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

by

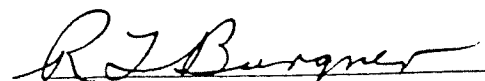
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## ABSTRACT

The ecology of fishes in the Nisqually Reach area of Puget Sound, Washington, particularly along the DuPont shoreline located to the east of the Nisqually River, was studied in 1977 and 1978. The project was initiated in response to a proposal by Weyerhaeuser Company and the City of DuPont, Washington, to construct a cargo loading dock in the area. Emphasis was placed on determining the spatial and temporal distribution of juvenile salmonids, especially chum salmon. Other objectives included studying non-salmonid species, analyzing fish food habits, studying planktonic organisms, and assessing the use of Sequelitchew Creek by anadromous species. Sampling gear included beach seine, townet, trynet, purse seine, bongo net, SCUBA, and in freshwater, a backpack electroshocker.

Juvenile chum, coho, pink, and chinook salmon migrated along all shorelines in the Nisqually Reach. Peak outmigration of chum salmon was mid-May through late June. Early in the season (through mid-May), chum fry were most abundant along the shorelines of Anderson Island and the mainland west of the Nisqually River. Later in the season (mid-May through June) an increase in abundance occurred along the DuPont shoreline, especially offshore. Most coho salmon, nearly all of which were smolts, migrated along the shorelines of Anderson Island during May. Coho were more abundant in beach seine than townet collections. Peak chinook salmon abundance in the area was from late May through July along the mainland shorelines east and west of the Nisqually River. Several chinook caught by beach seine were large sub-adult feeders (blackmouth). Catches of juvenile pink salmon were low during both years; peak catches were in the beach seine from the end of March through mid-April. Small, infrequent

catches of cutthroat and steelhead trout occurred mostly along the DuPont shoreline.

Shiner perch, Pacific herring, staghorn sculpin, and starry flounder were the most abundant non-salmonids that occurred in the beach seine, whereas herring and sand lance were the most abundant non-salmonids in townet collections. The large catches of juvenile herring indicate that the area was used for rearing. English sole and rock sole dominated demersal fish catches by trynet at the three stations sampled. Embiotocids (shiner, pile, and striped perches) were the most abundant pelagic fishes, and buffalo sculpin and painted greenling were the dominant demersal fishes seen in SCUBA surveys near an existing dock in the area considered for a construction site.

Adult coho, chum, chinook, and steelhead were captured by purse seine along the DuPont shoreline in 1977. Peak migrations of coho and chum along the DuPont shoreline were probably September-October and December-January, respectively. Recoveries of tagged salmonids, mostly coho, were primarily from freshwater sources south of the Tacoma Narrows area of Puget Sound.

Plankton studies indicated definite seasonal changes in the abundance of zooplankton, fish eggs, and fish larvae. The greatest catches were in May. The composition of zooplankton at all stations sampled was similar; calanoid copepods, crab zoea, chidaria, and caridean zoea were the dominant organisms. Pleuronectids and gadoids were both the most abundant fish eggs and larvae collected.

Studies of Sequelitchew Creek in 1977 were limited by low flows. Juvenile coho were the most abundant salmon occurring in both years. Fry

from natural spawners were present in the stream and smolts were present in Sequelitchew Lake from plants by the Washington State Department of Fisheries. Peak outmigrations of smolts from Sequelitchew Lake were 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 centarchid young-of-the-year were also captured. Coho and cutthroat trout were the only adult salmonids observed in the creek.

Most of the 44 species examined fed principally on epibenthic plankton and macroinvertebrates. During the early period of their residence in the Nisqually Reach, 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). Later in the season, as fish size and pelagic plankton abundance increased, diets of all juvenile salmonids were dominated by pelagic organisms. 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.

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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 (Vernon 1958, 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), Schreiner et al. (1977) and Bax et al. (1978) 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<sup>1</sup> 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; and 6) determining present use of Sequelitchew 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

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<sup>1</sup>"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).

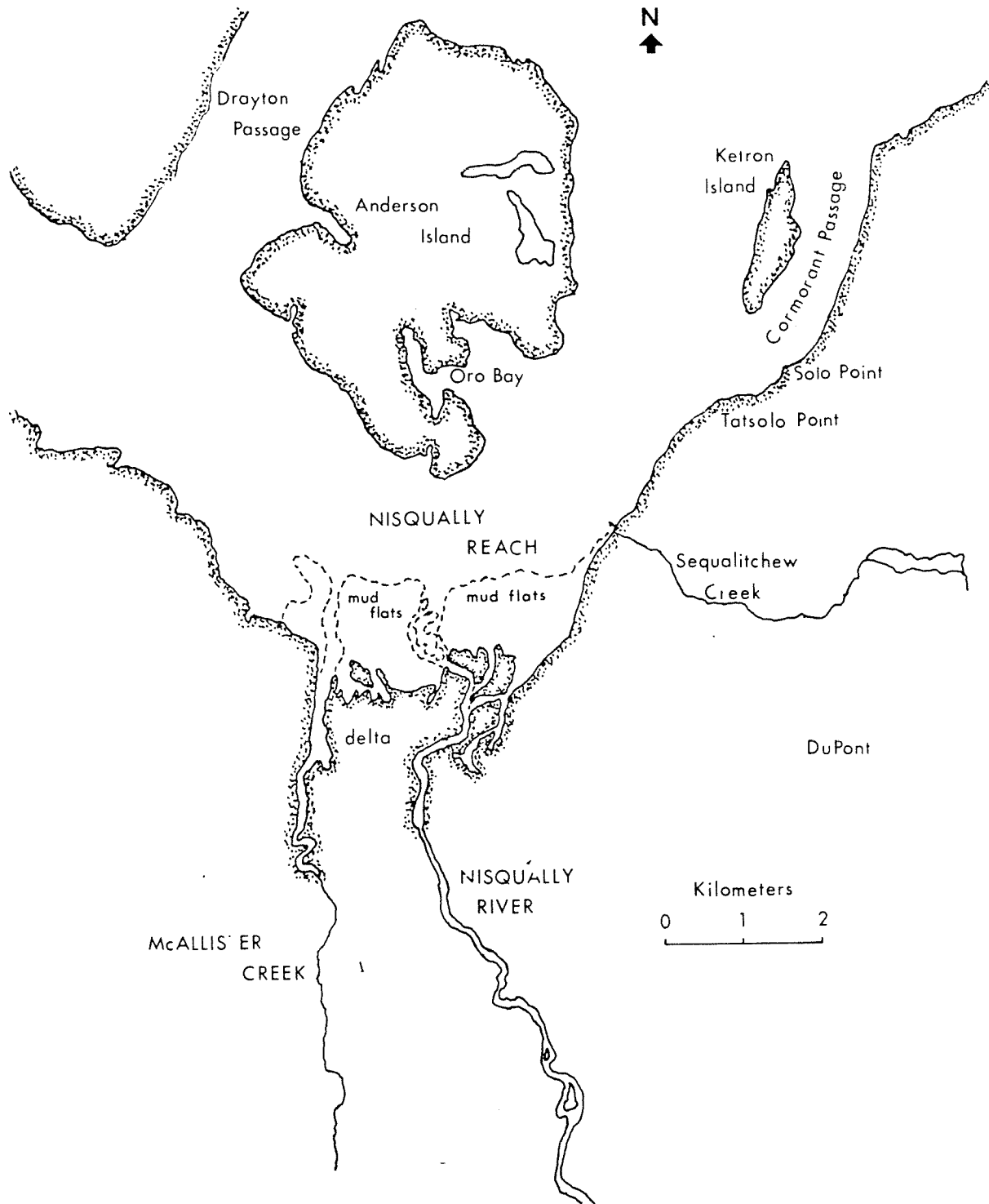


Fig. 1. Map of southern Puget Sound study area and associated landmarks.

Nisqually River, McAllister and Sequelitchew creeks discharge into the 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.

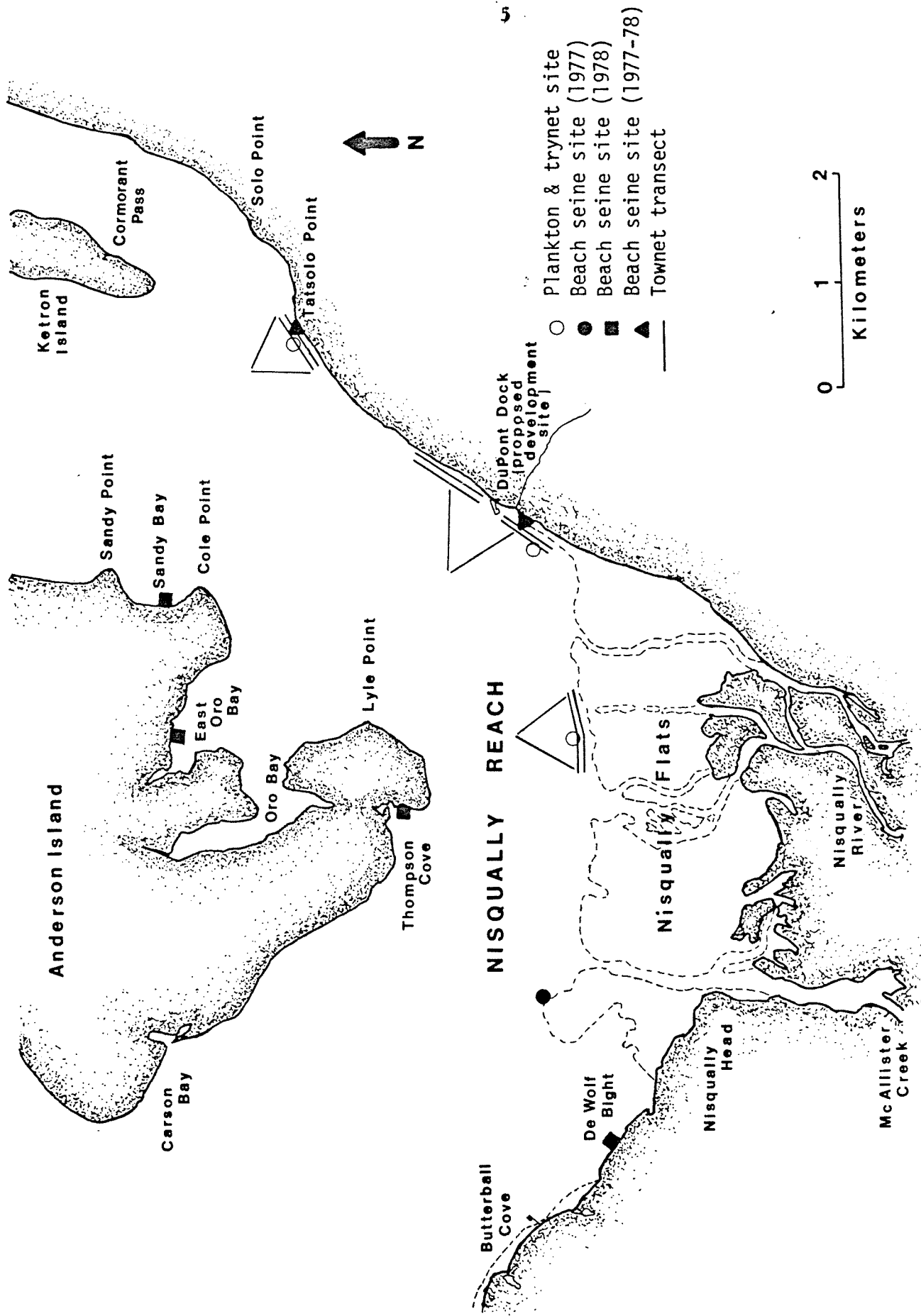


Fig. 2. Map of the study area and sampling sites used during 1977-78 in southern Puget Sound, Washington.

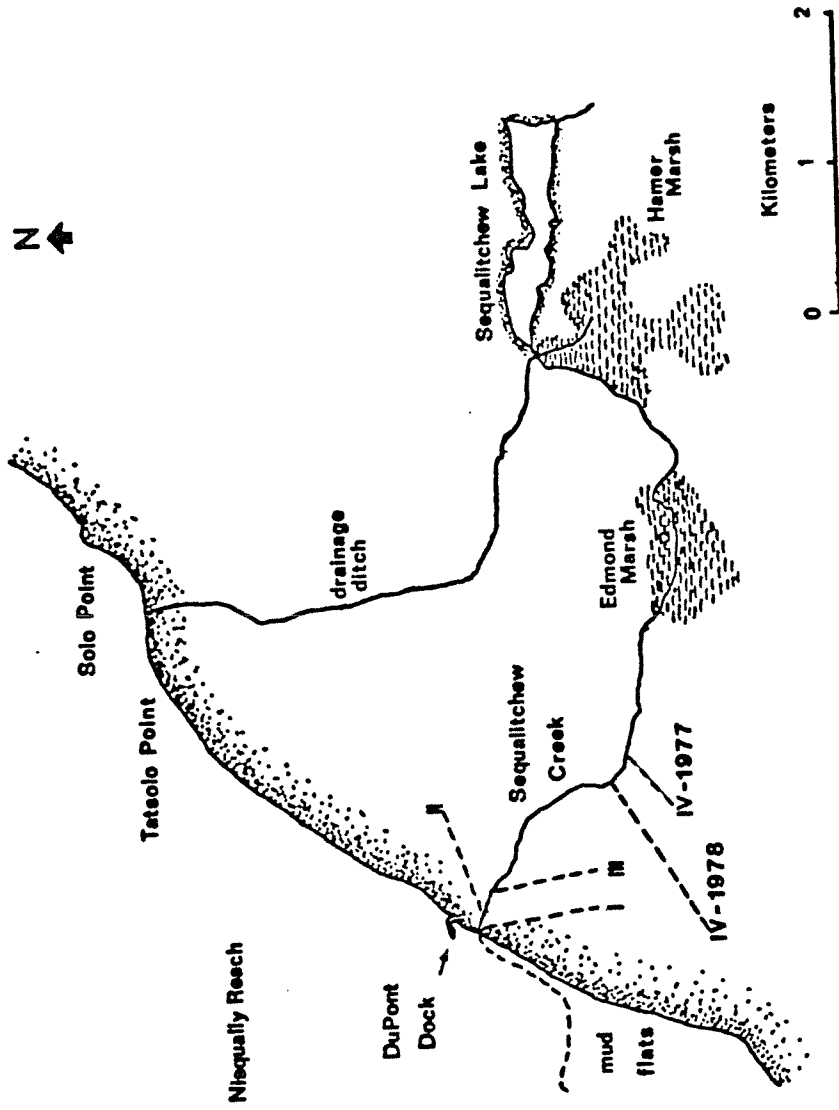


Fig. 3. Map of Sequilitchew Creek and study stations (I - IV), southern Puget Sound, Washington, 1977.

## 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 of 1977 studies 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 Misqually 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 Misqually Delta (1977 only)	Outer edge of the tidal flats of the Misqually River	moderate	Mixture of sand and silt	Some patches of algae
DeWolf Bight (1978 only)	Midway between Misqually 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

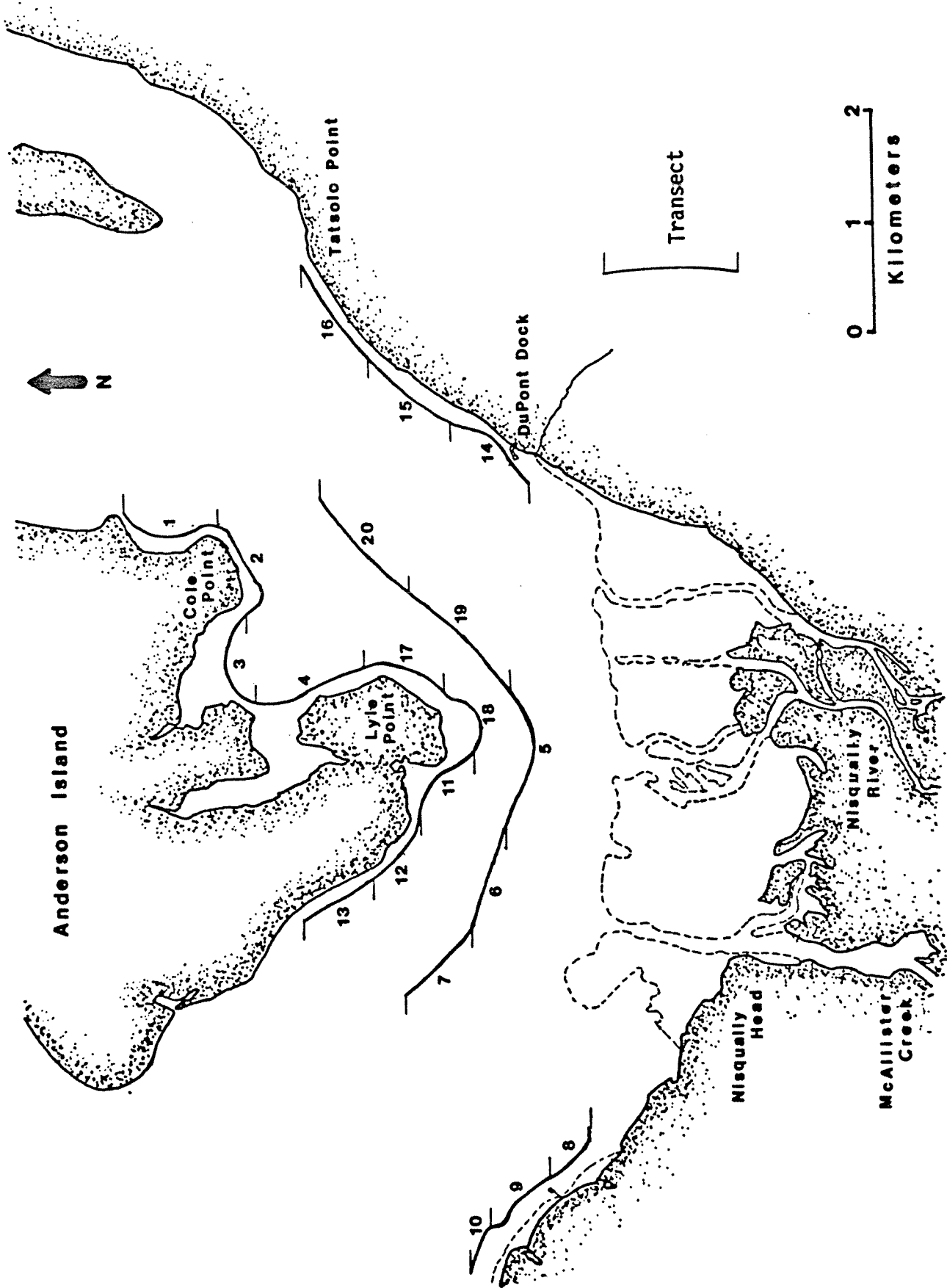


Fig. 4. Tonnage surface trawl pattern used during salmonid outmigration studies during 1978 in southern Puget Sound, Washington.

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 February, March 1978 April through July 1978	Monthly and biweekly Weekly (day only) Biweekly (day and night)
Townet	March through July 1977 April through June 1978	Monthly and biweekly (night only) 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 April, May 1978 June 1978	Biweekly Weekly 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 additional 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 sampling 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, we attempted to make all sets 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.

Because of problems with wind and cloudy weather during beach seine trips, too few visual surveys of salmon were successful to warrant presentation.

### 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. The vessel speed was kept constant in relation to the water, but due to differing tidal flow, the linear distance covered varied. At 10 minute intervals, personnel in a skiff pursed the cod end and emptied the catch into live buckets. Large catches were subsampled (see Subsampling); otherwise the entire catch was preserved in 10 percent formalin in plastic bags.

During each 1977 sampling date, four to six 10 minute tows were made at night at each of three sites (Fig. 2). Tows were made with and against the current along the shoreline and diagonally away from and toward the shore. During each 1978 townet cruise, four transects were taken with the prevailing tidal current during both the day and night (Fig. 4) along the Anderson Island shoreline, the DuPont shoreline, the mainland shore west of the delta, and in the middle of the reach. The number of tows along a transect varied depending on the strength of the tide. 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 deep 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 stretched mesh. The first 100 meshes below the cork line (except for the bunt) contained 12.7-cm stretch mesh; the remainder of the net contained 10.2-cm stretch mesh.

Three or four sets were made per sampling date 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).

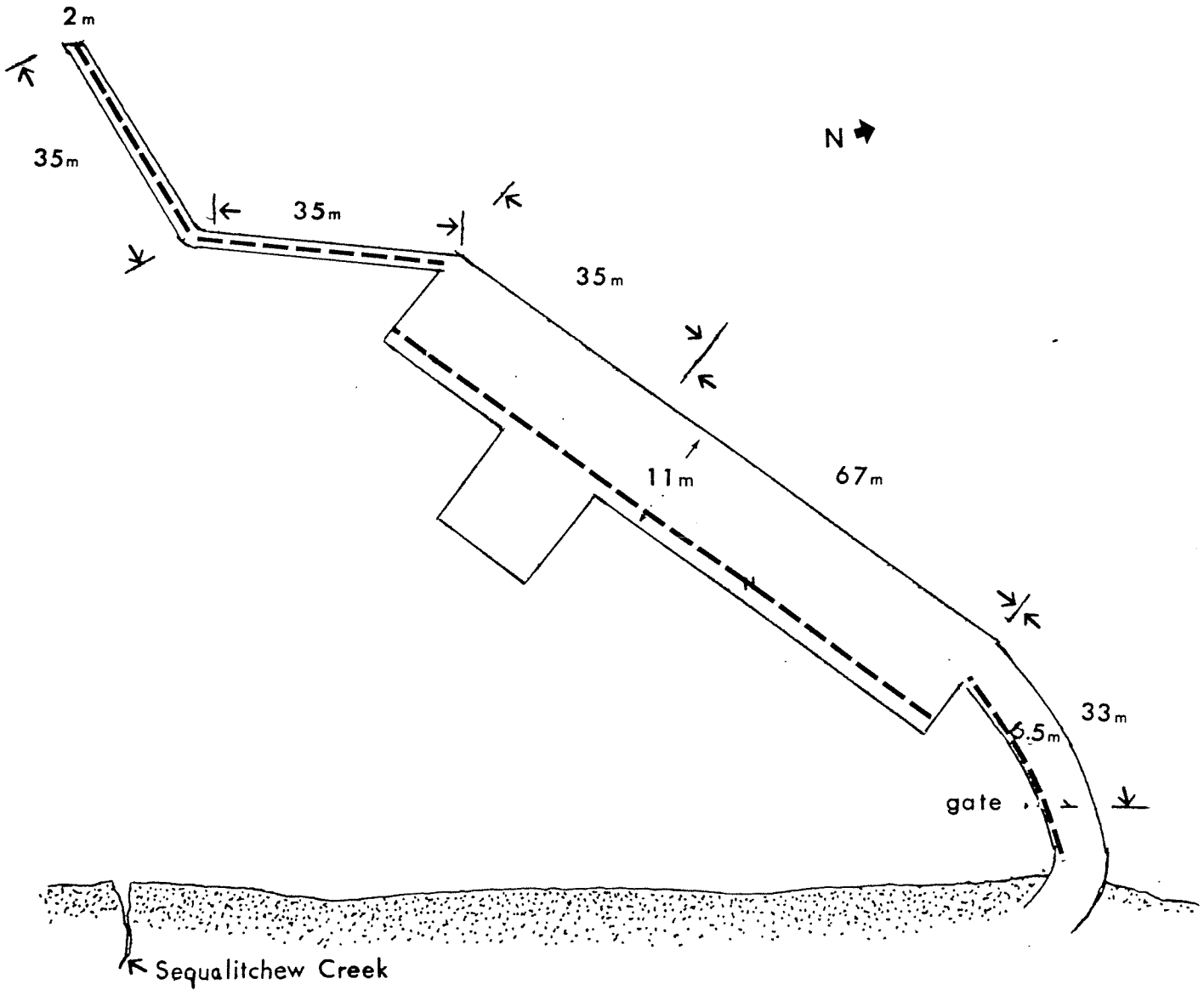


Fig. 5 Diagram of the DuPont Dock, southern Puget Sound, WA (not drawn to scale). SCUBA survey transect pattern represented by dashed line.

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.

#### Plankton Collections

Monthly plankton collections were made in 1977 at the Tatsolo Point, DuPont Dock, and the outer Nisqually Delta sites (Fig. 2). 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- $\mu$  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

Table 3. Summary of plankton samples analyzed.

Sample No.	Date	Sta. No.*	Surface or Oblique	Net No.	Flow-Meter Revs.	Duration of Haul	m <sup>3</sup> 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

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 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:

$$N = c_1^2 / (c_1 - c_2)$$

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 ( $^{\circ}\text{C}$ ) 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.

### 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 (FL), herring--tip of snout to hypural plate (SL), ratfish--snout to second dorsal, all other species--total length (TL). 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.

#### Definitions

- 1). Catch-per-unit-effort (CPUE) by any gear type -  
$$\frac{\text{number of fish captured}}{\text{number of capture attempts}}$$
- 2). Shorelines -
  - a) DuPont - from the eastern edge of the Nisqually Delta north to Tatsolo Point (towntows: 14, 15, 16)

- b) West mainland - from Nisqually Head north to Johnson Point  
(townet tows: 8, 9, 10)
  - c) West Anderson Island - from Lyle Point northwest to Carson Bay  
(townet tows: 11, 12, 13, 18)
  - d) East Anderson Island - Lyle Point northeast to Sandy Point  
(townet tows: 1, 2, 3, 4, 17)
- 3) Coefficient of variation -  $\left(\frac{\text{Standard deviation}}{\text{mean}}\right) \times 100\%$

#### 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 I - RESULTS AND DISCUSSION OF FISH CATCHES

Beach Seine and TownerGeneral Catch Results

Sixty-one species of fish were collected by beach seine and towner through July 1978, 51 by beach seine and 32 by towner (Appendix 3).

Beach Seine. Chinook salmon, staghorn sculpin, and chum salmon, comprising 52 percent of the total catch, were the most abundant species in 1977 (Table 4), whereas in 1978, chum salmon, shiner perch, and coho salmon were the most abundant species, accounting for 78 percent of the total catch (Table 5). In both 1977 and 1978, catches of salmonids and non-salmonids were generally smallest at the DuPont shoreline sites - Tatsolo Point and DuPont Dock. Overall abundance of fish in 1977 and 1978 was greatest at the outer Nisqually Delta and Thompson Cove sites, respectively.

Analysis of data collected by beach seine in 1977 was compounded by several problems, including: 1) lack of gear standardization (floating and sinking sets were made with 37-m and 10-m beach seines; thus the unit of effort varied); 2) differing numbers of sets made at each site over the sampling period; and 3) frequency of collections. Because these problems were significantly reduced in 1978, emphasis was placed on analysis of 1978 data.

During 1978, similar numbers of species occurred at all sites, ranging between 24 at Thompson Cove and 30 at DuPont Dock. Of the abundant non-salmonids (salmonids are considered in greater detail in following sections), adult shiner perch occurred primarily at Thompson Cove and East Oro Bay and were most abundant during night collections

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. %
<i>Hydrolagus colliei</i>	1			1 -
<i>Clupea harengus pallasii</i>	66	1	9	76 2.1
<i>Oncorhynchus gorbuscha</i>	28	9	111	148 4.0
<i>O. keta</i>	57	84	158	299 8.2
<i>O. kisutch</i>	82	53	14	149 4.1
<i>O. tshawytscha</i>	77	129	772	978 26.7
<i>Salmo clarki</i>		1		1 -
<i>S. gairdneri</i>	1			1 -
<i>Hypomesus pretiosus</i>	1		50	51 1.4
<i>Gobiesox maeandricus</i>	4			4 .1
Gadid larvae		2		2 .1
<i>Aulorhynchus flavidus</i>		88		88 2.4
<i>Gasterosteus aculeatus</i>	5	1	1	7 .2
<i>Syngnathus griseolineatus</i>	1	6	1	8 .2
<i>Cymatogaster aggregata</i>	138	34	78	250 6.8
<i>Embiotoca lateralis</i>	92	83		175 4.8
<i>Rhacochilus vacca</i>	59	3		62 1.7
Embiotocid-unidentified	2			2 .1
<i>Anoplarchus insignis</i>		1		1 -
<i>Lumpenus sagitta</i>		1		1 -
<i>Apodichthys flavidus</i>	32	49	1	82 2.2
<i>Pholis laeta</i>	22	34		56 1.5
<i>P. ornata</i>	11	19	2	32 .9
<i>Xererpes fucorum</i>	1		2	3 .1
<i>Sebastes caurinus</i>	1			1 -
<i>Artedius fenestralis</i>	18	5	3	26 .7
<i>A. lateralis</i>	2	19		21 .6
<i>Blepsias cirrhosus</i>	1			1 -
<i>Chitonotus pugetensis</i>	14	3	4	21 .6
<i>Clinocottus acuticeps</i>			1	1 -
<i>C. embryum</i>	1		2	3 .1
<i>Enophrys bison</i>	17	24	1	42 1.1
<i>Leptocottus armatus</i>	27	125	469	621 16.9
<i>Myoxocephalus polyacanthocephalus</i>	2	3		5 .1
Cottid-unidentified	3	3		6 .2
<i>Agonus acipenserinus</i>		2	6	8 .2
<i>Liparis rutteri</i>	2	1		3 .1

Table 4. (continued)

Species	Tatsolo Point	DuPont Dock	Nisqually Delta	Total No.	%
<i>Glyptocephalus zachirus</i>			1	1	-
<i>Lepidopsetta bilineata</i>	3	17	19	39	1.1
<i>Parophrys vetulus</i>	2	11	47	60	1.6
<i>Platichthys stellatus</i>		46	207	253	6.9
<i>Psettichthys melanostictus</i>		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 (percent of collections at each site each species occurred), abundance, and percent composition of fishes caught by beach seine from February 15 to July 20, 1978 in the Nisqually Reach study area.

Species	Site										Total No. 210 coll.	Total % coll.				
	Tatsolo Point		DuPont Dock		DeWolf Bight		Thompson Cove		East Oro Bay				Sandy Cove			
	Occur. No.	No.	Occur. No.	No.	Occur. No.	No.	Occur. No.	No.	Occur. No.	No.			Occur. No.	No.		
<i>Squalus acanthias</i>	34 coll.		2.9	1	2.9	1	36 coll.		8.3	130	2.8	3	36 coll.		0.9	2
<i>Hydrolagus colliei</i>			5.8	3	20.0	304		22.2	222	38.9	3828		20.0	1267	1.4	6
<i>Clupea harengus pallasi</i>	5.9	145	8.8	22	28.6	127		83.3	11209	77.8	2969		82.9	5497	17.6	5696
<i>Oncorhynchus gorbusha</i>	17.6	29	2.9	6	80.0	8600		69.4	3332	47.2	373		62.9	1183	19.0	653
<i>O. keta</i>	70.6	3502	73.5	1851	51.4	99		52.8	283	27.8	25		45.7	120	78.1	33628
<i>O. kisutch</i>	64.7	537	61.8	312	51.4	331		5.6	2	5.6	2		5.8	2	59.5	5836
<i>O. tshawytscha</i>	35.3	523	44.1	145	2.9	1		5.6	2	5.6	2		5.8	2	43.8	1427
<i>Salmo clarki</i>	17.6	7	14.7	7	8.6	3		5.6	2	5.6	2		5.8	2	7.6	19
<i>S. gairdneri</i>	2.9	1	11.8	7	2.9	1		5.6	2	5.6	2		5.8	2	5.7	15
<i>Salvelinus malma</i>					2.9	1									0.5	1
<i>Hypomesus pretiosus</i>	8.8	109	11.8	14	34.3	396		27.8	96	36.1	96		11.3	5	21.9	716
Gadidae			14.7	20	5.7	2		13.9	7	16.7	19		5.8	3	9.5	51
<i>Microgadus proximus</i>			5.8	4						5.6	3				1.9	7
<i>Aulorhynchus flavidus</i>			8.8	22	2.9	1		5.6	3	2.8	1		5.8	2	1.4	22
<i>Gasterosteus aculeatus</i>	8.8	8			2.9	1				2.8	1				4.3	15
<i>Syngnathus griseolineatus</i>			20.6	10	2.9	1		2.8	1	2.8	1				4.8	13
<i>Cymatogaster aggregata</i>	11.8	9	29.4	96	42.9	106		47.2	5810	52.8	754		31.4	42	36.2	6817
<i>Embiotoca lateralis</i>	8.8	6	20.6	26	2.9	1		19.4	20	11.1	4		2.9	1	11.0	58
<i>Rhacochilus vacca</i>	5.8	4	11.8	7	8.6	3		19.4	18	11.1	28		2.9	1	11.0	61
<i>Lumpenus sagitta</i>			8.8	19	5.7	5		16.7	37	8.3	10		17.1	28	9.5	99
<i>Apolectichthys flavidus</i>	11.8	14	8.8	28						2.9	2		5.8	3	4.8	47
<i>Photis laeta</i>	8.8	5	5.8	3	5.7	2		5.6	3	5.6	5		2.9	1	3.8	14
<i>P. ornata</i>	2.9	2	5.8	11	5.7	2		2.8	1	2.8	1		2.9	1	2.4	15
<i>Ammodytes hexapterus</i>					5.7	2		5.6	3	2.8	1				2.4	6
<i>Cleavelandia ios</i>					5.7	2		2.8	1	5.6	3				1.4	4
<i>Lepidogobius lepidus</i>			2.9	1									2.9	1	0.5	1
<i>Sebastes</i> spp.	2.9	3													0.9	4
<i>Hexagrammos</i> spp.	5.8	2											2.9	1	2.4	7
<i>Hexagrammos stelleri</i>								2.8	1	5.6	4		2.9	1	0.5	1



(Table 6). Catches of the economically important Pacific herring occurred entirely after June 1, 1978, with the largest proportion (89 percent) caught in East Oro Bay and Sandy Cove. All herring caught were juveniles, ranging in size up to 110 mm SL. Staghorn sculpin, both juveniles and adults, were most abundant at the shallower sites, especially DeWolf Bight. The dominant pleuronectids were English sole, rock sole, and starry flounder, and were most abundant at DeWolf Bight. Juvenile and adult surf smelt were most abundant after May 22 at DeWolf Bight and Tatsolo Point. The occurrence of juvenile surf smelt in the summer suggests use of the Nisqually Reach for rearing.

The large catches of demersal species, e.g., pleuronectids and cottids, at DeWolf Bight were likely a function of water depths which rarely exceeded 2.0 m. Thus, the floating seine actually sampled on or near the bottom and functioned as a sinking seine.

Commercial and recreational species (other than salmonids) caught by beach seine included: Pacific herring, surf smelt, Pacific tomcod, striped seaperch, pile perch, rock sole, English sole, starry flounder, and sand sole.

Townet. During 1977, chinook salmon, herring, and chum salmon were the dominant species, comprising 77 percent of the total catch (Table 7). Sand lance, chum salmon, and herring were the most abundant species (79 percent of the total catch) occurring in 1978 (Table 8). Demersal species (e.g., pleuronectids and cottids) were relatively rare in samples from both years. In 1978, larval and post-larval herring and sand lance were abundant along all shorelines during April and May, particularly in transects along the East Anderson Island and West Mainland shorelines.

Table 6. Comparison of day and night beach seine catches of the ten most abundant non-salmonid species caught during 1978 in the Nisqually Reach study area.

Species	Day		Night	
	Occur. <sup>1</sup>	$\bar{X}$ <sup>2</sup>	Occur.	$\bar{X}$
<i>Cymatogaster aggregata</i>	15.9	5.8	66.7	72.4
<i>Clupea harengus pallasii</i>	11.9	31.5	26.2	20.6
<i>Leptocottus armatus</i>	55.6	10.1	86.9	13.9
<i>Parophrys vetulus</i>	23.0	4.4	41.7	4.1
<i>Hypomesus pretiosus</i>	15.9	4.0	40.0	2.6
<i>Lepidopsetta bilineata</i>	24.6	1.2	40.0	1.3
<i>Platichthys stellatus</i>	23.8	1.2	16.7	0.8
<i>Clinocottus acutecips</i>	8.7	0.3	21.4	0.9
<i>Oligocottus maculosus</i>	5.6	0.4	14.3	0.7
<i>Artedius fenestralis</i>	7.9	0.8	<0.1	<0.1

<sup>1</sup>Percent of total collections each species occurred in.

<sup>2</sup>Calculated as total number of fish/total collections.

Table 7. 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.	%
<i>Squalus acanthias</i>	4	28	24	56	6.7
<i>Hydrolagus colliei</i>	1			1	.1
<i>Clupea harengus pallasii</i>	55	73	84	212	25.5
<i>Oncorhynchus gorbuscha</i>	14	18	4	36	4.3
<i>O. keta</i>	38	100	69	207	24.8
<i>O. kisutch</i>	5	6	9	20	2.4
<i>O. nerka</i>	1			1	.1
<i>O. tshawytscha</i>	95	90	40	225	27.0
<i>Salmo gairdneri</i>			1	1	.1
<i>Hypomesus pretiosus</i>		3		3	.4
<i>Gadus macrocephalus</i>	2	1		3	.4
<i>Merluccius productus</i>		2	1	3	.4
<i>Microgadus proximus</i>			1	1	.1
<i>Aulorhynchus flavidus</i>			1	1	.1
<i>Gasterosteus aculeatus</i>	1	1		2	.2
<i>Cymatogaster aggregata</i>	1	1	1	3	.4
<i>Embiotoca lateralis</i>		4	1	5	.6
<i>Pholis laeta</i>		1		1	.1
<i>P. ornata</i>		1	1	2	.2
<i>Ammodytes hexapterus</i>	2	2		4	.5
<i>Gilbertidia sigalutes</i>		1	1	2	.2
<i>Leptocottus armatus</i>	1	6	11	18	2.2
<i>Nautichthys oculo-fasciatus</i>		1		1	.1
<i>Rhamphocottus richardsoni</i>		1		1	.1
<i>Platichthys stellatus</i>	1	5	8	14	1.7
Pleuronectid larvae	1	7	2	10	1.2
Total	222	352	259	833	96.7

Table 8. Frequency of occurrence (percent of total tows along each transect each species occurred in), abundance, and percent composition of fishes caught by townet from April 3 to June 13, 1978 in the Nisqually Reach study area.

Species	Transect						Total Occur. No. 177 tows	Total No. %					
	DuPont		East		West								
	Shoreline Occur.	No. 27 tows	Anderson Shoreline Occur.	No. 49 tows	Anderson Shoreline Occur.	No. 31 tows			Delta Shoreline Occur.	No. 28 tows	Middle Reach Occur.	No. 42 tows	
<i>Entosphenus tridentatus</i>	14.8	16			3.2	1		4.8	2	1.1	2	1.1	2
<i>Squalus acanthias</i>	3.7	1								2.8	17	2.8	17
<i>Hydroloagus collettei</i>	33.3	35			9.7	19		17.6	208	1.1	5	1.1	5
<i>Clupea harengus pallasii</i>	7.4	6	2.0	4	9.7	3				21.5	1937	21.5	1937
<i>Oncorhynchus gorbuscha</i>	51.9	1594	6.1	12	45.2	94		28.6	72	4.8	2	5.6	23
<i>O. keta</i>	22.2	237	57.1	408				26.2	28	42.4	2196	42.4	2196
<i>O. kisutch</i>	37.0	419	2.0	1	3.2	1		14.6	6	7.3	248	7.3	248
<i>O. tshawytscha</i>			12.2	8				17.6	81	2.4	1	13.0	510
<i>Salmo gairdneri</i>								2.4	1	2.4	1	0.6	1
<i>Hypomesus pretiosus</i>	3.7	1	2.0	1				3.6	1	1.7	3	1.7	3
<i>Forichthys notatus</i>			2.0	1						0.6	1	0.6	1
Gadidae	22.2	31	14.3	12	6.5	10		21.4	21	18.1	111	18.1	111
<i>Microgadus proximus</i>	7.4	2						7.1	4	1.1	4	1.1	4
<i>Gasterosteus aculeatus</i>			6.1	5				7.1	2	2.3	4	2.3	4
<i>Syngnathus griseolineatus</i>	7.4	4	2.0	2	3.2	1		7.1	3	2.3	6	2.3	6
<i>Cymatogaster aggregata</i>			2.0	1	3.2	1		3.6	1	4.5	12	4.5	12
<i>Embiotoca lateralis</i>	3.7	2	4.1	9						0.6	1	0.6	1
<i>Lumpenus sagitta</i>	14.8	34	12.2	58	6.5	24		7.1	18	2.3	13	2.3	13
Pholidae	40.7	289	46.9	2713	29.0	56		21.4	1569	9.0	141	9.0	141
<i>Ammodytes hexapterus</i>								3.6	1	32.2	5002	32.2	5002
<i>Lepidogobius lepidus</i>	3.7	1	18.4	32	9.7	4				0.6	1	0.6	1
Scorpaenidae	3.7	1	2.0	16				9.7	36	9.6	73	9.6	73
Cottidae			2.0	1				2.4	2	1.7	19	1.7	19
<i>Clinocottus embryeum</i>										0.6	1	0.6	1
<i>Gilbertidia sigalutes</i>								3.6	1	1.1	2	1.1	2
<i>Leptocottus armatus</i>	18.5	7	10.2	7	6.5	3		14.3	5	9.0	22	9.0	22
<i>Psychrolutes paradoxus</i>	11.1	4						2.4	1	2.3	5	2.3	5
<i>Rhamphocottus richardsoni</i>								3.6	1	0.6	1	0.6	1



WDF baitfish surveys have also found large numbers of herring (mostly juveniles) in the Nisqually Reach area during the summer, especially in August and September (Penttilla, personal communication) (Table 9). These WDF townet catches and our beach seine catches indicate use of the Nisqually Reach as a rearing area by herring.

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

#### Chum Salmon

Migration Periods and Peaks. During 1977, chum fry first appeared in beach seine catches on April 7 and occurred in samples through July 27, when sampling ended (Table 10). Overall, CPUE values were usually low, and on only four occasions did beach seine CPUE exceed 10 fish/haul. Peaks occurred in early May, early June, and late June (the largest peak) (Fig. 6); however, the limited sampling effort probably missed other migratory peaks. Most chum fry sampled by beach seine during 1977 occurred at the Outer Nisqually Delta site.

Catches of chum by townet during 1977 occurred throughout the March 10 to July 7 sampling period (Table 11). As with the beach seine, CPUE of chum rarely exceeded 10 fish/haul. Peak abundances occurred in mid-May (outer Nisqually Delta) and early July (Tatsolo Point and DuPont Dock) (Fig. 6).

In 1978, chum occurred in beach seine catches as early as mid-February (Appendix 4a) although few fish were caught anywhere until late March. The timing of migration peaks varied somewhat by site (Fig. 7).

Table 9. Baftfish catches (each value is catch in one 10 min tow) by WDF in nighttime townet surveys in the Nisqually Reach, June to September 1977-1978. (Data provided by D. Penttilla, WDF).

	Cormorant Pass						Oro Bay			West Nisqually Reach Shoreline			
	J	J	A	S	S	J	J	A	S	J	J	A	S
Herring													
1977	0	0	4,062	386	2	0	14,066*	628	4	22	12,000*	4,360*	
1978	0	18	1,443	216	58	250	515	1,152	19	NS	437	15	
Surf Smelt													
1978	0	0	744	50	0	33	19	156	0	0	135	56	

\* Estimates

Table 10. 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	0	No sample taken			0
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			0	
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			0	
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.

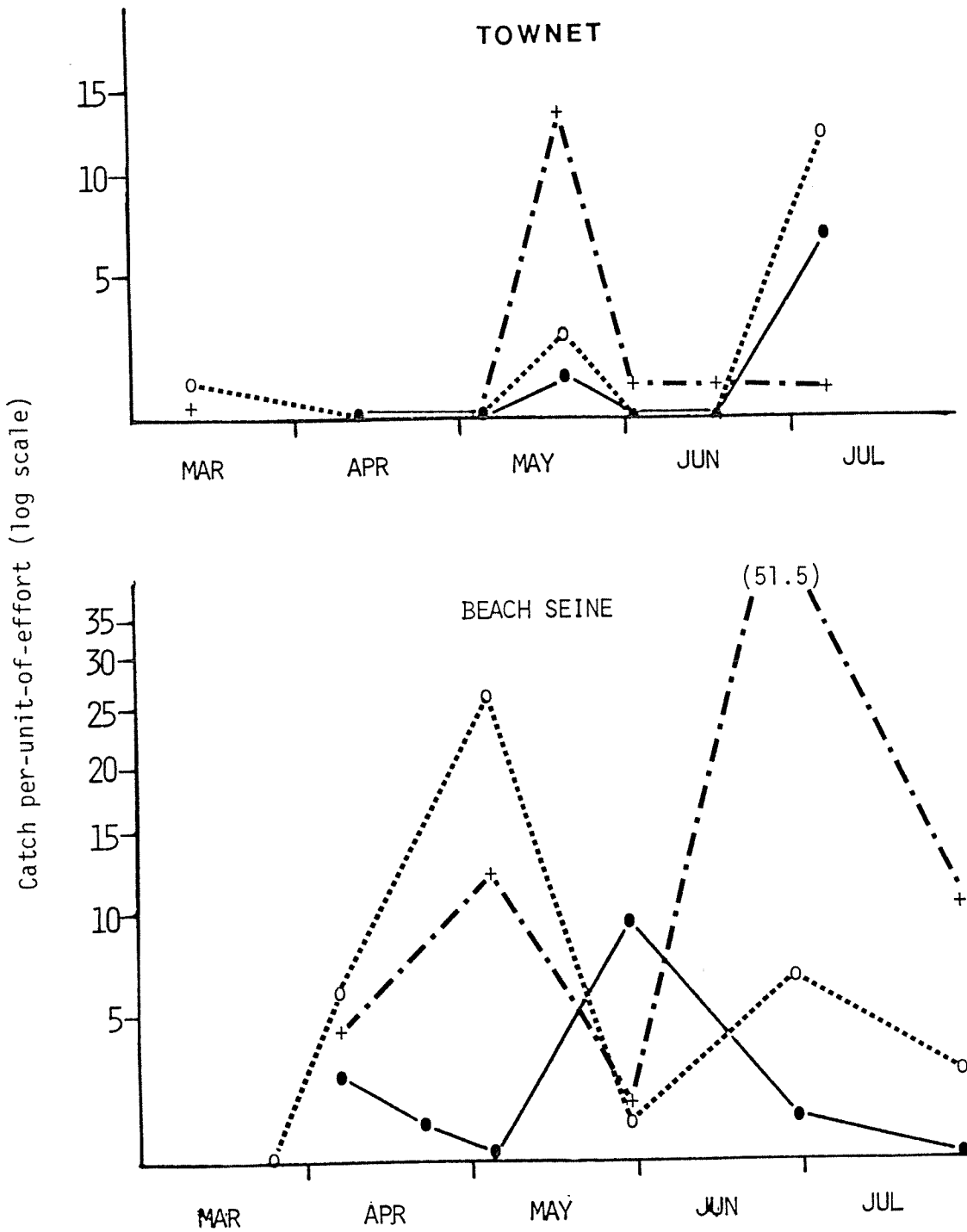


Fig. 6 . Beach seine and tow net catch per-unit-of-effort of juvenile chum salmon, southern Puget Sound, WA, 1977. Station identification: Tatsolo Point ●—●; DuPont Dock ○- - -○; Outer Nisqually Delta + - - +.

Table 11. 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.

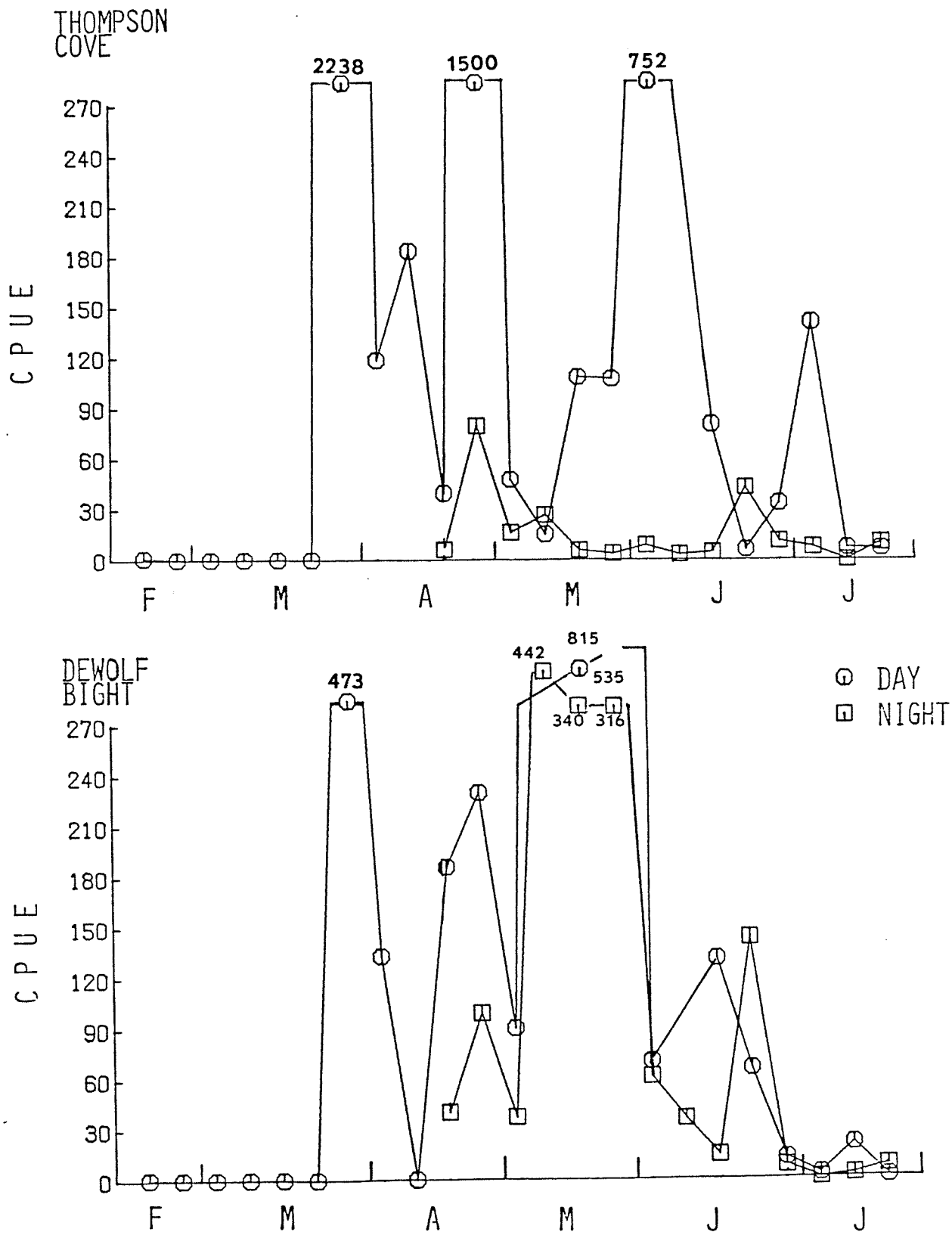


Fig. 7. Weekly CPUE of chum salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington.

