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FISHERIES RESEARCH INSTITUTE
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SALMONID OUTMIGRATION STUDIES IN HOOD CANAL

FINAL REPORT, PHASE II

by

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Approved

Submitted May 18, 1977

Director

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INTRODUCTION

In 1976, the Fisheries Research Institute continued studies initiated in March 1975 (Schreiner et al. 1975) on the salmonid outmigration in Hood Canal. This report reviews the second phase of a 5-year program that will assess the impact of Trident pier construction on the outmigration of juvenile salmon past the Bangor Annex (Fig. 1), the site for the Trident submarine base.

Hood Canal is an important passageway and rearing area for chum, chinook, coho, and pink salmon, as well as steelhead and cutthroat trout. Prey organisms that constitute smolt diets are also found in the area.

Objectives of this second phase were to:

1) establish baseline data on salmonid populations migrating past the Bangor Annex, including timing of the outmigration, diurnal movement patterns, and relative abundance;

2) study causes for an apparent concentration of migrating salmonids near the existing Marginal Wharf (Fig. 2);

3) monitor environmental conditions during the outmigration period, including water temperature, salinity, D.O., currents, tides, and weather.

METHODS AND MATERIALS

Big Beef Creek Fish Research Station of the College of Fisheries, University of Washington, was used as a base for study operations. The sampling stations on the Bangor Annex shoreline were found to be efficiently sampled by boat. The boats used were based at Seabeck or at the University's R/V Kumtuks moored at the Bangor Annex.

Nearshore Sampling

In 1976, east shore beach seine stations were increased from four to seven, with most of the increase in the area of active and proposed construction. Two stations on the west side of Hood Canal were used for comparisons (Fig. 2). All beach seine stations were sampled at regular intervals from late January to late March with a 10-m x 2-m beach seine of 6-mm stretch mesh bag. The seine was operated with one man at each end of the net. Transects, 30.5-m (100-ft.) long were seined parallel to the shoreline from water's edge to a depth of 1.5 m.

A 37-m beach seine, with 18-m, 3-cm 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 from late February until early July. This seine was set 30 m from shore and then drawn to the shore and closed, causing the catch to be funneled into the bag.

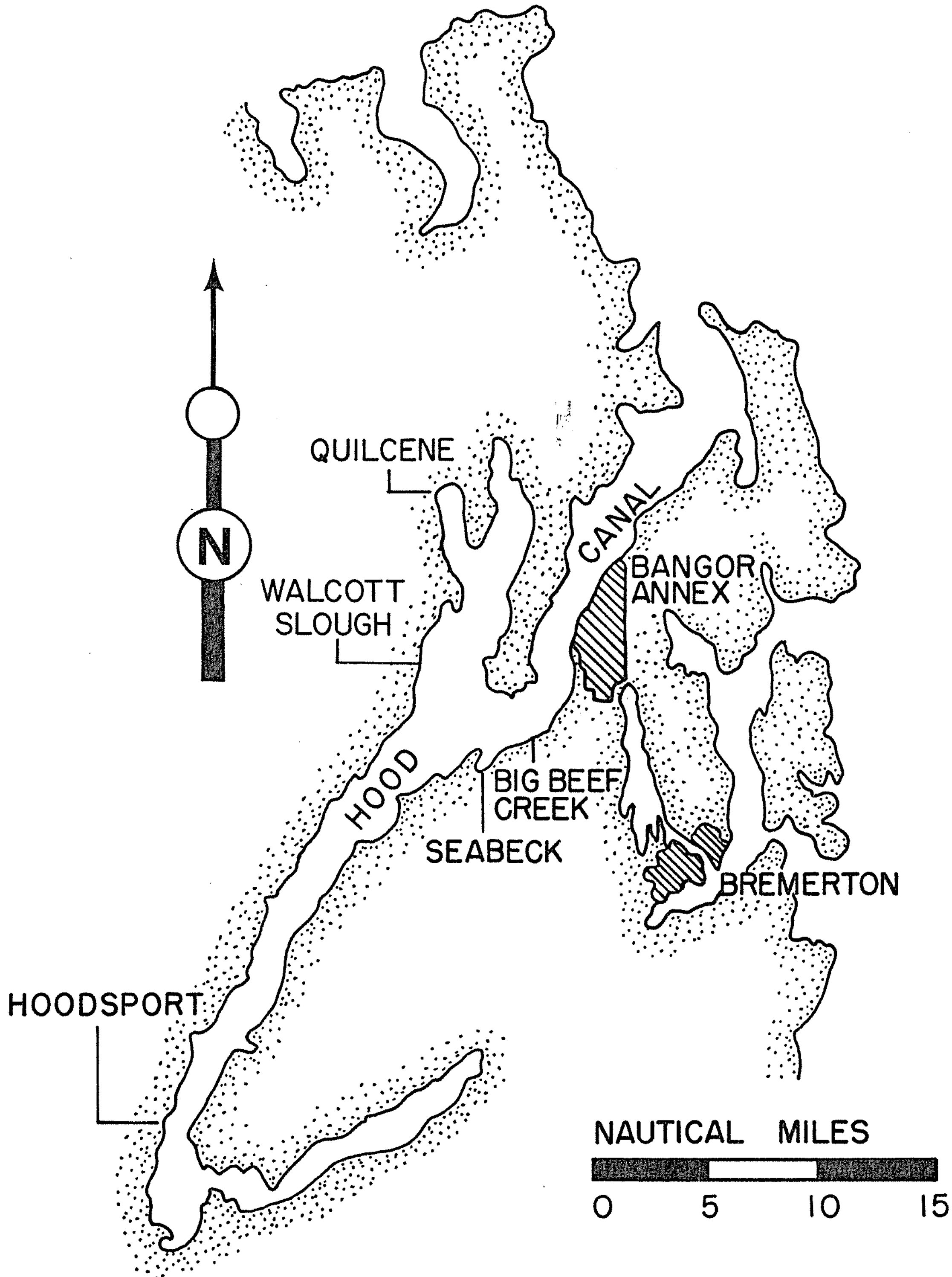


Fig. 1. Location of Bangor Annex (Trident site) and Big Beef Creek, Quilcene, and Hoodsport fish hatcheries, Hood Canal, Washington.

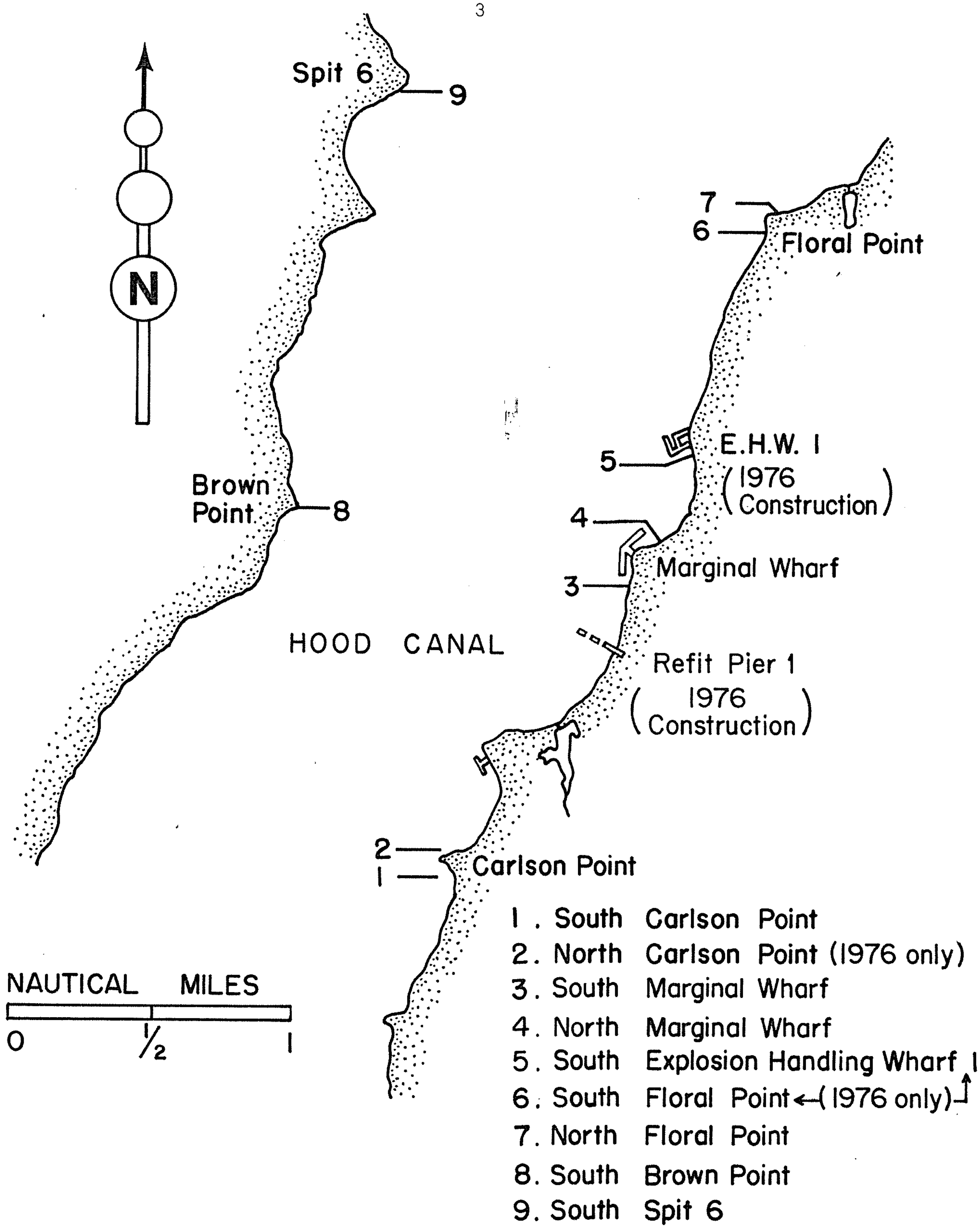


Fig. 2. Beach seine and epibenthic sampling stations for shoreline salmonid outmigration studies, February through July 1976, Hood Canal, Washington

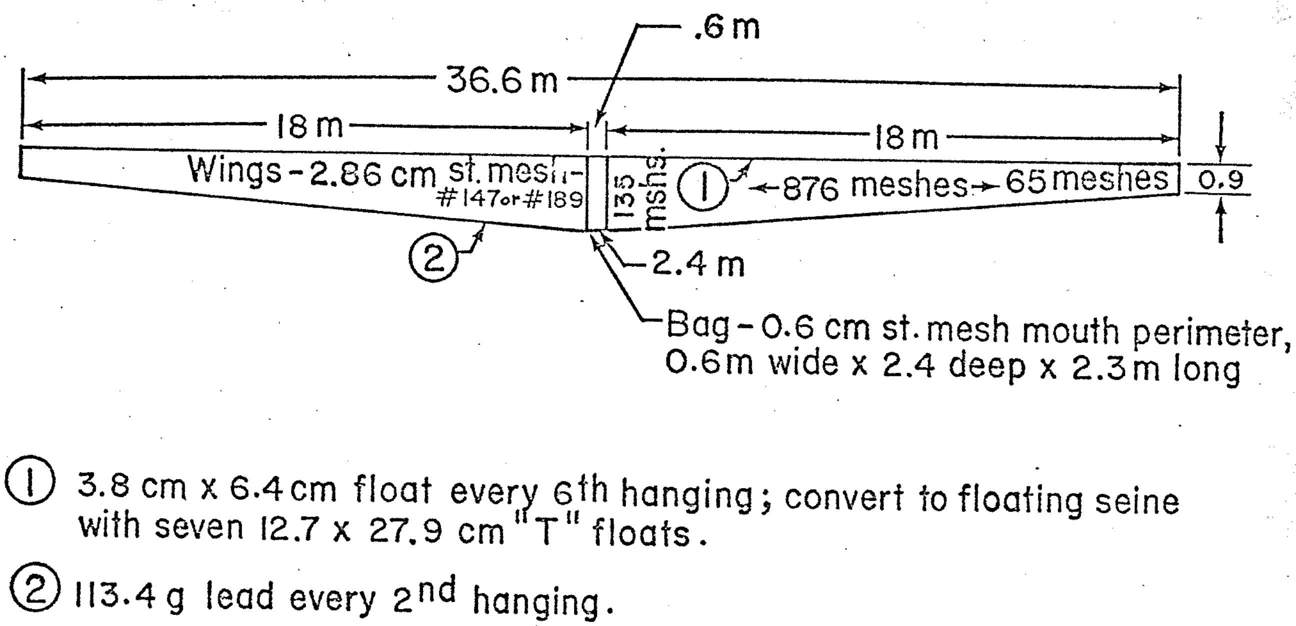


Fig. 3. Convertible beach seine utilized during nearshore surveys, February through July 1976, Hood Canal, Washington.

Though the seine could be adjusted to either float or sink during seining, the floating technique was most effective in capturing salmonid fry.

Visual survey transects 0.8 km (0.5 mile) long (Fig. 4) were conducted by boat 2 m to 15 m from shore from early June to mid-July. To achieve accurate counts, visual surveys required:

1) calm waters with little wave action,

2) sand or pebble substrates, and

3) a bright, sunny day with observations taken at midday.

Salmonids were counted with the aid of polarized glasses and a mechanical counter.

Offshore Sampling

In 1976, regular day and night surface townet transects 0.8-km (0.5-mile) long were conducted parallel to the shoreline and across Hood Canal (Fig. 5). The sampling net was a surface trawl, with a 3 m x 6 m net opening and mesh sizes grading from 76 m at the opening to 6 mm at the bag (Fig. 6). The net was towed at 3 ft/sec between the University's M/V *Tenas*, 38-ft diesel-powered vessel, and a 26-ft motor whaler with an inboard diesel motor. At 10-min intervals, 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 salmon were transported in 20-liter (5-gal) buckets with water to the M/V *Tenas* and counted.

Effects of Piers

The apparent concentration of migrating salmonids near the existing Marginal Wharf was analyzed by 1) identification and enumeration of prey organisms, 2) fish stomach analysis, and 3) trapping studies beneath Marginal Wharf.

Prey organisms utilized by chum and pink salmon were sampled using a modified epibenthic pump (Fig. 7) used by Feller and Kaczynski (1975). This pump enabled us to sample in almost all habitats and substrates present (e.g., gravel, cobble, and rock unavailable to corers).

The pump system consisted of a self-priming, gasoline-powered 5.1-cm (2-inch) centrifugal pump which draws water and associated plankters through a 25.4-cm (10-inch) conical expander into a 5.1-cm flexible plastic hose. Once through the pump, the water sample passes 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 206-µ mesh sizes with area/aspect ratios of 1:2.54 and 1:5.3 respectively.

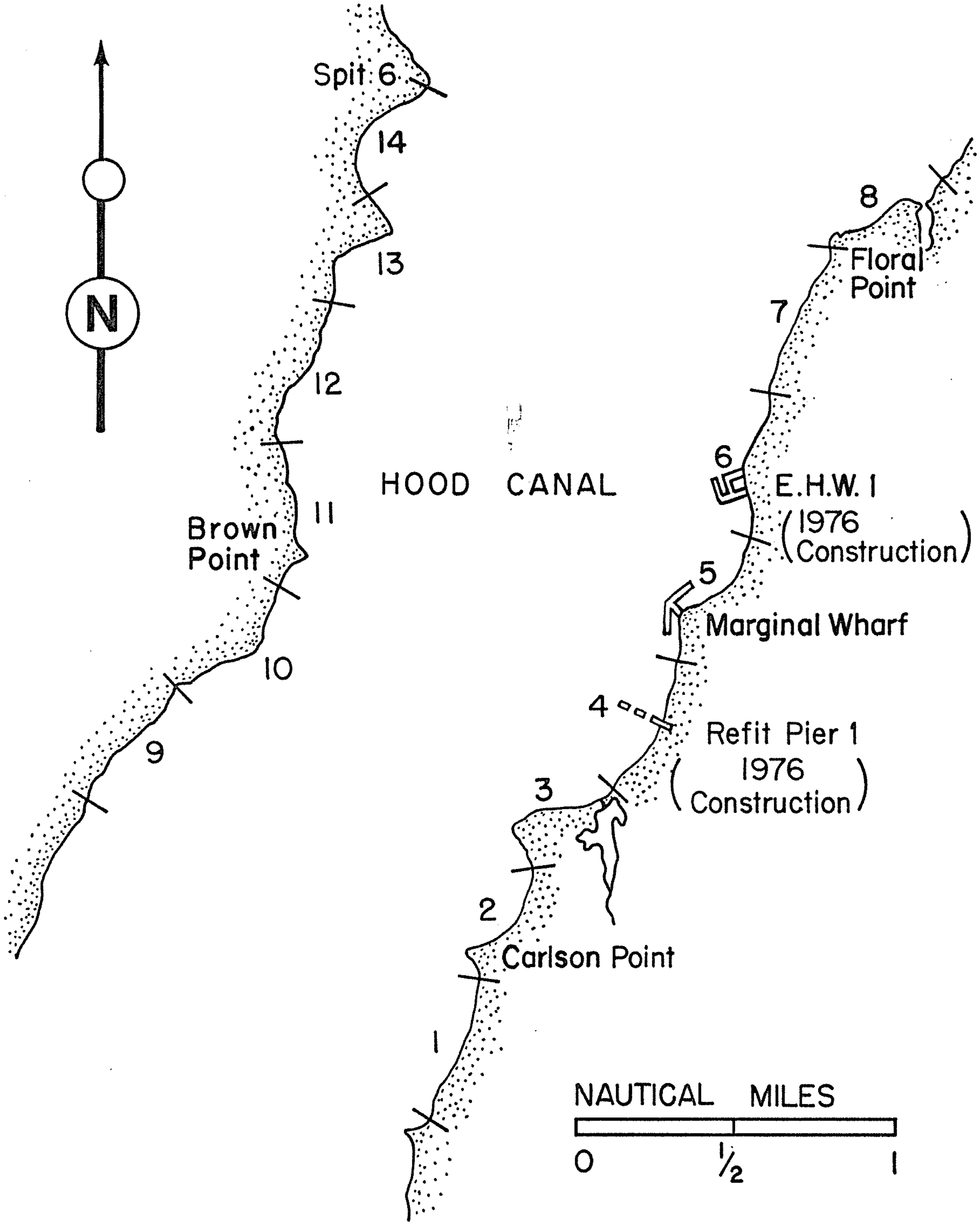


Fig. 4. Visual survey intervals for the east and west shoreline of Bangor Annex, Hood Canal, Washington.

