. Relative abundance of wild juvenile chum (Oncorhynchus keta), coho (O. kisutch), and chinook (O. tshawytscha) salmon captured at four beach study areas in Yaquina Bay, Oregon in 1978. CPUE = bimonthly catch of each species divided by number of sets of the beach seine. Maximum CPUE, upper estuary: chum = 30.0; coho = 4.0; chinook = 18.0. Maximum CPUE, lower estuary: chum = 18.7; coho = 17.5; chinook = 72.3.

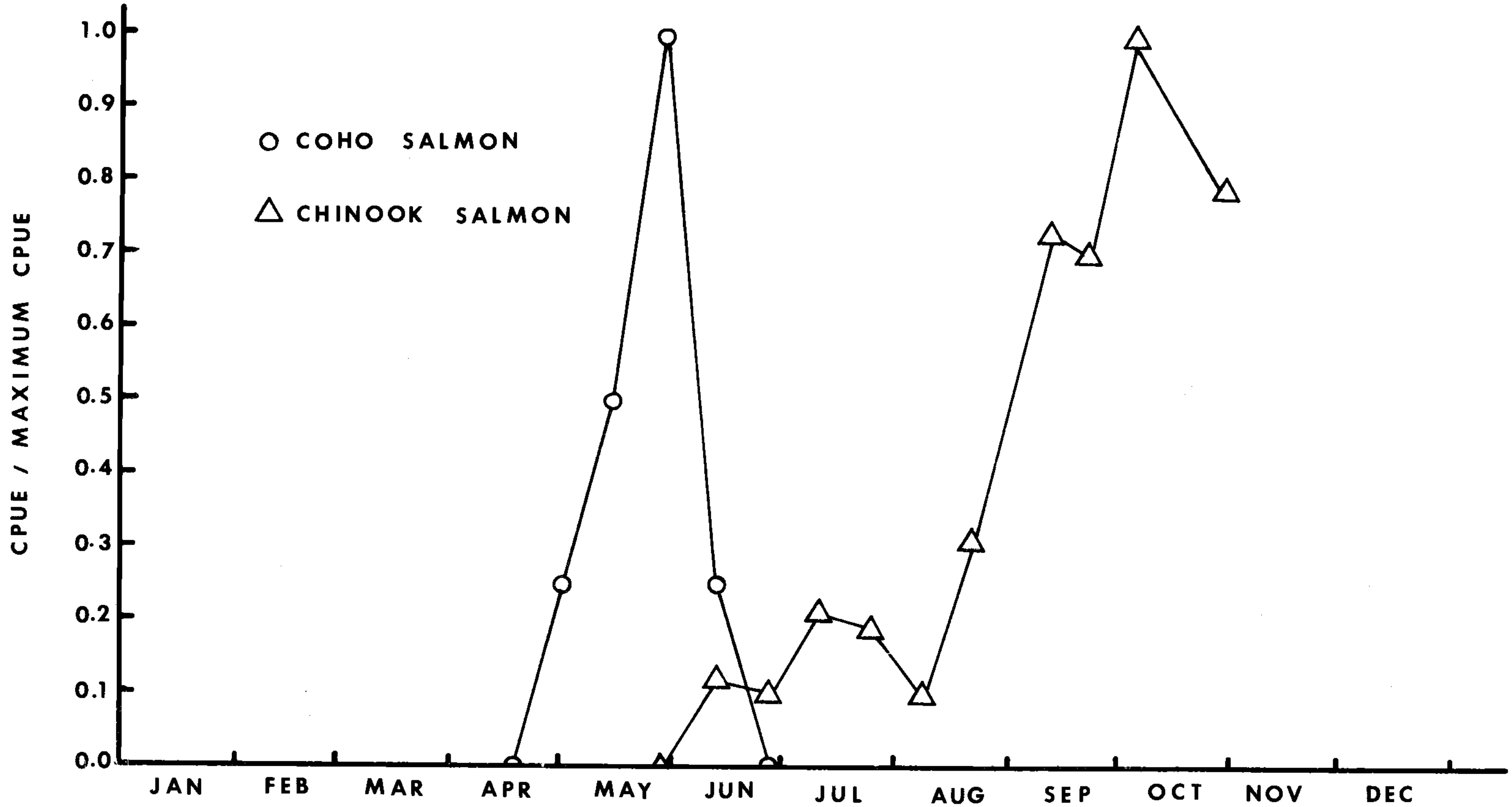

Figure 9. Relative abundance of wild juvenile coho (*Oncorhynchus kisutch*) and chinook (*O. tshawytscha*) salmon captured at two channel study areas in Yaquina Bay, Oregon from March through October 1978. CPUE = pooled catch of each species at the two study areas divided by the number of sets of the lampara net. Maximum CPUE: coho = 2.0; chinook = 33.5.

the beach seine made during the same interval. Figure 9 represents pooled catch data from samples collected at the two channel study areas. The CPUE is the pooled catch of each species at Sites 5 and 6 on a particular sample date, divided by the number of sets of the lampara net. Maximum bimonthly CPUE for each species is also given, to provide a measure of relative abundance (Figs. 8 and 9).

Three yearling chinook salmon, ranging in fork length from 12.2-15.0 cm, were captured at Site 2 on January 21, 1978. These fish were the first wild juvenile salmonids captured in the beach study areas in 1978, and may represent a small emigration of yearling fall chinook that reared in the river or estuary over the winter. The scales of these fish had a zone of improved growth at the outer edge indicating, perhaps, some estuarine growth.

The next species to occur in samples taken at the beach study areas in 1978 was chum salmon. Chum salmon fry appeared to enter the estuary in the early spring prior to the start of migrations of yearling coho salmon in April (Fig. 8). Chum salmon juveniles were present in samples taken at the beach study areas during March and April. During this period, the mean fork length of chum salmon increased from 3.7 to 5.2 cm (Fig. 10).

The catch of chum salmon at the beach study areas in 1978 peaked in the upper estuary (Site 4) during the third week in March, and in the lower estuary (Sites 1-3) during the first week in April

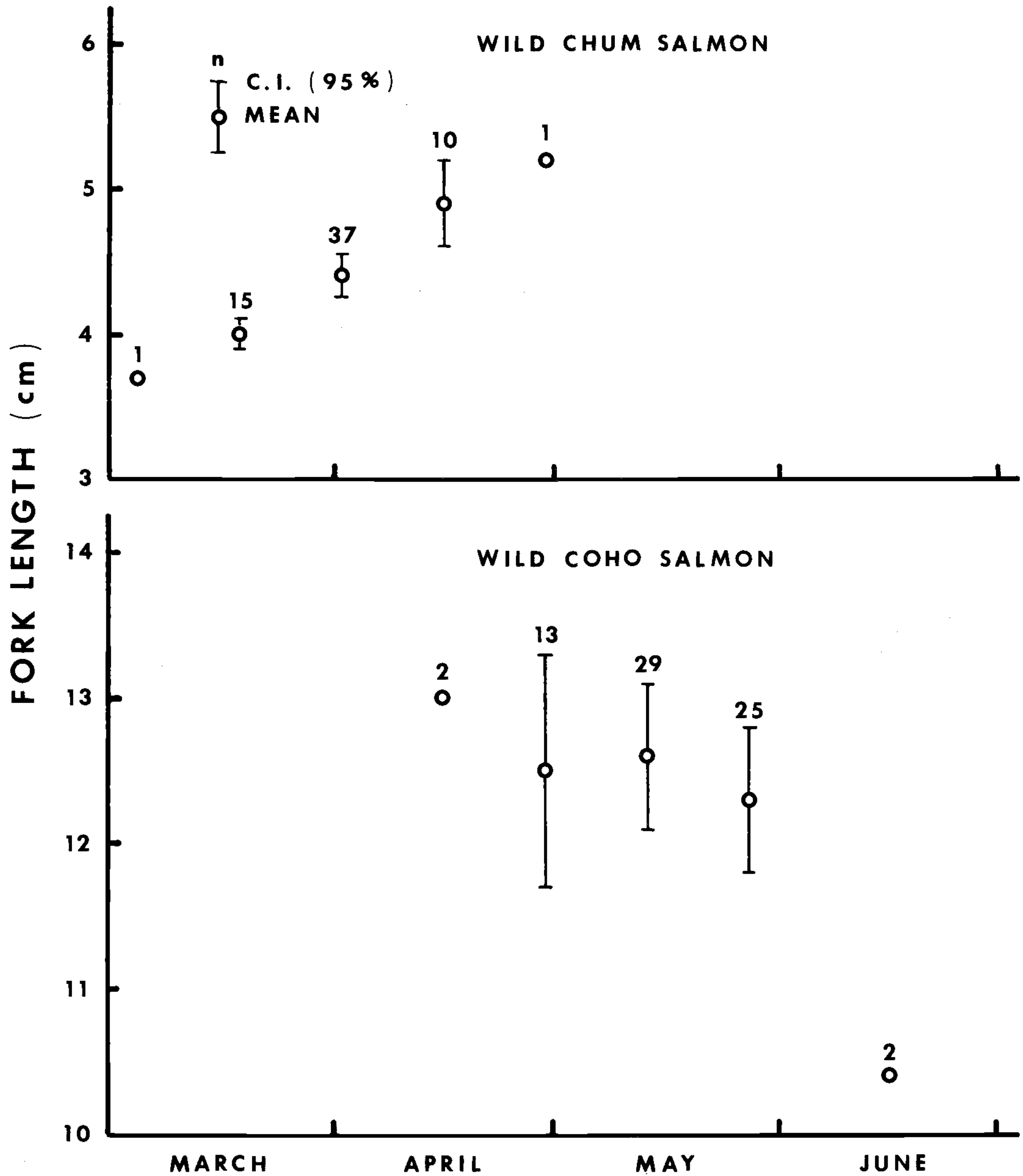

Figure 10. Mean fork lengths of wild juvenile chum (Oncorhynchus keta) and coho (O. kisutch) salmon captured by beach seine at four study areas in Yaquina Bay, Oregon in 1978.

(Fig. 8). No juvenile chum salmon were present in samples taken in the upper estuary after April 1, or in the lower estuary after April 29, 1978.

Wild yearling coho salmon did not occur in samples taken at the study areas in 1978 until after the peak of the chum migration (Fig. 8). Juvenile coho were present in samples taken at the beach and channel study areas for a period of about 3 mo during April, May, and June of 1978 (Figs. 8 and 9). Although sample sizes were small, the mean fork length of wild yearling coho appeared to decrease over this period (Fig. 10).

The catch of wild juvenile coho at the beach study areas peaked in the upper estuary during the last week in April, and in the lower estuary during the second week in May (Fig. 8). The catch of wild coho at the channel study areas peaked about two weeks later, during the last week in May, although this peak represents a CPUE of only two fish (Fig. 9). No wild juvenile coho were present in samples taken in the upper estuary after May 27, or in the lower estuary after June 15, 1978.

Wild juvenile chinook salmon were the last salmonids to occur in samples taken at the beach and channel study areas in the spring of 1978, and did not occur until the peak of the coho migration (Figs. 8 and 9). Wild juvenile chinook salmon were the only salmonids captured for an extended period of time (> 3 mo) at the study areas in the estuary. Wild juvenile chinook salmon were present in samples taken in 1978 for a period of about 7 mo from late April through November (Fig. 8). During this period, the mean fork length of chinook salmon increased from 6.6 cm in late April and early May to 15.7 cm in October and November. However, a large range of sizes usually was present (Fig. 11).

Figure 11 shows monthly length frequencies of wild juvenile chinook salmon captured at the beach and channel study areas during 1978. In general, juvenile chinook captured in the upper estuary were smaller than chinook captured in the lower estuary, and chinook captured at the channel study areas were larger than chinook captured at the beach study areas (Fig. 11).

Wild juvenile chinook salmon were first captured in samples taken in the upper estuary during the last week in April, and did not occur in samples taken at the beach and channel study areas in the lower estuary until the second week in June (Figs. 8 and 9). The timing of apparent migrations of juvenile chinook salmon through the upper estuary in 1978 was trimodal, with a primary peak in late May, a secondary peak in early August, and a tertiary peak in November (Fig. 8). The CPUE of juvenile chinook at the beach study areas in the lower estuary increased to a peak during the first week in August (Fig. 8). This peak is coincident with the lowest CPUE of wild juvenile chinook at the channel study areas

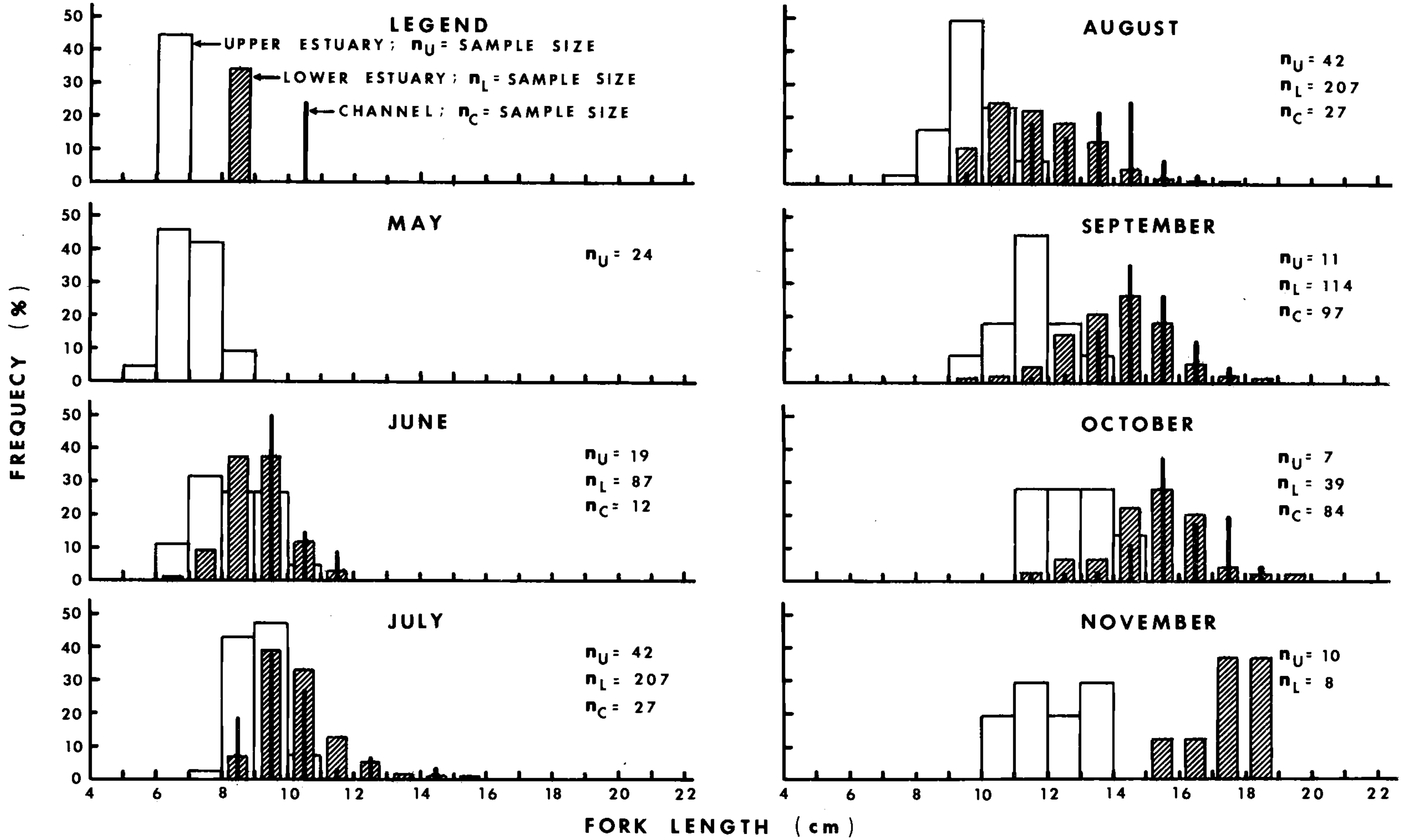

Figure 11. Monthly length frequencies of wild juvenile chinook salmon (Oncorhynchus tshawytscha) captured at four beach and two channel study areas in Yaquina Bay in 1978. Upper estuary = 16.1 river km; lower estuary = 3.1-5.1 river km; channel = 3.4-8.8 river km.

(Fig. 9). As the catch of juvenile chinook decreased at the beach study areas after the first week in August (Fig. 8), the catch increased at the channel study areas to a peak during the first week in October (Fig. 9). No wild juvenile chinook were captured at the beach study areas after November 25, 1978. Because sampling at the channel study areas was terminated at the end of October 1978, the length of time that wild juvenile chinook remained at the channel study areas is not known.

No wild chum or coho salmon juveniles were captured in samples taken at the beach study areas in 1977. Sampling at the beach study areas began in July 1977 after wild chum and coho salmon had, apparently, already emigrated to the ocean. The CPUE of wild chinook at the beach study areas in 1977 peaked during the third week in July, somewhat earlier than in 1978. However, wild chinook were captured through November of 1977 for a period of time similar to that in 1978.

Hatchery salmonids released into Yaquina Bay, 1977-1978

Approximately 2,203,000 juvenile hatchery salmonids were released into Yaquina Bay during 1977. About 97% of the hatchery fish released into the estuary were coho salmon, 2% were chinook salmon, and 1% were chum salmon. The species and number of hatchery fish released weekly into Yaquina Bay during 1977 is shown in Figure 12.

A total of 2, 146, 000 juvenile hatchery coho salmon were released on eight different dates during the period of February 14 through July 18, 1977. All of these were 0-age fish, grown at accelerated rates in heated water, except for a group of 63, 000 yearling coho salmon released on February 14, 1977. The mean size of the 0-age coho at release ranged from 15. 5 to 21. 3 gm, and the mean size of the yearling coho salmon at release was 23. 9 gm.

The majority of hatchery coho salmon (90%) in 1977 were released from Oregon Aqua Foods' release-recapture facility at Southbeach, approximately 3 river km from the mouth of the bay. The remainder were released into Wright Creek, which enters the estuary at the head of Pooles Slough approximately 10. 5 river km from the mouth of the bay.

Approximately 40, 400 juvenile spring chinook salmon were released from Wright Creek Hatchery on July 15, and a group of 1, 600 juvenile spring chinook salmon was released from Southbeach on July 18, 1977. Both groups of chinook were released at a mean size of 15. 6 gm. In addition, a release of approximately 15, 000 chum salmon at a mean size of 1. 5 gm was made at Southbeach on May 28, 1977.

Approximately 9, 621, 000 juvenile hatchery salmon were released into Yaquina Bay during 1978. About 92% of the hatchery fish

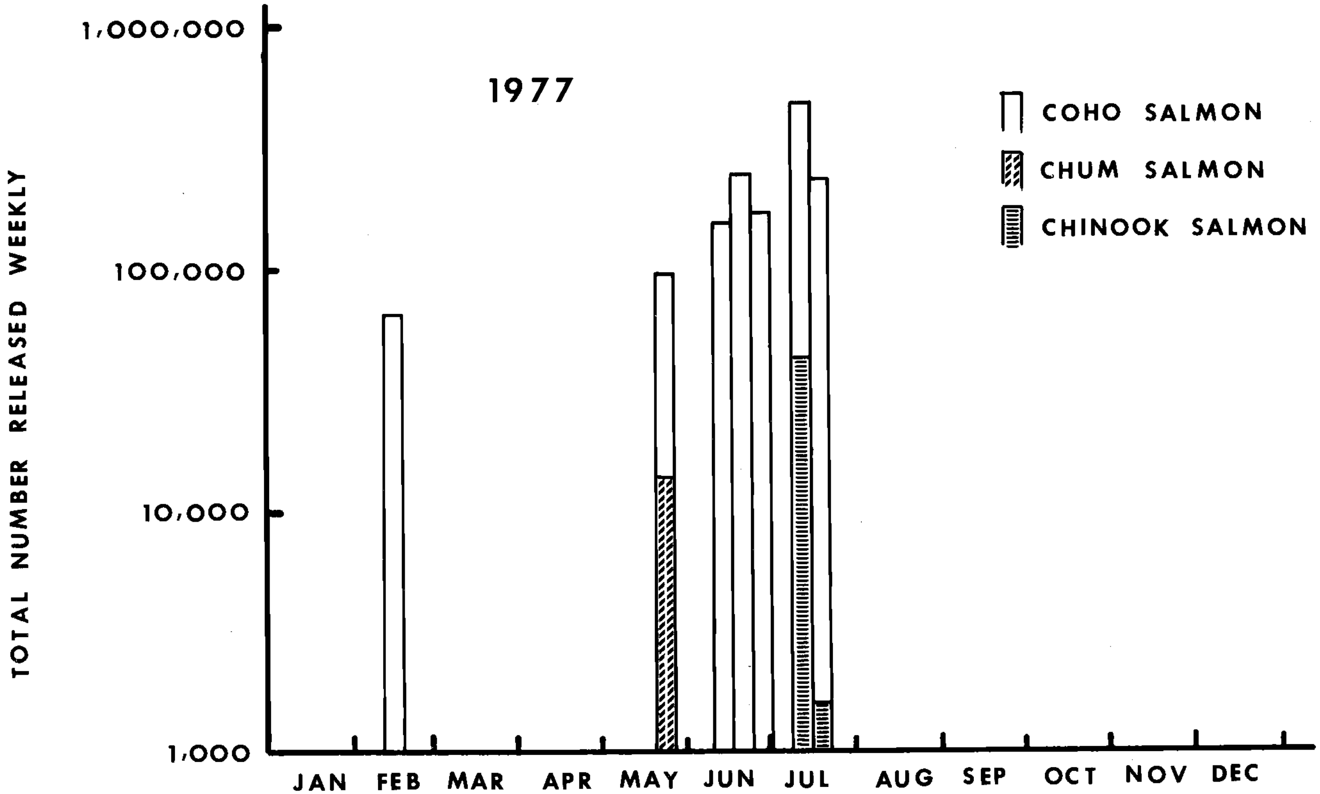

Figure 12. The number of hatchery juvenile coho (Oncorhynchus kisutch), chum (O. keta, and chinook (O. tshawytscha) salmon released weekly into Yaquina Bay, Oregon during 1977.

released into the estuary were coho salmon, 4% were chinook salmon, 3% were pink salmon, and less than 1% were chum salmon. The species and number of hatchery fish released weekly into Yaquina Bay during 1978 are shown in Figure 13.

About four times as many hatchery coho as in 1977 were released into the estuary in 1978. A total of 8, 898, 000 juvenile coho salmon were released on 25 dates during the period of April 6 through October 20, 1978. All of these were 0-age fish except for two groups of yearling coho released during the first week in April. One group of 184, 000 yearling coho was released at a mean size of 68. 7 gm, and the other group of 68, 000 yearling coho was released at a mean size of 61. 3 gm. The mean size at release of the 0-age coho ranged from 10. 0 to 27. 0 gm. All hatchery coho were released into the estuary from Southbeach during 1978.

About 10 times as many chinook as in 1977 were released into the estuary in 1978. A total of 427, 000 juvenile chinook were released on five dates during the period of June 15 through October 25, 1978 at a mean size of 22. 4 to 37. 2 gm. All hatchery chinook were released into the estuary from Southbeach except for a group of 18, 000 Yaquina River stock fall chinook salmon released at the public boat ramp at Toledo (river km 19. 0) by the Oregon Department of Fish and Wildlife on October 25, 1978. In addition, 312, 343 pink salmon at a mean size of 1. 4 gm, and 2, 174 chum salmon at a mean

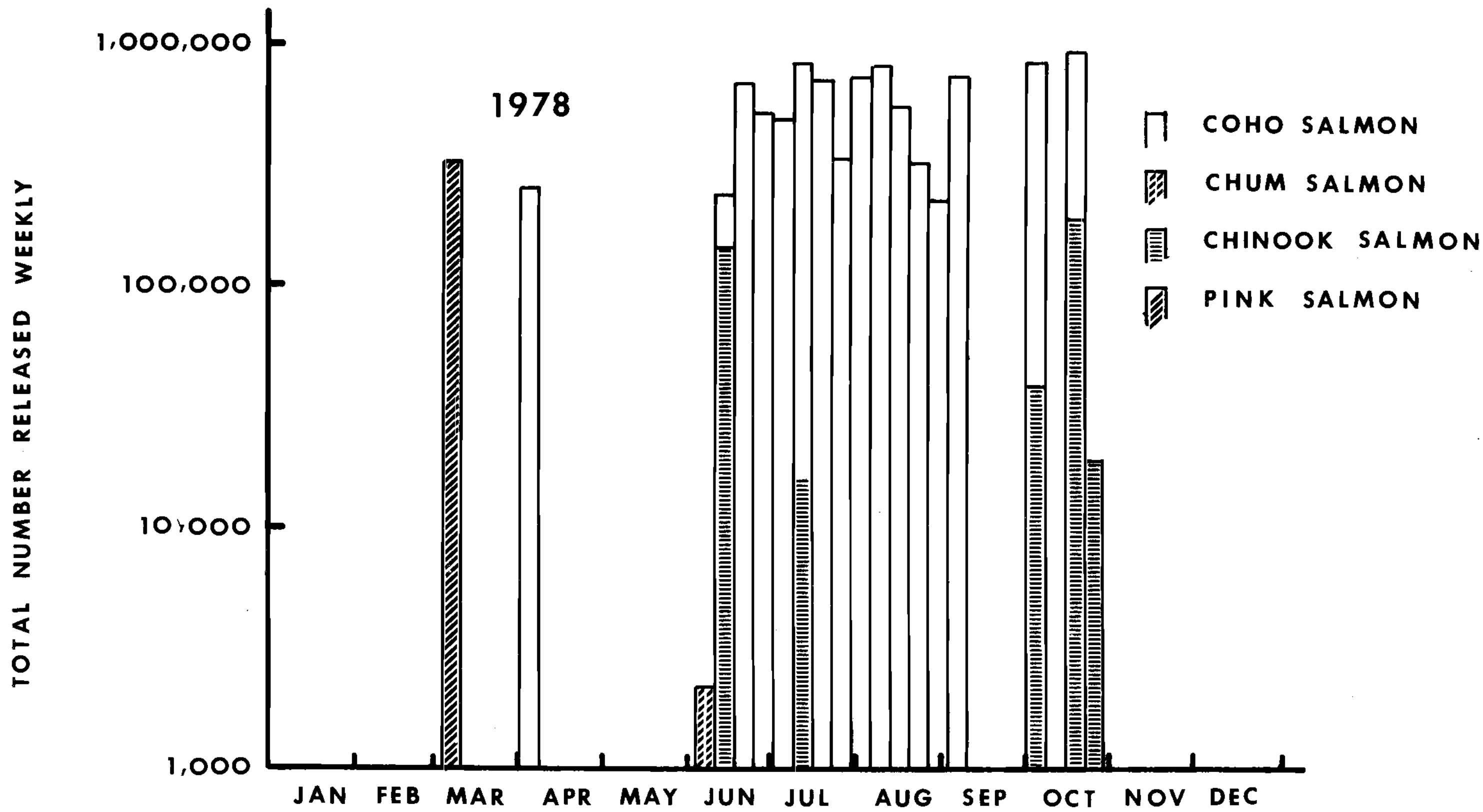

Figure 13. The number of hatchery juvenile coho (Oncorhynchus kisutch), chum) O. keta), chinook (O. tshawytscha), and pink (O. gorbuscha) salmon released weekly into Yaquina Bay, Oregon during 1978.

size of 7.6 gm were released from Southbeach on March 7 and June 5, respectively.

Length of residence of hatchery coho salmon

There is a general supposition that coho salmon smolts emigrate rapidly to the ocean, and do not remain in river estuaries for extended periods of time (Royal 1972; Lichatowich et al. 1978). Because of the possibility that all hatchery coho salmon smolts released into Yaquina Bay might leave the estuary within a week after being released, in 1977 the four beach study areas were sampled once a day for 7 days after the release of hatchery coho salmon on July 18.

The catch of juvenile hatchery coho salmon at the four beach study areas from July 19 through July 25, 1977 is shown in Table 3. Although the catch at the beach study areas was quite variable, the number of hatchery coho appeared to decrease during this period (Table 3). However, hatchery coho were still present at the study areas on July 25, 1977, and had not all left the estuary within one week after being released (Table 3).

Because the exact date of release for many of the fish marked with coded wire tags in 1977 was unknown, and because recovery of tagged fish at the study areas was inadequate (N=17), an empirical model utilizing the mean daily catch per sample week (MDC/SW) was used to describe the length of residence of hatchery coho salmon at the

Table 3. The number of juvenile hatchery coho salmon (Oncorhynchus kisutch) captured by beach seine at four study areas in Yaquina Bay, Oregon from July 19 through July 25, 1977.

	Study Area			
Date*	1	2	3	4
7/19	106	5	59	3
7/10	408	18	20	1
7/21	41	8	22	2
7/22	1000**	26	14	0
7/23	50**	67	9	1
7/24	53	32	--***	1
7/25	1	14	--	3

*During 1977 no hatchery fish were released into Yaquina Bay after July 18.

**The number of juvenile coho salmon captured at Site 1 on July 22 and July 23, 1977 was estimated on the basis of the ratio of salmon to herring (Clupea harengus pallasi). On July 22, 1977 approximately 100,000 herring were captured in the beach seine. The ratio of juvenile salmonids to herring was determined to be 1:100. On July 23, 1977 approximately 50,000 herring were captured with a ratio of juvenile salmonids to herring of 1:1000.

***Dashes indicate that no sample was taken.

four beach study areas in 1977. The MDC/SW was calculated by dividing the total weekly catch at the four study areas by the number of days sampled during that week. The weekly catch at the four beach study areas was pooled to make the model as representative of the entire estuary as possible. If Site 3 was not sampled because of high tidal levels, the catch at Site 3 was assumed to be the mean of the pooled catch at Sites 1 and 2 on that date. The MDC/SW was used because sampling was not conducted at equal time intervals within the 1-week periods. Weekly sampling was consistent, however, except for the period from July 19 through July 25, 1977 when the study areas were sampled daily. In addition, sampling at the beach study areas was not consistent with respect to tidal levels, tidal currents, and other environmental variables. Frequent sampling of the study areas and pooling of samples reduced variability in the catch data, while maintaining a reasonable representation of the number of salmon present at the study areas during a particular period of time.

The MDC/SW of hatchery coho salmon at the four beach study areas in 1977 is shown in Figure 14. The catch appeared to decrease exponentially after the last release of hatchery fish on July 18 (Fig. 14). To determine if this was an exponential decrease, the catch data presented in Figure 14 were transformed to natural logarithms to determine if the catch decreased linearly. The best fit for these

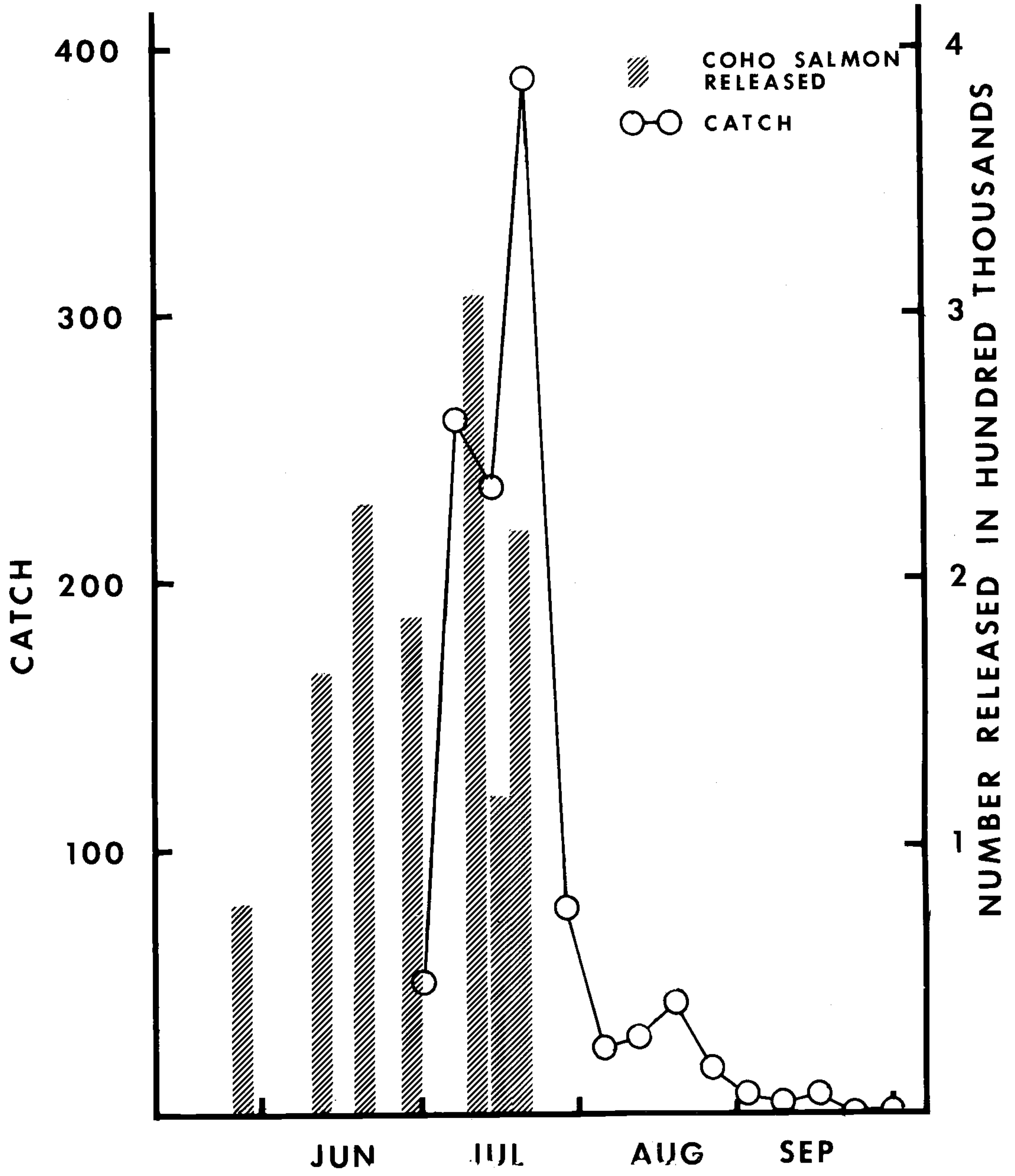

Figure 14. The mean daily catch per sample week of juvenile hatchery coho salmon (Oncorhynchus kisutch) captured by beach seine at four study areas in Yaquina Bay, Oregon in 1977, and the number of juvenile hatchery coho salmon released into Yaquina Bay during 1977.

catch data was calculated by the method of least squares.[1] The regression equation, calculated for 11 cases, is shown in Figure 15. The standard error of the estimate of the slope, indicating variance about the regression, was 0.01. The relationship between the logarithm of the catch and time was significant at the 1% level (H_o:β=0; t=3.250). In addition this appears to be a significant, predictive relationship. The use of the independent variable time, measured in days elapsed since the date of last release, reduced the total variation of the logarithm of the catch by 89% (Fig. 15).

On this basis, the length of residence of juvenile hatchery coho salmon in the estuary can be described by the simple model for exponential decrease. The basic assumptions of the model are:

1. The rate that coho salmon leave the estuary is proportional to the number of coho, N, present.
2. There is no preferred time for coho salmon to leave the estuary.
3. All coho salmon have the same chance of leaving the estuary, independent of each other.

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[1]Points representing sample periods during which no hatchery coho were captured were not included in the calculation of the regression equation if they occurred in an interval between sample periods in which one or more coho salmon were captured. In addition, if zero catches occurred for three or more weeks in a row, the first zero catch was assumed to be a small value (0.1), and points after these were not included in the calculation of the regression equation.

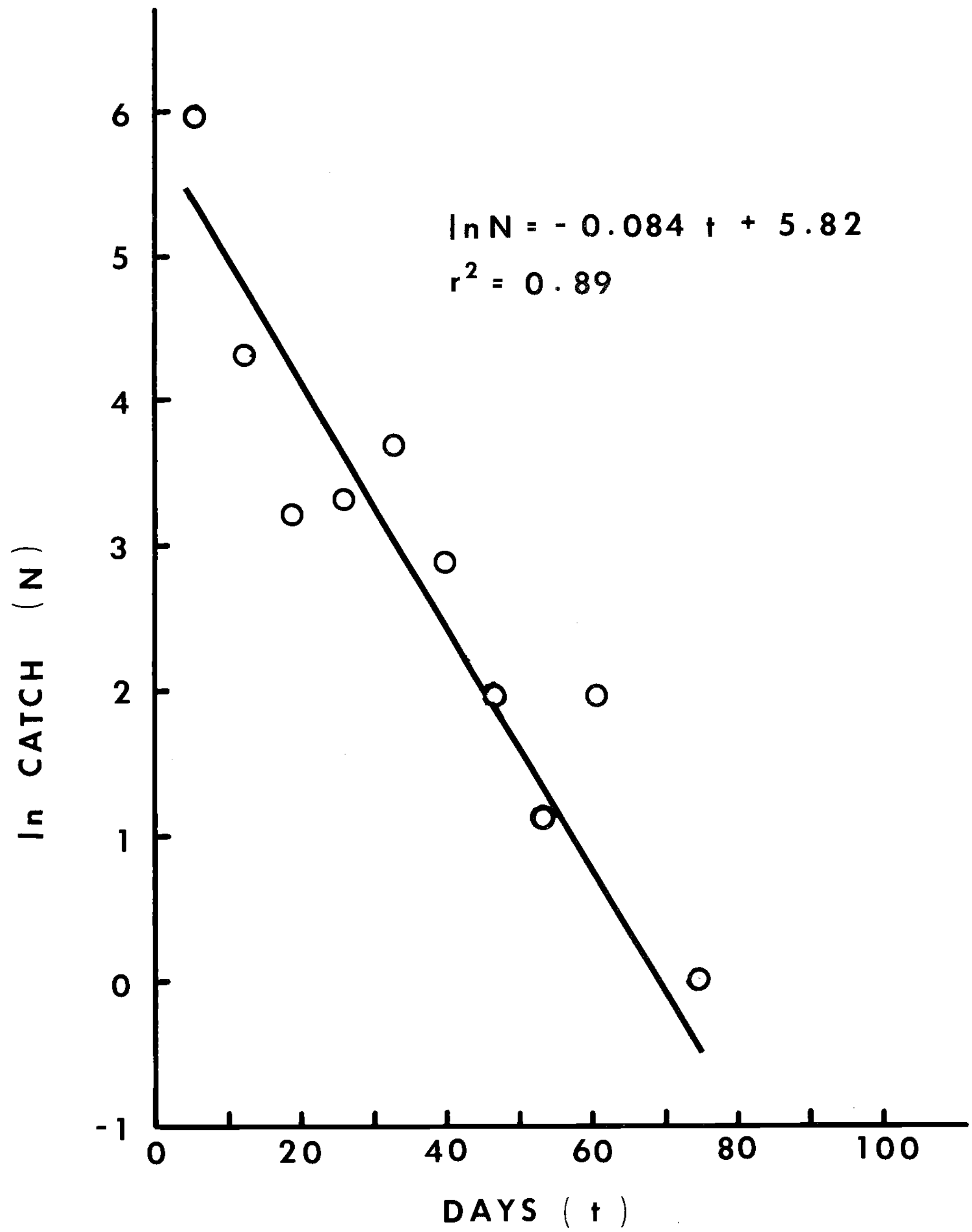

Figure 15. The regression of the natural logarithm (ln) of the mean daily catch per sample week of juvenile hatchery coho salmon (Oncorhynchus kisutch) captured at four beach study areas in Yaquina Bay, Oregon in 1977 on time, measured in days elapsed since the date of last release of hatchery fish on July 18, 1977.

