FRI-UW-7921
November 1979

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

SALMONID OUTMIGRATION STUDIES IN HOOD CANAL

FINAL REPORT, PHASE IV

January to July 1978

by

Nicholas J. Bax, Ernest O. Salo
and Bruce P. Snyder

This work was sponsored by the U.S. Navy, and the Washington Sea Grant Program under the National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Approved

Submitted November 28, 1979

Robert L Burgner
Director

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX TABLES

LIST OF FIGURES

LIST OF APPENDIX FIGURES

ACKNOWLEDGMENTS

The 1978 field crew of Clifford Whitmus, Gary Maxwell, Eric Martinson, and Keith Kurko made this project a success through their cooperation and long hours of hard work. Their contributions are gratefully acknowledged. The help of Katie Swanson in computer programming was invaluable. We thank Steven Schroder for his advice and critique of the data. Mrs. Dorothy Beall and staff provided a great service in finalizing the manuscript.

This study was made possible by funding provided by the U.S. Navy and by the Washington Sea Grant Project under the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

INTRODUCTION

The fourth phase of a 5-year program to monitor the migrations of juvenile salmonids in the Bangor area of Hood Canal was completed by the Fisheries Research Institute (FRI) in 1978. This report presents data from January through July 1978.

The area of Hood Canal studied was the Bangor Annex, site of the U.S. Naval Submarine Base now under construction (Fig. 1). The juveniles or smolts of four species of salmon and two species of anadromous trout pass through the area during their outmigrations. These outmigrations comprise both wild stocks, from rivers flowing into Hood Canal, and hatchery stocks from the George Adams, Hood Canal, Big Beef Creek, and Quilcene fish hatcheries. These juveniles migrate out of Hood Canal during their first month of acclimation to the marine environment. This period of early marine life is one of the least studied periods in their lives (Allen 1974). Chum salmon populations have been characterized by extreme fluctuations in abundance (Bakkala 1970) and considerable evidence from various sources has suggested that the early marine period may be of prime importance in determining these fluctuations (Shepard 1948; Manzer and Shepard 1962; Martin 1966; Neave 1966a; Hurley and Woodall 1968; Kron 1976; Taylor 1976; and others). Gilhousen (1962), studying the Fraser River pink salmon, concluded that the conditions for survival in the early marine environment have been so variable that variations in fry abundance have had a secondary effect on total survival. Work by Wickett (1958) and Vernon (1958) found close correlations (up to 89%) between coastal water salinity and temperatures during the outmigrations of the fry and the subsequent returns of adult pinks. Blackbourn (1976), looking at the seven odd-year runs of Fraser River pink salmon since 1963, explained over 90% of the variance in marine survival (with groups of three factors) operating on the migrating fry. These factors included river discharge, solar radiation, timing, and initial size of the pinks, and catch-per-unit-effort (CPUE) of coho in the area. Parker (1965, 1968) and Hunter (1959) have tried to numerically evaluate the early mortality of pink and chum fry. Parker marked two groups of Bella Coola area pink fry at different periods of their outmigration and compared the numbers of returning adults. If it is assumed that the two groups suffered the same exploitation rate given the temporal and spatial differences, then any difference in percentage return of adults would be attributable to the period between the two markings. Extrapolating these data, Parker estimated that losses of 77, 55, and 59% occurred during the first 40 days of marine life in 1961, 1962, and 1963, respectively. Hunter (1959) found losses of a similar magnitude studying mortality along a 2-mile stretch of Hooknose Creek. Mortalities of 23-85% were computed for pink and chum salmon fry.

This study was designed to monitor the effect of environmental conditions and the impact of pier construction on migrating juvenile salmonids. An additional Navy-funded salmonid monitoring study was conducted in conjunction with the outmigration project to determine the effects of the Explosives Handling Wharf (EHW) security lighting on

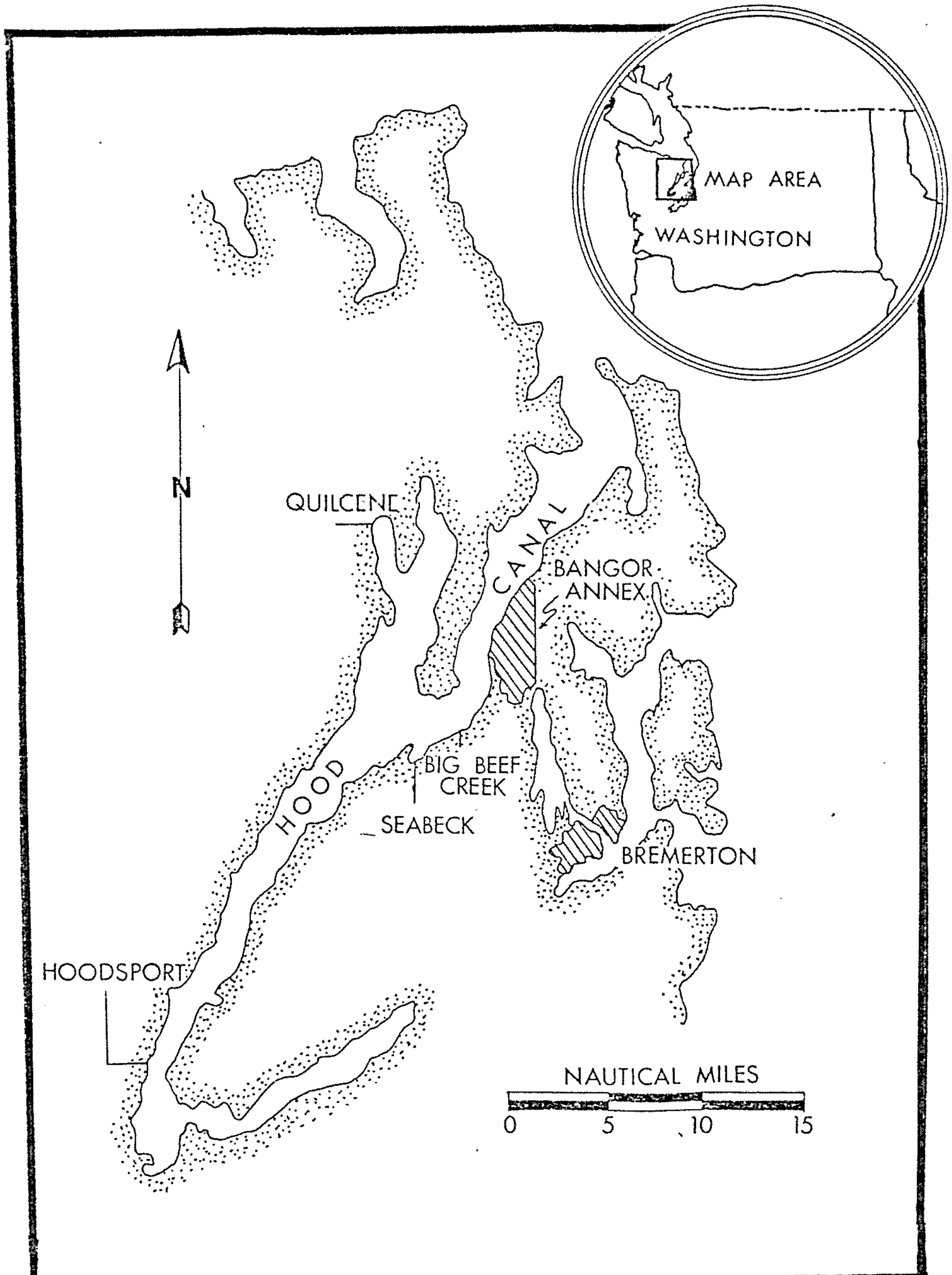


Fig. 1. Location of Hood Canal, Bangor Annex, Big Beef Creek, Quilcene, and Hoodsport hatcheries.

salmonid migratory behavior (Prinslow, Salo, and Snyder 1979). Chum salmon were marked with fluorescent pigments and released from Big Beef Creek, then traced northward to Bangor and intensively monitored through the EHW area. This study required additional beach seining and townetting during March and April of 1978; these outmigration data are included in the lighting report (Prinslow et al. 1979).

The objectives of this fourth outmigration study were to:

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

2) Determine the effect of the Hood Canal and Quilcene fish hatchery releases into Hood Canal on the CPUE of salmonids at the Bangor Annex.

3) Further investigate the preference observed in 1976 of migrating chum smolts for the east shore (the shore where the piers are being constructed).

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

5) Monitor environmental conditions to which outmigrants were subjected, such as water temperature, salinity, currents, tides, and weather, to enable any important environmental variables affecting their distribution to be singled out.

6) Collect length and weight data on the captured salmonids to determine if smolts of different sizes or condition factors are to be found in different habitats.

METHODS AND MATERIALS

The University of Washington Fish Research Station located at Big Beef Creek was used as the base for study operations. The R/V TENAS, M/V NARWHAL, and attendant skiffs used in the sampling procedure were based at Seabeck, about 10 km south of the Bangor Annex.

Nearshore Sampling

Seven beach seine stations on the east shore and four on the west shore (Fig. 2) were sampled regularly from January to late June. A 10-m x 2-m beach seine of 6-mm stretch-mesh bag was used at the beginning of the season until late March. With one man at either end of the net a transect of 30 m long and parallel to the shore was seined. The maximum depth of the transect was 1.5 m.

When more personnel became available in March, a 37-m beach seine with 18-m, 3-cm stretch-mesh wings and a 0.6-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 June. The seine was set 30 m from and parallel to the shore by means of an outboard skiff. With two men on a rope at either end of the seine, the net was drawn to the shore. At 10 m distance from the shore the wings of the seine were closed, funneling the catch into the bag. The seine was operated as a floating seine, this technique having proved most effective for the capture of salmonid smolts in the 1975 and 1976 field seasons.

Offshore Sampling

From March until late July surface townet transects 0.8 km long were sampled (Fig. 4). Increased emphasis was placed on the distribution of fish near to, and away from, shore in 1978. The sampling net was a surface trawl with a 3-m x 6-m opening and stretch-mesh sizes ranging from 76 mm at the opening to 6 mm at the bag (Fig. 5). The wings of the gear were spread vertically by 3.8 cm diameter galvanized pipes and were connected by short nylon bridles to single warps leading to each vessel. The net was towed between the R/V TENAS, an 11.6-m diesel-powered vessel moving at a water speed of between 1.5 knots and 2.0 knots, and the M/V MARWHAL, a 7.9-m motor whaler. At 10-min intervals, two crewmen in an outboard skiff pursed the cod-end of the townet and removed all fish. This technique allowed continuous sampling of the offshore transect pattern. The fish were identified and sorted in the skiff while the next transect was towed.

Environmental Data Collection

Salinity, temperature, and visibility readings were taken after each beach seine set. A water sample was taken at 1 m depth, 10 to 15 m from shore. The temperature of this sample was taken using a

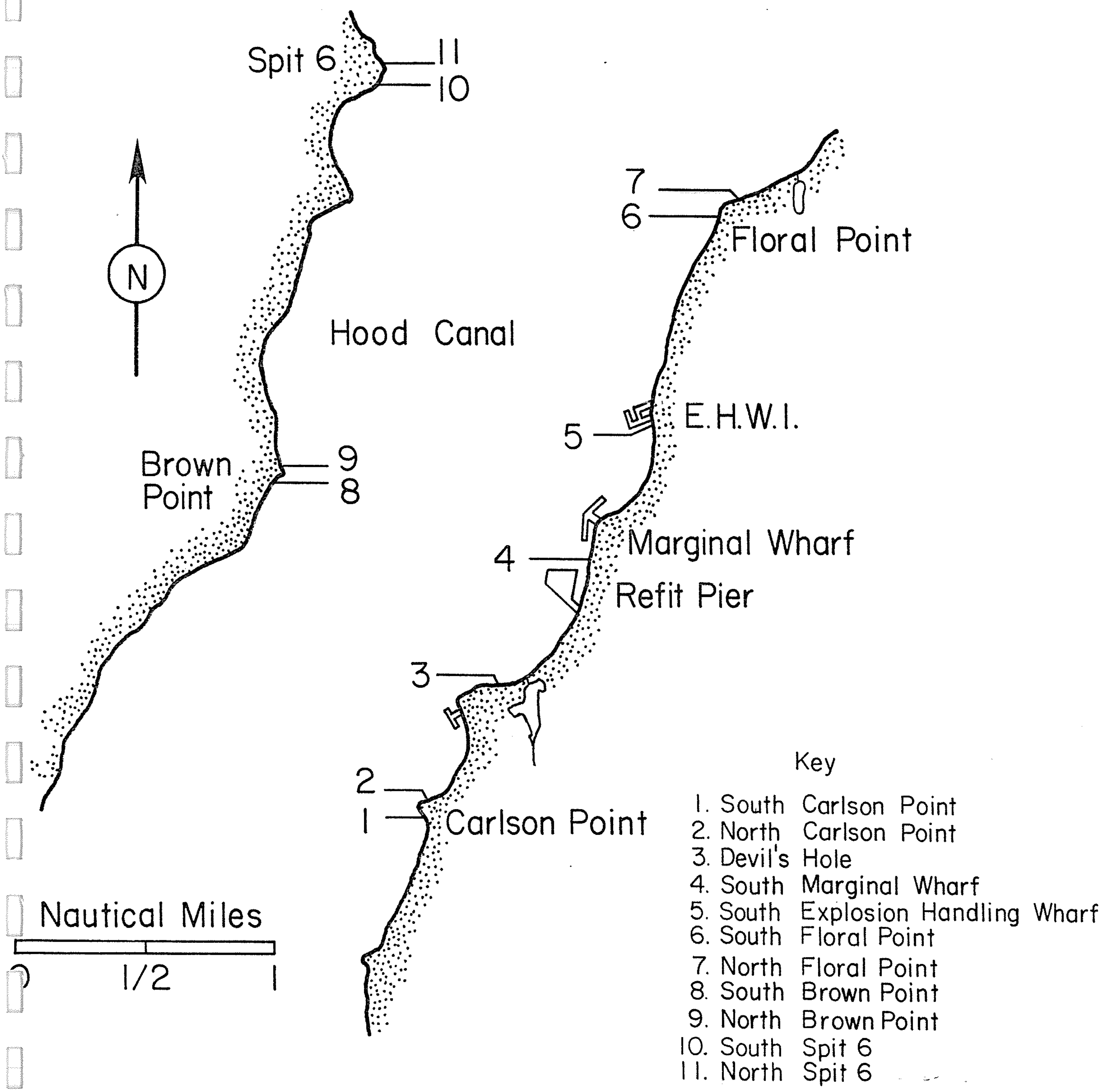


Fig. 2. Beach seine sampling stations for shoreline salmonid outmigration studies, January through July 1978, Hood Canal, Washington.

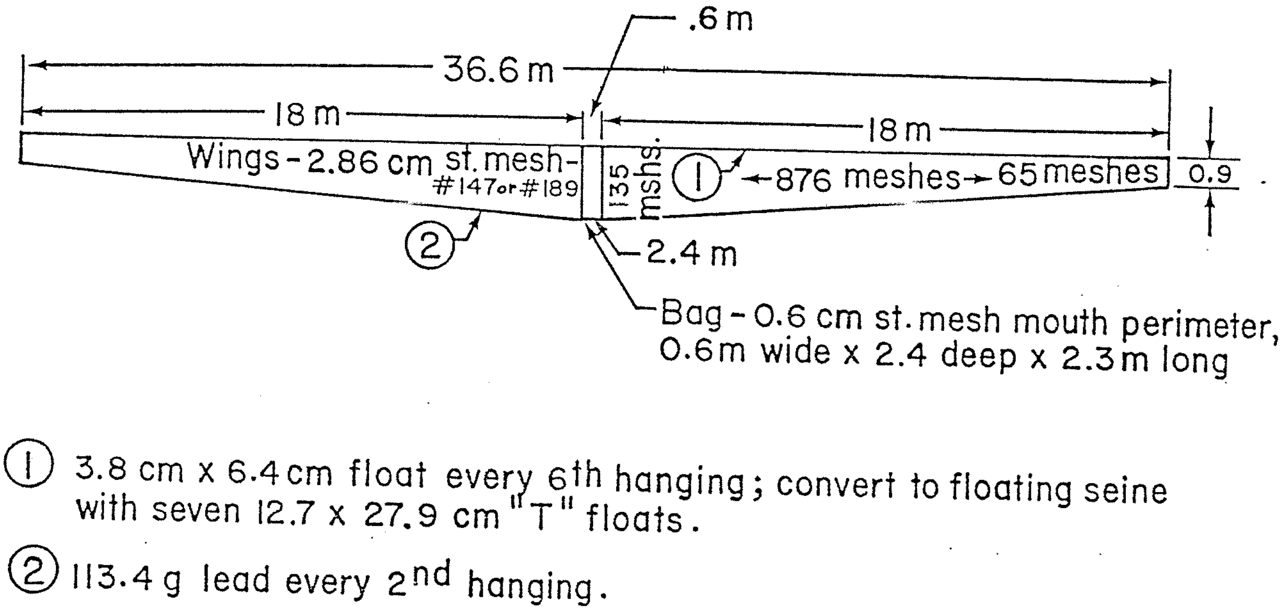


Fig. 3. Convertible beach seine utilized during nearshore surveys, April through June 1975 and February through July 1976, in Hood Canal, Washington.

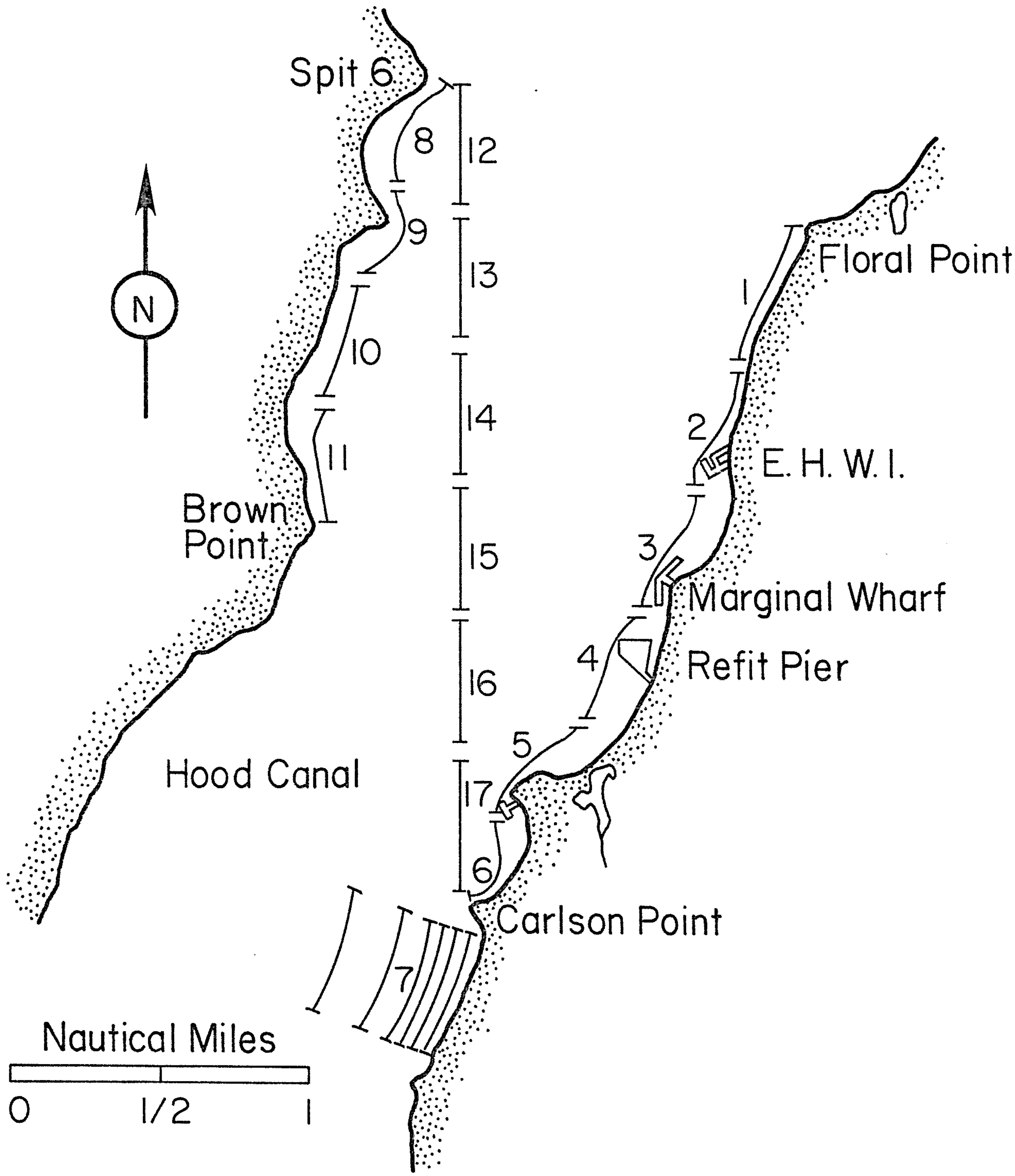
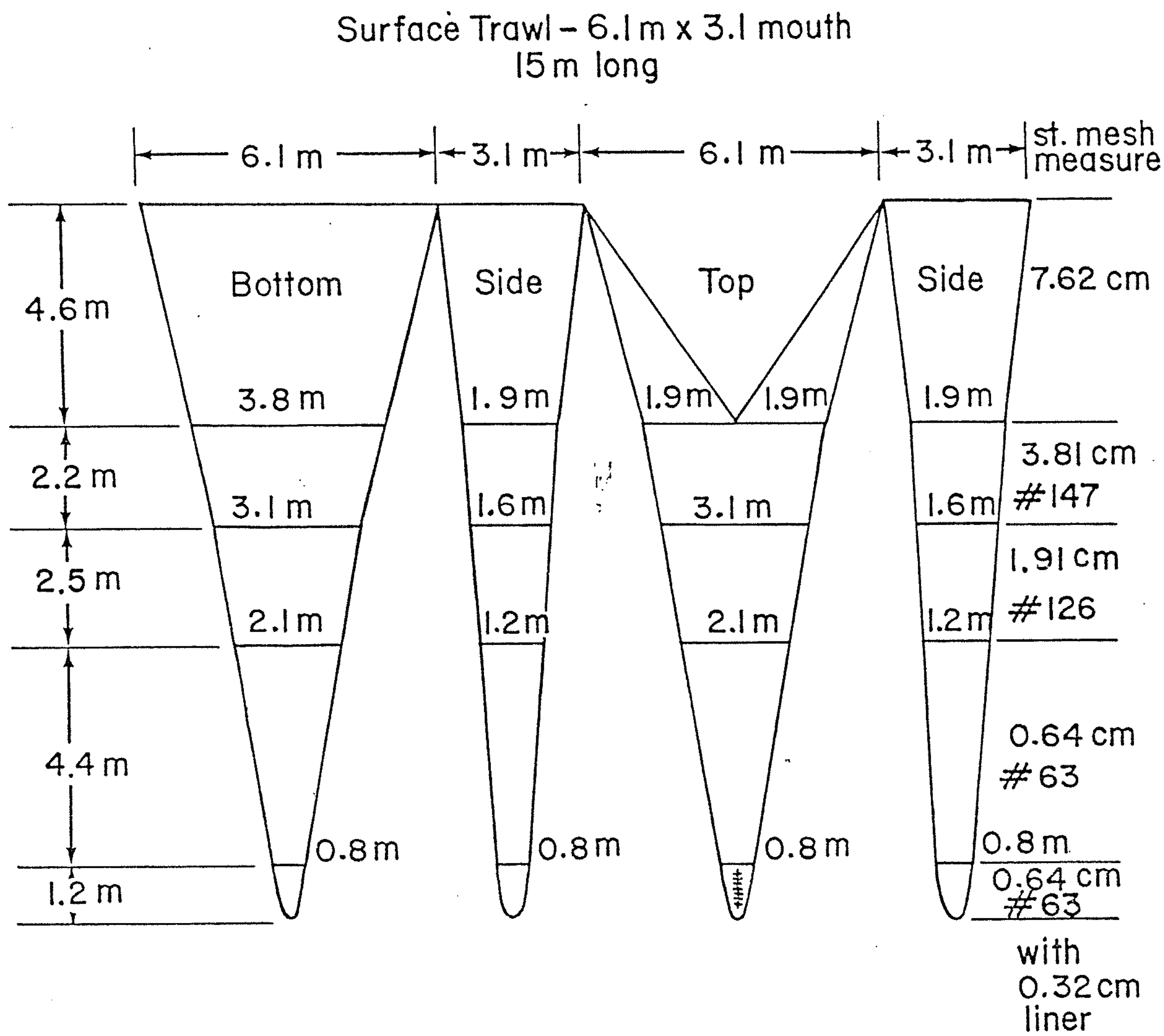


Fig. 4. Townet surface trawl pattern used during salmonid outmigration studies, January through July 1978, Hood Canal, Washington.



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 - 0.64 cm seam.

Fig. 5. Surface townet utilized during offshore sampling in mid-May and mid-July 1975 and April through July 1976, in Hood Canal, Washington.

mercury thermometer. Salinity was taken using an American Optical T.C. Refractometer, calibrated before each sampling period against the induction salinometer used while townetting.

During each tow, temperature and salinity readings were taken at 1 m depth using a Kahl Scientific Instrument Corporation Model RSF-3 electrodeless induction salinometer, calibrated before each set of transects with a coil of known resistance. Water visibility measurements were taken at the beginning and end of each tow using a 15-cm Secchi disk, and a mean value for each transect found.

RESULTS AND DISCUSSION

Catch-Per-Unit-Effort

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

$$CPUE = C_j / E_j$$

where C_j is the number of fish caught in the interval j and E is the effort during the same interval. One unit of effort was established as being a 10-min haul with the surface townet or one retrieval of the 37-m beach seine set 30 m from shore. The CPUE for the two gears cannot be quantitatively compared until gear efficiency experiments have been conducted.

In the presentation of the data the CPUE is averaged over a week because daily sampling was inconsistent with regard to tidal conditions Weekly sampling was consistent in this regard.

The CPUE data for pink and chum salmon with both gears were found to be lognormally distributed. Consequently, logarithmic transformation was used, where the dependent variable (D.V.):

$$D.V. = \log_{10} (CPUE + 1)$$

Environmental Results

Environmental data were collected following both beach seine and townet hauls. The data from both collections showed similar trends and will be considered together.

Water visibility, as measured with a Secchi disk, was highest at the start of sampling in March, dropped until late May/early June, and then increased until the end of sampling (Fig. 6).

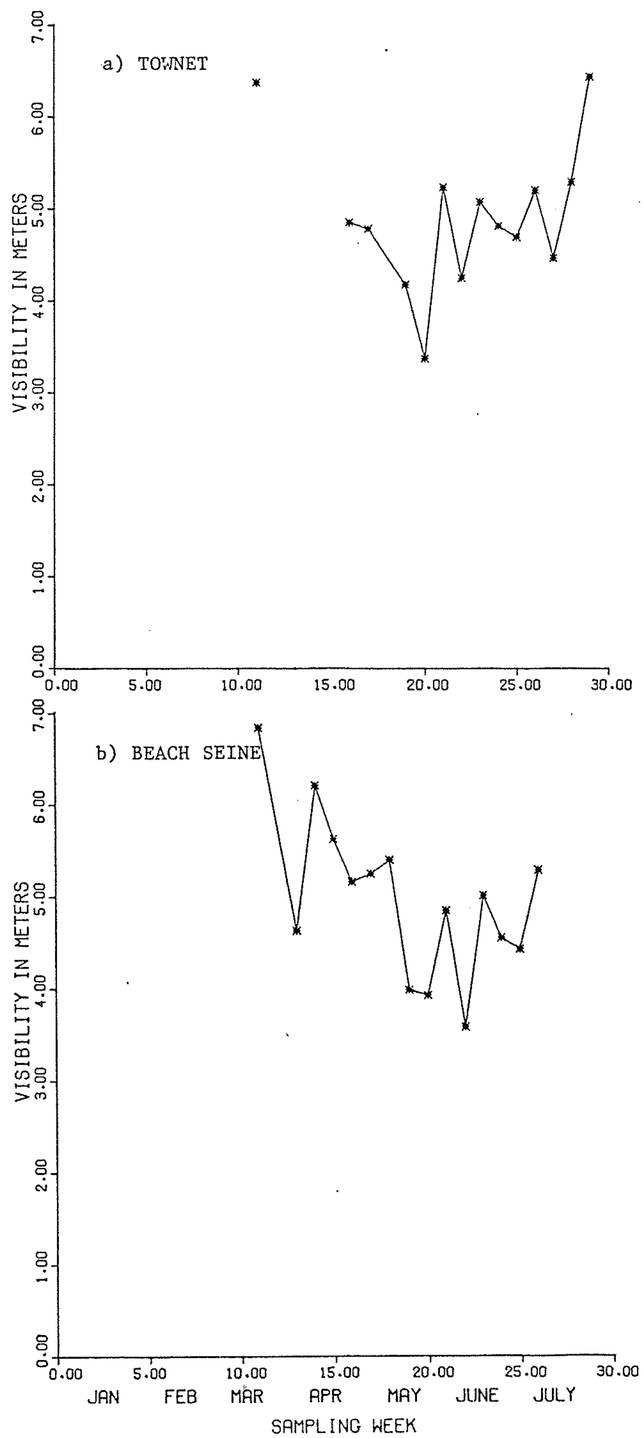


Fig. 6. Mean visibility at a) townet and b) beach seine sites as measured with a Secchi disk in Hood Canal, Washington, 1978.