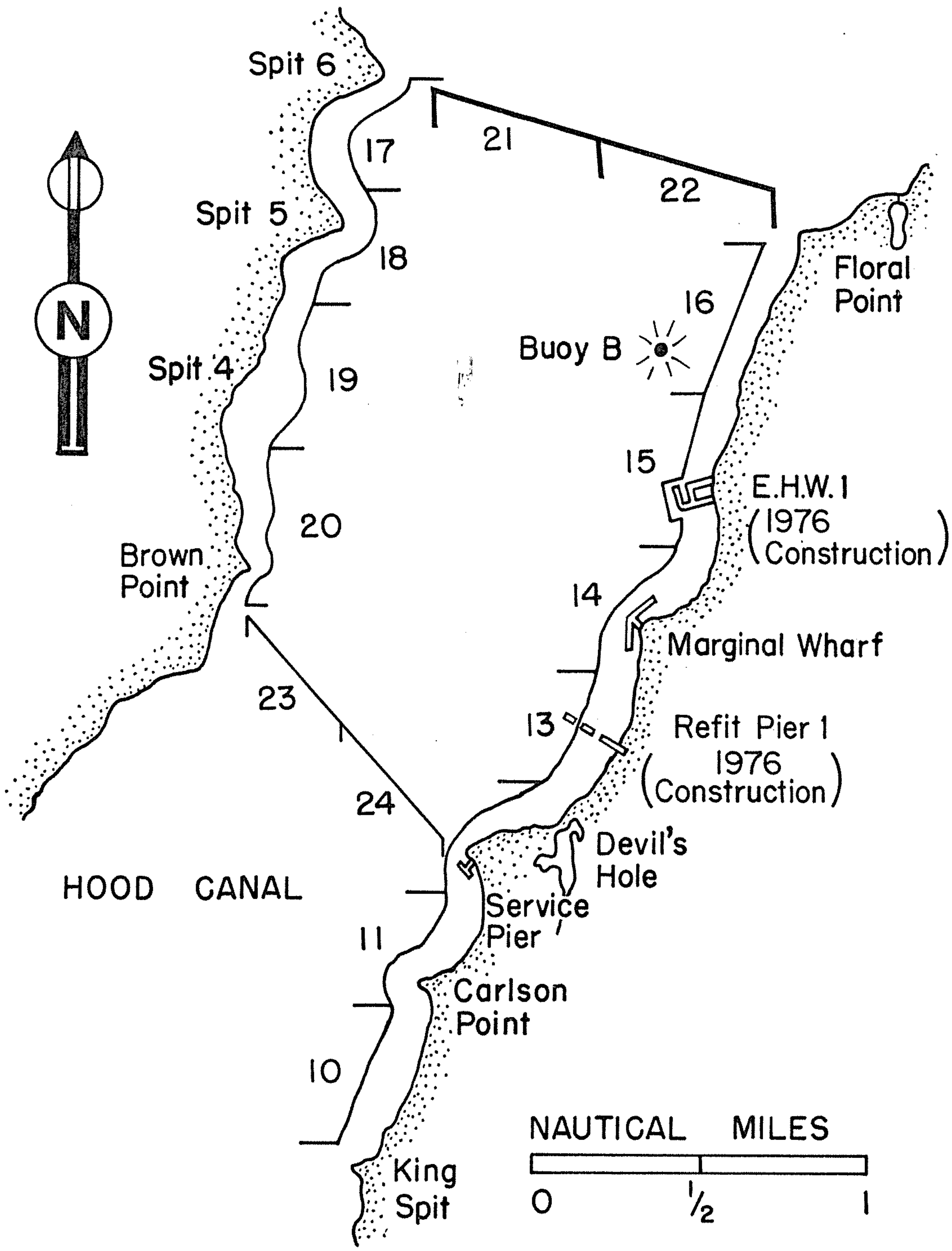
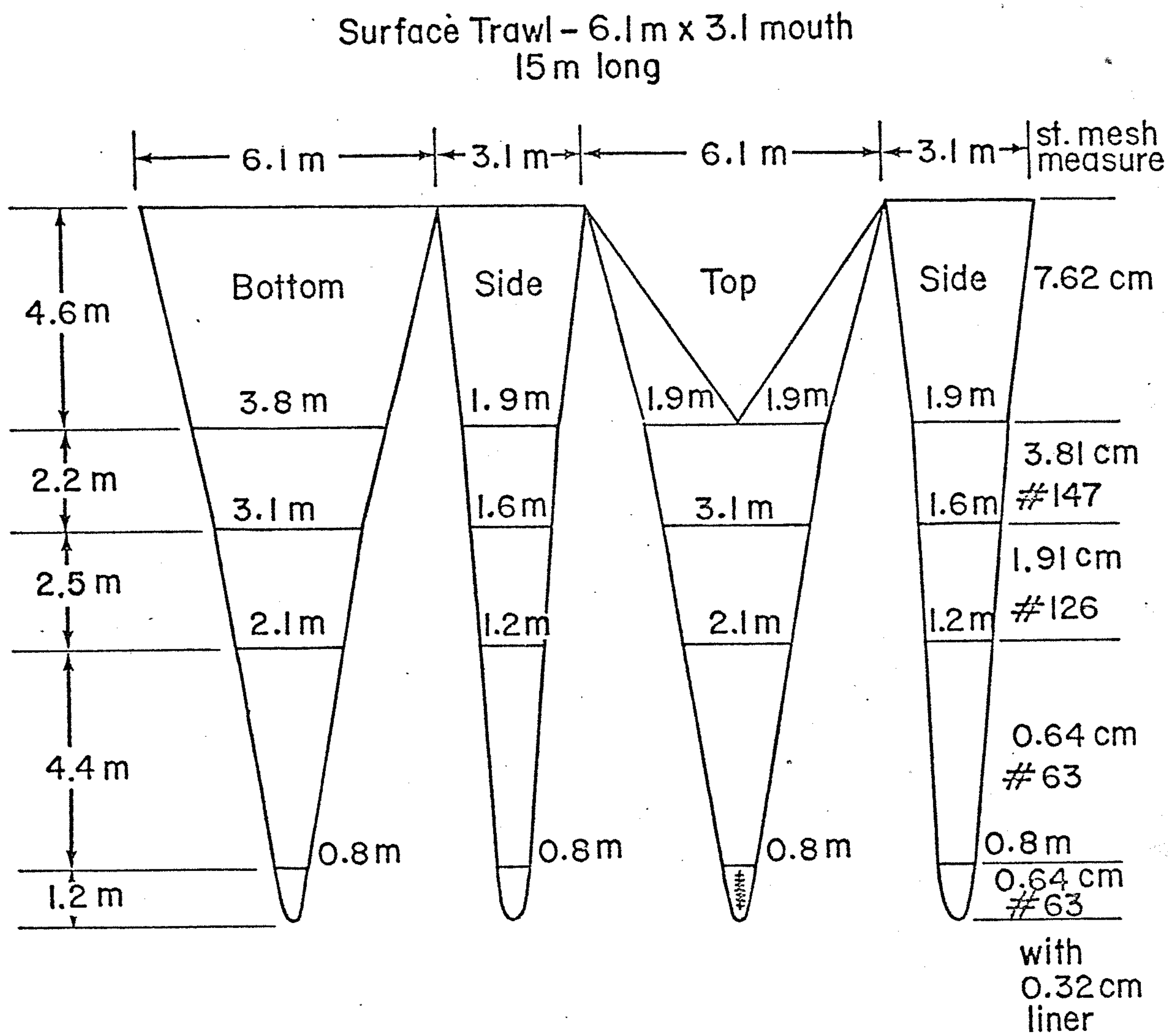
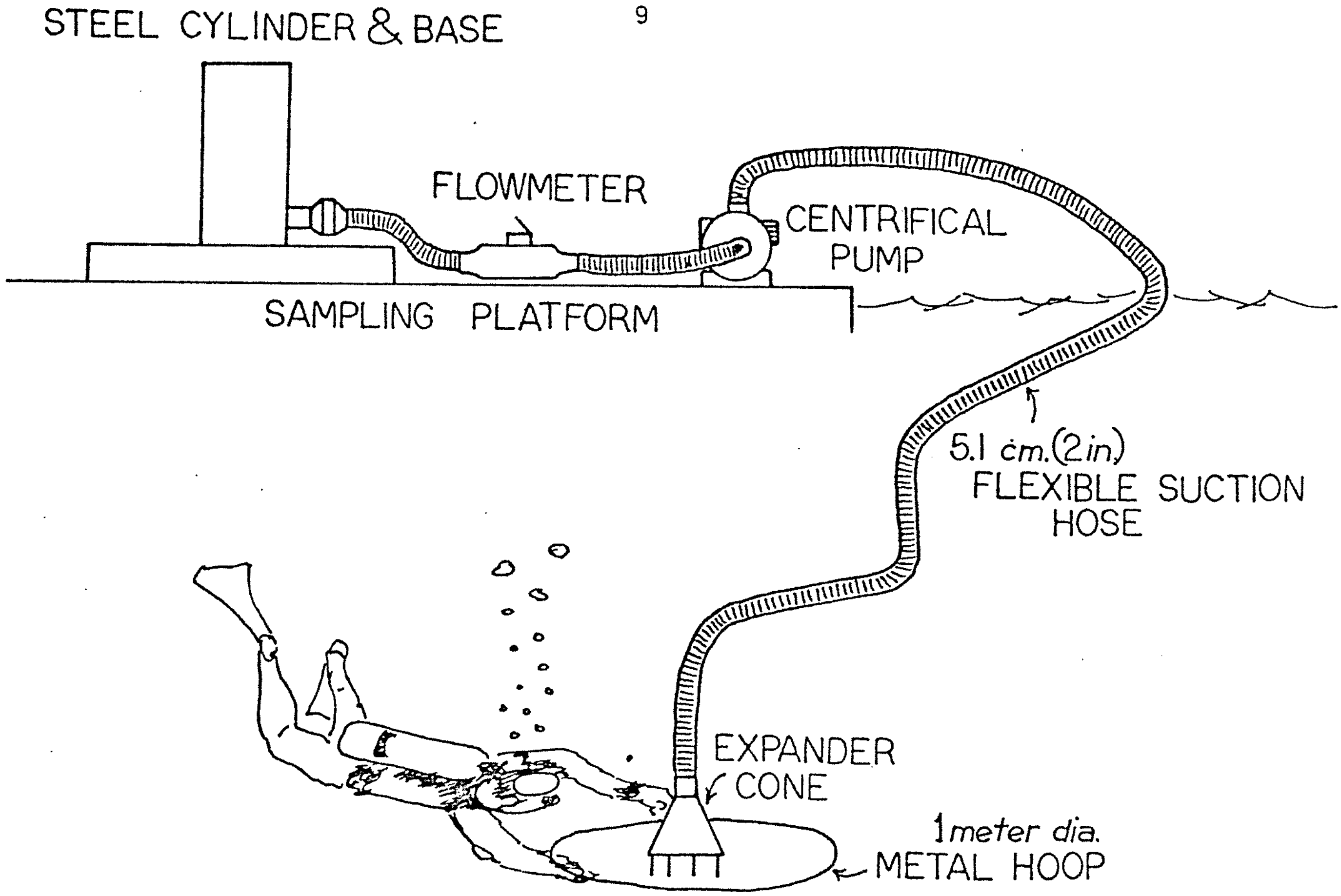


Fig. 5. Townet surface trawl pattern used during salmonid outmigration studies, March through July 1976, Hood Canal, Washington.

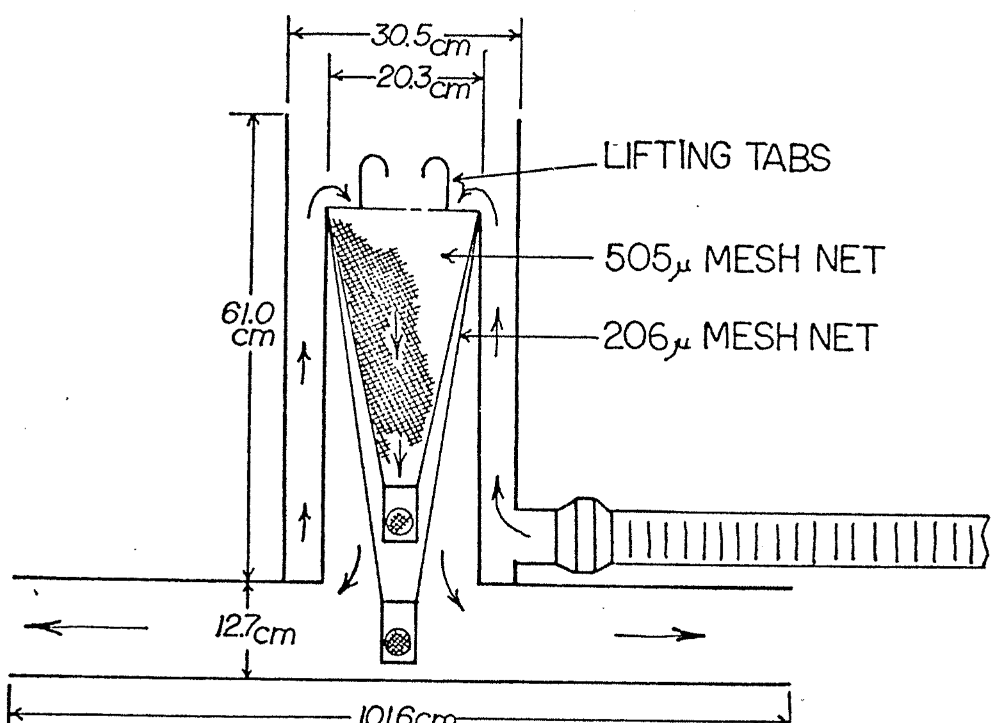


All seams are of 3.81 cm and smaller mesh reinforced with heavy 2.54 cm nylon tape including center lines of bottom and top panels; rib-lines of 0.95 cm diameter polypropylene on four corner seams full length. Mouth of net is double twine and hung on 0.35 cm polypropylene single braid with mimbles at 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. 6. Surface townet utilized during offshore sampling, March through July 1976, Hood Canal, Washington.



a. Epibenthic pump system components



b. Cross-section of steel cylinder and nested conical nets

Fig. 7. Overall system design and construction detail of epibenthic pump sampling system.

The epibenthic organisms were retained in standard net buckets with window screen of appropriate mesh size.

The pumping system was operated from aboard a 26-ft boat anchored 15 m from the beach. SCUBA-equipped divers surveyed the bottom and placed at random a 3.14-m^2 metal hoop over a representative area. The pump was started and the suction hose end was passed to the divers who moved to the chosen sampling location. Upon a signal from the boat, the diver began to move the expander cone about 10 cm off the surface of the benthos within the sampling area, "vacuuming" the epibenthic region. Four projecting bolts on the expander were used to stir the surface layer of the benthos. Several seconds after the diver had initiated the suction sampling, the two nested nets were dropped into place within the steel cylinder. This lag time ensured that the water and organisms within the pumping system at the starting time had passed through before the nets were in place and filtering. One hundred gallons were pumped before the nets were removed and the divers signaled to stop sampling. Organisms were removed from the plankton net cups and preserved in labeled PVC jars containing 5 percent buffered Formalin.

The sampling process was repeated for three replicates, the sampling hoop being moved to a new area of similar substrate for each sample.

In the laboratory, the epibenthic plankton samples were transferred to 70 percent isopropyl alcohol and stained with rose bengal dye for one week. The organisms were then separated from the sediment and detritus, sorted to the lowest taxonomic level possible by examination through a 30X dissecting microscope, and total counts and weights (to nearest 0.01 g) taken for each taxon.

Fish Stomach Analysis

All salmonids selected for stomach analyses were anesthetized, their abdominal wall slit and then preserved in 10 percent buffered Formalin.

Stomach contents were analyzed using a standardized procedure that provided degree of stomach fullness, numerical and gravimetric composition of prey organisms ingested, and the state of digestion

Sampling Sites

During the peak migration period (May-June), beach seine and townet collections, from which juvenile salmonids were retained for stomach analysis, were made approximately biweekly at the standard sampling stations (Figs. 2 and 5). Epibenthic plankton samples were taken from shallow sublittoral areas at the beach seine sampling sites and from the neritic zone at an offshore piling adjacent to one townet transect (Fig. 2).

Wharf Surveys

To assess the attraction of salmonids to the existing Marginal Wharf, baited Alaskan minnow traps were placed at various depths beneath the wharf, and diver observations were periodically carried out with the use of SCUBA gear. The minnow traps were placed beneath the wharf during April and May at depths ranging from the bottom at 11 m to the surface on self-adjusting floats. The traps were made of metal or plastic with a 6-mm mesh size. When open, each trap resembled two baskets attached together by a hinge. The trap was closed and locked securely with a wire clip. Chopped clams, chopped mussels, brine shrimp, juvenile shrimp, Oregon Moist Pellets, and oatmeal were used as baits. Traps were checked and rebaited only at irregular intervals due to Navy security restrictions around Marginal Wharf.

Environmental Data Collection

Environmental conditions were monitored at beach seine stations throughout the season. Water temperatures and conductivity readings were taken at 1-m depths, 3 m to 15 m from shore, with a Kahlsico electrodeless induction salinometer or a Martek TDC metering instrument. Water visibility was measured with a 6-inch Secchi disk. Tides and weather conditions were also noted.

Fish Specimen Analysis

Subsamples of no greater than 100 fish were taken for each salmon species from each catch. All beach seining subsamples were transported live in 20-liter (5-gal) water buckets and processed the day of capture. Townetting subsamples were killed by narcotizing in MS-222 (Tricane methane sulfonate), labeled and preserved in ice until the specimens could be processed the following day. At regular intervals, 10 chum and 10 pink specimens with abdominal walls slit were preserved immediately upon capture in 5 percent Formalin for stomach analysis.

Fork lengths were taken to the nearest mm for all salmon caught and group weights were taken to the nearest 0.01 g for each 5-mm increment on a Mettler 1200 electrobalance. Some scale samples were taken for age and growth studies.

RESULTS AND DISCUSSION

Sampling Techniques

While the 10-m beach seine was effective in capturing chum and pink salmon, the floating 37-m beach seine was more effective for nearshore collection of all salmonid size classes. Beach seine sampling near wharf structures was subject to Navy security regulations and therefore irregular. Visual surveys were effective along shoreline areas but were weather-dependent.

Salmon identification and enumeration by visual means was not effective around piers due to the tendency of the juveniles to sound beneath the structures. Townetting was effective for offshore areas and around piers, but access to pier structures was limited due to security restrictions.

Migration Routes and Catch-Per-Unit-of-Effort (CPUE)

Nearshore

The beach seine sampling sites are described in Table 1. Catch-per-unit-of-effort computed for any salmonid species and collection method is of the form:

$$\text{CPUE} = \frac{\text{Number of fry captured}}{\text{Number of capture attempts}}$$

Beach seine CPUE of all salmonid species is shown in Appendix 1 and is displayed for chum and pink salmon in Figs. 8 and 9. Visual counts (Table 2) and catch statistics indicated that fewer salmonids were present along the western shore of Hood Canal. Major construction at Explosion Handling Wharf-1 (EHW-1) and Refit Pier-1 took place along the east shore of Hood Canal during the spring outmigration period.

Offshore

Townet CPUE statistics for all salmonid species are compared in Appendix 2. Chum and pink CPUE data are shown in Figs. 10, 11, and 12. Townet catches showed little salmonid fry activity in mid-canal and, similar to beach seine catches, indicated a larger number of chum and pink salmon along the east side of Hood Canal. Townetting was more effective than beach seining in collecting fish near the piers, but due to frequent security restrictions and construction activity on Refit Pier-1, it was not possible to verify the aggregation of salmonids near Marginal Wharf as was shown in 1975. Townet catches were greatest for both chum and pink salmon during the daylight hours (Table 3). The higher standard deviation of CPUE during daylight suggests that surface schooling occurred in daylight, and dispersion of these schools occurred at night.

Table 1. Location and description of beach seine transects used during Spring 1976 for the Bangor Annex shoreline and west shoreline of Hood Canal, *Washington*

	Station Name	Location	Slope	Substrate	Vegetation
Bangor Annex shoreline	1. South Carlson Point	30 m south of Carlson Point	Moderate	Sand, small to medium cobble	Rich beds of eelgrass (*Zostera marina*) and green algae (*Ulva* sp.)
	2. North Carlson Point	45 m north of Carlson Point	Moderate	Medium to large cobble with few oyster shells	Rich beds of eelgrass (*Zostera marina*) and green algae (*Ulva* sp.)
	3. South Marginal Wharf	9 m south of Marginal Wharf	Moderate	Sand and small cobble	Thin patches of eelgrass (*Zostera marina*)
	4. North Marginal Wharf	9 m north of Marginal Wharf	Moderate	Mud, sand, and small cobble	Sparse eelgrass (*Zostera marina*)
	5. South Explosion Handling Wharf - 1	3 m south of E. H. W. - 1	Gentle	Mud, sand, and small cobble	Thin patches of eelgrass (*Zostera marina*)
	6. South Floral Point	60 m south of Floral Point	Gentle	Sand, small to medium cobble	Thin patches of eelgrass (*Zostera marina*)
	7. North Floral Point	60 m north of Floral Point	Gentle	Medium to large cobble	Rich beds of eelgrass (*Zostera marina*)
West shoreline	8. Brown Point	18 m south of lighted navigation marker at Brown Pt	Steep	Sand and small cobble	Moderate eelgrass (*Zostera marina*)
	9. Spit No. 6	30 m south of spit located 1½ nautical miles north of Brown Point and northwest of Floral Point	Gentle	Sand and small cobble	Rich beds of eelgrass (*Zostera marina*) and green algae (*Ulva* sp.)