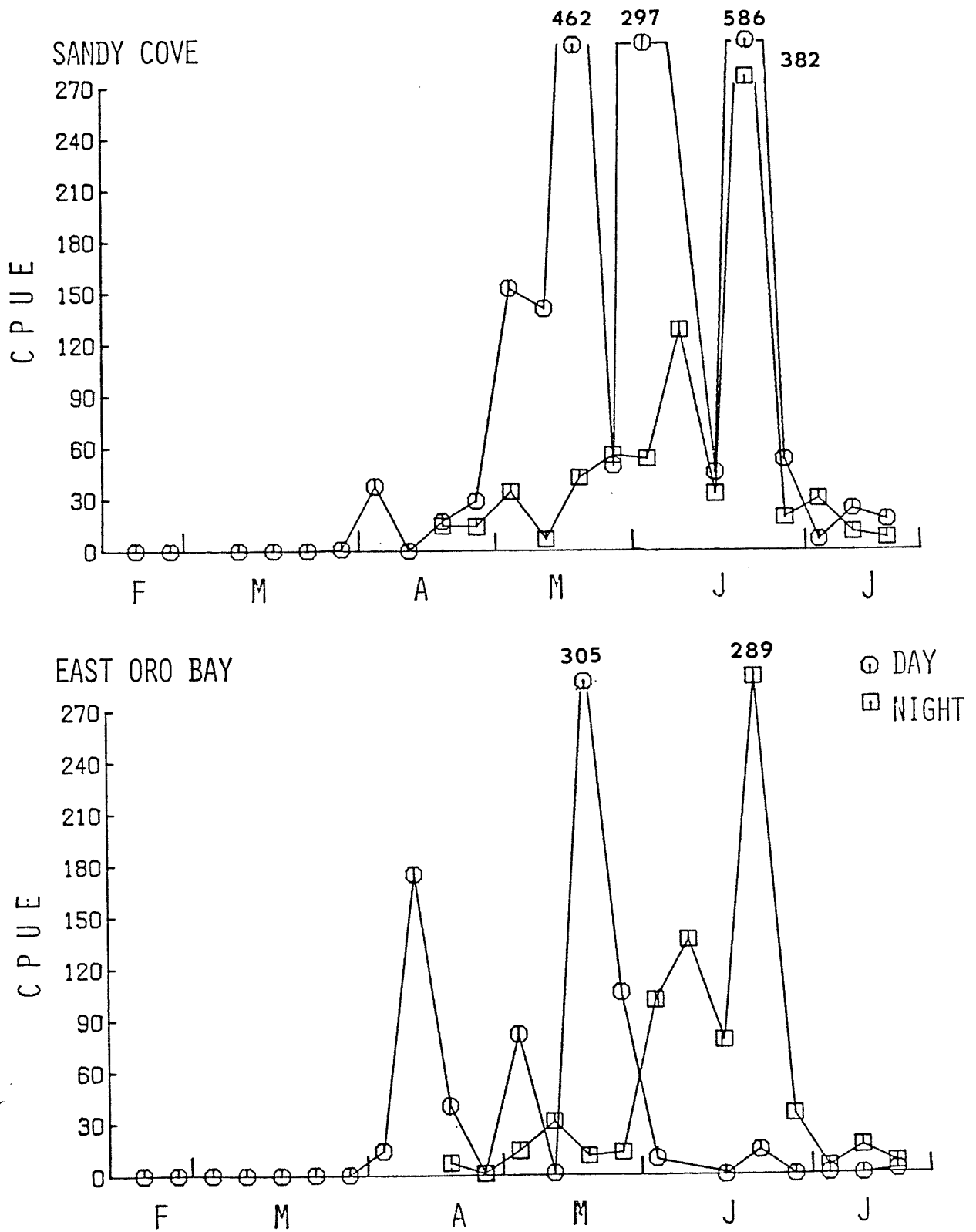


Fig. 7. Weekly CPUE of chum salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington. (continued)



Peaks in late March, early April, and late April occurred primarily at Thompson Cove and DeWolf Bight. The mid-late May and early June peak was characteristic of all sites, but in particular DeWolf Bight and Sandy Cove. Peaks in mid- to late June were characteristic of the DuPont shoreline and eastern Anderson Island shoreline. By July, a reduction in chum CPUE at all sites indicated chum movement from the system. As the migration of adult chum into the Nisqually River is later than most chum salmon runs in southern Puget Sound, the later peaks may represent outmigration of wild Nisqually stocks.

Chum occurred in townet samples during all cruises in 1978 (April 3-June 13) (Appendix 5). A minor peak occurred in early April, and a major peak occurred in late-May and mid-June (Figs. 8-12). The bimonthly sampling frequency, however, is probably not sufficient to reflect offshore temporal distributions. At least weekly samples such as used in Hood Canal studies (Schreiner 1977; Bax et al. 1978) would probably be more appropriate.

The multiple peaks that were characteristic of the chum outmigration suggests movements of fish through the system in waves. The lack of peaks occurring at all sites simultaneously makes it difficult to determine the overall major outmigration period. The occurrence of large CPUE's at most sites in mid-May through mid-June indicates, however, that this may be the peak of the chum migration through the system.

The multiple CPUE peaks and the variability in timing of outmigration by site may be a function of movements of different stocks of fish through the area (e.g., wild stocks from the Nisqually River, hatchery fish released at McAllister Creek). Size of chum fry typically varied

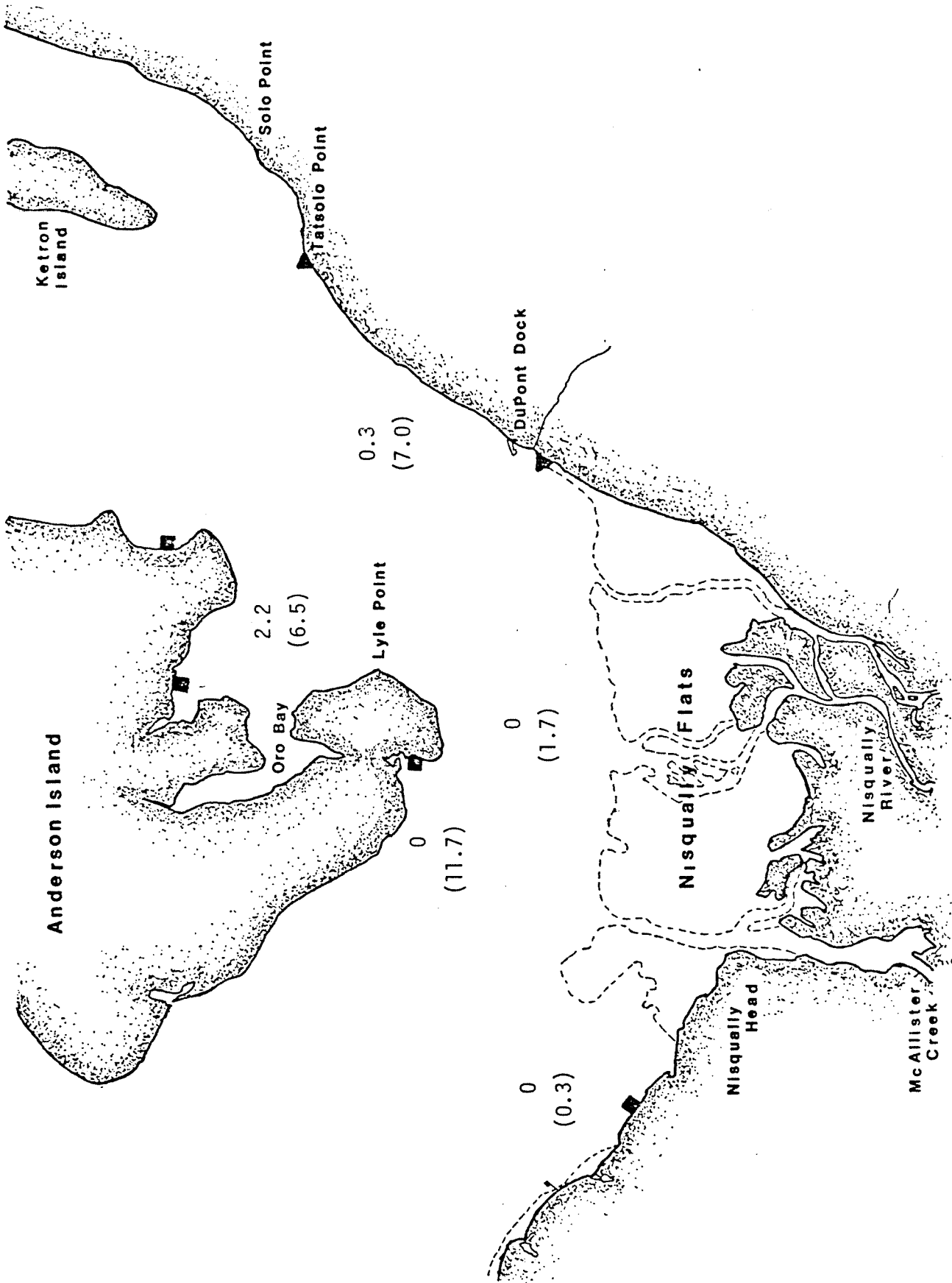


Fig. 8. Offshore (townnet) CPUE of chum salmon by transect, April 3-4, 1978, in the Nisqually Reach. (Nighttime CPUE is in parentheses under daytime CPUE.)

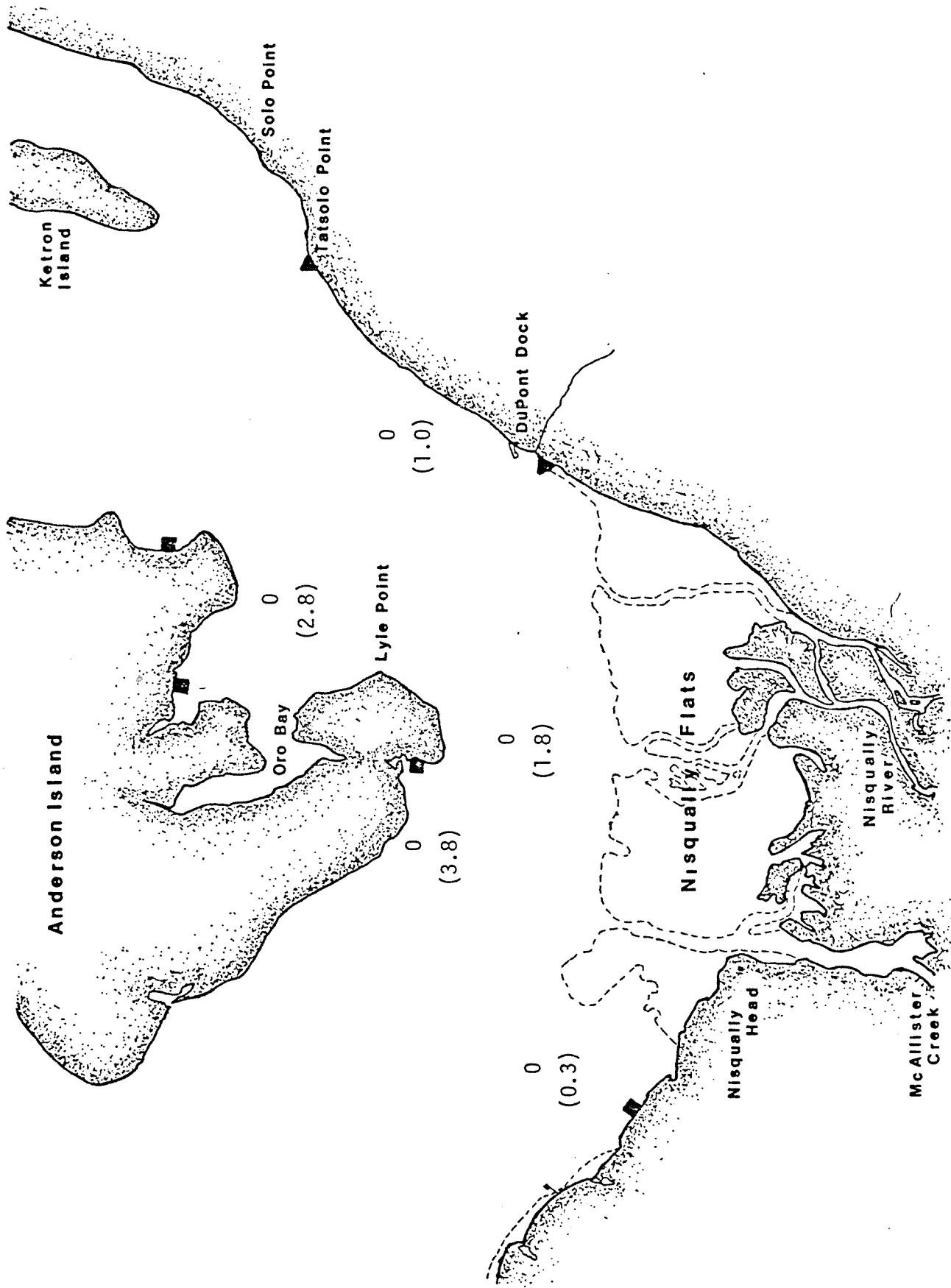


Fig. 9. Offshore (townet) CPUE of chum salmon by transect, April 17-18, 1978, in the Nisqually Reach. (Nighttime CPUE is in parentheses under daytime CPUE.)

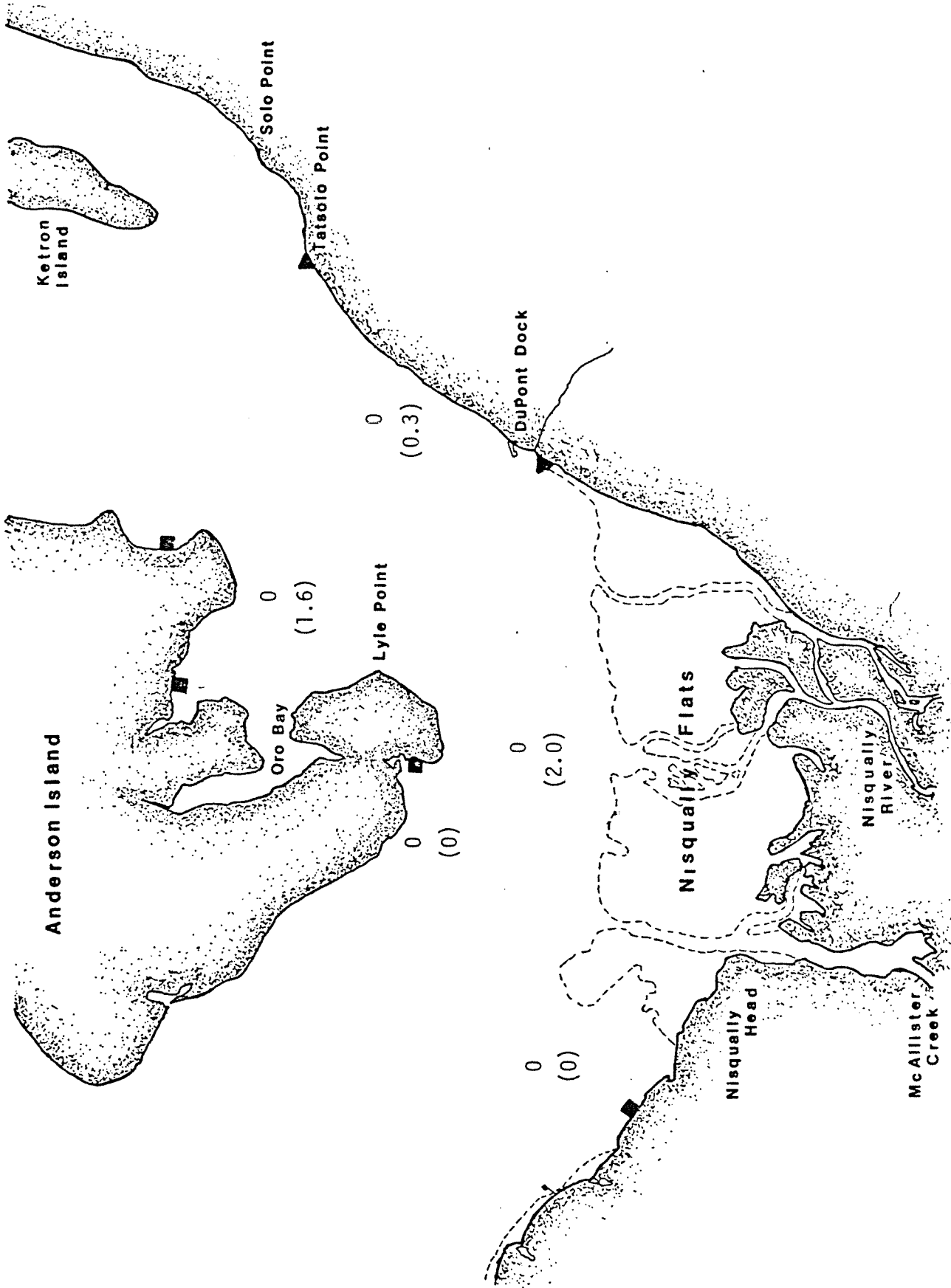


Fig. 10. Offshore (townet) CPUE of chum salmon by transect, May 7-8, 1978, in the Nisqually Reach. (Nighttime CPUE is in parentheses under daytime CPUE.)

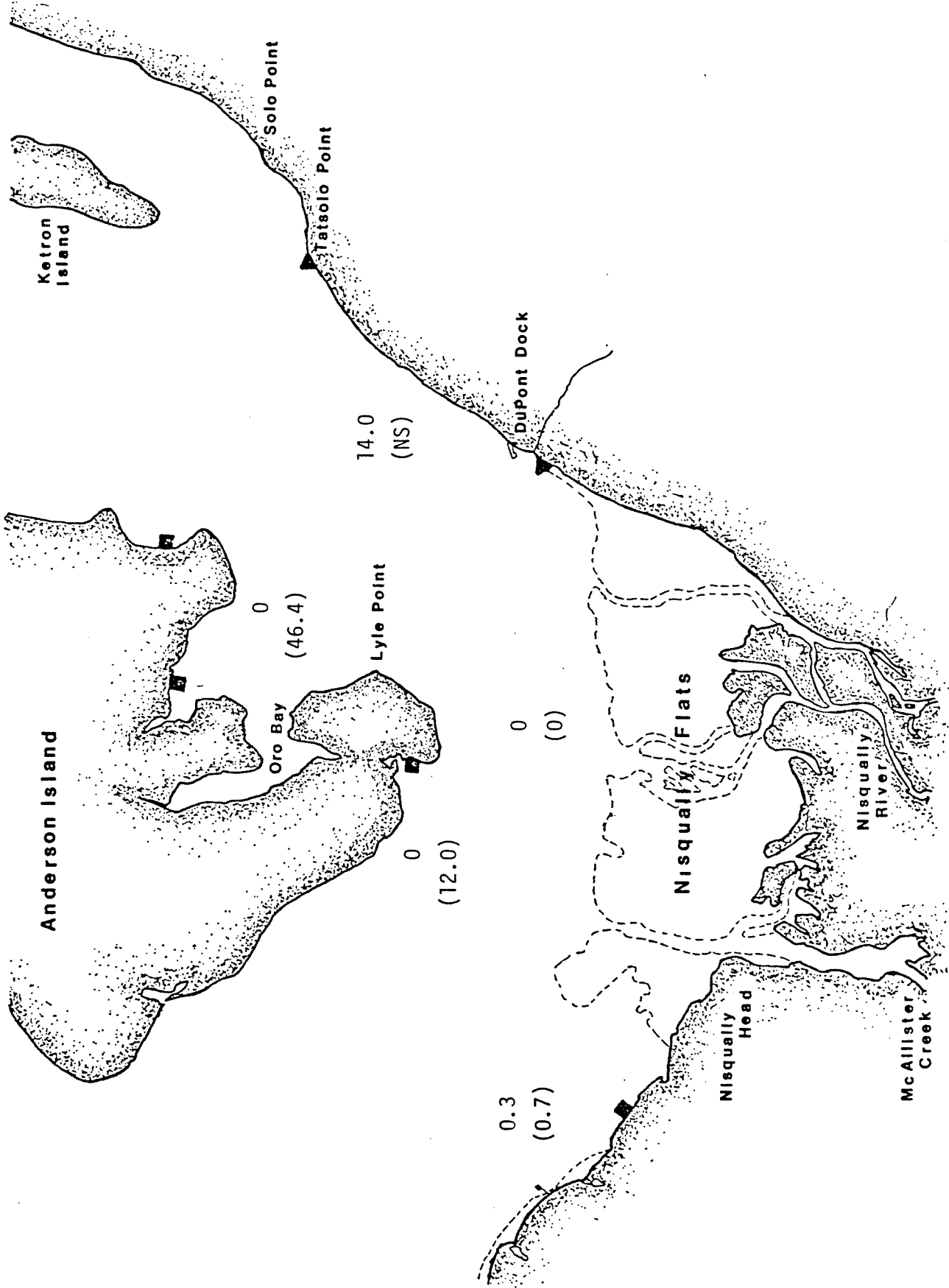


Fig. 11. Offshore (townet) CPUE of chum salmon by transect, May 28-29, 1978, in the Nisqually Reach. (Nighttime CPUE is in parentheses under daytime CPUE.)

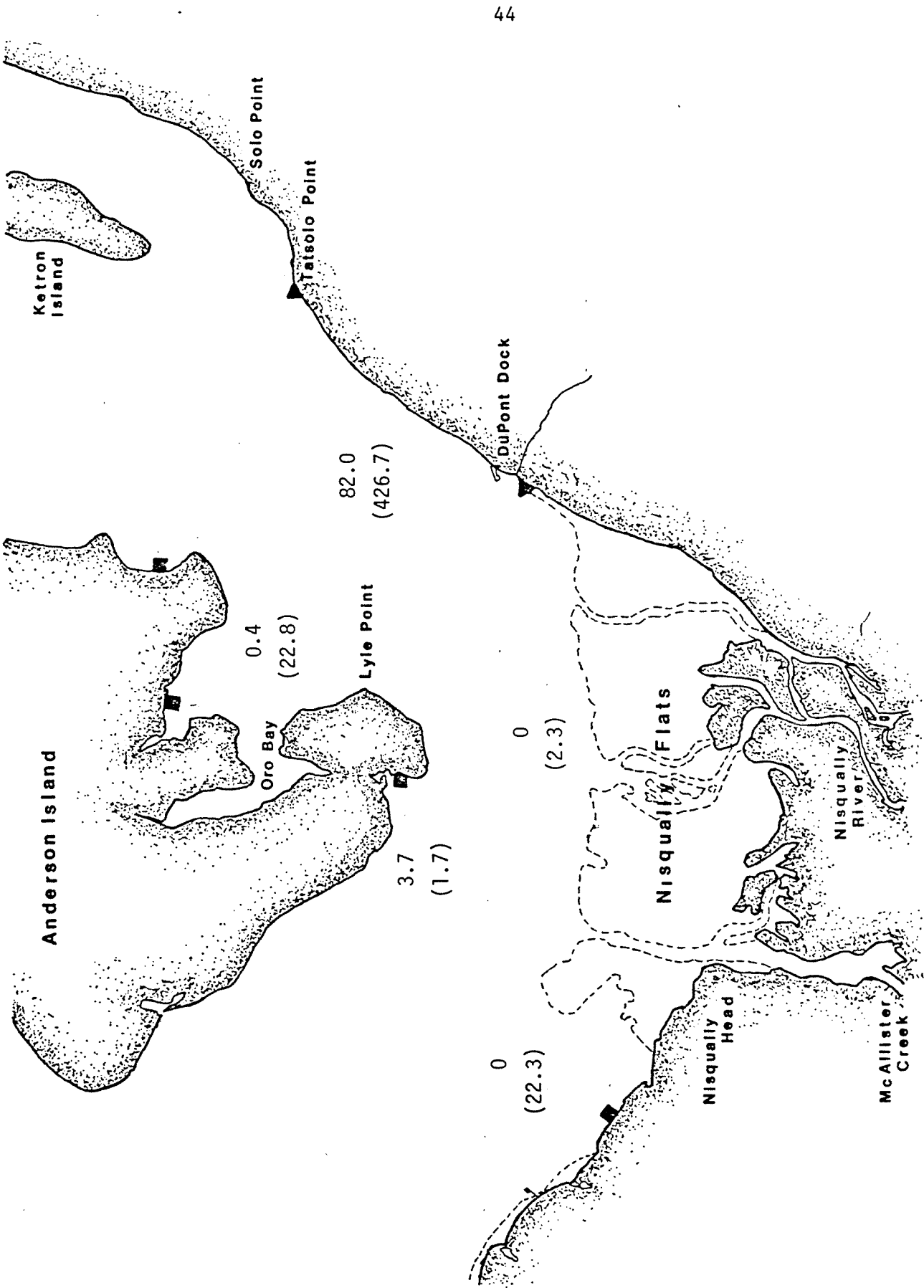


Fig. 12. Offshore (townnet) CPUE of chum salmon by transect, June 12-13, 1978, in the Nisqually Reach. (Nighttime CPUE is in parentheses under daytime CPUE.)

considerably in most individual collections. It was not unusual to see three length modes in one sample with a range in length from 40 mm to 100 mm FL. Smaller fish (many of which were probably wild stocks) were more characteristic of non-DuPont shoreline sites (Figs. 13 and 14).

The extended time period during which chum were caught, and the corresponding increase in fish length, indicated prolonged use of the Nisqually Reach nearshore environments as a nursery area (Figs. 15 and 16, Table 12). However, increasing mean length of chum may be a result of increasing size of resident fish and/or increasing recruitment of larger fish into the system. Residency in the area varies with time of the year. Studies in the Hood Canal by Whitmus and Olson (in press) indicate that early outmigrants move through the system at a faster rate than those later in the season.

Comparison with other areas indicates similar temporal distributional patterns (see Iwamoto and Salo 1977 for review). In Washington studies, Sjolseth (1969) and Tyler (1964) reported chum migration peaks in May in Bellingham Bay. Hood Canal studies by Schreiner (1977) and Bax et al. (1978) found peaks in early to late May in 1975, to late May and mid to late June in 1976, and late May to early July in 1977. Stober and Salo (1973) in Skagit/Similk bays found peak outmigration in late April and early May. In the Anderson Island area, Feller (1974) reported peak abundance in the 1970-1972 period, varying from mid-May to mid-June.

Quantitative comparisons of temporal distribution between 1977 and 1978 were limited by differences in sampling methodology, as discussed previously. Because of the spatial variability and mobility of the schooling chum salmon, more frequent samples are likely required to

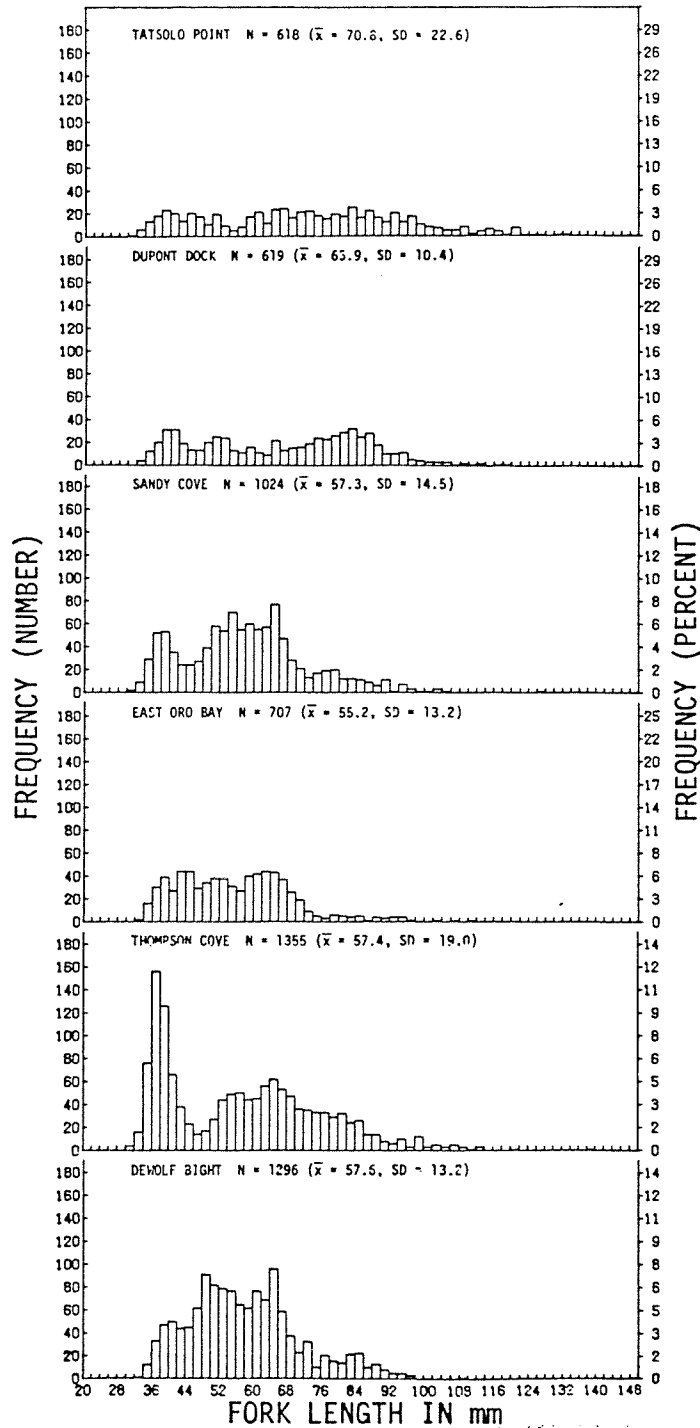


Fig. 13. Length frequency of chum salmon by site from daytime beach seine collections in the Nisqually Reach, 1978.

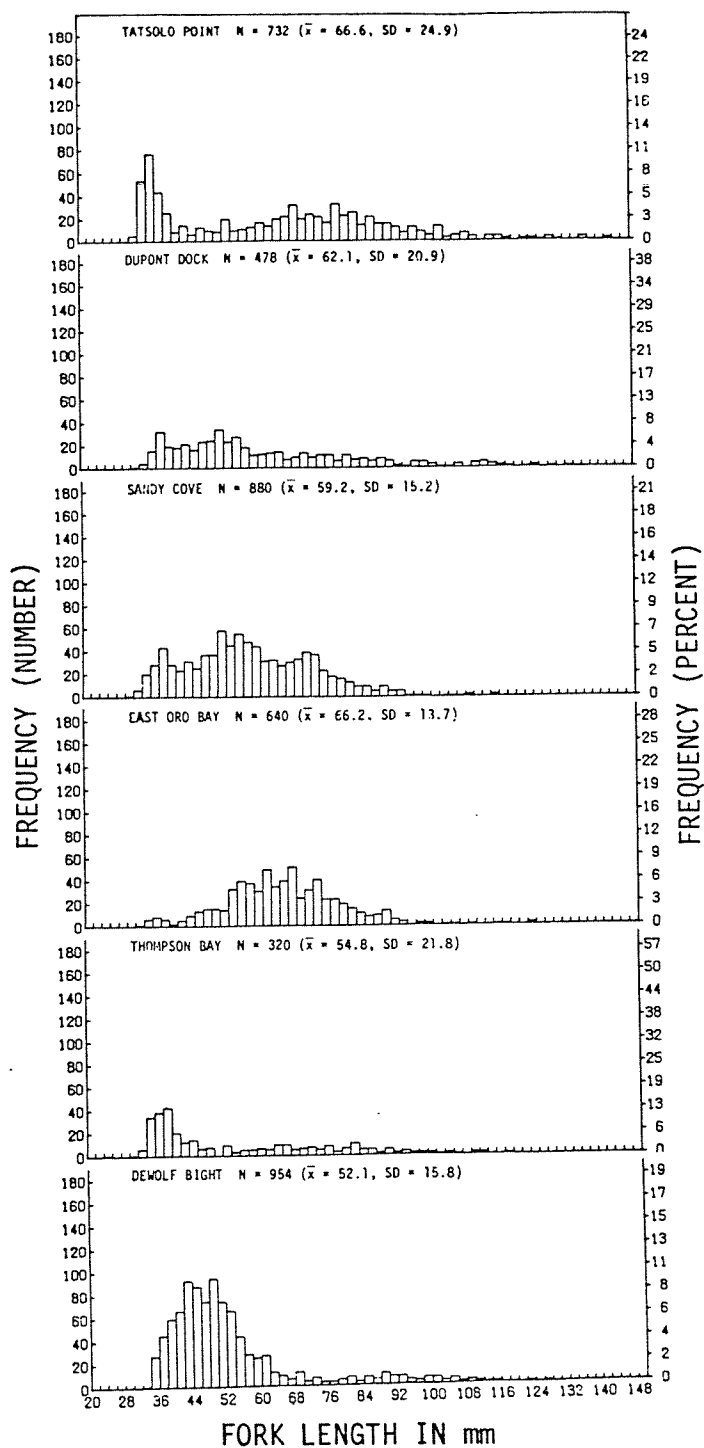


Fig. 14. Length frequency of chum salmon by site from night beach seine collections in the Nisqually Reach, 1978.

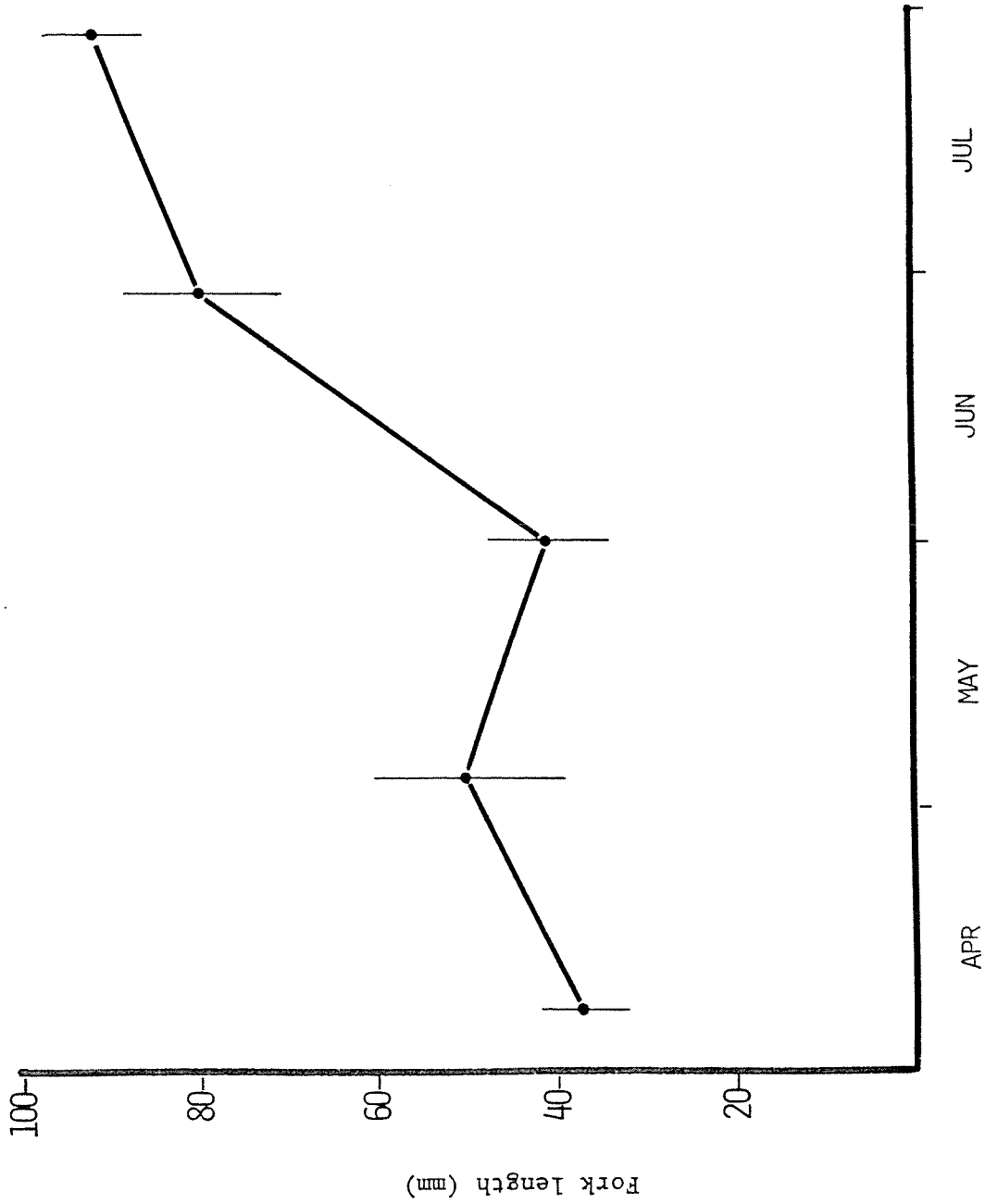


Fig. 15. Growth of juvenile chum salmon caught in the DuPont-Nisqually study area, southern Puget Sound, WA, 1977. Vertical lines represent  $\pm 1$  standard deviation in length from the mean ( $\bullet$ ).

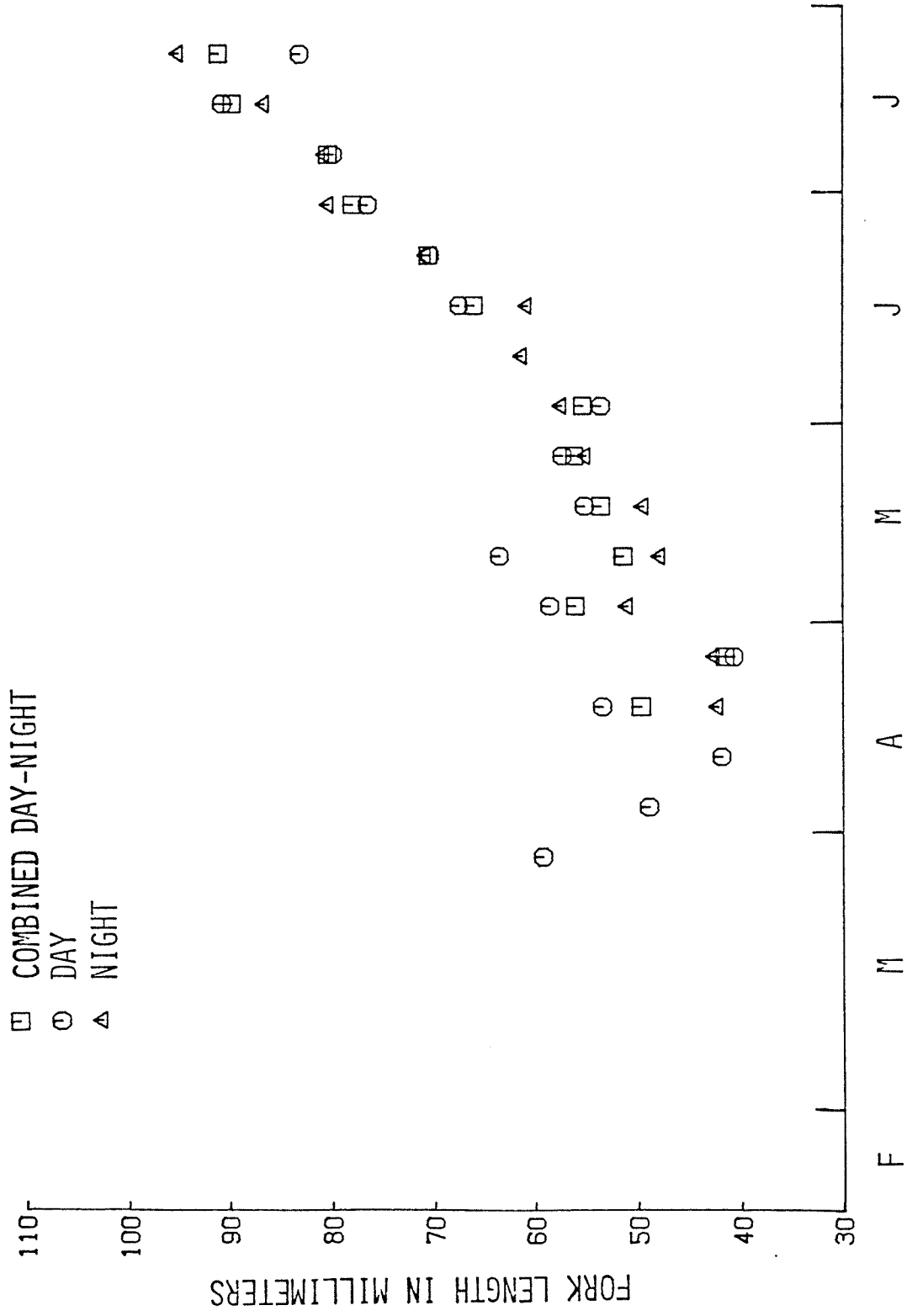


Fig. 16. Weekly mean length of chum salmon collected by beach seine from February 15 to July 20, 1978 in the Nisqually Reach, Washington.

Table 12. Mean fork length of chum in 1978 townet collections in the Nisqually Reach during the day, night, and overall (day and night, combined).

Date	Day			Night			Overall		
	$\bar{x}^1$	SD <sup>2</sup>	N <sup>3</sup>	$\bar{x}$	SD	N	$\bar{x}$	SD	N
April 3-4	60.3	15.5	12	58.1	28	87	58.3	9.0	99
April 17-18	0	0	0	46.1	10.9	44	46.1	10.9	44
May 7-8	36.0	0	1	43.7	13.1	21	43.4	12.9	22
May 28-29	80.3	11.0	22	66.9	16.7	202	68.2	16.7	224
June 12-13	70.3	7.5	130	74.3	14.1	372	73.1	13.1	497

<sup>1</sup>Mean

<sup>2</sup>Standard deviation

<sup>3</sup>Number of measurements

accurately reflect temporal distribution. In addition, sinking sets made during 1977 may be inappropriate in sampling juvenile salmon fry, especially in areas with steep subtidal gradients. Schreiner et al. (1977) indicated the floating beach seine was more effective in sampling juvenile salmonids than the sinking beach seine.

Spatial Distribution. Because samples were not taken along other shorelines (e.g., Anderson Island), the spatial distribution of chum fry in the Nisqually Reach during 1977 could not be determined.

In 1978, beach seine catches were greatest at the two sites northwest of the Nisqually River (Thompson Cove and DeWolf Bight). Both sites, but especially DeWolf Bight, are characterized by an extensive, shallow nearshore zone. Mean CPUE at Thompson Cove was over twice as large as at sites along shorelines east of the Nisqually River (Table 13). While overall CPUE was greatest at sites along the western shorelines, there was evidence of a seasonal shift in the spatial distribution of the outmigrating chum fry. From February through April, CPUE was substantially greater along the West Anderson Island and the west Nisqually Reach shorelines, whereas in May, catches were greatest along the west mainland shoreline (Figs. 17-21). In June chum CPUE was high at all but the DeWolf Bight station (west Nisqually Reach), and by July, the chum adopted a more even distribution, as mean monthly CPUE was similar along all shorelines. CPUE of chum along the DuPont shoreline was greatest in May and June and indicated outmigration along this shoreline occurred late in the season.

The offshore spatial distribution of chum fry as indicated by townet samples during 1978 (Figs. 8-12) was similar along all shorelines through mid-May. In late May and mid-June, catches increased markedly along the

Table 13. Average beach seine catch (by site) of chum salmon in 1978 during the day, night, and overall (day and night collections pooled) in the Nisqually Reach study area, Washington.

Site	Day			Night			Overall		
	Mean <sup>1</sup> CPUE	SD <sup>2</sup>	N <sup>3</sup>	Mean CPUE	SD	N	Mean CPUE	SD	N
Tatsolo Point	49.3	109.2	40	54.6	62.2	28	51.5	92.2	68
DuPont Dock	28.3	51.7	40	25.6	41.1	28	27.2	47.3	68
Sandy Cove	91.3	208.7	42	59.4	114.2	28	78.5	176.7	70
East Oro	34.5	78.8	43	53.0	78.8	28	41.8	78.8	71
Thompson Cove	250.2	577.5	43	16.0	29.2	28	157.9	462.3	71
DeWolf Bight	131.3	264.6	42	110.1	175.5	28	122.9	231.9	70

<sup>1</sup>Calculated as: total fish caught/total hauls.

<sup>2</sup>Standard deviation.

<sup>3</sup>Number of hauls.

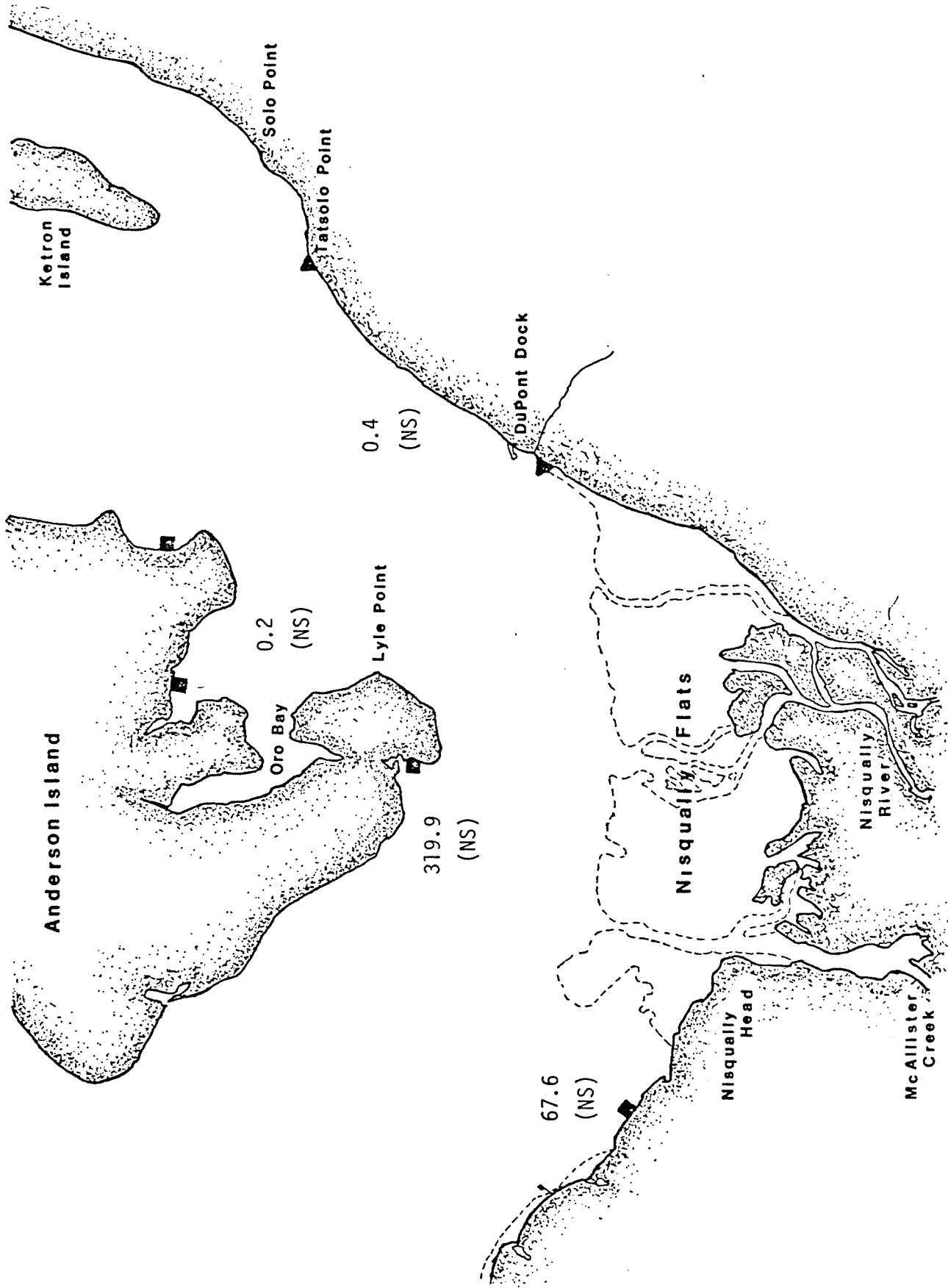


Fig. 17. Inshore (beach seine) CPUE of chum salmon by shoreline, February-March 1978, in the Nisqually Reach. (Nighttime CPUE in parentheses under daytime CPUE.)

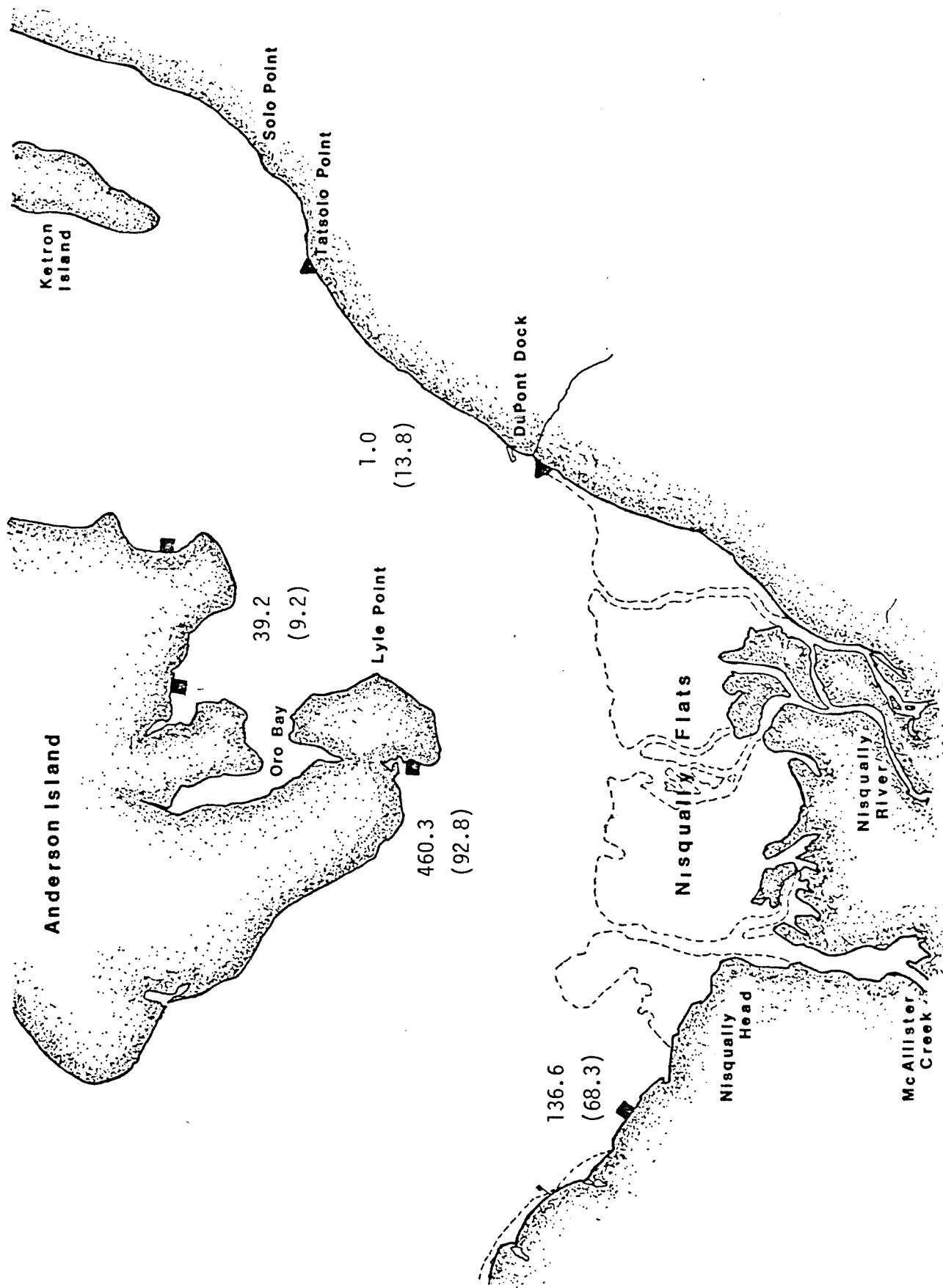


Fig. 18. Inshore (beach seine) CPUE of chum salmon by shoreline, April 1978, in the Nisqually Reach. (Nighttime CPUE in parentheses under daytime CPUE.)

