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SALMONID OUTMIGRATION STUDIES IN HOOD CANAL

FINAL REPORT, PHASE III

January to July 1977

by

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INTRODUCTION

In 1977 the Fisheries Research Institute (FRI) conducted the third phase of a 5-year program to study the salmonid outmigrations in Hood Canal and to assess the impact of pier construction and associated human activities on these migrations past Bangor Annex (Fig. 1). Bangor Annex is the site of the Trident Submarine Base now being constructed by the U.S. Navy. The peak of shoreline construction for the submarine facility at the Bangor Annex occurred in 1977, which included dredging for the new drydock. To coincide with this increased activity FRI conducted a more intensive study than in the previous 2 years. Thus the salmonid outmigration research was carried out in conjunction with the monitoring of the silt plume associated with dredging. The data from the plume monitoring study, which included static and flow-through bioassays on juvenile salmon, laboratory and field behavioral work, live-boxes, and a disease study, will be available in a separate report (Salo et al., in preparation). The increased effort in 1977 allowed simultaneous beach seining and townetting to be carried out at any time during the day or night.

In 1977 a mark-recapture program was initiated by FRI and the Washington State Department of Fisheries (WDF) (Whitmus and Olsen, in preparation). This study provided valuable information to confirm the migration routes and timing suggested by the outmigration work.

This report reviews the third phase of the outmigration program and compares the results to those obtained in 1975 and 1976 (Schreiner 1977).

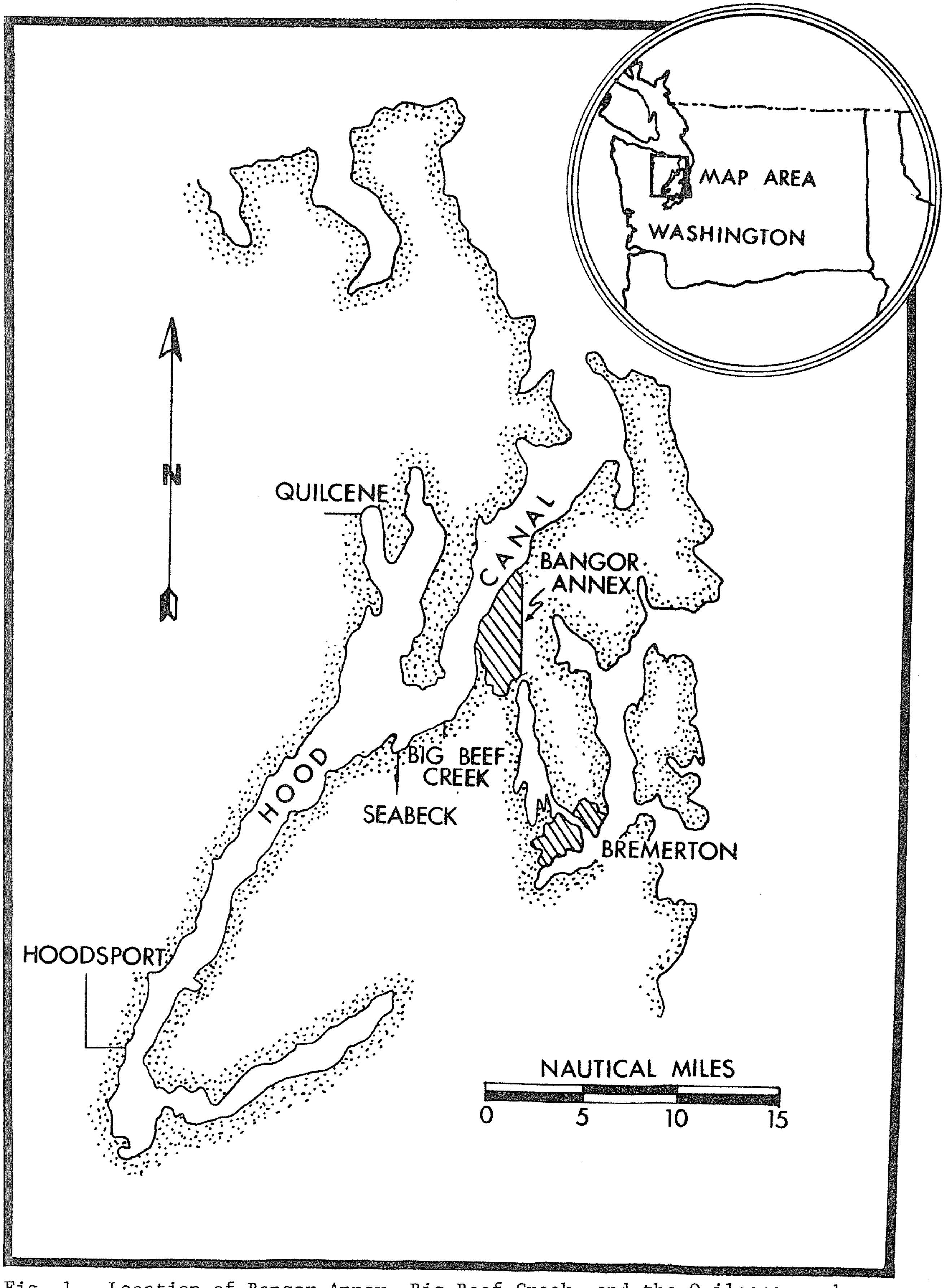


Fig. 1. Location of Bangor Annex, Big Beef Creek, and the Quilcene, and Hood Canal (Hoodsport) fish hatcheries, Hood Canal, Washington.

Hood Canal is an important migration route and nursery area for four species of salmon, two species of anadromous trout, and the organisms that form their food supply. Both pink and chum salmon (*Oncorhynchus gorbuscha* and *O. keta*) pass through the study area in early marine life, a time of high natural mortality (Parker 1965 and 1968). Several investigators have concluded that the conditions during early marine life are exceedingly important to overall salmonid growth and survival (Shepard 1948, Vernon 1958, Wickett 1958, Gilhousen 1962, Manzer and Shepard 1962, Martin 1966, Hurley and Woodall 1968). The emphasis in this report is placed on the chum salmon, it being the predominant salmonid species in the sampling area during 1977.

The objectives of this third phase were to:

1. Continue the collection of data on salmonid populations migrating past the Bangor Annex, and determine the time of migration, the diurnal movement patterns, and the relative abundance for each salmonid species.

2. Notify OICC TRIDENT of any abberant behavior of salmonids during the monitoring program, including that due to the wharves and piers.

3. Monitor environmental conditions to which outmigrants were subjected, such as water temperature, salinity, turbidity, dissolved oxygen concentrations, currents, tides, and weather.

METHODS AND MATERIALS

Big Beef Creek, Fisheries Field Research Facility of the University of Washington, was used as the base for study operations. The M/V TENAS, M/V NARWHAL, and attendant skiffs used in the sampling operations were based at Seabeck or at the University of Washington's R/V KUMTUKS moored at Bangor Annex.

The salmonid outmigrants in 1977 were studied using both nearshore and offshore sampling techniques in the vicinity of Bangor Annex. Bangor Annex is approximately 6 miles north of Seabeck, Washington (Fig. 1), and is the site for the Trident Submarine Base now being constructed by the U.S. Navy.

Nearshore Sampling

Eight beach seine stations on the east shore and four on the west shore (Fig. 2) were sampled regularly from early January to late July. Nighttime sampling was conducted from early April to early July. A 10-m x 2-m beach seine with bag of 6-mm stretch mesh was used at the beginning of the season until late March. With one man wearing waders, waist deep in the water and another on the shore a transect 30 m long and parallel to the shore was seined. The maximum depth of the transect was 1.5 m.

When chum salmon fry became available to the 10-m seine in late January, a 37-m beach seine with 18-m, 3-cm stretch mesh wings and a 0.6-m x 2.4-m x 2.3-m bag of 6-mm stretch mesh (Fig. 3) was used in addition. The 37-m beach seine was used until late July. The seine was set from an outboard skiff, 30 m from, and parallel to, the shore. With two men on a rope at either end of the seine, the net was drawn toward the shore. At 10 m from the shore the wings of the net were closed, funneling the catch into the bag. The seine was operated as a floating seine, since this technique was most effective for the capture of salmonid fry in the 1975

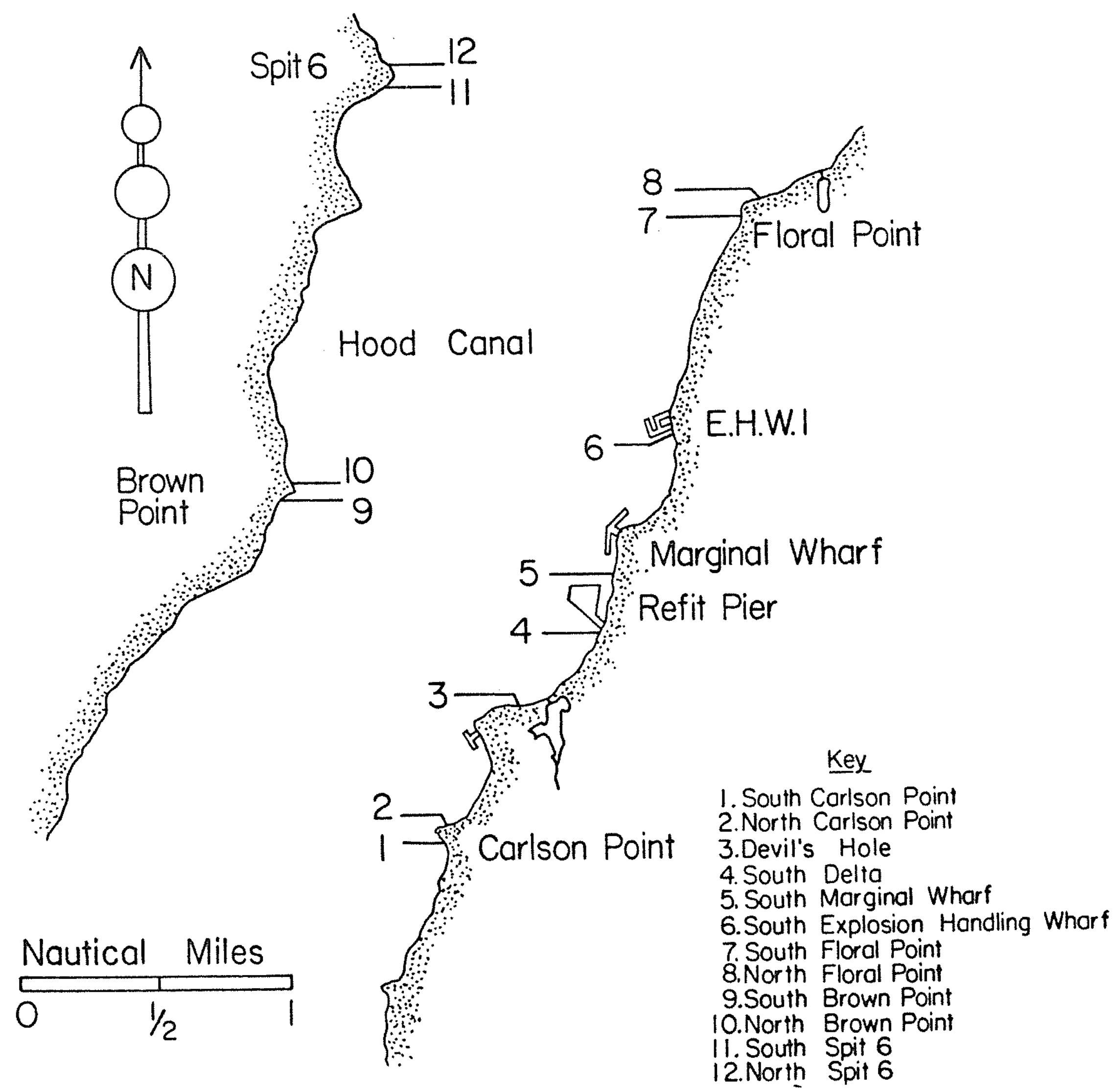


Fig. 2. Beach seine sampling stations for shoreline salmonid out-migration studies in Hood Canal, Washington, January through July, 1977.

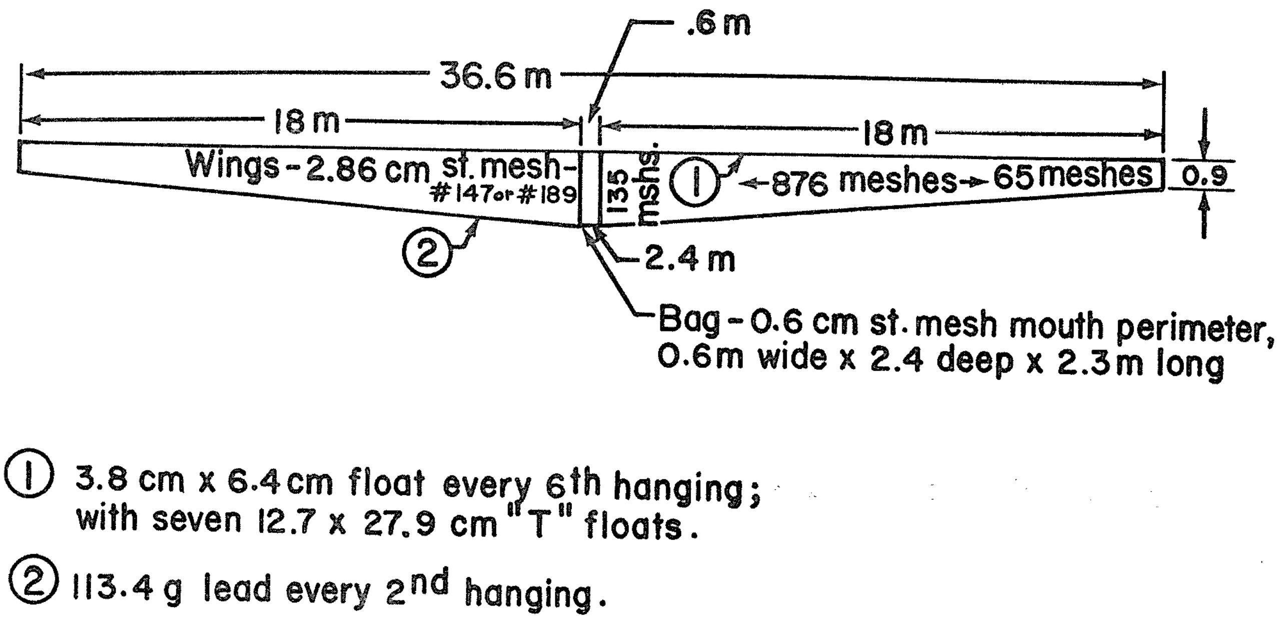


Fig. 3. Beach seine utilized during nearshore surveys, January through July, 1977, Hood Canal, Washington.

and 1976 field seasons. The location and a description of all beach seine sites used in 1977 are given in Table 1.

Visual survey transects 0.8-km long were conducted by boat 2-15 m from the shore through to late July (Fig. 4). Salmonids were counted with the aid of polarized glasses and a mechanical counter. Accurate surveys required special environmental conditions (Schreiner et al. 1977).

Offshore Sampling

From late January until late July surface townet transects 0.8-km long were sampled (Fig. 5). From early April until late July nighttime sampling was conducted over the same pattern of transects. The sampling net was a surface trawl with a 3- x 6-m opening and stretch mesh sizes ranging from 76 mm at the opening to 6 mm at the bag (Fig. 6). The wings of the net were spread vertically by 3.75-cm diameter galvanized pipes, which were connected with a short nylon bridle to single warps leading to each vessel. The net was towed between the M/V TENAS, a 38-foot (11.6-m) diesel-powered vessel moving at a water speed of between 1.5 and 2.0 knots, and the M/V NARWHAL, a 26-foot (7.9-m) motor whaler. At 10-min intervals, two crewmen in an outboard skiff pursed the codend of the townet and removed all fish and debris. This technique allowed continuous sampling of the offshore transect pattern. Any salmonids were transported in 20-liter, nontoxic, plastic buckets of water to the M/V TENAS, to be identified and sorted.

Table 1. Location and description of beach seine stations sampled from January through July, 1977, in the Bangor Annex area of Hood Canal, Washington.

	Station Name	Shoreline	Location	Slope	Substrate	Percentage cover of vegetation[1]
1.	South Carlson Point	East	30 m south of Carlson Point	Moderate	Sand, small to medium cobble	40% *Zostera marina* (L) 50% *Ulva lactuca* and *Enteromorpha linza* <5% *Sargassum muticum* *Laminaria saccharina* *Agardhiella* sp. *Ceramium* sp. *Ralphsia* sp.
2.	North Carlson Point	East	45 m north of Carlson Point	Moderate	Medium to large cobble with oyster shells	100% *Z. marina* 100% *U. lactuca* and *E. linza* <5 % *L. saccharina* *S. muticum*
3.	Devil's Hole	East	100 m east of Devil's Hole lake outlet	Gentle	Mud, sand, small cobble and rocks. H_2S present	30% *Z. marina* 20% *L. saccharina* 20% *U. lactuca* and *E. linza* <5% *Gigantina exasperata* *G. cristata*
4.	South Delta	East	5 m south of South Trestle of Refit Pier 1	Gentle	Sand, small to medium cobble	100% *Z. marina* 25% *S. muticum* 20% *U. lactuca* and *E. linza* <5% *L. saccharina*

Table 1. Location and description of beach seine stations sampled from January through July, 1977, in the Bangor Annex area of Hood Canal, Washington - continued.

	Station name	Shoreline	Location	Slope	Substrate	Percentage cover of vegetation[1]
5.	South Marginal Wharf	East	9 m south of South Trestle of Marginal Wharf	Moderate	Sand and small cobble	100% *Z. marina* (thinning to 20% at c. 3-m depth) 10% *U. lactuca* and *E. linza* <5% *L. saccharina*
6.	South Explosion Handling Wharf - No. 1	East	3 m south of South Trestle of E. H. W.-No.1	Gentle	Mud, sand and small cobble	100% *Z. marina* <5% *U. lactuca* and *E. linza* <5% *S. muticum*
7.	South Floral Point	East	60 m south of Floral Point	Gentle	Sand, small to medium cobble	100% *Z. marina* <5% *U. lactuca* and *E. linza* <5% *L. saccharina* <5% *Agardhiella* sps.
8.	North Floral Point	East	60 m north of Floral Point	Moderate	Medium to large cobble	100% *Z. marina* 100% *U. lactuca* and *E. linza*
9.	South Brown Point	West	18 m south of lighted navigation marker at Brown Point	Gentle for 20-m then steep drop-off	Sand and small cobble	50% *Z. marina* <5% *U. lactuca* and *E. linza* <5% *G. exasperata* <5% *G. cristata*
10.	North Brown Point	West	20 m north of lighted navigation marker at Brown Point	Moderate	Sand and small cobble H_2S present	<5% *U. lactuca* and *E. linza* <5% *Z. marina* <5% red algae

Table 1. Location and description of beach seine stations sampled from January through July, 1977, in the Bangor Annex area of Hood Canal, Washington - continued.

Station name	Shoreline	Location	Slope	Substrate	Percentage cover of vegetation[1]
11. South Spit No. 6	West	30 m south of spit located 1 1/2 nautical miles north of Brown Point	Gentle	Sand and small cobble	95% *Z. marina* <5% *E. linza* <5% *Costaria costata* <5% *L. saccharina* <5% *Ceramium* sp.
12. North Spit No. 6	West	20 m north of Spit No. 6	Gentle	Sand and small cobble	20% *Z. marina* 5% *U. lactuca* and *E. linza* <5% *S. muticum* <5% *L. saccharina* <5% *Agardhiella* sp. <5% *Ceramium* sp.

[1]Where *Z. marina* and *U. lactuca* were found together, the latter was higher up on the beach and geographically distinct from the former.

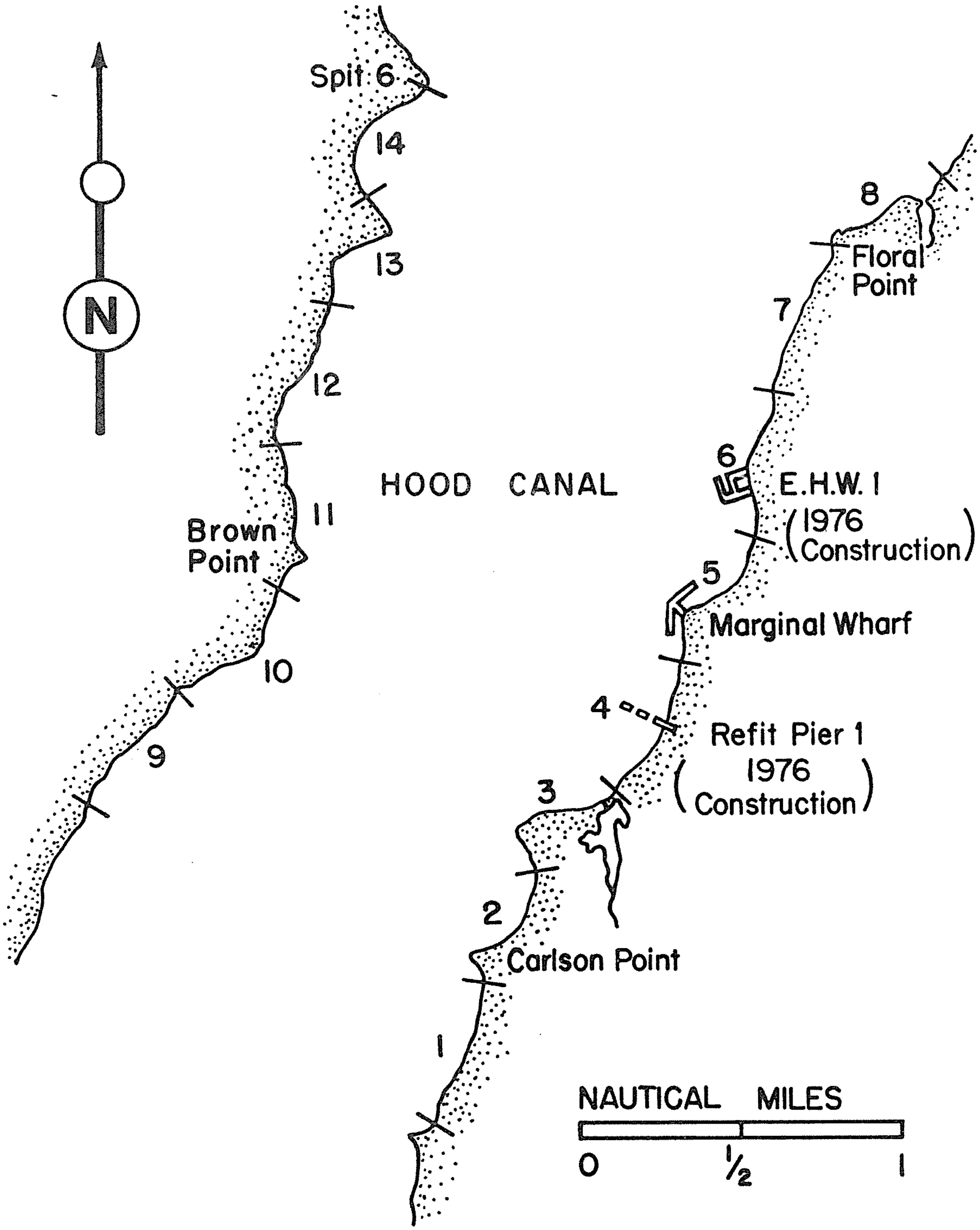


Fig. 4. Visual survey intervals for the east and west shoreline of Bangor Annex, Hood Canal, Washington.

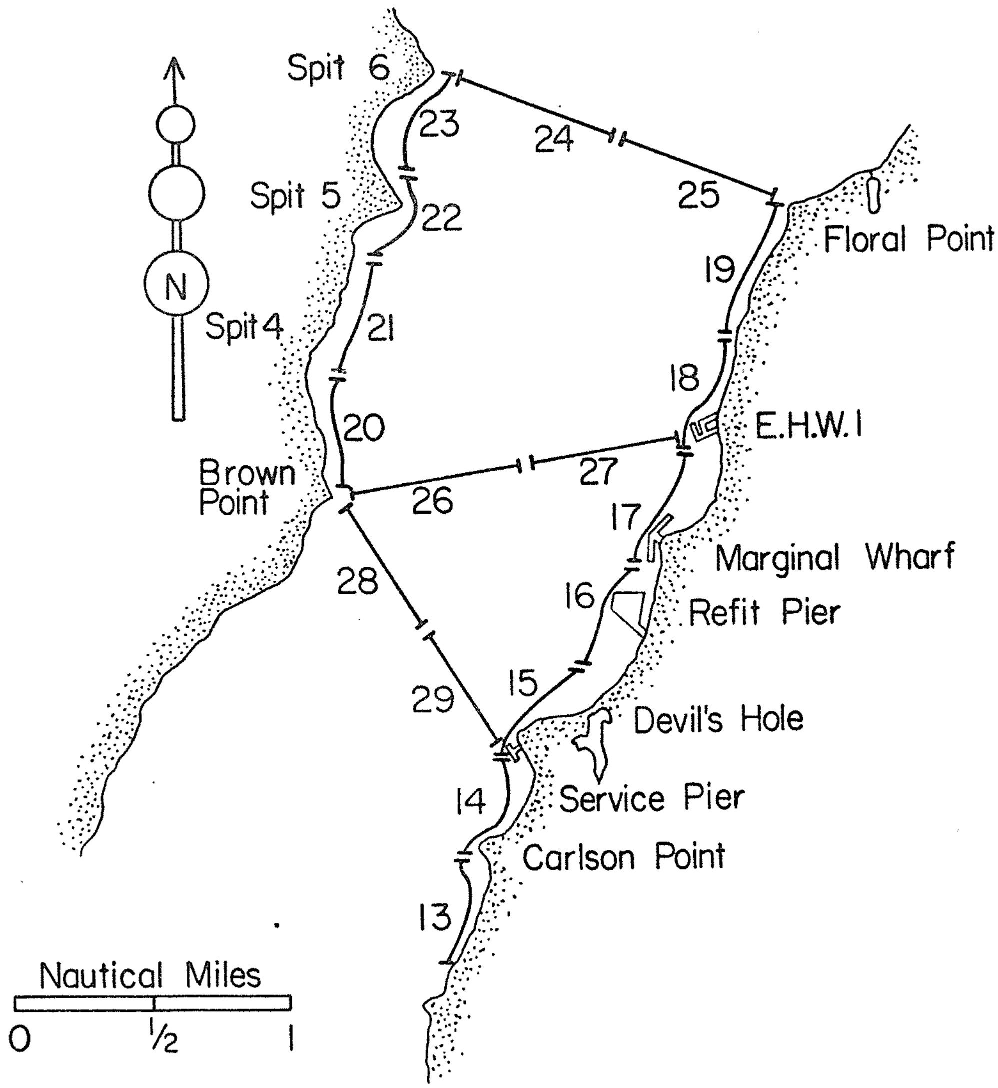
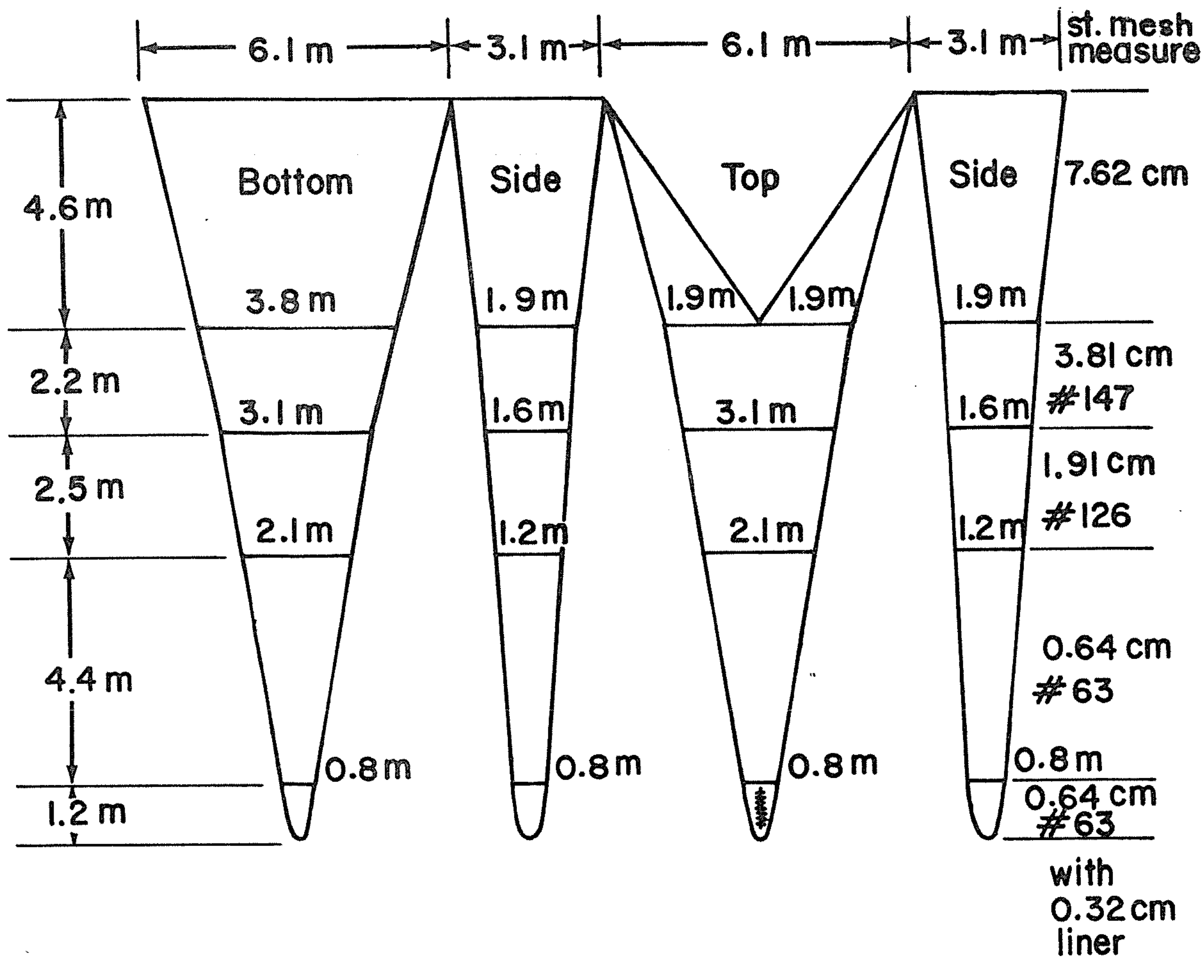


Fig. 5. Townet surface trawl pattern used during salmonid outmigration studies, January through July, 1977, Hood Canal, Washington.

Surface Trawl - 6.1 m x 3.1 m mouth
15 m long



All seams are of 3.81 cm and smaller mesh reinforced with heavy 2.54 cm nylon tape including center lines of bottom and top panels; rib-lines of 0.95 cm diameter polypropylene on four corner seams full length. Mouth of net is double twine and hung on 0.35 cm polypropylene single braid with mimbles at each corner. A 0.9 m nylon coil zipper is in the cod end and on liner in the top panel. Six 4 oz leads are spaced evenly along the foot line. 5.08 cm rings are sewn on top panel at 1.91 cm to 0.64 cm seam.

Fig. 6. Surface townet utilized during offshore sampling, February through July, 1977, Hood Canal, Washington.

Fish Specimen Analysis

Subsamples of no greater than 100 fish were taken for each sample species from each catch for subsequent analysis. The remaining fry were counted and immediately released. Occasional large catches of chum fry with the beach seine were transported to live pens at the R/V KUMTUKS.

The subsamples were killed by narcotizing in MS-222 (tricaine methane sulfonate), preserved on ice, and returned to the laboratory for processing later that day. At regular intervals, and concurrent with plankton sampling, five chum fry were preserved in a solution of formalin for stomach analysis. Likely predators were treated in the same manner.

Lengths from tip of snout to fork of tail were taken to the nearest millimeter for all salmonids caught, and group weights for each 5-mm length increment were weighed to the nearest 0.01 g on a Mettler 1200 electrobalance.

Environmental Data Collection

Nearshore environmental observations were taken after each beach seine set, when possible. Samples and readings were taken at 0.5 to 1.0 m depths 10 to 15 m from shore. The dissolved oxygen concentration was measured with a Yellow Springs Instrument (YSI) Model 54 oxygen meter, calibrated by titration before each sampling session. Temperature was measured with a glass thermometer. Water samples were collected and processed later for tital nonfilterable residues (TNFR) following procedures laid down in Standard Methods (American Public Health Association (APHA) et al. 1975). Weather and sea conditions at each site were also recorded.

At the end of each 10-min townetting transect water samples were taken for TNFR processing. Temperature, salinity, and conductivity readings were taken with a Kahl Scientific Instrument Corp. Model RS5-3 electrodeless induction salinometer, calibrated prior to each outing following the procedures as laid down in Standard Methods. Water visibility was measured with a 15-cm Secchi disk. Samples and readings were taken at 1-m depths.

Epibenthic Plankton Sampling

Epifauna at four shallow, sublittoral sites in the vicinity of the Trident Submarine Base (Fig. 7) was sampled in replicate using a suction-pump system. The pump system (Fig. 8) consisted of a self-priming, gasoline-powered, 5.1-cm (2-inch) centrifugal pump which drew water and associated planktors through a 25.4-cm (10-inch) conical expander into a 5.1-cm flexible plastic hose. Once through the pump, the water sample passed through a sealed-register, totalizing flowmeter into a double stainless steel cylinder in which two nested, conical nets were suspended. The nets were of 505-μ and 209-μ mesh sizes with area/aspect ratios of 1:2.5 and 1:5.3, respectively. The epibenthic organisms were retained in standard net buckets with window screen of appropriate mesh size.