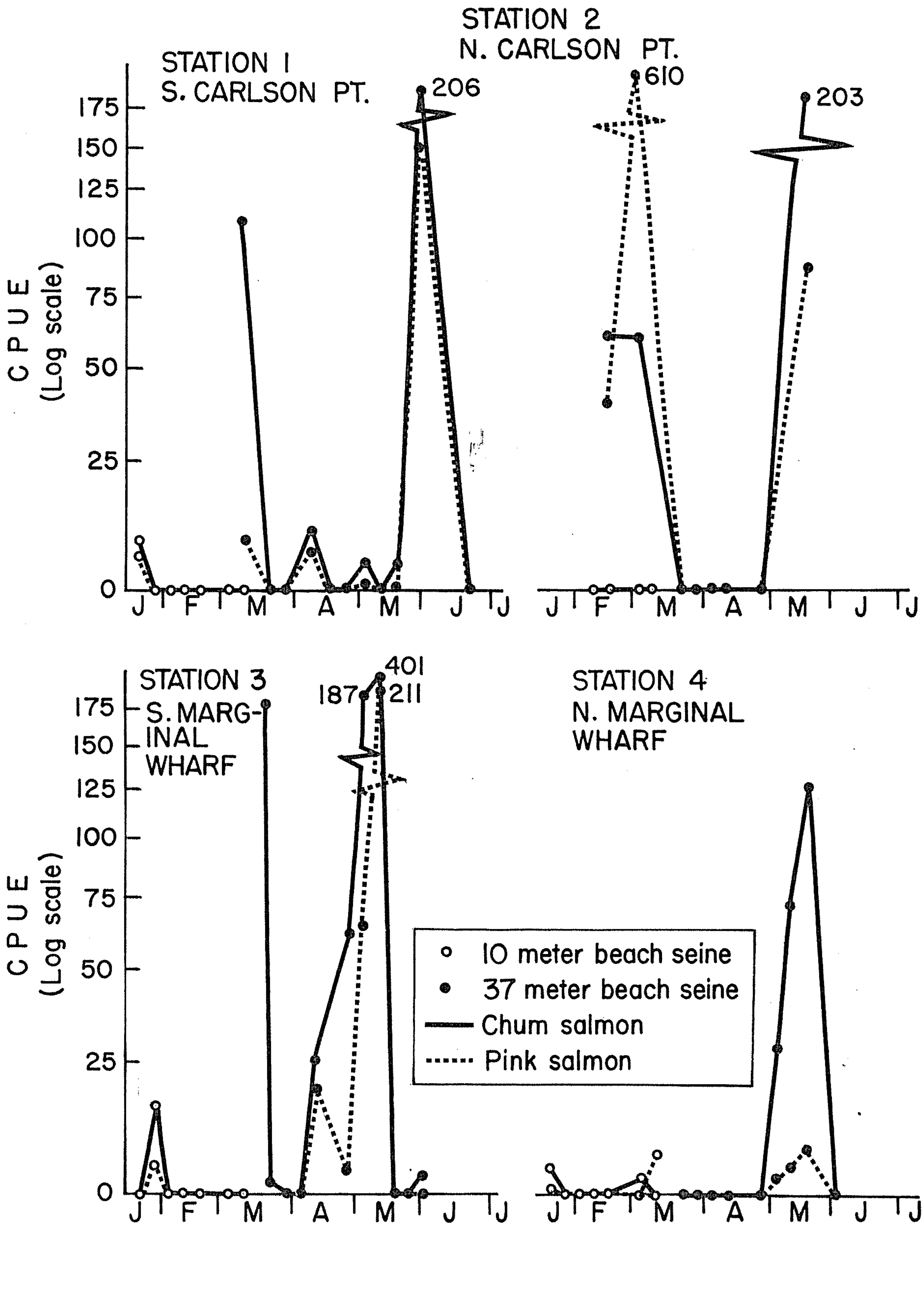


Fig. 8. Weekly catch per unit effort of chum and pink salmon collected from January 22 to July 7, 1976 along the east shore beach seine sites on Hood Canal, Washington.

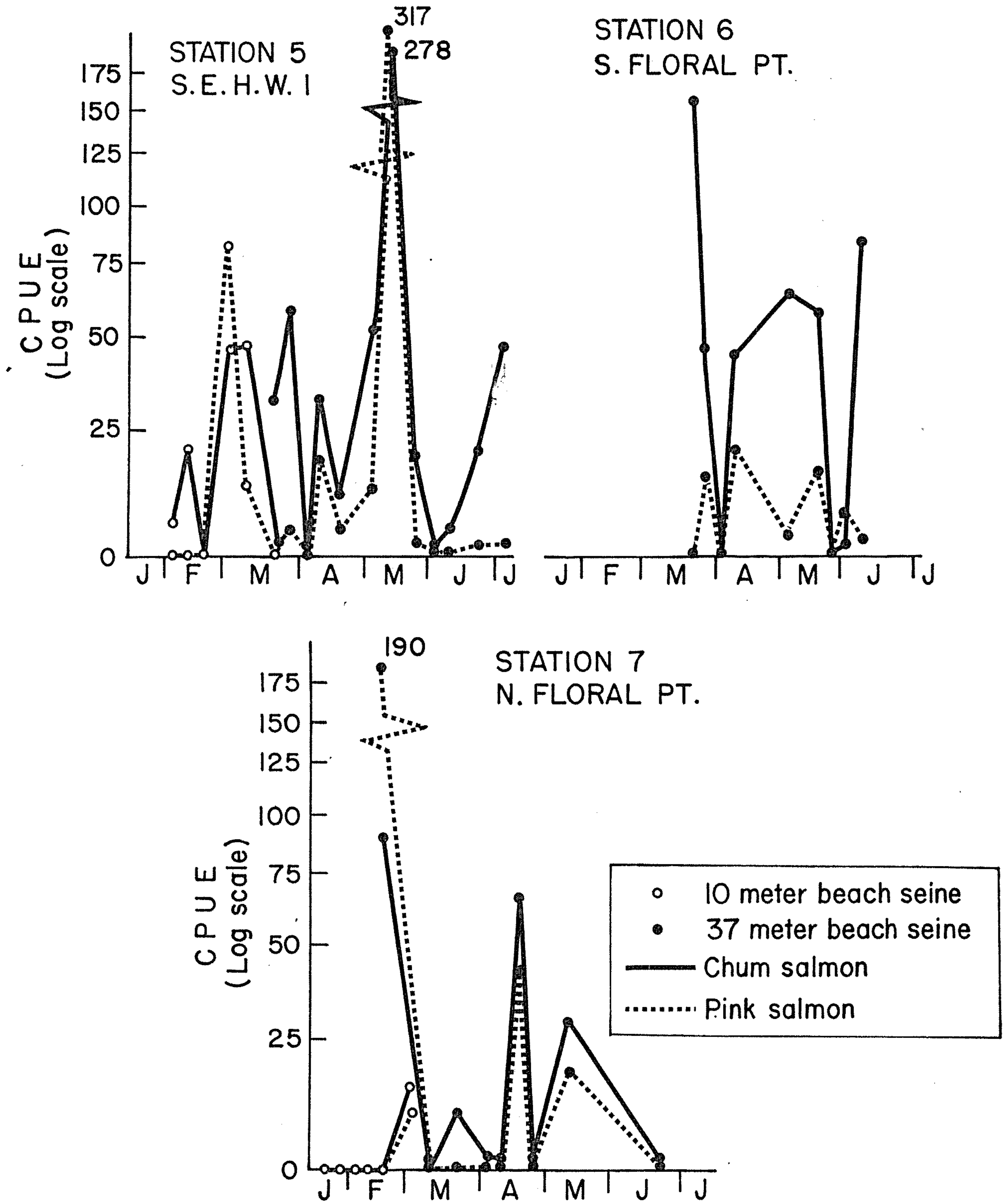


Fig. 8. Weekly catch per unit effort of chum and pink salmon collected from January 22 to July 7, 1976 along the east shore beach seine sites on Hood Canal, Washington. - Continued.

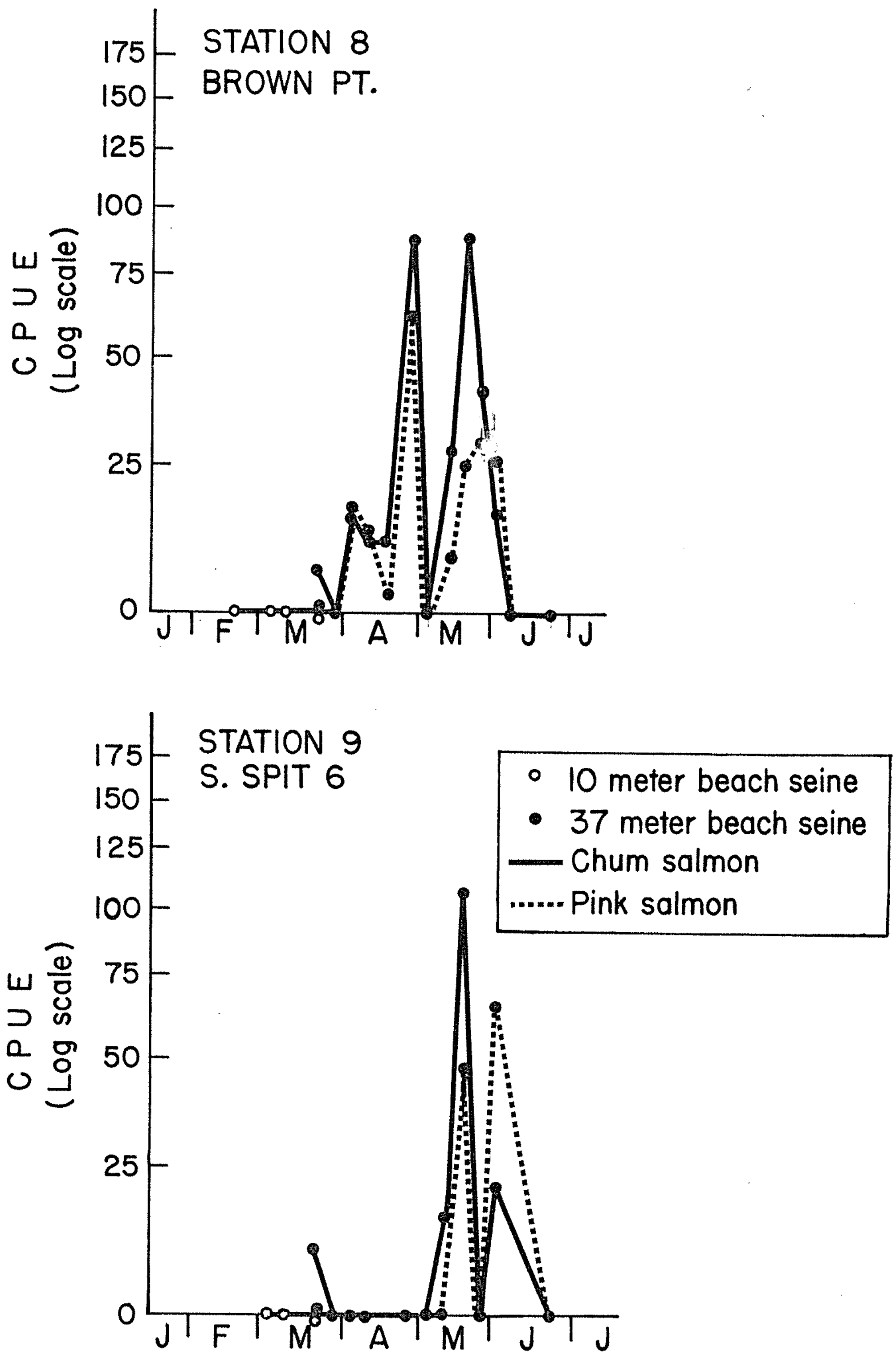


Fig. 9. Weekly catch per unit effort of chum and pink salmon collected from January 22 to July 7, 1976 along the west shore beach seine sites on Hood Canal, Washington.

Table 2. Shoreline visual counts of salmonid fry at Bangor Annex during June and July, 1976

Date	Sky Conditions	Sea State	Tide Stage	Location	Count
6/3	Clear	Calm	Ebb	8	52
			Ebb	7	37
			Ebb	6	64
			Ebb	5	1545
			Ebb	4	67
			Total from	east shore	1765
			Ebb	14	475
			Ebb	13	800
			Ebb	12	1000
			Ebb	11	1000
			Ebb	10	100
			Ebb	9	0
			Total from	west shore	3375
6/10	Clear	Calm	Flood	3	3500
			Flood	2	1500
			Flood	1	5800
			Flood	6	1400
			Flood	5	2900
			Total from	east shore	15,100
			Flood	10	1000
			Flood	14	4100
			Total from	west shore	5100
6/14	Clear	Calm	Ebb	8	200
			Ebb	7	0
			Ebb slack	6	10
			Ebb slack	5	10
			Ebb slack	4	550
			Ebb slack	3	550
			Flood	2	550
			Flood	1	250
			Total from	east shore	2120
			Flood	12	50
			Flood	11	300
			Total from	west shore	350
6/28	Clear	Calm	Ebb slack	8	200
			Ebb slack	7	200
			Flood	6	0
			Flood	5	300
			Flood	4	0
			Flood	3	0
			Flood	2	400
			Flood	1	900
			Total from	east shore	2000
			Flood	14	150
			Flood	13	50
			Flood	12	50
			Flood	11	50
			Flood	10	0
			Flood	9	0
			Total from	west shore	300
7/19	Clear	Calm	Flood slack	7	50
			Flood slack	6	20
			Ebb	5	0
			Ebb	4	0
			Ebb	3	7
			Ebb	2	5
			Ebb	1	0
			Total from	east shore	82

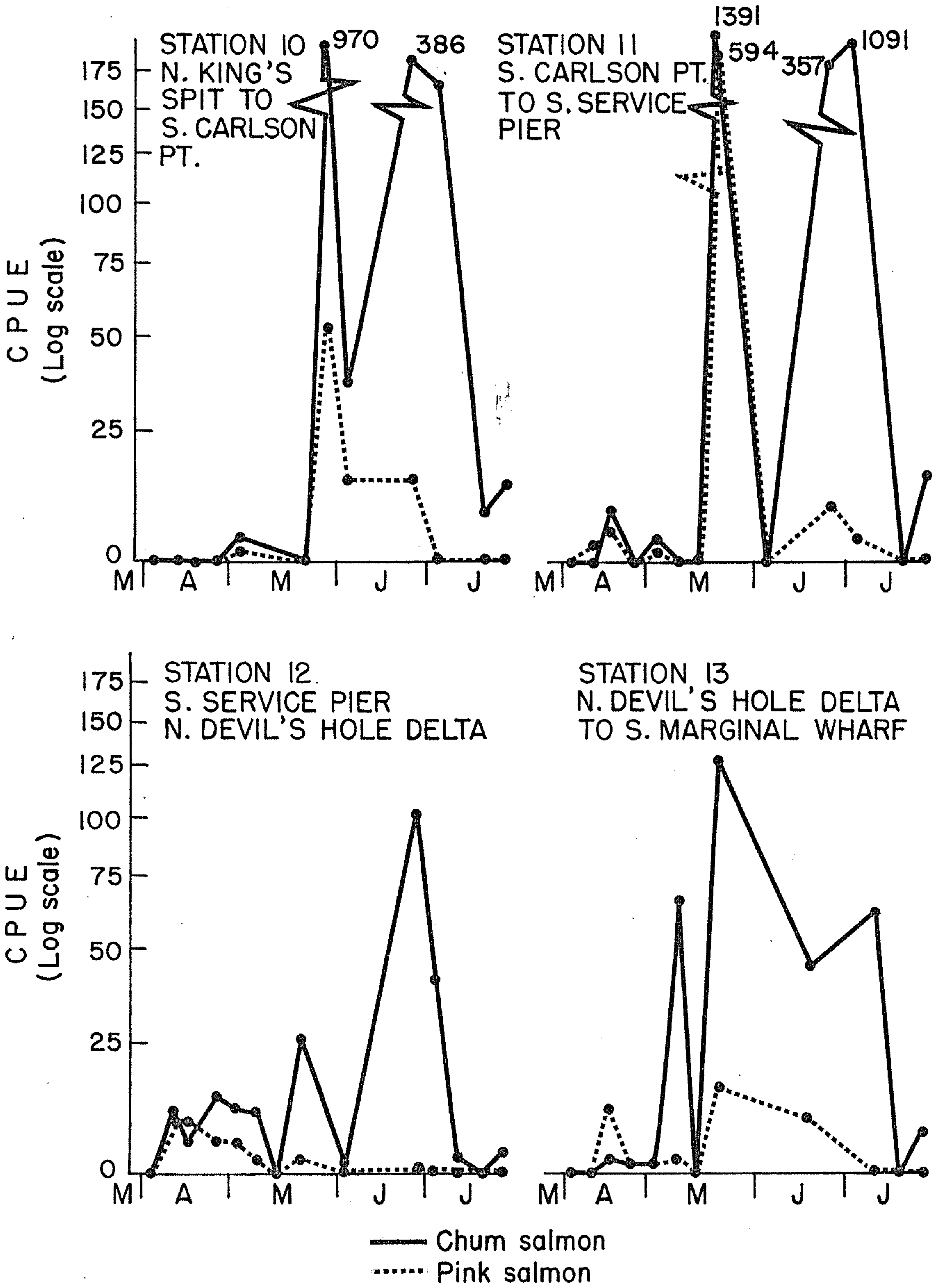


Fig. 10. Weekly catch per unit effort of chum and pink salmon collected from March 31 to July 23, 1976 along the east shore surface townet transects on Hood Canal, Washington.

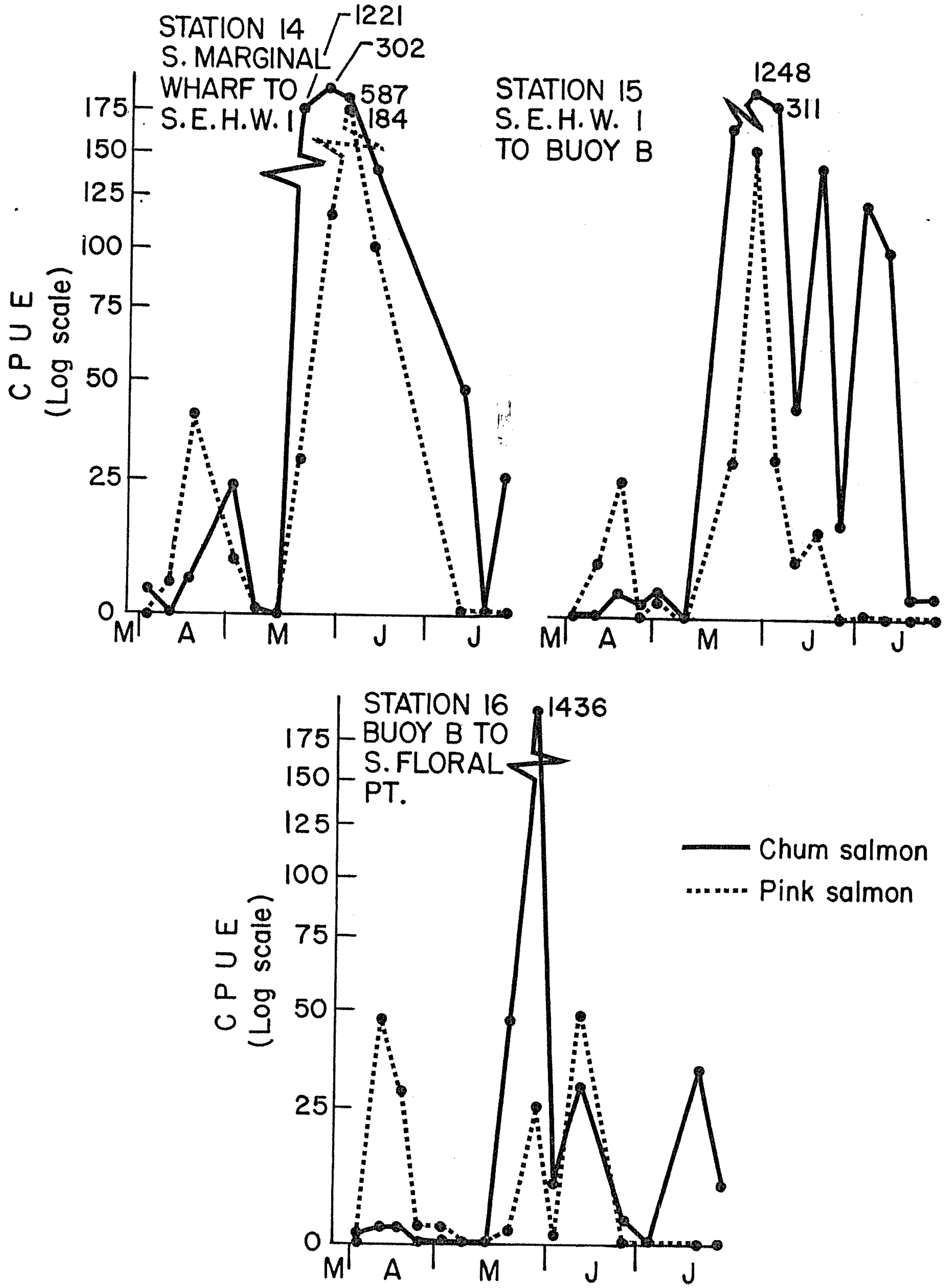


Fig. 10. Weekly catch per unit effort of chum and pink salmon collected from March 31 to July 23, 1976 along the east shore surface townet transects on Hood Canal, Washington. - Continued.