The model is represented by the differential equation:

$$dN/dt = -kN,$$

or its solution: $N = N_o e^{-kt}$ or $\ln N = -kt + \ln N_o$, where N is the number of coho present at the study areas at time t, N_o is the number of coho present at the study areas at time t=0, t is the number of days elapsed since the date of release of hatchery coho salmon into the estuary, and k is a rate constant.

Because the rate constant, k, has no immediate intuitive meaning, the introduction of the concept of a "residency half-life" is useful. This is identical to the concept of half-life used to describe radioactive decay. The residency half-life ($t_{\frac{1}{2}}$) is the length of a time interval in which the number of juvenile coho salmon at the study areas is reduced by 50%, that is:

$$N/N_o = 1/2 = e^{-kt_{\frac{1}{2}}},$$

or:

$$t_{\frac{1}{2}} = \ln(1/2)/-k = 0.693/k.$$

The value of k can be determined empirically from the regression of the logarithm of the catch (lnN) on days elapsed since release (t) for individual groups of tagged or marked coho when the exact release date is known or, as in the case of 1977, for a combination of release groups after the date of last release. For 1977, the value of k was 0.084 (Fig. 15), and the residency half life ($t_{\frac{1}{2}}$) was 8.25 days.

Therefore, in three half-lives, or about 25 days, approximately 90% of the juvenile hatchery coho salmon originally present on July 18, 1977 had left the study areas.

Whereas the majority of juvenile hatchery coho salmon released in 1977 left the study areas in less than 1 mo after the date of last release, a small number remained for an extended period of time (Fig. 14). The mean fork length of hatchery coho salmon that remained in the estuary in 1977 increased from 11.5 cm in the middle of July to 21.0 cm in October (Fig. 16). Most of these fish were captured in the lower estuary (Sites 1-3). The last hatchery coho salmon to occur in samples taken in the upper estuary (Site 4) was captured on July 25, 1977. The last juvenile hatchery coho salmon to occur in samples taken at the beach study areas in the lower estuary during 1977 was captured at Site 2 on December 17 at a fork length of 26.8 cm. However, a few large juvenile hatchery coho salmon ($\overline{X}$=36.0 cm FL; n=5) captured at the beach study areas in the lower estuary in January, March, and April (prior to the first release of hatchery coho in 1978) had, apparently, remained in the estuary or in the coastal waters near Yaquina Bay during the winter.

Because hatchery coho salmon were released throughout the summer in 1978 (Fig. 13), information on length of residence of hatchery coho salmon in the estuary had to be obtained from recapture of CWT and FDM fish. Release and recovery information on CWT

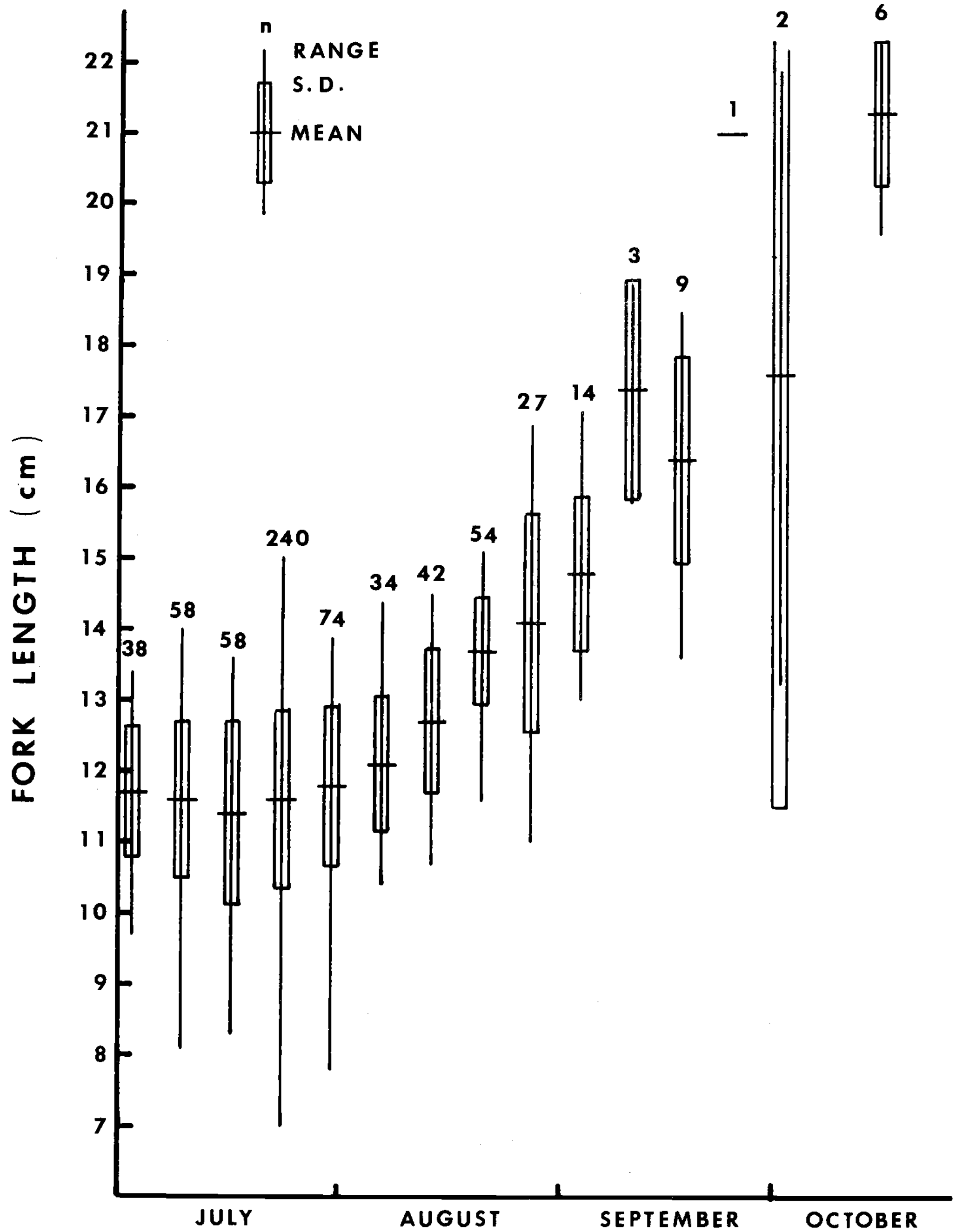

Figure 16. Weekly mean fork lengths of juvenile hatchery coho salmon (Oncorhynchus kisutch) captured by beach seine at four study areas in Yaquina Bay, Oregon in 1977.

coho salmon in 1978 is shown in Table 4. When subsamples of CWT coho salmon (adipose fin clips) were taken, the number of coho from each tag group in the sample was estimated from the proportion in the subsample. The estimates, as well as the actual number of tags recovered from each release group, are shown in Table 4. Although CWT coho were released into Yaquina Bay on 13 dates, recoveries of CWT fish on a sufficient number of dates to test the exponential model of length of residence were obtained only for hatchery coho released on June 19, July 7, and August 16 (Table 4).

The largest release of CWT coho salmon was made on June 19, 1978, and the best recovery of tags was obtained for this group (Table 4). The MDC/SW of CWT coho salmon from the June 19 release group at the four beach study areas in 1978 is shown in Figure 17. Similar to the catch of hatchery coho at the beach study areas in 1977 (Fig. 14), the catch of coho salmon juveniles from the June 19 release group also appeared to decrease exponentially (Fig. 17). The regression of the natural logarithm of the catch on time was significant at the 1% level, and the residency half-life calculated for this release group was 9 days. Similar to hatchery coho released in 1977, the majority of the coho from the June 19 release group left the study areas in less than 1 mo after being released, and a small number remained for an extended period of time (Fig. 17). The mean size of fish from the June 19 release group that remained in the

Table 4. Release and recovery information for hatchery juvenile coho salmon (*Oncorhynchus kisutch*) marked with coded wire tags in Yaquina Bay, Oregon during 1978.

Release Date	Number Released	Total Number Recovered	Recovery Date or Period	Number of Recovery Dates	Recovery Sites*
4/06	10,000	0	--	--	--
6/13	9,355	4	6/15	1	1, 3
6/19	203,788	743** (109)	6/22-9/18	19	1, 2, 3, 4
6/24	28,918	7** (3)	7/19-9/07	3	1, 2
6/30	14,553	14** (2)	7/06, 7/17	2	1, 2
7/06	13,595	6** (3)	7/13-8/21	3	2, 3
7/07	63,627	288** (37)	7/06-9/18	11	1, 2, 3
7/11	14,240	23** (3)	7/13-8/21	3	1, 2, 3
7/27	9,372	0	--	--	--
8/01	8,231	0	--	--	--
8/07	25,310	3	8/10, 8/21	2	2, 3
8/16	35,932	97** (24)	7/20[+]-9/14	10	1, 2, 3
9/07	8,419	65** (23)	8/28[+]-9/14	4	1, 2, 3

*Sites 1-3 were in the lower estuary at 3.1-5.1 river km. Site 4 was in the upper estuary at 16.1 river km.

**Estimate based on proportion of coded wire tagged coho in subsamples. The actual number recovered appears in parentheses.

[+]Four fish from the 8/16 tag group and one fish from the 9/07 tag group were recovered prior to the "official" release date.

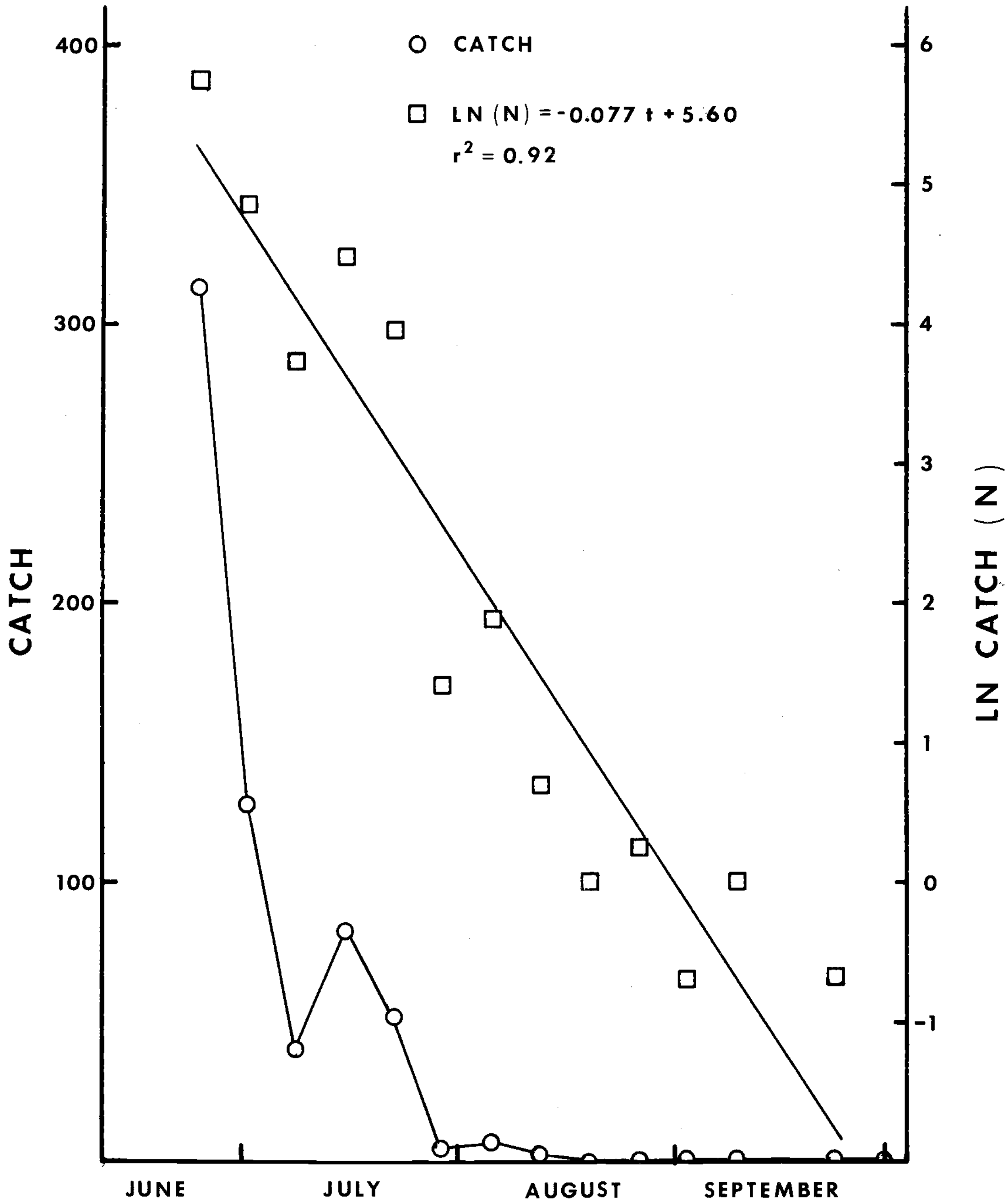

Figure 17. The mean daily catch per sample week of juvenile hatchery coho salmon (*Oncorhynchus kisutch*) released into Yaquina Bay, Oregon on June 19, 1978, and captured by beach seine at four study areas in Yaquina Bay during 1978; and the relationship between the natural logarithm (ln) of the catch and time, measured in days elapsed since the date of release.

estuary was less than 12. 0 cm FL until the end of August (Fig. 18). The last coho salmon from this release group to occur in samples taken at the beach study areas was captured at Site 3 on September 18, 1978 at a FL of 11. 8 cm, and had been in the estuary for 91 days.

Parameters of the residency model calculated for the June 19, July 7, and August 16, 1978 CWT release groups are shown in Table 5. The residency half-lives of the latter two groups were about 4 days (Table 5). Although these two groups were released 18 and 58 days, respectively, after the June 19 release group, tagged fish from all three release groups were last captured at the study areas in mid September (Table 4).

Release and recovery information on FDM coho salmon in 1978 is shown in Table 6. On dates when subsamples of coho salmon were taken, the total number of FDM fish in the catch was estimated from the proportion in the subsample. The estimates, as well as the actual number of dye marks recovered from each release group, are shown in Table 6. Although six releases with over 50, 000 FDM coho salmon were made, recovery of FDM coho at the study areas was poor (Table 6). No FDM salmon from any of the release groups were captured on more than six sample dates (Table 6). Recovery of fish from groups marked with yellow dye was especially poor (Table 6).

Parameters of the residency model calculated for release

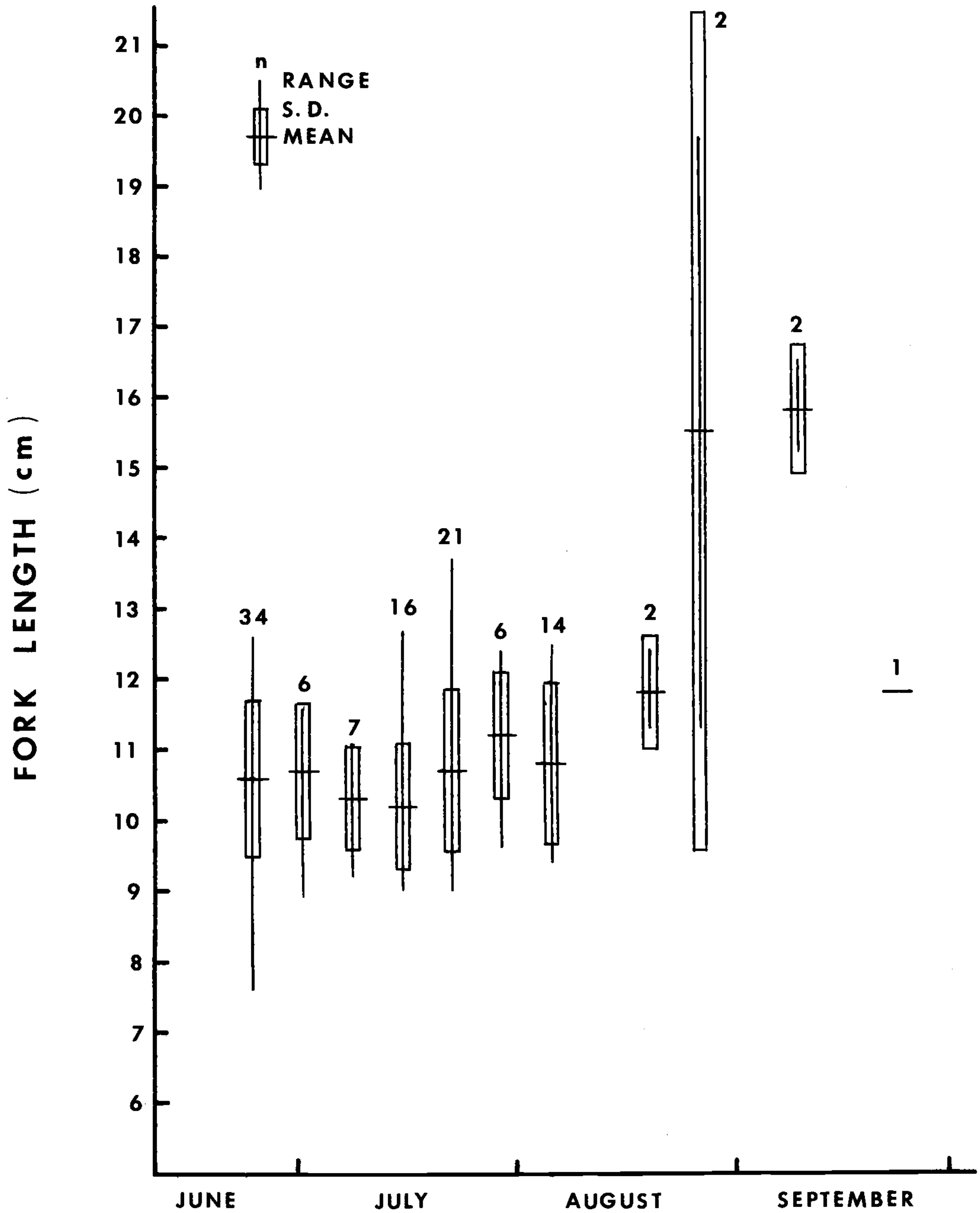

Figure 18. Weekly mean fork lengths of juvenile hatchery coho salmon (*Oncorhynchus kisutch*) released into Yaquina Bay, Oregon on June 19, 1978, and captured by beach seine at four study areas in Yaquina Bay during 1978.

Table 5. Parameters of a model used to describe length of residence of hatchery juvenile coho salmon (Oncorhynchus kisutch) in Yaquina Bay, Oregon calculated for three groups of coded wire tagged fish captured at four beach study areas in Yaquina Bay during 1978.

Release Date	Regression Coefficients[a] k	$\ln N_o$	r^2	SE	n	$t_{\frac{1}{2}}$[b] (days)
6/19	0.077*	5.60	0.92	0.0067	14	9.0
7/07	0.186*	5.88	0.98	0.0145	6	3.7
8/16	0.164*	4.23	0.93	0.0224	6	4.2

[a]The model is: $N = N_o e^{-kt}$ where N = number of coho present at the study areas at time t; N_o = number of coho present at the study areas at time t = 0; t = number of days elapsed since release; and k = rate constant.

[b]$t_{\frac{1}{2}}$ = residency half-life = 0.693/k.

*Significant at the 1% level (H_o:β = 0; p < .01).

Table 6. Release and recovery information for hatchery juvenile coho salmon (*Oncorhynchus kisutch*) marked with fluorescent dyes in Yaquina Bay, Oregon during 1978.

Release Date	Number Released	Dye Color	Total Number Recovered*	Recovery Date or Period	Number of Recovery Dates	Recovery Sites*
4/06	36,367	Red	17** (15)	4/15, 4/29	2	1, 2, 3, 4
4/06	14,480	Yellow	1	5/13	1	1
6/13	44,399	Green	105** (32)	6/15-7/06	4	1, 2, 3
6/29	56,150	Yellow	0	--	--	--
7/11	50,988	Red	107** (30)	7/06+-8/03	6	1, 2, 3
7/27	57,654	Orange/Green	36** (25)	7/31-8/10	4	1, 2, 3
8/10	51,089	Red/Green	33** (12)	8/14-8/28	3	1, 2, 3
8/22	50,421	Red	146** (52)	8/24-9/14	5	1, 2, 3, 4
10/07	55,733	Yellow	1	10/07	1	1

*Sites 1-3 were in the lower estuary at 3.1-5.1 river km. Site 4 was in the upper estuary at 16.1 river km.

**Estimate based on proportion of dyed coho in subsamples. The actual number recovered appears in parentheses.

+Four fish from the 7/11 dye mark group were recovered prior to the "official" release date.

groups of FDM coho captured on more than one sample date are shown in Table 7. Because FDM coho salmon were recovered on so few dates (Table 6), samples of FDM coho salmon captured at the four beach study areas were not pooled on a weekly basis. The data in Table 7 represent the regression of the pooled catch of FDM coho at the four beach study areas on a particular sample date on the number of days elapsed since the date of release. In other respects, the regression equations were calculated in the same manner as described for the 1977 catch data. The residency half-lives calculated for FDM groups ranged from 1.6 to 4.0 days (Table 7). However, none of the regression equations were significant at the 5% level (Table 7).

Although large numbers of juvenile hatchery coho salmon were released into the estuary in September and October of 1978 (Fig. 13), these fish were captured at the study areas for only a short period of time. Approximately 730,000 juvenile coho salmon were released into the estuary on September 3 and September 7, 1978. The MDC/SW at the four beach study areas after the date of last release of hatchery coho salmon on September 7 decreased exponentially ($\ln N = -0.297\,t + 7.91$; $r^2 = 0.89$; SE = 0.06; $p < .05$; n=5), and the residency half-life of these fish was only 2.3 days. Over 1.6 million hatchery coho salmon were released into the estuary on October 7 and October 20, 1978, but these numbers were not reflected in the catch at the beach and

Table 7. Components of a model used to describe length of residence of hatchery juvenile coho salmon (Oncorhynchus kisutch) in Yaquina Bay, Oregon calculated for six groups of fluorescent dye marked fish captured at four beach study areas in Yaquina Bay during 1978.

Release Date	Regression Coefficients[a] k	Regression Coefficients[a] $\ln N_o$	r^2	SE	n	$t_{\frac{1}{2}}$[b] (days)
4/06	0.186*	4.83	0.97	0.03	3	3.7
6/13	0.192*	5.20	0.69	0.07	5	3.6
7/11	0.174*	4.07	0.62	0.18	6	4.0
7/27	0.445*	4.90	0.79	0.84	4	1.7
8/10	0.329*	5.98	0.70	0.94	3	2.1
8/22	0.247*	5.04	0.88	0.23	6	2.8

[a]The model is: $N = N_o e^{-kt}$ where N = number of coho present at the study areas at time t; N_o = number of coho present at the study areas at time t=0; t = number of days elapsed since release; and k = rate constant.

[b]$t_{\frac{1}{2}}$ = residency half-life = 0.693/k.

*Not significant at the 5% level (H_o:β=0; p > .05).

channel study areas. The largest catch was 62 coho salmon captured at Site 1 on October 7. These fish were small, with a mean FL of 10.3 cm, and were not silvery in appearance (parr marks were still prominent). Although 23 sets of the beach seine were made on six dates after October 7, only 25 juvenile hatchery coho salmon were captured at the beach study areas (CPUE = 1.09). Only one juvenile hatchery coho salmon was captured at the two channel study areas in samples taken on October 30 (CPUE = 0.5). Two juvenile hatchery coho salmon were captured in November (CPUE = 0.25) at Site 4, and none were captured on December 10, the last sample date in 1978.

Length of residence of hatchery chinook salmon

The length of residence of juvenile hatchery chinook salmon in the estuary was determined by recovery of CWT and FDM fish at the study areas. The number of fish released, the release date, the percentage marked with CWT or FDM, and the weekly CPUE for the five groups of tagged and marked hatchery chinook recovered at the four beach study areas during 1977 and 1978 is shown in Figure 19.

Trask River stock spring chinook (Fig. 19, groups 1 and 3) were released into the estuary in July of both 1977 and 1978. Although the 1977 release was into Wright Creek and the 1978 release was from Southbeach, fish were recovered at the beach study areas

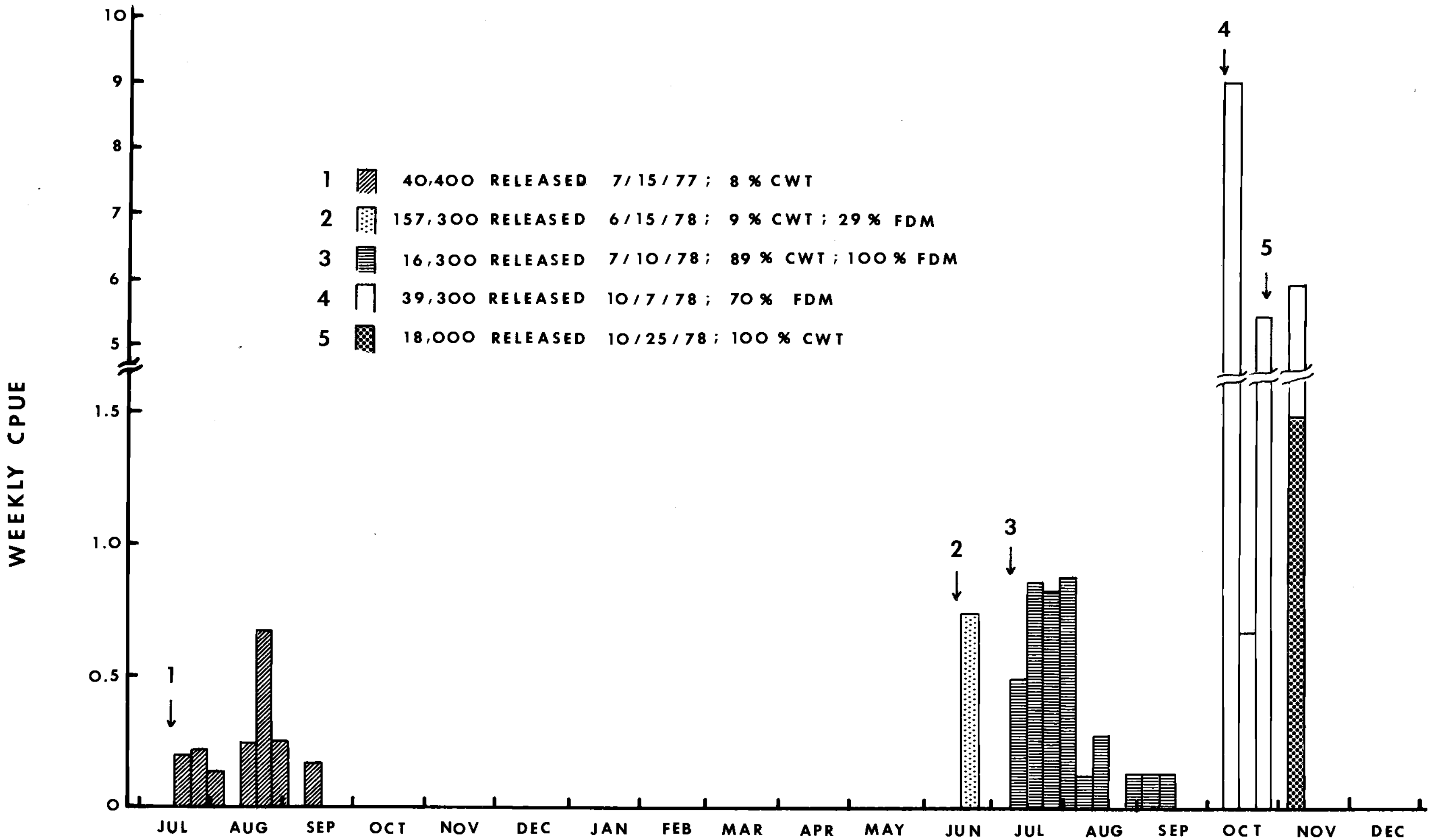

Figure 19. The weekly catch per unit effort for five groups of coded wire tagged (CWT) and fluorescent dye marked (FDM) juvenile hatchery chinook salmon (<u>Oncorhynchus tshawytscha</u>) released into Yaquina Bay, Oregon during 1977 and 1978, and recovered by beach seine at four study areas in Yaquina Bay from July 1977 through December 1978.

for similar periods of time in both years (Fig. 19). CWT and FDM fish from these release groups were recovered at the beach study areas for a period of nine weeks after release in 1977, and 10 weeks after release in 1978 (Fig. 19). CWT and FDM fish from the 1978 release of Trask River spring chinook were also recovered at the channel study areas (Sites 5-6) on four sample dates from July 11 through August 22, 1978.

CWT and FDM fish from a large release of University of Washington stock fall chinook (Fig. 19, group 2) were recovered at the beach study areas only during the 2nd week after release. No CWT or FDM fish from this release group were recovered at the channel study areas.

FDM Oregon Aqua Foods stock chinook (Fig. 19, group 4), rleased into the estuary on October 7, 1978, were recovered at the beach study areas for a period of 5 weeks after release. FDM fish from this release group were also recovered at the channel study areas on October 30, the last sample date at the channel study areas in 1978.

Yaquina River stock fall chinook (Fig. 19, group 5), released at the public boat ramp at Toledo (19.0 river km) on October 25, 1978, were recovered at beach study areas in the upper and lower estuary on November 11, 17 days after release. Three CWT fish from this release group were also recovered in the channel at Site 5 on October 30, 1978.

Relative abundance of hatchery and wild juvenile salmon

The monthly CPUE of juvenile hatchery and wild chinook and coho salmon captured at beach study areas in the estuary is shown in Table 8. The monthly CPUE was calculated by dividing the total monthly catch for each species and area by the number of sets made with the beach seine during the same period.

Both hatchery and wild coho salmon were present at the beach study areas during April, May, and June of 1978. During this period hatchery coho were more abundant than wild coho in both the upper and lower estuary except in May (Table 8).

Both hatchery and wild chinook salmon were present at the beach study areas from July through September 1977, and June through November 1978. During these periods wild chinook were usually more abundant than hatchery chinook (Table 8). However, hatchery chinook were more abundant than wild chinook in the upper estuary in July 1977, and in both the upper and lower estuary during October and November 1978 (Table 8).

Both hatchery coho and wild chinook were present at the beach study areas for 13 of the 18 months that this study was conducted, including July through October 1977, January 1978, and April through November 1978. Wild chinook were usually more abundant

Table 8. The monthly catch per unit effort of juvenile hatchery and wild chinook (<u>Oncorhynchus tshawytscha</u>) and coho (<u>O. kisutch</u>) salmon captured by beach seine at study areas in upper (U) and lower (L) Yaquina Bay, Oregon from July 1977 through December 1978.

Month and Year	Number of Sets*		Chinook				Coho			
			Hatchery		Wild		Hatchery		Wild	
	U**	L***	U	L	U	L	U	L	U	L
7/77	12	32	3.0	1.8	1.3	8.6	1.0	81.9	0.0	0.0
8/77	8	24	0.4	2.1	0.8	4.4	0.0	8.9	0.0	0.0
9/77	8	18	0.6	1.1	0.9	4.4	0.0	1.3	0.0	0.0
10/77	4	10	0.0	0.0	1.8	1.8	0.0	0.7	0.0	0.0
11/77	2	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/77	2	4	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
1/78	2	5	0.0	0.0	0.0	0.6	0.0	0.4	0.0	0.0
2/78	2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/78	2	6	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
4/78	3	8	0.0	0.0	0.3	0.0	10.3	5.2	5.0	0.4
5/78	2	5	0.0	0.0	12.5	0.0	0.0	0.6	2.0	12.8
6/78	4	10	0.2	1.4	4.8	20.0	1.2	73.3	0.0	0.2
7/78	6	23	0.0	0.9	8.8	64.7	1.7	206.6	0.0	0.0
8/78	9	24	0.0	0.2	3.6	40.1	3.6	246.1	0.0	0.0
9/78	8	19	0.0	0.1	1.2	14.1	14.9	167.6	0.0	0.0
10/78	4	10	7.8	8.2	1.8	2.8	2.2	8.7	0.0	0.0
11/78	2	6	27.0	21.5	5.0	3.3	1.0	0.0	0.0	0.0
12/78	1	3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0

*One set of the beach seine is equal to one unit of effort.

**U = upper estuary = Site 4 @ 16.1 river km.

***L = lower estuary = Sites 1-3 @ 3.1-5.1 river km.

than hatchery coho in the upper estuary, except during April, September, and October 1978 (Table 8). And hatchery coho were usually more abundant than wild chinook in the lower estuary, except during September and October 1977, and January and November 1978 (Table 8).

June 15, 1978 was the only date that both hatchery chinook and wild coho were present at the beach study areas at the same time. On this date hatchery chinook were more abundant than wild coho (Table 8).

Although the monthly CPUE for juvenile chum salmon at the beach study areas is not shown in Table 8, both hatchery coho and wild chum salmon were present at the beach study areas in March and April. Wild chum salmon (CPUE = 1. 0) were more abundant than hatchery coho (Table 8) in the lower estuary during March. During April hatchery coho (Table 8) were more abundant than wild chum (CPUE = 8. 7) in the upper estuary, and less abundant than wild chum (CPUE = 8. 5) in the lower estuary. None of the hatchery chum salmon released into Yaquina Bay during 1977 and 1978 (Figs. 13 and 13) were captured at the beach study areas.

Only two of the hatchery pink salmon released into Yaquina Bay in 1978 (Fig. 13) were recovered at the beach study areas. These fish were captured 11 days after release at Site 2 on March 18, 1978, along with 5 wild chum salmon.

The monthly CPUE of juvenile hatchery and wild chinook and coho salmon captured at the channel study areas (Sites 5-6) from March through October 1978 is shown in Table 9. Both hatchery and wild coho salmon were present at the channel study areas during May and June 1978. Wild coho were more abundant than hatchery coho in May, and less abundant in June (Table 9). Both hatchery and wild chinook salmon were present at the channel study areas from June through August, and in October 1978. Wild chinook were usually more abundant than hatchery chinook except during October 1978 (Table 9). Both hatchery coho and wild chinook were present at the channel study areas from June through October 1978. Hatchery coho were more abundant than wild chinook except during September and October (Table 9). No hatchery or wild chum or pink salmon were captured at the two channel study areas.

The annual CPUE of juvenile hatchery and wild coho and chinook salmon at the four beach and two channel study areas is shown in Table 10. During the period of this study hatchery and wild coho and chinook salmon were captured at all six study areas (Table 10). However, the catch at the four beach study areas was not uniform. In 1977 and 1978 hatchery coho salmon were most abundant at Site 1 and least abundant at Site 4 (Table 10). Although catches were small, wild coho salmon also appeared to be more abundant at Site 1 (Table 10). In 1977 and 1978 both hatchery and

Table 9. The monthly catch per unit effort of juvenile hatchery and wild coho (*Oncorhynchus kisutch*) and chinook (*O. tshawytscha*) salmon captured by lampara net at channel study areas in Yaquina Bay, Oregon from March through October 1978.

Month	Number of Sets *	Coho		Chinook	
		Hatchery	Wild	Hatchery	Wild
March	4	0.0	0.0	0.0	0.0
April	2	3.0	0.0	0.0	0.0
May	6	0.8	1.1	0.0	0.0
June	4	19.2	0.2	0.2	3.8
July	4	16.8	0.0	1.8	6.8
August	4	22.0	0.0	0.5	7.0
September	4	17.2	0.0	0.0	24.0
October	4	3.5	0.0	48.2	30.0

*One set of the lampara net is equal to one unit of effort.

Table 10. The annual catch per unit effort of juvenile hatchery and wild coho (Oncorhynchus kisutch) and chinook (O. tshawytscha) salmon captured by beach seine at four study areas and by lampara net at two study areas in Yaquina Bay, Oregon during 1977 and 1978.