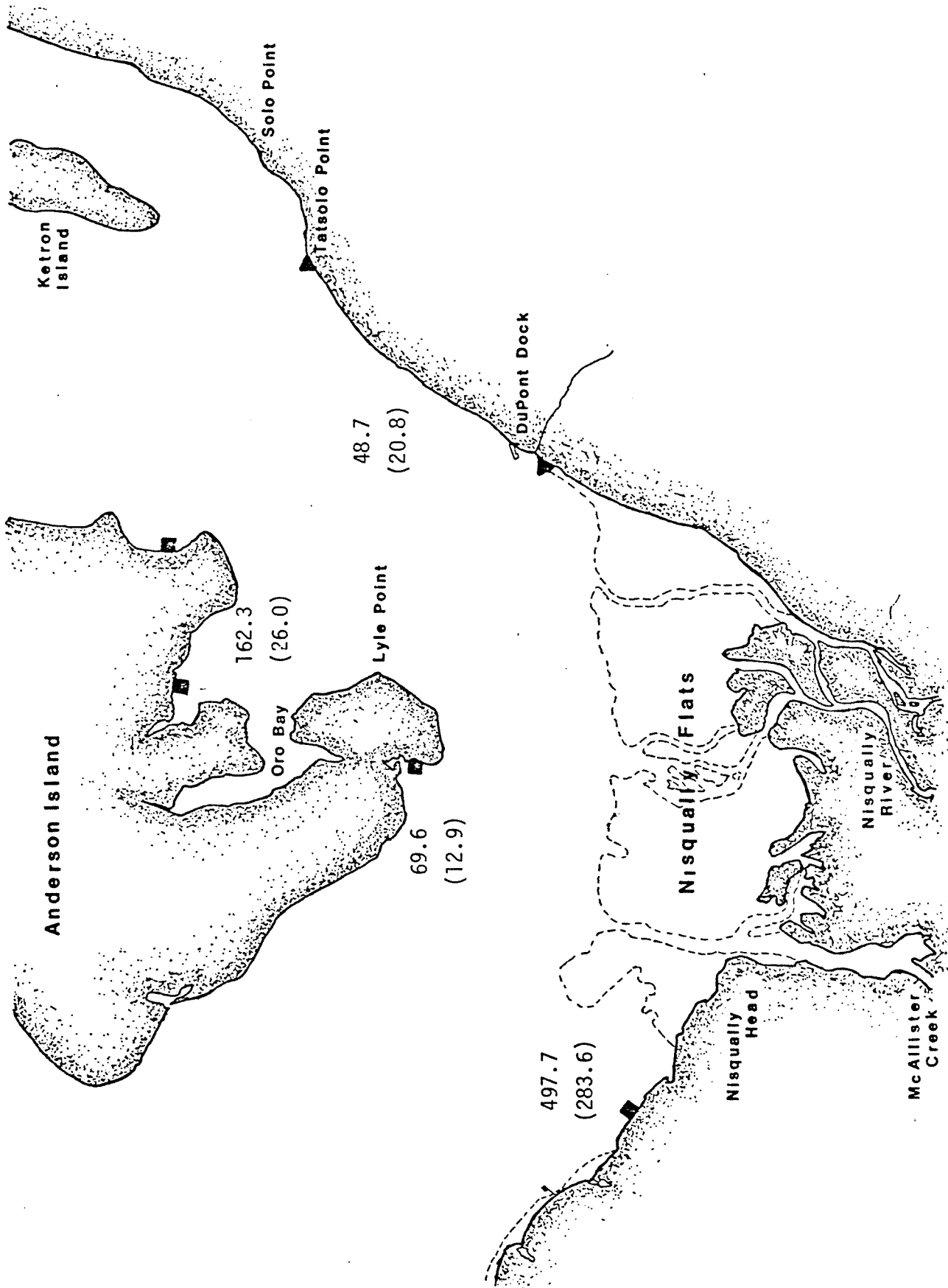


Fig. 19. Inshore (beach seine) CPUE of chum salmon by shoreline, May 1978, in the Nisqually Reach. (Nighttime CPUE in parentheses under daytime CPUE.)

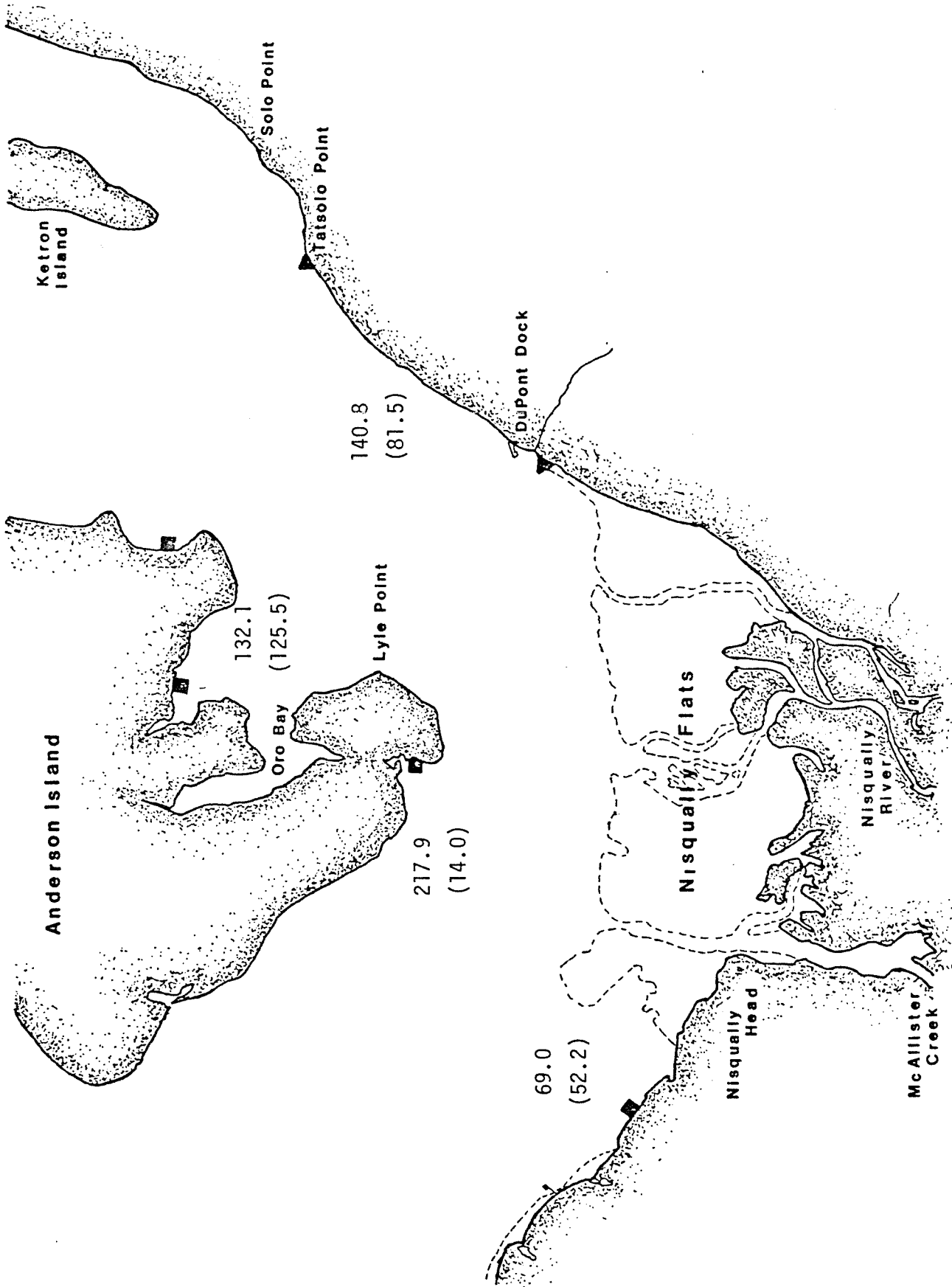


Fig. 20. Inshore (beach seine) CPUE of chum salmon by shoreline, June 1978, in the Nisqually Reach. (Nighttime CPUE in parentheses under daytime CPUE.)

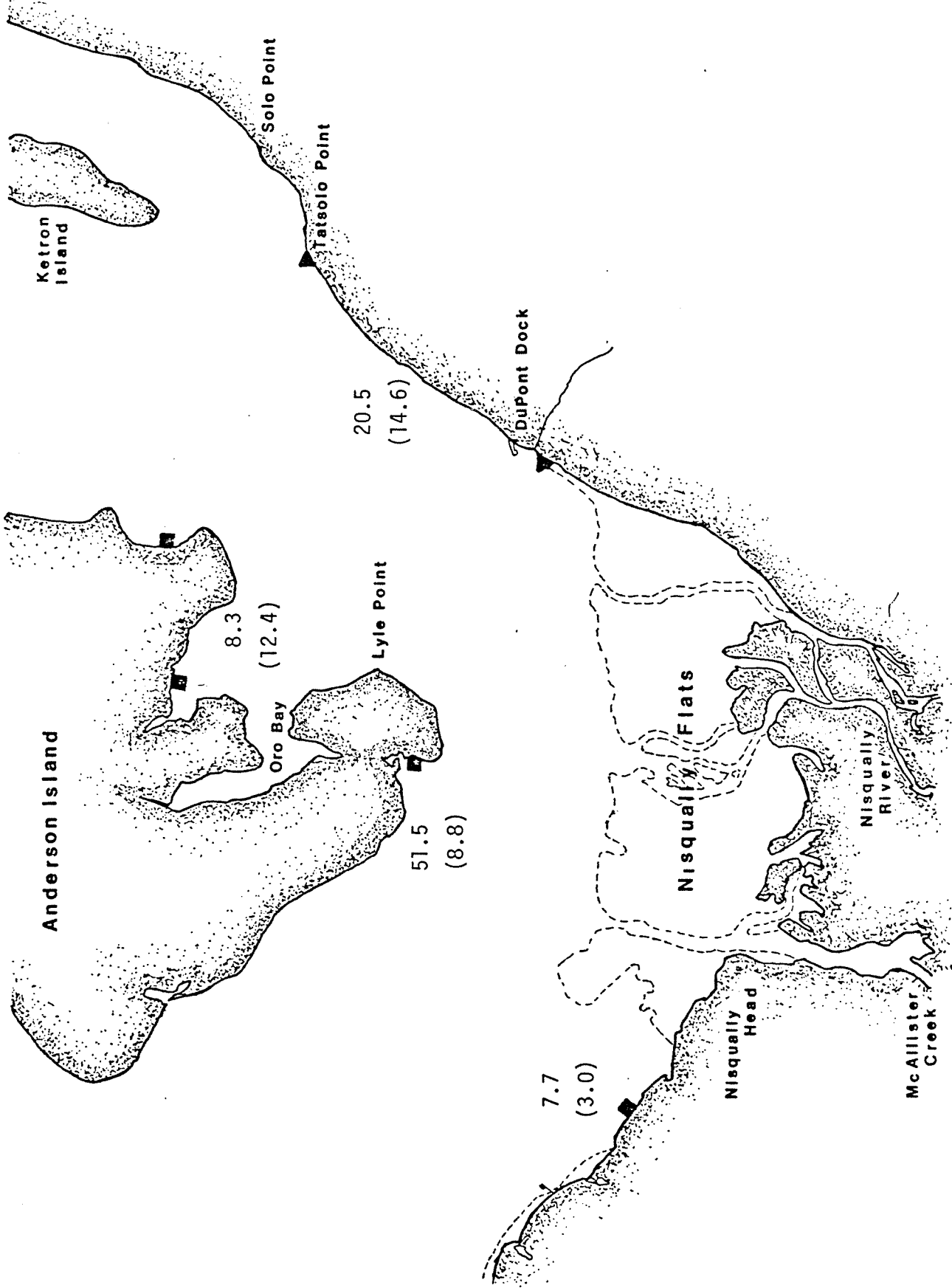


Fig. 21. Inshore (beach seine) CPUE of chum salmon by shoreline, July 1978, in the Nisqually Reach. (Nighttime CPUE in parentheses under daytime CPUE.)

DuPont shoreline, and to a lesser degree along other shorelines. Overall, mean townet CPUE was greatest along the DuPont shoreline (Table 14). The largest townet catches along the DuPont shoreline coincided with the largest beach seine catches, and suggested much of the outmigration along the DuPont shoreline may be in more offshore waters, out of the range of the beach seine. WDF townet surveys for herring in the reach also found large catches of chum occurred in June along the DuPont shoreline, specifically in Cormorant Pass (Penttilla, personal communication). Because of the greater relative amount of shallower habitats, much of the movements of fish along other shorelines may be more inshore. Lack of shallow habitats along the steeper DuPont shoreline may result in chum occurring in a portion of the water column more fishable by the townet. Visual observations along the DuPont shoreline also found large numbers of chum in more offshore waters, more so than along other shorelines.

Numerous factors interact to determine the spatial distribution of chum salmon in the Nisqually Reach. Among these factors are: food abundance, predation, environmental variables (e.g., tide, temperature), size of fish, preferred habitats, movements of river waters, and timing of outmigration from freshwater. It is important to note as Healy (1978) suggests that there may be annual variability in the distribution of juvenile salmon. Maintaining annual (and seasonal) unpredictability in spatial distribution may be a predator defense mechanism of the chum. Precise explanations of the spatial distribution of chum in the Nisqually Reach are not possible with the existing data; however, several reasons can be suggested. Trophic studies of chum (see PART II) indicated food habits of chum may be important. There was a change in the prey spectra

Table 14. Average townet catch (by transect) of chum salmon in 1978 during the day, night, and overall (day and night collections pooled) in the Nisqually Reach study area, Washington.

Site	Day			Night			Overall		
	Mean <sup>1</sup> CPUE	SD <sup>2</sup>	N <sup>3</sup>	Mean CPUE	SD	N	Mean CPUE	SD	N
DuPont Shoreline	19.2	37.6	15	108.8	213.3	12	59.0	148.6	27
East Anderson Island Shoreline	0.5	1.1	25	16.5	27.8	24	8.3	20.9	49
West Anderson Island Shoreline	0.7	1.7	15	5.2	6.5	16	2.9	5.2	31
West Mainland (Reach)	0.1	0.3	14	5.1	10.7	14	2.6	7.9	28
Middle Reach	0	0	22	1.5	1.7	19	0.7	1.4	41

<sup>1</sup>Calculated as: Total fish caught/total tows.

<sup>2</sup>Standard deviation.

<sup>3</sup>Number of tows.

of chum in 1978 from harpacticoid copepods (epibenthic organisms) found in shallow habitats in March to calanoid copepods (planktonic) in June. Studies of these prey (see Simenstad and Kinney 1978 - harpacticoids, Plankton studies section this report - calanoids) indicate harpacticoids are most abundant in April and May, whereas calanoids are most abundant in May-July. Thus, chum may move rapidly through the DuPont area early in the year because of low abundance of harpacticoids (a function of the lack of shallow sublittoral habitats) and calanoids (due to their low seasonal abundance). In addition, early in the season, the chum are smaller and likely more subject to the strong currents, particularly those on ebftide, characteristic of the DuPont shoreline. Length frequencies indicated a relative lack of smaller fish (<50 mm FL) at Tatsolo Point and DuPont Dock. Later in the season, as chum size increases, harpacticoid abundance decreases, and calanoid abundance increases, chum occur in greater numbers along the DuPont shoreline, especially in more offshore waters. The steep subtidal region of the DuPont shore may also increase exposure to predators moving up from deeper water. Allen (1974) reported preference by young chum fry for areas in the intertidal zone with cover and low current velocities.

Because of the proximity to the Nisqually River, river water movements are probably important in influencing juvenile chum distribution; however, the sampling was not designed to study this. Early in the season during spring runoff, the outflow of water from the Nisqually may "push" fish north and west. In addition, the outmigrating chum may seek a gradual salinity gradient (McInerney 1964), which is probably more characteristic of the reach northwest of the Nisqually

River. Yearly differences in freshwater outflow from the Nisqually River may, therefore, cause annual variability in chum distribution. Hurley and Woodall (1968), Schreiner (1977), and Healy (1978) have suggested the importance of river water movements on juvenile salmon distribution.

Relationship to Releases of Hatchery Reared Fish. Both wild and hatchery reared stocks of fish use the various shorelines. Sampling in 1977 was too infrequent to suggest any relationship between CPUE and releases of hatchery fish; thus, only 1978 releases into McAllister Springs and the Nisqually River (Table 15) will be considered. However, fish from other areas, such as Chambers Creek, probably utilize the area to some degree during outmigration. It is recognized that only a mark-recapture program can prove that CPUE peaks and declines are due to movements of hatchery reared fish.

Catch-per-unit-effort data indicated peaks usually within several days after releases and suggested rapid movement into the reach after release. For instance, on March 30, 1978, a CPUE peak was observed at Thompson Cove and DeWolf Bight and was primarily fish of the same size as released two days previously in McAllister Creek. In general, CPUE peaks after hatchery releases did not occur at all sites but were restricted to several sites.

Not all releases from McAllister Creek, however, were reflected by peaks in CPUE. As indicated by Cole (personal communication) for the Nisqually River, chum may outmigrate rapidly (within several days) from McAllister Creek into the reach. Once into the reach, the chum may also move rapidly out of the system. Thus, because of this rapid movement out

Table 15. Releases of chum salmon in 1978 into waterways entering the Nisqually Reach.

Release Site <sup>1</sup>	Release Date (1978)	Fish/lb.	No. of lbs.	Number
McAllister Creek	3/28	214	5470	1,170,580
McAllister Creek	4/13	544	1300	707,200
McAllister Creek	5/12	270	200	54,000
McAllister Creek	5/19	240	1259	302,160
McAllister Creek	5/26	228	606	138,168
McAllister Creek	5/27	228	1329	303,012
McAllister Creek	5/31	190	2131	404,890
Nisqually River	6/1	~400	~2125	~850,000
TOTAL				3,930,010

<sup>1</sup> McAllister Creek releases by WDF, Nisqually River releases by Nisqually Indian Tribe.

of the system, samples three or four days after releases could have missed the bulk of the released fish.

Movements of hatchery reared fish through the area in April and May are also indicated by marked increases in weekly mean length followed by decreases (Fig. 16).

Diel Behavior Patterns. Because of a lack of nighttime beach seine and daytime townet samples in 1977, there was concern fish may have been present in large numbers in periods not sampled. Consequently, day and night samples were taken by both gear types in 1978. Both the beach seine CPUE and its coefficient of variation decreased at night when compared to day (Table 16), indicating a more clumped (schooled) distribution of fry during the day. Schooling behavior in daytime would be important to the small fish as a predator defense mechanism (Eibl-Eibesfeldt 1970, Shaw 1978). Large coefficient of variations for between-haul variability in daytime CPUE (values ranged up to 141 percent) also indicated patchy (schooling) fry distribution.

Townet CPUE was greater at night than during the day (Table 17). Similar to the beach seine, the coefficient of variation for townet CPUE was greater during the daytime. This may be an indication of an offshore movement of fry and dispersion of schools at night. Bax et al. (1978) noted similar diel behavior patterns in the Hood Canal in 1977.

Lengths of chum fry in beach seine and townet samples were larger and less variable during the day than at night (Tables 16 and 17).

Substantial diel variation in beach seine CPUE occurred at Thompson Cove; daytime CPUE at Thompson Cove was over 15 times greater than CPUE at night. The largest diurnal and smallest nocturnal catches of all the

Table 16. Comparison of day-night beach seine catches of chum salmon from April 17 to July 20, 1978 in the Nisqually Reach study area, Washington

	Day	Night
<u>CPUE</u>		
Mean CPUE	121.2	53.1
SD <sup>1</sup>	263.9	100.2
CV <sup>2</sup>	218 %	188%
No. of hauls	148	168
<u>Length (mm)</u>		
Mean length	61.5	60.0
SD	17.9	19.3
CV	29.1%	32.2%
No. of measurements	4582	4004
<sup>1</sup> Standard deviation. <sup>2</sup> Coefficient of variation.		

Table 17. Comparison of day-night surface townet catch of chum salmon during 1978 in the Nisqually Reach study area, Washington.

	Day	Night
<u>CPUE</u>		
Mean CPUE	3.4	22.2
SD <sup>1</sup>	16.5	86.5
CV <sup>2</sup>	485.0%	389.6%
No. of tows	91	86
<u>Length (mm)</u>		
Mean length	70.3	67.6
SD	11.3	16.0
CV	16.1%	23.7%
No. of measurements	165	719
<sup>1</sup> Standard deviation <sup>2</sup> Coefficient of variation		

sites occurred at Thompson Cove (Table 13). These data suggest Thompson Cove may be used as a feeding area and/or refuge from predation during the day, with fish moving out at night.

### Coho Salmon

Migratory Peaks and Routes. During 1977, coho was the rarest of the five salmon species caught, and, as a result, migratory peaks were poorly defined (Tables 10 and 11). All coho in 1977 were caught after May 3. Peak abundance was observed during mid-May at Tatsolo Point and may be related to the WDF release of approximately 1.4 million smolts into Sequelitchew Lake, four days prior to sampling.

Coho salmon was the second most abundant salmonid species caught during 1978 (Tables 5 and 8) and all but four coho caught were smolts. Outmigration of coho occurred from April 10 through July 20. Coho salmon did not occur in the Nisqually Reach in waves as did chum (as evidenced by multiple peaks), but instead exhibited one major outmigration period in May (Fig. 22, Appendix 6). There was, however, a small peak in mid-June. Most fish were caught at sites along Anderson Island shorelines, particularly at Thompson Cove (Table 18). Substantially smaller CPUE's were characteristic of the DuPont shoreline and western mainland shoreline. DuPont shoreline catches of coho were greatest after late May, similar to chum, although inshore abundance of coho along the DuPont shoreline was probably underestimated because of avoidance. On several occasions (especially in June and July) schools of several hundred coho were seen around Tatsolo Point, but subsequent beach seine sets resulted in most fish avoiding the net because of the steep subtidal dropoff.

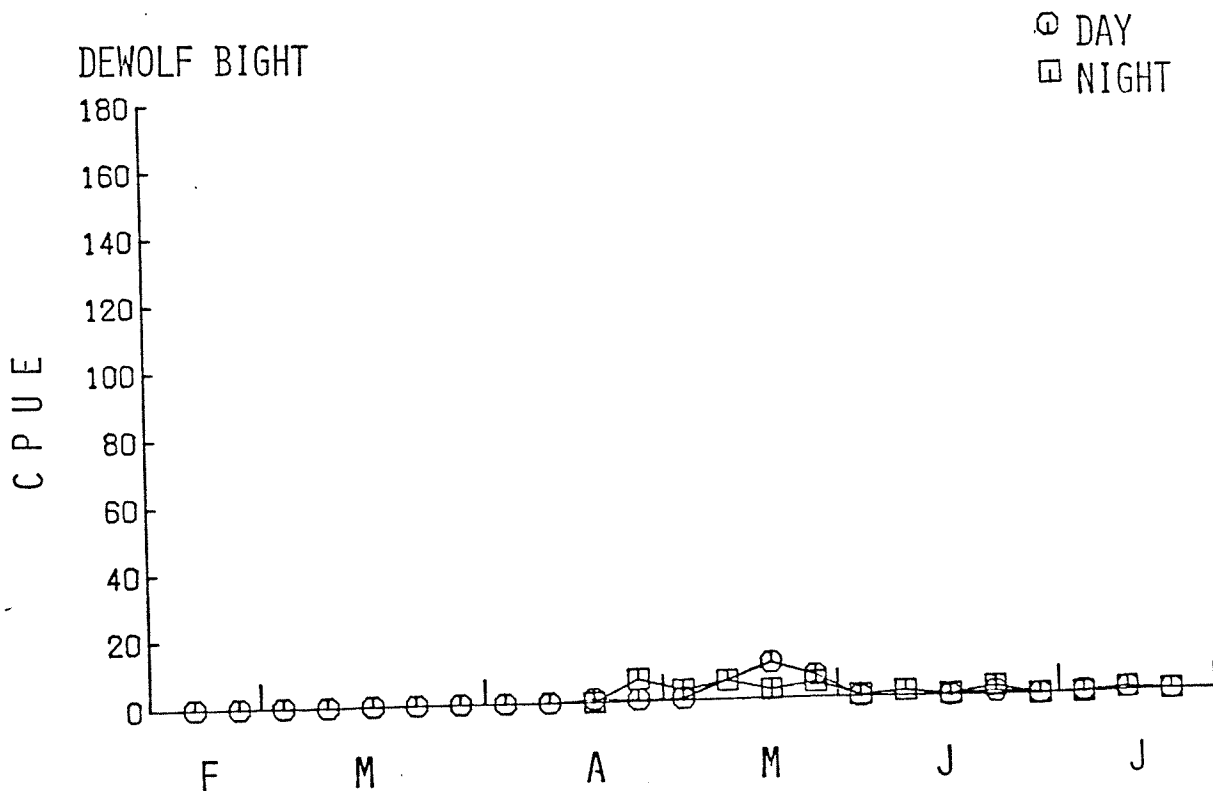
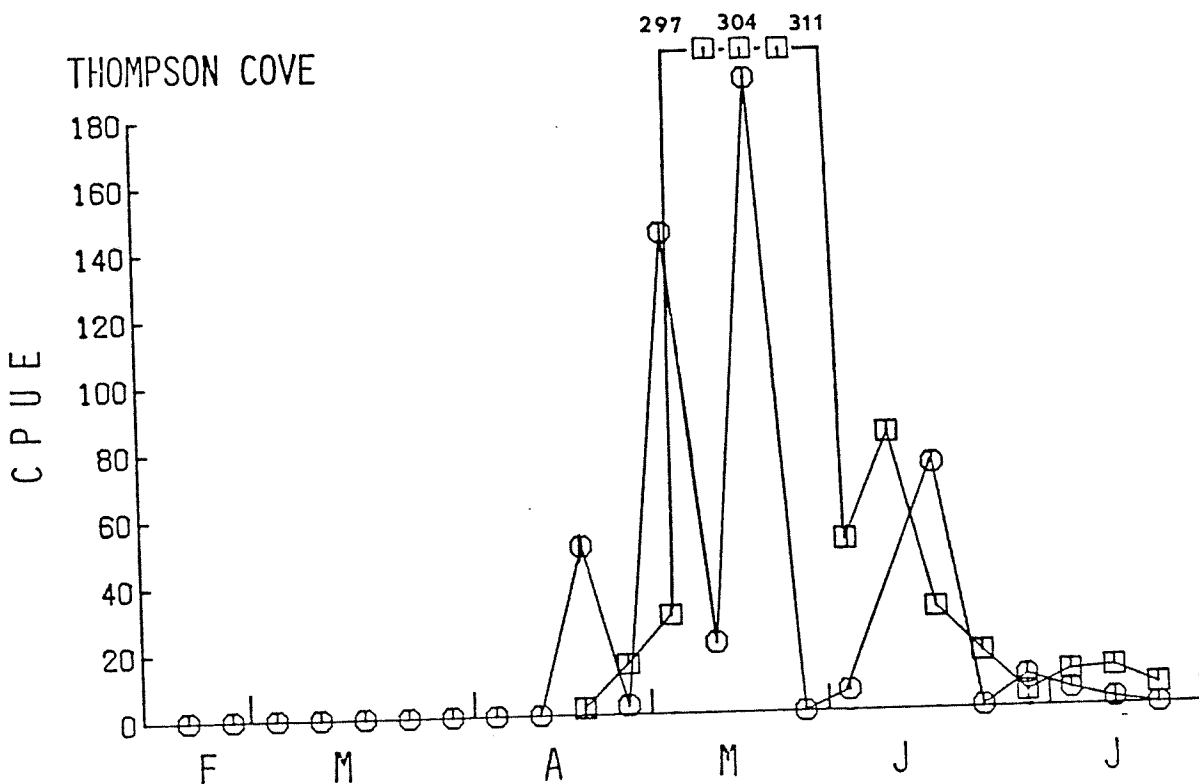


Fig. 22. Weekly CPUE of coho salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington.

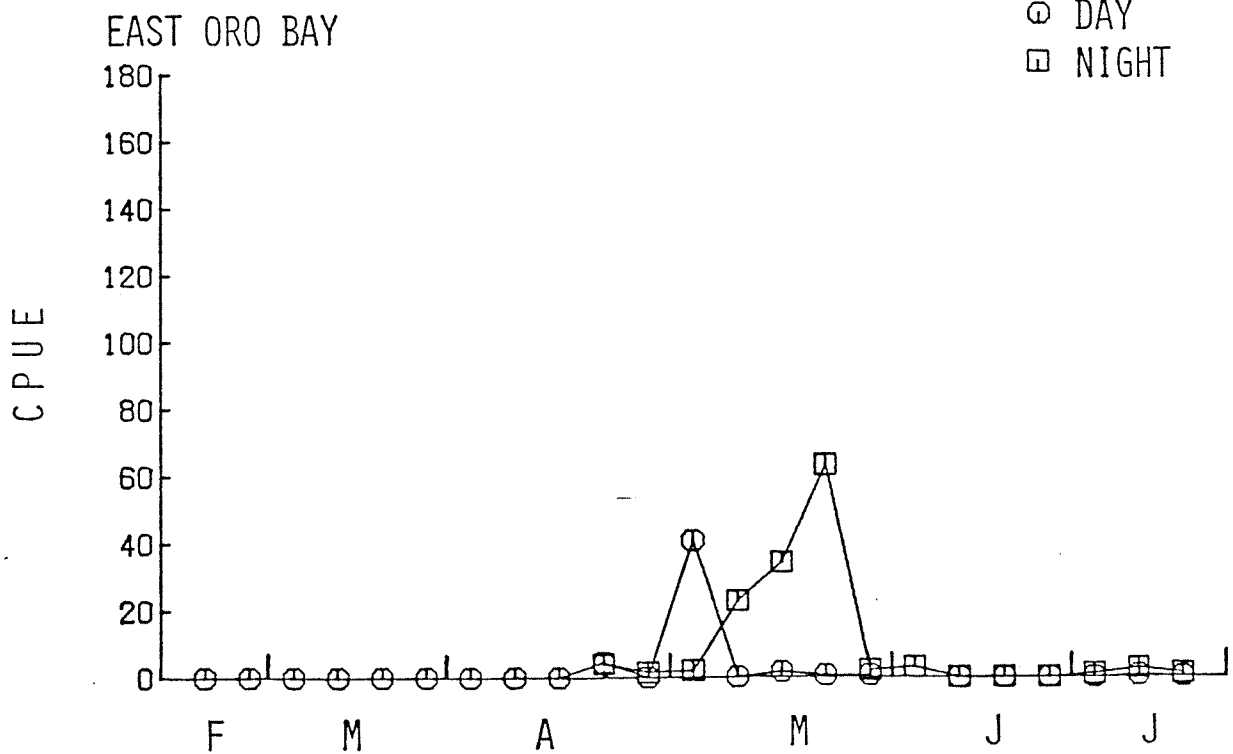
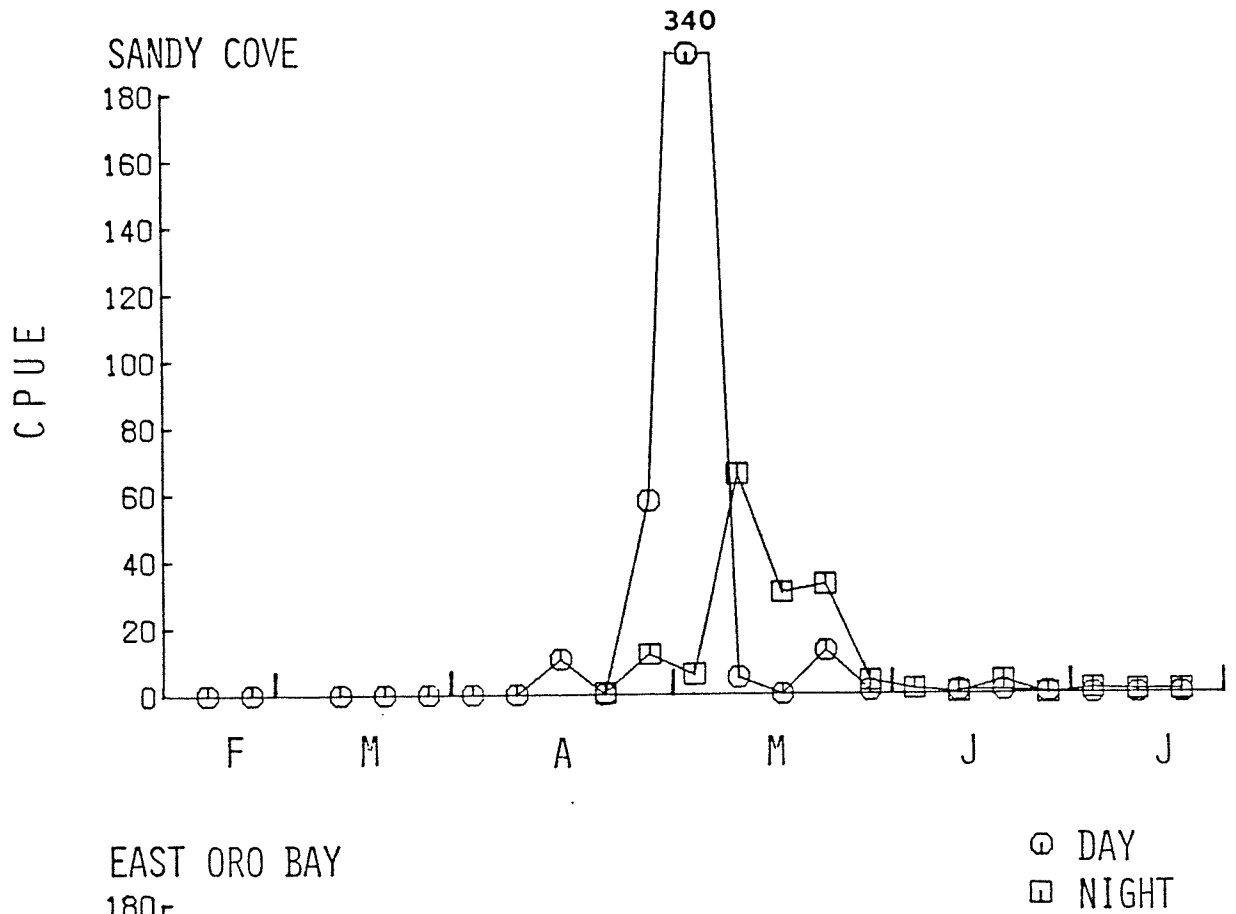


Fig. 22. Weekly CPUE of coho salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington. (continued)

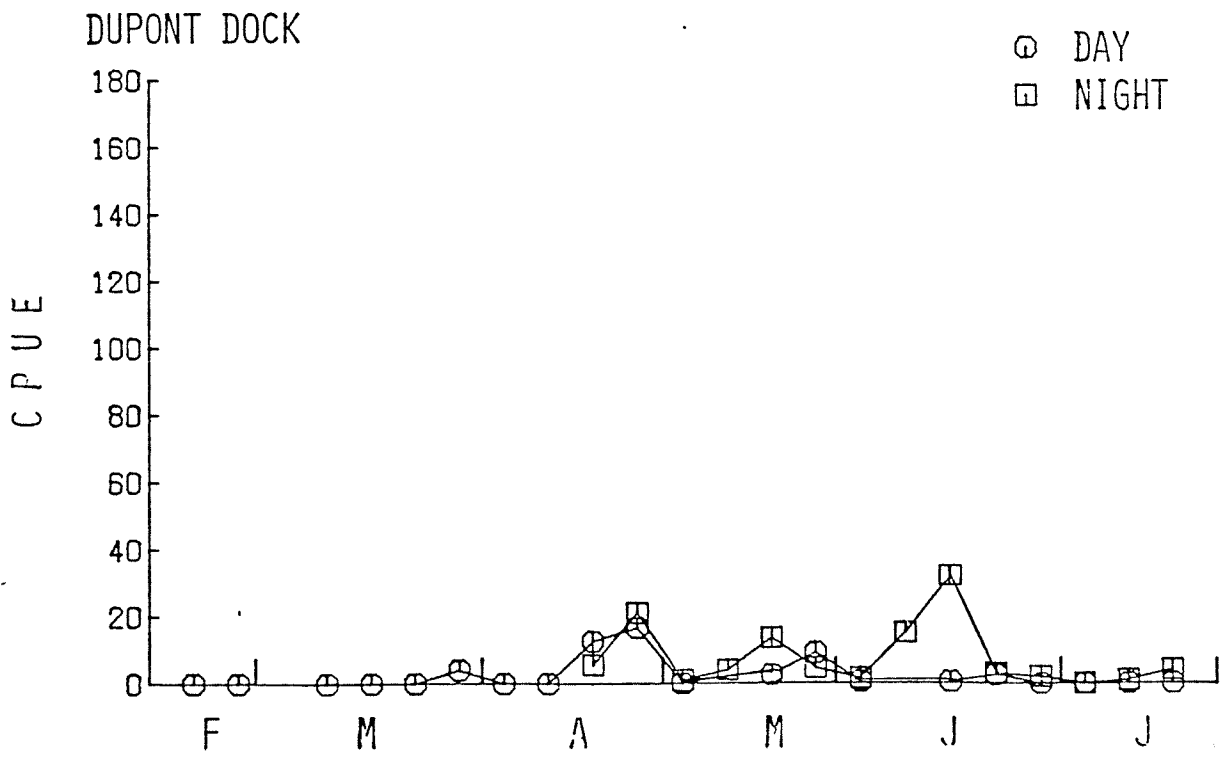
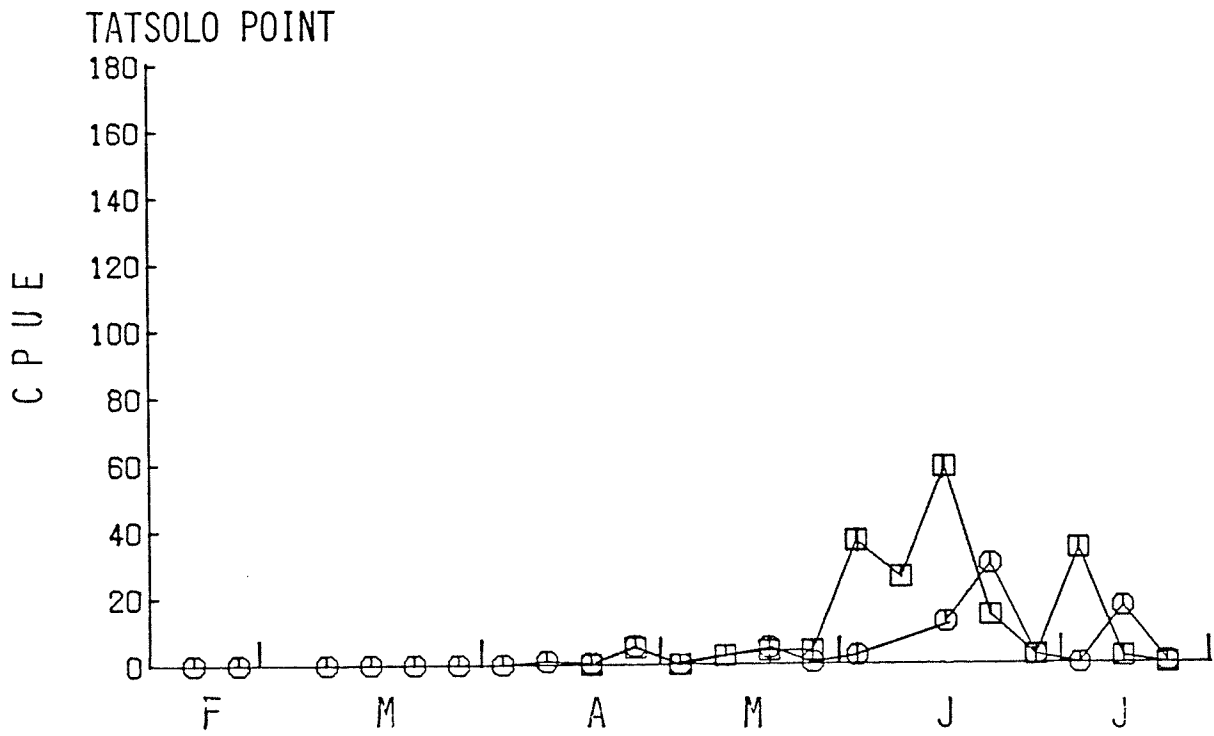


Fig. 22. Weekly CPUE of coho salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington. (continued)

Table 18. Average beach seine catch (by site) of coho salmon in 1978 during the day, night, and overall (day and night collections pooled) in the Nisqually Reach study area, Washington.

Site	Day			Night			Overall		
	Mean CPUE <sup>1</sup>	SD <sup>2</sup>	N <sup>3</sup>	Mean CPUE	SD	N	CPUE	SD	N
Tatsolo Point	3.9	10.5	40	13.1	19.5	28	7.7	15.4	68
DuPont Dock	2.4	6.3	40	7.7	10.8	28	4.6	8.8	68
Sandy Cove	18.3	104.8	42	12.3	20.7	28	15.6	81.7	70
East Oro	2.3	8.8	43	9.9	19.2	28	5.3	14.2	71
Thompson Cove	23.0	62.3	43	83.7	141.1	28	46.9	104.4	71
DeWolf Bight	1.0	3.2	42	2.0	2.7	28	1.4	3.0	70

<sup>1</sup>Calculated as: total fish caught/total hauls.

<sup>2</sup>Standard deviation.

<sup>3</sup>Number of hauls.

Even considering difficulties of between-gear comparisons, townet catches of coho during both 1977 and 1978 were small relative to beach seine catches. Most coho (96 percent) caught in 1978 by townet occurred along the DuPont shoreline and most of these were caught in mid-June at night (Appendix 5). The small townet catches of coho relative to beach seine catches suggests: 1) coho may be better able to avoid the townet; and/or, 2) coho may remain closer inshore and hence be unavailable to the townet.

Mean fork length of coho increased relatively steadily during April and May (Fig. 23) while in June and July, lengths remained relatively constant.

Relationships to Releases of Hatchery Reared Fish. Releases of coho salmon into southern Puget Sound included releases into Sequelitchew Lake and the Nisqually River system (Table 19). The lack of any substantial increase in CPUE along the DuPont shoreline after Sequelitchew Lake releases in both 1977 and 1978 indicated coho moved rapidly out of Sequelitchew Creek and nearshore areas along the DuPont shoreline. These smolts may move across to Anderson Island or, as suggested by visual observations, into Cormorant Passage near Ketron Island.

Marked coho (both coded wire tags and fin clips) were recovered during beach seining in 1978. The first coho from an April 14 release of 50,942 fish into Ohop Creek (Table 20) were captured on May 1. Most recoveries of marked fish were between May 15-25 at the Thompson Cove site. (Recoveries of fish from extra sets periodically made at Thompson Cove were also included in the results.) Fish released May 5 into Tanawax Creek appeared mostly with the same group from the April 14 release into

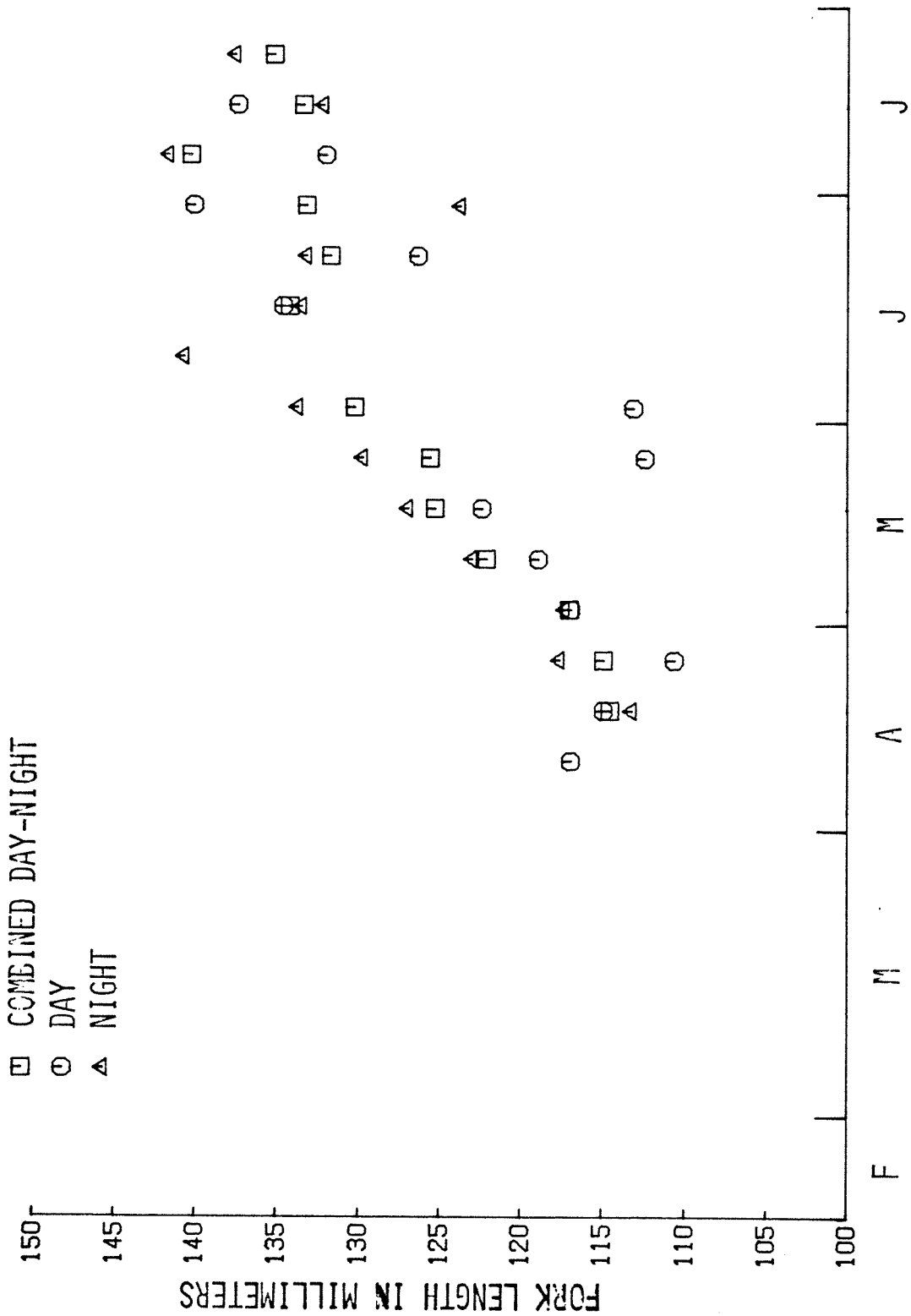


Fig. 23. Weekly mean length of coho salmon collected by beach seine from February 15 to July 20, 1978 in the Nisqually Reach, Washington.

Table 19. Releases of salmon in 1978, other than chum, into streams draining into the Nisqually Reach.<sup>1</sup>

Species	Site Planted	Date Planted	Number	Fish/lb
Coho	Ohop Creek	3/09/78	183,480	1,390
	Mashel River	4/14/78	183,632	23
	Ohop Creek	4/14/78	79,350	23 <sup>2</sup>
	Mashel River	4/19/78	295,000	20
	Sequalitchew Creek	4/30/78	50,000	26
	Murray Creek	5/1/78	150,274	331
	Tanwax Creek	5/2/78	150,274	312 <sup>3</sup>
	Tanwax Creek	5/5/78	72,580	20
	Sequalitchew Creek	5/19/78	867,800	26
Chinook	Mashel River	1/25/78	300,000	950
	Schorno Pond	5/15/78	362,424	140
	Schorno Pond	5/31/78	238,452	100
Pink	McAllister Creek	2/21/78	591,700	344
	Nisqually River	3/09/78	106,480	650

<sup>1</sup>Data from Washington Department of Fisheries and USFWS. Some releases are estimates, and may be revised after data have been completely compiled.

<sup>2</sup>51,405 fish marked with adipose clips and coded wire tags.

<sup>3</sup>42,040 fish marked with adipose clips and coded wire tags.



Ohop Creek and indicated these two releases probably moved out at approximately the same time. Most fish from the Tanwax Creek release were also recovered from Thompson Cove. Only 9 percent of fish captured with coded wire tags were recovered along the DuPont shoreline. Recoveries of finclipped fish without coded wire tags were probably from releases into the Deschutes River, but as the same marks were used on fish released different days in the Deschutes River, a more precise determination of release times is impossible.

Diel Behavior Patterns. Beach seine CPUE and mean length of coho were larger at night (Table 21). It is possible that avoidance or offshore movements by larger coho during the day may decrease daytime CPUE and length.

#### Chinook Salmon

Juvenile chinook salmon was the most abundant salmonid occurring in both beach seine and townet in 1977 (Tables 4 and 7), with the largest catches occurring in the beach seine at the outer Nisqually Delta station in late June. In 1978, chinook was the second and third most abundant salmonid caught by townet and beach seine, respectively (Tables 5 and 8).