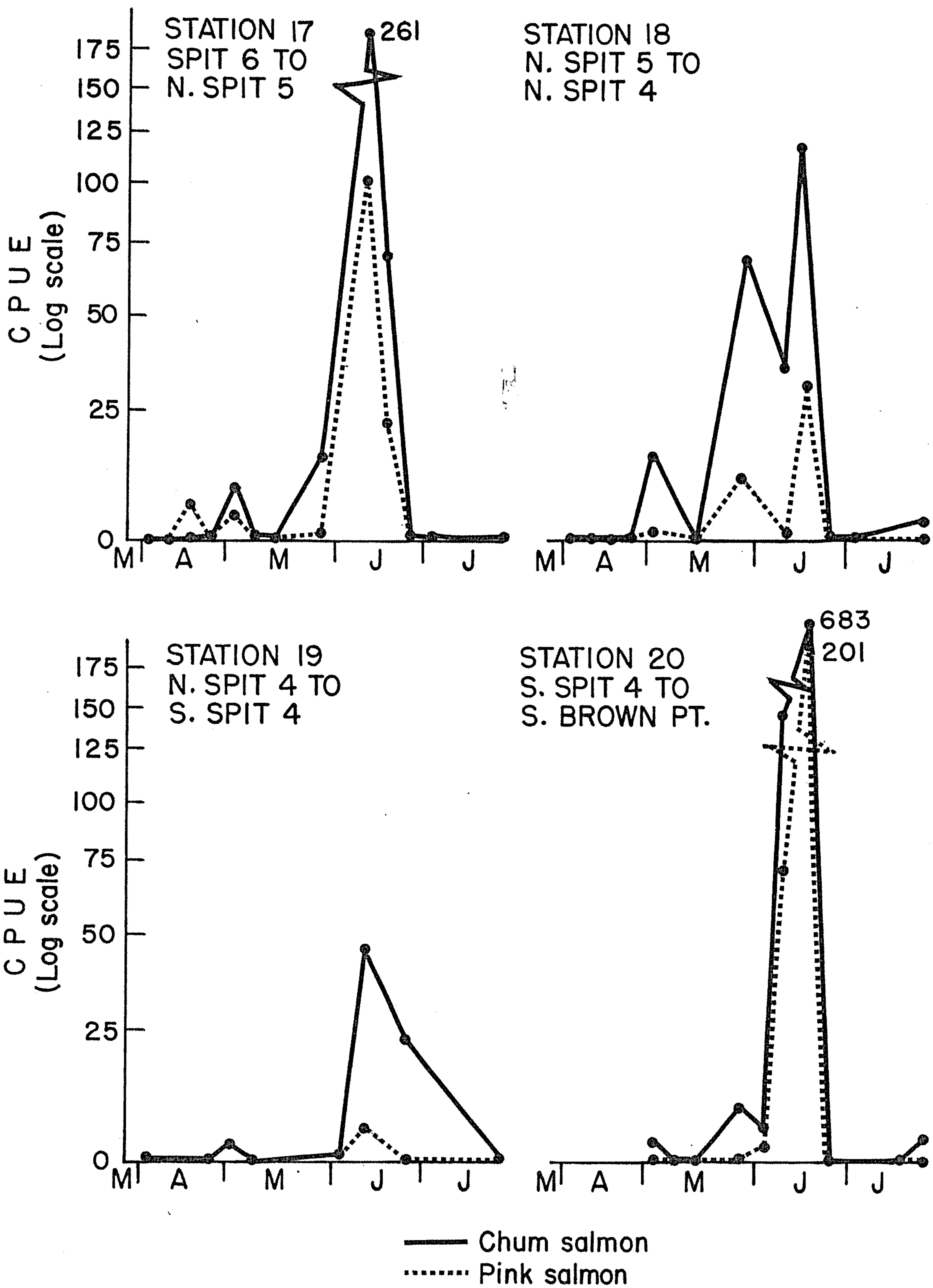


Fig. 11. Weekly catch per unit effort of chum and pink salmon collected from March 31 to July 23, 1976 along the west shore surface townet transects on Hood Canal, Washington.

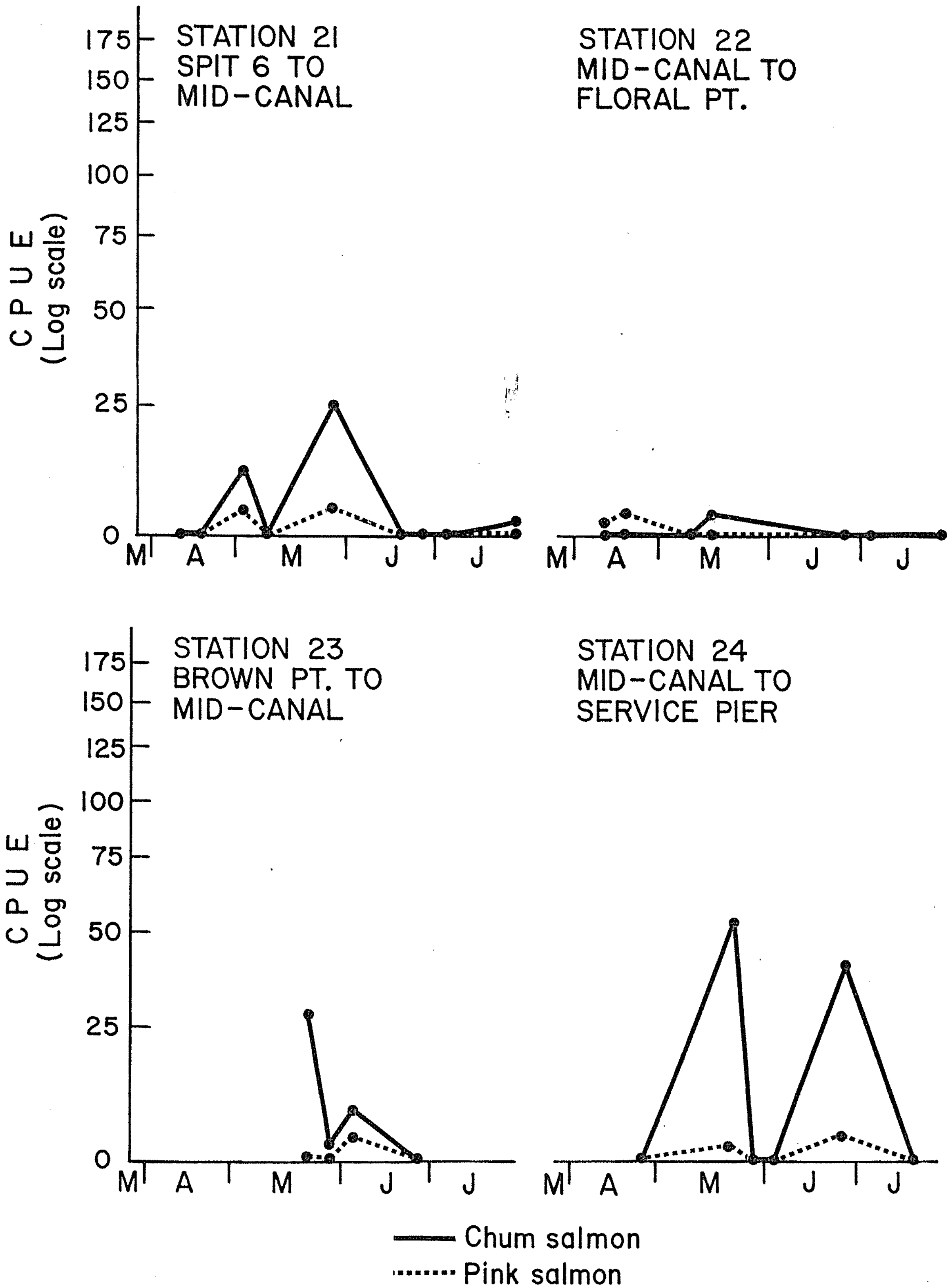


Fig. 12. Weekly catch per unit effort of chum and pink salmon collected from March 31 to July 23, 1976 along the mid-canal surface townet transects on Hood Canal, Washington.

Table 3. Comparison of day-night surface townet catch of chum and pink salmon for the period March 31 to July 23, 1976

	Day		Night	
	Chum	Pink	Chum	Pink
CPUE	225.5	34.7	29.3	9.2
Standard deviation	650.1	165.6	112.4	28.8

Hatchery Influence

In 1976, releases from Hoodsport and Quilcene fish hatcheries constituted a major portion of the Hood Canal outmigrating chum salmon population (Table 4). Although releases from both hatcheries are made on the west shore of Hood Canal (Fig. 1), in 1976 the majority of the outmigrating fry crossed to the east shore sometime before they reached Bangor Annex. This caused the bulk of chum fry to be influenced by the east shoreline construction.

Chum and pink CPUE curves (Figs. 8 to 12) showed major peaks approximately 3 weeks after Hoodsport release dates, and approximately 1 week after Quilcene release dates. Although a mark and recovery program would be required to prove that these CPUE peaks are caused by hatchery fish, the pattern during the 1976 season occurred consistently enough to suggest that this was the case. Future surveys on larger releases should verify this pattern. Also, beach seine condition factor data (Appendix 3 and Figs. 13 and 14) consistently showed a marked increase in condition factor for the fish caught during these peak periods. Surface townet catches comprised of larger fish showed consistently high condition factors (Appendix 4 and Figs. 15 to 17), and correlation with CPUE peaks was not as readily seen. Average length of chum, pink, and chinook salmon shown in Appendix 5 and Figs. 18 to 20 also indicated a correlation with hatchery releases. Recruitment from wild stocks until late April kept the average length low, but as recruitment subsided, the length data indicated rapid growth.

The timing of releases by the hatcheries directly affects the size and condition factor of the fry and their arrival time at Bangor Annex. Condition factor variance between wild and hatchery stocks may indicate a difference in the ability of the two populations to survive stressful situations such as pier construction or dredging in combination with increased spring disease (vibriosis) levels. Future examination of wild and hatchery stock differences will be necessary to interpret the impact of Trident pier construction on Hood Canal salmonid populations.

Table 4. Comparison of salmonid juvenile releases from Quilcene and Hoodsport hatcheries during the period from February to June, 1976

		Quilcene hatchery (U.S. Depart. of Fish and Wildlife)			Hoodsport hatchery (Wash. Depart. of Fisheries)		
Month	Date	Species	No. of Fish	Release Point	Species	No. of fish	Release Point
February	13	Coho	120,000	Big Quilcene R.			
	17				Pink	493,900	Hoodsport
March	24				Pink	347,491	Hoodsport
	30				Pink	346,800	Hoodsport
April	1				Chinook	468,000	Hoodsport
	5				Pink	345,000	Hoodsport
	9	Coho	58,080	Big Quilcene R.			
	15	Coho	200,760	Big Quilcene R.			
	26	Coho	48,000	Big Quilcene R.			
	27				Chinook	468,000	Hoodsport
	21–28				Chum	2,000,350	Hoodsport
	29	Coho	69,744	Big Quilcene R.			
	30	Coho	73,440	Big Quilcene R.			
May	3	Coho	183,504	Big Quilcene R.	Chum	700,000	Hoodsport
	9				Chum	2,619,000	Hoodsport
	10				Chum	360,000	Hoodsport
					Chinook	186,000	Hoodsport
	13	Chum	363,036	Walcott Slough			
	27	Coho	59,688	Big Quilcene R.			
	28				Chum	758,000	Hoodsport
June	4	Coho	26,208	Big Quilcene R.	Chum	1,668,000	Hoodsport
	7	Chum	55,800	Walcott Slough	Chum	339,000	Hoodsport
	8	Chum	406,445	Walcott Slough			
	10	Chum	117,793	Walcott Slough			
		Chinook	161,040	Big Quilcene R.			
	15	Chum	395,277	Walcott Slough			
	16	Chum	493,905	Walcott Slough			
	18	Chum	908,576	Walcott Slough			
	21	Chum	1,218,354	Walcott Slough			
	22	Chum	194,404	Walcott Slough			
		Chinook	288,956	Big Quilcene R.			
	23	Chinook	634,288	Big Quilcene R.			
			Total			Total	
		Chum	4,153,590		Chum	8,444,350	
		Chinook	1,084,284		Pink	1,533,191	
		Coho	839,424		Chinook	1,122,000	

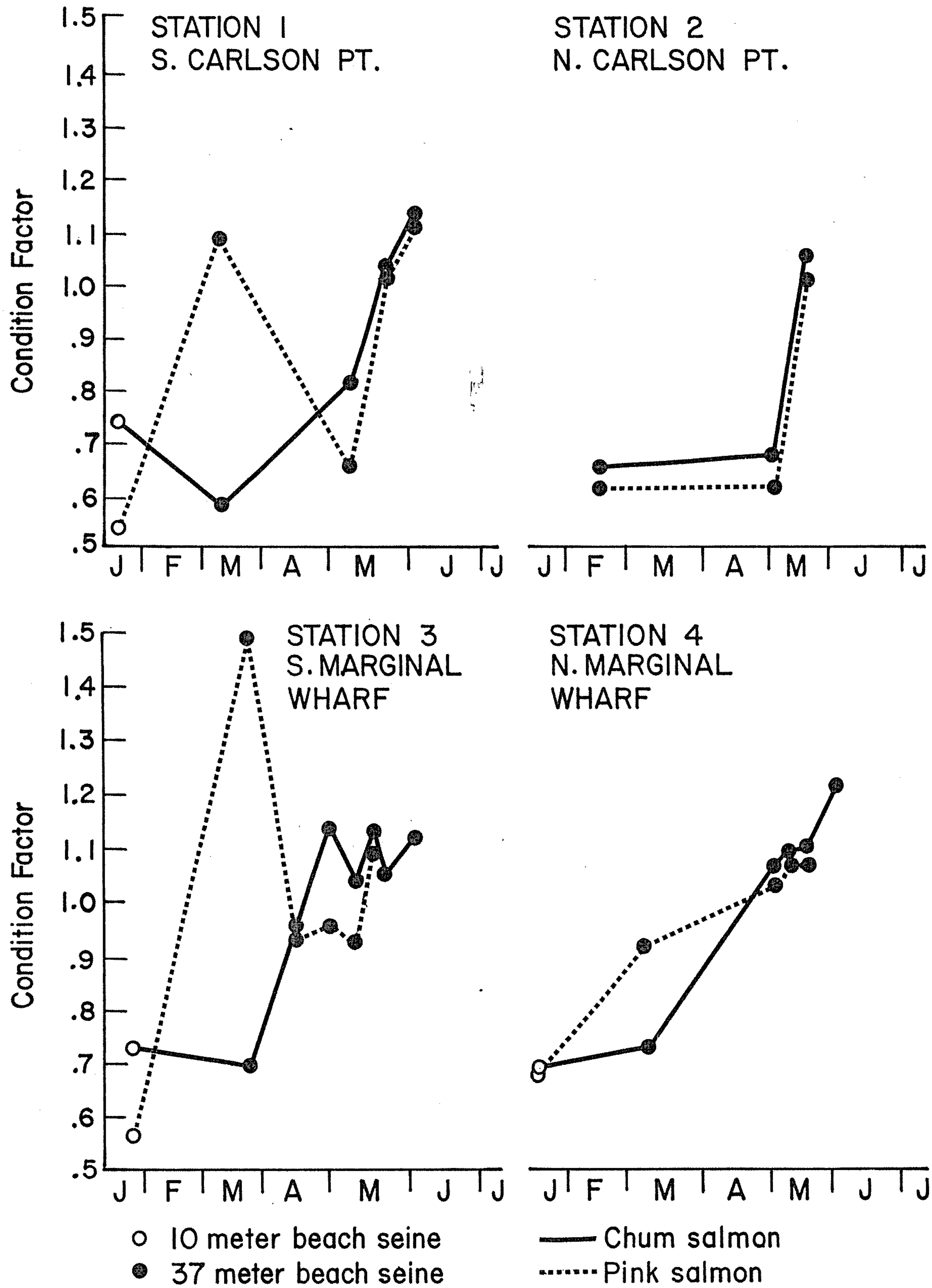


Fig. 13. Weekly condition factor of chum and pink salmon collected from January 22 to July 7, 1976 along the east shore beach seine sites on Hood Canal, Washington.