Sample Site*	Number of Sets**		Hatchery Coho		Wild Coho		Hatchery Chinook		Wild Chinook	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
1	38	47	56.8	205.1	0.0	1.0	0.8	1.5	1.7	13.9
2	36	45	13.1	52.6	0.0	0.5	0.5	0.4	1.3	10.3
3	18	33	13.0	82.8	0.0	0.03	4.6	5.2	20.6	58.2
4	36	45	0.3	4.6	0.0	0.4	1.2	1.9	1.1	3.5
5	0	16	--***	10.2	--	0.1	--	6.2	--	4.4
6	0	16	--	10.1	--	0.4	--	6.4	--	13.5

*Sample sites 1-4 were beach study areas where juvenile salmonids were captured by beach seine. Sample sites 5-6 were channel study areas where juvenile salmonids were captured by lampara net.

**One set of the net is equal to one unit of effort.

***Dashes indicate that no samples were taken.

wild chinook were most abundant at Site 3, and least abundant at Site 4 (Table 10). The catch of hatchery and wild coho and chinook salmon at the two channel study areas was more uniform (Table 10).

Environmental variables

The mean weekly water temperatures and surface salinities at beach study areas in the upper (Site 4) and lower (Sites 1-3) estuary are shown in Figures 20 and 21. In general, water temperatures and salinities at the beach study areas were lowest in the winter and highest in the summer and fall (Figs. 20 and 21). Salinities were always higher in the lower estuary than in the upper estuary (Fig. 21). And water temperatures in the upper estuary were usually warmer than in the lower estuary, except during the winter months (Fig. 20). In addition, a greater range in temperatures and salinities occurred in the upper estuary, than in the lower estuary. Water temperatures in the lower estuary ranged from 7°C in November 1978 to 17°C in September 1978 (Fig. 20). Water temperatures in the upper estuary ranged from 7°C in November 1978 to 24°C in July 1977 and August 1978 (Fig. 20). Surface salinities in the lower estuary ranged from 10‰ in December 1978 to 33‰ in July and August 1977, and August 1978 (Fig. 21). Salinities in the upper estuary ranged from 0‰ in December 1977 to 26‰ in August 1977 (Fig. 21).

Although there appear to be general spatial and seasonal

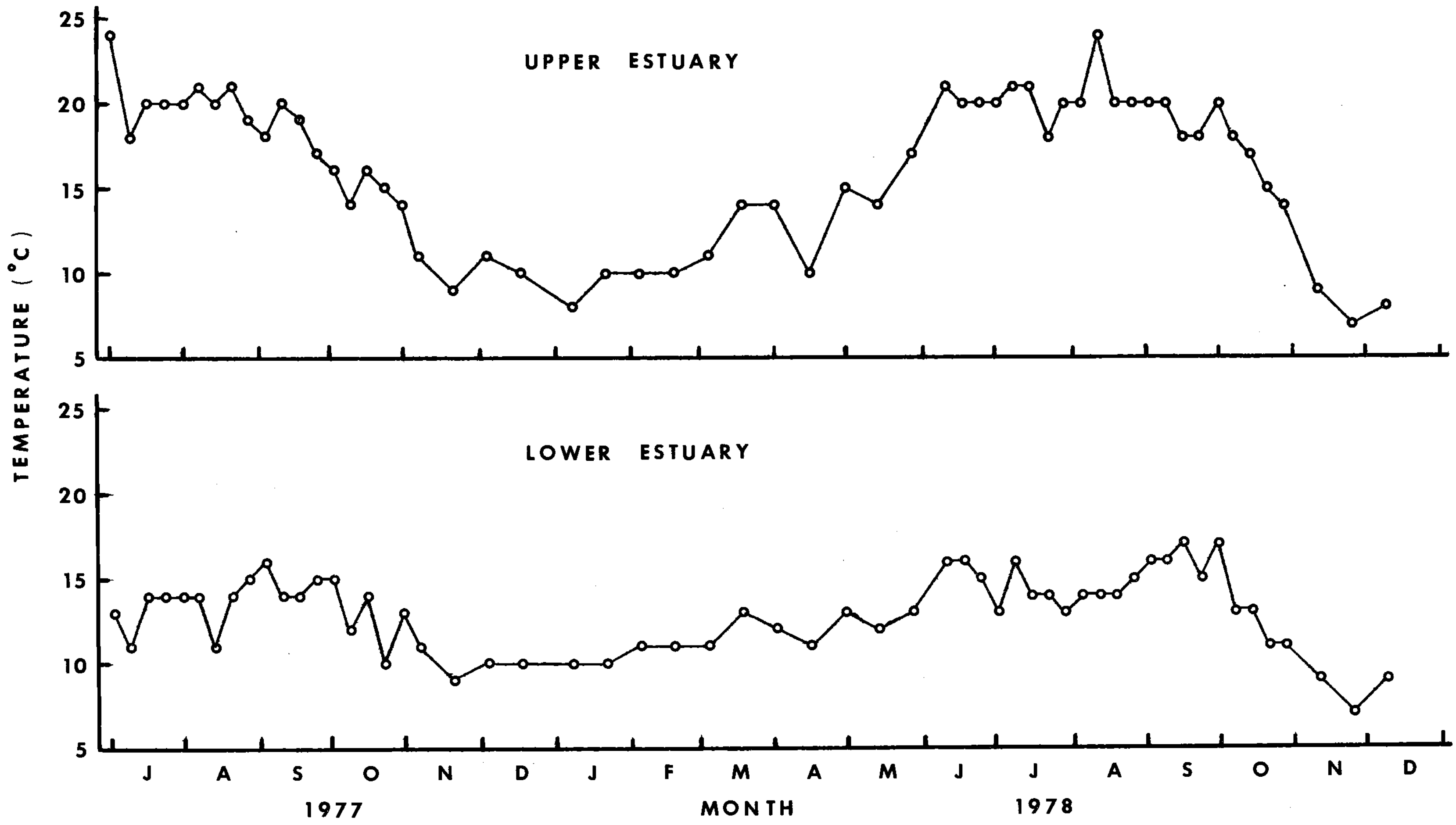

Figure 20. Mean weekly water temperatures at beach study areas in the upper (16.1 river km) and lower (3.1-5.1 river km) estuary in Yaquina Bay, Oregon from July 1977 through December 1978.

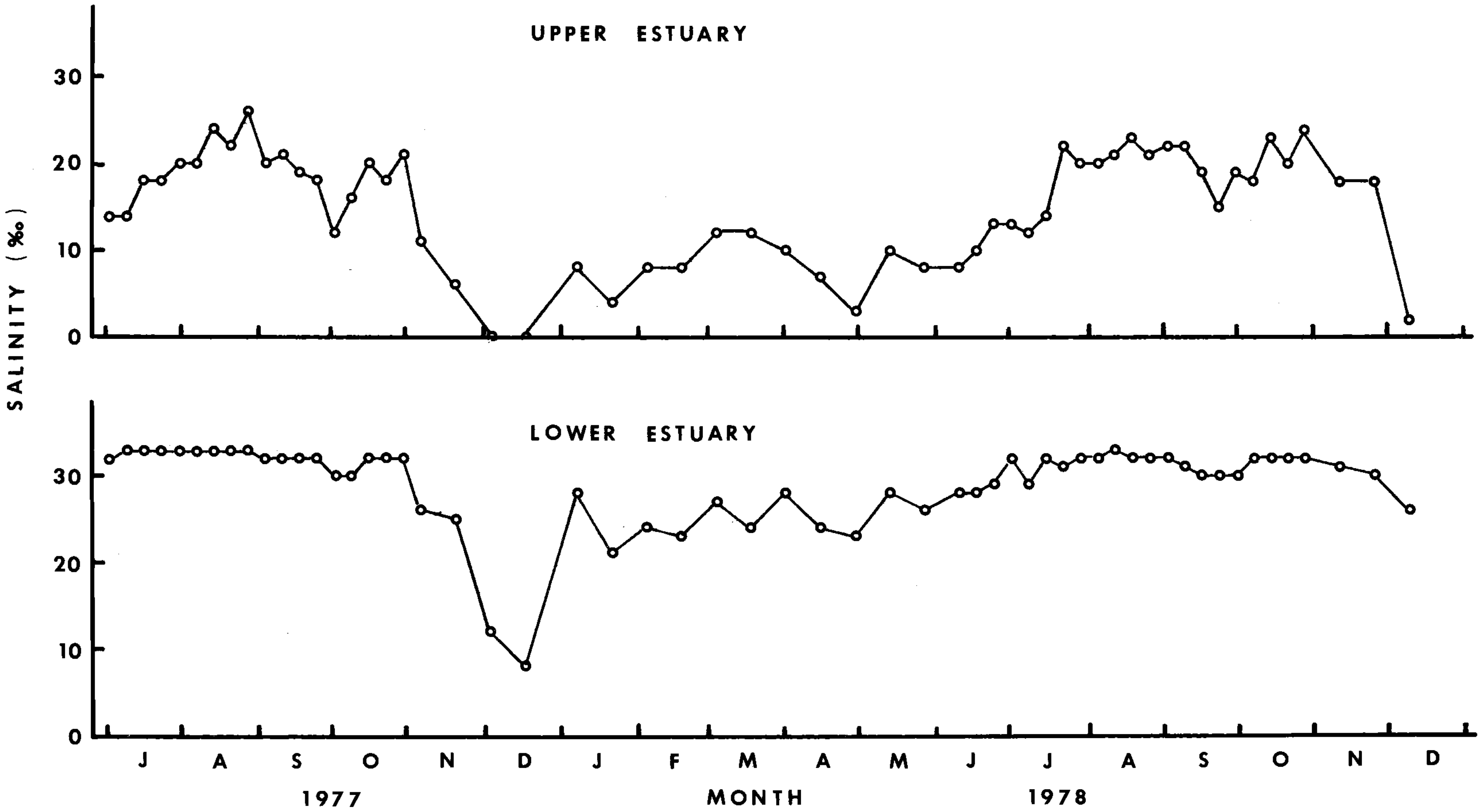

Figure 21. Mean weekly surface salinities at beach study areas in the upper (16.1 river km) and lower (3.1-5.1 river km) estuary in Yaquina Bay, Oregon from July 1977 through December 1978.

relationships between water temperature and salinity (Figs. 20 and 21) and the catch of hatchery and wild juvenile salmon at beach study areas in the upper and lower estuary (Table 8), no quantitative relationships were calculated.

The catch of juvenile salmon at the beach study areas, even within 1-week intervals, was often quite variable (Table 3). To determine if the catch of juvenile salmon at the study areas was directly related to environmental variables at the time of sampling, the relationship between temperatures, salinities, or tidal levels, and the number of hatchery coho salmon captured at the four beach study areas from July 19 through July 25, 1977 (Table 3) was examined using simple linear regression analysis. No significant relationships (H_o:B=0; $p > .05$) were found.

Overlap in Food Habits of Hatchery and Wild Juvenile Salmon

Hatchery coho and wild chinook salmon

Overlap in stomach contents of hatchery coho and wild chinook salmon captured at the four beach study areas from July through October 1977 is shown in Figure 22. From July through October 1977 juvenile Osmeridae, primarily whitebait smelt (*Allosmerus elongatus*) and surf smelt (*Hypomesus pretiosus*), was the most important food category in terms of biomass in the stomach contents of hatchery coho salmon (Fig. 22). The percentage of the total weight of stomach contents represented by smelt in the stomach

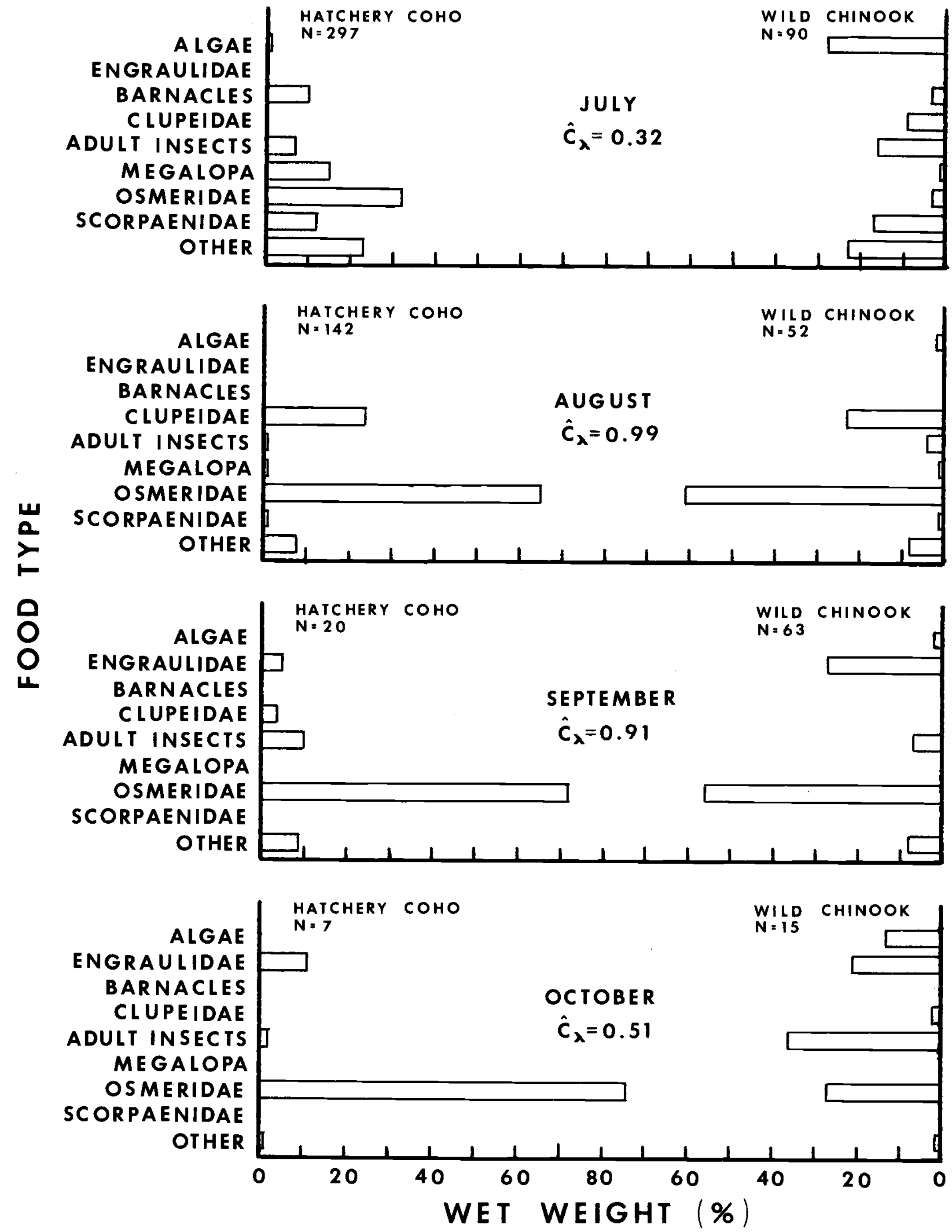

Figure 22. Percentage composition by weight of major food types in the pooled stomach contents of juvenile hatchery coho (Oncorhynchus kisutch) and wild chinook (O. tshawytscha) salmon captured by beach seine at four study areas in Yaquina Bay, Oregon from July through October 1977. $\hat{C}_\lambda$ = Morisita's index of overlap (Horn 1966).

contents of hatchery coho increased from approximately 32% in July to 85% in October 1977 (Fig. 22). The overlap in stomach contents of hatchery coho and wild chinook in 1977 was high during August ($\hat{C}_\lambda$ = 0.90) and September ($\hat{C}_\lambda$ = 0.99), when smelt accounted for the highest percentage of the biomass of stomach contents of both groups, and much lower during July ($\hat{C}_\lambda$ = 0.32) and October ($\hat{C}_\lambda$ = 0.51) when the stomach contents of wild chinook contained lower proportions of smelt, and higher proportions of algae, primarily Ulva sp. and Enteromorpha sp., and adult insects, primarily Diptera, Homoptera, and Hymenoptera in July, and Isoptera and Hymenoptera (Formicidae) in October (Fig. 22). Overlap in stomach contents of hatchery coho and wild chinook captured at the beach study areas during July 1977 was lower in the upper estuary ($\hat{C}_\lambda$ = 0.29) than in the lower estuary ($\hat{C}_\lambda$ = 0.35).

The overlap in stomach contents of 122 hatchery and 111 wild chinook from samples taken at the beach study areas during June 1978 was relatively high ($\hat{C}_\lambda$ = 0.74). Decapod zoea accounted for the highest percentage of the total biomass of stomach contents of both hatchery coho (30%) and wild chinook (33%). Adult insects and algae accounted for 23% and 18%, respectively, of the total biomass of stomach contents of wild chinook captured at the beach study areas in June 1978. However, these items were relatively insignificant (algae = 2%; adult insects = 6%) in the stomach contents of hatchery coho captured during the same period. Adult barnacles (Balanomorpha), megalopa, and crustacean debris represented 26% of the biomass of stomach contents of hatchery coho, and only 2% of the biomass of stomach contents of wild chinook in June 1978. Juvenile fish, primarily rockfish (Sebastes sp.) and smelt accounted for 21% of the biomass of stomach contents of hatchery coho, while juvenile fish, primarily herring (Clupea harengus pallasi) and rockfish, represented only 12% of the total biomass of stomach contents of wild chinook.

Overlap in stomach contents of hatchery coho and wild chinook salmon captured at the beach study areas from July through October 1978 is shown in Figure 23. In contrast to 1977, overlap in stomach contents of hatchery coho and wild chinook captured at the beach study areas was high during all four months in 1978 (Fig. 23). Juvenile fish, primarily anchovy (Engraulis mordax) and smelt, were the most important food categories in terms of biomass for both hatchery coho and wild chinook during this period (Fig. 23). Juvenile herring and smelt represented a larger percentage of the total biomass of stomach contents of both hatchery coho and wild chinook in August, September, and October 1978, than during the period in 1977 (Figs. 22 and 23).

While overlap in the stomach contents of hatchery coho and wild chinook was high for pooled samples taken at the four beach study

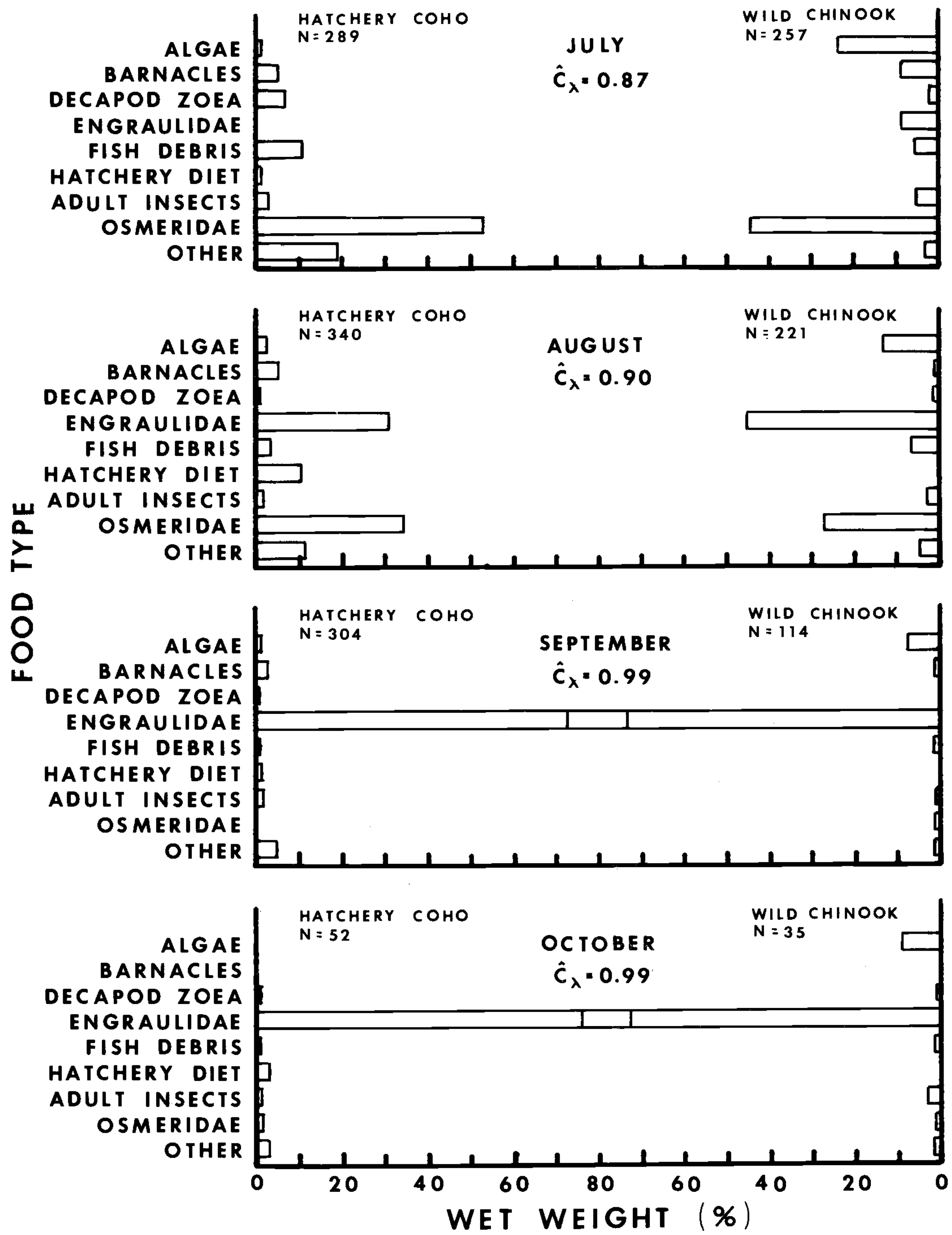

Figure 23. Percentage composition by weight of major food types in the pooled stomach contents of juvenile hatchery coho (Oncorhynchus kisutch) and wild chinook (O. tshawytscha) salmon captured by beach seine at four study areas in Yaquina Bay, Oregon from July through October 1978. $\hat{C}_\lambda$ = Morisita's index of overlap (Horn 1966).

areas in July and August 1978 (Fig. 23), this reflects a high degree of overlap in the stomach contents of fish captured in the lower estuary (Sites 1-3) only. Overlap in stomach contents of hatchery coho and wild chinook captured in the upper estuary (Site 4) was low in July ($\hat{C}_\lambda$ = 0.10) and August ($\hat{C}_\lambda$ = 0.48). In a sample of 11 coho and 47 chinook captured at Site 4 during July 1978, hatchery food accounted for the largest percentage (47%) of the total biomass of stomach contents of hatchery coho, while juvenile anchovy (61%) was the most important food category in the stomach contents of wild chinook. In August 1978, hatchery food (27%) and gammarid amphipods (27%) were the most important food categories in the stomach contents of 24 hatchery coho, while adult insects (37%) and juvenile anchovy (19%) were the most important food categories in the stomach contents of 32 wild chinook captured in the upper estuary. During September overlap in the stomach contents of hatchery coho and wild chinook was high in both the upper ($\hat{C}_\lambda$ = 0.90) and lower ($\hat{C}_\lambda$ = 0.99) estuary. However, in the upper estuary both adult insects and juvenile anchovy were important constituents in the stomach contents, and were represented in similar proportions in both hatchery coho (insects = 28%; anchovy = 26%) and wild chinook (insects = 23%; anchovy = 32%), while juvenile anchovy were the only major food category in the stomach contents of hatchery coho (89%) and wild chinook (88%) in the lower estuary.

The overlap in stomach contents of hatchery coho and wild chinook in samples taken at the two channel study areas from July through October 1978 is shown in Figure 24. In contrast to the beach study areas (Fig. 23), overlap in the stomach contents of hatchery coho and wild chinook at the channel study areas was low ($\hat{C}_\lambda = 0.19$) in July 1978 (Fig. 24). During July adult barnacles accounted for approximately 40% of the total biomass of stomach contents of hatchery coho, while juvenile anchovy and algae accounted for 65% of the total biomass of stomach contents of wild chinook (Fig. 24). Overlap in stomach contents was higher in August ($\hat{C}_\lambda = 0.79$) when juvenile fish, primarily anchovy and smelt, accounted for 70% of the total biomass of stomach contents of hatchery coho and 91% of the total biomass of stomach contents of wild chinook in samples taken at the channel study areas. Similar to the beach study areas in 1978 (Fig. 23), overlap in stomach contents was high at the channel study areas during September ($\hat{C}_\lambda = 0.98$) and October ($\hat{C}_\lambda = 0.94$), when juvenile anchovy were the most important food item in terms of biomass in the stomach contents of both hatchery coho and wild chinook (Fig. 24).

Hatchery and wild chinook salmon

The overlap in stomach contents of wild chinook and Trask River stock spring chinook, released into the estuary in July 1977 (Fig. 12), is shown in Figure 25. Overlap in stomach contents was

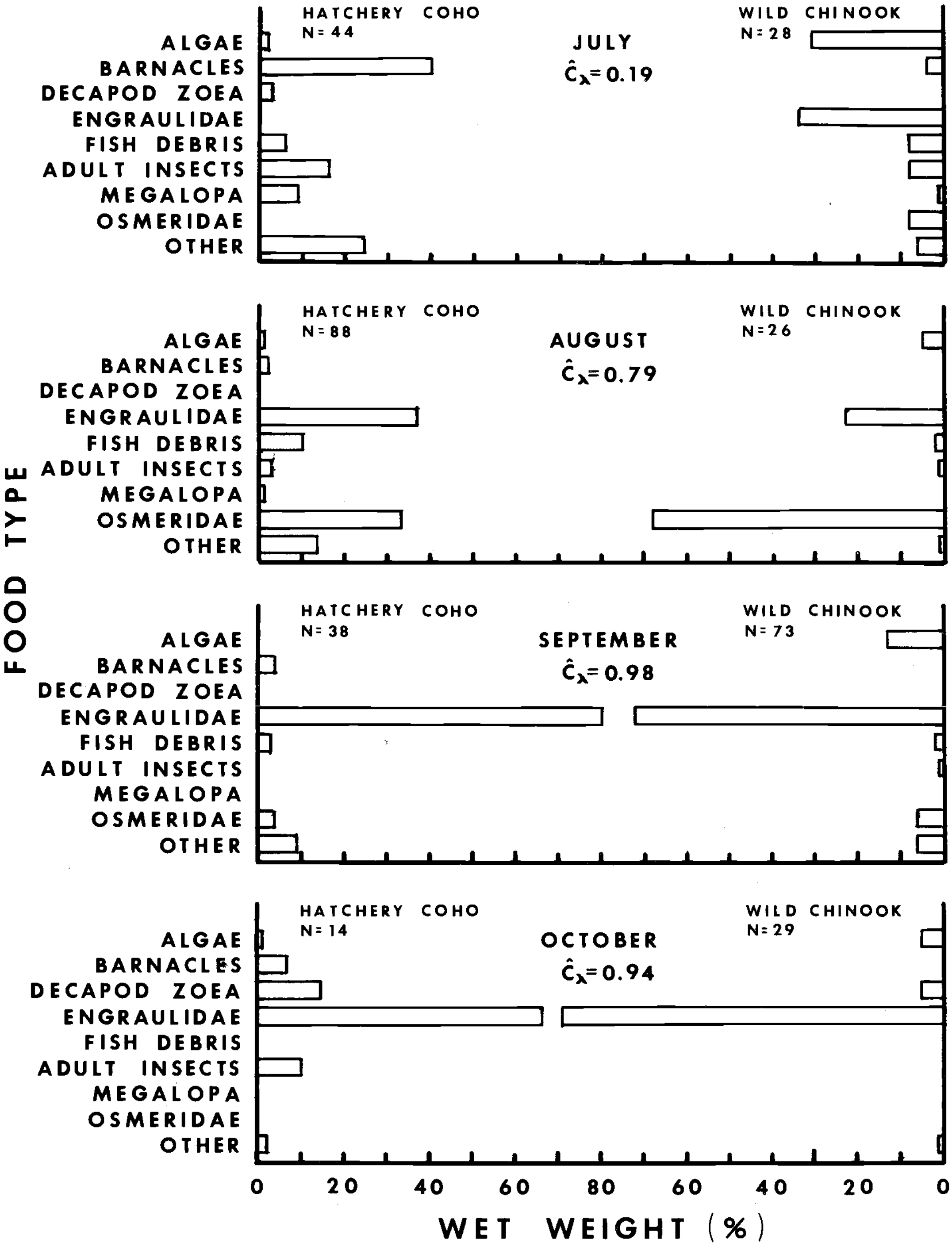

Figure 24. Percentage composition by weight of major food types in the pooled stomach contents of juvenile hatchery coho (Oncorhynchus kisutch) and wild chinook (O. tshawytscha) salmon captured by lampara net at two study areas in Yaquina Bay, Oregon from July through October 1978. $\hat{C}_\lambda$ = Morisita's index of overlap (Horn 1966).

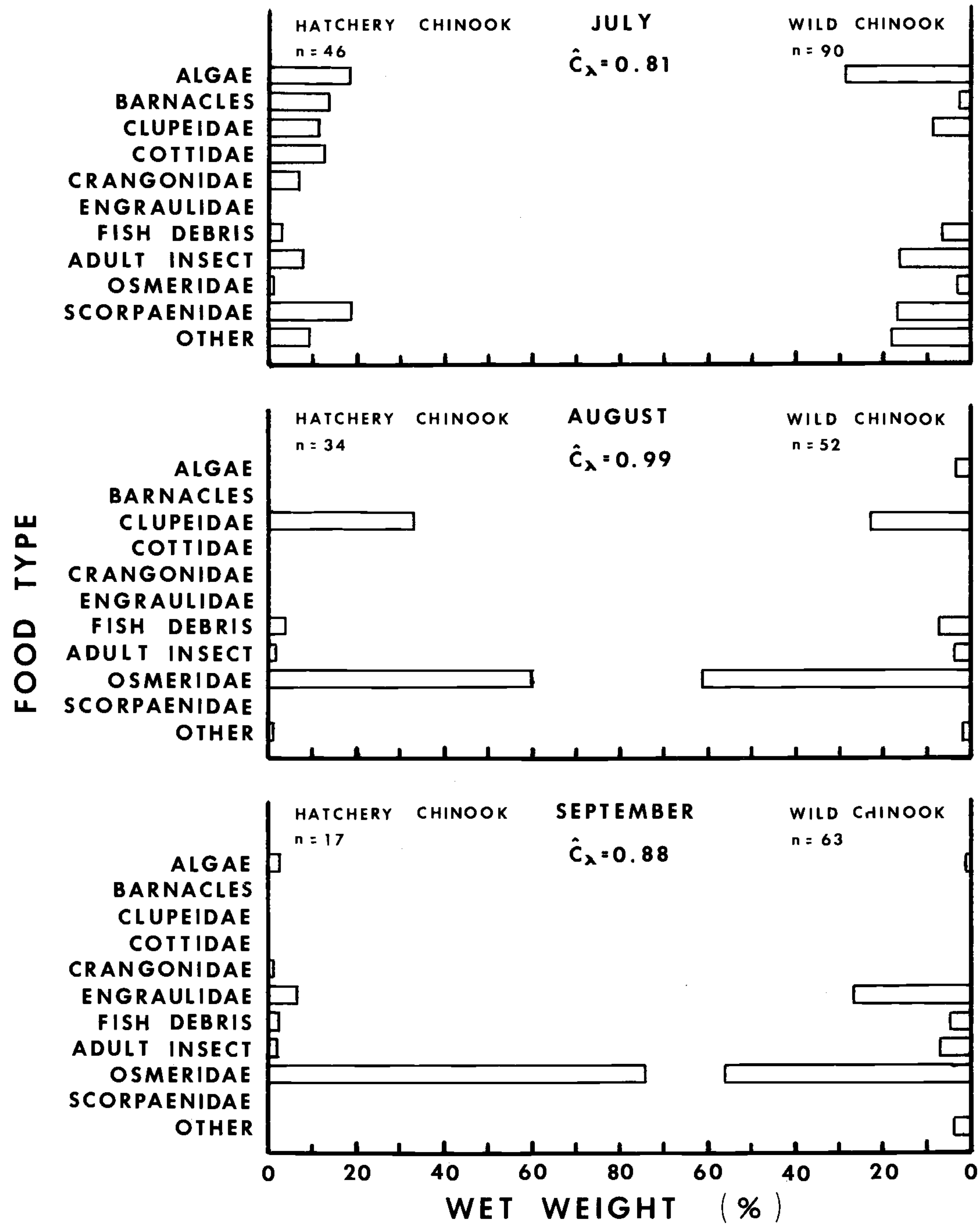

Figure 25. Percentage composition by weight of major food types in the pooled stomach contents of juvenile hatchery and wild chinook salmon (Oncorhynchus tshawytscha) captured by beach seine at four study areas in Yaquina Bay, Oregon from July through September 1977. $\hat{C}_\lambda$ = Morisita's index of overlap (Horn 1966).

lowest ($\hat{C}_\lambda$ = 0.81) in July 1977, when the stomach contents of both groups were composed of a large variety of food categories, present in small proportions (Fig. 25). Overlap was higher in August ($\hat{C}_\lambda$ = 0.99) and September ($\hat{C}_\lambda$ = 0.88) when both groups were feeding on juvenile fish, primarily herring and smelt in August, and smelt and anchovy in September (Fig. 25).

Overlap in stomach contents of 10 University of Washington stock fall chinook and 18 wild chinook captured at Sites 1 and 2 on June 15, 1978 (date of release of hatchery chinook) was low ($\hat{C}_\lambda$ = 0.47). Algae represented the largest portion (48%) of the total biomass of stomach contents of hatchery chinook, and only 20.9% of the stomach contents of wild chinook. Adult barnacles (27%) and terrestrial plant debris (14.1%) were also important constituents of the stomach contents of hatchery chinook, while adult insects (22%), decapod zoea (19.1%), and juvenile rockfish (15.4%) were important constituents of the stomach contents of wild chinook.

Overlap in stomach contents of hatchery and wild chinook captured at the beach study areas in October and November 1978 is shown in Figure 26. The hatchery chinook salmon used in this analysis were released into the estuary on October 7 and October 20, 1978. Although the mean sizes of hatchery (14.4 cm FL) and wild (14.7 cm FL) fish used in this comparison were similar, overlap ($\hat{C}_\lambda$ = 0.36) in stomach contents during October was low (Fig. 26).

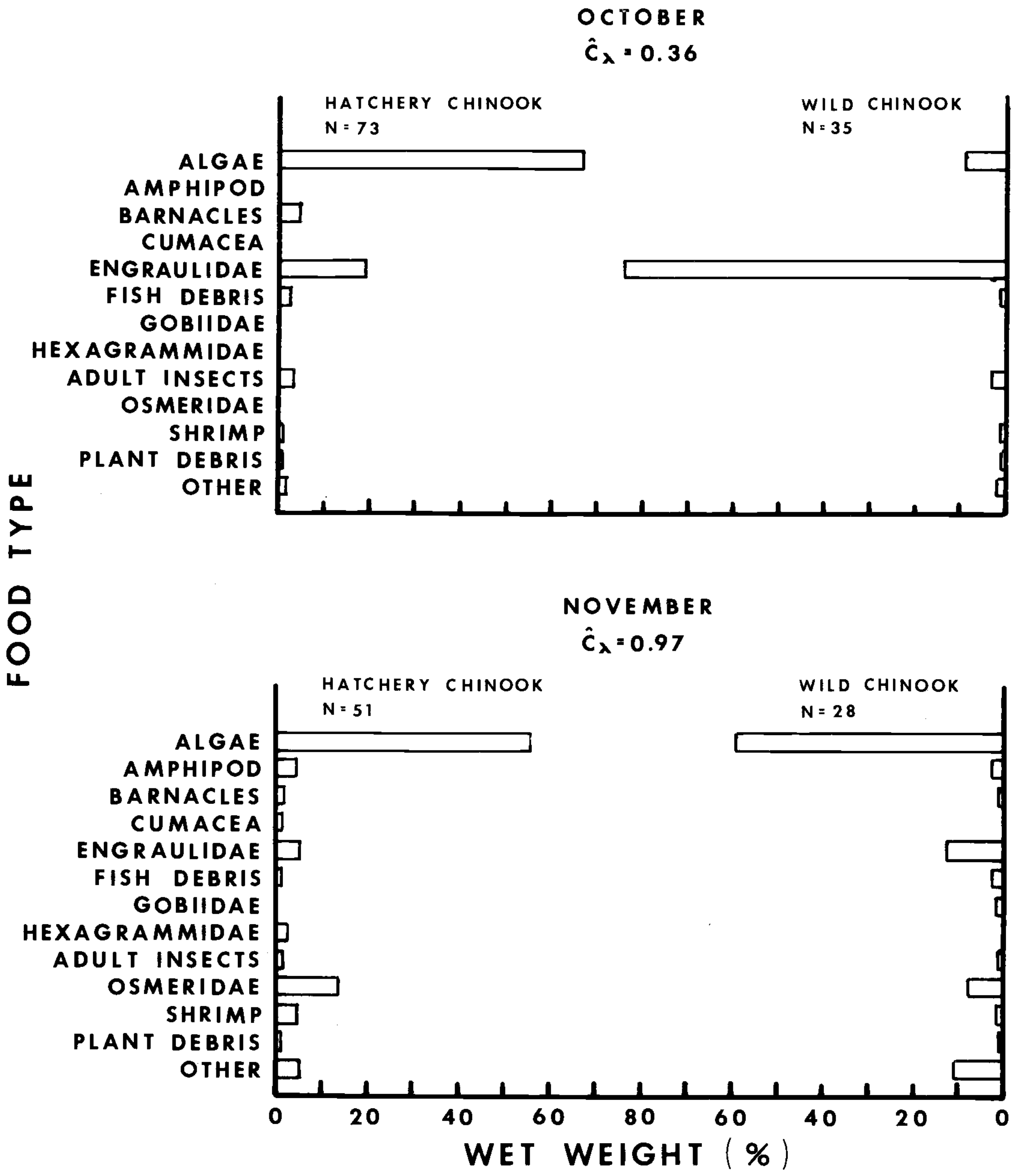

Figure 26. Percentage composition by weight of major food types in the pooled stomach contents of juvenile hatchery and wild chinook salmon (Oncorhynchus tshawytscha) captured by beach seine at four study areas in Yaquina Bay, Oregon during October and November 1978. $\hat{C}_\lambda$ = Morisita's index of overlap (Horn 1966).