Most chinook in both years were caught after late May, indicating a later outmigration than for other salmonid species. Peak inshore outmigration of chinook during 1978 occurred in mid- to late June (Fig. 24, Appendices 4c and 5) along the mainland shorelines of the Nisqually Reach. As with coho and chum, peak offshore catches occurred along the DuPont shoreline in late May and mid-June. As there was not a large number of chinook caught, differences between shorelines were not as marked as with coho and chum. Reduction of CPUE in July indicated most chinook had

Table 21. Comparison of day-night beach seine catches of coho salmon April 17 to July 20, 1978 in the Nisqually Reach study area, Washington.

	Day	Night
<u>CPUE</u>		
$\bar{X}$	14.3	21.3
SD <sup>1</sup>	65.4	64.9
CV <sup>2</sup>	457%	301%
No. of hauls	148	168
<u>Length (mm)</u>		
$\bar{X}$	118.4	128.8
SD	21.9	20.0
CV	18.5%	15.5%
No. of measurements	638	1137
<sup>1</sup> Standard deviation.		
<sup>2</sup> Coefficient of variation.		

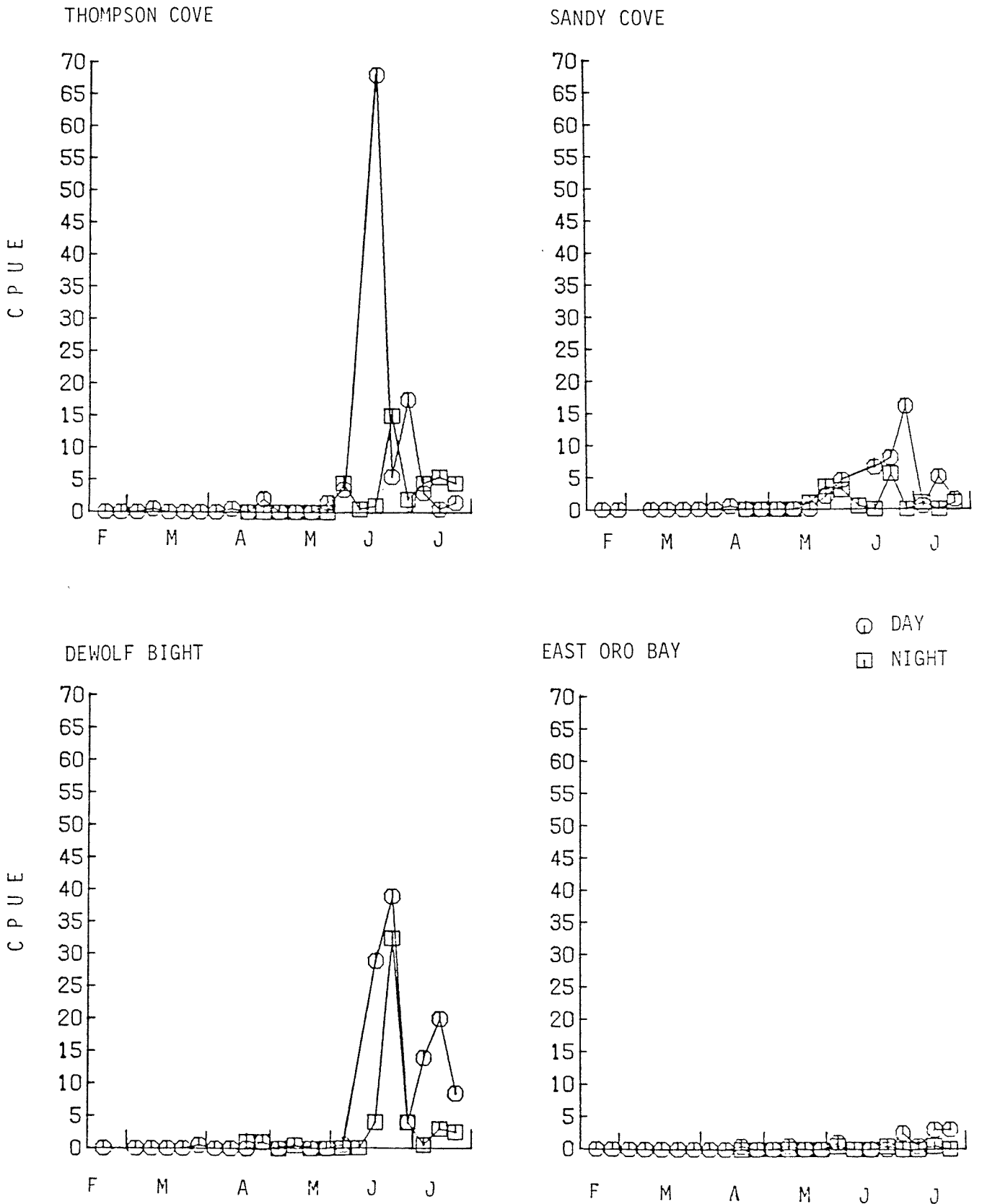


Fig. 24. Weekly CPUE of chinook salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington.

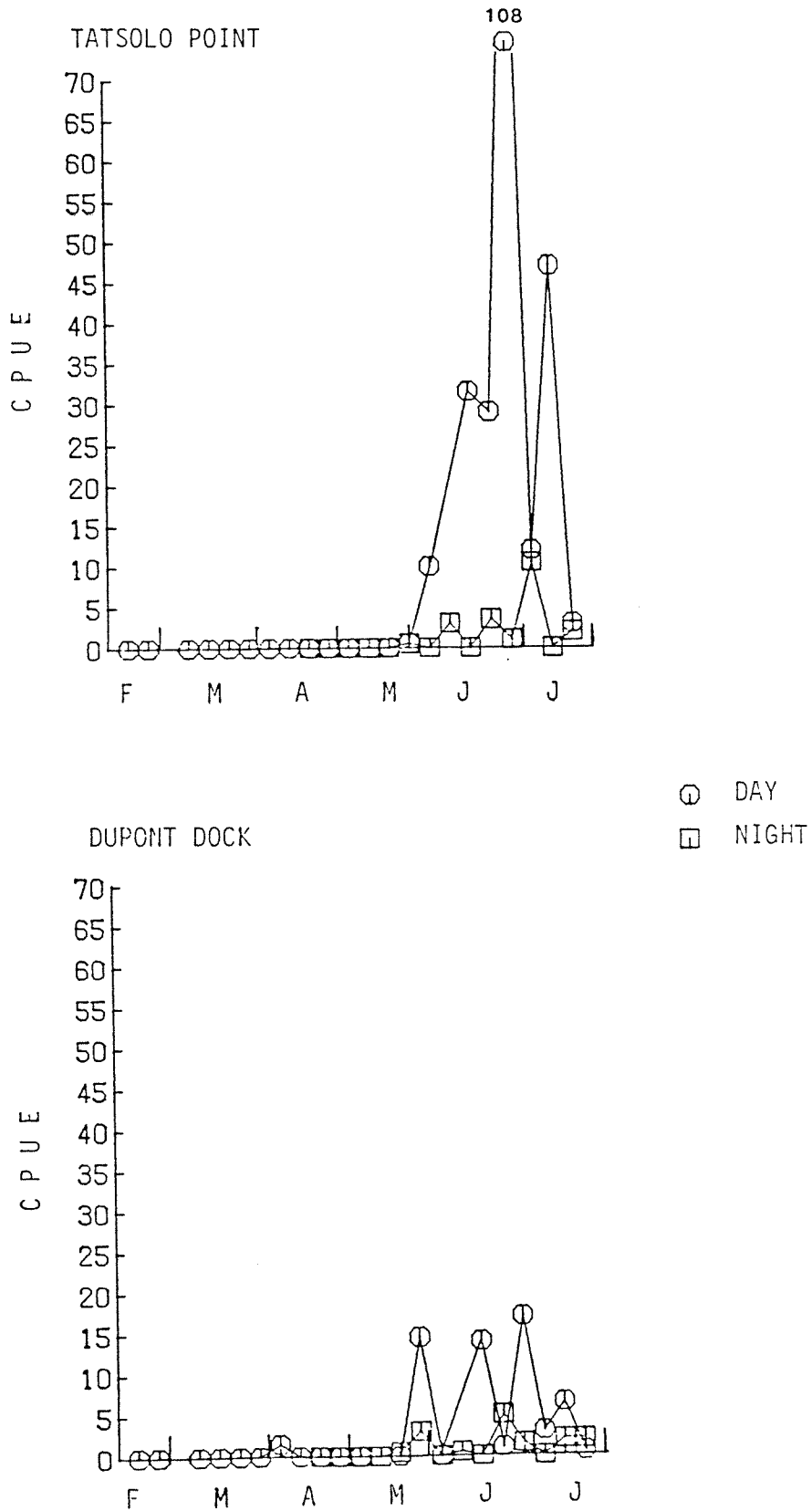


Fig. 24. Weekly CPUE of chinook salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington. (continued)

outmigrated from the area. Mean fork length of chinook varied little during the season and indicated rapid movement through the Nisqually Reach system (Fig. 25).

Several of the chinook caught during both years were large resident or "feeder" chinook which represent potential predators to smolt and fry. During 1978, most of these were caught at the Thompson Cove site, along the western Anderson Island shoreline. The relative abundance of feeder chinook was probably underestimated because of their ability to avoid the sampling gear employed.

#### Pink Salmon

Catches of juvenile pink salmon occurred during both years of the study; however, adult pink salmon are known to spawn in Puget Sound primarily in odd-numbered years, making catches in 1977 somewhat unusual.

All pinks caught by beach seine and townet during 1978 were caught between the beginning of March and mid-June (Fig. 26, Appendices 4d and 5). Peak catches were made from the end of March through mid-April along non-DuPont shorelines. Only 6 percent of all pinks caught by beach seine were caught along the DuPont shoreline. Offshore catches of pinks were low in both years and did suggest particular spatial and temporal patterns. On the whole, catches of pinks were low along all shorelines in 1978, even after releases of hatchery reared fish into McAllister Creek and the Nisqually River. Since sampling occurred 6 days after these releases, and fish were somewhat larger, it is possible that we missed these fish. There was also a poor return of adults in 1977 which could have resulted in small numbers of outmigrating wild stocks of pinks (Cole, personal communication).

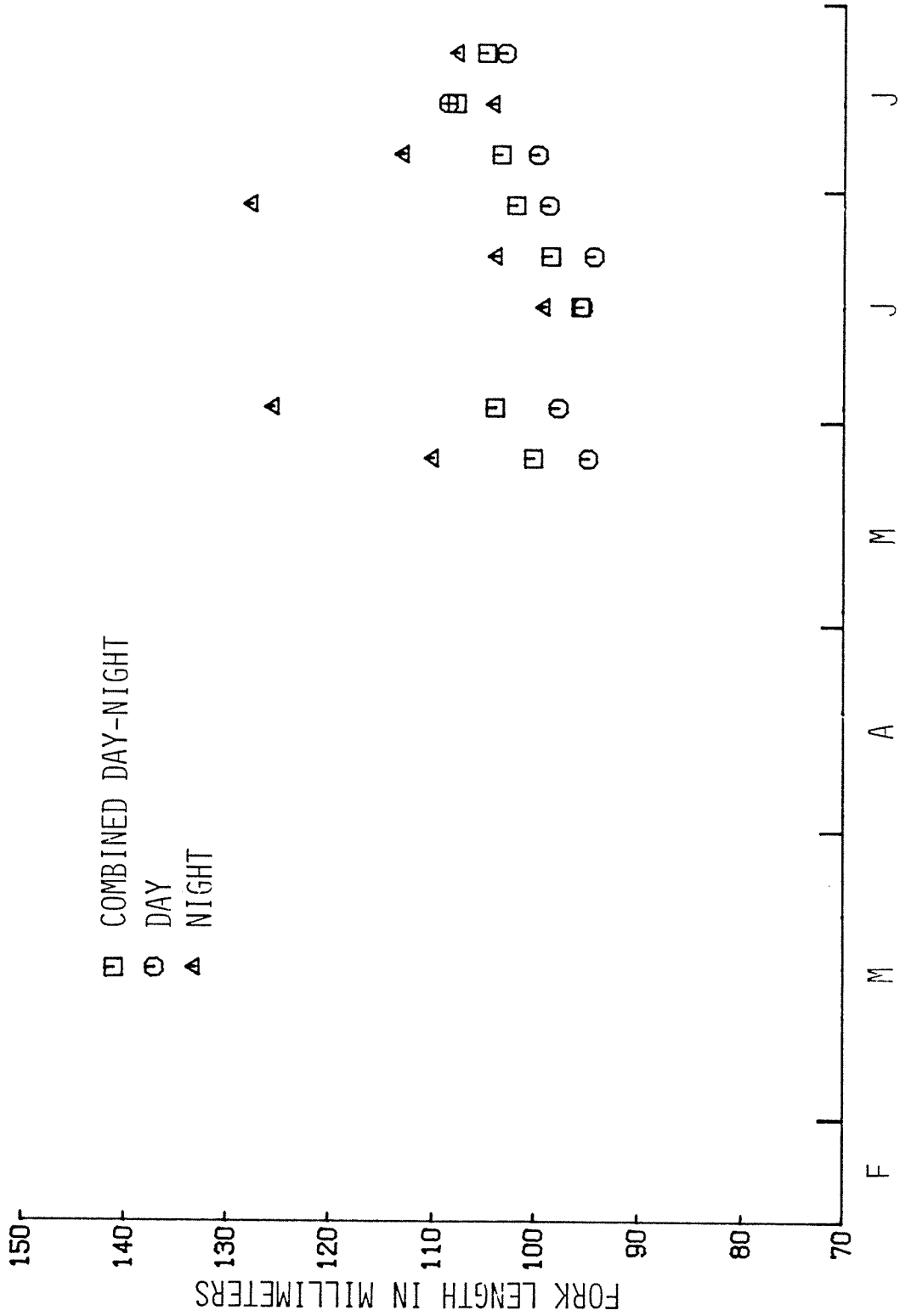


Fig. 25. Weekly mean length of chinook salmon collected by beach seine from February 15 to July 20, 1978 in the Nisqually Reach, Washington. (Only values with <75 are plotted)



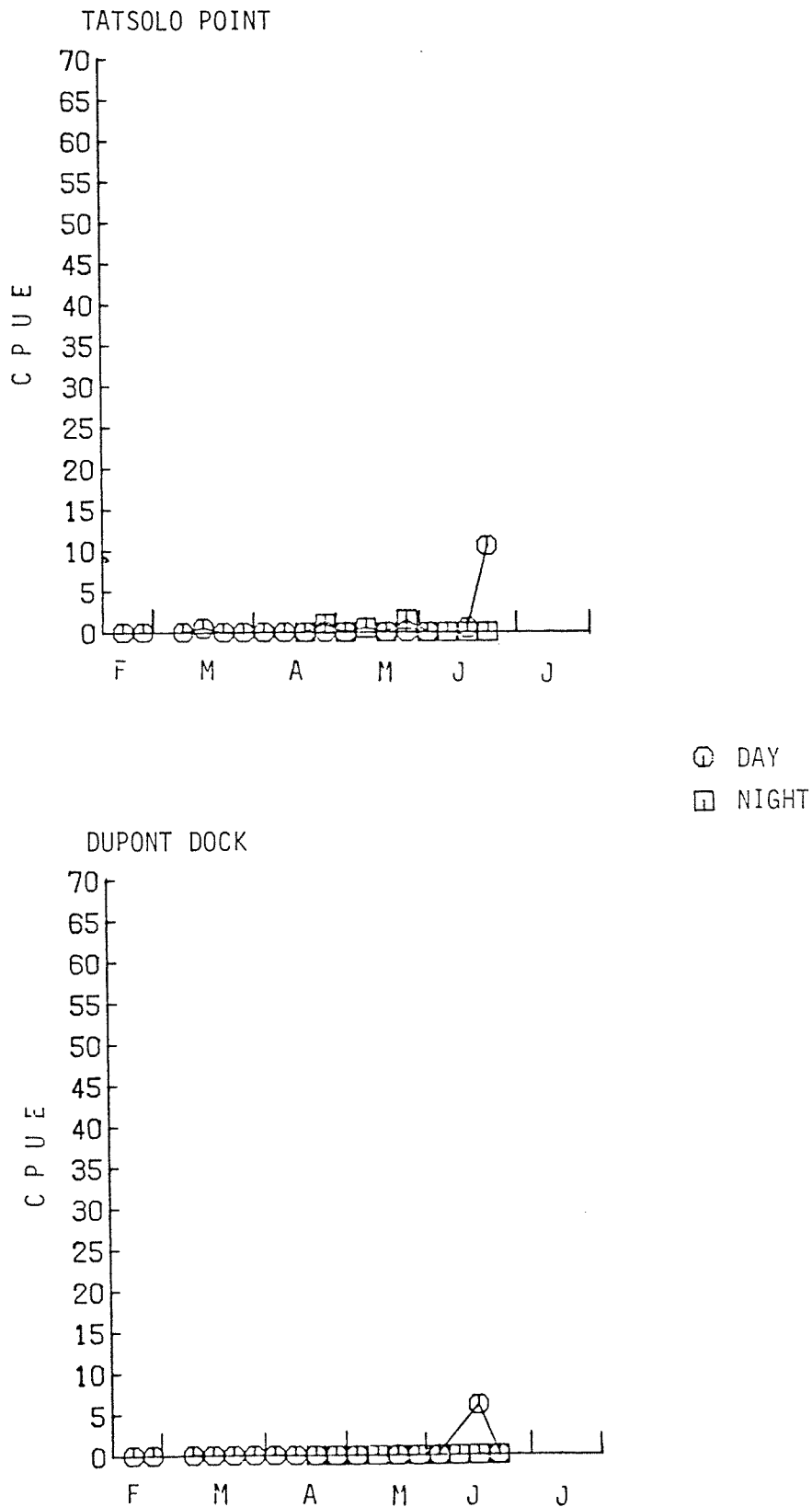


Fig. 26. Weekly CPUE of pink salmon in day and night beach seine collections from February 15 to July 20, 1978 in the Nisqually Reach, Washington. (continued)

### Other Salmonids

Other salmonids caught incidentally in 1977 included two steelhead (rainbow) trout, one cutthroat, and one sockeye salmon. In 1978, catches included 19 cutthroat, 16 steelhead, and one Dolly Varden. Forty percent of the steelhead and 74 percent of the cutthroat caught in 1978 occurred along the DuPont shoreline. Catches of these species were insufficient to suggest temporal or spatial trends. With exception of the sockeye, these infrequently caught species were of sufficient size to represent potential predators of small fish. Sockeye salmon are rare in Puget Sound, and Dolly Varden have not been previously reported from this area (DeLacy et al. 1972).

### Summary - Beach Seine and Townet Catches

Non-salmonids. Catches of non-salmonids by beach seine were generally smallest at the DuPont shoreline sites - Tatsolo Point and the DuPont Dock. Shiner perch, Pacific herring, and Pacific staghorn sculpin were overall the most abundant non-salmonid species. The occurrence of juveniles of several species, notably herring and surf smelt, suggests use of the Nisqually Reach for rearing. Pacific sand lance in 1978 and herring in 1977 and 1978 were the most abundant non-salmonid species caught by townet.

Salmonids. Four species of juvenile salmon (chum, coho, chinook, and pink) were abundant in the Nisqually Reach.

Overall, chum was the most abundant of the juvenile salmon. Peak outmigration of chum fry in the Nisqually Reach was mid-February through late July. The extended time period over which chum were caught and increasing size of fish with time suggests prolonged use of the area as a

nursery. There was considerable spatial variation in the distribution of chum in 1978 when all shorelines in the reach were sampled. Overall, most chum in 1978 were caught by beach seine in inshore areas along the Anderson Island and west Nisqually Reach shorelines, particularly from late March through late May. Along the DuPont shoreline, chum catches increased substantially in June, especially in the townet, and indicated that most fish moving along the DuPont shoreline do so later in the season and in more offshore waters that are out of the range of the beach seine. Because of the low frequency of townet collections, the relative abundance of chum occurring in the more offshore waters sampled by the townet was probably underestimated. Factors that determine the distribution of the chum include: food abundance, predation pressures, environmental variables (such as tide and salinity), size of fish, and movements of river waters. It is important to note that there may be annual variability in the distribution of chum (and other salmonids).

Most coho outmigrated along the shorelines of Anderson Island during May. Abundance along the DuPont shoreline, however, may have been underestimated because of net avoidance. Few coho were caught by townet during either year of the study. Most recoveries of marked coho were in mid- to late May from releases into the Nisqually River, and coincided with the largest overall catches. The lack of a significant increase in CPUE after Sequelitchew Creek releases in both 1977 and 1978 along the DuPont shoreline indicated rapid movement out of the DuPont shoreline nearshore area.

The peak chinook outmigration (after late May) was later than that documented for the other salmonids, and occurred along the mainland

shorelines, east and west of the Nisqually River. Spatial differences in chinook abundance were not as pronounced as with chum and coho because of overall low numbers caught. Several of the chinook caught both years were resident or "feeder" chinook which represent potential predators of smolts and fry.

Catches of juvenile pink salmon were low during both years of the study. Peak catches were in the beach seine and occurred from the end of March through mid-April along non-DuPont shorelines.

Other salmonids caught incidentally included steelhead trout, cutthroat trout, sockeye salmon, and Dolly Varden. Catches of these species were insufficient to suggest temporal or spatial patterns.

#### Trynet

A total of 4,277 fish representing 41 species were caught by trynet (Table 22). The 10 most abundant of these species comprised 92.8 percent of the catch (Table 23). 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 6). 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. 27). 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 23). Other studies have

Table 22. 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.	Percent*
<i>Hydrolagus colliei</i>	22	34	12	68	1.6
<i>Porichthys notatus</i>	2	6	3	9	.2
<i>Gadus macrocephalus</i>	2	1	1	4	.1
<i>Microgadus proximus</i>	74	145	124	343	8.0
<i>Theragra chalcogramma</i>	7	5	2	14	.3
<i>Aulorhynchus flavidus</i>		14		14	.3
<i>Syngnathus griseolineatus</i>	1	7		8	.2
<i>Cymatogaster aggregata</i>	163	254	35	452	10.6
<i>Embiotoca lateralis</i>	4	2	6	12	.3
<i>Rhacocochilus vacca</i>	22	3	3	28	.6
<i>Anoplarchus purpureus</i>	1			1	-
<i>Lumpenus sagitta</i>		5		5	.1
<i>Apodichthys flavidus</i>	1			1	-
<i>Sebastes caurinus</i>	8			8	.2
<i>S. maliger</i>	1	1		2	-
<i>Anoplopoma fimbria</i>	1			1	-
<i>Hexagrammos lagocephalus</i>	1			1	-
<i>H. stelleri</i>	7			7	.2
<i>Oxylebius pictus</i>	1	1		2	-
<i>Artedius fenestralis</i>	40	2	6	48	1.1
<i>A. lateralis</i>		2		2	-
<i>Chitonotus pugetensis</i>	305	151	34	490	11.5
<i>Enophrys bison</i>	38	8		46	1.1
<i>Leptocottus armatus</i>	41	53	152	246	5.8
<i>Myoxocephalus polyacanthocephalus</i>	8	3		11	.3
<i>Nautichthys oculofasciatus</i>	6	2		8	.2
<i>Agonopsis emmelane</i>	6			6	.1
<i>Agonus acipenserinus</i>	15	42	68	125	2.9
<i>Odontopyxis trispinosa</i>			1	1	-
<i>Pallasina barbata</i>		1		1	-

Table 22. (continued)

Species	Tatsolo Point (21 hauls)	DuPont Dock (21 hauls)	Outer Nisqually Delta (21 hauls)	Totals	
				No.	Percent*
<i>Xeneretmus latifrons</i>		1		1	-
<i>Citharichthys sordidus</i>			2	2	-
<i>C. stigmaeus</i>	16	150	5	171	4.0
<i>Glyptocephalus zachirus</i>		1		1	-
<i>Isopsetta isolepis</i>			15	15	.4
<i>Lepidopsetta bilineata</i>	95	305	174	574	13.4
<i>Microstomus pacificus</i>	1	6	6	13	.3
<i>Parophrys vetulus</i>	258	584	604	1,446	33.8
<i>Platichthys stellatus</i>		8	3	11	.3
<i>Pleuronichthys coenosus</i>	14	8	3	25	.6
<i>Psettichthys melanostictus</i>		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 23. 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
<i>Parophrys vetulus</i>	1,446	408	456	582
<i>Lepidopsetta bilineata</i>	574	107	158	309
<i>Chitonotus pugetensis</i>	490	193	141	156
<i>Cymatogaster aggregata</i>	452	45	91	316
<i>Microgadus proximus</i>	343	27	61	255
<i>Leptocottus armatus</i>	246	159	62	25
<i>Citharichthys stigmaeus</i>	171	34	93	44
<i>Agonus acipenserinus</i>	125	44	44	37
<i>Hydrolagus colliei</i>	68	9	20	39
<i>Psettichthys melanostictus</i>	52	12	14	26
Total	3,967			

NUM OF FISH P MI TO

DEPTH OF TOW

- 5m
- 10m
- x 15m

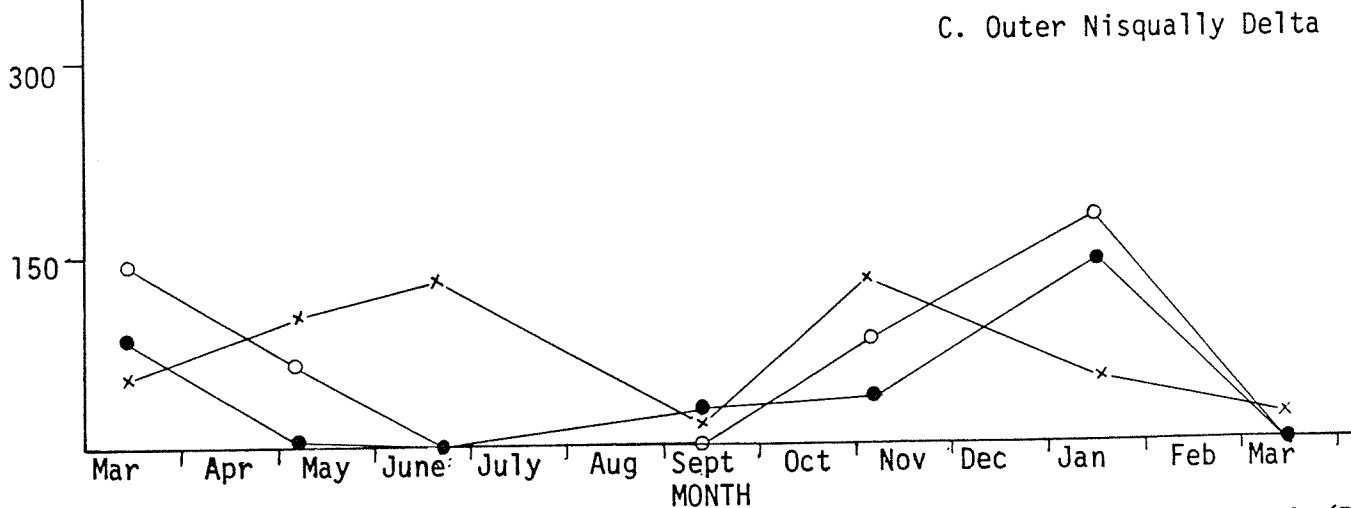
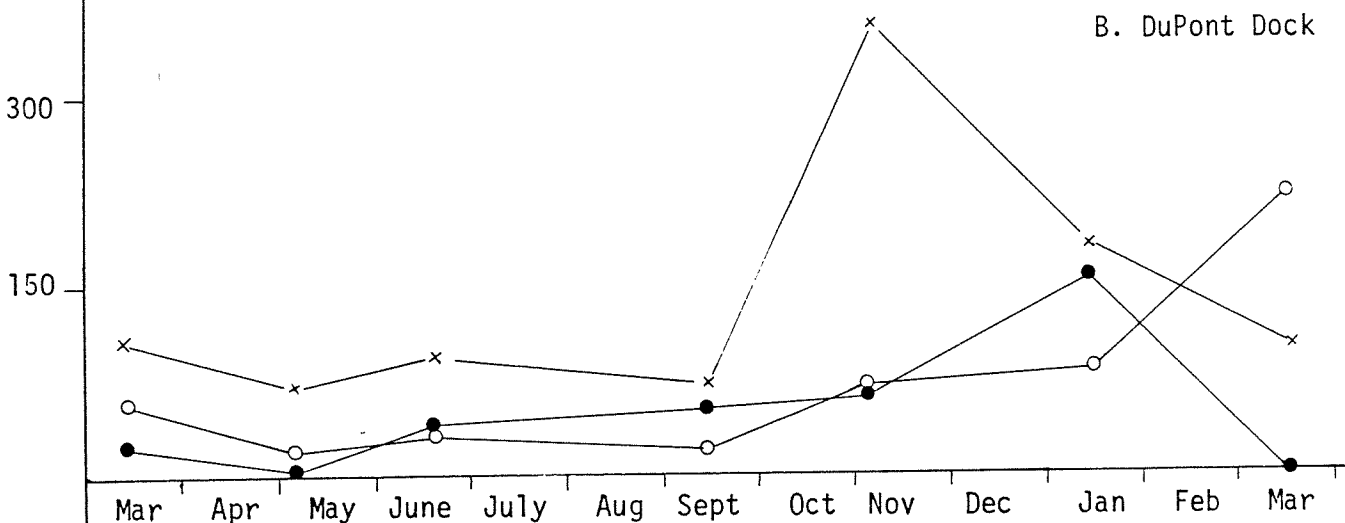
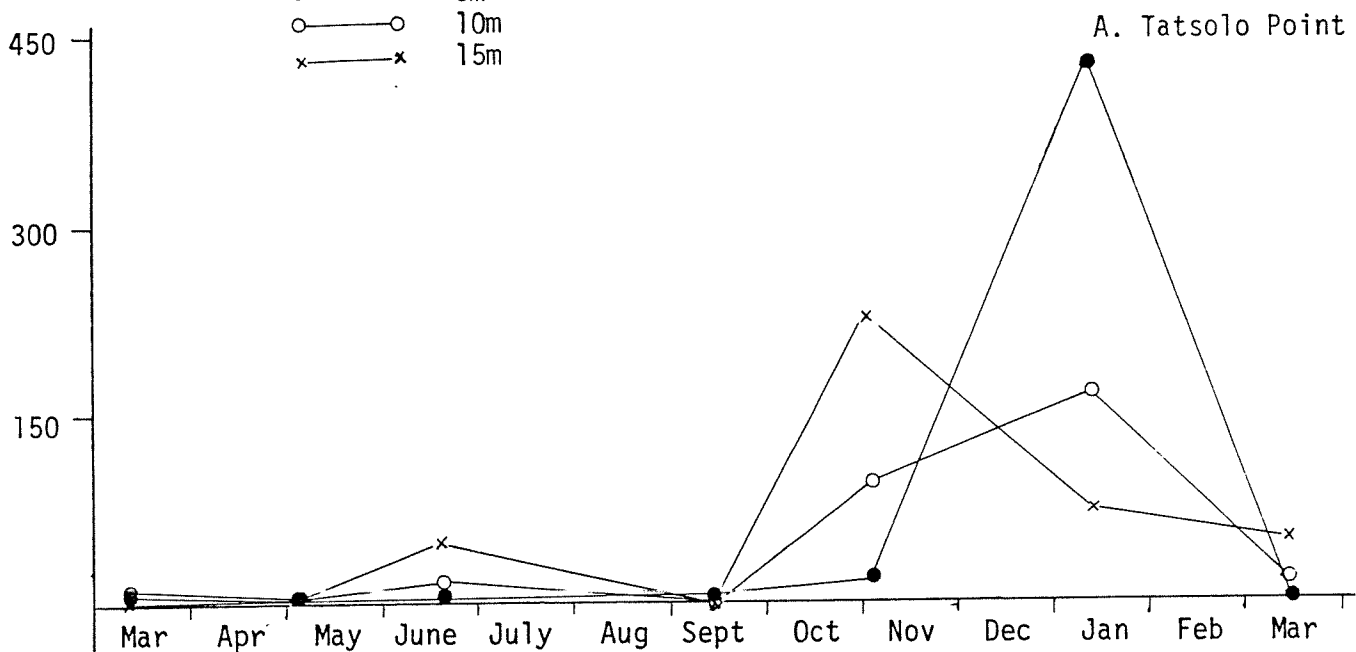


Fig. 27. Number of fish caught per trynet haul at Tatsolo Point (A), DuPont Dock (B), and the outer Nisqually Delta (C), southern Puget Sound, 1977-1978.

found English sole and rock sole to be among the predominant trawl-caught species occurring in Puget Sound (Moulton et al. 1974, Miller et al. 1975, Miller et al. 1977). 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 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.

Both nematodes and tumors occurred in pleuronectids (Table 24). The percentage of tumor-infected fish (all English sole) was 4.8 percent. 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 of nematodes at Stadium in Case Inlet, but lower rates at Union in the Hood Canal.

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

Month	Station	Rock Sole <sup>†</sup>		English Sole <sup>†</sup>	
		Percent Infected	Sample Size	Percent Infected	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.

<sup>†</sup>Fish less than 150 mm in total length are not included.

(Table 25). 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).

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. 28). Tag returns from all directions from the

Table 25. 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.	%
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.

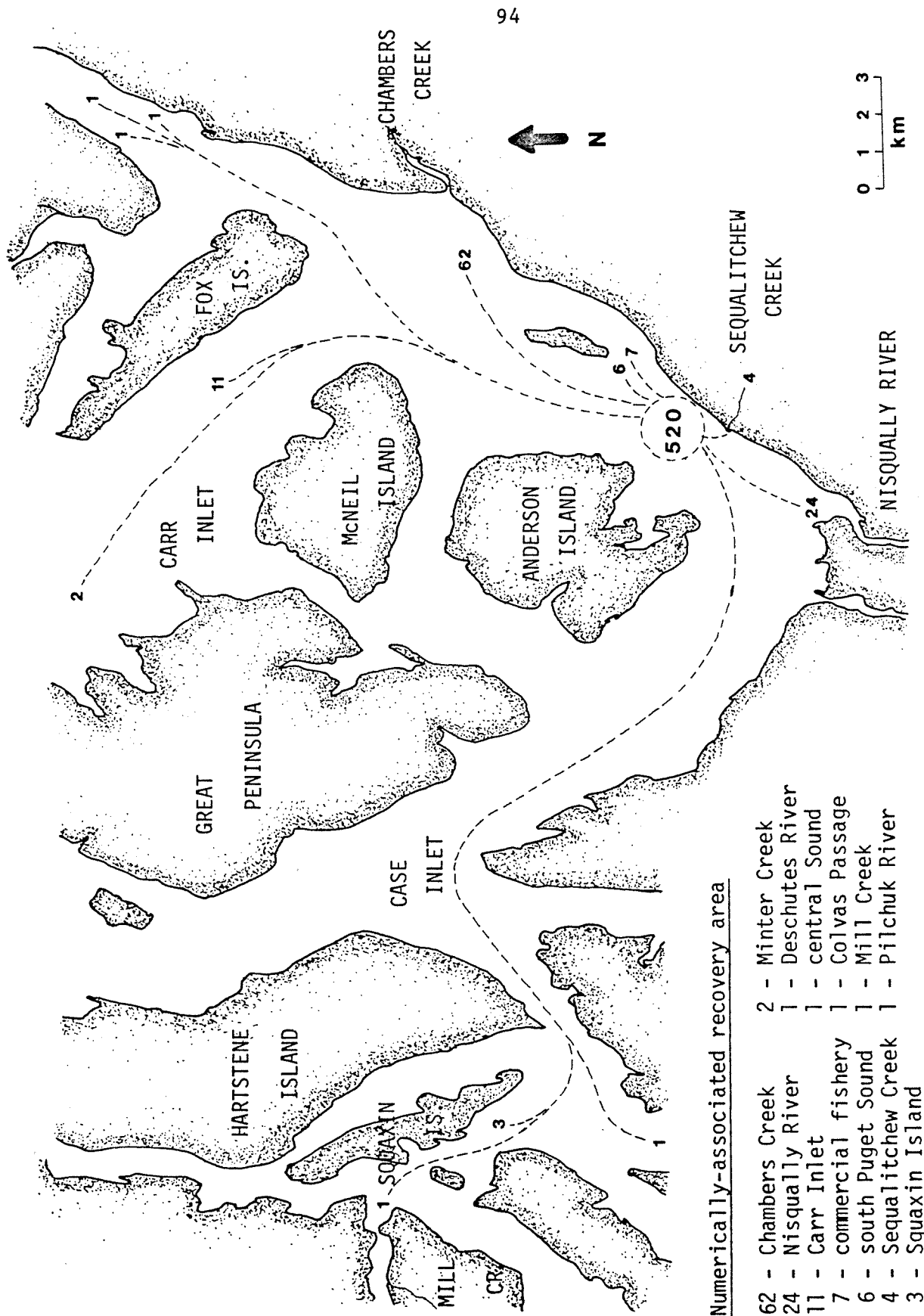


Fig. 28. Diagrammatic representation of tagging/recovery areas of adult and sub-adult coho salmon in southern Puget Sound, Washington, October-January, 1977-1978.

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 small size of the chinook captured (Fig. 29) indicates the chinook were mostly residents (blackmouth).

#### SCUBA Surveys

SCUBA observations at the DuPont Dock included 26 demersal and 11 pelagic species (Tables 26 and 27). 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.

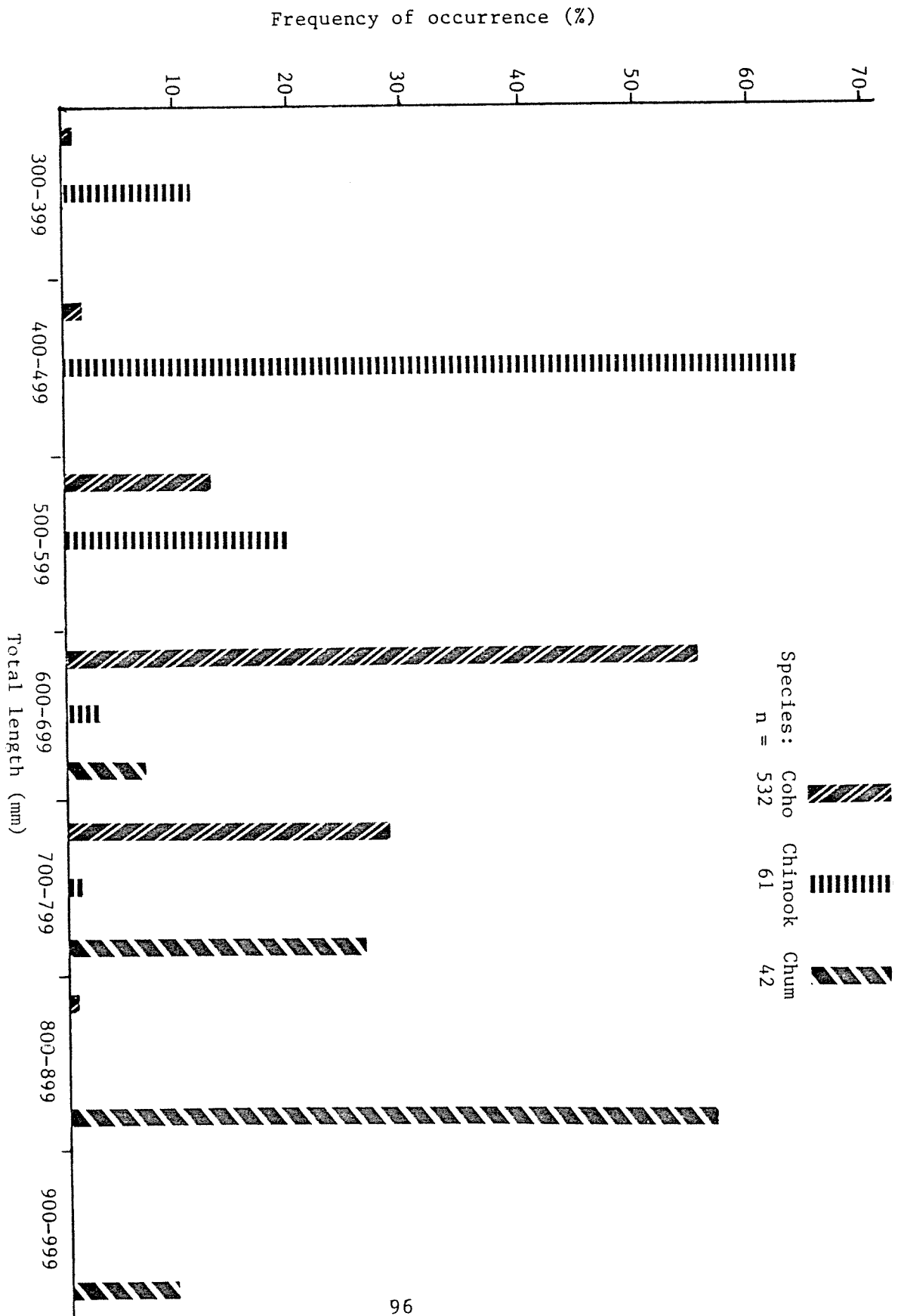


Fig. 29. Length-frequency distribution of salmon captured by purse seine in October and November, 1977 in the east Nisqually Reach, southern Puget Sound. Note: within each length category, e.g. 600-699, fish species are arrayed by identity, not by size.

Table 26. Monthly mean number of demersal fishes observed per SCUBA survey at the DuPont Dock, 1977-1978.

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

(?) = identity of fish unconfirmed



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 as predators of juvenile salmon (see Iwamoto and Salo 1977 for review). Abundance of the larger predators, especially subadult and adult salmon, may have been underestimated because of avoidance of the divers who may simulate large, salmon eating predators. Because the dock is 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 7). 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. 30) 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

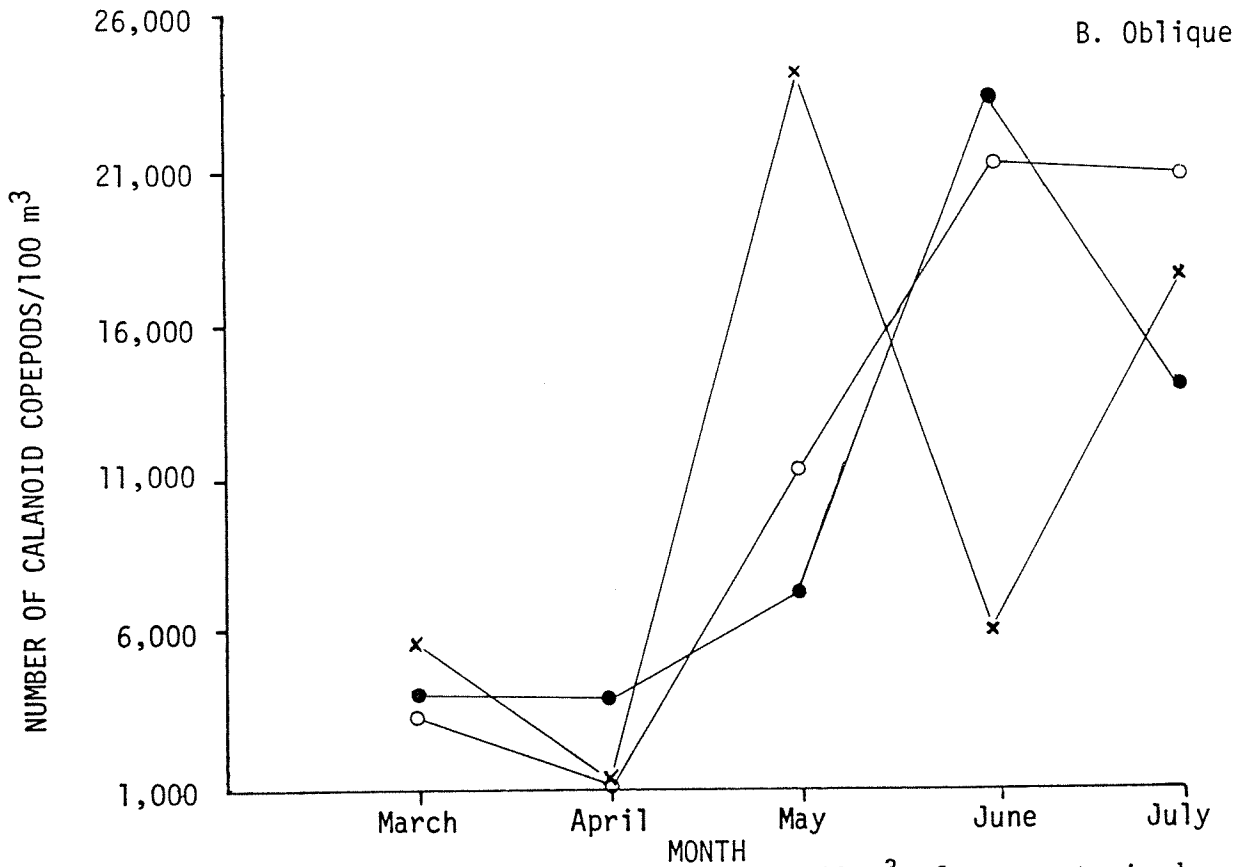
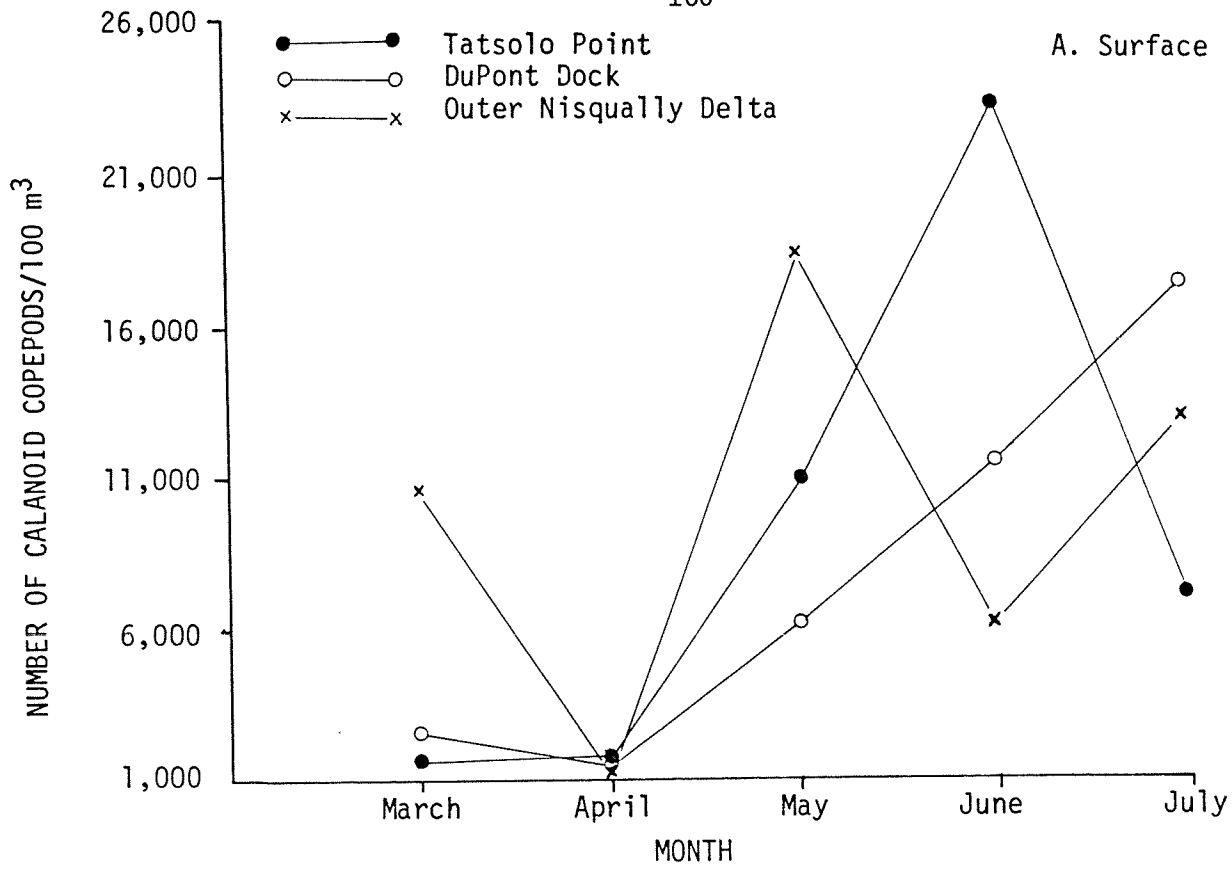


Fig. 30. Numbers of calanoid copepods per 100 m<sup>3</sup> of water strained in surface (A) and oblique (B) bongo net hauls in the DuPont area, southern Puget Sound, 1977.