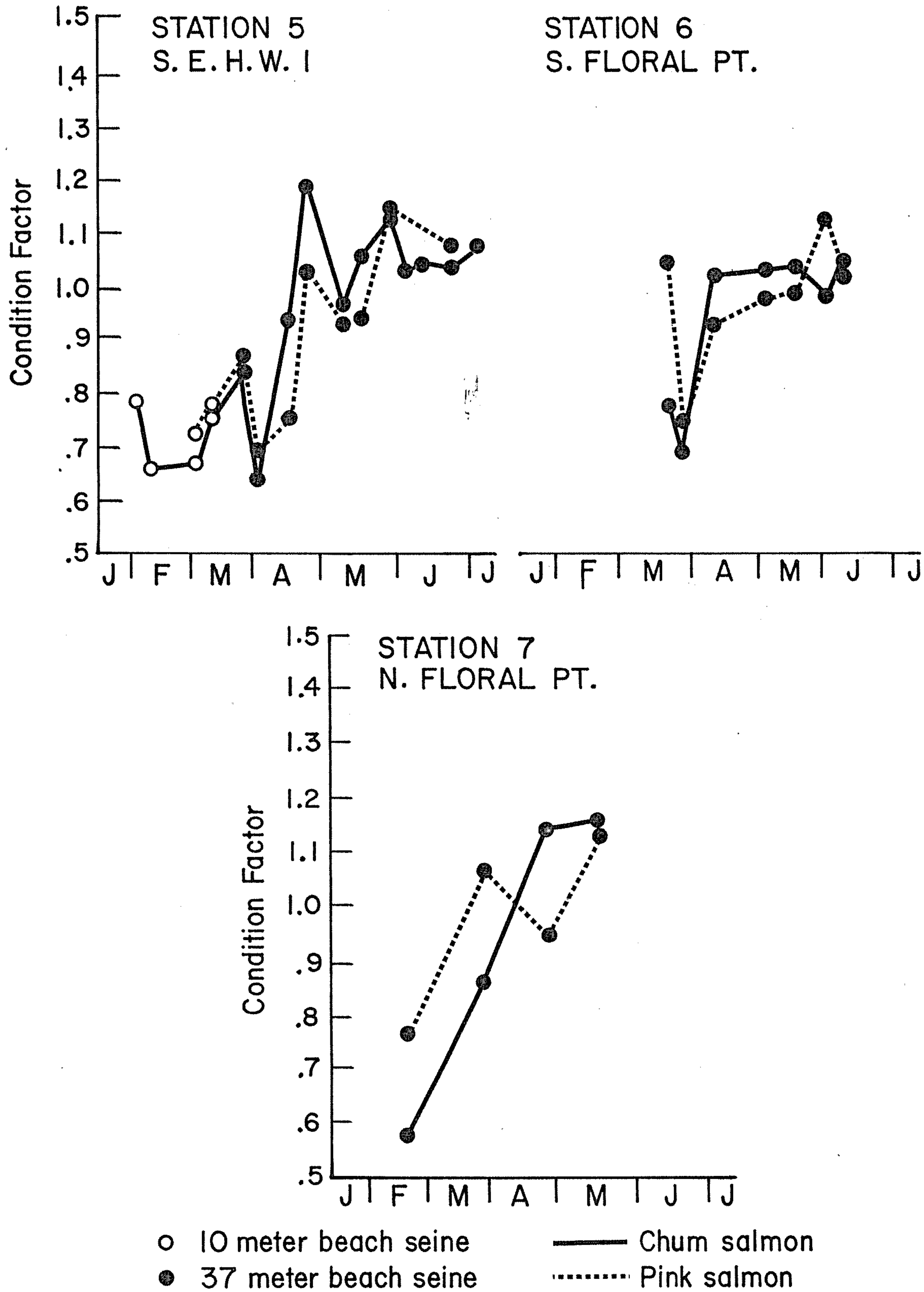


Fig. 13. Weekly condition factor of chum and pink salmon collected from January 22 to July 7, 1976 along the east shore beach seine sites on Hood Canal, Washington. - Continued.

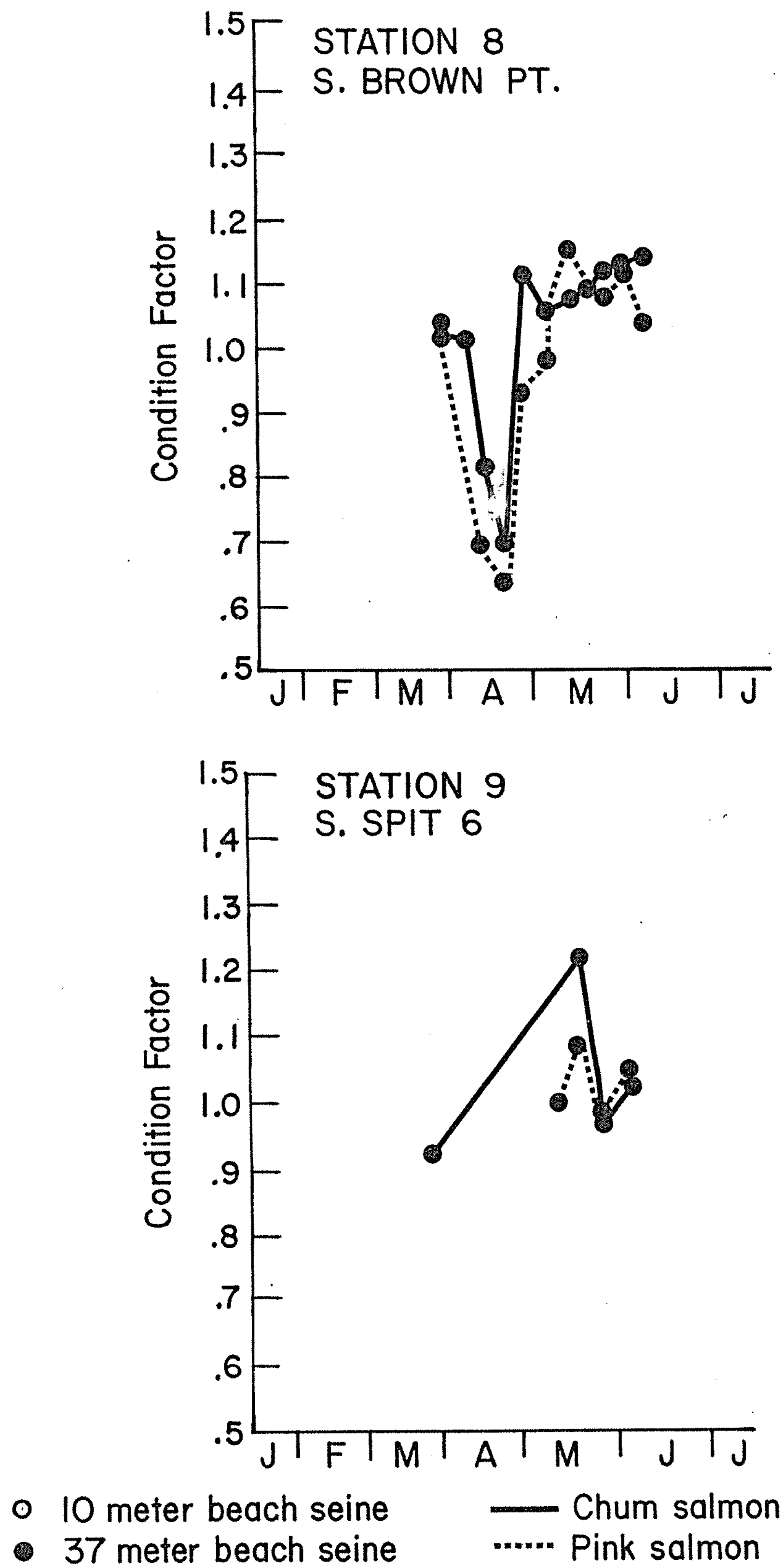


Fig. 14. Weekly condition factor of chum and pink salmon collected from January 22 to July 7, 1976 along the west shore beach seine sites on Hood Canal, Washington.

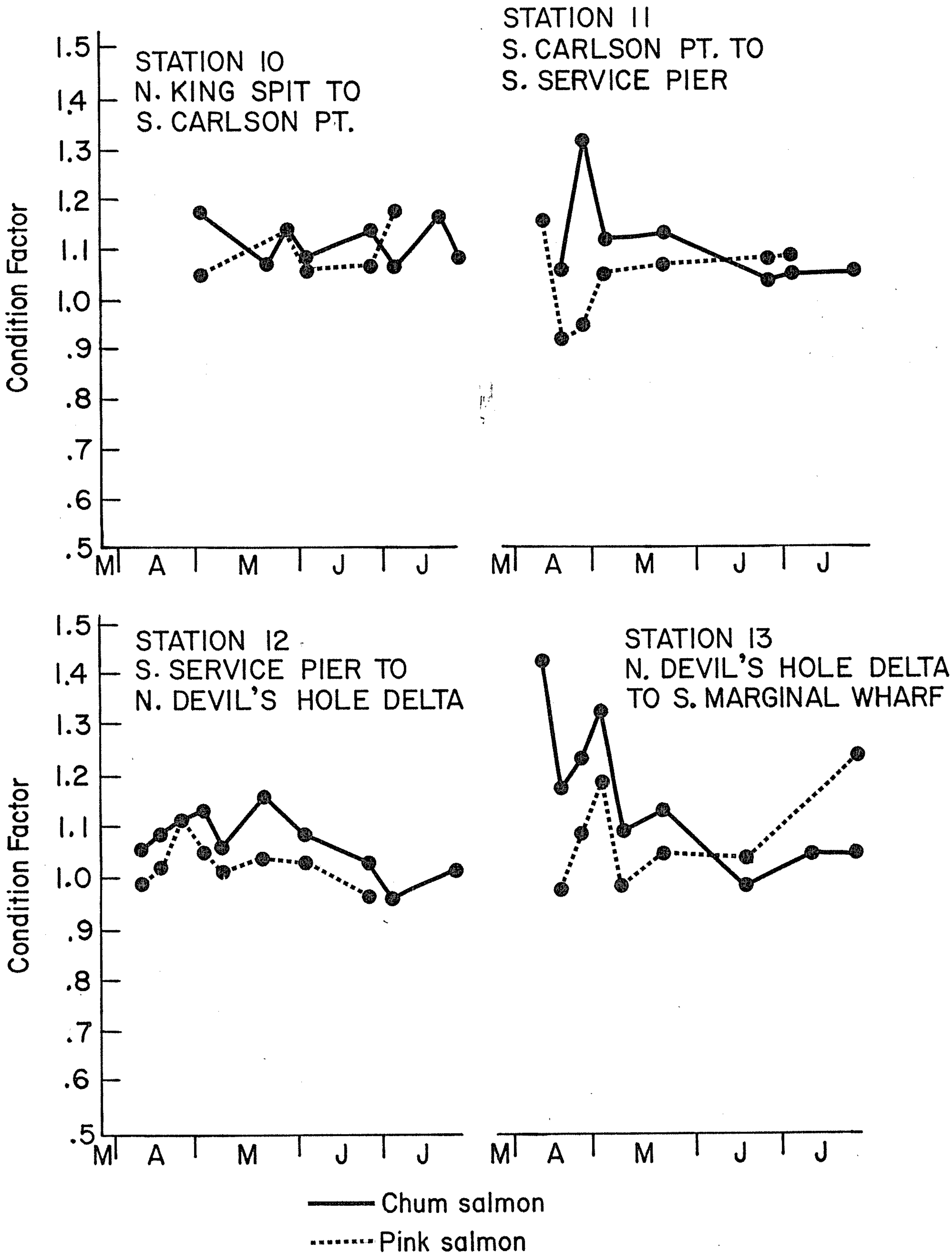


Fig. 15. Weekly condition factor of chum and pink salmon collected from March 31 to July 23, 1976 along the east shore surface townet transects on Hood Canal, Washington.

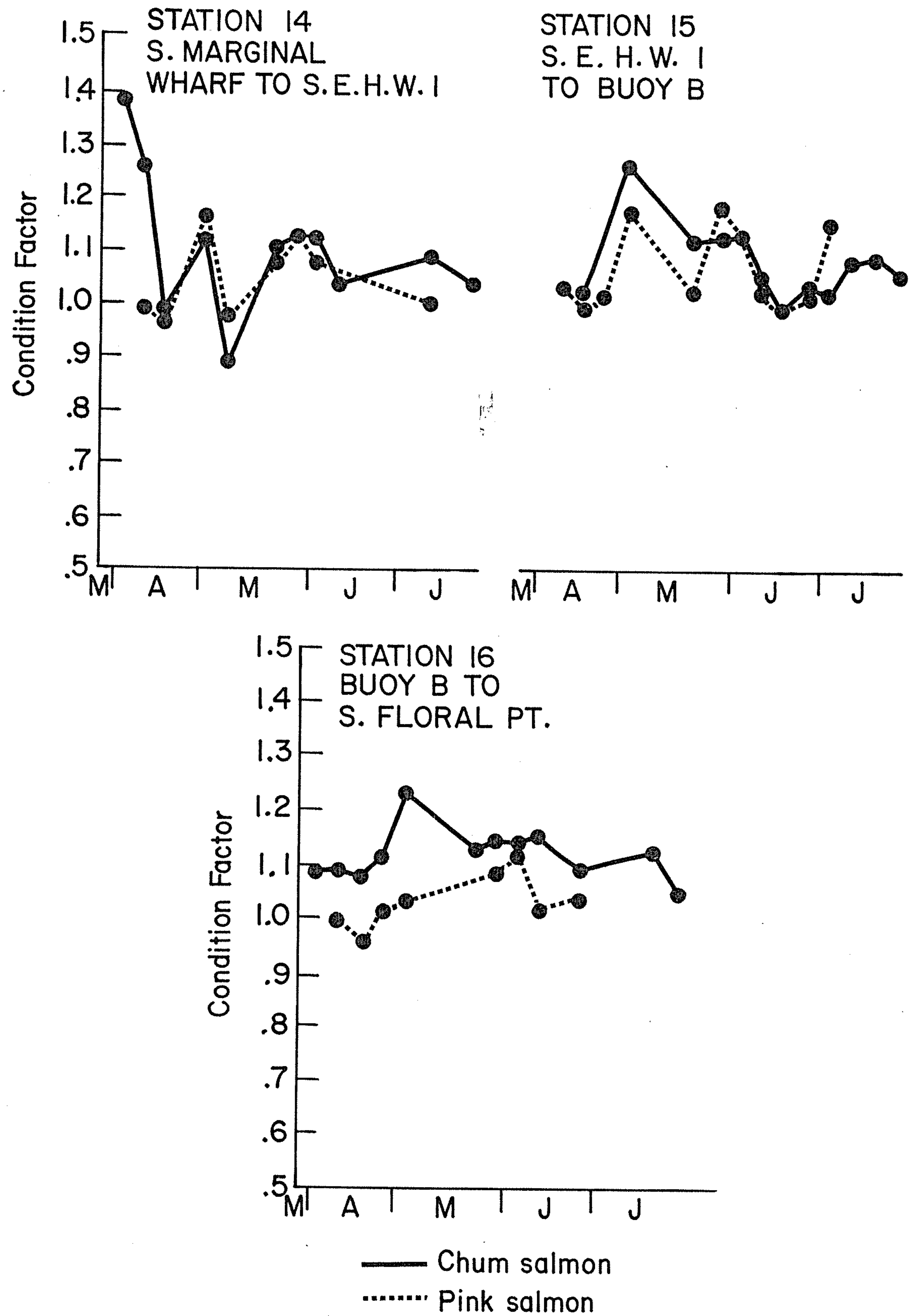


Fig. 15. Weekly condition factor of chum and pink salmon collected from March 31 to July 23, 1976 along the east shore surface townet transects on Hood Canal, Washington. - Continued.

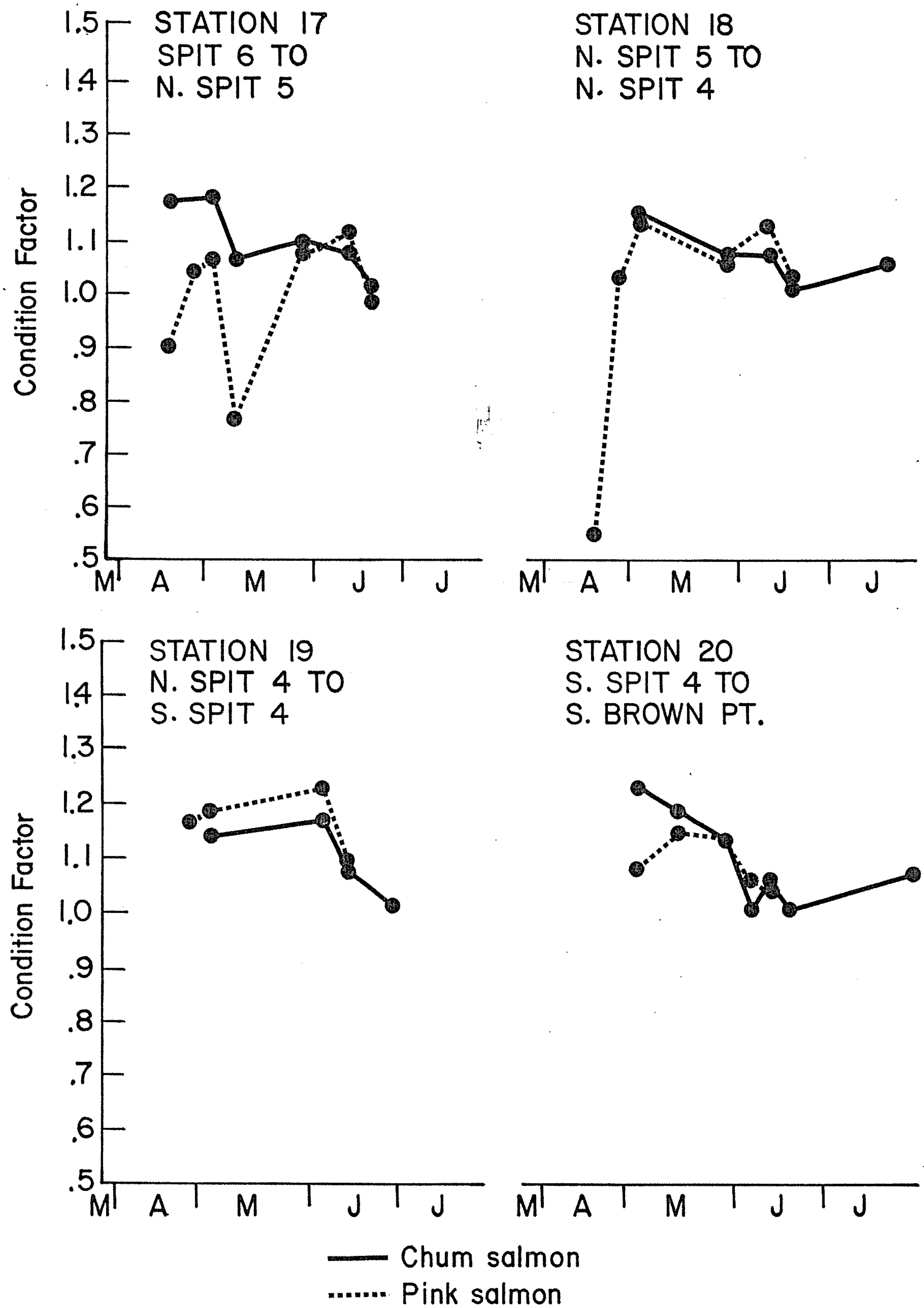


Fig. 16. Weekly condition factor of chum and pink salmon collected from March 31 to July 23, 1976 along the west shore surface townet transects on Hood Canal, Washington.

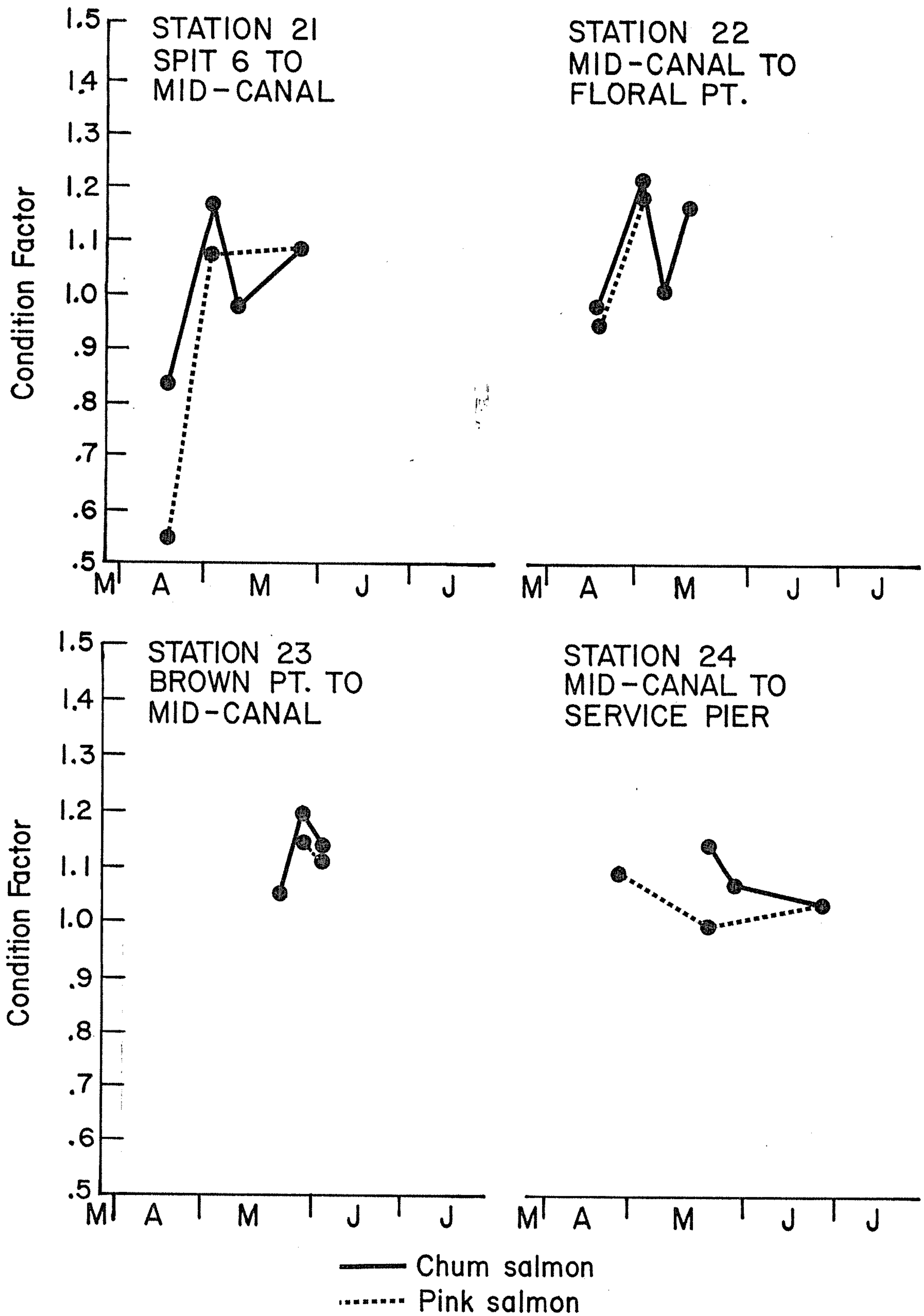


Fig. 17. Weekly condition factor of chum and pink salmon collected from March 31 to July 23, 1976 along the mid-canal townet transects, Hood Canal, Washington.