Algae accounted for approximately 67% of the total biomass of stomach contents of hatchery chinook, while approximately 84% of the total biomass of stomach contents of wild chinook was juvenile anchovy. However, in November overlap was high ($\hat{C}_\lambda$ = 0.97). During this period algae was the most important category in terms of biomass in the stomach contents of both hatchery (56%) and wild (59%) chinook salmon.

Although not shown in Figure 26, overlap in the stomach contents of 29 hatchery chinook and 29 wild chinook captured at the channel study areas in October 1978 was also low ($\hat{C}_\lambda$ = 0.44). Juvenile anchovy (89%) was also the most important food category in the stomach contents of wild chinook salmon captured at the channel study areas during October. However, algae was not as important a constituent of the stomach contents of hatchery chinook captured at the channel study areas as at the beach study areas in October, accounting for only 34% of the total biomass of stomach contents. Juvenile anchovy (23%) and decapod zoea (27%) were also important food categories in the stomach contents of hatchery chinook captured at the channel study areas in October 1978.

Hatchery and wild coho salmon

The overlap in stomach contents of yearling hatchery and wild coho salmon captured at the beach and channel study areas during

April and May 1978 is shown in Figure 27. The hatchery coho salmon used in this analysis were fish from a group of yearling coho released into the estuary during the first week in April 1978 (Fig. 13). Hatchery coho salmon from this release group recovered at the beach study areas ranged in size from 11.3 to 38.0 cm FL ($\overline{X}$ = 18.0 cm), while wild coho were smaller at a mean size of approximately 12.0 cm FL. Because of small sample sizes and the low relative abundance of hatchery and wild coho salmon at the beach and channel study areas (Tables 8 and 9), samples were pooled over the 2-mo period of April and May. At the beach study areas, juvenile fish, primarily anchovy, surf smelt, and sand lance (*Ammodytes hexapterus*), accounted for approximately 80% of the total biomass of stomach contents of both hatchery and wild coho salmon (Fig. 27). At the channel study areas, crustaceans, primarily adult crangonid shrimp and megalopa larvae of Dungeness crab (*Cancer magister*), accounted for approximately 85% of the total biomass of stomach contents of hatchery coho, while juvenile surf smelt represented 86% of the total biomass of stomach contents of wild coho. The index of overlap calculated for these data shows a high degree of similarity ($\hat{C}_\lambda$ = 0.90) in the stomach contents of hatchery and wild coho captured at the beach study areas, and almost no similarity ($\hat{C}_\lambda$ = 0.02) in the stomach contents of hatchery and wild coho captured at the channel study areas.

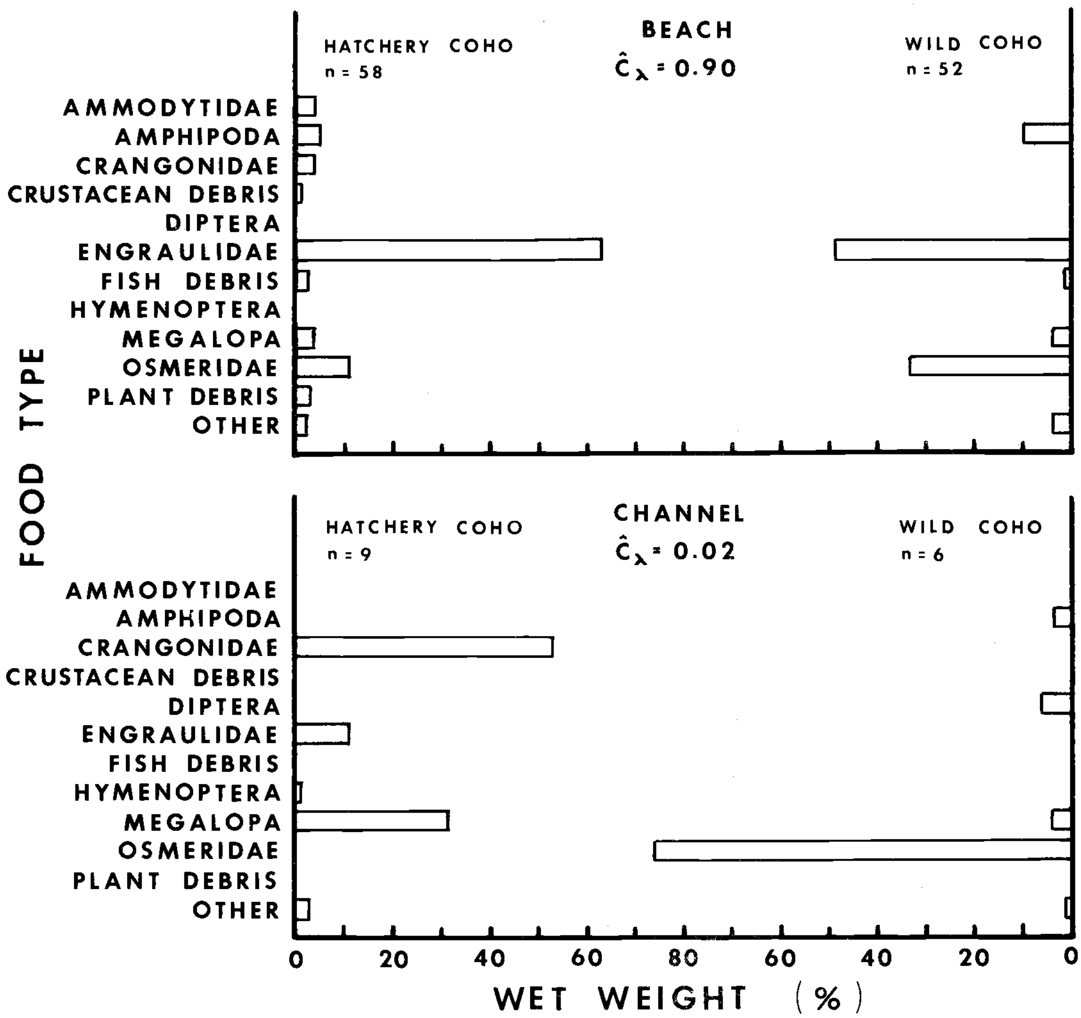

Figure 27. Percentage composition by weight of major food types in the pooled stomach contents of juvenile hatchery and wild coho salmon (Oncorhynchus kisutch) captured by beach seine at four beach study areas and by lampara net at two channel study areas in Yaquina Bay, Oregon during April and May 1978. $\hat{C}_\lambda$ = Morisita's index of overlap (Horn 1966).

Hatchery coho and wild chum salmon

The overlap in stomach contents of 10 wild chum salmon and 12 yearling hatchery coho salmon captured at Site 2 on April 15, 1978 is shown in Figure 18. This was the only sample in which 10 or more fish of each species were captured at the same time and place. Adult Diptera accounted for 55% of the total biomass of stomach contents of wild chum, while Osmeridae (Hypomesus pretiosus), gammarid amphipods, and adult crangonid shrimp accounted for over 60% of the total biomass of stomach contents of hatchery coho (Fig. 28). While hatchery coho and wild chum salmon had several food categories in common, i. e. an unidentified species of larval fish, larval Callianassidae (Upogebia sp.), gammarid amphipods, and cumaceans, there was almost no overlap ($\hat{C}_\lambda$ = 0. 015) in terms of proportional composition of stomach contents (Fig. 28).

The mean size of hatchery coho salmon in this sample was 22. 6 cm FL and 195. 5 gm, while chum salmon averaged 4. 9 cm FL and 1. 1 gm. Although hatchery coho salmon were much larger than wild chum salmon, no juvenile chum salmon were found in the stomach contents of hatchery coho in this or any other sample taken during the period of this investigation.

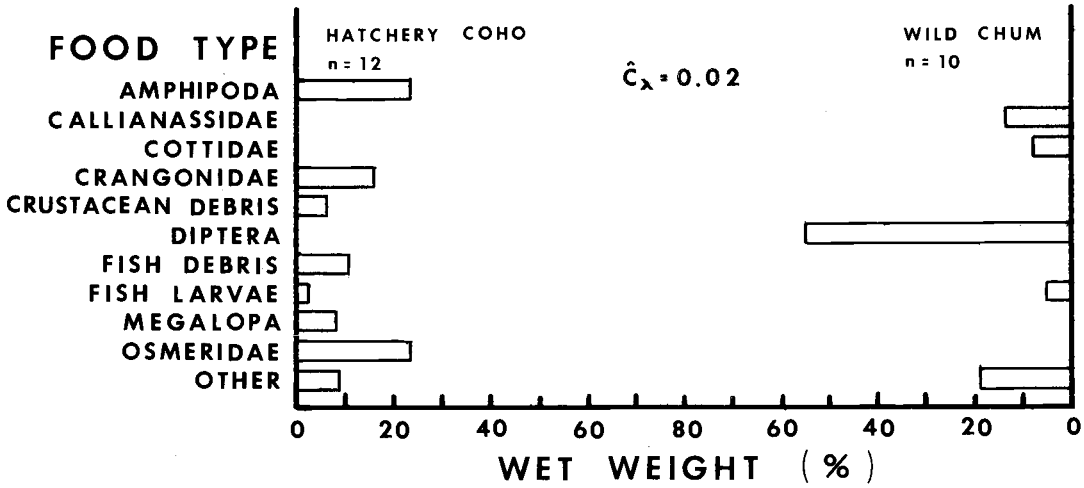

Figure 28. Percentage composition by weight of major food types in the pooled stomach contents of juvenile hatchery coho (Oncorhynchus kisutch) and wild chum (O. keta) salmon captured by beach seine in Yaquina Bay, Oregon on April 15, 1978. $\hat{C}_\lambda$ = Morisita's index of overlap (Horn 1966).

Species Composition, Relative Abundance, and Size

Records were kept on size and numbers of all species of fish captured at the beach and channel study areas to provide information on potential prey, predators, and competitors of juvenile salmonids, and, in addition, supply baseline data for future evaluations of the impact of large releases of privately cultured salmon on other fish species present in the estuary.

The family, species, and common name of fish captured in samples taken at the beach and channel study areas during the period of this investigation are shown in Tables 11 and 12. A total of 57 species of fish were identified in samples taken at the four beach study areas from July 1977 through December 1978 (Table 11). And a total of 30 species were identified in samples taken at the two channel study areas from March through October 1978 (Table 12). The only species of fish captured at the channel study areas that was not also present in samples taken at the beach study areas was a single specimen of juvenile vermilion rockfish (Sebastes miniatus) captured at Site 5 on May 29, 1978.

The number of fish species present in samples taken at beach study areas in the upper (Site 4) and lower (Sites 1-3) estuary during the period of this investigation is shown in Figure 29. The number of species present at the study areas varied seasonally in both the upper and lower estuary. In general, the number of species

Table 11. Family, species, and common name of fish captured by beach seine at four beach study areas in Yaquina Bay, Oregon from July 1977 through December 1978.

Family[1]	Species	Common Name
Acipenseridae:	Acipenser medirostris Ayres	green sturgeon
Agonidae:	Pallasina barbata (Steindachner)	tubenose poacher
Ammodytidae:	Ammodytes hexapterus Pallas	Pacific sand lance*
Anarhichadidae:	Anarrhichthys ocellatus Ayres	wolf-eel
Atherinidae:	Atherinops affinis (Ayres)	topsmelt*
Bothidae:	Citharichthys stigmaeus Jordan and Gilbert	speckled sanddab
Carangidae:	Trachurus symmetricus (Ayres)	jack mackerel
Clupeidae:	Alosa sapidissima (Wilson)	American shad*
	Clupea harengus pallasi Valenciennes	Pacific herring*
Cottidae:	Blepsias cirrhosus (Pallas)	silverspotted sculpin
	Clinocottus acuticeps (Gilbert)	sharpnose sculpin
	Cottus asper Richardson	prickly sculpin
	Enophrys bison (Girard)	buffalo sculpin
	Hemilepidotus hemilepidotus (Tilesius)	red Irish lord
	Leptocottus armatus Girard	Pacific staghorn sculpin*
	Oligocottus maculosus Girard	tidepool sculpin
	Scorpaenichthys marmoratus (Ayres)	cabezon*
Cyprinodontidae:	Lucania parva (Baird)	rainwater killifish*
Embiotocidae:	Amphistichus rhodoterus (Agassiz)	redtail surfperch
	Cymatogaster aggregata Gibbons	shiner perch*
	Embiotoca lateralis Agassiz	striped seaperch
	Hyperprosopon argenteum Gibbons	walleye surfperch
	Hyperprosopon ellipticum (Gibbons)	silver surfperch
	Phanerodon furcatus Girard	white seaperch
	Rhacochilus vacca (Girard)	pile perch

Table 11. (Continued)

Family[1]	Species	Common Name
Engraulidae:	*Engraulis mordax* Girard	northern anchovy*
Gadidae:	*Microgadus proximus* (Girard)	Pacific tomcod*
Gasterosteidae:	*Aulorhynchus flavidus* Gill	tube-snout
	Gasterosteus aculeatus Linnaeus	threespine stickleback
Gobiidae:	*Clevelandia ios* (Jordan and Gilbert)	arrow goby*
	Coryphopterus nicholsi (Bean)	blackeye goby
Hexagrammidae:	*Hexagrammos decagrammus* (Pallas)	kelp greenling*
	Hexagrammos lagocephalus (Pallas)	rock greenling
	Ophiodon elongatus Girard	lingcod*
Ictaluridae:	*Ictalurus nebulosus* (Lesueur)	brown bullhead
Osmeridae:	*Allosmerus elongatus* (Ayres)	whitebait smelt*
	Hypomesus pretiosus (Girard)	surf smelt*
	Osmerus mordax (Mitchill)	rainbow smelt
Petromyzontidae:	*Lampetra ayresi* (Gunther)	river lamprey
Pholidae:	*Apodichthys flavidus* Girard	penpoint gunnel
	Pholis ornata (Girard)	saddleback gunnel*
Pleuronectidae:	*Parophrys vetulus* (Girard)	English sole*
	Platichthys stellatus (Pallas)	starry flounder
	Psettichthys melanostictus Girard	sand sole
Salmonidae:	*Oncorhynchus gorbuscha* (Walbaum)	pink salmon[2]
	Oncorhynchus keta (Walbaum)	chum salmon
	Oncorhynchus kisutch (Walbaum)	coho salmon
	Oncorhynchus tshawytscha (Walbaum)	chinook salmon
	Salmo clarki Richardson	cutthroat trout
	Salmo gairdneri Richardson	steelhead trout

Table 11. (Continued)

Family[1]	Species	Common Name
Scorpaenidae *:	Sebastes caurinus Richardson	copper Rockfish
	Sebastes diploproa (Gilbert)	splitnose rockfish
	Sebastes melanops Girard	black rockfish
	Sebastes mystinus (Jordan and Gilbert)	blue rockfish
	Sebastes paucispinis Ayres	bocaccio
Stichaeidae:	Lumpenus sagitta Wilimovsky	snake prickleback
Syngnathidae:	Syngnathus griseolineatus Ayres	bay pipefish

[1] Nomenclature according to Bailey et al. (1970).

[2] Two juvenile pink salmon captured in Yaquina Bay, Oregon on March 18, 1978 were determined to be of hatchery origin.

*Asterisk indicates family or species of fish present in the stomach contents of hatchery and wild juvenile salmonids examined during the period of this investigation.

Table 12. Family, species, and common name of fish captured by lampara net at two channel study areas in Yaquina Bay, Oregon from March through October 1978.

Family[1]	Species	Common Name
Agonidae:	Pallasina barbata (Steindachner)	tubernose poacher
Anarhichadidae:	Anarrhichthys ocellatus Ayres	wolf-eel
Atherinidae:	Atherinops affinis (Ayres)	top smelt*
Bothidae:	Citharichthys stigmaeus Jordan and Gilbert	speckled sanddab
Clupeidae:	Alosa sapidissima (Wilson)	American shad*
	Clupea harengus pallasi Valenciennes	Pacific herring*
Cottidae:	Enophrys bison (Girard)	buffalo sculpin
	Leptocottus armatus Girard	Pacific staghorn sculpin*
Embiotocidae:	Cymatogaster aggregata Gibbons	Shiner perch*
	Embiotoca lateralis Agassiz	striped seaperch
	Hyperprosopon argenteum Gibbons	walleye surfperch
	Phanerodon furcatus Girard	white seaperch
	Rhacochilus vacca (Girard)	pile perch
Engraulidae:	Engraulis mordax Girard	northern anchovy*
Gadidae	Microgadus proximus (Girard)	Pacific tomcod*
Hexagrammidae:	Ophiodon elongatus Girard	lingcod*
Osmeridae:	Hypomesus pretiosus (Girard)	surf smelt*
	Osmerus mordax (Mitchill)	rainbow smelt
Petromyzontidae:	Lampetra ayresi (Gunther)	river lamprey
Pleuronectidae:	Parophrys vetulus Girard	English sole*
	Platichthys stellatus (Pallas)	starry founder
	Psettichthys melanostictus Girard	sand sole

Table 12. (Continued)

Family[1]	Species	Common Name
Salmonidae:	*Oncorhynchus kisutch* (Walbaum)	coho salmon
	Oncorhynchus tshawytscha (Walbaum)	chinook salmon
	Salmo clarki Richardson	cutthroat trout
	Salmo gairdneri Richardson	steelhead trout
Scorpaenidae*:	*Sebastes melanops* Girard	blackrockfish
	Sebastes miniatus Jordan and Gilbert	vermilion rockfish
Stichaeidae:	*Lumpenus sagitta* Wilimovsky	snake prickleback
Syngnathidae:	*Syngnathus griseolineatus* Ayres	bay pipefish

[1] Nomenclature according to Bailey *et al*. (1970).

*Asterisk indicates family or species of fish present in the stomach contents of hatchery and wild juvenile salmonids examined during the period of this investigation.

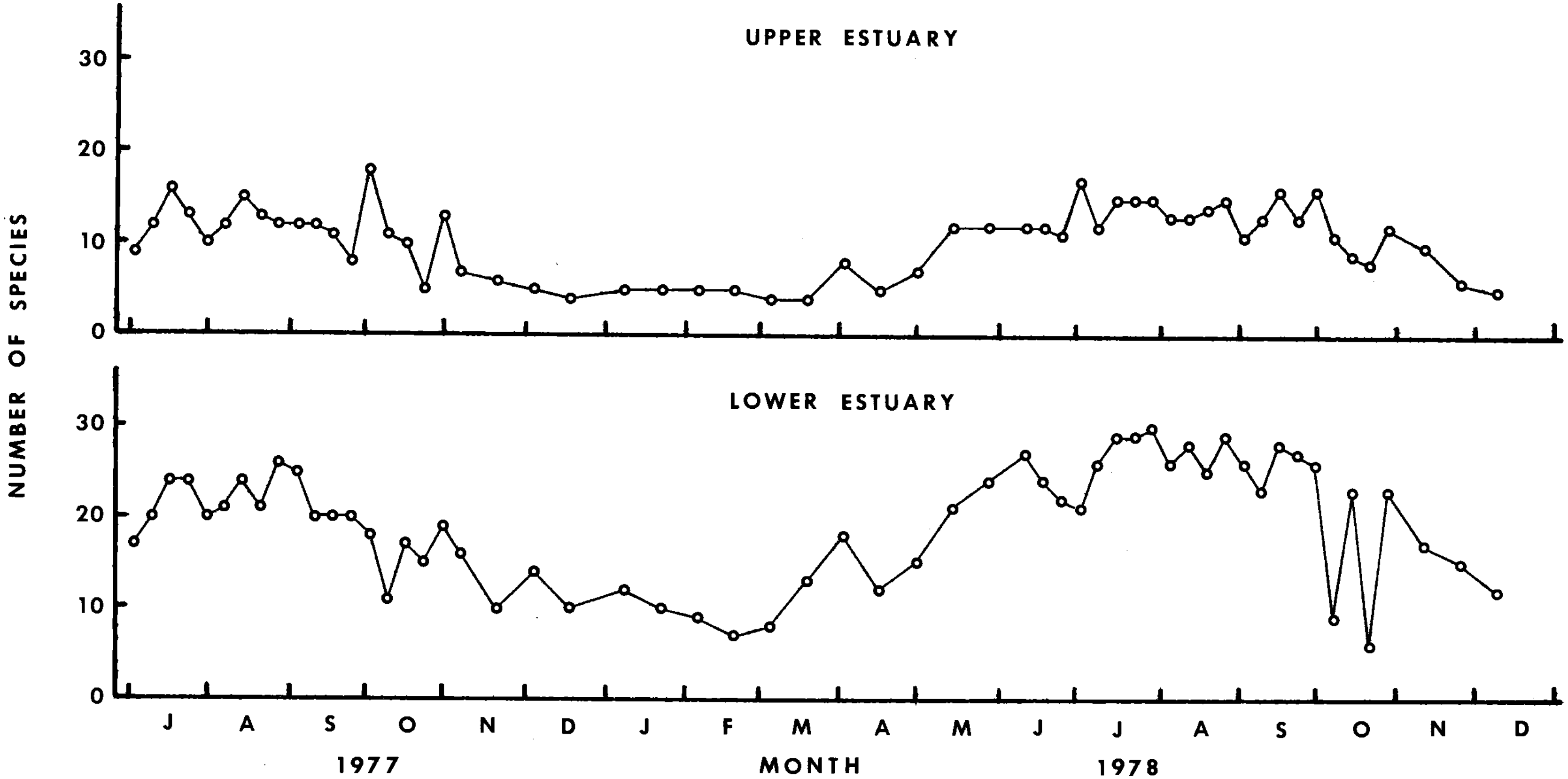

Figure 29. The monthly number of fish species captured by beach seine at four beach study areas in the upper (16.1 river km) and lower (3.1-5.1 river km) estuary in Yaquina Bay, Oregon from July 1977 through December 1978. Species of salmonids are not included.

present in samples taken in both the upper and lower estuary was highest during the summer or early fall, and lowest during winter months (Fig. 29). Only six species, including staghorn sculpin (Leptocottus armatus), tube-snout (Aulorhynchus flavidus), surf smelt, English sole (Parophrys vetulus), starry flounder (Platichthys stellatus), and bay pipefish (Syngnathus griseolineatus), were present at any of the four beach study areas during all 12 mo of the year in 1977 or 1978. In addition, the number of species present in samples taken in the lower estuary was always higher than the number in the upper estuary except during October of 1977 and 1978 (Fig. 29). Only four species, including green sturgeon (Acipenser medirostris), brown bullhead (Ictalurus nebulosus), prickly sculpin (Cottus asper), and jack mackerel (Trachurus symmetricus), were present in samples taken in the upper estuary (Site 4) that were not also present in samples taken in the lower estuary (Sites 1-3). Twenty-two species were present in samples taken at beach study areas in the lower estuary only. These included tubenose poacher (Pallasina barbata), Pacific sand lance, wolf-eel (Anarrhichthys ocellatus), all members of the family Cottidae (Table 11) except for Pacific staghorn sculpin (Leptocottus armatus) and prickly sculpin, tube-snout, blackeye goby (Coryphopterus nicholsi), all members of the family Hexagrammidae (Table 11), rainbow smelt (Osmerus mordax), whitebait smelt, sand sole (Psettichthys melanostictus), and all members of the family Scorpaenidae (Table 11).

The monthly CPUE of all fish species captured at the four beach study areas from July 1977 through December 1978, and the monthly sampling effort at the beach study areas are shown in Appendix Tables 1 and 2, respectively. The monthly CPUE of all fish species captured at the two channel study areas from March through October 1978, and the monthly sampling effort at the channel study areas are shown in Appendix Tables 3 and 4, respectively. Common species are defined, here, as those for which the CPUE was greater than 100 fish in any one month during the period of this investigation. Common species at the beach study areas included topsmelt (Atherinops affinis), Pacific herring, shiner perch (Cymatogaster aggregata), striped perch (Embiotoca lateralis), northern anchovy, whitebait smelt, surf smelt, English sole, coho salmon, chinook salmon, and black rockfish (Sebastes melanops). Common species at the channel study areas included American shad (Alosa sapidissima), Pacific herring, shiner perch, northern anchovy, surf smelt, and chinook salmon. Abundant species are defined as those for which the CPUE was greater than 1000 fish in any one month during the period of this investigation. Abundant species at the beach study areas included Pacific herring, shiner perch, northern anchovy, and surf smelt. Abundant species at the channel study areas included Pacific herring, shiner perch, and northern anchovy.

Species of fish present in the stomach contents of hatchery and wild juvenile salmonids examined during the period of this investigation are marked with an asterisk in Tables 11 and 12. Over 17 species of fish were identified in the stomach contents of hatchery and wild juvenile salmonids (Figs. 11 and 12). The identification of the species of juvenile rockfish (Sebastes sp.) found in the stomach contents of juvenile salmonids was not made. Figures 30 through 36 show mean SL and monthly CPUE at the four beach study areas for the four major prey species of fish found in the stomach contents of juvenile hatchery and wild coho and chinook salmon. These species include northern anchovy (Figs. 30 and 31), surf smelt (Figs. 32 and 34), whitebait smelt (Figs. 33 and 34), and Pacific herring (Figs. 35 and 36). Although the sizes of fish found in the stomach were not quantified, standard lengths of fish prey in the stomach contents of juvenile salmonids were usually ≤ 7.0 cm SL. Juvenile anchovy ≤ 7.0 cm SL were present in samples taken in the upper and lower estuary from May through October (Fig. 30), although they were most abundant in September and October. The mean size of anchovy captured in the upper estuary (Site 4) was consistently smaller than the mean size of anchovy in the lower estuary (Fig. 31). Surf smelt ≤ 7.0 cm SL were present throughout the year (Fig. 34), however they were most abundant from January through May. No whitebait smelt > 7.0 cm SL were captured in samples taken in the lower estuary

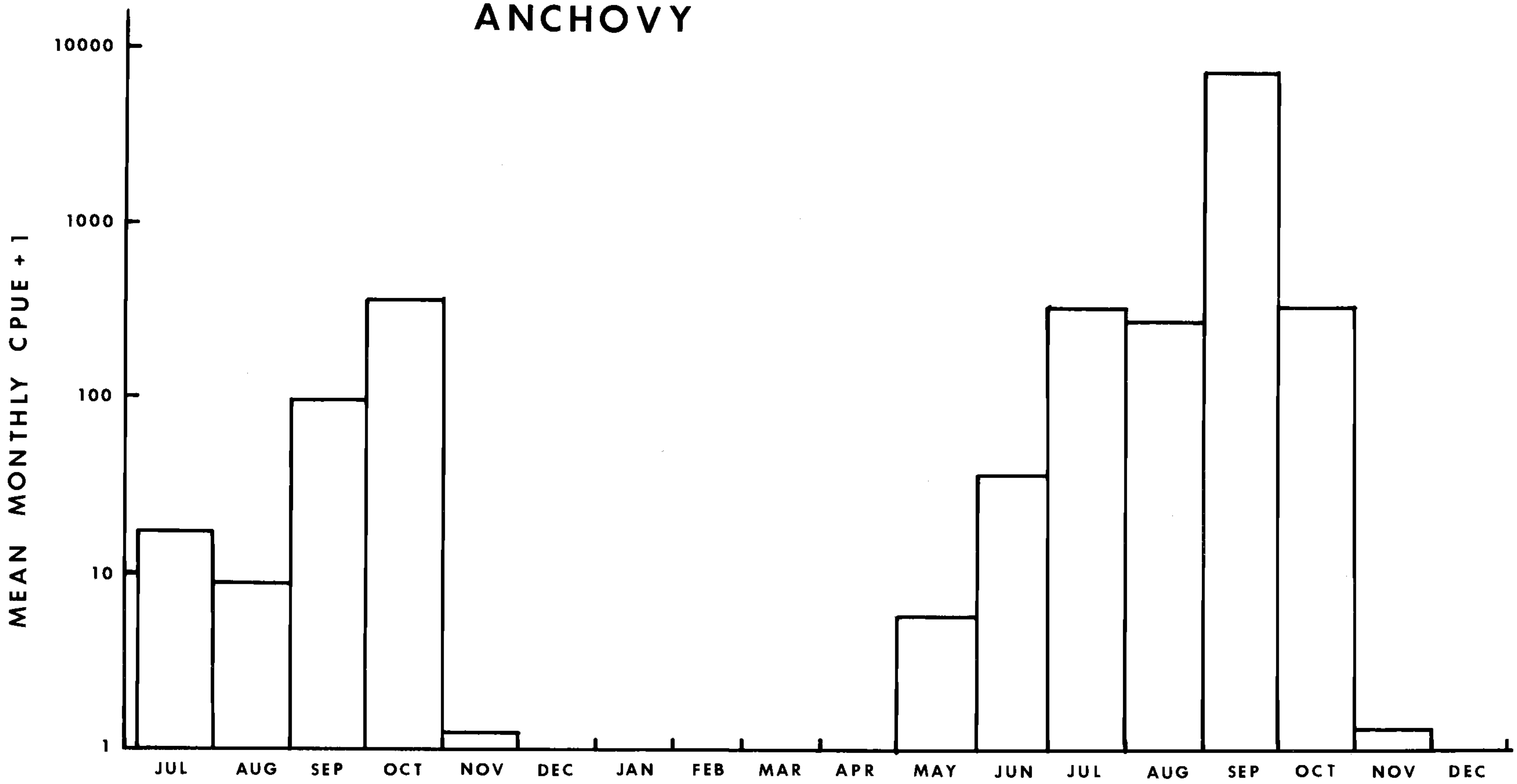

Figure 30. The monthly catch per unit effort of northern anchovy (Engraulis mordax) captured by beach seine at four beach study areas in Yaquina Bay, Oregon from July 1977 through December 1978. One set of the beach seine is equal to one unit of effort.

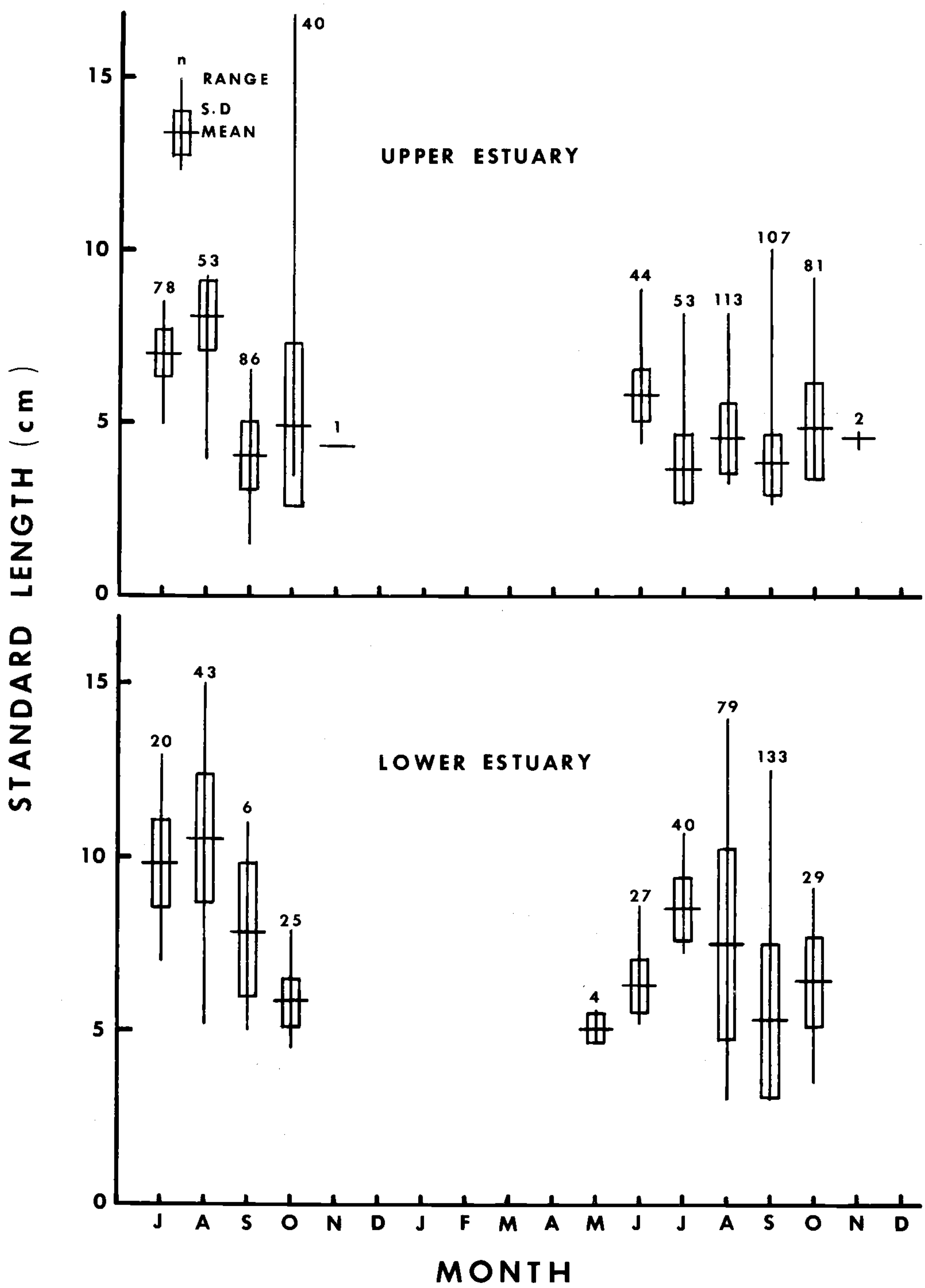

Figure 31. Monthly mean lengths of northern anchovy (Engraulis mordax) captured by beach seine at study areas in the upper (16.1 river km) and lower (3.1-5.1 river km) estuary in Yaquina Bay, Oregon from July 1977 through December 1978.

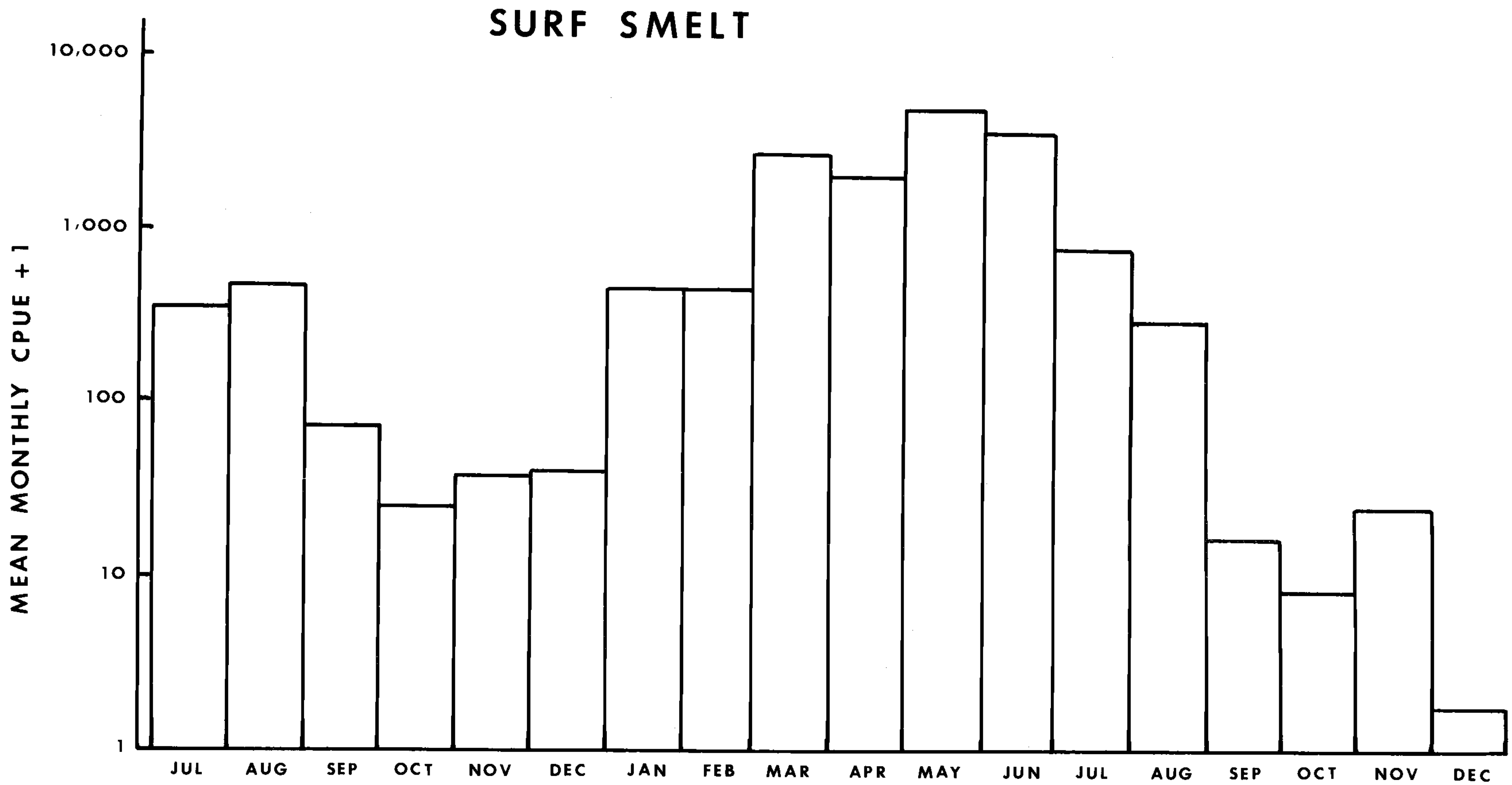

Figure 32. The monthly catch per unit effort of surf smelt (Hypomesus pretiosus) captured by beach seine at four beach study areas in Yaquina Bay, Oregon from July 1977 through December 1978. One set of the beach seine is equal to one unit of effort.