Salinity increased gradually throughout the sampling season, although weekly fluctuations were obvious, especially for beach seine data (Fig. 7). Whether these weekly fluctuations are significant is uncertain as the refractometer used gave variable readings, accuracy being no better than 1 ppt.

Water temperatures gradually rose throughout the sampling season (Fig. 8). A peak, particularly evident in the townet records, was noticed in early June. This followed a week of unseasonably hot temperatures.

Migration Periods and Peaks

Chum Salmon

Chum salmon smolts were the predominant salmonid species captured in the beach seine and townet in 1978. Similar trends in the CPUE were found with both gear types (Figs. 9-12).

From late February to mid-March two small peaks in CPUE were noticed with the beach seine (townet sampling had yet to begin). These peaks, occurring before the first hatchery releases (Fig. 13), represent the outmigration of naturally-spawning chum salmon stocks. The CPUE for both gears increased subsequent to the initial releases of hatchery-reared chum salmon smolts, with several smaller peaks before the major peak in late May for the beach seine and late June to early July for the townet. The CPUE had apparently started to decline by the end of sampling in mid-July.

Pink Salmon

Pink salmon fry were the second most abundant salmonid caught at the Bangor Annex in 1978. Pink fry were captured from late February to early July with both gears (Figs. 14-17). Peak abundance occurred in April and May. As the hatchery releases of pink salmon occurred at the same time as the first recaptures at Bangor Annex (Fig. 18), it was difficult to distinguish the outmigrations of naturally-spawned and hatchery-reared fry.

Coho Salmon Smolts

The third most abundant salmonid species caught in 1978 was coho salmon smolts. Coho smolts were caught sporadically from March until May (Figs. 19 and 20). From mid-May and through to the end of sampling in July the numbers caught increased, peaking in early June and perhaps early July. This second peak was noticed only with the west shore townet data. Beach seining had been terminated at this point.

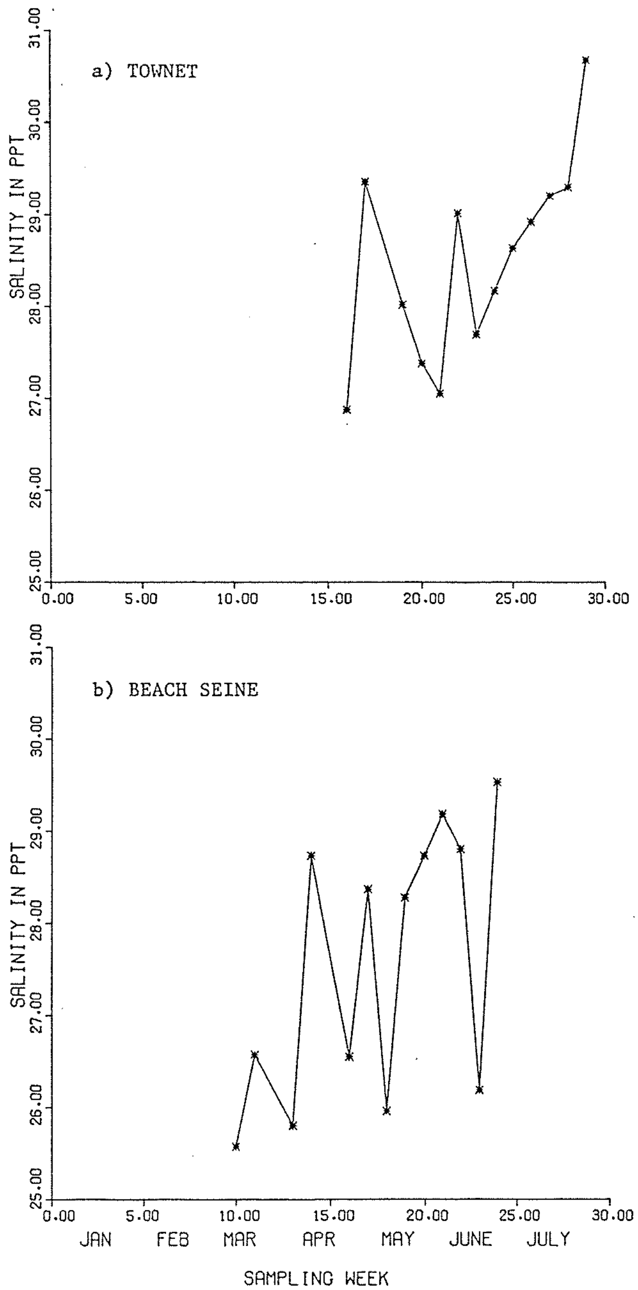


Fig. 7. Mean weekly salinity at 1-m depth at, a) townet, and b) beach seine sites in Hood Canal, Washington, 1978.

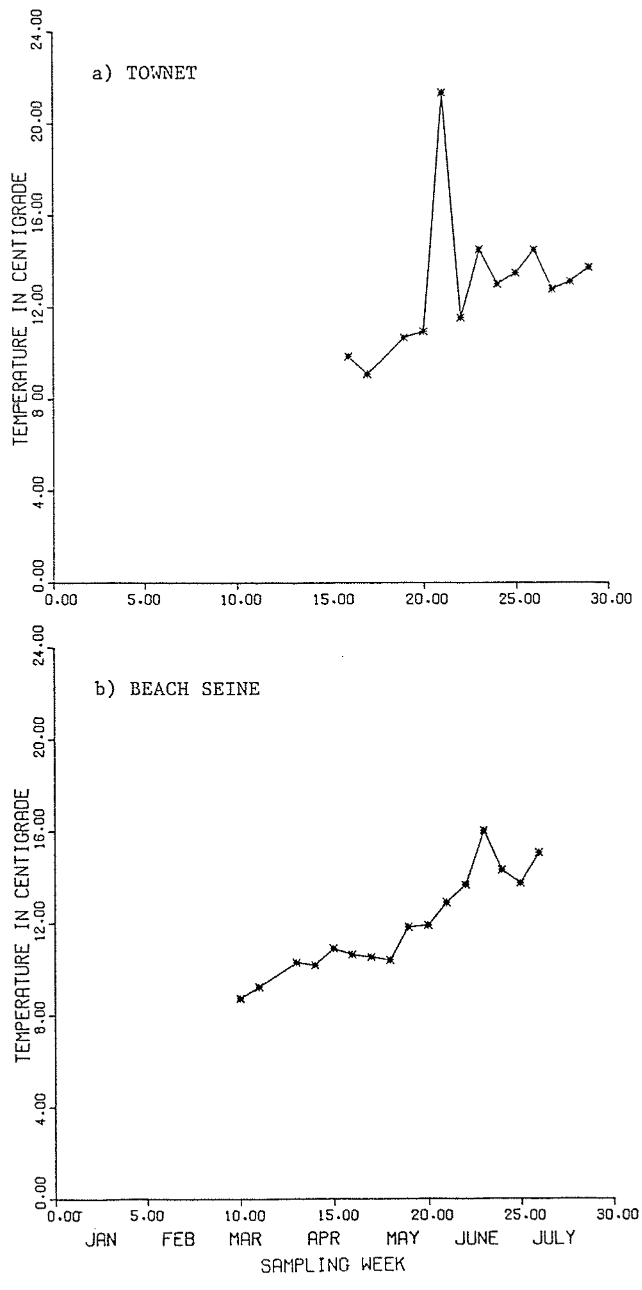


Fig. 8. Mean weekly water temperature at 1-m depth at, a) townet, and b) beach seine sites in Hood Canal, Washington, 1978.

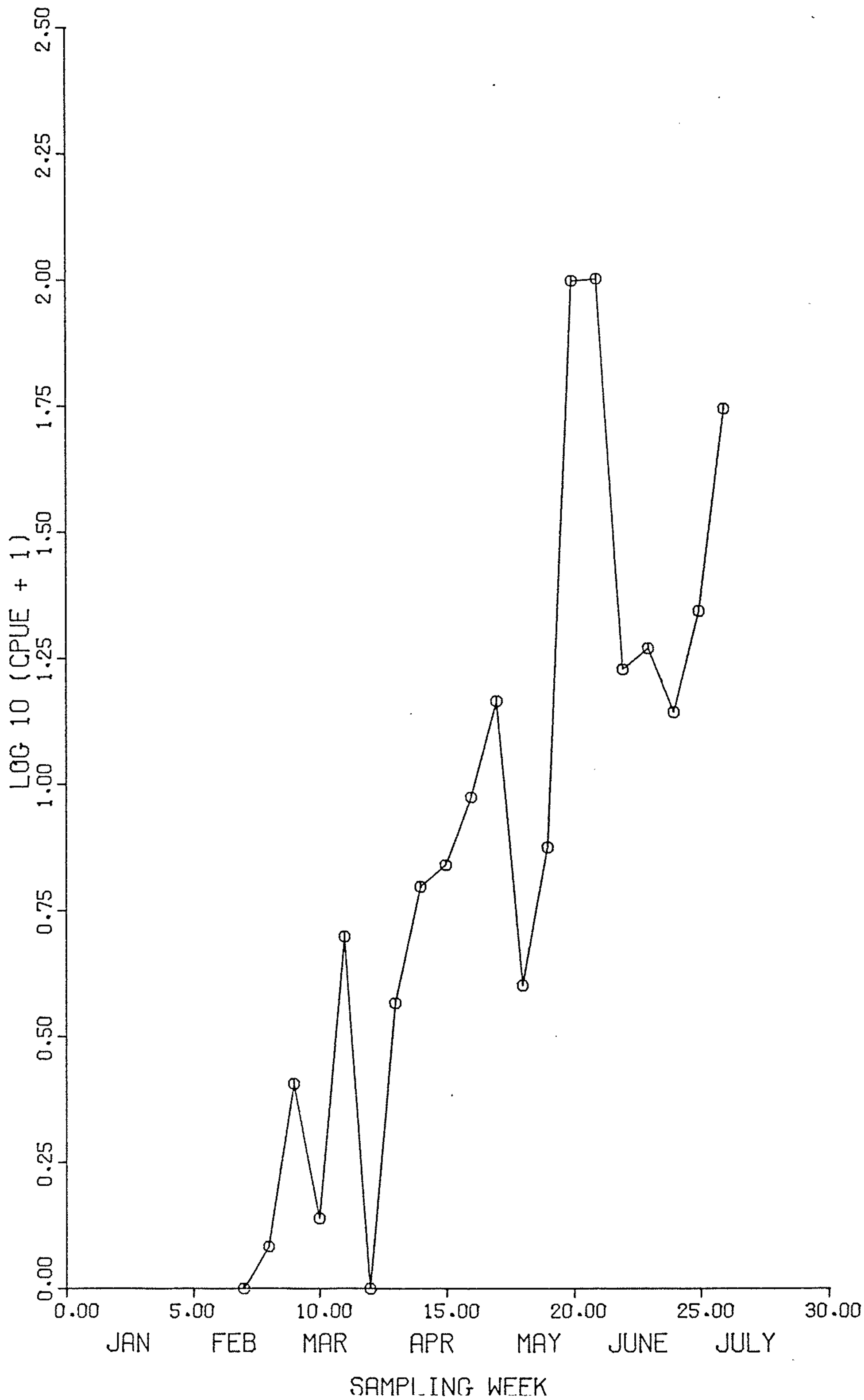


Fig. 9. Mean weekly CPUE of chum with the beach seine at statistically similar sites on the east shore of Hood Canal, Washington, 1978. (All east shore sites except South EHW and South Marginal).

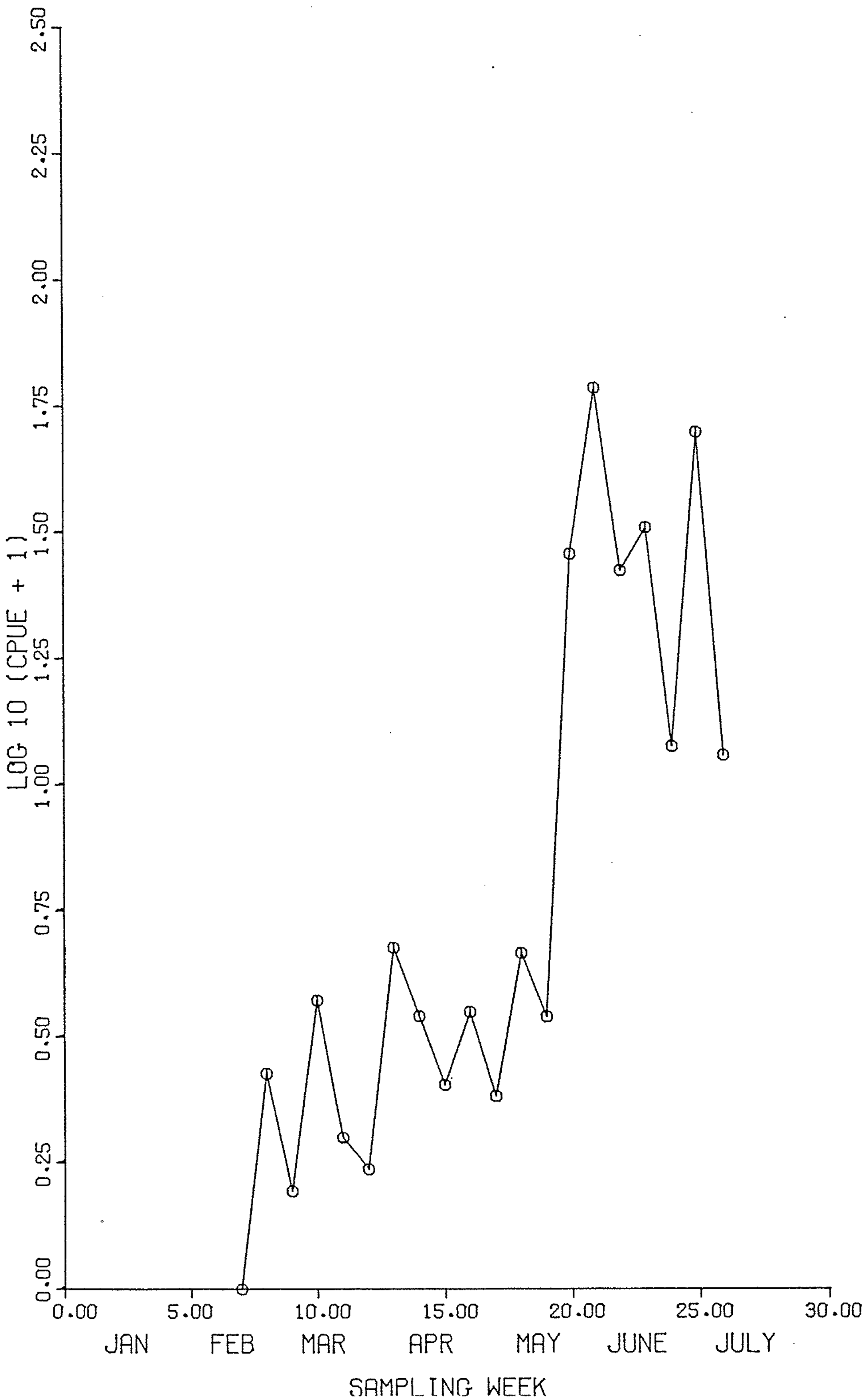


Fig. 10. Mean weekly CPUE of chum with the beach seine at statistically similar sites on the west shore of Hood Canal, 1978. (All west shore sites except North Spit 6).

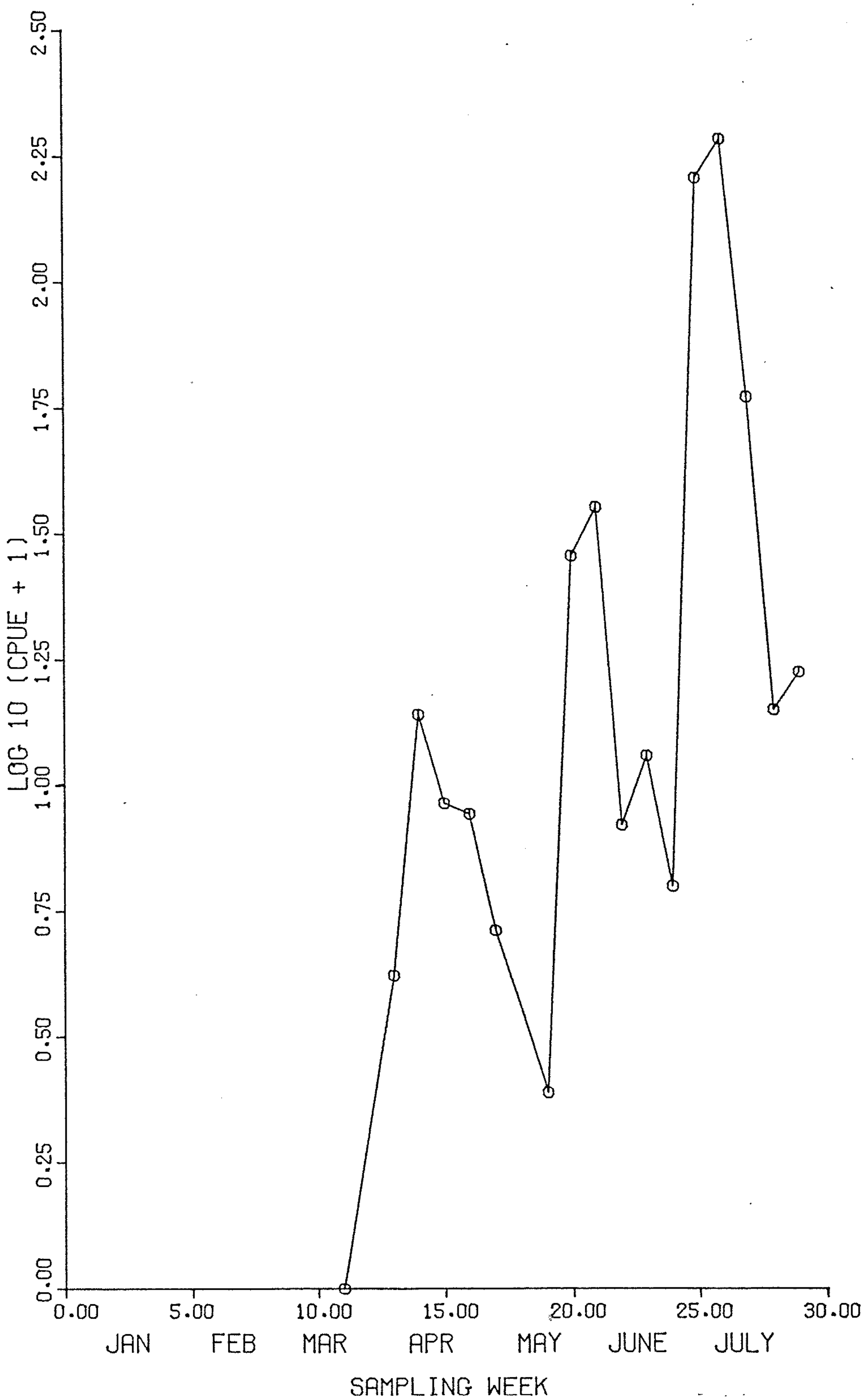


Fig. 11. Mean weekly CPUE of chum with the townet on the east shore of Hood Canal, Washington, 1978.

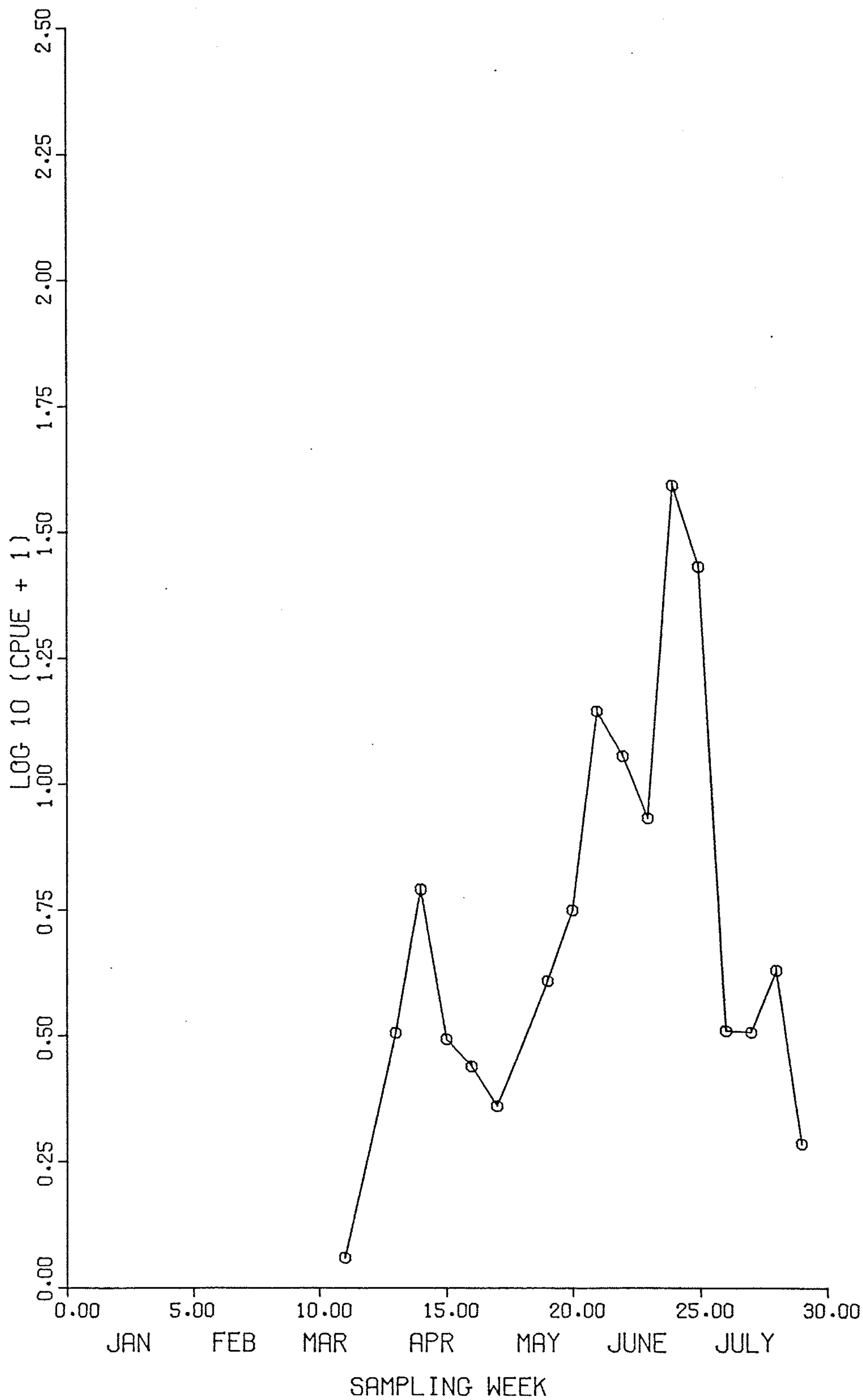


Fig. 12. Mean weekly CPUE of chum with the townet on the west shore of Hood Canal, Washington, 1978.

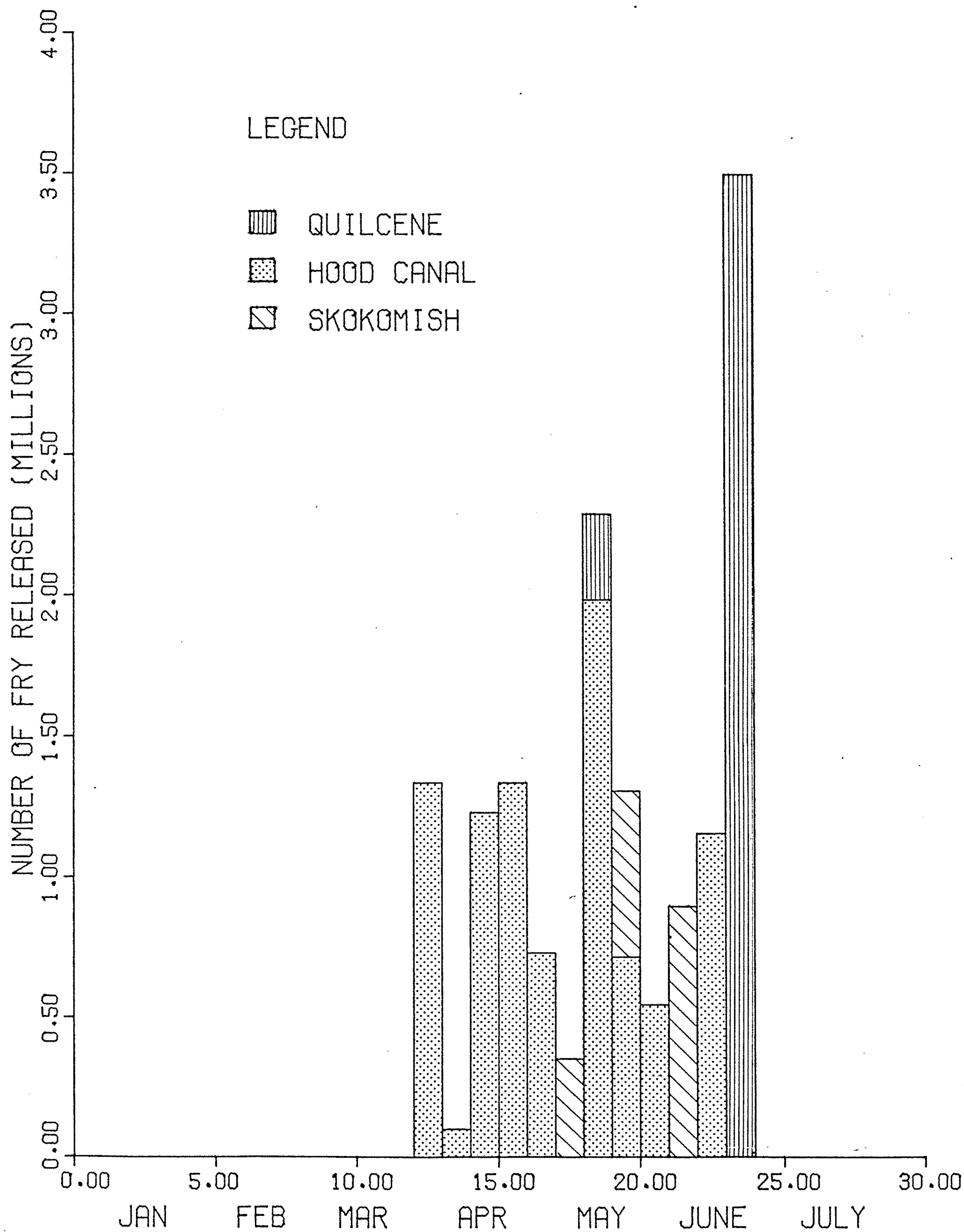


Fig. 13. Releases of chum fry into Hood Canal, Washington, from the Quilcene, Hood Canal, and Skokomish facilities, 1978.