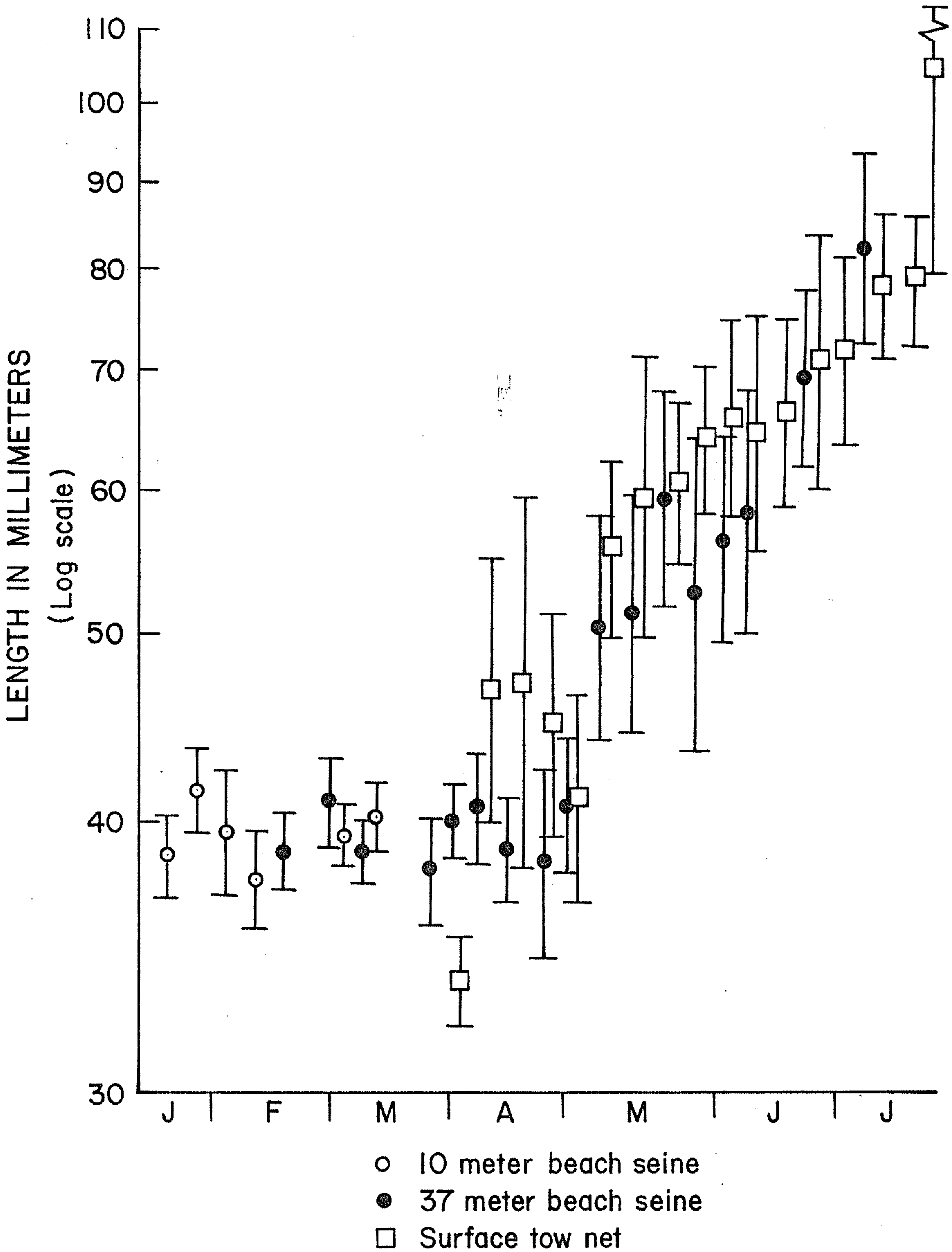


Fig. 18. Weekly mean lengths and standard deviation of chum salmon collected with all sampling methods from January 22 to July 23, 1976, Hood Canal, Washington.

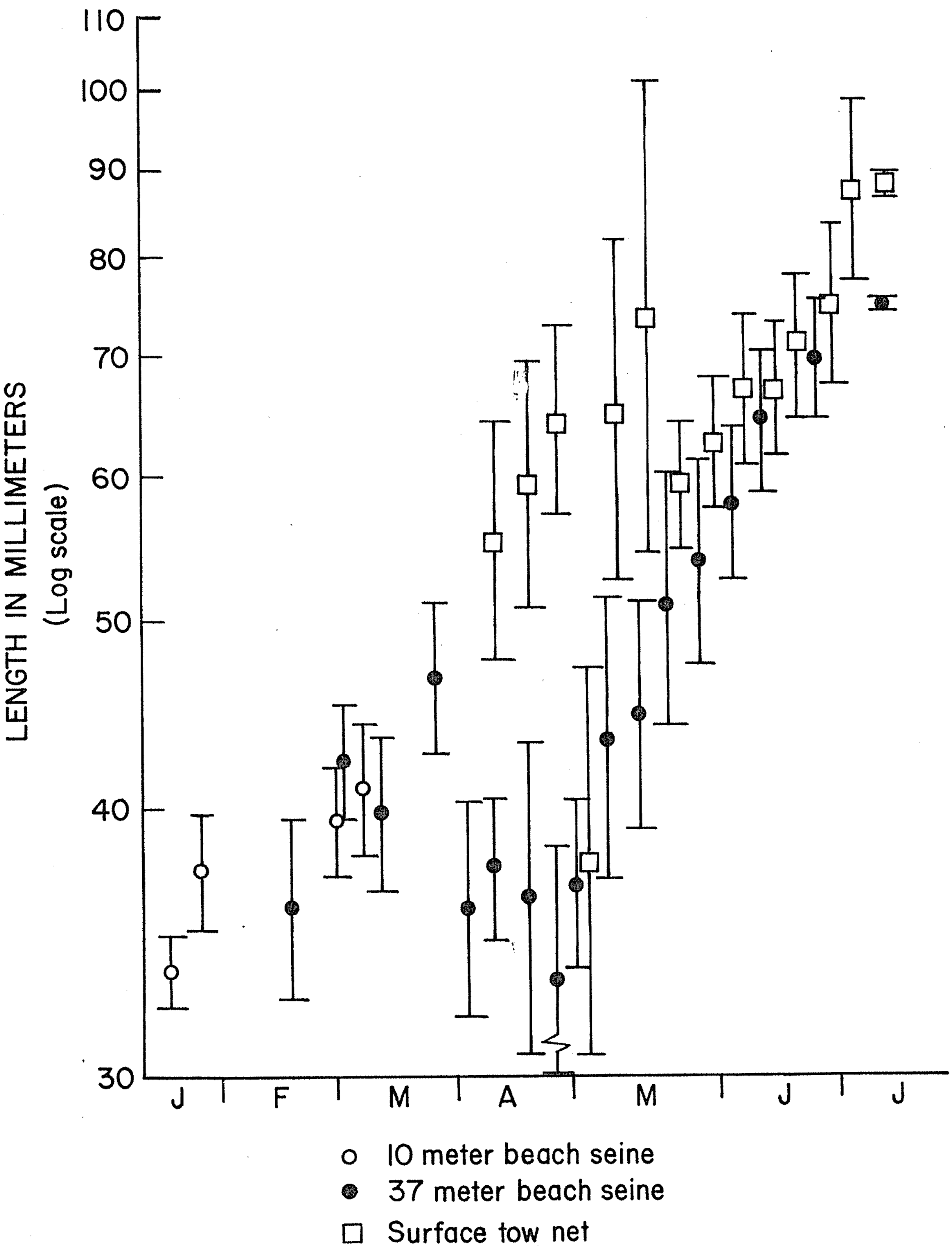


Fig. 19. Weekly mean lengths and standard deviation of pink salmon collected with all sampling methods from January 22 to July 23, 1976, Hood Canal, Washington.

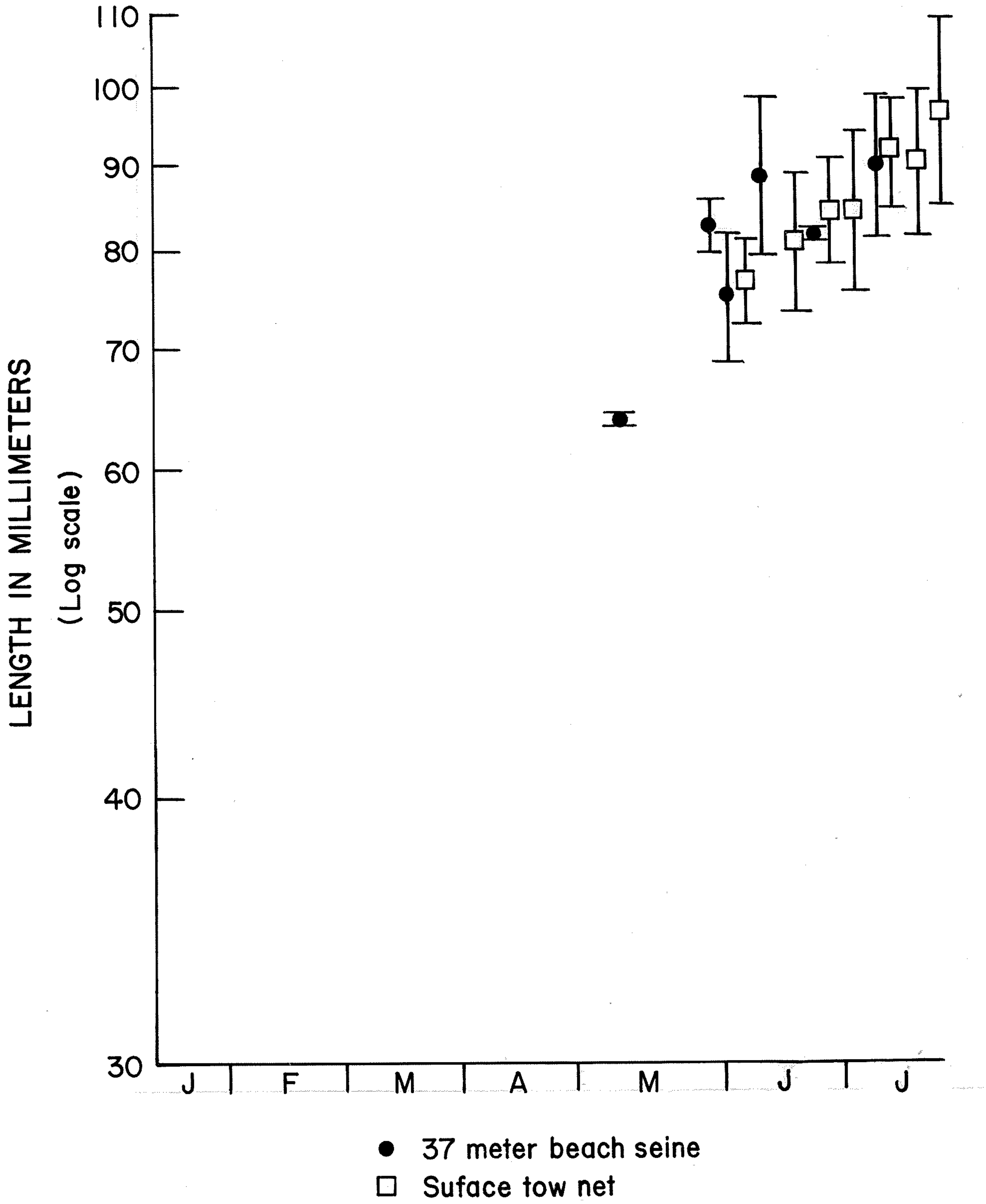


Fig. 20. Weekly mean lengths and standard deviation of juvenile chinook salmon collected with all sampling methods from January 22 to July 23, 1976, Hood Canal, Washington.

Migration Periods and Peaks

Chum Salmon

Chum salmon were the most abundant salmon during the period from January through July. A minor peak occurred in March and a major peak from mid-May to late June (Figs. 8 to 12). The earlier March peak probably represents wild stocks as there were no hatchery releases of chum prior to that time. The May and June peak was comprised of wild and hatchery chum stocks, with the bulk being contributed by the hatcheries. The major peak during 1976 was later and more extended than in 1975.

Pink Salmon

Pink salmon were observed from January to late June, with the peak lasting from mid-May to mid-June (Figs. 8 to 12). Pinks outnumbered the chums in early March as a result of releases from Hoodsport Hatchery in mid-February. Smaller catch peaks of pink salmon during the middle to late April may reflect releases from Hoodsport in late March and early April; however, catch peaks in May and June represent wild stocks of pink salmon. Pink salmon outmigrate in Hood Canal only during even years.

Chinook Salmon

Chinook salmon began appearing in early May, with a peak of migration in early July (Appendices 1 and 2). Catch data for chinook salmon are limited but the CPUE peak in early July may represent a large release of chinook fry from Quilcene hatchery on June 22 and 23. Larger initial sizes of chinooks were due to their 3-month rearing period in freshwater (Appendix 5 and Fig. 20).

Coho Salmon

Coho salmon were observed from early April through July, but due to the small number collected, a peak period was undetectable (Appendices 1 and 2). Based on data from Big Beef Creek, the migration from freshwater begins in early to mid-March and ends in mid-May. Coho CPUE during 1976 was considerably higher than in 1975.

Cutthroat Trout

Sea-run cutthroat trout were first observed in mid-March but too few were captured to detect a peak period. Cutthroat CPUE during 1976 was also greater than in 1975.

Other Salmonids

Two steelhead were captured during the study period, while no rainbow trout or Dolly Varden were observed. Salt-water migration patterns remain unclear and will require more intensive sampling.

Salmonid Relative Abundance

Numerical estimates of individual species were not possible; however, chum salmon were the most abundant, followed by pink, chinook, coho, and cutthroat trout. Combined hatchery releases for 1976 of chum and pink salmon were 12.6 and 1.5 million, respectively, while total catches of chum and pink salmon at Bangor Annex were 50 thousand and 10 thousand, respectively.

Environmental Data

Environmental observations were recorded following beach seine hauls, except when beach seines were conducted simultaneously with townetting operations. Time limitations during these combined operations reduced the collection of environmental data. Water temperatures ranged from 6.9 C in March to 13.1 C in June (Table 5). Salinities varied little over the season.

Impact of Piers

Fish stomach samples and epibenthic prey organisms were collected from mid-March to late May. Representative stomach samples from juvenile salmonids caught in nearshore and offshore sites were analyzed and compared to epibenthic food resources.

Epibenthic Plankton Populations

Preliminary sampling of shallow sublittoral epibenthic plankton with a modified suction pump indicates that, with some improvements, this system may provide a valuable source of quantitative information about the composition of prey organisms available to juvenile salmonids. As a tool for sampling neritic plankton, however, it may need further reconsideration or some modifications in sampling design.

Table 6 illustrates the numerical and gravimetric composition of epipelagic plankton at two shallow sublittoral sites and one neritic site at Hood Canal, March to May 1976. The abundance of organisms is shown for both the 206-μ and the 505-μ mesh samples. For the larger organisms retained by the 505-μ mesh net, biomass is indicated where possible.

The composition of our samples taken at the Trident base was similar to the composition found by Feller and Kaczynski (1975) in their epibenthic sampling of Dabob Bay, Hood Canal. Some changes in composition between the two sampling periods are evident. At the North Carlson site, harpacticoid copepods remained relatively constant between March and April, while gammarid amphipods, calanoid copepods, and harpacticoid eggs declined and decapod larva, isopods, and gammarid amphipod eggs increased. The South Marginal site indicated both harpacticoids and gammarids remained at relatively the same percentage between April and May, with gammarid eggs declining and *Polinices lewisii* (moon snail) larva and juveniles and caprellid amphipods increasing over that period.

Table 5. Weekly mean environmental data * at beach seine stations for the period February 16 to June 23, 1976

		Station 1 S. Carlson Pt.			Station 2 N. Carlson Pt.			Station 3 S. Marginal Wharf			Station 4 N. Marginal Wharf			Station 5 S.E.H.W. 1		
Month	Date	Temp.	Sal.	Vis.	Temp.	Sal.	Vis.	Temp.	Sa .	Vis.	Temp.	Sal.	Vis.	Temp.	Sal.	Vis.
February	11	7.5	25.8					7.4	28.8		7.5	27.5		7.6	18.2	
	18	7.3	25.9					7.3	27.6	6.0	7.1	25.8		7.3	23.6	
March	3	6.9	26.4								7.0	26.6	4.3			
	10	7.3	25.9	3.8	7.3	26.1		7.1	26.0		7.3	26.3	4.4	7.4	25.7	
	17	8.0	24.4		8.0	24.4								8.0	25.0	
	24	8.0	24.4	4.9	7.8	24.8	5.7							7.5	25.6	5.6
	31	7.8	24.4	7.5	8.5	24.6	4.0	8.2	24.7	5.5				8.2	24.7	5.5
April	7				9.0	24.8	2.7				8.7	25.0	2.7			
	14				8.2	25.2	2.8				8.7	25.2	2.6			
	17	9.5	25.8	2.5												
May	5			2.7									2.0			2.5
	12												3.0			3.0
	26												3.3			3.3
June	2	11.5	31.5	2.5				11.1	31.5	2.5	11.3	31.4	2.7	11.3	31.4	2.7
	23	13.1	31.1	4.2	13.1	31.4	4.4				13.0	30.9	5.2	13.1	31.0	4.0

* Temperatures given in degrees centigrade.
Salinity given in parts-per-thousand.
Visibility given in feet.