(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. 31), 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 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. 32). All fish eggs were bothids, gadoids, and pleuronectids (Table 28). 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-0 sole eggs were the predominant egg type found in later collections (May to July). Over half of the C-0 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. 33). The dominant fish larvae were gadoids and pleuronectids (Table 29), 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

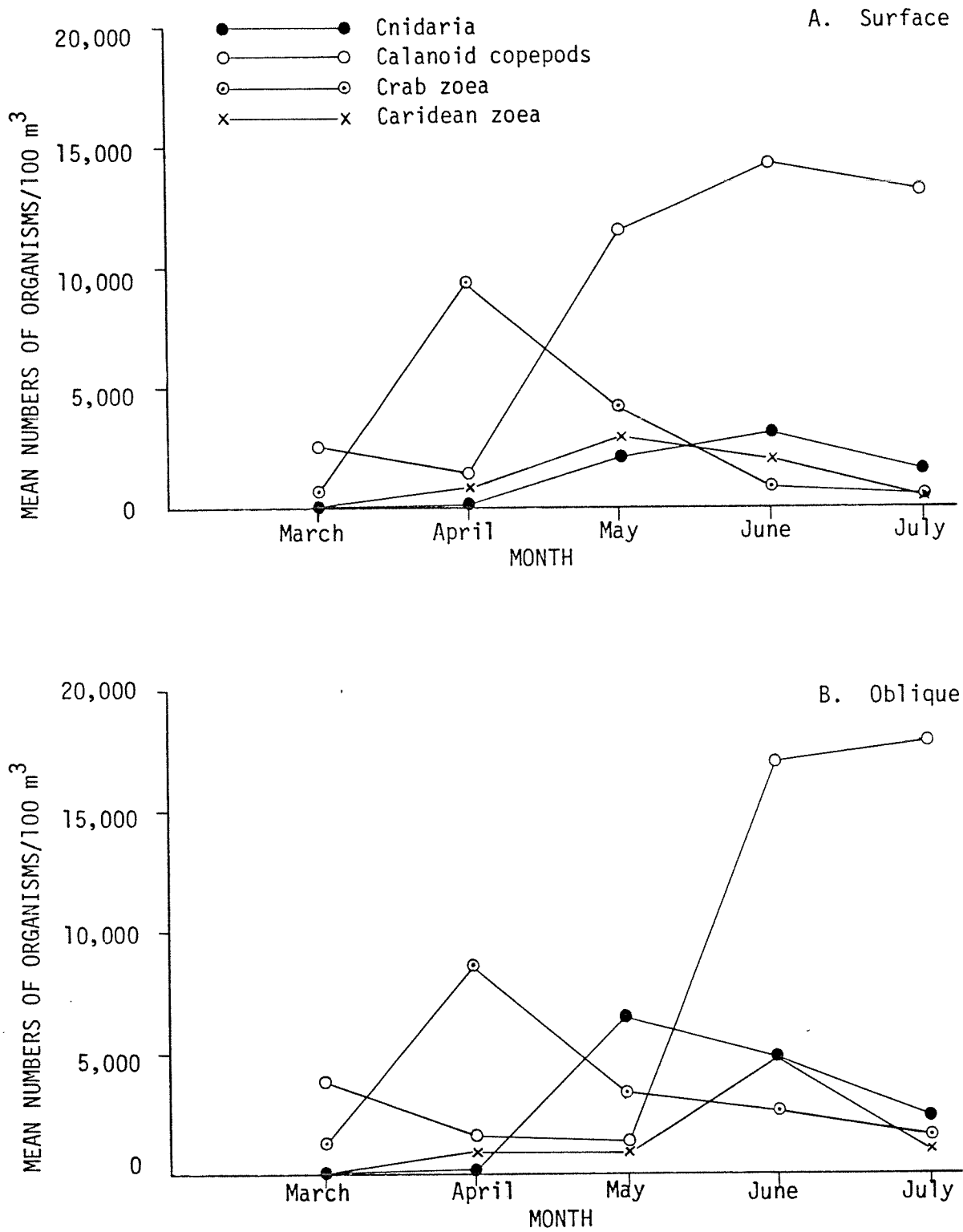


Fig. 31. Numbers of organisms per 100 m<sup>3</sup> of water strained in surface (A) and oblique (B) bongo net hauls of the most abundant zooplankton taxa in the DuPont study area, 1977.

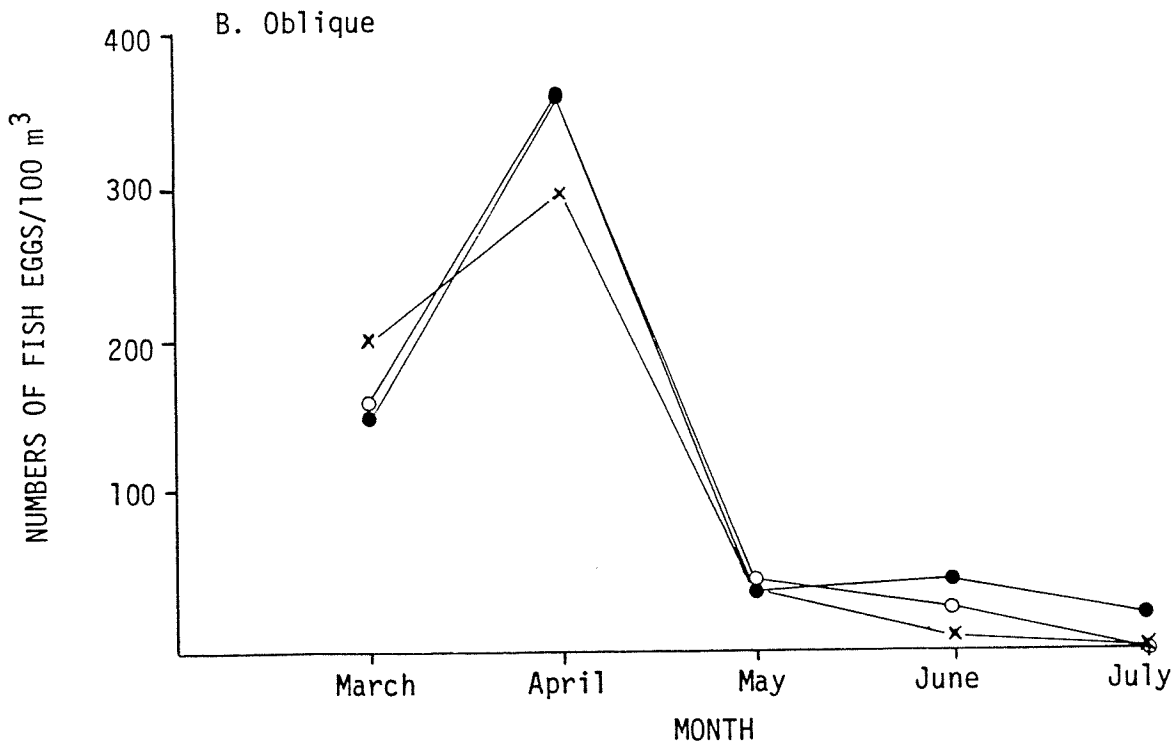
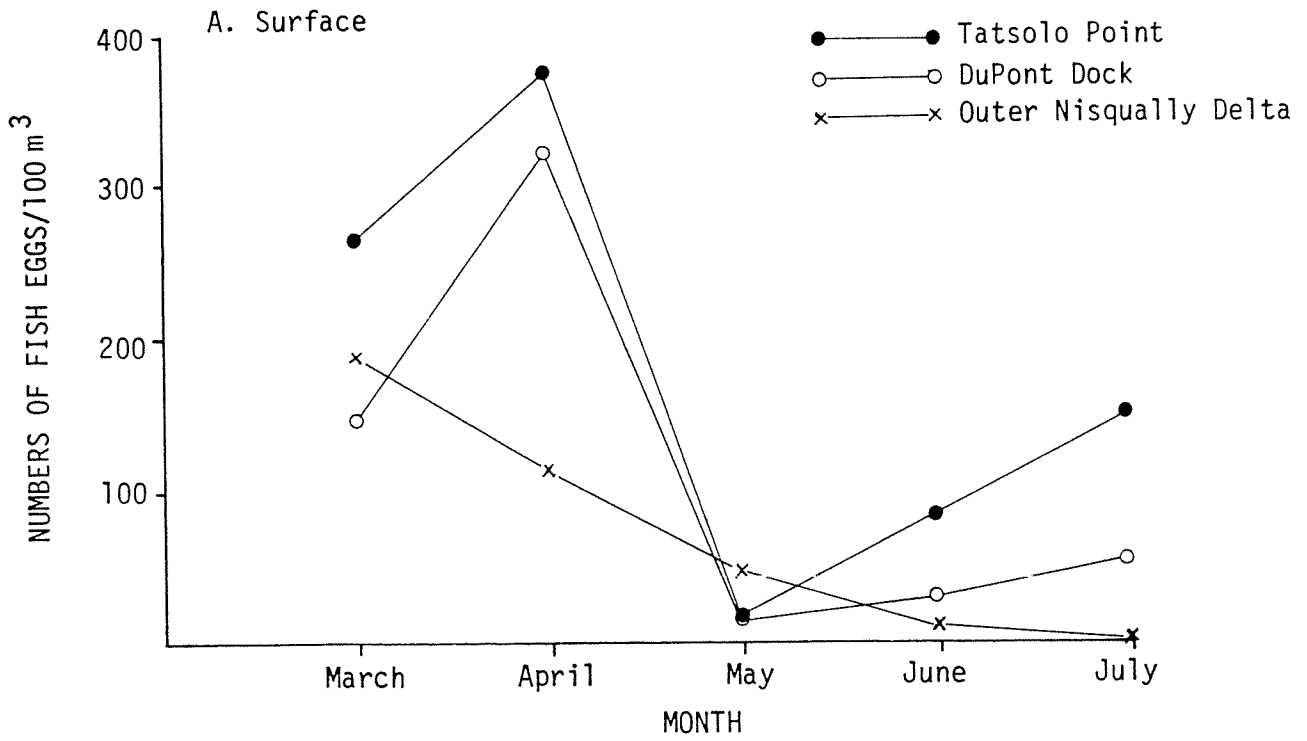


Fig. 32. Numbers of fish eggs per 100 m<sup>3</sup> of water strained in surface (A) and oblique (B) bongo net hauls in the DuPont study area, southern Puget Sound, 1977.

Table 28. Numbers of fish eggs per 100 m<sup>3</sup> of water strained at sites in the DuPont-Nisqually study area in southern Puget Sound, 1977.

Taxon	Tatsolo Point			DuPont Dock			Outer Nisqually Delta																				
	Mar	Apr	May	June	July	Mar	Apr	May	June	July																	
	S <sup>1</sup>	O <sup>2</sup>	S	O	S	O	S	O	S	O																	
Bothidae																											
<i>Citharichthys</i> sp.				1						3																	
Gadidae	6	26	210	191	2	15	36	125	117	72	98	16	100														
Pleuronectidae																											
<i>Hippoglossoides</i>																											
<i>elassodon</i>	1		2			4	4																				
<i>Lyopsetta exilis</i>	12	6	16	19		14	5	19	8	36		22															
<i>Pleuronichthys</i> sp.		92	18	16	36	81	37	143	22		38	26	15	35	27	24	52										
Parophrys-Psettichthys-complex	247	121	44	99						115	124	120	107	1	5	2											
Platichthys																		78	98	91	149						
Unidentified																						6					
Total	265	154	373	361	22	36	82	55	148	22	144	165	318	264	16	53	29	186	202	137	295	46	37	7	9	4	3

1 surface tow  
2 oblique tow

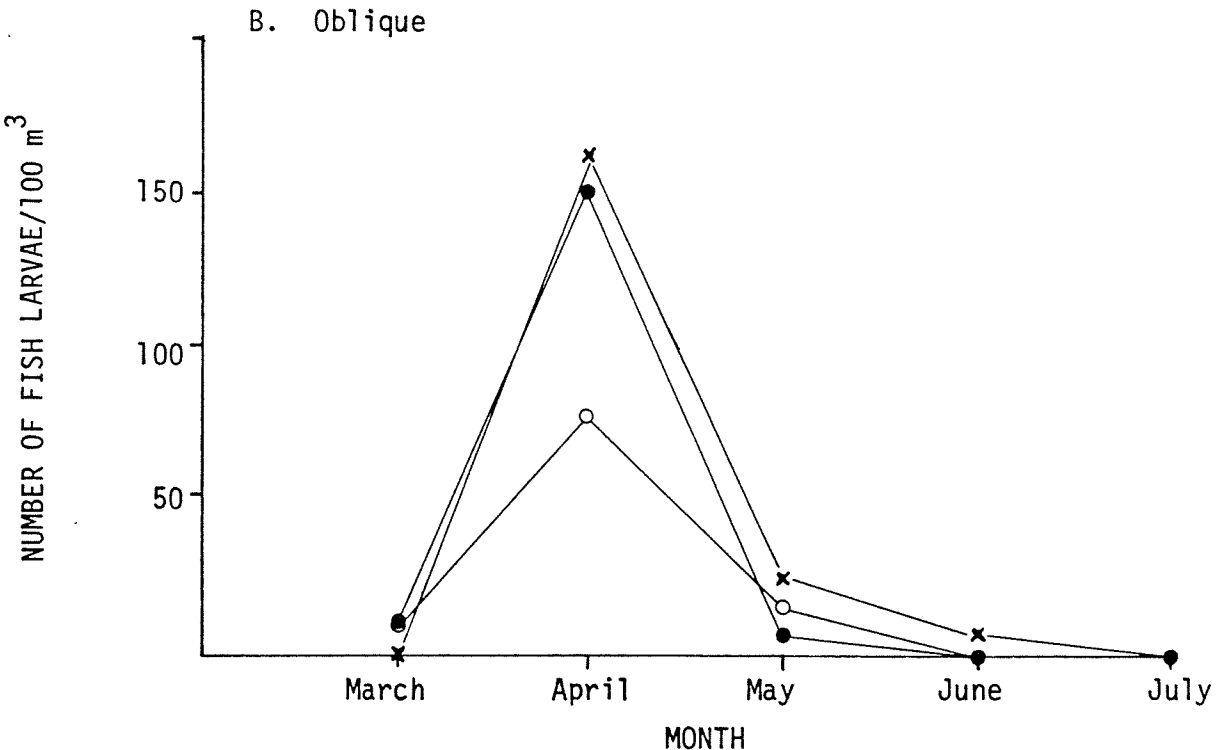
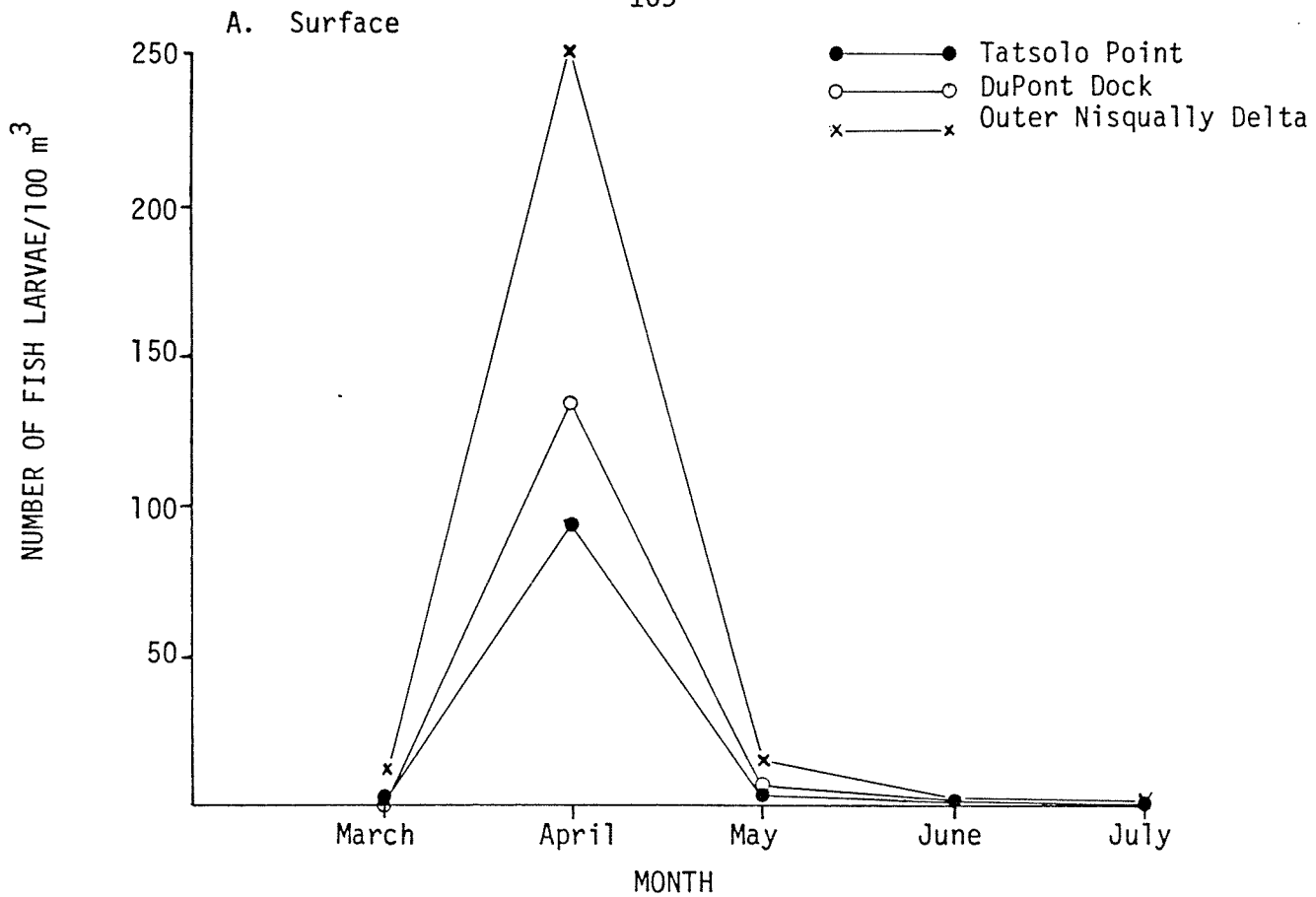


Fig. 33. Numbers of fish larvae per 100 m<sup>3</sup> of water strained in surface (A) and oblique (B) bongo net hauls in southern Puget Sound, 1977.



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.

### 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 30). 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 (~ 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

Table 30. Juvenile salmon surveyed in Sequelitchew Creek, Washington, April through June, 1977.

Survey Date	Study Sections			
	I	II	III*	IV
April 26	NS 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

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 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 was made.

Coho salmon fry and smolts were the most abundant fish caught (Table 31). The numbers of fry in all three sections decreased markedly from the first sampling to the end of April (Fig. 34). As most population estimates of 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

Table 31. Fish surveyed by electroshocking in Sequelitchew Creek, Washington, during 1978. (All values represent the sum of catches from 2 electrofishing passes through the section.)

Date	Section		
	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

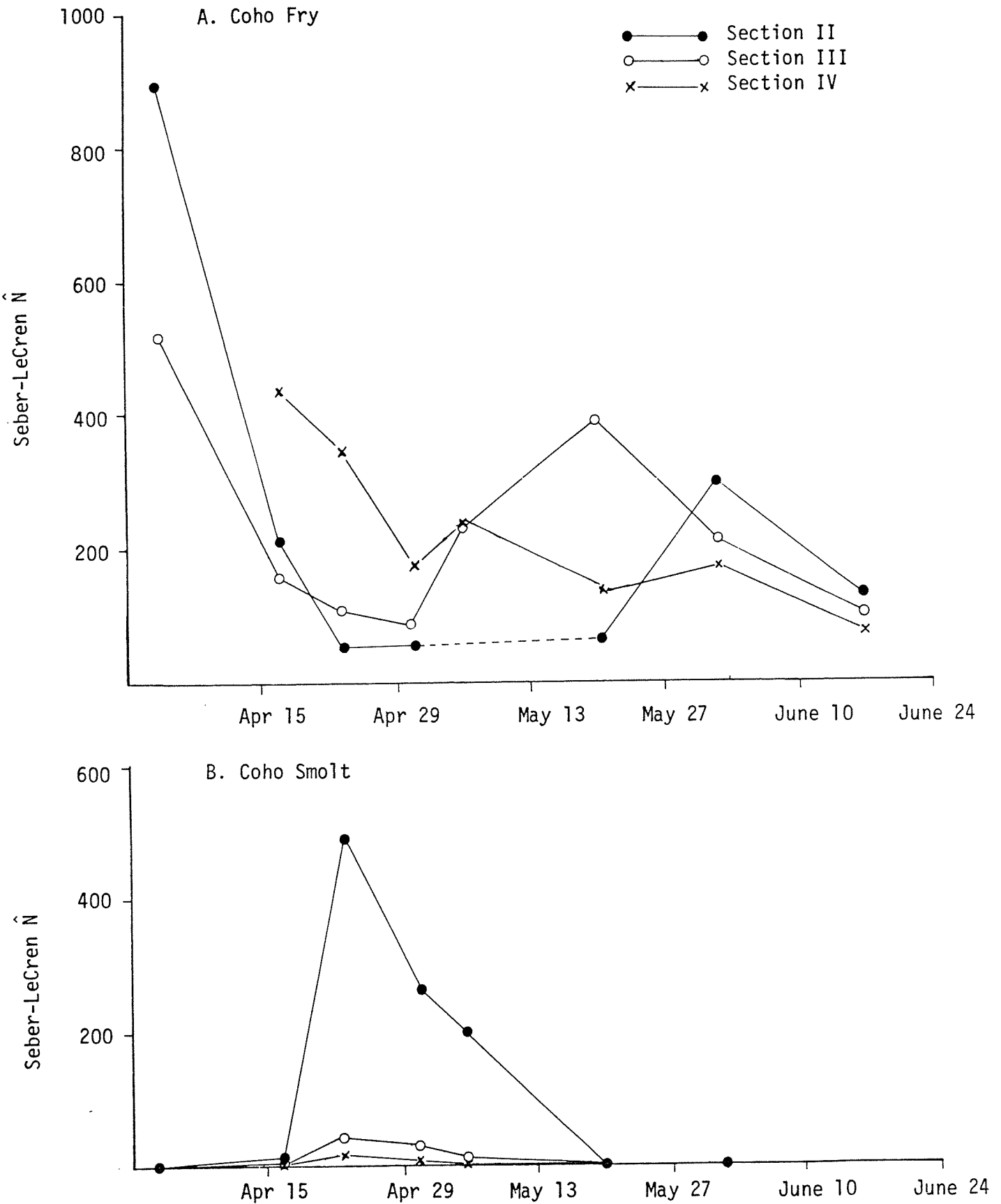


Fig. 34. Seber-LeCren ( $\hat{N}$ ) estimates of coho fry (A) and smolt (B) abundance in Sequalitchew Creek, 1978.

month period (Fig. 35). 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 likely occurred in two periods. The first period was the latter part of April during which fish moved primarily 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. 35) and low numbers of marked smolts recovered. The abundance of smolts 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.

○ Section 2  
 ● Section 3  
 × Section 4

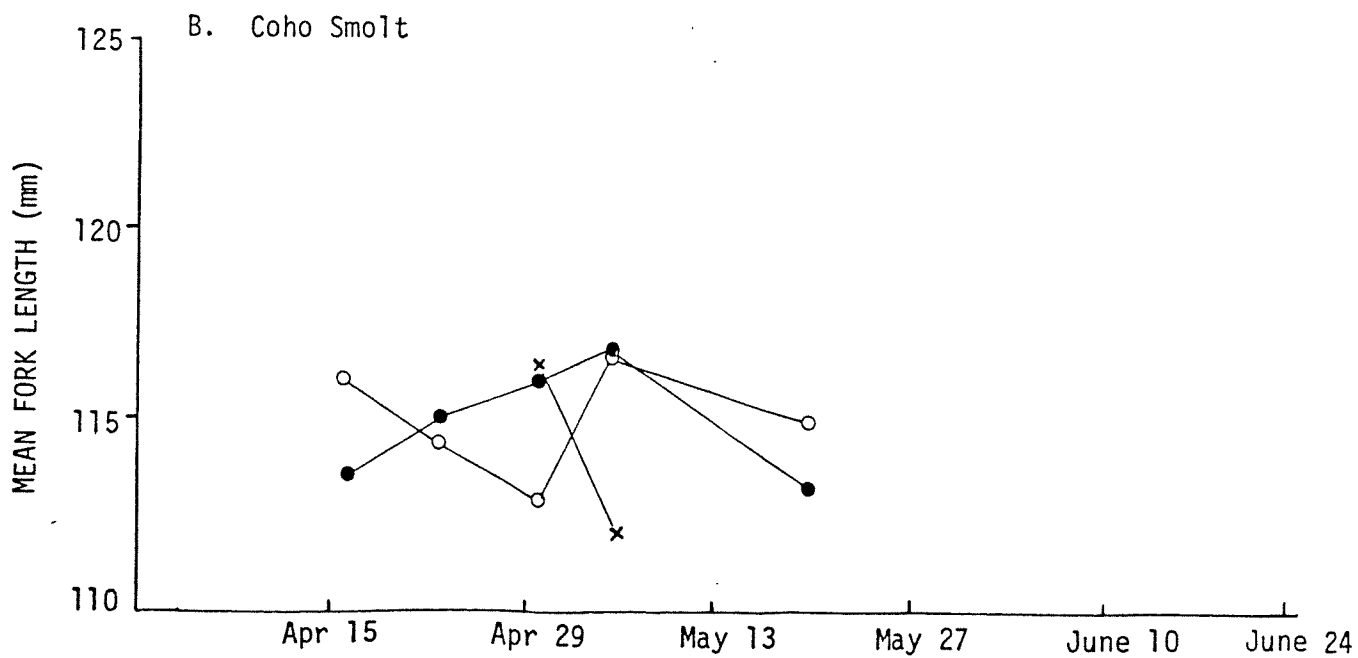
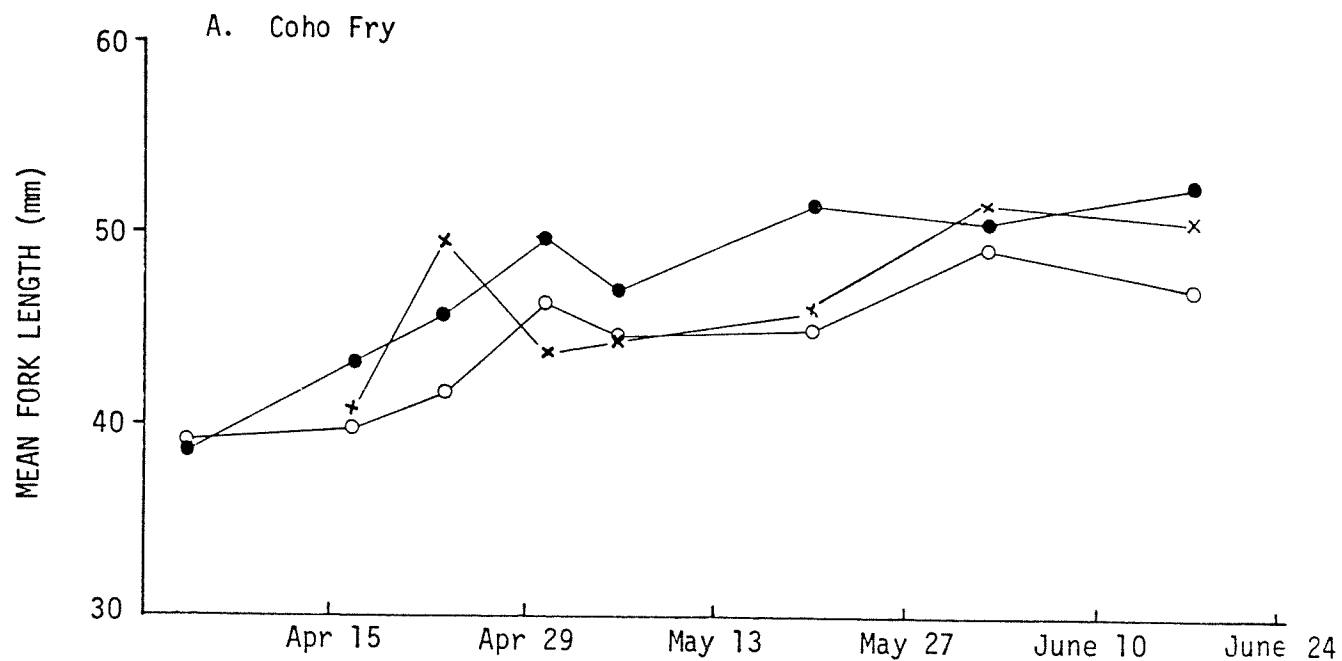


Fig. 35. Changes in length (fork length) of coho fry (A) and smolt (B) in Sequelitchew Creek during 1978 electroshocking surveys.

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 32). 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.

Table 32. Number of adult salmon observed in the lower 1,700 meters of Sequelitchew Creek, Washington, November 15, 1977, to February 27, 1978.

Survey Date	Number of Coho Salmon Observed*			Additional Observations
	Live	Dead	Total	
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 Sequelitchew Lake
Jan 22	0	91	91	
Feb 10	0	15 <sup>1</sup>	25	- 2 large mouth bass (~225 mm)
Feb 27	0	0	0	

\*No adult chum salmon were observed in the creek.

<sup>1</sup>badly decomposed

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

3. Beach seine and townet catches of juvenile chum, coho, pink, and chinook occurred during both 1977 and 1978. Peak outmigration of chum was mid-May through late June. Overall, more chum outmigrated along the Anderson Island and west Nisqually Reach shorelines, especially through late May. A substantial increase in chum abundance along the DuPont shoreline, particularly in the more offshore waters the townet sampled, was indicated in June. Most coho outmigrated along the shorelines of Anderson Island during May. Few coho were caught by townet in either year. Peak chinook outmigration occurred from late May through July along the mainland shorelines east and west of the Nisqually River. Catches of pinks were low in both years; peak catches were in the beach seine from the end of March through mid-April along non-DuPont shorelines.

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. Sequelitchew 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 were the only adult salmonids observed in the creek.

## PART II - TROPHIC RELATIONSHIPS OF NISQUALLY REACH FISHES

Results

The food habits and feeding behavior of Nisqually Reach fishes is important from two standpoints. First, the occurrence of nearshore fishes, both the resident species and the economically important migratory salmonids, is partly a function of the available prey resources characterising the shallow sublittoral and neritic habitats of the Nisqually Reach. In addition, populations of potential predators of outmigrating juvenile salmonids may be associated with specific habitats such that alteration of the shoreline might influence the natural mortality of the salmon fry and smolts due to predation.

In order to assess the trophic relationships among Nisqually Reach fishes, the occurrence, abundance, and biomass of prey taxa were identified from 1,858 stomachs of 44 fish species (Appendix Table 8) obtained from collections made in 1977-1978. Emphasis, however, was focused upon juvenile salmonids and their potential predators. The stomach contents of the other species are briefly described in Appendix 9.

An explanation of the Index of Relative Importance (IRI), used to present food habits data, is provided in Appendix 2.

Outmigrating Juvenile Salmonids

Juveniles of four of the five species of Pacific salmon migrate through Nisqually Reach between March and July; coho and chinook may

actually establish small local resident stocks which never complete their migration out of southern Puget Sound.

Pink Salmon (Oncorhynchus gorbuscha)

1977 - Juvenile pink salmon were common only 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 was 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 IRI (Fig. 36); 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.

1978 - Early April beach seine collections primarily at Thompson Cove and East Oro Bay, provided the greatest percentage of the pink salmon fry samples. Harpacticoid and calanoid copepods were the predominant prey items (Fig. 37). Harpacticoid copepods were more prominent in the prey spectra of these fish than those examined in 1977. The East Anderson Island shoreline, which was not sampled in 1977, however, has more shallow sand/eelgrass habitat which tends to have higher populations of epibenthic crustaceans such as harpacticoid copepods (Kaczynski et al. 1973).

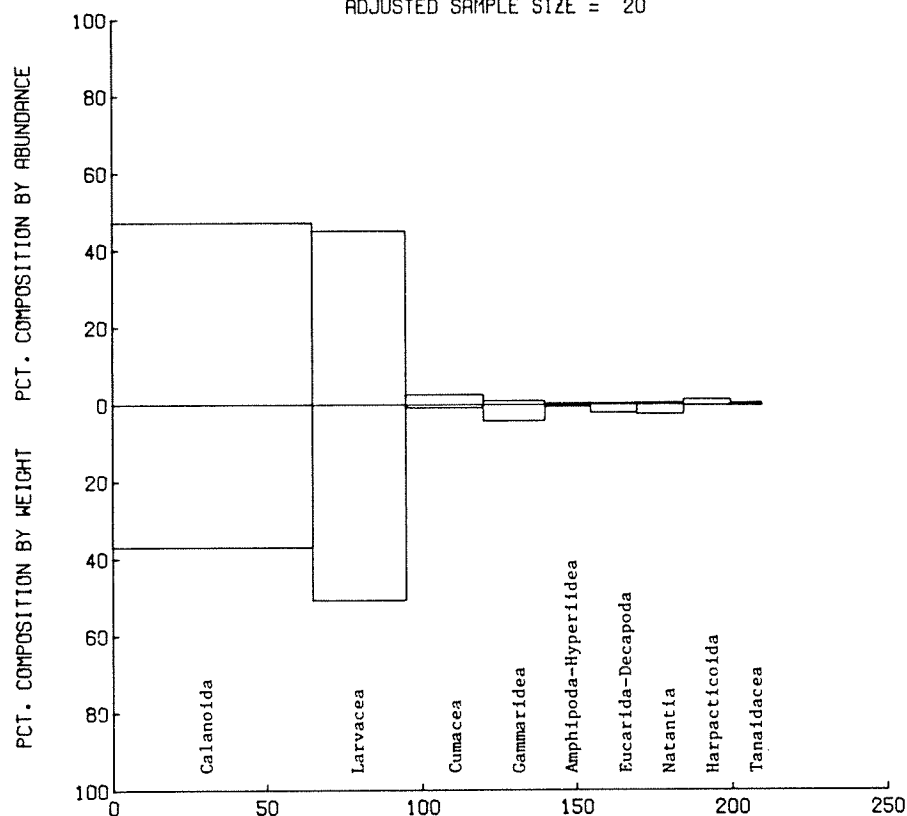
Few pink salmon were captured during townet collections, principally during early April along the eastern shoreline of Anderson Island. Their

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

8755010201 - ONCORHYNCHUS GORBUSCHA

PINK SALMON

ADJUSTED SAMPLE SIZE = 20



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CALANOIDA	55.00	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-HYPERIDEA	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-WIENER DIVERSITY	1.55	1.75	1.23
EVENNESS INDEX	.38	.43	.30

Fig. 36. IRI prey spectrum of juvenile pink salmon in Nisqually Reach, southern Puget Sound, 1977.

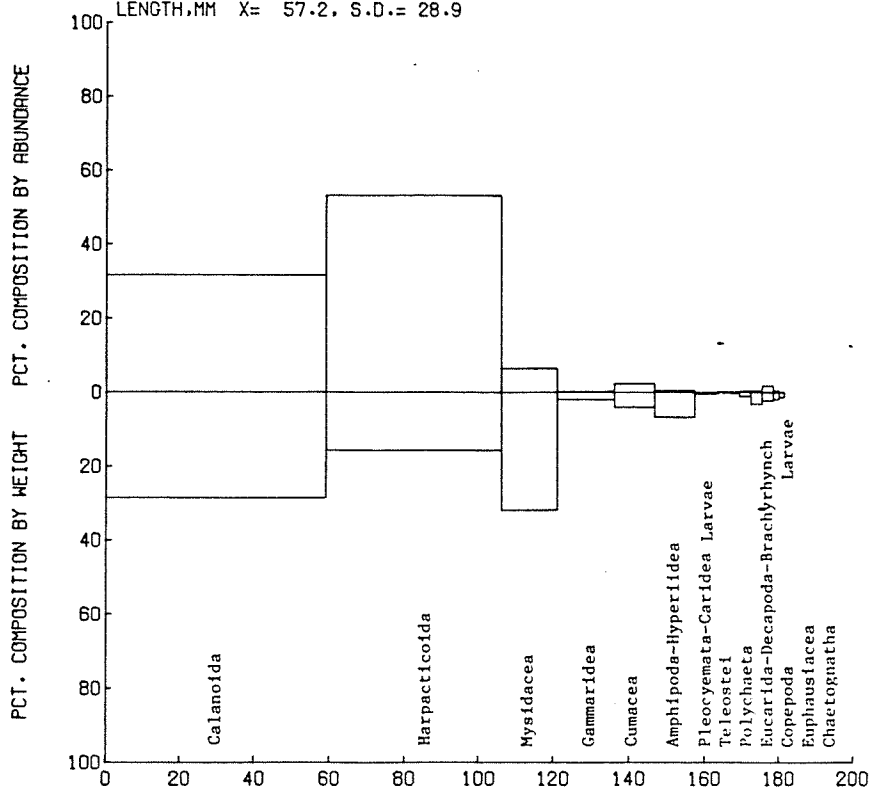
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM

FROM FILE IDENT. DUPONT, STATION ALL

PREDATOR 8755010201 - ONCORHYNCHUS GORBUSCHA

(PINK SALMON ) ADJUSTED SAMPLE SIZE = 66

LENGTH,MM X= 57.2, S.D.= 28.9



CUMULATIVE FREQUENCY OF OCCURRENCE

PREY ITEM	FREQ. OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CALANOIDA	59.09	31.61	28.54	3554.4	46.77
HARPACTICOIDA	46.97	53.31	15.58	3235.7	42.58
MYSIDACEA	15.15	6.49	31.89	581.6	7.65
GAMMARIDEA	15.15	.29	1.95	33.9	.45
CUMACEA	10.61	2.37	4.03	67.9	.89
AMPHIPODA-HYPERIDEA	10.61	.58	6.68	77.0	1.01
PLEOCYEMATA-CARIDEA LARVAE	6.06	.16	.48	3.9	.05
TELEOSTEI	6.06	.24	.24	2.9	.04
POLYCHAETA	3.03	.48	1.04	4.6	.06
EUCARIDA-DECAPODA-BRACHYRRHYNCH LARVAE	3.03	.48	3.22	11.2	.15
COPEPODA	3.03	1.77	2.27	12.2	.16
EUPHAUSIACEA	1.52	.48	1.94	3.7	.05
CHAETOGNATHA	1.52	.08	1.32	2.1	.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		.39	.22		.41
SHANNON-WEINER DIVERSITY		1.84	2.69		1.55
EVENNESS INDEX		.45	.66		.38

Fig. 37. IRI prey spectrum of juvenile pink salmon caught by beach seine in Nisqually Reach, southern Puget Sound, 1978.

stomach contents (Fig. 38) were dominated by epibenthic harpacticoid copepods.

Chum Salmon (Oncorhynchus keta)

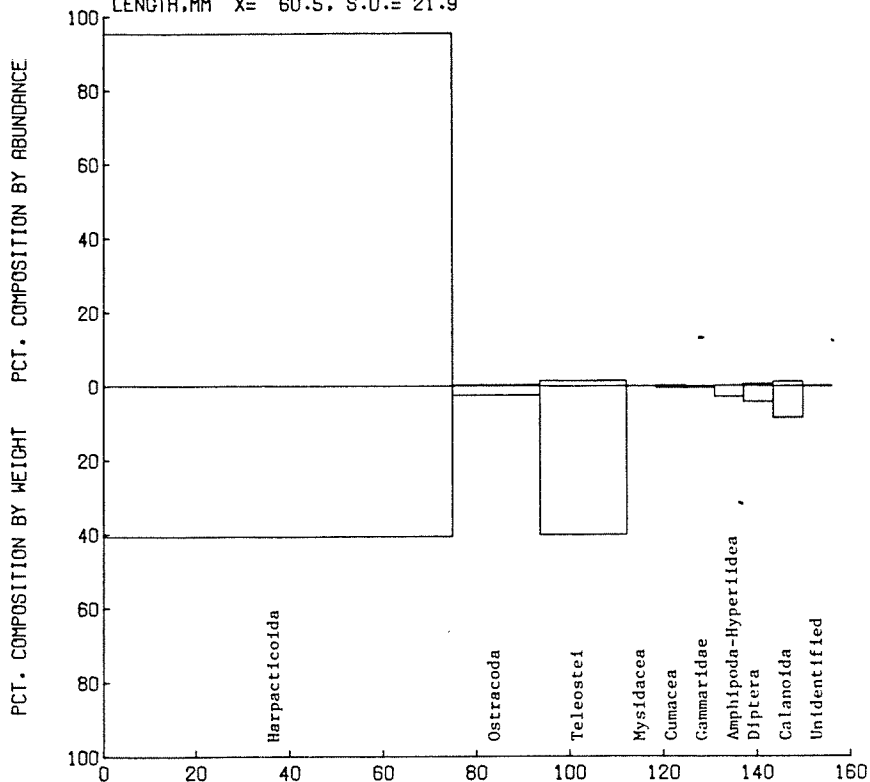
1977 - Juvenile chum salmon occurred in beach seine and townet collections from early April to late July. Ninety-two stomachs were collected by beach seine and 25 by townet, only one stomach from each sampling method was empty.

The composite prey spectrum for 1977 chum fry indicates that they fed primarily upon epibenthic organisms; 96.6 percent of the total IRI was contributed by harpacticoid copepods and gammarid amphipods (Fig. 39). 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. 40) whereas, those captured with the townet (nearshore pelagic zone) had fed more on gammarid amphipods, and less so on harpacticoid copepods (Fig. 41). The high representation of various insect taxa (26.3 percent of total IRI) in the food spectrum 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. Towntet-caught fish tended to 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, implying that at this stage of their outmigration, juvenile chum feed in shallow sublittoral areas during daylight (diurnally) rather than at night in neritic waters.

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

PREDATOR 8755010201 - ONCORHYNCHUS GORBUSCHA  
(PINK SALMON ) ADJUSTED SAMPLE SIZE = 16

LENGTH, MM X= 60.5, S.D.= 21.9



CUMULATIVE FREQUENCY OF OCCURRENCE

PREY ITEM	FREQ. OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	75.00	95.42	40.74	10211.8	91.44
OSTRACODA	18.75	.42	2.46	54.0	.48
TELEOSTEI	18.75	1.53	40.17	781.8	7.00
MYSIDACEA	6.25	.08	.05	.8	.01
CUMACEA	6.25	.25	.47	4.5	.04
GAMMARIDEA	6.25	.09	.47	3.5	.03
AMPHIPODA-HYPERIIDEA	6.25	.17	2.84	18.8	.17
DIPTERA	6.25	.68	4.25	30.8	.28
CALANOIDA	6.25	1.27	8.51	61.1	.55
UNIDENTIFIED	6.25	.08	.05	.8	.01

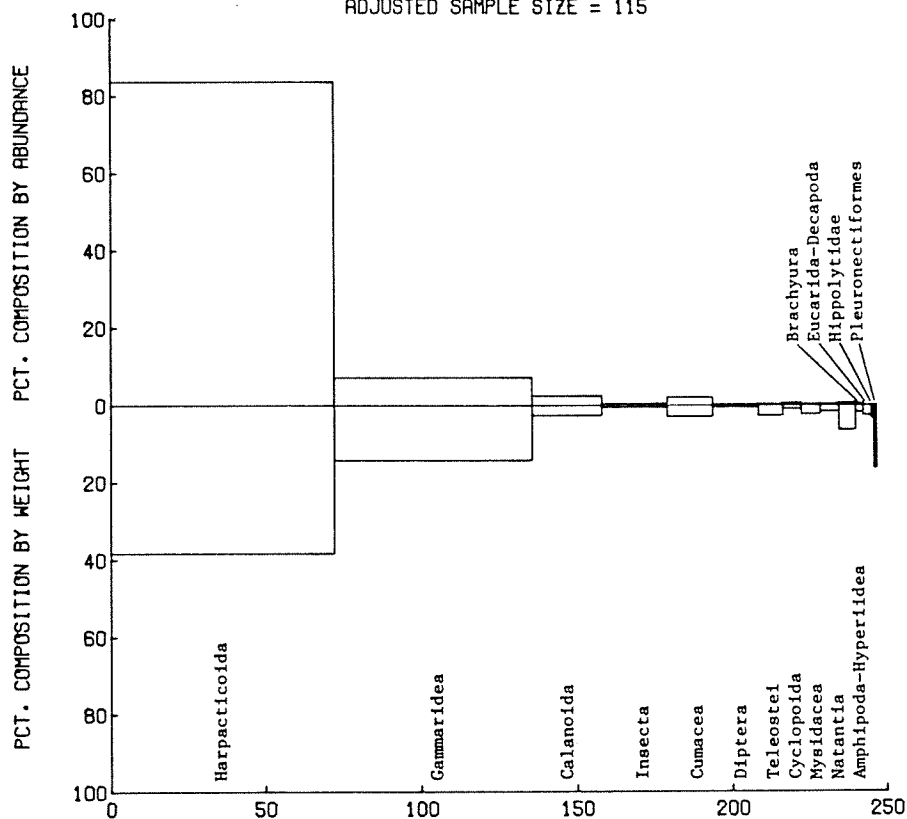
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PERCENT DOMINANCE INDEX	.91	.34	.84
SHANNON-WINER DIVERSITY	.38	1.91	.51
EVENNESS INDEX	.12	.58	.15

Fig. 38. IRI prey spectrum of juvenile pink salmon caught by townet in Nisqually Reach, southern Puget Sound, 1978.

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

8755010202 - ONCORHYNCHUS KETA  
CHUM SALMON  
ADJUSTED SAMPLE SIZE = 115



CUMULATIVE FREQUENCY OF OCCURRENCE

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/ BRACHYURA	5.22	.63	6.37	36.5	.35
EUCARIDA-DECAPODA	2.61	.38	1.75	5.6	.05
HIPPOLYTIDAE	2.61	.07	2.52	6.8	.06
PLEURONECTIFORMES	.87	.01	3.29	2.9	.03
	.87	.09	16.27	14.2	.14

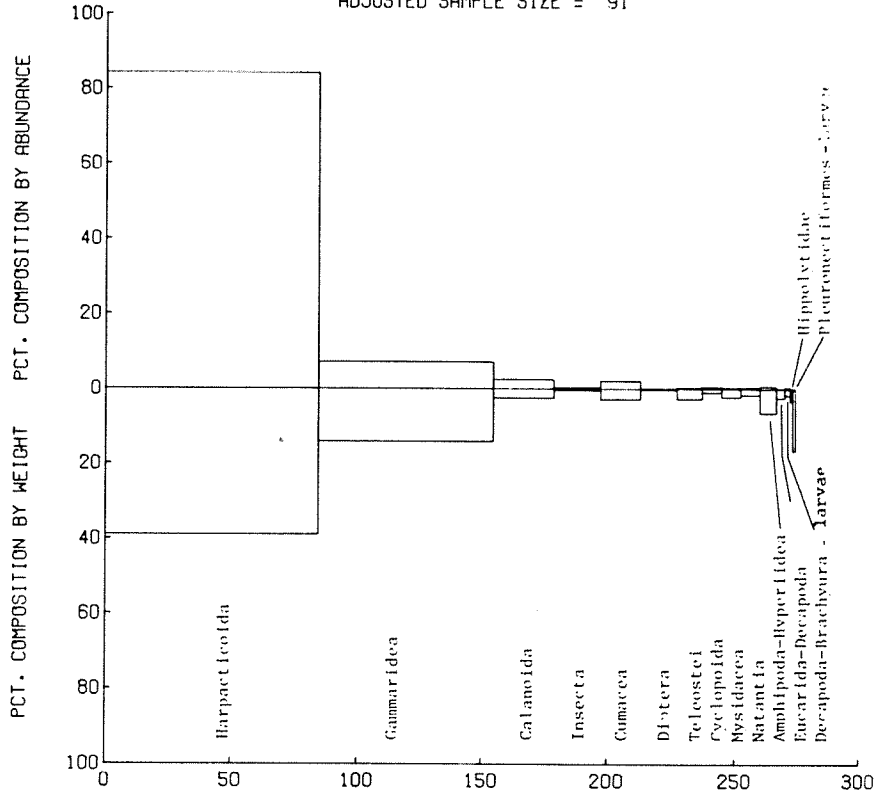
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PERCENT DOMINANCE INDEX	.71	.20	.72
SHANNON-WIENER DIVERSITY	1.10	3.04	.87
EVENNESS INDEX	.23	.63	.18

Fig. 39. 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



CUMULATIVE FREQUENCY OF OCCURRENCE

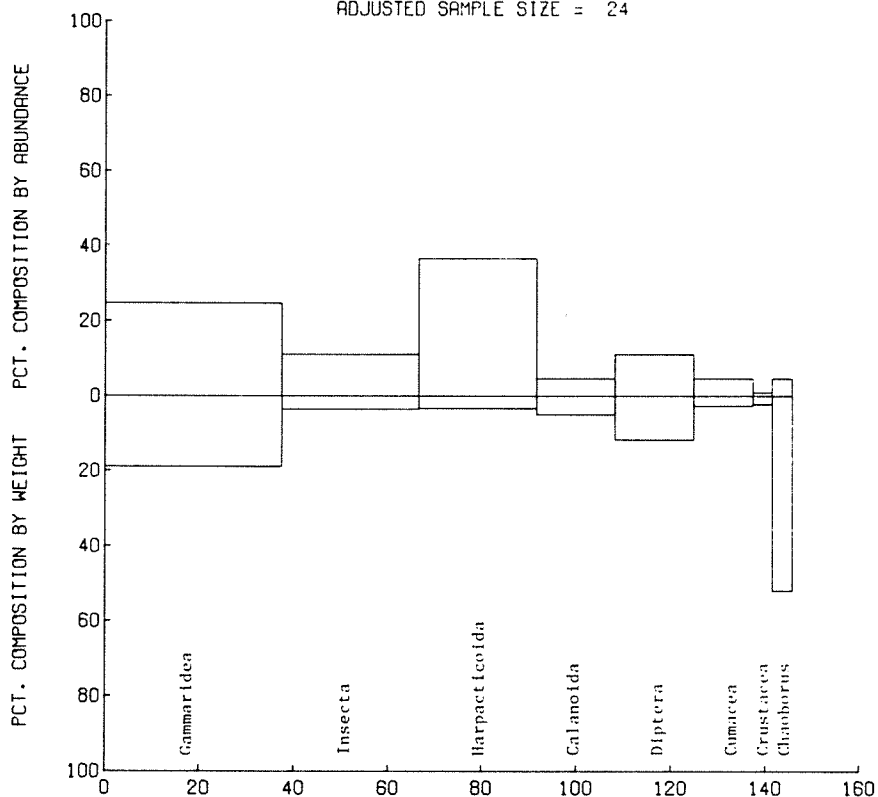
PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PPFY I.R.I.	PERCENT TOTAL IPI
HARPACTICOIDA	84.62	84.22	38.98	10424.5	84.71
GAMMARIDEA	70.33	7.05	14.18	1493.5	12.14
CALANOIDA	24.18	2.44	2.55	120.7	.98
INSECTA	18.68	.39	.49	16.5	.13
CUMACEA	15.38	2.06	2.88	76.0	.62
DIPTERA	14.29	.20	.24	6.3	.05
TELEOSTEI	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-HYPERITIDA	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
PTERONECTIFORMES	1.10	.09	16.57	18.2	.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	.21	.73
SHANNON-WEINER DIVERSITY	1.07	2.97	.83
EVENNESS INDEX	.23	.63	.18

Fig. 40. IRI prey spectrum of juvenile chum caught by beach seine in Nisqually Reach, southern Puget Sound, 1977.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM  
 FROM FILE IDENT. DUPONT, STATION ALL S  
 8755010202 - ONCORHYNCHUS KETA  
 CHUM SALMON  
 ADJUSTED SAMPLE SIZE = 24



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IPI
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)

PERCENT DOMINANCE INDEX	.23	.33	.26
SHANNON-WIENER DIVERSITY	2.53	2.17	2.30
EVENNESS INDEX	.76	.65	.69

Fig. 41. IRI prey spectrum of juvenile chum salmon caught by tonet in Nisqually Reach, southern Puget Sound, 1977.

1978 - With the expansion of the sampling design to the eastern end of Anderson Island in 1978, chum fry were obtained for stomach analyses from late March through late June; 450 specimens (including 11 with empty stomachs) were collected during beach seining, and 99 (including 3 with empty stomachs) were collected during townet sampling.