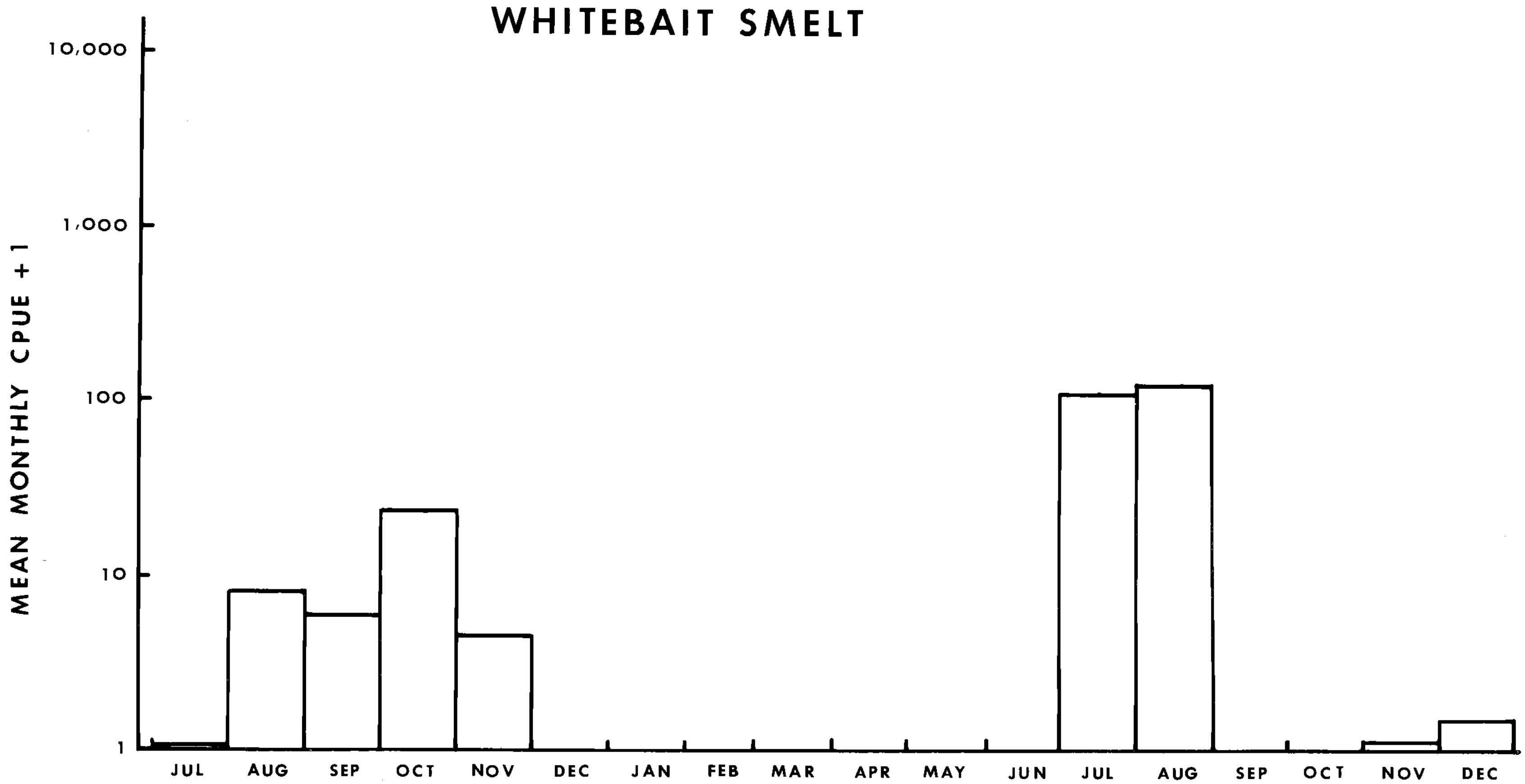

Figure 33. The monthly catch per unit effort of whitebait smelt (*Allosmerus elongatus*) captured by beach seine at four beach study areas in Yaquina Bay, Oregon from July 1977 through December 1978. One set of the beach seine is equal to one unit of effort.

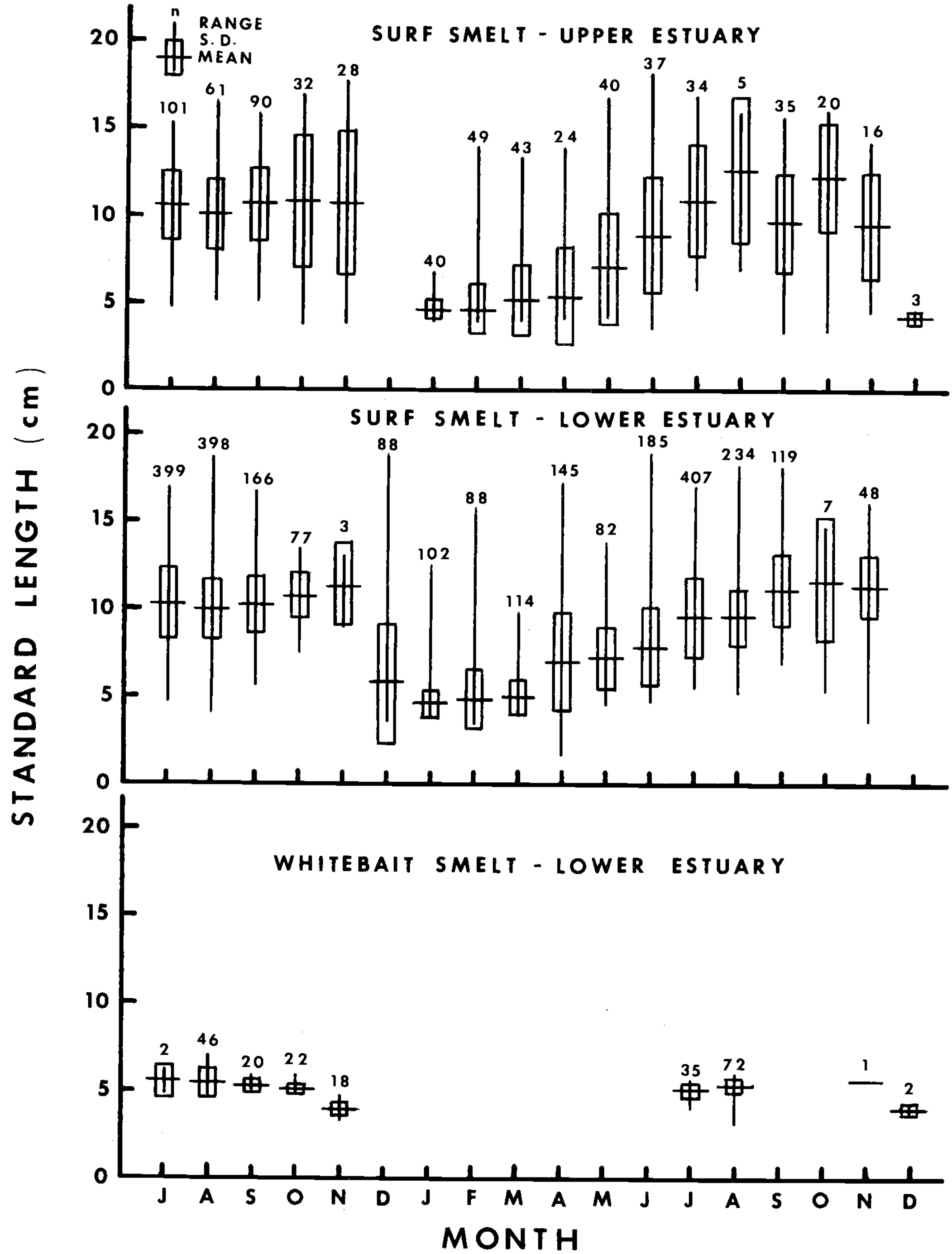

Figure 34. Monthly mean lengths of surf smelt (Hypomesus pretiosus) and whitebait smelt (Allosmerus elongatus) captured by beach seine at study areas in the upper (16. 1 river km) and lower (3. 1-5. 1 river km) estuary in Yaquina Bay, Oregon from July 1977 through December 1978.

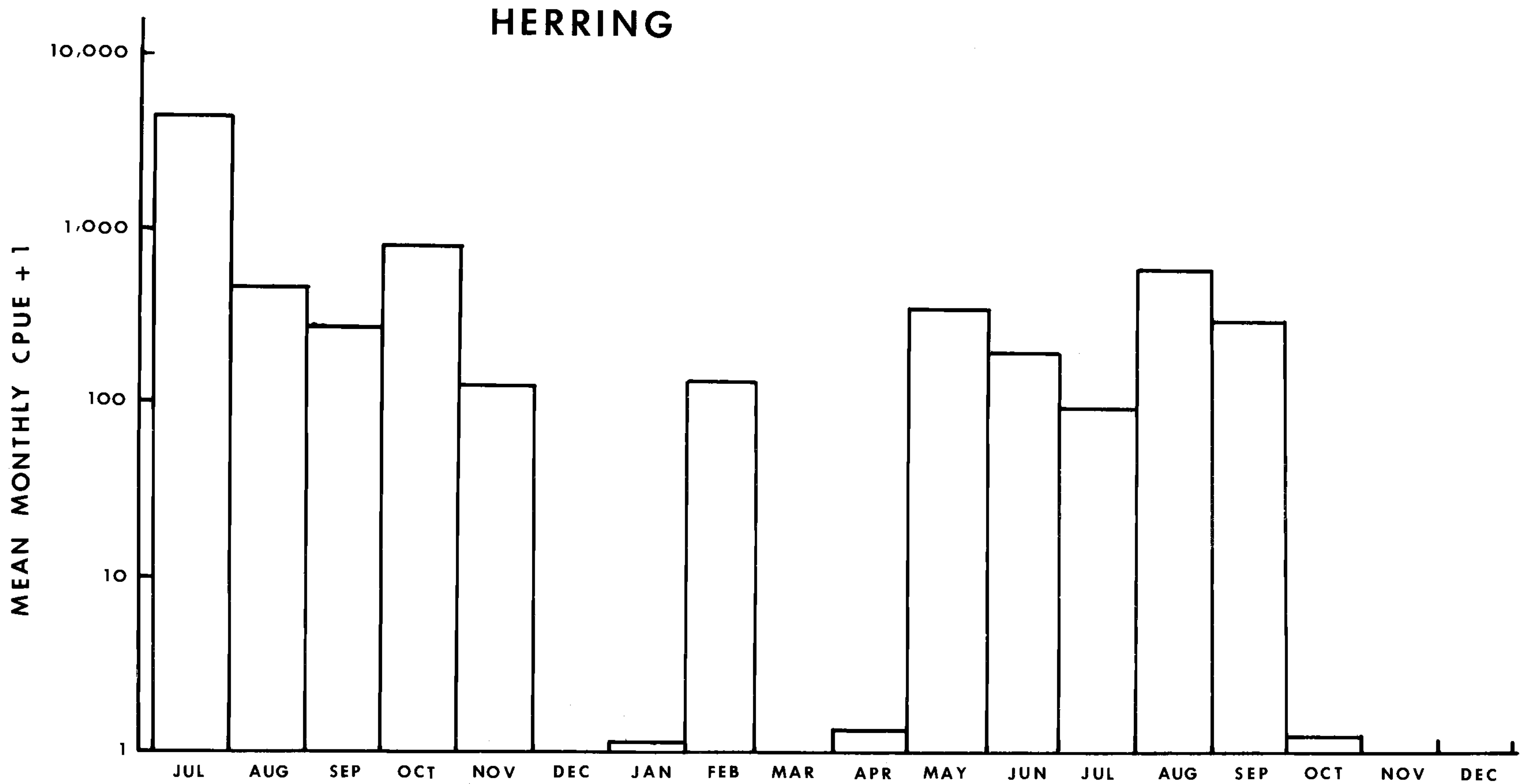

Figure 35. Monthly catch per unit effort of Pacific herring (Clupea harengus pallasi) captured by beach seine at four beach study areas in Yaquina Bay, Oregon from July 1977 through December 1978. One set of the beach seine is equal to one unit of effort.

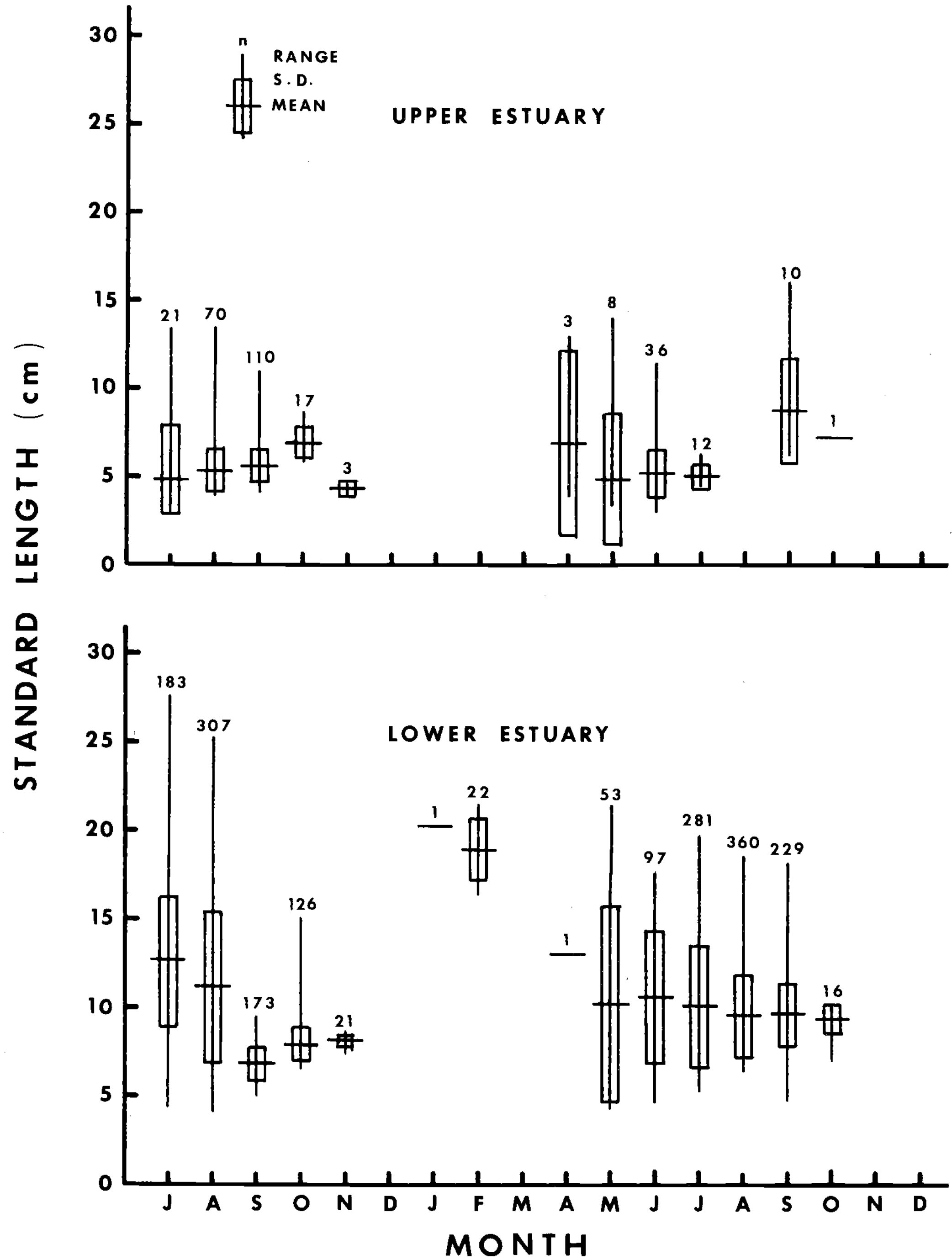

Figure 36. Monthly mean lengths of Pacific herring (Clupea harengus pallasi) captured by beach seine at study areas in the upper (16.1 river km) and lower (3.1-5.1 river km) estuary in Yaquina Bay, Oregon from July 1977 through December 1978.

during the period of this investigation (Fig. 34). No whitebait smelt were captured in the upper estuary. Juvenile herring $\leq$ 7.0 cm SL were present in samples taken at the beach study areas from April through November (Fig. 36), although smaller individuals were most abundant from April through August. Similar to anchovy, the mean size of herring captured in the upper estuary was consistently smaller than that of herring captured in the lower estuary (Fig. 36).

A comparison of the CPUE from July through December 1977 to the CPUE during the same period in 1978 for the four prey species shown in Figures 30, 32, 34, and 36 shows several differences in relative abundance between 1977 and 1978. Anchovy were more abundant in July, August and September of 1978, than during the same period in 1977 (Fig. 30). Herring were more abundant in July 1977 than in July 1978 (Fig. 35). And whitebait smelt were much more abundant in July and August of 1978, than during the same period in 1977 (Fig. 33). The CPUE of surf smelt was similar in both years (Fig. 32).

The monthly mean, range, and standard deviation of lengths of all species of fish captured at the beach study areas from July 1977 through December 1978, and at the channel study areas from March through October 1978 are shown in Appendix Tables 5 and 6, respectively.

DISCUSSION

Spatial and Temporal Utilization

Residence and migration of wild juvenile salmonids

Among wild populations of juvenile salmonids known to occur in Yaquina Bay, study areas sampled during 1977 and 1978 appeared to be utilized almost exclusively by juvenile chum, coho, and chinook salmon (Figs. 8 and 9). Because populations of sea-run cutthroat and steelhead trout are known to occur in the Yaquina system (Smith and Lauman 1972), their absence from catches at the beach and channel study areas probably reflects a combination of factors including: the small number of samples taken during peak periods of migration of juvenile steelhead and cutthroat trout, the utilization by these species of habitats other than those sampled, gear selectivity, and low population abundance.

Peak migrations of steelhead and cutthroat smolts occur during April and May in other coastal Oregon estuaries (Sims 1970; Giger 1972; Tomasson 1979). Sampling at the beach and channel study areas in Yaquina Bay during April and May of 1978 was minimal. Populations of steelhead and cutthroat juveniles in Yaquina Bay may have been too small, or populations may have passed through the estuary too rapidly to be detected with bimonthly samples.

In general, juvenile steelhead trout are not considered to have a habitat relationship to the estuary (Royal 1972). According to Sims (1970), juvenile steelhead pass rapidly through the Columbia River estuary utilizing channel areas and avoiding shallow nearshore waters. Although sampling was conducted in channel areas of Yaquina Bay during 1978, large, mobile steelhead smolts may have been able to escape from the open end of the lampara net during retrieval.

Except for minor differences in mesh size, the beach seine used in this study was identical to a beach seine used during a six year study of juvenile salmonids in the Columbia River estuary (Sims and Johnsen 1974). The net used in the Columbia River was effective in sampling for fall chinook salmon less than 1 year old, yearling coho salmon, chum salmon fry, and cutthroat trout fry, and ineffective for sampling yearling chinook salmon and steelhead trout, as these species were usually found in deeper channel areas (Sims and Johnsen 1974). With the exception of cutthroat trout fry, the results of beach seining in Yaquina Bay during 1977 and 1978 confirm these observations.

The absence of juvenile cutthroat trout from beach seine catches in Yaquina Bay is probably related to habitat utilization. A study conducted on the Alsea River estuary in Oregon showed that cutthroat trout were most abundant in central areas of the estuary where sampling by beach seine was made difficult by strong currents, debris, and absence of shoreline seining sites (Giger 1972). The preferred habitat of cutthroat trout in the Alsea estuary was described by Giger (1972) as "fairly long shoal sections which were interrupted by deeper pools normally occurring at turns in the estuary." Habitats of this description were not sampled in Yaquina Bay during 1977 and 1978.

Cutthroat trout are known to make extensive utilization of river estuaries (Deschamps et al. 1971; Giger 1972; Cramer 1979; Tomasson 1979). In Oregon, Giger (1972) found that the Alsea River estuary was utilized briefly as a staging area by outmigrant cutthroat trout in the spring, and as a rearing area for cutthroat parr, which were present in the estuary from April through October. In addition, anadromous cutthroat trout are known to rear in the Rogue River estuary in Oregon throughout the summer, and do not migrate in large numbers beyond the estuary (Tomasson 1979). In view of the apparent extensive use of river estuaries by juvenile cutthroat trout, overlap in utilization of Yaquina Bay by juvenile hatchery salmon and wild cutthroat trout requires further investigation.

The extent and type of utilization of estuarine study areas in Yaquina Bay by wild populations of juvenile chum, coho, and chinook salmon was different for each species. During 1978, wild populations of juvenile chum and coho salmon utilized the estuary for a relatively short period of time (2-3 mo), whereas wild populations of juvenile chinook salmon utilized the estuary for an extended period of time (9 mo) (Fig. 8 and Table 8).

Periods of estuarine residence and migration of wild populations of juvenile chum, coho, and chinook salmon at beach and channel study areas in Yaquina Bay were, in general, similar to periods reported for these species in other Oregon estuaries (Henry 1953; Sims 1970, 1975; Reimers 1971, 1973; Durkin and Sims 1975; Lichatowich 1976; Forsberg et al. 1977; Mullen 1978; Cramer 1979). However, comparisons with other studies are often difficult to make as many investigators do not make the distinction between hatchery and wild fish.

The most notable difference between periods of residence and migration of wild salmon in Yaquina Bay and periods reported for juvenile salmon in other Oregon estuaries was for wild populations of juvenile chum salmon. The period of estuarine residence of wild populations of chum salmon juveniles in Yaquina Bay during 1978 (Fig. 8) was much shorter than reported for Tillamook Bay, Oregon (Henry 1953; Forsberg et al. 1977). Henry (1953) and Forsberg et al. (1977) captured juvenile chum in Tillamook Bay from February to July. Although little is known about wild populations of chum salmon in the Yaquina system, population size is probably much smaller than in Tillamook Bay. Therefore, my sampling techniques may have detected juvenile chum salmon only when they were most abundant in the estuary. In addition, chum salmon in Yaquina Bay may represent a single, discrete population, so that all fish migrate to the ocean at approximately the same time. Several different rivers drain into Tillamook Bay, and if chum populations from different rivers arrive in the estuary at different times, then the period of estuarine residence of populations of juvenile chum salmon in Tillamook Bay would be extended. Investigations conducted in Alaska, British Columbia, and Washington report either extended periods of residence (4-5 mo) in river estuaries by populations of juvenile chum salmon (Lagler and Wright 1962; Deschamps et al. 1971; Sibert et al. 1977; Harris et al. 1978) or immediate outmigration on entrance to river estuaries (Bostic 1955; Tyler 1963). In general, periods of residence of populations of juvenile chum salmon in river estuaries appears to be quite variable from estuary to estuary, and may be determined by stream flow, tidal cycles, turbidity, and topographical profile at the river mouth (Iwamoto and Salo 1977).

No juvenile chum salmon were captured in samples taken at the two channel study areas in Yaquina Bay during 1978. However, juvenile chum salmon are known to gather in schools both inshore and offshore in estuarine and marine environments (Fraser 1946; Tyler and Bevan 1964; Healey 1967; Stober et al. 1972; Bailey et al. 1975; Forsberg et al. 1977; Schreiner 1977). In general, juvenile chum salmon are thought to move offshore as they increase in size (Tyler and Bevan 1964; Gerke and Kaczynski 1972; Harris and Hartt 1977), so that nearshore peaks in abundance occur earlier than offshore peaks (Manzer 1956; Moore et al. 1978). Gerke and Kaczynski (1972) found that chum fry in Puget Sound and Hood Canal move offshore at a length of 4.5-5.0 cm. No wild juvenile chum salmon > 5.6 cm FL were captured at the beach study areas in Yaquina Bay during 1978, and the mean size of juvenile chum when they disappeared from the beach study areas in April was approximately 5.0 cm FL (Fig. 10). Rather than moving to channel areas of the estuary, wild juvenile chum salmon in Yaquina Bay may emigrate to the ocean when they reach a size of approximately 5.0 cm FL.

Because sampling was conducted at 2 wk intervals in March, April, and May, peak periods of migration of wild chum and coho salmon shown in Figure 8 should be considered as general representations only. However, peaks in abundance of chum and coho salmon in the upper and lower estuary were offset by only one sample date (2 wk interval) (Fig. 8), indicating fairly rapid movement of individuals of these species through the estuary.

Wild juvenile chum salmon were first captured in Yaquina Bay on March 4, 1978 at a size of 3.7 cm FL, and last captured on April 29, 1978 at a size of 5.2 cm FL (Fig. 10). The middle part of the run increased in mean length from 3.9 cm FL on March 18 to 4.9 cm FL on April 15 (Fig. 10). Unless smaller individuals emigrate to the ocean prior to larger individuals, the increase in fork length of wild juvenile chum salmon when they were present in Yaquina Bay indicates that they utilize the estuary not only as a staging area, but also as a rearing area prior to entrance to the ocean. That juvenile chum salmon do utilize river estuaries as rearing areas is subtantiated by Sibert et al. (1977), who found that individual juvenile chum salmon remained in the Nanaimo River estuary in British Columbia for an average of 13 to 18 days in March and April, and increased in body weight by an average of 4% per day. Growth of juvenile chum salmon has also been reported for Tillamook Bay, Oregon, where populations of chum salmon increased in mean length from 4.0 cm to 6.5 cm in June (Forsberg et al. 1977).

Wild coho salmon were first captured in Yaquina Bay on April 15, 1978 at a mean size of 13.0 cm FL, and were last captured on June 15 at a mean size of 10.4 cm FL (Fig. 10). The middle part of the run, during the peak period of migration in May, was composed of fish with a mean size of approximately 12.5 cm FL (Fig. 10). The decrease in mean fork length of wild juvenile coho salmon when they were present in Yaquina estuary (Fig. 10), indicates that larger individuals emigrate to the ocean prior to smaller individuals, and that wild coho salmon utilize the estuary mainly as a staging area for entrance into the ocean. Durkin and Sims (1975) also found that larger coho smolts migrated into the Columbia River estuary prior to smaller individuals. Salo and Bayliff (1958) found that smaller coho in Minter Creek, Washington migrated to saltwater first, followed by larger smolts, which were, in turn, followed by smaller fish. Regardless of whether the first part of the run was composed of larger or smaller coho than the middle part of the run, the last to migrate were always the smallest fish (Salo and Bayliff 1958). These findings are contrary to results obtained by Reimers (1971) in the Sixes River estuary in Oregon, where juvenile coho salmon increased in mean size from 10.5 cm FL in March to 12.5 cm FL in May and early June. If increase in mean size of coho in the Sixes River estuary represents estuarine growth, then some river estuaries may also be utilized as rearing areas by wild populations of juvenile coho salmon.

On the basis of the presence of an annulus on the scale (Fig. 2), all wild coho salmon captured at the beach and channel study areas in Yaquina Bay during 1978 were judged to be yearlings. Several investigators have reported early spring or fall and winter movements of coho underyearlings to the ocean (Reimers 1971; Crone and Bond 1976). No wild coho underyearlings were identified in samples taken in Yaquina Bay during 1977 or 1978, although wild coho underyearlings may have been misidentified as 0-age hatchery fish using the technique of separation based on scale characteristics (Fig. 3) described in this thesis.

No wild yearling coho salmon were captured in Yaquina Bay after June 1978 (Fig. 8). Reimers (1971), who sampled the Sixes River estuary in Oregon from 1965 through 1969, also reported that he never captured wild yearling coho salmon after June. This would explain the absence of wild coho salmon from samples taken at the beach study areas in Yaquina Bay during 1977 (Table 8), as sampling did not begin until July. Drucker (1972), who reviewed a large number of investigations of downstream migrations of coho salmon, found, in general, that most coho salmon migrate in the spring, although smaller numbers may migrate at almost any time of the year. Numbers of wild juvenile coho salmon present in Yaquina Bay after June of 1977 and 1978 may have been too small to detect by sampling methods utilized in the present study.

Regardless of time, size, or age at entry, most investigators report that coho salmon remain for only a few days to a few weeks in river estuaries (Fraser 1946; Sjolseth 1969; Sims 1970; Royal 1972; Reimers 1978). The lack of increase in mean size, and the short interval of time between peak abundances of wild coho salmon in the upper and lower estuary in 1978 (Figs. 8 and 10), indicate that populations of wild coho salmon, as well as individuals within these populations, pass rapidly through Yaquina Bay, and do not make extensive utilization of the estuary as a rearing area.

Of the species of Pacific salmon captured at the study areas in Yaquina Bay during 1977 and 1978, wild juvenile fall chinook salmon exhibited the most complex life history characteristics and habitat relationships to the estuarine environment. The complexity of life histories exhibited by wild populations of juvenile fall chinook salmon was first described in detail by Reimers (1973). Reimers (1973) defined five major types of life histories of juvenile chinook salmon in Sixes River, Oregon on the basis of the length of time spent rearing in freshwater and estuarine areas, and the timing of migrations to the estuary or ocean. Life history types described by Reimers (1973) ranged from fry that migrate directly to the ocean after emergence to juveniles which rear in freshwater for a year prior to entrance to the ocean. In between these two extremes, there may be a continuous range of life history types characterized by the amount of time spent rearing in freshwater and estuarine areas. Because tagging studies to determine length of estuarine residence of individuals within wild populations of juvenile fall chinook salmon were not conducted in Yaquina Bay during 1977 or 1978, and because no sampling of juvenile salmonids was conducted in freshwater, data obtained on length frequencies and periods of residence and migration of wild juvenile fall chinook salmon were interpreted in light of Reimers' (1973) observations of wild juvenile fall chinook salmon in the Sixes River and estuary.

Peaks in the CPUE of wild juvenile fall chinook salmon at Site 4 in Yaquina Bay during 1978 (Fig. 8) appear to represent peaks of migrations to the estuary or ocean of populations which have reared for different periods of time in freshwater or in the estuary above Site 4. This is evidenced by the consistently smaller mean length frequencies and range of length frequencies of wild juvenile chinook salmon present in samples taken in the upper estuary as compared to the lower estuary (Fig. 11). If this interpretation is correct, the largest migrations of wild juvenile fall chinook salmon from the river into the upper estuary during 1978 occurred in the late spring (May) (Fig. 8). This is somewhat earlier than in the Sixes River, where peak abundance in the upper estuary occurred during the early summer (Reimers 1978). Secondary peaks in abundance of wild juvenile fall chinook salmon in the upper Yaquina estuary occurred in August and November (Fig. 8). Similar to Yaquina Bay, Cramer (1979) observed 3 peaks in migrations of wild juvenile chinook salmon through the lower Rogue River in Oregon. The first peak occurred in late May, the second in July, and the third in October or November (Cramer 1979). In the upper Columbia River estuary, Sims (1975) observed two peaks in outmigrations of juvenile fall chinook salmon. The first peak occurred in late May, and a second, larger peak occurred in late July or early August. However, catches of juvenile fall chinook in the Columbia represented mixed populations of both hatchery and wild fish (Sims 1975). Mullen (1977a) observed two peaks in outmigrations of wild fall chinook in the Salmon River estuary in Oregon, the first in the last week of July or first week of August, and the second in mid to late September.

In addition to peak periods of abundance in the upper Yaquina estuary, the continual presence of smaller numbers of wild juvenile chinook at Site 4 from May through November (Fig. 8), as well as the presence of a large range of length frequencies, including smaller sized individuals in both the upper and lower estuary (Fig. 11), indicates continuous recruitment of wild juvenile fall chinook salmon from freshwater to upper and lower estuarine environments during this period. Similar observations were made by Stober et al. (1973) in Skagit Bay, Washington.

The upper estuary appears to be important to wild populations of juvenile fall chinook salmon, not only as a staging area for entrance into the lower estuary, but also as a rearing area. In Yaquina Bay during 1978, wild juvenile chinook salmon were first captured in the upper estuary in late April and early May at a mean size of approximately 6.6 cm FL, and were not captured at beach study areas in the lower estuary until 1 month later (June 8) at a mean size of approximately 8.8 cm FL (Figs. 8 and 11). The 1 mo delay in capture of wild juvenile fall chinook between the upper and lower estuary, as well as the apparent increase in mean size during this interval indicates that populations of wild juvenile chinook entering the estuary in the spring utilize the upper estuary as a rearing area prior to entrance into the lower estuary. Reimers (1973) also reported capture of wild juvenile fall chinook in the upper Sixes River estuary 1 mo prior to their appearance at stations in the lower estuary. Van Hyning (1973) reported that most juvenile fall chinook arrive in the upper Columbia River estuary in May, and that substantial numbers rear there through July.

Wild juvenile fall chinook salmon were first captured at beach and channel study areas in the lower estuary in early June. However, the mean size of juvenile chinook at the beach study areas (8. 8 cm FL) was considerably smaller than the mean size of juvenile chinook at the channel study areas (10. 6 cm FL) (Fig. 11). Because sampling gear utilized at beach and channel study areas was not standardized, this size differential may represent selectivity of the lampara net for larger juveniles, or the beach seine for smaller juveniles. However, if gear selectivity is not involved, this size difference indicates that smaller juveniles entering the lower estuary rear in intertidal areas, moving offshore into channel areas as they increase in size. This is substantiated not only by the, generally, larger mean length frequencies of wild juvenile fall chinook salmon at the channel study areas as compared to the beach study areas in the lower estuary (Fig. 11), but also by the offset of peak periods of abundance of wild juvenile chinook between these two areas (Fig. 8 and 9). Peak periods of abundance of wild juvenile fall chinook salmon at the beach study areas in the lower estuary (Fig. 8) occurred 2 mo prior to peak abundances at the channel study areas (Fig. 9). The offset in peak periods of abundance at beach and channel study areas (Figs. 8 and 9) also indicates that movement to channel areas may be initiated by increases in population density in shoreline areas.

These observations are substantiated by Reimers (1973), who found that wild juvenile fall chinook salmon captured in the Sixes estuary prior to June were confined to shoreline areas. Later in the season, however, as population density and size of juvenile chinook increased, juvenile chinook were captured throughout the estuary, even in deep water areas (Reimers 1973). These changes in distribution appear to involve not only changes in fish size and density, but also behavioral changes. Reimers (1973) reported that wild juvenile chinook at entrance to the estuary were characterized by agonistic behavior, hiding, and orientation to the bottom, and that as size and density increased juvenile fall chinook adopted a "pelagic aggregative mode of life."

The lower estuary also appears to be important to wild populations of juvenile chinook salmon in the Yaquina system as both a staging area and rearing area prior to entrance to the ocean. This is substantiated by the gradual build-up in population size (relative abundances) at the beach study areas in the lower estuary from June to August, and at the channel study areas from August to October

(Figs. 8 and 9). In addition, the gradual increase in mean length frequencies of wild populations of juvenile chinook at beach and channel study areas in the lower estuary (Fig. 11) indicates growth of individuals within populations of wild juvenile chinook in the lower estuary during this period.

The capture of wild juvenile chinook salmon during 9 mo of the year in Yaquina Bay during 1978 (Fig. 8 and Table 8) indicates that wild populations of juvenile fall chinook salmon, in varying degrees of abundance, may be present in the estuary throughout the entire year. Several other investigators have reported the presence of populations of juvenile chinook salmon in river estuaries throughout the year (Rich 1922; Ganssle 1966; Deschamps et al. 1971). In addition, extensive temporal utilization (> 3 mo) of river estuaries by populations of juvenile chinook salmon has been reported by many other investigators (Snyder 1931; Bostic 1955; Sims 1970, 1975; Reimers 1973; Sibert 1975; Forsberg et al. 1977; Mullen 1977a, 1978). The importance of estuarine residence to individual juvenile fall chinook within these populations has been demonstrated by Reimers (1973), who found that 90% of successful spawners returning to Sixes River, Oregon had spent 3 mo rearing in the estuary as juveniles.

One of the most striking features of spatial and temporal utilization of Yaquina Bay by wild populations of juvenile chum, coho, and chinook salmon was that peak periods of residence and migration for each species were separated in time and space so that there was little overlap in utilization of estuarine study areas by different species of wild salmon (Figs. 8 and 9). Interspecific differences in spatial and temporal utilization of the estuary by wild populations of juvenile salmonids may be the result of genetic differences between species, evolved as mechanisms to reduce competition or predation among juvenile salmonids in river estuaries. The lack of overlap in periods of estuarine residence and migration of wild populations of Pacific salmon may also be the result of direct interactions, such as predation or agonistic behavior, between different species. For example, Stober et al. (1973) reported that the catch of juvenile coho salmon in Skagit Bay, Washington increased as the catch of juvenile chum and pink salmon decreased, and that juvenile chum and pink salmon were found in the stomach contents of juvenile coho. Agonistic behavior in the form of nipping, lateral displays, and other aggressive behaviors between coho, which are usually regarded as social dominants, and other species of salmonids in freshwater is well known (Stein 1971; Allee 1975), and this type of behavior may also occur in estuarine habitats. Mason (1966), who studied the social behavior of coho smolts exposed to estuarine conditions in aquaria, found that intensity of aggression increased on exposure to high salinities, but freshwater controls showed no significant changes in aggression. Size of fish may also be an important factor in the regulation of agonistic behavior in estuarine environments. For example, Mason (1974) observed larger chum fry chasing smaller coho fry as well as other chum fry away from "obviously preferred feeding stations" in a small estuary in British Columbia. Regardless of the mechanism involved, lack of overlap in periods of residence and migration of different species of Pacific salmon in Yaquina Bay is indicative of resource partitioning (Schoener 1974, review), and suggests the need to minimize interspecific as well as intraspecific interactions between hatchery and wild juvenile salmon in river estuaries.

Because the present study was conducted for a period of only 18 months, the consistency of peak periods of migration of species of wild juvenile salmonids in Yaquina Bay from year to year is not known. However, studies conducted in other rivers or estuaries for longer periods of time have shown that periods of salmonid outmigration can be quite consistent from year to year (Salo and Bayliff 1958; Drucker 1972; Durkin and Sims 1975; Lichatowich 1976; Cramer 1979). If peak periods of residence and migration of wild populations of juvenile salmon in Yaquina Bay remain relatively consistent from year to year, this will provide resource managers with a powerful tool for minimizing overlap in utilization and the potential for competition between wild salmonids and large releases of privately cultured salmon in the estuary. That is, the timing of releases of juvenile hatchery salmon might be planned so that releases do not directly coincide with peak periods of abundance of species of wild juvenile salmonids in the estuary.

