FISHERIES RESEARCH INSTITUTE
College of Fisheries
University of Washington
Seattle, Washington 98195

FISH ECOLOGY STUDIES IN THE NISQUALLY REACH AREA OF SOUTHERN PUGET SOUND, WASHINGTON

by

Kurt L. Fresh, Douglas Rabin, Charles A. Simenstad,
E. O. Salo, Kathryn Garrison, and Linda Matheson

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Roy E. Nakatani
Director

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ABSTRACT

Fishes of the Nisqually Reach, primarily along the DuPont shoreline, were studied by the Fisheries Research Institute in 1977 and 1978. Objectives included determining use of the area by salmonid and nonsalmonid species, analyzing food habits, and assessing the use of Sequalitchew Creek by anadromous species. Sampling gear included beach seine, townet, trynet, purse seine, bongo net, SCUBA, and in freshwater a backpack electroshocker.

Juvenile salmonids were found to migrate along all shorelines in the Nisqually Reach. Data collected through mid-May 1978, indicated salmonids did not migrate extensively along the DuPont shoreline, the area considered for wharf development. However, preliminary analysis of data collected after mid-May 1978 indicated extensive use of the DuPont shoreline later in the year, especially by juvenile chum salmon. The most abundant juvenile salmonid caught in 1977 was the chinook salmon, whereas juvenile chum salmon was the most abundant in 1978.

Nonsalmonids predominating in the beach seine collections were staghorn sculpin, shiner perch, and starry flounder. Among the most numerous nonsalmonids caught by townet were larval Pacific herring and Pacific sand lance.

Trynet collections at three stations along the DuPont shoreline between March 1977 and March 1978 were dominated by two pleuronectids--English sole and rock sole. Species richness and numbers of fish were greater at DuPont Dock than at the other two stations.

Adult coho, chum, chinook, and steelhead were captured by purse seine along the DuPont shoreline in October and November 1977. Coho abundance decreased with time while chum abundance increased. Peak migrations of

adult coho and chum along the DuPont shoreline were probably September-October and December-January, respectively. Recoveries of tagged salmonids were primarily from freshwater sources south of the Tacoma Narrows.

SCUBA surveys indicated several potential predators of juvenile salmonids associated with the existing DuPont Dock. Buffalo sculpin, painted greenling, and rock sole were the most numerous demersal species; shiner perch, pile perch, striped seaperch, and tubesnout were the most abundant pelagic species.

Plankton collections at three stations from March to July 1977 were sorted into the various zooplankton and ichthyoplankton. Seasonal changes in abundance were indicated with the greatest abundance of zooplankton, fish eggs, and fish larvae in May. Zooplankton at all three stations sampled were similar in composition and were dominated by calanoid copepods, crab zoea, cnidaria, and caridean zoea. Pleuronectids and gadoids were both the most abundant fish eggs and larvae collected.

Studies of Sequalitchew Creek in 1977 were hindered by low flows which were not repeated in 1978. Juvenile coho were the most abundant salmon occurring in both years. Fry were present from naturally reproducing fish and smolts were present from plants by the Washington State Department of Fisheries in Sequalitchew Lake. Peak outmigrations of smolts from Sequalitchew Lake were probably in May. Chum fry were observed in 1977 but not in 1978. Cutthroat trout, prickly and coastrange sculpin, threespine stickleback, largemouth bass, and an unidentified centrarchid young-of-the-year were also surveyed. Coho and cutthroat trout were the only adult salmonids observed in the creek.

The majority of fish species examined fed principally on epibenthic plankton and macroinvertebrates. Juvenile chum, coho, and chinook salmon fed predominantly on epibenthic organisms (harpacticoid copepods, gammarid amphipods), whereas juvenile pink salmon fed primarily on pelagic prey (calanoid copepods). Of the fish in the area, only maturing chinook salmon (blackmouth), copper rockfish, and staghorn sculpin were considered potential predators of juvenile salmon. Of the species observed during SCUBA surveys of the DuPont Dock, three embiotocids, a greenling, and a rockfish species fed on organisms characteristic of the piling community. Habitat factors other than food availability may influence the association of these species with the dock.

PREFACE

This report summarizes studies completed to June 1, 1978. As studies on the juvenile salmonid outmigration were in progress at the time this report was written, a subsequent report will follow completing the 1978 outmigration studies.

ACKNOWLEDGMENTS

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INTRODUCTION

Construction of a cargo loading dock has been proposed along the DuPont shoreline of the Nisqually Reach in southern Puget Sound, Washington, by the Weyerhaeuser Company. In preparation for the potential development, a multidisciplinary research program was initiated in 1977 by Weyerhaeuser to assemble baseline data in the area. Research has emphasized the assessment of potential environmental impacts of the proposed construction for use in a Weyerhaeuser/DuPont environmental impact statement (EIS). As part of the overall research effort, the Fisheries Research Institute (FRI) has studied the fish resources of the area since March 1977.

The Nisqually River estuary is known to be an important rearing area for juvenile salmonids (Williams et al. 1975), and as the Washington State Department of Fisheries (WDF) plans an intensive salmonid enhancement program (W. Williams, personal communication), use of the area will increase. As conditions during the early marine life of salmon are important (Gilhousen 1962, Manzer and Shephard 1962, Martin 1966), FRI has emphasized documenting use of the area by anadromous species.

Development of similar nearshore structures in Puget Sound has received considerable attention. Heiser and Finn (1970) observed the effects of piers and bulkheads in northern Hood Canal on the behavior of juvenile salmon and their potential predators. Marine studies related to the proposed Kiket Island power plant in northern Puget Sound were coordinated by Stober and Salo (1973). Conley (1977) sampled fishes in areas of log rafting in Everett Bay. Weitkamp (1977) studied juvenile salmonids during the filling of pier areas at the Port of Seattle. In the Walan Point vicinity of Port Townsend Bay, where the U.S. Navy is constructing loading piers for ammunition, Moore et al. (1977) monitored the juvenile salmon outmigration. Schreiner (1977) and Schreiner et al. (1977) have conducted research on salmonids in the vicinity of the construction of Trident nuclear submarine facilities in Hood Canal.

During 1977, specific objectives of the study included: 1) assessing use of the DuPont-Nisqually Delta shoreline by juvenile salmon; 2) documenting nearshore[1] fish assemblages in the study area; 3) evaluating the use of the DuPont shoreline by adult salmon; 4) studying planktonic organisms occurring in the area; 5) analyzing stomach contents of juvenile salmon and their potential predators; 6) evaluating results relative to potential effects of the new dock structure at DuPont on fish communities; and 7) determining present use of Sequalitchew Creek by salmonid species. Studies in 1978 emphasized documenting the shoreline migration of salmonids in the Nisqually Reach and determining their food habits and potential predators.

DESCRIPTION OF STUDY AREA

The study area is located in the vicinity of the confluence of the Nisqually River with Puget Sound (Fig. 1) and is referred to as the Nisqually Reach. The delta formed by the Nisqually River consists of broad mudflats and salt marsh. Islands occurring in the study area include Anderson Island, located directly north of the delta, and Ketron Island, located along the shore east of the delta. In addition to the Nisqually River, McAllister and Sequalitchew creeks discharge into the

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[1]"Nearshore," as used hereafter, refers to the littoral and inner sublittoral (bottom) and neritic (surface) waters inshore of the 20-m depth level (see Hedgpeth 1963).

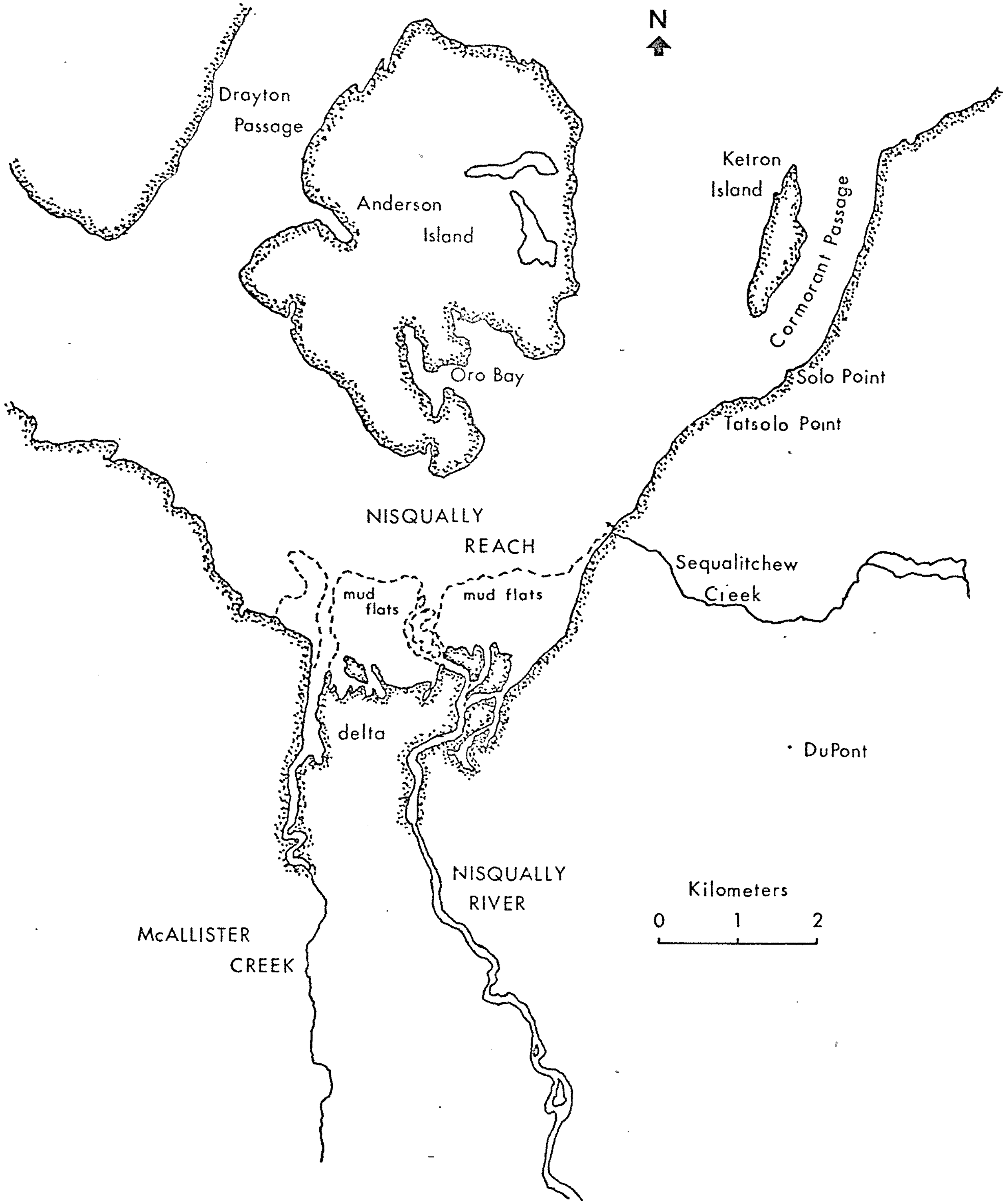

Fig. 1. Map of southern Puget Sound study area and associated landmarks.

Nisqually Reach. Tidal currents in the Nisqually Reach swirl westward past the Nisqually Delta on flood tides (McGary and Lincoln 1977), whereas during ebb tides, a relatively stronger flow sweeps northeast along the DuPont shoreline. Beaches to the northwest of the delta generally have gentle slopes and are predominantly sand and mud; beaches to the northeast are steeper and are typically gravel and cobble.

The DuPont shoreline, as referred to in this paper, extends from the eastern edge of the Nisqually Delta north to Tatsolo Point. The proposed construction is along the DuPont shoreline at the site of an existing dock (Fig. 2). Beaches in the area are primarily sand/gravel and gravel/cobble substrates and have moderately steep slopes. The existing dock consists of wooden pilings driven into the sand/silt or sand/gravel substrates and extends from the littoral zone to approximately 100 m from shore. Water depths under the dock are up to 10 m. The dock formerly serviced an explosives plant, and during the study period, was still in occasional use.

Sequalitchew Creek is 5 km long, originates at Sequalitchew Lake (Fig. 3), and drains through two marshes before descending vertically 60 m through a 1,000-m-long ravine. The creek then passes through a culvert under the Northern Pacific and Burlington Northern railroad tracks before entering Puget Sound just south of the existing dock. Streamflow in some upper sections is low (< 10 cfs) or intermittent during summer and autumn periods. Only the lower 2 km of the stream (below the marshes) would appear to offer suitable substrate for salmon egg deposition.

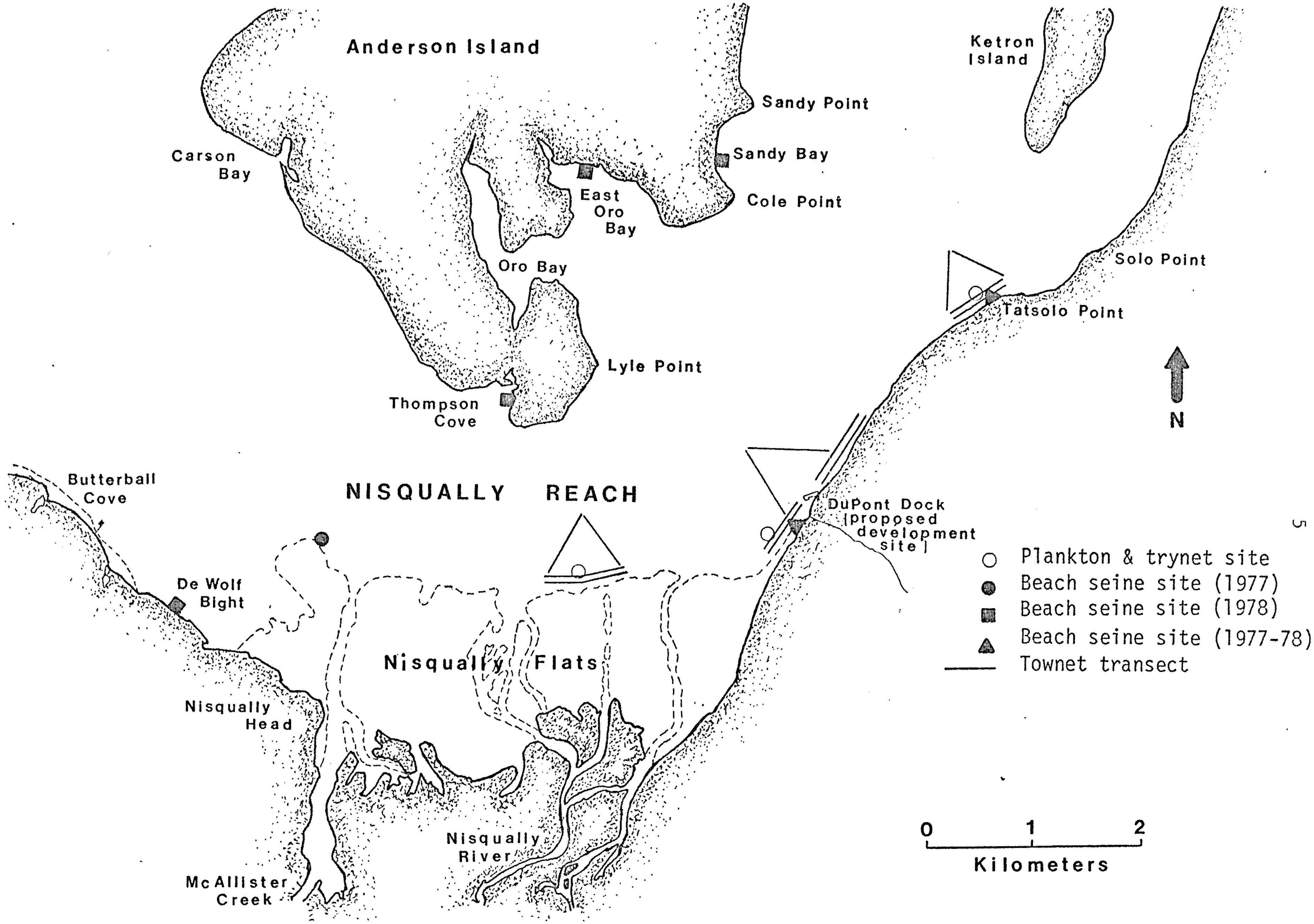

Fig. 2. Map of the study area and sampling sites used during 1977-78 in southern Puget Sound, Washington.

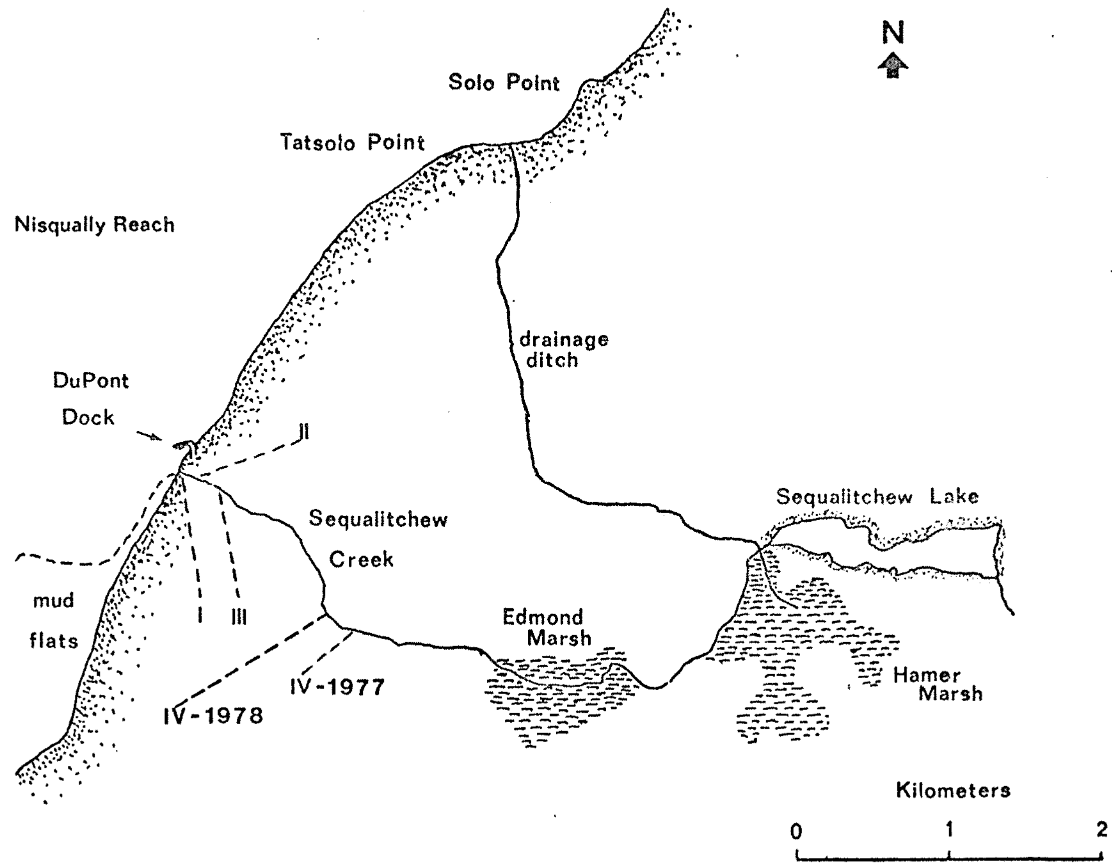

Fig. 3. Map of Sequalitchew Creek and study stations (I - IV), southern Puget Sound, Washington, 1977.

MATERIALS AND METHODS

Study Sites

In March 1977, three sites--Tatsolo Point, DuPont Dock, and the outer edge of the Nisqually mudflats (Fig. 2 and Table 1)--were chosen as study sites because of their proximity to: 1) the proposed dock site; and 2) the benthos transects established by Evergreen State College and Dames and Moore, Consultants. Results in 1977 indicated relatively low numbers of juvenile salmon along the DuPont shoreline (Rabin et al. 1977). In order to confirm these findings, several new beach seine and townet sites (Figs. 2 and 4, Table 1) were added in February 1978. Because in 1977 the outer edge of the Nisqually mudflat beach seine station could be sampled only on minus tides, the station was eliminated in 1978.

Sampling Techniques

Gear types and methods have been used by other FRI studies (Miller et al. 1977, Schreiner et al. 1977, Simenstad et al. 1977). Sampling frequency varied with technique, year, and season (Table 2).

Beach Seine

A 37-m beach seine was used to sample demersal and pelagic fishes occurring within 30 m of shore. The seine consisted of two 18-m wings with 3-cm mesh joined to a 0.6-m x 2.4-m x 2.3-m bag of 6-mm mesh. A solid core lead line kept the seine on the bottom and prevented rolling in eelgrass beds. The seine could either be fished as a sinking seine or by attaching seven floats at regular intervals along the cork line, a floating seine. Polypropylene lines 60 m long and 2 cm in diameter were used to retrieve the net. The net was set parallel 30 m from shore from

Table 1. Location and description of beach seine stations used during 1977 and 1978 in the Nisqually Reach, southern Puget Sound.

Site	Location	Slope	Substrate	Vegetation
Tatsolo Point	On Tatsolo Point	moderate	Mixture of cobbles and gravel	Small amounts of kelp and eelgrass
South DuPont Dock	200 m south of the DuPont Dock	gentle	Mixture of sand and silt	Sparse eelgrass
Outer Nisqually Delta (1977 only)	Outer edge of the tidal flats of the Nisqually River	moderate	Mixture of sand and silt	Some patches of algae
DeWolf Bight (1978 only)	Midway between Nisqually Head and Butterball Cove	very gentle	Mixture of sand and silt	Thin patches of eelgrass
Thompson Cove (1978 only)	50 m from the head of the cove	moderately gentle	Mixture of cobbles and gravel	Thin patches of eelgrass
East Oro Bay (1978 only)	Northwest corner of East Oro Bay	gentle	Coarse sand	Moderately dense eelgrass
Sandy Cove (1978 only)	200 m north of Cole Pt.	very gentle	Fine to coarse sand	Rich areas of eelgrass

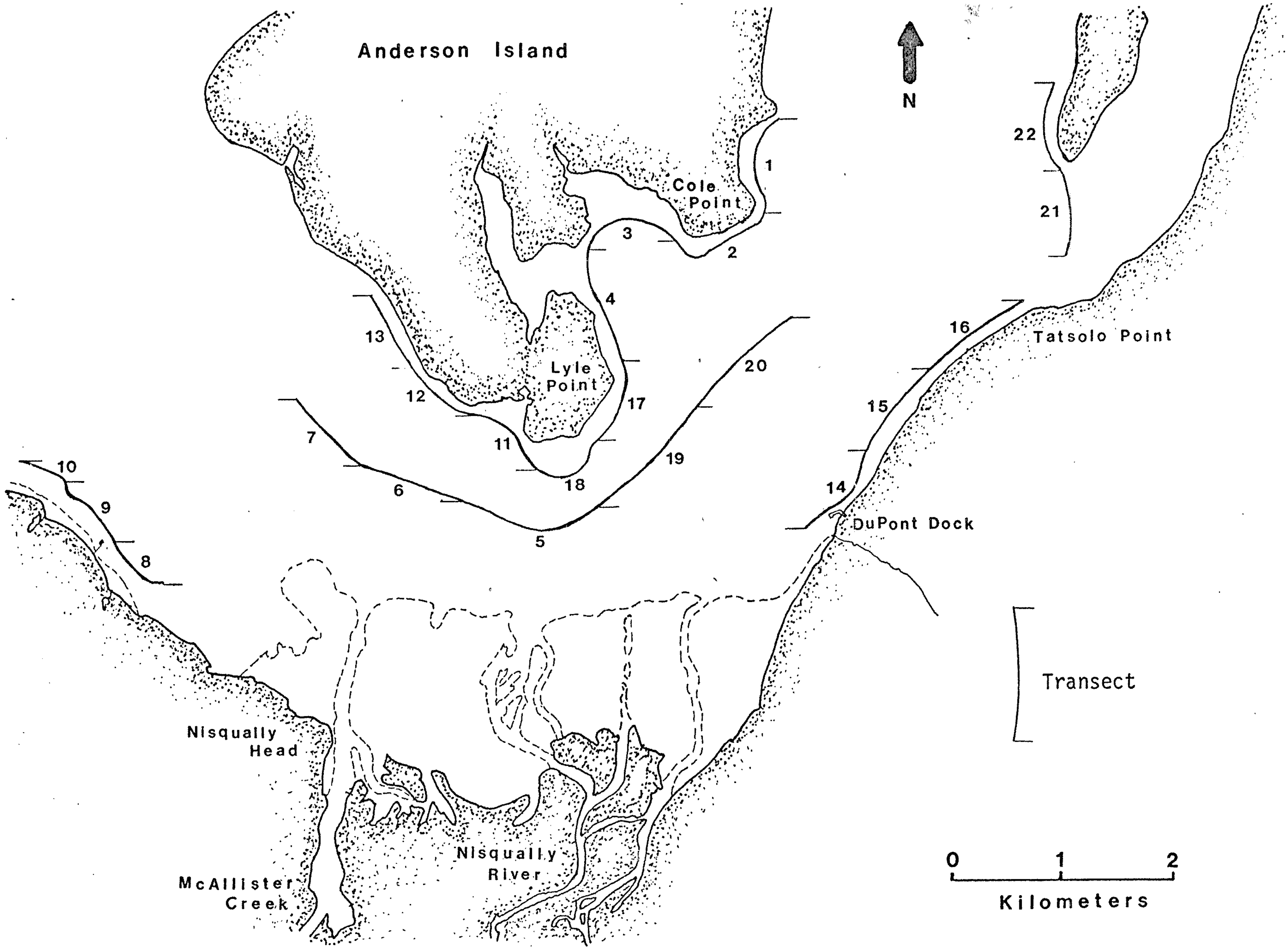

Fig. 4. Townet surface trawl pattern used during salmonid outmigration studies during 1978 in southern Puget Sound, Washington.

Table 2. Sampling gear employed and frequency and period of use in the study area, southern Puget Sound, Washington, 1977-1978.

Sampling Gear	Period of Use	Frequency of Use
Beach seine	March through July 1977	Monthly and biweekly
	February, March 1978	Weekly (day only)
	April through July 1978	Biweekly (day and night)
Townet	March through July 1977	Monthly and biweekly (night only)
	April through June 1978	Approx. biweekly (day and night)
Trynet	March 1977 through March 1978	Approx. bimonthly (night only)
Purse seine	October and November 1977	Approx. biweekly
SCUBA surveys	June 1977 through May 1978	Monthly
Electroshocker	April through June 1977	Biweekly
	April, May 1978	Weekly
	June 1978	Biweekly
Plankton nets	March through June 1977	Monthly

the bow of a powered, 4.3-m skiff. The net was hauled in by four persons toward shore at about 15 m/minute. For the first 20 m the teams were 40 m apart and 10 m apart for the final 10 m.

In 1977, the net was hauled completely onto the beach and the entire catch of fish was bagged, labeled, placed in 10 percent formalin, and put in coolers. In 1978, the larger catches were subsampled after the catch was sorted for the more unusual species (see Subsampling).

On each sampling date in 1977, two sinking sets were made at Tatsolo Point, DuPont Dock, and the outer Nisqually Delta sites and two floating sets were made at Tatsolo Point. All 1977 beach seining was conducted around slack water at low tide during daylight hours.

Because the floating beach seine was found to be more effective for juvenile salmonids than the sinking seine (Schreiner 1977, Schreiner et al. 1977), only floating sets (during both day and night) were used in 1978. To minimize between-station variability, sets were made during a single tidal phase. Two floating sets, at least 10 to 15 minutes apart, were made per site on each sampling date.

In 1978, visual surveys 0.8 km to 1.6 km long were conducted by boat 3 m to 15 m from shore. DuPont Dock, Sandy Cove, Thompson Cove, and DeWolf Bight were surveyed concurrent with beach seine trips beginning May 1, 1978. Visual surveys required: 1) calm waters; 2) sand or pebble substrates; 3) low water turbidity levels; and 4) a bright, sunny day.

Townet

Fishes in nearshore surface waters, adjacent to and away from the shore, were sampled by a 15-m townet, with a mouth opening of 3.1 m x 6.0 m. The net was of knotless nylon, with mesh sizes grading from 76 mm at the opening to 6 mm at the bag (cod end). The net was towed at 800 rpm between the 12-m FRI R/V vessel, MALKA, and a 2.8-m purse seine skiff. At 10-minute intervals, personnel in a skiff towed over the cod end pursed and emptied the catch into live buckets. Large catches were subsampled (see Subsampling); otherwise the catch was preserved in 10 percent formalin in plastic bags.

During 1977, four to six 10-minute tows were made at night at each of three sites. Tows were made with and against the current along the shoreline and diagonally away from and toward the shore (Fig. 2). In 1978, four transects were taken during the day and night (Fig. 4) along the Anderson Island shoreline, the DuPont shoreline, the shore west of the delta, and in the middle of the Reach. All inshore tows were conducted as close to the shoreline as possible.

Trynet

Demersal fish were sampled bimonthly beginning in March 1977 with a trynet (small otter trawl 6.1 m long, 3.3 m wide, and 0.76 m at the mouth) fished from the R/V MALKA. The throat and body of the net were made of 3.8-cm stretch mesh, and the cod end was 2.9-cm stretch mesh with 0.64-cm stretch mesh liner. Towing speed was usually 2-3 knots; however, this varied with direction and strength of tide. A single, 5-minute tow was made at each of three depths (5 m, 10 m, and 15 m) at the Tatsolo Point, DuPont Dock and Nisqually flat sites (Fig. 2). All sampling was conducted at dusk or at night. Fish from each haul were bagged, labeled, and preserved in 10 percent formalin.

Purse Seine

Adult salmonids were sampled with the same commercial purse seine and vessel used by the U.S. Fish and Wildlife Service (USFWS) in the Nisqually Reach. A seine 457 m (250 fathoms) long and approximately 23 m (425 meshes) in depth was fished off the 17-m-long ADANA-R. The bunt of the seine was 18 m (10 fathoms) in length, 9 m (200 meshes) in depth, and contained 8.9-cm stretch mesh. The first 100 meshes below the cork line (except for the bunt) contained 12.7-m stretch mesh; the remainder of the net contained 10.2-cm stretch mesh.

Sampling was conducted biweekly in October and November 1977. Three or four sets were made during daylight between Tatsolo Point and the DuPont Dock. The net was set perpendicular to the shore, held open for approximately 40 minutes, closed, and pursed. The salmon were removed, measured (total length), tagged with an orange "spaghetti" tag (identifying fish, tagging agency, and telephone number), and released. Environmental information was taken during the first and third sets.

SCUBA Surveys

Monthly SCUBA surveys were made at the DuPont Dock beginning in June 1977. Two divers swam parallel benthic transects between the pilings of the dock from the intertidal zone to the end of the dock (Fig. 5). Demersal fish occurring within 1 m on either side of each transect line were classified as to life history stage; in addition, fish seen among the pilings were counted. All dives were made during daylight, high slack water tides.

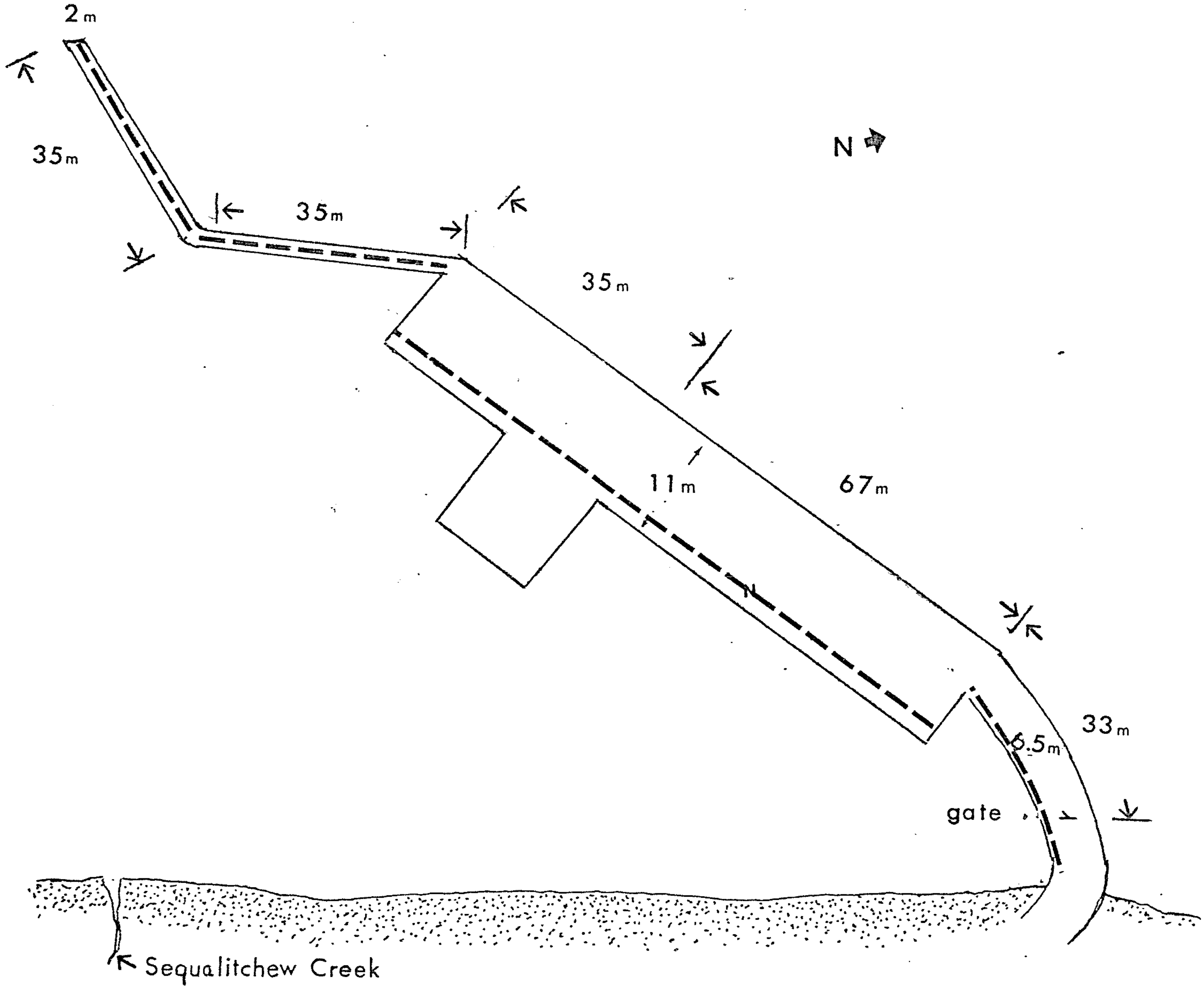

Fig. 5 Diagram of the DuPont Dock, southern Puget Sound, WA (not drawn to scale). SCUBA survey transect pattern represented by dashed line.

Plankton Collections

Monthly plankton collections were made from March to July 1977 at the Tatsolo Point, DuPont Dock, and the outer Nisqually Delta sites. A horizontal (surface) and an oblique haul of 5- and 10-minute duration, respectively, were made using a 60-cm aluminum bongo net array with nets of 505-μ mesh. All sampling occurred after dark from the R/V MALKA. General Oceanic flowmeters, mounted on the frame, were used to determine the volume of water sampled by each net, a tide-depth recorder recorded sampling duration at depth, and an inclinometer measured the angle of each tow. The plankton from each haul was preserved in 5 percent formalin buffered with sodium tetraborate.

Zooplankton, chosen at random from one of the two nets (Table 3), was sorted under an illuminated magnifier and organisms were counted and identified to major taxonomic groups. Fish eggs and larvae were removed and stored in vials with 70 percent ethyl alcohol. Copepods and smaller organisms were subsampled volumetrically with a 5-ml automatic pipette and counted under a dissecting microscope.

Sequalitchew Creek Surveys

Studies of Sequalitchew Creek included electroshocking for downstream juvenile migrants in the spring and summer and visually enumerating spawning adults in the fall and early winter. Electroshocking study sections 30 to 50 m in length were located at the mouth and approximately 100, 400, and 2,000 m upstream (Fig. 3). Section I was located within the intertidal portion of the creek, sections II and III in gravel habitats shaded by a canopy, and section IV in an unshaded, mud/silt area situated below Edmonds Marsh. In 1977, when section I could not be examined due to

Table 3. Summary of plankton samples analyzed.

Sample No.	Date	Sta. No.*	Surface or Oblique	Net No.	Flow-Meter Revs.	Duration of Haul	m^3 Filtered
1	3/11/77	OND	O	3	11,795	5 min	91.9895
2	3/11/77	OND	S	2	36,565	10	285.1929
3	3/11/77	SDD	O	2	7,210	2.5	56.2239
4	3/11/77	SDD	S	3	36,204	10	282.3797
5	3/11/77	TP	O	2	7,925	2.5	61.8009
6	3/11/77	TP	S	3	32,509	10	253.5587
7	4/15/77	OND	O	2	5,770	-	44.9919
8	4/15/77	OND	S	2	33,220	10	259.1019
9	4/15/77	SDD	O	3	6,479	5	50.5247
10	4/15/77	SDD	S	2	32,154	10	250.7871
11	4/15/77	TP	O	2	10,533	5	82.1433
12	4/15/77	TP	S	2	33,410	10	260.5839
13	5/20/77	OND	O	3	5,846	10	45.5873
14	5/20/77	OND	S	2	12,562	5	97.9695
15	5/20/77	SDD	O	2	4,772	10	37.2075
16	5/20/77	SDD	S	2	19,933	10	155.4633
17	5/20/77	TP	O	2	6,464	10	50.4051
18	5/20/77	TP	S	3	21,241	10	165.668
19	6/17/77	OND	O	3	4,244	5	33.0917
20	6/17/77	OND	S	3	26,469	10	206.4467
21	6/17/77	SDD	O	2	3,218	5	25.0863
22	6/17/77	SDD	S	2	10,752	5	83.8515
23	6/17/77	TP	O	2	2,784	-	21.7011
24	6/17/77	TP	S	3	13,484	5	105.1637
25	7/8/77	OND	O	2	3,640	5	29.3779
26	7/8/77	OND	S	2	14,915	5	116.3229
27	7/8/77	SDD	O	2	5,371	5	41.8797
28	7/8/77	SDD	S	2	14,902	5	116.2215
29	7/8/77	TP	O	2	5,774	5	45.0231
30	7/8/77	TP	S	2	12,269	5	95.6841

*Station key

TP = Tatsolo Point
SDD = South DuPont Dock
OND = Outer Nisqually Delta

excessive algal growth, section III was added. In 1978, section IV was shifted 100 m downstream where algal coverage was minimal.

Blocking nets prevented fish from entering or leaving the area. Two passes were made with a battery-powered (12-volt) backpack electroshocker with the fish from each pass kept separate. Captured fish were anesthetized with MS-222 (tricaine methanosulfonate) and separated according to size class (smolt and fry). When more than 100 individuals of a particular size class were captured in a pass, between 30 and 75 fish were measured (nearest mm) and a 10-20 fish subsample retained for weights (nearest 0.1 g). During the second season of sampling, small numbers of juvenile salmonids from each section were marked prior to release, and recoveries of marked fish were noted during subsequent samplings. With the exception of those retained for weighing and stomach samples, all fish were released back into the upper half of the study section.

The Seber-LeCren (1967) two-catch method was used to make population estimates:

$$\hat{N} = c_1^2/(c_1-c_2)$$

where c_1 = catch in the first pass and c_2 = catch in the second.

Visual counts of live and dead adult salmon in the lower 1,700 m, passable to salmon, were made during the fall of 1977 and winter of 1978.

Subsampling Procedures

In 1978, subsamples were taken of large catches of salmonids and nonsalmonids. Procedures employed are described in Appendix 1.

Data Collection

Various collection, oceanographic, and other pertinent environmental information was recorded on computer formatted forms (NODC/MESA). These data included: location, date, time, fish identification number, tide stage and height, weather conditions, water temperature, salinity, dissolved oxygen, water state and color, bottom depth, area or volume sampled, distance fished, sampling duration, and light intensity.

Temperature, salinity, and dissolved oxygen were generally taken at a depth of 1 m; on trynet trips additional temperature and salinity measurements were taken at depths of 5 and 10 m. During beach seine trips, temperature (^{o}C) was determined by thermometer, salinity (o/oo) by the potentiometric method, and dissolved oxygen (percent saturation) by Winkler titration. During field operations from the R/V MALKA, temperature and salinity were determined using a Beckman salinity-temperature probe, and dissolved oxygen was determined by Winkler titration. Environmental data will be summarized in the final report.