The pumping system was operated from a 26-ft whaleboat maneuvered to stations at approximately the -0.3-m tide level and anchored. SCUBA equipped divers randomly placed a 1-m^2 round sampling cylinder on the substrate, then proceeded to "vacuum" the area within by moving the expander cone systematically 10 cm above the surface of the benthos, this

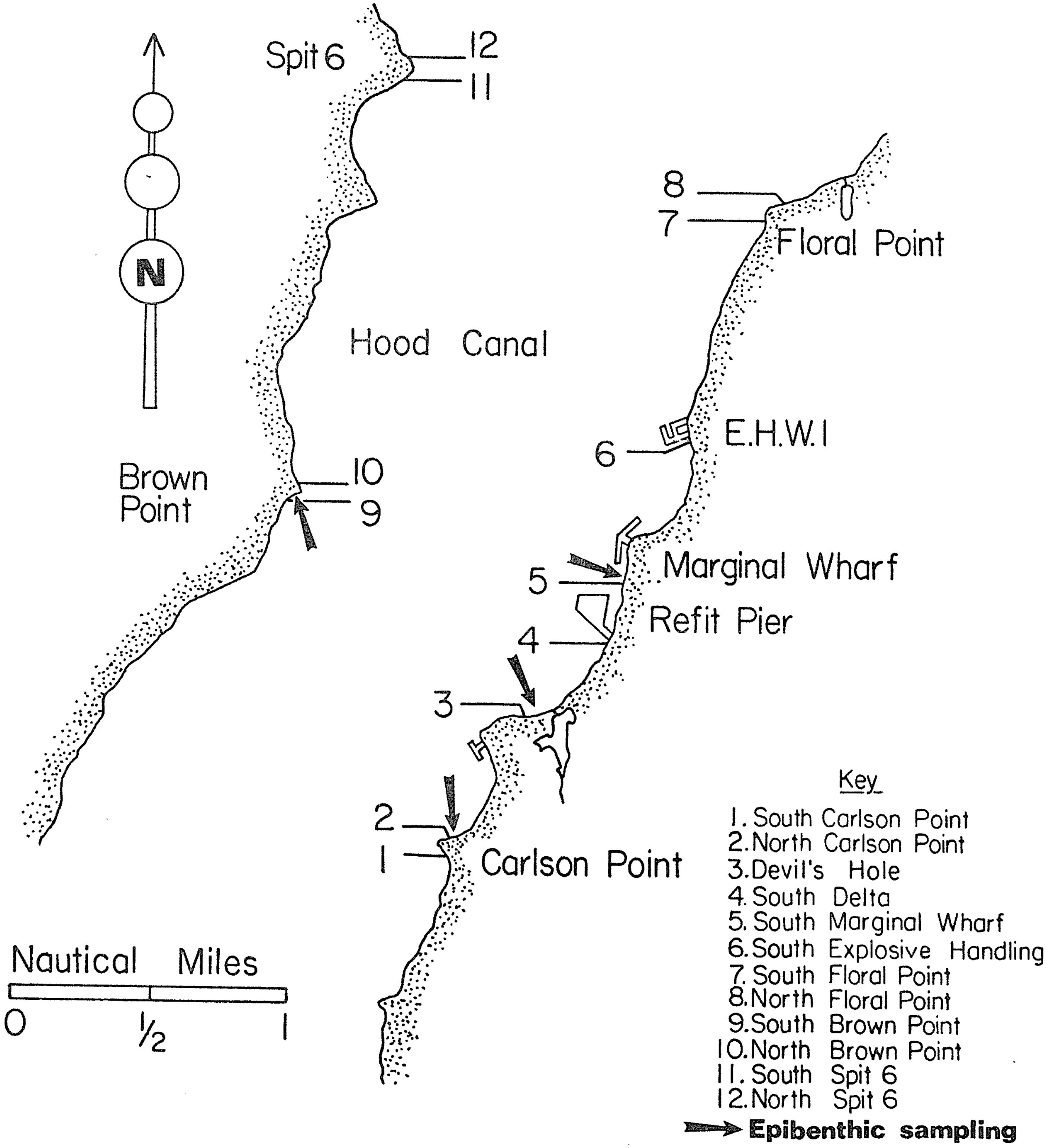


Fig. 7. Beach seine and epibenthic sampling stations for shoreline salmonid outmigration studies January through July, 1977, in Hood Canal, Washington.

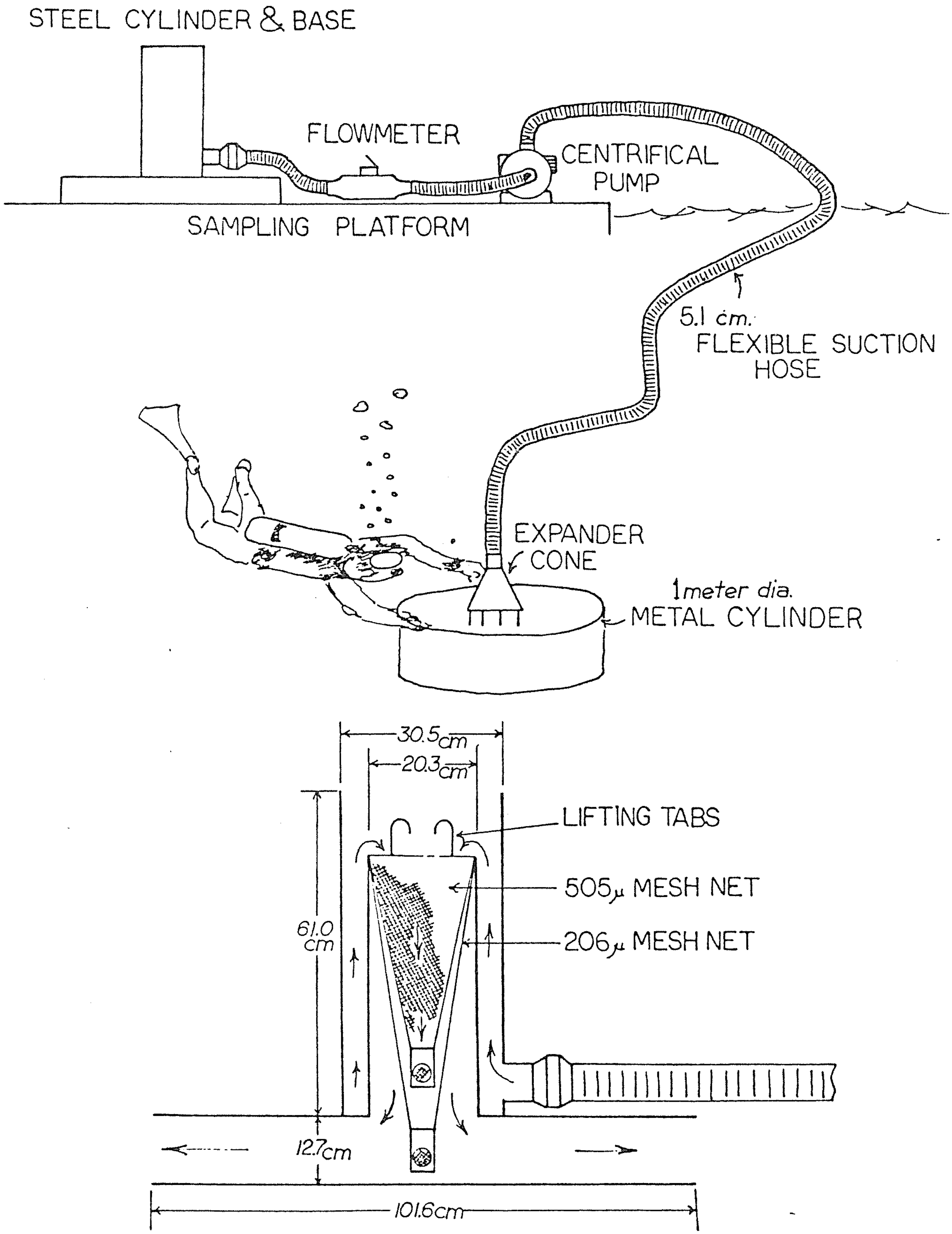


Fig. 8. Overall system design and construction detail of epibenthic pump sampling system.

distance maintained by a ring (which did contact the substrate) extended from the expander cone. Two nested nets were dropped into place within the sampling tank and removed after 378.5 liters (100 gal) had been filtered. Organisms retained in the nets were removed and preserved in 5 percent buffered seawater formalin in labeled PVC jars. The sampling process was repeated twice at each site after replacement of the sampling cylinder upon nearby, similar substrate.

Plankton Analysis

After 2 days of fixation, epibenthic samples were rinsed, transferred with field tags to vials, and preserved with 37 percent isopropanol, with 8 percent glycerol. The smaller (209-μ) fractions were also dyed with rose bengal.

The 505-μ fractions of each replicate were identified and enumerated in full. Gammarid amphipods and the remainder of this fraction were rinsed with isopropanol and water to remove glycerol, and dried at 70° C for 24 hr, then weighed separately to .001 of a gram on a top-loading Mettler balance. The two weights were combined to form the total sample weight.

The 209-μ fractions of each replicate required panning to remove sand, and subsampling to accomodate the very large numbers of organisms. Subsampling was found to be most consistent when using a stoppered, 10-cc glass syringe with a 2-mm orifice, and a 250-cc flask. The sample and preservative were placed in the flask to the 200-cc level. When the sample had settled, the syringe was inserted and slowly filled with the fluid. The fluid was then forcefully expelled back into the flask to agitate the sample, and one of five 2-cc subsamples was quickly withdrawn.

Identification of epibenthic organisms was taken as far as possible within the limits of our resources. Samples of gammarid amphipods were identified by Helmut Koch, Western Washington University. Some harpacticoid copepod samples were identified by Beverly Kask, Pacific Marine Biological Station, Nanaimo, British Columbia.

Laboratory results were recorded on MESA/EDS format forms, which included prey code, life history stage, count, wet weight, total contents weight and remarks. These raw results were processed statistically. Replicate statistics were also calculated after multiplying the mean of the five 209-μ subsamples by 100, and then adding the 505-μ fraction.

Approximately 100 specimens of gammarid amphipods and harpacticoid copepods from selected epibenthic and chum salmon samples were lengthed in order to determine the size frequency of these abundant taxa utilized by juvenile salmonids. Total length minus antennae and setae was measured to the nearest 0.1 mm on amphipods, and to the nearest 0.025 mm on harpacticoids. Each measurement was made using a dissecting microscope with a calibrated reticle micrometer.

Fish Stomach Analysis

Juvenile chum salmon and associated fishes were collected at, or just offshore of beaches where epibenthic plankton samples were collected, using both beach seine and townet. Chum samples of three to five fish were injected with and preserved whole in 10 percent buffered formalin at the time of capture.

Stomach contents were identified and enumerated at Big Beef Creek Station, using a systematic, standardized procedure which provides the numerical and gravimetric composition of prey organisms contained in the stomach, the degree of fullness of the stomach, and the state of digestion of its contents.

RESULTS AND DISCUSSION

Catch-Per-Unit-Effort

Catch-per-unit-effort (CPUE) computed for each salmonid species was of the form:

$$CPUE = C^E/_I E$$

where C is the number of fry captured, I is the intensity of sampling effort, and E is any given unit of time (Ricker 1968). Imperfect sets of the beach seine or hauls of the townet were excluded from the analysis of the data. The mean weekly CPUE was used in many instances, as day-to-day sampling was not consistent in regard to the time of day. Week-to-week sampling was consistent in this respect. The mean weekly CPUE was recorded in the figures as of the final day of the sampling week.

Environmental Results

Environmental data were collected following both beach seine and townet hauls, with several exceptions. Visibility and salinity readings were taken only subsequent to townetting. Dissolved oxygen measurements were taken following beach seine hauls only.

Visibility as measured with a Secchi disk dropped throughout the sampling season from 8.7 m in early March to 4.2 m in late June (Fig. 9). A sharp drop was observed in late March and early April, perhaps attributable to algal blooms beginning with the increased temperature.

Salinity in the towing area varied from 27.4 ppt in early April to 31.8 ppt 2 weeks later (Fig. 10). The low salinity readings followed increased spring runoff.

The water temperature in the Bangor area rose steadily throughout the sampling season from a minimum of 7.5^{o} C in late February to a peak of 15.6^{o} C in mid-June (Fig. 11).

Dissolved oxygen measurements were difficult to obtain accurately as the meter required very frequent calibration. The data available suggest an increase in dissolved oxygen from 8.0 ppt in February to 11.0 ppt in late July (Fig. 12).

Total nonfiltrable residue (TNFR) measurements were taken from mid-March until the end of sampling. The TNFR's collected at nearshore sites were more variable than those at offshore locations. This is probably due to greater influence from wave action at the beach seine sites. The data from the offshore locations are presented here (Fig. 13). No obvious trend was observable through the season.

A stepwise multiple regression analysis was carried out to show the relative importance of each of the recorded environmental variables on the CPUE for chum fry throughout the season. The data were subdivided by gear and tidestage. While tidestage does have an effect on the distribution of chum fry (Table 2), it is not recorded on a linear scale, and so would be unsuitable for regression analysis. Sampling week was entered first into

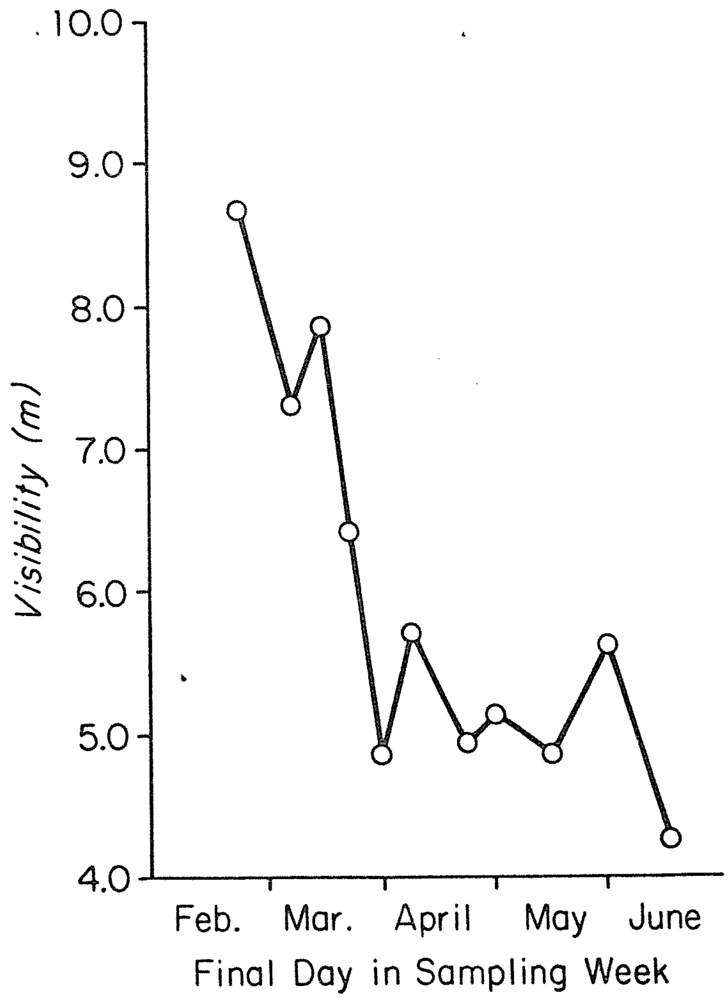


Fig. 9. Weekly mean visibility as measured by Secchi disk for the period February through June, 1977, Hood Canal, Washington.

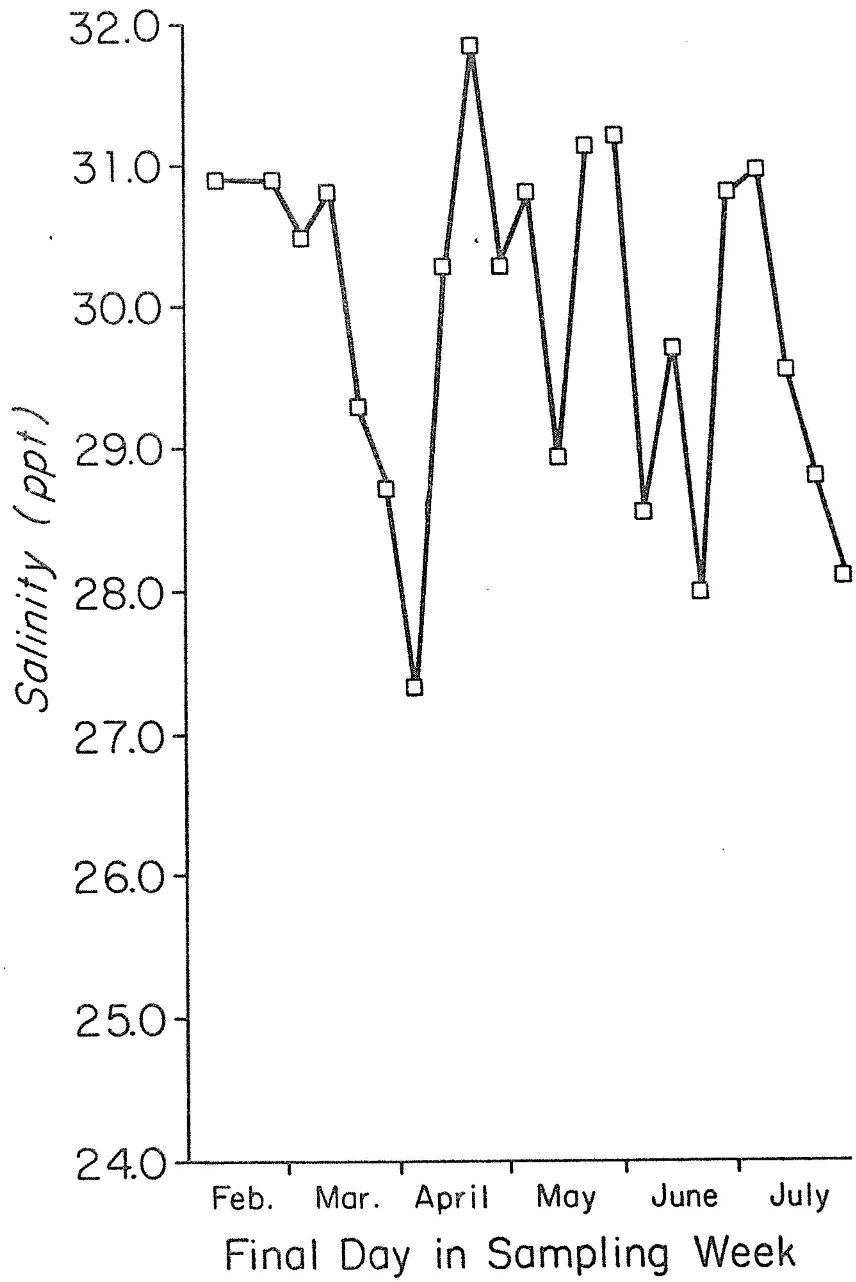


Fig. 10. Weekly mean salinity for the period February through July, 1977, Hood Canal, Washington.

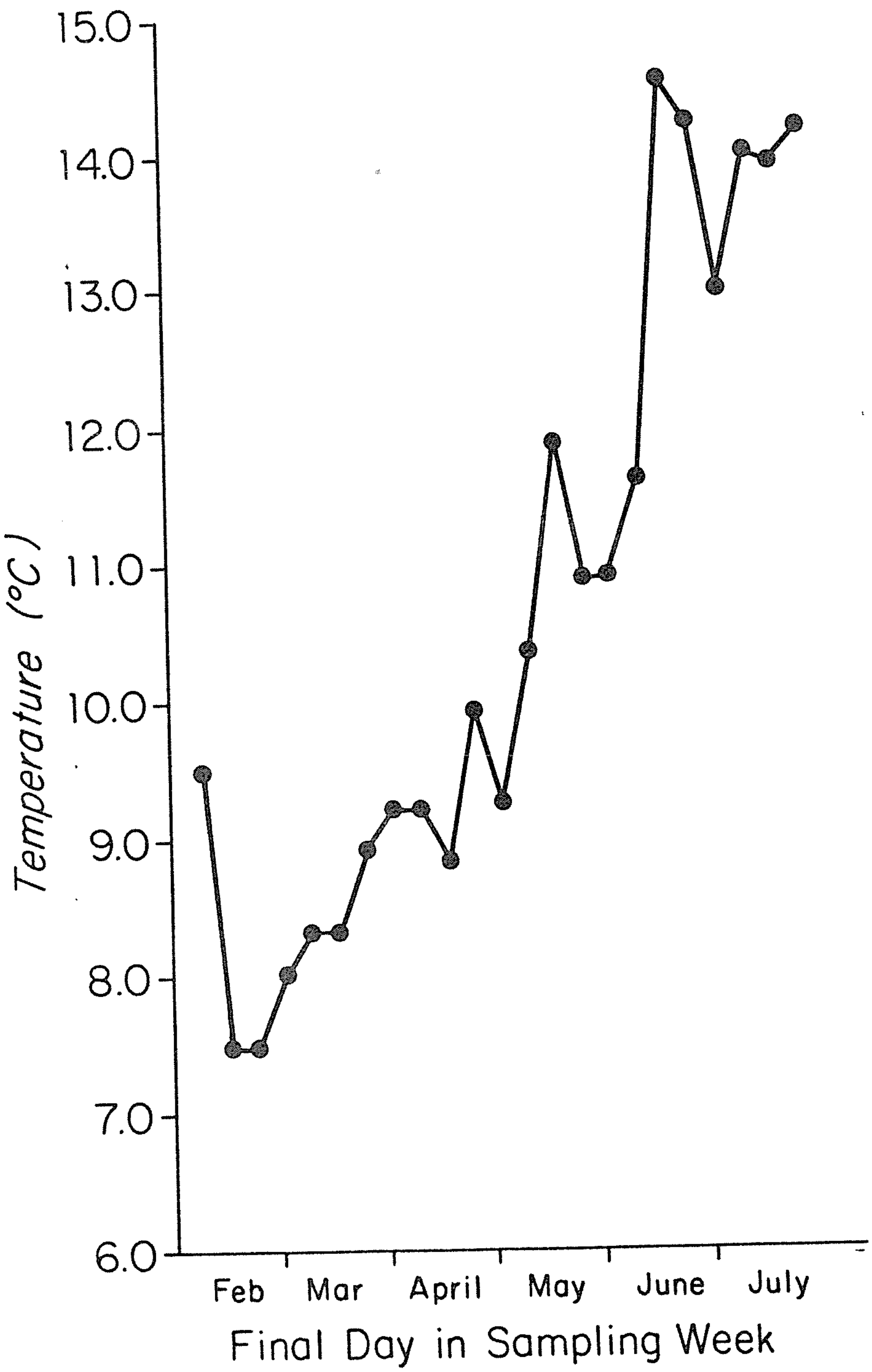


Fig. 11. Weekly mean surface water temperature measured 10-15 m from shore for the period February through July, 1977, Hood Canal, Washington.

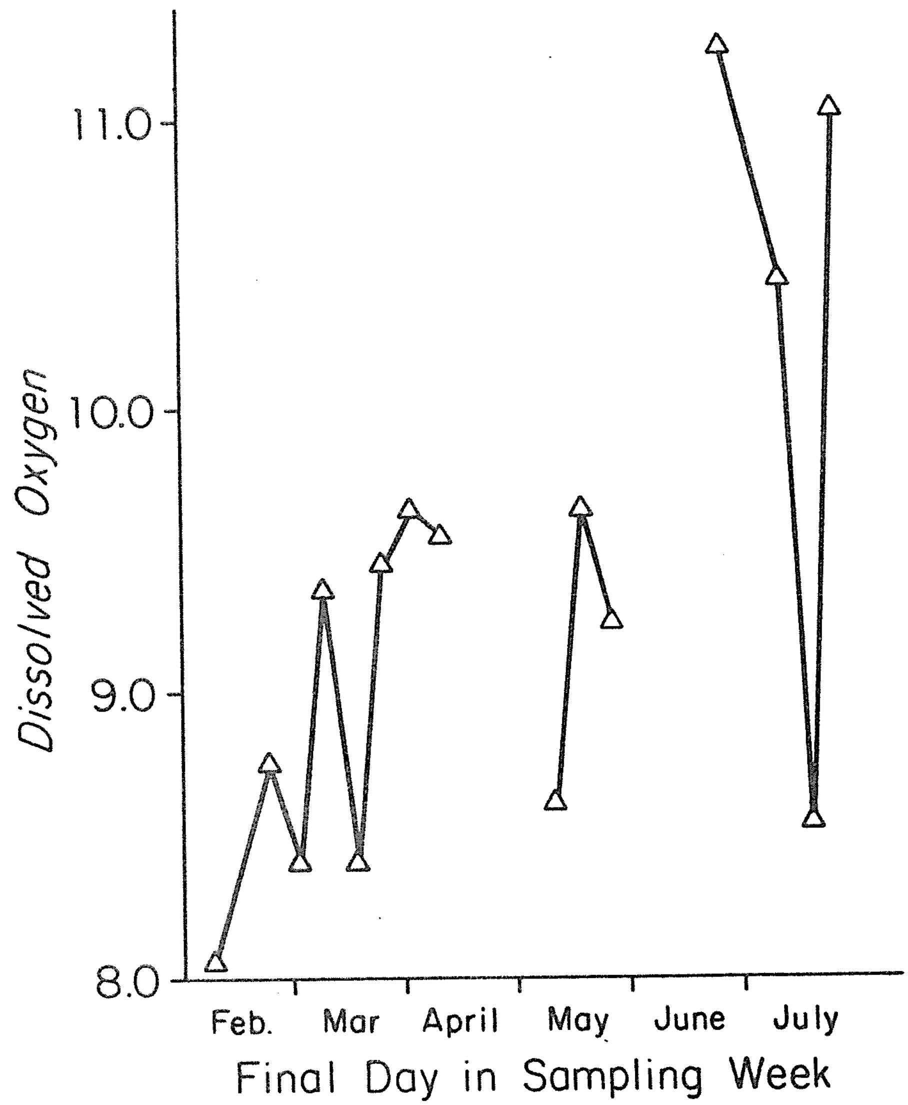


Fig. 12. Weekly mean dissolved oxygen concentration for the period February through July, 1977, Hood Canal, Washington.

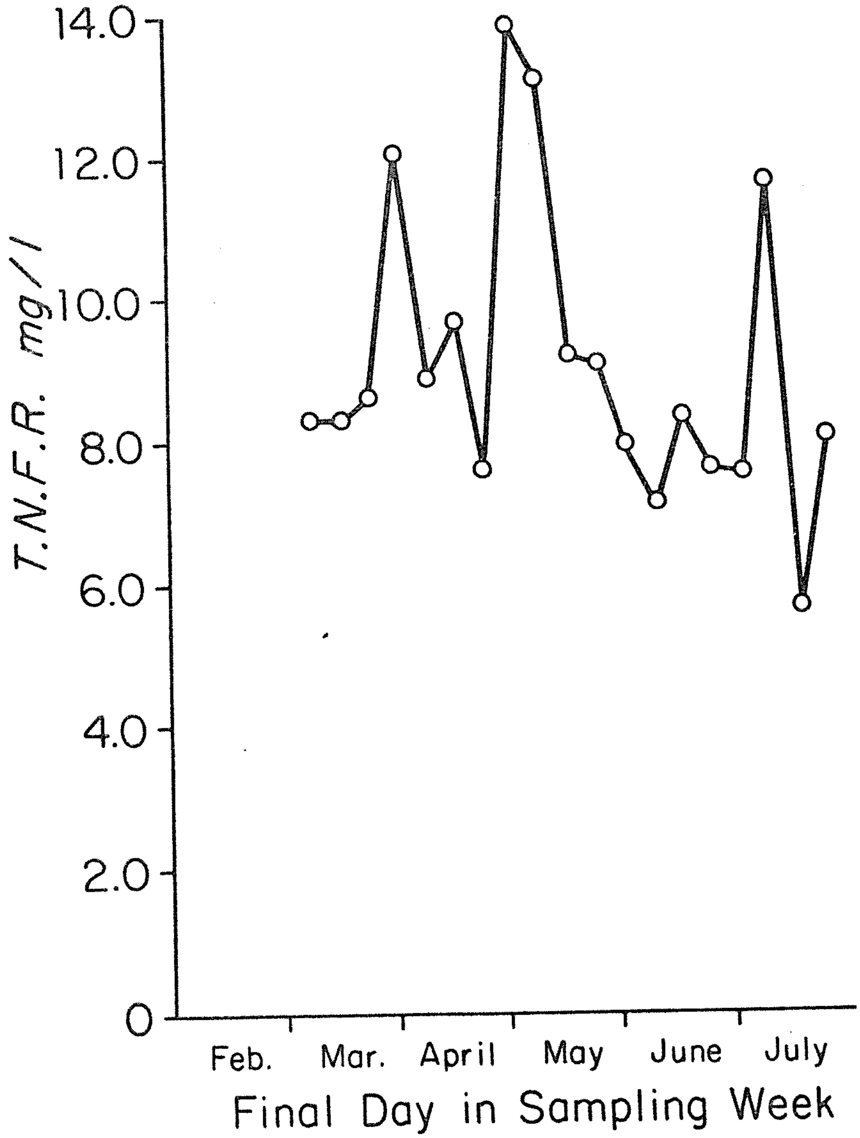


Fig. 13. Weekly mean TNFR for the period March through July, 1977, Hood Canal, Washington.

Table 2. Mean CPUE of chum fry with the 37-m beach seine at stations on points when exposed to, or protected from, the incident tides from January through July, 1977, Hood Canal, Washington.

Sampling station	Mean CPUE of chum fry	
	Tide incident on same side of spit	Tide incident on opposite side of spit
South Carlson Point	11.2	128.3
North Carlson Point	26.7	39.3
South Floral Point	28.5	42.3
North Floral Point	13.1	15.0
South Brown Point	44.3	52.6
North Brown Point	10.3	33.5
South Spit No. 6	9.3	44.3
North Spit No. 6	2.2	11.4

the regression equation so that seasonal trends would not affect the choice of subsequent variables to be entered into the equation. The results indicate that for the beach seine a highly significant positive relationship (at the 0.99 level) exists on the flood tide between the CPUE and temperature (Table 3). No other significant relationships were found between CPUE of chum fry by beach seine and other environmental variables.

Several significant results were found in the data for the townet (Table 4). On both stages of the tide a highly significant seasonal trend was noticed in the CPUE data. Environmental factors significantly related to CPUE were the weather condition on the flood tide (at the 0.01 level), and salinity and tide height on the ebb tide (at the 0.05 level).

Although the relationships mentioned above were found to be significant, they explained little of the variance in the CPUE (coefficient of determination, r^2, less than 0.10 in all cases). Before they can be accepted, further data are required to see if these relationships are repeated in other years.

Migration Periods and Peaks

Chum Salmon

Chum salmon fry were the major salmonids encountered with the beach seine and surface townet in 1977.

The weekly CPUE with the 37-m beach seine (Fig. 14, and Appendix Table 1) indicated that two major peaks in abundance of chum occurred in the nearshore environment. The earlier peak in early February was noticeable mainly on the west shore. The later, and larger, peak was observed on both sides of Hood Canal from late-May to early-July. In this

Table 3. A comparison of environmental factors affecting the CPUE of chum fry[1] with the 37-m beach seine from January to July, 1977, using multiple regression analysis.

Step	Variable entered	F to enter	Significance	Partial regression coefficient	Coefficient of determination	Overall F	Significance
				Ebb Tide			
1	Week	1.23	0.27	0.02	0.01	1.23	0.27
2	Tide height	2.36	0.13	0.02	0.03	1.80	0.17
3	Weather	0.94	0.33	-0.08	0.04	1.62	0.20
4	Sea conditions	0.71	0.40	-0.05	0.04	1.31	0.27
5	Sea temperature	0.26	0.61	-0.04	0.04	1.10	0.37
				Flood Tide			
1	Week	0.91	0.34	-0.07	0.01	0.91	0.34
2	Sea temperature	8.98	0.00	0.28	0.10	4.98	0.01
3	Tide height	1.31	0.26	0.03	0.11	3.77	0.01
4	Weather	0.39	0.53	0.06	0.11	2.91	0.03

[1]Logarithmic transformation [LG_{10} (chum + 1)] used to stabilize variance and achieve normality.

Table 4. A comparison of environmental factors affecting the CPUE of chum fry[1] with the surface townet from February to July, 1977, using multiple regression analysis.

Step	Variable entered	F to enter	Significance	Partial regression coefficient	Coefficient of determination	Overall F	Significance
				Ebb Tide			
1	Week	46.74	0.00	0.04	0.14	46.74	0.00
2	Salinity	5.01	0.03	0.05	0.15	26.20	0.00
3	Tide height	4.02	0.05	0.03	0.17	18.99	0.00
4	Sea state	2.30	0.13	0.05	0.17	14.88	0.00
5	Weather	0.44	0.51	0.03	0.17	11.97	0.00
6	Sea temperature	0.08	0.78	0.01	0.17	9.96	0.00
				Flood Tide			
1	Week	30.20	0.00	0.06	0.12	30.20	0.00
2	Weather	17.28	0.00	-0.19	0.18	24.83	0.00
3	Tide height	2.36	0.13	0.02	0.19	17.44	0.00
4	Salinity	0.42	0.52	0.02	0.19	13.15	0.00
5	Sea state	0.53	0.47	0.05	0.19	10.61	0.00
6	Sea temperature	0.36	0.55	-0.04	0.20	8.87	0.00

[1] Logarithmic transformation [LG_{10} (chum + 1)] used to stabilize variance and achieve normality.