Because wild juvenile chinook salmon appear to be present in Yaquina Bay throughout most of the year, management directed at minimizing overlap in utilization of river estuaries by juvenile hatchery and wild salmonids will be more difficult for this species than for wild populations of chum and coho salmon. In addition, because of their extended periods of residence in river estuaries, a greater potential for competition may exist between hatchery salmon and wild juvenile chinook salmon, than for populations of wild coho and chum salmon.

Because periods of estuarine residence and migration of wild populations of juvenile salmonids were not examined prior to large releases of privately cultured juvenile salmonids into Yaquina Bay, there is no way of knowing if releases of hatchery salmon have affected periods of residence and migration of wild salmonids in Yaquina Bay. However, because releases of juvenile hatchery salmon into Yaquina Bay during 1977 and 1978 (Figs. 12 and 13) were considerably less than the number approved for release into the estuary by the Oregon Department of Fish and Wildlife (20 million chum, 9.5 million coho, and 10.6 million chinook), information on periods of residence and migration of wild salmonids reported in the present study can be regarded as baseline data for future evaluations.

Length of residence of hatchery coho salmon

The number of hatchery coho salmon released into Yaquina Bay and recaptured at the beach study areas during 1977 and 1978 (Tables 1, 4, and 6) was sufficient to develop a model to describe length of residence of juvenile hatchery coho salmon in a tidal river estuary. The model for length of residence of juvenile hatchery coho salmon described in the present thesis meets, in most cases, the biological, mathematical, and statistical criteria of biological models as presented by Gallucci and Quinn (1979). The CPUE of populations of juvenile hatchery coho salmon in Yaquina Bay during 1977 and 1978 appeared to decrease exponentially, so that the length of residence of juvenile hatchery coho salmon in the estuary was described by a negative exponential equation (Figs. 15 and 17; Tables 5 and 7). The recapture of coded wire tagged coho salmon was sufficient in several cases to achieve a statistically significant fit of pooled observational data to the exponential model (Figs. 15 and 17; Tables 4 and 5). Subsamples of up to 100 juvenile coho salmon from each set of the beach seine were not large enough to obtain a sufficient number of sample points to achieve a statistically significant fit for release groups of fluorescent dye marked fish (Tables 6 and 7). However, even in cases where statistical significance was not achieved, high coefficients of determination (r^2) indicated significantly predictive relationships (Table 7). A negative exponential model was also used to describe the length of residence of juvenile chinook salmon in the Duwamish River estuary in Washington (Wetherall 1970), and may, in many cases, be appropriate for the description of the length of residence of all species of anadromous juvenile salmonids in river estuaries. In addition, the model could also be used to estimate the number of juvenile hatchery coho salmon present in the estuary at any point in time after hatchery releases of known size and date, providing that the rate constant, k, was determined by field sampling or estimated to be a particular value by reasonable assumption.

The length of time that it took for the number of juvenile hatchery coho salmon present at the study areas to be reduced by 50% (residency half-life) ranged for different release groups from 1.7 to 9.0 days (Tables 5 and 7). Therefore, while the majority of individuals from a particular release group had left the estuary within a relatively short period of time ($<$ 1 mo), a smaller portion remained for an extended period of time (1-3 mo). In addition, the negative exponential model, as well as the concept of a residency half-life, implies that there may always be at least a few juvenile hatchery coho salmon present in the estuary, and this appears to be a reasonably accurate description of the situation in Yaquina Bay. The capture of a few large juvenile hatchery coho salmon ($\overline{X}$= 36.0 cm FL; n=5) at the beach study areas in the lower estuary in January, March, and April of 1978 (Table 8), prior to the first release of hatchery coho salmon in 1978, indicates that a small number of coho salmon may remain in the estuary or in the coastal waters near Yaquina Bay during the entire saltwater phase of their life history. This is substantiated by a recent survey of juvenile salmonids in the ocean waters off the Oregon coast in June 1979 (Pearcy 1979), where the capture of juvenile coho ranging in size from 9.4-29.4 cm FL, as well as coho larger than 30.0 cm FL, indicates that at least a portion of the coho population may rear in nearshore waters off Oregon during the entire marine phase of their life history. Populations of coho salmon are also known to remain for the duration of their marine lives in Puget Sound (which is an estuary as defined by Ketchum (1951)) (Pressey 1953; Allen 1956; Haw et al. 1967), and in the Strait of Georgia (Fraser 1946). Fish resident in nearshore ocean waters may, on occasion, enter river estuaries to feed. However, whether hatchery coho salmon resident in nearshore ocean or estuarine waters constitute a number sufficient to warrant concern about competition or predation on wild juvenile salmonids in river estuaries is unknown.

The exponential decrease in the CPUE of juvenile hatchery coho salmon in Yaquina Bay indicates that the underlying biological processes, i.e. mortality in the estuary or timing of migrations of juveniles to the ocean, may, in part, be related to density (abundance) of juvenile salmonids in the estuary. In view of recent evidence that an increase in the number of juvenile salmonids released from hatcheries does not necessarily result in an increase in adult returns (Royal 1972; Petermann 1975, 1978; Gunsolus 1978; Lichatowich et al. 1978), further research is needed to identify density dependent mechanisms at work in the estuarine environment, and to determine if these mechanisms are a major factor involved in the survival of hatchery salmonids following large releases.

Allen (1956) discussed the complexity of interpreting results from marking experiments involving one or a few groups of fish. The results of Allen's (1956) study of the migration and distribution of five different marked release groups of coho salmon in Puget Sound showed that time, location, and method of release, as well as age of fish, "produced distinctly different salt-water migrational and distributional behavior." In view of the large number of marked groups of juvenile coho salmon released into Yaquina Bay and recaptured at the study areas in 1978 (Tables 4 and 6), the interpretation of the possible effects of variables such as age, size, location, and time of release on length of residence of juvenile hatchery coho salmon in th estuary was very complex. The exponential model developed in this thesis was useful in clarifying the relationship between time of release and length of estuarine residence for different release groups of juvenile hatchery coho salmon, and may prove useful in future investigations of the effects of other variables on length of residence of hatchery salmon in river estuaries.

Time of release appears to be an important factor involved in determining the length of residence of juvenile hatchery coho salmon in Yaquina Bay. This was particularly evident from the recapture of marked fish from three different groups of CWT coho salmon released into the estuary in June, July, and August of 1978. The residency half-life of CWT coho salmon released in June (9.0 days) was over twice as long as the residency half-life of groups of CWT coho salmon released in July and August (3.7-4.2 days) (Table 5). Regardless of time of release, tagged fish from all 3 release groups were last captured at the study areas at the same time in mid September (Table 4). In addition, the residency half-life of coho salmon released into the estuary during July and August (Table 5) was approximately twice as long as the residency half-life of coho salmon released into the estuary during the first week in September 1978 (2.3 days). Over 1.6 million juvenile hatchery coho salmon were released into Yaquina Bay during October 1978 (Fig. 13). However, the CPUE of fish from these release groups was very low, and no juvenile hatchery coho salmon were captured at the beach study areas in the lower estuary in November (Table 8). These results indicate that juvenile hatchery coho salmon released later in the season remain in the estuary for a shorter period of time.

The residency half-life of a group of yearling hatchery coho released into Yaquina Bay during the first week in April 1978 (Table 7) was similar to the residency half-life of 0-age coho salmon released in July and August (Table 5). Because this was the only release group of yearling hatchery coho salmon sampled in the estuary during the period of this investigation, as well as the only group of hatchery coho salmon released prior to peak migrations of wild juvenile coho salmon in May (Fig. 8), the effect of differences in age, size, and time of release between these groups on length of estuarine residence is unknown. However, the results of a 6-year study of the downstream migrations of juvenile coho salmon in the Columbia River estuary showed that hatchery coho salmon released before mid April moved downstream at a slower rate than coho salmon released in late April and May (Durkin and Sims 1975). Regardless of considerable within and between year variation in the timing of major releases from the 19 coho salmon hatcheries on the Columbia River system (January-May), peak migrations of both hatchery and wild coho salmon always occurred in the upper Columbia River estuary between May 6-16 of each year (Durkin and Sims 1975). The results of their study led Durkin and Sims (1975) to conclude that early release of juvenile coho salmon from hatcheries failed to result in correspondingly earlier seaward migration. They suggested that if direct seaward migration was desired, March to May release times for hatchery coho salmon recommended by Wallis (1968) should be modified to a mid April to May schedule. However, they did find that 0-age coho salmon (5.0-10.0 cm) released on July 28, 1969 also moved downstream to the estuary in "large numbers" (Durkin and Sims 1975).

On the basis of results obtained in the present study, I would also recommend September and October releases to reduce the length of residence of juvenile hatchery coho salmon in river estuaries and minimize the potential for competition between hatchery and wild salmon in the estuary. However, if survival of fall releases of juvenile hatchery coho salmon is low, this practice may not be biologically or economically feasible for private salmon aquaculture operations. Monitoring of adult returns of marked groups of juvenile hatchery cono salmon released in September and October should help to clarify this matter.

Juvenile hatchery coho salmon that remained in Yaquina Bay after release appeared to grow during their extended period of residence in the estuary. This was most evident from length measurements of juvenile hatchery coho salmon recaptured after the date of last release in July 1977, where populations of hatchery coho salmon were found to increase in mean fork length from 11.5 cm in mid July to 21.0 cm in October (Fig. 16). However, juvenile hatchery coho salmon that remain in the estuary may not grow at a rate similar to juveniles that migrate directly to the ocean environment. Allen (1956) found that few coho salmon that remained in Puget Sound during the entire marine phase of their life history grew larger than 58 cm FL, while almost all fish that migrated to the ocean exceeded 60 cm FL. The continual release of groups of juvenile hatchery coho salmon into Yaquina Bay from June through October 1978 (Fig. 13) obscured any evidence of growth of hatchery coho salmon in the estuary during 1978. In addition, mean fork lengths of a group of CWT hatchery coho salmon released into the estuary on June 19, 1978 and recaptured at the beach study areas remained, for the most part, below 12.0 cm FL (Fig. 18). The lack of increase in mean lengths of coho salmon from this release group indicates emigration to the ocean of fish larger than 12.0 cm FL, or, possibly, a suppression of growth due to high population densities of juvenile hatchery coho salmon in the estuary. Reimers (1973) hypothesized that high population densities were responsible for depressed growth rates of juvenile chinook salmon in the Sixes River estuary in Oregon during summer months.

Length of residence of hatchery chinook salmon

Length of residence for different marked release groups of juvenile hatchery chinook salmon in Yaquina Bay was found to vary from a few weeks to several months. This result is consistent with observations on the length of residence of marked juvenile hatchery chinook salmon in other river estuaries, where fish were found either to pass rapidly through river estuaries (Heg 1952; Sjolseth 1969; Sims 1970, 1975; Wetherall 1970; Forsberg et al. 1977), or to remain for extended periods of time (at least 2 mo) (Miller et al. 1968; Salo 1969; Sims 1975; Forsberg et al. 1977; Oregon Dept. Fish Wildl. 1977a). The number of juvenile hatchery chinook salmon recaptured in Yaquina Bay was insufficient to be used to develop a model to describe the rate at which hatchery chinook leave the estuary. Wetherall (1970), in developing a stochastic model of survival rates for chinook salmon during their downstream migration in the Green River, Washington, found that a negative exponential distribution could be used in most cases to describe the delay, or length of residence, of marked fish in the Duwamish estuary. This indicates that juvenile hatchery chinook may leave the estuary, whether by death or emigration, in a manner similar to that described for juvenile hatchery coho salmon in Yaquina Bay. If juvenile hatchery chinook salmon leave the estuary at an exponential rate, then the majority of fish from a particular release group would leave the estuary in a short period of time, while a smaller portion would remain for an extended period of time. Depending on such variables as the number of fish released, the size of the estuary and the area sampled, sampling schedule, and intensity of sampling, juvenile hatchery chinook might be reported either as passing rapidly through river estuaries, or remaining for extended periods of time. This may be a partial explanation for observed variability in the length of residence of juvenile hatchery chinook salmon in Yaquina Bay and other river estuaries. In Yaquina Bay, stock of hatchery fish released and time of release also appeared to be important factors in determining length of residence of juvenile hatchery chinook salmon in the estuary.

Differences in the length of estuarine residence may be the result of genetic variability. Of the two stocks of hatchery chinook released into Yaquina Bay during the summer of 1978, marked University of Washington stock fall chinook were captured in the estuary for only a short period of time (< 3 weeks), while marked Trask River stock spring chinook were present in samples taken in the estuary for over 2 mo. Sims (1975) reported that Washougal River stock fall chinook released into the Columbia River at six different locations in June 1969 behaved differently than other release groups of marked chinook, and remained in the estuary for an extended period of time (> 2 mo). In the Elk River in Oregon, successfully returning adult spawners in wild populations of fall chinook were found to rear as juveniles in the river or estuary throughout their first summer, delaying emigration to the ocean until the fall

(Reimers and Concannon 1977). In an attempt to increase hatchery production, hatchery-reared Elk River stock fall chinook juveniles were released into the Elk River in June 1971. Hatchery juveniles were found to behave "according to their genetic dictates," and many did not migrate to the ocean until fall (Reimers and Concannon 1977). Although it is difficult to separate genetic and environmental effects, it is quite possible that certain genetic stocks are more prone toward extended residence in river estuaries.

Within a single stock of fish, size of fish at release and location of release in Yaquina Bay appeared to have little effect on length of estuarine residence. Trask River stock spring chinook released into Yaquina Bay at Southbeach during July 1978 had a mean weight (32.9 gm) over two times the mean weight (15.6 gm) of Trask River stock released from Wright Creek Hatchery in July 1977. Nevertheless, marked individuals from both release groups were captured in the estuary for similar periods of time (9-10 weeks). Wetherall (1970) reported that larger individuals from releases of marked hatchery chinook spent a shorter period of time in the Duwamish estuary than smaller individuals. No decreasing trend in mean sizes was found for daily samples of Trask River stock spring chinook captured at beach study areas in Yaquina Bay during the first week after release in July 1977, and mean weight during this period ($\overline{X}$=18.8 ± 4.2 gm; n=41) was actually somewhat larger than that reported for the entire release group. However, the large range of sizes found for recaptures from this release group (11.8-30.4 gm) may have obscured relationships between size and length of residence. If larger individuals do emigrate to the ocean faster than smaller fish, increasing the mean size of release groups of hatchery fish may have little effect on reducing length of residence for the entire release group if a large range of sizes above and below the mean are present.

Time of release appears to be a most important factor in determining length of residence of hatchery chinook salmon in the estuary. Marked hatchery chinook juveniles released into Yaquina Bay during July 1978 remained in the estuary twice as long as those released in October 1978. Although Oregon Aqua Foods chinook were the only marked group of hatchery chinook released into the estuary in October, two other unmarked stocks of fall chinook, Trask River and Alsea River, were also released into Yaquina Bay in October. Regardless of stock, most juvenile hatchery chinook had left the estuary by December. Forsberg et al. (1977) also found that marked hatchery chinook juveniles released into Tillamook Bay estuary in the fall remained for a shorter period of time than fish released in the summer. Decrease in length of residence of juvenile hatchery chinook in river estuaries as winter approaches (Fig. 19) appears to be correlated with seasonal decreases in water temperature and salinity (Figs. 20 and 21), as well as a reduction in the number and abundance of fish prey species (Figs. 29, 30, and 35).

Relative abundance of hatchery and wild juvenile salmon

Juvenile chinook, chum, and coho salmon, in decreasing order, were the most abundant species of wild salmonids present at the study areas in Yaquina Bay during 1978 (Fig. 8). Relative abundance of species of wild juvenile salmonids in Yaquina Bay appear to be more representative of the extent of utilization of the estuary by individuals within wild populations of juvenile salmon than of absolute population sizes. For example, wild juvenile chinook salmon were more abundant at the study areas than wild coho salmon (Fig. 8 and Table 8), even though the number of wild adult coho salmon spawning in the Yaquina system is reported to be much larger than the number of wild chinook salmon spawners (Smith and Lauman 1972). However, wild juvenile chinook salmon utilized Yaquina Bay as a rearing area, while wild coho salmon did not.

The greater relative abundance of wild juvenile chinook salmon in 1978 as compared to 1977 (Table 8) indicates that population sizes of wild juvenile salmon in the estuary may be quite variable from year to year, and points out the need to exercise caution in attributing short term changes in the relative abundances of wild salmon to large releases of hatchery salmon. In this case, increases in the number of juvenile hatchery salmon released into Yaquina Bay (Table 1) could be correlated with an increase in the abundance of wild chinook salmon in 1978 (Table 8). Spawning ground counts of 16 adult chinook salmon in the Yaquina index area in 1976 were considerably lower than the 15-year median of 52 fish, while counts of 180 fish in 1977 were considerably higher than the 15-year median (Cummings 1979b). Therefore, the increase in abundance of wild juvenile chinook salmon at the study areas in 1978 was probably the result of larger spawning escapements and greater egg to smolt survival during the fall and winter of 1977-1978, than during the same period in 1976-1977, which was a drought year in Oregon. In addition, the continued declining trend in the number of wild coho salmon spawning in the Yaquina system since 1972 (Cummings 1979b) will make it difficult to determine any detrimental impacts of large releases of hatchery salmon on the abundance of wild populations of coho salmon.

In general, relative abundance of species of hatchery juvenile salmon at the study areas appears to directly reflect the number of hatchery fish released into the estuary. For example, the number of hatchery coho salmon released into the estuary in 1978 was approximately 4 times the number released in 1977 (Table 1), and the annual CPUE of hatchery coho salmon in 1978 (Table 10), particularly at Site 1, was approximately 4 times the annual CPUE in 1977. The majority of hatchery fish released into the estuary during 1977 and

1978 were coho salmon (Table 1; Figs. 12 and 13), and coho salmon were also the most abundant species of hatchery salmon captured at the study areas (Table 10).

Because the majority of hatchery coho salmon leave the estuary within 1 mo after being released (Figs. 14, 15, and 17; Tables 5 and 7), they were, in general, more abundant than wild salmonids (Tables 8, 9, and 10) only during the months in which they were released (Figs. 12 and 13). In 1978 releases of hatchery coho salmon (Fig. 13) coincided with the peak period of residence and migration of wild chinook salmon at the beach study areas (Fig. 8), and hatchery coho salmon were more abundant than wild chinook salmon at that time (Table 8). This was not the case with wild coho salmon, since hatchery coho salmon were not released in May 1978 (Fig. 13), when the peak of the wild coho migration occurred (Figs. 8 and 9). These results indicate that at release levels similar to those in 1978 (Fig. 13), juvenile hatchery coho salmon can be expected to be more abundant in Yaquina Bay during the months in which they are released than wild populations of juvenile salmonids. Therefore, to minimize the potential for competition between hatchery coho salmon and wild salmonids in the estuary, consideration should be given to not releasing large numbers of hatchery coho salmon into the estuary during the months when peak migrations of wild chum, coho, and chinook salmon occur (Fig. 8).

In comparison to coho salmon, the number of juvenile hatchery chinook salmon released into Yaquina Bay during 1977 and 1978 was small (Figs. 12 and 13), and, with the exception of the upper estuary in July 1977, wild juvenile chinook salmon were more abundant during their peak periods of residence and migration than hatchery chinook salmon (Table 8). In July 1977 hatchery chinook salmon were released from Wright Creek Hatchery, and entered the estuary approximately 7.5 km closer to Site 4 than hatchery chinook salmon released at Southbeach in 1978. This may explain the greater relative abundance of hatchery chinook salmon in the upper estuary in July 1977. Juvenile hatchery chinook salmon released into Yaquina Bay in July of 1977 and 1978 were found to remain in the estuary for an extended period of time (> 2 mo) (Fig. 19), and when full hatchery production in Yaquina Bay (10.6 million chinook) is achieved, juvenile hatchery chinook salmon will probably also be more abundant during the months in which they are released than wild juvenile salmonids.

All of the study areas sampled during the period of this investigation were utilized by hatchery and wild coho and chinook salmon (Table 10). However, juvenile salmonids should not be assumed to be confined to these areas or types of habitat within the estuary. Juvenile salmon were also reported to be present in large numbers under the port docks at Newport, as well as within the small boat basin at Southbeach (pers. comm. Al Fox). In addition, many other types of habitats, e.g. mudflats, tidal creeks, and rocky beaches, not sampled during the present investigation have been reported to be utilized by juvenile salmonids in other river estuaries (Congleton and Smith 1976; Forsberg et al. 1977; Healey et al. 1977; Sibert et al. 1977). The overlap in utilization by hatchery and wild juvenile salmon of areas and habitats other than those sampled during the present study requires further investigation.

Although all of the study areas were utilized by hatchery and wild juvenile salmonids, distribution at the beach study areas was not uniform. Both hatchery and wild coho salmon were most abundant at Site 1, while both hatchery and wild chinook were most abundant at Site 3. This non-random distribution of hatchery and wild juvenile salmon at the beach study areas in Yaquina Bay, particularly in the case of juvenile chinook salmon, indicates species preferences for certain areas or habitats within the estuary. Non-random distribution of juvenile salmon in river estuaries or nearshore waters has also been reported by many other investigators (Tyler and Bevan 1964; Day 1966; Stober et al. 1973; Schreiner 1977). Preferred habitats of juvenile salmonids within the estuary should be identified and protected from further development or habitat degredation, as reduction of salmonid rearing habitats within the estuary may have a negative impact on populations of both hatchery and wild juvenile salmonids.

Although hatchery coho and chinook salmon were, in general, less abundant in the upper estuary than in the lower estuary, their presence at Site 4 indicates up-bay movement of some hatchery salmon after release (Table 8 and 10). However, the extent of upstream movement of juvenile hatchery salmon after release is unknown. Sims (1970) reported that some groups of marked coho salmon fingerlings released into the Columbia River estuary in late March actually moved upstream out of the estuary, and did not return to the estuary until mid May. Secondary peaks in the CPUE of juvenile hatchery coho salmon occurring approximately 1 mo after release into Yaquina Bay (Figs. 14 and 17) may represent groups of fish which moved up-bay to freshwater habitats or to other habitats within the estuary, and were passing back over the beach study areas in the lower estuary on their way to the ocean. In view of the more limited food and space available for rearing juvenile salmonids in freshwater as compared to ocean environments, if large numbers of juvenile hatchery salmon move upstream into freshwater environments after release into the estuary, then the potential for competition between hatchery and wild juvenile salmonids would be greatly increased. Further studies are needed to determine the extent of upstream migrations of juvenile hatchery salmon after their release into the estuary.

Overlap in Food Habits of Hatchery and Wild Juvenile Salmon

The results of stomach content analyses show, in many cases, a high degree of overlap in the food habits of hatchery and wild juvenile salmonids in Yaquina Bay. Because concern over releases of large numbers of privately cultured juvenile salmon into river estuaries is often directed toward the possibility of food competition between hatchery and wild fish (Cummings 1979a; Kadera 1979), an important question is whether indices of overlap can be used as a measure of competition. Obrebski and Sibert (1976) found a high degree of overlap in the stomach contents of juvenile chum salmon and stickleback (*Gasterosteus aculeatus*) in the Nanaimo River estuary, and observed that high values of C_λ "strongly suggest" food competition. However, they also conjectured that if food resources were not limited or if mixed species groups increase feeding efficiency, different species might have a high degree of overlap in stomach contents but partition resources in some other manner (Obrebski and Sibert 1976).

For natural communities of fish, a high degree of overlap in stomach contents may be a better indicator of a *lack* of competition for food resources. Ricklefs (1973) cautions against the use of overlap values calculated for one environmental dimension or resource as a measure of competition, and advises that their main value is as an index of the co-occurrence of species on resources or other environmental dimenstions. In the context of the present study, indices of overlap were used as a measure of the potential for interspecific and intraspecific competition between groups of fish that would not co-occur under natural conditions. In this case, a high degree of overlap is an indicator of the potential for food competition in the event that food resources become a limiting factor.

In addition to providing a measure of the potential for food competition between hatchery and wild salmon, variability in overlap values suggests dimensions in which resource partitioning may occur, and factors which may be involved in determining the extent of overlap in food habits of hatchery and wild juvenile salmon in the estuary. While hatchery and wild juvenile salmon captured in Yaquina Bay during the same period of time often consumed the same types of food organisms in similar proportions, overlap in stomach contents are sometimes low, and degree of overlap was found to vary with species, time, habitat, and space.

As could be expected, overlap in food habits of hatchery and wild fish of the same species was usually high. Variability in overlap of food habits within species of hatchery and wild salmon appears to reflect differences in rearing regime, primarily differences in size of fish and length of residence in the estuary.

Although the mean size of wild coho salmon (Fig. 10) was approximately 6 cm less than that of hatchery coho salmon in April and May 1978, the stomach contents of both groups in samples taken at the beach study areas contained the same types of food organisms in similar proportions (Fig. 27). The low degree of overlap in stomach contents of hatchery and wild coho at the channel study areas in 1978 (Fig. 27) can be attributed primarily to small sample sizes, although adult crangonid shrimp in the stomach contents of larger hatchery coho were probably too big to be eaten by smaller wild coho.

Overlap in stomach contents of hatchery and wild chinook was usually high (Figs. 25 and 26), except when comparisons were made using the stomach contents of recently released hatchery chinook. In some cases the stomachs of recently released hatchery fish contained nothing but hatchery food. Obviously in this case there would be no ovelap in stomach contents between hatchery and wild fish. In addition, stomachs of recently released hatchery fish often contained large amounts of food items such as pine needles, seeds, wood and paint chips, and pieces of plastic and styrofoam. These differences in stomach contents indicate that recently released hatchery salmon are in the process of learning to feed on natural prey organisms in the estuary. Flynn and Frolander (1977) found unusual items such as seeds, rocks, and feathers in the stomach contents of wild juvenile chinook in Tillamook Bay, Oregon, and suggested that the presence of such materials indicated that size was the primary criterion for selection of food. Indiscriminent feeding on food items or objects of a size suitable to the fish may be the primary mechanism whereby juvenile salmon learn to select appropriate food, as types or abundance of prey organisms change with the seasons, or as they increase in size or enter new habitats on their feeding migrations.

That hatchery salmon can learn to feed on particular food items in the estuary was demonstrated by Levings and Levy (1976), who conditioned juvenile chum salmon to feed on specific prey organisms in the Squamish River estuary in British Columbia. Smith et al. (1970) found little but wood chips and debris in the stomachs of marked hatchery chinook captured recently after their arrival into Elliot Bay in Puget Sound, Washington, and suggested that this might be related to a scarcity of appropriate food items. However, this did not appear to be the case in Yaquina Bay. Even though juvenile anchovy were abundant in Yaquina Bay in October 1978 (Fig. 30), and comprised the major component of the stomach contents of wild chinook (Fig. 26), the major component of the stomach contents of hatchery chinook released into the estuary in October was algae (Fig. 26). Because hatchery and wild chinook used in this comparison were the same size, these differences indicate that even though appropriate food organisms may be present, recently released hatchery fish may not feed on them. It may require a certain amount of time for hatchery fish to learn to feed on active prey organisms such as juvenile fish. Therefore, overlap in food habits, and the potential for competition over limited food resources is likely to be much greater between hatchery and wild salmon of the same species that have been present in the estuary for an extended period of time, than between fish which have only recently arrived in the estuary.

In addition, fish which have been in the estuary for a longer period of time, whether hatchery or wild, may have a competitive advantage over recent arrivals. This advantage might be reflected not only in the types of food organisms in the stomach contents, but also in the amount of food in the stomach contents. For example, in a comparison of five hatchery and five wild chinook salmon of similar size (15.0-15.5 cm FL) captured at Site 3 on October 14, the stomach contents of hatchery chinook which had been in the estuary for only one week, represented an average of only 1.7% of the total body weight, while stomach contents of wild chinook represented an average of 5.7% of the total body weight.

Overlap in food habits between different species of hatchery and wild juvenile salmon was sometimes low. For example, there was almost no overlap in stomach contents of hatchery coho and wild chum salmon captured in Yaquina Bay in April (Fig. 28). Species differences in food habits of chum salmon fry and coho salmon smolts in estuarine and nearshore environments are well known (Iwamoto and Salo 1977, review), and a lack of overlap in stomach contents of juvenile hatchery coho and wild chum salmon in Yaquina Bay was not surprising in view of the large difference in mean sizes of these two groups (> 17 cm). However, this size difference does suggest the possibility of predator-prey interactions between these two groups in the estuary. Although no chum salmon were found in the stomach contents of hatchery or wild coho salmon during this investigation, predation by coho smolts on chum salmon fry in river estuaries and nearshore environments is a common observation (Parker 1971; Johnson 1974). It is possible that the decrease in the CPUE of wild chum fry as the CPUE of hatchery and wild coho smolts increased at the beach study areas in April (Fig. 8; Table 8) was related to predator-prey interactions. Therefore, while release of large numbers of juvenile hatchery coho (or chinook) salmon during periods when wild chum salmon are present in the estuary might not result in an increase in the potential for competition over limited food resources, there is the possibility of an increase in predation, and subsequent decrease in populations of wild chum salmon.

The greatest potential for food competition between hatchery and wild salmon in Yaquina Bay was expected for populations of hatchery coho and wild chinook, as the majority of hatchery fish released into Yaquina Bay in 1977 and 1978 were coho salmon (Figs. 12 and 13), and chinook salmon were the most abundant species of wild salmon in the estuary (Table 8). In addition, juvenile coho and chinook salmon are often considered to have similar food habitats, although some differences in food habits of coho and chinook salmon in estuarine and nearshore environments, particularly in the diversity of stomach contents, have been found (Pritchard and Tester 1944; Foskett 1951; Heg and Van Hyning 1951; Prakish 1962; Sibert and Kask 1978). Overlap in stomach contents of hatchery coho and wild chinook in Yaquina Bay was often high, but varied with time, space, and habitat. In general, much of this variability appears to be related to spatial and temporal differences in type and abundance of prey organisms in the estuary.

Seasonal patterns in the abundance of prey organisms in the estuary or nearshore waters off Yaquina Bay correspond closely with the occurrence of these same organisms in the stomach contents of hatchery coho and wild chinook. Although the relative abundance of crustacean larvae in Yaquina Bay during 1977 and 1978 was not determined, peak abundances of shrimp larvae have been found to occur in the coastal waters off Yaquina Bay from March through June, while peak abundances of crab larvae occur in May and June (Richardson and Pearcy 1977). Peak abundances of fish larvae occur in Yaquina Bay from February to July, and in the coastal waters off Yaquina Bay from February to July (Pearcy and Myers 1974; Richardson and Pearcy 1977). In the present study, juvenile fish were found to be most abundant in Yaquina Bay from July through September. In general, these seasonal patterns correspond to seasonal changes in the major types of food organisms in the stomach contents of hatchery and wild juvenile salmon in Yaquina Bay. For example, shrimp larvae (Decapod zoea) were the most important constituent in the stomach contents of both hatchery coho and wild chinook in June 1978, while larval and juvenile fish were the most important constituent in the stomach contents from July through September in both 1977 and 1978.

Changes in the type and abundance of prey organisms in the stomach contents of hatchery coho and wild chinook salmon occurred not only seasonally, but from year to year. These differences were seen not only in the stomach contents of hatchery and wild fish, but also in the relative abundance of prey organisms at the study areas. For example, juvenile anchovy were much more abundant in the stomach contents of hatchery coho and wild chinook in August, September, and October of 1978 (Fig. 23) than during the same period in 1977 (Fig. 22), and juvenile anchovy were also much more abundant in the catch at the beach study areas in August and September 1978, than during the same period in 1977 (Fig. 30). Richardson and Pearcy (1977) reported considerable year to year variability in the abundance of larval fish off Yaquina Bay, Oregon. Annual variability in the type and abundance of prey species is probably the norm, and adds to the difficulty of making generalizations about the potential for food competition between hatchery and wild juvenile salmon. The potential for food competition between hatchery and wild juvenile salmon in the estuary is likely to be much higher during years when populations of fish larvae and other prey species are less abundant in the estuary and nearshore waters off Yaquina Bay than during years when prey species are abundant. Many of the food organisms consumed by juvenile coho and chinook in the estuary (e.g., larval whitebait smelt) appear to be supplied by tidal exchange from nearshore ocean waters. In addition, there is some indication that survival of juvenile salmon may be related to coastal upwelling (Gunsolus 1978).

With the exception of shiner perch, the most abundant species of fish at the study areas in Yaquina Bay (i.e. Pacific herring, shiner perch, surf smelt, and northern anchovy) were also the most common fish prey species in the stomach contents of hatchery coho and wild chinook. Overlap in stomach contents of hatchery coho and wild chinook was highest when both groups were feeding on fish, and particularly when the fish prey species was abundant in the estuary. For example, the relative abundance of juvenile anchovy at the beach study areas increased from August to September 1978 (Fig. 30), and the degree of overlap in stomach contents of hatchery coho and wild chinook also increased over this period (Fig. 23). A high degree of overlap in stomach contents of hatchery coho and wild chinook in the estuary appears to be more indicative of the presence of abundant food resources than of food competition between these two groups.

When abundant food resources are not present in the estuary, overlap in food habits of hatchery coho and wild chinook salmon is likely to be much lower because of species differences in food habits. By examining the diversity and overlap in stomach contents of juvenile salmon and other species from four estuaries in British Columbia, Sibert and Kask (1978) found that coho and chinook appear to have distinct feeding habits. Coho apparently specialized by feeding on a small number of items not consumed by other estuarine species, while chinook fed on a large number of prey items that were also utilized by other species of fish in the estuary (Sibert and Kask 1978). Food habits of juvenile hatchery coho released into Yaquina Bay in July 1977 appeared to become increasingly specialized with time (Fig. 22). This is probably related to the increase in size of hatchery coho (Fig. 16), the increase in abundance of Osmeridae (whitebait smelt) (Fig. 33), or the development of a preference for fish prey during this period. As was discussed with chinook, it may take a certain amount of time for hatchery coho to learn to feed on active prey organisms like fish. The stomach contents of juvenile chinook also appeared to become more specialized over time (Fig. 25), but chinook may be more adaptable to the absence of fish prey species in the estuary than coho. When fish prey species were not abundant in the estuary, the stomach contents of wild chinook contained algae and small amounts of a variety of prey organisms. For example, in November 1978, juvenile anchovy were much less abundant at the beach study areas than they had been in October (Fig. 30), and the stomach contents of wild chinook, which were comprised primarily of anchovy in October, were composed of a combination of algae, fish, insects, and crustaceans (Fig. 26). In spite of large releases of hatchery coho in October (> 1.6 million), almost all hatchery coho had left the estuary (either by death or emigration) before November 1978.

Algae was a relatively common component of the stomach contents of both hatchery and wild juvenile chinook salmon in Yaquina Bay. Flynn and Frolander (1977) also reported algae as a common constituent of the stomach contents of wild chinook in Tillamook Bay. Sheets of Ulva-like algae in the stomach contents of juvenile chinook were usually rolled into a pellet shape and, when unrolled, small detritivors such as harpacticoid copepods were sometimes found inside. Enteromorpha-like algae was often tangeled around amphipods or other small invertebrates in the stomach contents. The presence of algae in the stomach contents of juvenile chinook may be an indirect result of juvenile chinook feeding on associated invertebrates. Although algae in the stomach contents appeared to be relatively undigested, it is also possible that juvenile chinook may derive some nutrient, such as water, directly from the algae, or from bacteria or other micro-organisms on the surface of the algae. Algae was not present in any significant amounts in the stomach contents of other species of juvenile salmonids in Yaquina Bay, and indicates a type of feeding behavior peculiar to juvenile chinook salmon in the estuary.

Because juvenile coho and chinook salmon are active and mobile fish, it is difficult to know if the food found in their stomachs was obtained in the same habitat in which they were captured or in some other habitat within the estuary. However, some differences were seen in food type and the degree of overlap in the stomach contents of hatchery coho and wild chinook captured in different habitats or areas in the estuary.

Overlap in stomach contents of hatchery coho and wild chinook was usually higher in the lower estuary than in the upper estuary. The smaller mean size of wild juvenile chinook at Site 4 (Fig. 11) indicated that the upper estuary may be utilized by wild fish primarily as a staging area for entrance into the lower estuary. After release from the saltwater holding ponds at Southbeach, hatchery coho appear to disperse throughout the estuary. Some probably emigrate immediately to the ocean, while others move to the upper estuary. This is substantiated by the capture of juvenile hatchery coho salmon at Site 4 that still had hatchery food in their stomachs. Because hatchery coho and wild chinook may arrive at Site 4 from different directions, i.e. wild chinook from the river and hatchery coho from the lower estuary, the potential for food competition between hatchery coho and wild chinook in the upper estuary is probably less than for the lower estuary.

In July 1978 overlap in stomach contents of hatchery coho and wild chinook was high at the beach study areas (Fig. 23) and low at the channel study areas (Fig. 24). The difference in overlap appears to be due to the absence of Osmeridae (whitebait smelt) from the stomach contents of juvenile salmon captured at the channel study areas in July (Fig. 24). Therefore, differences in overlap appear to be related to differences in the distribution of prey organisms in the estuary. While whitebait smelt were common in samples taken at beach study areas in the lower estuary in July (Fig. 33), no whitebait smelt were captured in samples taken at the two channel study areas. In the absence of smelt, hatchery coho captured at the channel study areas fed primarily on adult barnacles (Fig. 24) of the suborder Balanomorpha. They were usually found in the stomach contents without a shell and, presumably, had been broken off rocks, boats, and other surfaces by wave action, feeding activities of other fish, or human activities. Prey organisms forming part of the drift become concentrated in tidal rip currents in the channel, and become increasingly available for consumption by juvenile salmonids. Sibert and Kask (1978) made a statistical comparison of stomach contents of juvenile coho and chinook salmon between four different estuaries and between different habitats within these estuaries (i.e. marshy intertidal, non-marshy intertidal, and deep water). They found significant overlap between coho and chinook salmon only in the marshy intertidal habitat. In addition, the composition of stomach contents of juvenile salmon was as different between estuaries as it was between habitats within an estuary (Sibert and Kask 1978). Therefore, the potential for food competition between hatchery and wild juvenile salmon is probably different for different estuaries, as well as for different habitats within a single estuary.