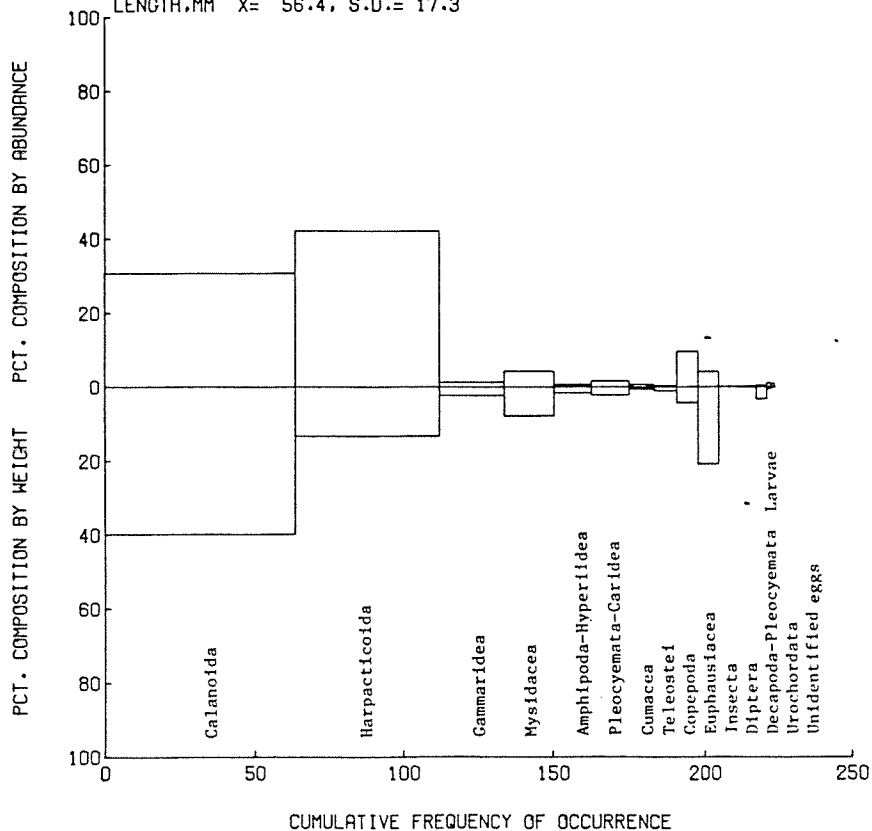
The composite prey spectrum of the beach seine-caught fish (Fig. 42) was dramatically different than that observed in 1977. Epibenthic harpacticoid copepods composed only 34 percent of the total IRI, while calanoid copepods accounted for 57 percent. These data sets are not directly comparable, however, because of the additional sampling sites along Anderson Island and collections occurring through June. Those fish caught with the townet, 75 percent of which were collected in early April, had a composite prey spectrum more evenly split between calanoid and harpacticoid copepods (Fig. 43).

Temporal variability in prey composition for daylight and nighttime beach seine collections at the six sites (Figs. 44 and 45) indicated the dominant prey organisms varied according to: 1) period in outmigration, 2) size of fish, and 3) habitat. Thus, chum fry caught during the day at the West Delta site, typically the first estuarine habitat they encounter upon migration out of the Nisqually River, had fed predominantly upon harpacticoid copepods while at night calanoids were generally more predominant. Chum fry captured along the DuPont shoreline, a shoreline with steeper subtidal gradients and a narrow, shallow sublittoral zone, had consumed more pelagic prey, especially after mid-May. The prey compositions of chum fry from the three Anderson Island sites were quite variable, but generally showed a progression in dominant prey from

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

 PREDATOR 8755010202 - ONCORHYNCHUS KETA  
 (CHUM SALMON ) ADJUSTED SAMPLE SIZE = 439

LENGTH,MM X= 56.4, S.D.= 17.3



PREY ITEM	FREQ. OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
CALANOIDA	63.55	30.71	39.82	4492.4	57.11
HARPACTICOIDA	48.52	42.12	13.28	2697.8	34.24
GAMMARIDEA	21.64	1.36	2.24	78.1	.99
MYSIDACEA	16.63	4.25	7.79	200.2	2.55
AMPHIPODA-HYPERIDEA	12.30	.71	1.60	28.5	.36
PLEOCYEMATA-CARIDEA LARVAE	12.30	1.66	2.23	47.8	.61
CUMACEA	8.20	.74	.57	10.8	.14
TELEOSTEI	7.52	.41	1.08	11.1	.14
COPEPODA	7.06	9.64	4.27	98.3	1.25
EUPHAUSIACEA	7.06	4.11	20.84	176.2	2.24
INSECTA	6.83	.16	.08	1.4	.02
DIPTERA	5.69	.11	.16	1.5	.02
DECAPODA-PLEOCYEMATA	3.64	.39	3.29	13.4	.17
UROCHORDATA	1.37	1.05	.55	2.7	.03
UNIDENTIFIED EGGS	1.37	1.01	.16	1.4	.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)

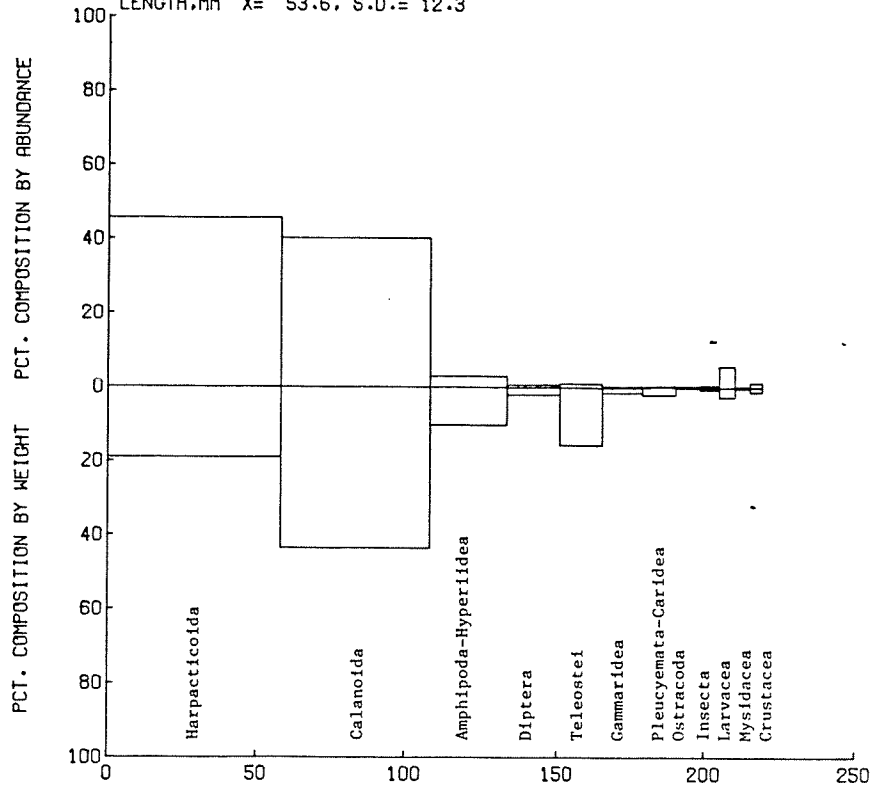
PERCENTY DOMINANCE INDEX	.79	.23	.44
SHANNON-WFINER DIVERSITY	2.40	2.73	1.53
EVENNESS INDEX	.49	.56	.31

Fig. 42. IRI prey spectrum of juvenile chum salmon caught by beach seine in Nisqually Reach, southern Puget Sound, 1978.

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

PREDATOR 8755010202 - ONCORHYNCHUS KETA  
(CHUM SALMON ) ADJUSTED SAMPLE SIZE = 96

LENGTH,MM X= 53.6, S.D.= 12.3



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	58.33	45.71	19.00	3774.5	43.31
CALANOIDA	50.00	40.30	43.56	4192.8	48.11
AMPHIPODA-HYPERIDIFA	25.00	3.03	10.20	330.8	3.80
DIPTERA	17.71	.73	2.08	49.7	.57
TELEOSTEI	14.58	1.07	15.57	242.7	2.78
GAMMARIDEA	13.54	.42	1.45	25.3	.29
PLEUROMMATA-CARIDEA	11.46	.33	2.06	27.4	.31
OSTRACODA	8.33	.38	.08	3.8	.04
INSECTA	6.25	.59	.64	7.6	.09
LARVACEA	5.21	5.73	2.66	43.7	.50
MYSIDACEA	5.21	.17	.20	1.9	.02
CRUSTACEA	4.17	1.30	1.28	10.8	.12
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		.38	.26		.42
SHANNON-WIENER DIVERSITY		1.81	2.43		1.52
EVENNESS INDEX		.45	.61		.38

Fig. 43. IRI prey spectrum of juvenile chum salmon caught by townet in Nisqually Reach, southern Puget Sound, 1978.

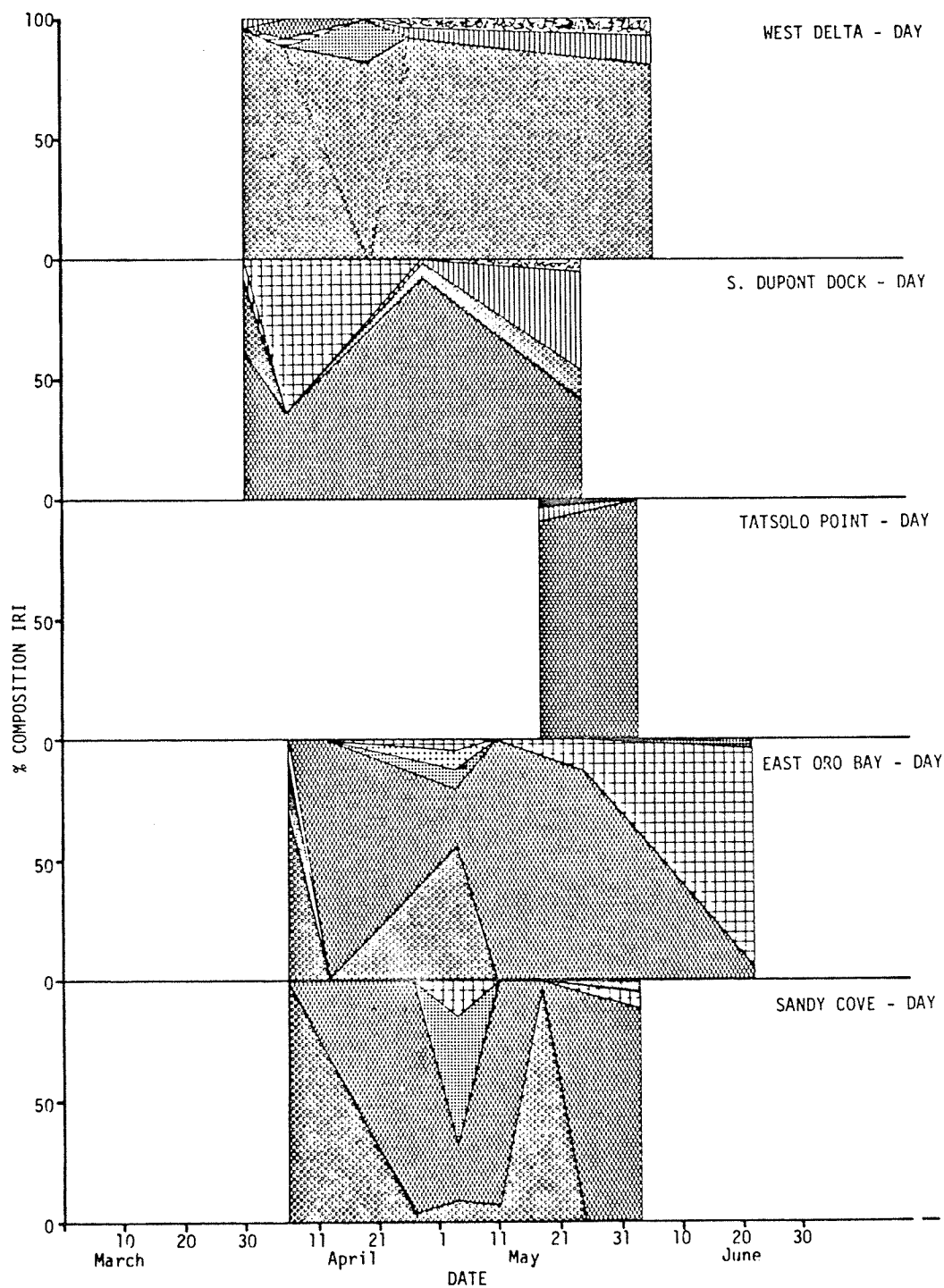
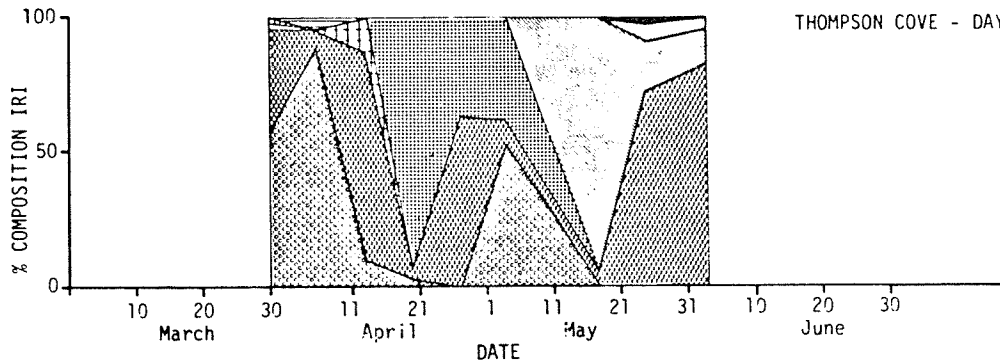
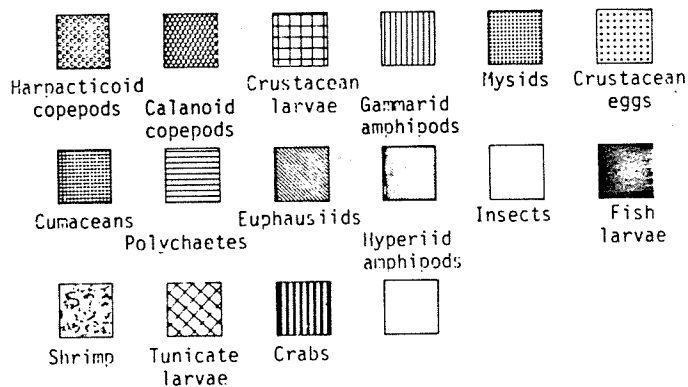


Fig. 44 Prey composition (% total IRI) of juvenile chum salmon collected during daytime beach seine collections at six sites in Nisqually Reach, southern Puget Sound, 1978. Prey legend is on page 131



PREY LEGEND:



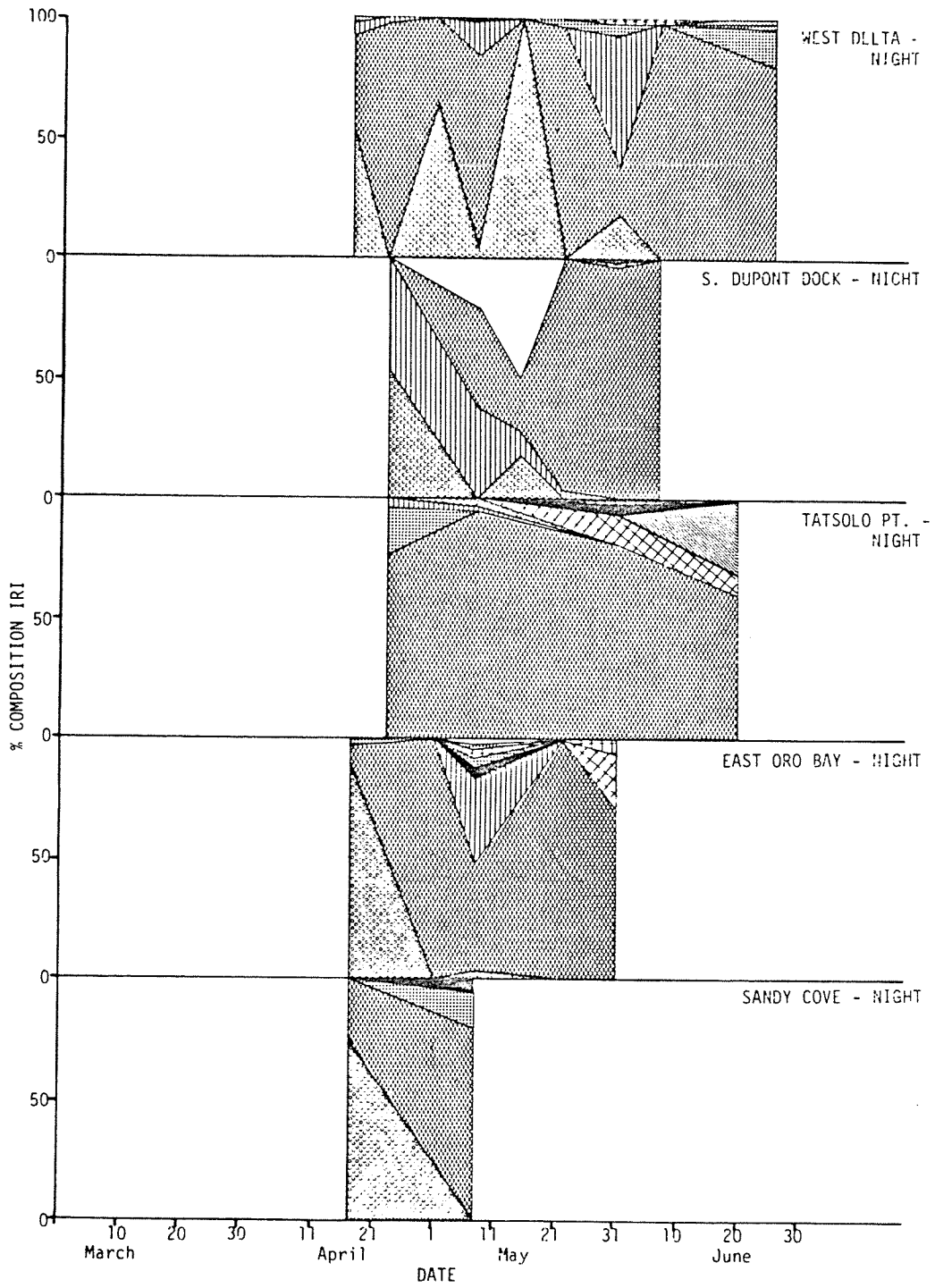
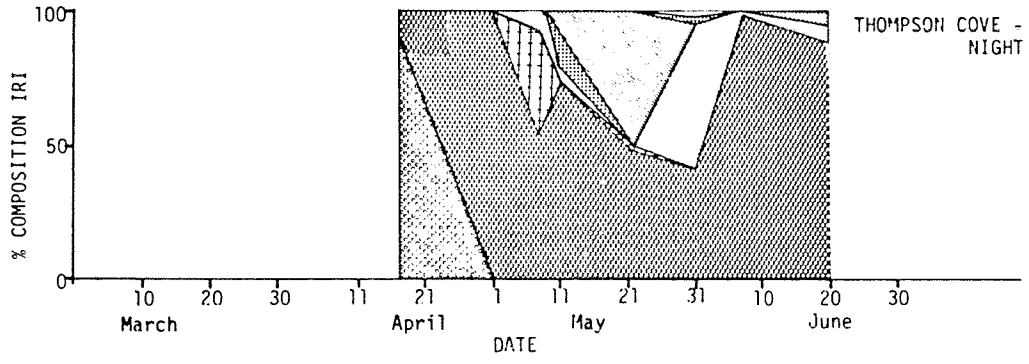


Fig. 45 Prey composition (% total IRI) of juvenile chum salmon collected during nighttime tow-net collections at six sites in Nisqually Reach, southern Puget Sound, 1978. Prey legend is on page 131



epibenthic harpacticoids to neritic calanoid copepods and crustacean larvae as the outmigration period progressed and the fish occupying the reach increased in size. This sequence is probably the combined result of concurrently increasing fish size and densities of neritic plankton.

Some qualitative differences between sites could also be generalized. Sandy Cove and Thompson Cove, for instance, were the only sites where mysids appeared in any abundance in the chum fry diet. Similarly, euphausiids were distinctly important only at Thompson Cove.

Differences in prey composition between daytime and nighttime collections were also evident. In general, calanoid copepods and hyperiid amphipods tended to be more prevalent in the nighttime prey spectra, while mysids and crustacea larvae were more common in the daytime prey spectra. The apparent variability from collection to collection, however, makes any quantitative comparisons difficult.

Monthly prey spectra (Table 33) indicated the gradual transition from feeding upon epibenthic harpacticoid copepods to neritic calanoid copepods as the outmigration period progressed.

Although chum fry caught during townetting were not collected as frequently or consistently as in beach seine collections, the April collections permitted several comparisons (Table 34). Samples from the night of April 3-4 showed varying predominance between harpacticoid and calanoid copepods. The mid-Reach and east Anderson Island transects had prey spectra favoring the epibenthic copepod, whereas west Anderson Island and DuPont shoreline fish, the pelagic form. Chum fry collected along the east Anderson Island shoreline during the next day had almost identical prey spectra, except for increased contributions by fish and crustacea

Table 33. Monthly variation in predominant prey organisms of juvenile pink (a), chum (b), coho (c), and chinook (d) salmon fry caught during beach seining in Nisqually Reach, southern Puget Sound, 1978.

Species	Prey Taxa	% Total IRI			
		March(n)	April(n)	May(n)	June(n)
a) Pink	Harpacticoid copepods	92.54(2)	33.49(52)	0.63(2)	
	Gammarid amphipods	4.23	0.07	2.18	
	Cumaceans	2.24		13.33	
	Calanoid copepods		56.80	55.36	
	Mysids		8.65	1.83	
	Hyperiid amphipods		0.76	4.31	
	Crustacea larvae		0.02	13.66	
	Euphausiids			4.86	
	Chaetognaths			2.35	
b) Chum	Harpacticoid copepods	86.06(64)	56.29(177)	10.78(150)	3.68(48)
	Calanoid copepods	10.75	33.57	77.10	87.38
	Gammarid amphipods	2.52	0.49	1.39	0.50
	Mysids		8.57	2.04	0.06
	Euphausiids			6.88	3.54
	Crustacea larvae	0.02	0.36	0.65	2.62
	Hyperiid amphipods		0.17	0.42	1.40
c) Coho	Gammarid amphipods	64.61(5)	71.50(63)		
	Harpacticoid copepods	17.63	7.07		
	Polychaetes	10.18	0.38		
	Calanoid copepods	6.01	0.19		
	Insects	1.08	0.40		
	Mysids		13.82		
Crustacea larvae	0.48	3.93			
d) Chinook	Euphausiids	36.53(3)	(12)	1.04(21)	14.42(23)
	Gammarid amphipods	1.61	66.18	52.94	1.97
	Insects	1.25	2.49	0.53	0.09
	Mysids		13.81	2.04	
	Fish		9.24	9.43	8.56
	Calanoid copepods		5.83	1.16	6.13
	Shrimp		1.44	2.38	
	Crustacea larvae	0.59		23.03	51.83
	Polychaeta			5.78	
Hyperiid amphipods	0.22		0.21	16.24	

Table 34. Prey composition (% total IRI) of chum fry caught during townet collections in Nisqually Reach, southern Puget Sound, April 1978.

Townet Transect Locations	April 3*/4			April 4	April 18*	
	DuPont Dock	Mid- Reach	Thompson Cove	East Oro Bay	East Oro Bay	East Oro Bay
Prey Taxa	(n=16)	(n=5)	(n=26)	(n=22)	(n=11)	(n=12)
Calanoid copepods	72.72	5.58	63.73	29.40	17.35	59.14
Harpacticoid copepods	12.93	64.89	25.12	49.54	50.13	30.26
Insects	9.05	8.63	1.04	0.57		0.15
Hyperiid amphipods	4.23	5.74	0.65	14.80	7.38	<0.01
Fish larvae	0.52	6.30	0.28	4.40	17.82	1.37
Crustacea larvae	0.35	5.59		0.51	7.27	0.03
Ostracods		2.36		0.05		<0.00
Larvacea			7.14	0.27		
Gammarid amphipods		0.80	1.67	0.35		0.02

\*Nighttime collection

larvae; another nighttime townet collection along the same shoreline two weeks later indicated increased importance of calanoid copepods.

Coho Salmon (Oncorhynchus kisutch)

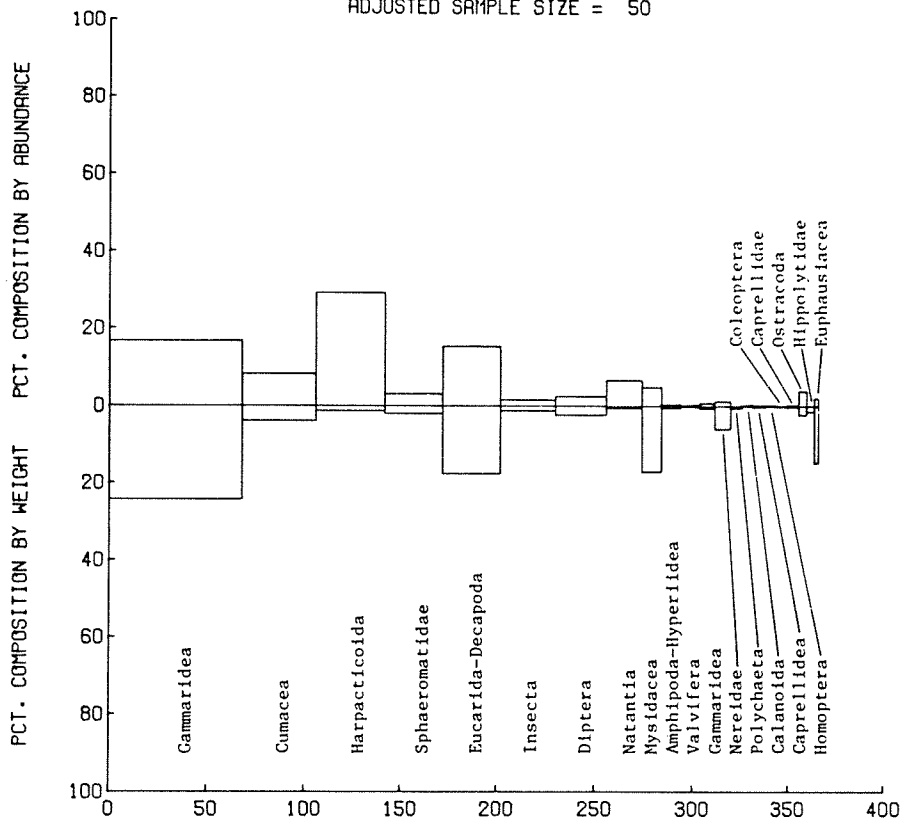
1977 - Beach seine collections during May accounted for the majority of the juvenile coho captured.

The composite prey spectrum of all juvenile coho examined was quite diverse and emphasized epibenthic crustaceans, specifically gammarid amphipods, cumaceans, flabelliferan isopods (Gnorimosphaeroma oregonensis, Exosphaeroma amplicauda), harpacticoid copepods and mysids (Fig. 46). Coho originating from beach seine collections had a more diverse prey spectrum, both numerically and gravimetrically than coho caught by townet (Figs. 47 and 48). 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 suggested that juvenile coho were feeding principally in the shallow sublittoral during daylight, but fed in neritic waters at night although on larger organisms and apparently not as intensively, since there were fewer organisms per stomach.)

1978 - Most juvenile coho sampled for stomach contents during 1978 originated from beach seine collections at all sites. The composite prey spectrum (Fig. 49) was similar to that documented for 1977 (Fig. 46), with gammarid amphipods and crustaceae larvae remaining as the principal prey.

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.P.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-HYPERIIDAE	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
CAPRELLIDAE	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

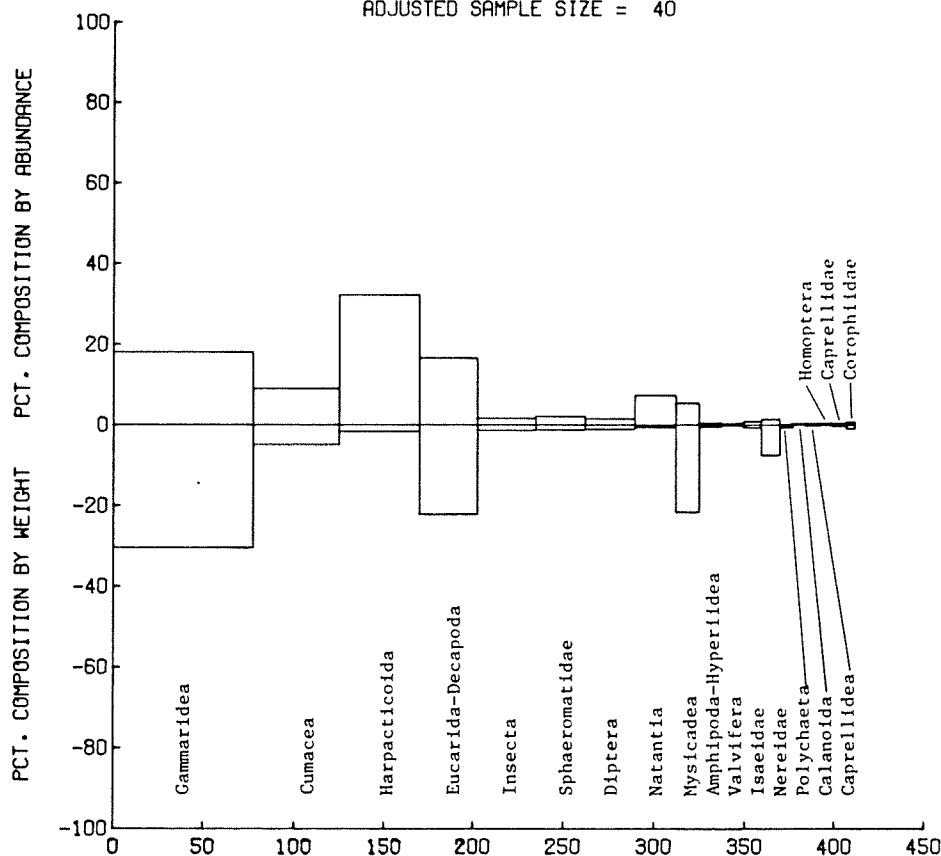
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

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

Fig. 46. 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 B

8755010203 - ONCORHYNCHUS KISUTCH  
COHO SALMON  
ADJUSTED SAMPLE SIZE = 40



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	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

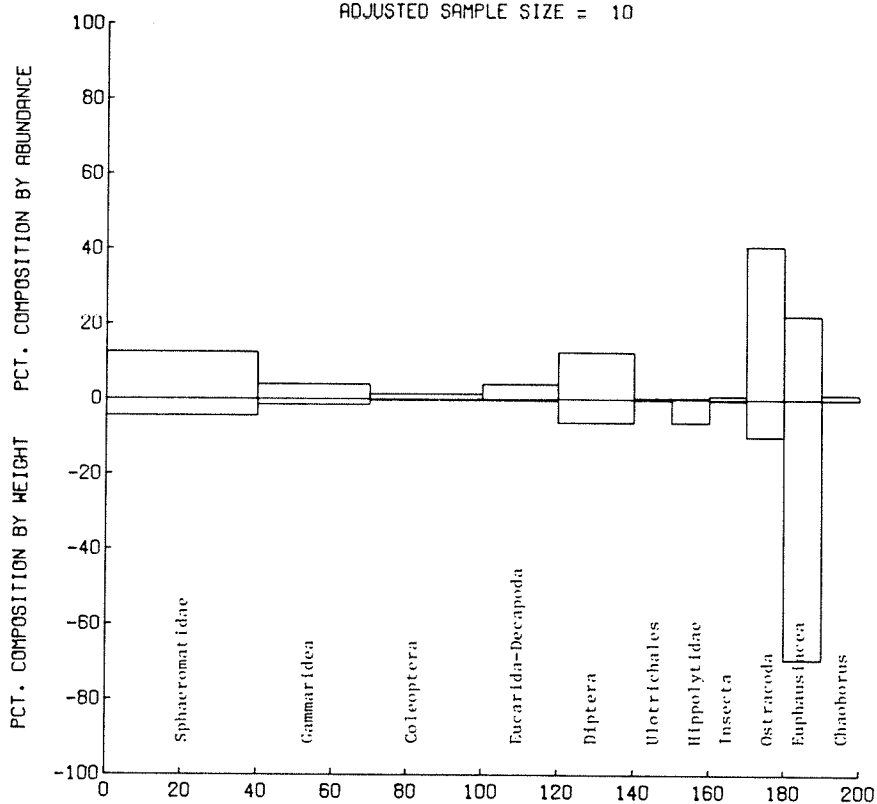
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

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

Fig. 47. IRI prey spectrum of juvenile coho salmon caught in beach seine collections in Nisqually Reach, southern Puget Sound, 1977.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM  
FROM FILE IDENT. DUPONT, STATION ALL 5

8755010203 - ONCORHYNCHUS KISUTCH  
COHO SALMON  
ADJUSTED SAMPLE SIZE = 10



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
SPHAEROMATIDAE	40.00	12.45	4.50	677.9	23.49
GAMMARIDAE	30.00	3.86	1.59	163.5	5.67
COLEOPTERA	30.00	1.29	.54	54.7	1.90
FUCARIDA-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
CHAORORUS	10.00	1.29	.13	14.2	.49

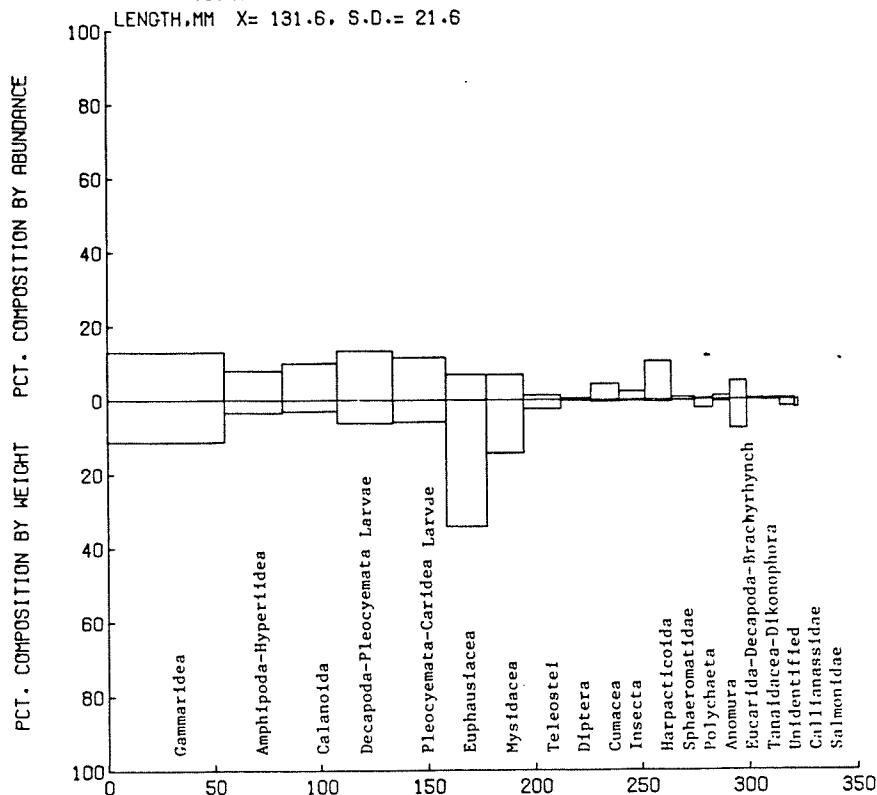
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

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

Fig. 48. IRI prey spectrum of juvenile coho salmon caught in totnet collections in Nisqually Reach, southern Puget Sound, 1977.

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

PREDATOR 8755010203 - ONCORHYNCHUS KISUTCH  
(COHO SALMON ) ADJUSTED SAMPLE SIZE = 233



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE			PREY I.R.I.	PERCENT TOTAL IRI
	FREQ OCCUR	NUM. COMP.	GRAV. COMP.		
GAMMARIDEA	54.94	13.08	11.28	1338.7	29.37
AMPHIPODA-HYPERIIDEA	27.47	8.02	3.42	314.1	6.89
CALANOIDA	25.75	10.10	3.01	337.5	7.41
DECAPODA-PLEOCYEMATA LARVAE	25.75	13.40	6.22	505.3	11.09
PLEOCYEMATA-CARIDEA LARVAE	24.89	11.61	5.85	434.6	9.54
EUPHAUSIACEA	18.45	6.91	34.20	758.6	16.65
MYSIDACEA	17.60	6.90	14.24	372.0	8.17
TELEOSTEI	17.60	1.32	2.42	65.8	1.44
DIPTERA	14.16	.56	.35	12.9	.28
CUMACEA	13.30	4.34	.56	65.1	1.43
INSECTA	12.45	2.24	.47	33.7	.74
HARPACTICOIDA	12.02	10.40	.58	132.0	2.90
SPHAEROMATIDAE	10.73	.74	.29	11.1	.24
POLYCHAETA	8.58	.40	2.24	22.6	.50
ANOMURA	8.15	1.07	.56	13.3	.29
EUCARIDA-DECAPODA-BRACHYRRHYNCH	7.73	4.98	7.81	98.8	2.17
TANAIDACEA-DIKONOPHORA	7.30	.32	.12	3.2	.07
UNIDENTIFIED	7.30	.40	.17	4.2	.09
CALLINANASSIDAE	6.87	.39	1.79	15.0	.33
SALMONIDAE	1.72	.03	2.15	3.8	.08

Fig. 49. IRI prey spectrum of juvenile coho salmon in Nisqually Reach, southern Puget Sound, 1978.

Larval and juvenile fish, including juvenile chums and prickleback (Stichaeidae) and flatfish (Pleuronectidae) larvae, were insignificant in the diet; the four salmon fry constituted only 0.08 percent of the total IRI.

Prey composition grouped for March and April indicated a relatively equal dietary emphasis upon gammarid amphipods, but replacement of harpacticoid copepods and polychaetes by mysids (Table 33).

Comparisons of diel prey composition during the outmigration between early April and late June (Fig. 50) suggested several variations. Mysids and harpacticoid copepods were prevalent in the early half of the outmigration, principally during the day. Euphausiids were consumed during both periods, but occurred earlier and more often in the nighttime collections, particularly in June. Hyperiid amphipods originated almost exclusively from nighttime collections. Crustacean larvae were prominent in both the day and night prey spectra but often did not coincide in relative importance. Much of the temporal shifts in exploitation of neritic prey may be associated with the changes in dominant zooplankton taxa (see Appendix 7), although selectivity for the larger plankters is evident.

#### Chinook Salmon (*Oncorhynchus tshawytscha*)

1977 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

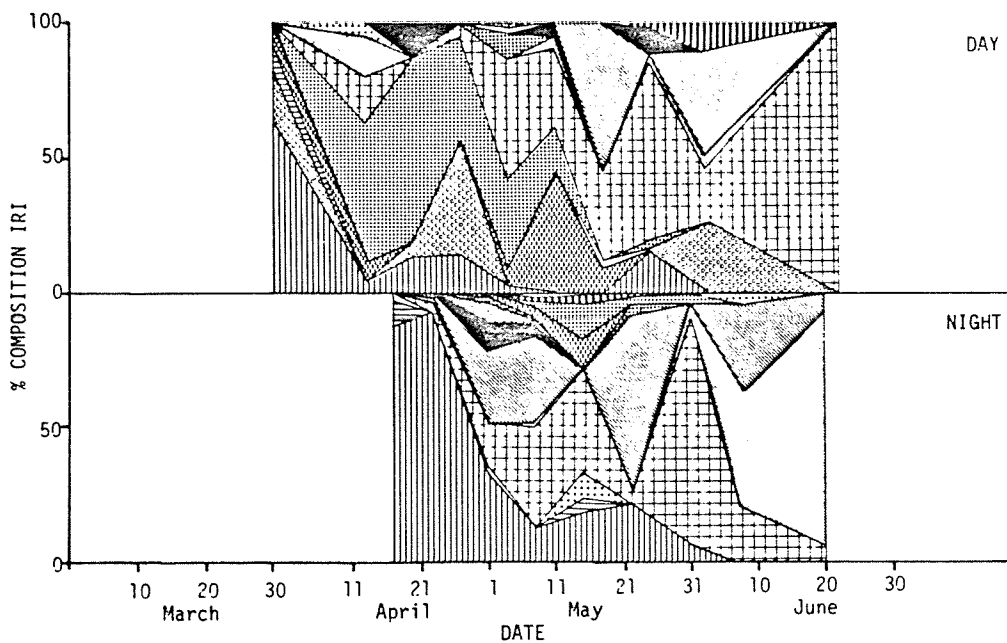


Fig. 50 Prey composition (% total IRI) of juvenile coho salmon collected during (a) daytime and (b) nighttime beach seine collections in Nisqually Reach, southern Puget Sound, 1978. Prey legend is on page 131

resident chinook (blackmouth) were collected in the April beach seine collection at the outer Nisqually Delta.

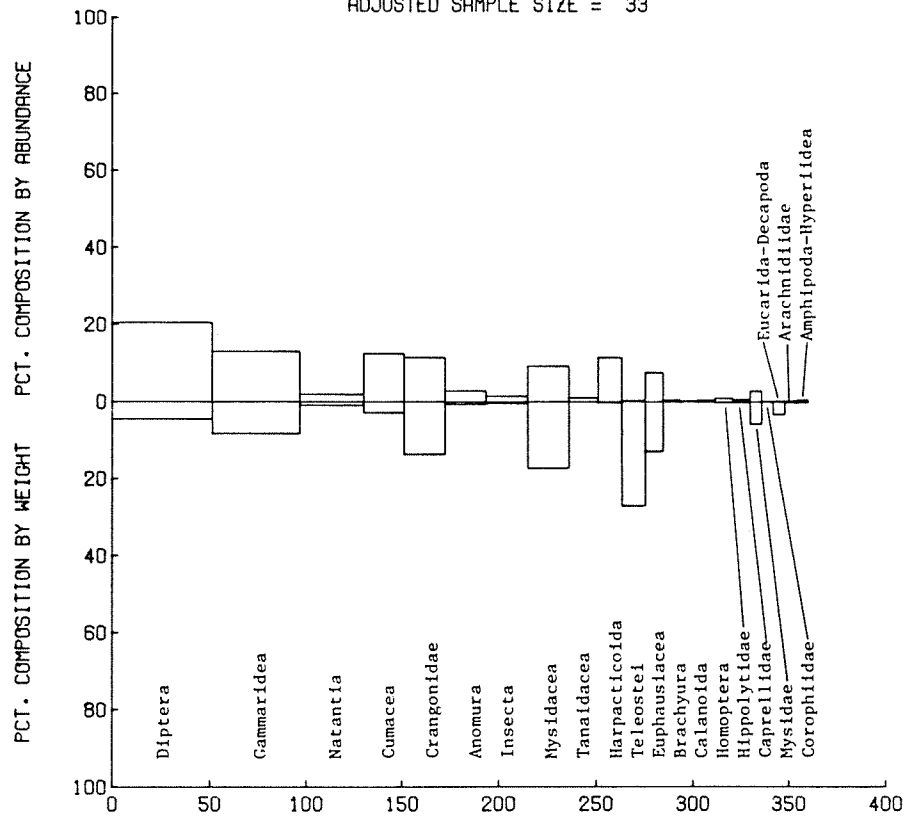
The overall diet of juvenile chinooks was, like juvenile coho, extremely diverse (Appendix 8). The chinook prey spectrum was based principally upon epibenthic crustacea - gammarid amphipods (20.7 percent of total IRI), mysids (13.2 percent), cumaceans (6.9 percent), shrimp (13.8 percent) (Crangon sp.) 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. 51). 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.

1978 - Most stomach samples of juvenile chinook were collected after mid-April; few collected by townet were examined for stomach contents.

A major difference between the 1977 (Fig. 51) and 1978 prey spectra (Fig. 52) was the low contribution (0.50 percent of total IRI) of dipteran (drift) insects in 1978. Conversely, crustacean larvae, euphausiids, hyperiid amphipods, and calanoid copepods were relatively more important in the 1978 prey spectra. The decline in the dietary contribution by drift insects may have been due to the increased sampling on the east shoreline of Anderson Island, more removed from the influence of the Nisqually River plume. The overall diet, however, was still rather evenly divided between epibenthic and neritic prey; this diversity in the prey

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

8755010206 - ONCORHYNCHUS TSHAWYTSCHA  
CHINOOK SALMON  
ADJUSTED SAMPLE SIZE = 33



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	FRFQ OCCUR	NUM. COMP.	GRAV. COMP.	PRFY I.R.I.	PERCENT TOTAL IRI
DIPTERA	51.52	20.50	4.53	1289.1	27.57
GAMMARIDEA	45.45	12.95	8.37	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
CAPRELLIDAE	9.09	.59	.21	7.2	.15
MYSIDAE	6.06	2.82	5.78	52.1	1.11
COROPHIDAE	6.06	.17	.03	1.2	.02
EUCARIDA-DECAPODA	6.06	.17	3.33	21.2	.45
ARACHNIDAE	6.06	.17	.12	1.7	.04
AMPHIPODA-HYPERIDEA	6.06	.50	.16	4.0	.08

PREY TAXA WITH FRFQ. 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	.15	.16
SHANNON-WIENER DIVERSITY	3.47	3.09	3.07
EVENNESS INDEX	.71	.64	.63

Fig. 51. IRI prey spectrum of juvenile chinook salmon in Nisqually Reach, southern Puget Sound, 1977.

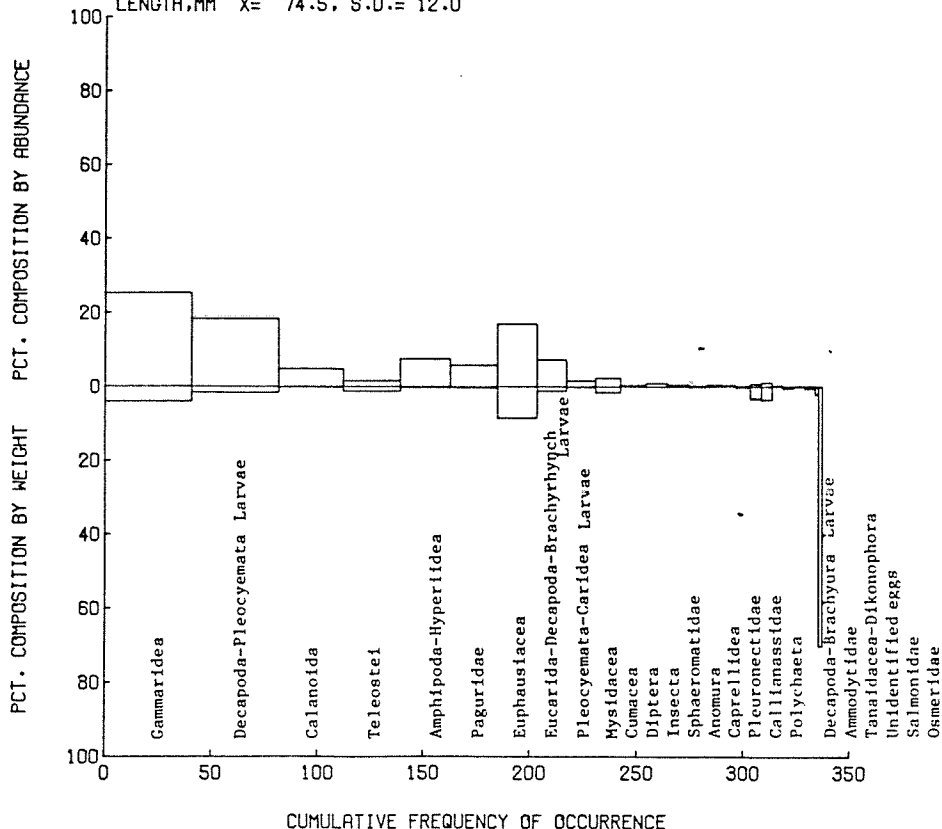
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM

FROM FILE IDENT. DUPONT, STATION ALL

PREDATOR 8755010206 - ONCORHYNCHUS TSHAWYTSCHA

(CHINOOK SALMON ) ADJUSTED SAMPLE SIZE = 59

LENGTH,MM X= 74.5, S.D.= 12.0



PREY ITEM	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	40.68	25.24	4.06	1191.5	34.66
DECAPODA-PLEOCYEMATA LARVAE	40.68	18.34	1.69	814.8	23.71
CALANOIDA	30.51	4.79	.17	150.8	4.39
TELEOSTEI	27.12	1.62	1.29	78.9	2.30
AMPHIPODA-HYPERIIDAE	23.73	7.48	.32	185.0	5.38
PAGURIDAE	22.03	5.77	.36	135.0	3.93
EUPHAUSTACEA	18.64	16.94	8.49	474.3	13.80
EUCARIDA-DECAPODA-BRACHYRYHNCH L.	13.56	7.30	1.23	115.7	3.37
PLEOCYEMATA-CARIDEA LARVAE	13.56	1.62	.13	23.8	.69
MYSIDACEA	11.86	2.39	1.57	47.0	1.37
CUMACEA	11.86	.54	.02	6.7	.20
DIPTERA	10.17	.99	.02	10.7	.30
INSECTA	10.17	.63	.06	7.0	.20
SPHAEROMATIDAE	8.47	.27	.13	3.4	.10
ANOMURA	6.78	.63	.05	4.6	.14
CAPRELLIDAE	6.78	.54	.03	3.8	.11
PLEURONECTIDAE	6.78	.23	.19	2.8	.08
CALLINANASSIDAE	5.08	.81	3.18	20.7	.59
POLYCHAETA	5.08	1.22	3.56	24.3	.71
DECAPODA-BRACHYURA LARVAE	5.08	.32	.03	1.7	.05
AMMODYTIDAE	5.08	.14	.46	3.0	.09
TANAIDACEA-DIKONOPHORA	5.08	.18	.00	.0	.03
UNIDENTIFIED EGGS	5.08	.18	.52	3.5	.10
SALMONIDAE	1.69	.14	2.13	3.8	.11
OSMERIDAE	1.69	.05	70.16	119.0	3.46

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	.14	.50	.20
SHANNON-WIENER DIVERSITY	3.35	1.88	2.87
EVENNESS INDEX	.65	.37	.56

Fig. 52. IRI prey spectrum of juvenile chinook salmon caught by beach seine in Nisqually Reach, southern Puget Sound, 1978.

spectrum may be due to the broad size range and distribution of juvenile chinook obtained in the collections. The sample size was not large enough within discrete time periods to partition the analysis by size classes. Fish again accounted for about 7 percent of the total IRI, principally due to the biomass contribution of one surf smelt. Larval and juvenile gadoids, Pacific sand lance, pricklebacks (Stichaeidae), and flatfish (Pleuronectidae) were also found in the stomachs; only three juvenile chum fry were included in this prey category, providing only 2.1 percent of the total IRI.