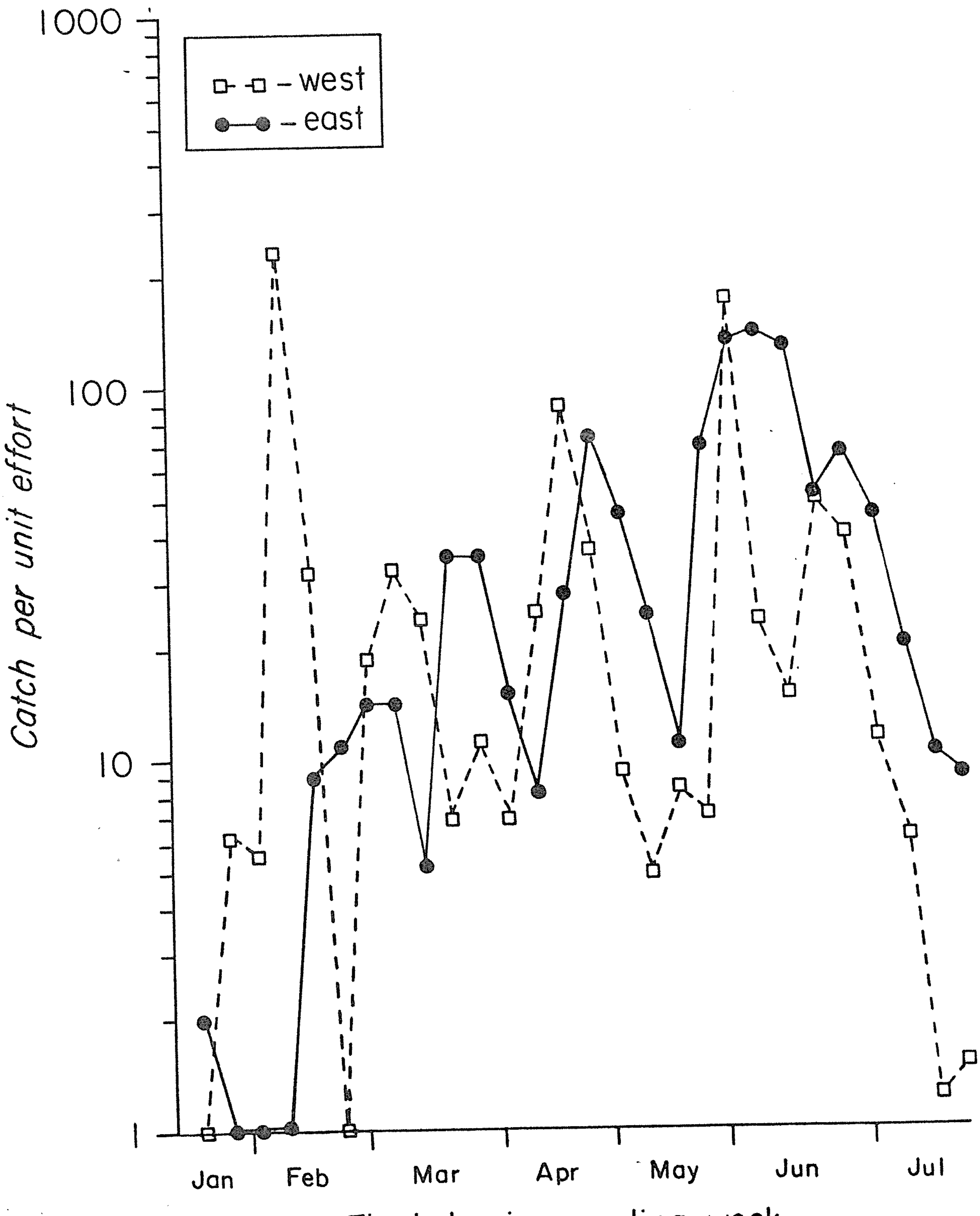


Fig. 14. Comparison of CPUE on the east and west shores of Hood Canal in the Bangor Annex area, for chum fry, with the 37-m beach seine, January 14 to July 28, 1977.

case CPUE's were higher on the east shore, although they peaked 1 week later than on the west shore. This same relation between the size and timing of east and west shore peaks in fry abundance was noticed for earlier, smaller peaks in mid-April and mid-March. North and South Carlson Point were the sites of the highest CPUE's on the east shore (Table 5). North Floral Point, a site with a very steeply shelving beach, had the lowest mean CPUE for the season. South Delta Refit Pier and South Marginal Wharf also had a low mean CPUE for the season. On the west shore South Brown Point, a site with an extensive shallow nearshore zone, had the highest abundance of chum fry. The lowest abundance of chum fry was observed at North Spit 6, another site with a fairly restricted nearshore environment.

Weekly CPUE with the surface townet indicated a peak chum fry abundance from early June to mid-July (Fig. 15 and Appendix Table 2). An earlier, and smaller, peak was noticed in late April. The major peak in abundance observed with the townet started slightly later than that observed with the beach seine but extended later into the season. As with the beach seine, the peak was higher on the east shore but started 1 week earlier on the west side of Hood Canal. On the east shore the mean CPUE for the season was highest near Carlson and Floral Point, and lowest in the Marginal Wharf area (Table 6). This may be due to the greater distance from shore in the latter case. Townet catches along the west shore suggested that the highest abundance of chum fry was in the vicinity of Spit 4.

Due to the stringent weather requirements for the visual surveying of fry abundance (Schreiner 1977), visual surveys were carried out only

Table 5. Mean CPUE and its variance for chum salmon fry caught with the 37-m beach seine from January through July, 1977, in Hood Canal, Washington.

Sampling station	Mean CPUE ($\bar{x}$)	Variance CPUE (s^2)	Coefficient of variation[1] (CV)
East shore			
1. South Carlson	78.96	27618.08	2.10
2. North Carlson	41.24	12279.13	2.69
3. Devil's Hole	36.35	5083.88	1.96
4. South Delta	15.90	1411.34	2.36
5. South Marginal	19.46	3509.51	3.04
6. South E.H.W. No. 1	42.62	4525.90	1.58
7. South Floral	30.34	3750.57	2.02
8. North Floral	16.02	1638.43	2.53
West shore			
9. South Brown	48.47	22264.87	3.08
10. North Brown	26.18	2920.52	2.06
11. South Spit 6	25.10	6569.44	3.23
12. North Spit 6	6.91	143.51	1.73

[1]Coefficient of variation (CV) $= \frac{s}{\bar{x}}$.

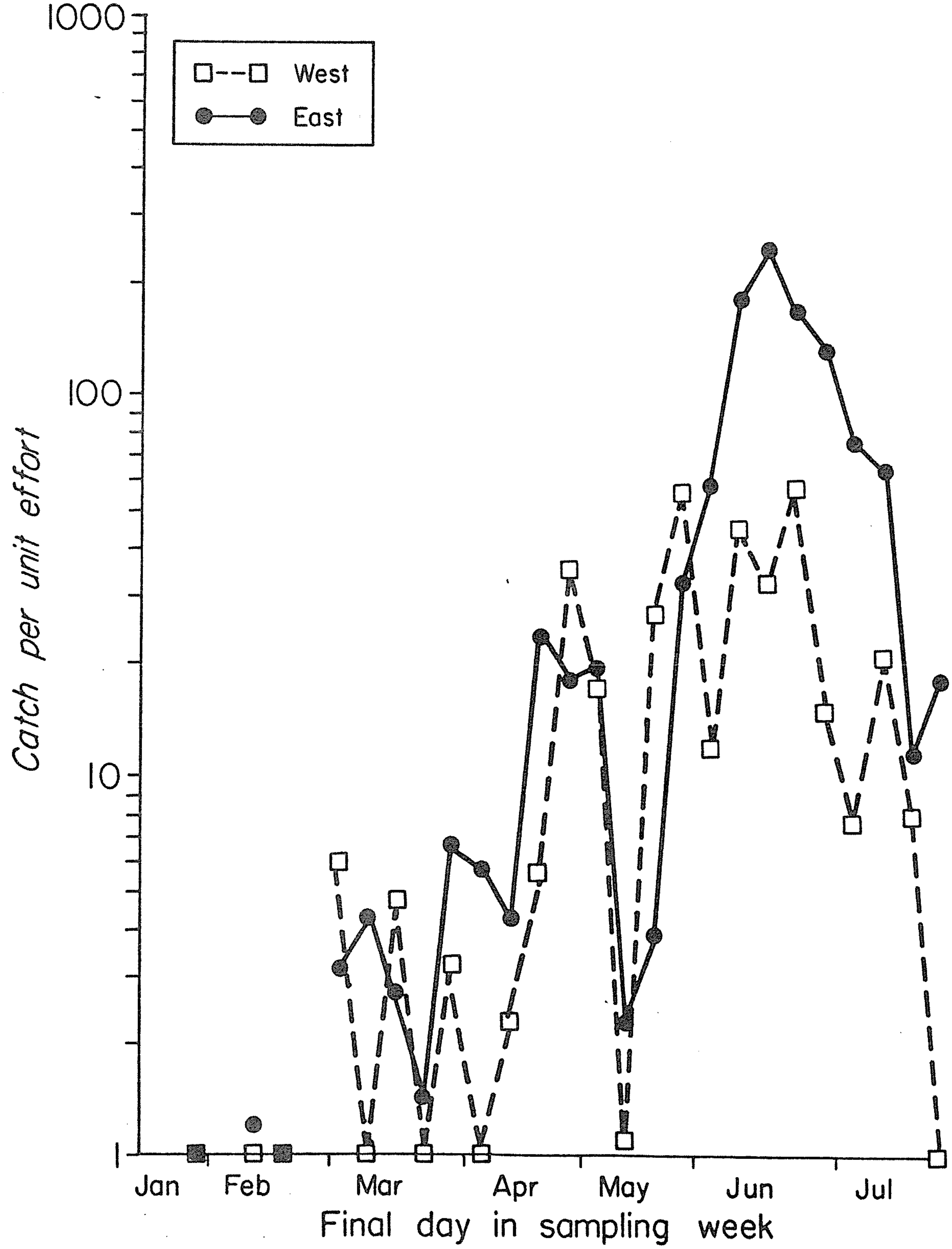


Fig. 15. Comparison of CPUE on the east and west sides of Hood Canal in the Bangor Annex area, for chum fry with the surface townet, January 21 to July 28, 1977.

Table 6. Mean CPUE and its variance for chum salmon fry caught with the surface townet from January through July, 1977, Hood Canal, Washington.

Transect	Mean CPUE ($\bar{x}$)	Variance CPUE (s^2)	Coefficient of variation (CV)[1]
East side			
13. King Spit - Carlson Pt.	53.68	12058.77	2.05
14. Carlson Pt. - Service Pr.	65.10	32947.93	2.79
15. Service Pr. - Devil's Hole	30.64	6550.70	2.64
16. Devil's Hole - Marginal	16.30	921.13	1.86
17. Marginal - E.H.W. No. 1	19.83	3202.51	2.85
18. E.H.W. No. 1 - Buoy B	27.19	3461.71	2.16
19. Buoy B. - Floral Pt.	32.82	7546.38	2.65
West side			
20. Brown Pt. - Spit 4	9.80	543.72	2.38
21. S. Spit 4 - N. Spit 4	18.72	2473.68	2.66
22. N. Spit 4 - Spit 5	25.87	2924.28	2.09
23. Spit 5 - Spit 6	12.60	512.79	1.80
Mid-channel			
24. Spit 6 - Midcanal	2.44	10.14	1.31
25. Midcanal - Floral Pt.	3.30	81.22	2.73
26. Brown Pt. - Midcanal	4.92	217.63	3.00
27. Midcanal - Ehw. No. 1	6.42	424.08	3.21
28. Brown Pt. - Midcanal	5.43	138.36	2.17
29. Midcanal - Service Pr.	6.04	234.75	2.54

[1]Coefficient of variation (CV) = $\frac{s}{\bar{x}}$.

sporadically throughout the 1977 sampling season. The data from transects 1, 2, 3, and 7 on the east shore and from transects 10, 11, 12, and 14 on the west shore were used to compare east and west shore fry abundance (Fig. 4). Although the data are rather sparse, the peaks of fry abundance as indicated by visual surveying agree with those indicated by beach seining and townetting on both shores (Fig. 16). The data are too irregular for analysis except on a qualitative basis.

Diurnal variation in catches was noticed for both the beach seine and townet (Table 7). Both the CPUE with the 37-m beach seine and it's coefficient of variation decreased at nighttime, when compared to daytime catches ($\alpha < .001$ and $\alpha < .0005$, respectively).

For the surface townet the same decrease in the coefficient of variation of the CPUE was noticed at nighttime ($\alpha < .01$). The CPUE with the surface townet, in contrast to that of the beach seine, increased at nighttime ($\alpha < .0005$). It has been suggested that this is an indication of the offshore movement of the fry and the breaking up of schooling activity at night.

Coho Salmon Smolts

Coho salmon smolts (*Oncorhynchus kisutch*) were caught in the beach seine and surface townet from late April through to the end of sampling (Figs. 17 and 18). CPUE of smolts was higher with the 37-m beach seine than with the surface townet for the duration of the sampling season. The CPUE was higher during nighttime sampling than daytime sampling for both the 37-m beach seine and surface townet (Table 8). Peak catches for coho smolts occurred in the week ending July 14 for the beach seine and in the

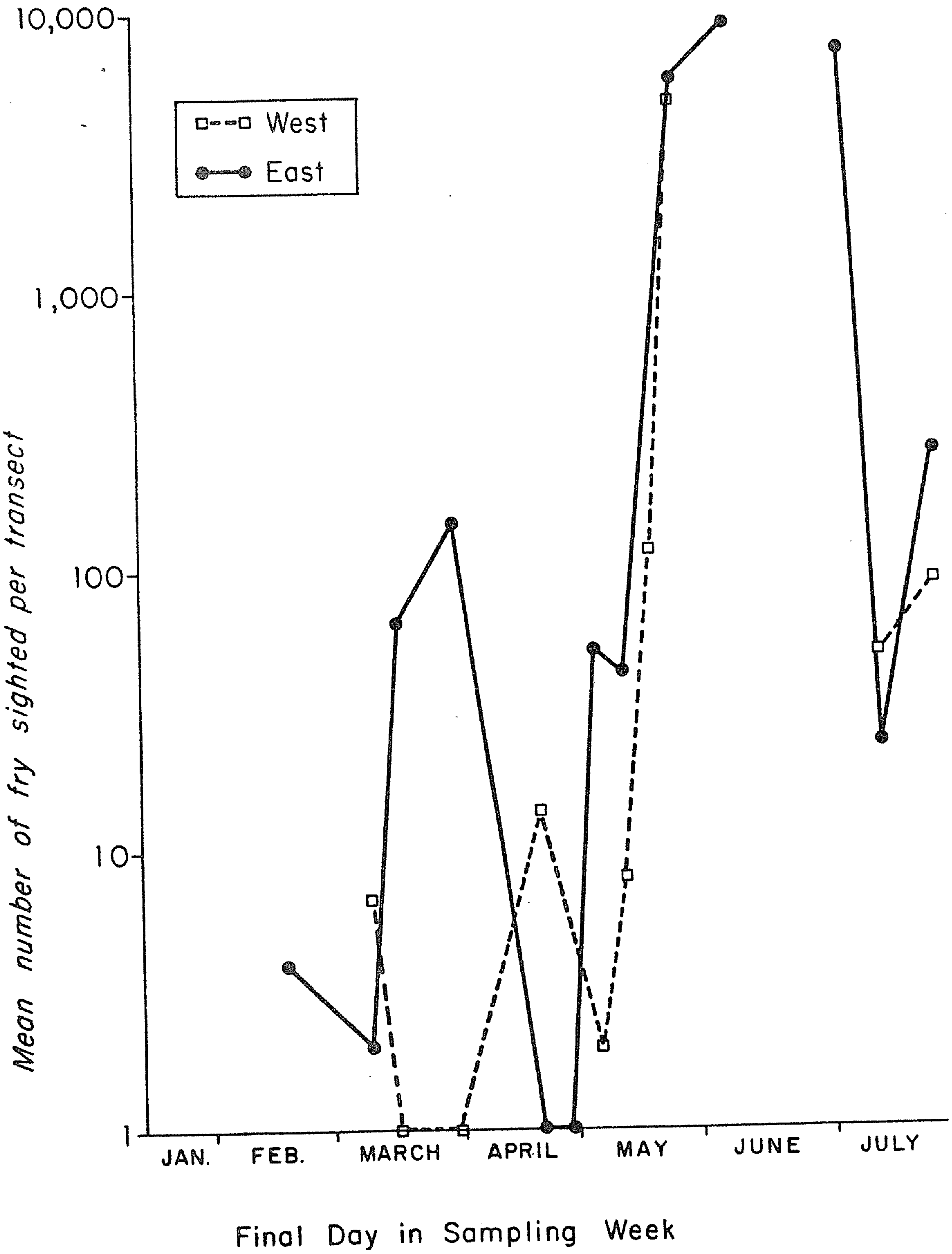


Fig. 16. Comparison of east and west shore visual counts of salmonid fry in the Bangor Annex area of Hood Canal, Washington, February to July, 1977.

Table 7. Comparison of day-night catches of chum salmon fry with the 37-m beach seine and surface townet from February to July, 1977, Hood Canal, Washington.

37-m Beach Seine			Surface Townet	
Day	Night	Variable	Day	Night
38	23	Mean CPUE	24	29
98	41	Standard deviation	89	85
256%	181%	Coefficient of variation	378%	292%

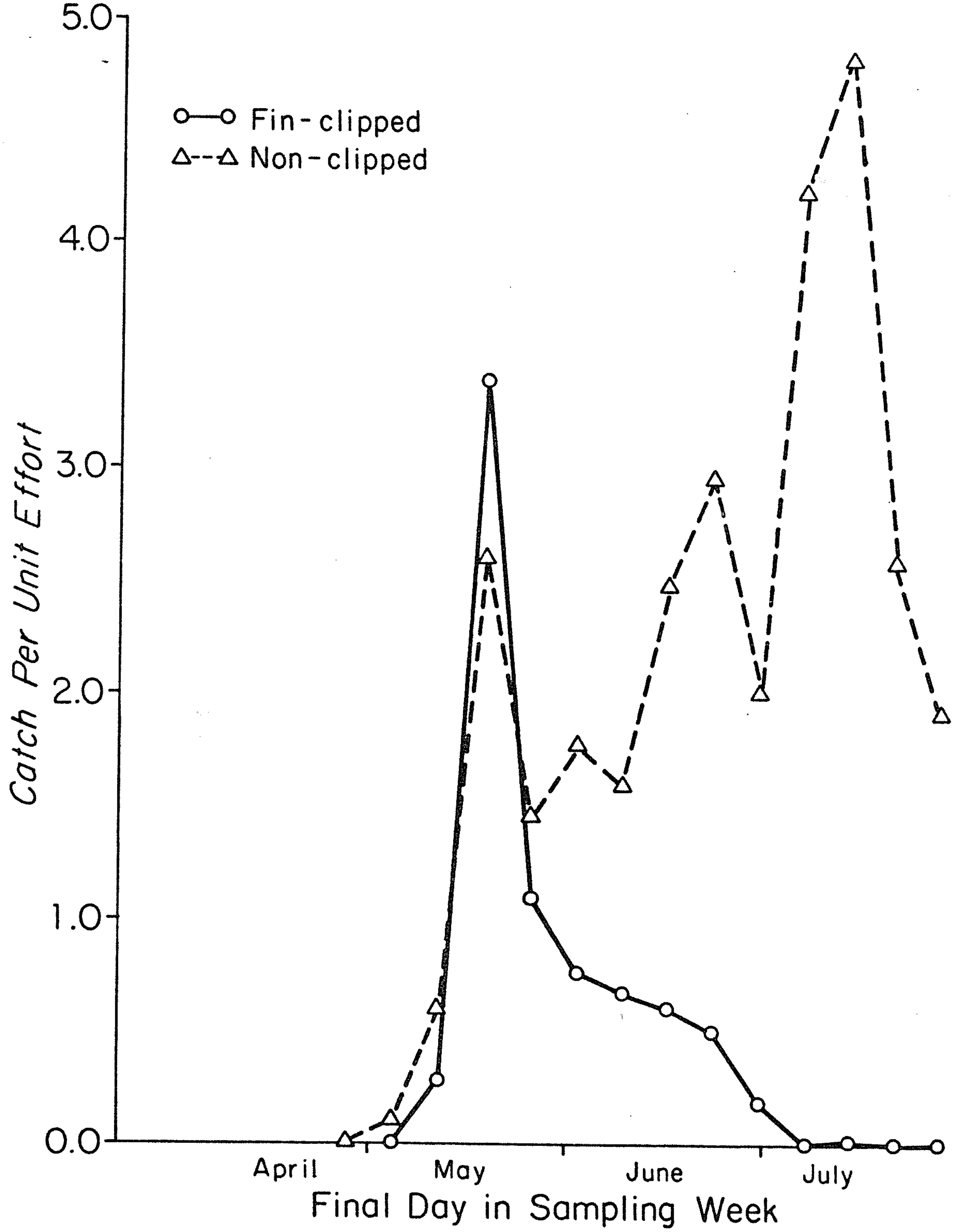


Fig. 17. CPUE of finclipped and nonclipped coho smolts with the 37-m beach seine in Hood Canal, Washington, from April through July, 1977.

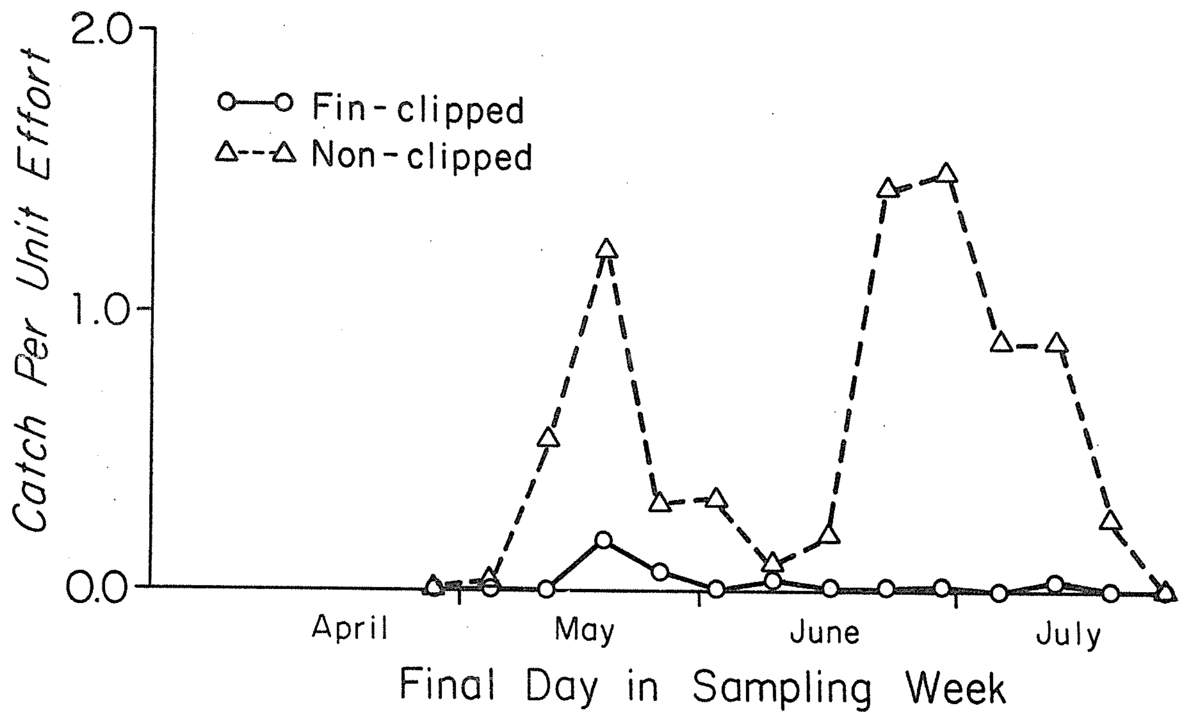


Fig. 18. CPUE of finclipped and nonclipped coho smolts with the surface townet in Hood Canal, Washington, from April through July, 1977.

Table 8. Comparison of day-night catches of coho smolts from April to July, 1977 with the 37-m beach seine and surface townet in Hood Canal, Washington.

37-m Beach Seine			Surface Townet	
Day	Night	Variable	Day	Night
1.89	3.64	Mean CPUE	0.28	1.17
7.47	2.96	Standard deviation	0.63	1.51
395%	81%	Coefficient of variation	226%	129%

week ending June 30 for the townet. The smolts may have been wild fish or in part hatchery-reared smolts released from Hoodsport on June 27 (Appendix Table 4). An earlier peak in both beach seine and townet catches was observed in the week ending May 19. This peak was coincident with a peak in recaptures of adipose fin-clipped coho smolts from Big Beef Creek wild outmigration. The peak of marking and release of coho smolts occurred 1 week before the peak in recaptures (Table 9; Gary Schurman, WDF, personal communication).

Chinook Salmon

Chinook salmon smolts, yearlings and adults (*Oncorhynchus tshawytscha*) were caught throughout the 1977 sampling season. Larger numbers were caught with the 37-m beach seine than the surface townet (Appendix Tables 1 and 2). There was a slight peak in the capture of smolts and yearlings in May. The three adults caught were caught in July. Chinook salmon smolts were released from the Hood Canal Hatchery at Hoodsport from April 21 to May 18 (Appendix Table 4), i.e., prior to the peak catches of smolts at the Bangor Annex.

Cutthroat Trout

Coastal cutthroat trout juveniles and adults (*Salmo clarki*) were caught throughout the sampling season. They were caught in the 37-m beach seine in all cases. Peak catches were in early June (Appendix Table 1 and Fig. 19).

Table 9. Weekly release of fin-clipped coho smolts from the Big Beef Creek wild outmigration, and weekly CPUE of coho smolts in Hood Canal, Washington from April to July, 1977.

Final day in sampling week		No. of coho smolts tagged and released in Big Beef Creek	Weekly CPUE of coho smolts					
			37-m Beach Seine			Surface Townet		
			Finclipped	Nonclipped	No. sets	Finclipped	Nonclipped	No. tows
April	28	568	0	0	35	0	0	52
May	5	9454	0	0.11	37	0	0.04	56
	12	10521	0.28	0.51	39	0.02	0.53	59
	19	6541	3.39	2.61	41	0.17	1.21	48
	26	1569	1.11	1.47	36	0.07	0.31	45
June	2	2066	0.77	1.77	39	0	0.33	55
	9	335	0.68	1.61	31	0.03	0.09	32
	16		0.62	2.49	37	0	0.20	45
	23		0.52	2.96	23	0	1.44	25
	30		0.19	2.03	36	0.02	1.49	47
July	7		0.03	4.23	40	0	0.89	47
	14		0.14	4.82	22	0.03	0.89	35
	21		0	2.58	24	0	0.26	39
	28		0	1.92	12	0	0	12

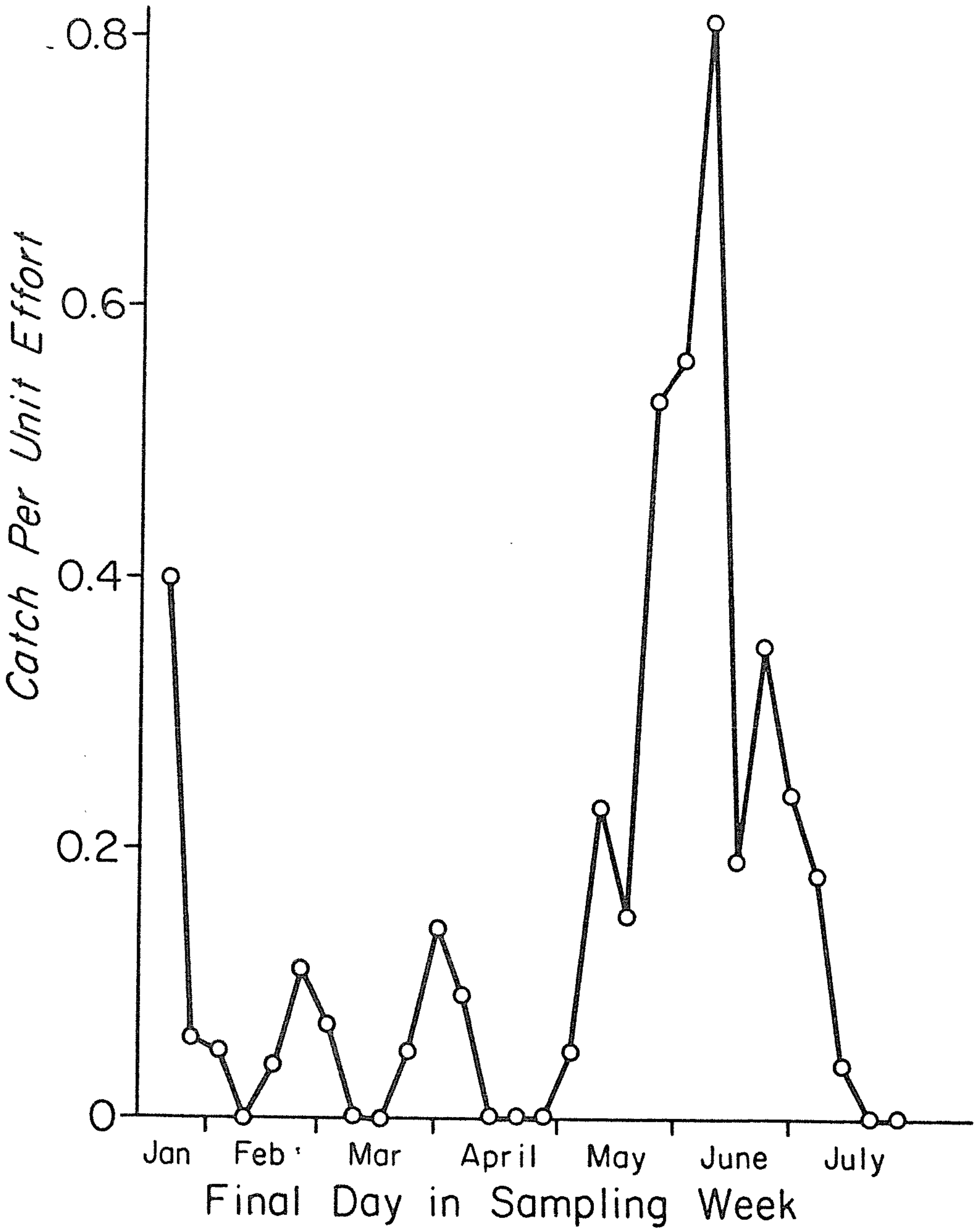


Fig. 19. CPUE of adult cutthroat trout with the 37-m beach seine from January through July, 1977, in Hood Canal, Washington.

Steelhead Trout

Thirteen steelhead trout (*Salmo gairdneri*) were caught in the 1977 sampling season. Eight juveniles were caught in the townet. The remainder, one adult and four juveniles, were caught with the 37-m beach seine.

Hatchery Influence

Hatchery-reared chum salmon fry are released from the Hood Canal and George Adams fish hatcheries at Hoodsport as well as from the Quilcene fish hatcheries all located on the west shore of Hood Canal (Fig. 1); however, beach seine and townet catch statistics from 1975 and 1976 suggested that the majority of hatchery fry crossed to the east shore prior to reaching Bangor Annex.

The catch statistics in 1977 show a more even distribution of chum fry on both shores, though with the majority still on the east shore (Fig. 14 and 15). The observed peaks in CPUE of fry at Bangor Annex did not appear as closely related to hatchery releases as in the previous 2 years. Interpretation of the results was compounded by the almost continuous hatchery releases from late March to early July (Fig. 20 and Appendix Table 4). In addition there is a strong possibility that early migrants (both hatchery and wild stocks) migrate through Hood Canal at a faster rate earlier in the season. Data from mark-recapture experiments (Whitmus and Olsen, in preparation) show an April release of marked fry

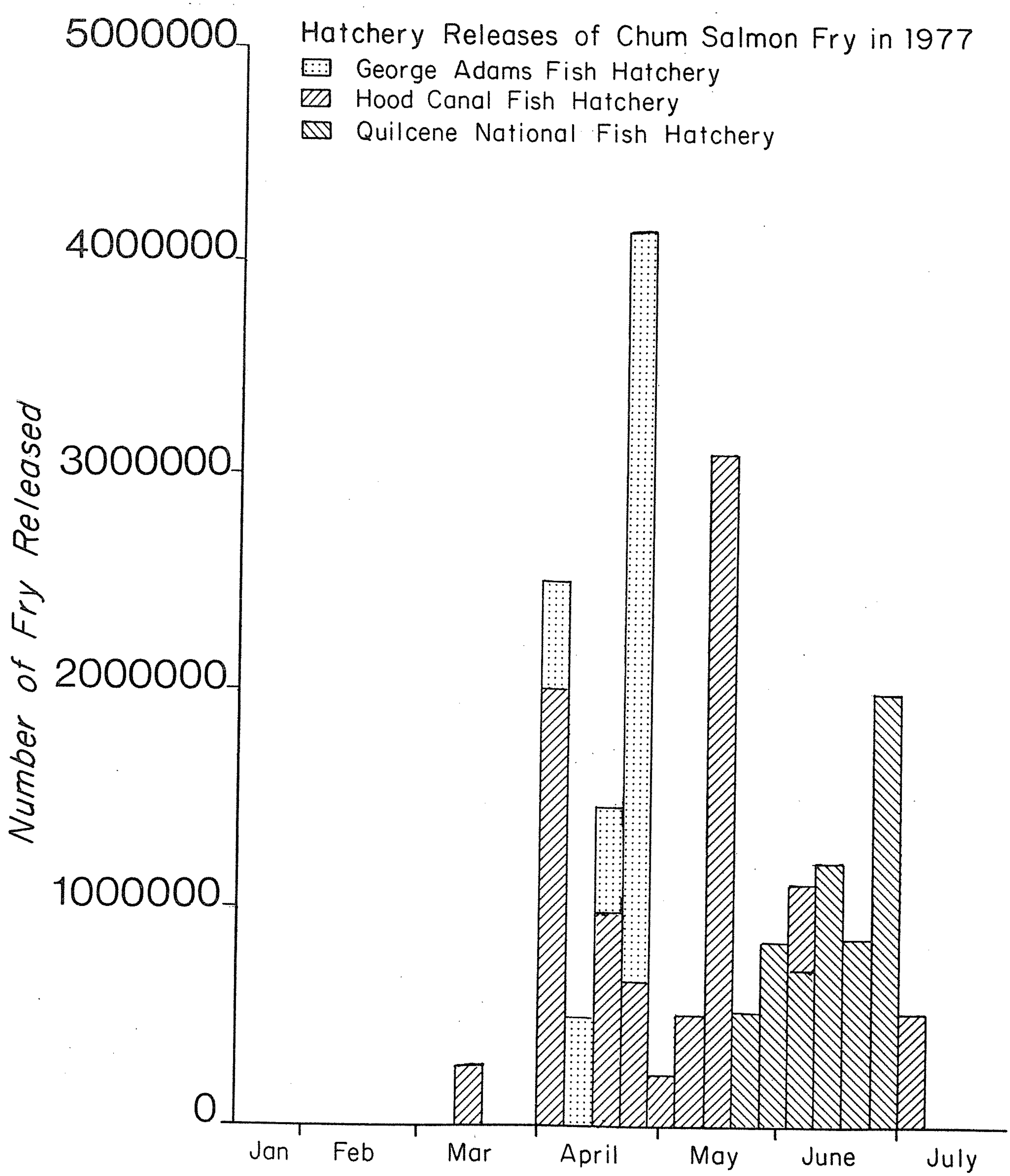


Fig. 20. Comparison of releases of hatchery-reared chum fry from the George Adams, Hood Canal and Quilcene fish hatcheries in 1977.

from Hoodsport taking a shorter time to arrive at the Bangor Annex than a later June release.