Values of overlap indices calculated for stomach contents of juvenile salmon show, in many cases, that the potential for food competition between hatchery and wild juvenile salmon in Yaquina Bay does exist, should food resources become a limiting factor. However, this study provides no evidence that the rearing capacity of Yaquina Bay for juvenile salmonids is limited, or that anadromous salmonids will not switch to other prey organisms within the estuary if food resources presently abundant in Yaquina Bay and in the stomach contents of hatchery and wild juvenile salmonids become reduced in number by releases of large numbers of privately cultured juvenile salmonids directly into the estuary.

A reduction in abundant or preferred prey organisms in the estuary might also result in more rapid emigration to the ocean. While this may be desirable in the case of hatchery fish, rapid emigration to the ocean might have a negative impact on populations of wild salmon, particularly wild chinook salmon. Reimers (1973) found that 90% of successful fall chinook spawners returning to the Sixes River in Oregon had reared in the estuary for 3 mo. While appropriate prey organisms might be more abundant in the nearshore oceanic environment, large predatory fish species are also more abundant, so that rapid emigration of smaller wild juveniles may result in increased predation, and subsequent decrease in survival of wild populations of chinook salmon and other salmonid species.

The continued monitoring of changes in overlap of stomach contents, along with changes in growth, survival, and relative abundance of hatchery and wild juvenile salmonids, and changes in the type or abundance of prey organisms in the estuary as numbers of privately cultured juvenile salmon released into the estuary increases would be useful in determining the level of hatchery releases at which food resources may become a limiting factor.

Fish Species in Yaquina Bay, Oregon, and Potential Interactions Between Juvenile Hatchery Salmon and Other Species in the Estuary

The results of this study as well as other investigations show that Yaquina Bay is important, not only as a rearing and staging area for oceanic migrations of anadromous salmonids, but also as a spawning area, nursery area, and feeding ground for numerous species of fish (Westreheim 1955; Russell 1964; Parrish 1966; Swedberg 1966; Gnose 1968; Beardsley 1969; Wares 1971; Steinfield 1972; Olsen and Pratt 1973; Gaumer et al. 1974; Pearce and Myers 1974; Swartz et al. 1974; Barton 1978; Bayer 1979; Tresierra-Aguilar 1980). All species of fish in the estuary are of interest not only as potenital prey, predators, and competitors of juvenile salmonids, but also as members of the estaurine fauna. In addition, many of the fish species captured in samples during this investigation are economically important to recreational and commercial fisheries within Yaquina Bay (Gaumer et al. 1974), as well as to ocean sport and commercial fisheries.

Species composition at the four beach study areas (Table 11) was similar to that found by other fish surveys where sampling was conducted by beach seine in Yaquina Bay (Beardsley 1969; Bayer 1979), as well as in other Oregon estuaries (Cummings and Schwartz 1971; Cummings and Berry 1974; Hostick 1975; Reimers and Baxter 1976; Forsberg et al. 1977; Misitano 1977; Mullen 1977a, b).

However, the 58 species identified in samples taken at the beach and channel study areas (Tables 11 and 12) represent only a portion of the total number of fish species reported for Yaquina Bay. Beardsley (1969) listed 49 additional species known to occur in Yaquina Bay, but not identified in samples taken at the beach and channel study areas during 1977 and 1978. Many of the species listed by Beardsley (1969) are found in habitats, e.g. rocky intertidal or deep water benthic, that were not sampled during the present study, or are infrequent visitors to the estuary from the marine environment.

Although direct comparisons between the number of fish species captured at the beach and channel study areas cannot be made because sampling gear was not standardized and sampling schedules for beach and channel study areas were different, the number of fish species captured at the channel study areas was approximately half the number captured at the beach study areas (Tables 11 and 12). This difference is probably due, in part, to the small number of samples taken at the channel study areas (n=32). However, tideland areas in Yaquina Bay, as well as in other estuaries, are usually considered to be more productive than deep water or subtidal channel areas, and, therefore, are probably capable of supporting a larger number of fish species. Because the number and abundance of species is apparently higher in intertidal, as opposed to subtidal areas, the potential for interactions between hatchery salmon and other species of fish may be greater in intertidal habitats, than in subtidal areas of the estuary.

The results of this study show that the number of fish species was higher in the lower estuary than in the upper estuary, and that the number of fish species in both the upper and lower estuary was high during the summer and low during the winter (Fig. 29). Similar observations were made in Tillamook Bay, Oregon (Forsberg et al. 1977). Bayer (1979) also found peak diversity of fish species in summer and minimum diversity in winter in eel grass bed areas of Yaquina Bay. In addition, Swartz et al. (1974) found seasonal patterns in a variety of community structure indices applied to demersal fish and epibenthic crustaceans collected by bottom trawl in Yaquina Bay. In general, faunal density and species richness were high during summer months and low during winter months (Swartz et al. 1974).

By comparing the plot of the number of fish species captured by month at beach study areas in the upper and lower estuary (Fig. 29) with the plots of temperature (Fig. 20) and salinity (Fig. 21) for the same samples, the relationship between temperatures, salinities, and the number of fish species at the study areas is apparent. During the winter when temperatures and salinities at the beach study areas were low, the number of fish species at the beach study area was also low. During periods when temperatures and salinites are low, most species of fish apparently move either to ocean environments or to other areas of the estuary, while some freshwater species, e.g. brown bullhead, move from the river into the upper estuary. Similarly, low temperatures and salinities in the upper estuary during winter, and high temperatures during summer may inhibit the up-bay movement of predominantly marine species from the lower estuary.

Although the number of fish species in the upper estuary was less than in the lower estuary (Fig. 29), the presence of juvenile anchovy and herring of a mean size consistently smaller than anchovy and herring in the lower estuary (Figs. 31 and 36) indicates that the upper estuary may be an important rearing area for juvenile fish. Although stomach contents of juvenile anchovy and herring were not examined during the present study, juvenile anchovy and herring in Yaquina Bay are known to feed on copepods (Russell 1964; Johnson 1974). An indigenous population of calanoid copepods (Acartia californiensis) is known to have its center of abundance in the area of Site 4 (Fig. 1) (Johnson and Miller 1973; Johnson 1974). Peak abundances of A. californiensis (16,000/m^3) occur during summer months (Johnson 1974), so that abundant food resources appear to be available for planktivorous species of juvenile fish in the upper estuary in July, August, and September.

Relatively few species of fish were year-round residents of the four beach study areas in Yaquina Bay. Only 6 species of fish were present at the beach study areas during all 12 months of the year

(Appendix Table 1). However, Bayer (1979) also reported the pen-point gunnel (*Apodichthys flavidus*) and sharpnose sculpin (*Clinocottus acuticeps*) as year-round residents of the intertidal zone in Yaquina Bay. In addition, Beardsley (1969), who sampled channel areas in Yaquina Bay with an otter trawl, gill nets, and a fyke net, reported 12 additional species present in the estuary during all months of the year. Combining the results of the present study with those of Beardsley (1969), three species: staghorn sculpin, English sole, and starry flounder were present in both intertidal and subtidal habitats of Yaquina Bay during all months of the year.

Because the number and abundance of fish species in the estuary is less during winter (Appendix Table 1; Fig. 29), the potential for competition for space between juvenile hatchery salmon and other species of fish in the estuary would probably be less if juvenile hatchery salmon were released during winter months. However, food competition and predation by juvenile salmon on larvae and juveniles of the few species of fish present in intertidal areas during winter months, e.g. English sole, surf smelt, staghorn sculpin, would probably be high as most prey species are less abundant in the estuary and nearshore environments during winter months.

Pacific herring, shiner perch, northern anchovy, and surf smelt were the most abundant species at the beach and channel study areas in Yaquina Bay during 1977 and 1978 (Appendix Tables 1 and 3).

These results are somewhat different than other investigations in Yaquina Bay where different sampling gear was used, or where different areas of the estuary were sampled. Bayer (1979), who sampled intertidal areas in Yaquina Bay with a small (3-meter) beach seine, reported shiner perch, surf smelt, staghorn sculpin, and English sole as the most abundant species in eel grass beds and upper intertidal areas, although he suggested that anchovy, herring, and juvenile salmon may have been able to escape from his small beach seine. The greater relative abundance of herring and anchovy found in the present study was, no doubt, due to the size of the beach seine (100-m), which was large enough to completely surround large schools of herring and anchovy, as well as juvenile salmonids, in the intertidal zone. Swartz et al. (1974), who sampled demersal species in channel areas of Yaquina Bay with a bottom trawl, reported snake prickleback (Lumpenus sagitta), buffalo sculpin (Enophrys bison), English sole, starry flounder, and pile perch (Rhacochilus vacca) as the most abundant species. Bayer (1979), in a review of other Oregon estuarine beach seine surveys, found that shiner perch had been reported as the dominant species more often than any other species.

Although relationships between hatchery salmon and other estuarine fish species were not directly observed or quantified, large catches of juvenile hatchery coho and chinook salmon were most often associated with large catches of Pacific herring, northern anchovy, American shad, shiner perch, and surf smelt, and the potential for interactions between hatchery coho and chinook salmon and these species may be higher than for other estuarine species of fish.

A large number of fish, birds, and crustaceans have been identified as real or potential predators and competitors of juvenile chum, coho, and chinook salmon in estuarine and nearshore environments (Iwamoto and Salo 1977, review). Because the stomach contents of species other than salmonids were not examined during this study, little can be said in this regard. However, my impression was that juvenile coho and chinook salmon were the top predators in intertidal and eel grass bed areas of Yaquina Bay. Very few fish species captured at the beach study areas, with the exception of staghorn and buffalo sculpin, had a large enough body or mouth size to consume juvenile coho and chinook salmon, and large staghorn and buffalo sculpin were not common in the catch at the beach study areas (Appendix Tables 1 and 5). Because of their smaller size at release, predation on hatchery salmon by other species of fish in the intertidal zone is likely to be higher when releases of large numbers of juvenile hatchery chum salmon are made.

River lamprey (Lampetra ayresi) has been identified as a predator of juvenile salmon in estuaries where it is common (Miller et al. 1968). Although hatchery coho salmon were sometimes found with scars from lamprey on the dorso-lateral surface near the dorsal fin, these were uncommon, as were river lamprey in the catch at the beach and channel study areas (Appendix Tables 1 and 3).

The primary predators of juvenile coho salmon in the intertidal zone of the estuary appear to be birds, particularly great blue herons (Ardea herodias). Heron were often observed feeding on juvenile salmon near the fish ladder at Oregon Aqua Foods (Site 1), particularly after large releases of juvenile hatchery coho salmon in October 1978. Bayer (1979), who examined the regurgitated stomach contents of great blue herons at a heron colony near Yaquina Bay during summers from 1973-1979, found that herons had eaten juvenile salmon ranging in size from 8.5-32.0 cm.

Because of the extensive examination of the stomach contents of juvenile salmon during the present study, the most apparent relationship between hatchery coho and chinook salmon and other fish species in the estuary was that of hatchery salmon as a predator on other species of fish in the estuary. Over 17 species of larval or juvenile fish were identified in the stomach contents of juvenile coho and chinook salmon in the estuary (Tables 11 and 12). Juvenile Pacific herring, northern anchovy, surf smelt, and whitebait smelt were the most common fish prey species found in the stomach contents of hatchery coho and chinook salmon. Peak periods of abundance of herring, anchovy, and smelt of the size consumed by juvenile coho and chinook salmon (usually $\leq$ 7.0 cm) reported in the present study (Figs. 31, 34, and 36) were similar to those previously reported for Yaquina Bay and other Oregon estuaries (Forsberg *et al*. 1977; Misitano 1977; Bayer 1979).

Although Pacific herring, northern anchovy, surf smelt, and whitebait smelt are presently abundant at the beach study areas in Yaquina Bay (Figs. 30, 32, 33, and 35), it is possible that releases of large numbers of hatchery coho and chinook salmon might result in an increase in predation, and subsequent reduction in populations of these, as well as other, fish species in the estuary. Pacific herring use Yaquina Bay as both a spawning and a feeding ground (Russell 1964; Steinfeld 1972). In addition, tagging studies have shown that Pacific herring form distinct populations that return to the same estuary to spawn (Rounsefell 1930; Stevenson 1955). Because of their apparent dependence on the estuary to complete their life cycle, Paciric herring may be more vulnerable to increased predation in the estuary by hatchery salmon than anchovy or smelt.

Long-term reductions in the abundance of fish prey species in the estuary might have a negative impact on the growth and survival of both hatchery and wild juvenile salmon in the estuary. However, if the abundance of primary fish prey species is not limited by the numbers of hatchery coho and chinook salmon currently allocated for release into Yaquina Bay, release of hatchery salmon during periods when herring, anchovy, and smelt are abundant in the estuary might result, not only in an increase in growth and survival of hatchery salmon, but also in a decrease in predation on less abundant fish prey species. The continued monitoring of the size and relative abundance of all fish species in the estuary as the number of juvenile hatchery salmon released into the estuary increases would be useful in determining the impact, if any, of releases of large numbers of juvenile hatchery salmon on other populations of fish in the estuary.

CONCLUSIONS

Yaquina Bay is important to species of wild juvenile salmonids as both a rearing area and staging area for entrance to the ocean. Wild populations of juvenile coho salmon pass rapidly through Yaquina Bay, and do not make extensive utilization of the estuary as a rearing area. Wild populations of juvenile chum salmon also pass rapidly through Yaquina Bay. However, increase in mean length from March through April 1978 indicates that Yaquina Bay is important as an initial rearing area for wild juvenile chum salmon prior to entrance to the ocean. Wild populations of juvenile fall chinook salmon make extensive utilization of Yaquina Bay, and may be present in the estuary, in varying degrees of abundance, throughout the entire year. Increase in mean length frequencies of wild juvenile chinook salmon from May through October 1978 indicates that at least a portion of the wild population utilizes Yaquina Bay as a rearing area prior to entrance to the ocean. The lack of overlap in peak periods of residence and migration of wild populations of juvenile chum, coho, and chinook salmon in Yaquina Bay during 1978 is indicative of resource partitioning, and suggests the need to minimize interspecific as well as intraspecific interactions between hatchery and wild juvenile salmon in river estuaries.

Juvenile hatchery coho salmon leave Yaquina Bay, either by death or emigration, at an exponential rate. The majority of individuals within a particular release group of juvenile hatchery coho salmon leave the estuary within 1 mo after being released, although a smaller portion remains in the estuary for an extended period of time (1-3 mo). Juvenile hatchery coho that remain in Yaquina Bay feed and grow during their extended period of residence. At least a portion of the individuals within summer release groups of juvenile hatchery chinook salmon also remain in the estuary for an extended period of time (> 2 mo). Groups of juvenile hatchery coho and chinook salmon released into Yaquina Bay earlier in the year (June-August) remained in the estuary for a longer period of time than groups released later in the year (September-October).

Overlap in spatial and temporal utilization of Yaquina Bay by hatchery and wild juvenile salmon and relative abundances of hatchery and wild juvenile salmon was variable, depending, primarily, on time of release and number of juvenile hatchery salmon released into the estuary during 1977 and 1978. At release levels similar to those in 1978 (9 million coho salmon), juvenile hatchery coho salmon can be expected to be more abundant in the lower estuary than all species of wild juvenile salmon during the months in which juvenile hatchery coho salmon are released into the estuary.

Stomach content analyses showed, in many cases, a high degree of overlap in the food habits of hatchery and wild juvenile salmonids in Yaquina Bay, although the degree of overlap was found to vary with species, time, habitat, space, length of estuarine residence of hatchery and wild juvenile salmon, and abundance of prey organisms. In terms of biomass, larval and juvenile fish were the most important prey organisms of hatchery and wild juvenile coho and chinook salmon in Yaquina Bay. Overlap in stomach contents of hatchery and wild juvenile coho and chinook salmon was highest when both groups were feeding on fish, particularly when the prey species was abundant in the estuary.

Yaquina Bay is important, not only as a rearing and staging area for oceanic migrations of anadromous juvenile salmonids, but also as a spawning area, nursery area, and feeding ground for numerous species of fish. Of the 58 species of fish captured in samples taken at the beach and channel study areas in Yaquina Bay during 1977 and 1978, 17 species were identified in the stomach contents of hatchery and wild juvenile salmonids. A decrease in the abundance of principle fish prey species, particularly herring, smelt, and anchovy, may have a negative impact on the growth and survival of both hatchery and wild coho and chinook salmon.

Because studies of wild populations of juvenile salmonids were not conducted prior to releases of large numbers of privately cultured juvenile salmon into Yaquina Bay, there is no way of knowing if these releases have already had an impact on spatial and temporal utilization, food habits, or growth and survival of wild populations of salmonids in the Yaquina system. However, overlap in spatial and temporal utilization and food habits of hatchery and wild juvenile salmon in Yaquina Bay during 1977 and 1978 demonstrates that the potential for competition between hatchery and wild juvenile salmon does exist, should space or food resources become a limiting factor.

Continued monitoring of spatial and temporal utilization, relative abundances, overlap in stomach contents, growth, and survival of hatchery and wild salmon, as well as size and relative abundance of other fish species in the estuary as the number of privately cultured juvenile salmonids released into Yaquina Bay is increased would be useful in determining the impact, if any, of releases of large numbers of privately cultured salmon on wild populations of fish. This would also be useful in determining the level, if any, of hatchery releases at which space or food resources become a limiting factor. However, if releases of large numbers of privately cultured juvenile salmon into river estuaries do have a detrimental impact on wild populations of fish, conclusive biological evidence may not be acquired for many years. Therefore, my opinion as a biologist is that every effort should be made to reduce overlap in spatial and temporal utilization of river estuaries by hatchery and wild juvenile salmonids and to reduce the length of residence of privately cultured juvenile salmon in river estuaries. These efforts should include continued research into the effects of such variables as size of fish, time and location of release, and genetic stock on length of residence of juvenile hatchery salmon in the estuary. To reduce overlap in spatial and temporal utilization of Yaquina Bay by hatchery and wild juvenile salmon, consideration should be given to not releasing large numbers of hatchery salmon during peak periods of residence and migration of wild juvenile salmonids in the lower estuary. To reduce the length of residence of juvenile hatchery coho and chinook salmon released into Yaquina Bay after May of each year, mid to late summer releases should be considered.

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APPENDICES

Appendix Table 1. Monthly catch per unit effort for species of fish captured by beach seine at four beach study sites in Yaquina Bay, Oregon from July 1977 through December 1978.

Family and Species	Site[1]	1977 Jul	1977 Aug	1977 Sep	1977 Oct	1977 Nov	1977 Dec	1978 Jan	1978 Feb	1978 Mar	1978 Apr	1978 May	1978 Jun	1978 Jul	1978 Aug	1978 Sep	1978 Oct	1978 Nov	1978 Dec
Acipenseridae:																			
Acipenser	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
medirostris	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Agonidae:																			
Pallasina	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
barbata	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0.2	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammodytidae:																			
Ammodytes	1	0.1	0	0.1	0	0	0	0	0	0	0.3	1.5a	1.5	0.4	0.3	0	0	0	0
hexapterus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anarhichadidae:																			
Anarrhichthys	1	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
ocellatus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atherinidae:																			
Atherinops	1	0	0	0	2.0	1.2a	0	2.0	0	0	0	5.0	7.9a	0	0	5.3	0.2	4.5	8.0
affinis	2	0.1	2.0	2.0	0.5	2.3a	2.2a	0	0	0	2.0	0	0.5	0.2	3.4	1.2a	0	1.0	1.0
	3	0.8	9.0	9.0	4.5a	--	--	0	0	4.0	1.4a	1.3a	4.0	0.1	8.5	6.1a	6.0a	0	0
	4	5.0	5.7a	3.9a	8.4a	0	0	0	0	0	0	3.2b	2.4a	3.3	1.1b	8.8a	6.0a	1.0	0

Appendix Table 1. (Continued)

Family and Species	Site	Month																	
		1977						1978											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bothidae:																			
Citharichthys	1	0	0	0	0	0	0	0	0	0	0	0	5.3a	2.6a	2.1a	5.6	0	0	1.0
stigmaeus	2	2.0	0.3	0	0	0	0	0	0	0	0	4.0a	1.2b	7.0a	3.9a	1.3	0.2	1.5	0
	3	0.2	0	0	0	--	--	0	0	0.5	0	5.4a	1.4a	1.0a	1.1a	1.1a	4.0	6.5	0
	4	0.2	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
Carangidae:																			
Trachurus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
symmetricus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0
Clupeidae:																			
Alosa	1	0	1.0	0.6	0.3	0	0	0	0	0	0	0	0	0	0.9	2.8	3.5	0	0
sapidissima	2	0	0.2	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0
	3	0	0.2	0.3	0	--	--	0	0	0	0	0	1.5	8.0	0.2	0.8	0	0	0
	4	0.5	2.0	1.0a	2.2a	0	0.5	0	0	0	9.0	2.0	1.7a	7.2	1.3a	1.0a	2.0a	5.0	0
Clupeidae:																			
Clupea	1	1.7d	1.8c	4.2b	1.7c	0	0	0.5	0	0	0	1.4c	1.4b	1.8b	1.7c	9.8b	0	0	0
harengus	2	2.7b	9.0	1.7b	1.5c	3.6b	0	0	0	0	0.3	1.2a	6.8a	7.9a	4.2b	6.0a	0	0	0
pallasi	3	1.0a	2.3a	3.6b	0	--	--	0	4.5b	0	0	4.0	4.8b	1.2b	2.6b	1.4b	0.5	0	0
	4	4.0	1.1b	1.5b	5.0	2.0	0	0	0	0	1.0	4.0	9.8a	2.0	0	1.2	0.2	0	0
Cottidae:																			
Blepsias	1	0	0	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cirrhosus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	1978 Jul	Aug	Sep	Oct	Nov	Dec
Cottidae:																			
Clinocottus	1	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0.3	0.1	0	2.0	1.0
acuticeps	2	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0.2	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottidae:																			
Cottus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
asper	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0.5	0	0	0	0	0.5	1.2	0	0	0	0	0	0
Cottidae:																			
Enophrys	1	2.0	2.0	2.0	0.5	0	0	0	0	0	1.0	1.0a	4.2	1.0a	1.8	0.1	0	0	0
bison	2	0.7	0.3	0.3	0	0	0	0	0	0	1.0	0.5	2.0	5.6	1.9	0	0	0	0
	3	0	0	0.3	0.5	--	--	0	0	0.5	3.0	0	0	0	0	0.8	1.5	0.5	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottidae:																			
Hemilepidotus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
hemilepidotus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0.2	0.3	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottidae:																			
Leptocottus	1	8.0	8.0	8.0	4.0	2.0	0.5	0.5	5.0	2.0	6.0	2.5a	9.8a	2.2a	2.4a	6.4	0.8	0.5	2.0
armatus	2	2.3a	1.0a	1.0a	1.1a	7.0	1.1a	2.0	1.4a	5.3a	4.7a	5.2a	7.7a	3.8a	2.8a	7.7	4.5	1.2a	7.0
	3	1.0a	4.0	1.5a	6.0	--	--	0	2.0	6.0	1.0a	2.9a	2.0a	1.8a	3.1a	9.2	6.0	2.0	6.0
	4	8.0	1.0a	6.0	8.0	7.0	1.4a	3.8a	8.2a	5.9a	1.7a	2.5a	1.0a	1.6a	1.5a	1.6a	9.2	6.5	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	1977 Aug	1977 Sep	1977 Oct	1977 Nov	1977 Dec	1978 Jan	1978 Feb	1978 Mar	1978 Apr	1978 May	1978 Jun	1978 Jul	1978 Aug	1978 Sep	1978 Oct	1978 Nov	1978 Dec
Cottidae:																			
Oligocottus	1	0	0	0	0	0	0	0	0	0	0	0	3.8	0.1	0	0	0	0	0
maculosus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0.2	0	0	0	--	--	0	0	0	0.5	0	3.5	0.1	0	0	0	0.5	1.0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottidae:																			
Scorpaenichthys	1	0.7	2.0	1.0	0	0	1.0	0.5	0	2.0	2.0	5.0a	6.6a	1.3a	1.2a	4.8	0	1.0	0
marmoratus	2	0.6	0.3	0.3	0	0	0	0	0	0	0.7	6.0	9.5	9.0	9.7	0.2	0.2	0	0
	3	0.3	1.0	0.3	2.0	--	--	0	0	1.0	0.5	0	2.0	2.6	2.5	4.6	1.0	2.0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprinodontidae:																			
Lucania	1	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0
parva	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Embiotocidae:																			
Amphistichus	1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rhodoterus	2	0.4	0	0	0	0	0	0.5	0	0	0	0	0.2	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Embiotocidae:																			
Cymatogaster	1	2.9b	1.1c	6.8b	5.2b	7.0	0	0	0	2.0	0.3	3.9c	1.8c	3.7c	2.9c	3.0b	1.5b	1.0a	0
aggregata	2	1.8b	2.2b	2.0b	3.8b	4.0	1.0	2.0	0	0	3.0	4.9a	8.3b	2.9c	2.7c	2.2b	4.8	0.5	0
	3	7.2b	2.7b	5.1b	1.3b	--	--	0	0	0	0	6.8a	2.9b	2.0c	1.7c	3.2b	5.5	0	0
	4	2.5b	1.2b	6.2a	1.0b	0	0	0	0	0	1.0	3.8b	6.0b	3.1b	1.8b	1.1b	9.1a	1.0	0

Appendix Table 1. (Continued)

Family and Species	Site	Month																	
		1977						1978											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Embiotocidae:																			
<u>Embiotoca</u>	1	3.2a	3.7a	2.0	1.0	1.0	1.0	0	0	0	0.7	5.0	4.9b	1.1b	7.6a	1.5a	2.0	0.5	1.1a
<u>lateralis</u>	2	1.1a	1.6a	2.0	2.0	2.0	3.0	4.0	0	0	0	5.0	1.0b	8.3a	8.3a	9.8	0.5	1.0	0
	3	9.0a	5.2a	3.3a	2.1a		--	--	0	0	0.5	0	3.1a	2.9a	2.6a	1.1a	7.0	0.5	0
	4	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
Embiotocidae:																			
<u>Hyperprosopon</u>	1	0.1	0.2	0.5	5.0	0	0	0	0	0	0	4.0a	0	0	0	0.1	0	0	0
<u>argenteum</u>	2	0.1	0.7	0.3	8.0	1.8a	0	0	0	0	0	1.0	7.5	4.8	8.4	0	0	0	0
	3	0.2	2.0	0.3	1.0	--	--	0	0	0	0	0	6.0	2.9a	1.3a	7.6	0.5	0	0
	4	0	0	0	4.0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
Embiotocidae:																			
<u>Hyperprosopon</u>	1	0.1	0.2	0.5	0	0	0	0	0	0	0	0	1.9a	4.4	2.6a	1.2a	1.2	0	0
<u>ellipticum</u>	2	0.2	0.2	3.0	0	1.8a	0	0	0	0	0	0	1.0	3.2	3.4a	9.3	0.2	0	0
	3	1.0	0.2	0.8	0	--	--	0	0	0	0	0	9.5	3.8a	6.7	3.2	2.0	0	0
	4	3.0	5.0	1.0	0	0	0	0	0	0	0	0	2.1a	3.3	6.2	2.1	1.5	0	0
Embiotocidae:																			
<u>Phanerodon</u>	1	1.9a	1.6a	8.0	1.2a	3.0	3.0	1.0	2.0	0	1.0	2.5a	2.9a	4.3	1.4a	9.1	7.2	0	4.0
<u>furcatus</u>	2	4.0	4.0	1.0	6.0	3.0	3.0	5.0	0	0	0	3.0	1.2a	1.8a	1.0a	0.2	0.2	0	2.0
	3	5.0	5.0	1.0a	2.0	--	--	0	0	0	0	3.0	1.0	1.3a	7.5	7.0	6.5	0	0
	4	1.4a	7.0	1.0	5.0	0	0	0	0	0	0.7	5.0	2.5	1.7a	8.0	4.6	0.8	0	0
Embiotocidae:																			
<u>Rhacochilus</u>	1	0	1.6a	3.0	4.0	0	3.0	0	0	0	0	3.5a	2.0a	2.7a	9.1a	1.9a	0.8	0	0
<u>vacca</u>	2	0.2	6.0	3.0	7.0	2.0	0	0	0	0	0	0	1.2a	4.3a	4.6a	3.0	0	0	0
	3	0	1.1a	5.0	2.0	--	--	0	0	0	0	0	1.0	1.7a	1.4a	3.8	1.5	0	0
	4	0	0.5	0.3	0.3	0	0	0	0	0	0	0	1.0	2.6a	1.6a	3.2	0.5	0	0

Appendix Table 1. (Continued)

Family and Species	Site	Jul 1977	Aug	Sep	Oct	Nov	Dec	Jan 1978	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Engraulidae:																			
Engraulis	1	3.6a	5.0	1.0	5.3a	0	0	0	0	0	0	2.0a	3.8	0	6.6b	8.5c	0	0	0
mordax	2	2.0	2.0	0	1.3a	0	0	0	0	0	0	0	0	3.4	1.6a	8.8b	6.8	0	0
	3	0.2	0.2	0	0	--	--	0	0	0	0	0	1.3a	1.8a	4.0	2.0d	1.5	0	0
	4	3.3a	2.3a	3.9b	1.4c	0.5	0	0	0	0	0	0	1.3b	1.2c	4.8b	1.1b	1.4c	1.0	0
Gadidae:																			
Microgadus	1	0.1	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0.6	0	0	0
proximus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasterosteidae:																			
Aulorhynchus	1	0	0	0	0	3.0	2.6a	0	0	1.0	4.0	6.5a	2.6a	1.3a	1.2a	2.0	4.5	2.0	0
flavidus	2	0	0	0	0	0	2.2a	3.0a	2.0	0	1.0	8.0	4.2	1.3a	6.0a	0.8	5.8	1.5	4.0
	3	0	0	0	0	--	--	0	0	0	0	0	2.0	0.4	0.8	0.6	3.5	5.0	1.0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasterosteidae:																			
Gasterosteus	1	0	0	0	0	0	1.9a	0.5	0	0	0	0	0	0.1	1.4	0	0	1.0	0
aculeatus	2	0.2	0	0	0	0	0.5	0	0	0	0	0	0	2.2	3.3	0.7	0	0.5	0
	3	0	0	0	0	--	--	1.0	0	0	0	0	0	0.3	0.5	0	1.0	0.5	0
	4	2.0	2.0	0.6	0	2.0	2.0a	4.0	1.0	0	0	4.0	1.2	1.5	6.0	2.2	0.5	0.5	1.0
Gobiidae:																			
Clevelandia	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ios	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
	3	0	0.2	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0.2	0.6	6.0	0	0	0	0	0	0	0	0	0	1.0	2.7	2.1	0.2	0	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gobiidae:																			
Coryphopterus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nicholsi	2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexagrammidae:																			
Hexagrammos	1	1.0	4.0	2.0	0	2.0	0	0	0	1.0	2.0	3.5a	6.4a	2.7a	1.0a	5.6	1.0	4.5	0
decagrammus	2	4.0	2.0	0.2	0	0	0	0	0	0	2.0	9.0	3.4a	1.4a	1.4a	1.3	0	0.5	0
	3	1.0	0	0.3	2.0	--	--	0	0	0	0.5	0	4.5	0.7	0.7	0.8	6.0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexagrammidae:																			
Hexagrammos	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lagocephalus	2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexagrammidae:																			
Ophiodon	1	0.3	0	0	0	0	0	0	0	0	0.7	5.0	7.3a	7.4	0.8	0	0	0	0
elongatus	2	2.0	0.4	0	0	0	0	0	0	0	0.7	8.0	1.3a	5.0	0.8	0	0	0	0
	3	0.2	0.2	0	0	--	--	0	0	0	0.5	2.0	2.0	3.4	2.2	0.2	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ictaluridae:																			
Ictalurus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nebulosus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Osmeridae:																			
Allosmerus	1	0.1	2.8a	1.9a	8.6a	9.0	0	0	0	0	0	0	0	4.3b	2.8b	0	0	0	0
elongatus	2	0	0	0	0	1.0	0	0	0	0	0	0	0	0.4	2.3b	0	0	0.5	2.0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Osmeridae:																			
Hypomesus	1	7.8b	1.7c	1.6b	3.5a	1.0	5.6a	4.6b	1.9b	1.0b	2.4c	1.7d	1.4d	2.5c	1.1c	4.8a	2.1a	1.1a	0
pretiosus	2	4.9b	1.2b	8.5a	5.6a	0.5	6.3a	1.2c	7.3b	1.4c	5.6c	2.4c	6.5b	5.6b	1.2b	2.2	0.2	1.0	0
	3	8.2a	6.8a	3.0	1.0	--	--	5.0a	2.8b	7.7a	1.3b	0	3.1b	1.0b	3.7	4.8	1.5	7.6a	0
	4	7.1a	3.9a	4.4a	1.2a	1.2b	0	1.4b	6.1b	9.4c	8.0	1.4b	1.1a	8.3	0.4	6.5	7.5	8.0	3.0
Osmeridae:																			
Osmerus	1	0	0	0	0	0	0	0	0	0	0	0	0	3.0	1.0a	0.1	0	0	0
mordax	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petromyzontidae:																			
Lampetra	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ayresi	2	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0.2	0	0.1	0.3	0	0	0	0	0	0	0	0.8	0.3	0	0	0	0	0
Pholidae:																			
Apodichthys	1	0.2	2.0	2.0	2.0	0	1.0	0	0	0	0.3	4.0	7.2	7.8	3.8	1.5	0	1.0	0
flavidus	2	0	0.1	0	0.3	0	0	0.5	0	0	0	0.5	2.2	2.1	1.5	0.2	0	0	0
	3	0.3	1.0	0.5	1.0	--	--	0	0	0	0	3.0	1.5	1.0	2.2	1.6	1.5	2.5	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pholidae:																			
Pholis	1	0.1	0	0	0	0	0	0	0	0.5	0.3	1.0	3.8	1.3	3.8	0.1	0	0	0
ornata	2	0.8	1.0	8.0	1.0a	0.5	0	0	1.0	0	0.7	8.8a	3.7a	3.1a	4.0a	3.7	0.8	0	0
	3	3.0	2.0	1.0	0	--	--	0	0	0	0.5	8.0	1.4a	9.3	9.2	7.4	3.5	1.5	0
	4	0.7	0.4	0.1	0.3	0	0	0	0	0	0	1.0	0	0.2	0.1	0	0.8	0	0
Pleuronectidae:																			
Parophrys	1	5.0	8.0	1.0	1.0	0.5	1.0a	5.0	8.0	3.1a	1.5a	1.5a	3.2a	8.8	1.5a	4.9	0	0	0
vetulus	2	6.0	6.0	3.0	4.0	1.0	3.4a	3.0	1.8a	8.6a	1.3a	5.4a	7.0a	2.7a	3.2a	1.0a	2.2	3.0	7.0
	3	2.5a	1.0a	2.0a	6.0	--	--	1.5a	3.2a	5.4a	3.0b	9.0	3.0a	2.6a	4.4a	3.7a	4.5	5.2a	4.5a
	4	8.0	4.0	1.0	4.0	0.5	0	5.0	6.0	8.4a	1.5a	6.4a	1.5a	2.0a	4.2	3.1	2.2	2.1b	1.6b
Pleuronectidae:																			
Platichthys	1	1.0	0.8	0	0.3	1.0	1.0a	2.0	2.0	2.0	3.0	5.0	9.0	0.4	0.7	0.1	0	0	1.0
stellatus	2	2.0	0.4	0.3	0.3	2.0	8.0	3.8a	1.8a	1.0	2.0	9.0	1.1a	6.1	8.3	1.3	0.5	2.5	3.0
	3	4.0	2.0	2.0	3.0	--	--	1.2a	2.0	1.0	4.0	2.2a	1.1a	4.0	2.3	1.0	1.5	2.5	0
	4	1.9a	1.1a	1.7a	1.0a	2.1a	2.1a	1.9a	5.8a	1.0a	2.0	4.0	3.2	1.6a	1.5a	6.4	8.0	7.5	0
Pleuronectidae:																			
Psettichthys	1	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0.3	0	0	0	0
melanostictus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonidae:[2]																			
Oncorhynchus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
gorbuscha	2	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Salmonidae:																			
Oncorhynchus	1	0	0	0	0	0	0	0	0	0	3.0	0	0	0	0	0	0	0	0
keta	2	0	0	0	0	0	0	0	0	3.0	1.9a	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	1.5	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	1.5a	8.7	0	0	0	0	0	0	0	0
Salmonidae:																			
Oncorhynchus	1	1.8b	1.1a	1.6	0.2	0	0	0	0	0.5	5.0	2.3	1.2b	3.4b	4.5b	2.9b	1.6a	0	0
kisutch	2	3.6a	3.8	0.2	0	1.0	0	1.0	0	0	8.3	1.0a	3.6a	1.4a	9.9a	2.7a	4.0	0	0
	3	2.2a	1.4a	2.2	3.0	--	--	0	0	0	2.5	0	5.4a	1.3a	1.6a	1.4a	2.5	0	0
	4	1.1	0	0	0	0	0	0	0	0	1.5a	2.0	1.2	2.0	3.6	1.5a	2.2	1.0	0
Salmonidae:																			
Oncorhynchus	1	4.2	1.9	8.0	0.8	0.5	0	0	0	0	0	0	9.0	2.7a	3.6a	1.2a	7.8	1.1a	0
tshawytscha	2	3.1	3.4	1.0	0	1.0	0	1.5	0	0	0	0	9.0	3.4a	1.5a	3.3	2.5	3.5	0
	3	4.9a	2.6a	7.0	7.5	--	--	0	0	0	0	0	7.8a	1.4b	8.7a	3.1a	3.4a	6.0a	1.0
	4	4.7	1.2	1.8	1.8	0	0	0	0	0	0.3	1.2a	4.5	9.0	3.6	1.2	9.5	3.0a	0
Salmonidae:																			
Salmo	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
clarki	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0.5	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0.7	0	1.0	0	0	0	0	0	0
Salmonidae:																			
Salmo	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
gairdneri	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Scorpaenidae:																			
Sebastes	1	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.7	0.4	0	0	0
caurinus	2	0.1	0.1	0	0.8	0	0	0	0	0	0	0	0	1.2	5.3	0	0	0	0
	3	0	0	2.0	7.0	--	--	0	0	0	0	0	0	0.1	1.8	0.4	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scorpaenidae:																			
Sebastes	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
diploproa	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0.5	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scorpaenidae:																			
Sebastes	1	2.8a	9.0a	3.7a	2.8	0	0	0	0	0	0	0	3.9b	8.3a	4.8a	4.0a	0	0	0
melanops	2	1.0a	1.9a	1.0	5.8	0	0	0	0	0	0	0	3.4a	3.5a	1.2a	5.0	0	0	0
	3	0.2	5.0	8.0	1.6a	--	--	0	0	0	0	0	0	1.4	5.7	2.1a	5.0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scorpaenidae:																			
Sebastes	1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mystinus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scorpaenidae:																			
Sebastes	1	0	0	0	0	0	0	0	0	2.0	2.0	1.5a	3.0a	1.3	0.5	0.1	0	0	0
paucispinis	2	0	0	0	0	0	0	0	0	0	0	3.0	1.8	2.8	2.9	0	0	0	0
	3	0	0	0	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 1. (Continued)

Family and Species	Site	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stichaeidae:																			
Lumpenus sagitta	1	2.0	8.0	0.6	0	0	0	0	0	0	0	0	1.2	5.6	4.0	2.0	0	0	0
	2	4.5a	4.1a	6.0	0.2	0	0	0	0	0	0	4.0	8.8a	3.5a	5.5a	0.3	0	0	0
	3	1.1a	3.0	9.0	1.5	--	--	0	0	0	0	4.0	1.0a	5.3	2.9a	3.4a	2.0	0	0
	4	0	0	0.3	0.8	0	0	0	0	0	0	4.0	0	0	0	0.2	0	0	0
Syngnathidae:																			
Syngnathus griseolineatus	1	0.3	1.0	2.0	0.3	1.0	1.8a	0.5	0	1.1a	7.0	0	5.8	2.3	3.0	6.2	0.5	6.0	4.0
	2	0.5	0.3	0.5	0	0.5	4.0	1.1a	2.0	0	0	4.0	8.5	5.6	7.8	1.8	1.2	3.0	1.2a
	3	0	0	0.3	0.5	--	--	2.0	0.5	0	0	1.0	0	1.1	2.2	2.8	2.5	1.5	1.0
	4	0.2	0	0.1	0.3	0.5	0	0	0	0	1.0	3.0	3.2	1.3	0.8	0.4	1.5	0	0

[1] Site 1 is at 3.1 river km, Site 2 is at 3.8 river km, Site 3 is at 5.1 river km, and Site 4 is at 16.1 river km from the mouth of the bay.