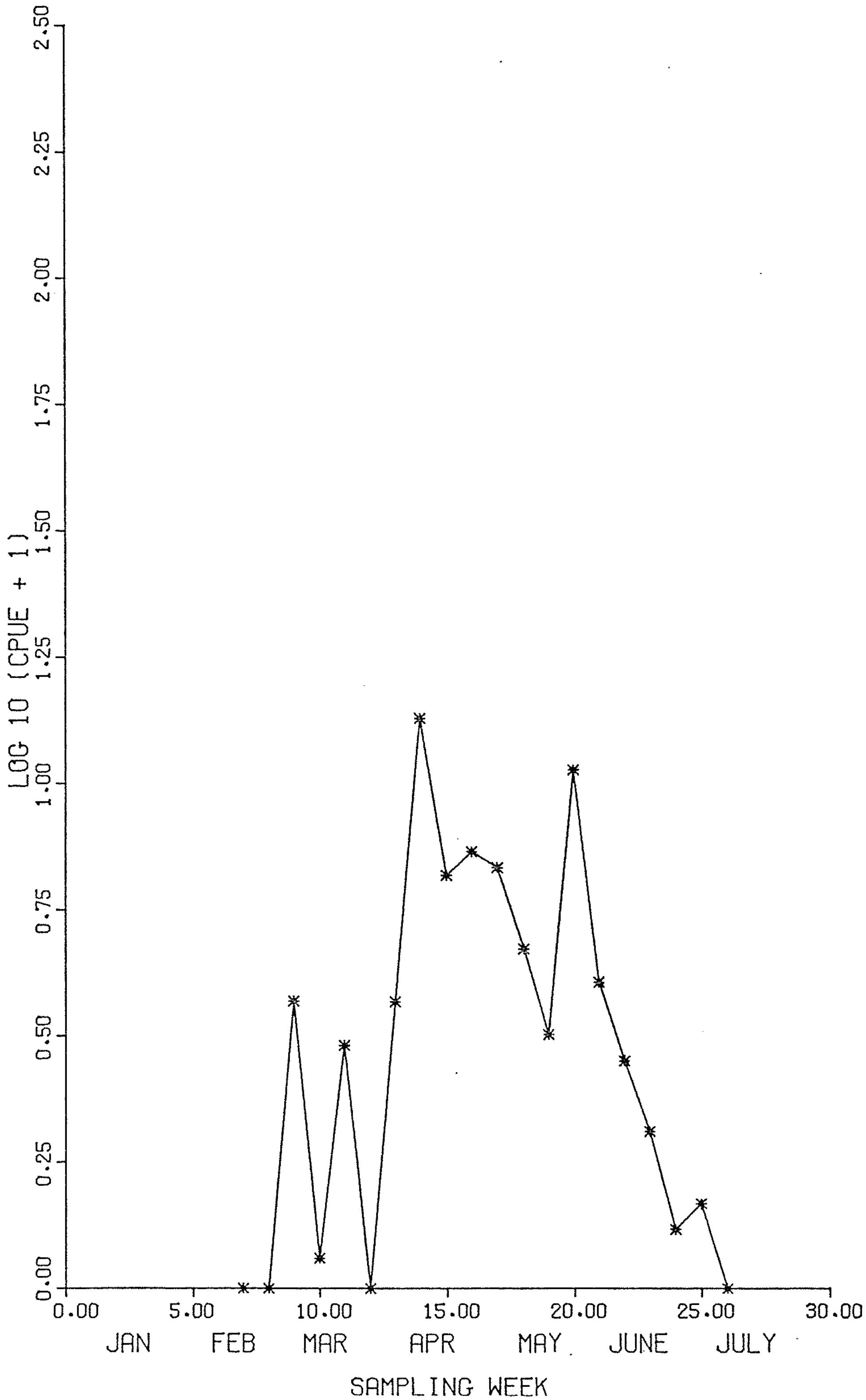


Fig. 14. Mean weekly CPUE of pinks with the beach seine on the east shore of Hood Canal, Washington, 1978.

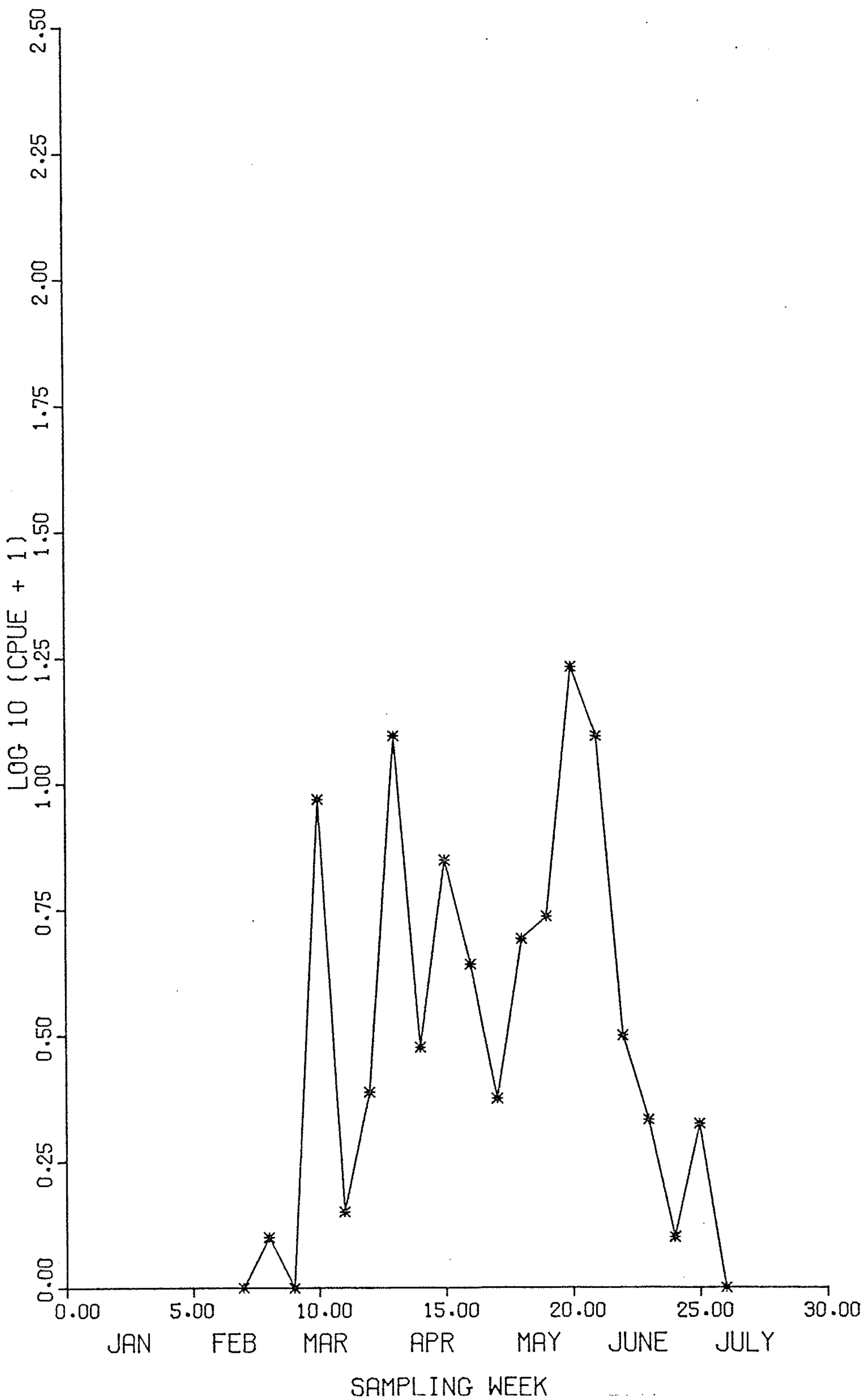


Fig. 15. Mean weekly CPUE of pinks with the beach seine on the west shore of Hood Canal, Washington, 1978.

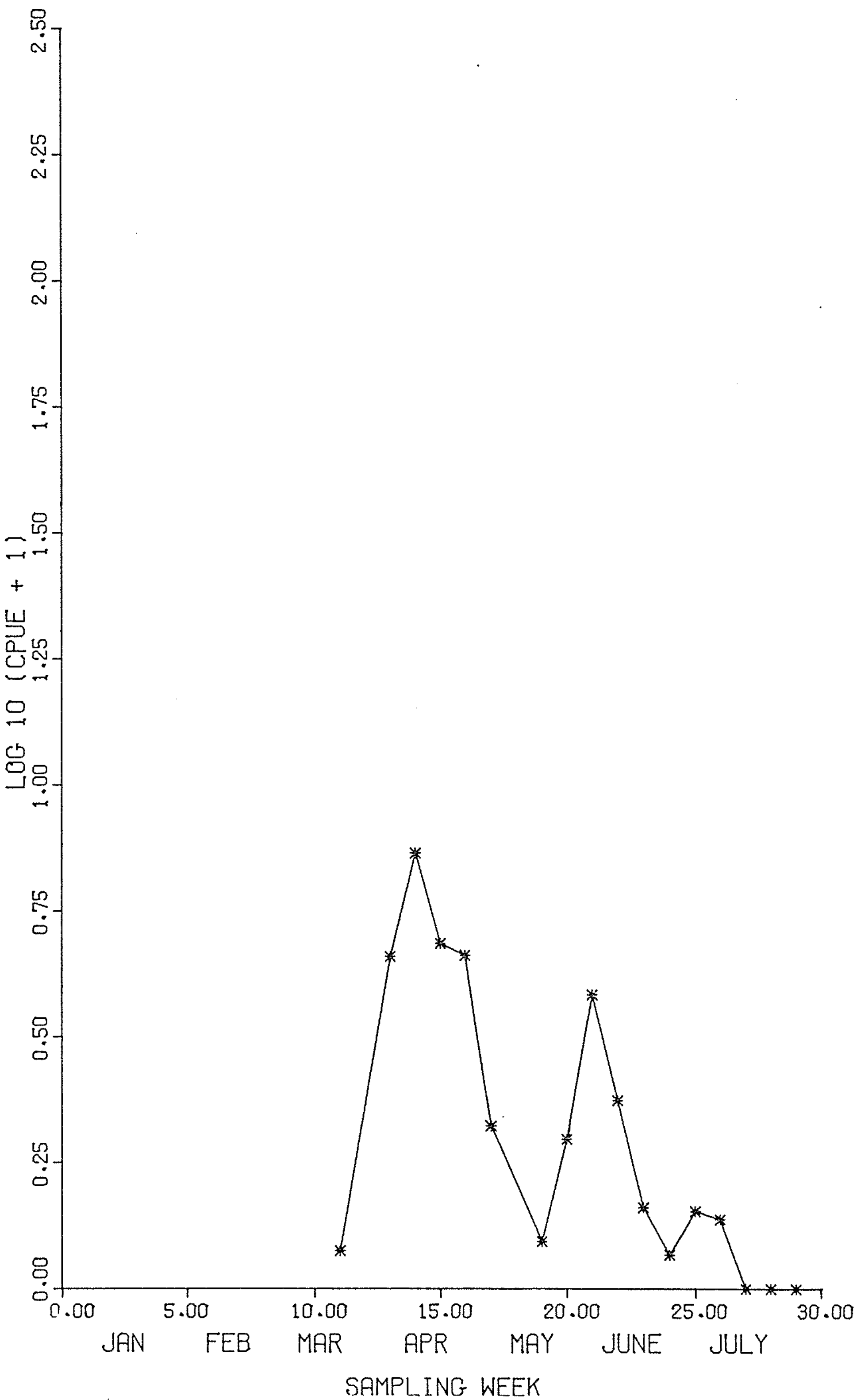


Fig. 16. Mean weekly CPUE of pinks with the townet on the east shore of Hood Canal, Washington, 1978.

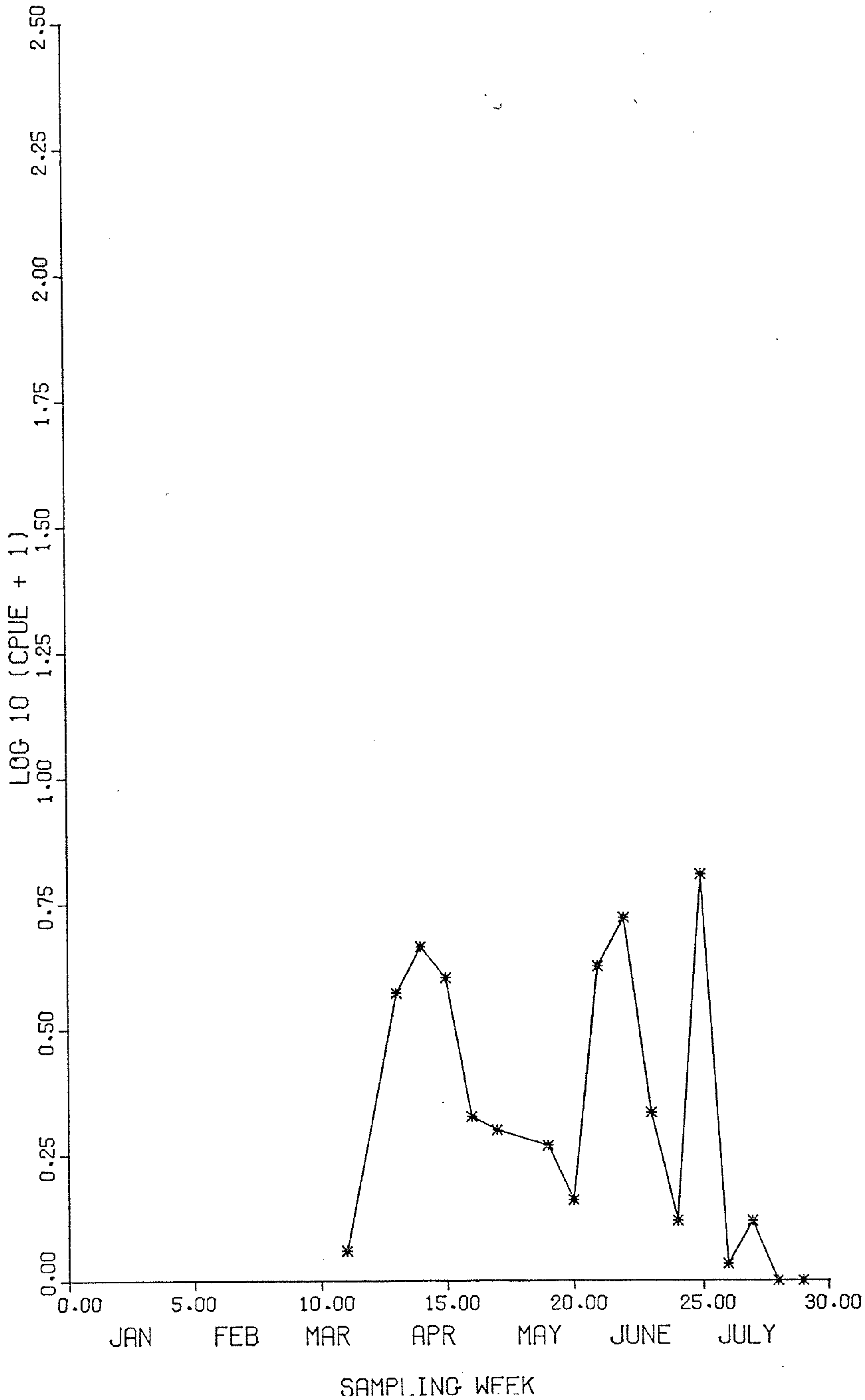


Fig. 17. Mean weekly CPUE of pinks with the townet on the west shore of Hood Canal, Washington, 1978.

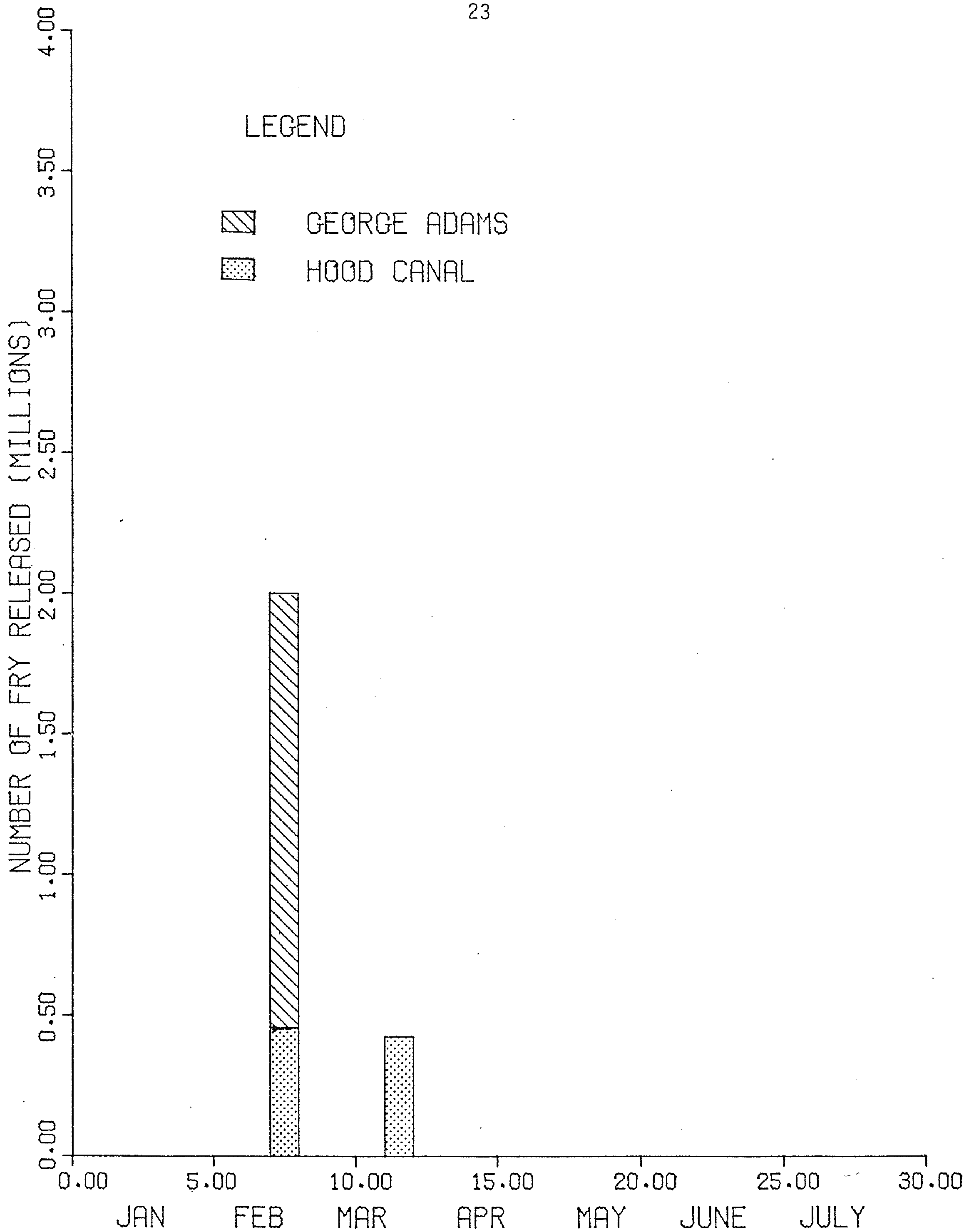


Fig. 18. Releases of pink fry into Hood Canal, Washington, from the George Adams and Hood Canal facilities, 1978.

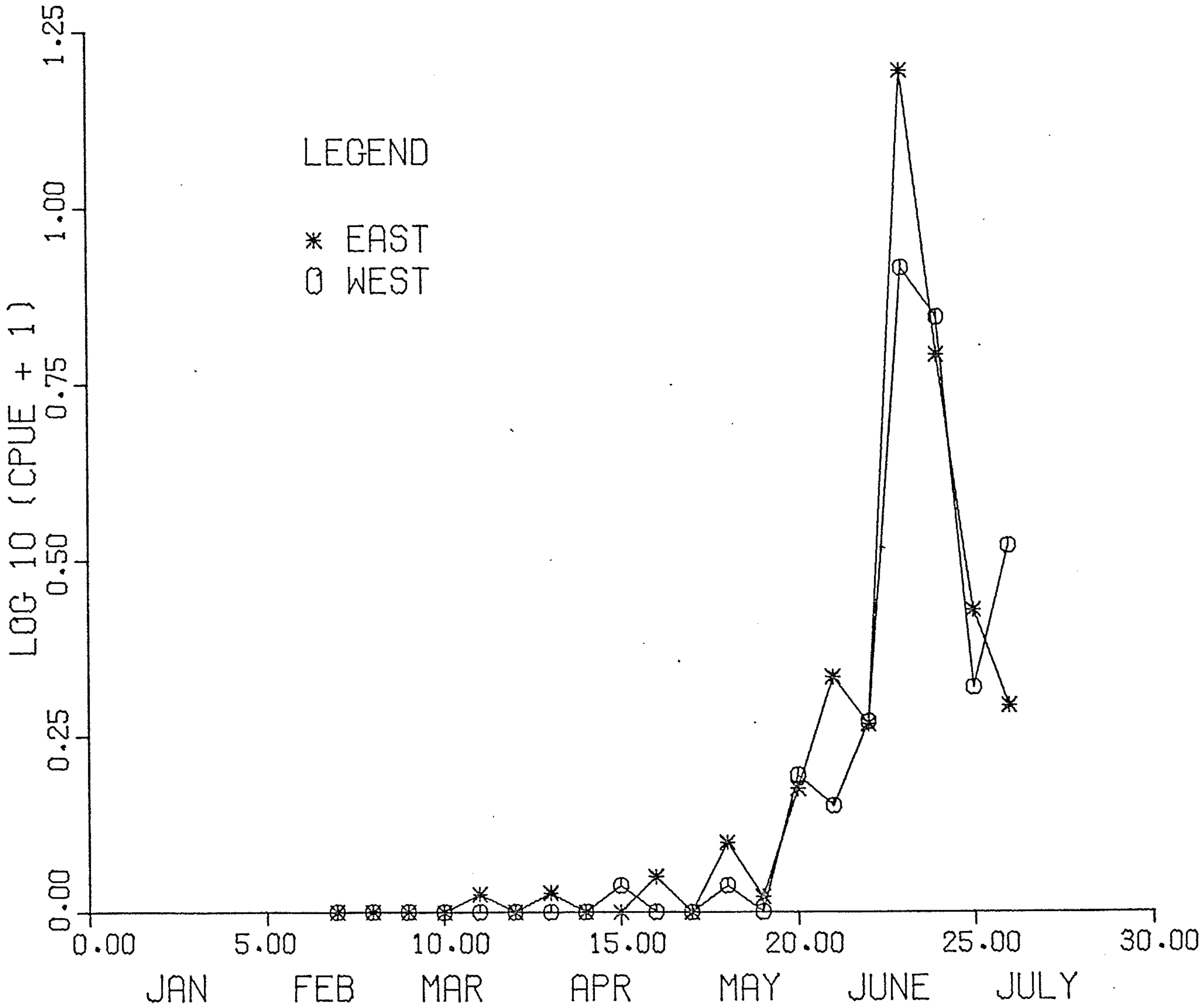


Fig. 19. Mean weekly CPUE of coho smolts with the beach seine at all sites on Hood Canal, Washington, 1978.

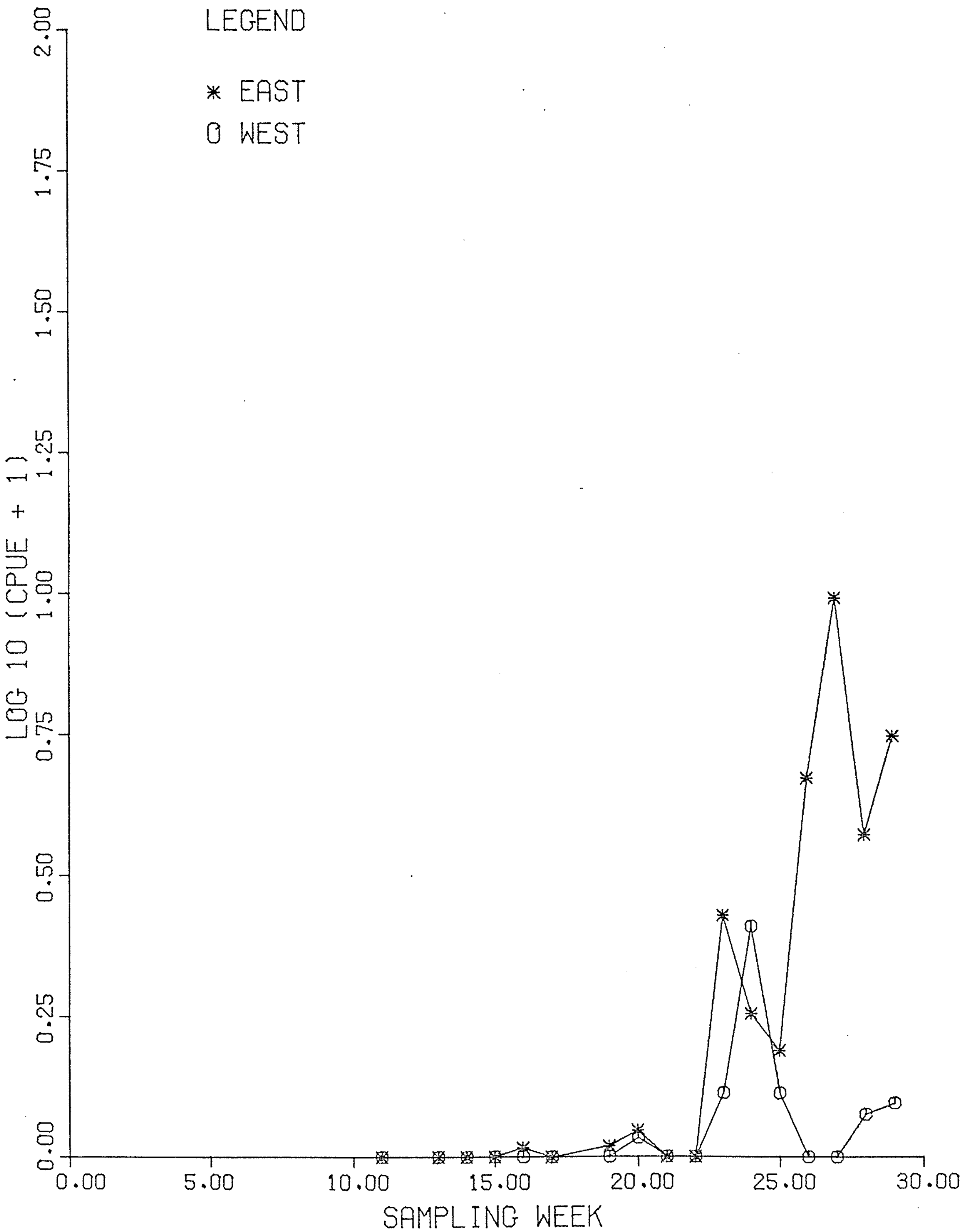


Fig. 20. Mean weekly CPUE of coho smolts with the townet at all sites on Hood Canal, Washington, 1978.

Chinook Salmon

Chinook salmon smolts, yearlings, and one adult were caught during the 1978 sampling season. The peak of captures came at the end of the sampling season in early July, and was increasing as sampling stopped (Figs. 21 and 22).

Cutthroat Trout

Coastal cutthroat trout juveniles and adults were caught throughout the sampling season (Fig. 23). All of the 47 cutthroat trout were caught with the beach seine. The majority was caught on the west side of Hood Canal.

Steelhead Trout

Two juvenile steelhead trout were caught in 1978. They were caught with the beach seine in May and June.

Factors Affecting Catch-Per-Unit-Effort

Site Preference

Data collected with the 37-m beach seine and surface townet from April to July were used to compare CPUE between sampling sites. Earlier data from both the 10-m and 37-m beach seine were not used as sampling was inconsistent from week to week in this period. The data were first subdivided so that the locations on the east and then the west shores were tested, using ANOVA. Subsequently, those sites on each shore showing no significant differences were used in an east versus west shore comparison.

Chum Salmon

Nearshore. Significant differences were found among east shore sites (Table 1). Further testing using the Student-Newman-Keuls (SNK) multiple comparison procedure showed that no one or two sites were significantly different from the rest, but that the two extremes were significantly different (Table 2). South Explosives Handling Wharf (EHW) was the site with the highest CPUE and South Marginal Wharf (MW) the site with the lowest (Appendix Figs. 1 and 2).

On the west shore, North Spit 6 did not have a lognormally distributed catch. Using Dunnett's test, a nonparametric test, we found it to have significantly smaller catch than the other sites (Appendix Fig. 3).