Nearshore

Major peaks in chum fry abundance on the east shore, as indicated by the 37-m beach seine catches, occurred approximately 3 weeks after Hood Canal Hatchery releases. This relationship is shown best at South Floral Point (Fig. 21). Catches on the west shore peaked a week earlier than catches on the east shore (Fig. 14), i.e., 2 weeks subsequent to Hood Canal Hatchery releases. No peak in abundance of chum fry was noticed in our sampling at the expected time of arrival of approximately 4 million chum fry released from the George Adams Hatchery from April 14-28. Concurrent releases of over 1.5 million chum fry from the Hood Canal hatchery also did not appear to be represented in CPUE statistics (Fig. 22). The CPUE statistics from South Floral Point were the sole exception to this on the east and west shores. Releases of chum fry from Quilcene hatchery which for the most part were made later in the season, coincided with the highest overall CPUE at Bangor Annex (Fig. 23). The arrival time of these fry is not clear from the CPUE values which may also be influenced by a release of over 3 million fry from the Hood Canal Hatchery on May 19. The decrease in CPUE at the end of June and in July may be because the fry were no longer available to the beach seine, as releases from Quilcene Hatchery were still occurring.

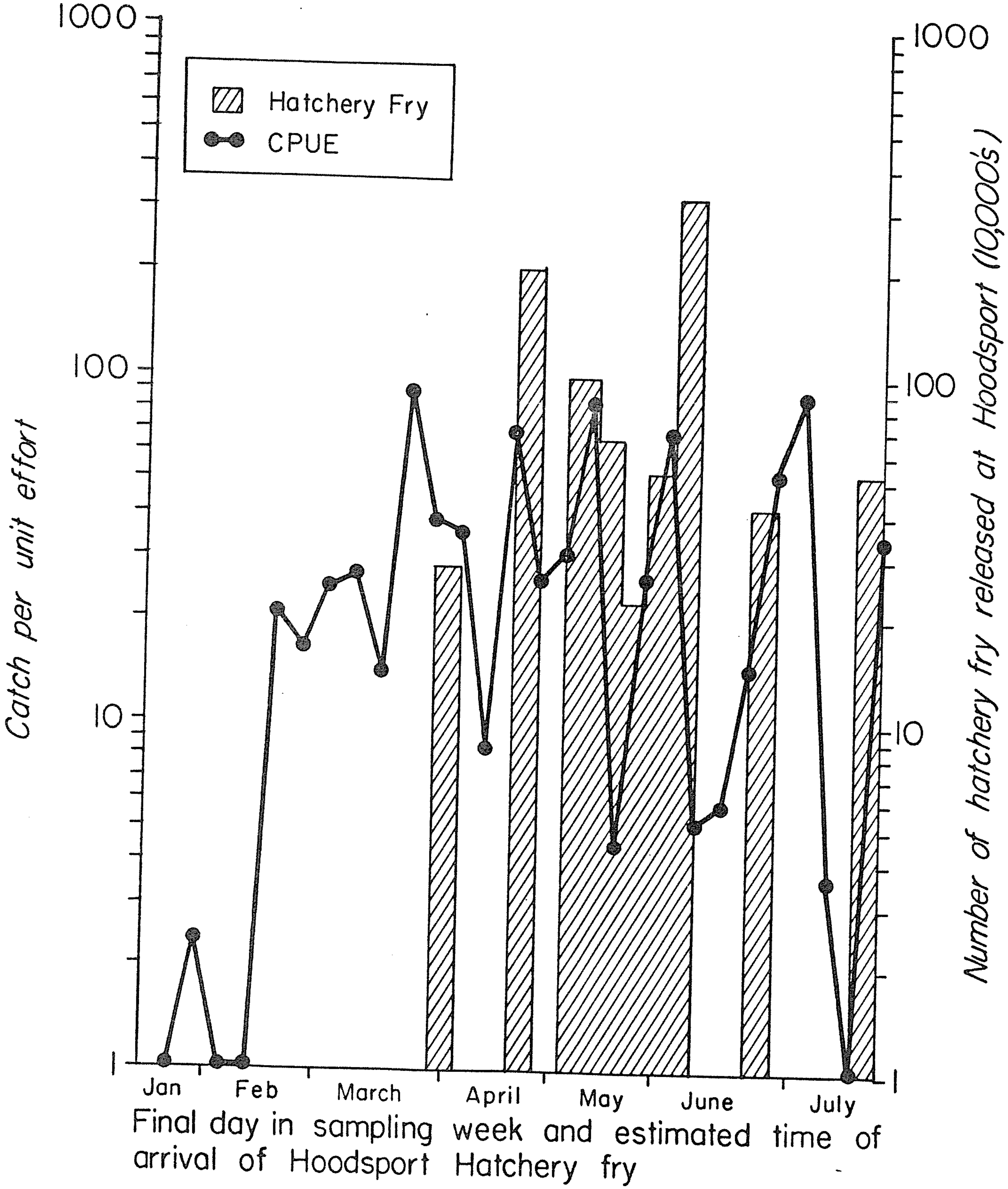


Fig. 21. Comparison of estimated time of arrival of Hood Canal hatchery chum fry at Bangor (date of release + 3 weeks) and CPUE of chum fry at South Floral Point with the 37-m beach seine from January 14 to July 28, 1977.

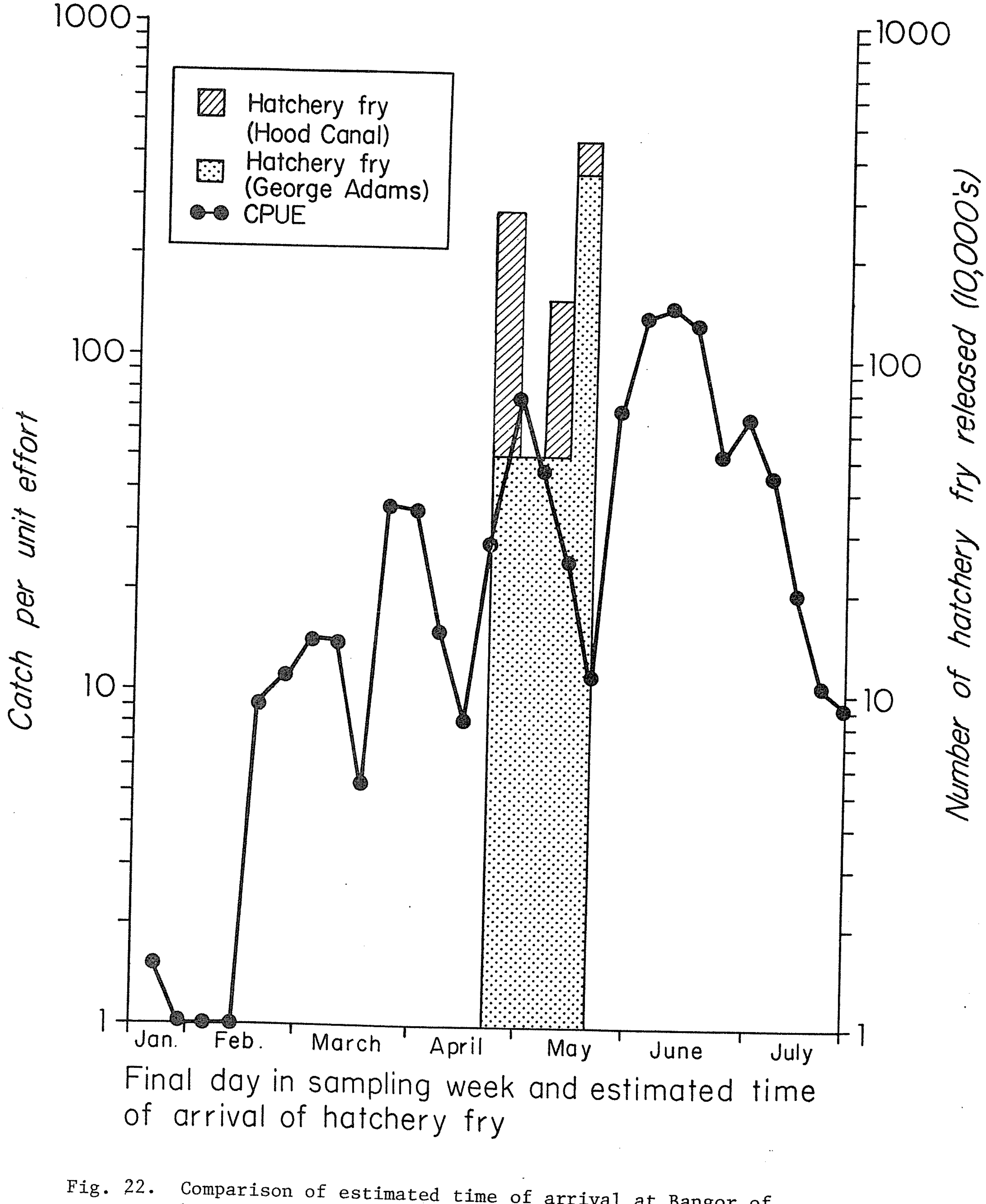


Fig. 22. Comparison of estimated time of arrival at Bangor of hatchery fry released from March 31 to April 28 (hatchery released date plus 3 weeks) and mean weekly CPUE with the 37-m beach seine from January 14 to July 28, 1977.

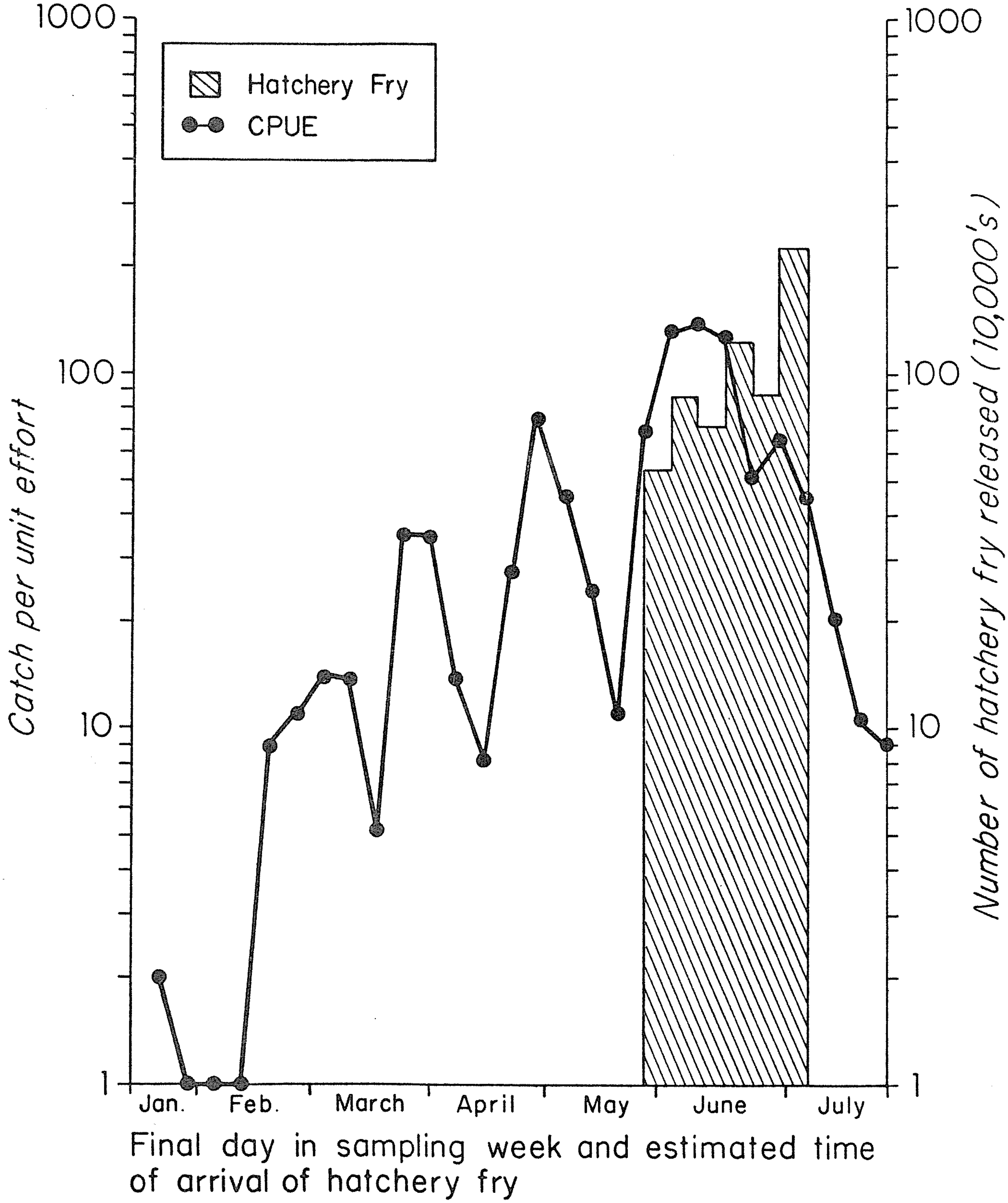


Fig. 23. Comparison of estimated time of arrival at Bangor of Quilcene hatchery fry (release date plus one week) and mean weekly CPUE with the 37-m beach seine from January 14 to July 28, 1977.

Offshore

The offshore abundance of chum fry, as indicated by the surface townet, appeared similarly affected by hatchery releases. The data suggest a 2-week delay from time of release of chum fry from Hood Canal Hatchery until their time of arrival at Bangor Annex (Fig. 24). Corresponding to the results from the nearshore sampling, there was no increase in CPUE at the expected arrival time of approximately 4 million chum fry released from the George Adams Hatchery (Fig. 25). From the middle of June to the end of sampling townet CPUE declined while Quilcene Hatchery releases were still occurring (Fig. 26). This may indicate avoidance of the net by the larger fry.

Fry Condition

At the start of the sampling season the mean fork length of captured chum fry was between 35 mm and 41 mm (Fig. 27), with small variance (Figs. 28 and 29). This represents the size of the outmigrating wild population at that time. At the end of March and beginning of April the mean length of chum fry captured with the townet showed a sharp peak, concurrent with an increase in variance. This peak may be due to the arrival at Bangor Annex of Hood Canal Hatchery fry released on March 11. The increase in mean length from 40 mm at release (Appendix Table 3) up to as much as 52 mm at capture suggests a considerable growth of the fry in their first few weeks in the marine environment. This rate of growth is comparable with maximum growth rates of chum fry in freshwater with unlimited food available under hatchery conditions (Schroder, personal communication).

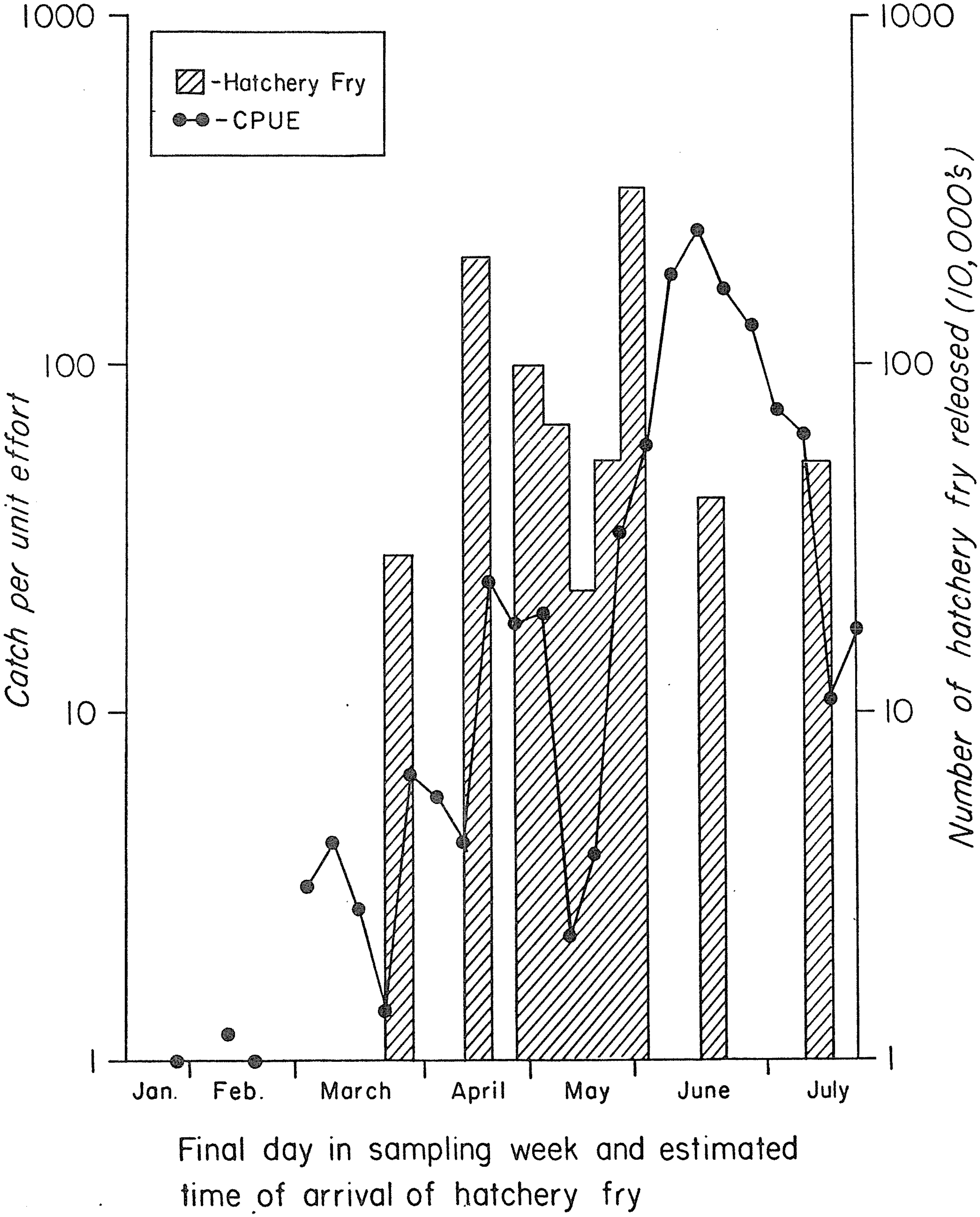


Fig. 24. Comparison of estimated time of arrival at Bangor of Hood Canal hatchery fry (release date plus two weeks) and mean weekly CPUE with the surface townet from January 21 to July 28, 1977.

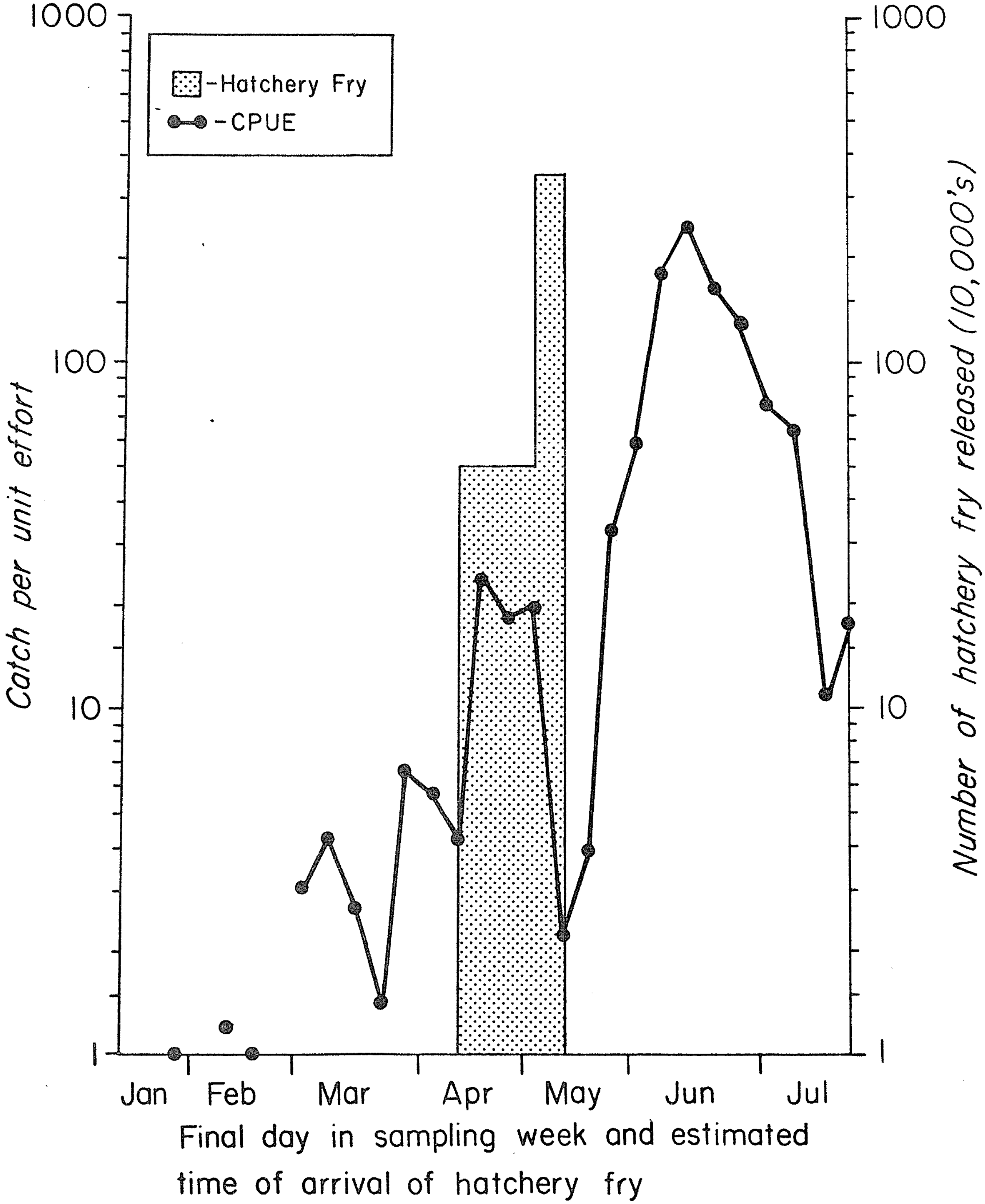


Fig. 25. Comparison of estimated time of arrival at Bangor of George Adams hatchery fry (release date plus two weeks) and mean weekly CPUE with the surface townet from January 21 to July 28, 1977.

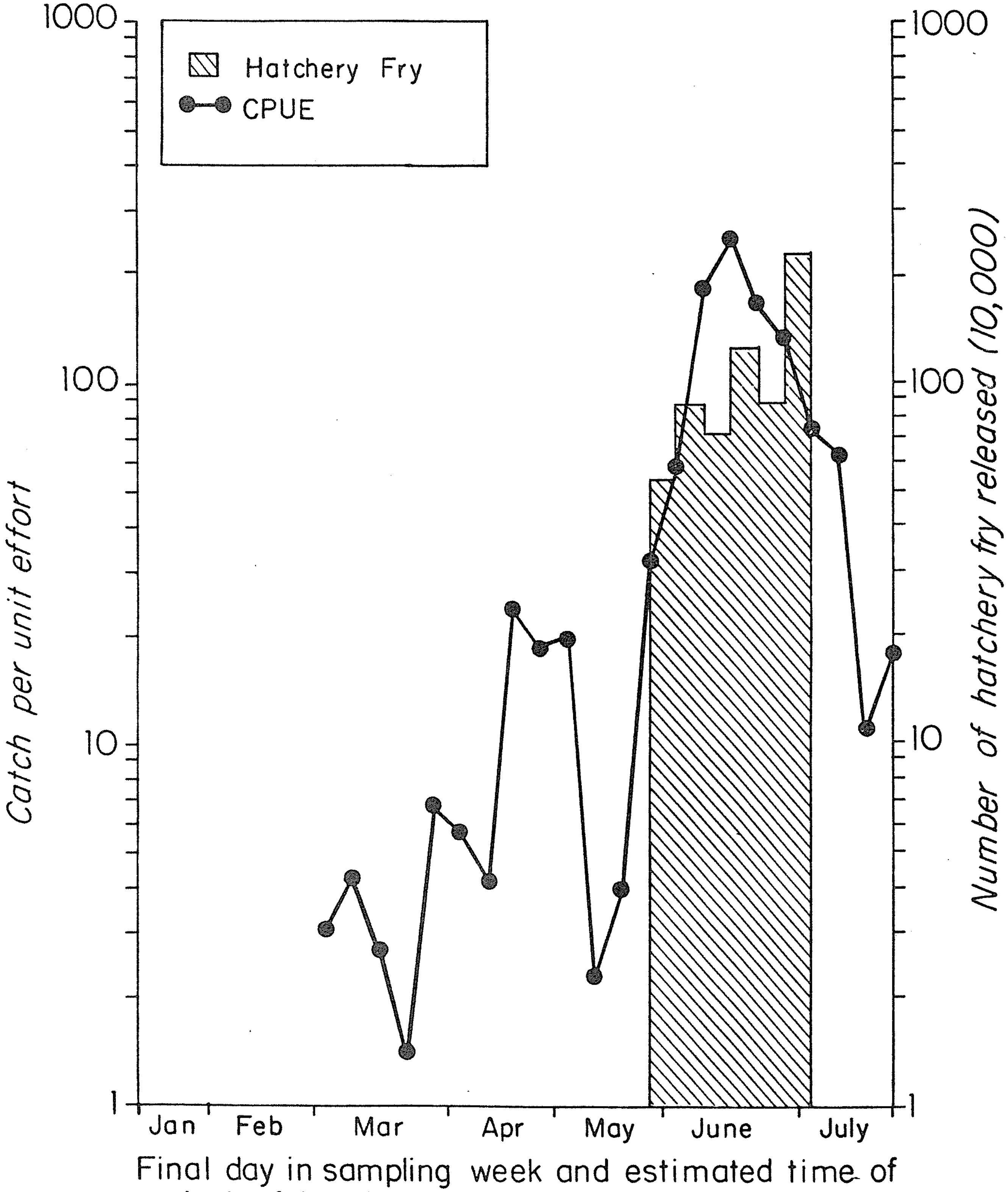


Fig. 26. Comparison of estimated time of arrival at Bangor of Quilcene hatchery fry (release date plus one week) and mean weekly CPUE with the surface townet from January 21 to July 28, 1977.

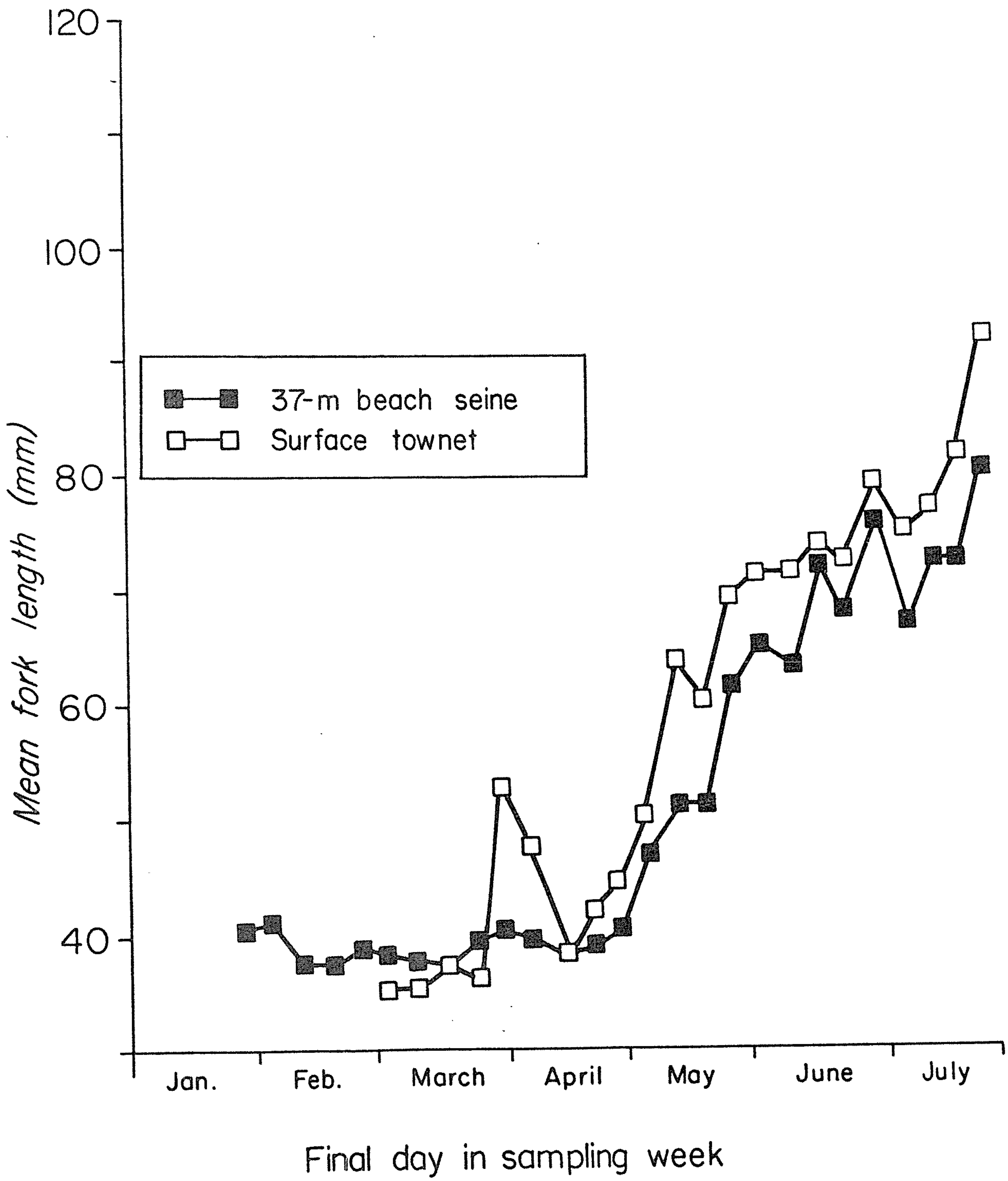


Fig. 27. A comparison of the mean lengths of chum fry caught with the 37-m beach seine and surface townet from January 21 to July 28, 1977, in Hood Canal, Washington.

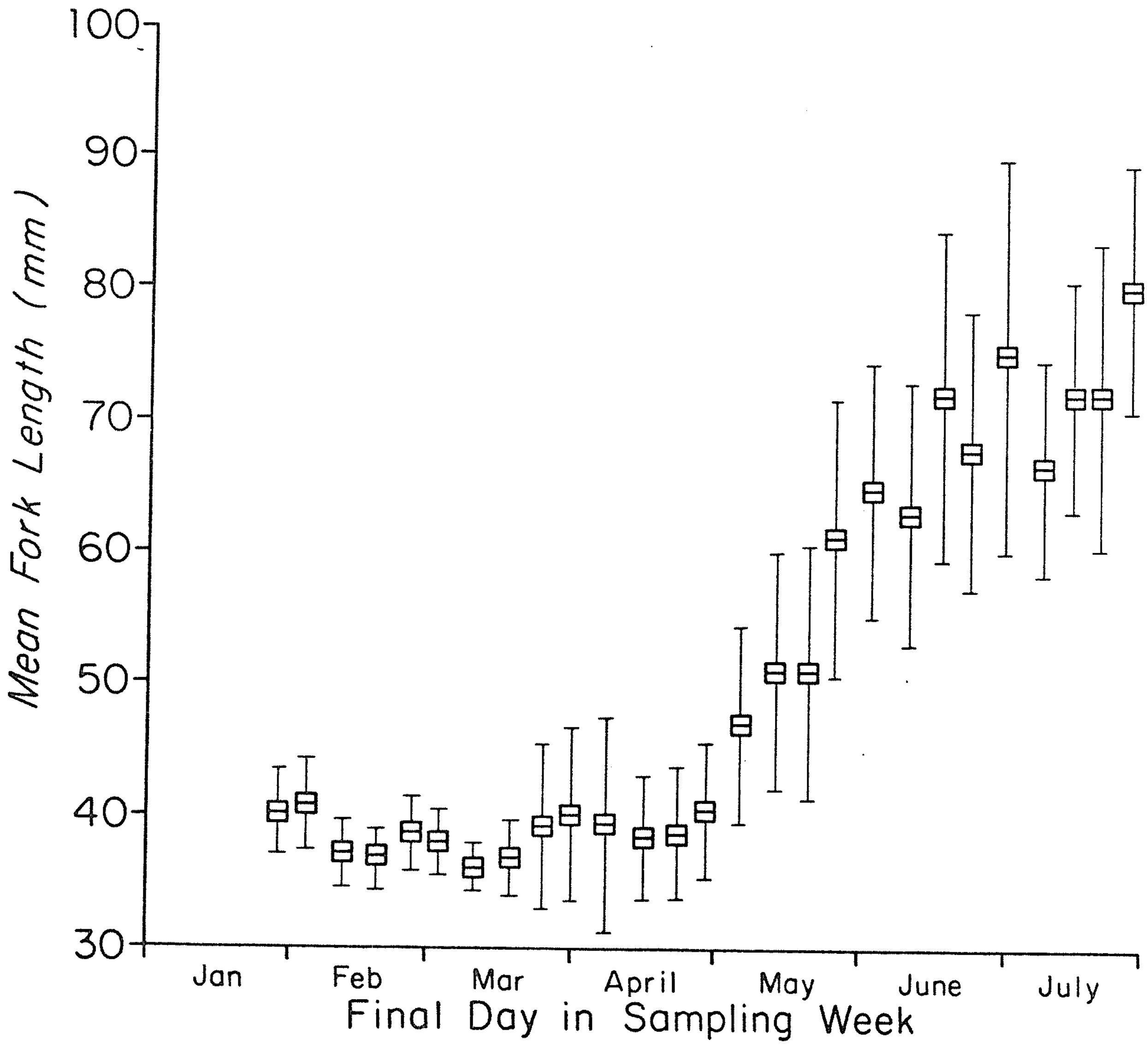


Fig.28. Weekly mean fork length and standard deviation of chum fry caught with the 37-m beach seine from January 21 to July 28, 1977, in Hood Canal, Washington.