Table 5. Weekly mean environmental data * at beach seine station for the period February 16 to June 23, 1976 (continued)

		Station 6 S. Floral Pt.			Station 7 N. Floral Pt.			Station 8 S. Brown Pt.			Station 9 S. Spit 6		
Month	Date	Temp.	Sal.	Vis.	Temp.	Sal.	Vis.	Temp.	Sal.	Vis.	Temp.	Sal.	Vis.
February	11				7.3	26.1							
	18				7.3	25.8							
March	3				6.8	26.2		6.9	26.4	5.0	7.1	26.6	
	10				7.4	25.7	4.0	7.5	26.6	5.0	7.7	26.4	
	17				8.0	25.0							
	24	7.7	25.6	5.3				7.3	26.2	5.3	7.3	26.2	5.3
	31	8.3	24.8	5.4				9.0	24.8	4.0	8.2	26.0	3.8
April	7	8.2	25.2	2.2				8.7	25.6				
	14	8.8	25.2	2.0	8.0	25.8	2.5	9.3	25.2	2.1	8.3	26.2	2.5
	17							9.6	25.2	2.3			
May	5			2.5						2.3			2.5
	12						2.5			3.5			3.5
	19			2.3						2.8			2.5
	26			3.5				9.6	29.2	3.9			
June	2	12.2	29.4	2.4				11.3	29.1	2.5	11.3	30.2	2.6
	23	13.0	31.3	4.3				12.5	31.7	3.6	12.4	31.6	3/5

* Temperatures given in degrees centigrade.
Salinity given in parts-per-thousand.
Visibility given in feet.

nd biomass (in parentheses) of epibenthic plankton from two shallow
ling site, March-May, 1976

Leptostraca	Insecta	Cumacea	Isopoda	Caprellidea	Mysidacea	Bivalvia	*Corophium*	Reptantia	Gastropoda-larva	Pleuronectiformes-egg	Cirripedia	Ophiuroidea	Pleuronectiformes-juvenile	Crustacea-egg	Nudibranchia	*Argulus* sp.	Natantia	Gastropoda
0.8	0.8																	
		1.3	1.3	3.5	0.6	0.3	0.6											
0.2	0.2	0.9	0.9	2.4	0.4	0.2	0.4											
(0.0)	(0.0)	(0.3)	(0.5)	(6.5)	(9.8)	(0.0)	(0.2)											
0.6			0.6	0.6		0.6												
		2.7	7.2	2.5		0.8	0.2	0.2	0.2									
0.2		2.0	5.5	2.0		0.8	0.2	0.2	0.2									
(0.0)		(1.3)	(6.6)	(7.0)		(0.6)	(0.2)	(1.5)	(0.2)									
										0.4								
		1.1		1.8	0.4	0.4												
		0.5		0.9	0.2	0.4				0.2								
		(0.4)		(1.5)	(0.2)	(0.4)				(0.0)								
0.6				2.5														
		1.0	0.6	14.3	1.3	0.2	0.4				1.4	0.1	0.1					
0.1		0.9	0.5	12.2	1.1	0.2	0.3				1.3	0.1	0.1					
(0.0)		(0.8)	(1.9)	(19.9)	(8.3)	(1.1)	(0.4)				(0.4)	(0.4)	(0.5)					
0.8														47.9				
2.4		1.8	0.6	0.6		3.0					19.3				1.2	1.2	0.6	0.6
1.2		0.4	0.1	0.1		0.7					4.5			6.7	0.3	0.3	0.1	0.1
(0.4)		(0.2)	(0.2)	(1.6)		(2.0)					(11.8)			(0.0)	(21.6)	(0.4)	(5.9)	(2.0)

The plankton samples from the pilings of the South Marginal Wharf had a different composition from those taken in the shallow sublittoral region, with fewer gammarid amphipods and more annelids and other typically sessile organisms. Harpacticoid copepods, however, were also abundant in these samples.

Prey Organisms of Juvenile Salmonids

Juvenile pinks and chums prey mainly upon epibenthic crustaceans in the daylight period of their early marine migration (Kaczynski et al. 1973; Feller and Kaczynski 1975; Simenstad 1976). Later in the migration period they feed on insects and some planktonic organisms, depending upon the nearshore habitat occupied. Larger chums and pinks found in neritic waters offshore at night consume larger pelagic prey, principally gammarid amphipods, calanoid copepods, and fish and macroinvertebrate larvae.

The 1976 data (Table 7) support the earlier information. Both chums and pinks in the 35-mm to 45-mm range concentrated their feeding upon shallow sublittoral populations of epibenthic crustaceans and their eggs--principally harpacticoid copepods, gammarid amphipods, mysids, cumaceans, and leptostracans, and harpacticoid and gammarid eggs. Larger prey such as gammarid amphipods and mysids provided higher biomass contributions to the diets, but smaller organisms such as harpacticoids and their eggs tended to dominate the diet numerically.

Some habitat or site differences were evident. Most notable was the high contribution of calanoid copepods and decapod larvae at the North Marginal beach seine site; both pinks and chums concentrated on these organisms, suggesting their feeding in an offshore water mass or current which passes nearshore in this region. At almost every other shallow sublittoral site, harpacticoid copepods were the primary prey organisms. Gammarid eggs and leptostracans became more important at South Marginal in early May.

Neritic feeding (townet-caught) salmonids, typically larger than those feeding in the shallow sublittoral, showed more generalized diets. While harpacticoid copepods and their eggs were still numerically important, pelagic barnacle (cypris) larva, calanoid copepods and gammarid amphipods were also well represented. Gammarids were especially important at the South Brown Point townet site.

The source of the gammarid and harpacticoid eggs in juvenile salmonid stomachs is not fully understood; however, these eggs and egg cases may be from ovigerous females and the separation of eggs from the adults takes place in the stomach. This is probably the case with harpacticoid copepods. In many instances, however, the abundance of eggs is far out of proportion to the number of adults in the stomach, suggesting that the eggs are consumed as separate food items. The data indicate that this may indeed be the case with gammarid amphipod eggs. Many of these organisms may be too large or difficult for small juvenile salmonids to handle, and in attempting to do so, the salmonids may cause the amphipods to release the eggs from the brood

Table 7. Prey organisms of juvenile chum and pink salmon captured in shallow sublittoral and neritic regions of Hood Canal, March-May, 1976. Top numbers are percent composition by abundance; the lower values (in parentheses) are percent composition by biomass

Sample source	Sample size	Calanoida	Harpacticoida	Gammaridea	Diptera	Harpacticoida-egg	Decapoda-larva	Larvacea	Decapoda	Gammaridea-egg	Leptostraca	Mysidacea	Cumacea	Cirripedia-larva (Cypris)	Clupeiformes-larva	Rostracoda	Isopoda	Pleuronectiformes-egg	Insecta	Reptantia	Gastropoda
BEACH SEINE																					
North Marginal 12 March 1976 *O. keta*	3	79.7 (92.1)	12.5 (0.0)	3.1 (5.3)	1.6 (2.6)	1.6 (0.0)	1.6 (0.0)														
O. gorbuscha	3	50.6 (100.0)	10.3 (0.0)	8.1 (0.0)			24.1 (0.0)	2.3 (0.0)	4.6 (0.0)												
South Carlson 16 March 1976 *O. keta*	3		76.2 (30.0)	10.1 (30.0)	5.5 (40.0)	8.3 (0.0)															
O. gorbuscha	3	0.2 (4.8)	86.4 (66.7)	1.0 (9.5)		10.9 (19.1)	1.0 (0.0)			0.2 (0.0)	0.4 (0.0)										
South Marginal 16 April 1976 *O. keta*	3		90.4 (38.9)	5.1 (38.9)		3.6 (5.6)						1.0 (16.7)									
O. gorbuscha	3	1.7 (19.1)	80.3 (28.6)	2.5 (33.3)		11.8 (14.3)				2.8 (0.0)			0.8 (4.8)								
7 May 1976 *O. keta*	3		59.6 (50.0)	7.3 (25.0)			0.9 (0.[illegible])			12.8 (0.0)	17.4 (25.0)	0.9 (0.0)		0.9 (0.0)							
O. gorbuscha	3	0.7 (18.2)	8.7 (9.1)	3.6 (9.1)						58.[illegible] (27.3)	28.3 (36.4)	0.4 (0.0)									
TOW NET																					
South Marginal - North Marginal 19 April 1976 *O. keta*	3		64.7 (4.2)	1.1 (0.8)		16.9 (0.8)				2.7 (0.0)				9.8 (0.8)	4.9 (93.3)						
O. gorbuscha	3	2.5 (0.7)	39.0 (0.4)	1.7 (0.7)	1.7 (0.7)	9.3 (0.0)	1.7 (0.7)			5.9 (0.4)		0.9 (0.0)	9.3 (1.1)	17.8 (0.0)	9.3 (95.4)	0.9 (0.0)					
South Marginal Mid Delta 25 May 1976 *O. keta*	3	22.2 (58.8)	22.2 (0.0)	40.0 (0.0)	2.2 (0.0)		2.2 (0.0)			2.2 (0.0)							2.2 (0.0)	2.2 (0.0)	2.2 (23.5)		2.2 (17.6)
O. gorbuscha	3	22.0 (15.7)	41.0 (17.1)	3.3 (5.7)	0.1 (0.0)	1.6 (1.4)					0.2 (0.0)	0.2 (0.0)	0.1 (0.0)	30.2 (25.7)					1.3 (34.3)		
South Brown 4 May 1976 *O. keta*	3	6.1 (17.5)	14.8 (0.0)	75.5 (80.8)		2.2 (0.0)						0.7 (0.8)							0.4 (0.8)		0.4 (0.0)
O. gorbuscha	3	0.3 (1.8)	49.7 (8.9)	38.6 (85.7)		2.7 (0.0)				7.1 (3.6)	0.3 (0.0)	0.3 (0.0)		1.1 (0.0)							

pouch. Then the predator could consume the free eggs. This should be tested in the laboratory.

There was considerable overlap in prey spectra between juvenile chum and pink salmon early in their concurrent marine residence, but divergence took place with time and size (Fig. 21). Pink salmon diet eventually shifted, however, to gammarid amphipod eggs, calanoid copepods, and leptostracans as they grew, while chums continued their feeding preference for harpacticoids. Leptostracans also increased in importance in chum salmon diet.

Nighttime townet catches indicate that larger juvenile salmonids occupy the neritic waters off the Hood Canal shoreline, although not in as dense schools as found along the shallow sublittoral during the day. Neritic-occurring juvenile chums and pinks were more catholic in their diet and tended to concentrate upon larger pelagic organisms. Harpacticoid copepods and gammarid amphipods were present in chum and pink diet at this time, but they may have been a remnant of daytime feeding in the shallow sublittoral, depending upon when the fish samples were obtained. Clupeid larvae were important in the diets of neritic chum and pink salmon in April, typically dominating the prey composition by biomass. Approximately one month later, decapod and cirriped larvae, insects, and calanoid copepods had replaced the fish larvae as the most important prey organisms. In May, the diets of neritic chums and pinks had become slightly more divergent. Chums consumed a greater percentage biomass of calanoid copepods and decapod larvae, while pinks had consumed more cirriped larvae.

Juvenile Salmonid Diets and Available Prey Organisms

A preliminary comparison of juvenile chum and pink salmon prey organisms with the overall spectrum of epibenthic and neritic plankton available for consumption (Fig. 22) suggests some interesting aspects of juvenile salmonid feeding behavior. In the shallow sublittoral, juvenile salmonids preferentially consume the smaller, less abundant harpacticoid copepods rather than the larger, more abundant gammarid amphipods. Although the incidence of gammarid eggs suggests that the salmon may attempt to prey upon adult gammarids, they may not be able to ingest them because of the amphipod's size or activity. Despite the fact that the epibenthic pump samples did not illustrate a great abundance of leptostracans, these small crustaceans also formed a large percentage of the plankters consumed in the shallow sublittoral at South Marginal Wharf.

Neritic-feeding juvenile salmonids consumed several organisms which either were not abundant components of the neritic plankton adjacent to the Marginal Wharf pilings or were not effectively sampled by the pump--e.g., cirriped larvae, clupeid larvae, and insects. Most of the important prey in this feeding realm are larger than those in the shallow sublittoral. This selection may be a result of the larger sizes of the neritic salmon and the feeding in limited light conditions.

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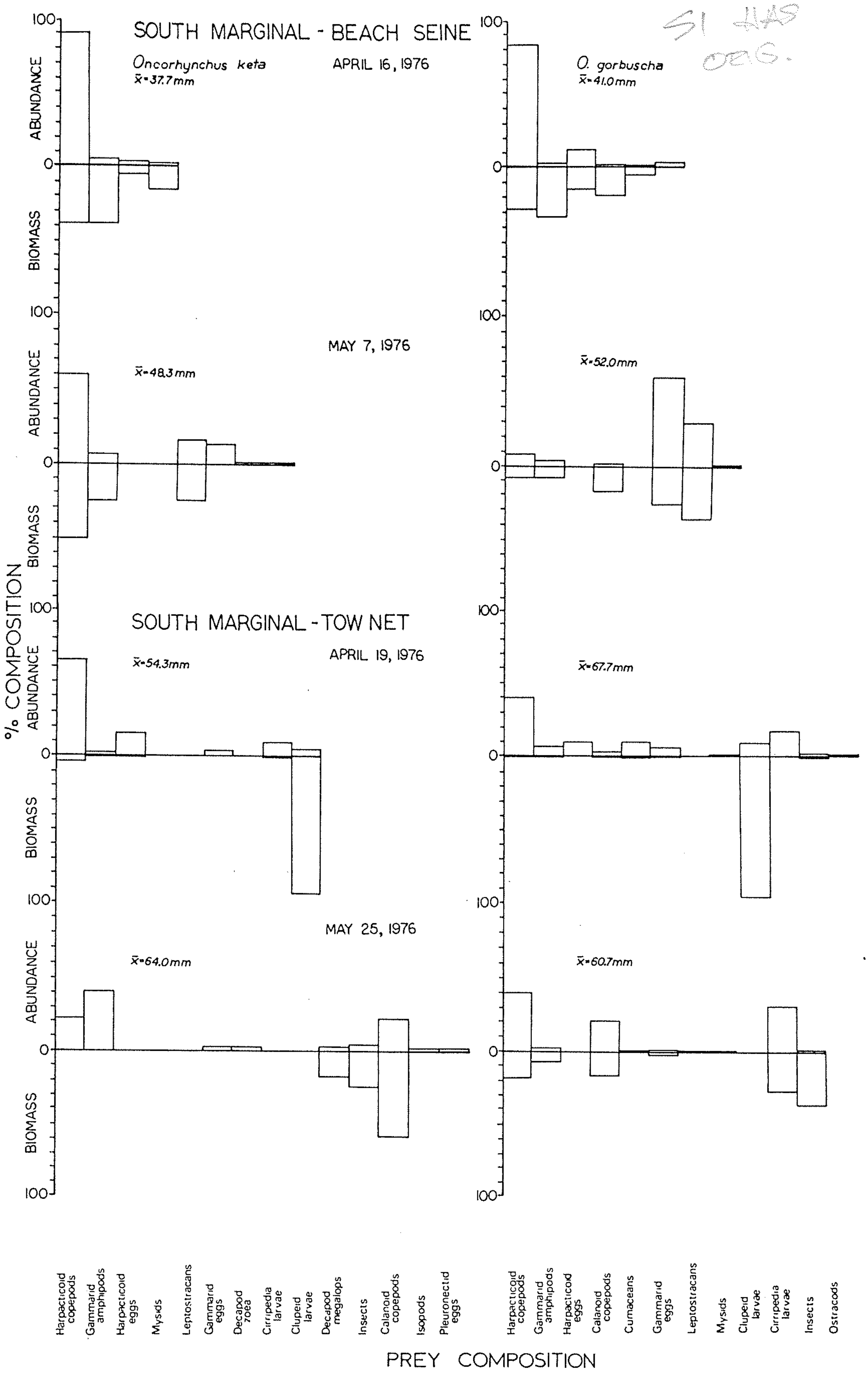

Fig. 21. Representative prey composition of juvenile chum, *Oncorhynchus keta*, and pink salmon, *O. gorbuscha*, in shallow sublittoral (a) and neritic (b) waters of Hood Canal, Washington, April-May, 1976.

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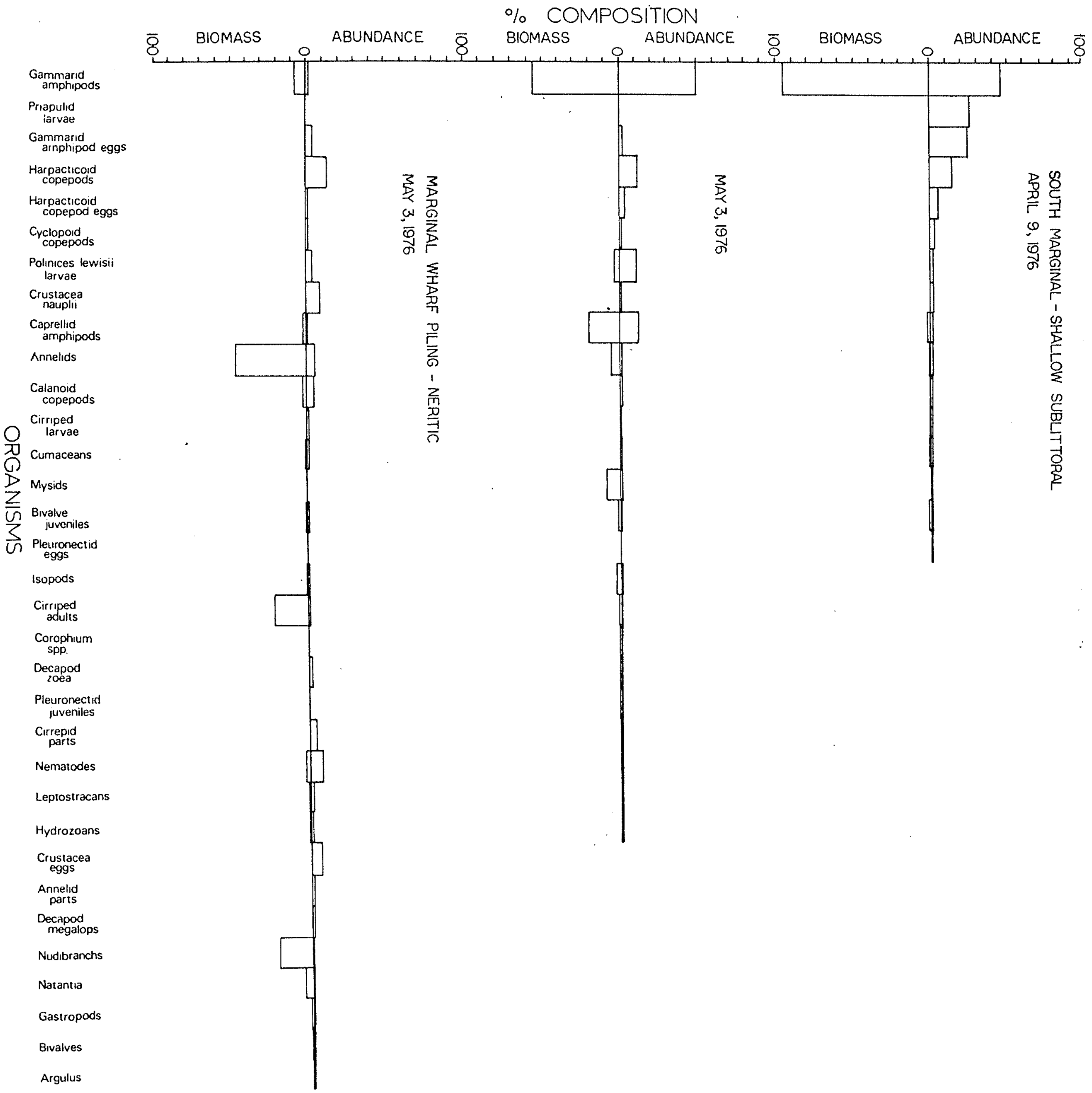

Fig. 22. Composition of shallow sublittoral and neritic plankton assemblages at two sites on Hood Canal, Washington, April-May, 1976.

While the wharf piling organisms themselves did not appear to contribute directly to juvenile salmonid diets, it should be noted that organisms such as barnacles which have pelagic larval stages utilized by neritic-feeding salmonids are significantly increased by the presence of the wharf pilings. It is not known, however, whether such organisms as gammarid and caprellid amphipods which are part of the piling community are being obtained from the wharf area or more natural habitats.