Catch Processing

Biological Information

Fish samples were sorted to species and general life history stage (larvae, juvenile, adult) using Hart (1973) as the general reference and McConnell and Snyder (1972) and Phillips (1977) for juvenile salmonids. Each species was first counted and weighed as a total by life history stage. The fish (or a subsample) were then measured (nearest mm) and weighed (nearest 0.1 g). For nonsalmonids, up to 50 fish per haul of each species-life history stage were measured and weighed. For salmonid species, up to 75-100 fish were selected per haul for measuring and weighing.

The following length types were measured: salmon--fork length, herring--tip of snout to hypural plate, ratfish--snout to second dorsal, all other species--total length. Where possible, information on sex, maturity stage, external diseases, parasites, and other abnormalities were recorded.

Food Habits Information

In the field, selected specimens, especially juvenile salmonids and their potential predators, were preserved for stomach analysis. These were then examined by a standardized procedure which describes the numerical and gravimetric composition of prey organisms, the stage of digestion, and the degree of stomach fullness (Terry 1977). Prey identification was made to the lowest taxonomic level possible and representative prey organisms were retained.

Trophic Diagrams

A modification of Pinkas et al. (1971), "Index of Relative Importance" (IRI), was used to rank the importance of prey organisms. The IRI values for prey taxa are displayed both graphically and in tabular form where justified by sample size ($n \geq 10$). A detailed explanation of the IRI diagrams is presented in Appendix 2.

Disposition of Data

Data were coded on computer sheets according to NODC/MESA specification used by previous Puget Sound studies (e.g., Simenstad et al.

1977). After keypunching onto 80-column IBM cards, data cards were transferred onto magnetic tape.

PART 1--RESULTS AND DISCUSSION OF FISH COLLECTIONS

Beach Seine and Townet

Beach seine and townet results are considered together, and again we mention that sampling was still in progress so conclusions concerning the juvenile salmon outmigration are speculative and incomplete. A final report will be submitted in fall 1978.

General Catch Results

Fifty-one species of fish, representing 20 families, were collected by beach seine and townet through June 1, 1978 (Appendix 3). During 1977 beach seine collections, chinook salmon, staghorn sculpin, and chum salmon were the most abundant species (Table 4) with the greatest numbers taken at the outer edge of the Nisqually Delta. Chum and coho salmon were the most abundant species in the 1978 beach seine collections (Table 5). Catches of both salmonids and nonsalmonids were greatest at Thompson Cove and DeWolf Bight. The large catches of nonsalmonid species at DeWolf Bight were likely a function of the water depths which rarely exceed 2.0 m. Thus, the floating seine actually functioned as a sinking seine.

In 1977, chinook salmon, herring, and chum salmon accounted for 77.3 percent of the townet catch (Table 6). The 1978 townet samples have not been analyzed but preliminary inspection indicates that herring and sand lance were most abundant. The largest catches of larval herring and sand lance occurred in East Oro Bay and around Cole Point. Large numbers of herring have also been recorded in East Oro Bay by WDF baitfish townet surveys (Pentilla, personal communication).

Table 4. Abundance and percent composition of fishes caught in beach seine hauls during 1977 in the DuPont-Nisqually study area, southern Puget Sound, Washington, March through July 1977.

Species	Tatsolo Point (22 hauls)	DuPont Dock (18 hauls)	Nisqually Delta (10 hauls)	Total* No.	Total* %
Hydrolagus colliei	1			1	-
Clupea harengus pallasi	66	1	9	76	2.1
Oncorhynchus gorbuscha	28	9	111	148	4.0
O. keta	57	84	158	299	8.2
O. kisutch	82	53	14	149	4.1
O. tshawytscha	77	129	772	978	26.7
Salmo clarki		1		1	-
S. gairdneri	1			1	-
Hypomesus pretiosus	1		50	51	1.4
Gobiesox maeandricus	4			4	.1
Gadid larvae		2		2	.1
Aulorhynchus flavidus		88		88	2.4
Gasterosteus aculeatus	5	1	1	7	.2
Syngnathus griseolineatus	1	6	1	8	.2
Cymatogaster aggregata	138	34	78	250	6.8
Embiotoca lateralis	92	83		175	4.8
Rhacochilus vacca	59	3		62	1.7
Embiotocid-unidentified	2			2	.1
Anoplarchus insignis		1		1	-
Lumpenus sagitta		1		1	-
Apodichthys flavidus	32	49	1	82	2.2
Pholis laeta	22	34		56	1.5
P. ornata	11	19	2	32	.9
Xererpes fucorum	1		2	3	.1
Sebastes caurinus	1			1	-
Artedius fenestralis	18	5	3	26	.7
A. lateralis	2	19		21	.6
Blepsias cirrhosus	1			1	-
Chitonotus pugetensis	14	3	4	21	.6
Clinocottus acuticeps			1	1	-
C. embryum	1		2	3	.1
Enophrys bison	17	24	1	42	1.1
Leptocottus armatus	27	125	469	621	16.9
Myoxocephalus polyacanthocephalus	2	3		5	.1
Cottid-unidentified	3	3		6	.2
Agonus acipenserinus		2	6	8	.2
Liparis rutteri	2	1		3	.1

Table 4. (continued)

Species	Tatsolo Point	DuPont Dock	Nisqually Delta	Total No.	%
Glyptocephalus zarchirus			1	1	-
Lepidopsetta bilineata	3	17	19	39	1.1
Parophrys vetulus	2	11	47	60	1.6
Platichthys stellatus		46	207	253	6.9
Psettichthys melanostictus		10	53	63	1.7
Pleuronectid larvae	2	4	8	14	.4
Total	775	871	2020	3666	99.9

*Hyphen (-) represents fish abundance less than .05%.

Table 5. Frequency of occurrence (No. of collections each species occurred in) and abundance of fishes caught by beach seine from February 15 to June 1, 1978, in the DuPont-Nisqually study area, southern Puget Sound, Washington.

	Site											
	Tatsolo Point		DuPont Dock		DeWolf Bight		Thompson Cove		East Oro Bay		Sandy Cove	
Species	Occur. (18 coll.)*	No.	Occur. (18 coll.)	No.	Occur (19 coll.)	No.	Occur. (20 coll.)	No.	Occur. (20 coll.)	No.	Occur. (19 coll.)	No.
Squalus acanthias					1	1						
Hydrolagus colliei			2	3								
Oncorhynchus gorbuscha	4	7			10	127	7	220	8	184	6	84
O. keta	9	567	9	262	13	5830	15	8781	15	1389	13	1999
O. kisutch	9	63	9	81	9	69	11	2731	9	351	10	1120
O. tshawytscha	1	1	2	9	5	8	3	6	2	2	3	10
Salmo clarki	1	1	1	1	1	1	2	2			1	1
S. gairdneri									2	2		
Salvelinus malma					1	1						
Hypomesus pretiosus			1	1	2	3	2	5	1	2		
Gasterosteus aculeatus	1	2									1	1
Syngnathus griseolineatus			5	6	1	1	1	1				
Cymatogaster aggregata	3	6	2	15	6	63	5	2917	7	151	5	12
Embiotoca lateralis	1	1	1	2			2	3	1	1		
Rhacochilus vacca					1	1	1	4	1	21		
Lumpenus sagitta							1	9	1	1	1	2
Apodicthys flavidus	2	7										
Pholis laeta	2	3							1	1		
P. ornata					1	1						
Ammodytes hexapterus							1	1				
Clevelandia ios									2	3		
Artedius fenestralis	2	2	1	1								
Chitonotus pugetensis	3	4									1	1
Cinocottus acutecips	2	6	2	2	3	4			3	4	1	2
Enophrys bison	2	2	1	1								
Leptocottus armatus	6	11	4	35	17	805	9	81	15	147	10	112

Table 5. (continued)

	Site											
	Tatsolo Point		DuPont Dock		DeWolf Bight		Thompson Cove		East Oro Bay		Sandy Cove	
Species	Occur. (18 coll.)	No	Occur. (18 coll.)	No.	Occur. (19 coll.)	No.	Occur. (20 coll.)	No.	Occur. (20 coll.)	No.	Occur. (19 coll.)	No.
Myxocephalus polyacanthocephalus			1	1								
Oligocottus maculosus	2	2										
Agonus acipenserinus							1	1				
Lepidopsetta bilineata	2	2	3	3	5	12	6	32	3	6	2	9
Microstomus pacificus					1	1						
Parophyrs vetulus					11	97	6	11	1	2	3	13
Platichthys stellatus			5	15	15	102	5	9	1	2		
Psettichthys melanostictus					1	1						
Totals												
#Species	17		16		19		17		17		13	
#Fish	687		438		7128		14814		2269		3366	

*One collection = two hauls with a 37-m beach seine set 30m from shore.

Table 6. Abundance and percent composition of fishes caught in surface townet hauls during 1977 in the DuPont-Nisqually study area, southern Puget Sound, Washington, March through July, 1977.

Species	Tatsolo Point (24 hauls)	DuPont Dock (42 hauls)	Nisqually Delta (28 hauls)	Total No.	Total %
Squalus acanthias	4	28	24	56	6.7
Hydrolagus colliei	1			1	.1
Clupea harengus pallasi	55	73	84	212	25.5
Oncorhynchus gorbuscha	14	18	4	36	4.3
O. keta	38	100	69	207	24.8
O. kisutch	5	6	9	20	2.4
O. nerka	1			1	.1
O. tshawytscha	95	90	40	225	27.0
Salmo gairdneri			1	1	.1
Hypomesus pretiosus		3		3	.4
Gadus macrocephalus	2	1		3	.4
Merluccius productus		2	1	3	.4
Microgadus proximus			1	1	.1
Aulorhynchus flavidus			1	1	.1
Gasterosteus aculeatus	1	1		2	.2
Cymatogaster aggregata	1	1	1	3	.4
Embiotoca lateralis		4	1	5	.6
Pholis laeta		1		1	.1
P. ornata		1	1	2	.2
Ammodytes hexapterus	2	2		4	.5
Gilbertidia sigalutes		1	1	2	.2
Leptocottus armatus	1	6	11	18	2.2
Nautichthys oculofasciatus		1		1	.1
Rhamphocottus richardsoni		1		1	.1
Platichthys stellatus	1	5	8	14	1.7
Pleuronectid larvae	1	7	2	10	1.2
Total	222	352	259	833	96.7

Commercially and recreationally important species, other than salmonids, included: Pacific herring, surf smelt, Pacific tomcod, striped seaperch, pile perch, rock sole, English sole, and starry flounder.

Salmonid Catch Results

Chum Salmon. Although not evident in large concentrations, outmigrating juvenile chum salmon occurred regularly in 1977 beach seine and townet catches at Tatsolo Point, DuPont Dock, and outer Nisqually Delta (Tables 7 and 8, Fig. 6). Catch-per-unit-effort (CPUE)[2] values were usually low and on only six occasions did beach seine or townet CPUE exceed 10 fish/haul. Chum were first caught in early March and peak abundances occurred in the first and third weeks of May and in early July (Fig. 6). These peaks reflect natural runs and some of the 6 million hatchery-reared fish planted at McAllister Springs (Williams, personal communication). Low numbers of chum occurring along the DuPont shoreline in 1977 indicated outmigrating chum salmon do not utilize the DuPont shoreline extensively. Evidence for use of shorelines north (e.g., Anderson Island) and west of the delta was indicated by WDF visual surveys for juvenile salmon (Morrill 1974). Since 1964, they have shown juvenile salmon to be relatively abundant or at least consistently present along shorelines west and north of the Nisqually Delta on a year-to-year basis.

Beach seine catches in 1978 through mid-May indicated most juvenile chum were migrating along shorelines west and north of the delta. The highest catches, during both day and night, through mid-May were at sites

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[2] $\text{CPUE} = \dfrac{\text{number of fish caught per station}}{\text{number of hauls per station}}$

Table 7. Beach seine catch-per-unit-effort of juvenile salmon in the DuPont-Nisqually study area, southern Puget Sound, Washington, March 23 to July 27, 1977.*

Date	Tatsolo Point				DuPont Dock				Outer Nisqually Delta			
	Chum	Pink	Chinook	Coho	Chum	Pink	Chinook	Coho	Chum	Pink	Chinook	Coho
March 23	No sample taken				0	0	0	0	No sample taken			
April 7	2.5	0	0	0	6.0	0	0	0	4.0	0	0	0
April 21	1.0	0	0	0	No sample taken				No sample taken			
May 3	0.3	0	0	0.5	25.5	0	0	9.0	12.0	0	0	0.5
May 15	2.0	0	0	36.0	0	0		1.5	No sample taken			
May 31	9.3	0	2.3	0.5	1.0	0	9.0	6.5	1.5	0	20.5	6.5
June 28	1.5	14.0	28.0	1.5	7.0	4.0	50.5	11.0	51.5	51.5	305.5	0
July 27	0	0	3.0	0	2.5	0.5	5.0	0	10.0	4.0	58.0	0

*All values are averages of salmon caught in two or four hauls. Beach seine unit of effort = 30-m beach seine hauls (distance from beach) with a 37-m beach seine, except on May 15 when a 10-m beach seine was used.

Table 8. Townet catch per-unit-effort of juvenile salmon in the DuPont-Nisqually study area, southern Puget Sound, Washington, March 10 to July 7, 1977.*

Date	Tatsolo Point				DuPont Dock				Outer Nisqually Delta			
	Chum	Pink	Chinook	Coho	Chum	Pink	Chinook	Coho	Chum	Pink	Chinook	Coho
March 10	No sample taken				1.0	0	0	0	0.3	0	0	0
April 14	0.5	0	0	0	0	0	0	0	0	0	0	0
May 5	0.3	0	0	0	0.5	0	0	0	0.3	0	0	0
May 19	1.3	0	0	0	2.5	0	0	1.0	13.3	0	0	0.5
June 2	0	0	1.3	0.3	0	0	0	0	1.3	0	0	0
June 15	0	2.8	14.0	0.5	0.2	0.2	4.8	0	1.3	0.8	9.3	1.8
July 7	7.3	0.8	8.8	0	12.5	2.8	10.2	0	1	0.3	0.8	0

*Townet catch per-unit-effort = mean number of fish per 10-minute tow. All numbers are averages of salmon caught in three or four tows.

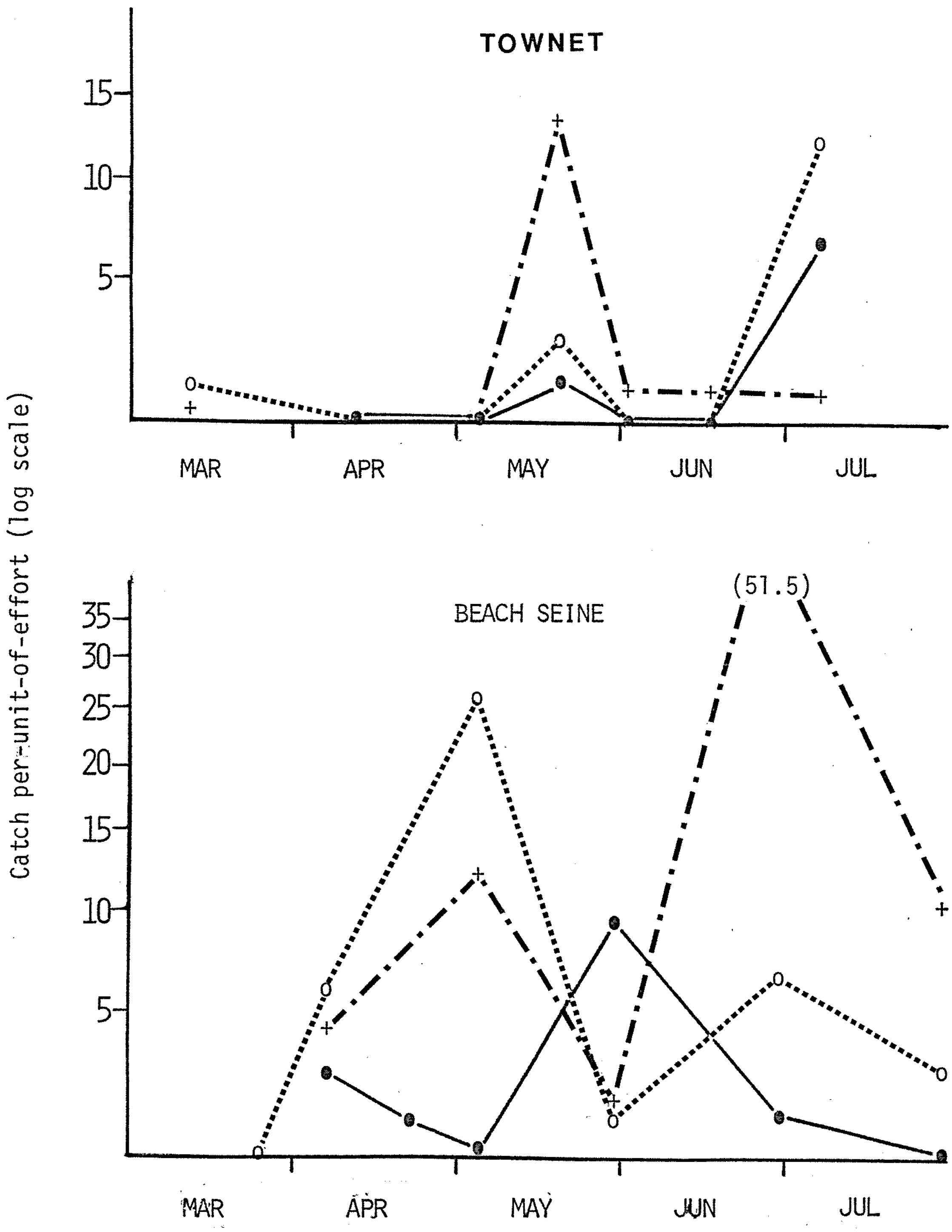


Fig.6 . Beach seine and tow net catch per-unit-of-effort of juvenile chum salmon, southern Puget Sound, WA, 1977. Station identification: Tatsolo Point ●——●; DuPont Dock o······o; Outer Nisqually Delta +·-·—+.

along Anderson Island and west of the delta (Table 9). Catches were greatest at the Thompson Cove and DeWolf Bight stations; the smallest catches occurred along the DuPont shoreline. Catches of small (< 40 mm FL) salmon in townet transects in early April from the middle of the Nisqually Reach suggest fish move out of the Nisqually River and McAllister Creek and across to Anderson Island.

Preliminary analysis of catches after mid-May 1978, however, indicate larger numbers of fish may move along the DuPont shoreline later in the season. Until analysis of all data is completed and the significance of these later catches determined, conclusions on the chum salmon outmigration should be limited.

Because of the lack of any marking program, the origin of fish caught by beach seine and townet could not be determined. Undoubtedly, both wild and hatchery-reared stocks of fish utilize the various shorelines. The March 30 catches at Thompson Cove and DeWolf Bight were approximately the same size as fish planted several days earlier in McAllister Creek. Many of the small (< 40 mm) chums caught were probably wild stocks of fish since most hatchery releases were at a larger size. There was a large range of sizes (32-110 mm FL) of fish caught in the beach seine and townet along all shorelines. The larger fish are either moving through the area from other parts of southern Puget Sound or are Nisqually system fish who have remained and reared in the area.

Because of problems with wind and cloudy weather during beach seine trips, too few visual surveys of chum (and pink) salmon were made to warrant presentation.

Coho Salmon. Coho salmon was the third and fourth most abundant salmonid species caught by beach seine and townet, respectively, during 1977

Table 9. CPUE of chum salmon for the period February 15 to May 22, 1978, at sites in the DuPont-Nisqually study area, southern Puget Sound, Washington. All values are the average of two floating beach seine hauls. (NS = no survey.)

Month	Day	Day (D) or Night (N)	Tatsolo Point	DuPont Dock	DeWolf Bight	Thompson Cove	East Oro Bay	Sandy Cove
February	15	D	0	0	0.5	1.0	0	0
	21	D	0.5	0	0	0	0	0
March	2	D	NS	NS	0	0	0	NS
	8	D	0	0	0	0	0	0
	15	D	0	0	0	0	0	0
	23	D	0.5	0	0	0	0.5	0
	30	D	0	3.0	473.0	2238.0	0.5	1.0
April	6	D	1.0	1.0	132.5	118.5	14.0	37.5
	13	D	0	0	0	183.5	174.5	0
	17	N	11.0	1.5	39.5	6.0	7.0	14.5
	20	D	0	0	185.0	39.5	40.0	17.0
	23	N	42.0	0.5	97.0	79.5	1.0	14.0
	27	D	0	5.5	229.0	1500.0	1.0	29.0
May	1	N	0	0	36.5	16.0	14.0	34.5
	4	D	0	0	89.0	47.5	81.5	153.0
	8	N	28.0	2.5	442.0	26.5	31.0	6.5
	11	D	NS	NS	NS	15.0	1.0	141.0
	15	N	37.0	3.0	340.0	5.5	11.0	34.5
	18	D	140.0	43.0	535.0	110.5	304.5	461.5
	22	N	23.5	72.5	316.0	3.5	13.0	55.5

(Tables 4 and 6). In 1978 beach seine catches, coho was the second most abundant salmonid (Table 10). Catches during 1977 were substantially higher in the beach seine than in the townet. This difference in catches between gear types indicated: 1) coho remained closer to shore and hence were not available to the townet; and/or 2) coho were better able to avoid the townet. Coho catches in 1977 occurred after May 3. Peak abundance in 1977 was in the mid-May beach seine collections at Tatsolo Point, 4 days after WDF began to release approximately 1.4 million smolts into Sequalitchew Lake (Table 7).

During 1978, coho appeared in beach seine collections as early as March 30 and peak catches occurred from early to mid-May at sites along Anderson Island. Low catches indicated coho do not migrate extensively along the DuPont shoreline. Many of the fish caught in early May were likely fish from the May 5 release of ∿ 900,000 smolts from Sequalitchew Lake into Sequalitchew Creek (Rodgers, personal communication), as well as wild fish. As other releases into the Mashel River of the Nisqually system occurred in mid-April (Foster, personal communication), some of these stocks may also have been represented in catches.

Pink Salmon. Catches of pink salmon occurred during both years of the study. Adult pink salmon return to spawn primarily in odd-numbered years in Puget Sound waters; as a result, catches of pink salmon during 1977 were somewhat unusual and should not be used to indicate juvenile pink outmigration patterns in the area. Largest 1978 catches were in the beach seine from late March through mid-April at sites west and north of the Nisqually River (Table 11). Surprisingly, large numbers of pinks did not appear in catches at any time during 1978. WDF visual surveys during 1978 to date have also failed to find large numbers of juvenile pinks in

Table 10. CPUE of coho salmon for the period February 15 to May 22, 1978, at sites in the DuPont-Nisqually study area, southern Puget Sound, Washington. All values are the average of two floating beach seine hauls. (NS = no survey.)

Month	Day	Day (D) or Night (N)	Tatsolo Point	DuPont Dock	DeWolf Bight	Thompson Cove	East Oro Bay	Sandy Cove
February	15	D	0	0	0	0	0	0
	21	D	0	0	0	0	0	0
March	2	D	NS	NS	0	0	0	NS
	8	D	0	0	0	0	0	0
	15	D	0	0	0	0	0	0
	23	D	0	0	0	0	0	0
	30	D	4.0	0	0	0	0	0
April	6	D	0	0	0	0	0	0
	13	D	1.0	0	0	0	0	10.5
	17	N	0	5.5	0	2.0	4.0	0.5
	20	D	0.5	12.5	1.0	50.5	4.5	0
	23	N	5.0	21.0	6.5	15.0	1.5	12.0
	27	D	5.5	16.5	0.5	2.5	0	58.0
May	1	N	0	1.0	3.0	29.5	2.0	6.0
	4	D	0	0	0.5	144.0	41.0	340.0
	8	N	2.5	4.0	5.5	296.5	23.0	66.0
	11	D	NS	NS	NS	21.0	0	5.0
	15	N	4.0	13.5	2.5	303.5	34.5	29.0
	18	D	5.0	2.5	10.5	190.0	1.5	0
	22	N	4.0	4.5	4.5	311.0	63.5	33.0

Table 11. CPUE of pink salmon for the period February 15 to May 22, 1978, at sites in the DuPont-Nisqually study area, southern Puget Sound, Washington. All values are the average of two floating beach seine hauls. (NS = no survey.)

Month	Day	Day (D) or Night (N)	Tatsolo Point	DuPont Dock	DeWolf Bight	Thompson Cove	East Oro Bay	Sandy Cove
February	15	D	0	0	0	0	0	0
	21	D	0	0	0	0	0	0
March	2	D	NS	NS	2.0	3.0	0	NS
	8	D	0	0	0	0	0	0
	15	D	0.5	0	0.5	0	0	0
	23	D	0	0	0	0	0.5	0
	30	D	0	0	17.0	12.0	0	0.5
April	6	D	0	0	27.5	29.5	1.5	19.0
	13	D	0	0	0	58.0	75.5	0
	17	N	0	0	1.0	0	0	1.0
	20	D	0	0	2.5	4.0	6.0	1.5
	23	N	1.0	0	1.5	2.5	0.5	0
	27	D	0	0	2.5	0	0	0
May	1	N	0	0	0	0	0.5	0
	4	D	0	0	7.5	1.0	4.0	0
	8	N	0.5	0	0	0	0	0
	11	D	NS	NS	NS	0	0	0.5
	15	N	0	0	0	0	0	0
	18	D	0	0	1.5	0	3.5	19.5
	22	N	1.5	0	0	0	0	0

the study area (McBride, personal communication). Even after releases of juvenile pinks into the Nisqually River by the Nisqually Indian Tribe (Wilson, personal communication) and into McAllister Creek by WDF (Rodgers, personal communication), catches of pinks in the beach seine and townet were small. Purse seine catches of adult pinks in fall 1977 by USFWS were low and may be indicative of a poor return of pinks into the Nisqually River (Cole, personal communication). Thus, the lack of wild stocks of outmigrating pinks during 1978 was most likely a result of a poor return of adults. The lack of any apparent relationship between our catches and hatchery releases is more difficult to explain. Factors such as poor food supply or predation pressures may have caused juvenile pinks from hatchery releases to move rapidly through the area and thus be missed by our sampling.

Chinook Salmon. Juvenile chinook salmon was the most abundant species caught by both beach seine and townet in 1977 (Tables 4 and 6), and all were caught after May 30, indicating a later outmigration than for the other salmonid species (Tables 7 and 8). The largest catches occurred in beach seine collections at the Nisqually mudflat station in late June. Catches of chinook through June 1, 1978 were very low at all stations; however, catches after this time indicate a substantial increase in chinook abundance.

Several of the chinook caught during both years were large resident or "feeder" chinook which represent potential predators to smolt and fry. The relative abundance of "feeder" chinook was probably underestimated because of their greater ability to avoid the sampling gear.

Other Salmonids. Other salmonids caught incidentally in 1977 included two rainbow trout (steelhead), one cutthroat, and one sockeye salmon. In 1978, catches included six cutthroat trout, two rainbow trout (steelhead), and one Dolly Varden. Sockeye salmon are rare in southern Puget Sound and Dolly Varden had not been previously reported from this area (DeLacy et al. 1972). With the exception of the sockeye, these infrequently caught species were of sufficient size to represent potential predators of small fish.

Trynet

A total of 4,277 fish representing 41 species were caught by trynet (Table 12). The 10 most abundant of these species comprised 92.8 percent of the catch (Table 13). More species (31) and more fish (1,809 = 42.3 percent) were caught at DuPont Dock than at the other two stations.

Numbers of species (species richness) caught per 5-minute haul ranged up to 19 and numbers of fish per haul were as high as 439 (Appendix 4). Overall, abundance of fish per haul was generally low from March 1977 through September 1977 and substantially greater in November 1977 and January 1978 (Fig. 7). The bimonthly sampling frequency and lack of replication makes the significance of this "trend" difficult to determine.

English sole and rock sole, comprising 47.2 percent of the total catch, were the most abundant species. Both species were more numerous at the DuPont Dock and outer Nisqually mudflat stations and were relatively more abundant in hauls at 15 m than at 5 m (Table 13). Other studies have found English sole and rock sole to be among the predominant trawl-caught species occuring in Puget Sound (Moulton et al. 1974, Miller et al. 1975). Several species--notably English sole, staghorn sculpin, and sturgeon poacher--increased in abundance with proximity to the delta, indicating a preference for the fine, sand/silt substrate associated with the delta and

Table 12. Abundance and percent composition of fishes caught by trynet in the DuPont-Nisqually study area, southern Puget Sound, Washington, 1977-1978.

Species	Tatsolo Point (21 hauls)	DuPont Dock (21 hauls)	Outer Nisqually Delta (21 hauls)	Totals No.	Totals Percent*
Hydrolagus colliei	22	34	12	68	1.6
Porichthys notatus	2	6	3	9	.2
Gadus macrocephalus	2	1	1	4	.1
Microgadus proximus	74	145	124	343	8.0
Theragra chalcogramma	7	5	2	14	.3
Aulorhynchus flavidus		14		14	.3
Syngnathus griseolineatus	1	7		8	.2
Cymatogaster aggregata	163	254	35	452	10.6
Embiotoca lateralis	4	2	6	12	.3
Rhacochilus vacca	22	3	3	28	.6
Anoplarchus purpurescens	1			1	-
Lumpenus sagitta		5		5	.1
Apodichthys flavidus	1			1	-
Sebastes caurinus	8			8	.2
S. maliger	1	1		2	-
Anoplopoma fimbria	1			1	-
Hexagrammos lagocephalus	1			1	-
H. stelleri	7			7	.2
Oxylebius pictus	1	1		2	-
Artedius fenestralis	40	2	6	48	1.1
A. lateralis		2		2	-
Chitonotus pugetensis	305	151	34	490	11.5
Enophrys bison	38	8		46	1.1
Leptocottus armatus	41	53	152	246	5.8
Myoxocephalus polyacanthocephalus	8	3		11	.3
Nautichthys oculofasciatus	6	2		8	.2
Agonopsis emmelane	6			6	.1
Agonus acipenserinus	15	42	68	125	2.9
Odontopyxis trispinosa			1	1	-
Pallasina barbata		1		1	-

Table 12. (continued)

Species	Tatsolo Point (21 hauls)	DuPont Dock (21 hauls)	Outer Nisqually Delta (21 hauls)	Totals No.	Totals Percent*
Xeneretmus latifrons		1		1	-
Citharichthys sordidus			2	2	-
C. stigmaeus	16	150	5	171	4.0
Gylptocephalus zachirus		1		1	-
Isopsetta isolepis			15	15	.4
Lepidopsetta bilineata	95	305	174	574	13.4
Microstomus pacificus	1	6	6	13	.3
Parophrys vetulus	258	584	604	1,446	33.8
Platichthys stellatus		8	3	11	.3
Pleuronichthys coenosus	14	8	3	25	.6
Psettichthys melanostictus		4	48	52	1.2
Totals: # of species	30	31	22		
# of fish	1,161	1,809	1,307	4,277	99.7

*Hyphen (-) = <.1 percent

Table 13. Abundance by depth of trynet hauls of the ten most abundant species in the DuPont-Nisqually study area, 1977-1978.

Species	Total	Depth of Tow (meters) 5	10	15
Parophrys vetulus	1,446	408	456	582
Lepidopsetta bilineata	574	107	158	309
Chitonotus pugetensis	490	193	141	156
Cymatogaster aggregata	452	45	91	316
Microgadus proximus	343	27	61	255
Leptocottus armatus	246	159	62	25
Citharichthys stigmaeus	171	34	93	44
Agonus acipenserinus	125	44	44	37
Hydrolagus colliei	68	9	20	39
Psettichthys melanostictus	52	12	14	26
Total	3,967			

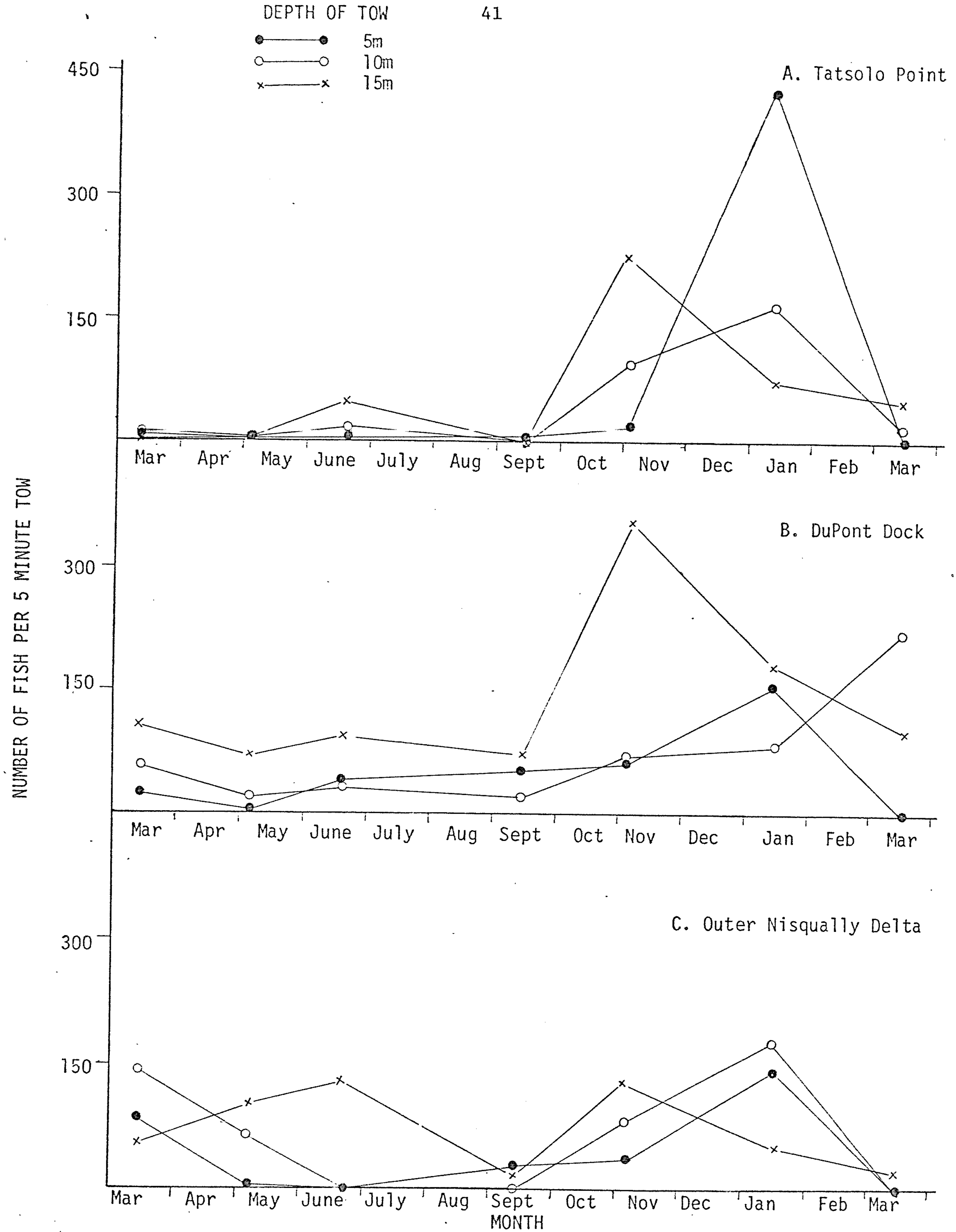


Fig. 7. Number of fish caught per trynet haul at Tatsolo Point (A), DuPont Dock (B), and the outer Nisqually Delta (C), southern Puget Sound, 1977-1978.

a tolerance of low salinity waters. Other species, such as roughback sculpin and buffalo sculpin, appeared to prefer the sand/gravel substrate and steep dropoff associated with the Tatsolo Point site; these species may also prefer more saline water. Of the abundant species, roughback sculpin and staghorn sculpin were more numerous in shallower hauls, whereas English sole, rock sole, shiner perch, Pacific tomcod, and ratfish were more abundant in deeper sets. It is questionable whether the 5-m difference in depth is significant, as a result, differences between hauls at 5 and 15 m may be more indicative of any depth preference.

The occurrence of nematodes and tumors was quite high in pleuronectids (Table 14). Of 219 adult rock sole and 248 adult English sole examined, the infection rate of nematodes was 42.9 percent and 40.3 percent, respectively. Miller et al. (1974) found comparable infection rates at Stadium in Case Inlet, but lower rates at Union in the Hood Canal. The percentage of tumor-infected fish (all English sole) was 4.8 percent.

Purse Seine

Fourteen purse seine hauls during October and November 1977 captured 643 salmon. Their relative abundances were: coho--83.3 percent, chinook--9.8 percent, chum--6.5 percent, and steelhead--0.3 percent (Table 15). The average number of fish captured per set was 38.2 coho, 4.5 chinook, 3.0 chum, and 0.1 steelhead.

Prior to FRI purse seining, the USFWS sampled the DuPont shoreline between August 10 and September 12, 1977. Of the 223 salmon captured by USFWS, 70.4 percent were coho, 14.8 percent pink, 14.4 percent chinook, and 0.4 percent chum (Cole, personal communication).

Table 14. Occurrence of nematode-infected and tumor bearing* fish in trynet catches, southern Puget Sound, Washington, 1977.

Month	Station	Rock Sole+ Percent Infected	Rock Sole+ Sample Size	English Sole+ Percent Infected	English Sole+ Sample Size
March	Tatsolo Point	0	5	0	0
"	DuPont Dock	37.9	29	21.7(13.0)	23
"	Outer Nisqually Delta	17.6	17	28.9(4.4)	45
May	Tatsolo Point	25.0	4	0	0
"	DuPont Dock	52.4	21	73.3	15
"	Outer Nisqually Delta	34.4	32	33.3(9.5)	63
June	Tatsolo Point	36.8	19	16.7(16.7)	6
"	DuPont Dock	40.0	25	39.5	38
"	Outer Nisqually Delta	60.0	10	43.5	23
Sept	Tatsolo Point	66.7	3	0	0
"	DuPont Dock	67.5	40	68.8	32
"	Outer Nisqually Delta	35.7	14	66.7	3
	Summary:	mean - 42.9	219	mean - 40.3	248

*Percents of fish bearing tumors are in parentheses. No parentheses indicates no tumors.

+Fish less than 150 mm in total length are not included.

Table 15. Relative abundance of anadromous species captured with a commercial purse seine along the Dupont shoreline, southern Puget Sound, Washington, October and November, 1977.

Species	Oct 7	Oct 24	Nov 7	Nov 21	Totals No.	Totals %
Coho	373	149	13	1	536	83.3
Chinook	9	11	31	12	63	9.8
Chum	0	2	8	32	42	6.5
Steelhead	0	0	1	1	2	.3
Total	382	162	53	46	643	99.9
Number of sets	3	3	4	4		
Catch/unit effort*	127.3	54.0	13.3	11.5		

*Catch/unit effort = mean number of fish caught per set. The average duration of each set was 39 minutes.

As our sampling progressed, coho abundance decreased markedly. Coho abundance in the August-September 1977 USFWS surveys increased during the later part of their survey (Cole, personal communication). Peak migration of adult coho salmon along the DuPont shoreline is probably during September and October.

Catches of chum salmon in FRI hauls, while small relative to coho catches, increased steadily through the sampling period. Prior to FRI sampling, one chum salmon was caught in the 33 purse seine sets by USFWS in August and September 1977 (Cole, personal communication). Large catches of chum along the DuPont shoreline by USFWS in 1974-1975, 1975-1976, 1976-1977, and 1977-1978 occurred in December and January (Cole, personal communication; Olney, personal communication). Thus, peak migration of chum salmon along the DuPont shoreline is likely during December and January.