The monthly prey composition (Table 33) indicated that the overall prey composition may change from euphausiids in March, to gammarid amphipods, mysids, fish and crustacean larvae in April and May, and crustacean larvae, euphausiids, fish, and calanoid copepods in June. The March data are weak, however, due to a low sample size.

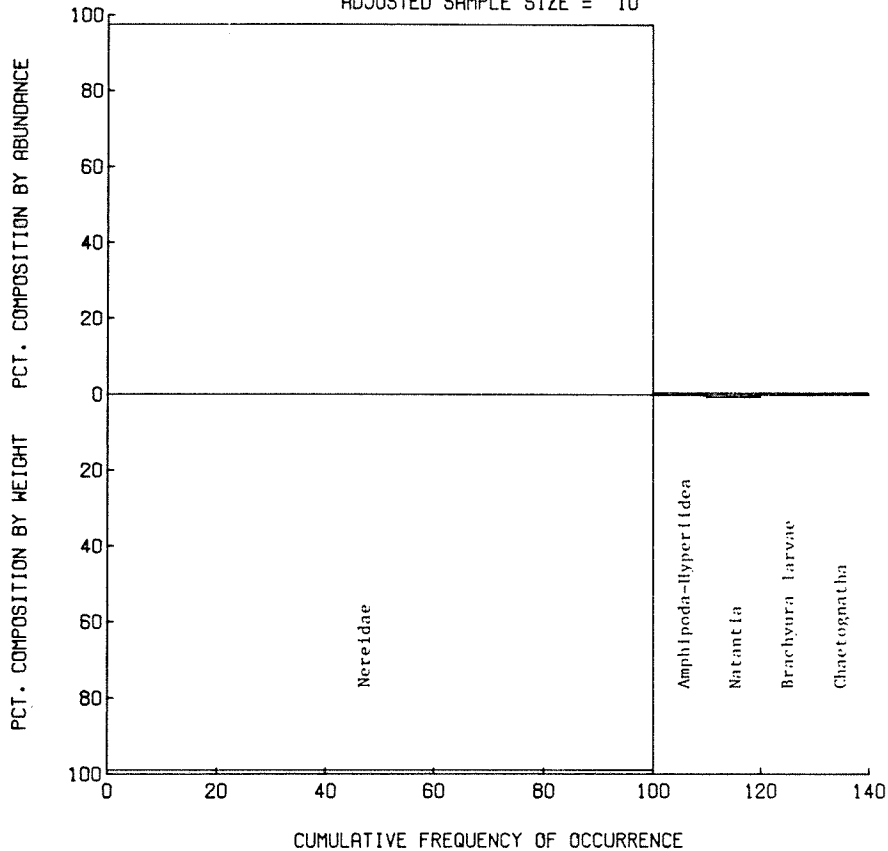
#### Potential Predators of Juvenile Salmon

##### 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. 53). 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.

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

8710010201 - SQUALUS ACANTHIAS  
SPINY DOGFISH  
ADJUSTED SAMPLE SIZE = 10



Prey Taxa	(%)	(%)	(%)	Prey I.R.I.	Σ I.R.I.
	Frequency of Occurrence	Numerical Composition	Gravimetric Composition		
Nereidae	100.00	97.55	99.00	10655.1	99.82
Amphipoda-Hyperidea	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. 53 IRI prey spectrum of spiny dogfish in Nisqually Reach, southern Puget Sound, 1977.

Ratfish (*Hydrolagus colliei*)

Seventeen ratfish were collected during the winter 1977-1978 (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) the most important food organisms in a diverse prey spectrum (Fig. 54). The remains of two sculpins, *Artedius* sp., and buffalo sculpin constituted 1.3 percent of the total IRI.

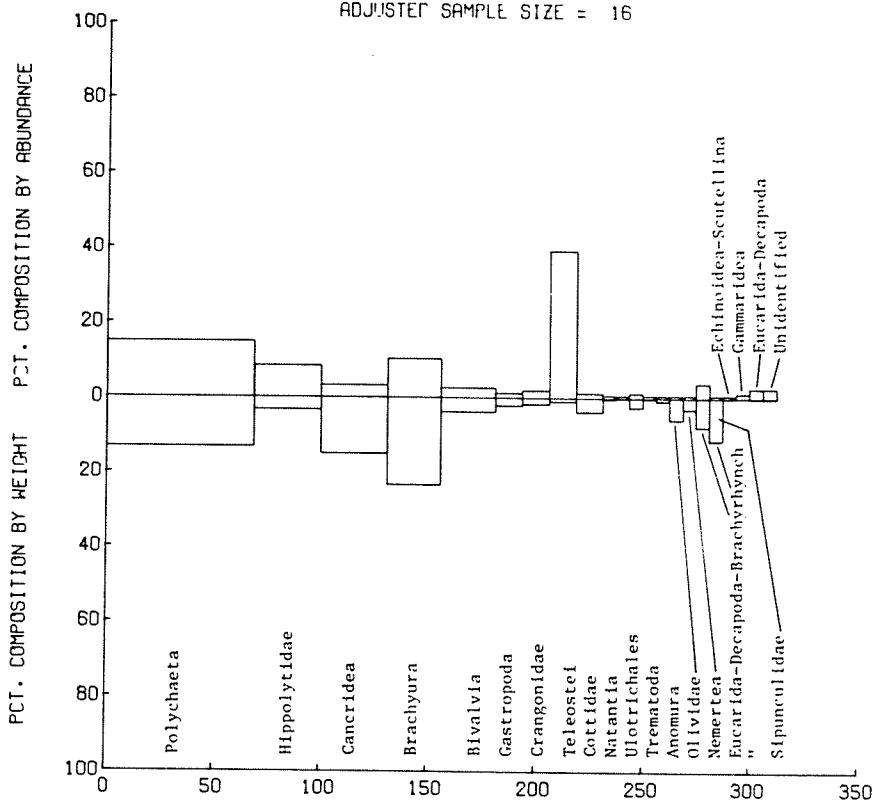
One ratfish captured in an April 8, 1978 beach seine collection at the South DuPont Dock site has a diverse array of prey in its stomach, dominated by 28 *Hemigrapsus* sp. shore crabs (21.7 percent total abundance, 38.2 percent total biomass) and gammarid amphipods (41.5 percent total abundance, 13.6 percent total biomass).

Sea-Run Cutthroat Trout (*Salmo clarki*)

One 322-mm FL sea-run cutthroat trout was captured in the April 1977 beach seine collection south of the DuPont Dock. Unfortunately, the stomach was damaged upon removal, disallowing quantitative interpretation; however, no fish remains were evident.

Six cutthroat trout (4 juveniles, 2 adults) from spring 1978 beach seine collections were analyzed for stomach contents, three at Tatsolo Point. Gammarid amphipods (46.2 percent total abundance, 19.3 percent total biomass), euphausiids (21.7 percent total abundance, 14.2 percent total biomass) and callianassid shrimp (20.3 percent total abundance, 26.2 percent total biomass) were the principal prey. Fish, though not numerically important (4.2 percent total abundance), did account for the highest proportion of the total biomass (39.5 percent) and included two

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM  
 FROM FILE IDENT. DUPONT, STATION ALSTA  
 8716020101 - HYDROLAGUS COLLIE;  
 RATFISH  
 ADJUSTED SAMPLE SIZE = 16



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-WFINER DIVERSITY	3.14	3.41	2.77
EVENNESS INDEX	.70	.77	.62

Fig. 54. IRI prey spectrum of ratfish in Nisqually Reach, southern Puget Sound, 1977.

salmon fry (probably chum) which accounted for 25.7 percent of the total biomass.

Rainbow (Steelhead) Trout (*Salmo gairdneri*)

A steelhead trout (359 mm FL) caught during the beach seine collections at Tatsolo Point in late June 1977 had two Pacific herring in its stomach.

The stomach contents of five steelhead captured in late May and June, 1978 beach seine collections were numerically dominated by gammarid amphipods (66.2 percent total abundance). Fish dominated the total prey biomass (85.8 percent) and included juvenile English sole, Pacific sand lance, and only one salmon fry (0.5 percent total abundance, 1.6 percent total biomass).

Dolly Varden (*Salvelinus malma*)

The stomach of one Dolly Varden captured in the April 17, 1978 beach seine collection at the west Delta contained no identifiable prey organisms.

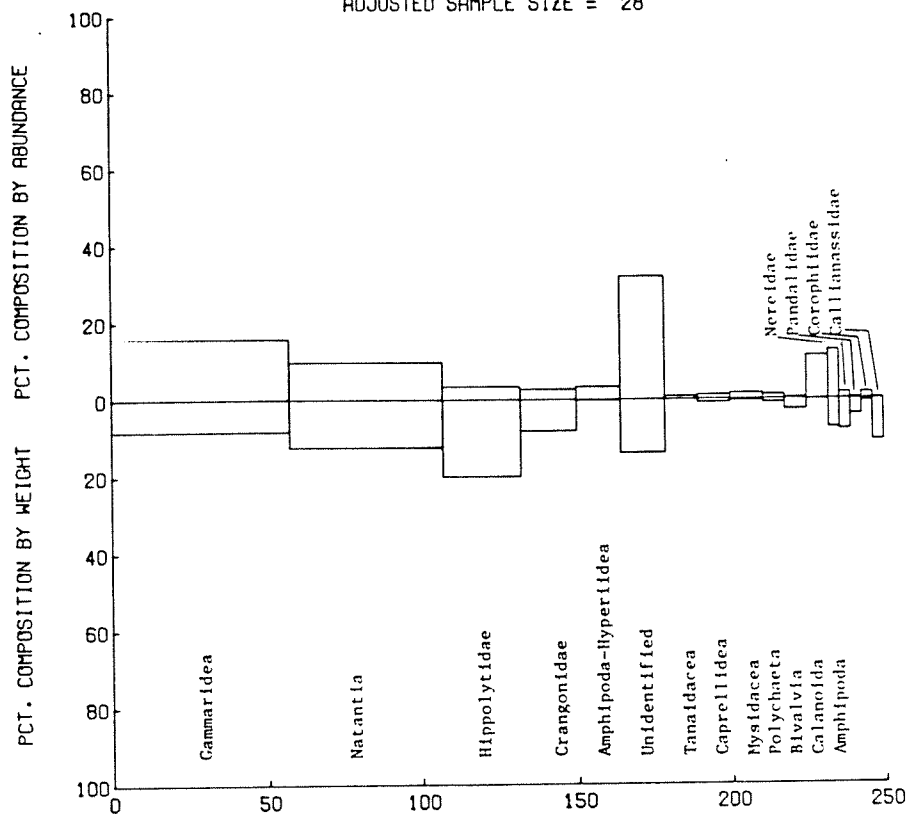
Pacific Tomcod (*Microgadus proximus*)

Trynet collections from June-November 1977 period at Tatsolo Point and 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. 55). 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.

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

8791030601 - MICROGADUS PROXIMUS  
PACIFIC TOMCOD  
ADJUSTED SAMPLE SIZE = 28



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IPI
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-HYPERTIDEA	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	.40	20.7	.48
POLYCHAETA	7.14	1.08	.91	14.2	.33
BIVALVIA	7.14	.36	2.76	22.3	.52
CALAMOIDA	7.14	11.15	.17	80.8	1.87
AMPHIPODA	3.57	12.59	7.45	71.6	1.66
NEPHELIDAE	3.57	1.62	7.91	34.0	.79
PANDALIDAE	3.57	.18	4.07	15.2	.35
COROPHIDAE	3.57	1.62	.61	8.0	.18
CALLINANASSIDAE	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)

PERCENT DOMINANCE INDEX	.17	.11	.21
SHANNON-WIENER DIVERSITY	3.10	3.38	2.65
EVENNESS INDEX	.70	.77	.60

Fig. 55. IRI prey spectrum of Pacific tomcod in Nisqually Reach, southern Puget Sound, 1977-1978.

Copper Rockfish (Sebastes caurinus)

Beach seine and trynet collections in 1977 at Tatsolo Point produced the five copper rockfish specimens (mostly juveniles) used for stomach analysis.

Shrimp, including Heptacarpus stylus, H. taylori, Pandalus spp. and Crangon spp., 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.

Roughback Sculpin (Chitonotis pugetensis)

The most abundant cottid caught during trynet sampling was the roughback sculpin. Its prey spectrum (Fig. 56) 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 Oreponia gracilis). Shrimp accounted for 61.4 percent of the total IRI and crabs, 7.5 percent.

Three adult roughback sculpin captured at Tatsolo Point in late April-early May beach seine collections had stomach contents dominated by hippolytid shrimp (37.5 percent total abundance, 50 percent total biomass) and gammarid amphipods (22.5 percent total abundance, 6.6 percent total biomass).

Buffalo Sculpin (Enophrys bison)

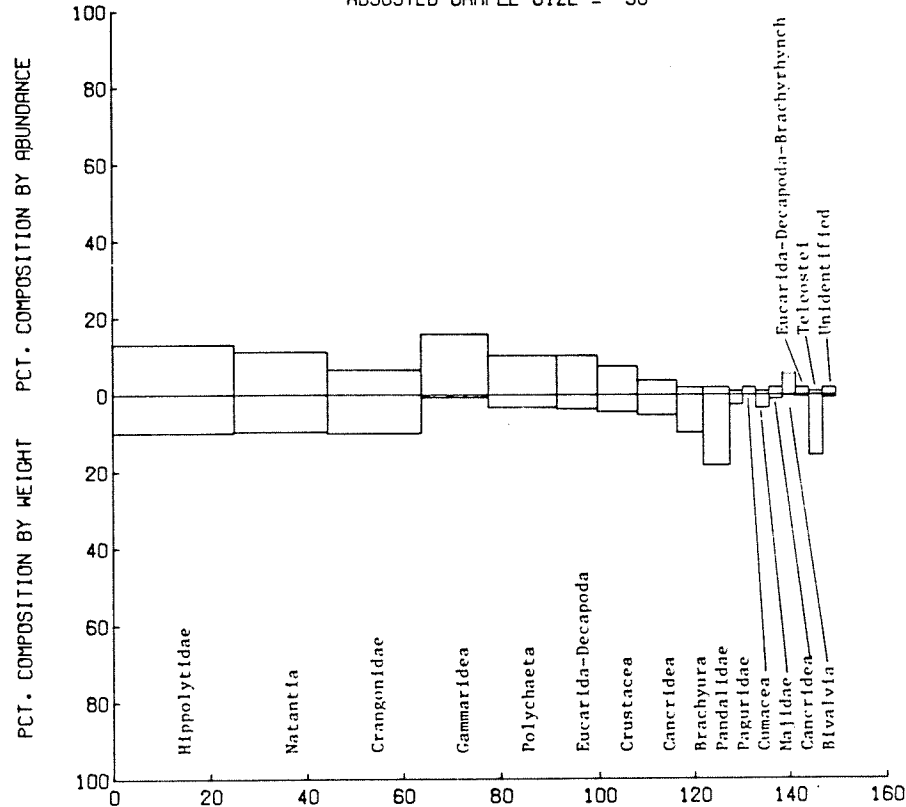
The buffalo sculpin was one of the most common demersal species caught by beach seine in the DuPont Dock vicinity and was also the most common demersal species observed along the DuPont Dock SCUBA transect. Fall and winter trynet collections also provided specimens.

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

8831024001 - CHITONOTIS PUGETENSIS

ROUGHBACK SCULPIN

ADJUSTED SAMPLE SIZE = 36



CUMULATIVE FREQUENCY OF OCCURRENCE

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	9.68	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
CANCRIDAE	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
CANCRIDAE	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-WIENER DIVERSITY	3.74	3.52	3.25
EVENNESS INDEX	.87	.81	.75

Fig. 56. IRI prey spectrum of roughback sculpin in Nisqually Reach, southern Puget Sound, 1977-78.

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. 57). Unidentified eggs (possibly from fish such as 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 sculpins had a much less diverse prey spectrum (Fig. 58) than did those caught with the trynet (Fig. 59). 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).

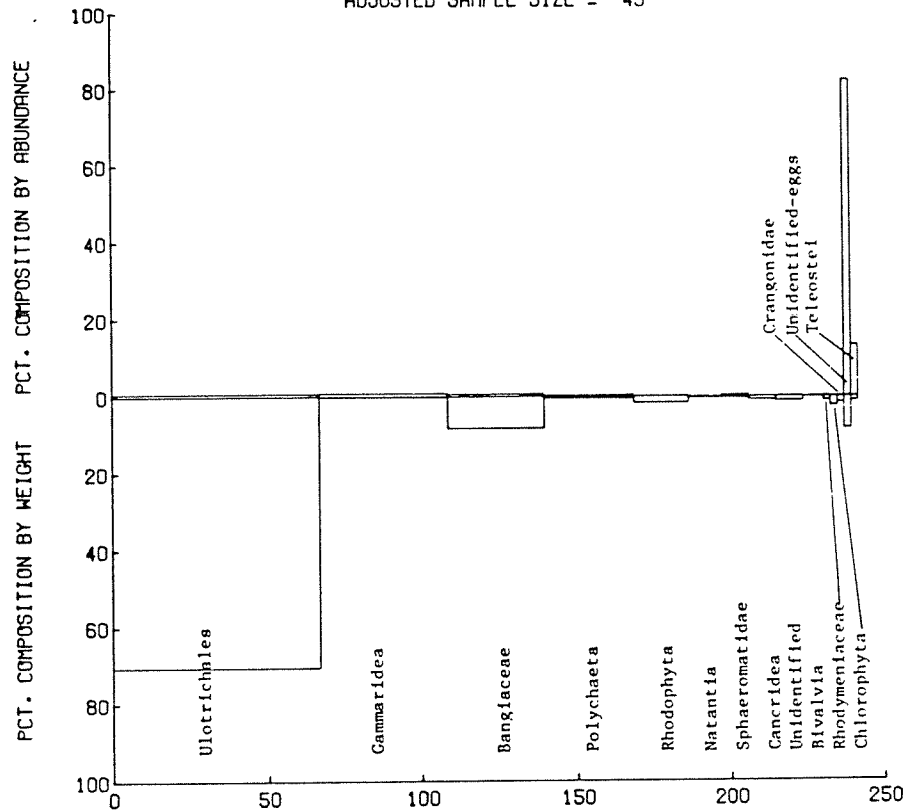
Although the low sample size for the trynet-caught buffalo sculpins did not permit a quantitative comparison, stomachs of these fish tended to have more Porphyra sp. and Rhodophyta algae than those from beach seine collections.

#### Pacific Staghorn Sculpin (Leptocottus armatus)

1977 - Pacific staghorn sculpin was the prominent nearshore cottid throughout the Nisqually Reach study area, especially along the outer edge

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

8831021001 - ENOPHRYS BISON  
BUFFALO SCULPIN  
ADJUSTED SAMPLE SIZE = 45



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	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	2.89	.07	.85	8.1	.15
UNIDENTIFIED	8.89	.12	1.16	11.3	.21
RIVALVIA	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	17.18	1.12	31.8	.59

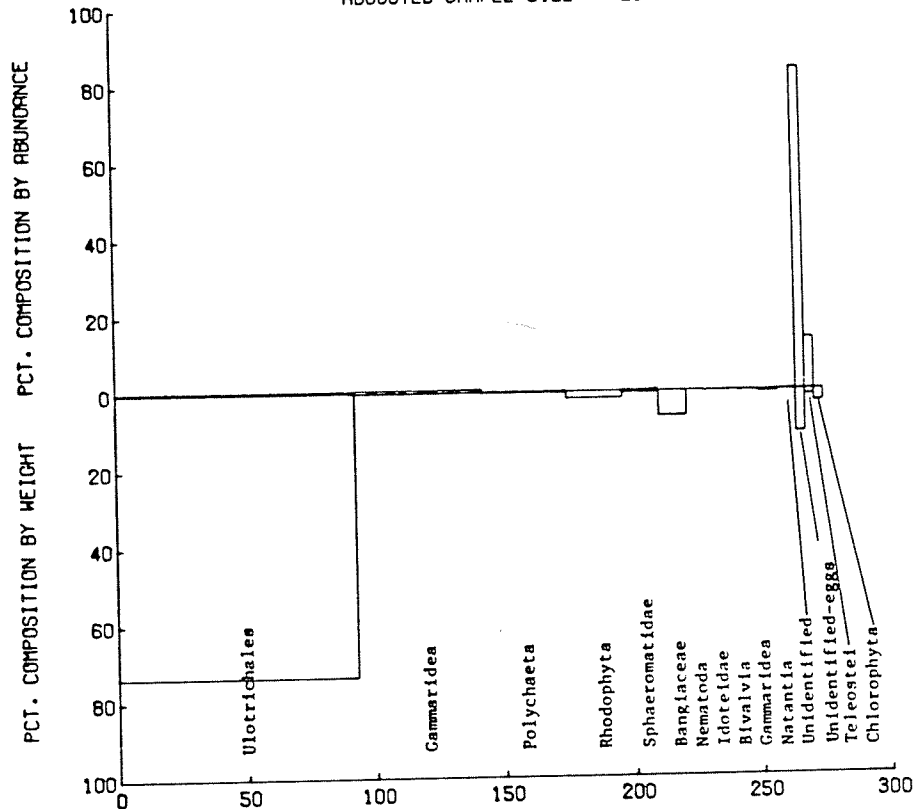
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

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

Fig. 57. IRI prey spectrum of Buffalo sculpin in Nisqually Reach, southern Puget Sound, 1977-1978.

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 IPI
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	13.75	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

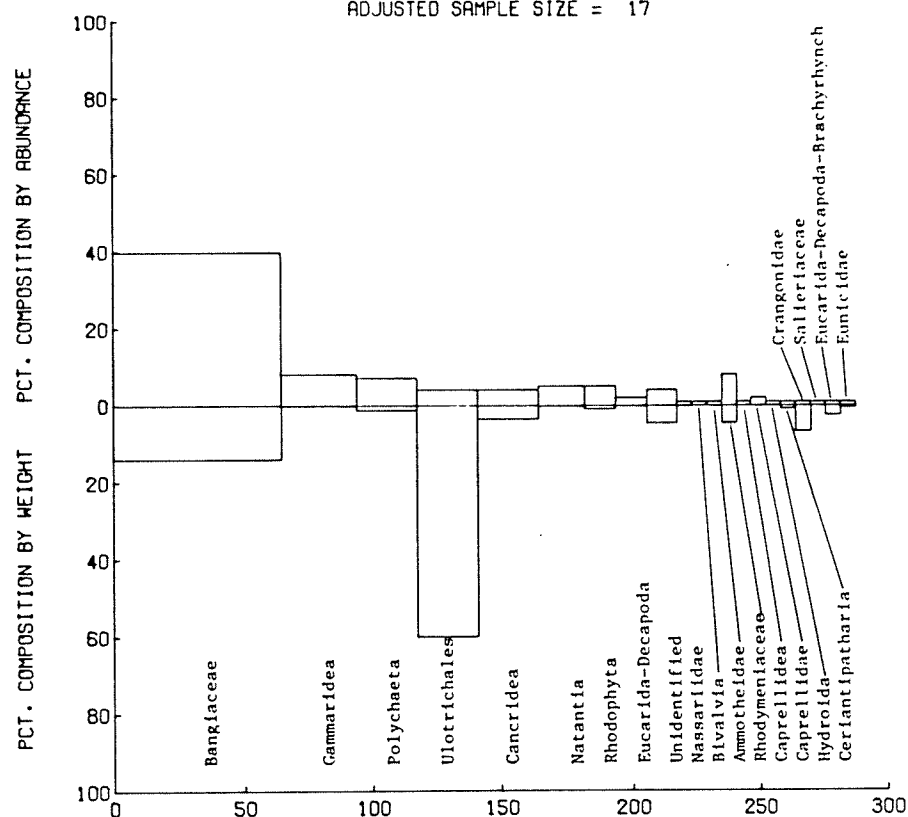
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

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

Fig. 58. 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	4.00	59.93	1506.1	24.66
CANCRIDAE	23.53	4.00	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
FUCARIDA-DECAPODA	11.76	2.00	.06	24.7	.41
UNIDENTIFIED	11.76	4.00	4.59	102.0	1.67
NASSARIIDAE	5.88	1.02	.14	6.8	.11
RIVALVIA	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
CAPRELLIIDAE	5.88	1.02	.02	6.1	.10
CAPRELLIIDAE	5.88	2.04	.06	12.4	.20
HYDROIDA	5.88	1.02	.02	6.1	.10
CERTANTIPATHARTIA	5.88	1.02	.84	11.0	.19
CRANGONIDAE	5.88	1.02	6.64	45.1	.74
SALIERIACEAE	5.88	1.02	.02	6.1	.10
FUCARIDA-DECAPODA-BRACHYRHYNCH	5.88	1.02	2.50	20.7	.34
FUNICIDAE	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)

PERCENT DOMINANCE INDEX	.19	.39	.39
SHANNON-WIENER DIVERSITY	3.30	2.12	2.02
EVENNESS INDEX	.75	.48	.46

Fig. 59. IRI prey spectrum of buffalo sculpin caught by trynet in Nisqually Reach, southern Puget Sound, 1977-78.

of the Nisqually Delta. Staghorn sculpin were also observed during SCUBA transects beneath the existing DuPont Dock.

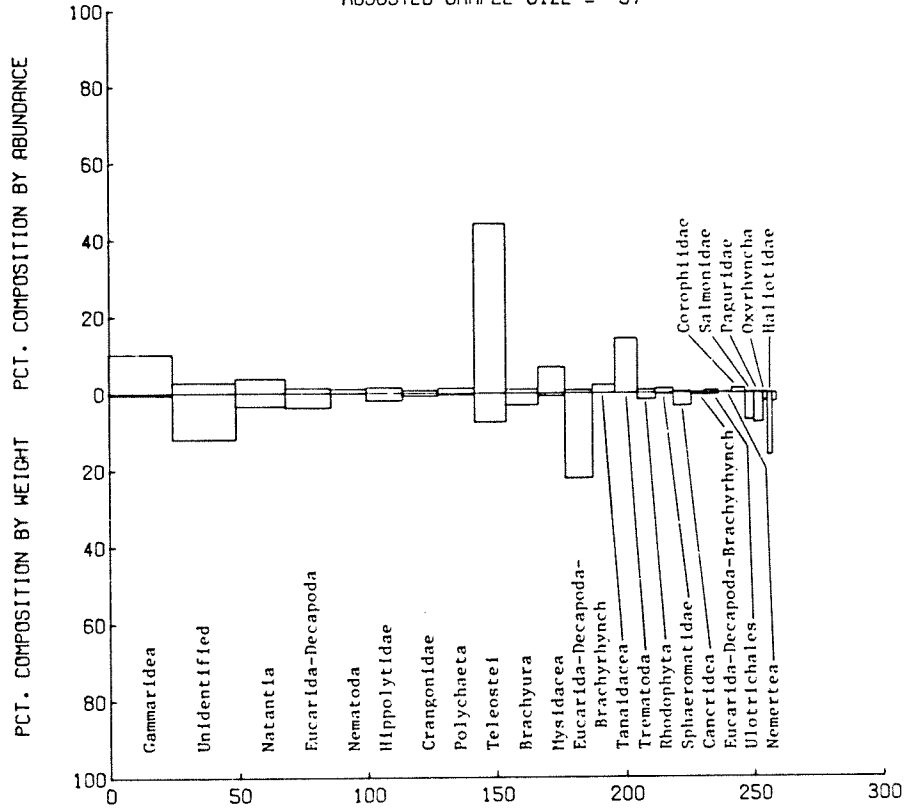
Of all species examined, the prey spectrum of staghorn sculpin was the third most numerically diverse (Appendix Table 8). Benthic and epibenthic crustaceans: gammarid amphipods (11.6 percent of total IRI), natantian shrimp (8.9 percent, including Crangon sp. and Heptacarpus sp.), reptantian shrimp (Callinassa 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. 60). 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 sculpin from beach collections had eaten as equally a diverse spectrum of prey organisms as 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 those caught by beach seine (Figs. 61 and 62).

1978 - Pacific staghorn sculpin collected during the 1978 beach seine samplings occurred most frequently and abundantly at DeWolf Bight; Thomposn Cove also provided a high proportion of the collected specimens. Unlike the comparable prey spectra for 1977 (Fig. 60), prey composition of the Pacific staghorn sculpin caught in 1978 beach seine collections was primarily gammarid amphipods, which accounted for over half of the total

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

8831021801 - LEPTOCOTTUS ARMATUS  
PAC. STAGHORN SCULPIN  
ADJUSTED SAMPLE SIZE = 57



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	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
CANCRIDAE	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
COROPHIDAE	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
OXYRHYNCHA	1.75	.19	1.93	3.7	.16
HALLIOTIDAE	1.75	.06	16.13	28.4	1.24
GASTEROSTEIDAE	1.75	.06	2.22	4.0	.18

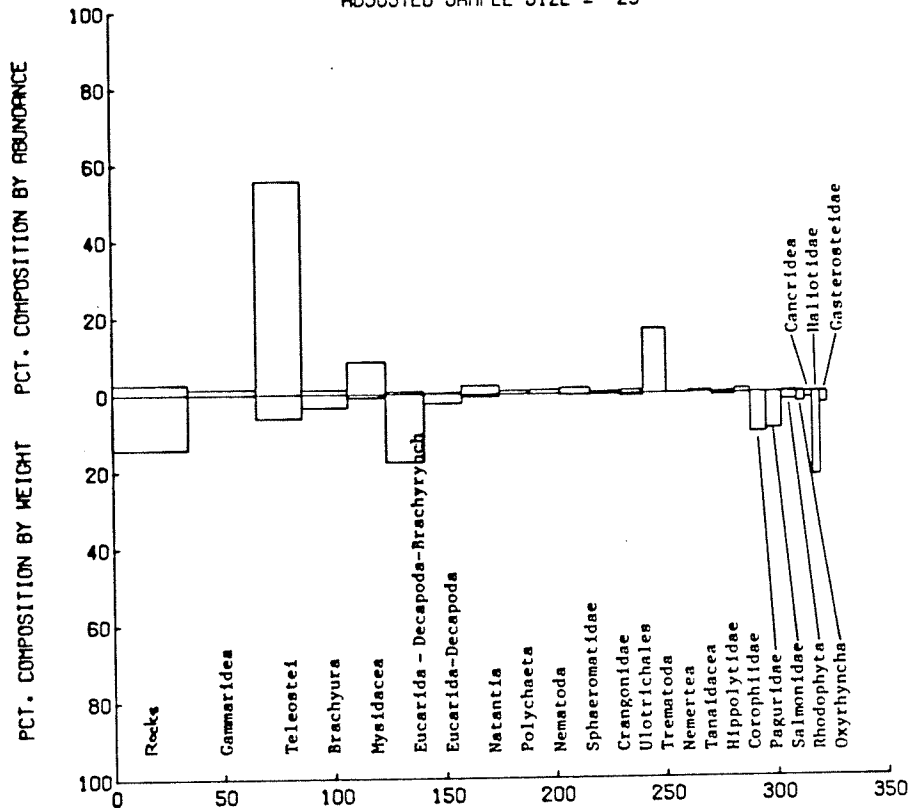
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.23	.11	.14
SHANNON-WIENER DIVERSITY	3.10	3.70	3.48
EVENNESS INDEX	.57	.69	.65

Fig. 60. 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 SCULPIN  
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-BRACHYRYHYNCH	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
TANALIDACEA	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	46.3	2.11
RHODOPHYTA	6.90	.41	1.98	16.4	.52
OXYRHYNCHA	3.45	.24	2.59	9.8	.31
CANCRIDAE	3.45	.08	1.61	5.8	.19
HALIOTIDAE	3.45	.08	21.69	75.1	2.39
	3.45	.08	2.99	10.6	.34

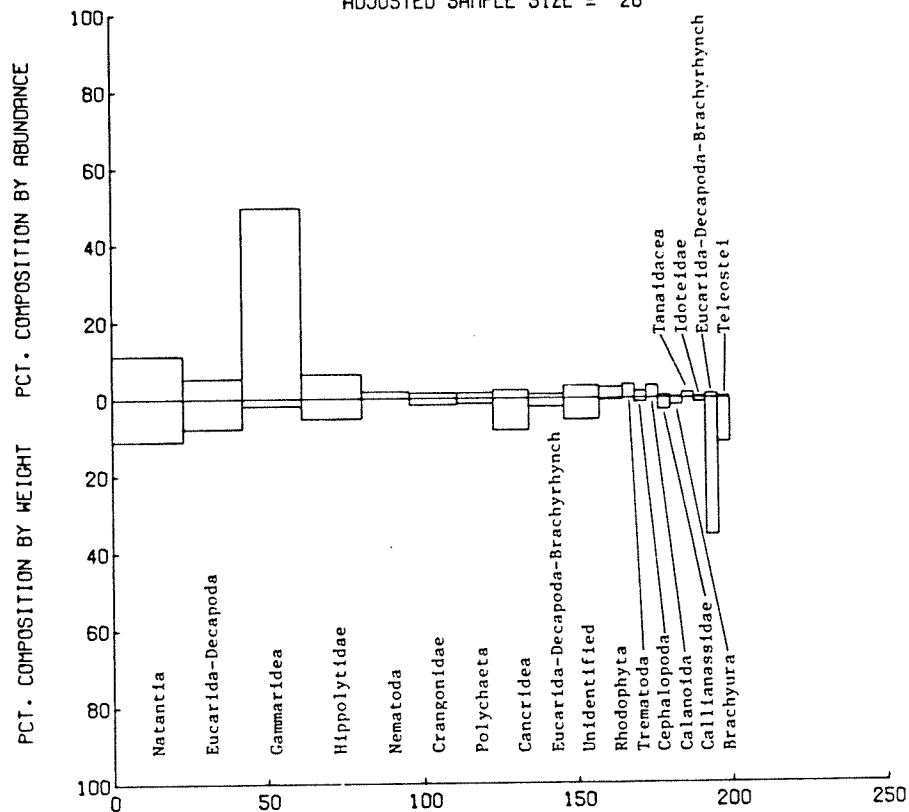
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

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

Fig. 61. 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.	GPAV. 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	37.4	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
CALLINANASSIDAE	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 GPAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.27	.17	.20
SHANNON-WIENER DIVERSITY	2.91	3.15	2.96
EVENNESS INDEX	.64	.70	.65

Fig. 62. IRI prey spectrum of Pacific staghorn sculpin caught by trynet in Nisqually Reach, southern Puget Sound, 1977-78.

IRI (Fig. 63). Epibenthic crabs, especially grapsids (shorecrabs), were similarly important in 1978. Fish (including two Pacific herring and two juvenile salmon) were not very important to the overall prey spectra.

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

#### Great Sculpin (Myoxocephalus polyacanthocephalus)

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

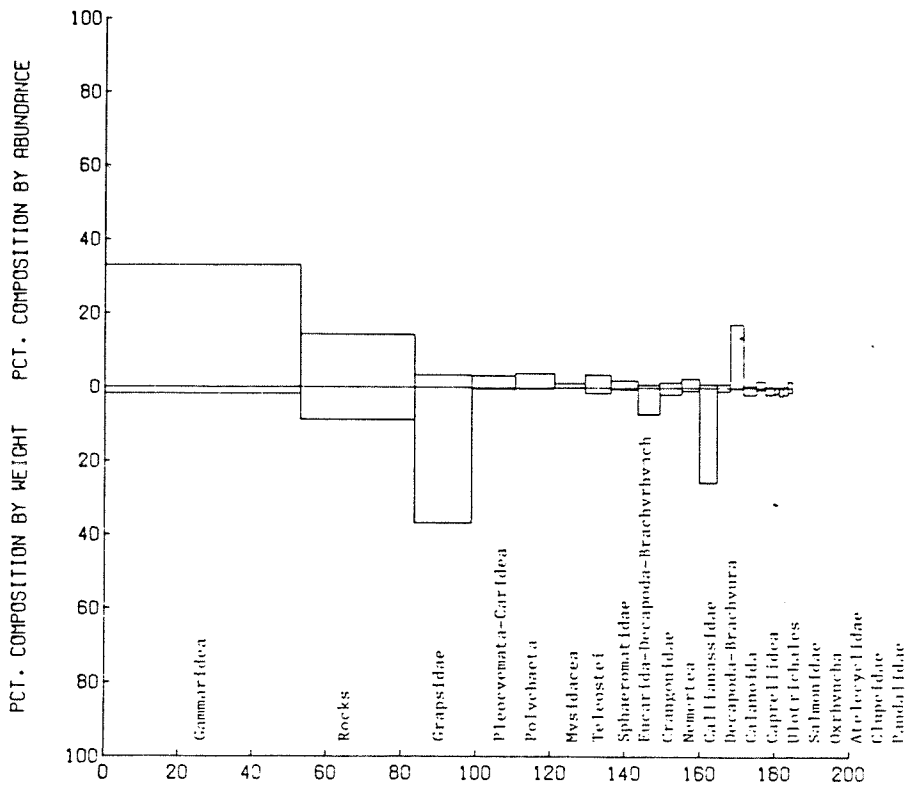
#### Rock Sole (Lepidopsetta bilineata)

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 collections at all three trynet study sites.

1977 - The overall prey spectrum for rock sole was composed of both benthic and epibenthic organisms (Fig. 64). Benthic polychaetes (Nereidae, Maldanidae, Pherusa sp.) contributed 33.8 percent of the total IRI, the green algae Ulva sp., 28.9 percent, gammarid amphipods,

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

PREDATOR 8831021801 - LEPTOCOTTUS ARMATUS  
(PAC. STAGHORN SCULPN) ADJUSTED SAMPLE SIZE = 85



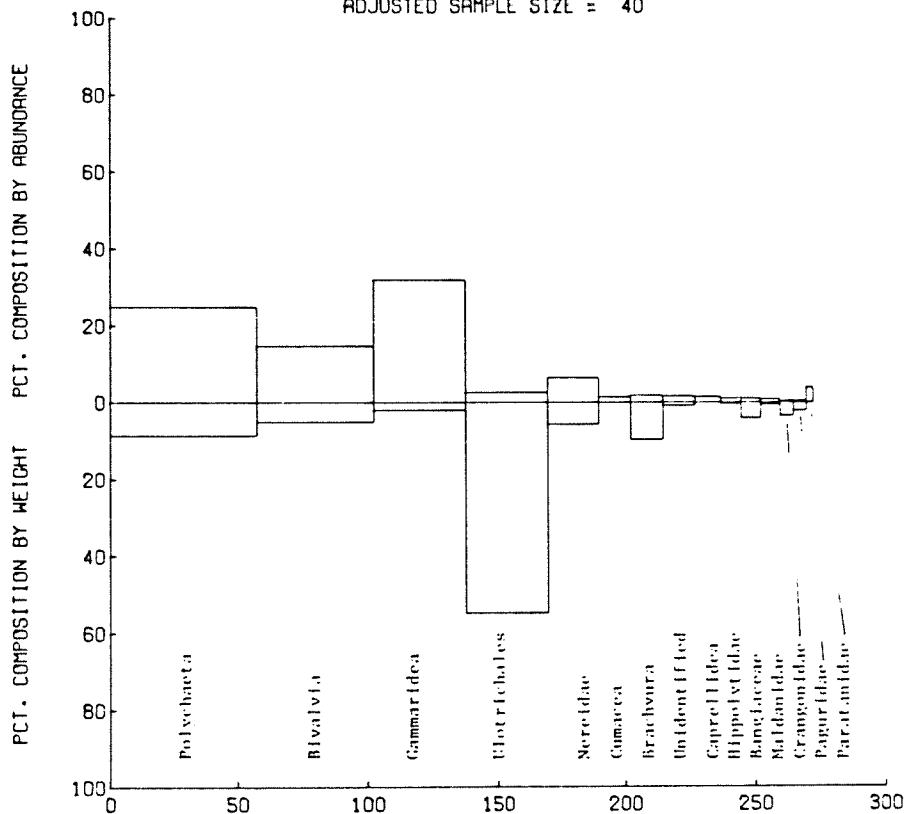
PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	FREQ. OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	52.94	33.00	1.79	1841.4	50.58
ROCKS	30.59	14.31	8.81	707.2	19.43
GRAPSIDAE	15.29	3.37	36.82	614.6	16.88
PLECOCYEMATA-CARIDEA LARVAE	11.74	3.20	.53	43.0	1.20
POLYCHAETA	10.59	3.87	.43	45.4	1.25
MYSIDACEA	8.24	1.18	.12	10.7	.29
TELEOSTEI	7.06	3.54	1.46	35.2	.97
SPHAEROMATIDAE	7.06	2.02	.44	17.4	.48
EUCARIDA-DECAPODA-BRACHYRHYNCH	5.88	.84	7.11	46.8	1.28
CRANGONIDAE	5.88	1.52	1.79	19.4	.53
NEMERTEA	4.71	2.53	.83	15.8	.43
CALLINANASSIDAE	4.71	1.01	25.71	125.7	3.45
DECAPODA-BRACHYURA	3.53	1.01	.92	6.8	.19
CALANOIDA	3.53	17.17	.20	61.3	1.68
CARPELLIDAE	3.53	.51	1.88	8.4	.23
MULTITRICHAELES	2.35	1.85	.54	5.4	.15
SALMONIDAE	2.35	.34	1.82	5.1	.14
CYPRINCHA	1.18	.17	1.52	2.0	.05
ATELECYCLIDAE	1.18	.17	2.18	2.8	.08
CLUPIDAE	1.18	.34	1.95	2.7	.07
PANDALIDAE	1.18	1.85	1.19	3.4	.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	.17	.22	.22
SHANNON-WIENER DIVERSITY	3.47	2.96	2.25
EVENNESS INDEX	.67	.57	.43

Fig. 63. IRI prey spectrum of Pacific staghorn sculpin caught in beach seine collections in Nisqually Reach, southern Puget Sound, 1978.

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	CUMULATIVE FREQUENCY OF OCCURRENCE				
	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	IRI	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
NEPHEIDAE	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 DATA 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-WIENER DIVERSITY	3.08	2.49	2.44
EVENNESS INDEX	.63	.51	.50

Fig. 64. IRI prey spectrum of rock sole in Nisqually Reach, southern Puget Sound, 1977-78.

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 sp. 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.

1978 - Beach seine collections in 1978 produced 26 rock sole for stomach contents analysis; collections at Thompson Cove, East Oro Bay, and DuPont Dock provided most of the samples.

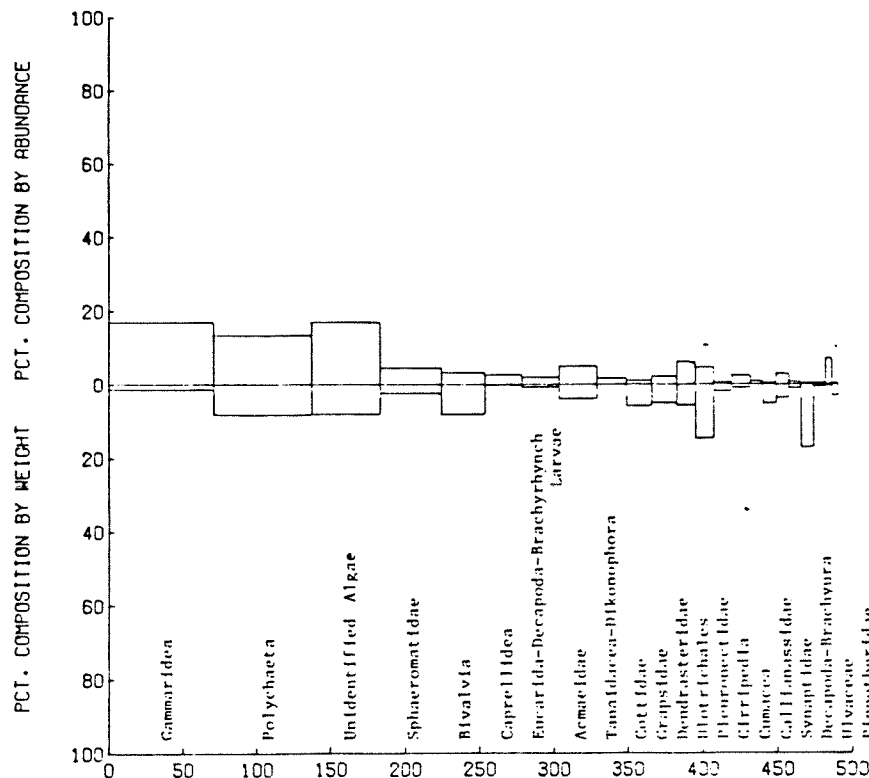
The prey spectrum of these rock sole was quite comparable to that in the previous year, primarily polychaete annelids, gammarid amphipods and algae (Fig. 65). The proportional contributions of limpets, bivalves, isopods, and sand dollars varied somewhat between the two years.

Sculpin, including Pacific staghorn sculpin, were the major fish consumed by rock sole; but snailfish (Liparis sp.) and other flatfish were also consumed. Only 1.2 percent of the total IRI was fish.

The rock sole diet composition from Nisqually Reach was 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

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

PREDATOR 8857040801 - LEPIDOPSETTA BILINEATA  
(ROCK SOLE ) ADJUSTED SAMPLE SIZE = 24



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE		GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
	FREQ. OCCUR.	NUM. COMP.			
GAMMARIDEA	70.83	16.95	1.40	1700.1	21.88
POLYCHAETA	64.67	13.37	8.21	1438.9	24.22
UNIDENTIFIED	45.83	16.95	8.02	1122.7	19.27
SPHAEROMATIDAE	41.67	4.51	2.43	289.0	4.87
BIVALVIA	29.17	3.27	8.07	370.6	5.57
CAPRELLIDEA	25.00	2.64	.19	76.8	1.19
EUCARIDA-DECAPODA-BRACHYRYNCH	25.00	2.02	.70	67.0	1.14
ACMAEIDAE	25.00	4.98	3.84	220.5	3.71
TANAIDACEA-PIKOPHORA	20.83	1.71	.04	36.8	.62
Gobiidae	16.67	1.09	5.79	114.6	1.93
Grapsidae	16.67	2.18	4.98	115.2	2.01
Decapoda-Brachyura	12.50	6.22	5.59	147.7	2.49
Amphipoda	12.50	4.67	14.55	247.2	4.04
Pleuromnecidae	12.50	.62	1.84	30.5	.52
Cirripedia	12.50	2.49	.91	42.5	.72
Cumacea	8.33	.93	.06	8.3	.14
Callinassidae	8.33	.47	5.14	46.7	.79
Synaptidae	8.33	2.05	3.60	54.4	.92
Decapoda-Brachyura	8.33	.78	.91	14.0	.24
Ulvaaceae	8.33	.47	16.98	145.4	2.45
Pinnotheridae	8.33	.47	.61	9.0	.15
Caprellidae	4.17	7.15	.37	31.2	.52
Langellaceae	4.17	.31	3.01	12.9	.23

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	.10	.00	.15
SHANNON-WIENER DIVERSITY	3.93	3.94	3.28
EVENNESS INDEX	.74	.76	.67

Fig. 65. IRI prey spectrum of rock sole caught in beach seine collections in Nisqually Reach, south Puget Sound, 1978.

that epibenthic gammarid amphipods, tanaids, and isopods usually are more important in diets than benthic polychaetes and bivalves (siphons).

English Sole (Parophrys vetulus)

1977 - English sole were the most abundant fish in trynet catches, and were also caught regularly during beach seining. Twenty-eight percent of the stomachs examined were empty.

Polychaetes (Nereidae, Malanidae) were the most important prey (69.7 percent total IRI) in a predominantly benthic prey spectrum (Fig. 66), 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.

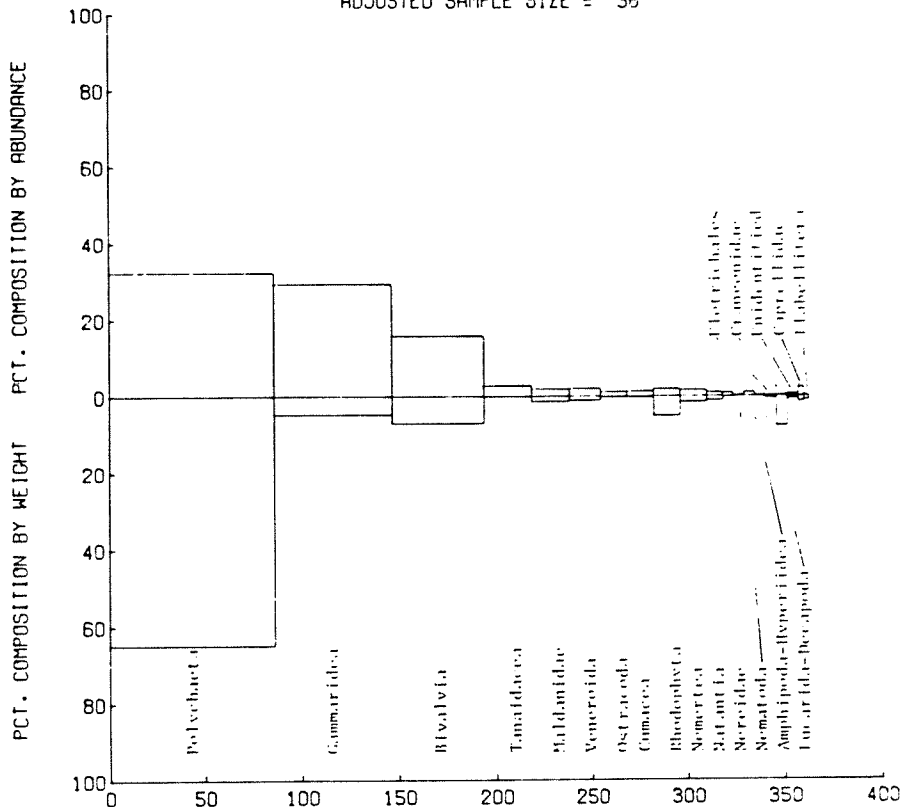
1978 - The prey spectra of English sole collected in 1978 (Fig. 67), though restricted to beach seine collections, was almost identical to that documented for 1977. However, epibenthic harpacticoid copepods which did not appear to be important to the predominantly trynet-caught English sole, were important food items.

Starry Flounder (Platichthys stellatus)

1977 - Starry flounder were regularly sampled by beach seine and trynet. 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).