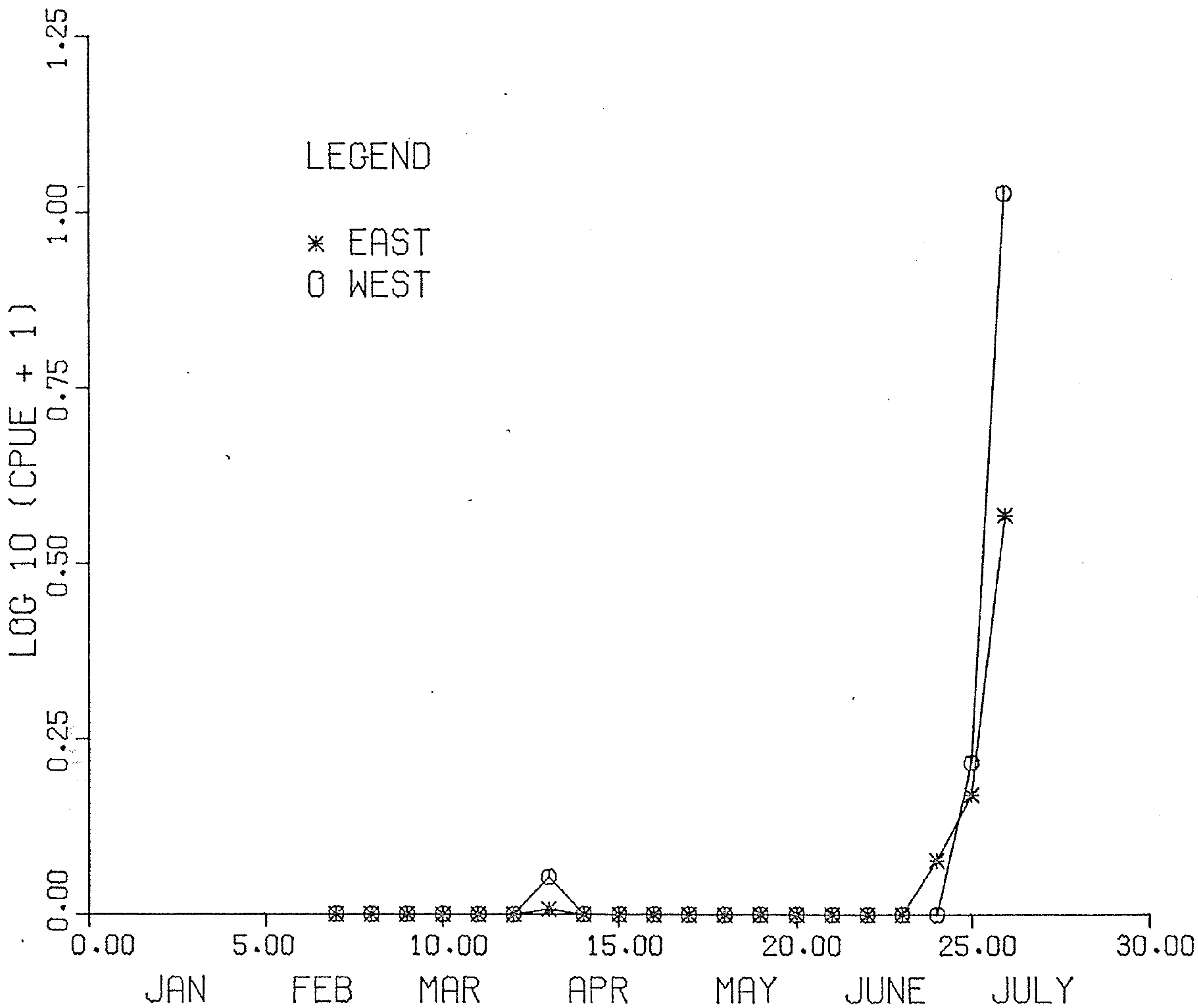


Fig. 21. Mean weekly CPUE of chinook smolts with the beach seine at all sites in Hood Canal, Washington, 1978.

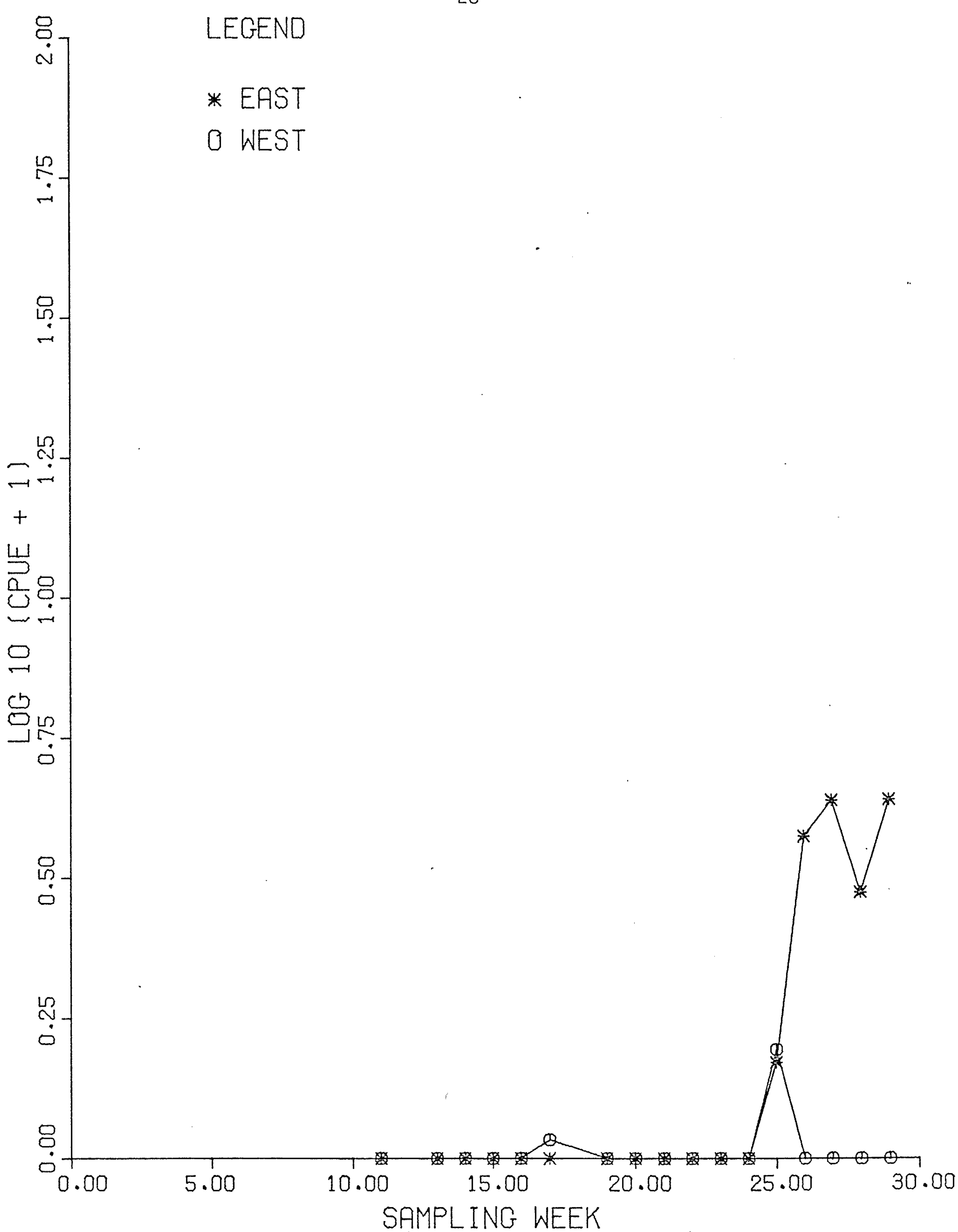


Fig. 22. Mean weekly CPUE of chinook smolts with the townet at all sites in Hood Canal, Washington, 1978.

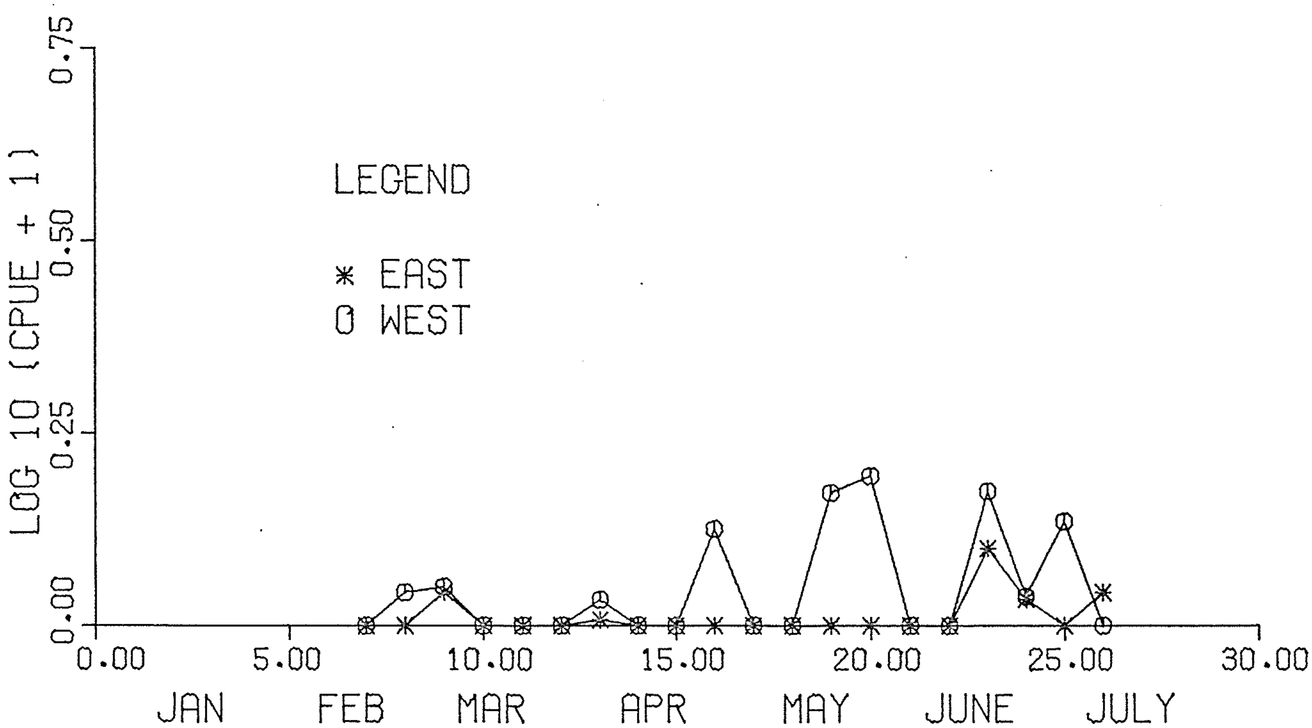


Fig. 23. Mean weekly CPUE of cutthroat trout with the beach seine at all sites in Hood Canal, Washington, 1978.

Table 1. A two-way analysis of variance on the effect of sampling week and sampling location on the CPUE of chum fry captured from April to July 1978, Hood Canal, Washington.

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
	East Shore Beach Seine Sites				
Total	149.601	174	.860		
Week	42.771	13	3.290	6.336	.001
Location	11.896	6	1.983	3.818	.002
Residual	41.540	80	.519		
Interactions	53.192	75	.709	1.366	.085
	West Shore Beach Seine Sites				
Total	48.563	68	.714		
Week	18.002	13	1.385	2.355	.029
Location	.624	2	.312	.531	.594
Residual	15.879	27	.588		
Interactions	14.142	26	.544	.925	.578
	West vs East Beach Seine Sites				
Total	153.951	188	.819		
Week	46.891	13	3.607	5.767	.001
Location	1.424	1	1.424	2.277	.133
Residual	100.701	161	.625		
Interactions	5.117	13	.394	.629	.827

Table 2. Student-Newman-Keuls Multiple Comparison test on the effect of east shore locations on CPUE of chum fry.

Location	Mean $\log_{10}$ (CPUE + 1)	Sample Size
South EHW	1.50	26
North Carlson	1.29	25
South Carlson	1.15	24
South Floral	1.02	28
Devil's Hole	0.97	24
North Floral	0.89	24
South Marginal	0.59	24

Conclusion:

The lines underline sites not significantly different from each other at the 0.05 significance level.

South EHW	North Carlson	South Carlson	South Floral	Devil's Hole	North Floral	South Marginal
———	———	———	———	———		
	———	———	———	———	———	
		———	———	———	———	———

For the comparison of east to west shore, South EHW, South MW, and North Spit 6 were not included, so that there were no within-group differences. All other sites were included in the analysis. The resulting ANOVA showed no significant differences between shores (Table 1).

The differences in CPUE between sites noticed this year were also noticed in 1977. As in 1977, the site at South EHW had the highest mean CPUE of chum of all beach seine sites, and the site at South MW had one of the lowest. It is encouraging that these consistencies between years are observed, lending credence to the observed differences being real and not merely random fluctuations in abundance. Healey (1978), studying juvenile salmon in the Strait of Georgia, concluded that the consistently high catches of young salmon in some areas indicated that certain areas were consistently good nursery areas. This is a possible explanation for the high catches at South EHW where there is an extensive littoral zone. Other studies have shown the attraction of young chum salmon, during their first 2-4 weeks in the marine environment, to sheltered nursery areas (Allen 1974; Cooney et al. 1978). However, if this were the sole reason for the increased catches at South EHW, it would be expected that the Devil's Hole area, which has an extremely extensive littoral zone and a large number of the principal prey items of juvenile chum salmon (Bax et al. 1978), to show even larger catches of juvenile chum. This was not the case. Perhaps other factors such as the wharf itself also serve to make the EHW area an attractive one for the chum juveniles. Work by Heiser and Finn (1970) in Puget Sound has shown that chum juveniles congregate inside marinas even when clear passage through was available.

It was suggested by Major (1977) that a pier might serve as protection from predation as it "limited the maneuverability and avenues of approach for all species of predators." That proximity to a wharf is not the only consideration of a suitable habitat for chum juveniles is illustrated by the low catches at South MW. This is a limited littoral area of high construction activity. Which factor exerts the greatest deleterious effect on the juvenile chum is not clear.

An alternative explanation for these differences in CPUE between South EHW and South MW is provided by Heiser and Finn (1970) where they observe that chum juveniles move offshore as they approach bulkheads but after a buildup in the area has occurred. If this is the case at Bangor Annex, then the large catches at South EHW would be due to a buildup of juveniles before they move offshore to pass EHW. Conversely, the low catches at South MW may be explained by the site at South MW being in the "shadow" of the Refit Pier (Fig. 2). That is, the fry may not come inshore directly after passing the Refit Pier, but stay offshore until they have passed MW. This would lead to the low observed catches at the South MW site.

A factor observed in 1975 and 1976 but not this year or in 1977 was the larger numbers of chum juveniles caught on the east shore compared to the west shore. As the majority of the chum originate from the west shore (from Hood Canal and Quilcene hatcheries as well as the large rivers), this crossing over was of considerable interest. Movement across deep bodies of water to superior nursery areas has been noted in other studies for chum salmon juveniles newly arrived in the marine environment (Cooney et al. 1978). The motivation for this crossing of the canal is not yet clear, although by following marked releases from Hood Canal hatchery, Whitmus and Olsen (1979) found that some chum juveniles cross almost immediately. Further analysis of the yearly fluctuations in the east-west distribution of the chum with regard to environmental varaibles (river discharge, for example) may give some clues as to the mechanism and reason for this aspect of the migration.

Offshore. The first transects to be tested were the shoreline transects on the east and west shores. There were no significant differences between transects on each shore, although there were significant differences between shores (Table 3).

To more closely delineate the distribution of salmonid smolts further offshore than the shoreline transects, six tows parallel to and at varying distances from the shore, as well as six tows crossing obliquely from shore to shore, were conducted in 1978 (Fig. 4). ANOVA showed significant differences between parallel transects run at varying distances from shore (Table 3); however, the differences were not great enough to be significant by the SNK multiple comparison procedure. When the data are graphed it can be seen that the data are variable, but that the 2 weeks when the highest CPUE's occurred had high CPUE's only in the transects nearest to shore (Fig. 24). Thus there were no data in 1978 that suggested overcrowding in the nearshore zone.

An ANOVA was run on the data from the six oblique cross-canal tows. No significant differences were found between transects (Table 3). If the data for all weeks are combined and graphed, a noticeable, although nonsignificant, trend is apparent, with higher catches closer to shore (Fig. 25). The high variance in CPUE along these transects undoubtedly affected the outcome of this test.

The sampling method in 1978, where 10-min tows were made continuously from one end of the base to the other, made it difficult to assess individual differences between locations. Although each transect was standardized with respect to time, the distance towed, and consequently the area towed, changed according to tidal and weather conditions. Thus under some conditions, townet transect 2 (Fig. 4) would inlcude EHW, while under other conditions it would not. Even so, the lack of differences between transects which were always close to the shore and those which were always further offshore around the piers suggests that the piers might be biasing the distribution offshore. Such a change in the distribution would agree with the

Table 3. A two-way analysis of variance on the effect of sampling week and sampling location on the CPUE of chum fry captured from April to July 1978, Hood Canal, Washington.

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
	East Shore Townet Transects				
Total	190.093	248	.767		
Week	83.543	16	5.221	10.341	.001
Location	3.843	6	.640	1.268	.276
Residual	66.148	131	.505		
Interactions	38.079	95	.401	.794	.883
	West Shore Townet Transects				
Total	80.855	125	.647		
Week	19.612	16	1.226	2.015	.027
Location	2.100	3	.700	1.151	.336
Residual	35.285	58	.608		
Interactions	23.648	48	.493	.810	.773
	West vs East Townet Transects				
Total	280.648	374	.750		
Week	73.766	16	4.610	9.297	.001
Location	11.381	1	11.381	22.950	.001
Residual	169.103	341	.496		
Interactions	28.079	16	1.755	3.539	.001
	Multiple Parallel Transects				
Total	32.46	59			
Week	12.26	9	1.36	3.89	.05 > p > .025
Location	4.62	5	.92	2.63	.0025 >p > .001
Residual	15.58	45	.35		
	Cross Canal Transects				
Total	24.59	59			
Week	6.23	9	.69	2.10	.10 > p > .05
Location	2.23	5	.45	2.42	p > .25
Residual	16.13	45	.36		

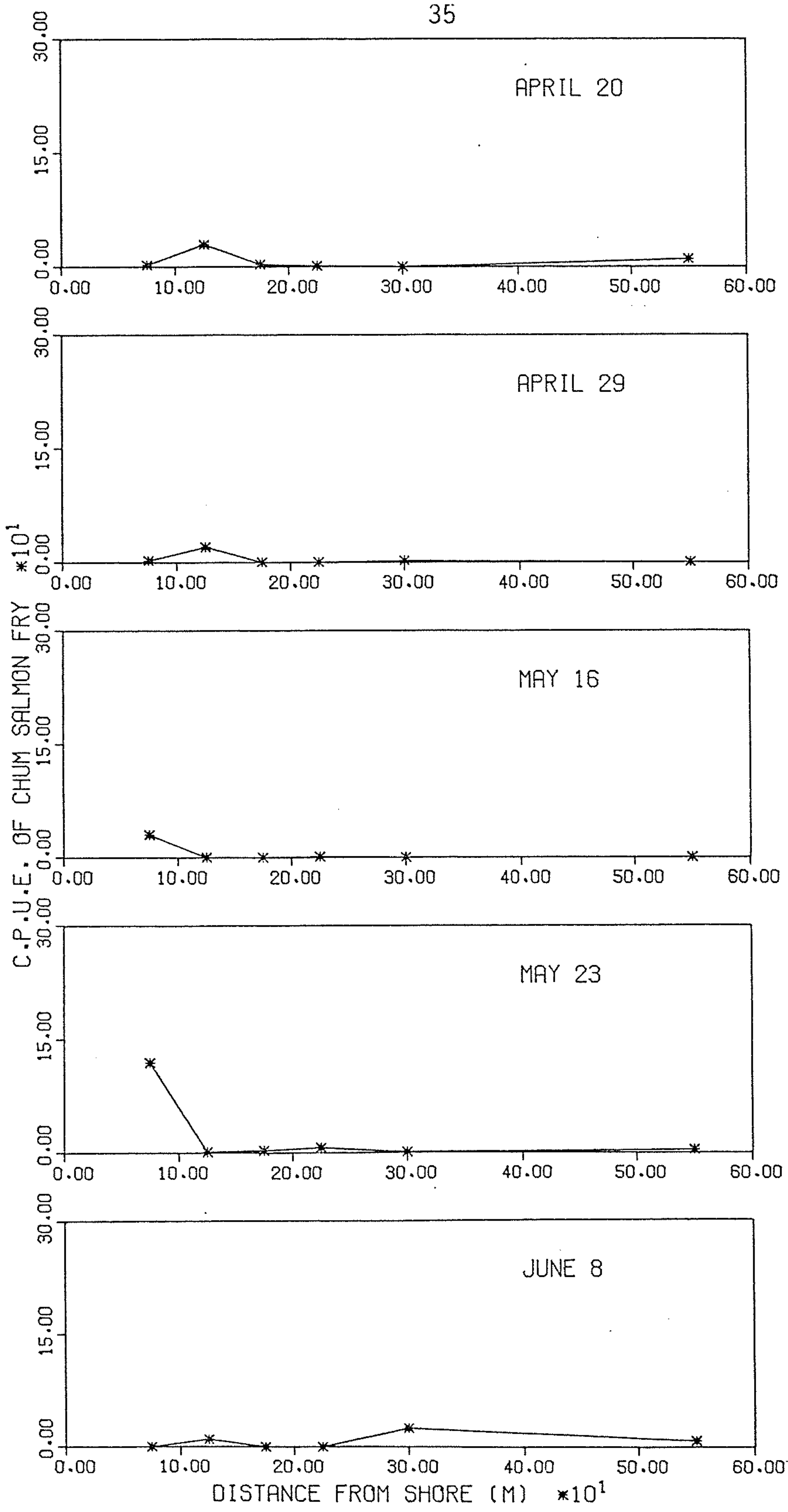


Fig. 24. CPUE of chum with the townet along transects parallel to the shore between King Spit and Carlson Point, Hood Canal, Washington, 1978.

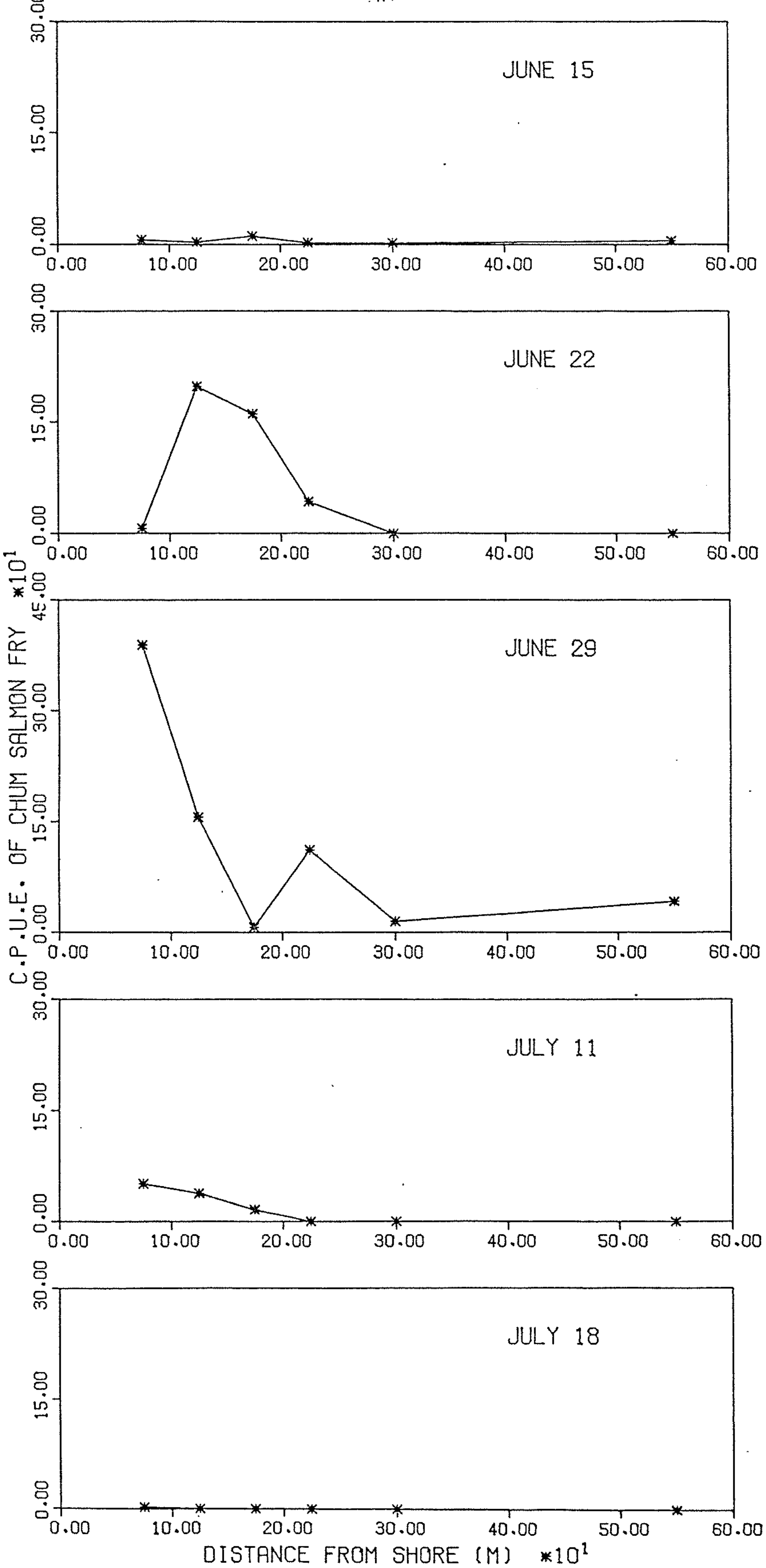


Fig. 24. CPUE of chum with the townet along transects parallel to the shore between King Spit and Carlson Point, Hood Canal, Washington, 1978 continued.

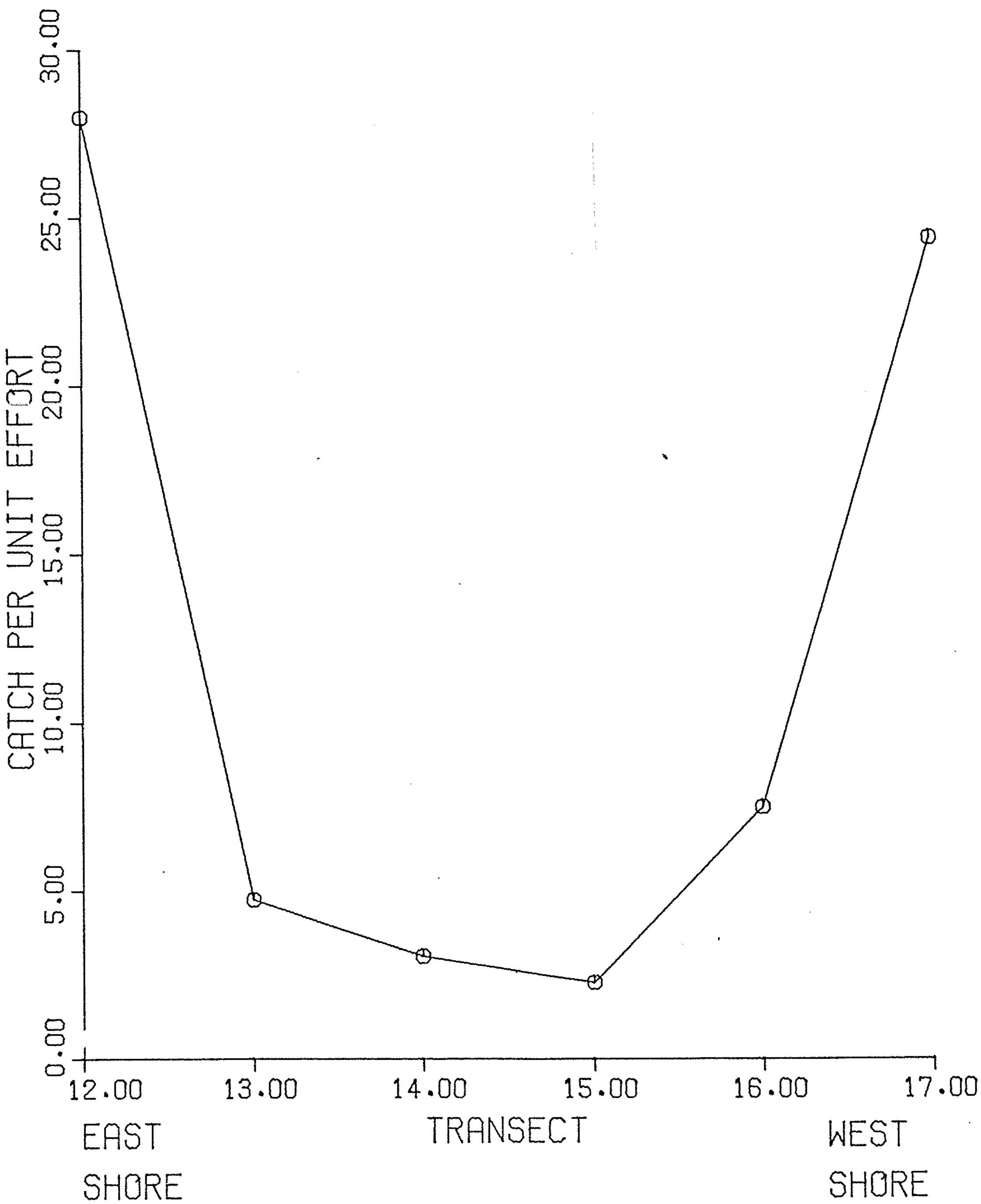


Fig. 25. CPUE of chum with the townet on a series of six oblique, cross canal transects in Hood Canal, Washington, 1978. (Ordinal scale numbers refer to transect numbers in Fig. 4.)

hypothesis proposed previously in this report in which it was suggested that the piers on the Naval Submarine Base could be causing the offshore movement of the chum juveniles after an initial buildup closer to shore.