To date, of the 617 salmon tagged from purse seine catches along the DuPont shoreline, 135 (21.9 percent) have been recovered, including 124 coho, eight chum, two chinook, and one steelhead; most recoveries were from areas south of the Tacoma Narrows Bridge. The majority of tagged coho were recovered in freshwater, in particular from Chambers Creek and the Nisqually River (Fig. 8). Tag returns from all directions from the DuPont Dock area suggests the DuPont shoreline may be used as a milling area by coho salmon. Of the eight recoveries of chum salmon, seven were from freshwater; four of these were recovered from the Nisqually River. Tagging by the USFWS has shown adult chum salmon tagged along the DuPont shoreline in December and January were bound primarily for the Nisqually River (Olney 1976, personal communication). Recoveries of chinook and steelhead were too few to yield information on movements; however, the

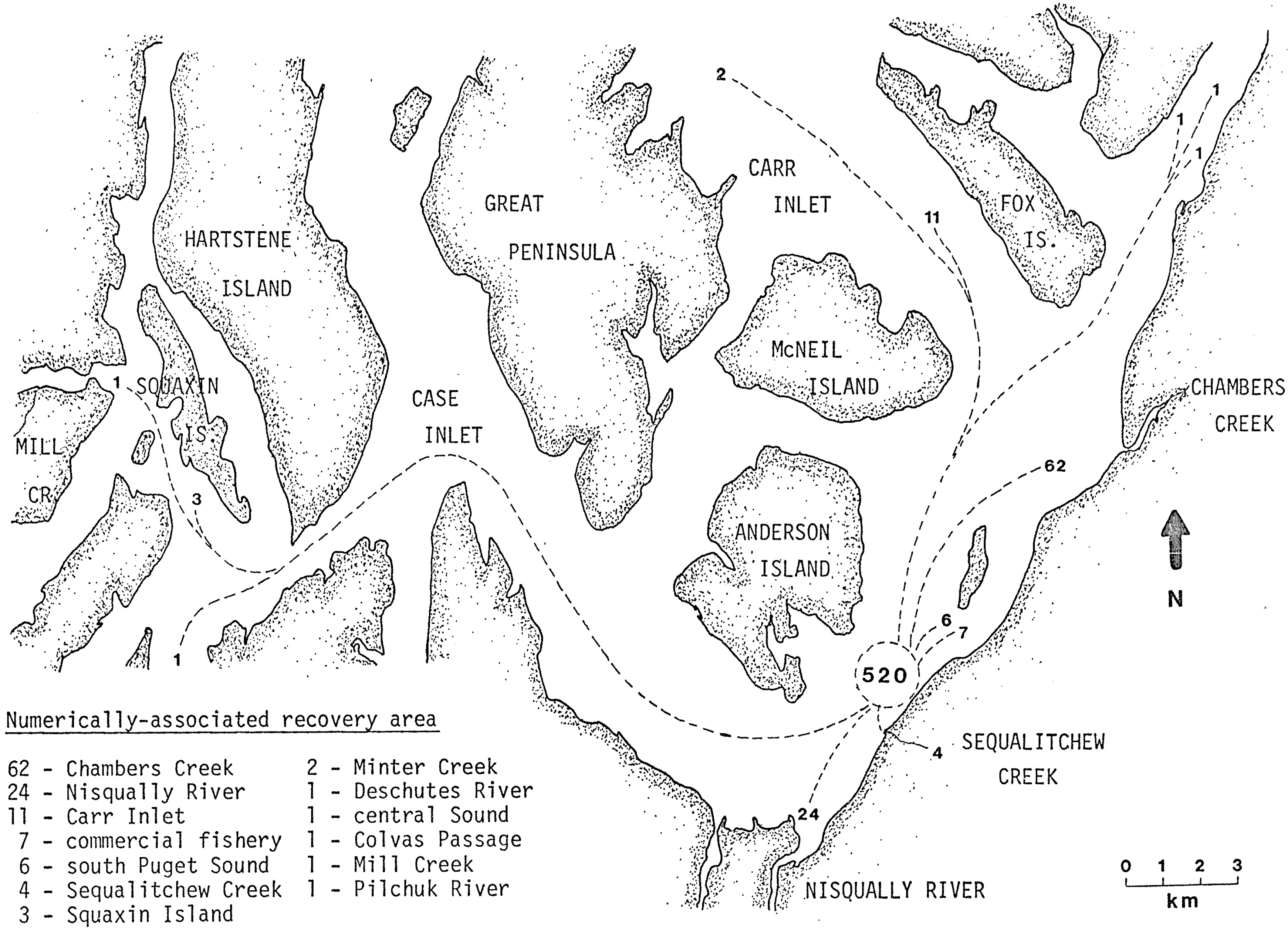


Fig. 8. Diagrammatic representation of tagging/recovery areas of adult and sub-adult coho salmon in southern Puget Sound, Washington, October-January, 1977-78.

small size of the chinook captured (Fig. 9) indicates the chinook were mostly residents (blackmouth).

SCUBA Surveys

SCUBA observations at the DuPont Dock included 26 demersal and 11 pelagic species (Tables 16 and 17). Demersal species were generally seen as solitary individuals while pelagic species were usually in schools or aggregations of varying sizes and densities. Pelagic fishes were relatively more abundant than demersal fishes. Buffalo sculpin were sighted on every dive and were the most abundant demersal species. Numbers of buffalo sculpin sighted were greatest during winter and early spring when males were observed guarding egg masses among the pilings. Other abundant demersal species included the rock sole and painted greenling. Three species of embiotocid and the tubesnout were the most abundant nondemersal species. Shiner perch were numerically the most abundant species; however, the species was only sighted during the seven dives between June and December. Striped seaperch and pile perch were less abundant than shiner perch but were seen during all dives. Tubesnouts occurred in the dock area from June through October as juveniles and adults.

Possible piscivorous fish species sighted during SCUBA dives included: spiny dogfish, Pacific cod, buffalo sculpin, great sculpin, red Irish lord, Pacific staghorn sculpin, copper and quillback rockfish, cabezon, subadult and adult salmon, rock sole, and starry flounder. Of these, other salmonids and various cottids have been particularly implicated (see Iwamoto and Salo 1977 for review). Because the dock is

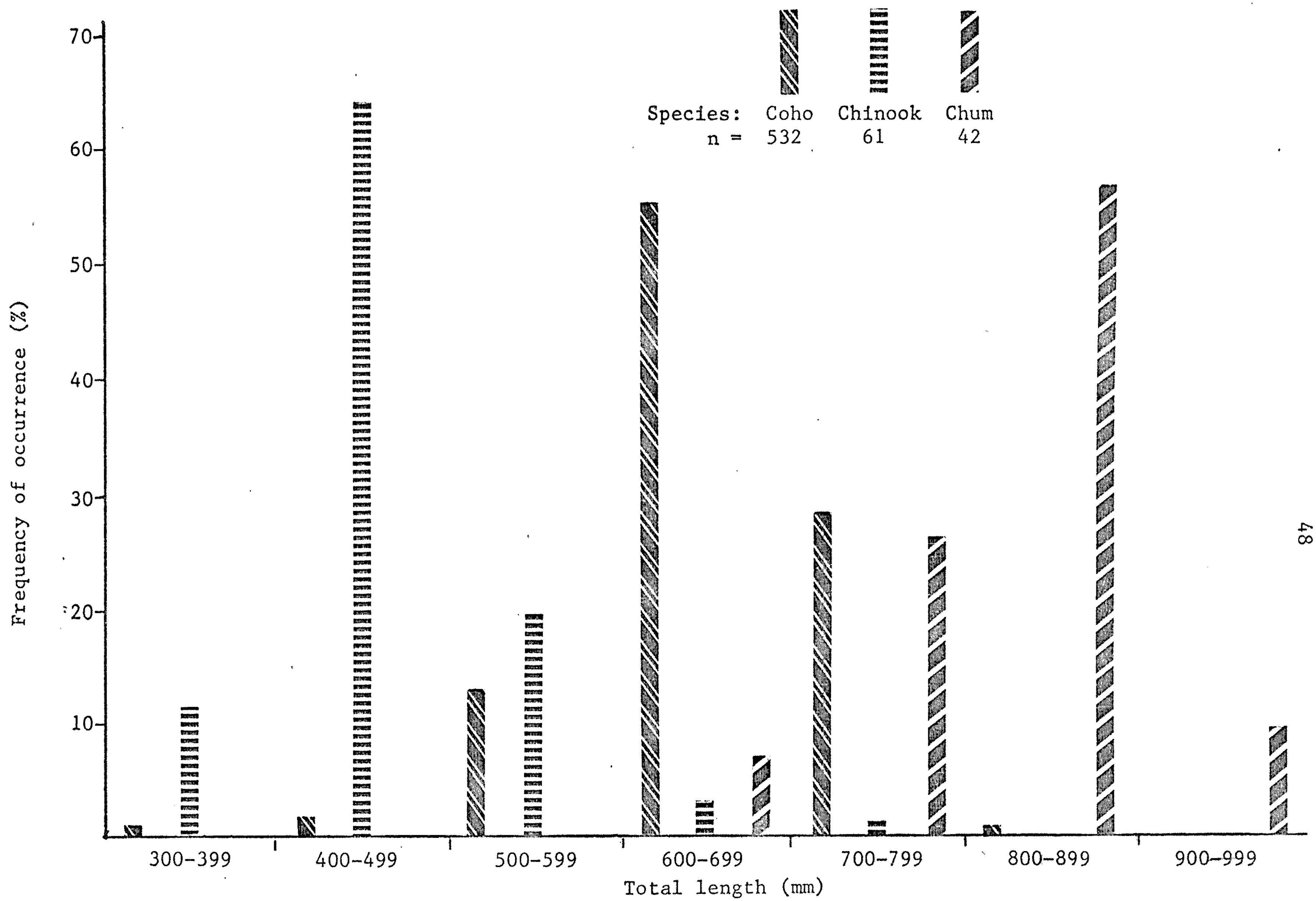


Fig. 9. Length-frequency distribution of salmon captured by purse seine in October and November, 1977 in the east Nisqually Reach, southern Puget Sound. Note: <u>within</u> each length category, e.g. 600-699, fish species are arrayed by identity, not by size.

Table 16. Monthly mean number of demersal fishes observed per SCUBA survey at the DuPont Dock, 1977-1978.

	June 24		July 22		Aug 22		Sept 19		Oct 22		Nov 29		Dec 20		Jan 19		Feb 28		Mar 22		May 1	
Species	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad
Squalus acanthias												.5										
Gadus macrocephalus								1														
Lumpenus sagitta		1		.5		.5	.5	3.5														
Apodichthys flavidus								3		2.5												
Pholis lacta								.5														
P. ornata				2	.5	.5		.5														
Sebastes auriculatus																	.5		.5		1	
S. caurinus	5		1.5	3	1	3	1.5	1.5														
S. maliger					.5					1												
Hexagrammos decagrammus					1	2.5																
Oxylebius pictus	1	1	.5	1.5	2.5	2.5	1.5	2.5	1.5	1	.5	1.5	.5			.5				1		
Artedius lateralis (?)	3				4		4		2	.5			.5									
Blepsias cirrhosus						1																
Enophrys bison		5	1	3	4	5.5	2.5	8	2.5	8	.5	1		2		16.5		2.5		17		34
Hemilepidotus hemilepidotus		1	1.5				5	2														
Leptocottus armatus	1	2			1	1	3	2.5			.5	1				.5						7
Myxocephalus polyacanthocephalus																		1				
Rhamphocottus richardsoni																1						
Scorpaenichthys marmoratus						.5						.5										
Agonus acipenserinus				2.5		.5	2	2	1	1		.5										
Glyptocephalus zachirus		3																				
Lepidopsetta bilineata		5	1	5.5	3.5	7.5	1	5.5		6.5	1	2		2		1		.5				8
Microstomus pacificus		1																				
Parophrys vetulus			1.5	1.5																		2
Platichthys stellatus		2						.5										.5				1
Pleuronichthys coenosus		1			1.5																	
Totals (Juv and Ad Combined):																						
# species	12		9		14		14		7		7		4		5		5		3		6	
# individuals	32		26.5		44.5		54		27.5		9.5		5		19.5		27.5		18.5		53	

(?) = identity of fish unconfirmed

Table 17. Monthly mean number of midwater and pelagic fishes observed per SCUBA survey at the DuPont Dock, 1977-1978.

	Survey Date																					
	June 24		July 22		Aug 22		Sept 19		Oct 22		Nov 29		Dec 20		Jan 19		Feb 28		Mar 22		May 1	
Species	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad
+*Clupea harengus pallasi*		10					250		200													
Oncorhynchus gorbuscha								2.5														
O. kisutch	20							1														
O. tshawytscha	260		10																			
Salmo clarki		1																				
+*Hypomesus pretiosus*								20		50												
+*Aulorhynchus flavidus*	870	45	21.5	90		592.5	1375	115		35												
Gasterosteus aculeatus			1	5																		
+*Cymatogaster aggregata*	3130*		4270*		3175*		4885*		590*			28	11	31.5								
+*Embiotoca lateralis*	230	50	29	21.5	38.5	13	885	7.5	60	27.5	10	2.5	5	34	9	100		500		285		100
+*Rhacochilus vacca*	250	104	252.5	64.5	75	29.5	550	35	70	18.5	21.5	69	.5			7		750		317.5		400

Totals (Juv and Ad combined):	June 24	July 22	Aug 22	Sept 19	Oct 22	Nov 29	Dec 20	Jan 19	Feb 28	Mar 22	May 1
# species	8	6	4	8	6	3	3	2	2	2	2
# individuals	4970	4765	3923.5	8126	1051	131	83	116	1250	602.5	500

+ Estimates, due to the difficulties in visually counting mixed, schooling fish.

* Adults and juveniles could not be counted separately due to similarity in lengths and large numbers observed.

adjacent to a steep dropoff to over 35 m, abundance of predatory fish may increase at night as a result of inshore feeding movements.

Plankton Studies

Zooplankton

The three stations sampled by bongo net appeared to have similar zooplankton populations (Appendix 5). Considering that the three sites sampled are located relatively close to each other and strong tidal currents are characteristic of this area, this was not surprising. Differences between sites may be due to patchy spatial distributions of the organisms. The zooplankton were sorted only to broad levels; further divisions would be necessary to reveal any local differences.

Calanoid copepods were the most numerous zooplankton collected at all three sites. Relative abundance of calanoid copepods decreased from March to April before increasing markedly in May (Fig. 10) and remaining high through July. The abundance of calanoids in surface and oblique tows was similar, indicating a relatively even vertical distribution. Other studies in Puget Sound--Hebard (1956) in central Puget Sound, Johnson (1931) at Friday Harbor, and Dempster (1938) in Hood Canal--also found calanoids to be the most abundant zooplankters.

Other abundant zooplankters included crab zoea, cnidaria, and caridean zoea. Peak catches of crab zoea occurred during April (Fig. 11), and were followed in later collections by crab megalops. Few cnidaria were collected during March and April; however, abundance of this taxon increased substantially during May and remained high through July. Cnidaria were comparatively more numerous in oblique tows than in surface

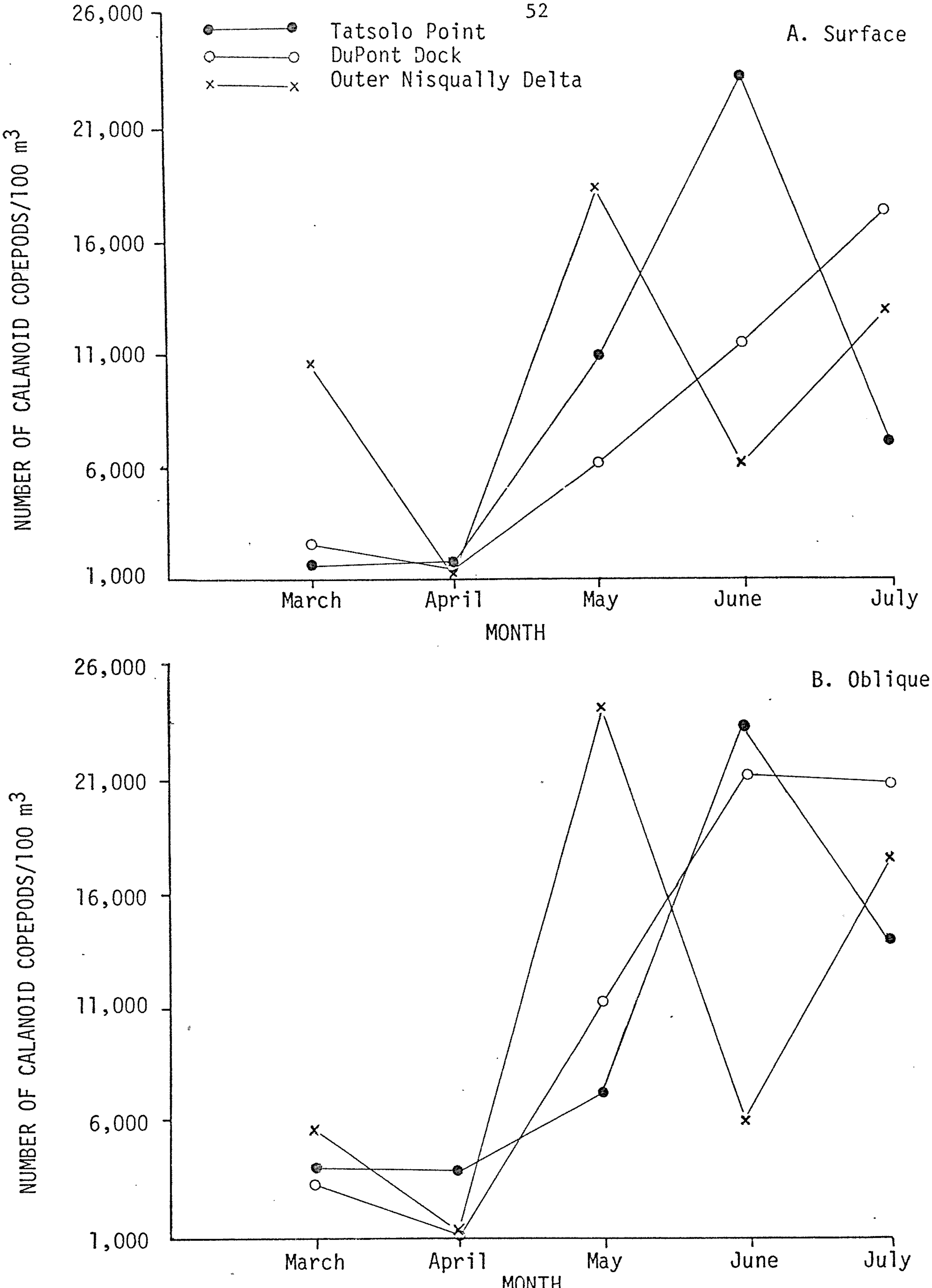


Fig. 10. Numbers of calanoid copepods per 100 m^3 of water strained in surface (A) and oblique (B) bongo net hauls in the DuPont area, southern Puget Sound, 1977.

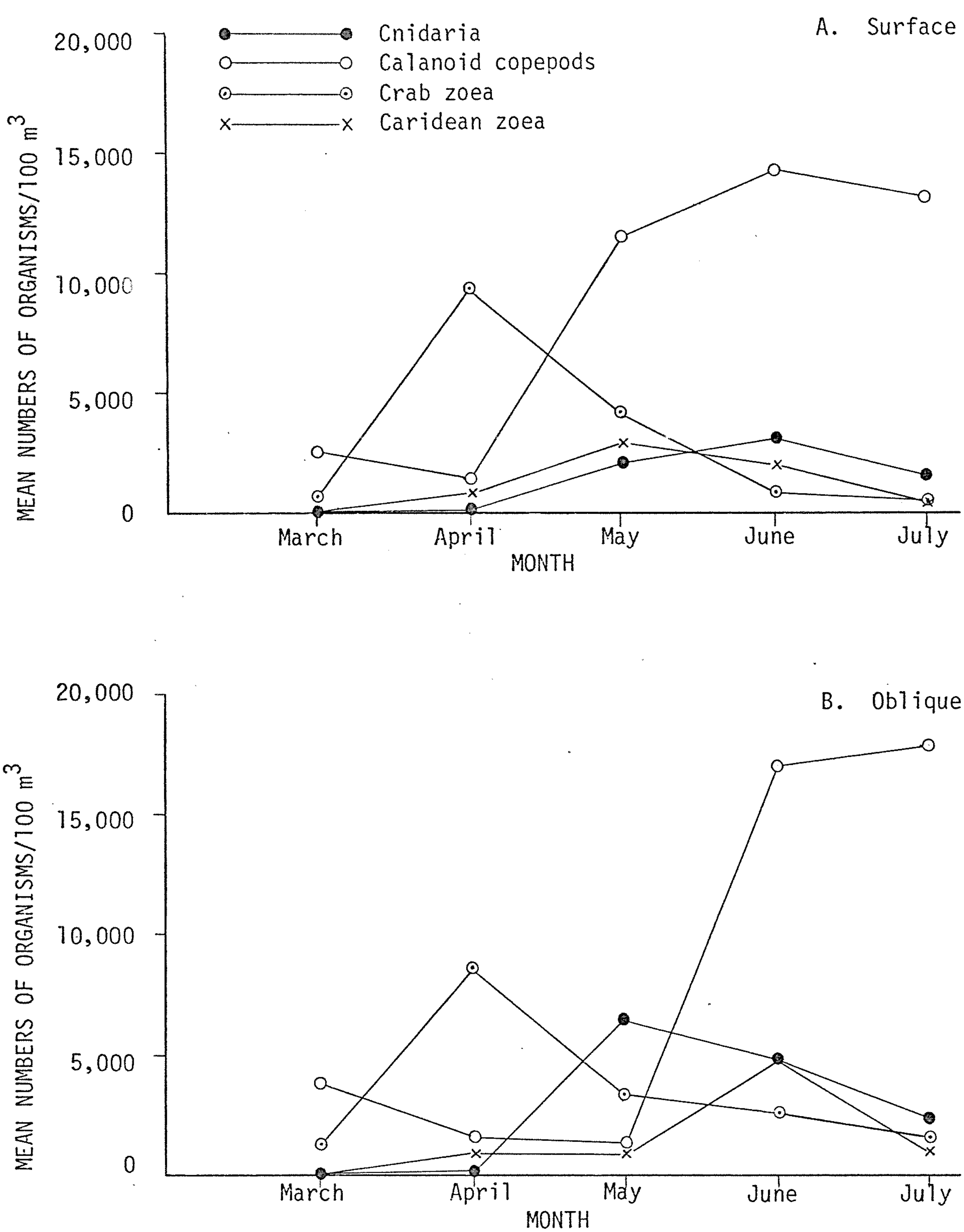


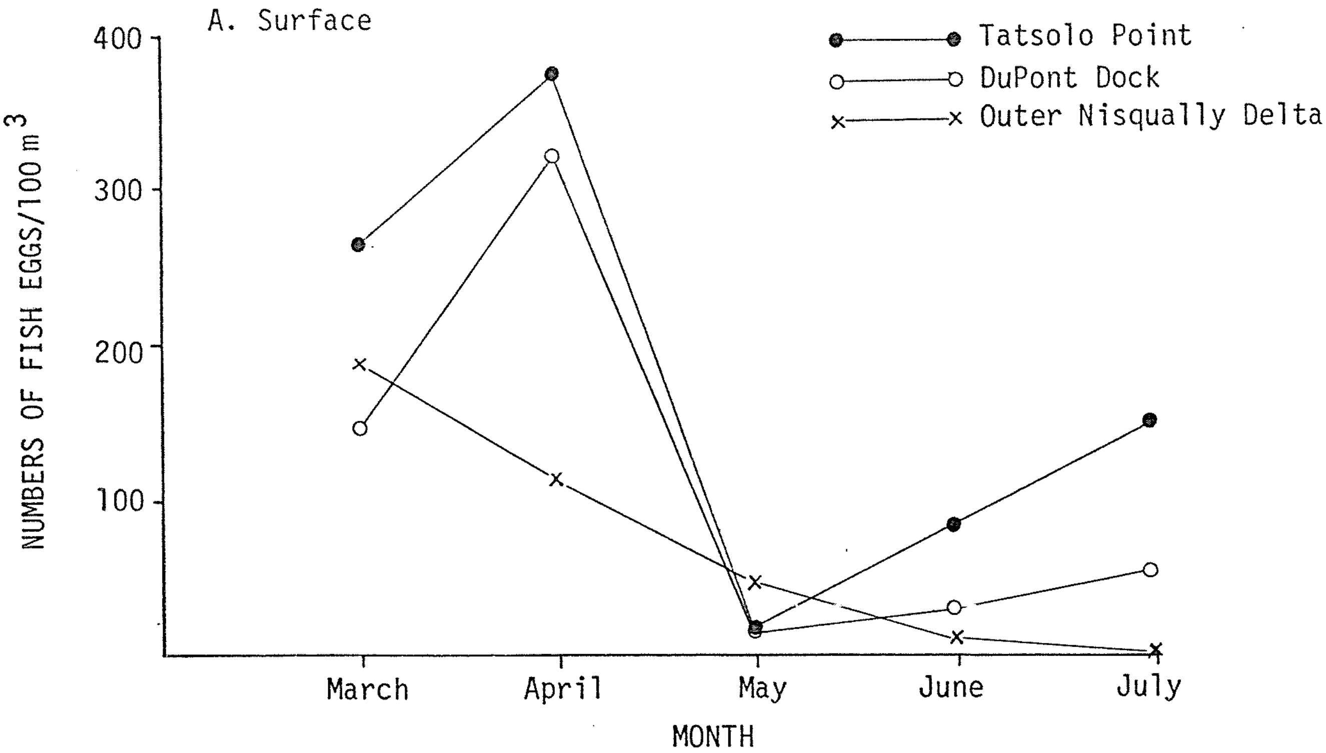
Fig. 11. Numbers of organisms per 100 m^3 of water strained in surface (A) and oblique (B) bongo net hauls of the most abundant zooplankton taxons in the DuPont study area, 1977.

tows, indicating a deeper distribution. Caridean zoea catches were very low during March before increasing markedly in April to peak levels during May and June.

Ichthyoplankton

Catches of fish eggs were greatest in April and then decreased steadily through July (Fig. 12). All fish eggs were bothids, gadoids, and pleuronectids (Table 18). Of the pleuronectids, the Parophrys-Psettichthys-Platichthys complex was the most abundant and occurred almost entirely in March and April. There did not appear to be significant depth or site differences in abundance of this taxon. C-O sole eggs were the predominant egg type found in later collections (May to July). Over half of the C-O sole eggs came from Tatsolo Point, and surface tows collected more than oblique tows.

Fish larvae, like the fish eggs, were most numerous in April before decreasing steadily through July (Fig. 13). The dominant fish larvae were gadoids and pleuronectids (Table 19), comprising 43.7 percent and 34.2 percent of the total fish larvae, respectively. Gadoid larvae occurred primarily as a single pulse in April at all sites. Of the pleuronectid larvae collected, English sole were by far the most abundant, particularly during April at the outer Nisqually Delta site. A lack of both Pacific herring and Pacific sand lance larvae in plankton samples was noted at all three sites; however, 1978 townet catches along Anderson Island, particularly in Oro Bay, had an abundance of both. These species likely do not utilize the DuPont shoreline for spawning and rearing.



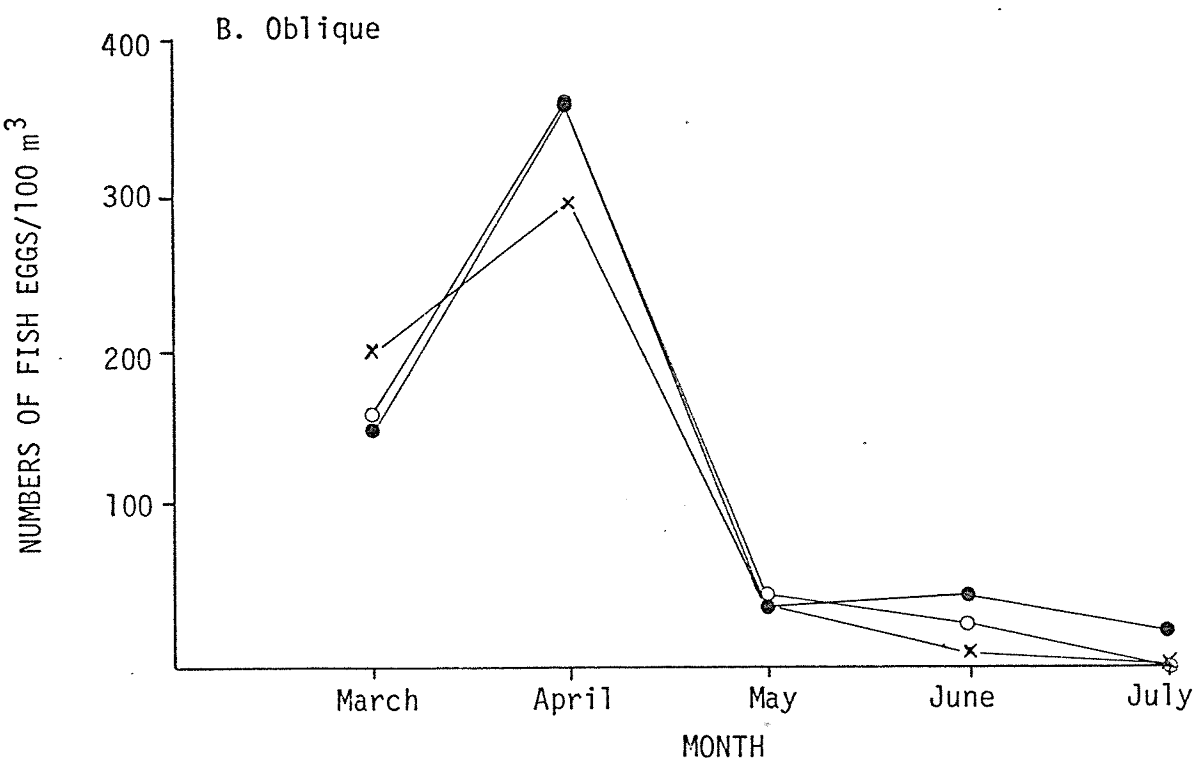


Fig. 12. Numbers of fish eggs per 100 m^3 of water strained in surface (A) and oblique (B) bongo net hauls in the DuPont study area, southern Puget Sound, 1977.

Table 18. Numbers of fish eggs per 100 m^3 of water strained at sites in the DuPont-Nisqually study area in southern Puget Sound, 1977.

	Tatsolo Point										DuPont Dock										Outer Nisqually Delta									
	Mar		Apr		May		June		July		Mar		Apr		May		June		July		Mar		Apr		May		June		July	
Taxon	S[1]	O[2]	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O
Bothidae																														
Citharichthys sp.							1																					3		
Gadidae	6	26	210	191					2		15	36	125	117							72	98	16	100						
Pleuronectidae																														
Hippoglossoides classodon		1		2									4	4																
Limanda aspera					3			9								5														
Lyopsetta exilis	12	6	16	19							14	5	19	8							36			22						
Pleuronichthys sp.			92	18	16	36	81	37	143	22			38	26	15	35	27	24	52				30	24	46	37	7	6	4	3
Parophrys-Psettichthys-Platichthys complex	247	121	44	99							115	124	120	107	1	5	2				78	98	91	149						
Unidentified			11	32	3			9	3				12	2		8						6								
Total	265	154	373	361	19	36	82	46	148	22	144	165	318	264	16	48	29				186	202	137	295	46	37	7	9	4	3

[1] surface tow

[2] oblique tow

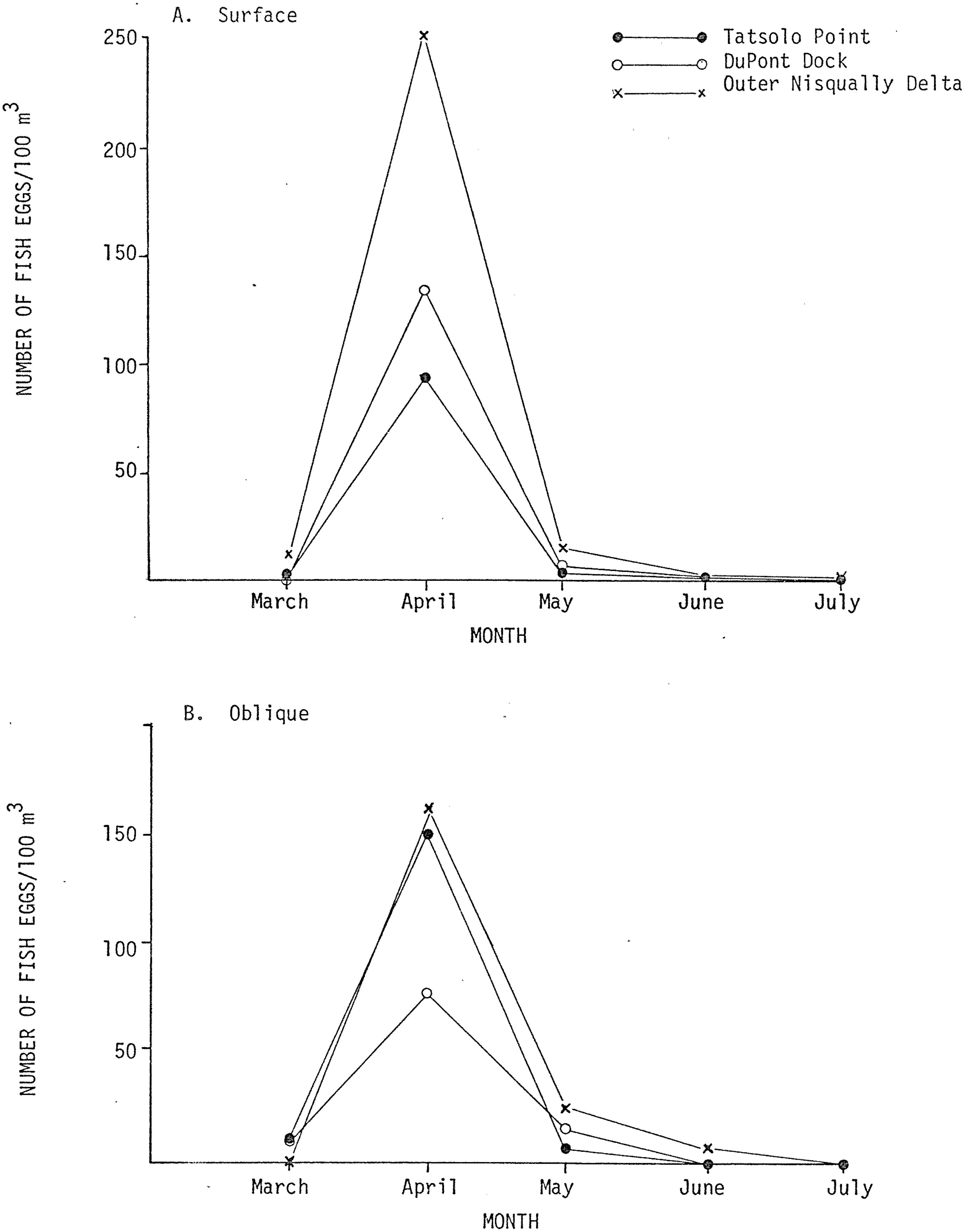


Fig. 13. Numbers of fish larvae per 100 m^3 of water strained in surface (A) and oblique (B) bongo net hauls in southern Puget Sound, 1977.

Table 19. Numbers of fish larvae per 100 m^3 of water strained at sites in the DuPont study area, southern Puget Sound, 1977.

	Tatsolo Point										DuPont Dock										Outer Nisqually Delta									
	Mar		Apr		May		June		July		Mar		Apr		May		June		July		Mar		Apr		May		June		July	
Taxon	S[1]	O[2]	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O	S	O
Agonidae		2		1											1								1		3	2				
Ammodytidae																														
Ammodytes hexapterus																							1	2						
Clupeidae																														
Clupea harengus pallasi				1								4	1	2									1							
Cottidae	1	2	1	4		2							1	2		5					1		2	2	2	2				
Cyclopteridae		2	1				1						1				1							2		2				
Gadidae	1	2	56	102								2	50	45	1						5		82	62	1	2				
Gobiidae						2							1										2							
Hexagrammidae																								2						
Pleuronectidae																														
Isopsetta isolepis																									1	4				
Lyopsetta exilis			1										1										1							
Parophrys vetulus			10	18									17	16	1	3					4		139	51	4					
Platichthys sp.			1	1		1							1																	
Psettichthys sp.			4	6									2	8	1								8	7	2	2			1	
Scorpaenidae			12	17	1	2						2	6	6	3	3					1		13	24		10				
Stichaeidae		2	2		1								1										1	2				3		
Unidentified			6	2												3							1	7	1			3		
Salmon					1										1															
Total	2	10	14	152	3	7	1					8	82	79	7	14	1				11		252	161	14	24		6	1	

[1] surface tow
[2] oblique tow

Sequalitchew Creek Surveys

Electrofishing Surveys

Fishes captured during the 1977 and 1978 electroshocking in Sequalitchew Creek included: coho salmon, chum salmon, cutthroat trout, prickly sculpin (Cottus asper), coastrange sculpin (Cottus aleuticus), threespine stickleback, largemouth bass (Micropterus salmoides), and an unidentified centrarchid young-of-the-year. The 1977 and 1978 samplings are considered separately.

1977 Surveys. Sequalitchew Creek surveys for fishes during 1977 were initiated on April 26 (Table 20). At that time, 88 juvenile chum, four juvenile coho, and two cutthroat trout were captured in section I. The chum salmon averaged 39 mm FL (range: 35-50 mm FL), coho averaged 69 mm FL (range: 60-87 mm FL), and the trout were 105 mm FL each. Section I also contained 51 cottids and 17 threespine sticklebacks.

On April 28, a beaver dam blocking waterflows ($\sim$ 2 cfs) resulted in high water temperatures. After the dam was removed and waterflows had resumed, only one 50-mm FL chum salmon, one 60-mm FL cutthroat trout, and five cottids were captured in section III, and eight coho with a mean length of 98 mm FL (range: 91-105 mm FL) in section IV.

The WDF started releasing 1,150,000 coho salmon into the creek from Sequalitchew Lake on May 11. On May 17, we observed approximately 14,000 coho in the lower 400 m of the stream. The coho smolt were too ubiquitous during this survey to allow population estimates to be made for other fish.

On June 9, approximately 200 coho were present in section I, 80 coho in section III, and one coho in section IV. Examination of section I was discontinued at this time due to excessive algal growth. A subsample of

Table 20. Juvenile salmon surveyed in Sequalitchew Creek, Washington, April through June, 1977.

Survey Date	Study Sections I	II	III*	IV
April 26	88 chum 4 coho 2 cutt.	NS	-	NS
May 1	NS	1 chum 1 cutt.	-	8 coho
May 17	~14,000 coho		-	salmon absent
June 9	~200 coho (overgrown with algae)	NS	80 coho	1 coho
June 30	overgrown with algae	1 cutt.	salmon absent	salmon absent

* = alternate to section I (see text)

NS = no survey

20 coho from section III had an average length of 138 mm FL (range: 117-160 mm FL). Three cottids were also caught incidentally during the June 9 survey. On June 30, one 28 mm FL cutthroat trout and one cottid were caught in section II. At that time waterflows (∿ 0.5)cfs) were present only in the lower 1.5 km of the creek so electrofishing was discontinued.

1978 Surveys. Surveys in Sequalitchew Creek during 1978 were initiated on April 1. Low flows and algal growth did not occur during 1978, so a more accurate study of changes in the fish fauna were made.

Coho salmon fry and smolts were the most abundant fish caught (Table 21). The numbers of fry in all three sections decreased markedly from the first sampling to the end of April (Fig. 14). As most population estimates in fry in each section after the initial decrease were around 200 fry, the populations in each section may stabilize after an initial, heavy mortality. Differences in fry abundances in the three sections were partially due to movements in the stream. Although most of the marked fish remained in their original section, some fry moved throughout the entire stream. The occurrence of fry less than 32 mm FL through June and periodic decreases in mean fry length suggest fry emergence over a several month period (Fig. 15). In addition, fry with yolk sac were observed in catches through May.

Coho smolts first appeared on April 15 and were probably from the WDF plantings of ∿ 900,000 smolts in Sequalitchew Lake on March 14-17 and April 7 (Rodgers, personal communication). Even though a blockage existed between the lake and stream, some smolts were observed by FRI personnel moving into the stream. Outmigrations of smolts occurred likely in two periods. The first period was the latter part of April and was primarily

Table 21. Fish surveyed by electroshocking in Sequalitchew Creek, Washington, during 1978. (All values represent the sum of catches from 2 electrofishing passes through the section.)