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	CUMULATIVE FREQUENCY OF OCCURRENCE				
	PREY OCCUR.	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
POLYCHAETA	86.11	32.42	44.90	8780.4	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
EUFETIDAE	5.56	.86	.21	6.0	.05
NEMATODA	5.56	.29	.15	2.4	.02
AMPHIRODA-HYPERIIDAE	5.56	1.01	.02	5.7	.05
EUCALIDA-DECAPODA	5.56	.29	.13	2.3	.02
ELECTRICALS	5.56	.29	.51	4.6	.04
CRUSTACEA	5.56	.29	7.79	44.9	.37
UNIDENTIFIED	5.56	.58	.68	7.0	.06
CARDILLIDAE	2.78	2.31	1.30	10.0	.08
FLABELLIFERA	2.78	.29	1.01	3.6	.03

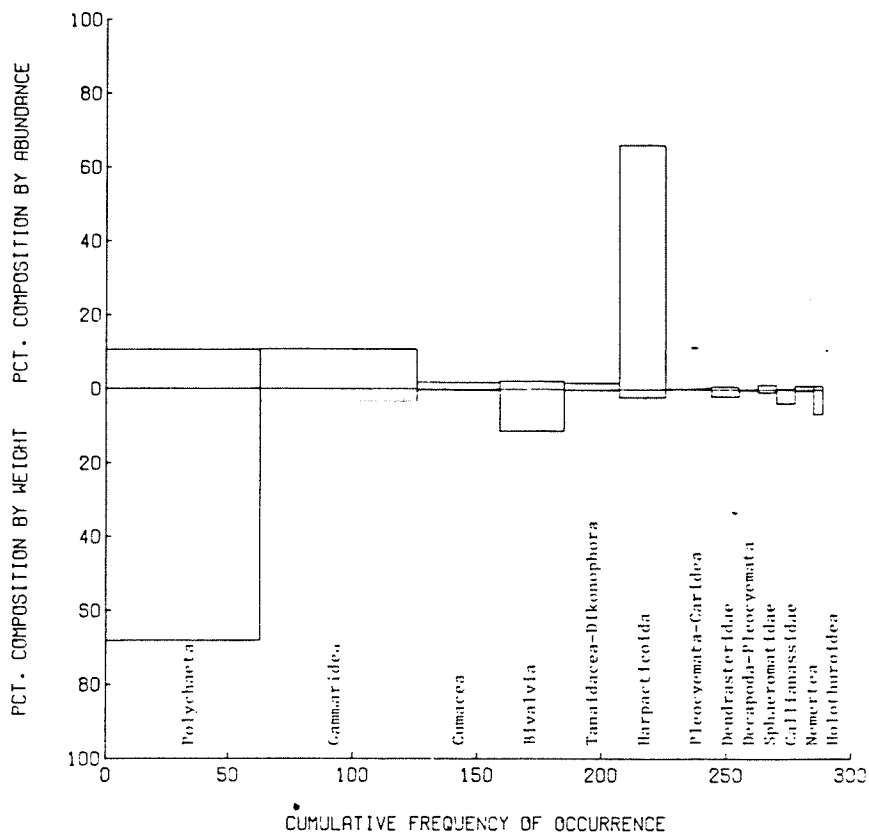
PREY TAXA WITH PREY OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION WITH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.22	.44	.52
SHANNON-WIENER DIVERSITY	2.88	2.12	1.44
EVERETT'S INDEX	.59	.44	.30

Fig. 66. 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. DUPONT, STATION ALL

PREDATOR 8857041301 - PAROPHYS VETULUS  
(ENGLISH SOLE ) ADJUSTED SAMPLE SIZE = 27



PREY ITEM	FFFO OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
POLYCHAETA	62.96	10.70	68.22	4969.1	64.34
GAMMARIDEA	62.96	10.80	3.23	883.2	11.44
CUMACEA	33.33	1.89	.38	75.7	.98
BIVALVIA	25.93	2.27	11.24	350.3	4.54
TANAIDACEA-DIKONOPHORA	22.22	1.89	.25	45.5	.59
HARPACTICOIDA	18.52	66.19	2.13	1265.2	16.38
PLECOCEMATA-CARIDEA	18.52	.47	.05	9.9	.13
DECAPODA-DECAPODA	11.11	.85	1.87	30.2	.39
DECAPODA-DECAPODA	7.41	.19	.18	2.7	.04
DECAPODA-DECAPODA	7.41	1.42	.68	15.4	.20
DECAPODA-DECAPODA	7.41	.28	3.64	29.0	.38
DECAPODA-DECAPODA	7.41	1.14	.32	10.8	.14
DECAPODA-DECAPODA	3.70	1.14	6.51	28.3	.37

PREY TAXA WITH FFFO 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	.44	.49	.46
SHANNON-WIENER DIVERSITY	1.88	1.80	1.66
EVENNESS INDEX	.43	.41	.38

Fig. 67. IRI prey spectrum of English sole caught in beach seine collections in Nisqually Reach, southern Puget Sound, 1978.

Bivalves (Tellina nukuloides, 76.0 percent of total IRI), and cephalaspidean mollusca (10.4 percent) composed the major prey items. 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.

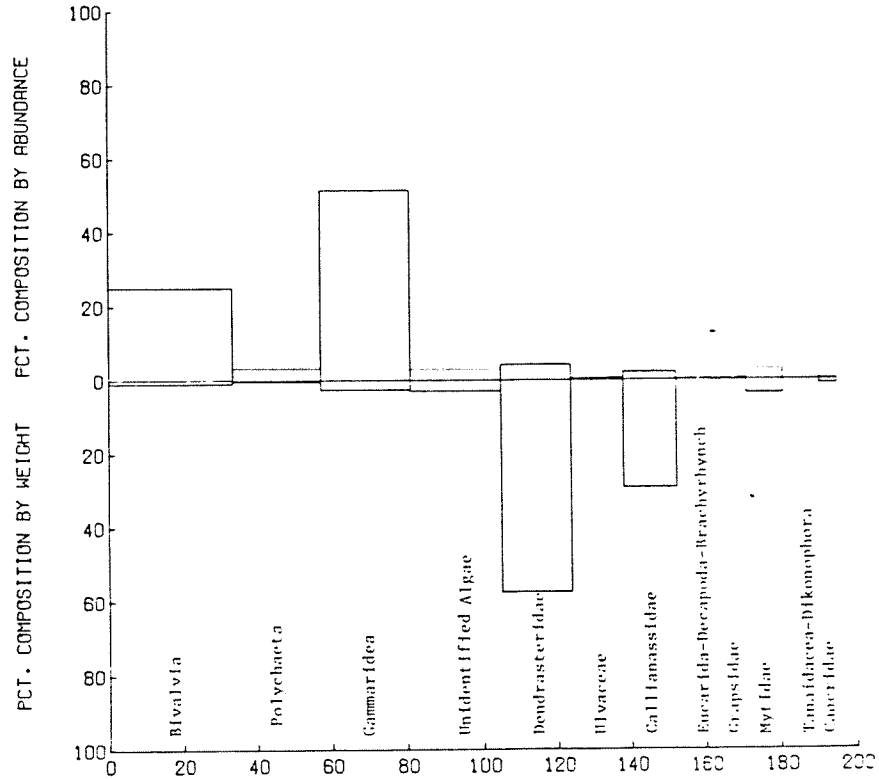
1978 - The prey spectrum generated from samples obtained in the 1978 beach seine collections, mostly from early April sampling at the west Delta site, was different from that of the year before (Fig. 68). Bivalve siphons were important (20.9 percent of total IRI), but gammarid amphipods (31.1 percent), echininoids (sand dollars, Dendraster excentricus, 28.4 percent), and callianassid shrimp (inc. Callianassia gigas, 18.8 percent) were relatively more important in the second year's specimens. As was the case in 1977, no fish remains were found in the stomach contents analyzed from 1978.

#### C-0 sole (Pleuronichthys coenosus)

C-0 sole stomach samples were obtained from 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 of C-0 sole (Fig. 69); bivalve siphons, gammarid amphipods, parts of hydroids shrimp (Hippolytidae), and crabs also appeared regularly in the stomach contents.

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

PREDATOR 8857041401 - PLATICHTHYS STELLATUS  
(STARRY FLOUNDER ) ADJUSTED SAMPLE SIZE = 21



PREY ITEM	CUMULATIVE FREQUENCY OF OCCURRENCE				
	FREQ. OCCUR	NUM. COMP.	GRAV. COMP.	PREFY I.R.I.	PERCENT TOTAL IRI
BIVALVIA	33.33	25.00	1.01	867.1	20.91
POLYCHAETA	23.21	3.32	.49	90.7	2.19
GAMMARIDEA	23.21	51.56	2.54	1288.1	31.06
UNIDENTIFIED ALGAE	23.21	3.13	2.93	144.2	3.42
DENDROASTERIDAE	19.05	4.30	57.43	1175.2	28.35
ULVACEAE	14.29	.59	.05	9.1	.22
CALLINASSIDAE	14.29	2.15	29.20	447.9	10.80
EUCARIDA-DECAPODA-BRACHYBRANCH	9.52	.39	.03	4.0	.10
CAPRELLIDAE	9.52	.39	.10	4.7	.11
MYTIDAE	9.52	2.73	3.64	60.7	1.45
TANAIDACEA-DIKRONOPHORA	9.52	2.54	.01	24.7	.59
CANCRIDAE	4.76	.20	1.05	5.9	.14

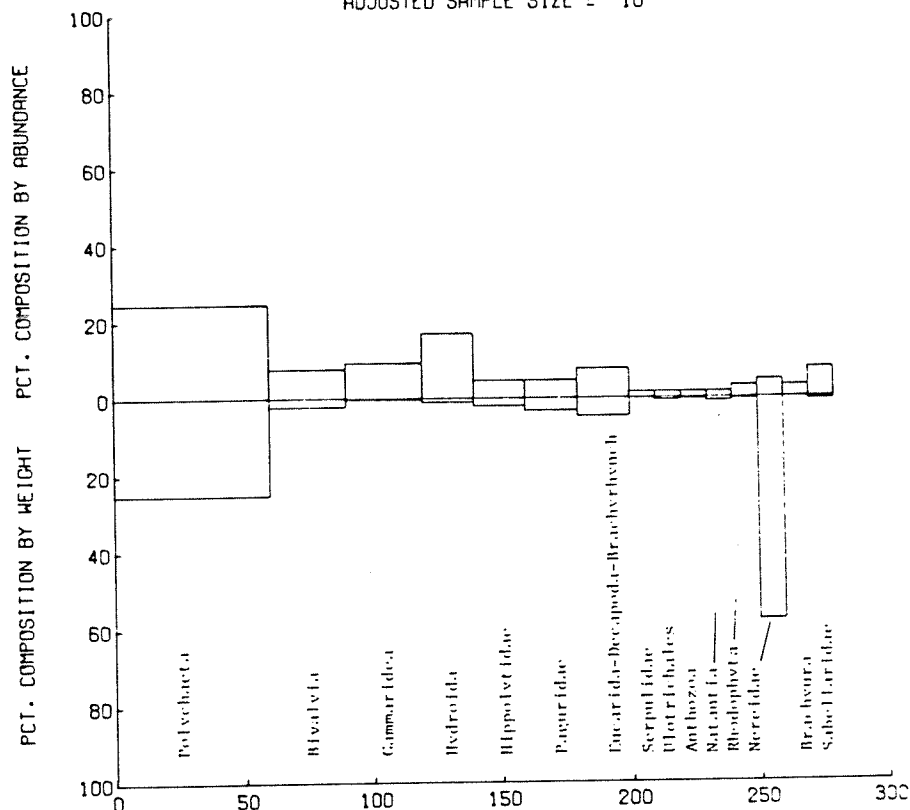
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.33	.42	.23
SHANNON-WEINER DIVERSITY	2.32	1.75	2.40
EVENNESS INDEX	.51	.39	.53

Fig. 68. IRI prey spectrum of starry flounder caught in beach seine collections in Nisqually Reach, southern Puget Sound, 1978.

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

8857041601 - PLEURONICHTHYS COENOSUS  
C-0 SOLE  
ADJUSTED SAMPLE SIZE = 10



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
POLYCHAETA	40.00	24.62	25.23	2000.5	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-BRACHYREMN	20.00	7.69	4.80	249.9	4.60
SEPPILLIDAE	10.00	1.54	.14	16.8	.31
ULCERICHAELES	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
BRACHYURIA	10.00	3.08	.02	31.0	.58
SARFILLIDAE	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-WIENER DIVERSITY	3.40	1.90	2.35
EVENNESS INDEX	.87	.49	.60

Fig. 69. IRI prey spectrum of C-0 sole in Nisqually Reach, southern Puget Sound, 1977-78.

### Discussion

The principal food resources utilized by the principal fish assemblages characterizing the nearshore habitats of Nisqually Reach, including those associated with the existing DuPont Dock, are summarized in Table 35. Wherever possible, indications of prey importance were based upon stomach samples obtained directly from the Nisqually Reach collections. 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 in these cases 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, period in estuary, and habitat.

Juvenile pink salmon appeared to feed primarily on planktonic organisms - calanoid copepods - when the young salmon were found along the Nisqually Delta in mid- to late June. Prey 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.

Juvenile chum salmon captured during beach seine collections fed on both epibenthic (haracticoid copepods and gammarid amphipods) and planktonic (calanoid copepods) organisms. Fish from areas with extensive shallow sublittoral habitats had fed more extensively on the epibenthic

Table 35. Summary of Principal food items of Nisqually Reach fishes.

Legend of prey importance																										
Primary	(75-100% of IRI)																									
Secondary	(50-74% of IRI)																									
Significant	(25-49% of IRI)																									
Common	(5-24% of IRI)																									
Insignificant	(1-4% of IRI)																									
Habitat	Dominant Members of Fish Assemblage	Algae	Nemertean	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			.							°										°	°	°	°		°
	Rock sole	°	°	°			°				°											.				
	*English sole			+			°				°															
Sublittoral Shelf (10-15m)	Starry flounder			°		0				.													.			
	*Ratfish	.	°	°	°		.			.									°	°			°			
	Pacific tomcod		°	.				°			°									°	°					
	Roughback sculpin			°							°									+	°					
	Pacific staghorn sculpin			.							°									°	°					
	Rock sole	°	°	.			°																			
Neritic	English sole			+			°				°															
	Spiny dogfish			•																						
	Pacific herring (juv.)						+			°	.													°		
	Pink salmon (juv.)						°				°	.													°	
	Chum salmon (juv.)			.					°	°	°	.											°			
	Coho salmon (juv.)													°	°			°					°	°		
Depont Dock	*Chinook salmon (juv.)										•											.	°			
	*Tube-snout								°	°								°								
	*Copper rockfish																			•				°		
	*Painted greenling																				•					
	*Smoothhead sculpin										°							°								
	Buffalo sculpin	•									.							.							°	
	Red Irish lord <sup>1</sup>																	°		.	°			°		
	Pacific staghorn sculpin			.							°							.	°	.	°	°		.	°	
	Sturgeon poacher			°							°									°						
	*Shiner perch									°	°															
	*Striped seaperch			°														°			°	°				
*Pile perch						+				°																
Rock sole	°	°				°				°																

<sup>1</sup> 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.

organisms whereas north of the DuPont Dock the chum fed more upon neritic prey, probably because of the steeper subtidal gradient, more current-swept shoreline. Those fish captured in neritic waters of the reach during townetting had utilized both epibenthic and pelagic organisms, including drift insects.

In general, over the period of outmigration the diet of juvenile chum salmon shifted from epibenthic prey - harpacticoid copepods and gammarid amphipods - to neritic prey such as calanoid copepods, crustacea larvae and hyperiid amphipods. This is probably a function of a concurrent increase in chum fry size and densities of neritic plankton.

Some distinct habitat differences were evident. The tideflats of the Nisqually River Delta and the sand/eelgrass flats of the bays along the eastern Anderson Island shoreline appeared to contribute significantly to the proportion of epibenthic crustacea chum fry migrating through these regions had fed on.

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 was harpacticoid copepods. Studies of the food habits of outmigrating juvenile chums in Hood Canal (Schreiner et al. 1977; Simenstad and Kinney 1978) 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 Sequelitchew 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 occurrence of large planktonic organisms (e.g., euphausiids, calanoid copepods, hyperiid amphipods and crustacea larvae). Similarly, epibenthic crustaceans were important prey organisms in juvenile coho diets in northern Puget Sound and remained so 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 later in the sampling period and 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). In addition, few fish from townet samples were analyzed.

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 fishes in Nisqually Reach, however, fish never comprised greater than 24 percent of the total IRI of any predator (Table 35).

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 dominated 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 no salmon remains were found in reach fish analyzed and data from other studies, 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 18 juvenile or adult fish were identified from the over 300 stomachs of juvenile coho examined from Nisqually Reach, including only four salmon fry among almost 14,500 prey organisms. Combined, fish accounted for less than 0.10 percent of the total IRI. 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 townet collections either year did not extend beyond July 8, we cannot say whether the juvenile coho would become significant predators on other juvenile salmonids after that time.

Sea-run cutthroat and rainbow (steelhead) trout were not abundant in our collections in Nisqually Reach nor were they caught in association with large numbers of juvenile chums or pinks, possibly because of increased avoidance by these larger fish. Only the cutthroat indicated any significant predation upon fish, based primarily on percentage of total prey biomass. Juvenile chinook salmon stomach contents contained only three salmon fry and thus it is doubtful outmigrating chinook would consume many fry; resident chinook (blackmouth) may represent a different situation, however. One of the three 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 most common demersal fish associated with the DuPont Dock structure, their presence may increase predation pressure for juvenile salmon passing through the dock piling habitat. 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 population.

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 were predators of 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. Fishes provided 29.1 percent (27.8 percent by eggs) of the total IRI of Pacific staghorn sculpins in Nisqually Reach in 1977 and 1.2 percent in 1978; salmon juveniles contributed only 1.1 percent of the total IRI in 1977 and 0.14 percent in 1978. 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 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 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--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, mysids and harpacticoid copepods were the most commonly utilized taxa of prey organisms. Benthic polychaetes, bivalve siphons, calanoid copepods, hyperiid amphipods, and crustacea larvae were also important to varying degrees.

3. During the early period of 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); later in the season, as a function of both increasing fish size and neritic plankton abundance and diversity, the diets of all juvenile salmon were dominated by neritic organisms.

4. Considerable variability existed in prey composition of juvenile salmon captured in different shoreline habitats and as a function of daytime vs. nighttime collections.

5. Juvenile salmonids were found in the stomach contents of chinook salmon, cutthroat trout, rainbow trout, buffalo sculpin and staghorn sculpin. 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.

6. 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 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 outmigrating 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  
TROPIC 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 Figure 2a). 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:

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

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 2a illustrates an example of the IRI values and percentages of total IRI generated from the data diagrammed in Appendix Figure 2a. The advantage of the IRI value is that numerically

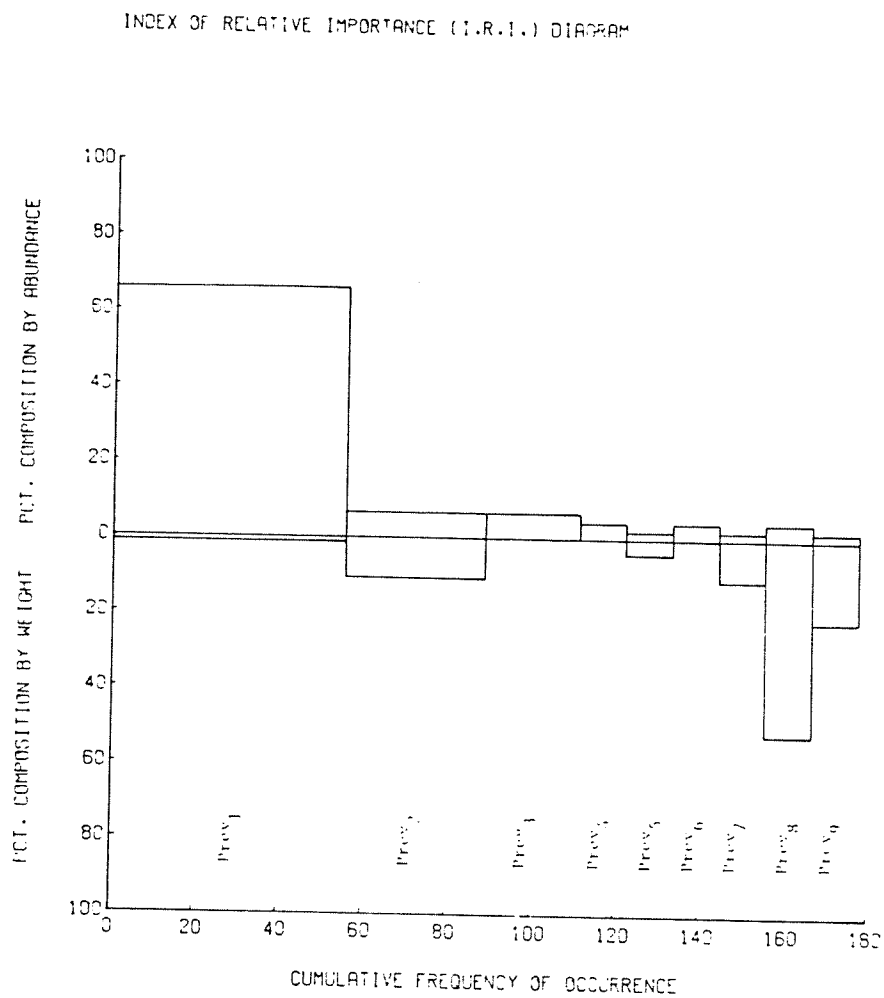


Fig. 2a. Example IRI (Index of Relative Importance) diagram.

Table 2a. 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

rare but high biomass prey (e.g., prey<sub>8</sub>); 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<sub>1</sub>, Appendix Table 2a) do not dominate the more representative prey.

APPENDIX 3  
LIST OF SPECIES CAUGHT IN THE  
NISQUALLY REACH

## Appendix

Table 3. List of fishes caught and/or observed in the Nisqually Reach study area, southern Puget Sound, Washington, 1977-1978. 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 Petromyzontidae		
<i>Entosphenus tridentatus</i>	Pacific lamprey	S
Family Squalidae		
<i>Squalus acanthias</i>	spiny dogfish	S,B,D
Family Chimaeridae		
<i>Hydrolagus colliei</i>	ratfish	S,B,T
Family Clupeidae		
<i>Clupea harengus pallasii</i>	Pacific herring	S,B,D
Family Salmonidae		
<i>Oncorhynchus gorbuscha</i>	pink salmon	S,B,D
<i>O. keta</i>	chum salmon	S,B
<i>O. kisutch</i>	coho salmon	S,B,D
<i>O. nerka</i>	sockeye salmon	S
<i>O. tshawytscha</i>	chinook salmon	S,B,D
<i>Salmo clarki</i>	cutthroat trout	B,D
<i>S. gairdneri</i>	rainbow trout	S,B
<i>Salvelinus malma</i>	Dolly Varden	B
Family Osmeridae		
<i>Hypomesus pretiosus</i>	surf smelt	S,B,D
Family Batrachoididae		
<i>Porichthys notatus</i>	plainfin midshipman	S,T
Family Gobiesocidae		
<i>Gobiesox maeandricus</i>	northern clingfish	B
Family Gadidae		
<i>Gadus macrocephalus</i>	Pacific cod	S,B,T,D
<i>Merluccius productus</i>	Pacific hake	S
<i>Microgadus proximus</i>	Pacific tomcod	S,T
<i>Theragra chalcogramma</i>	walleye pollock	T

Appendix Table 3. continued

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

Appendix Table 3. continued

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

Appendix Table 3. continued

Scientific name	Common name	Gear
Family Agonidae cont'd		
<i>Odontopyxis trispinosa</i>	pygmy poacher	T,S
<i>Pallasina barbata</i>	tubenose poacher	T
<i>Xeneretmus latifrons</i>	blacktip poacher	T
Family Cyclopteridae		
<i>Liparis rutteri</i>	ringtail snailfish	B
Family Bothidae		
<i>Citharichthys sordidus</i>	Pacific sanddab	T
<i>Citharichthys stigmaeus</i>	speckled sanddab	T,B
Family Pleuronectidae		
<i>Glyptocephalus zarchirus</i>	rex sole	B,T,D
<i>Hippoglossoides elassodon</i>	flathead sole	B
<i>Isopsetta isolepis</i>	butter sole	T
<i>Lepidopsetta bilineata</i>	rock sole	T,B,D,S
<i>Microstomus pacificus</i>	Dover sole	T,D,B
<i>Parophrys vetulus</i>	English sole	T,B,D,S
<i>Platichthys stellatus</i>	starry flounder	S,B,T,D
<i>Pleuronichthys coenosus</i>	C-0 sole	T,D
<i>Psettichthys melanostictus</i>	sand sole	B,T

(?) = identity of fish unconfirmed

APPENDIX 4  
BEACH SEINE CATCH DATA FOR SALMONIDS  
IN THE NISQUALLY REACH, 1978.

Appendix Table 4a. CPUE of chum salmon by sampling date in the Nisqually Reach for the period February 15 to July 20, 1978.<sup>1</sup>  
(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
	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	204.5	461.5
	22	N	23.5	72.5	316.0	3.5	13.0	55.5
	25	D	0	109.5	815.0	107.5	105.5	49.5
	31	N	32.5	26.5	60.5	8.5	101.0	53.5
	June	3	D	48.0	149.5	69.5	752.0	9.5
7		N	135.5	135.0	37.0	3.0	136.0	128.5
10		D	NS	NS	NS	NS	NS	NS
11		N	111.5	55.0	14.0	4.5	78.0	33.0
15		D	229.0	77.0	129.5	80.5	0	45.5
20		N	152.5	16.0	142.0	43.0	288.5	382.0
22		D	155.0	40.5	65.0	6.0*	14.0	585.5
26		N	133.0	17.5	7.5	11.0	35.0	19.0
29		D	328.5	98.5	12.0	35.5	0	53.0
July		3	N	36.5	7.0	0	7.5	4.5
	6	D	6.5	11.0	2.5	141.0	0.5	6.0
	11	N	2.0	8.0	2.0	0	16.0	10.5
	13	D	76.5	26.0	20.0	7.0	0	24.0
	17	N	20.0	14.0	7.0	10.0	6.5	7.0
	20	D	0.5	2.0	0.5	6.5	2.0	17.5

<sup>1</sup> All values except those marked with \* are the average of 2 sets. Values marked \* are for only 1 set.

Appendix Table 4b. CPUE of coho salmon by sampling date in the Nisqually Reach for the period February 15 to July 20, 1978.<sup>1</sup>  
(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
April	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
	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
May	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
	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
June	22	N	4.0	4.5	4.5	311.0	63.5	33.0
	25	D	0.5	9.0	6.5	0	0.3	13.0
	31	N	37.0	1.5	0.5	51.5	2.0	4.0
	3	D	2.5	0.5	0	6.0	0.5	1.0
	7	N	26.0	15.0	1.5	83.0	3.0	1.5
	10	D	NS	NS	NS	NS	NS	NS
	11	N	59.0	32.0	0.5	30.5	0	.5
	15	D	12.5	0.5	0	73.5	0	1.0
	20	N	14.5	3.0	2.5	17.0	0	4.0
	22	D	30.0	2.5	1.0	0.5	0*	1.0
July	26	N	2.5	2.0	0	4.5	0	0
	29	D	2.5	0	0	9.5	0	0.5
	3	N	34.5	0	0	10.5	1.0	1.5
	6	D	0	0	0.5	5.0	0	0
	11	N	2.0	1.0	1.0	11.5	2.5	1.0
	13	D	17.0	0	1.0	2.0	0.5	0
	17	N	0	4.0	0	6.0	1.0	1.0
	20	D	0.5	0	0	0	0	0

<sup>1</sup> All values except those marked with \* are the average of 2 sets. Values marked with \* are for 1 set only.

Appendix Table 4c. CPUE of chinook salmon by sampling date in the Nisqually Reach for the period February 15 to July 20, 1978.<sup>1</sup>  
(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	0.5	0	0
	15	D	0	0	0	0	0	0
April	23	D	0	0	0	0	0	0
	30	D	0	0	0.5	0	0	0
	6	D	0	1.5	0	0	0	0
	13	D	0	0	0	0.5	0	0.5
	17	N	0	0	1.0	0	0	0
	20	D	0	0	0	0	.5	0
May	23	N	0	0	1.0	0	0	0
	27	D	0	0	1.0	2.0	0	0
	1	N	0	0	0	0	0	0
	4	D	0	0	0	0	0	0
	8	N	0	0	0.5	0	0	0
	11	D	NS	NS	NS	0*	0.5	0
	15	N	0	0.5	0	0	0	1.0
	18	D	0	0	0	0	0	0
June	22	N	0.5	3.0	0	0	0	3.5
	25	D	0.5	14.5	0	1.5	0	2.0
	31	N	0	0	0	4.5	0.5	3.0
	3	D	10.0	0	.5	3.5	1.0	4.5
	7	N	3.0	0.5	0	0.5	0	0.5
	10	D	NS	NS	NS	NS	NS	NS
	11	N	0	0	4.0	1.0	0	0
	15	D	31.5	14.0	29.0	68.0	0	6.5
	20	N	3.5	5.0	32.5	14.5	0.5	5.5
	22	D	29.0	1	39.0	5.5	0*	8.0
July	26	N	1.0	1.5	4.0	2.0	0	0
	29	D	108.0	17.0	4.0	17.5	2.5	16.0
	3	N	10.5	0	0.5	4.5	0	1.0
	6	D	12.0	3.0	14.0	3.0	0.5	0.5
	11	D	0	2.0	3.0	5.5	0.5	0
	13	D	47.0	6.5	20.0	0.5	3.0	5.0
	17	N	2.0	2.0	2.5	4.5	0	1.0
20	D	3.0	0.5	8.5	1.5	3.0	1.5	

<sup>1</sup> All values except those marked with \* are the average of 2 sets. Values marked \* are for 1 set only.

Appendix Table 4d. CPUE of pink salmon by sampling data in the Nisqually Reach for the period February 15 to July 20, 1978.<sup>1</sup>  
(NS = no survey)

Month	Day	Day (D) or Night (N)	Tatsolo Point	DuPont Dock	DeWolf Bight	Thompson Cove	East Ore 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
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
25		D	0	0	0	0	0	0
31		N	0	0	1.0	0	0	0
June		3	D	0	0	0	0	0
	7	N	0	0	0	0	0	0
	10	D	NS	NS	NS	NS	NS	NS
	11	N	0	0	0	0	0	0
	15	D	0.5	6.0	0	0	0	0
	20	N	0	0	0	0	0	0
	22+	D	10.5	0	0	0	0*	0

<sup>+</sup>No fish were caught after June 22.

<sup>1</sup> All values except those marked with \* are the average of 2 sets. Values marked \* are for 1 set only.

APPENDIX 5  
TOWNET CATCH DATA FOR SALMONIDS IN  
THE NISQUALLY REACH, 1978

Appendix Table 5. Trawl catches of juvenile salmonids by shoreline during 1978 in the Nisqually Reach Study area.

Date	Day (D) or Night (N)	DuPont Shoreline				East Anderson				West Anderson				Middle Reach								
		Tows: 14, 15, 16	Tows: 1, 2, 14, 17	Tows: 11, 12, 11, 18	Tows: 8, 7, 10	Tows: 5, 4, 7, 18, 20																
		Chum	Pink	Chinook	Coho	Trawl	Chum	Pink	Chinook	Coho	Trawl	Chum	Pink	Chinook	Coho	Trawl	Chum	Pink	Chinook	Coho	Trawl	
April 3	M	7.0	1.3	0.7	0.3	3	6.5	2.5	0.3	4	11.7	0.7	3	0.3	0.3	3	1.7	0.3				
April 4	D	0.3				3	7.2		0.2	5			4			3						
April 17	M	1.0				3	2.8	0.2		5	3.8		4	0.3		3	1.8	0.3				
April 17	D					3				5			3			2						
May 7	M	0.3		0.3		3	1.6			5			4			2	2.0					
May 8	D					3				5			2			3						
May 28	M					3	46.4	0.2	0.2	5	12.0	0.3	2	0.7	0.3	3						
May 29	D	14.0	0.7	12.7	0.7	3				5			3	0.3		3						
June 12	M	428.7	75.3	42.7	3	22.8	1.2		0.3	5	1.3		3	22.3	1.7	3	2.3	0.3	1.3			
June 13	D	81.0		50.7	3	0.4				5	3.7		3	0		3						

APPENDIX 6  
RAW ABUNDANCE AND SPECIES RICHNESS  
OF TRYNET CATCHES



Appendix  
 Table 6a. 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		
Jatsolo Point	2	1	1	3	12	18	0	5.3	
	3	2	6	1	16	19	5	7.4	
	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	4	2	7	12	12	12	0	7.0	
	6	4	8	6	11	9	15	8.4	
	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	2	0	11	4	9	1	4.6	
	9	4	0	1	8	13	0	5.0	
	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 6b. Number of fish caught per try net haul, southern Puget Sound, 1977-1978.

Depth of tow (m)	Date										$\bar{X}$	
	Mar 11	May 6	Jun 16	Sept 15	Nov 4	Jan 13	Mar 13					
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					
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					
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					

Fatsolo  
Point

South  
DuPont  
Dock

Outer  
Nisqually  
Delta

APPENDIX 7  
RAW ZOOPLANKTON DATA

Appendix Table 7a. Zooplankton catches at the Outer Nisqually Delta site March-July, 1977.  
All values are numbers of organisms per 100 m<sup>3</sup> of water strained.

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

<sup>1</sup> surface tow

<sup>2</sup> oblique tow

Appendix Table 7b. Zooplankton catches at the South DuPont Dock site March-July, 1977. All values are numbers of organisms per 100 m<sup>3</sup> of water strained.

Organism	March		April		May		June		July	
	S <sup>1</sup>	O <sup>2</sup>	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	945	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	699
Isopoda	30	28	76	8	64	-	32	-	367	55
Cumacea	78	233	600	230	882	562	258	498	148	150
Ctenophora	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

<sup>1</sup> surface tow

<sup>2</sup> oblique tow

Appendix Table 7c. Zooplankton catches at the Tatsolo Point site March-July, 1977. All values are numbers of organisms per 100 m<sup>3</sup> of water strained.

Organism	March			April			May			June			July		
	S <sup>1</sup>	O <sup>2</sup>	S	S	O	S	S	O	S	S	O	S	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	156	158					
Cnidaria	32	31	110	116	1,387	4,196	107	668	1,491	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	1,243	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					

<sup>1</sup> surface tow

<sup>2</sup> oblique tow

APPENDIX 8  
SUMMARY STATISTICS OF FISH SPECIES  
ANALYZED FOR STOMACH CONTENTS IN THE  
NISQUALLY REACH, 1977-1978

Appendix Table 8. Summary statistics of nearshore fish species analyzed for food habits studies from Nisqually Reach, southern Puget Sound, 1977 - 1978.

Species	Total Sample Size n	% Empty	Condition Factor $\bar{x} \pm$ S.D.	Digestion Factor $\bar{x} \pm$ S.D.	Stomach Contents Biomass (grams) $\bar{x} \pm$ S.D.	Number of Prey Organisms $\bar{x} \pm$ S.D.	Prey Taxa (Inc. Life History Stages)	Shannon-Wiener Diversity Indices	
								Abundance	Biomass
<i>Squalus acanthias</i> , 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
<i>Hydrolagus colliei</i> , Ratfish (adult)	16 1	5 0	3.1±0.5 3.0	3.2±0.5 5.0	2.40±2.39 24.79	9.7±15.2 129.0	39 16	3.83 2.73	4.10 2.77
<i>Clupea harengus pallasii</i> , 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
<i>Oncorhynchus gorbusha</i> , Pink salmon (juvenile)	20 34	0 2	3.8±1.2 5.8±0.3	3.1±1.3 3.8±1.1	0.07±0.04 0.04±0.06	80.0±98.8 94.0±91.4	23 30	2.04 2.54	2.13 3.42
<i>Oncorhynchus keta</i> , Chum salmon (juvenile)	117 549	1 3	5.0±1.4 5.2±1.3	4.7±1.0 4.2±1.1	0.04±0.08 0.05±0.10	93.8±121.8 102.8±108.8	58 74	1.25 3.31	3.37 3.59
<i>Oncorhynchus kisutch</i> , Coho salmon (juvenile)	52 250	3 6	4.3±1.5 5.0±1.2	4.5±1.0 4.6±1.0	0.18±0.23 0.34±0.38	50.4±64.1 61.9±85.2	69 108	3.80 4.44	3.90 4.62
<i>Oncorhynchus tshawytscha</i> , Chinook salmon (juvenile)	34 65	2 5	5.1±1.2 5.1±1.6	4.0±1.2 4.3±1.3	0.31±0.59 1.61±8.67	36.5±43.2 37.6±43.0	52 64	4.16 3.96	3.70 2.09
<i>Salmo clarki</i> , Cutthroat (searun) trout	1 6	0 0	*	4.0 4.8±0.4	0.35 1.38±1.18	18 23.8±34.7	5 13	-- 2.19	-- 2.37
<i>Salmo gairdneri</i> , Rainbow (steelhead) trout	1 5	0 0	6.0 6.0±1.4	3.0 4.4±1.3	16.16 5.47±9.71	2.0 41.4±51.6	1 21	-- 2.13	-- 1.60

\* Stomach damaged in removal.

Appendix: Table 8. (continued)

<i>ypomesus pretiosus</i> , Surf smelt	1977	1	0	5.0	3.0	0.17	56.0	3	0.96	0.79
	1978	13	23	4.1±1.3	2.6±1.5	0.16±0.10	21.4±33.4	10	1.53	0.43
<i>adus macrocephalus</i> , Pacific cod (juvenile)	1977	3	0	5.0±1.0	4.0±1.7	0.05±0.06	3.0±1.0	5	2.20	1.33
<i>icrogadus proximus</i> , Pacific tomcod (juvenile & adult)	1977	29	3	3.9±1.2	2.9±1.0	0.20±0.23	19.9±42.6	41	3.68	4.33
<i>asterosteus aculeatus</i> , Threespine stickleback (adult)	1977	1	0	4.0	5.0	0.02	10.0	3	1.30	0.32
	1978	1	0	6.0	3.0	0.03	6.0	1	--	--
<i>ulorhynchus flavidus</i> , Tube-snout (juvenile)	1977	1	0	6.0	5.0	0.08	64.0	5	1.36	1.36
<i>ymnathus griseolineatus</i> , Bay pipefish (adult)	1977	1	0	3.0	5.0	0.01	17.0	2	0.98	0.17
<i>ebastes caurinus</i> , Copper rockfish (juvenile & adult)	1977	5	20	5.6±2.6	3.4±1.3	1.57±1.76	2.6±1.7	10	3.24	2.30
<i>lexagrammos lagocephalus</i> , Rock greenling (adult)	1977	1	0	6.0	3.0	10.14	15.0	3	1.27	1.12
<i>lexagrammos stelleri</i> , Whitespotted greenling (adult)	1977	5	0	4.0±1.6	3.4±1.5	1.92±2.09	12.0±8.4	16	3.21	2.09
<i>xylebius pictus</i> , painted greenling (adult)	1977	2	0	4.5±3.5	2.5±0.7	0.22±0.30	8.5±7.8	5	2.13	1.17
<i>rtedius fenestralis</i> , Padded sculpin (adult)	1977	6	0	5.3±0.8	3.3±0.5	0.18±0.23	4.2±2.8	10	3.05	2.46

Appendix: Table 8. (continued)

<i>Artedius lateralis</i> , smooth-head sculpin (adult)	1977	1	0	6.0	5.0	0.06	10.0	3	1.16	0.81
<i>Clinocottus acuticeps</i> , Sharpnose sculpin	1977	3	0	3.0±1.7	3.0±0.0	<0.01	1.0±0.0	3	1.58	0.82
<i>Enophrys dixon</i> , Buffalo sculpin (adult & juvenile)	1977	4	6	4.6±1.5	4.5±1.2	5.73±7.20	134.8±751.4	59	1.02	2.43
<i>Leptocottus armatus</i> , Staghorn sculpin (adult & juvenile)	1977	61	6	4.7±1.1	3.7±1.1	2.43±3.55	27.4±72.7	81	3.58	4.34
	1978	20	2	5.2±1.5	3.5±1.5	1.08±2.28	7.0±13.2	76	4.49	4.01
<i>Myoxocephalus polycanthocephalus</i> , Great sculpin (juvenile & adult)	1977	7	7	4.3±1.4	4.0±2.0	0.40±0.35	12.0±17.4	5	1.47	1.78
<i>Nautichthys oculofasciatus</i> , Sailfin sculpin (juv.)	1977	1	0	5.0	3.0	0.05	6.0	3	1.46	1.46
<i>Oligocottus maculosus</i> , Tidepool sculpin (adult)	1977	1	0	6.0	3.0	0.05	8.0	5	2.16	1.64
<i>Chitonotus pugetensis</i> , Roughback sculpin (adult & juvenile)	1977	42	14	4.3±1.0	3.3±0.7	0.16±0.22	3.0±3.3	37	4.60	4.46
	1978	3	0	5.7±2.3	5.0±0.0	0.43±0.32	13.3±8.5	12	2.81	2.53
<i>Agonus acipenserinus</i> , Sturgeon poacher (adult & juvenile)	1977	24	12	4.0±1.0	4.0±1.1	0.27±0.40	11.8±12.8	8	3.63	2.78
<i>Pallasina barbata</i> , Tubenose poacher (adult)	1977	1	0	6.0	3.0	0.04	10.0	1	0.0	0.0
<i>Xeneretmus latifrons</i> , Blacktip poacher (adult)	1977	1	0	6.0	3.0	0.18	14.0	5	2.07	1.32

Appendix Table 8. (continued)

<i>Matogaster aggregata</i> , Shiner perch (adult & juvenile)	1977 1978	13 24	53 25	4.0±1.1 2.6±1.6	3.5±1.2 2.4±1.8	0.03±0.01 0.09±0.14	32.0±61.4 26.5±76.7	9 5	1.27 0.65	2.93 1.62
<i>Amblyopteryx lateralis</i> , Striped seaperch (juvenile & adult)	1977 1978	5 2	0 50	3.4±1.1 5.0	3.6±1.7 1.0	0.74±1.00 0.18	9.4±8.6 0	10 0	2.64 --	2.18 --
<i>Macochilus vacca</i> , Pile perch (juvenile)	1977 1978	2 1	0 0	3.0±0.0 3.0	2.0±0.0 2.0	0.06±0.02 0.54	4.5±0.7 4.0	3 1	1.35 --	0.76 --
<i>Paralichthys flavidus</i> , Penpoint gunnel (adult)	1977	1	0	6.0	3.0	0.08	6.0	1	0.0	0.0
<i>Paralichthys laeta</i> , Crescent gunnel (adult)	1977	1	0	3.0	6.0	0.01	4.0	2	0.8	0.50
<i>Paralichthys sordidus</i> , Pacific sanddab (adult)	1977	3	33	5.5	3.0	0.10±0.12	2.0±0.0	3	1.50	0.43
<i>Paralichthys stigmaeus</i> , Speckled sanddab (adult)	1977	3	0	4.7±0.6	2.7±0.6	0.15±0.13	3.3±3.2	6	2.45	1.72
<i>Pseudopleuronectes bilineata</i> , Rock sole (adult & juvenile)	1977 1978	66 26	39 2	4.9±2.2 5.0±1.6	4.8±2.1 4.9±0.6	1.40±1.48 1.53±1.22	12.4±20.9 26.8±21.4	49 61	3.93 4.42	3.01 4.42
<i>Microstomus pacificus</i> , Dover sole (adult)	1977 1978	4 1	0 0	4.3±1.7 3.0	3.5±1.7 3.0	0.44±0.32 0.13	26.3±20.0 15.0	14 3	2.42 1.43	2.56 1.14
<i>Urophycis vetulus</i> , English sole (adult & juvenile)	1977 1978	50 31	28 12	4.1±1.5 5.4±1.1	3.6±1.7 3.3±1.5	0.28±0.53 0.27±0.67	19.3±17.9 39.1±69.9	48 31	3.89 2.80	3.16 2.20
<i>Paralichthys stellatus</i> , Starry flounder (adult & juvenile)	1977 1978	42 33	35 36	3.6±1.5 4.5±2.2	4.6±2.0 3.8±1.4	0.40±0.50 5.10±9.52	17.3±24.1 24.4±55.8	31 32	3.14 2.68	3.72 2.78



APPENDIX 9  
STOMACH CONTENTS OF INCIDENTAL  
NEARSHORE FISHES IN THE NISQUALLY  
REACH, 1977-1978

STOMACH CONTENTS OF INCIDENTAL  
NEARSHORE FISHES IN NISQUALLY REACH

Pacific Herring (Clupea harengus pallasii)

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.

Surf Smelt (Hypomesus pretiosus)

Of thirteen adult surf smelt collected during the 1978 beach seine collections, three (23%) had empty stomachs. Shrimp larvae were the predominant prey (69.2% total abundance, 92.7% total biomass).

Pacific Cod (Gadus macrocephalus)

One juvenile Pacific cod captured in a May 20, 1977 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.

Threespine Stickleback (Gasterosteus aculeatus)

A threespine stickleback caught in the May 3, 1977 beach seine collection at the south DuPont Dock site had consumed six harpacticoid copepods,

three gammarid amphipods (95.24 percent of total contents biomass) and one decapod zoea. One adult stickleback caught in a beach seine collection at Sandy Cove in early April 1977 had consumed six shrimp 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.

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 (DeLacey, 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 1977 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 1977 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.

Sailfin Sculpin (Nautichthys oculofasciatus)

A sailfin sculpin from the September 1977 trynet collections out 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, 1977 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 and were also sighted beneath the DuPont Dock during SCUBA transect surveys in July through October. Gammarid amphipods (including Corophidae spp.), polychaetes, and crangonid shrimp dominated the prey spectrum of the sturgeon poacher (Appendix Fig. 2).

Tube-nose Poacher (Pallasina barbata)

A tube-nose 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,

tanaiids, parasitic copepods (Argulus sp.), gammarid amphipods and shrimp zoea.

#### Shiner Perch (Cymatogaster aggregata)

Trynet collections in the DuPont Dock vicinity, particularly in November 1977, 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 were empty.

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

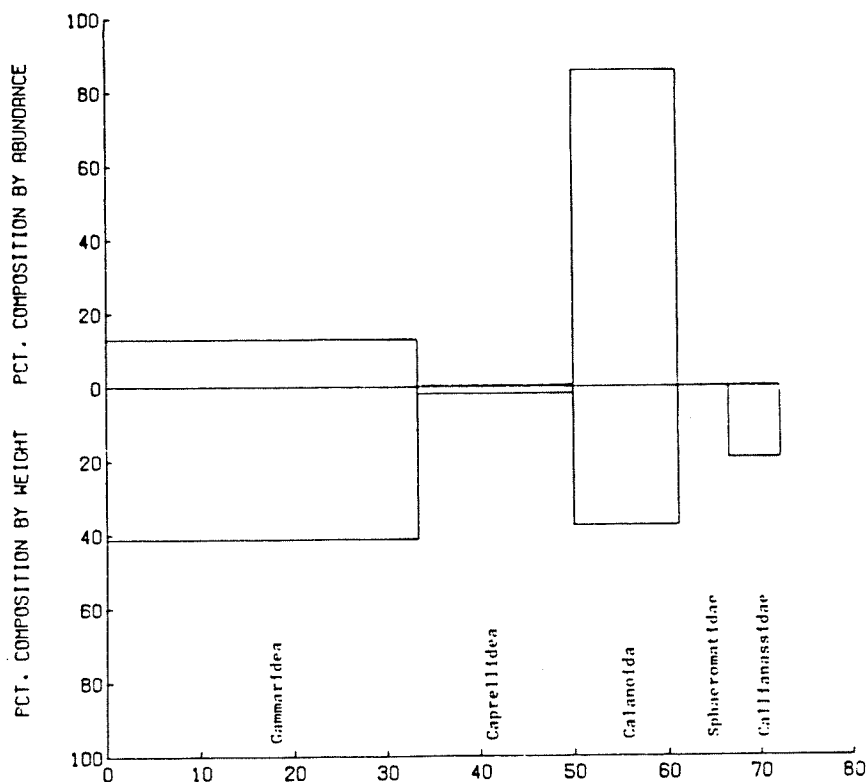
Of 24 shiner perch obtained in the 1978 beach seine collections, primarily at the west Delta and Thompson Cove sites, 6 (25 percent) were empty. Gammarid amphipods (54.3 percent of the total IRI) and calanoid copepods (41.2 percent of total IRI) were the principal prey of those containing identifiable stomach contents (Appendix Fig. 9a).

#### 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 1977 beach seine collection at DuPont Dock (north) and three from an April 1977 collection at Tatsolo were examined. Polynoid polychaete annelids, gammarid amphipods, shrimp (Hippolytidae), and brachyuran crabs (Hemigrapsus nudus) were the prevalent prey organisms.

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

PREDATOR 8835600201 - CYMATOCASTER AGGREGATA  
(SHINER PERCH ) ADJUSTED SAMPLE SIZE = 18



CUMULATIVE FREQUENCY OF OCCURRENCE

PREY ITEM	FREQ. OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IPI
GAMMARIDEA	33.33	13.00	41.27	1808.9	54.28
CAPRELLIDEA	16.67	.63	1.83	41.0	1.23
CALANOIDA	11.11	85.95	37.60	1372.9	41.20
SPHAEROMATIDAE	5.56	.21	.01	1.2	.04
CALLINASSIDAE	5.56	.21	19.28	108.3	3.25

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	.76	.35	.47
SHANNON-WIENER DIVERSITY	.65	1.62	1.25
EVENNESS INDEX	.28	.70	.54

Fig. 9a. IRI prey spectrum of shiner perch caught by beach seine in the Nisqually Reach, 1978.

One specimen collected in the 1978 beach seine collections had an empty stomach.

Pile Perch (Rhacochilus vacca)

Also a predominant member of the neritic fish assemblage at DuPont Dock, two juvenile pile perch from the November 1977 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.

A pile perch collected in an April 1978 beach seine collection had eaten four acmaeid limpets.

Penpoint Gunnel (Apodichthys flavidus)

One penpoint gunnel collected in the June 28, 1977 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 1977 beach seine collection south of the DuPont Dock.

Pacific Sanddab (Citharichthys sordidus)

Three Pacific 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 speckled sanddabs from the same collection as the C. sordidus specimens had fed predominantly upon polychaetes but also callianassid shrimp, crabs, gammarid amphipods and mysids.

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.

One adult dover sole from a 1978 beach seine collection had consumed seven polychaetes (57.4 percent total biomass), six bivalve siphon (32.6 percent total biomass) and two gammarid amphipods.

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. One juvenile sand sole from the 1978 beach seine collections had stomach contents including 68 harpacticoid copepods.