The offshore transects in 1978 did not show unequivocally a decreasing abundance of chum juveniles with increasing distance from shore. The trend of more juveniles close to shore with a rapid initial decrease when moving offshore is suggested. Offshore movement of the chum juveniles has been noted by many authors (Allen 1974, Cooney et al. 1978, Okada and Taniguchi 1971, Sano and Kobayashi 1952, among others. The noticeable difference between the observations in this study and the other ones is that there does not seem to be a distinct point at which the fry move offshore--either seasonally or size-dependent. It is difficult to assess whether the difference between Hood Canal and the other systems studied reflects lack of true offshore movement as defined by previous authors, or a more complex interaction of factors determining offshore movement in Hood Canal.

Pink Salmon

Nearshore. The data for pink salmon were analyzed in the same manner as those for chum. With the exception of North Spit 6 there were no significant differences between sites on either shore or between shores (Table 4). Using Dunnett's test, we found North Spit 6 to be significantly different from the other west shore beach seine sites (Appendix Fig. 4), but with so few pink juveniles caught that little can be concluded as to their site preferences.

Offshore. The transects along each shore were tested with ANOVA. No significant differences were found between transects on either shore or between the east and west shores (Table 5). There were insufficient data to analyze any change in CPUE of pink fry with distance from shore.

Environmental Variables

Data for the period April to July from the beach seine and townet were used for these analyses. Data were grouped into locations which had no significant differences in CPUE, as described in the previous section.

Initially, the effect of tidal influences, a nominal variable, was tested, by a t-test. In no case was a significant difference found (Tables 6 and 7); therefore the same groups were used for multiple regression analysis.

A backward elimination procedure was used in these regressions. This procedure enters all variables into the equation on the first step, and then removes variables one at a time until the best

Table 4. A two-way analysis of variance on the effect of sampling week and sampling location on the CPUE of pink fry captured from April to July 1978, Hood Canal, Washington.

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
		East Shore Beach Seine Sites			
Total	72.946	174	.419		
Week	22.779	13	1.752	6.206	.001
Location	1.971	6	.329	1.164	.334
Residual	22.588	80	.282		
Interactions	25.809	75	.344	1.219	.192
		West Shore Beach Seine Sites			
Total	33.690	68	.495		
Week	9.210	13	.708	1.447	.202
Location	.251	2	.126	.257	.775
Residual	13.216	27	.489		
Interactions	10.796	26	.415	.848	.661
		West vs East Beach Seine Sites			
Total	85.268	188	.454		
Week	21.084	13	1.622	4.290	.001
Location	.058	1	.058	.153	.696
Residual	60.872	161	.378		
Interactions	3.209	13	.247	.653	.806

Table 5. A two-way analysis of variance on the effect of sampling week and sampling location on the CPUE of pink fry captured from April to July 1978, Hood Canal, Washington.

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
	East Shore Townet Transects				
Total	53.026	164	.323		
Week	8.601	9	.956	2.903	.004
Location	2.177	6	.363	1.102	.367
Residual	31.602				
Interactions	10.542	53	.199	.604	.977
	West Shore Townet Transects				
Total	25.971	78	.333		
Week	3.564	9	.396	1.177	.336
Location	2.496	3	.832	2.473	.076
Residual	13.122	39			
Interactions	7.175	27	.266	.790	.737
	West vs East Townet Transects				
Total	79.371	243	.327		
Week	10.537	9	1.171	3.908	.001
Location	.174	1	.174	.580	.447
Residual	67.113	224	.300		
Interactions	1.346	9	.150	.499	.874

Table 6. Analysis of tidal effects on the CPUE of chum and pink fry caught with the 37-m beach seine from April to July 1978, using the t-test.

Variable	Number of Cases	Mean	T-Statistic	Degrees of Freedom	Significance
		Chum Salmon			
Ebb	54	1.04	-0.97	119	0.33
Flood	67	1.20			
		Pink Salmon			
Ebb	54	0.69	-0.72	122	0.47
Flood	70	0.78			

Table 7. Analysis of tidal effects on the CPUE of pink and chum fry caught with the surface townet from April to July 1978, using the *t*-test.

Variable	Number of Cases	Mean	T-Statistic	Degrees of Freedom	Significance
		Chum Salmon			
a) East Shore					
Ebb	69	1.35	-0.87	161	0.38
Flood	94	1.23			
b) West Shore					
Ebb	35	1.03	-1.86	87	0.07
Flood	54	0.69			
		Pink Salmon			
Ebb	148	0.37	0.34	339	0.73
Flood	193	0.89			

regression fit is found. This procedure is fraught with less theoretical deficiencies than the forward inclusion method (Mantel, in Zar 1974). Sampling week was always the last variable to be eliminated, if necessary, to prevent seasonal trends in CPUE affecting the choice of variables.

No single independent variable appeared consistently in the regression equations. The highest variability in CPUE accounted for by these equations was 21.4% for chum smolts in the beach seine.

Sea state and weather condition were significant variables for CPUE of both pink and chum salmon for the beach seine sampling (Table 8). Salinity and sampling week were also significant for chum salmon.

For the townet, no variable appeared in more than one regression equation (Table 9). Sampling week, weather condition, tide height, and salinity showed significant effects on the CPUE, but explained little of the variation.

Although various environmental variables have been implicated as affecting the orientation, migration routes and early marine survival of pink salmon, little evidence appears available on juvenile chum salmon. That chum salmon juveniles can respond to changing environmental conditions such as temperature (Bessey 1972), salinity (Houston 1957; Baggerman 1960; McInerney 1964), photoperiod (Hoar, Keenlyside, and Goodall 1957; Kobayashi 1960; McDonald 1960; Kobayashi and Susaki 1965) has been shown under laboratory conditions; but, there is little evidence available on any effect of environmental variables on the distribution of chum juveniles under natural conditions.

It must also be considered whether any change in catch correlated with an environmental variable is due to a change in the distribution or a change in the catchability of the chum or, alternatively, due to a change in the gear efficiency of the net. As Reynolds (1977) suggests:

> "where netting . . . is used in fish sampling studies an artifact might be introduced by a possible effect of temperature on . . . ability to escape from an area being netted."

Variables such as weather conditions, sea state, or light could be adversely affecting the catch efficiency of the net, leading to significant relationships between catch and environmental variables.

Until more conclusive data are available, no hypothesis regarding the observed statistically significant correlations between the catch of juvenile chum and the associated environmental variables can be forwarded.

Table 8. Linear regression equations describing the effect of measured environmental variables on the CPUE of pink and chum fry with the 37-m beach seine from April to July 1978.

Variable in Equation	Partial Regression Coefficient	F	Significance	Constant	Overall R^2	Overall F	Overall Significance
			Chum Salmon				
Week	0.062	4.662	0.033	-2.445	0.214	8.114	0.000
Weather	0.302	5.619	0.019				
Salinity	0.091	3.999	0.048				
Sea State	-0.305	16.320	0.000				
			Pink Salmon				
Sea State	-0.185	7.031	0.009	0.747	0.077	5.104	0.007
Weather	0.240	6.902	0.010				

Table 9. Linear regression equations describing the effect of measured environmental variables on the CPUE of pink and chum fry with the surface townet from April to July 1978.

Variable in Equation	Partial Regression Coefficient	F	Significance	Constant	Overall R^2	Overall F	Overall Significance
			Chum Salmon				
a) East Shore							
Week	0.082	20.344	0.000	-0.314	0.128	11.714	0.000
Weather	-0.169	4.598	0.034				
b) West Shore							
Tide height	-0.081	6.718	0.011	1.283	0.072	6.718	0.011
			Pink Salmon				
Salinity	-0.116	6.356	0.013	3.580	0.056	6.356	0.013

Hatchery Influence

Chum Salmon

Nearshore. Although, numerically, the CPUE on the east and west shores was not significantly different, the timing of the peaks in CPUE was dissimilar. Accordingly, the east and west shores will be dealt with separately.

The east shore had three main peaks in CPUE closely following large hatchery releases (Figs. 9 and 13, Table 10). The first in late April was in the week following a Hood Canal hatchery release. The second peak, in mid-May, occurred 1-2 weeks after a large release from the same hatchery, and the third peak in late June, was 2 weeks after a Quilcene release. This latter peak may also have been influenced by a Hood Canal hatchery release 3 weeks previous.

The west shore had only 2 major peaks in CPUE, the first occurring in late May; two weeks after a Hood Canal hatchery release. The second peak in mid-June, followed a large Quilcene hatchery release and was a week earlier than the peak on the east shore - that is, one week after release (Figs. 10 and 13, Table 10).

Offshore. There were three major peaks in CPUE with the townet on both shores of Hood Canal. The first two peaks in early April and May occurred at the same time on both shores. These peaks occurred 1 and 2 weeks after a Hood Canal hatchery release, respectively (Figs. 11, 12, and 13; Table 10). The third peak occurred in late June on the east shore 2 weeks after a large Quilcene release. The third peak on the west shore was 2 weeks earlier, i.e., the same week as the Quilcene release.

That there does sometimes appear to be a difference in the timing of the chum smolts on the east and west shores this year and in 1977, suggests that juvenile chum of the same origin split into two groups soon after release and remain in distinct east and west shore populations at least until they have passed Bangor Annex. This hypothesis is supported by data from the release of marked chum juveniles from the Hood Canal fish hatchery in 1977, where some of the chum crossed the Canal immediately after release (Whitmus and Olsen 1979). Whether this crossing over was the result of a predetermined migration route or due to a more random dispersal from the point of release is not clear.

Another factor that has become apparent from this year's data, and that of 1977, is the increased speed of migration earlier on in the year. Data on the release of marked chum from Hood Canal hatchery substantiate this observation. The advantages of this rapid migration early in the season must be considerable. As is shown in Harden Jones, Greer Walker, and Arnold (1978):

Table 10. Proposed relationship between hatchery releases of chum fry and their recapture at Bangor Annex, 1978.

Gear Type	Location	Peak in CPUE	Hatchery of Origin	Delay (Weeks)
Beach Seine	East	April 22-29	Hood Canal	1
		May 14-27	Hood Canal	1-2
		June 25-	*Hood Canal	3
			Quilcene	2
	West	May 21-27	Hood Canal	2
		June 18-24	*Hood Canal	2
			Quilcene	1
Townet	East	April 2-8	Hood Canal	1
		May 21-27	Hood Canal	2
		June 25-31	*Hood Canal	3
			Quilcene	2
	West	April 2-8	Hood Canal	1
		May 21-27	Hood Canal	2
		June 11-17	*Hood Canal	1
			Quilcene	0

*Quilcene fish were the major part of this release and presumably of the recaptures at this time.

"The force to be exerted against surface drag is proportional to the square of the fish's velocity through the water. An energy-conscious fish would therefore swim slowly."

The advantages of the rapid migration early in the season may be related to avoidance of predation by the smaller fish or perhaps related to food availability (Bax et al. 1978). Healy (1978) found that young salmon in Georgia Strait congregate in the best feeding areas and would leave if feeding conditions were poor. A possible way to test which of these two alternate hypotheses is working would be to compare growth rates of the fry early and late in the season. If predation pressures were higher early in the season, then the growth rate would be biased due to size-selective predation (Parker 1971). If, on the other hand, food availability was the factor of primary concern growth rate would not be expected to be as high early in the season as later on (LeBrasseur 1969). Differences in growth due to the different ambient temperatures early and late in the season could be accounted for by assuming a similar bioenergetic response of chum and sockeye salmon fry (Brett 1971). This analysis is beyond the scope of this report.

Pink Salmon

The relationship between the hatchery releases of pink salmon and the CPUE of pinks at Bangor Annex is not clear. There was a peak with the beach seine following 2 to 3 weeks after the first hatchery release on the west and east shores, respectively (Figs. 14, 15, and 18). Later peaks for both beach seine and townet occurred concurrently with peaks in CPUE of chum salmon (Figs. 16 and 17).

The apparent delay in seaward migration by some of the pink salmon seen in this study has also been noticed in other systems. Healey (1967) found the pink salmon outmigration in the Bella Coola River system to be saltatory with 1 or 2 days active migration followed by several days of residence in quiet bays and backwaters. Neave (1966b) also found the offshore movement of pink salmon in British Columbia to be gradual or irregular after an initial rapid migration away from the stream mouth. In Prince William Sound, Alaska, pink fry quickly formed schools upon reaching the river mouth and left the bay. The fry were later found converging in quiet coves and bays where they might remain for several weeks (Cooney et al. 1978). It is conceivable that this has also been happening in Hood Canal, the fry from the early hatchery releases residing in Hood Canal until they have reached a size at which active seaward migration begins. That the pink fry appeared to migrate when large numbers of chum salmon were in the system migrating seaward substantiates other studies which have found pink fry intermingling with chum fry of a similar size (Neave 1966a and 1966b; Parker 1971).

Coho Salmon

The peak in CPUE of coho salmon smolts occurred in late June and early July (Figs. 19 and 20). Peak hatchery releases from the Quilcene and Hood Canal hatcheries occurred late in the season and it is unlikely that the latter releases were monitored at Bangor Annex (Appendix Table 1). Based on the delay observed in peak CPUE of Big Beef Creek (BBC) marked smolts, described below, it seems probable that the peaks in CPUE observed at Bangor may be attributed to releases from Quilcene hatchery 5 weeks previous.

A small peak detected with the beach seine in mid-May coincided with the peak of recaptures of adipose fin-clipped coho smolts released from Big Beef Creek by the Washington State Department of Fisheries (WDF) (Fig. 26 and Appendix Table 2). These fin-clipped coho smolts comprised both wild Big Beef smolts and WDF Minter Creek hatchery-reared coho smolts released into Lake Symington above Big Beef Creek (Siler, personal communication)[1]. The peak of the releases of the smolts from Big Beef occurred 3 weeks before the peak of recapture at Bangor Annex.

The delay of 3 weeks between peak outmigration at Big Beef Creek and peak recaptures at Bangor Annex, 6 miles away, shows that the coho smolts are migrating seaward far slower than the chum salmon fry, which migrate from the Hood Canal fish hatchery to Bangor Annex, a distance of about 35 miles, in 1-2 weeks at that time of the year.

It has been suggested by many authors that coho smolts predate heavily on pink and chum fry in their early marine life; however, little numerical evidence is available to substantiate this (Simenstad and Kinney 1978). With the coho smolts residing in the same environment that the chum salmon fry must pass through, even a low daily predation rate by coho smolts on the chum could cause a substantial decrease in the marine survival of the chum.

Chinook Salmon

Despite large hatchery releases of chinook salmon smolts (Appendix Table 1), there were few recaptures at Bangor Annex (Figs. 21 and 22). Recaptures of chinook smolts were increasing at the end of the sampling season concurrent with large releases of smolts from the Quilcene hatchery.

Without data from a known population of fish it is impossible to know whether the early hatchery releases passed Bangor Annex and were for some reason unavailable to the sampling gear (e.g., swimming ability or vertical distribution), or alternatively whether the catches later in the season represented the earlier releases of chinook which had been residing further south since release.

---

[1] David Siler, Washington State Department of Fisheries, Olympia, Washington.

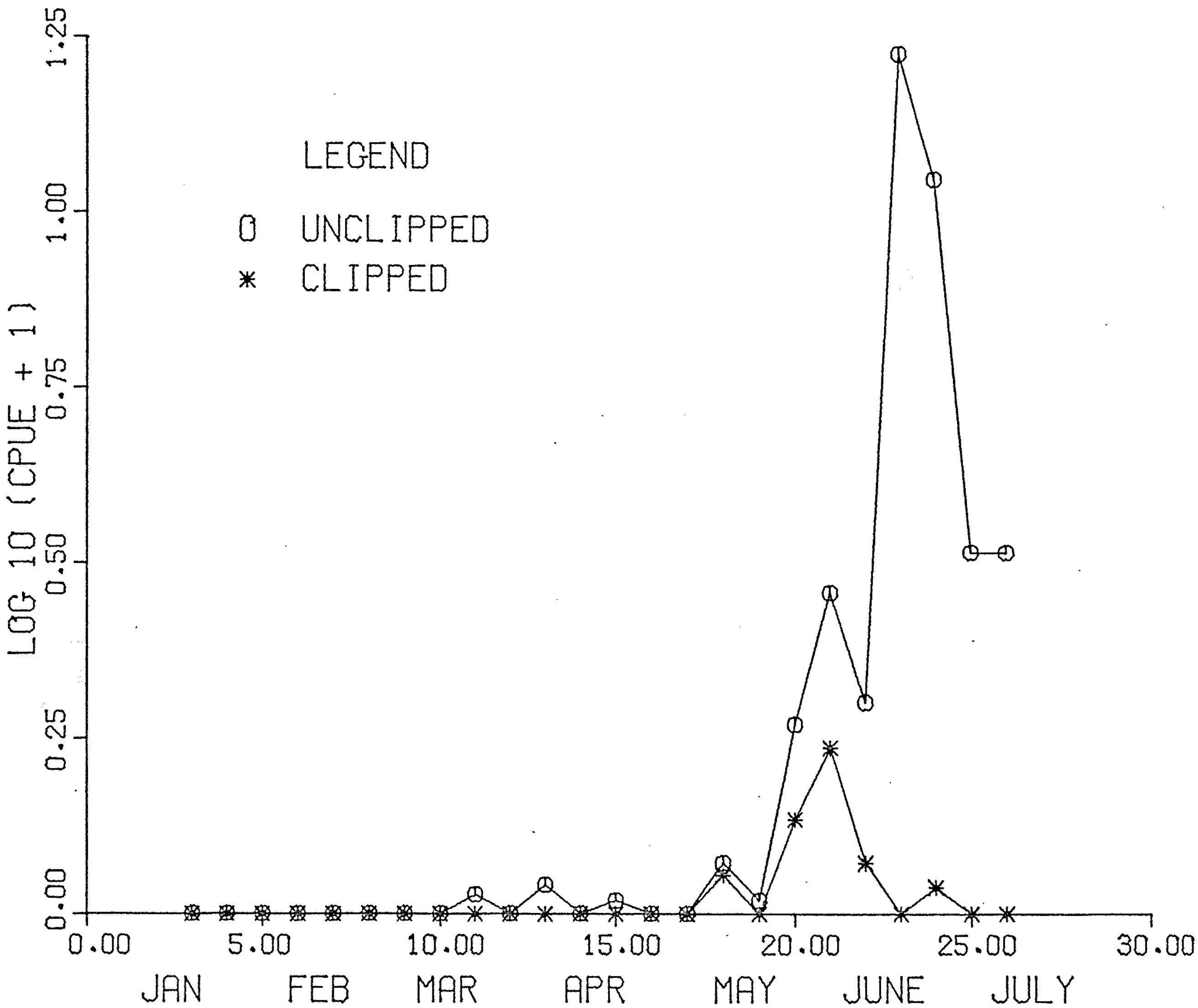


Fig. 26. Mean weekly CPUE of coho smolts and fin-clipped coho smolts with the beach seine at all sites in Hood Canal, Washington, 1978.

LENGTH-WEIGHT DATA

Length Data

Although the length data to be analyzed were not normally distributed, the variances were found to be homogeneous, and so the non-stringent requirement of normality for ANOVA testing was waived (Zar 1974, p. 135).

Chum Salmon

The mean length of chum smolts caught with the beach seine was variable early in the season, starting at 48 mm and subsequently dropping to 38 mm (Fig. 27). In early May, the mean length started to rise as the size of hatchery-reared fish at release increased (Appendix Table 3). The mean length had risen to the low sixties by the end of the sampling season.

Townet catches did not start until early April when the mean length of smolts caught was 45 mm (Fig. 28). The mean length increased rapidly through the season, reaching a high of 96 mm on the east shore in mid-July. The mean length of chum smolts caught with the townet was higher than that of those caught with the beach seine all season.

The higher mean length of chum fry caught offshore with the townet than those caught in the nearshore zone with the beach seine agrees with data from previous studies. Most authors have found a distinct size range at which the fry move offshore. Allen (1974) found a "definite movement offshore" when the fry were approximately 75 mm. Sano and Kobayashi (1952) found that offshore movement occurred when the fry were between 70 and 100 mm, and Sano (1966) found fry in a different area not moving offshore until 100-120 mm in length. This offshore movement has sometimes been recorded as accompanying a distinct change in maximum size of prey organisms taken by the chum as they moved offshore at 50-60 mm in length (Okada and Taniguchi 1972). Other authors have found definite behavioral changes, the fry responding to danger by diving deeper offshore instead of scattering across the surface as they had in the nursery areas (Cooney et al. 1978). In contrast to this distinct offshore movement, the movement offshore in Hood Canal as seen in this study and by Gerke and Kaczynski (1972) is a gradual process occurring at no distinct size range or time of year, although few chum are caught offshore until early May, when a dramatic change to pelagic organisms occurs, still feed predominantly on epibenthic organisms (Bax et al. 1978). This apparent difference between Hood Canal and the other systems studied may be due to the predominance of hatchery effects in Hood Canal. The hatcheries release fry of a larger initial size on entry into salt water as the season progresses, and if the offshore movement is dependent upon the time spent in the nearshore zone, as well as size, then it would be expected that the mean size at which offshore movement occurs would increase correspondingly as the season advanced.

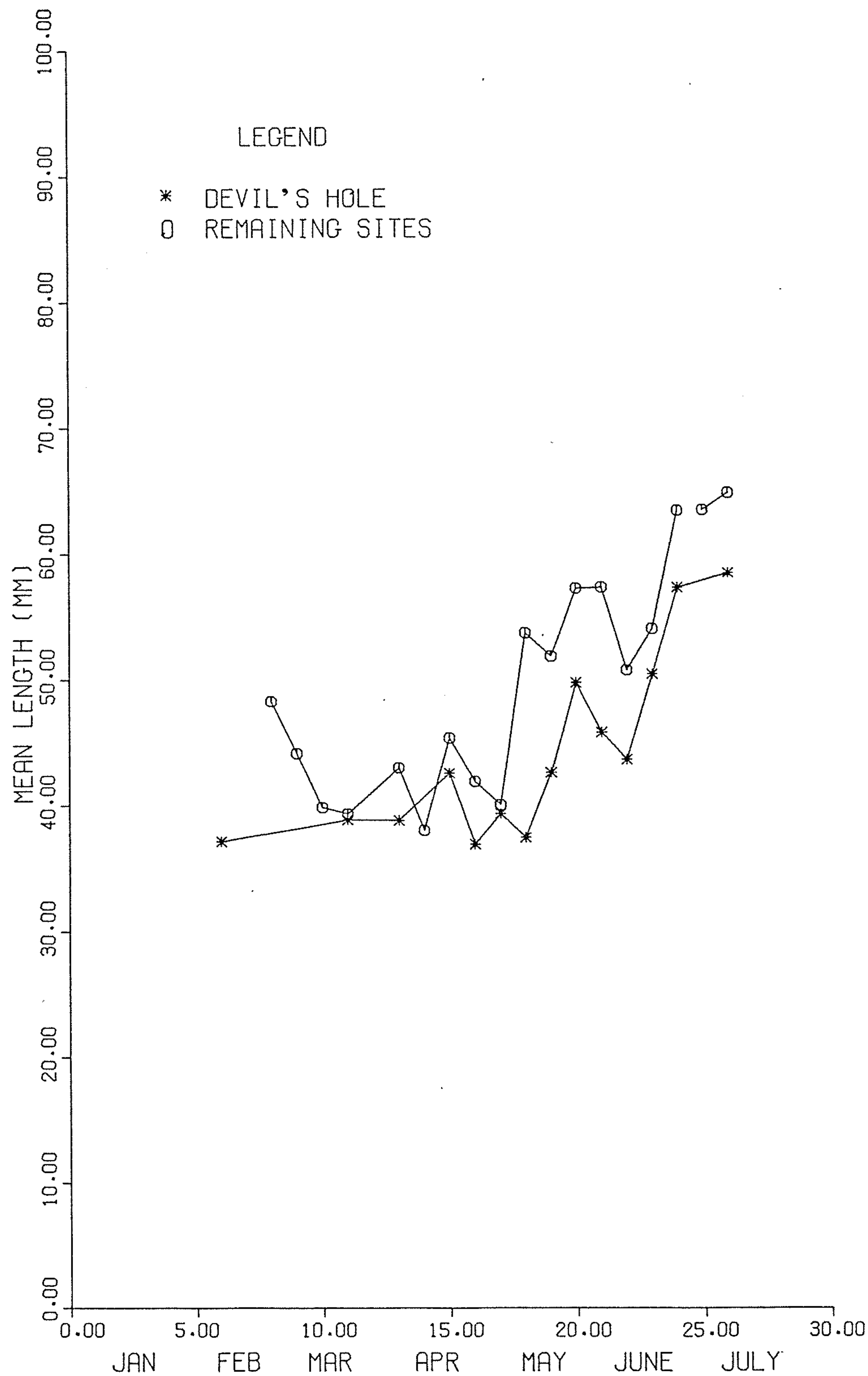


Fig. 27. Mean fork length of chum caught with the beach seine at Devil's Hole, and at all remaining sites in Hood Canal, Washington, 1978.

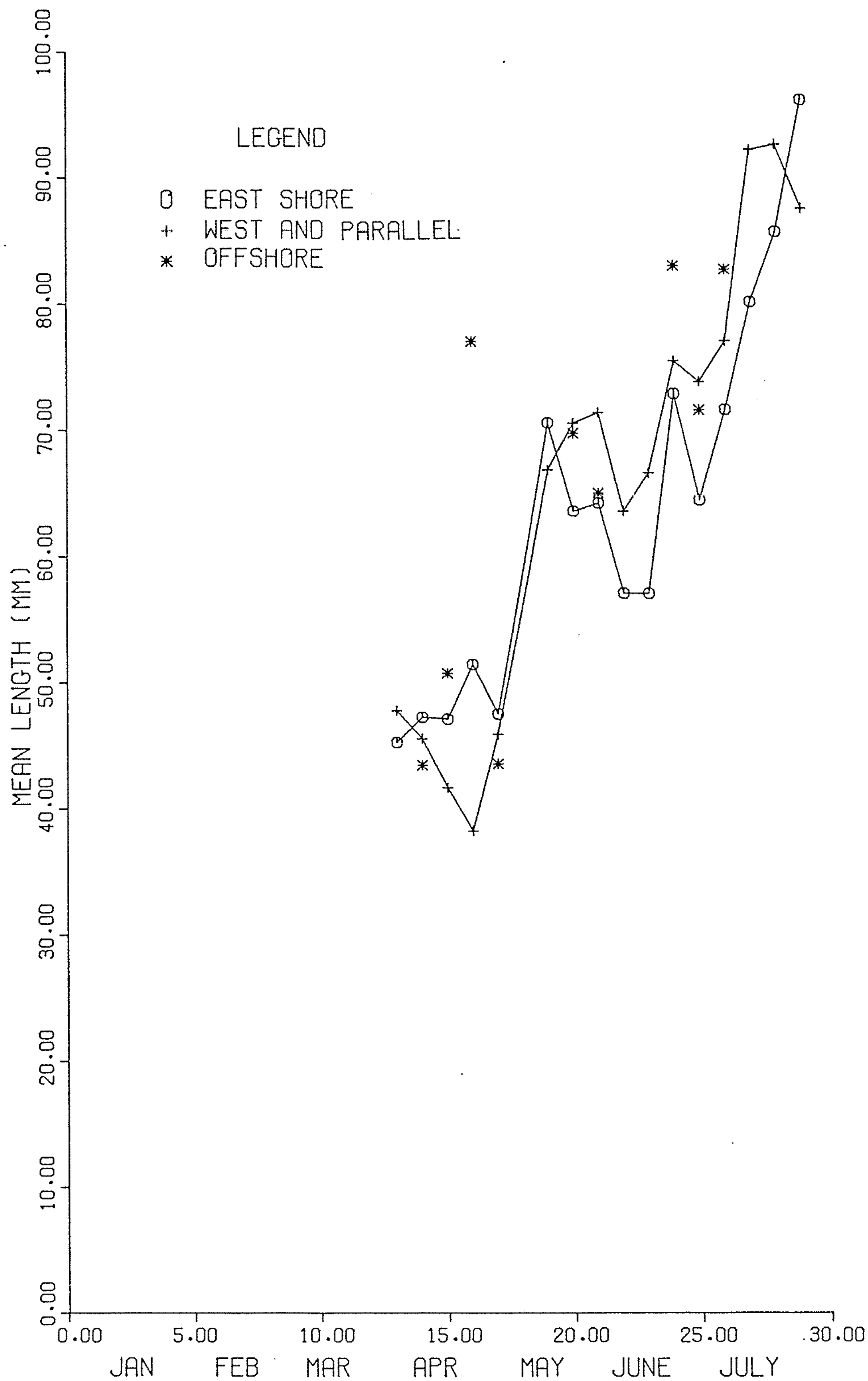


Fig. 28. Mean fork length of chum caught with the townet in Hood Canal, Washington, 1978.