	Section		
Date	II	III	IV
April 1	853 coho fry 1 cottid	513 coho fry	NS
April 15	206 coho fry 12 coho smolts 4 cottids	137 coho fry 9 coho smolts 2 cottids	401 coho fry 4 coho smolts
April 22	56 coho fry 296 coho smolts	101 coho fry 44 coho smolts	258 coho fry 18 coho smolts 1 cottid
April 29	53 coho fry 336 coho smolts	69 coho fry 33 coho smolts	176 coho fry 5 coho smolts
May 4	96 coho fry 188 coho smolts	198 coho fry 24 coho smolts	207 coho fry
May 20	69 coho fry 6 coho smolts 2 cottids	116 coho fry 6 coho smolts 15 cottids	57 coho fry
June 3	172 coho fry 11 centrarchids	187 coho fry 38 centrarchids 1 cottid	173 coho fry 27 centrarchids
June 17	123 coho fry 2 centrarchids 3 cottids	89 coho fry 6 centrarchids 1 cottid	81 coho fry 1 centrarchid

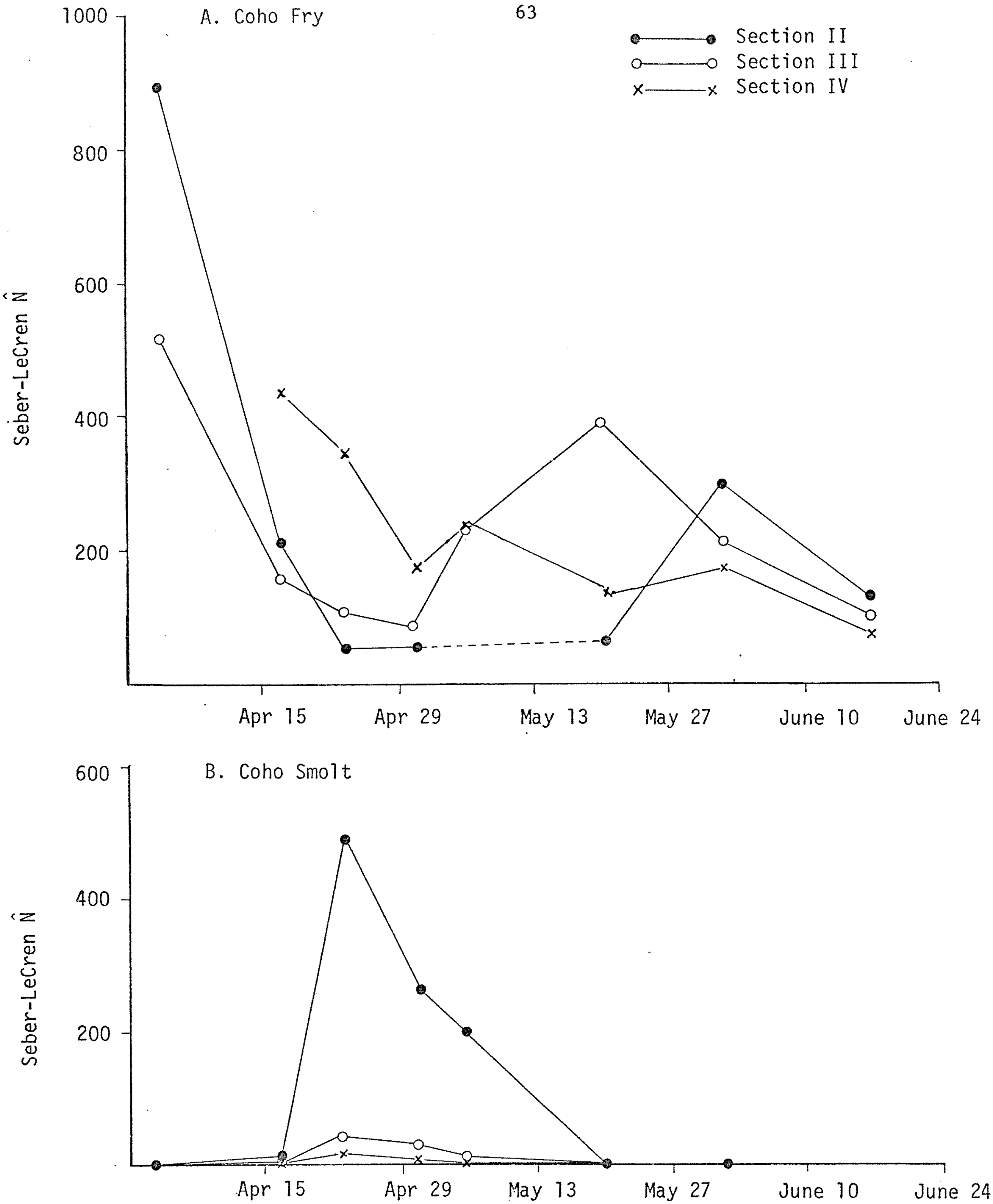


Fig. 14. Seber-LeCren ($\hat{N}$) estimates of coho fry (A) and smolt (B) abundance in Sequalitchew Creek, 1978.

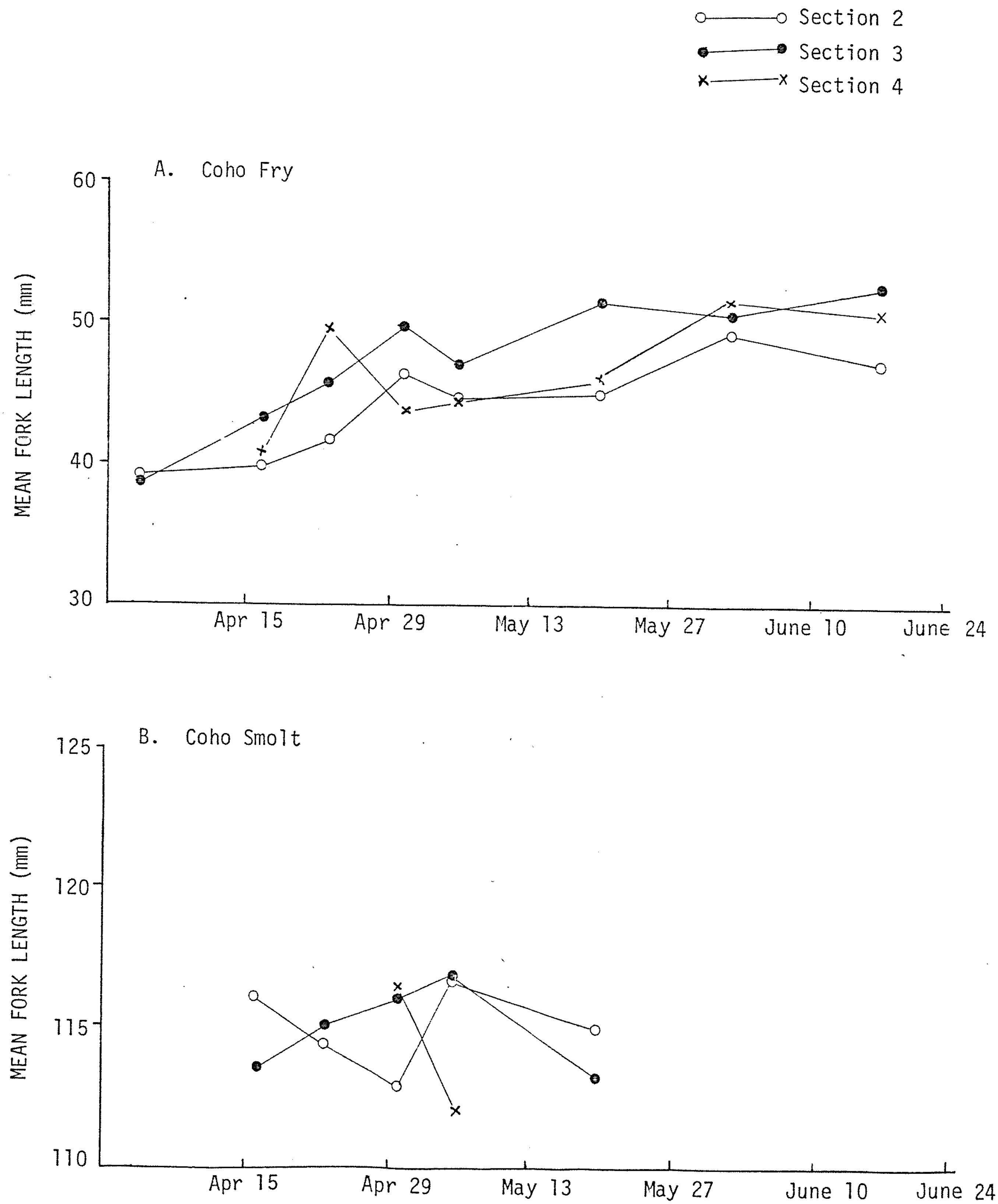


Fig. 15. Changes in length (fork length) of coho fry (A) and smolt (B) in Sequalitchew Creek during 1978 electroshocking surveys.

fish moving around the blockage, and the second peak, which represented most of the fish, was between May 5 and 18. We did not sample during the second period so our electrofishing does not reflect this peak. The gate was removed from the outlet on May 5 and no fish were observed in the lake after May 18. We caught low numbers of smolts in the creek on the May 20 survey, indicating that most smolts had left the creek by that date. A rapid movement through the creek from Sequalitchew Lake is further indicated by the relatively constant mean fork length over time (Fig. 15) and low numbers of marked smolts recovered. The abundance of smolt was usually greatest in the lowest section and decreased in sections moving upstream.

In addition to the coho, prickly sculpin, coastrange sculpin, largemouth bass, and an unidentified centrarchid young-of-the-year were sampled during 1978. The cottids came primarily from the middle section and increased in abundance during the season. Scott and Crossman (1973) report predation on salmon eggs and fry by prickly and coastrange sculpins. The largemouth bass, also potential juvenile salmon predators, were most likely out of Sequalitchew Lake.

Chum salmon juveniles were not sampled by electroshocking in 1978, and adults were not seen in fall of 1977 or winter of 1978. Williams et al. (1975) report that chum salmon are known to spawn in the lower 200 m of the creek.

Visual Surveys

Visual surveys for adult salmonids in Sequalitchew Creek were conducted between November 15, 1977, and February 27, 1978. With the exception of several cutthroat, only adult coho salmon were observed

Table 22. Number of adult salmon observed in the lower 1,700 meters of Sequalitchew Creek, Washington, November 15, 1977, to February 27, 1978.

Survey Date	Number of Coho Salmon Observed* Live	Dead	Total	Additional Observations
Nov 15	6	0	0	- 3 live ∿200 mm cutthroat - ∿50 coho in NPBN railroad culvert
Nov 22	29	15	44	
Nov 27	210	25	235	- coho migration extending into Edmond Marsh
Dec 4	138	75	213	- 1 dead ∿200 mm cutthroat
Dec 13	20	121	141	
Dec 22	13	188	201	
Dec 31	1	135	136	- 1 dead ∿200 mm cutthroat - counted 9 distinct redds
Jan 15	0	-	0	- 3 live and 5 dead coho at outlet of Sequalitchew Lake
Jan 22	0	91	91	
Feb 10	0	15[1]	25	- 2 large mouth bass (∿225 mm)
Feb 27	0	0	0	

*No adult chum salmon were observed in the creek.

[1]badly decomposed

(Table 22). Live coho salmon were observed from the first survey until December 31, 1977. Maximum numbers of live fish (210) occurred in the creek on November 27, and adults were sighted up to Sequalitchew Lake where eggs were observed deposited on the gravel. While we did not mark fish moving up the creek from Puget Sound and thus could not determine how many different fish moved into the stream, at least 235 fish (maximum number of live plus dead fish seen on any one occasion) migrated into the creek. This corresponds to the 200 fish capacity given by Williams et al. (1975). The only attempt to count redds was on December 31 when nine were counted.

Summary

1. Fishes in the Nisqually-DuPont study area were sampled beginning March 1977. Sampling gear included townet, beach seine, trynet, plankton nets, and purse seine. In addition, SCUBA observations were made at the DuPont Dock and a backpack electroshocker, in addition to visual observations, was used to survey Sequalitchew Creek.

2. Beach seine and townet catches in 1977 indicated low numbers of outmigrating juvenile chum, coho, pink, and chinook salmon along the DuPont shoreline. Sampling completed through June 1, 1978 tends to confirm these findings and indicates most outmigrants move along the shorelines west and north of the Nisqually River Delta. However, preliminary examination of data collected after June 1 indicate more salmonids move along the DuPont shoreline than earlier results had shown.

3. The most abundant nonsalmonid fishes caught by beach seine included staghorn sculpin, shiner perch, and starry flounder. Abundant nonsalmonid fishes caught by townet included herring and sand lance.

4. Fishes occurring at depths of 5, 10, and 15 m were sampled bimonthly from March 1977 to March 1978 by trynet at Tatsolo Point, DuPont Dock, and the outer Nisqually Delta stations. More species and more fish were caught at DuPont Dock than at the other two stations. The most abundant fish caught were English sole and rock sole.

5. Purse seining along the DuPont shoreline in October and November 1977 captured 643 adult salmonids. Coho was the predominant species caught during sampling. Tag returns indicate the migration routes of tagged fish were primarily in southern Puget Sound.

6. SCUBA surveys conducted monthly at the DuPont Dock between June 1977 and May 1978 found buffalo sculpin and shiner perch to be the most abundant demersal and nondemersal species, respectively. Pelagic species were more abundant than demersal species.

7. Monthly plankton collections were made between March and July 1977. Calanoid copepods were the most abundant zooplankton taxon, whereas gadoids and pleuronectids were both the predominant fish egg and fish larvae collected.

8. Sequalitchew Creek was sampled by electroshocker for juvenile fishes and visually surveyed for spawning adults in 1977 and 1978. Coho salmon was the most abundant species sampled by electroshocker during both years; chum salmon, cutthroat, coastrange and prickly sculpin, and largemouth bass were also caught. Peak outmigration for coho smolts was probably in May. Coho salmon and cutthroat trout were the only adult salmonids observed in the creek.

PART II--TROPHIC RELATIONSHIPS OF NISQUALLY REACH FISHES

Results

The occurrence of nearshore fishes--both resident and migratory--in the Nisqually Reach-DuPont area is partly a function of food resources. The importance of the DuPont shoreline as a source of food organisms was examined through the stomach contents of the dominant predatory fish. Findings were also considered relative to the potential affect of new dock structures at DuPont on fish communities. Only collections from spring 1977 through winter 1978 are available for this report and the results for the rest of 1978 will be presented in a later report. Forty-four fish species were examined (Table 23); however, juvenile salmonids and their potential predators were emphasized in analyses. These analyses are presented by phylogenetic order. An explanation of the Index of Relative Importance (IRI) diagrams used to present food habit information is given in Appendix 2.

Individual Species Accounts

Spiny Dogfish (*Squalus acanthias*). Townet collections along the outer Nisqually Delta on July 8, 1977 provided 10 dogfish for stomach analysis. Nereid polychaetes completely dominated the diet spectra (Fig. 16). Other incidental prey were typically pelagic organisms--hyperiid amphipods, shrimp, crab larvae and chaetognaths. Although, Jones and Geen (1977) indicate that the major dietary component of British Columbia dogfish is fish (55 percent of the balanced food budget), no fish remains were found in the dogfish stomach contents from the Nisqually Reach.

Table 23. Summary statistics of nearshore fish species analyzed for food habits studies in the DuPont-Nisqually study area, southern Puget Sound, Washington, 1977.

	Total Sample Size n	% Empty	Condition Factor $\bar{x}$ ± S.D.	Digestion Factor $\bar{x}$ ± S.D.	Stomach Contents Biomass (gr) $\bar{x}$ ± S.D.	Number of Prey Organisms $\bar{x}$ ± S.D.	Total Number Prey Taxa (Inc. Life History Stages)	Shannon-Wiener Diversity Indices (N')	
								Abundance	Biomass
Squalus acanthias, Spiny dogfish (subadult)	10	0	2.6±0.7	5.4±0.5	1.23±0.87	16.3±12.7	5	0.22	0.09
Hydrolagus colliei, Ratfish (adult)	16	5	3.1±0.5	3.2±0.5	2.40±2.39	9.7±15.2	39	3.83	4.10
Clupea harengus pallasi, Pacific herring (juv)	10	10	3.9±1.2	1.9±0.3	0.11±0.05	11.2±10.6	5	0.58	1.55
Oncorhynchus gorbuscha, Pink salmon (juvenile)	20	0	3.8±1.2	3.1±1.3	0.07±0.04	80.0±98.8	23	2.04	2.13
Oncorhynchus keta, Chum salmon (juvenile)	117	1	5.0±1.4	4.7±1.0	0.04±0.08	93.8±121.8	58	1.25	3.37
Oncorhynchus kisutch, Coho salmon (juvenile)	52	3	4.3±1.5	4.5±1.0	0.18±0.23	50.4±64.1	69	3.80	3.90
Oncorhynchus tshawytscha, Chinook salmon (juvenile)	34	2	5.1±1.2	4.0±1.2	0.31±0.59	36.5±43.2	52	4.16	3.70
Salmo clarki, Cutthroat (searun) trout	1	0	*	4.0	0.35	18	5	--	--
Salmo gairdneri, Rainbow (steelhead) trout	1	0	6.0	3.0	16.16	2.0	1	--	--

* Stomach damaged in removal.

Table 23. (continued)

Hypomesus pretiosus, Surf smelt	1	0	5.0	3.0	0.17	56.0	3	0.96	0.79
Gadus macrocephalus, Pacific cod (juvenile)	3	0	5.0±1.0	4.0±1.7	0.05±0.06	3.0=1.0	5	2.20	1.33
Microgadus proximus, Pacific tomcod (juvenile & adult)	29	3	3.9±1.2	2.9±1.0	0.20±0.23	19.9±42.6	41	3.68	4.33
Gasterosteus aculeatus, Threespine stickleback (adult)	1	0	4.0	5.0	0.02	10.0	3	1.30	0.32
Aulorhynchus flavidus, Tube-snout (juvenile)	1	0	6.0	5.0	0.08	64.0	5	1.36	1.36
Syngnathus griseolineatus, Bay pipefish (adult)	1	0	3.0	5.0	0.01	17.0	2	0.98	0.17
Sebastes caurinus, Copper rockfish (juvenile & adult)	5	20	5.6±2.6	3.4±1.3	1.57±1.76	2.6±1.7	10	3.24	2.30
Hexagrammos lagocephalus, Rock greenling (adult)	1	0	6.0	3.0	10.14	15.0	3	1.27	1.12
Hexagrammos stelleri, Whitespotted greenling (adult)	5	0	4.0±1.6	3.4±1.5	1.92±2.09	12.0±8.4	16	3.21	2.09
Oxylebius pictus, painted greenling (adult)	2	0	4.5±3.5	2.5±0.7	0.22±0.30	8.5±7.8	5	2.13	1.17
Artedius fenestralis, Padded sculpin (adult)	6	0	5.3±0.8	3.3±0.5	0.18±0.23	4.2±2.8	10	3.05	2.46

Table 23. (continued)

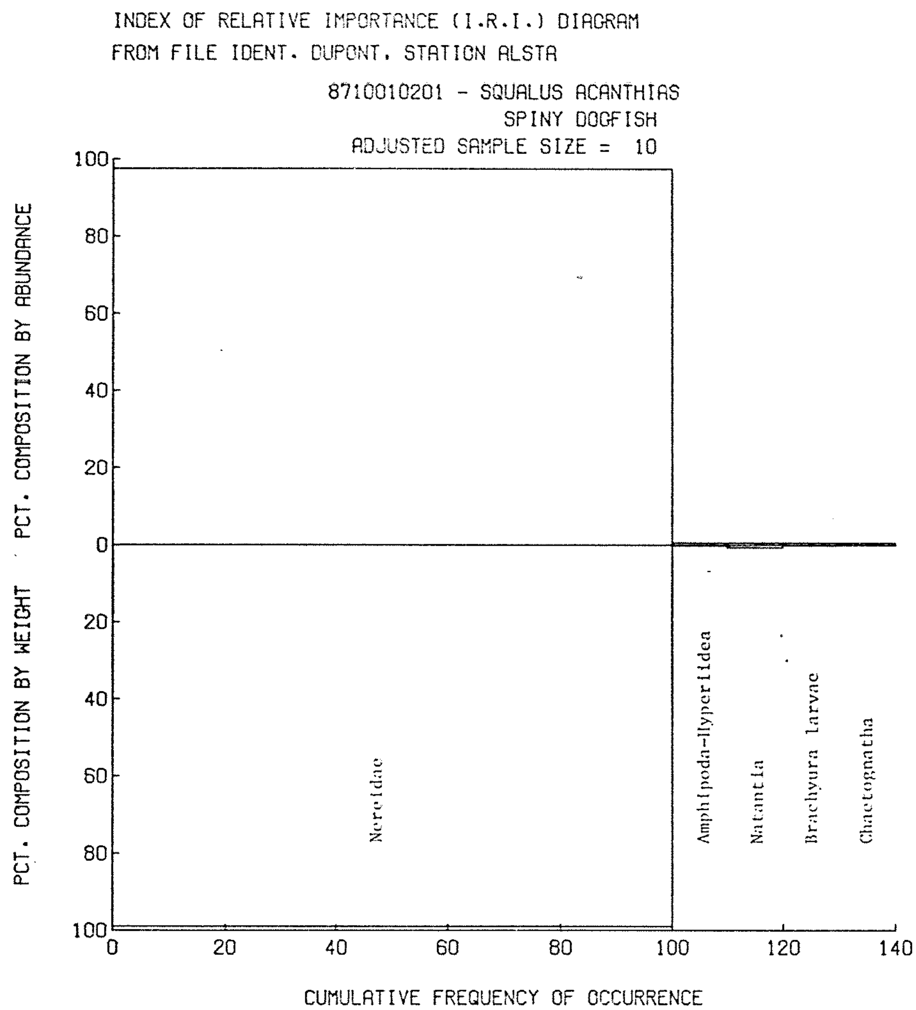
Artedius lateralis, smooth-head sculpin (adult)	1	0	6.0	5.0	0.06	10.0	3	1.16	0.81
Clinocottus acuticeps, Sharpnose sculpin	3	0	3.0±1.7	3.0±0.0	<0.01	1.0±0.0	3	1.58	0.82
Enophrys bison, Buffalo sculpin (adult & juvenile)	4	6	4.6±1.5	4.5±1.2	5.73±7.20	134.8±751.4	59	1.02	2.43
Leptocottus armatus, Staghorn sculpin (adult & juvenile)	61	6	4.7±1.1	3.7±1.1	2.43±3.55	27.4±72.7	81	3.58	4.34
Myoxocephalus polycanthocephalus, Great sculpin (juvenile & adult)	7	7	4.3 1.4	4.0 2.0	0.40 0.35	12.0 17.4	5	1.47	1.78
Nautichthys oculofasciatus, Sailfin sculpin (juv.)	1	0	5.0	3.0	0.05	6.0	3	1.46	1.46
Oligocottus maculosus, Tidepool sculpin (adult)	1	0	6.0	3.0	0.05	8.0	5	2.16	1.64
Chitonotus pugetensis, Roughback sculpin (adult & juvenile)	42	14	4.3±1.0	3.3±0.7	0.16±0.22	3.0±3.3	37	4.60	4.46
Agonus acipenserinus, Sturgeon poacher (adult & juvenile)	24	12	4.0±1.0	4.0±1.1	0.27±0.40	11.8±12.8	8	3.63	2.78
Pallasina barbata, Tubenose poacher (adult)	1	0	6.0	3.0	0.04	100	1	0.0	0.0
Xeneretmus latifrons, Blacktip poacher (adult)	1	0	6.0	3.0	0.18	14.0	5	2.07	1.32

Table 23. (continued)

Cymatogaster aggregata, Shiner perch (adult & juvenile)	13	53	4.0±1.1	3.5±1.2	0.03±0.01	32.C±61.4	9	1.27	2.93
Embiotoca lateralis, Striped seaperch (juvenile & adult)	5	0	3.4±1.1	3.6±1.7	0.74±1.00	9.4±8.6	10	2.64	2.18
Rhacochilus vacca, Pile perch (juvenile)	2	0	3.0±0.0	2.0±0.0	0.06±0.02	4.5±0.7	3	1.35	0.76
Apodichthys flavidus, Penpoint gunnel (adult)	1	0	6.0	3.0	0.08	6.0	1	0.0	0.0
Pholis laeta, Crescent gunnel (adult)	1	0	3.0	6.0	0.01	4.0	2	0.8	0.50
Citharichthys sordidus, Pacific sanddab (adult)	3	33	5.5	3.0	0.10±0.12	2.0±0.0	3	1.50	0.43
Citharichthys stigmaeus, Speckled sanddab (adult)	3	0	4.7±0.6	2.7±0.6	0.15±0.13	3.3±3.2	6	2.45	1.72
Lepidopsetta bilineata, Rock sole (adult & juvenile)	66	39	4.9±2.2	4.8±2.1	1.40±1.48	12.4±20.9	49	3.93	3.01
Microstomus pacificus, Dover sole (adult)	4	0	4.3±1.7	3.5±1.7	0.44±0.32	26.3±20.0	14	2.42	2.56
Parophrys vetulus, English sole (adult & juvenile)	50	28	4.1±1.5	3.6±1.7	0.28±0.53	19.3±17.9	48	3.89	3.16
Platichthys stellatus, Starry flounder (adult & juvenile)	42	35	3.6±1.5	4.6±2.0	0.40±0.50	17.3±24.1	31	3.14	3.72

Table 23.(continued)

Pleuronichthys coenosus, C-O sole (adult)	11	9	3.8±0.8	3.9±1.2	1.25±2.52	6.5±3.5	22	3.99	2.18
Psettichthys melanostictus, Sand sole	9	44	4.0±0.0	2.8±0.0	0.19±0.35	1.2±0.8	3	1.25	0.59
Total Sample Size	672								



Prey Taxa	(%) Frequency of Occurrence	(%) Numerical Composition	(%) Gravimetric Composition	Prey I.R.I.	% Total I.R.I.
Nereidae	100.00	97.55	99.00	10655.1	99.82
Amphipoda-Hyperiidea	10.00	0.61	0.22	8.4	0.04
Natantia	10.00	0.61	0.64	12.6	0.06
Brachyura-larva	10.00	0.61	0.10	7.2	0.04
Chaetognatha	10.00	0.61	0.03	6.4	0.03

Fig. 16. IRI prey spectrum of spiny dogfish in Nisqually Reach, southern Puget Sound, 1977.

Ratfish (*Hydrolagus colliei*). Seventeen ratfish were collected during the winter (November-March) trynet collections at Tatsolo Point and the DuPont Dock sites. Polychaete annelids (40 percent of total IRI), brachyuran crabs (*Cancer* sp., *Hemigrapsus nudus*) (28 percent total IRI), and fish eggs (10 percent) were the most important food organisms in a diverse prey spectrum (Fig. 17). The remains of two sculpins, *Artedius* sp. and buffalo sculpin constituted 1.3 percent of the total IRI.

Pacific Herring (*Clupea harengus pallasi*). A sample of 10 juvenile Pacific herring was obtained during the July 8 townet collections at Tatsolo Point; nine of these contained identifiable food organisms. Calanoid copepods and gammarid amphipods composed the most common (66.7 percent and 22.2 percent frequency of occurrence, respectively) and most numerous (91.1 percent and 5 percent composition, respectively) prey organisms. Fish (larvae) remains, though occurring in only one stomach, dominated the combined stomach contents biomass (60.8 percent of the total); calanoid copepods and gammarid amphipods each contributed 16.8 percent of the total biomass. Ostracods and crab (megalops) larvae were other, less important food organisms.

Pink Salmon (*Oncorhynchus gorbuscha*). Juvenile pink salmon were encountered frequently in the July 8 townet collections at all three study sites and in the June 28 beach seine collection at Tatsolo Point. Of the combined sample of 20 stomachs, none were empty and all averaged between 25 percent and 50 percent full of food; the stomach contents were typically partly digested.

Calanoid copepods were the most important prey organisms both numerically and gravimetrically, accounting for 63 percent of the total

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
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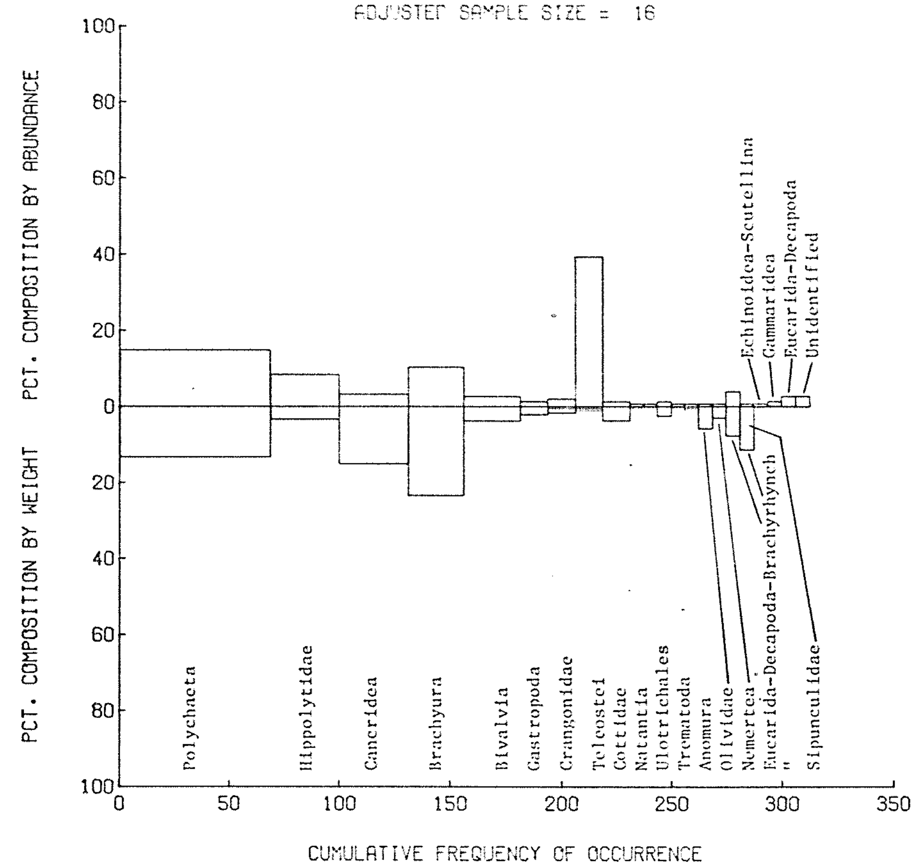


PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
POLYCHAETA	68.75	14.84	13.27	1932.2	39.94
HIPPOLYTIDAE	31.25	8.39	3.35	366.8	7.58
CANCRIDEA	31.25	3.23	15.05	571.1	11.80
BRACHYURA	25.00	10.32	23.43	843.7	17.44
BIVALVIA	25.00	2.58	3.88	161.5	3.34
GASTROPODA	12.50	1.29	2.15	43.0	.89
CRANGONIDAE	12.50	1.94	1.65	44.9	.93
TELEOSTEI	12.50	39.35	.94	503.7	10.41
COTTIDAE	12.50	1.29	3.79	63.5	1.31
NATANTIA	6.25	.65	.35	6.2	.13
ULOTRICHALES	6.25	.65	.14	4.9	.10
TREMATODA	6.25	1.29	2.55	24.0	.50
ANOMURA	6.25	.65	.17	5.1	.11
OLIVIDAE	6.25	.65	.80	9.0	.19
NEMERTEA	6.25	.65	5.88	40.8	.84
EUCARIDA-DECAPODA-BRACHYRHYNCH	6.25	.65	2.98	22.7	.47
EUCARIDA-DECAPODA-BRACHYRHYNCH	6.25	3.87	7.83	73.1	1.51
SIPUNCULIDAE	6.25	.65	11.42	75.4	1.56
ECHINOIDEA-SCUTELLINA	6.25	.65	.16	5.0	.10
GAMMARIDEA	6.25	1.29	.01	8.1	.17
EUCARIDA-DECAPODA	6.25	2.58	.05	16.4	.34
UNIDENTIFIED	6.25	2.58	.16	17.1	.35

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

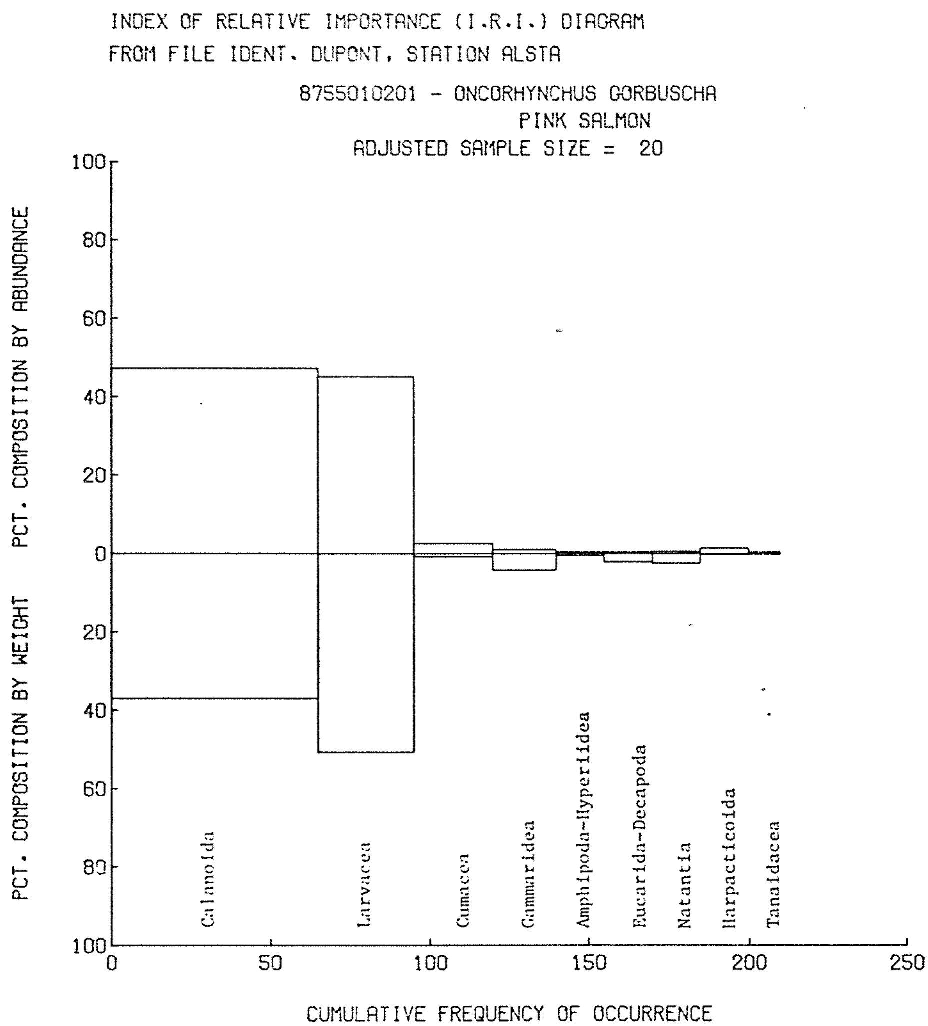
PERCENT DOMINANCE INDEX		.20	.12		.22
SHANNON-WEINER DIVERSITY		3.14	3.41		2.77
EVENNESS INDEX		.70	.77		.62

Fig. 17. IRI prey spectrum of ratfish in Nisqually Reach, southern Puget Sound, 1977.

IRI (Fig. 18); larvaceans were prevalent in beach seine samples contributing 33 percent. Other less important prey included gammarid amphipods, cumaceans, harpacticoid copepods, decapod larvae and tanaids, which are principally epibenthic organisms as compared to the pelagic calanoid copepods and larvaceans. Food habits of pink fry collected by beach seine (Fig. 19) and townet (Fig. 20) in late June and early July suggested that pink fry were feeding upon pelagic organisms in both environments by that period in their outmigration.

Chum Salmon (*Oncorhynchus keta*). Juvenile chum salmon occurred in beach seine and townet collections from early April to late July. Ninety-two stomach samples were collected by beach seine and 25 by townet; only one stomach from each sampling method was empty.

The composite prey spectra indicate that the outmigrating juvenile chum salmon in the study area fed primarily upon epibenthic organisms; 96.6 percent of the total IRI was contributed by harpacticoid copepods and gammarid amphipods (Fig. 21). Pelagic calanoid copepods provided only 1.1 percent of the total IRI. Chum fry captured in beach seine collections (shallow sublittoral zone) had been feeding almost entirely on harpacticoid copepods (85 percent of total IRI) (Fig. 22) whereas those captured with the townet (nearshore pelagic zone) had fed more on gammarid amphipods, and less so on harpacticoid copepods (Fig. 23). The high representation of various insect taxa (26.3 percent of total IRI) in the food spectra of townet-caught chums probably indicates contributions of drift food items from the Nisqually River, as over 75 percent of the sample originated from townet collections along the outer margin of the Nisqually Delta. Townet-caught fish fed primarily on epibenthic fauna but



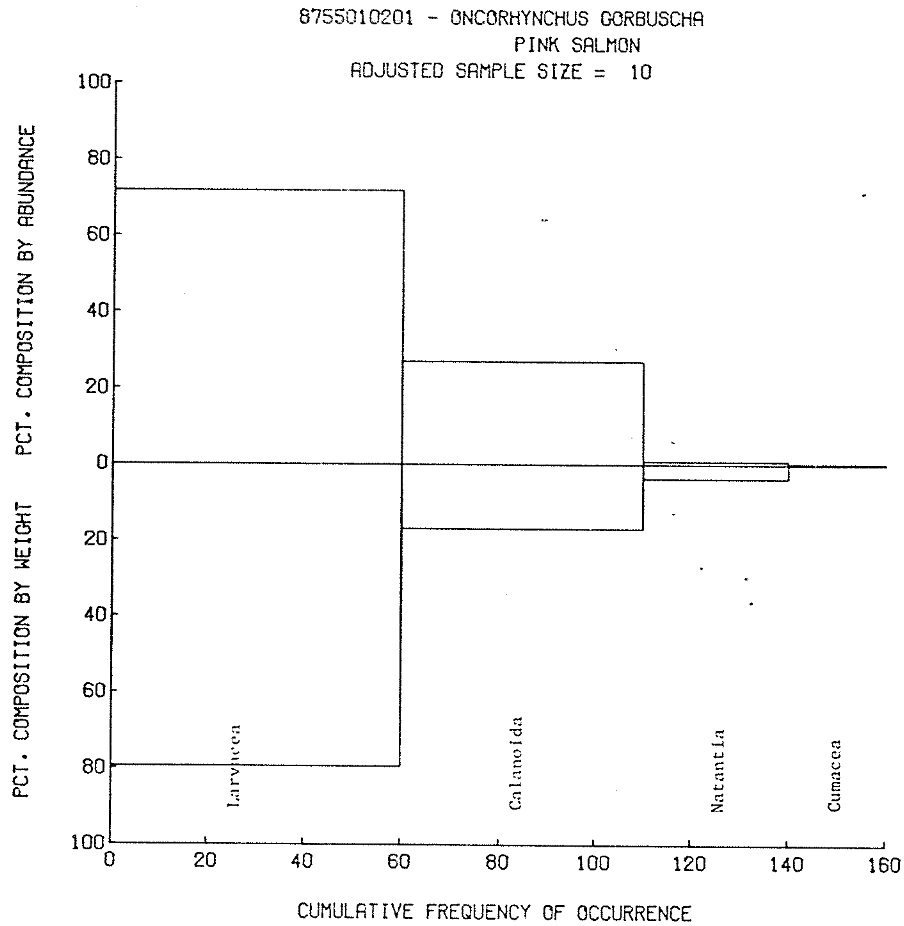
PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CALANOIDA	65.00	47.16	36.94	5466.3	63.03
LARVACEA	30.00	45.10	50.70	2874.1	33.14
CUMACEA	25.00	2.62	.82	86.2	.99
GAMMARIDEA	20.00	1.00	4.29	105.8	1.22
AMPHIPODA-HYPERIIDEA	15.00	.50	.51	15.1	.17
EUCARIDA-DECAPODA	15.00	.50	2.06	38.4	.44
NATANTIA	15.00	.56	2.38	44.1	.51
HARPACTICOIDA	15.00	1.31	.19	22.5	.26
TANAIDACEA	10.00	.44	.17	6.1	.07

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX		.43	.40		.51
SHANNON-WEINER DIVERSITY		1.55	1.75		1.23
EVENNESS INDEX		.38	.43		.30

Fig. 18. IRI prey spectrum of juvenile pink salmon in Nisqually Reach, southern Puget Sound, 1977.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT. STATION B7

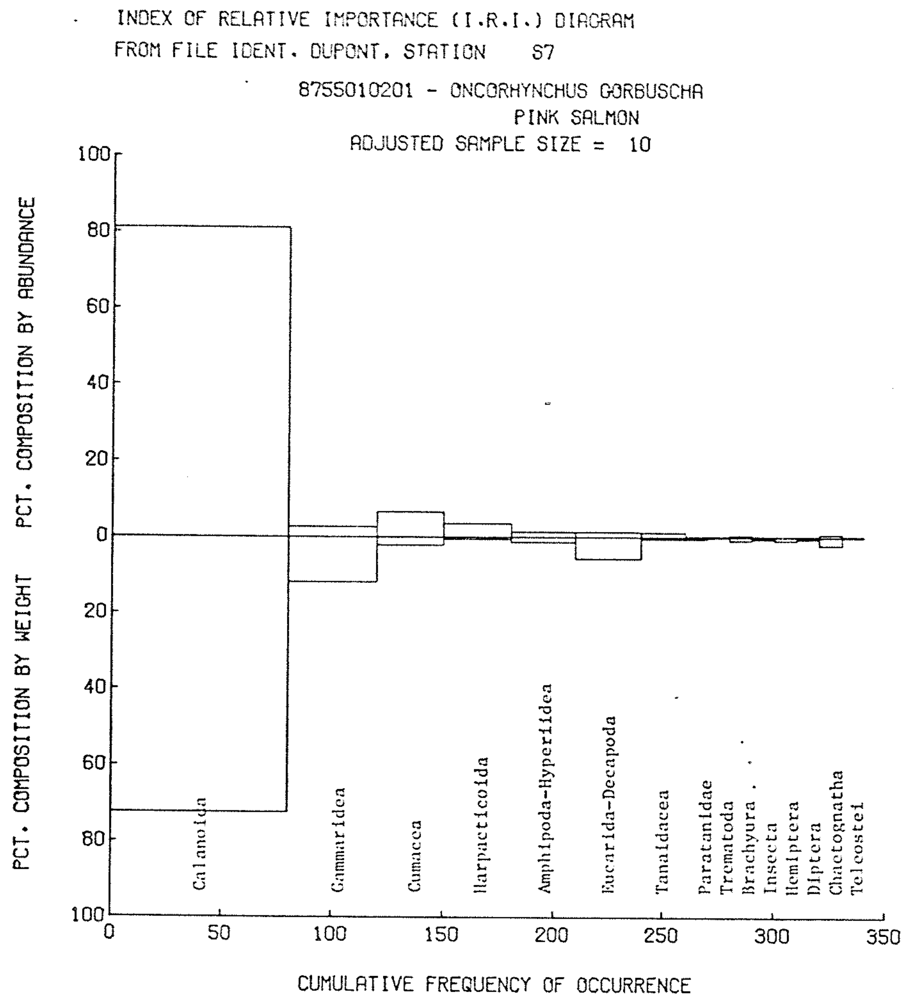


PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
LARVACEA	60.00	71.84	79.37	9072.7	79.52
CALANOIDA	50.00	26.97	16.86	2191.3	19.21
NATANTIA	30.00	.90	3.72	138.4	1.21
CUMACEA	20.00	.30	.05	7.0	.06

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.59	.66	.67
SHANNON-WEINER DIVERSITY	.94	.88	.80
EVENNESS INDEX	.47	.44	.40

Fig. 19. IRI prey spectrum of juvenile pink salmon caught in beach seine collections in Nisqually Reach, southern Puget Sound, on June 28, 1977.