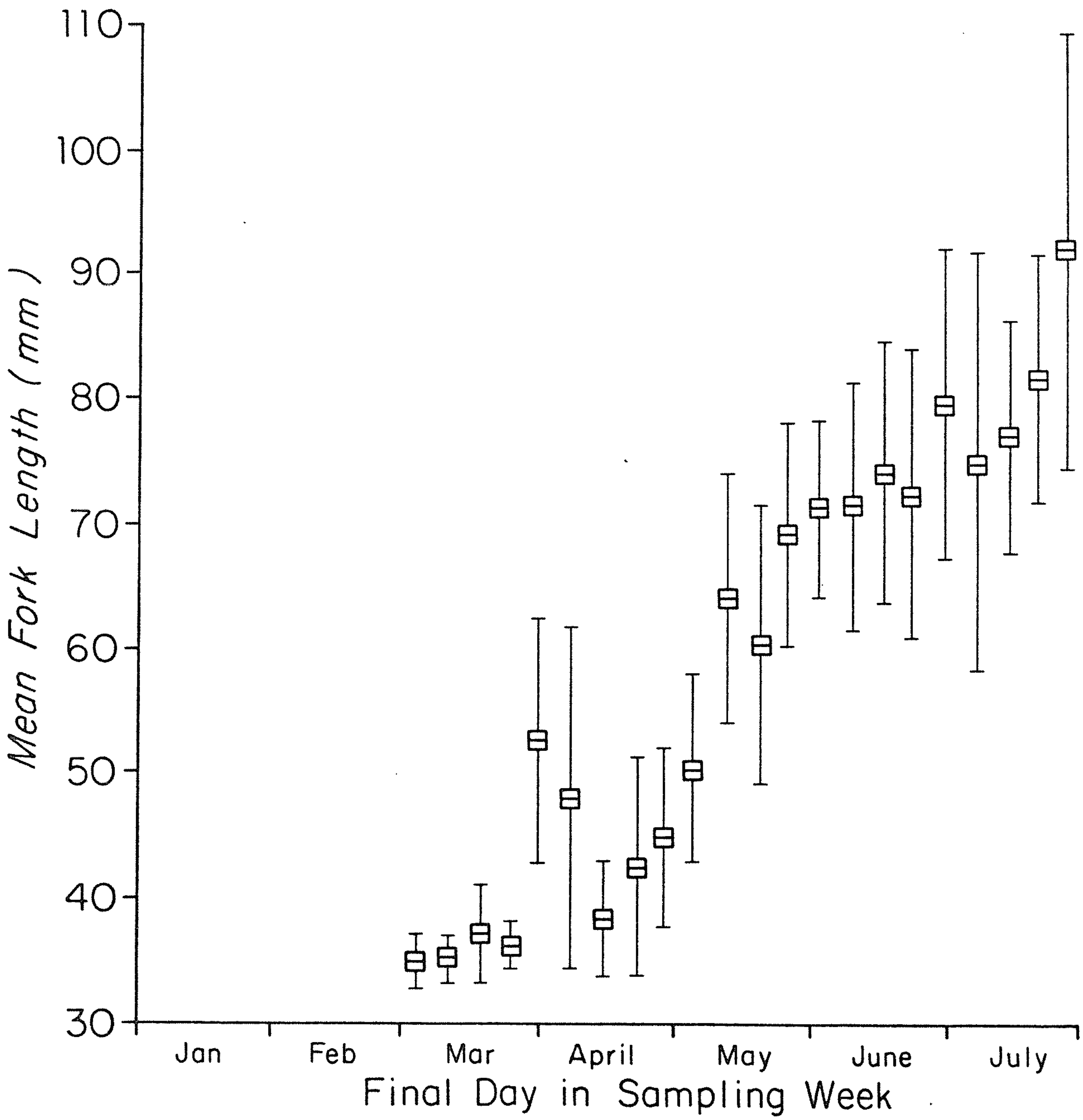


Fig. 29. Weekly mean fork length and standard deviation of chum fry caught with the surface townet from February 25 to July 28, 1977 in Hood Canal, Washington.

From mid-April, when the influence of hatchery-reared fish was detected in the catches at Bangor Annex, till the end of the sampling season the mean length of chum fry captured showed a steady increase, as did the variance. The length of fry released from the hatcheries showed a concurrent increase. The mean length of the fry caught in the townet was consistently slightly higher than those caught with the beach seine. A two-way multisample analysis of variance showed that the differences were significant (Table 10). The significant interaction of week and gear on mean length, together with the wide range of the fork lengths of the fry caught with the two gears, suggest that there is not a distinct size, or size range, when the fry move offshore so as to be available to the townet. Rather, an interaction of size and other factors influenced by the season determine the inshore/offshore distribution of the chum fry.

An analysis of variance on the weekly mean lengths of chum fry caught by sampling week and station was performed (Table 11). No significant differences (at the 0.05 level) among sites on the west shore, among sites on the east shore, nor a comparison between the two, were found for either the 37-m beach seine or the surface townet. Sampling week showed a significant effect (at the 0.05 level) in all cases.

The condition factors of the fry caught were computed according to the formula described by Ricker (1968):

$$CF = 10^5 \cdot W/L^3$$

where W is the empirical weight in grams and L is the empirical fork length in millimeters.

Table 10. A two-way analysis of variance on the effect of sampling week and sampling gear on the mean length of chum fry captured from March to July, 1977 in Hood Canal, Washington.

Analysis of Variance Summary Table

Source of variation	Sum of squares	DF	Mean square
Total	83838.171	354	
Cells	74571.384	37	
Week	67294.938	18	3738.608
Gear	3119.610	1	3119.610
Interaction	1389.328	18	77.185
Residual	9266.787	317	29.233

Ho: There is no effect of week on the mean length of captured fry

$$F = \frac{\text{Week MS}}{\text{Residual MS}} = 127.891 \gg F_{0.05(1),\ 18,317} = 1.64$$ therefore reject Ho, P << .0005

Ho: There is no effect of gear type on the mean length of captured fry

$$F = \frac{\text{Gear MS}}{\text{Residual MS}} = 106.716 \gg F_{0.05(1),\ 1,317} = 3.87$$ therefore reject Ho, P << .0005

Ho: There is no interaction of gear and week on the mean length of captured fry

$$F = \frac{\text{Interaction MS}}{\text{Residual MS}} = 2.64 > F_{.05(1),\ 18,317} = 1.64$$ therefore reject Ho, P <.0005

Table 11. A two-way analysis of variance on the effect of sampling week and sampling location on the mean length of chum fry[1] captured from March to July, 1977, Hood Canal, Washington.

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
		East Shore Beach Seine Sites			
Total	.638	57	.011		
Week	.496	8	.062	21.413	.001
Location	.021	5	.004	1.433	.231
Residual	.127	44	.003		
		West Shore Beach Seine Sites			
Total	.680	45	.015		
Week	.651	13	.050	67.951	.001
Location	.002	2	.001	1.121	.339
Residual	.022	30	.001		
		West vs East Shore Beach Seine Sites			
Total	2.692	198	.014		
Week	2.524	24	.105	106.784	.001
Location	.001	1	.001	.644	.424
Residual	.150	152	.001		

[1]Logarithmic transformation used to stabilize variance.

Table 11. A two-way analysis of variance on the effect of sampling week and sampling location on the mean length of chum fry[1] captured from March to July, 1977, Hood Canal, Washington - continued.

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
		East Shore Surface Townet Transects			
Total	.530	62	.009		
Week	.485	8	.061	71.677	.001
Location	.005	6	.001	.921	.489
Residual	.041	48	.001		
		West Shore Surface Townet Transects			
Total	.122	23	.005		
Week	.111	5	.022	36.811	.001
Location	.002	3	.001	1.325	.303
Residual	.009	15	.001		
		East vs West Shore vs Mid-Canal Surface Townet Transects			
Total	2.206	177	.012		
Week	1.939	16	.121	83.331	.001
Location	.005	2	.002	1.695	.188
Residual	.196	135	.001		

[1]Logarithmic transformation used to stabilize variance.

The mean condition factor of chum fry caught increased early on it the season, but decreased at the end of the season (Figs. 30 and 31). This trend was most noticeable in beach seine catches. The fry with the highest mean condition factors were caught at the period of maximum recruitment. These results are contrary to those obtained in 1975 and 1976, when the condition factor was found to be highest during periods of low recruitment. Thus, no drop in condition factor was found at the end of the sampling season in 1975 and 1976.

The drop in mean condition factor found at the end of the 1977 sampling season may be due to the short time spent in the marine environment by the fry released at Quilcene Hatchery, prior to their arrival at Bangor Annex. It is thought that Quilcene Hatchery fry were the predominant fry at Bangor Annex at the end of the sampling season.

As in 1975 and 1976, the condition factor of chum fry captured was more uniform at the end of the season. The decrease in variance may be due to a smaller number of populations comprising the outmigrating fry as the season progressed, or may be due to an increase in prey availability.

An analysis of variance of the mean weekly condition factor by location and week was carried out (Table 12). In only one case, surface townet transects along the east shore, was a significant relationship (at the 0.05 level) between location and condition factor found. Further analysis of the east shore transects, using the Student-Newman-Keuls multiple comparison procedure, showed that no one transect or group of transects was significantly different from the others (at the 0.10 level). While the sampling week showed a significant effect on the mean condition factor of chum fry caught with the beach seine, it did not do so for those caught with the surface townet.

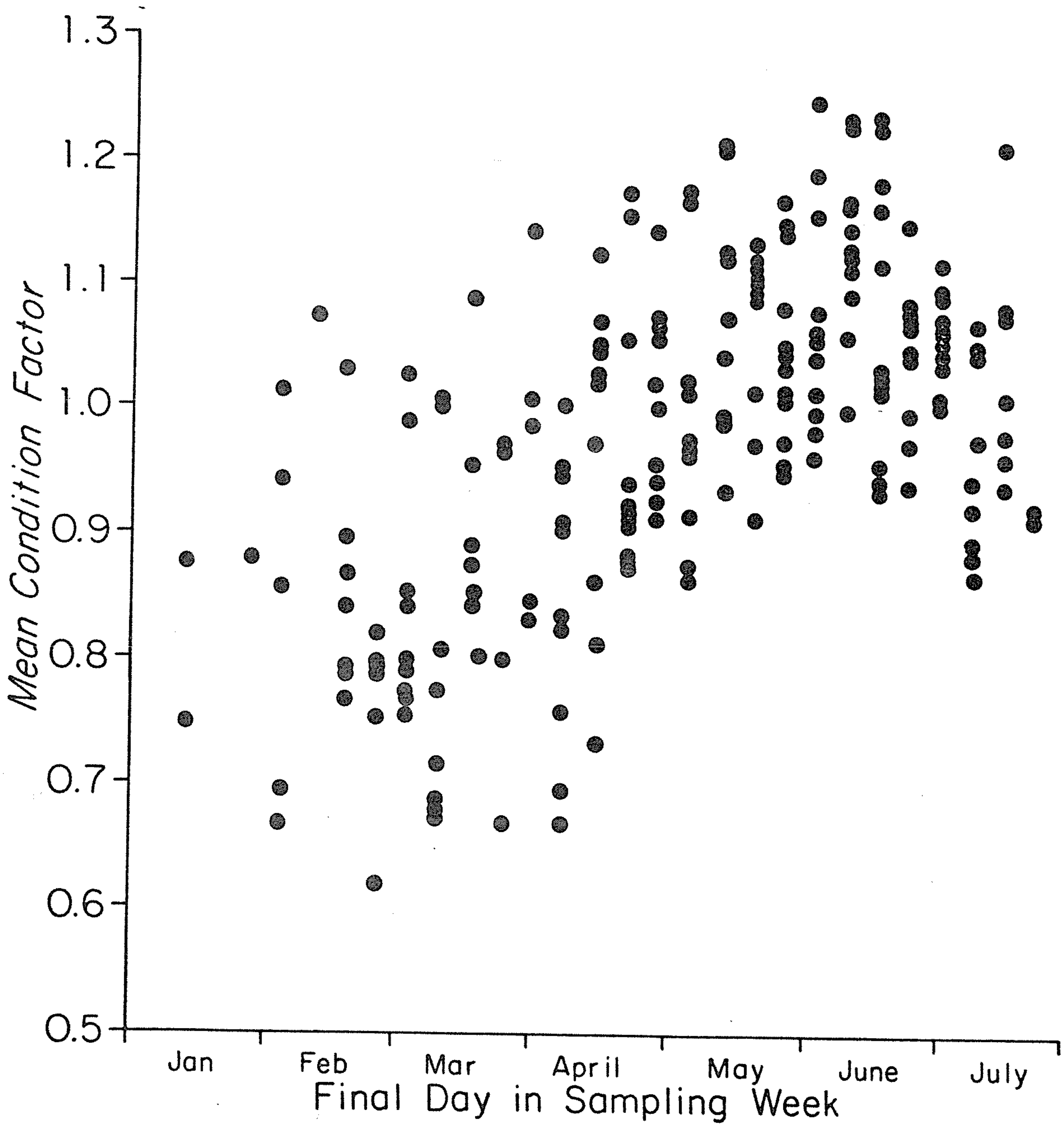


Fig. 30. Weekly mean condition factor of chum fry caught at each sampling site with the 37-m beach seine, from January 7 to July 28, 1977, in Hood Canal, Washington.

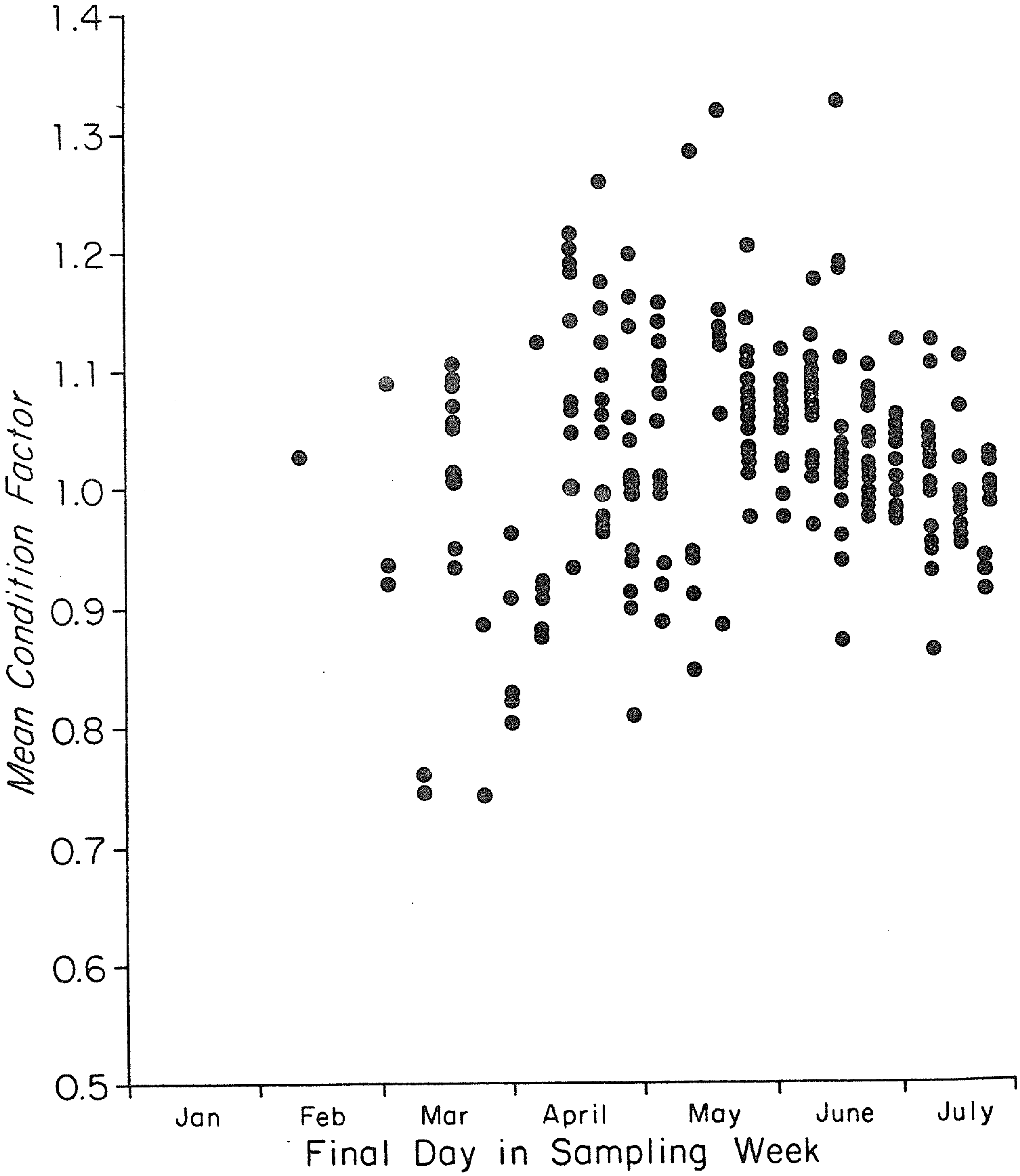


Fig. 31. Weekly mean condition factor of chum fry caught at each sampling site with the surface townet from February 4 to July 28, 1977, in Hood Canal, Washington.

Table 12. A two-way analysis of variance on the effect of sampling week and sampling location on the mean condition factor of chum fry captured from March to July 1977, Hood Canal, Washington.

Source of variation	Sum of spawners	DF	Mean square	F	Significance of F
		East Shore Beach Seine Sites			
Total	.531	57	.009		
Week	.169	8	.021	2.814	.013
Location	.026	5	.005	.686	.636
Residual	.331	44	.008		
		West Shore Beach Seine Sites			
Total	.611	45	.014		
Week	.373	13	.029	3.697	.002
Location	.002	2	.001	.156	.856
Residual	.233	30	.008		
		West vs East Shore Beach Seine Sites			
Total	3.524	198	.018		
Week	2.089	24	.087	11.764	.001
Location	.002	1	.002	.288	.592
Residual	1.125	152	.007		

Table 12. A two-way analysis of variance on the effect of sampling week and sampling location on the mean condition factor of chum fry captured from March to July, 1977, Hood Canal, Washington - continued.

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
		East Shore Surface Townet Transects			
Total	.220	62	.004		
Week	.042	8	.005	1.791	.102
Location	.039	6	.007	2.251	.054
Residual	.139	48	.003		
		West Shore Surface Townet Transects			
Total	.236	23	.010		
Week	.074	5	.015	1.548	.234
Location	.018	3	.006	.632	.606
Residual	.143	15	.010		
		East vs West Shore vs Mid-Canal Surface Townet Transects			
Total	1.854	177	.010		
Week	.553	16	.035	5.316	.001
Location	.014	2	.007	1.054	.351
Residual	.877	135	.006		

Trophic Relationships

Epibenthic Plankton Community

Thirty-four major taxa of epibenthic organisms were represented in the plankton pump collections (Table 13). The most taxonomically diverse groups included the harpacticoid copepods, polychaete annelids, gammarid amphipods, shrimp and bivalves.

The numerically prevalent organisms were harpacticoid copepods, followed by (in decreasing order of overall percent composition) gammarid amphipods, crustacean eggs, ostracods, calanoid copepods, asselotan isopods, nematodes, barnacle nauplii and cyprides, prosobranch larvae, juvenile shrimp and cumaceans. Of the harpacticoid copepods, the prevalent species were *Harpacticus* sp., *Amphiascopsis cinctus*, and a species of the family Laophontidae; the most common gammarids were an undescribed *Pontogeneia* sp., *Calliopiella pratti* (?) and *Anisogammarus pugettensis*.

Between December 30, 1976 and July 22, 1977 the abundance of epibenthic organisms varied between a minimum of 7,625.0 ± 2,322.1/1,000 liters occurring on February 17, and a maximum of 99,344 ± 15,030.4/1,000 liters occurring on April 21; the average density over the 27-week period was 28,902.0 ± 28,399.6/1,000 liters (Fig. 32). Densities of epibenthic organisms at the three principal sampling sites followed a similar seasonal trend, all showing maximum densities occurring in mid-April to early May. Harpacticoid copepod densities at the three sites tended to be quite variable; Devil's Hole delta typically had the highest densities and Carlson Point showed more frequent and extreme fluctuations than the other

Table 13. Taxa of epibenthic organisms collected in shallow sublittoral zone of northern Hood Canal, Washington, 1977. A = adult, J = juvenile, L = larvae, U = unknown.

Species	Life History Stages
Platyhelminthes	A,
Nemertea	A, J
Polychaeta	A, J, L
Polynoidae	A, J
Phyllodocidae	A, J
Anaitides sp.	A
Eteone longa	A
Ophiodromus pugettensis	A
Pillargiidae	U
Syllidae	A, J
Exogone sp.	
Nereidae	A, J
Nereis sp.	A
Platynereis bicanaliculata	A
Hemipodus borealis	A
Spionidae	A
Cirratulidae	A
Armandia brevis	A
Serpulidae	J
Oligochaeta	A
Tubificidae	A
Gastropoda	L, U
Prosobranchia	J, L
Acmaeidae	J
Margarites pupillus	J
Lirularia lirulatus	J
Lacuna sp.	A, J, L
Littorina sp.	J
Alvinia sp.	A
Barleeia sp.	A
Thais sp.	J

Table 13. Continued.

Species	Life History Stages
Opisthobranchia	J
Cephalaspidea	A, J
Sacoglossa	A, J
Olea hansineensis	A, J
Nudibranchia	A, J
Melibe leonina	J
Bivalvia	A, J
Mytilidae	J
Mytilus edulis	J
Modiolus sp.	J
M. rectus	J
Turtonia minuta	A
Pododesmus sp.	J
Veneroida	J
Kellia sp.	J
Mysella tumida	A
Clinocardium nuttallii	J
Transennella tantilla	A
Protothaca staminea	J
Halicaridae	A, J
Pycnogonida	U
Crustacea	J, L, U
Lightiellidae	A, J
Cladocera	
Myodocopa	A
Podocopa	A, J
Calanoida	A, J, L
Calanus plumchrus	A
Scaphocalanus sp.	U
Acartia clausi	A

Table 13. Continued.

Species	Life History Stages
Harpacticoida	A, J, L
Tegastidae	A
Porcellidiidae	A
Canuellidae	
Scottolana canadensis	
Ectinosomidae	A
Harpacticidae	A
Zaus sp.	A, J
Harpacticus sp.	A, J
Tisbidae	A
Tisbe sp.	A
Tachidiidae	A
Microarthridion littorale	A
Ameiridae	A
Diosaccidae	A
Amonardia sp. *(purtubata?)*	A
Amphiascopsis sp.	
A. cinctus	A
Amphiascus sp.	
Diosaccus spinatus	
Canthocamptidae	A
Thalestridae	A
Dactylopodia sp.	A
Diarthrodes sp.	A
Parathalestris sp.	A
P. californica	
Laophontidae	A
Cyclopoida	A
Corycaeus sp.	A
Oithona sp.	A
Caligoida	A
Argulus sp.	J

Table 13. Continued.

Species	Life History Stages
Balanomorpha	A, J, L
Balanidae	J
Balanus sp.	A
Nebalia bipes	A
N. pugettensis	A
Mysidae	A, J
Acanthomysis sp.	A
A. macropsis	A
Mysis sp.	A
Cumacea	A, J
Lamprops sp.	A, J
Cumella sp.	A, J
Tanaidacea	A, J
Tanaidae	A
Leptochelia dubia	A, J
Sphaeromatidae	A, J
Gnorimosphaeroma oregonensis	A, J
Exosphaeroma media	A, J
Valvifera	A, J
Idotea sp.	A, J
Asellota	A, J
Munna ubiquita	A, J, L
Epicaridea	A
Cryptoniscidae	A
Bopyridae	J
Gammaridea	A, J, L
Allorchestes augustus	A
Ampithoe sp.	J
Aoroides columbiae	A
Anisogammarus pugettensis	A
Pontogeneia sp.	A, J

Table 13. Continued.

Species	Life History Stages
Calliopidae	A
Calliopiella pratti	A, J
Calliopius sp.	A, J
Isaeidae	A
Podoceropsis sp.	A
Paraphoxus spinosus	A
Photis brevipes	A
Synchelidium shoemakeri	A
Hyperiidea	A, J
Caprellidea	A, J
Tritella sp.	A
Caprella sp.	A, J
Euphausiacea	J
Decapoda	L
Natantia	J, L
Hippolytidae	J
Pandalidae	J
Pandalus sp.	J
Crangonidae	A, J
Crangon sp.	J
Callianassidae	J
Paguridae	J
Majidae	L
Cancridea	L
Pinnotheridae	A, L
Collembola-Arthropleona	J, L
Diptera	A
Cheilostomata-Ascophora	A
Barentisia sp.	A, J
Ophiuroida	A, J
Holothuroidea	A
Chaetognatha	J

Table 13. Continued.

Species	Life History Stages
Urochordata	J
Teleostei	L
Unidentified	J, L

* Notes: In some cases, larval designation includes eggs.

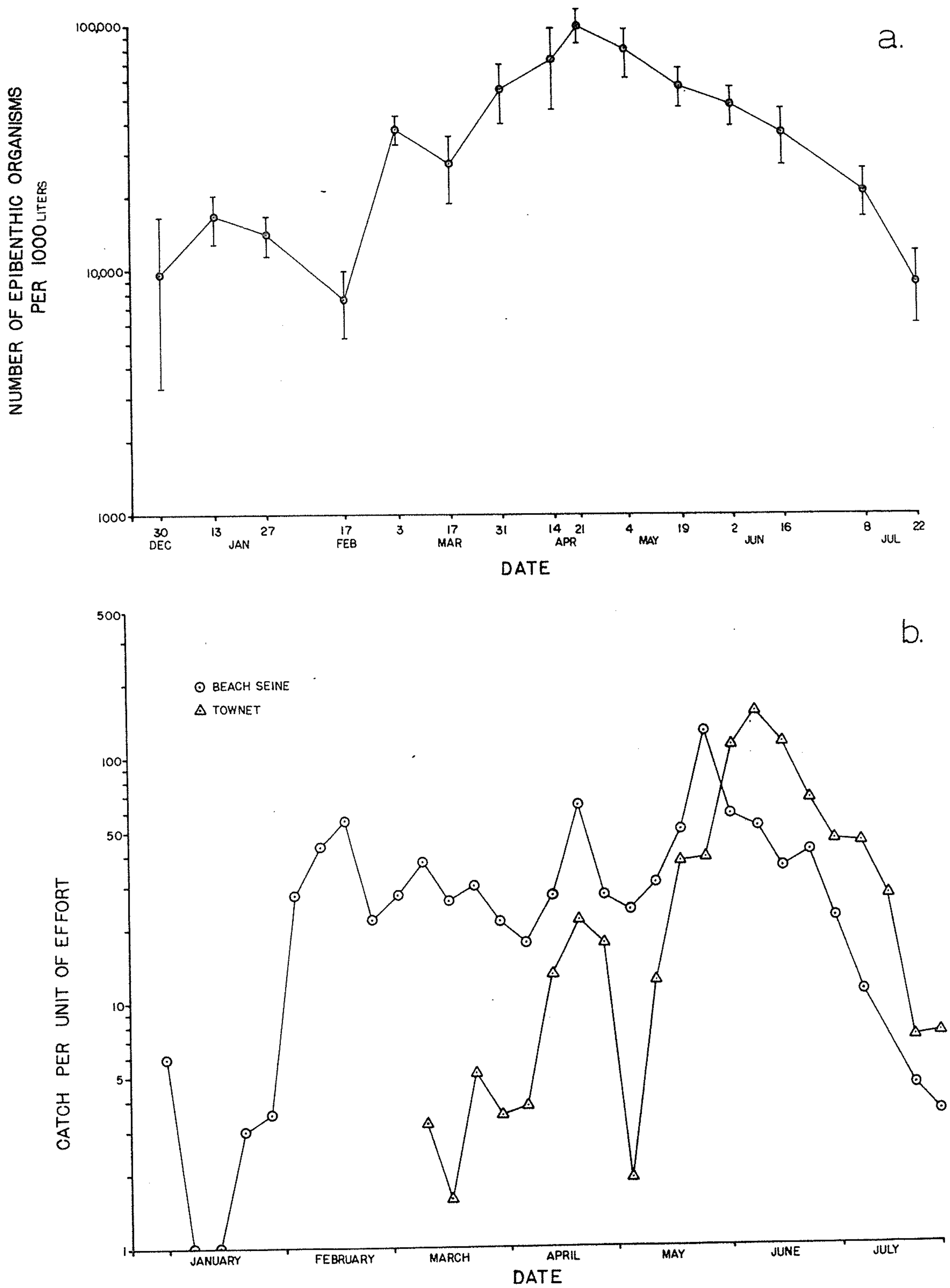


Fig. 32. Total mean number of shallow sublittoral epibenthic organisms per 1000 liters (a) and catch-per-unit-of effort of chum salmon (b) in Hood Canal, Washington, 1977. Bars represent ± 1 S.D.

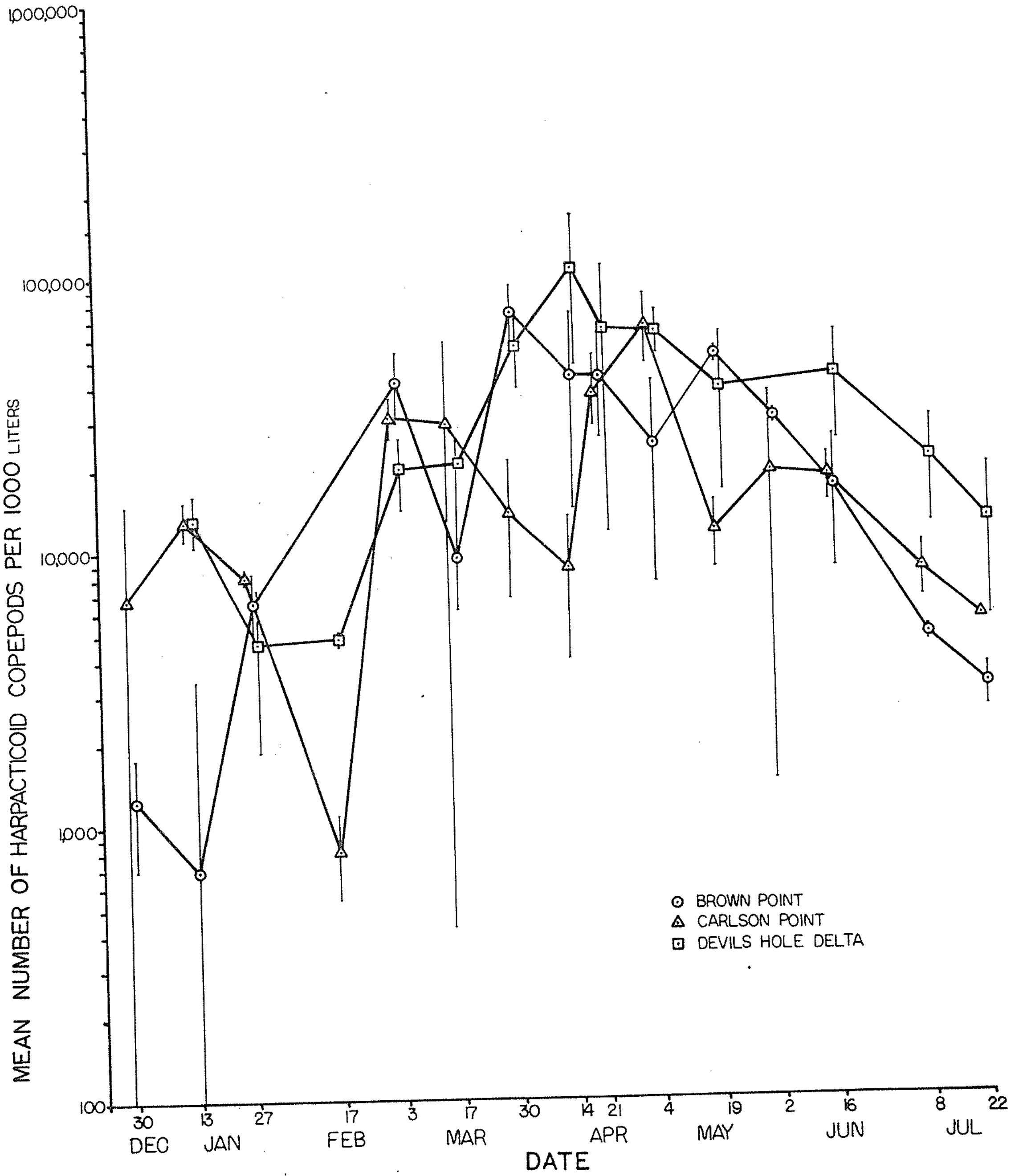


Fig. 33. Mean density of epibenthic harpacticoid copepods at three sites, Hood Canal, Washington, in 1977.