The weekly mean length of chum caught at individual locations was determined to find any effects of locality on fish size. For the beach seine, of all sites sampled, only one, Devil's Hole, was significantly different from the rest ($p < 0.01$). Smaller chum were caught at Devil's Hole (Fig. 27).

The biological significance of this is not clear. Devil's Hole has an extensive littoral zone, and data collected from plankton pumping in 1977 showed that it had the highest concentration of harpacticoid copepods, the principle prey item of the nearshore chum juvenile of the sampled sites (Bax et al. 1978). Devil's Hole could then perhaps be an important nursery area for the chum juveniles; however, if so, it would be expected that the CPUE of chum at Devil's Hole would be higher than elsewhere and this was not the case (Table 2).

The mean length of chum caught with the townet did not vary between transects in the same group, but did vary between groups. The chum caught on the east shore were the smallest, while the cross-canal, or offshore transects had the largest fish caught (Fig. 28). The chum caught on the west shore and on the parallel tows were not significantly different. These results show larger chum were found further from shore. That the fry caught on the west shore were significantly larger than those caught on the east shore may be explained by the greater distance from shore that the west shore transects are towed.

Pink Salmon

The mean length of pink smolts caught with the beach seine ranged from 30 mm in early March to 54 mm in early June, after which no more were caught (Fig. 29). The mean length of pink smolts caught with the townet was higher than those caught with beach seine, ranging from 40 mm in early April to 77 mm by late June (Fig. 30).

There were no significant differences in mean length between pink smolts caught at any of the beach seine locations. Similarly there were no significant differences among townet transects in the mean length of pink smolts caught.

Condition Factor

Length and weight data were used to compute the condition factor of the smolts according to the equation:

$$\text{Condition Factor} = \frac{\text{Weight (g)}}{\text{Length}^3\text{ (mm)}} \times 10^5$$

The mean condition factors for each 5-mm increment size class, at each location, for each week, were computed and used in the analyses.

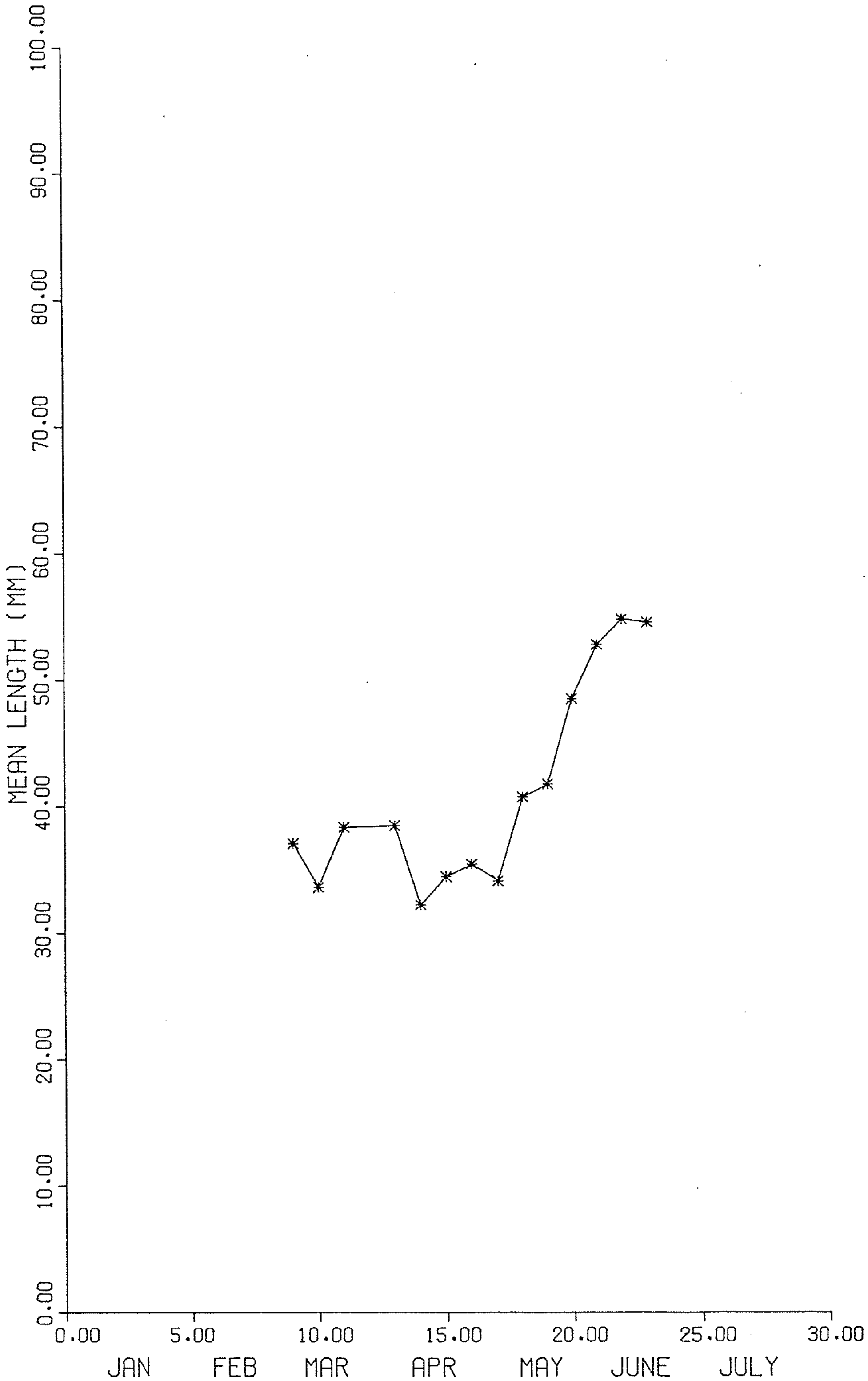


Fig. 29. Mean fork length of pinks caught with the beach seine at all sites in Hood Canal, Washington, 1978.

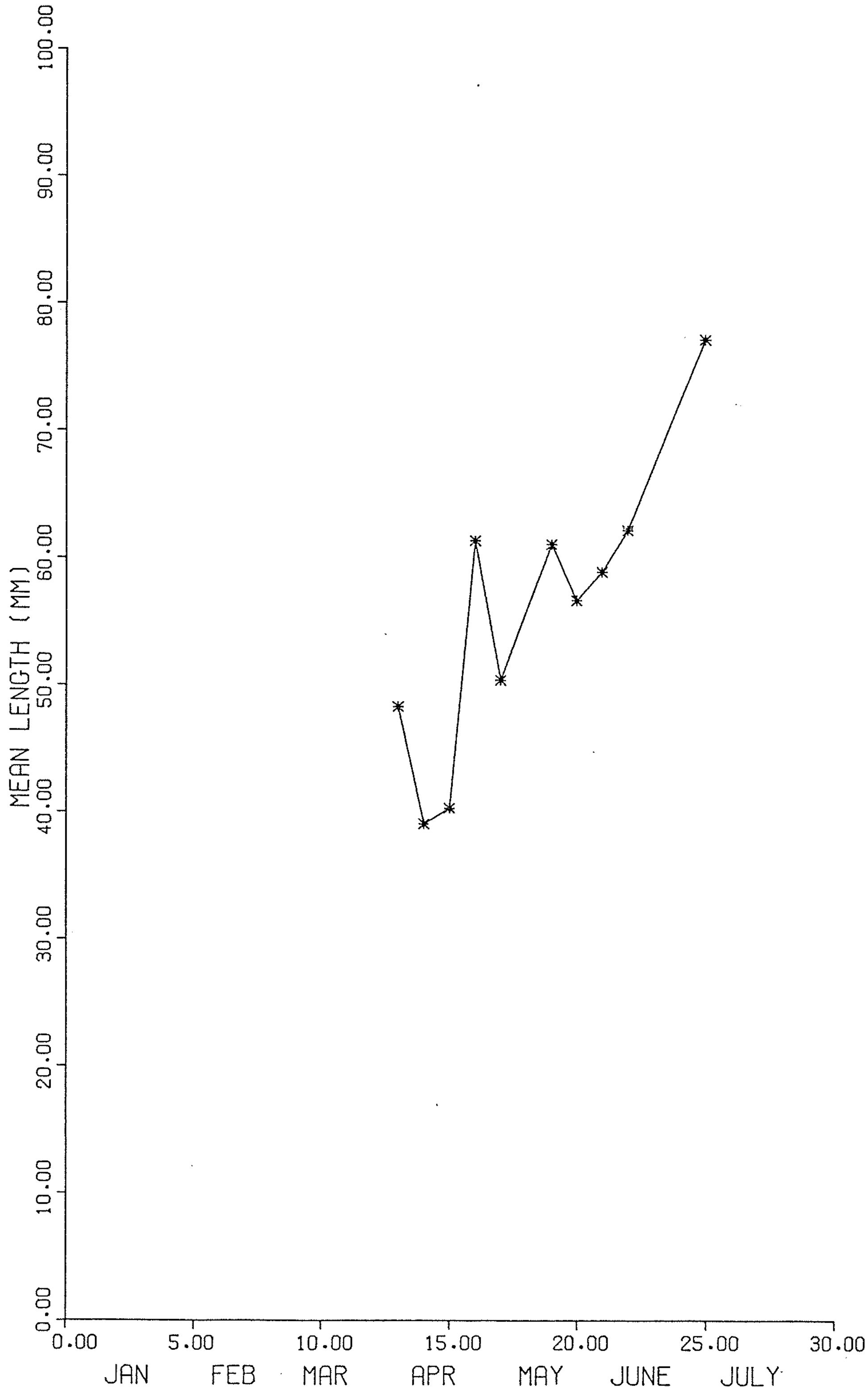


Fig. 30. Mean fork length of pinks caught with the townet at all sites in Hood Canal, Washington, 1978.

The use of this length-weight relationship to describe a fish's condition assumes that the heavier the fish at a given length the "better" its condition. The difficulties in this assumption as discussed by Abbasov and Polyakov (1978) are that the condition factor describes not only differences in the immediate life history of the fish, but also racial and age characteristics, degree of fullness of intestines, state of gonads, and other features. In our particular instance differences in the "condition" of the fish that we hope to attribute to local habitat differences or preferences may be confounded by differences in racial origins, size, or hatchery rearing techniques.

In use of this (Fulton's) condition factor the exponent in the equation is fixed at 3. This is most likely not the true case (Schreiner 1977); however, the difficulties in defining standard conditions and thus obtaining the exact exponent required for the allometric condition factor are severe. Ricker (1975, p. 209) does state, however, that:

> "Fulton's condition factor can also be used to compare fish of approximately the same length no matter what the value of b (the exponent)."

The use of the three-way analysis of variance in these analyses takes into account some of the above problems of racial origins, rearing practices and size differences, by standardizing condition factor with regard to length and width before analyzing location effects.

Initially, locations within each group of sampling locations (east, west, nearshore, offshore, beach seine, townet) were tested using ANOVA. If no significant differences were found then the groups for each gear type were tested against one another. When significant differences were found, a SNK multiple comparison analysis was carried out on the mean condition factors, adjusted to remove the effects of the other two independent variables: week and size. If one or two locations were found to be significantly different from the remainder, they were removed before between-group comparisons were made. Effects of sampling week and size class on condition factor were noted from these between-group comparisons.

No interaction effects were computed in their analyses because the procedure would have exceeded the central memory limits of the computer.

Chum Salmon

Beach Seine. Significant differences in condition factor of chum salmon were found between beach seine sites on the east shore (Table 11). Subsequent analysis showed that no site was significantly different from the remainder (Table 12). Consequently, all sites were used in the east-west comparison. No significant differences were found among sites on the west shore ($p = 0.175$). There was a

Table 11. Analysis of variance to show the effects of sampling week, location and size (mean fork length) on the condition factor of chum fry caught with the beach seine on the east shore of Hood Canal from February to July 1978.

ANALYSIS OF VARIANCE SUMMARY TABLE

Source of Variation	Sum of Squares	DF	Mean Square
Total	83.060	692	0.120
Cells	72.595	32	2.269
Week	59.687	14	4.263
Location	0.239	16	0.040
Size	0.328	12	0.027
Residual	10.465	660	0.016

H_0: There is no effect of week on the condition factor of captured fry

$F = 268.871 \gg F_{0.05(1),\ 14,\ \infty} = 1.69$ therefore reject H_0
pp << .0005

H_0: There is no effect of location on the condition factor of captured fry

$F = 2.515 > F_{0.05(1),\ 16,\ \infty} = 1.64$ therefore reject H_0
$.001 > p > .0005$

H_0: There is no effect of size (mean fork length) on the condition factor of captured fry

$F = 1.722 < F_{0.05(1),\ 12,\ \infty} = 1.75$ therefore do not reject H_0
$.10 > p > .05$

Table 12. Results of a SNK multiple comparison test on the effect of individual locations on the condition factor of chum fry captured with the beach seine on the east shore of Hood Canal from February to July 1978.

Site	N. Floral	S. Floral	Devil's Hole	S. Carlson	S. Marginal	N. Carlson	S. EHW
Sample Size	74	92	98	91	57	112	169
Mean Condition* Factor	0.88	0.86	0.85	0.84	0.83	0.82	0.82
Non-Significantly Different Groups		———	———	———	———	———	———
	———	———	———	———	———		

* Mean condition factor was adjusted for the independent variables; sampling week and size group so that only location effects remained for this analysis.

significant difference between condition factor on the east and on the west shore (Table 13). It was higher on the latter. Both sampling week and size group had a significant effect on the condition factor. Condition factors increased through the season, but decreased with size at any one time (Table 13 and Figs. 31 and 32).

Townet. No significant differences between condition factors of individual transects in any of the groups of townet transects were found. However, analysis of variance of the condition factors between the groups did show significant differences (Table 14). A multiple comparison separated out the offshore (cross canal) group of transects as being significantly different from the remainder (Table 15). The condition factor of smolts captured in the offshore transects was higher. The same relationship between sampling week, fish size, and condition factor that was observed in the beach seine captures--that is, condition factor increasing through the season but decreasing with size at any one time--was observed for the townet captures (Table 14, Figs. 33 and 34).

The lack of large differences in condition factor between individual locations sampled with either beach seine or townet is not unexpected. The suspected rate of migration through the sampling area probably precludes noticeable changes in condition factor during the migration past Bangor Annex.

The higher condition factor observed on the west shore than the east shore with the beach seine may be significant because it appears, as discussed previously, that the east and west shore populations are distinct once the initial selection has occurred.

The offshore townet transects had few captures of fish and these had a larger mean size than the remaining transects. The higher condition factor found for these offshore fish may be related to this increased length or, alternatively, due to fish well adapted to the environment which have made the transition from nearshore to offshore completely. Due to their higher mean length and condition factor, it is unlikely that they are fry from nearer to shore, either merely displaced or in the process of crossing the Canal.

As discussed previously in this section the observed differences in condition factors of chum fry, caught with either gear, and associated with sampling week or fork length could be due to reasons other than their early marine environment and/or behavior. This requires the results of this test to be treated with caution.

Pink Salmon

Beach Seine. On the east shore there were no significant differences between the condition factor of smolts captured at different locations ($p = 0.205$). North Spit 6, on the west shore, had only one sample and so was not included in the calculations. The

Table 13. Analysis of variance to show the effects of shoreline, sampling week and size (mean fork length) on the condition factor of chum fry caught with the 37-m beach seine from February to July 1978.

ANALYSIS OF VARIANCE SUMMARY TABLE

Source of Variation	Sum of Squares	DF	Mean Square
Total	102.400	943	0.109
Cells	89.851	32	2.808
Week	83.830	15	5.589
Location	0.155	1	0.155
Size	0.669	16	0.042
Residual	12.548	911	0.014

H_o: There is no effect of sampling week on the condition factor of captured fry

$F = 403.731 >> F_{0.5, \infty} = 1.67$ Therefore reject H_o $p << .0005$

H_o: There is no effect of shoreline on the condition factor of captured fry

$F = 11.245 >> F_{0.05, 1, \infty} = 3.84$ Therefore reject H_o $0.001 > p > 0.0005$

H_o: There is no effect of size on the condition factor of captured fry

$F = 3.036 << F_{0.05, 16, \infty} = 1.64$ Therefore reject H_o $p < 0.0005$

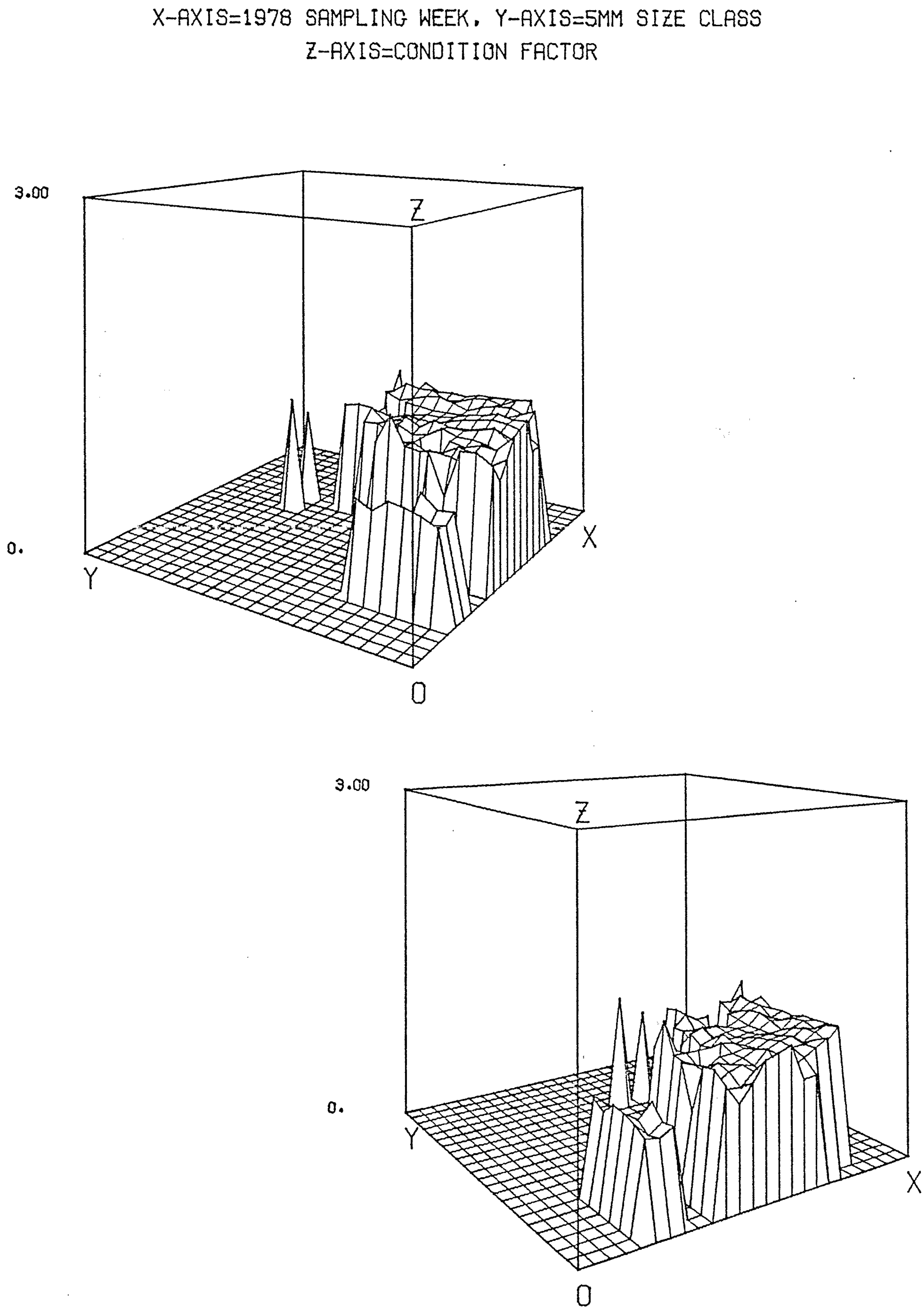
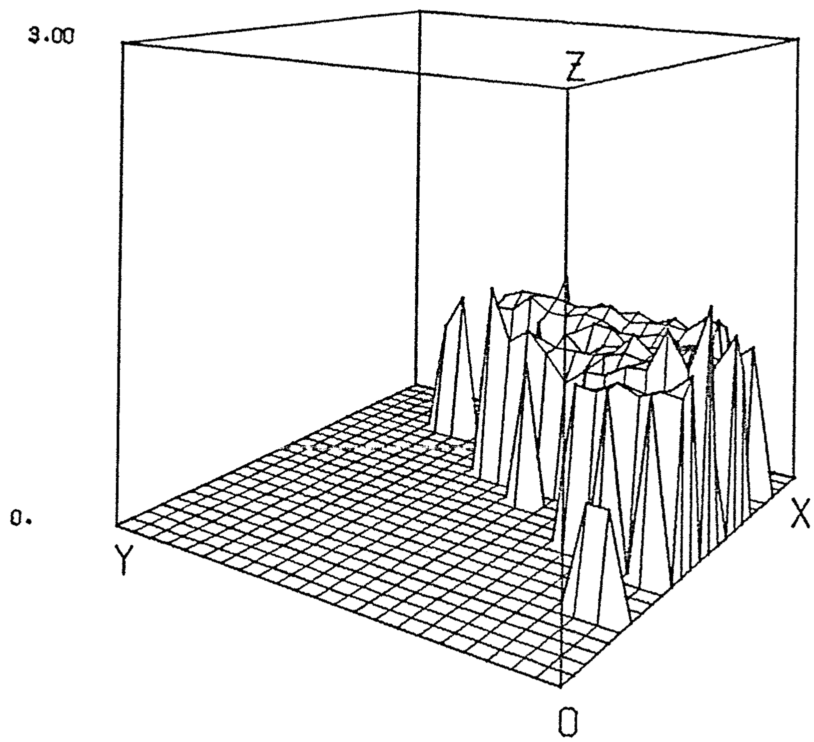


Fig. 31. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of chum caught with the beach seine on the east shore of Hood Canal, Washington, 1978.

X-AXIS=1978 SAMPLING WEEK, Y-AXIS=5MM SIZE CLASS
Z-AXIS=CONDITION FACTOR



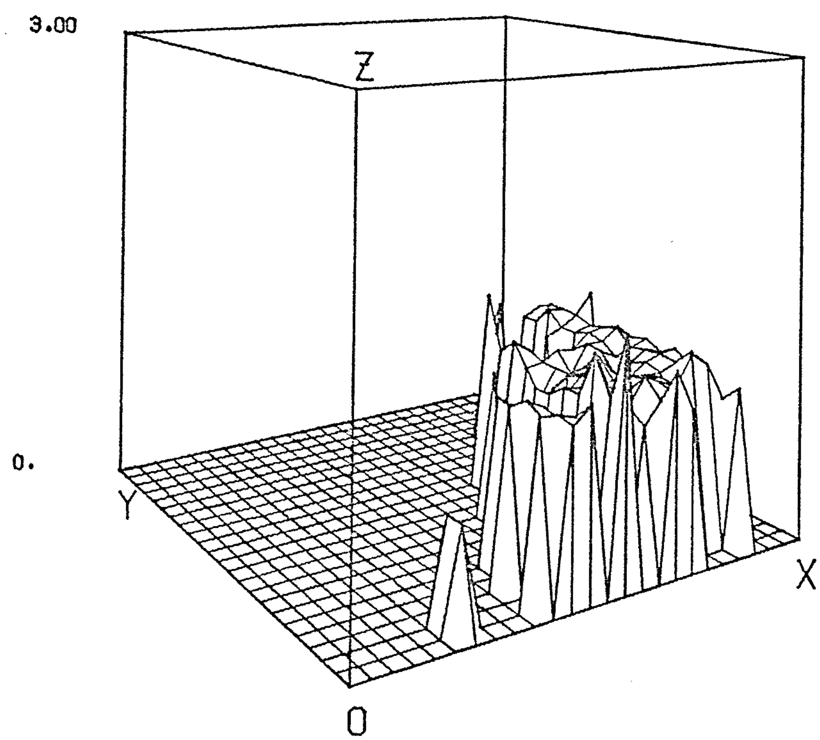


Fig. 32. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of chum captured with the beach seine on the west shore of Hood Canal, Washington, 1978.

Table 14. Analysis of variance to show the effects of location, sampling week and size (mean fork length) on the condition factor of chum fry caught with the townet from March to July 1978.

ANALYSIS OF VARIANCE SUMMARY TABLE

Source of Variation	Sum of Squares	DF	Mean Square
Total	130.104	1465	0.89
Cells	106.224	40	2.656
Week	90.929	15	6.062
Location	0.530	3	0.177
Size	1.490	22	0.068
Residual	23.880	1425	0.017

H_o: There is no effect of sampling week on the condition factor of captured fry

$F = 361.730 >> F_{0.05,\ 15,\ \infty} = 1.67$ therefore reject H_o $p << .0005$

H_o: There is no effect of sampling location on the condition factor of captured fry

$F = 10.540 >> F_{0.05,\ 3,\ \infty} = 2.61$ therefore reject H_o $p << .0005$

H_o: There is no effect of size on the condition factor of captured fry

$F = 4.041 >> F_{0.05,\ 22,\ \infty} = 1.54$ therefore reject H_o $p << .0005$

Table 15. Results of a SNK multiple comparison test on the effect of locations on the condition factor of chum fry captured by the townet from March to July 1978.