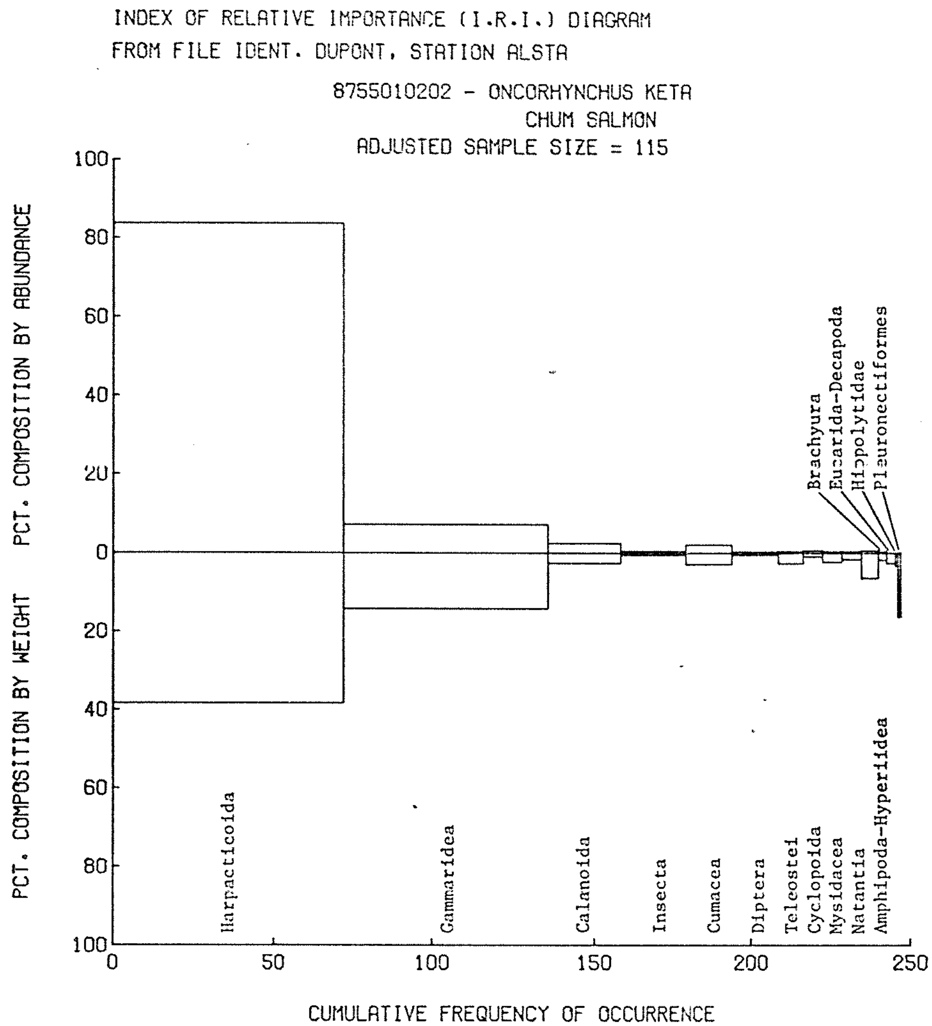


PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CALANOIDA	80.00	81.21	72.46	12293.1	89.98
GAMMARIDEA	40.00	2.68	11.89	582.8	4.27
CUMACEA	30.00	6.54	2.19	262.1	1.92
HARPACTICOIDA	30.00	3.52	.53	121.5	.89
AMPHIPODA-HYPERIIDEA	30.00	1.34	1.40	82.4	.60
EUCARIDA-DECAPODA	30.00	1.34	5.70	211.3	1.55
TANAIDACEA	20.00	1.17	.48	33.1	.24
PARATANIDAE	10.00	.17	.44	6.1	.04
TREMATODA	10.00	.17	.04	2.1	.02
BRACHYURA	10.00	.50	.88	13.8	.10
INSECTA	10.00	.17	.44	6.1	.04
HEMIPTERA	10.00	.17	.88	10.4	.08
DIPTERA	10.00	.17	.44	6.1	.04
CHAETOGNATHA	10.00	.67	2.19	28.6	.21
TELEOSTEI	10.00	.17	.04	2.1	.02

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.67	.54	.81
SHANNON-WEINER DIVERSITY	1.23	1.58	.72
EVENNESS INDEX	.32	.40	.18

Fig. 20. IRI prey spectrum of juvenile pink salmon caught in townet collections in Nisqually Reach, southern Puget Sound, on July 8, 1977.



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	72.17	83.74	38.34	8810.9	83.67
GAMMARIDEA	63.48	7.23	14.27	1364.8	12.96
CALANOIDA	22.61	2.47	2.59	114.4	1.09
INSECTA	20.87	.50	.55	21.9	.21
CUMACEA	14.78	2.09	2.87	73.3	.70
DIPTERA	14.78	.31	.45	11.2	.11
TELEOSTEI	7.83	.37	2.68	23.9	.23
CYCLOPOIDA	6.09	.58	.90	9.1	.09
MYSIDACEA	6.09	.37	2.24	15.9	.15
NATANTIA	6.09	.41	1.63	12.4	.12
AMPHIPODA-HYPERIIDEA	5.22	.63	6.37	36.5	.35
BRACHYURA	2.61	.38	1.75	5.6	.05
EUCARIDA-DECAPODA	2.61	.07	2.52	6.8	.06
HIPPOLYTIDAE	.87	.01	3.29	2.9	.03
PLEURONECTIFORMES	.87	.09	16.27	14.2	.14

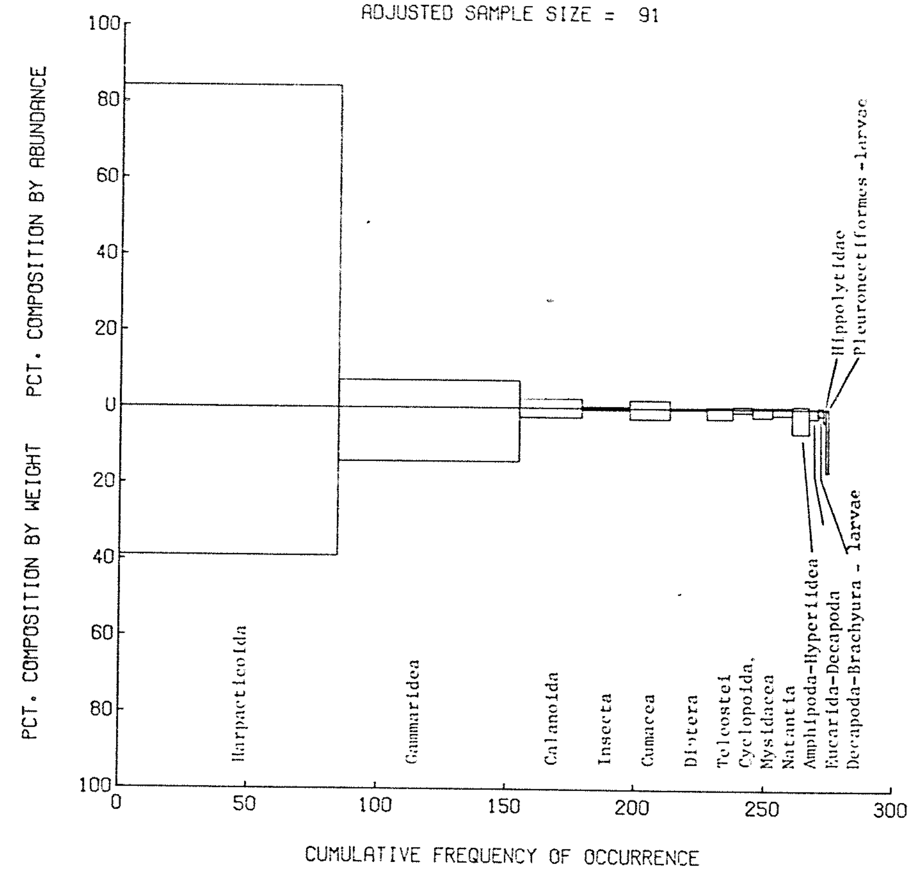
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM.	GRAV.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.71	.20	.72
SHANNON-WEINER DIVERSITY	1.10	3.04	.87
EVENNESS INDEX	.23	.63	.18

Fig. 21. IRI prey spectrum of juvenile chum salmon in Nisqually Reach, southern Puget Sound, 1977.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALL B

8755010202 - ONCORHYNCHUS KETA
CHUM SALMON
ADJUSTED SAMPLE SIZE = 91

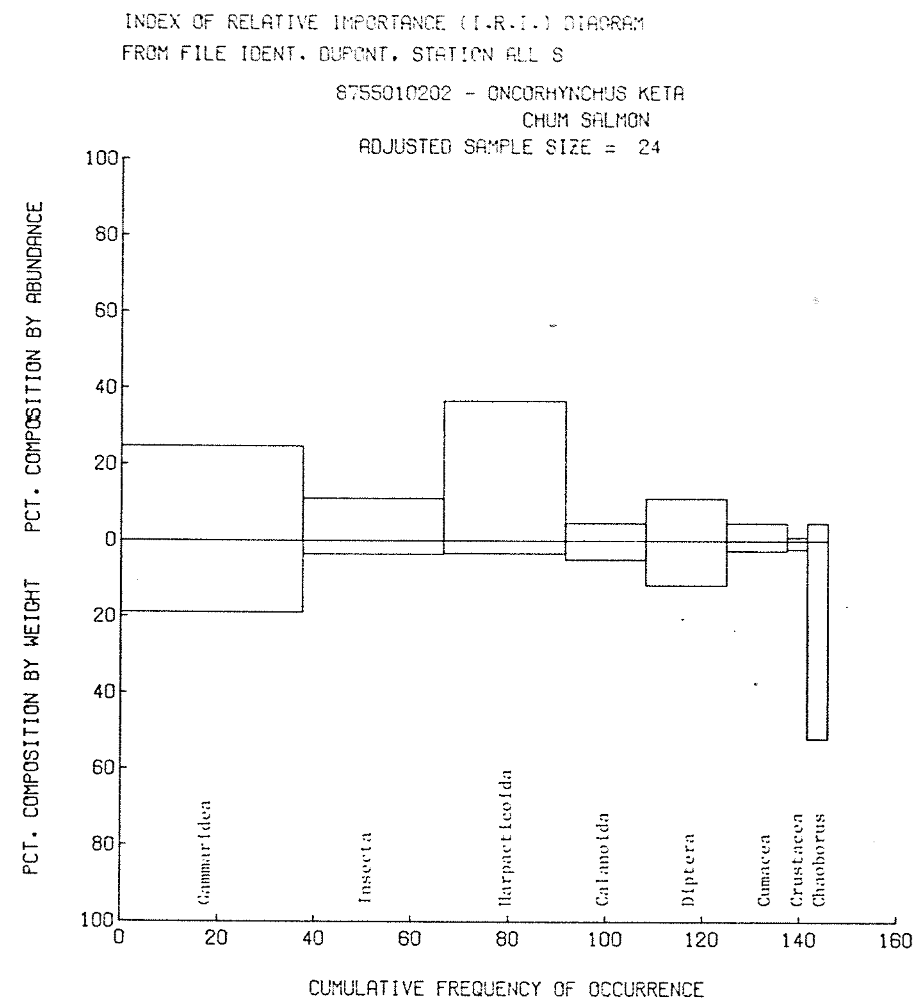


PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	84.62	84.22	38.98	10424.5	84.71
GAMMARIDEA	70.33	7.05	14.18	1493.5	12.14
CALANOIDA	24.18	2.44	2.55	120.7	.98
INSECTA	18.68	.39	.49	16.5	.13
CUMACEA	15.38	2.06	2.88	76.0	.62
DIPTERA	14.29	.20	.24	6.3	.05
TELEOSTEI	9.89	.37	2.73	30.7	.25
CYCLOPOIDA	7.69	.59	.92	11.6	.09
MYSIDACEA	7.69	.37	2.28	20.4	.17
NATANTIA	7.69	.41	1.66	15.9	.13
AMPHIPODA-HYPERIIDEA	6.59	.64	6.49	47.0	.38
EUCARIDA-DECAPODA	3.30	.07	2.56	8.7	.07
DECAPODA-BRACHYURA	2.20	.37	1.78	4.7	.04
HIPPOLYTIDAE	1.10	.01	3.35	3.7	.03
PLEURONECTIFORMES	1.10	.09	16.57	18.3	.15

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.72	.21	.73
SHANNON-WEINER DIVERSITY	1.07	2.97	.83
EVENNESS INDEX	.23	.63	.18

Fig. 22. IRI prey spectrum of juvenile chum caught by beach seine in Nisqually Reach, southern Puget Sound, 1977.



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	37.50	24.77	18.96	1640.0	41.45
INSECTA	29.17	11.01	3.61	426.4	10.78
HARPACTICOIDA	25.00	36.70	3.39	1002.1	25.33
CALANOIDA	16.67	4.59	4.97	159.2	4.02
DIPTERA	16.67	11.01	11.74	379.1	9.58
CUMACEA	12.50	4.59	2.71	91.2	2.31
CRUSTACEA	4.17	.92	2.26	13.2	.33
CHAOBORUS	4.17	4.59	51.92	235.4	5.95

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.23	.33	.26
SHANNON-WEINER DIVERSITY	2.53	2.17	2.30
EVENNESS INDEX	.76	.65	.69

Fig. 23. IRI prey spectrum of juvenile chum salmon caught by townet in Nisqually Reach, southern Puget Sound, 1977.

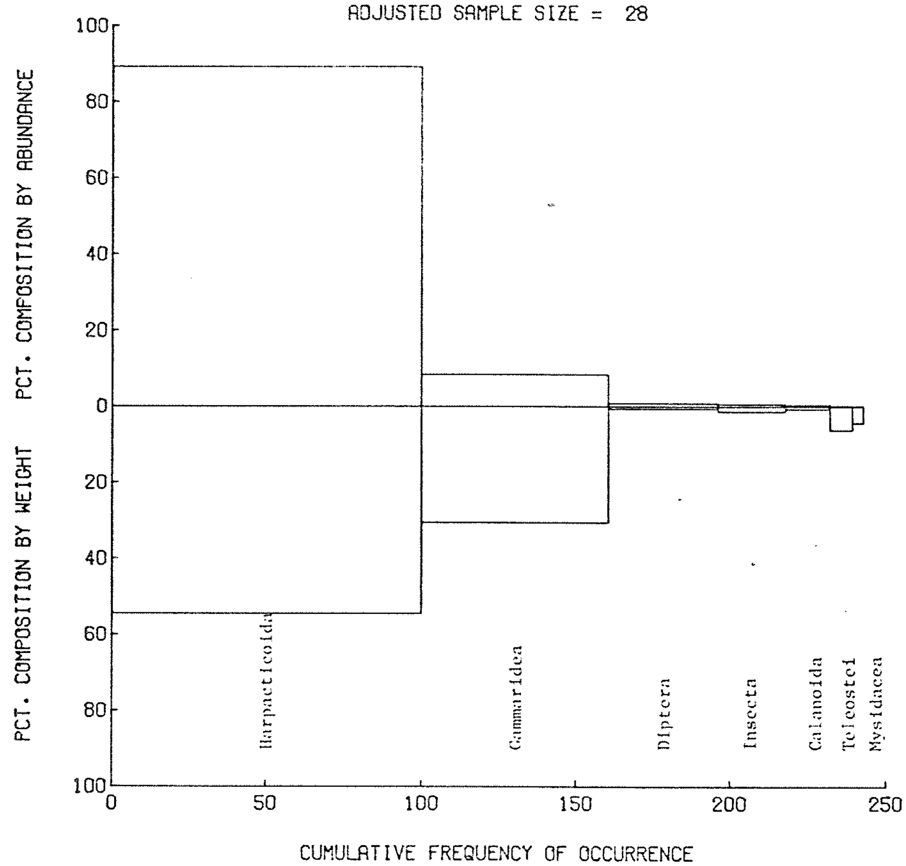
tended have emptier stomachs (fullness factor $\bar{x} = 3.4 \pm 1.1$ versus $\bar{x} = 5.3 \pm 1.4$) and more digested contents (digestion factor $\bar{x} = 3.8 \pm 1.5$ versus $\bar{x} = 5.1 \pm 0.7$) than beach seine-captured chum. This implies that at this stage of their outmigration, juvenile chum feed in shallow sublittoral areas during daylight (diurnally) rather than at night in neritic waters.

Prey spectra of chum fry from successive Nisqually Reach beach seine collections (B2, April 7; B4, May 5; B6, May 31; B7, June 28) provided evidence of possible temporal changes in juvenile chum food habits. Fish captured during early April and May gave indications of similar diets (Figs. 24 and 25) that were dominated by harpacticoid copepods and to a lesser degree by gammarid amphipods. By the end of May, however, the diets of juvenile chums had become numerically more diverse ($H'_{Abundance}$ (B2) = 0.63, $H'_{Abundance}$ (B4) = 0.54, $H'_{Abundance}$ (B6) = 1.46), gravimetrically less diverse ($H'_{Biomass}$ (B2) = 1.75, $H'_{Biomass}$ (B4) = 1.67, $H'_{Biomass}$ (B6) = 1.18), and had shifted primarily to pelagic calanoid copepods and epibenthic gammarid amphipods (Fig. 26). Prey spectra from late June collections again showed a substantial contribution of harpacticoid copepods (54 percent of total IRI), but with cumaceans, hyperiid amphipods, and flatfish larvae also of some importance (Fig. 27). Changes in prey spectra in samples taken from early April to late June may represent temporal changes in food habits; however, without replication we cannot determine the significance of these changes.

Coho Salmon (*Oncorhynchus kisutch*). Beach seine collections during May accounted for the majority of the juvenile coho captured.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT. STATION B2

8755010202 - ONCORHYNCHUS KETA
CHUM SALMON
ADJUSTED SAMPLE SIZE = 28



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	100.00	89.29	54.50	14378.7	84.97
GAMMARIDEA	60.71	8.37	30.59	2365.3	13.98
DIPTERA	35.71	.83	.60	51.1	.30
INSECTA	21.43	.62	1.32	41.7	.25
CALANOIDA	14.29	.42	.69	15.8	.09
TELEOSTEI	7.14	.21	6.29	46.4	.27
MYSIDACEA	3.57	.05	4.41	15.9	.09

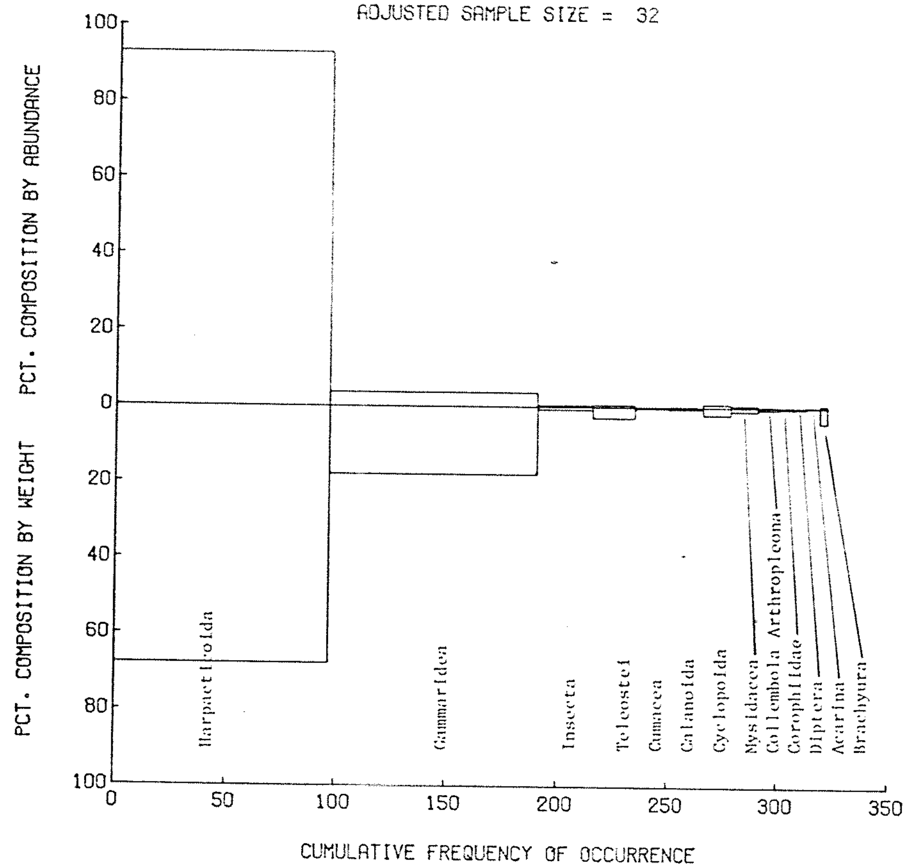
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.80	.40		.74
SHANNON-WEINER DIVERSITY	.63	1.75		.69
EVENNESS INDEX	.18	.50		.20

Fig. 24. IRI prey spectrum of juvenile chum salmon caught in beach seine collections in Nisqually Reach, southern Puget Sound, April 7, 1977.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION 54

8755010202 - ONCORHYNCHUS KETA
CHUM SALMON
ADJUSTED SAMPLE SIZE = 32

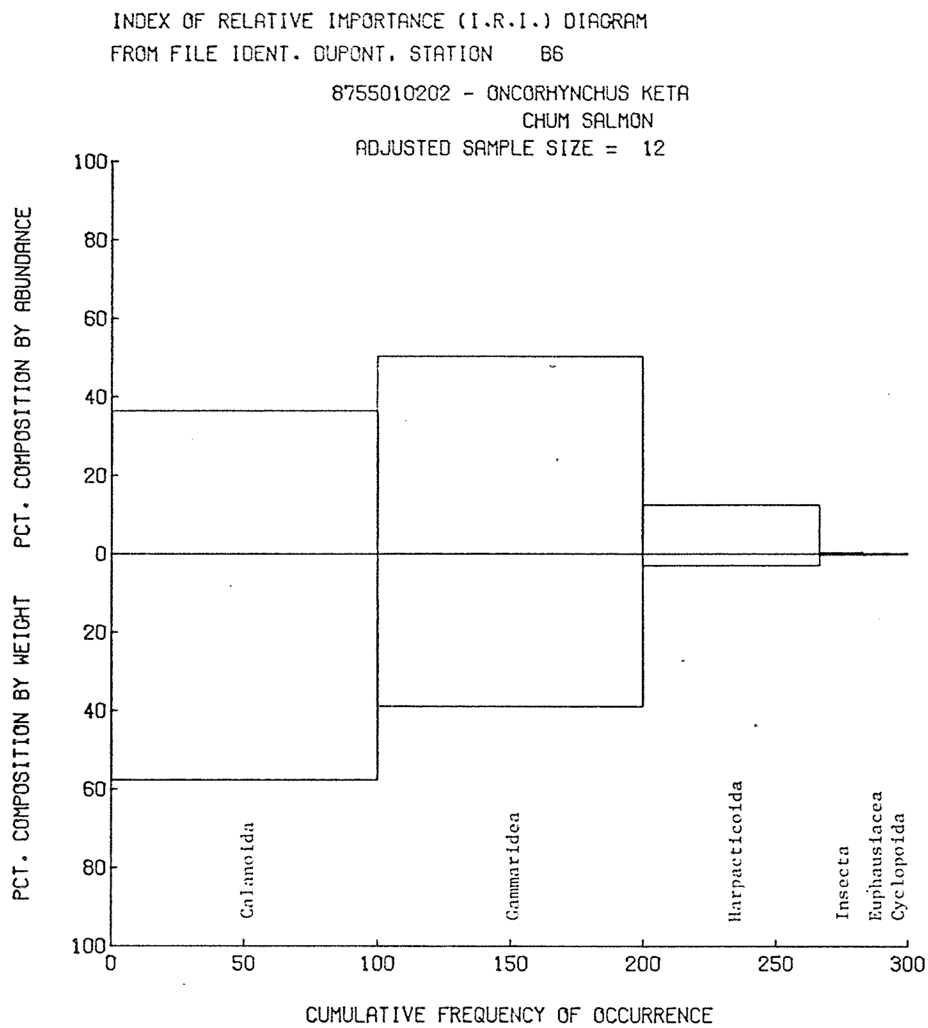


PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	96.88	92.99	67.77	15573.5	87.56
GAMMARIDEA	93.75	3.67	17.89	2020.7	11.36
INSECTA	25.00	.39	.73	28.1	.16
TELEOSTEI	18.75	.51	2.96	65.0	.37
CUMACEA	15.63	.07	.24	4.8	.03
CALANOIDA	15.63	.12	.41	8.3	.05
CYCLOPOIDA	12.50	.79	2.08	35.8	.20
MYSIDACEA	12.50	.48	.99	18.5	.10
COLLEMBOLA ARTHROPLEONA	9.38	.19	.50	6.5	.04
COROPHIIDAE	6.25	.06	.30	2.2	.01
DIPTERA	6.25	.06	.30	2.2	.01
ACARINA	6.25	.03	.02	.3	.00
BRACHYURA	3.13	.56	4.14	14.7	.08

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.87	.49	.78
SHANNON-WEINER DIVERSITY	.54	1.67	.63
EVENNESS INDEX	.13	.40	.15

Fig. 25. IRI prey spectrum of juvenile chum salmon caught in beach seine collections in Nisqually Reach, southern Puget Sound, May 5, 1977.

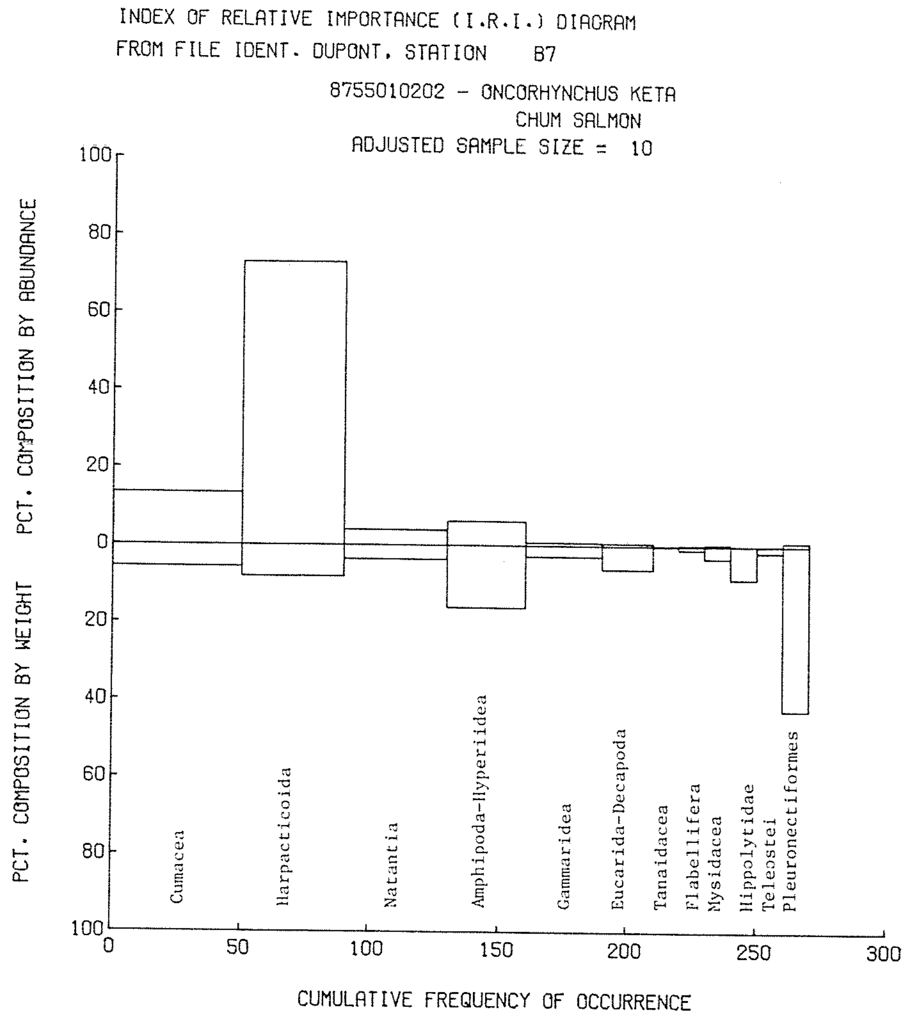


PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CALANOIDA	100.00	36.48	57.66	9413.9	48.55
GAMMARIDEA	100.00	50.39	38.92	8930.6	46.06
HARPACTICOIDA	66.67	12.52	2.98	1033.1	5.33
INSECTA	16.67	.31	.22	8.8	.05
EUPHAUSIACEA	8.33	.15	.11	2.2	.01
CYCLOPOIDA	8.33	.15	.11	2.2	.01

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.40	.48	.45
SHANNON-WEINER DIVERSITY	1.46	1.18	1.25
EVENNESS INDEX	.56	.46	.49

Fig. 26. IRI prey spectrum of juvenile chum salmon caught in beach seine collections in Nisqually Reach, southern Puget Sound, May 31, 1977.



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CUMACEA	50.00	13.40	5.74	956.7	15.89
HARPACTICOIDA	40.00	73.01	8.18	3247.8	53.96
NATANTIA	40.00	3.92	3.73	306.1	5.09
AMPHIPODA-HYPERIIDEA	30.00	6.22	16.15	671.1	11.15
GAMMARIDEA	30.00	.77	2.87	109.0	1.81
EUCARIDA-DECAPODA	20.00	.67	6.16	136.6	2.27
TANAIDACEA	10.00	.10	.01	1.1	.02
FLABELLIFERA	10.00	.29	.96	12.4	.21
MYSIDACEA	10.00	.48	3.29	37.7	.63
HIPPOLYTIDAE	10.00	.10	8.61	87.0	1.45
TELEOSTEI	10.00	.10	1.70	18.0	.30
PLEURONECTIFORMES	10.00	.96	42.61	435.6	7.24

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.56	.23	.34
SHANNON-WEINER DIVERSITY	1.41	2.69	2.16
EVENNESS INDEX	.39	.75	.60

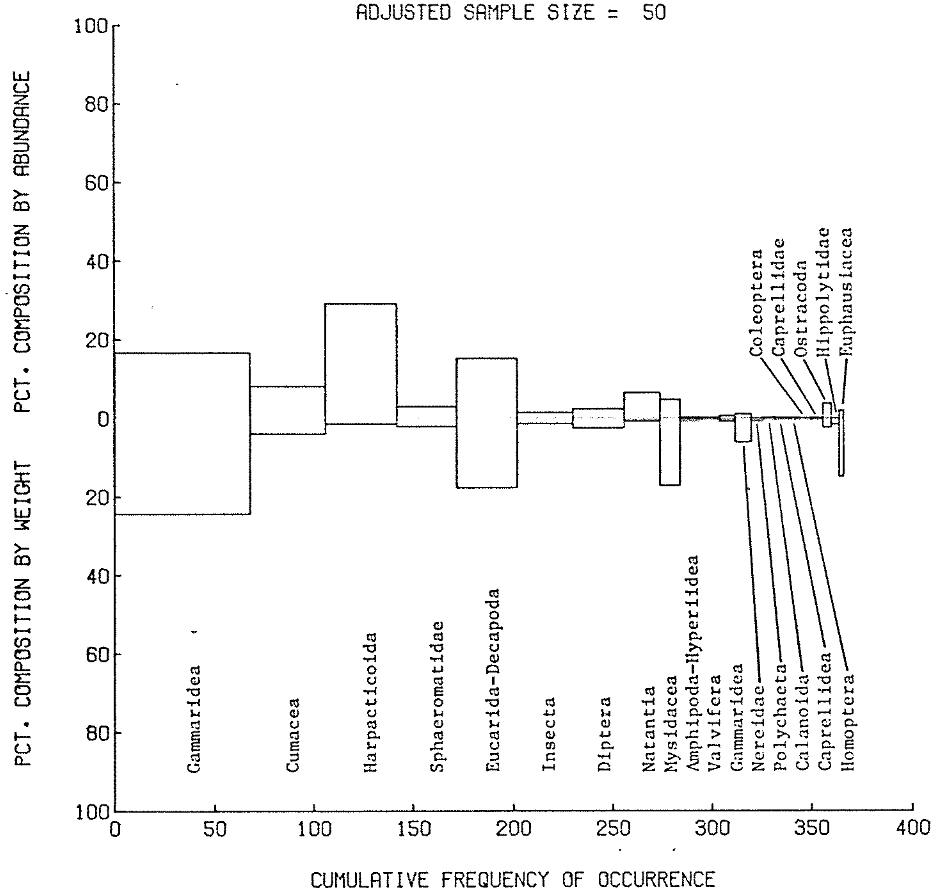
Fig. 27. IRI prey spectrum of juvenile chum salmon caught in beach seine collections in Nisqually Reach, southern Puget Sound, June 28, 1977.

The composite prey spectrum of all juvenile coho examined was quite diverse ($H'_{Abundance} = 3.30$; $H'_{Biomass} = 3.28$) and emphasized epibenthic crustaceans, specifically gammarid amphipods, cumaceans, flabelliferan isopods (*Gnorimosphaeroma oregonensis*, *Exosphaeroma amplicauda*), harpacticoid copepods and mysids (Fig. 28). Coho originating from beach seine collections had a more diverse prey spectrum, both numerically ($H'_{Abundance\ (beach\ seine)} = 3.03$ versus $H'_{Abundance\ (townet)} = 2.41$) and gravimetrically ($H'_{Biomass\ (beach\ seine)} = 2.89$ versus $H'_{Biomass\ (townet)} = 1.65$), than coho caught by townet (Figs. 29 and 30). Epibenthic crustaceans comprised 80.6 percent of the total IRI of beach seine-caught coho but only 31.5 percent for those caught by townet. Pelagic organisms, principally euphausiids and ostracods, accounted for a higher percentage of the total IRI (52.4 percent versus 15.6 percent) in the townet-caught coho; drift insects contributed 15.9 percent and 2.2 percent to the prey spectra of townet and beach seine-caught fish, respectively. These differences suggest that juvenile coho were feeding principally in the shallow sublittoral during daylight, but were feeding in neritic waters at night (though on larger organisms and apparently not as intensively, since there were fewer organisms per stomach).