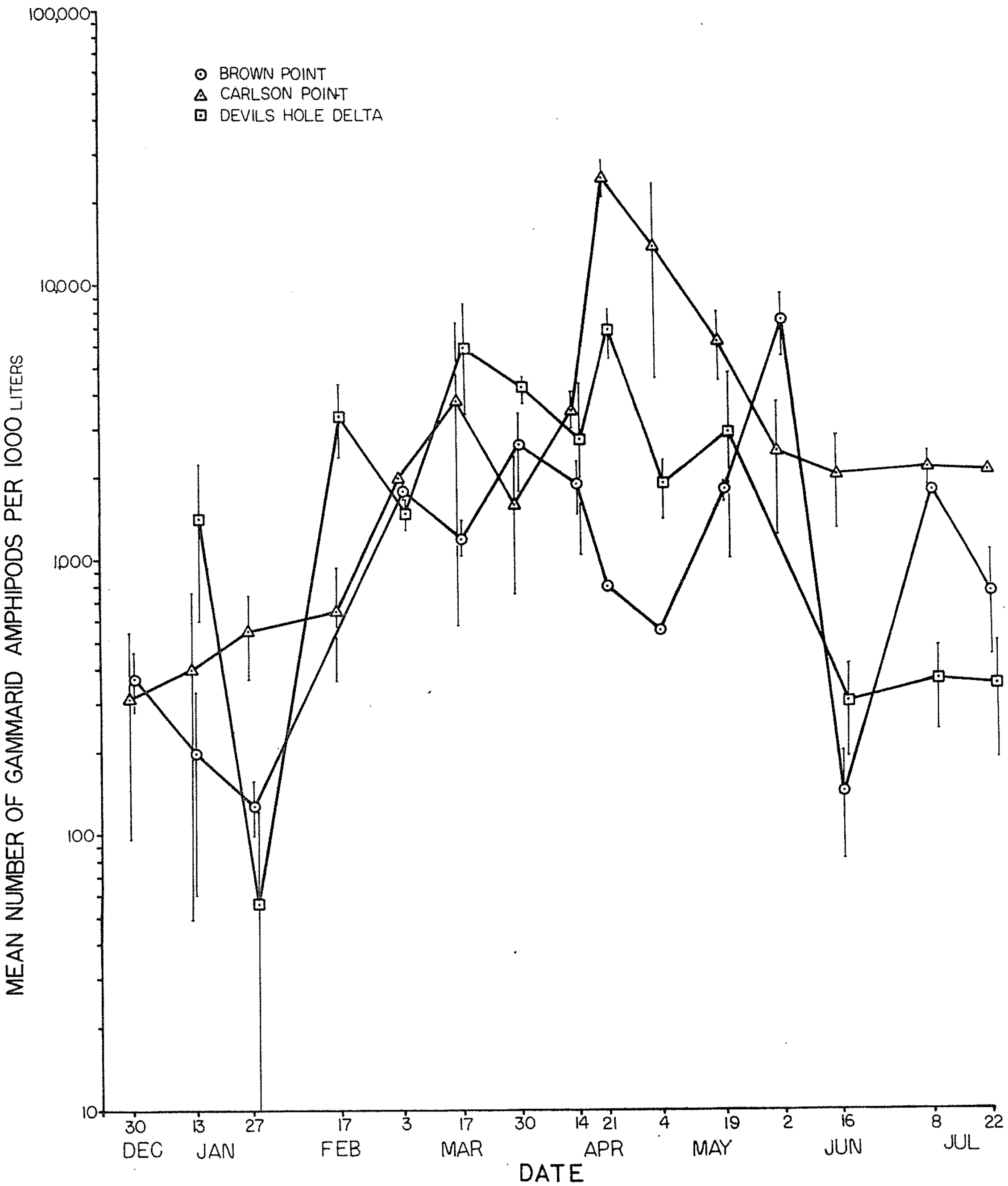


Fig. 34. Mean density of epibenthic gammarid amphipods at three sites, Hood Canal, Washington, in 1977.

sites (Fig. 33). Gammarid amphipod densities also varied considerably between sites, especially at Brown Point (Fig. 34). Specific taxa composition was quite variable for the dominant harpacticoids occurring at three sites with different genera or species predominating at each of the three sites; percent composition of gammarids occurring at Brown Point over time illustrated one species, the undescribed *Pontogeneia* sp., to predominate and three other species to vary in their relative importance.

The dominant organism taxa also showed some differences between the three sites (Table 14). The epibenthic community of Devil's Hole delta typically had higher densities of veneroid bivalves, general copepods, mysids and crangonid shrimps, while Carlson Point had significantly more polychaetes (principally polynoids), prosobranch larvae, unidentified crustacean larvae, barnacle larvae, spaeromatid, valviferan and epicaridean isopods, gammarid and caprellid amphipods, hippolytid shrimp, and holothurians.

Prey Composition of Juvenile Chum Salmon

Chum salmon captured in shallow sublittoral habitats with the beach seine had fed predominantly upon harpacticoid copepods and gammarid amphipods; calanoid copepods, insects, hyperiid amphipods, and euphausiids were of secondary importance (Fig. 35*). Harpacticoid copepods and gammarid amphipods predominated throughout the outmigration period except during mid-May when a pulse of euphausiids, calanoid copepods and hyperiids appeared in the prey spectra.

*Incomplete weight measurements of prey organisms has caused the % composition by weight in IRI graphs to reflect inaccurate values based on negligible prey weights.

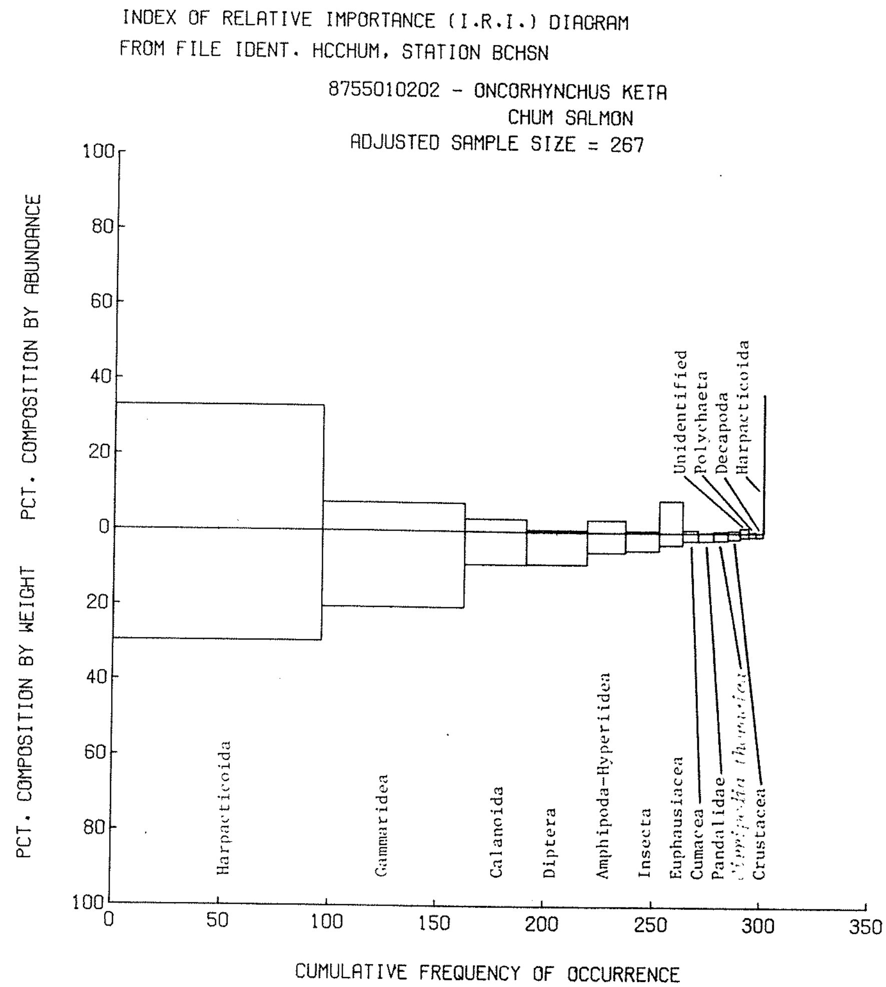
Table 14. Relative quantitative composition and life history stages of epibenthic plankton samples, expressed as sum of mean number/1000 liters, at three shallow sublittoral sites, Hood Canal, Washington, December 30, 1976 through July 22, 1977.

Major Taxonomic Groups	Life History Stages: Larvae	Juv.	Adult	Juv. or Ad.	$\Sigma\bar{x}$ no's/kl Brown Pt.	$\Sigma\bar{x}$ no's/kl Carlson Pt.	$\Sigma\bar{x}$ no's/kl Devil's Hole	$\Sigma\bar{x}$ no's/kl Three Sites Combined
Hydroida			x			4.3		1.5
Platyhelminthes			x			.2	1.4	.4
Nemertea		x	x				1.5	.5
Nematoda			x		693.5	697.7	651.6	682.0
Polychaeta*		x	x		81.1	150.0	98.6	111.0
Polynoidae		x	x		23.8	85.1	26.6	46.5
Phyllodocidae		x	x		2.1	5.2	5.7	4.5
Hesionidae			x				.1	.0
Pillargiidae				x		1.7		.6
Syllidae		x	x		18.0	2.5	38.1	18.7
Nereidae		x	x		.2	1.8	3.2	1.7
Glyceridae			x		.1			.0
Spionidae			x	x	7.2	8.6	12.8	9.4
Cirratulidae			x				.1	.0
Ophediidae			x	x	.2		.2	.2
Serpulidae		x					1.3	.4
Oligochaeta			x	x	12.3	3.9	5.4	7.2
Tubificidae			x	x	3.0	.7	4.5	2.6
Gastropoda*	x	x			10.4	14.4	11.1	11.9
Prosobranchia*	x	x			103.6	236.5	165.5	168.2
Acmaeidae		x				.1	5.7	1.8
Trochidae		x				.2		.1
Lacunidae	x	x	x		134.8	161.0	246.5	178.9
Littorinidae		x				.2		.1
Rissiodae			x	x	.8	1.3	.8	1.0
Thaididae		x				.1		.0
Opisthobranchia*		x		x	2.1	23.7		10.2
Cephalaspidea		x	x				.3	.1
Sacoglossa		x	x		.4	25.3	14.7	13.7
Nudibranchia		x	x		1.0	.1	40.1	12.8
Bivalvia*		x	x		18.2	12.5	13.1	14.6
Mytilidae		x			.6	7.3	4.4	4.2
Pinnidae			x				2.3	.7
Anomiidae				x			.3	.1
Veneroida		x		x	11.3	2.8	.1	4.3
Kelliidae		x				.1		.0
Montacutidae			x		.4	.5	1.0	.7
Cardiidae		x			.3	.1	.5	.3
Veneridae		x	x		.6		2.2	.9
Halicardae		x	x		29.2	89.5	185.8	99.2
Pycnogonida				x	1.8		2.8	1.5

Table 14. continued

Major Taxonomic Groups	Life History Stages: Larvae	Juv.	Adult	Juv. or Ad.	$\Sigma\bar{x}$ no's/kl Brown Pt.	$\Sigma\bar{x}$ no's/kl Carlson Pt.	$\Sigma\bar{x}$ no's/kl Devil's Hole	$\Sigma\bar{x}$ no's/kl Three Sites Combined
Crustacea*	x	x			3.8	39.6	25.2	23.2
Lightiellidae		x	x			.6		.2
Cladocera			x				1.4	.4
Ostracoda		x	x		2,017.2	1,064.5	2,608.3	1,861.1
Copepoda*	x	x	x		1,052.5	221.4	251.8	507.9
Calanoida	x	x	x		1,005.5	1,021.8	1,350.4	1,117.3
Harpacticoida	x	x	x		24,818.1	16,625.5	34,585.3	24,190.9
Cyclopoida			x		9.1	23.0	25.9	19.3
Argulidae		x				1.7		.6
Balanomorpha	x	x	x		437.0	780.5	439.7	560.3
Nebaliidae			x	x	.2	1.9		.7
Mysidae		x	x		29.2	4.8	1.3	11.9
Cumacea*		x	x		52.7	13.6	65.1	46.0
Lampropidae					100.7	34.7	197.1	107.0
Nannastasidae					129.7	53.4	396.1	185.1
Tanaidacea		x	x		35.1	29.2	595.8	207.4
Isopoda								
Sphaeromatidae		x	x		51.0	342.2	61.1	157.8
Valvifera					.5	8.6	.9	3.4
Asellota	x	x	x		126.9	677.9	1,397.6	717.7
Epicaridae		x	x		10.0	45.1	30.9	28.9
Gammaridae	x	x	x		1,438.6	4,135.9	2,353.5	2,683.6
Hyperiidae		x	x		16.4	13.9	.1	10.4
Caprellidae		x	x		10.8	132.4	85.0	77.1
Euphausiacea		x					6.4	2.0
Decapoda*	x	x			8.0	38.6	20.2	22.7
Hippolytidae		x		x	2.2	15.9	8.7	9.1
Pandalidae		x			.4	.4	3.4	1.4
Crangonidae		x	x		8.0	1.7	1.0	3.5
Callianassidae		x			.1			.0
Paguridae		x					.4	.1
Majidae	x				.1	.2		.1
Cancridae	x				.4	.1		.2
Pinnotheridae	x				1.8	.1	.2	.7
Insecta	x	x	x		3.0	2.3	6.3	3.7
Ectoprota			x			1.0		.4
Entoprota			x			.3		.1
Ophiuroida		x	z		2.8	1.0	6.7	3.2
Holothuroidea		x	x			6.1	4.7	3.6
Chaetognatha		x			.1			.0
Urochordata		x				1.1		.4
Teleostei	x					.9	.2	.3
Unidentified				x	61.5	534.8	210.8	276.5
$\bar{x}$ ABUNDANCE					34,644.0	34,340.2	50,187.0	39,359.6

*Unidentified beyond these groups, yet do not necessarily indicate groups other than those listed.



INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
USING FILEID= HCCHUM, STATION= BCHSN FOR PLOT

PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	95.88	33.10	29.53	6004.4	67.18
GAMMARIDEA	66.29	7.50	20.42	1850.5	20.70
CALANOIDA	28.46	3.32	8.77	344.0	3.85
DIPTERA	28.09	.55	8.65	258.4	2.89
AMPHIPODA-HYPERIIDEA	17.60	3.25	5.42	152.6	1.71
INSECTA	15.73	.47	4.84	83.6	.93
EUPHAUSIACEA	10.86	8.47	3.34	128.3	1.44
CUMACEA	7.12	.72	2.19	20.7	.23
PANDALIDAE	7.12	.14	2.19	16.6	.19
CIRRIPEDIA THORACICA	6.74	.39	2.08	16.7	.19
CRUSTACEA	5.62	.67	1.73	13.5	.15
UNIDENTIFIED	4.12	1.28	1.27	10.5	.12
POLYCHAETA	3.37	.30	1.04	4.5	.05
DECAPODA	3.37	.16	1.04	4.0	.05
HARPACTICOIDA	.37	36.77	.12	13.8	.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)

DIVERSITY INDICES BASED ON FRACTION OF TOTAL IRI --
PERCENT DOMINANCE INDEX .50
SHANNON-WEINER DIVERSITY 1.56
EVENNESS INDEX .30

Fig. 35. IRI (Index of Relative Importance) diagram showing prey spectra of chum salmon fry captured by beach seine in shallow sublittoral habitats of Hood Canal, Washington, in 1977.

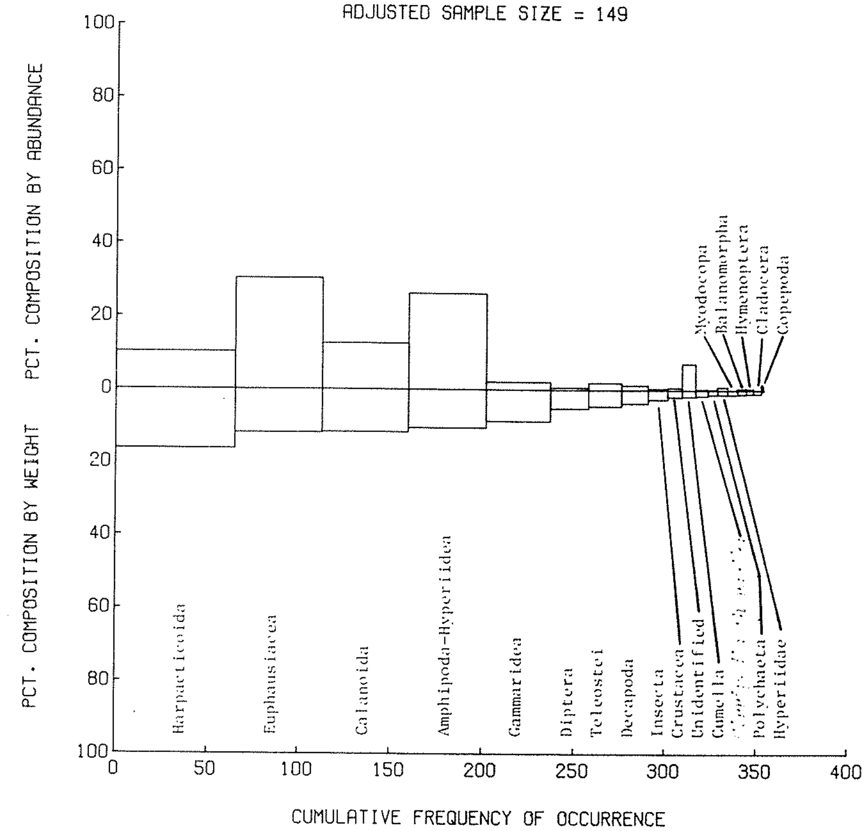
The stomachs of chum fry captured in neritic waters using the townet contained both epibenthic and nearshore prey organisms - harpacticoid copepods, gammarid amphipods, crustacean larvae and insects - and pelagic forms - euphausiids, calanoid copepods and hyperiid amphipods (Fig. 36). Even though they were captured offshore, chum fry caught in the townet contained mostly epibenthic organisms in their stomachs until early May, when prey composition shifted dramatically to pelagic organisms; euphausiids predominated in June, eventually tapering off with the appearance of calanoid copepods, and in late June, hyperiid amphipods.

Harpacticoid copepods dominated the IRI prey spectra for beach seine-caught chum fry at all sites (Table 15). Gammarid amphipods usually ranked second in importance except at Devil's Hole Delta where euphausiids ranked higher, at Marginal Wharf where calanoid copepods and hyperiid amphipods were more important, and at the EHW site where dipteran insects were prevalent.

Prey composition of townet-caught chum fry was more variable from site to site (Table 15) than for beach seine-captured chums. Harpacticoid copepods, hyperiid amphipods, euphausiids and calanoid copepods were the predominant prey of chum fry in neritic waters adjacent to Carlson Pt.; the same prey taxa predominated in chum fry at Devil's Hole Delta but euphausiids were more important. The prey spectra from Brown Pt. was less diverse than any other site and was dominated by euphausiids (87 percent of total IRI). Harpacticoid and calanoid copepods and hyperiid amphipods were the prevalent organisms composing the prey spectra from Marginal Wharf.

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. HCCHUM, STATION TOWNT

8755010202 - ONCORHYNCHUS KETA
CHUM SALMON
ADJUSTED SAMPLE SIZE = 149



INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
USING FILEID= HCCHUM, STATION= TOWNT FOR PLOT

PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
HARPACTICOIDA	65.10	10.18	16.30	1724.1	23.52
EUPHAUSIACEA	47.65	30.30	11.93	2012.6	27.46
CALANOIDA	46.98	12.53	11.76	1141.4	15.57
AMPHIPODA-HYPERIIDEA	42.28	26.23	10.59	1556.7	21.24
GAMMARIDEA	34.90	2.04	8.74	376.1	5.13
DIPTERA	20.81	.63	5.21	121.5	1.66
TELEOSTEI	18.12	1.93	4.54	117.3	1.60
DECAPODA	14.77	1.25	3.70	73.0	1.00
INSECTA	10.74	.41	2.69	33.3	.45
CRUSTACEA	8.05	.69	2.02	21.8	.30
UNIDENTIFIED	7.38	7.19	1.85	66.7	.91
CUMELLA	6.71	.29	1.68	13.2	.18
CIRRIPEDIA THORACICA	5.37	.20	1.34	8.3	.11
POLYCHAETA	5.37	.77	1.34	11.3	.15
HYPERIIDAE	5.37	.09	1.34	7.7	.11
MYODOCOPA	4.70	.47	1.18	7.8	.11
BALANOMORPHA	4.03	.37	1.01	5.6	.08
HYMENOPTERA	4.03	.06	1.01	4.3	.06
CLADOCERA	.67	1.49	.17	1.1	.02
COPEPODA	.67	1.30	.17	1.0	.01

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

DIVERSITY INDICES BASED ON FRACTION OF TOTAL IRI --
PERCENT DOMINANCE INDEX .20
SHANNON-WEINER DIVERSITY 2.62
EVENNESS INDEX .45

Fig. 36. IRI (Index of Relative Importance) diagram showing prey spectra of chum salmon fry captured by townet in neritic habitats of Hood Canal, Washington, in 1977.

Table 15. Dominant prey organisms, expressed as percent of total IRI, composing prey spectra of juvenile chum salmon at different sites in northern Hood Canal, Washington, in 1977.

	Harpacticoid copepods	Gammarid amphipods	Insects	Calanoid copepods	Euphausiids	Hyperiid amphipods	Cumaceans	Shrimp	Barnacle larvae	Decapod larvae
Beach seine										
Carlson Point	67.1	23.6	3.8	1.7	0.5	0.5	0.1	0.1		
Devils Hole Delta	57.5	13.5	2.5	9.6	13.1	2.6	0.1	0.2		
Brown Point	58.5	30.3	3.8	1.7	1.3	0.6	1.7	0.6		
Marginal Wharf	67.3	6.2	3.8	11.4	0.7	8.9	0.0	0.0		
EHW	74.4	7.6	10.7	3.1	0.0	2.7	0.2	1.1		
Spit 6	54.2	43.5	0.4	0.8	0.0	0.0	0.0	0.2		
Floral Point	59.1	32.7	5.2	0.6	0.0	0.3	0.3	0.0		
Townet										
Carlson Point	37.6	5.9	3.0	10.6	12.6	21.0	0.4	0.1	2.4	0.4
Devils Hole Delta	11.9	2.7	2.6	19.5	38.2	19.6	0.0	0.0	0.1	1.0
Brown Point	5.7	2.9	0.8	1.2	87.0	1.2	0.1	0.1	0.3	0.0
Marginal Wharf	29.8	7.9	2.9	27.6	5.5	18.5	0.0	0.1	0.4	0.6

Prey Composition of Other Salmonids

Juvenile coho and chinook salmon were often caught in association with the outmigrating chum fry; juvenile pink salmon were not common because of the lack of a significant adult return to Hood Canal in even-numbered years. Searun cutthroat and rainbow (steelhead) trout were also captured during the beach seining and townetting collections. In order to determine the significance of their predation upon chum fry, only specimens ≥100 mm in length were chosen for stomach analysis (Appendix Table 5).

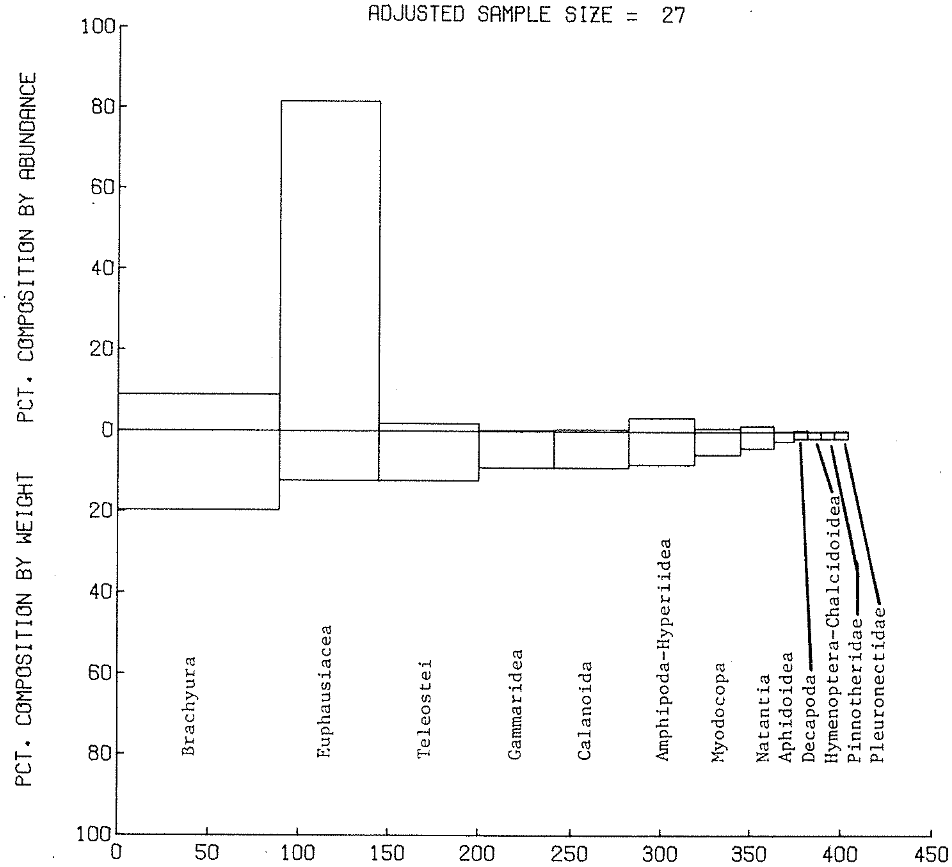
Coho juveniles (length $\bar{x}$ = 122.4 mm) had fed specifically upon brachyuran crab larvae and euphausiids, the latter comprising over 80 percent of the total number of prey in the sample (Fig. 37). Larval fish, gammarid and hyperiid amphipods and calanoid copepods were also common prey items, but were not numerically important.

Juvenile chinook salmon (length $\bar{x}$ = 267.0 mm), including immature resident blackmouth, fed most frequently upon shrimp larvae, insects and juvenile Pacific herring although brachyuran crab larvae and juvenile Pacific sand lance comprised greater percentages of the total number of prey (Fig. 38). Two chum fry were found in the stomach of one of the juvenile chinook, but comprised only 0.43 percent of the total number of prey items.

Searun cutthroat trout (length $\bar{x}$ = 327.5 mm) fed predominantly upon gammarid amphipods, which alone composed over 55 percent of the total number of prey organisms (Fig. 39). Spaeromatid isopods (*Gnorimosphaeroma oregonensis*, *Exosphaeroma media*), juvenile fish (including several chum

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

8755010203 - ONCORHYNCHUS KISUTCH
COHO SALMON
ADJUSTED SAMPLE SIZE = 27



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
BRACHYURA	88.89	8.96	19.67	2544.8	25.11
EUPHAUSIACEA	55.56	81.53	12.30	5212.4	51.42
TELEOSTEI	55.56	1.86	12.30	786.1	7.76
GAMMARIDEA	40.74	.26	9.02	378.0	3.73
CALANOIDA	40.74	.51	9.02	388.2	3.83
AMPHIPODA-HYPERIIDEA	37.04	3.43	8.20	430.5	4.25
MYODOCOPA	25.93	.83	5.74	170.3	1.68
NATANTIA	18.52	1.44	4.10	102.5	1.01
APHIDOIDEA	11.11	.11	2.46	28.5	.28
DECAPODA	7.41	.34	1.64	14.7	.15
HYMENOPTERA-CHALCIDOIDEA	7.41	.08	1.64	12.8	.13
PINNOTHERIDAE	7.41	.14	1.64	13.2	.13
PLEURONECTIDAE	7.41	.19	1.64	13.6	.13

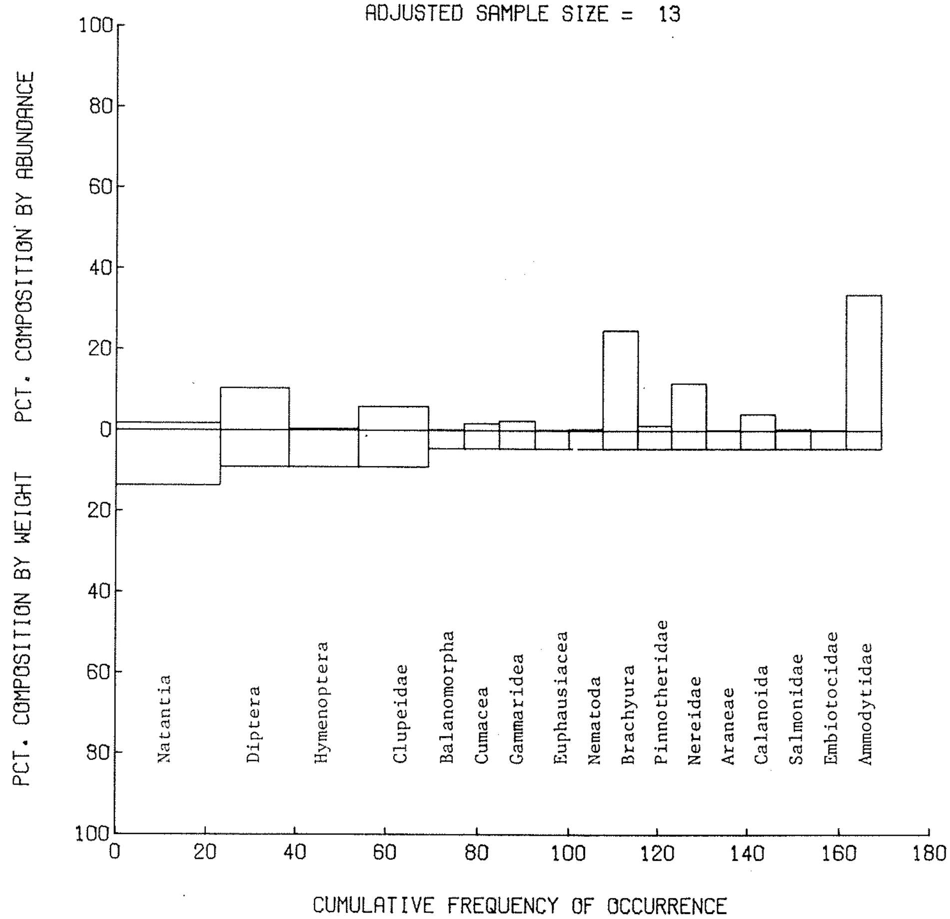
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.67	.10	.34
SHANNON-WEINER DIVERSITY	1.15	3.81	2.12
EVENNESS INDEX	.24	.81	.45

Fig. 37. IRI (Index of Relative Importance) diagram showing prey spectra of juvenile coho salmon captured during 1977 salmonid outmigration sampling in Hood Canal, Washington.

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

8755010206 - ONCORHYNCHUS TSHAWYTSCHA
CHINOOK SALMON
ADJUSTED SAMPLE SIZE = 13



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
NATANTIA	23.08	1.74	13.64	354.8	16.79
DIPTERA	15.38	10.43	9.09	300.4	14.21
HYMENOPTERA	15.38	.43	9.09	146.5	6.93
CLUPEIDAE	15.38	5.87	9.09	230.2	10.89
BALANOMORPHA	7.69	.22	4.55	36.6	1.73
CUMACEA	7.69	1.74	4.55	48.3	2.29
GAMMARIDEA	7.69	2.39	4.55	53.4	2.52
EUPHAUSIACEA	7.69	.22	4.55	36.6	1.73
NEMATODA	7.69	.43	4.55	38.3	1.81
BRACHYURA	7.69	24.78	4.55	225.6	10.67
PINNOTHERIDAE	7.69	1.30	4.55	45.0	2.13
NEREIDAE	7.69	11.74	4.55	125.3	5.93
ARANEAE	7.69	.22	4.55	36.6	1.73
CALANOIDA	7.69	4.13	4.55	66.7	3.16
SALMONIDAE	7.69	.43	4.55	38.3	1.81
EMBIOTOCIDAE	7.69	.22	4.55	36.6	1.73
AMMODYTIDAE	7.69	33.70	4.55	294.2	13.92

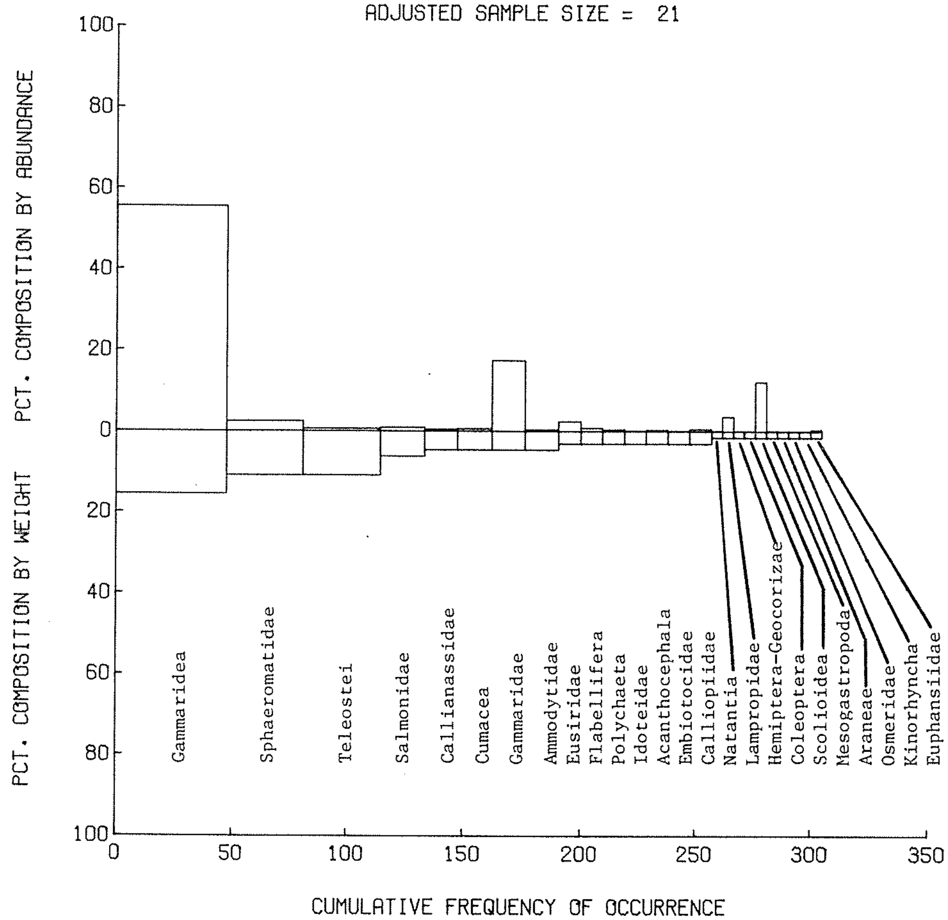
PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

PERCENT DOMINANCE INDEX	.21	.07	.10
SHANNON-WEAVER DIVERSITY	2.75	3.97	3.58
EVENNESS INDEX	.67	.97	.88

Fig. 38. IRI (Index of Relative Importance) diagram showing prey spectra of juvenile chinook salmon captured during 1977 salmonid outmigration sampling in Hood Canal, Washington

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

8755010301 - SALMO CLARKI
CUTTHROAT TROUT
ADJUSTED SAMPLE SIZE = 21



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
GAMMARIDEA	47.62	55.52	15.63	3397.7	63.90
SPHAEROMATIDAE	33.33	2.39	10.94	444.2	8.38
TELEOSTEI	33.33	.63	10.94	385.7	7.28
SALMONIDAE	19.05	.91	6.25	136.4	2.57
CALLIANASSIDAE	14.29	.49	4.69	74.0	1.40
CUMACEA	14.29	.63	4.69	76.0	1.43
GAMMARIDAE	14.29	17.43	4.69	315.9	5.96
AMMODYTIDAE	14.29	.42	4.69	73.0	1.38
EUSIRIDAE	9.52	2.39	3.13	52.5	.99
FLABELLIFERA	9.52	.77	3.13	37.1	.70
POLYCHAETA	9.52	.42	3.13	33.8	.64
IDOTEIDAE	9.52	.14	3.13	31.1	.59
ACANTHOCEPHALA	9.52	.35	3.13	33.1	.62
EMBIOTOCIDAE	9.52	.14	3.13	31.1	.59
CALLIOPIIDAE	9.52	.56	3.13	35.1	.66
NATANTIA	4.76	.07	1.56	7.8	.15
LAMPROPIDAE	4.76	3.58	1.56	24.5	.46
HEMIPTERA-GEOCORIZAE	4.76	.07	1.56	7.8	.15
COLEOPTERA	4.76	.07	1.56	7.8	.15
SCOLIOIDEA	4.76	12.23	1.56	65.7	1.24
MESOGASTROPODA	4.76	.14	1.56	8.1	.15
ARANEAE	4.76	.07	1.56	7.8	.15
OSMERIDAE	4.76	.07	1.56	7.8	.15
KINORHYNCHA	4.76	.07	1.56	7.8	.15
EUPHANSIIDAE	4.76	.42	1.56	9.4	.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)

	NUM. COMP.	GRAV. COMP.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.36	.07	.43
SHANNON-WEINER DIVERSITY	2.21	4.23	2.20
EVENNESS INDEX	.48	.91	.47

Fig. 39. IRI (Index of Relative Importance) diagram showing prey spectra of cutthroat trout captured during 1977 salmonid outmigration sampling in Hood Canal, Washington.

and other salmon fry), callianassid shrimp, cumaceans and Pacific sand lance were common but not abundant in the stomach contents examined.