Site	Offshore	West Shore	Parallel Tows	East Shore
Sample Size	124	318	144	880
Mean Condition Factor	1.00	0.95	0.93	0.93
Non-Significantly Different Groups				

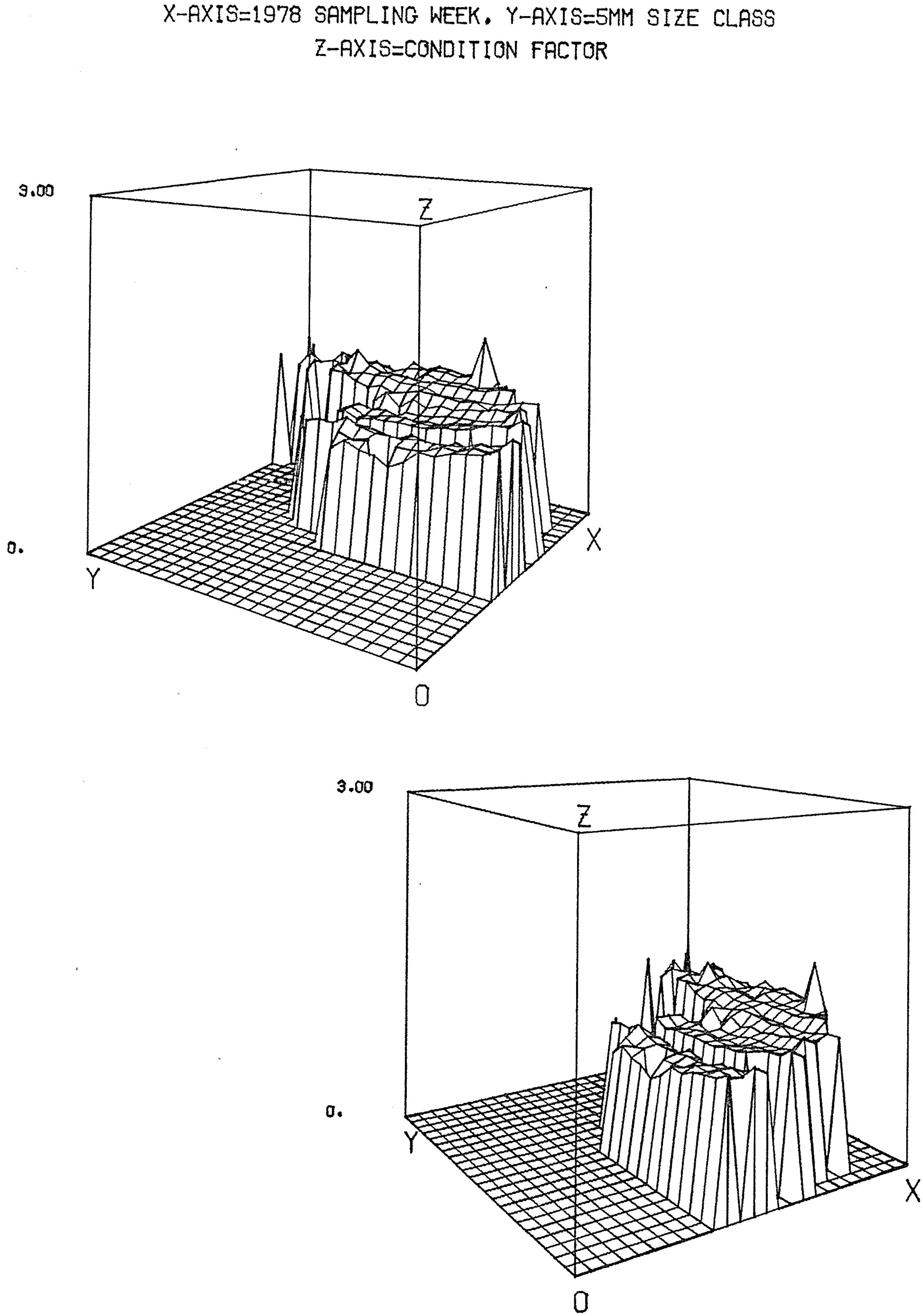
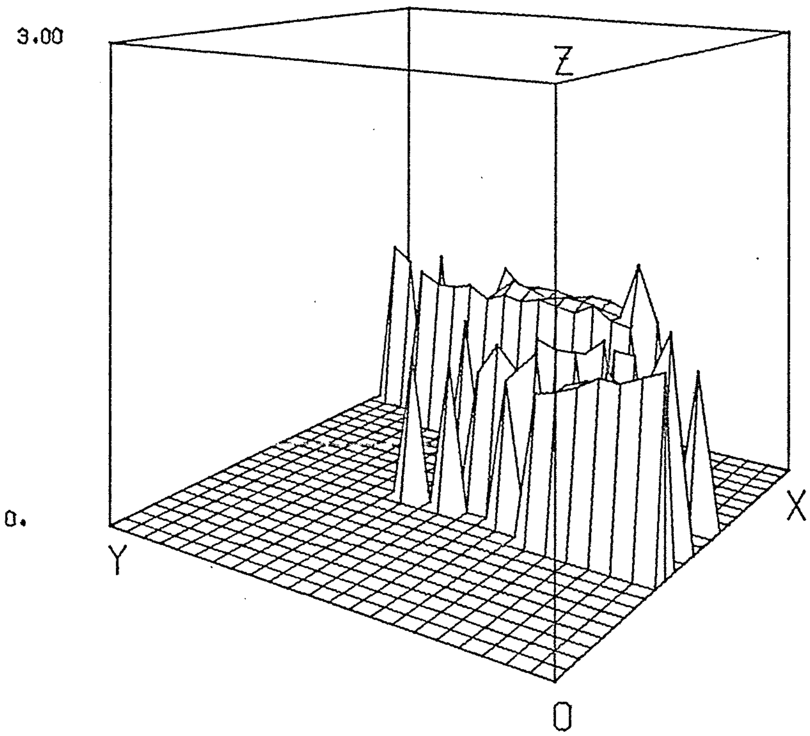


Fig. 33. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of chum captured with the tow-net on shoreline and parallel transects in Hood Canal, Washington, 1978.

X-AXIS=1978 SAMPLING WEEK, Y-AXIS=5MM SIZE CLASS
Z-AXIS=CONDITION FACTOR



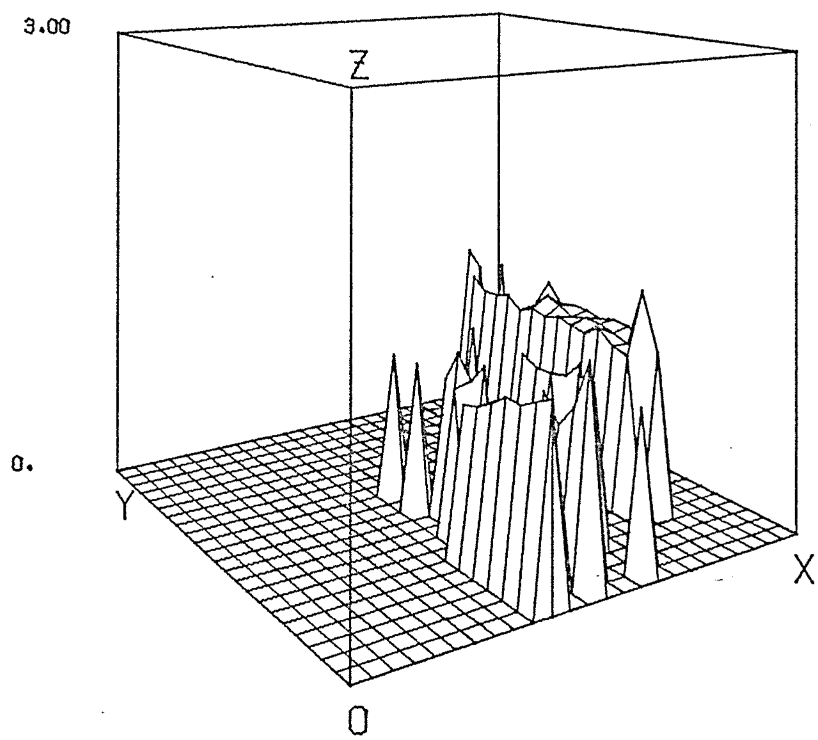


Fig. 34. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of chum captured in the tow-net along cross canal transects in Hood Canal, Washington, 1978.

condition factor at the remaining sites showed no significant differences ($0.2 < p < 0.5$). When the condition factors on the east and west shores were compared, it was found that the condition factors on the west shore were significantly different (higher) than those on the east shore (Table 16). In addition there was a significant increase in condition factor over the sampling period, but no apparent effect of size on the condition factor (Table 16, Figs. 35 and 36).

Townet. Significant differences were found between the condition factors of fry caught at different locations on the east shore (Table 17). No single site was significantly different from the remainder (Table 18). There were no significant differences on the west shore ($p = 0.179$). Insufficient fish were caught on the offshore and parallel tows for analysis. As the mean condition factor on the east and west shores was the same, no between-groups test was carried out. The size of the fish caught did have a significant effect on the condition factor on the east and west shore ($p = 0.03$, and $p = 0.001$, respectively) (Figs. 37 and 38). Sampling week showed no significant effect on condition for east shore sites where few weeks were available for analysis, but was significant ($p = 0.001$) on the west shore where more weeks were available.

The differences found in the condition factor of pink salmon are of the same nature as those discussed previously for the chum salmon, with one exception. The predominant lack of a seasonal trend in condition factor may be because there were only releases of pink salmon early in the year, thus reducing differences due to racial origins or hatchery influences.

Table 16. Analysis of variance to show the effects of location, sampling week and size (mean fork length) on the condition factor of pink fry caught with the beach seine from February to June 1978.

ANALYSIS OF VARIANCE SUMMARY TABLE

Source of Variation	Sum of Squares	DF	Mean Square
Total	67.697	398	0.170
Cells	61.610	27	2.282
Week	57.737	13	4.441
Size	0.166	13	0.013
Shoreline	0.135	1	0.135
Residual	6.087	371	0.016

H_o: There is no effect of sampling week on the condition factor of captured fry

$F = 270.690 >> F_{0.05,\ 28,\ 500} = 1.52$ therefore reject H_o $p << 0.0005$

H_o: There is no effect of sampling location on the condition factor of captured fry

$F = 8.234 > F_{0.05,\ 1,\ 500} = 3.86$ therefore reject H_o $0.0025 < p < 0.005$

H_o: There is no effect of fish size on the condition factor of captured fry

$F = 0.77 < F_{0.05,\ 13,\ 500} = 1.74$ therefore do not reject H_o $p > 0.25$

X-AXIS=1978 SAMPLING WEEK, Y-AXIS=5MM SIZE CLASS
Z-AXIS=CONDITION FACTOR

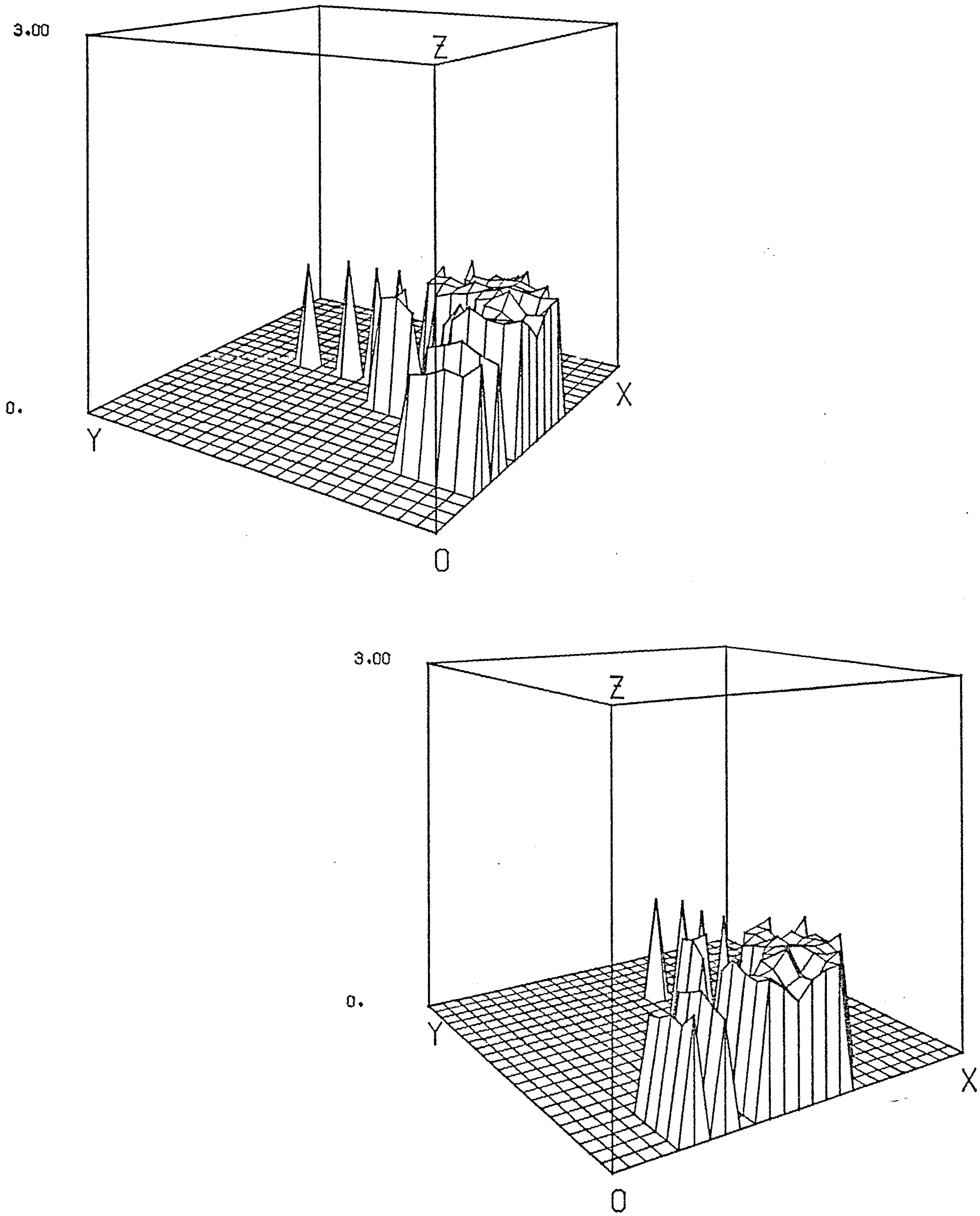
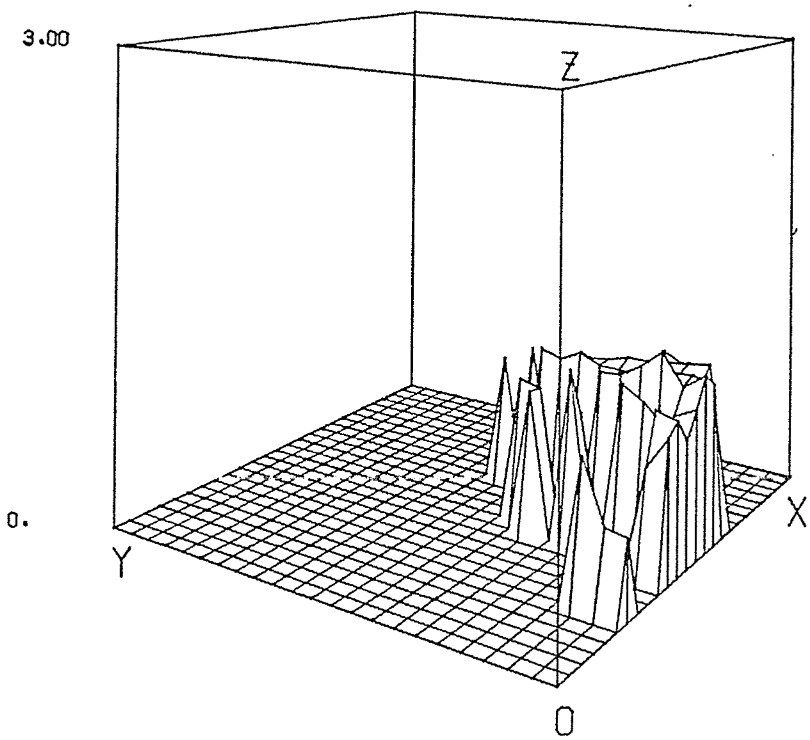


Fig. 35. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of pinks captured with the beach seine on the east shore of Hood Canal, Washington, 1978.

X-AXIS=1978 SAMPLING WEEK, Y-AXIS=5MM SIZE CLASS
Z-AXIS=CONDITION FACTOR



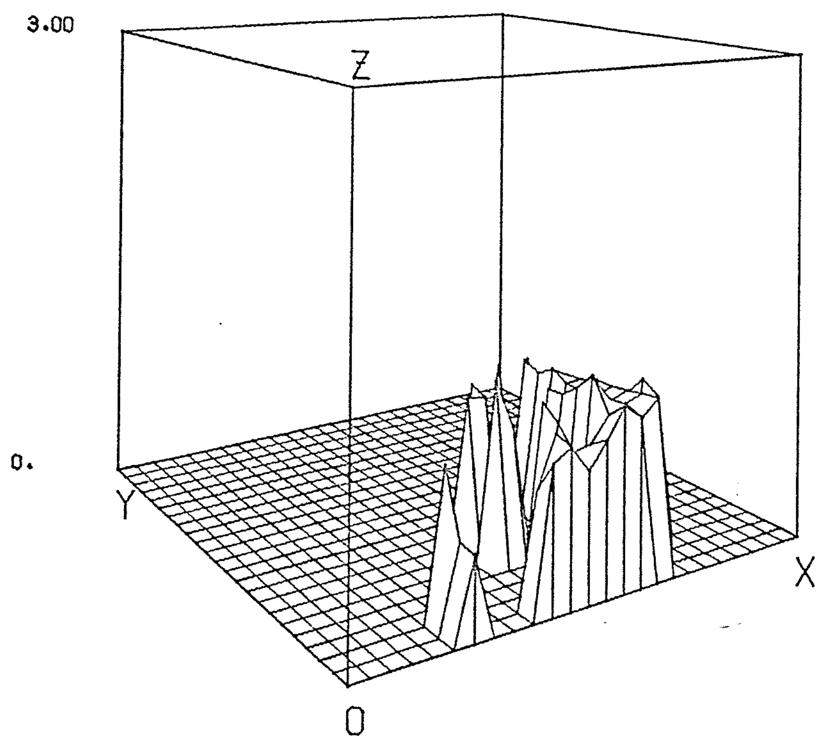


Fig. 36. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of pinks captured with the beach seine on the west shore of Hood Canal, Washington, 1978.

Table 17. Analysis of variance to show the effects of location, sampling week and size (mean fork length) on the condition factor of pink fry caught with the townet from March to June 1978, on the east shore of Hood Canal.

ANALYSIS OF VARIANCE SUMMARY TABLE

Source of Variation	Sum of Squares	DF	Mean Square
Total	3.492	120	0.029
Cells	1.181	23	0.051
Week	0.089	4	0.022
Location	0.482	6	0.80
Size	0.614	13	0.047
Residual	2.311	97	0.024

H_0: There is no effect of sampling week on the condition factor of captured fry

$F = 0.934 < F_{0.05,\ 4,\ 100} = 2.46$ do not reject H_0 $p > 0.25$

H_0: There is no effect of sampling location on the condition factor of captured fry

$F = 3.370 > F_{0.005,\ 6,\ 100} = 2.19$ reject H_0 $0.0025 < p < 0.005$

H_0: There is no effect of size on the condition factor of captured fry

$F = 1.984 > F_{0.05,\ 13,\ 100} = 1.82$ reject H_0 $0.01 < p < 0.05$

Table 18. Results of a SNK multiple comparison test on the effect of location on the condition factor of pink fry captured by the townet on the east shore of Hood Canal from March to June 1978.

Site	S. Carlson	N. EHW	Devils's Hole	N. Carlson	S. Floral	Marginal	EHW
Sample Size	10	25	12	25	14	16	19
Mean Condition Factor	1.08	1.01	0.94	0.93	0.90	0.88	0.87
Non-Significantly Different Groups			—	—	—	—	—
	—	—	—				
		—	—	—	—	—	

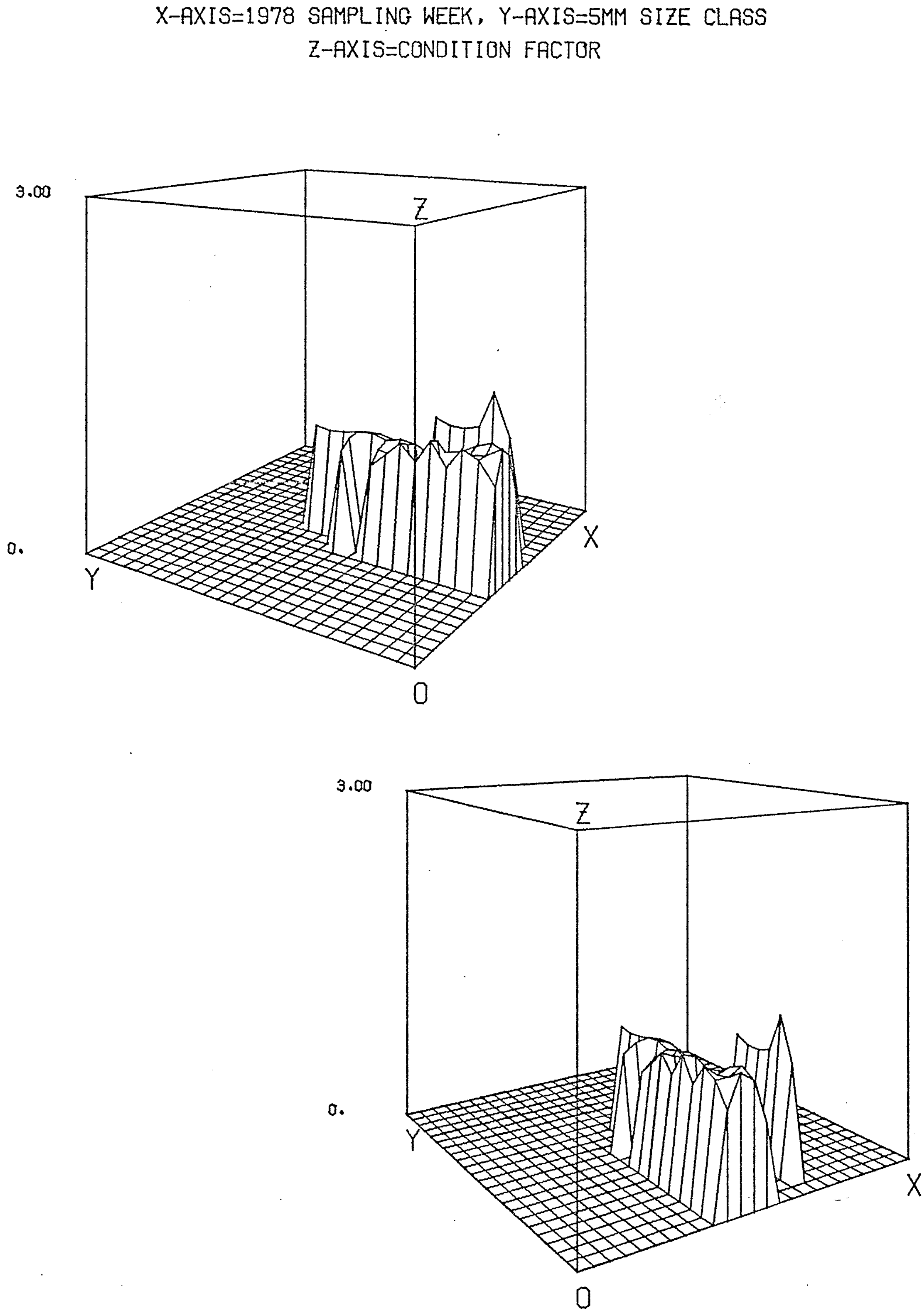
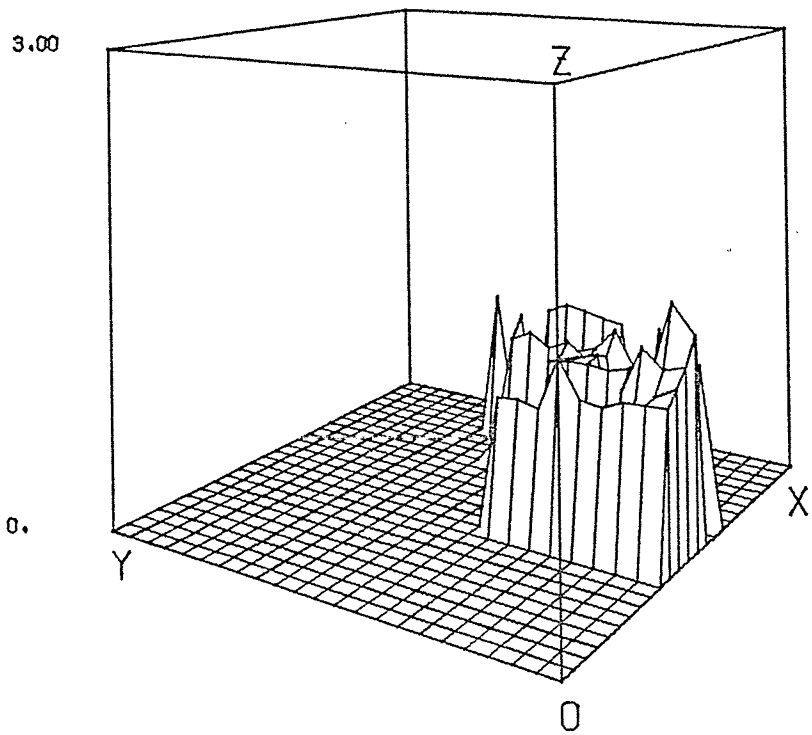


Fig. 37. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of pinks captured with the townet on the east shore of Hood Canal, Washington, 1978.

X-AXIS=1978 SAMPLING WEEK, Y-AXIS=5MM SIZE CLASS
Z-AXIS=CONDITION FACTOR



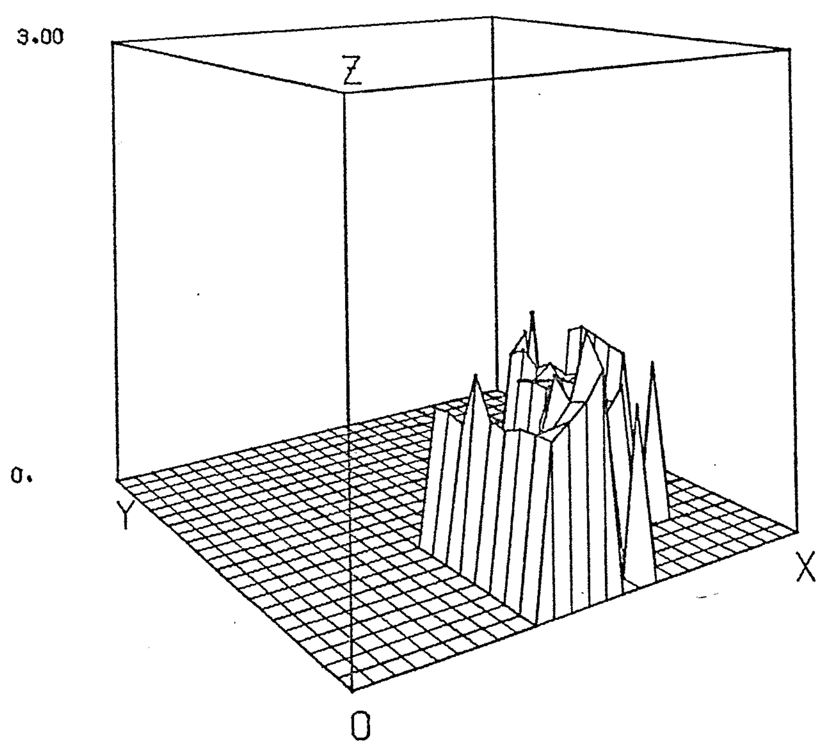


Fig. 38. Three dimensional plot to show the effect of sampling week and fork length on the condition factor of pinks caught with the townet on the west shore of Hood Canal, Washington, 1978.

SUMMARY

1. Juvenile salmonids were monitored as they migrated along the Bangor shoreline on Hood Canal, site of the U.S. Naval Submarine Base now under construction. Floating beach seines were used from January through June, and a surface townet from March through July 1978. Environmental variables were recorded.

2. Chum salmon smolts were the predominant salmonid species captured, with peak catches in May for the beach seine and June/July for the townet.

3. The peak catches of pink salmon smolts, the second most abundant species, were in April and May. Coho smolts and chinook smolts were also caught, with peak catches in June and July, respectively.

4. Significant differences in CPUE of chum at different sites were found. The beach seine had the highest catch at S. EHW and the lowest at S. Marginal. With the townet, CPUE of chum decreased as distance from shore increased, although high variability in the data affected interpretation.

5. No single environmental variable appeared consistently related to CPUE of pink or chum.

6. Peaks in CPUE of chum salmon were apparently caused by hatchery releases 1-3 weeks earlier.

7. No definite relationship between pink CPUE and hatchery releases was found. The peaks in CPUE of pink smolts were found several months after hatchery releases and concurrent with peak catches of chum smolts.

8. Peaks in CPUE of coho salmon may have followed 5 weeks after hatchery releases from Quilcene. The peak CPUE of Big Beef Creek coho smolts which had been fin-clipped was found 3 weeks later at Bangor Annex.

9. The mean length of chum smolts increased during the season and was related to the size of hatchery-reared chum at release.

10. The mean length of chum smolts caught at Devil's Hole was significantly lower than at other beach seine sites. The mean length of chum increased with distance from shore.

11. Condition factors were computed for captured chum smolts. Significant differences were found in condition factors of chum caught on the east shore with the beach seine. It was found that chum caught offshore with the townet had a significantly higher condition factor than those caught further inshore with the townet.