[2] Monthly catch per unit effort for species in the family Salmonidae represents the combined catch of both hatchery and wild fish. Tabled values represent the catch of juvenile salmonids only.

[a] Multiply tabled value by 10^1 to obtain value of catch per unit effort.

[b] Multiply tabled value by 10^2 to obtain value of catch per unit effort.

[c] Multiply tabled value by 10^3 to obtain value of catch per unit effort.

[d] Multiply tabled value by 10^4 to obtain value of catch per unit effort.

Appendix Table 2. Monthly sampling effort at 4 beach study sites in Yaquina Bay, Oregon from July 1977 through December 1978. One set of the beach seine is equal to one unit of effort.

Month[1] and Year	Site 1	2	3	4
07/77	12	12	6	11
08/77	9	9	6	8
09/77	8	6	4	8
10/77	4	4	2	4
11/77	2	2	0	2
12/77	2	2	0	2
01/78	2	2	1	2
02/78	2	2	2	2
03/78	2	2	2	2
04/78	3	3	2	3
05/78	2	2	1	2
06/78	4	4	2	4
07/78	8	8	7	6
08/78	9	9	6	9
09/78	8	6	5	8
10/78	4	4	2	4
11/78	2	2	2	2
12/78	1	1	1	1

[1]Each unit of sampling effort was expended at 3 or 4 day intervals in July, August, and September, 1 week intervals in June and October, and 2 week intervals during the remaining months.

Appendix Table 3. Monthly catch per unit effort of species of fish captured by lampara net at two channel study sites in Yaquina Bay, Oregon from March through October 1978.

Family and Species	Site[1]	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Agonidae:									
Pallasina	5	0	0	0	0	0	0	0	0
barbata	6	0	0	0	0	0	0	0.5	0
Anarhichichadidae:									
Anarrhichthys	5	0	0	0	0	0	0	0	0
ocellatus	6	0	0	0	0	0	0	0	0.5
Atherinidae:									
Atherinops	5	0	0	0	0	0	0	0	0
affinis	6	0	0	0	0	0	2.0	2.0	0
Bothidae:									
Citharichthys	5	0	0	0	0	1.5	0	0	0
stigmaeus	6	0	0	0	0	0	0	0	0
Clupeidae:									
Alosa	5	0	0	2.0	1.5	8.0	14.0	3.5	58.5
sapidissima	6	0	0	0	0	0	0.5	0	111.5
Clupeidae:									
Clupea harengus	5	12.0	2500.0	281.0	1145.5	200.0	49.0	6.5	311.0
pallasi	6	0	0	117.0	4900.0	4900.0	6675.0	11.0	165.5
Cottidae:									
Enophrys	5	0	0	0.3	0	0	0	0	0
bison	6	0	0	0	0	0	0	0	0.5

Appendix Table 3. (Continued)

Family and Species	Site	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
					Month				
Cottidae:									
<u>Leptocottus</u>	5	0	0	0	0	0	1.5	0	0
<u>armatus</u>	6	0	0	0	0	0	0	0	0
Embiotocidae:									
<u>Cymatogaster</u>	5	0	0	67.0	167.0	125.0	153.0	135.0	52.0
<u>aggregata</u>	6	0	0	0	0	0	0.5	0.5	2800.5
Embiotocidae:									
<u>Embiotoca</u>	5	0	0	0	0	0	4.5	1.5	0
<u>lateralis</u>	6	0	0	0	0	0	0	0	0
Embiotocidae:									
<u>Hyperprosopon</u>	5	0	0	0	3.0	2.5	1.5	0	0
<u>argenteum</u>	6	0	0	0	0	0	0	0	0
Embiotocidae:									
<u>Phanerodon</u>	5	0	0	12.0	0	1.5	5.0	25.0	0
<u>furcatus</u>	6	0	0	0	0	1.0	0	0	0
Embiotocidae:									
<u>Rhacochilus</u>	5	0	0	1.0	0	1.0	0	2.5	0
<u>vacca</u>	6	0	0	0	0	0	0	0	0
Engraulidae:									
<u>Engraulis</u>	5	0	0	5.0	135.5	1200.00	3575.0	0	126.0
<u>mordax</u>	6	0	0	1.0	0.5	3.0	0	0	0.5

Appendix Table 3. (Continued)

Family and Species	Site	Month Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Gadidae:									
Microgadus	5	0	0	0	0	2.5	0	0	0
proximus	6	0	0	0.3	0	0	0	0	0
Hexagrammidae:									
Ophiodon	5	19.0	0	0.7	0	0	0	0	0
elongatus	6	0	0	5.0	0	0	0	0	0
Osmeridae:									
Hypomesus	5	8.0	34.0	147.0	25.5	0.5	1.0	0	283.0
pretiosus	6	0	7.0	829.0	149.5	600.0	122.0	0	609.0
Osmeridae:									
Osmerus	5	0	0	0	0	0	2.0	0	0
mordax	6	0	0	0	0	0	0.5	0	0
Petromyzontidae:									
Lampetra	5	0	0	1.0	1.0	4.0	5.5	0.5	0.5
ayresi	6	0	0	0.7	0	0	0	0	0
Pleuronectidae:									
Parophrys	5	0	0	1.0	0	3.0	0.5	0	0
vetulus	6	0	0	0	0	0	0.5	0	1.5
Pleuronectidae:									
Platichthys	5	0	0	0.3	1.0	0	0.5	0	0
stellatus	6	0	0	0	0	0.5	2.0	0	0

Appendix Table 3. (Continued)

Family and Species	Site	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
					Month				
Pleuronectidae:									
Psettichthys	5	0	0	0	0	0.5	0	0	0
melanostictus	6	0	0	0	0	0	0	0	0
Salmonidae:[2]									
Oncorhynchus	5	0	5.0	1.0	27.5	16.0	29.5	5.5	1.0
kisutch	6	0	2.0	3.0	11.0	17.5	13.0	29.0	6.0
Salmonidae:									
Oncorhynchus	5	0	0	0	1.5	10.5	1.0	16.5	55.5
tshawytscha	6	0	0	0	6.5	10.0	15.5	31.5	101.0
Salmonidae:									
Salmo	5	0	0	0.3	0	0	0	0	0
clarki	6	0	0	0	0	0	0	0	0
Salmonidae:									
Salmo	5	0	2.0	0	0	0	0	0	0
gairdneri	6	0	0	0	0.5	0	0	0	0
Scorpaenidae:									
Sebastes	5	0	0	0.7	1.0	0	0	0	0
melanops	6	0	0	0	0	0	0	0	0
Scorpaenidae:									
Sebastes	5	0	0	0.2	0	0	0	0	0
miniatus	6	0	0	0	0	0	0	0	0

Appendix Table 3. (Continued)

Family and Species	Site	Month Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Stichaeidae:									
Lumpenus	5	0	0	0	0	3.5	0.5	2.0	1.5
sagitta	6	0	0	0	0	0	0	0	0.5
Syngnathidae:									
Syngnathus	5	0	0	0	0	0	0.5	0	0
griseolineatus	6	0	0	0	0	0	0	0	0

[1] Site 5 is at 8.8 river km and Site 6 is at 3.4 river km from the mouth of the bay.

[2] Monthly catch per unit effort for species in the family Salmonidae represents the combined catch of both hatchery and wild fish. Tabled values represent the catch of juvenile salmonids only.

Appendix Table 4. Monthly sampling effort at 2 channel sites in Yaquina Bay, Oregon from March 1978 through October 1978. One set of the lampara net is equal to one unit of effort.

	Site	
Month[1]	5	6
March	2	2
April	1	1
May	3	3
June	2	2
July	2	2
August	2	2
September	2	2
October	2	2

[1]Each unit of sampling effort was expended at approximately 2 week intervals from March through October 1978.

Appendix Table 5. Monthly sample size, mean length, standard deviation, and range of lengths of species of fish captured by beach seine in Yaquina Bay, Oregon from July 1977 through December 1978.

Family and Species	[1]Variable	1977 Jul	1977 Aug	1977 Sep	1977 Oct	1977 Nov	1977 Dec	1978 Jan	1978 Feb	1978 Mar	1978 Apr	1978 May	1978 Jun	1978 Jul	1978 Aug	1978 Sep	1978 Oct	1978 Nov	1978 Dec
Acipenseridae:																			
Acipenser	n		1													1			
medirostris	$\bar{x}$*		454													430			
	s		--													--			
	r		--													--			
Agonidae:	n															2			
Pallasina	$\bar{x}$															89			
barbata	s															13			
	r															80-98			
Ammodytidae:																			
Ammodytes	n	1		1							1	3	1	3	1				
hexapterus	$\bar{x}$	82		129							80	110	79	84	82				
	s	--		--							--	9	--	16	--				
	r	--		--							--	100-115	--	71-102	--				
Anarhichadidae:																			
Anarrhichthys	n								1										
ocellatus	$\bar{x}$								600										
	s								--										
	r								--										

Appendix Table 5. (Continued)

Family and Species	[1]Variable	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Atherinidae:																			
Atherinops	n	58	197	157	115	55	65	3		9	26	54	103	84	199	328	129	13	9
affinis	$\bar{x}$	150	127	152	132	158	95	66		266	231	118	125	111	118	142	138	105	81
	s	66	70	70	64	60	50	9		22	35	68	51	42	70	72	86	43	14
	r	31-	40-	44-	35-	57-	36-	55-		230-	188-	69-	44-	22-	34-	39-	50-	65-	62-
		291	374	300	261	273	250	73		300	290	395	315	275	298	314	318	235	97
Bothidae:																			
Citharichthys	n	27	4	1								45	105	228	147	91	9	17	1
stigmaeus	$\bar{x}$	80	102	52								57	74	75	77	68	48	56	76
	s	26	20	--								14	14	12	13	11	20	20	--
	r	21-	76-	--								31-	40-	40-	46-	46-	32-	20-	--
		110	122	--								142	145	104	107	107	75	87	
Carangidae:																			
Trachurus	n																1		
symmetricus	$\bar{x}$																149		
	s																--		
	r																--		
Clupeidae:																			
Alosa	n	6	30	55	55		1				28	5	33	59	54	106	66	10	
sapidissima	$\bar{x}$	140	154	113	73		72				101	116	185	173	162	90	84	66	
	s	10	21	55	25		--				12	23	58	29	30	48	24	7	
	r	125-	63-	42-	45-		--				81-	89-	70-	117-	55-	49-	56-	52-	
		150	182	183	180						120	152	270	262	223	246	192	77	

Appendix Table 5. (Continued)

Family and Species	[1]Variable	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Clupeidae:																			
Clupea harengus pallasi	n	198	371	281	145	24		1	20		4	61	133	294	360	256	15		
	$\bar{x}$	121	100	63	78	76		210	188		85	95	92	99	95	96	92		
	s	42	45	10	10	13		--	17		52	56	40	35	23	19	10		
	r	28-275	40-221	40-100	56-150	39-87		--	163-215		39-130	33-215	29-190	42-197	64-188	46-181	70-102		
Cottidae:																			
Blepsias cirrhosus	n			3	1														
	$\bar{x}$			58	100														
	s			3	--														
	r			55-61	--														
Cottidae:																			
Clinocottus acuticeps	n					1	1								1	1	1	4	1
	$\bar{x}$					32	30								20	27	31	31	37
	s					--	--								--	--	--	3	--
	r					--	--								--	--	--	28-35	--
Cottidae:																			
Cottus asper	n						1					1	4						
	$\bar{x}$						84					80	101						
	s						--					--	21						
	r						--					--	70-112						

Appendix Table 5. (Continued)

Family and Species	[1]Variable	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cottidae:																			
Enophrys	n	32	23	13	3					1	10	3	11	24	8	5	3	1	
bison	$\bar{x}$	196	179	190	158					55	37	104	113	175	183	77	92	140	
	s	47	41	43	43					--	37	105	34	50	48	50	30	--	
	r	100-	103-	100-	110-					--	10-	35-	73-	56-	136-	40-	62-	--	
		265	235	240	190						105	225	178	240	288	136	121		
Cottidae:																			
Hemilepidotus	n		1	1															
hemilepidotus	$\bar{x}$		47	54															
	s		--	--															
	r		--	--															
Cottidae:																			
Leptocottus	n	336	253	198	88	30	48	44	74	89	147	115	207	280	336	239	69	44	15
armatus	$\bar{x}$	109	118	124	121	104	39	53	63	68	62	84	97	105	116	116	111	100	99
	s	36	43	37	38	40	26	40	56	47	27	26	33	29	34	34	37	33	55
	r	47-	49-	50-	50-	30-	15-	13-	18-	35-	12-	45-	38-	40-	51-	57-	52-	34-	31-
		237	255	232	230	214	95	230	220	220	220	168	240	200	222	222	251	162	209
Cottidae:																			
Oligocottus	n										1		8	2				1	1
maculosus	$\bar{x}$										39		58	78				46	34
	s										--		6	11				--	--
	r										--		50-	70-				--	--
													66	86					

Appendix Table 5. (Continued)

Family and Species	Variable[1]	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cottidae:																			
Scorpaenichthys marmoratus	n	16	25	8	4		2	1		7	9	17	63	66	70	62	3	6	
	$\bar{x}$	114	110	116	85		45	37		38	51	57	67	76	89	85	98	75	
	s	48	38	10	42		14	--		6	13	29	22	24	30	34	26	21	
	r	45-260	21-207	105-130	46-145		35-55	--		33-50	35-80	22-130	37-127	36-116	37-148	30-207	68 114	48-110	
Cyprinodontidae:																			
Lucania parva	n						3												
	$\bar{x}$						24												
	s						1												
	r						23-25												
Embiotocidae:																			
Amphistichus rhodoterus	n	6	1					1					1						
	$\bar{x}$	152	250					235					225						
	s	19	--					--					--						
	r	118-174	--					--					--						
Embiotocidae:																			
Cymatogaster aggregata	n	646	622	422	189	22	5	3		3	12	147	273	597	704	535	145	23	
	$\bar{x}$	69	66	61	68	64	68	66		97	105	94	77	63	62	68	71	68	
	s	24	19	10	13	9	6	2		35	18	18	29	22	16	14	10	9	
	r	28-124	34-132	45-108	45-128	57-87	62-75	63-68		60-129	73-138	55-128	30-170	34-120	43-126	46-122	55-133	62-106	

Appendix Table 5. (Continued)

Family and Species	Variable[1]	1977 Jul	1977 Aug	1977 Sep	1977 Oct	1977 Nov	1977 Dec	1978 Jan	1978 Feb	1978 Mar	1978 Apr	1978 May	1978 Jun	1978 Jul	1978 Aug	1978 Sep	1978 Oct	1978 Nov	1978 Dec
Embiotocidae:																			
Embiotoca lateralis	n	265	361	59	46	5	7	8			4	11	175	378	242	156	24	5	11
	$\bar{x}$	84	86	101	86	113	190	203			192	164	73	67	83	86	110	174	249
	s	52	49	53	36	57	75	46			46	75	43	19	46	37	52	81	26
	r	40-298	50-280	68-245	75-250	45-211	90-260	100-250			128-230	55-252	23-285	47-275	57-285	57-260	70-265	84-265	210-282
Embiotocidae:																			
Hyperprosopon argenteum	n	23	67	68	34	20						10	73	76	105	132	16		
	$\bar{x}$	64	89	111	87	86						148	69	69	93	113	144		
	s	27	41	46	19	7						32	34	30	43	45	55		
	r	45-183	55-190	57-254	73-145	70-98						115-200	50-205	52-225	52-240	66-222	86-237		
Embiotocidae:																			
Hyperprosopon ellipticum	n	4	22	7									27	92	70	27	1		
	$\bar{x}$	52	85	73									47	56	62	72	90		
	s	7	35	11									4	12	15	6	--		
	r	46-62	48-224	60-95									60-95	47-166	43-158	57-77	--		
Embiotocidae:																			
Phanerodon furcatus	n	240	158	64	54	10	10	12	5		5	24	42	159	123	101	40		6
	$\bar{x}$	131	96	79	105	150	164	178	182		212	202	159	99	105	93	102		220
	s	80	54	20	51	64	52	40	98		12	52	65	66	65	33	40		21
	r	35-345	45-260	28-140	65-250	83-225	80-230	132-246	164-255		190-220	105-255	52-252	56-258	32-340	67-232	80-249		199-258

Appendix Table 5. (Continued)

Family and Species	[1]Variable	1977 Jul	1977 Aug	1977 Sep	1977 Oct	1977 Nov	1977 Dec	1978 Jan	1978 Feb	1978 Mar	1978 Apr	1978 May	1978 Jun	1978 Jul	1978 Aug	1978 Sep	1978 Oct	1978 Nov	1978 Dec
Embiotocidae:																			
<u>Rhacochilus</u>	n	4	199	57	24	3	5					7	23	225	348	139	8		
<u>vacca</u>	$\bar{x}$	60	142	95	89	166	280					113	135	92	84	89	201		
	s	9	86	49	35	138	38					8	60	51	36	36	116		
	r	53-68	60-340	66-335	70-250	84-326	220-325					98-122	60-335	53-320	56-312	66-356	84-354		
Engraulidae:																			
<u>Engraulis</u>	n	98	96	92	65	1						4	71	93	196	207	110	2	
<u>mordax</u>	$\bar{x}$	76	92	44	53	43						50	60	58	58	47	52	46	
	s	14	18	14	19	--						4	8	26	24	20	15	2	
	r	50-129	40-150	15-110	35-170	--						47-56	44-89	27-107	32-140	27-124	34-92	44-47	
Gadidae:																			
<u>Microgadus</u>	n	1			2									1	1	5			
<u>proximus</u>	$\bar{x}$	67			72									152	60	88			
	s	--			4									--	--	13			
	r	--			70-75									--	--	76-104			
Gasterosteidae:																			
<u>Aulorhynchus</u>	n					5	61	41	4	2	14	29	39	49	94	10	47	17	5
<u>flavidus</u>	$\bar{x}$					121	129	139	102	142	141	147	115	120	131	133	112	119	128
	s					6	23	25	48	4	17	17	29	29	27	24	17	17	8
	r					114-128	45-170	45-175	30-135	140-145	105-170	122-175	70-160	76-166	52-175	110-175	87-160	100-160	118-141

Appendix Table 5. (Continued)

Family and Species	[1]Variable	Month 1977 Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	1978 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gasterosteidae:																			
Gasterosteus	n	22	12	5		4	72	9	2			7	4	11	48	12	4	4	1
aculeatus	$\bar{x}$	44	49	33		40	35	42	26			40	46	44	45	43	39	36	37
	s	11	9	16		9	9	12	6			7	15	13	10	7	10	14	
	r	25-60	32-62	15-58		30-50	20-65	18-66	22-30			32-52	26-61	27-60	26-65	30-52	24-46	24-52	
Gobiidae:																			
Clevelandia	n	2	6	35										6	23	13	1	2	
ios	$\bar{x}$	41	49	43										42	40	42	38	40	
	s	1	9	4										2	4	3	--	7	
	r	40-42	42-67	30-52										39-45	27-47	36-46	--	35-45	
Gobiidae:																			
Coryphopterus	n	1																	
nicholsi	$\bar{x}$	66																	
	s	--																	
	r	--																	
Hexagrammidae:																			
Hexagrammos	n	67	52	18		3				2	13	25	91	84	77	54	16	10	
decagrammus	$\bar{x}$	92	94	109		106				47	57	71	66	78	84	99	131	114	
	s	27	20	54		15				4	5	26	12	20	14	16	17	9	
	r	55-220	40-124	76-270		89-117				44-50	50-70	50-150	45-102	58-210	62-121	74-120	110-162	110-162	

Appendix Table 5. (Continued)

Family and Species	[1]Variable	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hexagrammidae:																			
Hexagrammos	n													1	5				
lagocephalus	$\bar{x}$													82	149				
	s													--	87				
	r													--	84-270				
Hexagrammidae:																			
Ophiodon	n	28	5								5	21	51	43	10	1			
elongatus	$\bar{x}$	155	170								66	102	110	136	148	214			
	s	31	26								4	17	22	20	19	--			
	r	80-220	135-195								60-72	75-146	50-140	110-198	112-175	--			
Ictaluridae:																			
Ictalurus	n					1													
nebulosus	$\bar{x}$					178													
	s					--													
	r					--													
Osmeridae:																			
Allosmerus	n	2	47	20	22	18								36	72			1	2
elongatus	$\bar{x}$	56	55	54	52	40								51	54			56	4
	s	9	7	2	3	4								4	4			--	--
	r	49-62	32-70	50-59	49-60	33-47								40-56	32-62			--	--

Appendix Table 5. (Continued)

Family and Species	[1]Vari-able	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Osmeridae:																			
Hypomesus pretiosus	n	498	430	254	109	31	86	142	137	157	169	123	223	442	238	159	27	64	3
	$\bar{x}$	104	100	104	108	108	58	46	48	51	68	72	80	96	97	107	121	109	43
	s	20	17	17	23	40	34	7	16	13	28	23	24	24	17	26	32	22	4
	r	46-	40-	50-	36-	39-	35-	38-	35-	39-	18-	45-	35-	56-	51-	32-	43-	35-	39-
		170	186	180	170	177	185	118	160	135	173	170	182	170	184	182	162	160	47
Osmeridae:																			
Osmerus mordax	n													5	3	1			
	$\bar{x}$													72	102	32			
	s													22	11	--			
	r													56-	90-	--			
														99	111				
Petromyzontidae:																			
Lampetra ayresi	n	2		1	1								2	2					
	$\bar{x}$ **	196		240	170								250	185					
	s	51		--	--								7	69					
	r	160-		--	--								245-	136-					
		232											255	234					
Pholidae:																			
Apodichthys flavidus	n	6	21	9	6		2	1			1	8	20	26	27	21	3	7	
	$\bar{x}$	234	198	169	150		105	80			140	187	146	186	188	151	91	109	
	s	58	68	60	46		14	--			--	104	71	77	76	58	7	10	
	r	129-	67-	85-	90-		95-	--			--	60-	50-	73-	74-	82-	83-	100-	
		276	322	270	170		115					320	295	330	345	269	96	130	

Appendix Table 5. (Continued)

Family and Species	[1]Variable	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pholidae:																			
Pholis	n	37	27	48	19	1			2	1	4	47	87	112	110	55	12	3	
ornata	$\bar{x}$	106	112	79	84	79			122	80	98	118	113	118	118	114	105	92	
	s	27	27	26	25	--			11	--	32	23	22	21	25	19	19	13	
	r	43-161	29-150	50-142	50-125	--			115-130	--	58-127	60-155	65-154	40-182	13-166	62-153	80-131	80-105	
Pleuronectidae:																			
Parophrys	n	232	185	58	32	4	42	39	54	125	150	100	164	225	251	163	27	61	47
vetulus	$\bar{x}$	76	89	88	81	84	26	32	29	34	35	58	56	66	88	77	62	34	23
	s	24	20	18	19	20	18	10	9	8	11	17	17	21	22	16	25	28	10
	r	19-134	20-166	31-140	43-130	62-110	15-98	17-46	15-50	18-70	19-59	20-105	22-115	25-134	18-198	46-126	18-108	19-120	17-85
Pleuronectidae:																			
Platichthys	n	164	110	88	47	42	69	74	55	20	29	59	72	114	140	65	102	25	19
stellatus	$\bar{x}$	102	81	77	103	98	102	87	94	133	152	170	143	105	89	117	119	148	125
	s	70	53	56	62	63	83	93	96	71	55	58	55	74	64	54	59	48	56
	r	35-360	24-335	25-340	38-320	50-274	10-340	14-370	15-367	22-260	78-263	80-355	36-310	26-405	40-375	50-285	18-285	60-240	60-240
Pleuronectidae:																			
Psettichthys	n												5		1				
melanostictus	$\bar{x}$												80		210				
	s												40		--				
	r												32-143		--				

Appendix Table 5. (Continued)

Family and Species	[1]Variable	Jul 1977	Aug	Sep	Oct	Nov	Dec	Jan 1978	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Salmonidae:																			
Oncorhynchus	n									2									
gorbuscha	x̄ *									49									
	s									10									
	r									42-56									
Salmonidae:																			
Oncorhynchus	n									22	93								
keta	x̄*									39	42								
	s									2	5								
	r									34-44	30-56								
Salmonidae:[2]																			
Oncorhynchus	n	468	165	22	7		1	2		1	91	69	178	1355	2082	919	85	2	
kisutch	x̄*	116	132	165	207		268	294		336	172	127	110	104	113	120	106	114	
	s	12	13	22	19		--	37		--	68	13	11	15	16	19	14	4	
	r	75-151	106-169	136-219	170-223		--	267-320		--	104-425	100-157	83-141	73-308	80-197	86-191	81-163	112-117	
Salmonidae:[2]																			
Oncorhynchus	n	210	108	92	27	3		3			1	25	157	610	626	248	217	205	1
tshawytscha	x̄*	106	126	144	167	154		135			52	71	90	103	114	140	145	145	154
	s	10	18	20	26	31		14			--	6	10	13	16	16	12	16	--
	r	83-134	89-190	109-192	125-229	127-188		122-150			--	57-82	62-128	73-170	78-188	69-188	112-193	110-183	--

Appendix Table 5. (Continued)

Family and Species	[1]Vari-able	1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Salmonidae: *Salmo clarki*	n										3		4						
	$\bar{x}$*										239		203						
	s										53		16						
	r										181-284		186-222						
Salmonidae: *Salmo gairdneri*	n										1								
	$\bar{x}$*										211								
	s										--								
	r										--								
Scorpaenidae: *Sebastes caurinus*	n	1	1	6	16									7	14	5			
	$\bar{x}$	61	65	32	47									34	47	49			
	s	--	--	8	18									24	21	22			
	r	--	--	24-43	35-110									15-73	12-72	23-76			
Scorpaenidae: *Sebastes diploproa*	n																1		
	$\bar{x}$																19		
	s																--		
	r																--		

Appendix Table 5. (Continued)

Family and Species	[1]Variable	1977 Jul	1977 Aug	1977 Sep	1977 Oct	1977 Nov	1977 Dec	1978 Jan	1978 Feb	1978 Mar	1978 Apr	1978 May	1978 Jun	1978 Jul	1978 Aug	1978 Sep	1978 Oct	1978 Nov	1978 Dec
Scorpaenidae:																			
<u>Sebastes</u>	n	152	250	111	55								92	170	235	186	9		
<u>melanops</u>	$\bar{x}$	55	61	64	68								48	52	60	64	63		
	s	8	12	7	8								3	5	10	5	6		
	r	35-102	17-167	50-80	55-82								41-58	17-70	50-162	55-75	52-71		
Scorpaenidae:																			
<u>Sebastes</u>	n			1															
<u>mystinus</u>	$\bar{x}$			142															
	s			--															
	r			--															
Scorpaenidae:																			
<u>Sebastes</u>	n									4	5	6	28	7	9	1			
<u>paucispinis</u>	$\bar{x}$									32	37	56	56	97	96	78			
	s									5	3	11	21	20	15	--			
	r									27-37	35-43	40-68	32-140	76-136	78-115	--			
Stichaeidae:																			
<u>Lumpenus</u>	n	208	179	44	7							18	72	112	229	74	4		
<u>sagitta</u>	$\bar{x}$	235	239	238	244							208	243	249	228	227	261		
	s	48	44	53	31							91	75	55	60	60	16		
	r	65-360	49-360	130 358	205 290							73-336	85-350	48-350	128-351	129-334	245-283		

Appendix Table 5. (Continued)

Family and Species	Variable[1]	Month 1977 Jul	Aug	Sep	Oct	Nov	Dec	1978 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Syngnathidae:																			
Syngnathus	n	10	14	13	3	4	38	24	5	22	23	15	32	28	31	68	20	21	17
griseolineatus	$\overline{x}$	126	125	149	181	188	213	197	190	181	174	182	188	201	201	204	184	221	235
	s	63	32	63	83	57	59	64	82	50	56	28	34	45	43	41	51	40	39
	r	80-295	73-170	57-260	94-260	140-267	100-340	100-332	120-330	120-320	112-300	120-245	72-268	83-277	79-280	92-283	65-247	153-282	166-302

[1] n = sample size; $\overline{x}$ = mean standard length (mm); s = standard deviation (mm); r = range of lengths (mm).

[2] Tabled values include length measurements of both hatchery and wild fish. Adult salmonids were not included in the calculations.

*$\overline{x}$ = mean fork length (mm).

**$\overline{x}$ = mean total length (mm).

Appendix Table 6. Monthly sample size, mean length, standard deviation, and range of lengths of species of fish captured by lampara net in Yaquina Bay, Oregon from March through October 1978.

Family and Species	[1]Variable	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Agonidae:									
Pallasina barbata	n							1	
	$\bar{x}$							90	
	s							--	
	r							--	
Anarhichichadidae:									
Anarrhichthys ocellatus	n								1
	$\bar{x}$								70
	s								--
	r								--
Atherinidae:									
Atherinops affinis	n						4		
	$\bar{x}$						166		
	s						5		
	r						259-308		
Bothidae:									
Citharichthys stigmaeus	n			5	3	16	29	7	30
	$\bar{x}$			166	145	254	176	145	87
	s			81	4	18	12	50	16
	r			130-250	141-150	198-274	158-218	86-201	74-163

Appendix Table 6. (Continued)

Family and Species	[1]Variable	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
					Month				
Clupeidae:									
Alosa	n			5	3	16	29	7	30
sapidissima	$\bar{x}$			166	145	254	176	145	87
	s			81	4	18	12	50	16
	r			130-	141-	198-	158-	86-	74-
				250	150	274	218	201	163
Clupeidae:									
Clupea	n	4	20	121	66	85	79	32	94
harengus	$\bar{x}$	188	196	125	112	96	128	129	115
pallasi	s	12	20	30	42	44	40	32	33
	r	170-	160-	42-	58-	58-	62-	77-	77-
		195	245	180	185	230	195	170	200
Cottidae:									
Enophrys	n			4		1			1
bison	$\bar{x}$			98		245			172
	s			28		--			--
	r			80-		--			--
				140					
Cottidae:									
Leptocottus	n						15		
armatus	$\bar{x}$						99		
	s						20		
	r						83-		
							148		

Appendix Table 6. (Continued)

Family and Species	[1]Variable	Month: Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Embiotocidae:									
<u>Embiotoca lateralis</u>	n						9	11	
	$\bar{x}$						82	96	
	s						4	5	
	r						76-87	88-105	
Embiotocidae:									
<u>Hyperprosopon argenteum</u>	n				6	5		3	
	$\bar{x}$				127	72		115	
	s				7	38		40	
	r				120-139	49-137		71-149	
Embiotocidae:									
<u>Phanerodon furcatus</u>	n			21		5	10	38	
	$\bar{x}$			101		164	76	89	
	s			6		59	7	12	
	r			92-110		114-245	61-88	80-136	
Embiotocidae:									
<u>Rhacochilus vacca</u>	n			3		2		5	
	$\bar{x}$			113		148		87	
	s			6		107		8	
	r			108-120		72-223		79-98	

Appendix Table 6. (Continued)

Family and Species	[1]Variable	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
				Month					
Engraulidae:									
Engraulis	n			20	42	47	41		26
mordax	$\overline{x}$			64	78	91	80		102
	s			9	10	12	20		18
	r			44-	60-	72-	58-		64-
				78	110	117	145		130
Gadidae:									
Microgadus	n			1		5			
proximus	$\overline{x}$			45		194			
	s			--		29			
	r			--		143-			
						212			
Hexagrammidae:									
Ophiodon	n	20		16					
elongatus	$\overline{x}$	58		71					
	s	5		5					
	r	45-		62-					
		66		82					
Osmeridae:									
Hypomesus	n	17	20	105	67	21	26		71
pretiosus	$\overline{x}$	62	148	86	81	90	102		110
	s	9	9	34	25	28	19		15
	r	52-	135-	50-	50-	74-	85-		95-
		90	166	176	176	181	157		178

Appendix Table 6. (Continued)

Family and Species	[1]Variable	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
				Month					
Osmeridae:									
Osmerus	n						5		
mordax	$\bar{x}$						102		
	s						7		
	r						94-112		
Petromyzontidae:									
Lampetra	n			5	2	8	11	1	1
ayresi	$\bar{x}$**			176	166	172	212	257	205
	s			11	36	31	22	--	--
	r			160-185	141-192	144-236	181-248	--	--
Pleuronectidae:									
Parophrys	n					6	2		1
vetulus	$\bar{x}$					49	96		108
	s					19	19		--
	r					30-85	82-109		--
Pleuronectidae:									
Psettichthys	n					1			
melanostictus	$\bar{x}$					220			
	s					--			
	r					--			

Appendix Table 6. (Continued)

Family and Species	[1]Variable	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Salmonidae:[2]									
Oncorhynchus	n		7	13	76	68	88	73	14
kisutch	$\bar{x}$**		228	153	111	106	116	141	136
	s		32	42	23	11	16	13	9
	r		182-255	103-258	87-275	88-137	85-163	113-178	120-154
Salmonidae:[2]									
Oncorhynchus	n				14	40	30	97	201
tshawytscha	$\bar{x}$*				107	110	135	148	152
	s				16	22	18	11	13
	r				91-142	88-192	99-169	118-179	119-188
Salmonidae:									
Salmo	n			1					
clarki	$\bar{x}$*			180					
	s			--					
	r			--					
Salmonidae:									
Salmo	n		2		1				
gairdneri	$\bar{x}$*		214		190				
	s		8		--				
	r		209-220		--				

Appendix Table 6. (Continued)

Family and Species	[1]Variable	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
					Month				
Scorpaeinidae:									
Sebastes	n			1	2				
melanops	$\bar{x}$			45	48				
	s			--	4				
	r			--	45-50				
Scorpaenidae:									
Sebastes	n			1					
miniatus	$\bar{x}$			60					
	s			--					
	r			--					
Stichaeidae:									
Lumpenus	n					7		4	4
sagitta	$\bar{x}$					232		248	239
	s					50		33	28
	r					170-294		200-274	220-281

Appendix Table 6. (Continued)

Family and Species	Variable[1]	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
					Month				
Syngnathidae:									
Syngnathus	n						1		
griseolineatus	$\bar{x}$						198		
	s						--		
	r						--		

[1] n = sample size; $\bar{x}$ = mean standard length (mm); s = standard deviation (mm); r = range of lengths (mm).

[2] Tabled values include length measurements of both hatchery and wild fish. Adult salmonids were not included in the calculations.

* $\bar{x}$ = mean fork length (mm).

** $\bar{x}$ = mean total length (mm).