The most common prey organisms of steelhead (rainbow trout) smolts (length $\bar{x}$ = 166.7 mm) included crab larvae, various insect taxa (scolioidea, diptera, coleoptera), gammarid amphipods, euphausiids, and ostracods (Myodocopa); calanoid copepods, crab larvae, ostracods and dipteran insects were numerically predominant. The stomach of only one steelhead smolt contained fish remains - fifteen unidentified fish larvae.

Prey Composition of Other Nearshore Fish as Potential Predators

A number of non-salmonid marine fish commonly caught along the nearshore region of northern Hood Canal in conjunction with the salmonid outmigration sampling were also considered potential predators upon juvenile chum salmon. Thirteen species - spiny dogfish, Pacific herring, Pacific hake, Pacific tomcod, Pacific cod, whitespotted greenling, buffalo sculpin, great sculpin, cabezon, staghorn sculpin, striped seaperch, shiner perch and starry flounder - were specifically examined for stomach contents containing juvenile salmonids (Appendix Table 5).

None of the pelagic or epibenthic plankton-feeding species showed any indication of predation upon juvenile salmonids (Table 16). Pacific herring preyed predominantly upon calanoid copepods and the euphausiid, *Euphausia pacifica*. More facultative plankton feeders, such as spiny dogfish (Fig. 40), Pacific hake and Pacific tomcod, utilized both pelagic and epibenthic plankton - euphausiids, mysids and gammarid amphipods. Neither did the true benthic feeding fishes indicate any piscivorous food

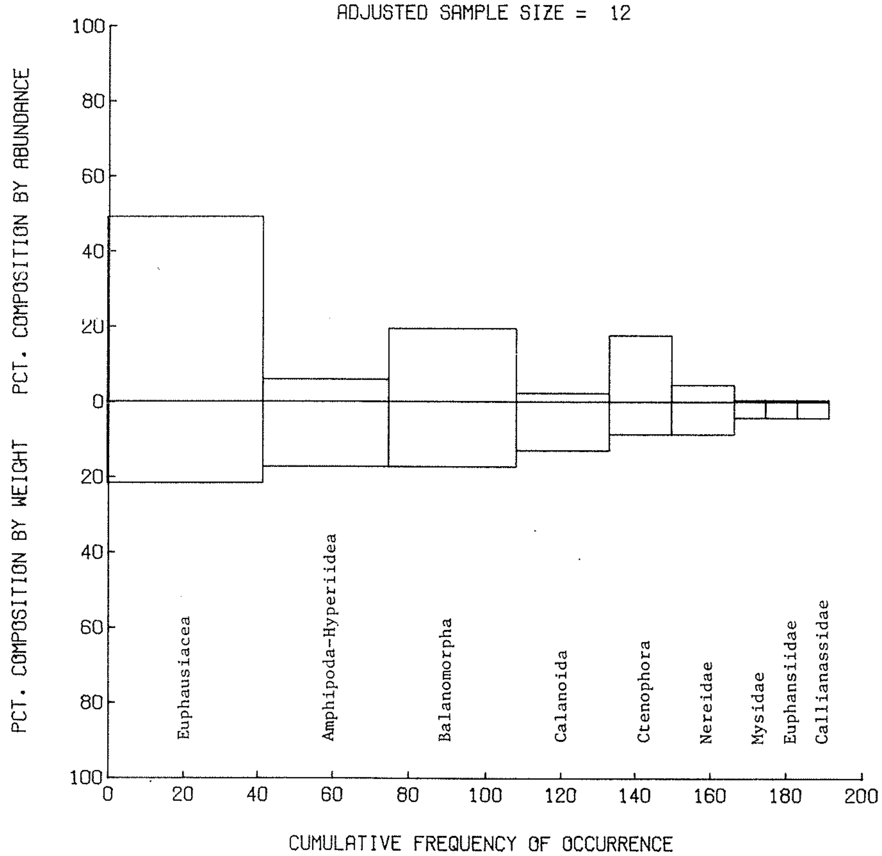
Table 16. Feeding categories of common marine species captured during 1977 salmonid outmigration sampling in Hood Canal, Washington.

Feeding type	Species	Feeding realm	Principal Food organisms
Planktivores (obligative)	Pacific herring	Pelagic	Calanoid copepods
			Hyperiid amphipods
			Euphausiids[1]
(facultative)	Spiny dogfish	Epibenthic	Euphausiids[1]
	Pacific hake	Pelagic	Mysids[2]
	Pacific tomcod		Gammarid amphipods[3]
			Nereid worms[4]
			Fish larvae[5]
Benthivores (obligative)	Starry flounder	Benthic	Bivalves[6]
	Cabezon		Crabs[7]
	Buffalo sculpin		Shrimp[8]
			Nereid worms[4]
			Isopods[9]
(facultative)	Pacific cod	Epibenthic	Gammarid amphipods[3]
	Whitespotted greenling	Benthic	Caprellid amphipods
	Great sculpin		Isopods[9]
	Staghorn sculpin		Shrimp[8]
	Striped seaperch		Crabs[7]
	Shiner perch		Fish
			Gastropods[10]

[1] *Euphausia pacifica*
[2] *Acanthomysis sp., Mysis oculata*
[3] *Pontogeneia sp., Anisogammarus confervicolus, Calliopius sp.*
[4] *Platynereis bicanaliculata, Lumbrinereis sp.*
[5] *Clupea harengus pallasi, Ammodytes hexapterus*
[6] *Lucinidae, Tellinidae, Clinocardium nuttallii, Tresus sp., Mopalia sp., Mytilus edulis*
[7] *Hemigrapsus oregonensis, Pugettia gracilis, Telmessus cheiragonus, Cancer productus, Pinnixa sp.*
[8] Callianassidae, *Crangon sp., Hippolyte clarki*
[9] *Gnorimosphaeroma oregonensis, Idotea resecata, Exosphaeroma media*
[10] *Lacuna sp., Littorina scutulata, Tonicella lineata, Collisella pelta, Margarites sp.*

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. HCPRED, STATION COMBD

8710010201 - SQUALUS ACANTHIAS
SPINY DOGFISH
ADJUSTED SAMPLE SIZE = 12



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
EUPHAUSIACEA	41.67	49.10	21.74	2951.6	48.29
AMPHIPODA-HYPERIIDEA	33.33	5.86	17.39	774.9	12.68
BALANOMORPHA	33.33	19.37	17.39	1225.4	20.05
CALANOIDA	25.00	2.25	13.04	382.4	6.26
CTENOPHORA	16.67	17.57	8.70	437.7	7.16
NEREIDAE	16.67	4.50	8.70	220.0	3.60
MYSIDAE	8.33	.45	4.35	40.0	.65
EUPHANSIIDAE	8.33	.45	4.35	40.0	.65
CALLIANASSIDAE	8.33	.45	4.35	40.0	.65

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

	NUM.	GRAV.	IRI
PERCENT DOMINANCE INDEX	.32	.15	.30
SHANNON-WEINER DIVERSITY	2.07	2.94	2.19
EVENNESS INDEX	.65	.93	.69

Fig. 40. IRI (Index of Relative Importance) diagram showing prey spectra of spiny dogfish captured during 1977 salmonid outmigration sampling in Hood Canal, Washington.

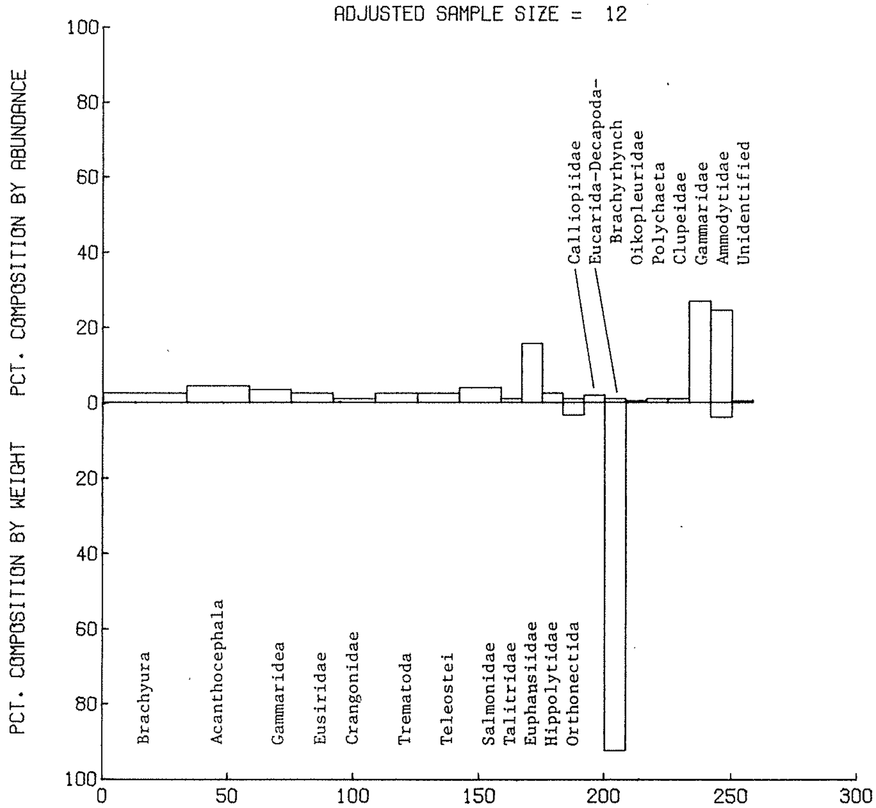
habits; starry flounder preyed upon bivalves and polychaetes while cabezon and buffalo sculpins ate a variety of benthic crab species.

Facultative benthivores, however, were quite omnivorous in the food habits and several included fishes in their stomach contents. Pacific cod preyed principally upon gammarid amphipods but one chum fry was found in one of the two Pacific cod stomachs examined. Three whitespotted greenling stomachs contained mostly gammarid and caprellid amphipods and cragonid shrimp. Of the several sculpins (family Cottidae) included in the analysis, only the staghorn sculpin had fed upon chum salmon fry (Fig. 41), where two of the twelve stomachs contained eight chum fry (4 percent of prey items). Gammarid amphipods (*Anisogammarus pugettensis*), euphausiids (*E. pacifica*), unidentified crabs and fish eggs were the predominate food items. Great sculpins had fed upon caligoid copepods and gammarid amphipods (*A. confervicolus*). One striped seaperch stomach contained 1,120 gammarid amphipods while the other embiotocid, shiner perch, had fed on a diverse array of isopods (*Exosphaeroma media*), bivalves (*Mytilus edulis*), gastropods (*Littorina scutulata*) and gammarid amphipods.

The role of predation as a principal component of mortality of juvenile pink and chum salmon in estuarine habitats has been supported by many (see Iwamoto and Salo 1977 for review), especially as related to the potential impact of shoreline docks and bulkheads. Other salmonids - juvenile and immature coho and chinook and cutthroat and Dolly Varden trout - have particularly been implicated. Allen (1974), Heiser and Finn (1970), Parker (1971), Sano (1966), and Walker (1974) have suggested, on the basis of observational data, that coho smolts are potentially

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. HCPRED, STATION COMBD

8831021801 - LEPTOCOTTUS ARMATUS
PAC. STAGHORN SCULPN
ADJUSTED SAMPLE SIZE = 12



PREY ITEM	FREQ OCCUR	NUM. COMP.	GRAV. COMP.	PREY I.R.I.	PERCENT TOTAL IRI
BRACHYURA	33.33	2.45	.00	81.8	4.24
ACANTHOCEPHALA	25.00	4.41	.00	110.4	5.71
GAMMARIDEA	16.67	3.43	.00	57.2	2.96
EUSIRIDAE	16.67	2.45	.00	40.9	2.12
CRANGONIDAE	16.67	.98	.00	16.4	.85
TREMATODA	16.67	2.45	.00	40.9	2.12
TELEOSTEI	16.67	2.45	.00	40.9	2.12
SALMONIDAE	16.67	3.92	.00	65.4	3.38
TALITRIDAE	8.33	.98	.00	8.2	.42
EUPHANSIIDAE	8.33	15.69	.00	130.7	6.76
HIPPOLYTIDAE	8.33	2.45	.00	20.4	1.06
ORTHONECTIDA	8.33	.98	3.43	36.8	1.90
CALLIOPIIDAE	8.33	1.96	.00	16.3	.85
EUCARIDA-DECAPODA-BRACHYRHYNCH	8.33	.98	92.50	779.0	40.31
OIKOPLEURIDAE	8.33	.49	.00	4.1	.21
POLYCHAETA	8.33	.98	.00	8.2	.42
CLUPEIDAE	8.33	.98	.00	8.2	.42
GAMMARIDAE	8.33	26.96	.00	224.7	11.63
AMMODYTIDAE	8.33	24.51	4.03	237.9	12.31
UNIDENTIFIED	8.33	.49	.00	4.1	.21

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

	NUM.	GRAV.	PERCENT TOTAL IRI
PERCENT DOMINANCE INDEX	.17	.86	.20
SHANNON-WEINER DIVERSITY	3.21	.46	3.05
EVENNESS INDEX	.74	.11	.71

Fig. 41. IRI (Index of Relative Importance) diagram showing prey spectra of staghorn sculpins captured during 1977 salmonid outmigration sampling in Hood Canal, Washington.

significant predators upon chum fry. Stober et al. (1973) suggested stomach analysis evidence of coho smolt predation upon chum and pink fry but no data was provided. Thus, there is no concrete data in the available literature which documents the actual incidence of chum fry in the stomachs of coho smolts although few studies have specifically been designed around the predation hypothesis.

Similarly, evidence of predation by juvenile and immature chinook in the literature is confined to the incomplete evidence in Stober et al. (1973). Our Hood Canal data shows only minimal evidence (1.8 percent total IRI) of chinook predation on other juvenile salmonids; samples from Nisqually Reach (Fresh et al., in press) and northern Puget Sound (Miller et al. 1977) also provide little or no evidence. Resident chinook (blackmouth) were not effectively sampled during most of these studies, however, and they may represent a significant mortality factor (especially considering the WDF delayed release programs designed to expand these stocks). Studies specifically designed to sample these larger, deeper-occurring salmonids and other neritic predators must be implemented before their trophic role can be adequately assessed and new sampling techniques, such as purse seining and midwater trawling, will be required if they are to be sampled effectively.

Searun cutthroat trout have also been implicated as potential predators upon chum fry (Heiser and Finn 1970). This potential has been illustrated by the results of our Hood Canal collections, where salmon fry were fourth in frequency of occurrence of all prey taxa; fish overall constituted only 11.4 percent of the total IRI prey spectra, however.

Other marine fish which have been suggested as potential predators include numerous cottid (sculpin) species (Beall 1972, Heiser and Finn 1970, and Simenstad 1976) and walleye pollock (Armstrong and Winslow 1968). Chum fry occurred in only two species - Pacific cod and Pacific staghorn sculpin. The sample size of Pacific cod stomachs was too low to draw any conclusions concerning the significance of predation by this species. Juvenile salmonids occurred in 17 percent of the Pacific staghorn sculpin stomachs examined but comprised only 3.4 percent of the total IRI prey spectrum. Stomach analysis of Pacific staghorn sculpins from Nisqually Reach (Fresh et al., in press), northern Puget Sound (Miller et al. 1977) and the Strait of Juan de Fuca (Simenstad et al. 1977) also provided no indication of significant predation upon juvenile salmonids.

Overlap Between Epibenthic Plankton Community and Chum Prey

Positive electivity of epibenthic organisms by chum fry occurring in shallow sublittoral habitats, as measured by Ivlev's coefficient, E (Fig. 42), appears to shift from crustacean larvae, juvenile shrimp and calanoid copepods early in the outmigration period to gammarid amphipods, harpacticoid copepods, euphausiids, crustacean eggs and hyperiid amphipods during the peak outmigration period and to calanoid copepods and hyperiid amphipods as the migration ends. Insects always had positive values of E, primarily because they were not well sampled by the plankton pump.

Size selection of harpacticoid copepods and gammarid amphipods was quite apparent (Fig. 43). For example, the sizes (metasome lengths) of harpacticoid copepods characterizing the Brown Point epibenthic plankton community ranged from 0.817 $\pm$ 0.812 mm to 0.628 $\pm$ 0.144 mm, averaging 0.716 $\pm$ 0.174 mm, through the period of the 1977 outmigration period while

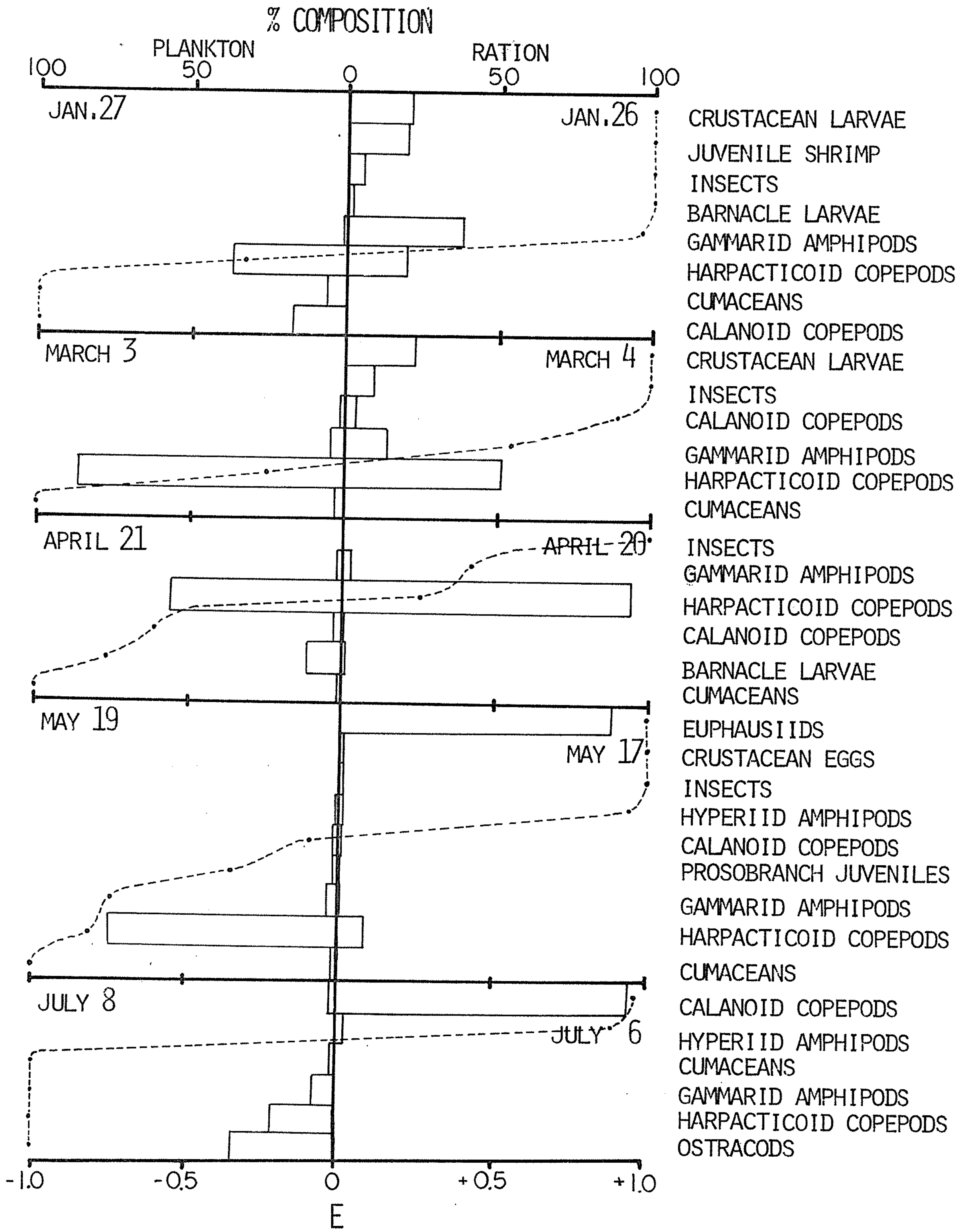


Fig. 42. Electivity curves for epibenthic plankton sample composition and ration composition of juvenile chum salmon, Hood Canal, Washington, in 1977.

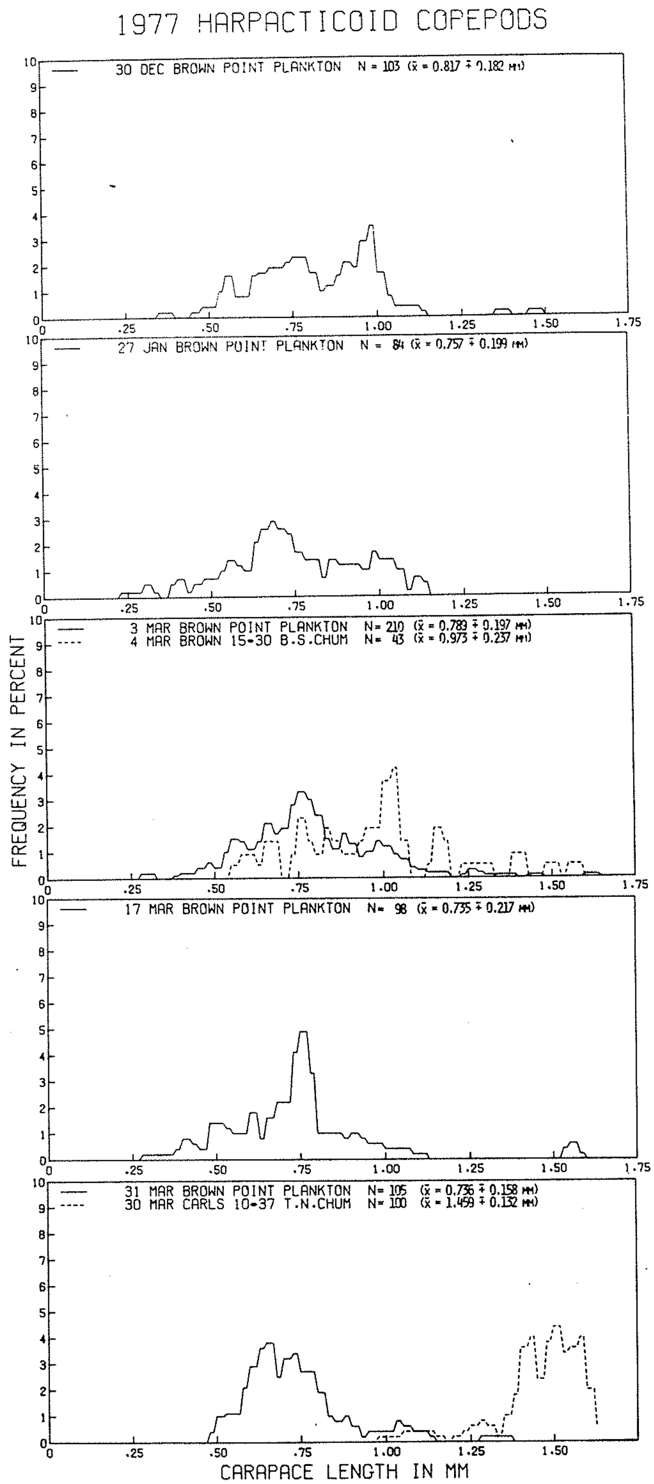


Fig. 43. Harpacticoid copepod size (metasome length) distributions from epibenthic plankton community (solid line) and in stomach contents of juvenile chum salmon (dashed line) during 1977 outmigration period in Hood Canal, Washington.

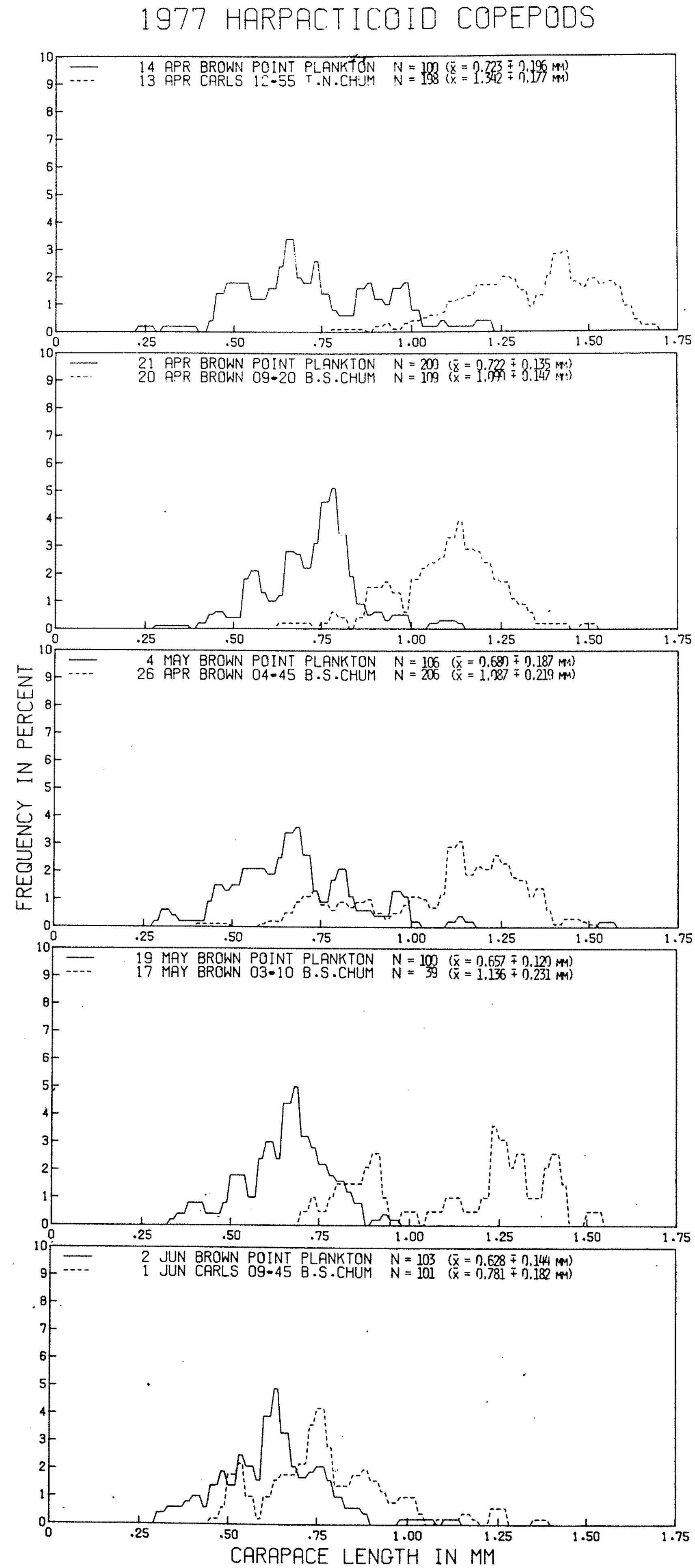


Fig. 43. (continued).

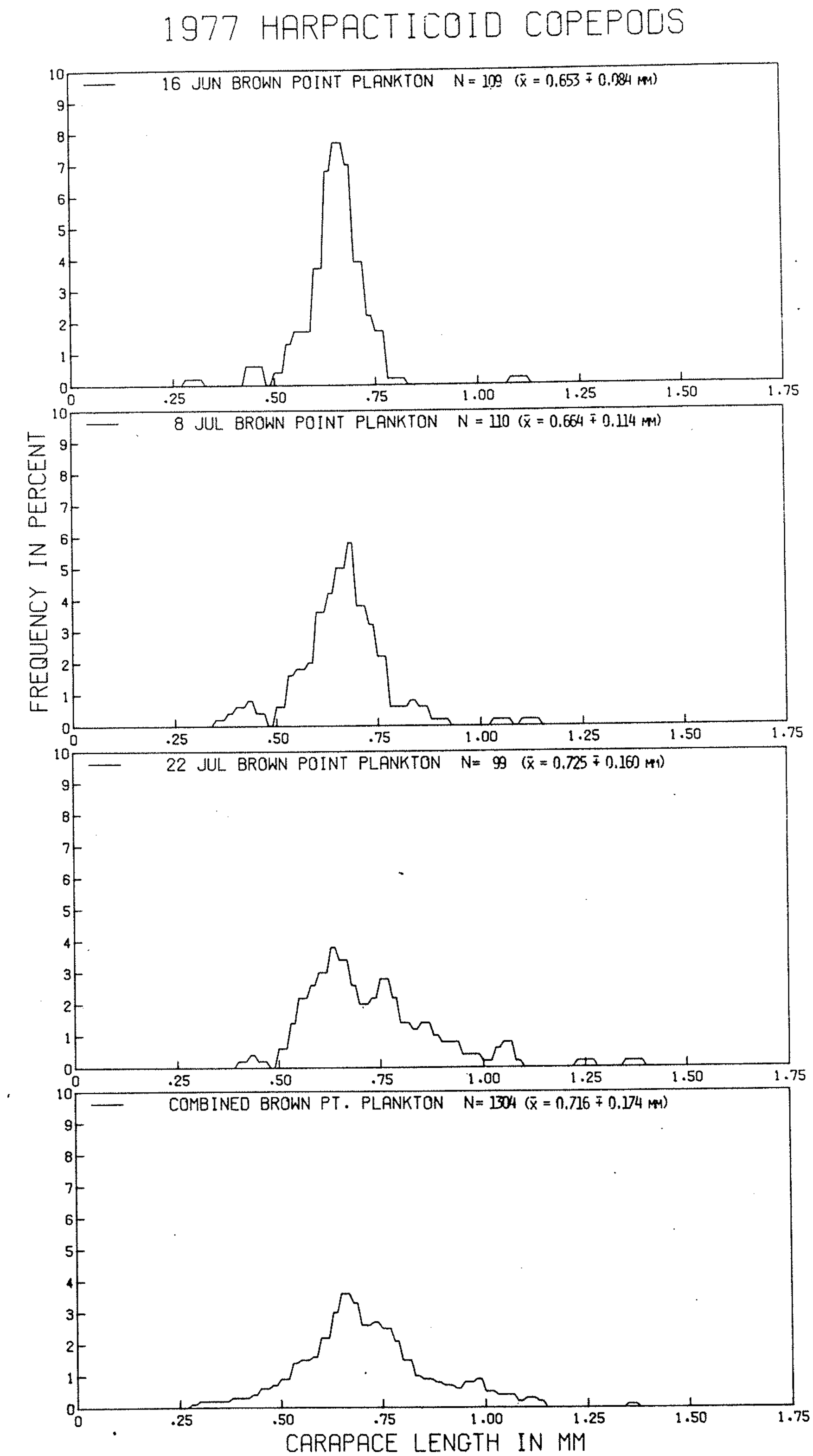


Fig. 43. (continued).

the sizes of harpacticoids found in the stomach contents of juvenile chums caught in the nearshore region adjacent to the plankton pumping site ranged from 1.499 ± 0.132 mm to 0.781 ± 0.182 mm. In many instances the upper distributions of the harpacticoids consumed by the chum fry were completely out of range of those sampled by the plankton pump. In addition, the mean harpacticoid sizes were typically larger in the stomach contents of chum fry caught with the townet in neritic waters compared to those chum fry caught in shallow sublittoral habitats with the beach seine (Fig. 44); this may also reflect size selective predation as a function of predator size since townet-caught chums are also generally larger than those caught in the beach seine.