12. The condition factor increased during the season for chum smolts caught with both gears, and decreased with size when seasonal effects were removed.

13. Differences in condition factor and mean length of the populations of chum and pink fry on the east and west shores support the hypothesis that fry released from the hatcheries split into two distinct populations one crossing the Canal to the east shore, and the other staying along the west shore.

LITERATURE CITED

Abbasov, G. S., and G. D. Polyakov. 1978. Evaluation of feeding conditions and the biological state of a fish population by means of condition factor. J. Ichthyol. 18(3):407-417.

Allen, B., 1974. Early marine life history of Big Qualicum River chum salmon. Pages 137-148 in D. R. Hargind, ed. Proc. 1974 N.E. Pac. pink and chum salmon workshop. Dep. Environ., Fish., Vancouver, B.C.

Baggerman, B. 1960. Salinity preference, thyroid activity and the seaward migration of four species of Pacific salmon (*Oncorhynchus*). J. Fish. Res. Board Can. 17(3):295-322.

Bakkala, R. G. 1970. Synopsis of biological data on the chum salmon (*Oncorhynchus keta*). FAO Species synopsis. No. 41. Circ. 315.

Bax, N. J., E. O. Salo, B. P. Snyder, C. A. Simentstad, and W. J. Kinney. 1978. Salmonid outmigration studies in Hood Canal. Final Report, Phase III. Univ. Washington, Fish. Res. Inst. Final Report FRI-UW-7819. 128 pp.

Bessey, R. F. 1972. Behavioral responses of juvenile salmon in a moving thermal gradient. M.S. Thesis, Univ. Washington, Seattle. 50 pp.

Blackbourn, D. J. 1976. Correlation analysis of factors related to the marine growth and survival of Fraser River pink salmon. Pages 198-199 in G. K. Gunstrom, ed. Proc. 1976 N.E. Pac. pink and chum salmon workshop. Alaska Dep. Fish Game, Juneau, Alaska.

Brett, J. R. 1971. Energetic responses of salmon to temperature. A study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (*Oncorhynchus nerka*). Amer. Zool. 11:99-113.

Cooney, R. T., D. Urquhart, R. Nevé, J. Hilsinger, R. Clasby, and D. Barnard. 1978. Some aspects of the carrying capacity of Prince William Sound, Alaska for hatchery released pink and chum salmon fry. Alaska Sea Grant Rep. AKU-T-78-006. 48 pp.

Gerke, R. J., and V. W. Kaczynski. 1972. Food of juvenile pink and chum salmon in Puget Sound, Washington State Dep. Fish., Tech. Rep. 10. 27 pp.

Gilhousen, P. 1962. Marine factors affecting survival of Fraser River pink salmon. Pages 105-109 in N. J. Wilimovsky, ed. Sympos. on pink salmon. H. R. MacMillan lectures in fish., Univ. British Columbia, Vancouver.

Harden Jones, F. R., M. Greer Walker, and G. P. Arnold. 1978. Tactics of fish movement in relation to migration strategy and water circulation. Pages 185-207 in H. Chamock and G. Deacon, eds. Advances in oceanography. Plenum Press, New York and London.

Healey, M. C. 1967. Orientation of pink salmon (Oncorhynchus gorbuscha) during early marine migration from Bella Coola River system. J. Fish. Res. Board Can. 24(11):2321-2338.

Healey, M. C. 1978. The distribution, abundance, and feeding habits of juvenile Pacific salmon in Georgia Strait, British Columbia. Canad. Fish. and Mar. Serv. Tech. Rep. 788.

Heiser, D. W., and E. L. Finn. 1970. Observations of juvenile chum and pink salmon in marine and bulkheaded areas. Washington Dep. Fish., Mgmt. and Res. Div., Suppl. Prog. Rep., Puget Sound stream studies. 28 pp.

Hoar, W. S., M. H. A. Keenlyside, and R. G. Goodall. 1957. Reactions of juvenile Pacific salmon to light. J. Fish. Res. Board Can. 14(6):815-830.

Houston, A. H. 1957. Responses of juvenile chum, pink, and coho salmon to sharp seawater gradients. Canad. S. Zool. 35:371-383.

Hunter, J. G. 1959. Survival and production of pink and chum salmon in a coastal stream. J. Fish. Res. Board Can. 16(6):835-886.

Hurley, D. A., and W. L. Woodall. 1968. Responses of young pink salmon to vertical temperature and salinity gradients. Int. Pac. Sal. Fish. Comm. Prog. Rep. 19. 80 pp.

Kobayashi, T. 1960. An ecological study on the salmon fry, Oncorhynchus keta. VI. Note on the feeding activity of chum salmon fry. Nikon Suisan Gakkai-Shi. 26(6):577-580.

Kobayashi, T., and M. Sasaki. 1965. Experiments using air bubbles and the light to deflect migrating chum salmon fry. Oncorhynchus keta (Walbaum). Sci. Rep. Hokkaido Salmon Hatchery 19:33-42.

Kron, T. 1976. Pink salmon (Oncorhynchus gorbuscha) time of release in relation to their estuarine food supply - some preliminary observations. Page 210 in G. K. Gunstrom, ed. Proc. 1976 N.E. Pac. pink and chum salmon workshop. Alaska Dep. Fish Game, Juneau, Alaska.

LeBrasseur, R. J. 1969. Growth of juvenile chum salmon (Oncorhynchus keta) under different feeding regimes. J. Fish. Res. Board Can. 26(6):1631-1645.

McDonald, J. 1960. The behavior of Pacific salmon during their downstream migration to freshwater and saltwater nursery areas. J. Fish. Res. Board Can. 17(5):655-676.

McInerney, J. E. 1964. Salinity preference: an orientation mechanism in salmon migration. J. Fish. Res. Board Can. 21(5):995-1018.

Major, P. F. 1977. Predator prey interactions in schooling fishes during periods of twilight: A study of the silverside, *Pranesus insularum*, in Hawaii. U.S. Nat. Mar. Fish. Serv., Fish. Bull. 75(2):415-426.

Manzer, J. I., and M. P. Shepard. 1962. Marine survival, distribution and migration of pink salmon (*Oncorhynchus gorbuscha*) off the British Columbia coast. Pages 113-122 *in* N. J. Wilimovsky, ed. Sympos. on pink salmon. H. R. MacMillan Lectures in Fisheries, Univ. British Columbia.

Martin, J. W. 1966. Early sea life of pink salmon. Pages 111-124 *in* W. L. Sheridan, ed. Proc. 1966 northeast Pac. pink salmon workshop. Alaska Dep. Fish Game Inform. Leafl. 87.

Neave, F. 1966a. Salmon of the North Pacific Ocean - Part III. A review of the life history of North Pacific salmon. 5. The pink salmon in British Columbia. Int. N. Pac. Fish. Comm. Bull. 18:71-79.

Neave, F. 1966b. Salmon of the North Pacific Ocean - Part III. A review of the life history of North Pacific Salmon. 6. The chum salmon in British Columbia. Int. N. Pac. Fish. Comm. Bull. 18:81-85.

Okada, S., and A. Taniguchi. 1972. Size relationship between salmon juveniles in inshore waters and their prey animals. Bull. Fac. Fish. Hokkaido Univ. 22:30-36.

Parker, R. R. 1965. Estimation of sea mortality rates for the 1961 brood-year pink salmon of the Bella Coola area, British Columbia. J. Fish. Res. Board Can. 22(6):1523-1531.

Parker, R. R. 1968. Marine mortality schedules of pink salmon of the Bella Coola River, central British Columbia. J. Fish. Res. Board Can. 25:757-794.

Parker, R. R. 1971. Size selective predation among juvenile salmonid fishes in a British Columbian inlet. J. Fish. Res. Board Can. 28:1503-10.

Prinslow, T. E., E. O. Salo, and B. P. Snyder. 1979. Studies of behavioral effects of a lighted and an unlighted wharf on outmigrating salmonids--March-April 1978. Univ. Washington, Fish. Res. Inst. FRI-UW-7920. 35 pp.

Reynolds, W. W. 1977. Temperature as a proximate factor in orientation behavior. J. Fish. Res. Board Can. 34:734-739.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191. 382 pp.

Sano, S. 1966. Salmon of the North Pacific Ocean. Part III. A review of the life history of North Pacific salmon. 3. Chum salmon in the Far East. Int. N. Pac. Fish. Comm. Bull. 18:41-59.

Sano, S., and T. Kobayashi. 1952. An ecological study of the salmon fry (*Oncorhynchus keta*). The migration and growth of the fry in the marking experiment. Sci. Rep., Hokkaido Fish Hatchery 8(2):71.

Schreiner, J. U. 1977. Salmonid outmigration studies in Hood Canal, Washington. M.S. Thesis, Univ. Washington, Seattle. 91 pp.

Shepard, M. P. 1948. Responses of young chum salmon, *Oncorhynchus keta* (Walbaum), to changes in the sea water of the environment. M.A. Thesis, Univ. British Columbia, Vancouver, B.C.

Simenstad, C. A., and W. J. Kinney. 1978. Trophic relationships of outmigrating chum salmon in Hood Canal, Washington 1977. Univ. Washington, Fish. Res. Inst. Final Rep. FRI-UW-7810. 75 pp.

Taylor, S. G. 1976. Marine survival of the fry of early and late spawning pink salmon produced in gravel incubation hatchery at Auke Creek, Alaska. Pages 188-195 *in* G. K. Gunstrom, ed. Proc. 1976 N.E. Pac. pink and chum salmon workshop. Alaska Dep. Fish Game, Juneau, Alaska.

Vernon, E. H. 1958. An examination of factors affecting the abundance of pink salmon in the Fraser River. Int. Pac. Salmon Comm., Prog. Rep.

Whitmus, C. J., and S. Olsen. 1979. The migratory behavior of juvenile chum salmon released in 1977 from the Hood Canal hatchery at Hoodsport, Washington. Univ. Washington, Fish. Res. Inst. Final Rep. FRI-UW-7916. 46 pp.

Wickett, W. P. 1958. Review of certain environmental factors affecting the production of pink and chum salmon. J. Fish. Res. Board Can. 15(5):1103-1126.

Zar, J. H. 1974. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, NJ. 620 pp.

APPENDICES

Appendix Table 1. Releases of coho and chinook salmon smolts from Quilcene, Hood Canal and George Adams fish hatcheries into Hood Canal, Washington, 1978.

Quilcene Fish Hatchery (USFWS)				Hood Canal Fish Hatchery (WDF)				George Adams Fish Hatchery (WDF)			
Date of Release	Fish* Species	Number Released	Fish/lb	Date of Release	Fish* Species	Number Released	Fish/lb	Date of Release	Fish Species	Number Released	Fish/lb
May 3	Coho	62,000	20-25	March 7	S/FCS	223,500	120	April 20	Coho	30,171	27
10/11	FCS	310,000	100	25	SCS	49,840	280	May 19	FCS	375,583	73
25	Coho	204,000	20-25	25	FCS	199,881	297				
31	Coho	67,500	20-25	31	FCS	44,100	245				
June 5	Coho	18,800	20-25	April 8	FCS	50,000	200				
6	Coho	45,500	20-25	15	FCS	99,925	175				
16	FCS	339,000	100	25	FCS	846,880	134				
23-29	FCS	1,778,000	100	May 23	FCS	61,582	82				
				28	Coho	249,840	18				
				July 3	Coho	232,297	13				

* Key to fish species: FCS = Fall chinook; SCS = Spring chinook; S/FCS = Spring/Fall chinook

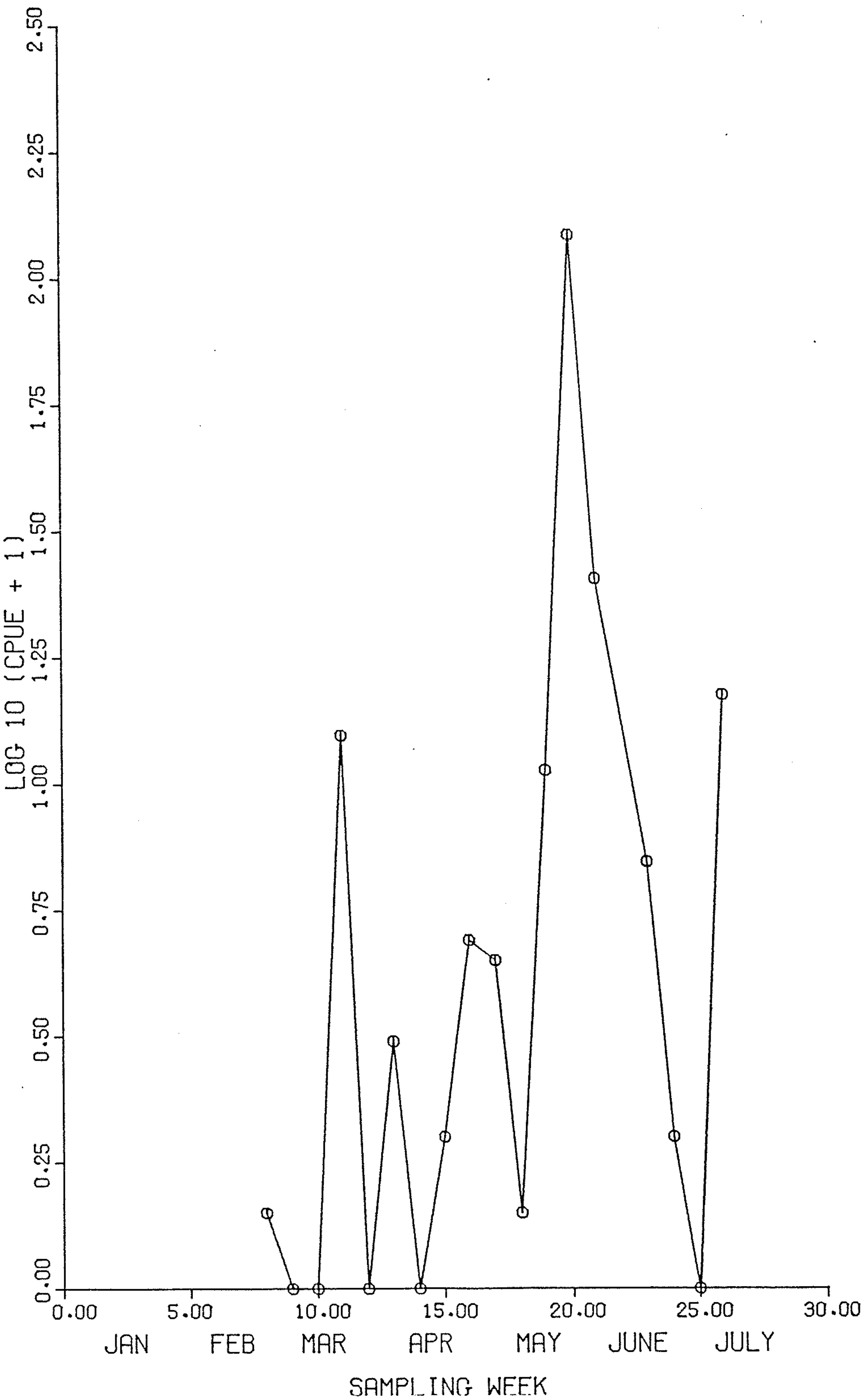
Appendix Table 2. Weekly release of fin-clipped coho smolts from the Big Beef Creek wild outmigration into Hood Canal, Washington, 1978.

Week	Number of coho smolts tagged and released in Big Beef Creek
Prior to April 14	Approx. 500
April 14 - 16	1,778
April 17 - 23	4,110
April 24 - 30	8,767
May 1 - 7	7,269
May 8 - 14	4,531
May 15 - 21	2,346
May 22 - 28	237
May 29 to June 4	79
Total Released	29,117

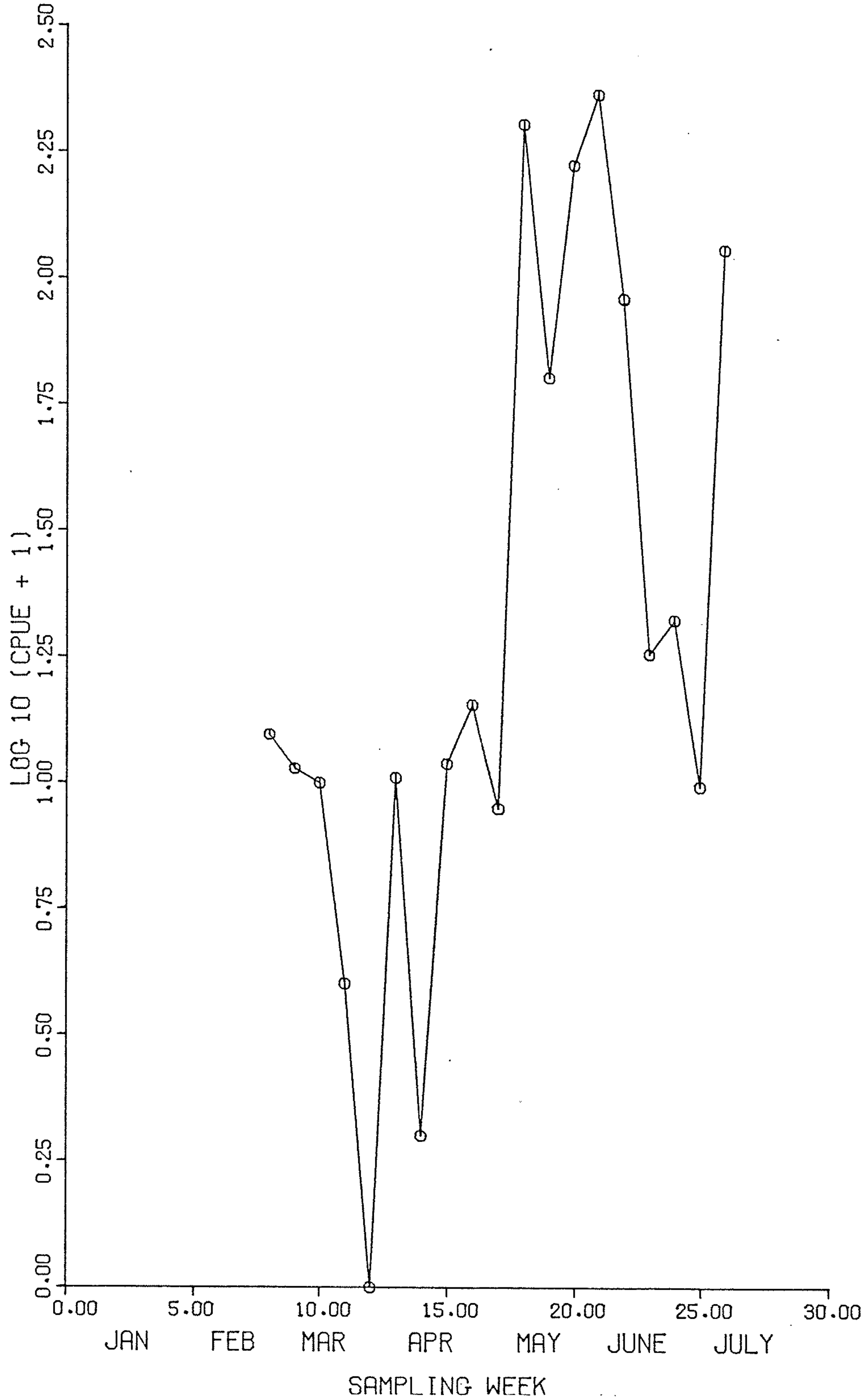
Appendix Table 3. Estimate* of mean length of chum fry at time of release from hatcheries; based on fish/lb data.

Sampling Week	Final Day In Week	Size of Release	Mean Length* Estimate (mm)	Hatchery/s.
13	April 1	1,324,075	49	Hood Canal
14	April 8	99,953	44	Hood Canal
15	April 15	1,226,900	43	Hood Canal
16	April 22	1,333,067	49	Hood Canal
17	April 29	725,506	56	Hood Canal
18	May 6	346,953	61	Skokomish
19	May 13	2,287,030	59	Hood Canal; Quilcene
20	May 20	1,298,245	63	Hood Canal; Skokomish
21	May 27	540,416	63	Hood Canal
22	June 3	890,359	55	Skokomish
23	June 10	1,156,200	?	Hood Canal
24	June 17	3,490,450	68	Quilcene

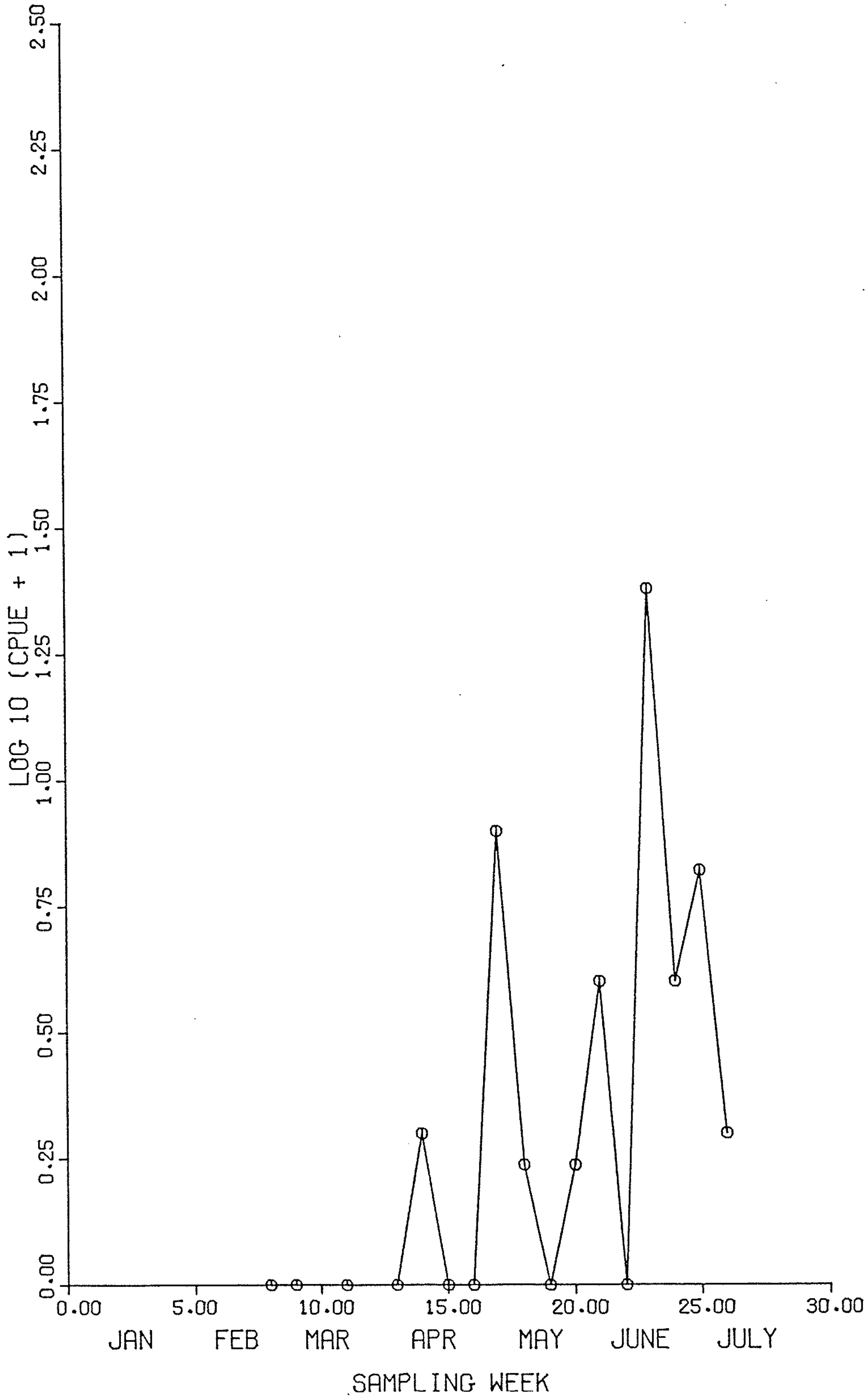
* This is a rough estimate calculated from fish/lb data only assuming that condition factor = 0.75 in all cases.



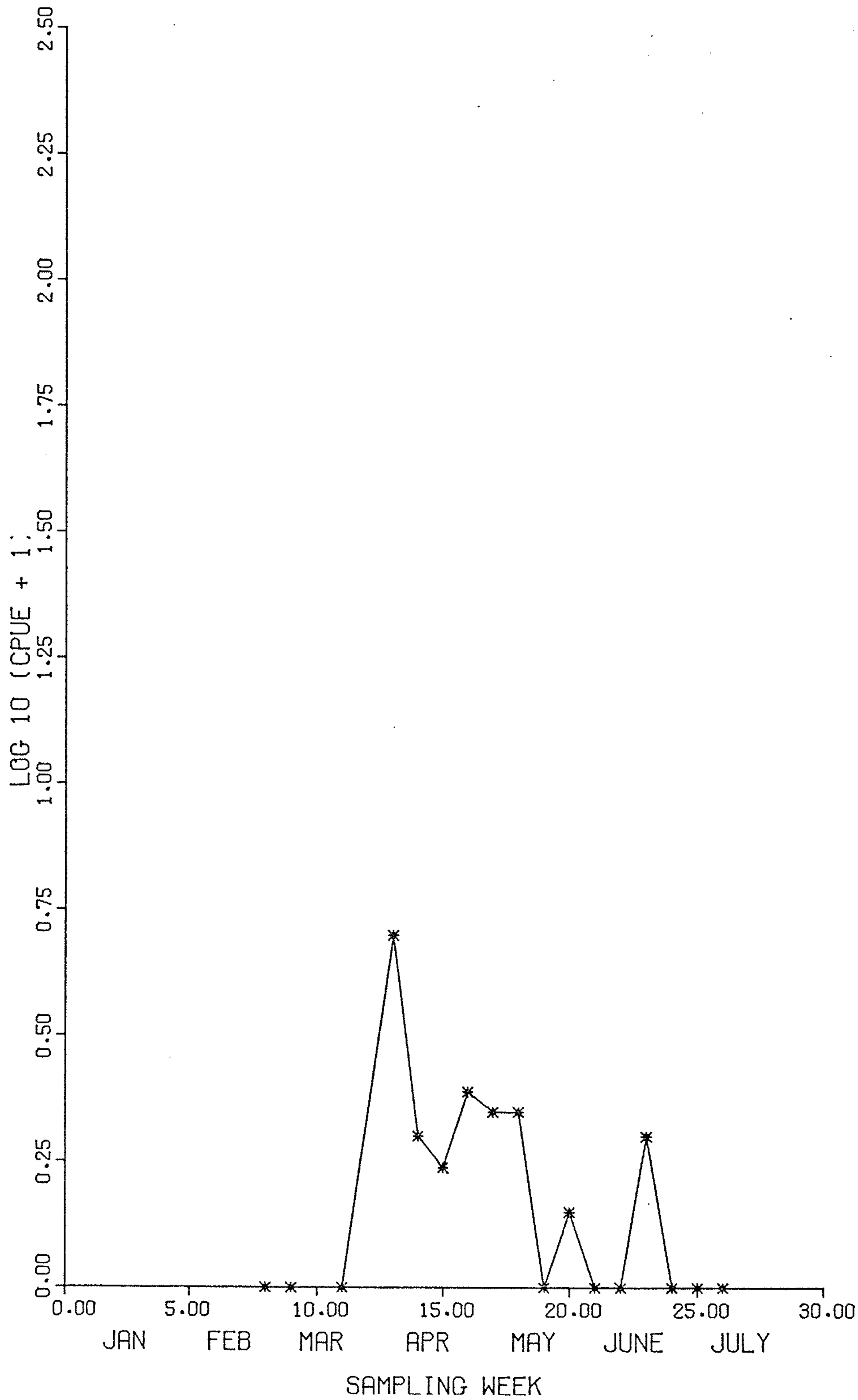
Appendix Fig. 1. Mean weekly CPUE of chum with the beach seine at South Marginal Wharf on the east shore of Hood Canal, Washington, 1978.



Appendix Fig. 2. Mean weekly CPUE of chum with the beach seine at South EHW on the east shore of Hood Canal, Washington, 1978.



Appendix Fig. 3. Mean weekly CPUE of chum with the beach seine at North Spit 6 on the west shore of Hood Canal, Washington, 1978.



Appendix Fig. 4. Mean weekly CPUE of pinks with the beach seine at North Spit 6 on the west shore of Hood Canal, Washington, 1978.