Limited sample sizes did not permit us to generate IRI diagrams for individual beach seine samples but there were indications that, through the May 3, May 15, May 31 and June 28 collections, the predominant prey shifted. From a predominance of gammarid amphipods, cumaceans, isopods, and harpacticoid copepods in early May, the prey spectra shifted to mysids, decapod larvae, and harpacticoid copepods in late May; and then changed to decapod larvae, harpacticoid copepods, and shrimp in late June.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALSTA

8755010203 - ONCORHYNCHUS KISUTCH
COHO SALMON
ADJUSTED SAMPLE SIZE = 50



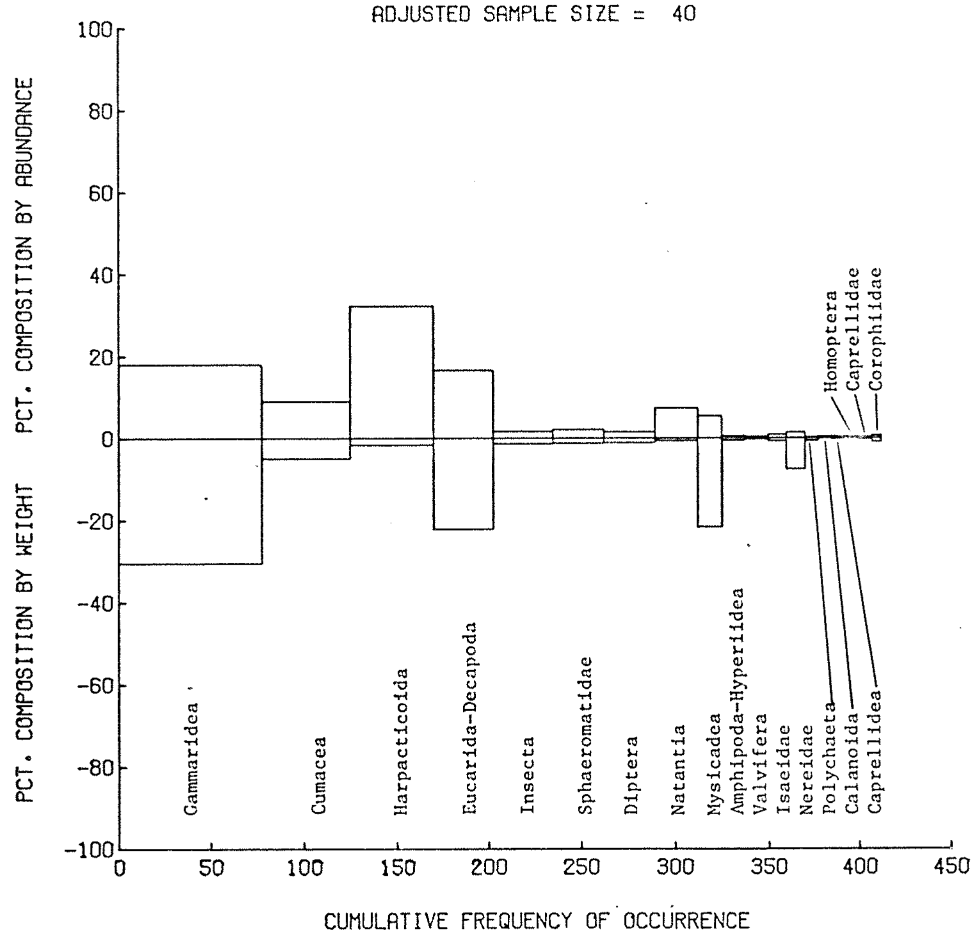
PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	68.00	16.71	24.34	2791.8	44.88
CUMACEA	38.00	8.18	3.91	459.3	7.38
HARPACTICOIDA	36.00	29.18	1.35	1099.0	17.67
SPHAEROMATIDAE	30.00	3.06	2.02	152.4	2.45
EUCARIDA-DECAPODA	30.00	15.36	17.59	988.5	15.89
INSECTA	28.00	1.55	1.26	78.7	1.26
DIPTERA	26.00	2.46	2.31	124.0	1.99
NATANTIA	18.00	6.59	.59	129.3	2.08
MYSIDACEA	10.00	4.84	17.05	218.9	3.52
AMPHIPODA-HYPERIIDEA	10.00	.40	.54	9.4	.15
VALVIFERA	10.00	.28	.20	4.8	.08
GAMMARIDEA	8.00	.75	.61	10.9	.18
NEREIDAE	8.00	1.23	5.97	57.6	.93
POLYCHAETA	6.00	.16	.55	4.3	.07
CALANOIDA	6.00	.32	.03	2.1	.03
CAPRELLIDEA	6.00	.28	.17	2.7	.04
HOMOPTERA	6.00	.28	.06	2.0	.03
COLEOPTERA	6.00	.12	.11	1.4	.02
CAPRELLIDAE	6.00	.24	.20	2.6	.04
OSTRACODA	4.00	3.85	2.18	24.1	.39
HIPPOLYTIDAE	4.00	.08	1.41	6.0	.10
EUPHAUSIACEA	2.00	2.06	14.81	33.8	.54

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.15	.15	.27
SHANNON-WEINER DIVERSITY	3.30	3.28	2.51
EVENNESS INDEX	.63	.63	.48

Fig. 28. IRI prey spectrum of juvenile coho salmon in Nisqually Reach, southern Puget Sound, 1977.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALL 8
8755010203 - ONCORHYNCHUS KISUTCH
COHO SALMON
ADJUSTED SAMPLE SIZE = 40

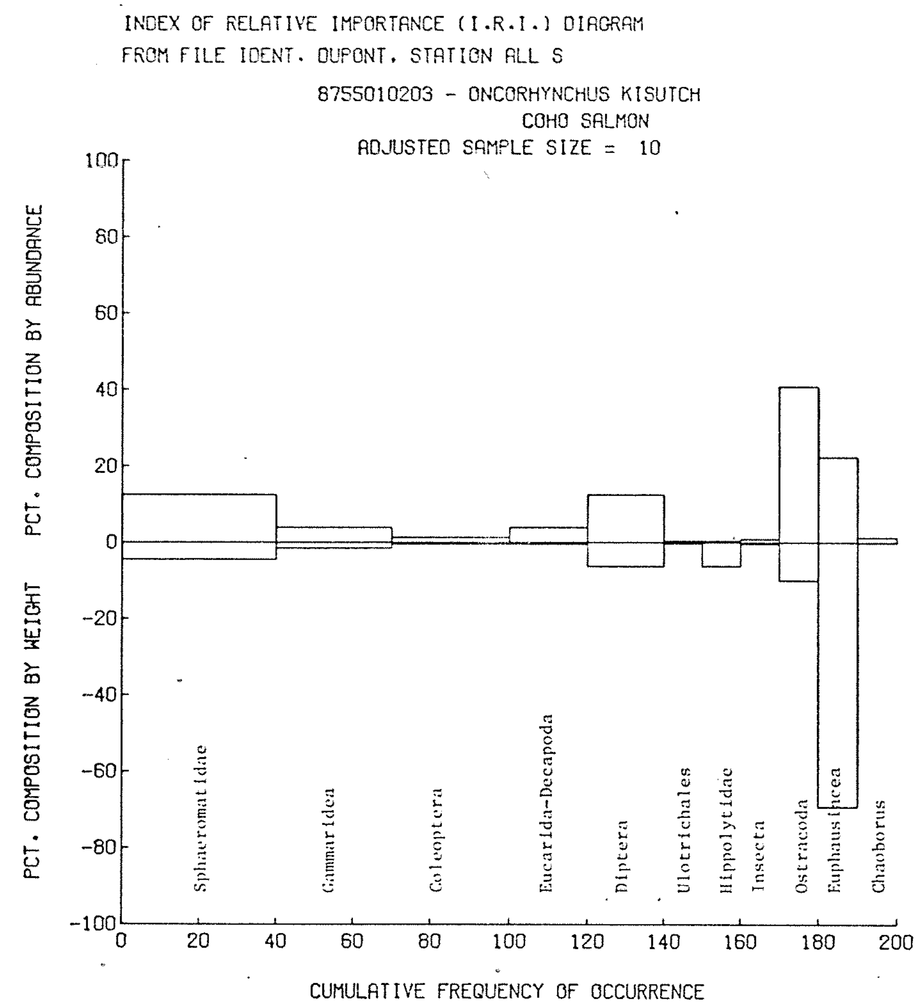


PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	77.50	18.02	30.52	3762.3	46.06
CUMACEA	47.50	9.01	4.97	664.2	8.13
HARPACTICOIDA	45.00	32.15	1.71	1524.0	18.66
EUCARIDA-DECAPODA	32.50	16.54	22.22	1259.6	15.42
INSECTA	32.50	1.62	1.48	100.6	1.23
SPHAEROMATIDAE	27.50	2.10	1.35	94.9	1.16
DIPTERA	27.50	1.44	1.21	73.0	.89
NATANTIA	22.50	7.26	.75	180.4	2.21
MYSIDACEA	12.50	5.34	21.68	337.7	4.13
AMPHIPODA-HYPERIIDEA	12.50	.44	.68	14.0	.17
VALVIFERA	12.50	.31	.25	7.0	.09
ISAEIDAE	10.00	.83	.77	16.0	.20
NEREIDAE	10.00	1.36	7.59	89.4	1.09
POLYCHAETA	7.50	.17	.70	6.6	.08
CALANOIDA	7.50	.35	.04	2.9	.04
CAPRELLIDEA	7.50	.31	.22	3.9	.05
HOMOPTERA	7.50	.31	.07	2.8	.03
CAPRELLIDAE	7.50	.26	.25	3.9	.05
COROPHIIDAE	5.00	.57	1.08	8.2	.10

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.18	.20	.28
SHANNON-WEINER DIVERSITY	3.03	2.89	2.38
EVENNESS INDEX	.59	.56	.46

Fig. 29. IRI prey spectrum of juvenile coho salmon caught in beach seine collections in Nisqually Reach, southern Puget Sound, 1977.



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
SPHAEROMATIDAE	40.00	12.45	4.50	677.9	23.49
GAMMARIDEA	30.00	3.86	1.59	163.5	5.67
COLEOPTERA	30.00	1.29	.54	54.7	1.90
EUCARIDA-DECAPODA	20.00	3.86	.53	87.8	3.04
DIPTERA	20.00	12.45	6.35	376.0	13.03
ULOTRICHALES	10.00	.43	.26	6.9	.24
HIPPOLYTIDAE	10.00	.43	6.29	67.2	2.33
INSECTA	10.00	.86	.46	13.2	.46
OSTRACODA	10.00	40.77	9.99	507.7	17.59
EUPHAUSIACEA	10.00	22.32	69.35	916.7	31.77
CHAOBORUS	10.00	1.29	.13	14.2	.49

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.25	.50	.21
SHANNON-WEINER DIVERSITY	2.41	1.65	2.56
EVENNESS INDEX	.70	.48	.74

Fig. 30. IRI prey spectrum of juvenile coho salmon caught in townet collections in Nisqually Reach, southern Puget Sound, 1977.

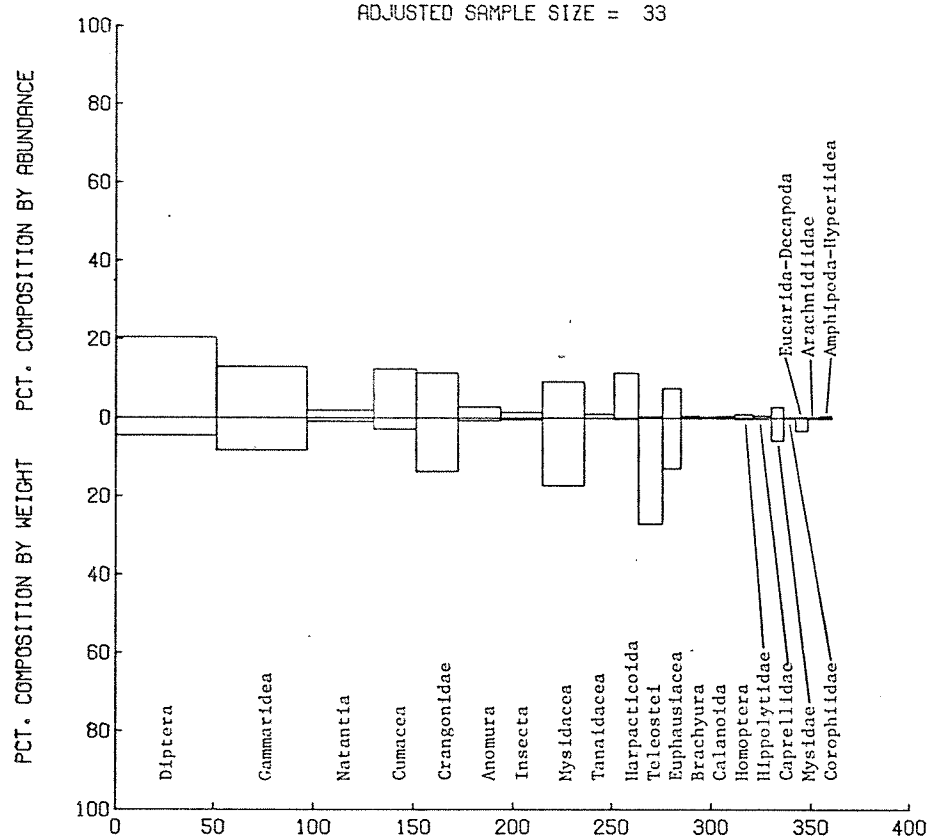
Chinook Salmon (Oncorhynchus tshawytscha). Juvenile chinook salmon were abundant in both beach seine and townet collections from late May through July; peak beach seine catches occurred at the outer Nisqually Delta site in late June and peak townet catches at Tatsolo Point in mid-June. Three (228-284 mm FL) maturing resident chinook (blackmouth) were collected in the April beach seine collection at outer Nisqually Delta.

The overall diet of juvenile chinooks was, like juvenile coho, extremely diverse (Table 23). The chinook prey spectrum was based principally upon epibenthic crustacea--gammarid amphipods (20.7 percent of total IRI), mysids (13.2 percent), cumaceans (6.9 percent), shrimp (13.8 percent) (Crangon sp.), and harpacticoid copepods (3.0 percent)--although some pelagic prey (drift insects, 42.4 percent and crab larvae, 2.1 percent) were also important (Fig. 31).

Although sample sizes were too small to permit quantitative comparisons, the predominant prey organisms of beach seine-caught chinook changed from gammarid amphipods, mysids, and insects on May 31 to euphausiids, insects, and shrimp on June 28, and to crangonid shrimp, cumaceans, insects, and mysids on July 27. No fish, other than eggs or larvae, occurred in the stomach contents of the outmigrating juvenile chinook salmon examined. The three blackmouth had fed predominantly upon epibenthic crustaceans, mostly gammarid amphipods and mysids. Shrimp (Crangon sp.) were also an important contributor to the total contents biomass, as was an unidentified fish which constituted 60 percent of the stomach contents for one blackmouth.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALSTA

8755010206 - ONCORHYNCHUS TSHAWYTSCHA
CHINOOK SALMON
ADJUSTED SAMPLE SIZE = 33



CUMULATIVE FREQUENCY OF OCCURRENCE

PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
DIPTERA	51.52	20.50	4.53	1289.1	27.57
GAMMARIDEA	45.45	12.95	8.32	966.5	20.67
NATANTIA	33.33	1.91	.94	95.0	2.03
CUMACEA	21.21	12.37	2.88	323.3	6.92
CRANGONIDAE	21.21	11.37	13.71	532.1	11.38
ANOMURA	21.21	2.82	.64	73.5	1.57
INSECTA	21.21	1.41	.49	40.2	.86
MYSIDACEA	21.21	9.21	17.35	563.4	12.05
TANAIDACEA	15.15	1.00	.08	16.3	.35
HARPACTICOIDA	12.12	11.37	.28	141.2	3.02
TELEOSTEI	12.12	.33	27.15	333.2	7.13
EUPHAUSIACEA	9.09	7.55	13.02	187.0	4.00
BRACHYURA	9.09	.50	.08	5.2	.11
CALANOIDA	9.09	.25	.03	2.5	.05
HOMOPTERA	9.09	.50	.05	5.0	.11
HIPPOLYTIDAE	9.09	.91	.24	10.4	.22
CAPRELLIDEA	9.09	.58	.21	7.2	.15
MYSIDAE	6.06	2.82	5.78	52.1	1.11
COROPHIIDAE	6.06	.17	.03	1.2	.02
EUCARIDA-DECAPODA	6.06	.17	3.33	21.2	.45
ARACHNIDIIDAE	6.06	.17	.12	1.7	.04
AMPHIPODA-HYPERIIDEA	6.06	.50	.16	4.0	.08

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.12	.15	.16
SHANNON-WEINER DIVERSITY	3.47	3.09	3.07
EVENNESS INDEX	.71	.64	.63

Fig. 31. IRI prey spectrum of juvenile chinook salmon in Nisqually Reach, southern Puget Sound, 1977.

Sea-Run Cutthroat Trout (*Salmo clarki*). One 322-mm FL sea-run cutthroat trout was captured in the April beach seine collection south of the DuPont Dock. Unfortunately, the stomach was damaged upon removal, disallowing quantitative interpretation. Included among the food items were gammarid amphipods and several caprellid amphipods, cumaceans, and insects; no fish remains were evident.

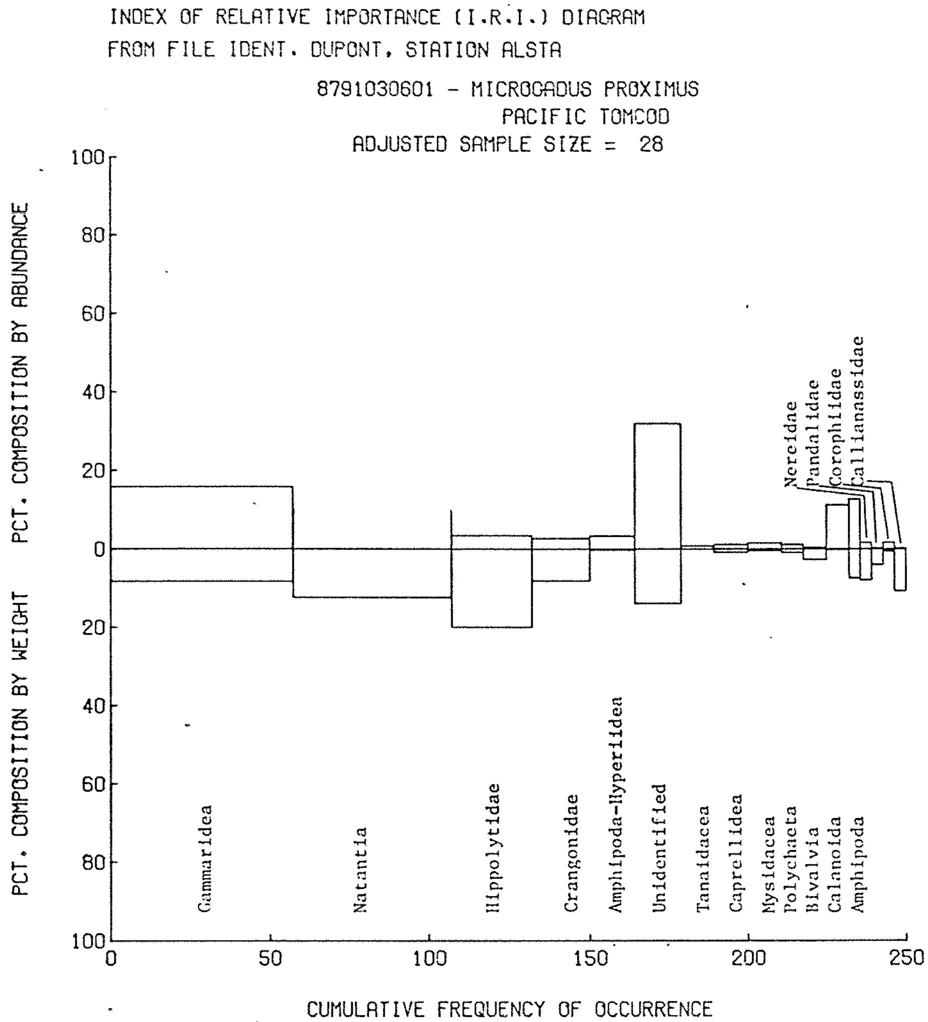
Rainbow (Steelhead) Trout (*Salmo gairdneri*). A steelhead trout (359m FL) caught during the beach seine collections at Tatsolo Point in late June had two Pacific herring in its stomach.

Pacific Cod (*Gadus macrocephalus*). One juvenile Pacific cod captured in a May 20 townet collection at Tatsolo Point had consumed calanoid and cyclopoid copepods and two from a March 15, 1978 trawl collection at Tatsolo Point had hippolytid shrimp and hyperiid amphipods in their stomachs.

Pacific Tomcod (*Microgadus proximus*). Trynet collections from June-November period at Tatsolo Point and south DuPont Dock collected the greatest numbers of Pacific tomcod.

Although the diverse prey spectrum was composed of both epibenthic and pelagic prey organisms--hippolytid and crangonid shrimp, gammarid amphipods--epibenthic forms predominated (Fig. 32). The high incidence of rocks in the stomach contents suggests that at least some of their feeding activity involves picking up organisms directly upon the substrate.

Threespine Stickleback (*Gasterosteus aculeatus*). A threespine stickleback caught in the May 3 beach seine collection at the south DuPont



PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	57.14	15.83	8.31	1379.5	31.94
NATANTIA	50.00	9.71	12.48	1109.7	25.70
HIPPOLYTIDAE	25.00	3.42	20.00	585.4	13.56
CRANGONIDAE	17.86	2.70	8.22	195.0	4.51
AMPHIPODA-HYPERIIDEA	14.29	3.24	.28	50.3	1.16
UNIDENTIFIED	14.29	32.01	13.98	657.1	15.22
TANAIDACEA	10.71	.72	.07	8.5	.20
CAPRELLIDEA	10.71	1.08	.89	21.1	.49
MYSIDACEA	10.71	1.44	.49	20.7	.48
POLYCHAETA	7.14	1.08	.91	14.2	.33
BIVALVIA	7.14	.36	2.76	22.3	.52
CALANOIDA	7.14	11.15	.17	80.8	1.87
AMPHIPODA	3.57	12.59	7.45	71.6	1.66
NEREIDAE	3.57	1.62	7.91	34.0	.79
PANDALIDAE	3.57	.18	4.07	15.2	.35
COROPHIIDAE	3.57	1.62	.61	8.0	.18
CALLIANASSIDAE	3.57	.18	10.82	39.3	.91

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM.	GRAV.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.17	.11	.21
SHANNON-WEINER DIVERSITY	3.10	3.38	2.65
EVENNESS INDEX	.70	.77	.60

Fig. 32. IRI prey spectrum of Pacific tomcod in Nisqually Reach, southern Puget Sound, 1977-1978.

Dock site had consumed six harpacticoid copepods, three gammarid amphipods (95.24 percent of total contents biomass) and one decapod zoea.

Tubesnout (Aulorhynchus flavidus). The stomach of one tubesnout from the March 23 beach seine collection at the south DuPont Dock site was filled with harpacticoid and cyclopoid copepods though a few juvenile euphausiids comprised 67.2 percent of the total contents biomass.

Bay Pipefish (Syngnathus griseolineatus). Ten crustacean eggs and seven gammarid amphipods (97.6 percent of the total biomass) had been eaten by an adult bay pipefish collected in the beach seine at south DuPont Dock on March 23, 1977.

Copper Rockfish (Sebastes caurinus). Beach seine and trynet collections at Tatsolo Point produced the five copper rockfish specimens used for stomach analysis; most were juveniles captured in the November trynet collections.

Shrimp, including Heptacarpus stylus, H. taylori, Pandalus sp. and Crangon sp., were numerically the predominant prey and comprised 50 percent of the total prey biomass. The remains of two unidentifiable fish comprised the rest of the biomass.

Rock Greenling (Hexagrammos lagocephalus). One specimen of this species, rarely encountered in southern Puget Sound (DeLacy et al. 1972), was caught during trynetting at Tatsolo Point on November 3, 1977. Its stomach contained the remains of eight hippolytid shrimp and one crab, Cancer sp.

Whitespotted Greenling (Hexagrammos stelleri). A hexagrammid species common to southern Puget Sound (DeLacy et al. 1972), the whitespotted greenling, was collected during trynetting in November 1977 and January 1978 at Tatsolo Point and south DuPont Dock. Fish and fish eggs (demersal, perhaps cottids or hexagrammids) predominated in the stomach contents; crabs (Cancer oregonensis) and shrimp (Hippolytidae) were also important.

Painted Greenling (Oxylebius pictus). Painted greenling were one of the most common species (ranked third in abundance) observed during the SCUBA transect surveys of the DuPont Dock. Because of the sampling design, fish were not collected from the dock assemblage and only two specimens, one from the November trynet collection at Tatsolo Point and one from the March 15, 1978 trynet collection from south DuPont Dock, were available for stomach analysis. Over 70 percent of the prey and 97 percent of the prey biomass included shrimp, pandalid species, and Spirontocaris arcuata. Caprellid amphipods were also found in the stomach.

Sablefish (Anoplopoma fimbria). The stomach of one sablefish caught in a January 15, 1978 trynet collection at Tatsolo Point was empty.

Padded Sculpin (Artedius fenestralis). Six padded sculpins were caught in the DuPont Dock area during trynet collections on March 15, 1978. Their stomach contents were almost completely dominated by hippolytid shrimp.

Smoothhead Sculpin (Artedius lateralis). One adult smoothhead sculpin captured in the beach seine at the south DuPont Dock site in early

May had eaten seven isopods, Gnorimosphaeroma oregonensis (80 percent total contents biomass), two gammarid amphipods, and one tanaid.

Sharpnose Sculpin (Clinocottus acuticeps). Three sharpnose sculpins caught during May-June beach seine collections at the Tatsolo Point, south DuPont Dock, and outer Nisqually Delta sites had entirely different prey; one had an isopod, Gnorimosphaeroma oregonensis, one a gammarid amphipod, and one a shrimp zoea.

Roughback Sculpin (Chitonotis pugetensis). The most abundant cottid caught during trynet sampling was the roughback sculpin. Its prey spectrum (Fig. 33) indicates that it is relatively selective toward shrimp (hippolytids such as Spirontocaris sp., pandalids, and crangonids such as Crangon nigricauda and Crangon sp.), and to a lesser extent, brachyuran crabs (Cancer sp. and Oregonia gracilis). Shrimp accounted for 61.4 percent of the total IRI and crabs, 7.5 percent.

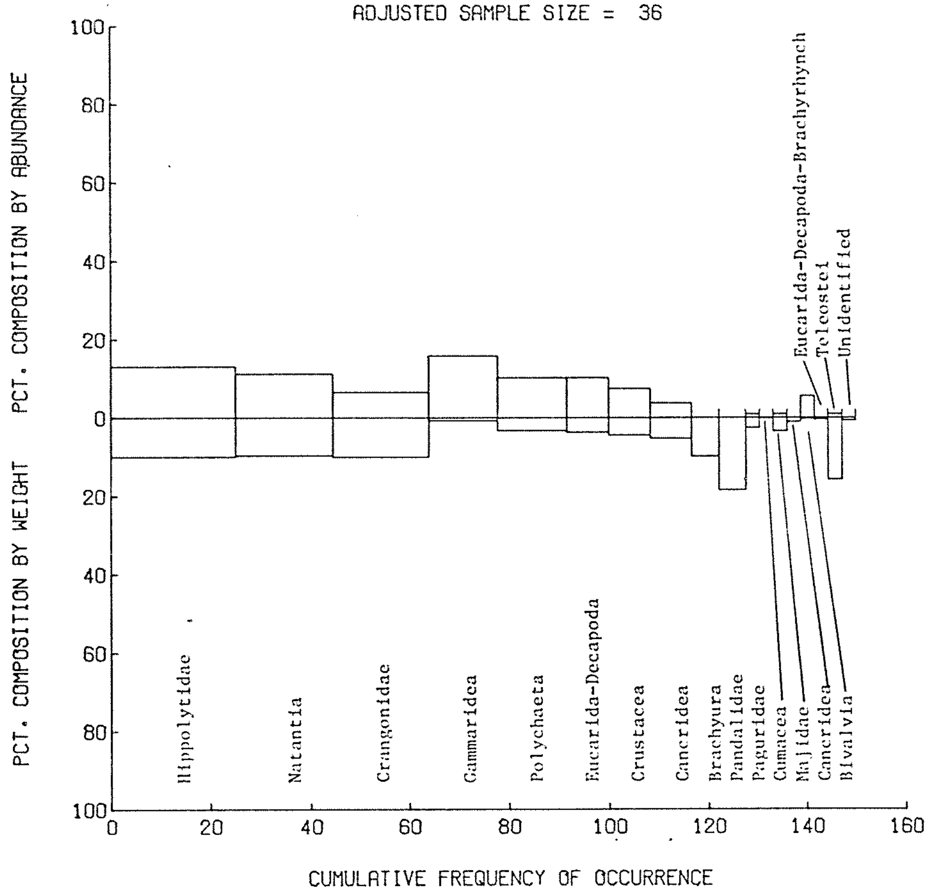
Whereas low sample sizes did not allow quantitative comparisons between sampling dates, it appeared that gammarid amphipods were more important late in the winter (March 1978).

Buffalo Sculpin (Enophrys bison). The buffalo sculpin was one of the most common demersal species caught by beach seine in the DuPont Dock vicinity and was also the most common demersal species observed along the DuPont Dock SCUBA transect. Fall and winter trynet collections also provided specimens.

Benthic algae, principally the ulvoid types (Ulva sp., Enteromorpha sp., Porphyra sp. and Bangiaceae spp.), accounted for 93.0 percent of the total IRI (Fig. 34). Unidentified eggs (possibly from fish such as

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALSTA

8831024001 - CHITONOTIS PUGETENSIS
ROUGHBACK SCULPIN
ADJUSTED SAMPLE SIZE = 36



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HIPPOLYTIDAE	25.00	13.08	9.98	576.5	24.94
NATANTIA	19.44	11.21	9.69	406.3	17.58
CRANGONIDAE	19.44	6.54	10.07	323.0	13.97
GAMMARIDEA	13.89	15.89	.71	230.6	9.98
POLYCHAETA	13.89	10.28	3.26	188.1	8.14
EUCARIDA-DECAPODA	8.33	10.28	3.75	116.9	5.06
CRUSTACEA	8.33	7.48	4.44	99.3	4.30
CANCRIDEA	8.33	3.74	5.33	75.6	3.27
BRACHYURA	5.56	1.87	9.86	65.2	2.82
PANDALIDAE	5.56	1.87	18.37	112.4	4.86
PAGURIDAE	2.78	.93	2.53	9.6	.42
CUMACEA	2.78	1.87	.05	5.3	.23
MAJIDAE	2.78	.93	3.40	12.0	.52
CANCRIDEA	2.78	1.87	1.08	8.2	.35
BIVALVIA	2.78	5.61	.28	16.3	.71
EUCARIDA-DECAPODA-BRACHYRHYNCH	2.78	1.87	.44	6.4	.28
TELEOSTEI	2.78	.93	15.70	46.2	2.00
UNIDENTIFIED	2.78	1.87	.69	7.1	.31

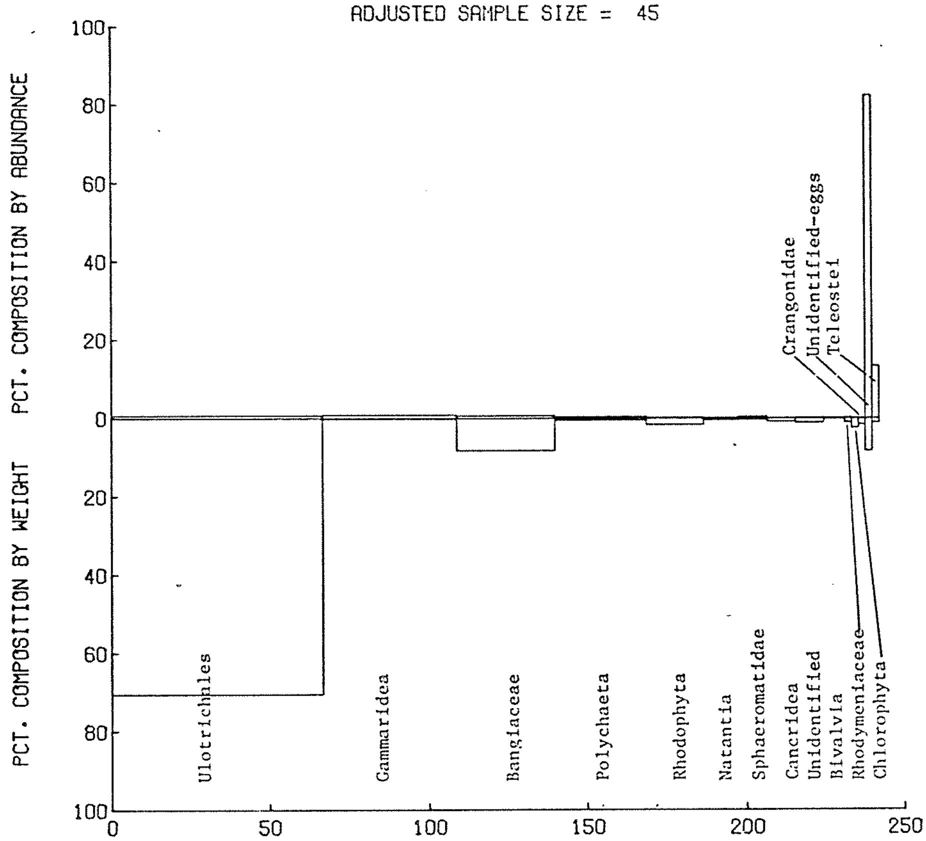
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.09	.11	.14
SHANNON-WEINER DIVERSITY	3.74	3.52	3.25
EVENNESS INDEX	.87	.81	.75

Fig. 33. IRI prey spectrum of roughback sculpin in Nisqually Reach, southern Puget Sound, 1977-78.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALSTA

8831021001 - ENOPHRYS BISON
BUFFALO SCULPIN
ADJUSTED SAMPLE SIZE = 45



CUMULATIVE FREQUENCY OF OCCURRENCE

PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
ULOTRICHALES	66.67	.73	70.39	4740.7	87.75
GAMMARIDEA	42.22	.86	.14	42.0	.78
BANGIACEAE	31.11	.69	8.29	279.3	5.17
POLYCHAETA	28.89	.38	.45	23.8	.44
RHODOPHYTA	17.78	.20	1.62	32.3	.60
NATANTIA	11.11	.12	.43	6.1	.11
SPHAEROMATIDAE	8.89	.38	.31	6.1	.11
CANCRIDEA	8.89	.07	.85	8.1	.15
UNIDENTIFIED	8.89	.12	1.16	11.3	.21
BIVALVIA	6.67	.08	.10	1.2	.02
RHODYMENIACEAE	2.22	.13	1.09	2.7	.05
CHLOROPHYTA	2.22	.02	2.37	5.3	.10
CRANGONIDAE	2.22	.02	1.59	3.6	.07
UNIDENTIFIED-eggs	2.22	82.40	8.41	201.8	3.74
TELEOSTEI	2.22	13.18	1.12	31.8	.59

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX		.70	.51		.77
SHANNON-WEINER DIVERSITY		.98	1.82		.84
EVENNESS INDEX		.19	.35		.16

Fig. 34. IRI prey spectrum of Buffalo sculpin in Nisqually Reach, southern Puget Sound, 1977-78.

cottids or hexagrammids) were the second most important food category (3.2 percent of total IRI) but as these occurred in but one stomach, they cannot be considered a representative food item. Gammarid amphipods and polychaetes occurred more often and formed the highest proportion of the animate prey organisms. Fish only accounted for 0.6 percent of the prey spectrum.

Beach seine-caught buffalo sculpin had a much less diverse prey spectrum (Fig. 35) than did those caught with the trynet (Fig. 36). Gammarid amphipods, polychaetes, and shrimp were more prominent in the trynet collections from the deeper nearshore areas.

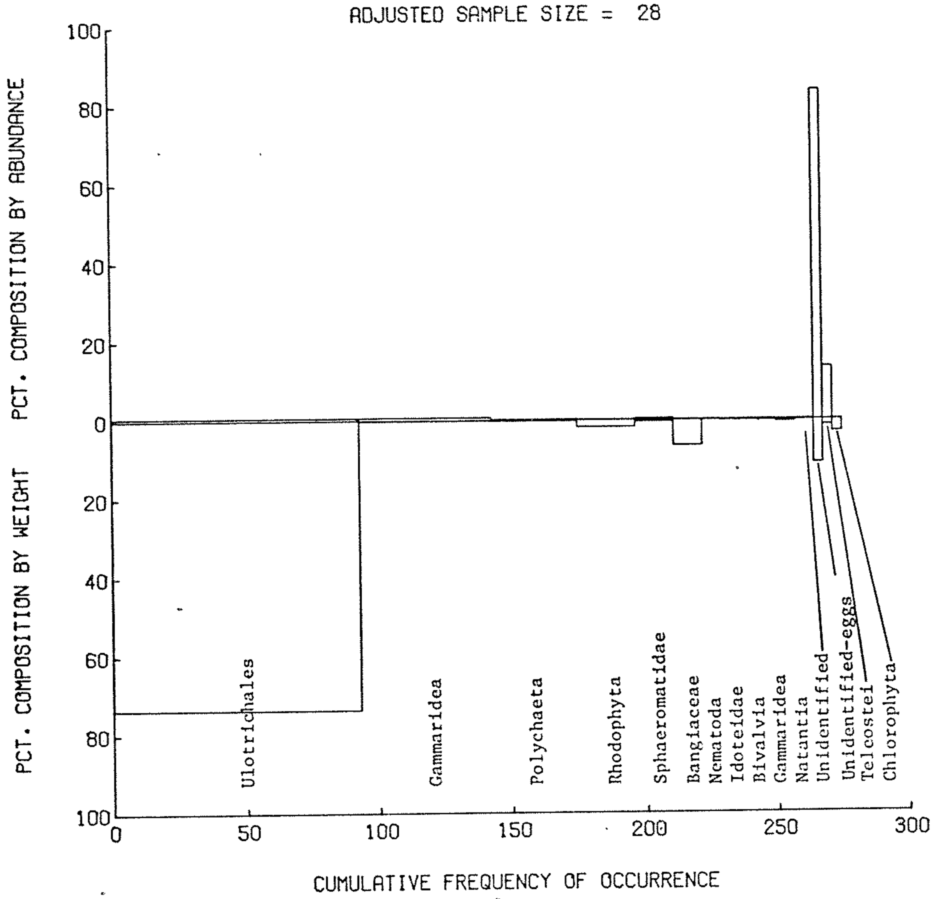
Buffalo sculpin from northern Puget Sound also had prey spectra based on algae (61.8 percent of total IRI at San Juan Island, 45.8 percent at Cherry Point); however, nonalgal prey items such as gammarid amphipods, insects, polychaetes, crabs, nudibranchs, pycnogonids, flabelliferan isopods, and fish (unidentified) were also represented (Miller et al. 1977).

Although the low sample size for the trynet-caught buffalo sculpins did not permit a quantitative comparison, stomachs of these fish tended to have more Porphyra sp. and Rhodophyta algae than those from beach seine collections.

Pacific Staghorn Sculpin (Leptocottus armatus). Pacific staghorn sculpin was the prominent nearshore cottid throughout the Nisqually Reach study area, especially along the outer edge of the Nisqually Delta. Staghorn sculpin was also commonly observed during SCUBA transects beneath the existing DuPont Dock.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION BCHSN

8831021001 - ENOPHRYS BISON
BUFFALO SCULPIN
ADJUSTED SAMPLE SIZE = 28



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
ULOTRICHALES	92.86	.67	73.68	6904.0	92.04
GAMMARIDEA	50.00	.74	.14	43.7	.58
POLYCHAETA	32.14	.27	.19	14.7	.20
RHODOPHYTA	21.43	.12	1.83	41.7	.56
SPHAEROMATIDAE	14.29	.39	.40	11.2	.15
BANGIACEAE	10.71	.05	6.50	70.2	.94
NEMATODA	7.14	.07	.00	.5	.01
IDOTEIDAE	7.14	.03	.14	1.2	.02
BIVALVIA	7.14	.07	.13	1.4	.02
GAMMARIDEA	7.14	.10	.17	2.0	.03
NATANTIA	7.14	.03	.50	3.8	.05
UNIDENTIFIED	7.14	.05	.08	.9	.01
UNIDENTIFIED(eggs)	3.57	83.75	11.06	338.6	4.51
TELEOSTEI	3.57	13.40	1.48	53.1	.71
CHLOROPHYTA	3.57	.02	3.12	11.2	.15

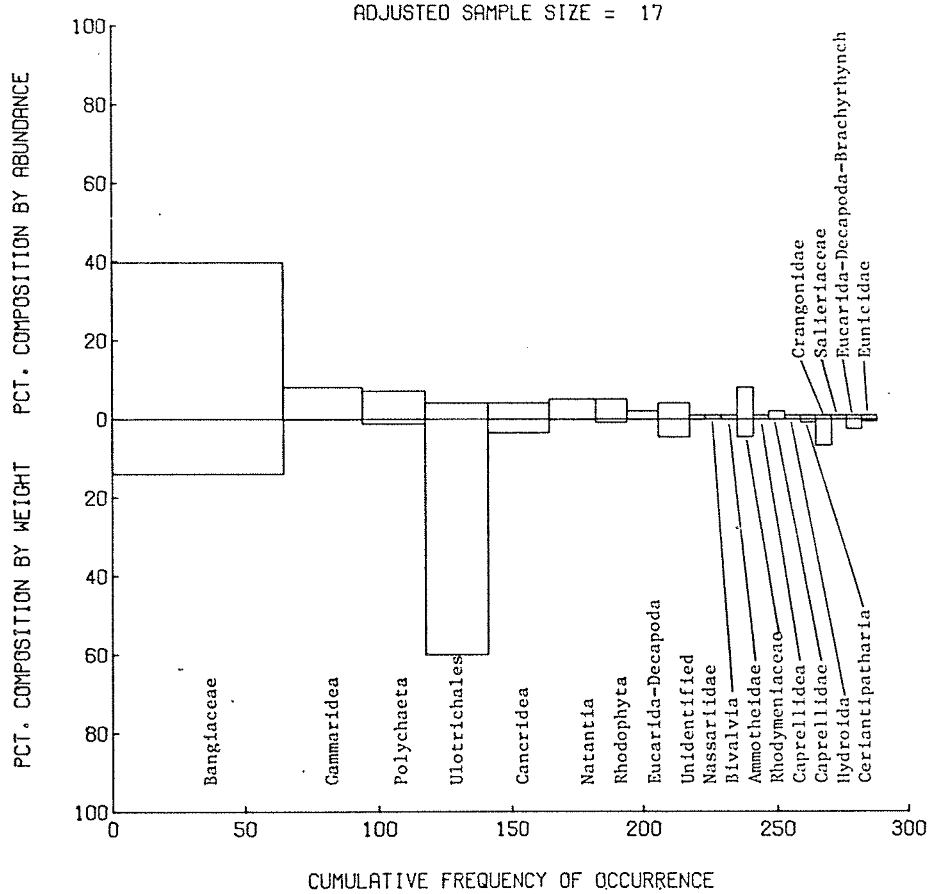
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.72	.56	.85
SHANNON-WEINER DIVERSITY	.84	1.49	.58
EVENNESS INDEX	.18	.32	.12

Fig. 35. IRI prey spectrum of buffalo sculpin caught by beach seine in Nisqually Reach, southern Puget Sound, 1977-78.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION TRWL

8831021001 - ENOPHRYS BISON
BUFFALO SCULPIN
ADJUSTED SAMPLE SIZE = 17



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
BANGIACEAE	64.71	39.80	13.95	3477.6	56.94
GAMMARIDEA	29.41	8.16	.14	244.2	4.00
POLYCHAETA	23.53	7.14	1.26	197.7	3.24
ULOTRICHALES	23.53	4.08	59.93	1506.1	24.66
CANCRIDEA	23.53	4.08	3.53	179.2	2.93
NATANTIA	17.65	5.10	.22	94.0	1.54
RHODOPHYTA	11.76	5.10	.95	71.2	1.17
EUCARIDA-DECAPODA	11.76	2.04	.06	24.7	.41
UNIDENTIFIED	11.76	4.08	4.59	102.0	1.67
NASSARIIDAE	5.88	1.02	.14	6.8	.11
BIVALVIA	5.88	1.02	.02	6.1	.10
AMMOTHEIDAE	5.88	1.02	.04	6.2	.10
RHODYMENIACEAE	5.88	8.16	4.55	74.8	1.22
CAPRELLIDEA	5.88	1.02	.02	6.1	.10
CAPRELLIDAE	5.88	2.04	.05	12.4	.20
HYDROIDA	5.88	1.02	.02	6.1	.10
CERIANTIPATHARIA	5.88	1.02	.84	11.0	.18
CRANGONIDAE	5.88	1.02	6.64	45.1	.74
SALIERIACEAE	5.88	1.02	.02	6.1	.10
EUCARIDA-DECAPODA-BRACHYRHYNCH	5.88	1.02	2.50	20.7	.34
EUNICIDAE	5.88	1.02	.51	9.0	.15

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

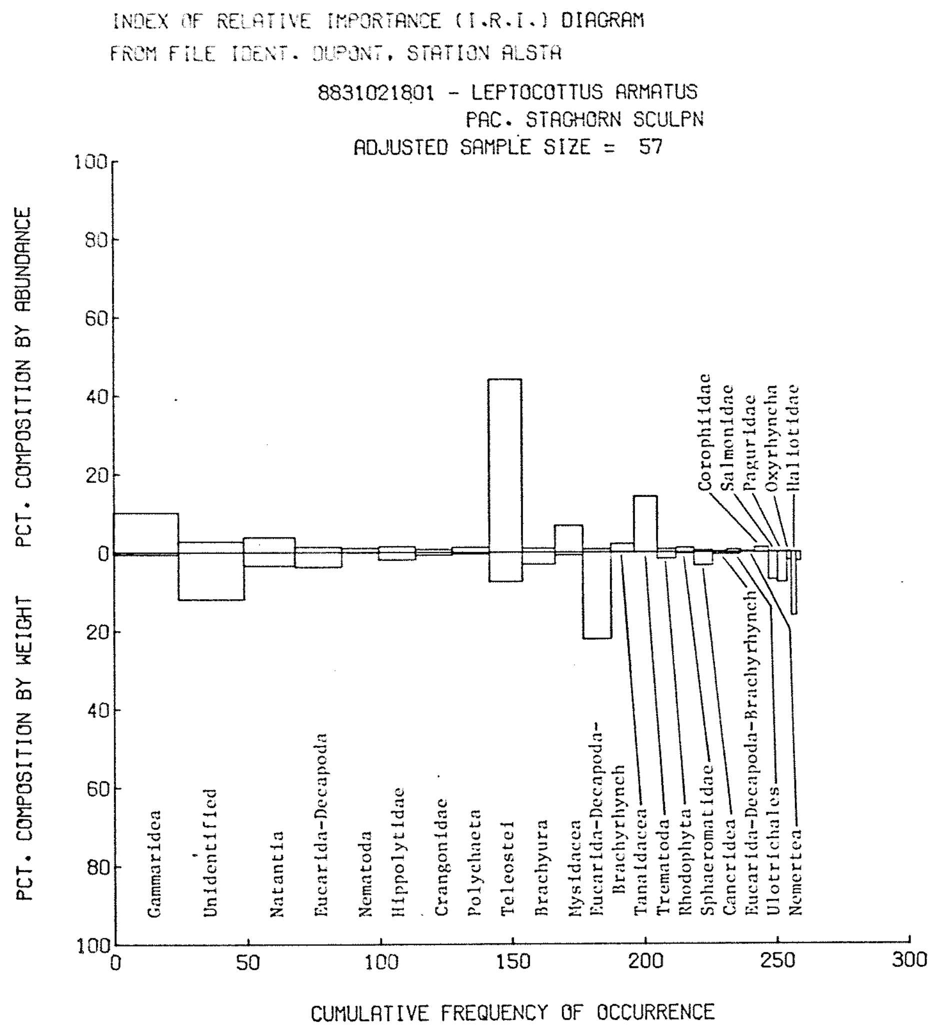
	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.19	.39	.39
SHANNON-WEINER DIVERSITY	3.30	2.12	2.02
EVENNESS INDEX	.75	.48	.46

Fig. 36. IRI prey spectrum of buffalo sculpin caught by trynet in Nisqually Reach, southern Puget Sound, 1977-78.