There was some indication, though far from conclusive, that the intense pressures of such size-specific predation was depressing the mean size distributions of epibenthic harpacticoids during the peak outmigration period.

There were few differences in prey composition for chum fry migrating through the shallow sublittoral zones of different habitats in northern Hood Canal; harpacticoid copepods appear to be the preferred food organism in all cases, accounting for 53-74 percent of the total IRI prey spectra. The highest contributions by harpacticoids originated from chum fry collected north of Devil's Hole Delta. This suggests, and is supported by the epibenthic pump data, that the shallow delta region, with sandy substrate and abundant eelgrass, may provide the maximum abundances of this prey resource. Conversely, gammarid amphipods appear to be most common in the diets of chum fry collected from exposed spits which typically have clean gravel-course sand substrates in the shallow sublittoral zone (Brown Pt., Floral Pt. and Spit 6).

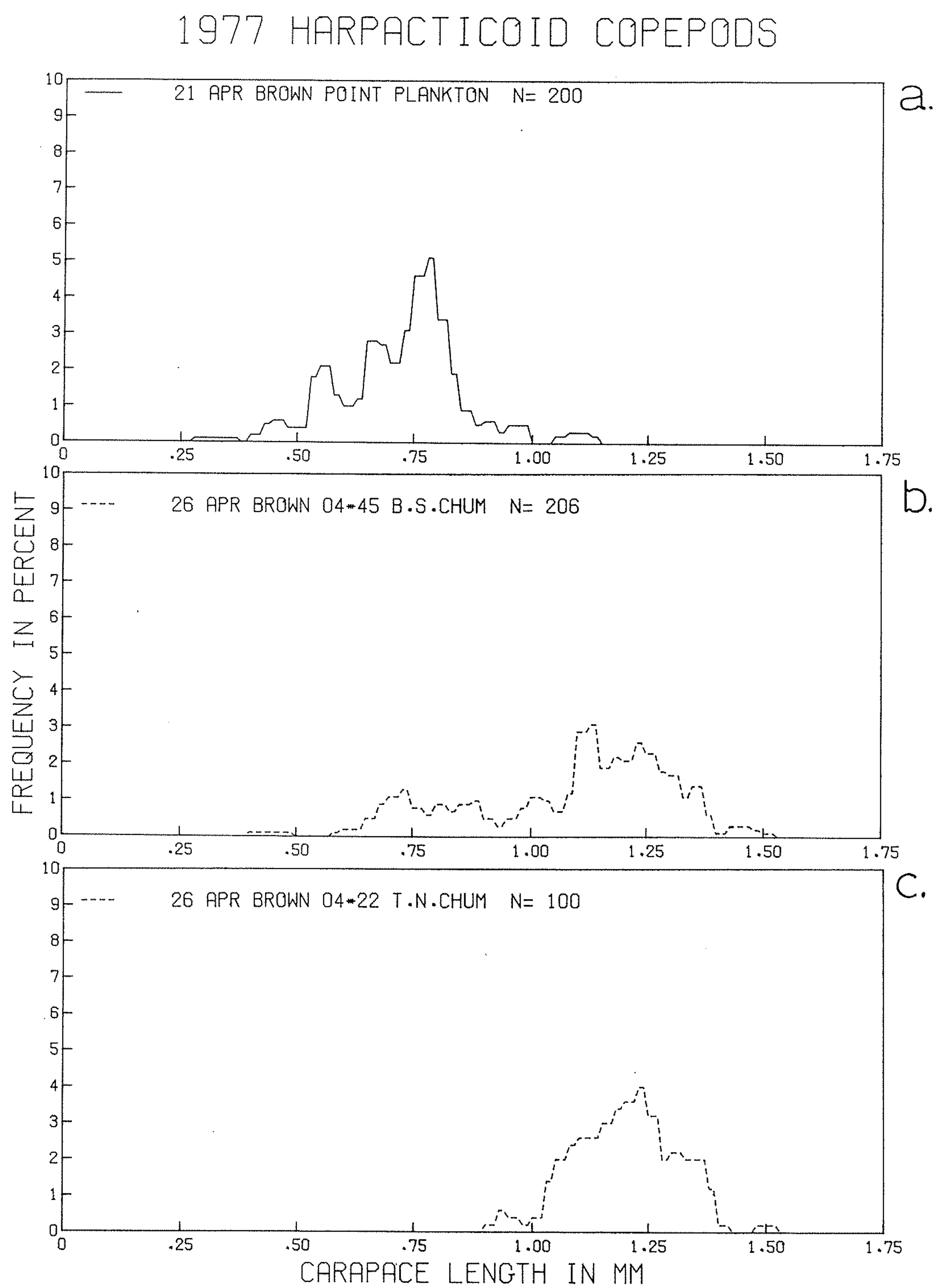


Fig. 44. Harpacticoid copepod size (metasome length) distributions from epibenthic plankton community (a), and from stomach contents of juvenile chum salmon caught in shallow sublittoral (b) and neritic (c) environments in Hood Canal, Washington, late April, 1977.

SUMMARY

1. Beach seine sampling was conducted from January 5, 1977 to July 25, 1977 at eight shoreline stations on the Bangor Annex and four shoreline stations on the west side of Hood Canal.

2. Townetting surveys were conducted from January 28, 1977 to July 25, 1977 at transects in the Hood Canal area adjacent to the Bangor Annex.

3. Chum salmon outmigrants were the most abundant salmonids, with a minor peak of wild stock in early February, and a major peak of both wild and hatchery stock from mid-May to mid-July.

4. Coho salmon appeared in late April, with a minor peak in mid-May, associated with Big Beef Creek stock, and a major peak of wild and hatchery stock in mid-July.

5. Chinook salmon were caught throughout the sampling period, with a small peak of hatchery and wild stock in May.

6. Cutthroat trout were caught over the entire sampling period, with a peak in early June.

7. From 1977 data it appears that the CPUE is affected by hatchery releases, as in 1975 and 1976. Preliminary mark-recapture studies have shown that fry released from the Hood Canal and Big Beef Creek hatcheries are caught at the Bangor Annex (Whitmus & Olson, in press). Further mark-recapture studies are needed if the

contribution of the hatcheries to the CPUE at the Bangor Annex is to be quantified.

8. Larger numbers of salmonids were caught on the west shoreline than in the previous 2 years. This was especially evident in the early wild stocks. The majority of later wild and hatchery stocks was found on the east shoreline.

9. Concentration of salmonids around piers was not noticed in 1977.

10. The mean condition factor of fry caught decreased at the end of the season. A decrease in mean lengths was not evident.

11. Some significant relationships between CPUE and environmental variables were found.

12. Harpacticoid copepods, gammarid amphipods, crustacean eggs, ostracods, calanoid copepods, asselotan isopods, nematodes, barnacle and prosobranch larvae, juvenile shrimp, and cumaceans were the prevalent epibenthic organisms in the area's shallow sublittoral environment.

13. Inshore, chum fry fed predominantly upon harpacticoid copepods and gammarid amphidpods, calanoid copepods, insects, hyperiid amphipods and euphausiids; offshore, they fed upon gammarid amphipods, euphausiids, calanoid copepods, crustacean larvae, hyperiid amphipods and insects.

14. Predation upon chum fry by other salmonids and co-occurring nearshore marine fish did not appear to be significant; only chinook salmon, searun cutthroat trout, Pacific cod and staghorn sculpins had stomach contents including chum fry.

15. Both taxonomic and size feeding selectivity was evidenced by the chum fry.

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APPENDIX TABLES

Appendix Table 1. Comparison of weekly beach seine CPUE of juvenile salmon for the period January 2 to July 28, 1977 in Hood Canal, Washington

Final Day in Sampling Week		STATION 1 South Carlson Point					STATION 2 North Carlson Point				
Month	Day	Chum	Chinook	Coho	Cutthroat	No. hauls	Chum	Chinook	Coho	Cutthroat	No. hauls
January	7					1					
	14					2	24.5;				2;
	21	11.0;6.0[1]				1;1	5.0;				1;1
	28					1	3.0;0.3				3;3
February	4						0.7;0.3				3;3
	11						30.2;0.7				4;3
	18						15.0;0.2				2;4
	25						22.0;1.0				1;1
March	3						4.3;4.2	1.7			3;6
	10						1.7				1;3
	17					1;3	8.0;				1;4
	24					1	1.0;5.7				1;3
	31	0.5				2	0.5				4
April	7	3.0	0.5			2	1.3	0.7			3
	14	19.0				2	1.0				3
	21	9.3				3	6.4				5
	28	242.0				1;3	8.5				1;2
May	5	6.5				2	92.5				4
	12	10.5	0.5	1.0	0.5	2	1.4	0.2	0.5		5
	19	26.0	0.5	14.0		2	11.0		21.6		5
	26	33.3		0.3	1.0	3	216.0		4.0		3
June	2	183.0	0.3	1.0		3	231.2		1.0	0.2	4
	9	22.0;210.0	0.3	1.0		1;3	190.0;354.5		1.0		1;2
	16	333.7		0.3		3	185.0		5.0		1
	23	70.5				2	84.0		0.5		2
	30	176.0		6.5		2	40.0		2.0	0.5	4
July	7	28.5		1.7		4	51.0		0.5		2
	14	42.0		5.0		2	29.3		1.7		3
	21	2.5		1.0		2	25.5		2.5		4
	28	2.0				1					1

[1] Where two entries appear in one column separated by a semicolon, the first figure applies to the 10-m beach seine and the second to the 37-m beach seine.

Appendix Table 1. Comparison of weekly beach seine CPUE of juvenile salmon for the period January 2 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		STATION 3 Devil's Hole					STATION 4 South Delta No. 1				
Month	Day	Chum	Chinook	Coho	Cutthroat	No. hauls	Chum	Chinook	Coho	Cutthroat	No. hauls
January	7										
	14										
	21										
	28										
February	4					1					
	11	0.5; 3.5				2; 2					
	18	54.0;20.5				4; 4					
	25	17.0;68.0				2; 2					
March	3	21.3	0.3			1; 6					
	10	1.7;23.3				3; 3					
	17	9.6				1; 5					
	24	8.5				1; 2					1
	31	1.0				; 3	60.0				3
April	7	12.5				4	6.0				3
	14	7.0				2	59.0				1
	21	3.2				4	3.0				4
	28	14.5				2	4.0				1
May	5	59.0				5	23.3		0.7	0.7	3
	12	24.2				4	0.7		0.5		3
	19	152.7				3				0.3	3
	26	163.7				4	12.3		1.7		3
June	2	163.3				3	23.2	0.2	0.5	1.7	4
	9	33.7				1; 3	0.5	0.5	0.5		2
	16	29.0		0.7		3	75.0		0.5		2
	23	15.0				3	2.0		1.0		1
	30	8.5		3.3		4	7.0				3
July	7	11.5		0.5		4					
	14			0.5		1			2.0		1
	21	1.5		1.0		2	6.0	0.5	2.5		2
	28			1.0		1			3.0		1

Appendix Table 1. Comparison of weekly beach seine CPUE of juvenile salmon for the period January 2 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		STATION 5 South Marginal Wharf					STATION 6 South E.H.W. No. 1				
Month	Day	Chum	Chinook	Coho	Cutthroat	No. hauls	Chum	Chinook	Coho	Cutthroat	No. hauls
January	7					2					
	14	6.0				2					
	21					1					1
	28					2					1
February	4	2.5				1 4	16.0; 3.0				2; 3
	11	10.5; 2.5				2 2	115.0;				1; 1
	18	17.7; 7.7				4 4	183.0;21.7				3; 3
	25	41.0;22.0				2 1	224.0;60.5				3; 2
March	3	155.0; 4.5	0.5	0.2		1 6	88.0;18.8				1; 6
	10	162.7; 5.3	0.5			3 3	3.0; 9.5				2; 2
	17	51.5				4	151.5;114.0				2; 5
	24					1	3.0;125.0				1; 2
	31					3	73.7	0.2			4
April	7	13.5				4	95.2	0.2			4
	14	43.0				1					1
	21	11.5				4	48.2				6
	28	80.0		1.0		1	149.0				1
May	5	0.6				5	15.5		0.2		4
	12	200.0				2	3.2		0.2		5
	19	64.8		6.8		5	42.4		2.8		5
	26	43.5		6.7		2	29.7		2.5		4
June	2	5.3	0.2	3.2		3	77.5	0.2	1.5		4
	9	16.0	0.3	6.0		1 3	20.7		1.6		3
	16	22.5		14.8		4	37.4		1.2		5
	23	1.0				1	37.0		12.0		3
	30	4.8	0.6	2.8		5	82.6	0.2	8.2		5
July	7	10.0		2.6	0.2	5	13.6		1.2		5
	14	3.0		9.0		3	5.0		9.0		2
	21	2.0		2.5		2	2.5		3.0		2
	28					1			2.0		1

Appendix Table 1. Comparison of weekly beach seine CPUE of juvenile salmon for the period January 2 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		STATION 7 South Floral Point					STATION 8 North Floral Point				
Month	Day	Chum	Chinook	Coho	Cutthroat	No. hauls	Chum	Chinook	Coho	Cutthroat	No. hauls
January	7	5.0				3	4.5				2
	14					2					1
	21					1					
	28	2.3				3					2
February	4	10.5 0.5				2; 4					
	11					1; 2					
	18	69.5 20.7				2; 3					
	25	25.3 16.0			0.5	3; 2					
March	3	6.0 24.3	0.3		0.3	1; 6					
	10	21.3 26.3				3; 3					
	17	13.8	0.4			1; 5	2.0				2
	24	1.0 87.0	0.3		1.0	1; 3	2.0				1
	31	37.7	0.3		0.3	3	131.5				2
April	7	34.0				3	16.2			1.0	4
	14	8.3				3	7.5				2
	21	66.5				6	4.0				3
	28	500.0 25.2				1; 4	16.0 9.3				1; 3
May	5	30.6				5	11.0				1
	12	81.0			0.2	4	10.7		1.0		3
	19	4.3		0.3	0.3	3	7.7		2.3		3
	26	25.3				3	3.0				3
June	2	65.7		0.7	0.7	4	1.5		1.0		2
	9	5.0		0.7	0.7	1; 3	11.0				1; 2
	16	5.7	0.3	2.3	0.3	3	20.7		3.3	0.3	3
	23	14.0		3.0		1	10.5				2
	30	50.0		0.5	1.0	2	42.7		0.7	0.7	4
July	7	84.7				3	19.0		3.3		3
	14	3.5		0.5	2.0	2			1.0		2
	21	1.0				3	0.5		5.5		2
	28	33.0		11.0		1			1.0		1

Appendix Table 1. Comparsion of weekly beach seine CPUE of juvenile salmon for the period January 2 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		STATION 9 South Brown Point					STATION 10 North Brown Point				
Month	Day	Chum	Chinook	Coho	Cutthroat	No. hauls	Chum	Chinook	Coho	Cutthroat	No. hauls
January	7										
	14	1.0				1					
	21		1.0			1					
	28		8.3			3					
February	4	0.2	7.8			4 5					
	11	18.5	230.5			2 2					
	18	100.3	52.0			3 3					
	25	13.0	1.0			1 1					
March	3	54.0	25.0			1 6	77.0;32.0				1; 2
	10	7.0	43.0	0.7		4 3					
	17		50.5			4	6.0; 2.7				1; 3
	24					1 2					2
	31		3.0	0.5		2	1.0				2
April	7		3.0			2	7.5				2
	14		47.0	0.3		3	38.0				2
	21		252.0			3	41.5				4
	28	47.0	57.0			1 2	86.0;54.0				1; 2
May	5		16.7			3	7.0				2
	12		8.0	2.0		1	1.7	0.2			4
	19		15.0	1.3	1.0	3	14.7		0.7		3
	26		4.2	2.7	0.7	4	12.5		1.0	0.5	2
June	2		272.0	0.5	0.7	4	37.0				2
	9		28.0	1.3		1 3	52.0		1.5		1; 2
	16		6.7		1.0	3	20.0				3
	23		18.0	2.0	0.5	2	157.0		0.5		2
	30		37.5	7.0		2	100.0		12.5		2
July	7		4.3			3	5.0		19.0		3
	14		5.0	9.0		2	5.5		15.5		2
	21		1.0	5.5		2	0.3				3
	28					1	1.0		3.0		1

Appendix Table 1. Comparison of weekly beach seine CPUE of juvenile salmon for the period January 2 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		STATION 11 South Spit No. 6					STATION 12 North Spit No. 6				
Month	Day	Chum	Chinook	Coho	Cutthroat	No. hauls	Chum	Chinook	Coho	Cutthroat	No. hauls
January	7										
	14	2.0				1					
	21					1					
	28	4.0				3					
February	4					1; 2					
	11										
	18	20.0; 3.0				1; 2					
	25										
March	3	7.0; 5.3	0.1	0.1		1; 6	25.0				2
	10	102.0; 1.0				1; 1					
	17	14.0				1	76.0;6.5				1;2
	24	86.0; 24.0				1; 2					1
	31	48.0				1					
April	7	20.0			1.0	1	3.5				2
	14	6.7				3	4.0				2
	21	59.7				4	0.5				2
	28	2.0; 16.0				1; 2	4.0				1
May	5	4.0				2	2.0				1
	12	13.5	0.5	3.5	2.5	2	2.7	0.2	1.7	1.2	4
	19	1.3		10.0	0.3	3	1.7		3.3		3
	26	7.5		1.0	4.0	2	6.7		9.0	1.0	3
June	2	205.5		0.7	1.7	4	19.5		24.0	0.5	2
	9	6.0		2.7	6.0	1; 3	12.0		9.5	2.0	1;2
	16	16.5			0.5	2	16.2		1.5		4
	23	2.0	0.5	2.0	2.0	2	17.5		0.5	1.0	2
	30	11.7		0.3	1.3	3	7.0		9.0	2.0	1

Appendix Table 1. Comparison of weekly beach seine CPUE of juvenile salmon for the period January 2 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		STATION 11 South Spit No. 6					STATION 12 North Spit No. 6				
Month	Day	Chum	Chinook	Coho	Cutthroat	No. hauls	Chum	Chinook	Coho	Cutthroat	No. hauls
July	7	33.0		0.3		3	2.0		2.0	1.0	3
	14	13.5		5.0		2			5.5		2
	21	2.4		0.4		5			0.7		3
	28	5.0		2.0		1					1

[1] Where two entries appear in one column separated by a semicolon, the first figure applies to the 10-m beach seine and the second to the 37-m beach seine.

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington

Final Day in Sampling Week		TRANSECT No. 13 King's Spit to Carlson Point				TRANSECT No. 14 Carlson Point to Service Pier			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28								1
February	4								
	11				2	3.2			4
	18				1	0.7			6
	25								
March	3					1.0			4
	10					8.5			2
	17	1.0			3	1.4			5
	24				1				3
	31				1	4.0			5
April	7	1.0			1	7.5			4
	14	3.6			5	7.7			4
	21	4.0			2	60.2	0.2		5
	28	7.5			4	26.2			4
May	5				1	29.5	0.2		6
	12	2.0	1.0	3.5	2	2.4	0.2	0.4	5
	19			1.0	2	7.6		2.0	5
	26	29.0			2	82.7	0.2		4
June	2	4.2			4	117.4		0.2	5
	9	135.7			3	726.0		1.0	2
	16	154.0			3	381.5		0.2	4
	23	70.5		2.5	2	285.0		2.5	2
	30	166.2		5.6	5	148.8		2.0	5
July	7	182.0		1.0	4	20.2			5
	14	75.0		3.0	2	110.7		3.0	3
	21	11.6			5	10.7		1.3	4
	28	90.0			1				2

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 15 Service Pier to Devil's Hole				TRANSECT No. 16 Devil's Hole to Marginal Wharf			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28								
February	4								
	11				1	0.5			2
	18				3	1.0			2
	25								
March	3	1.0			2	1.0			2
	10	1.2			4	2.0			4
	17	7.5			2	3.3			3
	24				1	25.0			1
	31	10.7			3	1.3			3
April	7	2.0	0.4		5	2.2			4
	14	0.7	0.3		3	0.5			2
	21	16.7			4	13.2			5
	28	134.7			3	18.0			3
May	5	18.6			7	23.5			4
	12	0.7	0.5	0.5	4	3.2		0.2	5
	19	1.0		1.8	5	1.0		1.5	4
	26	18.7		0.3	3	17.7		2.3	3
June	2	27.0		0.2	4	42.7		0.3	3
	9	66.0		0.5	2	69.5			2
	16	163.3		0.3	3	43.3		1.0	3
	23	324.0		1.0	2	59.0		2.0	2
	30	7.5		0.5	4	11.8		1.4	5
July	7	11.0			4	59.3		0.3	3
	14	41.0		2.0	2	24.0		1.0	1
	21	1.0			2			0.5	2
	28				1				1

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 17 Marginal Wharf to E.H.W. No. 1				TRANSECT No. 18 E.H.W. No. 1 to Buoy B.			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28								1
February	4								
	11	0.5			2				2
	18	1.3			3	2.0			3
	25								
March	3				1	8.0			3
	10	15.7			3				1
	17	3.3			3	2.5			4
	24	4.0			1	4.5			2
	31	7.7			3	15.6			5
April	7	4.8			5	5.2	0.2		5
	14	3.0	0.5		2	3.0	0.3		3
	21	13.4			5	14.5	0.2		6
	28	11.5			4	16.0			4
May	5	10.1			7	22.5			6
	12	1.8	0.2		5	3.4	0.2	1.4	5
	19	0.2		1.7	4	2.2		2.2	5
	26	25.0			2	7.5		0.2	4
June	2	10.7			3	47.8		0.3	6
	9	44.7		0.7	3	34.7			3
	16	225.7			3	169.2			4
	23	15.0		0.5	2	129.0		4.0	2
	30	9.5		1.2	4	52.7		0.7	4
July	7	23.0			3	56.2			5
	14	42.5		3.0	2	41.0		1.5	2
	21				1	10.5			4
	28				1				1

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 19 Bouy Bay to South Floral Point				TRANSECT No. 20 Brown Point to Spit 4			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28				1				
February	4								
	11				3				2
	18	1.0			3				2
	25								
March	3				2				2
	10				1	2.0			1
	17	9.5			2	0.5			2
	24	1.0			2				2
	31	1.6			5	1.0			1
April	7	5.8	0.2		5	1.0			1
	14	1.7	0.3		3	1.7			4
	21	5.0			5	10.0			2
	28	23.0			4	3.5			4
May	5	8.8			5	17.0			2
	12	0.7		0.5	4	1.7		0.3	3
	19	2.5		0.5	2	14.5			2
	26	8.0	0.2	0.5	4	13.7			3
June	2	57.6	0.6	2.2	5	0.5			2
	9	17.0			3	74.5			2
	16	245.7	0.7	0.2	4	22.0		0.2	4
	23	191.0		3.0	1	32.5		2.5	2
	30	145.2		0.7	4	4.5		8.5	2
July	7	51.0		1.3	3	2.5			2
	14	0.5			2	14.0			2
	21	11.2			4				1
	28				1				1

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 21 North to South Spit No. 4				TRANSECT No. 22 Spit No. 5 to Spit No. 4			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28								
February	4								
	11	2.5			2	1.0			1
	18	2.0			2				2
	25								
March	3				2	10.0			2
	10				2	0.5			2
	17				2	3.0			1
	24	6.0			2	0.5			2
	31	0.5			1	2.0			1
April	7	3.5			2				1
	14	1.0			4	2.0			4
	21	36.3			2	5.0			2
	28	18.5			3	100.3			3
May	5	1.5			2	8.3			3
	12	11.0			4	1.0		0.7	3
	19	121.0		1.0	4	62.7		0.7	4
	26	11.7		0.3	3	44.0			4
June	2	25.0	0.3		3	29.5			2
	9	61.0			2	30.0			2
	16	44.5			2	50.0			2
	23	17.5			2	79.5		1.5	2
	30			1.5	2	36.5		4.5	2
July	7				2	6.0			2
	14			0.5	2	39.5			2
	21			1.5	2	0.3		0.7	3
	28								

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 23 Spit 6 to Spit 5				TRANSECT No. 24 Spit 6 to Midcanal			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28								
February	4								
	11				1				
	18	0.5			2				1
	25								
March	3	9.3			3				
	10				1				
	17	9.5			2				
	24	1.5			2				
	31	3.0			1				
April	7				1	1.0	1.0		1
	14	1.7			4	5.0			1
	21	6.0			2	1.7			3
	28				2	3.7			3
May	5	32.5			2	7.0			2
	12	1.0		0.7	3				1
	19	3.0		0.5	2				
	26	41.5		0.5	2				
June	2	1.0			1	5.0			1
	9	49.5			2				
	16	5.5			2				1
	23	68.5			2				
	30	0.5		2.0	2	1.0			1
July	7	20.0			2				
	14	24.0		0.5	2	0.7		0.3	3
	21				2				
	28								

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 25 Midcanal to Floral Point				TRANSECT No. 26 Brown Point to Midcanal			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28								1
February	4								
	11				2				3
	18					0.3			3
	25								
March	3					1.0			4
	10								
	17					4.3			3
	24								2
	31								1
April	7	0.5			2	4.2			4
	14	1.0			2				1
	21	18.0			3	0.7			4
	28	1.3			3				1
May	5	1.0			3				4
	12				2	0.5			2
	19					0.5		0.5	2
	26					3.5			4
June	2	10.0			1	18.0			1
	9					39.5			2
	16				1				
	23								
	30				2	31.0			3
July	7					1.0			2
	14	1.0			2	1.7			3
	21								
	28								

Appendix Table 2. Comparison of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 27 Midcanal to E.H.W. No. 1				TRANSECT No. 28 Brown Point to Midcanal			
Month	Day	Chum	Chinook	Coho	No. tows	Chum	Chinook	Coho	No. tows
January	7								
	14								
	21								
	28				1				1
February	4								
	11				3				2
	18	0.7			4				2
	25								
March	3				2	1.0			1
	10					3.0			1
	17				2	2.5			2
	24				1				3
	31				1				1
April	7					1.0			1
	14	0.7			3	2.8			6
	21	2.0			1	2.0			3
	28	0.5			4	2.7			4
May	5				1	9.0			2
	12	0.2		0.2	4			0.5	2
	19	3.3		2.7	3	2.0		0.7	2
	26	3.0		0.5	2	5.0		0.2	4
June	2	36.2			4	2.3		0.3	3
	9	6.0			1	31.0			2
	16	20.7			3	21.5			2
	23					27.5			2
	30				1	1.0		2.0	1
July	7	20.3		0.3	3	16.7			3
	14	1.5			2				2
	21	2.5			2				2
	28								2

Appendix Table 2. Comparisons of weekly surface townet CPUE of juvenile salmon for the period January 28 to July 28, 1977 in Hood Canal, Washington - continued

Final Day in Sampling Week		TRANSECT No. 29 Midcanal to Service Pier			
Month	Day	Chum	Chinook	Coho	No. tows
January	7				
	14				
	21				
	28				1
February	4				
	11	1.7			3
	18	0.3			3
	25				
March	3	0.5			2
	10				1
	17	2.3			3
	24				2
	31	2.0			1
April	7	1.0			1
	14	3.2			4
	21	2.0			3
	28	10.0			3
May	5	7.5			2
	12				3
	19				2
	26	11.7			3
June	2	1.2			4
	9	36.0			2
	16	4.5			2
	23	21.0			2
	30	42.0			2
July	7	4.3			3
	14	0.5			2
	21	0.5			2
	28	1.0			1

Appendix Table 3. Releases of juvenile chum salmon from Quilcene, George Adams and Hood Canal fish hatcheries during the period from March to July, 1977

		Quilcene Hatchery (U.S. Dep. Fish Wildl.)		Hood Canal Hatchery (Wash. Dep. Fish.)		George Adams Hatchery (Wash. Dep. Fish.)	
Month	Date	No. of fish	Mean fork length (mm)	No. of fish	Mean fork length (mm)	No. of fish	Mean fork length (mm)
March	11			282,825	40		
April	5			575,580	40		
	5			1,184,010	40		
	5			280,462	40		
	20			982,833	54		
	4-22					1,500,000	
	22					3,500,000	41
	28			662,070	51		
	30			225,000	51		
May	11			518,175	58		
	16			184,656	77		
	19			3,030,250	55		
	23	197,425	54				
	23	336,285	58				
	31	178,200	64				
June	1	296,200	64				
	2	385,800	64				
	3	146,000	64				
	5			414,145	58		
	8	566,255	61				
	13	340,560					
	14	362,766					
	15	130,203	61				
	16	390,553					
	17	384,610					
	20	336,592	63				
	21	155,220					
	27	773,813					
	28	679,447					
	29	631,263					
July	5			519,750			
Totals		6,291,192		8,859,755		5,000,000	

Combined Total = 20,050.947

Appendix Table 4. Releases of coho and chinook salmon smolts from Quilcene and Hood Canal fish hatcheries into Hood Canal, Washington, 1977

Hood Canal Fish Hatchery (WDF)				Quilcene Fish Hatchery (USFWS)			
Date of Release	Fish* Species	Number of Fish Released	Fish/lb	Date of Release	Fish* Species	Number of Fish Released	Fish/lb
February 26	S/FCS	179,400	10	March 30	Coho	420,000	375
April 21	SCS	58,650	510	April 1	Coho	460,000	383
22	SCS	49,447	197	18	Coho	129,870	26
May 3	FCS	195,360	120	26	Coho	63,986	26
12	FCS	549,800	100	May 2	Coho	125,750	25
18	FCS	85,512	84	9	Coho	64,550	25
June 27	Coho	149,760	16	10	Coho	191,250	25
				19	Coho	270,000	385
				20	Coho	84,000	20
				June 21	FCS	210,600	150
				22	FCS	913,350	150
				23	FCS	448,980	140

* Key to Fish Species: FCS - Fall Chinook; SCS - Spring Chinook; S/FCS - Spring/Fall Chinook.

Appendix Table 5. Nearshore fish samples analyzed for stomach contents and summary statistics, Hood Canal, 1977.

Species	Sample size, n	% empty stomachs	Stomach fullness factor $\bar{x} \pm 1S.D.$	Contents digestion factor $\bar{x} \pm 1S.D.$	Total prey abundance $\bar{x} \pm 1S.D.$	Total prey weight $\bar{x} \pm 1S.D.$	Shannon-Weiner diversity index (Numbers)	Shannon-Weiner diversity index (Biomass)	Brillouin diversity index (Numbers)
Squalus acanthias, Spiny dogfish	12	0	1.9 ± 1.1	1.8 ± 1.4	18.5 ± 26.6	2.25 ± 2.64	2.45	3.19	2.34
Clupea harengus pallasi, Pacific herring	5	0	2.0 ± 2.8	1.4 ± 1.9	198.6 ± 318.6	0.24 ± 0.38	1.91	1.51	1.88
Oncorhynchus keta, Chum salmon [beach seine]	267	0.1	3.4 ± 1.6	3.3 ± 2.0	101.8 ± 615.7	0.02 ± 0.07	2.53	3.48	--
O. keta [townet]	178	2	3.4 ± 1.0	4.1 ± 1.1	105.9 ± 148.2	0.06 ± 0.09	3.01	4.33	--
O. kisutch	36	0	3.5 ± 1.3	3.8 ± 1.3	244.7 ± 438.5	0.34 ± 0.40	2.20	4.84	2.19
O. tashawytscha	13	0	3.3 ± 1.6	3.5 ± 1.6	35.4 ± 52.0	1.49 ± 2.47	2.80	4.28	2.70
Salmo clarki, Cutthroat trout	21	4	3.4 ± 1.5	3.4 ± 1.8	90.3 ± 198.3	4.45 ± 6.49	2.50	5.08	2.45
S. gairdneri, Rainbow trout	7	12	3.9 ±	4.6 ±	56.0 ± 54.2	0.58 ± 0.27	2.82	4.13	2.71
Merluccins productus, Pacific hake	5	0	2.6 ± 1.5	2.6 ± 1.8	24.8 ± 35.7	0.06 ± 0.14	2.32	0.05	2.15
Microgadus proximus, Pacific tomcod	4	0	3.3 ± 1.9	2.3 ± 1.9	27.2 ± 23.2	0.31 ± 0.41	2.29	0.02	2.14
Gadus macrocephalus, Pacific cod	2	0	2.5 ± 0.7	2.0 ± 0.0	25.0 ± 21.2	<C.001	1.11	2.58	0.94
Hexagrammos stelleri, Whitespotted greenling	3	0	4.3 ± 1.5	3.3 ± 0.6	12.7 ± 7.1	4.62 ± 6.17	2.39	2.95	2.04
Enophrys bison, Buffalo sculpin	2	33	4.3 ± 1.2	5.0 ± 0.0	2.0 ± 1.4	1.3 ± 0.42	1.58	1.58	0.86
Myoxocephalus polyacanthocephalus, Great sculpin	2	0	3.5 ± 0.7	3.0 ± 1.4	30.0 ± 28.3	<0.001	2.47	3.46	2.15
Scorpaenichthys marmoratus, Cabezon	1	0	7	5	19	350.67	1.72	1.92	1.41
Leptocottus armatus, Staghorn sculpin	12	0	3.8 ± 1.1	3.3 ± 1.7	17.0 ± 24.2	3.17 ± 5.37	3.32	0.46	3.07
Embiotoca lateralis, Striped seaperch	1	0	5	3	1130	<0.001	0.10	3.00	0.09
Cymatogaster aggregata, Shiner perch	7	0	2.4 ± 2.3	1.4 ± 1.0	18.0 ± 38.2	0.87 ± 2.31	2.69	0.07	2.44
Platichthys stellatus, Starry flounder	9	0	3.1 ± 2.0	2.6 ± 1.4	57.2 ± 106.8	3.95 ± 9.06	2.82	1.24	2.66