Of all species examined, the third highest numerical diversity was exhibited by the staghorn sculpin prey spectrum (Table 23). Benthic and epibenthic crustaceans--gammarid amphipods (11.6 percent of total IRI), natantian shrimp (8.9 percent, including Crangon sp. and Heptacarpus sp.), reptantian shrimp (Callianassa californiensis), and brachyuran crabs (9.26 percent, including Cancer oregonensis, Hemigrapsus nudus, and H. oregonensis) and mysids (3.5 percent)--were the principal prey organisms (Fig. 37). Fish (primarily eggs and larvae, but including adult threespine stickleback and two unidentified salmon fry) comprised 29.1 percent of the total IRI. Juvenile salmonids constituted 1.1 percent of the total IRI.

Pacific staghorn sculpins from beach collections had eaten an equally diverse ($H'_{Abundance}$ (beach seine) = 2.49 versus $H'_{Abundance}$ (trynet) = 2.91 and $H'_{Biomass}$ (beach seine) = 3.45 versus $H'_{Biomass}$ (trynet) = 3.15) spectrum of prey organisms than had those caught in deeper water during trynet collections. Gammarid amphipods (37.7 percent of total IRI for trynet collections versus 1.5 percent for beach seine) and natantian shrimp (29.8 percent versus 2.4 percent) comprised higher proportions of the prey spectrum of trynet-caught sculpins than of those caught by beach seine (Figs. 38 and 39).

Similar to our results, Pacific staghorn sculpin from northern Puget Sound have been shown to feed primarily upon benthic and epibenthic prey, such as isopods, crabs, polychaetes, and gammarid amphipods (Miller et al. 1977). Fish were not very important to the overall prey spectra and included no salmonids.



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	24.56	10.13	.61	263.9	11.56
UNIDENTIFIED	24.56	2.76	12.01	362.8	15.89
NATANTIA	19.30	3.78	3.37	138.0	6.04
EUCARIDA-DECAPODA	17.54	1.35	3.81	90.5	3.96
NEMATODA	14.04	1.09	.08	16.4	.72
HIPPOLYTIDAE	14.04	1.48	1.84	46.5	2.04
CRANGONIDAE	14.04	.71	.70	19.7	.86
POLYCHAETA	14.04	1.28	.46	24.5	1.07
TELEOSTEI	12.28	44.13	7.53	634.4	27.78
BRACHYURA	12.28	1.03	3.04	49.9	2.19
MYSIDACEA	10.53	6.80	.70	79.0	3.46
EUCARIDA-DECAPODA-BRACHYRHYNCH	10.53	.77	22.19	241.6	10.58
TANAIDACEA	8.77	2.12	.03	18.8	.82
TREMATODA	8.77	14.24	.01	125.0	5.47
RHODOPHYTA	7.02	.83	1.58	17.0	.74
SPHAEROMATIDAE	7.02	1.15	.30	10.2	.45
CANCRIDEA	7.02	.45	3.32	26.4	1.16
EUCARIDA-DECAPODA-BRACHYRHYNCH	5.26	.19	.56	4.0	.17
ULOTRICHALES	5.26	.64	.51	6.1	.27
NEMERTEA	5.26	.19	.03	1.2	.05
COROPHIIDAE	5.26	1.22	.09	6.9	.30
SALMONIDAE	3.51	.13	7.03	25.1	1.10
PAGURIDAE	3.51	.13	7.68	27.4	1.20
OXRHYNCHA	1.75	.19	1.93	3.7	.16
HALIOTIDAE	1.75	.06	16.13	28.4	1.24
GASTEROSTEIDAE	1.75	.06	2.22	4.0	.18

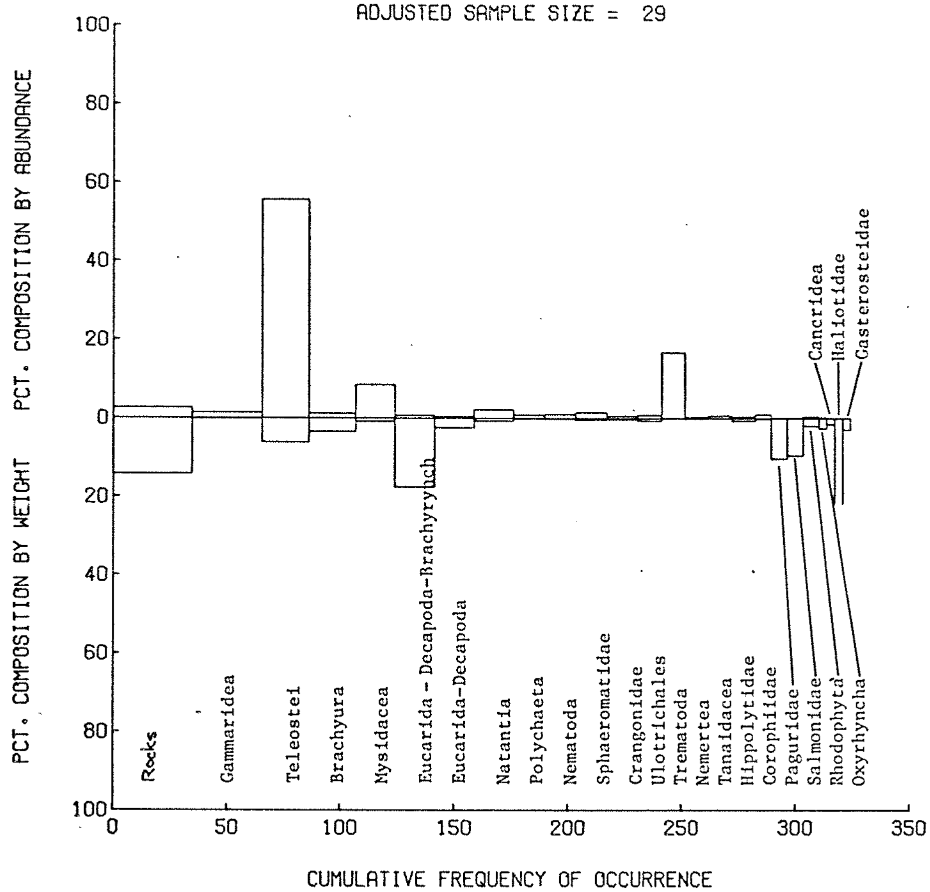
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.23	.11	.14
SHANNON-WEINER DIVERSITY	3.10	3.70	3.49
EVENNESS INDEX	.57	.69	.65

Fig. 37. IRI prey spectrum of Pacific staghorn sculpin in Nisqually Reach, southern Puget Sound, 1977-78.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION BCHSN

8831021801 - LEPTOCOTTUS ARMATUS
PAC. STAGHORN SCULPN
ADJUSTED SAMPLE SIZE = 29



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
ROCKS	34.48	2.67	14.23	582.9	18.57
GAMMARIDEA	31.03	1.38	.16	47.7	1.52
TELEOSTEI	20.69	55.67	6.20	1280.1	40.77
BRACHYURA	20.69	1.22	3.47	97.0	3.09
MYSIDACEA	17.24	8.51	.94	162.9	5.19
EUCARIDA-DECAPODA-BRACHYRHYNCH	17.24	.73	17.57	315.6	10.05
EUCARIDA-DECAPODA	17.24	.49	2.46	50.7	1.62
NATANTIA	17.24	2.19	.77	50.9	1.62
POLYCHAETA	13.79	.89	.07	13.3	.42
NEMATODA	13.79	.97	.11	14.9	.47
SPHAEROMATIDAE	13.79	1.46	.40	25.6	.82
CRANGONIDAE	13.79	.57	.34	12.5	.40
ULOTRICHALES	10.34	.81	.69	15.5	.49
TREMATODA	10.34	16.77	.01	173.7	5.53
NEMERTEA	10.34	.24	.04	2.9	.09
TANAIDACEA	10.34	.65	.01	6.8	.22
HIPPOLYTIDAE	10.34	.41	.68	11.2	.36
COROPHIIDAE	6.90	.97	.11	7.4	.24
PAGURIDAE	6.90	.16	10.32	72.3	2.30
SALMONIDAE	6.90	.16	9.45	66.3	2.11
RHODOPHYTA	6.90	.41	1.98	16.4	.52
OXRHYNCHA	3.45	.24	2.59	9.8	.31
CANCRIDEA	3.45	.08	1.61	5.8	.19
HALIOTIDAE	3.45	.09	21.69	75.1	2.39
	3.45	.09	2.99	10.6	.34

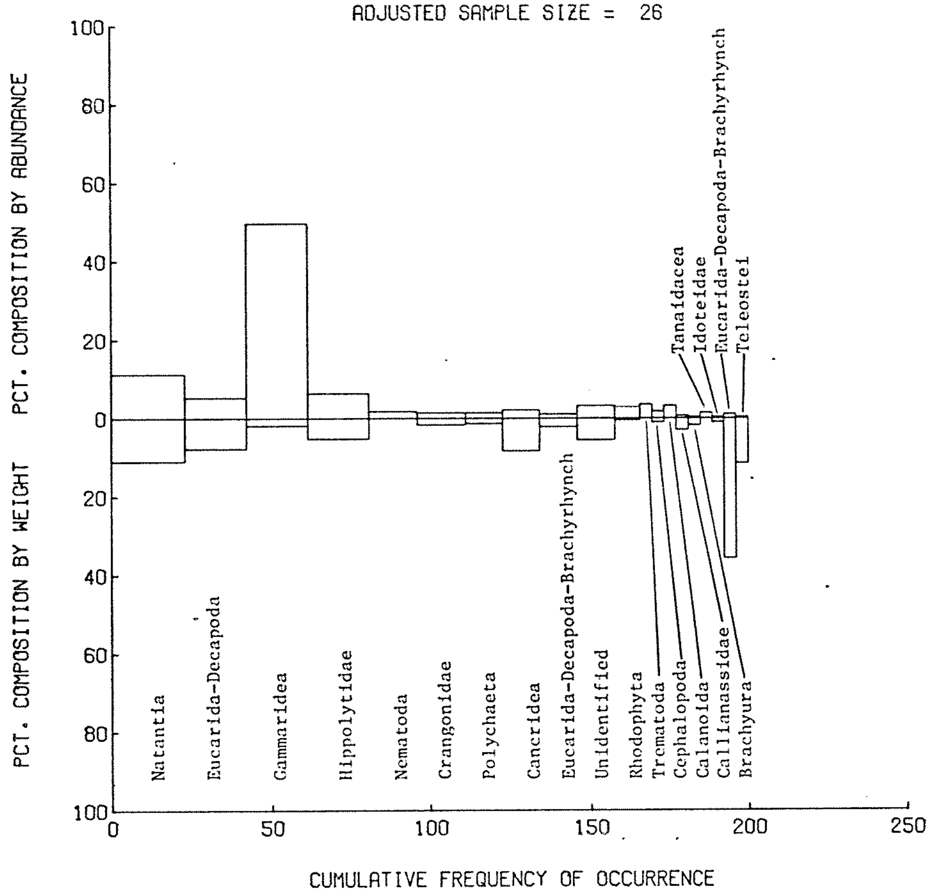
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.35	.13	.22
SHANNON-WEINER DIVERSITY	2.49	3.45	3.00
EVENNESS INDEX	.48	.66	.58

Fig. 38. IRI prey spectrum of Pacific staghorn sculpin caught by beach seine in Nisqually Reach, southern Puget Sound, 1977-78.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION TRWL

8831021801 - LEPTOCOTTUS ARMATUS
PAC. STAGHORN SCULPN
ADJUSTED SAMPLE SIZE = 26



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
NATANTIA	23.08	11.27	10.97	513.2	19.49
EUCARIDA-DECAPODA	19.23	5.28	7.77	251.1	9.54
GAMMARIDEA	19.23	49.65	1.93	991.9	37.67
HIPPOLYTIDAE	19.23	6.34	5.24	222.6	8.46
NEMATODA	15.38	1.76	.01	27.2	1.03
CRANGONIDAE	15.38	1.41	1.75	48.5	1.84
POLYCHAETA	11.54	1.41	1.38	32.2	1.22
CANCRIDEA	11.54	2.11	8.31	120.3	4.57
EUCARIDA-DECAPODA-BRACHYRHYNCH	11.54	1.06	2.20	37.6	1.43
UNIDENTIFIED	11.54	3.17	5.61	101.3	3.85
RHODOPHYTA	7.69	2.82	.44	25.1	.95
TREMATODA	3.85	3.52	.00	13.6	.51
CEPHALOPODA	3.85	1.76	1.09	11.0	.42
CALANOIDA	3.85	3.17	.01	12.2	.46
CALLIANASSIDAE	3.85	.70	3.00	14.2	.54
BRACHYURA	3.85	.35	1.78	8.2	.31
TANAIDACEA	3.85	1.41	.01	5.4	.21
IDOTEIDAE	3.85	.35	1.04	5.4	.20
EUCARIDA-DECAPODA-BRACHYRHYNCH	3.85	1.06	35.75	141.6	5.38
TELEOSTEI	3.85	.35	11.46	45.4	1.72

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.27	.17	.20
SHANNON-WEINER DIVERSITY	2.91	3.15	2.96
EVENNESS INDEX	.64	.70	.65

Fig. 39. IRI prey spectrum of Pacific staghorn sculpin caught by trynet in Nisqually Reach, southern Puget Sound, 1977-78.

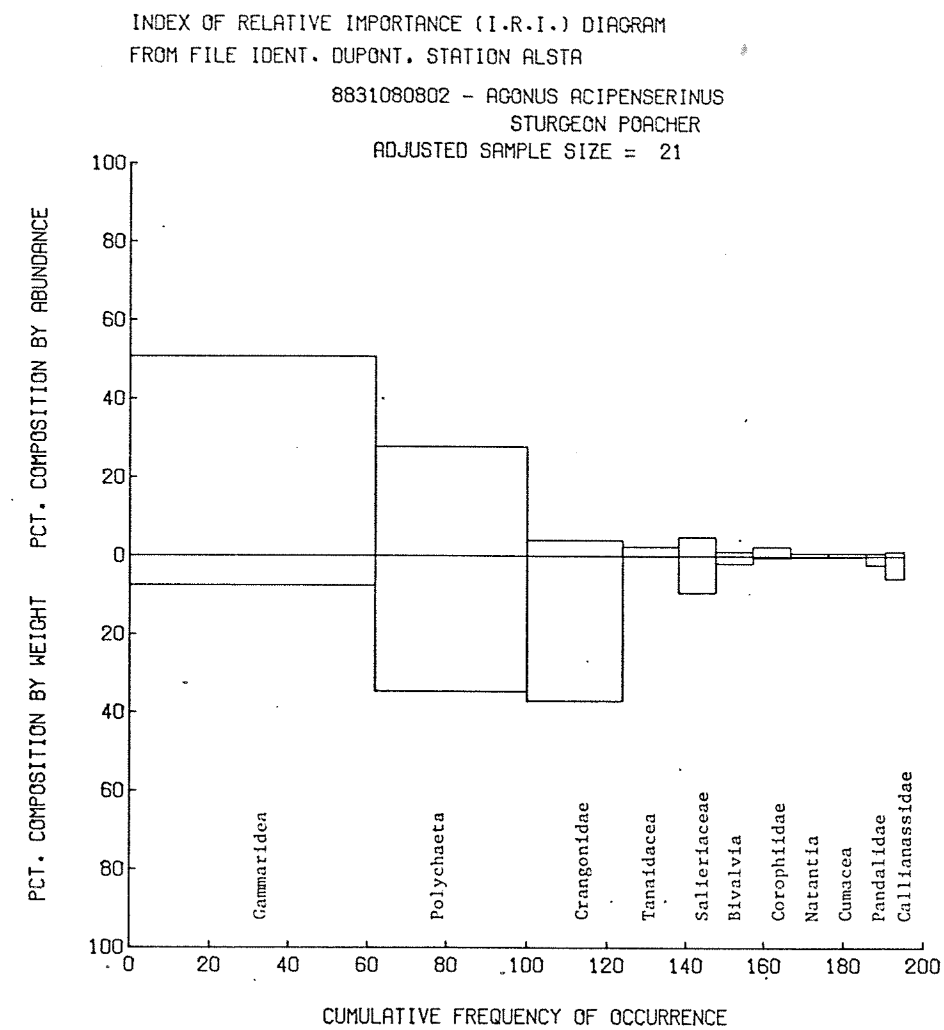
Great Sculpin (Myoxocephalus polyacanthocephalus). Two of the four great sculpin beach seined from the Tatsolo Point and south DuPont Dock sites in April and May had empty stomachs; the remaining two stomachs contained crab (including Scleropax granulata) and shrimp (Crangon sp.) remains. Two of the three great sculpin caught in January 1977 and March 1978 trynet collections in same areas were also empty; the remaining stomach contained fish scales and unidentified eggs.

Sailfin Sculpin (Nautichthys oculofasciatus). A sailfin sculpin from the September trynet collections south of the DuPont Dock had consumed three polychaetes, two gammarid amphipods, and one shrimp.

Tidepool Sculpin (Oligottus maculosus). One tidepool sculpin caught in the June 28 beach seine collection at south DuPont Dock had eaten mostly epibenthic crustaceans, including gammarid and caprellid amphipods, tanaids, and flabelliferan isopods, but a polychaete accounted for much of the prey biomass.

Sturgeon Poacher (Agonus acipenserinus). Sturgeon poachers were abundant during March (1977 and 1978) and September trynet collections at the south DuPont Dock and outer Nisqually Delta sampling sites. Sturgeon poachers were also sighted beneath the DuPont Dock during SCUBA transect surveys in July through October.

Gammarid amphipods (including Corophidae sp.), polychaetes, and crangonid shrimp dominated the prey spectrum of the sturgeon poacher (Fig. 40).



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	61.90	50.81	7.57	3613.8	49.65
POLYCHAETA	38.10	27.82	34.58	2377.2	32.66
CRANGONIDAE	23.81	4.03	37.00	977.0	13.42
TANAIDACEA	14.29	2.42	.06	35.4	.49
SALIERIACEAE	9.52	4.84	9.33	135.0	1.85
BIVALVIA	9.52	1.21	1.87	29.3	.40
COROPHIIDAE	9.52	2.42	.39	26.7	.37
NATANTIA	9.52	.81	.20	9.5	.13
CUMACEA	9.52	.81	.14	9.0	.12
PANDALIDAE	4.76	.81	2.20	14.3	.20
CALLIANASSIDAE	4.76	1.21	5.70	32.9	.45

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

	NUM.	GRAV.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.34	.28	.37
SHANNON-WEINER DIVERSITY	2.21	2.28	1.73
EVENNESS INDEX	.54	.56	.42

Fig. 40. IRI prey spectrum of sturgeon poacher in Nisqually Reach, southern Puget Sound, 1977-78.

Tubenose Poacher (Pallasina barbata). A tubenose poacher from the March 1977 trynet collection at south DuPont Dock had consumed 100 harpacticoid copepods.

Blacktip Poacher (Xeneretmus latifrons). One blacktip poacher from the March 1978 trynet collection at south DuPont Dock, had fed upon diverse arrays of prey, including polychaetes, tanaids, parasitic copepods (Argulus sp.), gammarid amphipods, and shrimp zoea.

Shiner Perch (Cymatogaster aggregata). Trynet collections in the DuPont Dock vicinity, particularly in November, provided the greatest sample of shiner perch for stomach analysis. Shiner perch were also the most abundant neritic fish observed during the DuPont Dock SCUBA transect surveys. As is characteristic of this species (Terry 1975, Miller et al. 1977), a high percentage (53 percent) of the stomachs was empty.

Shiner perch preyed predominantly upon epibenthic plankton, principally harpacticoid copepods and gammarid and caprellid amphipods, and to a lesser extent pelagic hyperiid amphipods.

Striped Seaperch (Embiotoca lateralis). Although abundant beneath the DuPont Dock, striped seaperch were not common in beach seine or trynet catches. Two specimens from a March beach seine collection at DuPont Dock (north) and three from an April collection at Tatsolo were examined. Polynoid polychaete annelids, gammarid amphipods, shrimp (Hippolytidae), and brachyuran crabs (Hemigrapsus nudus) were the prevalent prey organisms.

Pile Perch (Rhacochilus vacca). Also a predominant member of the neritic fish assemblage at DuPont Dock, only two juvenile pile perch, from the November trynet collections at Tatsolo Point, could be collected for stomach analysis. Gastropod and bivalve larvae (veliger) comprised 88.9 percent of the total numbers and 81.6 percent of the total biomass of prey organisms in these stomachs.

Penpoint Gunnel (Apodichthys flavidus). One penpoint gunnel collected in the June 28 beach seine collections at the outer Nisqually Delta site had consumed six gammarid amphipods.

Crescent Gunnel (Pholis laeta). Three gammarid amphipods and one tanaid were found in the stomach of a crescent gunnel caught in a March beach seine collection south of the DuPont Dock.

Pacific Sanddab (Citharichthys sordidus). Three speckled sanddabs from the March 15, 1978 trynet collections at south DuPont Dock had been feeding on shrimp and gammarid amphipods.

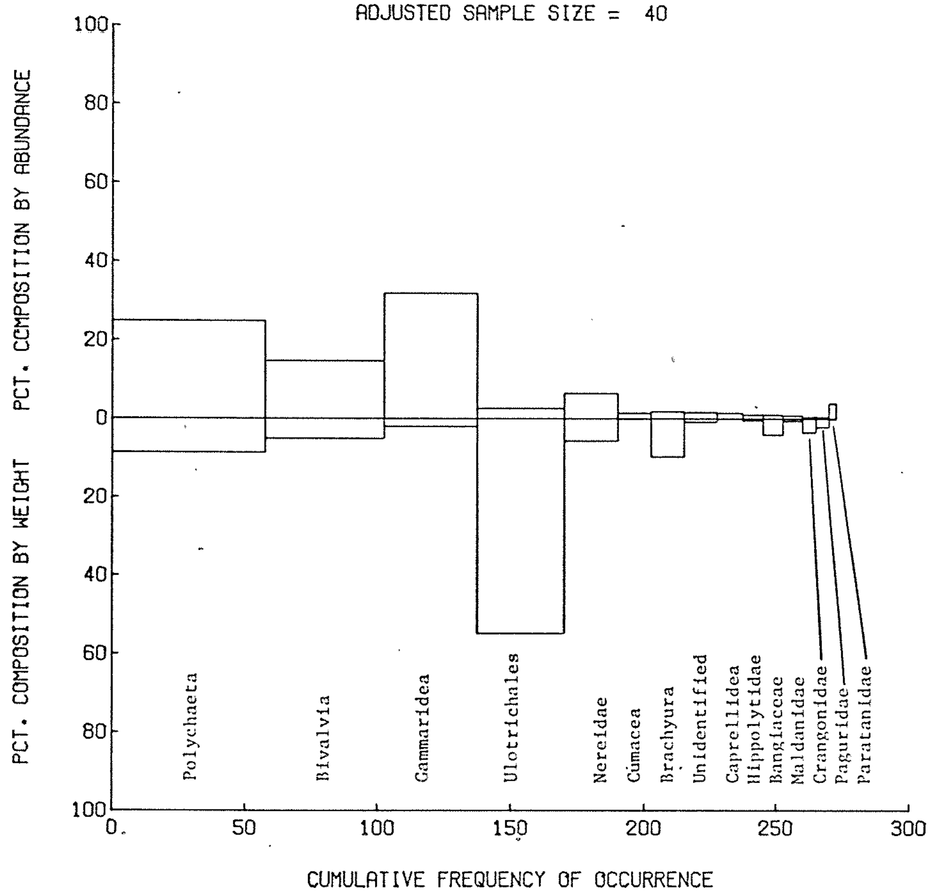
Speckled Sanddab (Citharichthys stigmaeus). Three Pacific sanddabs from the same collection as the C. sordidus specimens had fed predominantly upon polychaetes but also callianassid shrimp, crabs, gammarid amphipods, and mysids.

Rock Sole (Lepidopsetta bilineata). Rock sole were the second most abundant fish captured during trynet sampling and were also caught regularly in beach seine collections. The majority of the stomach samples originated from trynet collections at all three study sites.

The overall prey spectrum for rock sole was composed of both benthic and epibenthic organisms (Fig. 41). Benthic polychaetes (Nereidae, Maldanidae, Pherusa sp.) contributed 33.8 percent of the total IRI, the

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALSTA

8857040801 - LEPIDOPSETTA BILINEATA
ROCK SOLE
ADJUSTED SAMPLE SIZE = 40



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
POLYCHAETA	57.50	24.85	8.67	1927.5	29.86
BIVALVIA	45.00	14.75	5.13	894.3	13.85
GAMMARIDEA	35.00	31.92	1.99	1186.8	18.38
ULOTRICHALES	32.50	2.63	54.82	1867.1	28.92
NEREIDAE	20.00	6.46	5.76	244.5	3.79
CUMACEA	12.50	1.41	.05	18.3	.28
BRACHYURA	12.50	1.82	9.72	144.2	2.23
UNIDENTIFIED	12.50	1.62	.86	31.0	.48
CAPRELLIDEA	10.00	1.41	.04	14.6	.23
HIPPOLYTIDAE	7.50	1.01	.46	11.1	.17
BANGIACEAE	7.50	1.01	4.15	38.7	.60
MALDANIDAE	7.50	.81	.60	10.6	.16
CRANGONIDAE	5.00	.40	3.44	19.2	.30
PAGURIDAE	5.00	.40	2.14	12.7	.20
PARATANIDAE	2.50	3.84	.05	9.7	.15

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.19	.33		.23
SHANNON-WEINER DIVERSITY	3.08	2.49		2.44
EVENNESS INDEX	.63	.51		.50

Fig. 41. IRI prey spectrum of rock sole in Nisqually Reach, southern Puget Sound, 1977-78.

green alga Ulva sp., 28.9 percent, gammarid amphipods, 18.4 percent, bivalve siphons, 13.9 percent, brachyuran crab larvae and juveniles, 2.2 percent. The high incidence of Ulva sp. may be coincidental with associated prey organisms although it was often the most frequently occurring food item. Unidentified fish remains accounted for less than 0.5 percent of the total IRI.

Although low sample sizes did not allow quantitative comparison, rock sole prey composition appeared to shift from Ulva sp., polychaetes, and bivalve siphons (in decreasing order of percent total IRI) in September to brachyuran larvae and juveniles, polychaetes and Ulva in November. Beach seine-caught rock sole also appeared to eat more gammarid amphipods than townet-caught rock sole, which had consumed more algae, polychaetes, and bivalve siphons.

The rock sole diet composition from Nisqually Reach is similar to that reported for northern Puget Sound and along the Strait of Juan de Fuca (Miller et al. 1977 and Simenstad et al. 1977) with the exception that epibenthic gammarid amphipods, tanaids, and isopods usually are more important in diets than benthic polychaetes and bivalves (siphons).

Dover Sole (Microstomus pacificus). Polychaetes and gammarid amphipods were the most numerous prey organisms found in the stomachs of four Dover sole caught during September 1977 and March 1978 trynet collections south of the DuPont Dock. Although not abundant in the stomach contents, juvenile bivalves ranked second, after polychaetes, in contribution to total contents of biomass.

English Sole (Parophrys vetulus). English sole were the most abundant fish in trynet catches, and were also caught regularly during beach seining. Stomach samples were taken from all three trynet sampling sites. Twenty-eight percent of the stomachs were empty.

Polychaetes (Nereidae, Malanidae) were the most important prey in a predominantly benthic prey spectrum (Fig. 42), with 69.7 percent of the total IRI, followed by gammarid amphipods (17.4 percent) and bivalve siphons (9.0 percent).

Low sample sizes limited the quantitative comparison of monthly samples; however, prey compositions of the English sole caught in September and November do differ somewhat. A higher proportional biomass of bivalve siphons occurred in September than November and an increase in polychaete and gammarid amphipod biomass was observed in November.

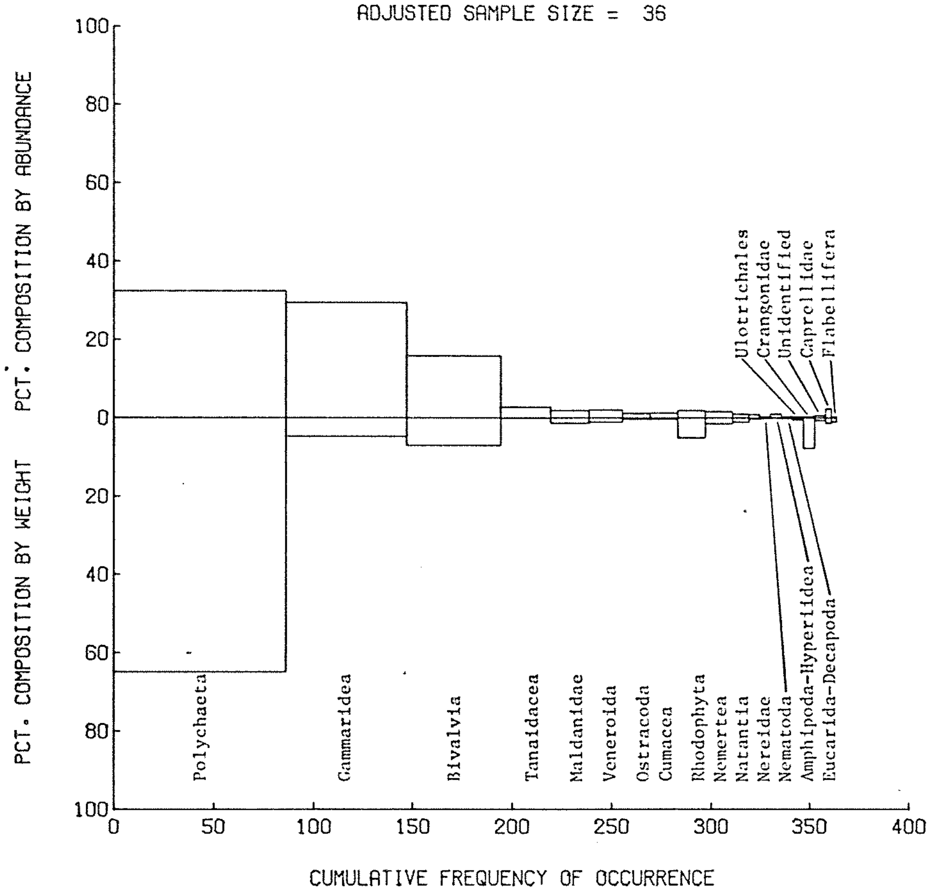
Starry Flounder (*Platichthys stellatus*). Starry flounder were regularly sampled by beach seine and trynet, but never occurred in great abundance. Beach seine collections, primarily from the DuPont Dock and the outer Nisqually Delta, provided the majority of the stomach samples. As with English sole, the incidence of empty stomachs was high (35 percent).

Bivalves (Tellinidae) and 76.0 percent of total IRI, cephalaspidean molluscs (10.4 percent) composed the majority of the IRI spectrum (Fig. 43). Polychaetes, gammarid amphipods, tanaids, and shrimp (*Heptacarpus paludicola*, *Heptacarpus* sp.) provided most of the remaining prey organisms. No fish remains were found in the stomach contents.

C-O Sole (*Pleuronichthys coenosus*). C-O sole stomach samples were obtained in September and November 1977, and March 1978, trynet collections at the south DuPont Dock and Tatsolo Point sites. Benthic polychaetes (69.4 percent of total IRI) were the principal food organisms

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT, STATION ALSTA

8857041301 - PAROPHRYS VETULUS
ENGLISH SOLE
ADJUSTED SAMPLE SIZE = 36



PREY ITEM	FREQ. OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
POLYCHAETA	86.11	32.42	64.90	8380.4	69.66
GAMMARIDEA	61.11	29.39	4.80	2089.7	17.37
BIVALVIA	47.22	15.85	7.05	1081.2	8.99
TANAIDACEA	25.00	2.74	.08	70.3	.58
MALDANIDAE	19.44	1.87	1.32	62.1	.52
VENEROIDA	16.67	2.02	1.04	51.0	.42
OSTRACODA	13.89	1.15	.33	20.5	.17
CUMACEA	13.89	1.30	.30	22.1	.18
RHODOPHYTA	13.89	1.87	5.12	97.1	.81
NEMERTEA	13.89	1.59	1.47	42.4	.35
NATANTIA	8.33	1.01	1.09	17.5	.15
NEREIDAE	5.56	.86	.21	6.0	.05
NEMATODA	5.56	.29	.15	2.4	.02
AMPHIPODA-HYPERIIDEA	5.56	1.01	.02	5.7	.05
EUCARIDA-DECAPODA	5.56	.29	.13	2.3	.02
ULOTRICHALES	5.56	.29	.51	4.4	.04
CRANGONIDAE	5.56	.29	7.79	44.9	.37
UNIDENTIFIED	5.56	.58	.68	7.0	.06
CAPRELLIDAE	2.78	2.31	1.30	10.0	.08
FLABELLIFERA	2.78	.29	1.01	3.6	.03

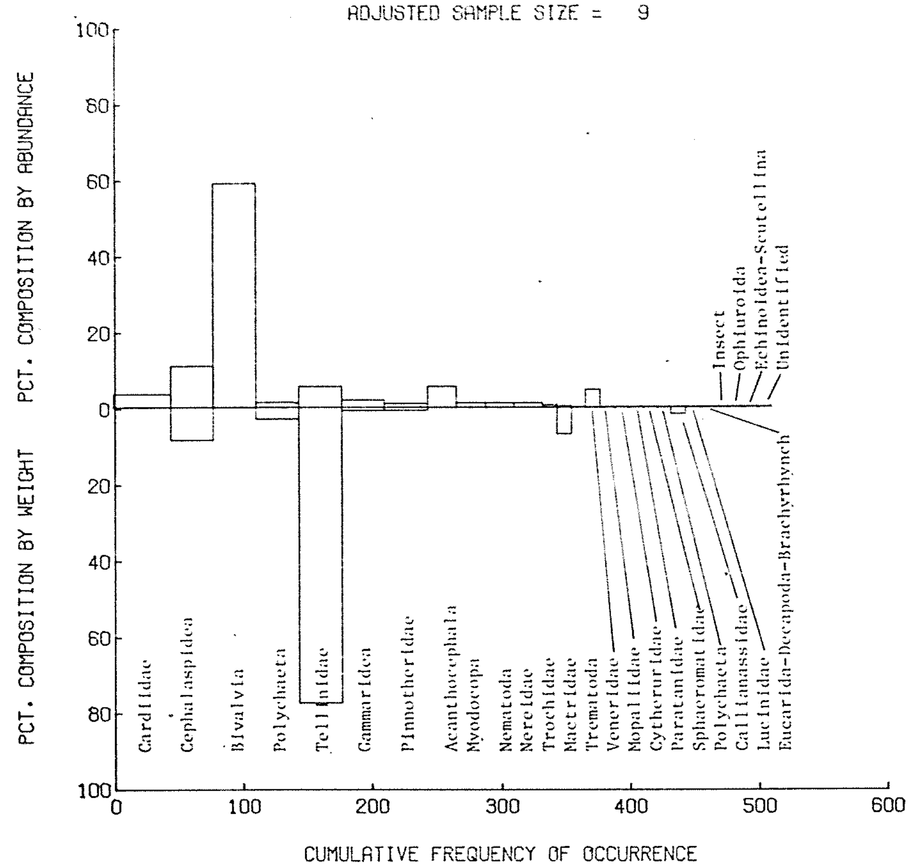
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.22	.44	.52
SHANNON-WEINER DIVERSITY	2.88	2.12	1.44
EVENNESS INDEX	.59	.44	.30

Fig. 42. IRI prey spectrum of English sole in Nisqually Reach, southern Puget Sound, 1977-78.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. HCFRED. STATION COMBO

8857041401 - PLATICHTHYS STELLATUS
STARRY FLOUNDER
ADJUSTED SAMPLE SIZE = 9



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CARDIIDAE	44.44	3.50	.00	155.5	2.50
CEPHALASPIDEA	33.33	10.87	8.61	649.3	10.42
BIVALVIA	33.33	58.83	.00	1961.3	31.48
POLYCHAETA	33.33	1.36	3.16	150.5	2.42
TELLINIDAE	33.33	5.44	77.75	2772.9	44.51
GAMMARIDEA	33.33	1.94	.86	93.3	1.50
PINNOTHERIDAE	33.33	.97	.83	59.9	.96
ACANTHOCEPHALA	22.22	5.44	.00	120.9	1.94
MYODOCOPA	22.22	1.17	.00	25.9	.42
NEMATODA	22.22	1.17	.00	25.9	.42
NEREIDAE	22.22	1.17	.00	25.9	.42
TROCHIDAE	11.11	.58	.00	6.5	.10
MACTRIDAE	11.11	.39	6.97	81.7	1.31
TREMATODA	11.11	.19	.00	2.2	.03
VENERIDAE	11.11	4.66	.00	51.8	.83
MOPALIIDAE	11.11	.19	.00	2.2	.03
CYTHERURIDAE	11.11	.19	.00	2.2	.03
PARATANAIDAE	11.11	.19	.00	2.2	.03
SPHAEROMATIDAE	11.11	.19	.00	2.2	.03
POLYCHAETA	11.11	.19	.00	2.2	.03
CALLIANASSIDAE	11.11	.19	1.81	22.2	.36
LUCINIDAE	11.11	.19	.00	2.2	.03
EUCARIDA-DECAPODA-BRACHYRHYNCH	11.11	.19	.00	2.2	.03
INSECTA	11.11	.19	.00	2.2	.03
OPHIUROIDA	11.11	.19	.00	2.2	.03
ECHINOIDEA-SCUTELLINA	11.11	.19	.00	2.2	.03
UNIDENTIFIED	11.11	.19	.00	2.2	.03

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.37	.62	.31
SHANNON-WEINER DIVERSITY	2.42	1.24	2.24
EVENNESS INDEX	.51	.26	.47

Fig. 43. IRI prey spectrum of starry flounder in Nisqually Reach, southern Puget Sound, 1977-78.

of C-O sole (Fig. 44); bivalve siphons, gammarid amphipods, parts of hydroids shrimp (Hippolytidae) and crabs, also appeared regularly in the stomach contents.

Sand Sole (*Psettichthys melanostictus*). Four of nine sand sole stomachs examined from June and November 1977 and March 1978 trynet collections at the outer Nisqually Delta and south DuPont Dock sites were empty; the remaining five contained fish remains, gammarid amphipods, and shrimp.

Discussion

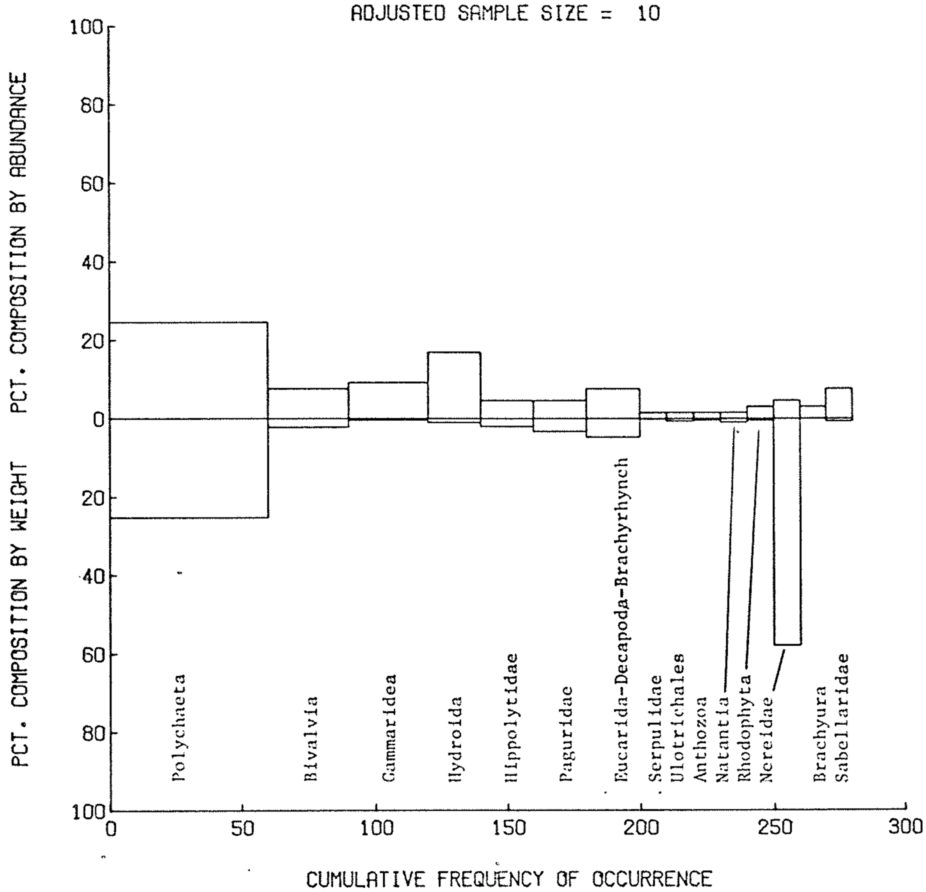
The principal food resources utilized by the dominant fish assemblages characterizing the nearshore habitats of Nisqually Reach, including those associated with the existing DuPont Dock, are summarized in Table 24. Wherever possible, indications of prey importance were based upon stomach samples obtained directly from the specific fish assemblages. In many instances, most notably in the case of the DuPont Dock assemblages, stomachs were not or could not be obtained even though the species occurred there often or in significant numbers. Results from samples collected in adjacent habitats were utilized for these situations and, in a few cases, appropriate literature sources were utilized.

Food Habits of Juvenile Salmonids

Juvenile salmonids migrating through Nisqually Reach utilized either shallow sublittoral epibenthos or neritic plankton, depending upon species, size, and period in estuary. Juvenile pink salmon appeared to feed primarily on neritic organisms--calanoid copepods--when the young salmon were found along the Nisqually Delta in mid- to late June. Prey

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. DUPONT. STATION ALSTA

8857041601 - PLEURONICHTHYS COENOSUS
C-O SOLE
ADJUSTED SAMPLE SIZE = 10



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
POLYCHAETA	60.00	24.62	25.23	2990.5	56.09
BIVALVIA	30.00	7.69	2.18	296.1	5.55
GAMMARIDEA	30.00	9.23	.43	289.8	5.44
HYDROIDA	20.00	16.92	1.00	358.4	6.72
HIPPOLYTIDAE	20.00	4.62	1.97	131.7	2.47
PAGURIDAE	20.00	4.62	3.25	157.4	2.95
EUCARIDA-DECAPODA-BRACHYRHYNCH	20.00	7.69	4.80	249.9	4.69
SERPULIDAE	10.00	1.54	.14	16.8	.31
ULOTRICHALES	10.00	1.54	.67	22.1	.41
ANTHOZOA	10.00	1.54	.37	19.1	.36
NATANTIA	10.00	1.54	.91	24.5	.46
RHODOPHYTA	10.00	3.08	.47	35.5	.67
NEREIDAE	10.00	4.62	57.91	625.2	11.73
BRACHYURA	10.00	3.08	.02	31.0	.58
SABELLARIDAE	10.00	7.69	.65	83.4	1.56

PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.12	.40	.34
SHANNON-WEINER DIVERSITY	3.40	1.90	2.35
EVENNESS INDEX	.87	.49	.60

Fig. 44. IRI prey spectrum of C-O sole in Nisqually Reach, southern Puget Sound, 1977-78.

Table 24. Summary of principal food items of Nisqually Reach fishes.

Legend of prey importance
- ● Primary (75-100% of IRI)
- + Secondary (50-74% of IRI)
- θ Significant (25-49% of IRI)
- ° Common (5-24% of IRI)
- · Insignificant (1- 4% of IRI)

Habitat	Dominant Members of Fish Assemblage	Algae	Nemerteans	Polychaetes	Gastropods	Mollusc larvae	Bivalves (inc. siphons)	Calanoid copepods	Harpacticoid copepods	Cyclopoid copepods	Gammarid amphipods	Caprellid amphipods	Cumaceans	Ostracods	Tanaids	Isopods	Mysids	Euphausiids	Shrimp	Crabs	Decapod larvae	Insects	Fish (inc. larvae)	Demersal eggs (fish & gastropods)	Larvaceans	Rocks
Shallow (0-5m) Sublittoral	Chum salmon (juv.)							·	●		°															
	Coho salmon (juv.)			·					°		°	°				·	°				°	·				
	Chinook salmon (juv.)										°	°					°				·	°	°			
	Buffalo sculpin	●									·					·								°		
	Pacific staghorn sculpin			·							°					·	°		·	°	°		θ			°
	Rock sole	θ		θ			°				°										·					
	*English sole			+			°				°															
	Starry flounder			θ			θ				·				°	·			·				°			
Sublittoral Shelf (10-15m)	*Ratfish	·	°	θ	°		·				·								°	θ			°			
	Pacific tomcod		°	·				°			θ						·		θ	°						
	Roughback sculpin			°							°								+	°						
	Pacific staghorn sculpin			°							θ								θ	°				°		
	Rock sole	θ		°	·		°																			·
	English sole			+			°				°										·					
Neritic	Spiny dogfish			●																						
	Pacific herring (juv.)							+			°		·										°			
	Pink salmon (juv.)							θ			°	·									·				θ	
	Chum salmon (juv.)			·					θ		θ	·										°				
	Coho salmon (juv.)												°	°		°		θ				°				
	*Chinook salmon (juv.)								·		●										·	°				
Dupont Dock	*Tube-snout								θ	θ								°								
	*Copper rockfish																		●				°			
	*Painted greenling											·							●							
	*Smoothhead sculpin									°				·		θ										
	Buffalo sculpin	●									·					·								°		
	Red Irish lord[1]															θ			·	θ			°			
	Pacific staghorn sculpin			·							°					·	θ		·	°	°		·	°		
	Sturgeon poacher			θ							θ								·							
	*Shiner perch								θ		θ															
	*Striped seaperch			θ							°					°			°	°						
	*Pile perch					+					°															
	Rock sole	θ		θ			°				°										·					

[1] Prey importance assigned on basis of food habits reported in Miller, et al., (1977).

* Prey importance subjectively assigned because inadequate sample size did not permit quantitative evaluations.

spectra from juvenile pink salmon in northern Puget Sound and the Strait of Juan de Fuca illustrated similarly pelagic food habits (Miller et al. 1977, Simenstad et al. 1977) when the juvenile salmon moved into neritic waters (from nearshore, shallow sublittoral) during their outmigration in early summer.

Chum salmon juveniles captured during our collections appeared to have fed predominantly on epibenthic plankton--harpacticoid copepods and gammarid amphipods--from the shallow sublittoral habitats of the Nisqually Delta and the shoreline north toward the DuPont Dock. Those fish captured in neritic waters of the reach during townetting had not utilized many pelagic organisms other than drift insects.

The results of our stomach contents analyses would suggest that at least until they are greater than 50 mm in length, juvenile chum would continue primarily to occupy the shallow sublittoral habitats. Kaczynski et al. (1973) sampled nearshore juvenile chum and pink salmon at Anderson Island in spring 1970 and 1971, and found that 57 percent of the chum diet and 36 percent of the pink diet were harpacticoid copepods. Studies of the food habits of outmigrating juvenile chums in Hood Canal (Schreiner et al. 1977; Simenstad and Kinney, in preparation) suggest that, when over 50 mm in length, they gradually convert to the larger planktonic organisms in offshore neritic waters. Juvenile chum salmon occurring in neritic waters of northern Puget Sound later in the summer (and of larger size) had converted almost completely to pelagic feeding behavior (Miller et al. 1977). Although the sample sizes did not warrant quantitative interpretations, it appeared that the few juvenile chums available to the townet in Nisqually Reach during June and July had also fed predominantly upon pelagic organisms.

Coho juveniles occupying the shallow sublittoral habitat (apparently including those released from Sequalitchew Lake) fed primarily upon epibenthic organisms--gammarid amphipods, harpacticoid copepods, cumaceans, isopods and mysids--and surface drift insects. Some coho were also found to be feeding in the neritic waters of the Reach, as evidenced by the incidence of large planktonic organisms (e.g., euphausiids) predominating the stomach contents of townet-caught coho. Similarly, epibenthic crustaceans were important prey organisms in juvenile coho diets in northern Puget Sound and remained so still later in the summer months when the coho were more available to the townet (Miller et al. 1977).

The diets of chinook salmon, both juveniles and several maturing (resident) blackmouth, were based upon epibenthic crustaceans; blackmouth had fed on the larger forms, especially crangonid shrimp. The trophic contribution of pelagic prey was not extensive; this was unusual, considering the high relative abundances of juvenile chinook in the townet catches. This food habit may be a seasonal phenomenon, as juvenile chinook present in the neritic habits of northern Puget Sound later in the summer months had diet spectra oriented more toward pelagic and drift organisms (Miller et al. 1977).

Predation upon Juvenile Salmonids

Among the nearshore demersal and neritic fishes present in Nisqually Reach, 17 species are known to be piscivorous and could be considered as potential predators of outmigrating juvenile salmon (principally juvenile pink and chum salmon); these include the spiny dogfish, ratfish, juvenile and maturing (resident) coho and chinook salmon, sea-run cutthroat and rainbow (steelhead) trout, walleye pollock, copper and quillback rockfish, roughback sculpin, buffalo sculpin, red Irish lord, Pacific staghorn sculpin, great sculpin, cabezon, rock sole, and starry flounder. In our analyses of the food habits of the dominant fishes in Nisqually Reach, fish never comprised greater than 24 percent of the total IRI (Table 24) of any predator. In only one case (Pacific staghorn sculpin) were identifiable juvenile salmonids found, in the other cases most were larvae of Pacific herring.

Jones and Geen (1977) indicated that the major dietary component of British Columbia dogfish was fish (55 percent of the balanced food budget). Pacific herring, hake, and eulachon were the principal prey species, whereas salmon were less than 0.3 percent of the total balanced food budget. Dogfish in northern Puget Sound and Strait of Juan de Fuca had varying amounts of fish remains in their stomachs (Simenstad et al. 1977, Miller et al. 1977). Pacific sand lance dominanted the total prey biomass of dogfish stomachs from northern Puget Sound but no salmonids were found. Similarly, ratfish from Nisqually Reach and the northern Puget Sound region did not have significant fish remains in their stomachs. Considering our results and that reported in the literature, neither of these species appears to be a significant predator of juvenile salmon in Nisqually Reach.

Predation upon chum and pink juveniles in estuarine habitats has been attributed to other juvenile or maturing salmonids in a number of cases (see Iwamoto and Salo 1977 for review), especially to coho smolts. Parker (1968, 1971) identified juvenile coho salmon as a significant predator of juvenile pink salmon during the first 40 days of their marine life. Allen (1974), Heiser and Finn (1970), Johnson (1974), and Walker (1974) have also provided some indications of juvenile coho predation on pink and chum salmon juveniles in the estuarine environment. Only four fish were identified from the 42 juvenile coho stomachs examined from Nisqually Reach--three larvae (possibly herring) and a prickleback, Anoplarchus sp. Combined, fish accounted for only 0.06 percent of the total IRI. Coho juveniles in our collections, however, were not appreciably larger than the cooccurring juvenile pink and chum salmon ($L_{\bar{x}}$ = 115.8 mm). As evidenced from studies in northern Puget Sound (Miller et al. 1977), juvenile coho occurring in neritic waters later in the summer have a large piscivorous component to their feeding behavior. As our townet collections did not extend beyond July 8 we cannot say whether the juvenile coho would become significant predators on other juvenile salmonids after that time; they certainly did not appear to be prior to July.

Sea-run cutthroat and rainbow (steelhead) trout were not abundant in our 1977 collections in Nisqually Reach nor were they caught in association with large numbers of juvenile chums or pinks. Only the steelhead had any fish (herring) remains in its stomach. Even considering their piscivorous food habits, the apparent low abundance of cutthroat and steelhead in the Reach does not suggest excessive predation. One of the three maturing chinook salmon (blackmouth) examined had an unidentified fish in its stomach and therefore, because of their relative abundance in the Reach (see accompanying adult tagging studies report), blackmouth might be considered significant predators in the DuPont Dock vicinity. The low sample size, however, is not adequate to measure the actual incidence of juvenile salmon in blackmouth diets.

Armstrong and Winslow (1968) suggested that walleye pollock might be significant predators upon juvenile salmonids. Pollock, however, did not commonly occur in abundance in shallow sublittoral or neritic habitats during the period of juvenile pink and chum salmon outmigration.

Juvenile copper rockfish from Tatsolo Point contained the remains of two (unidentifiable) fish. Because adult copper rockfish were one of the common demersal fish associated with the DuPont Dock structure, their presence may increase predation pressure for juvenile salmon passing through the dock pilings. Substantial stomach analyses of copper rockfish in northern Puget Sound (Miller et al. 1977) indicated that fish (Pacific sand lance, juvenile rockfish, and threespine sticklebacks) comprised 13.7 percent to 16.4 percent of the total IRI in the prey spectra from that region. Quillback rockfish were not abundant enough to constitute an important predator.

Of the six sculpins considered potential predators, two species, roughback and buffalo sculpins, did not have significant fish remains in their stomach contents. No specimens of red Irish lord or cabezon from Nisqually Reach were available for examination of stomach contents. Miller et al. (1977) indicated that only 13.4 percent of the total IRI for northern Puget Sound red Irish lord was fish (unidentifiable) remains. Both Miller et al. (1977) and Simenstad et al. (1977) indicated that cabezon from the northern Puget Sound and Strait of Juan de Fuca region did not consume fish but rather epibenthic crabs and shrimp. Similarly, great sculpin prey spectra described in this study, Miller et al. (1977) and Simenstad et al. (1977), all emphasized crabs and shrimp, although pricklebacks (family Stichaeidae) were reported as incidental prey. Pacific staghorn sculpin, because of its high abundance in the shallow sublittoral environments of Nisqually Reach and opportunistic feeding behavior, constitutes the only sculpin of probable significance as a predator upon juvenile salmonids. Although fishes provided 29.1 percent of the total IRI of Pacific staghorn sculpins in Nisqually Reach, 27.8 percent was contributed by eggs rather than nektonic fishes; salmon juveniles contributed only 1.1 percent of the total IRI. In northern Puget Sound and the Strait of Juan de Fuca, fish appeared predominantly in the prey spectra of Pacific staghorn sculpins and provided as much as 51.7 percent of the total IRI (Miller et al. 1977 and Simenstad et al. 1977). Pacific sand lance, shiner perch, Pacific herring, juvenile striped seaperch, and flatfish were identified in staghorn sculpin stomach contents from these areas. Juvenile salmonids were not found in staghorn sculpin stomachs in any of these studies. Although staghorn sculpins appear to be prime suspects as major predators of juvenile salmonids in the Nisqually Reach, there is little evidence to that effect.

Neither rock sole nor starry flounder contained any significant amount of fish remains in their stomachs.

Food Organisms of DuPont Dock Fish Assemblage

Four species in the DuPont Dock fish assemblage--buffalo sculpin, Pacific staghorn sculpin, sturgeon poacher, and rock sole--did not appear exclusively nor more abundantly around the dock than in other areas. Their food habits have been described previously under the general results section. The two sculpins and the red Irish lord (which was specifically associated with the dock) might benefit by an association with the dock, as it may support a slightly higher density of small fishes which they could utilize as prey. The seven other fish species in the assemblage, which are specifically associated with the dock structure, may utilize food organisms attached to or similarly associated with the dock piling community.

The one tubesnout examined from our Nisqually Reach collections had fed upon both epibenthic and pelagic crustaceans, similar to those examined by Miller et al. (1977) from northern Puget Sound. The smoothhead sculpin also fed principally upon epibenthic crustacea which are not necessarily a product of the piling community. The prey spectra of the embiotocids--shiner perch, striped seaperch, and pile perch--and the painted greenling and copper rockfish contained prey organisms which are probably enhanced by the piling community, including shrimps, both caprellid and gammarid amphipods, isopods, several crabs, various gastropods, and polychaetes. Their prey spectra, however, are not wholly dependent upon organisms which are found only in the piling community. The additional food resources provided by the piling community's diverse encrusting and "epibenthic" invertebrates (see Kozloff 1973, Chapter 3 for detailed description of piling and float communities) may be partly responsible for the unique assemblage of fishes associated with the DuPont Dock. But the piling structure itself may also provide other habitat requirements (e.g., protection from predation, spawning substrate, shading, etc.) which may be more important factors.

Summary

1. The stomach contents of 44 species of nearshore fish from Nisqually Reach were examined to determine: 1) the trophic importance of the DuPont shoreline in the nearshore food web; 2) the extent of predation upon juvenile salmon by other nearshore fishes (including other salmonids); and

3) the possible role of the DuPont Dock piling community in providing prey for the fish assemblage specifically associated with the dock.

2. The majority of species examined had food habits based on epibenthic plankton or macroinvertebrates. Gammarid amphipods, shrimps, crabs, isopods, and harpacticoid copepods were the most commonly utilized prey organisms. Benthic polychaetes and bivalve siphons were also important to the demersal fishes, and calanoid copepods to the neritic fishes.

3. During their residence in Nisqually Reach, juvenile chum, coho, and chinook salmon appeared to feed principally on epibenthic plankton and macroinvertebrates (harpacticoid copepods, gammarid amphipods, cumaceans, isopods, and shrimps) whereas juvenile pink salmon typically fed upon neritic plankton (calanoid copepods).

4. Juvenile salmonids were found only in the stomach contents of staghorn sculpins examined in 1977. Of those considered potential predators (based on existing knowledge of feeding ecology and reports of predation upon salmon in the study area), only maturing chinook salmon (blackmouth), copper rockfish, and staghorn sculpins prey upon nearshore fishes to any extent.

5. Although 12 species were seen abundantly during SCUBA surveys of the DuPont Dock fish assemblage, only five species--three embiotocids, a greenling, and a rockfish species--have prey spectra containing organisms characterizing the piling community. It appears, however, that most of their food items are not exclusively piling organisms and that their association with the dock structure may relate to other requirements.

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APPENDIX 1

SUBSAMPLING PROCEDURES

Field procedures were adopted to reduce the impact of sampling on the populations of outmigration juvenile salmon. When a haul was observed to have large numbers of fish to sample, the bag or cod end was left in the water and all fish were worked into a holding pocket. Rarer species were first removed and placed in plastic bags. When coho or chinook were present in large numbers (more than 50 per haul), 25-50 individuals (of each species) were randomly removed for preservation, and the rest were counted and released. At night or during inclement weather, it was sometimes difficult to distinguish coho and chinook. In these situations ~50 coho-chinook were saved and the rest counted and released. The total numbers of coho and chinook in the haul were then estimated using the proportion from the subsample.

When chum or pink fry were present in large numbers, all fry were counted out of the net and a random subsample of ~ 100 fish preserved. The proportion of pink and chum fry in the subsample was then assumed to be constant for the whole haul, such that the abundance and total weight of pink and chum in the whole haul could be estimated.

For any large catches of nonsalmonid species, subsampling was volumetric and depended on the magnitude of the catch. Measured dips of fish were counted out of the net with one or more saved at random for preservation.

APPENDIX 2

TROPHIC DIAGRAMS

In the presentation of the food habit data, a modification of Pinkas et al. (1971), "IRI" has been utilized to rank the importance of prey organisms. The IRI values for prey taxa are displayed both graphically and in tabular form where justified by sample size ($n \geq 10$). The three-axis IRI graphs illustrate frequency of occurrence (that proportion of stomachs containing a specific prey organism) plotted sequentially on the horizontal axis, and percentage of total abundance and percentage of total biomass plotted above and below the horizontal axis, respectively (Appendix Table 1). Prey taxa of differing stages of digestion (e.g., partly digested shrimp "Natantia-unidentified," as opposed to family, "Pandalidae," or species, "Pandalus borealis") are graphed separately.

All prey groups, including those assigned to a broad taxonomic level (family, order, class) because of advanced digestion, have been arranged from left to right by decreasing frequency of occurrence.

The IRI value was computed as follows:

$$\text{IRI} = \%\ \text{frequency of occurrence}_i\ [\%\ \text{numerical composition}_i + \%\ \text{gravimetric composition}_i\ ],$$

and is equivalent to the area encompassed by the bar for each prey category i composing the IRI diagrams. In order to compare the IRI values between prey spectra with different sample sizes, the overall importance of general prey taxa (e.g., all shrimp, including "unidentified Natantia" and those identified to family and species, added together) has been discussed as a percentage of the total combined IRI (areas) of the different prey taxa. Appendix Table 1 illustrates an example of the IRI values and percentages of total IRI generated from the data diagrammed in Appendix Figure 1. The advantage of the IRI value is that numerically rare but high biomass prey (e.g., prey_8); infrequently occurring but abundant or high biomass (when eaten) taxa; and numerically abundant or frequently occurring taxa (but which contribute little in the way of trophic input, e.g., $prey_1$, Appendix Table 1) do not dominate the more representative prey.

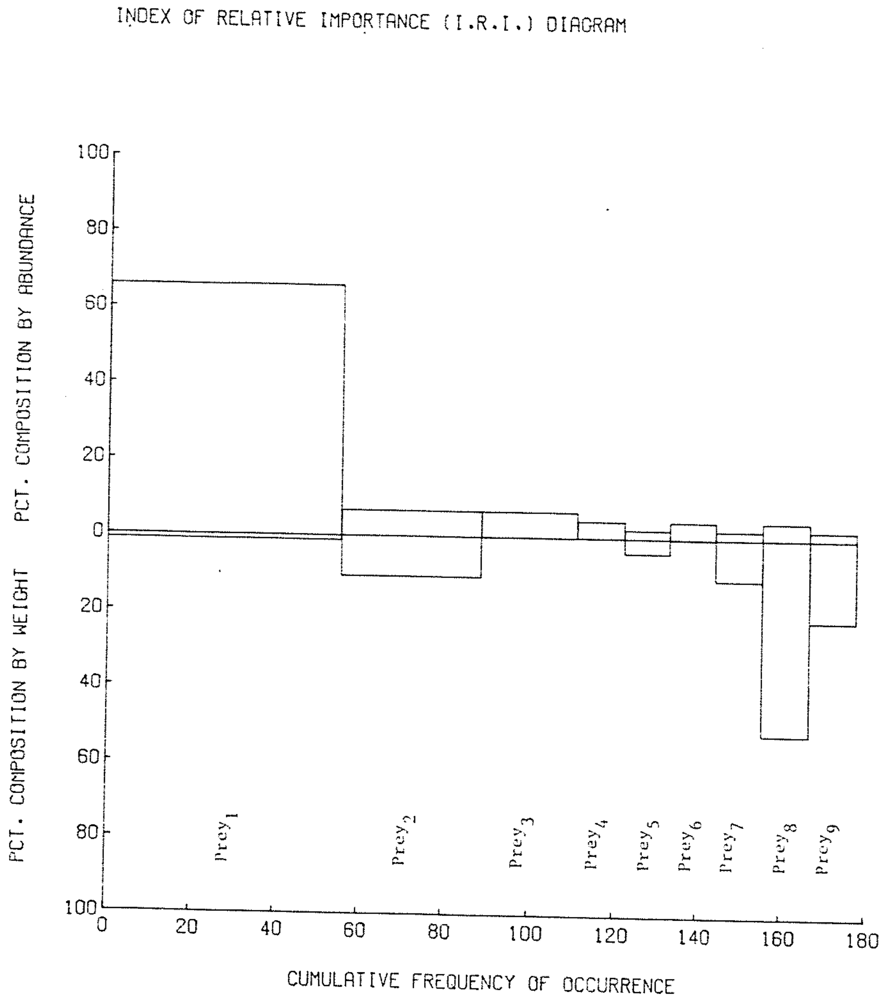

Fig. **1.** Example IRI (Index of Relative Importance) diagram.

Table **1.** Example computation of IRI values and percentages of total IRI from data illustrated in Fig. 1.

Prey Category	% Freq. of occurrence	% Numerical composition	% Gravimetric composition	Prey IRI	% Total IRI
1	55.56	65.91	1.22	3729.5	65.76
2	33.33	6.82	10.69	583.7	10.29
3	22.22	6.82	0.04	152.5	2.69
4	11.11	4.55	< 0.01	50.5	0.89
5	11.11	2.27	3.84	67.9	1.20
6	11.11	4.55	0.12	51.8	0.91
7	11.11	2.27	10.89	146.3	2.58
8	11.11	4.55	51.67	624.6	11.01
9	11.11	2.27	21.52	264.4	4.66

APPENDIX 3

LIST OF SPECIES CAUGHT IN THE NISQUALLY REACH

Appendix Table 3. List of fishes caught and/or observed in the DuPont study area, southern Puget Sound, WA, 1977. Gear types used to capture fish have the following symbols: S = surface trawl, B = beach seine, T = try net, D = SCUBA survey.

Scientific name	Common name	Gear
Family Squalidae		
Squalus acanthias	spiny dogfish	S,B,D
Family Chimaeridae		
Hydrolagus colliei	ratfish	S,B,T
Family Clupeidae		
Clupea harengus pallasi	Pacific herring	S,B,D
Family Salmonidae		
Oncorhynchus gorbuscha	pink salmon	S,B,D
O. keta	chum salmon	S,B
O. kisutch	coho salmon	S,B,D
O. nerka	sockeye salmon	S
O. tshawytscha	chinook salmon	S,B,D
Salmo clarki	cutthroat trout	B,D
S. gairdneri	rainbow trout	S,B
Salvelinus malma	Dolly Varden	B
Family Osmeridae		
Hypomesus pretiosus	surf smelt	S,B,D
Family Batrachoididae		
Porichthys notatus	plainfin midshipman	T
Family Gobiesocidae		
Gobiesox maeandricus	northern clingfish	B
Family Gadidae		
Gadus macrocephalus	Pacific cod	S,B,T,D
Merluccius productus	Pacific hake	S
Microgadus proximus	Pacific tomcod	S,T
Theragra chalcogramma	walleye pollock	T

Appendix Table 3, continued

Scientific name	Common name	Gear
Family Aulorhynchidae		
Aulorhynchus flavidus	tube-snout	S,B,T,D
Family Gasterosteidae		
Gasterosteus aculeatus	threespine stickleback	S,B,D
Family Syngnathidae		
Syngnathus griseolineatus	bay pipefish	B,T
Family Embiotocidae		
Cymatogaster aggregata	shiner perch	S,B,T,D
Embiotoca lateralis	striped seaperch	S,B,T,D
Rhacochilus vacca	pile perch	B,D,T
Family Stichaeidae		
Anoplarchus insignis	slender cockscomb	B
A. purpurescens	high cockscomb	T
Lumpenus sagitta	snake prickleback	B,T,D
Family Pholidae		
Apodichthys flavidus	penpoint gunnel	B,D,T
Pholis laeta	crescent gunnel	S,B,D
P. ornata	saddleback gunnel	S,B,D
Xererpes fucorum (?)	rockweed gunnel	B
Family Ammodytidae		
Ammodytes hexapterus	Pacific sand lance	S,B
Family Godiidae		
Clevelandia ios	arrow goby	B

Appendix Table 3. continued

Scientific name	Common name	Gear
Family Scorpaenidae		
Sebastes auriculatus	brown rockfish	D
S. caurinus	copper rockfish	B,T,D
S. maliger	quillback rockfish	T,D
Family Anoplopamatidae		
Anoplopoma fimbria	sablefish	T
Family Hexagrammidae		
Hexagrammos decagrammus	kelp greenling	D
H. lagocephalus (?)	rock greenling	T
H. stelleri	whitespotted greenling	T
Oxylebius pictus	painted greenling	T,D
Family Cottidae		
Artedius fenestralis	padded sculpin	B,T
A. lateralis	smoothhead sculpin	B,T,D
Blepsias cirrhosus	silverspotted sculpin	B,D
Chitonotus pugetensis	roughback sculpin	B,T
Clinocottus acuticeps	sharpnose sculpin	B
C. embryum (?)	calico sculpin	B
Enophrys bison	buffalo sculpin	B,T,D
Gilbertidia sigalutes	soft sculpin	S
Hemilepidotus hemilepidotus	red Irish lord	D
Leptocottus armatus	Pacific staghorn sculpin	S,B,D,T
Myoxocephalus polyacanthocephalus	great sculpin	B,T,D
Nautichthys oculofasciatus	sailfin sculpin	S,T
Oligocottus maculosus	tidepool sculpin	B
Rhamphocottus richardsoni	grunt sculpin	S,D
Scorpaenichthys marmoratus	cabezon	D
Family Agonidae		
Agonopsis emmelane	northern spearnose poacher	T
Agonus acipenserinus	sturgeon poacher	T,B,D

Appendix Table 3. continued

Scientific name	Common name	Gear
Family Agonidae cont'd		
Odontopyxis trispinosa	pygmy poacher	T
Pallasina barbata	tubenose poacher	T
Xeneretmus latifrons	blacktip poacher	T
Family Cyclopteridae		
Liparis rutteri	ringtail snailfish	B
Family Bothidae		
Citharichthys sordidus	Pacific sanddab	T
Citharichthys stigmaeus	speckled sanddab	T
Family Pleuronectidae		
Glyptocephalus zarchirus	rex sole	B,T,D
Isopsetta isolepis	butter sole	T
Lepidopsetta bilineata	rock sole	T,B,D
Microstomus pacificus	Dover sole	T,D
Parophrys vetulus	English sole	T,B,D
Platichthys stellatus	starry flounder	S,B,T,D
Pleuronichthys coenosus	C-O sole	T,D
Psettichthys melanostictus	sand sole	B,T

(?) = identity of fish unconfirmed

APPENDIX 4

RAW ABUNDANCE AND SPECIES RICHNESS OF TRYNET CATCHES

Appendix
Table 4. Number of species caught per try net haul, southern Puget Sound, 1977-1978.

	Depth of tow (m)	Date							$\bar{X}$
		Mar 11	May 6	June 16	Sept 15	Nov 4	Jan 13	Mar 13	
Tatsolo Point	5	2	1	1	3	12	18	0	5.3
	10	3	2	6	1	16	19	5	7.4
	15	2	1	9	0	13	13	12	7.1
	$\bar{X}$	2.3	1.3	5.3	1.3	13.7	16.7	5.7	
South DuPont Dock	5	4	2	7	12	12	12	0	7.0
	10	6	4	8	6	11	9	15	8.4
	15	9	6	10	6	11	10	15	9.6
	$\bar{X}$	6.3	4.0	8.3	8.0	11.3	10.3	10.0	
Outer Nisqually Delta	5	5	2	0	11	4	9	1	4.6
	10	9	4	0	1	8	13	0	5.0
	15	9	8	6	6	9	10	7	7.9
	$\bar{X}$	7.7	4.7	2.0	6.0	7.0	10.7	2.7	

Appendix
Table 4. Number of fish caught per try net haul, southern Puget Sound, 1977-1978.

	Depth of tow (m)	Date: Mar 11	May 6	Jun 16	Sept 15	Nov 4	Jan 13	Mar 13	$\bar{X}$
Tatsolo Point	5	4	1	2	6	18	439	0	67.1
	10	8	2	16	1	92	162	11	41.7
	15	2	3	55	0	236	70	45	58.9
	$\bar{X}$	4.7	2.0	24.3	2.3	115.3	223.7	18.7	
South DuPont Dock	5	24	2	42	52	60	155	0	47.9
	10	61	16	33	18	63	82	217	70.0
	15	125	68	101	71	355	180	107	143.8
	$\bar{X}$	70.0	28.7	58.7	47.0	159.3	139.0	108.0	
Outer Nisqually Delta	5	89	4	0	32	36	147	0	44.3
	10	144	66	0	1	81	174	0	66.6
	15	58	96	130	24	129	44	42	74.7
	$\bar{X}$	97.0	55.3	43.3	19.0	82.0	121.7	14.7	

APPENDIX 5

RAW ZOOPLANKTON DATA

Appendix Table 5a. Zooplankton catches at the Outer Nisqually Delta site. All values are numbers of organisms per 100 m^3 of water strained.

	March		April		May		June		July	
Organism	S[1]	O[2]	S	O	S	O	S	O	S	O
Calanoid copepod	10,814	5,337	1,112	1,334	19,292	24,480	6,684	5,802	13,824	18,183
Chaetognatha	508	203	363	567	103	507	12	18	378	543
Gammarid amph.	2	22	54	7	11	614	1	3	64	98
Hyperiid amph.	424	134	8	11	96	64	493	205	134	268
Euphausiid ad.	-	1	-	-	-	2	-	-	-	-
Euphausiid larv.	-	-	34	13	1,965	3,325	21	148	423	88
Cnidaria	2	141	170	238	1,867	7,574	2,101	662	2,061	1,163
Ctenophora	1	-	2	67	841	1,456	154	130	-	-
Larvacea	21	163	764	4,178	735	1,272	136	725	-	-
Octopoda	-	-	-	-	-	-	-	-	-	-
Pteropoda	-	-	23	-	1,102	702	-	-	-	-
Annelida	30	4	136	64	493	788	.5	9	7	;4
Barnacle cypr.	-	-	-	-	-	-	-	-	-	-
Barnacle naup.	21	163	1,366	6,934	122	44	19	121	-	141
Crab zoea	296	507	14,215	9,008	2,218	3,994	1,147	928	703	1,846
Crab megal.	-	-	1	-	293	202	35	27	72	53
Caridean shrm.	-	-	-	-	-	-	-	-	-	-
Caridean zoea	43	27	593	1,511	7,958	1,474	3,101	2,324	928	63
Caridean larv.	-	-	2	-	31	72	-	-	158	176
Ostracoda	173	5	1	-	1	132	-	-	43	70
Siphonophora	108	26	153	478	4,667	3,573	226	27	27	32
Cumacea	-	-	126	44	62	46	-	41	41	81
Isopoda	-	-	-	-	-	-	-	103	103	70
Mysid	-	-	-	-	-	-	-	-	-	-
Total	12,443	6,736	19,123	24,454	41,857	50,321	14,130	11,130	18,967	24,653

[1] surface tow

[2] oblique tow

Appendix
Table 5b. Zooplankton catches at the South DuPont Dock site. All values are numbers of organisms per 100 m^3 of water strained.

	March		April		May		June		July	
Organism	S[1]	O[2]	S	O	S	O	S	O	S	O
Calanoid copepod	2,946	3,486	1,627	1,029	6,201	11,288	12,307	21,526	18,138	20,965
Chaetognatha	66	295	310	168	40	38	83	60	1,242	874
Gammarid amph.	16	73	9	16	20	215	45	52	242	100
Hyperiid amph.	504	370	39	26	68	13	946	2,444	164	351
Euphausiid ad.	-	-	-	-	-	-	-	-	-	-
Euphausiid larv.	-	-	4	-	677	844	54	20	54	418
Cnidaria	8	4	107	63	2,341	7,566	7,156	13,135	1,624	2,409
Ctenophora	-	-	11	42	933	1,217	1,026	231	52	29
Larvacea	92	226	1,699	910	90	699	-	638	241	334
Octopoda	-	-	-	-	-	-	-	-	1	-
Pteropoda	7	-	48	-	103	322	-	-	-	-
Annelida	22	25	182	28	64	822	48	-	184	150
Barnacle cypr.	-	-	-	-	-	-	-	-	-	-
Barnacle naup.	283	142	4,163	2,791	-	54	-	-	34	96
Crab zoea	1,417	1,277	6,046	4,101	1,344	4,969	398	3,273	481	1,581
Crab megal.	-	-	-	-	45	40	15	339	44	45
Caridean shrm.	-	-	-	-	-	8	-	-	-	-
Caridean zoea	16	32	869	180	346	844	780	7,080	46	1,409
Caridean larv.	-	-	2	2	10	-	-	24	317	499
Ostracoda	30	28	76	8	64	-	32	-	367	55
Siphonophora	78	233	600	230	882	562	258	498	148	150
Cumacea	14	-	28	28	26	5	2	-	209	-
Isopoda	7	-	-	2	1	-	-	-	103	-
Mysid	1	9	-	-	-	-	-	-	-	-
Total	5,507	6,200	15,820	9,624	13,255	29,495	23,150	49,318	23,692	29,465

[1] surface tow

[2] oblique tow

Appendix

Table 5c. Zooplankton catches at the Tatsolo Point site. All values are numbers of organisms per 100 m^3 of water strained.

	March		April		May		June		July	
Organism	S[1]	O[2]	S	O	S	O	S	O	S	O
Calanoid copepod	1,712	2,872	1,842	2,678	10,937	7,777	23,848	23,409	7,713	14,215
Chaetognatha	180	82	564	805	171	121	140	78	359	187
Gammarid amph.	24	6	22	6	161	24	18	18	223	9
Hyperiid amph.	177	82	62	13	1	30	1,214	1,415	101	155
Euphausiid ad.	-	-	-	-	-	6	-	-	-	-
Euphausiid larv.	1	-	74	12	526	1,319	210	309	126	158
Cnidaria	32	31	110	110	1,387	4,196	107	668	1,291	3,603
Ctenophora	1	13	14	19	276	788	117	664	96	42
Larvacea	162	186	944	1,217	1,847	238	57	553	-	755
Octopoda	1	-	-	-	-	-	-	-	2	-
Pteropoda	-	-	69	49	507	238	171	184	-	-
Annelida	33	26	201	32	430	190	11	120	255	51
Barnacle cypr.	-	-	-	-	-	79	-	-	-	-
Barnacle naup.	225	154	5,526	6,476	353	238	57	92	-	44
Crab zoea	560	1,320	7,980	13,082	9,292	1,313	1,248	3,516	543	1,166
Crab megal.	-	-	-	-	97	81	95	115	10	9
Caridean shrm.	-	-	-	-	-	-	-	-	1	-
Caridean zoea	11	24	978	892	567	319	2,528	5,258	397	1,555
Caridean larv.	-	-	-	-	26	28	6	5	13	251
Ostracoda	79	146	62	49	39	26	50	32	136	9
Siphonophora	168	230	301	515	105	210	541	829	266	344
Cumacea	-	-	94	-	7	-	62	5	126	-
Isopoda	-	-	23	-	36	-	61	-	-	-
Mysid	-	-	-	1	-	-	-	-	-	-
Total	3,366	5,172	18,866	25,956	26,765	17,222	30,541	37,270	11,662	22,553

[1] surface tow

[2] oblique tow