Wharf Surveys

The apparent concentration of migrating salmonids near the wharf in 1975 was not observed in 1976. Beach seining and townet efforts were reduced (*see* Methods) during the peak outmigration period. Attempts to sample salmonids beneath the wharf using baited minnow traps were unsuccessful due to unacceptable bait and inability to service the traps on a regular schedule. Underwater (SCUBA) visual surveys were also infrequent, and were unsuccessful. The effects of existing shoreline structures on outmigrating salmonids at this time remain unclear. More intensive sampling is anticipated in 1977.

SUMMARY

1. Beach seine sampling was conducted from January 22, 1976 to July 7, 1976 at seven shoreline stations on the Bangor Annex and two shoreline stations on the west side of Hood Canal.

2. Townetting surveys were conducted from March 31, 1976 to July 23, 1976 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 March, and a major peak of both wild and hatchery stock from mid-May to late June.

4. Pink salmon outmigrants were also present in Hood Canal during 1976. Peak abundance occurred from mid-May to mid-June.

5. Chinook salmon appeared in early May, with a peak in early July.

6. Cutthroat trout were first encountered in mid-March and coho salmon in early April, but insufficient data are available to establish peaks of migration or definitive routes.

7. Chum and pink salmon beach seine CPUE and condition factor peaks show a consistent correlation with hatchery releases; however, a mark and release program will be required to prove these peaks are due to hatchery fish passing Bangor Annex.

8. A majority of the salmonids was observed along the east shoreline of Bangor Annex during their migration.

9. With the data collected in 1976 we were unable to detect a concentration of salmonids near Marginal Wharf. However, sampling was necessarily restricted and reduced because of security restrictions near the wharf.

10. Chum and pink salmon fry use the nearshore beach environment as a source of food during their initial period of residence in the marine environment; however, additional data are needed on the seasonal cycle of zooplankton populations to make predictions on optimal hatchery release times, possible detrimental effects of shoreline development, and survivorship of natural stocks of chum and pink salmon fry in Hood Canal.

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APPENDICES

Appendix Table 1. Comparison of weekly beach seine catch per unit effort* of juvenile salmon for the period from January 22 to July 7, 1976

		Station 1, South Carlson Point					Station 2, North Carlson Point					Station 3, South Marginal Wharf				
Month	Date	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
January	21	7.8	5.8			4						1.0	0.4			5
	28	0.5	0			2						15	4.5			2
February	4	0	0			1						1.5	0.5			2
	11	0	0			1	1	0			1	0.5	0			2
	18	0;0	0;0.5			0;2	0;59	0;39			0;1	0;0.5	0;0			0;2
	25															
March	3	0;0	0;0			0;1	0;58	0;610			0;1	0;0	0;0			1;1
	10	0;108	0;8			1;1	0;0	0;0			0;2	0;2	0;0			2;1
	17															
	24	0;0	0;0			0;2	0;0	0;0			0;2	0;178	0;2			0;1
	31	0	0			2	0	0			2	0	0			2
April	7						0	0			1	0	0			1
	14	10.5	6.5			2	0	2			1	25.7	18.7		0.3	3
	21	0	0			1										
	28	0	0			1	0	0		0.5	2	61	4			1
May	5	4	1.3			4						187	63	0.3	1	4
	12	0	0			2						401	211.3		2.7	3
	19	5	1		3	1	203	88			1	3	0		1	1
	26											0	0	1		1
June	2	206	147		2	1						4	0		29	1
	9															
	16															
	23	0	0			1										
	30															
July	7															

10-m beach seine

37-m beach seine

* Whenever two values are noted for the same week, the first is from the 10-m beach seine, and the second from the 37-m beach seine.
10-m beach seine - unit of effort is 30.5 meter haul; 37-m beach seine - unit of effort is 30 meter haul

Appendix Table 1. Comparison of weekly beach seine catch per unit effort * of juvenile salmon for the period from January 22 to July 7, 1976 - (continued)

Month	Date	Station 4, North Marginal Wharf					Station 5, South Explosion Wharf-1					Station 6, South Floral Point				
		Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
January	21	5.3	1.5			6										
	28	0.5	0			2										
February	4	0.5	1			2	6	0			1					
	11	1.0	0			2	19	0			1					
	18	0: 0	0;0			0;2	0;4	0; 0		0;1	0;1					
	25															
March	3	4.0;0	0;0			1;1	45;0	79; 0			1;1					
	10	0.5;4.5	7;7.5			2;2	48;0	13; 1			1;1					
	17															
	24	0;0	0;0			0;1	0;31	0; 2			0;1	0;153	0; 1			0;1
	31	0	0			1	57	5			2	45.5	14			2
April	7	0	0	3		1	1	0; 0			1	0	0			1
	14	0.5	0			2	29.5	16.5			2	44	18.7			3
	21						9	4			1					
	28	0	0			1										
May	5	29	4			2	51.5	12.3		0.8	4	62.5	4.5			2
	12	72	6		16.5	4	278	317		1	1					
	19	125	7		3	1						58	14.5			2
	26						17	3	1		1	0.5	0			2
June	2	3	0			1	1	0	1	7	1	3	8			1
	9						5	0		3	1	79	4	1	2	1
	16															
	23						20	2	1	17	1					
	30															
July	7						47	0.5	2		2					

←10-m beach seine→ (January 21 to March 24)

←37-m beach seine→ (February 18 to July 7)

* Whenever two values are noted for the same week, the first is from the 10-m beach seine, and the second from the 37-m beach seine. 10-m beach seine - unit of effort is 30.5 meter haul; 37-m beach seine - unit of effort is 30 meter haul

Appendix Table 1. Comparison of weekly beach seine catch per unit effort * of juvenile salmon for the period from January 22 to July 7, 1976 - (continued)

		Station 7, North Floral Point					Station 8, Brown Point					Station 9, South Spit 6				
Month	Date	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
January	21	0.3	0			4										
	28	0	0			1										
February	4	0	0			1										
	11	0	0			1										
	18	0 ;89	0;190			0;1	0; 0	0; 0			0;1					
	25															
March	3	16 ; 0	8; 0			1;1	0; 0	0; 0			0;1	0;0	0;1			0;1
	10	0.5; 0	0; 0			2;1	0; 0	0; 0			0;1	0;0	0;1			0;1
	17															
	24	0 ;10	0; 1			0;1	0; 7	0; 1			0;1	0;10	0;0			0;1
	31						3	0			1	0	0			1
April	7	0	0			1	15	17			1	0	0			1
	14	0	0			1	10	12			1	1	0			2
	21	66	41			1	11	3.5			2					
	28	0	0		1	1	87.5	62.5		0.5	2	0	0			1
May	5						0.3	.3		3.3	3	0	1.3			3
	12	28	17.7			3	28.3	8.3			3	14	1			1
	19						89	24			1	104.5	47			2
	26						40.5	28.5	0.5	8	2	0	0		1	1
June	2						15	25		1	1	20	66			1
	9						3	0			1					
	16															
	23	0	0		1	0	0				1	0	0			1
	30															
July	7															

10-m beach seine

37-m beach seine

* Whenever two values are noted for the same week, the first is from the 10-m beach seine, and the second from the 37-m beach seine.

10-m beach seine - unit of effort is 30.5 meter haul; 37-m beach seine - unit of effort is 30 meter haul

Appendix Table 2. Comparison of weekly surface townet catch per unit of effort* of juvenile salmon for the period of March 31 to July 23, 1976

Townet

		Station 10 N. King's Spit to S. Carlson Point					Station 11 S. Carlson Point to S. Service Pier					Station 12 S. Service Pier to N. Devil's Hole Delta				
Month	Date	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
March	31	0	0			1	0	0			1	0	0			1
April	7	0	0		1	1	0	3			1	11	10			1
	14	0	1			1	8	6			2	6	9.5			2
	21	0	0			1	0.7	0.7			1	13.3	6		0.5	2
	28	5	3			1	4	3			1	11.5	6			1
May	5						0	0			1	11	2.5			2
	12						0	0		2	1	0	0			1
	19	0.7	0			1	1391.1	593.9		1.6	3	27	3			1
	26	970	53			1										
June	2	35.5	12.5		0.3	4	0	0			1	2	1			1
	9															
	16															
	23	386	12	13		1	356.5	8	5	0.5	2	103.5	1	2.5		2
	30	166	0.5	22		2	1090.8	5.3	25.8		3	42	0	2		1
July	7											3	0			1
	14	9	0	3		1	0	0	0.5		1	0	0			1
	21	14	0			1	15	0	1	1	1	5	0		1	1

* Townet - unit of effort is 10-minute surface trawl

Appendix Table 2. Comparison of weekly surface townet catch per unit of effort* of juvenile salmon for the period of March 31 to July 23, 1976 - (continued)

TOWNET

		Station 13					Station 14					Station 15				
		N. Devil's Hole Delta to S. Marginal Wharf					S. Marginal Wharf to S. E. H. W. -1					S. E. H. W. -1 to Buoy B				
Month	Date	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
March	31	0	0			1	3	0			1	0	0			1
April	7	1	0			1	0.5	5			2	1	8			1
	14	3	11.2			2	6.3	40.7			3	4.5	25			2
	21	1.5	2			1						0.5	2.5			1
	28	2	1			1	24	8			1	5.3	3.3			1
May	5	65	2			1	1.2	1			3	0	0			1
	12	0	0			1	0	0			2					
	19	126.5	14.5	0.5	2	2	302	31		2.3	2	166	29.5		1	2
	26						1220.5	117		4.3	2	1248.3	151.5		0.2	2
June	2						587	184		4	1	311	32		1	1
	9						141	102	0.5	2.5	1	43.5	9	0.5	0.5	1
	16	42	8			1						139	15			1
	23											16.8	0.4	3.6		1
	30											121	1.8	2.8		2
July	7	61	0			1	49	1	2		1	102	0	5.3		1
	14	0	0			1	1	0	1		1	4	0	3		1
	21	7	0	1	1	1	26.5	0	1	0.5	2	3.3	0	0.8		2

* Townet - Unit of effort is 10-minute surface trawl

Appendix Table 2. Comparison of weekly surface townet catch per unit of effort* of juvenile salmon for the period of March 31 to July 23, 1976 - (continued)

		Station 16 Buoy B. to S. Floral Point					Station 17 Spit 6 to N. Spit 5					Station 18 N. Spit 5 to N. Spit 4				
Month	Date	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
March	31	2	0			1	0	0			1	0	0			1
April	7	3	49			1	0	1			1	0	0			1
	14	2.9	28.3			2	1	6			2	0	1			1
	21	1	3			1	1	1			1	0	1			1
	28	1	2			1	8	4			1	13	1.5			1
May	5	0	0			1	0.5	1			2					
	12	0	0			1	0	0			1	0	0		0.7	1
	19	47.7	3.3		0.3	2										
	26	1435.7	25		0.3	2	15	1.5			2	65.7	9.5		0.7	2
June	2	9	2			1										
	9	31.3	59.3			1	261	99			1	33	2			1
	16						67	21	1		1	114	29			1
	23	3	1		1	1	1	0	1		1	0	0			1
	30	1	0			1	0	0			1	0	0			1
July	7															
	14	35	0			1										
	21	10	0	1		1	1	0			1	3	0			1

TOWNET

* Townet - Unit of effort is 10-minute surface trawl

Appendix Table 2. Comparison of weekly surface townet catch per unit of effort* of juvenile salmon for the period of March 31 to July 23, 1976 - (continued)

TOWNET

		Station 19 N. Spit 4 to S. Spit 4					Station 20 S. Spit 4 to S. Brown Point					Station 21 Spit 6 to mid-canal				
Month	Date	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
March	31	0	0			1										
April	7											0	0			1
	14											0.7	0.2			2
	21	0	1			1										
	28	2	2			1	2.7	0.7			1	11	4			1
May	5	0	0			1	1	0			1	1.5	0			2
	12						0.5	1		1	1					
	19															
	26						8	1			1	24	4		1	1
June	2	1	1			1	6	3			1					
	9	43	5.5			1	143	72			1					
	16						683	201			1	0	0			1
	23	22	0			1	0	0			1	1	0			1
	30											0.5	0			1
July	7															
	14						1.5	0			1					
	21	1	0			1	3	0			1	2	0			1

* Townet - Unit of effort is 10-minute surface trawl

Appendix Table 2. Comparison of weekly surface townet catch per unit of effort* of juvenile salmon for the period of March 31 to July 23, 1976 - (continued)

		Station 22 Mid-Canal to Floral Point					Station 23 Brown Point to Mid-Canal					Station 24 Mid-Canal to Service Pier				
Month	Data	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows	Chum	Pink	Chinook	Coho	No. Tows
March	31															
April	7	0	2			1										
	14	1	3.5			2										
	21											0	1		1	1
	28															
May	5	0.3	0			1										
	12	3	0			1										
	19						27	0		3	1	51.5	3			1
	26						2.5	0.5			1	1	0			1
June	2						7.5	5.5		0.5	1	0	0			1
	9															
	16															
	23	0	0			1	0	0			1	38	6			2
	30	1.5	0	0.5		1										
July	7															
	14											1.6	0	1.5		1
	21	0	0			1										

* Townet - Unit of effort is 10-minute surface trawl

TOWNET

Appendix Table 3. Comparison of weekly condition factor* of juvenile salmon sampled with beach seines during the period from January 22 to July 7, 1976

		Station 1 South Carlson Point			Station 2 North Carlson Point			Station 3 South Marginal Wharf		
Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
January	21	.742	.535							
	28							.724	.562	
February	4									
	11									
	18				--;.649	--;.618				
	25									
March	3									
	10	--;.586	--;.1.089							
	17									
	24							--;.695	--;1.486	
	31									
April	7									
	14							.945	.912	
	21									
	28							1.130	.946	
May	5	.804	.654		.674	.640		1.031	.910	1.171
	12							1.123	1.091	
	19	1.033	1.017		1.056	1.005		1.046		
	26									
June	2	1.133	1.116					1.107		
	9									
	16									
	23									
	30									
July	7									

10 m BEACH SEINE

37 m BEACH SEINE

* Whenever two values are noted for the same week - the first is from the 10 m beach seine, and the second from the 37 m beach seine.

Appendix Table 3. Comparison of weekly condition factor* of juvenile salmon sampled with beach seines during the period from January 22 to July 7, 1976 - (continued)

			Station 4 North Marginal Wharf			Station 5 South Explosion Handling Wharf-1			Station 6 South Floral Point		
	Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
10 m BEACH SEINE	January	21	.678	.683							
		28									
	February	4				.794					
		11				.660					
37 m BEACH SEINE		18									
		25									
	March	3				.675	.724				
		10	--;.721	.795;.880		.763	.775				
		17									
		24				--;.829	--;.866		--;.778	--; 1.031	
		31				.696	.642		.692	.744	
	April	7									
		14				.919	.749		1.005	.908	
		21				1.190	1.018				
		28									
	May	5	1.059	1.028		.962	.914		1.034	.986	
		12	1.092	1.056		1.054	.919				
		19	1.091	1.056					1.049	.997	
		26				1.112	1.131	1.050			
	June	2	1.204			1.033		1.324	.985	1.123	
		9				1.042			1.066	1.037	1.094
		16									
		23				1.033	1.059	1.185			
		30									
	July	7				1.065	1.062	1.198			

* Whenever two values are noted for the same week the first is from the 10 m beach seine, and the second from the 37 m beach seine.

Appendix Table 3. Comparison of weekly condition factor* of juvenile salmon sampled with beach seines during the period from January 22 to July 7, 1976 - (continued)

		Station 7 North Floral Point			Station 8 South Brown Point			Station 9 South Spit 6		
Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
January	21									
	28									
February	4									
	11									
	18	--;.584	--;.760							
	25									
March	3									
	10									
	17									
	24	--;.856	--; 1.062		--; 1.018	--; 1.028		--;.938		
	31				1.007					
April	7				.802	.692				
	14				.696	.638				
	21	1.138	.994		1.103	.923				
	28				1.060	.987				
May	5				1.093	1.147			1.009	
	12	1.150	1.117		1.097	1.095		1.216	1.093	
	19				1.113	1.073		.972	.989	
	26				1.125	1.116	1.131			
June	2				1.139	1.036		1.029	1.039	
	9									
	16									
	23									
	30									
July	7									

10 m BEACH SEINE

37 m BEACH SEINE

* Whenever two values are noted for the same week the first is from the 10 m beach seine, and the second from the 37 m beach seine.

Appendix Table 4. Comparison of weekly condition factor of juvenile salmon sampled with surface townet during the period from March 31 to July 23, 1976

		Station 10 N. King Spit to S. Carlson Pt.			Station 11 S. Carlson Pt. to S. Service Pier			Station 12 S. Service Pier to N. Devil's Hole Delta		
Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
March	31									
April	7					1.153		1.049	.991	
	14				1.053	.917		1.094	1.024	
	21				1.323	.944		1.106	1.109	
	28	1.172	1.038		1.114	1.053		1.122	1.055	
May	5							1.062	1.011	
	12									
	19	1.078			1.126	1.070		1.160	1.039	
	26	1.130	1.141							
June	2	1.080	1.053					1.090	1.027	
	9									
	16									
	23	1.120	1.049	1.177	1.038	1.089	1.189	1.031	.973	1.239
	30	1.042	1.155	1.208	1.050	1.094	1.217	.951		1.059
July	7									
	14	1.160		1.144						
	21	1.075			1.059		1.229	1.012		

TOWNET

Appendix Table 4. Comparison of weekly condition factor of juvenile salmon sampled with surface townet during the period from March 31 to July 23, 1976 - (continued)

		Station 13 N. Devil's Hole Delta to S. Marginal Wharf			Station 14 S. Marginal Wharf to S. E. H. W.-1			Station 15 S. E. H. W.-1 to Buoy B.		
Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
March	31				1.389					
April	7	1.423			1.255	.998			1.028	
	14	1.176	.973		.992	.969		1.012	.994	
	21	1.232	1.064						1.001	
	28	1.303	1.174		1.110	1.149		1.263	1.178	
May	5	1.087	.996		.891	.985				
	12									
	19	1.131	1.050		1.100	1.089		1.109	1.011	
	26				1.110	1.115		1.104	1.179	
June	2				1.108	1.087		1.117	1.121	
	9				1.039			1.039	1.011	
	16	.985	1.035					.994	.995	
	23							1.029	1.002	1.162
	30							1.013	1.143	1.132
July	7	1.051			1.091	.996	1.122	1.088		1.177
	14							1.093		1.243
	21	1.049	1.240		1.031		1.069	1.068		1.160

TOWNET

Appendix Table 4. Comparison of weekly condition factor of juvenile salmon sampled with surface townet during the period from March 31 to July 23, 1976 - (continued)

		Station 16 Buoy B to S. Floral Pt.			Station 17 Spit 6 to N. Spit 5			Station 18 N. Spit 5 to N. Spit 4		
Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
March	31	1.099								
April	7	1.093	.993							
	14	1.081	.955		1.173	.900			.557	
	21	1.116	1.017			1.040			1.040	
	28	1.219	1.019		1.187	1.063		1.157	1.148	
May	5				1.061	.757				
	12									
	19	1.115								
	26	1.134	1.088		1.088	1.099		1.063	1.052	
June	2	1.126	1.112							
	9	1.132	1.002		1.085	1.101		1.093	1.127	
	16				1.016	.995	1.106	1.009	1.018	
	23	1.094	1.026							
	30									
July	7									
	14	1.110								
	21	1.029		1.121				1.056		

TOWNET

Appendix Table 4. Comparison of weekly condition factor of juvenile salmon sampled with surface townet during the period from March 31 to July 23, 1976 - (continued)

TOWNET

		Station 19 N. Spit 4 to S. Spit 4			Station 20 S. Spit 4 to S. Brown Pt.			Station 21 Spit 6 to Mid-Canal		
Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
March	31									
April	7									
	14							.827	.536	
	21		1.158							
	28	1.137	1.182		1.222	1.096		1.168	1.063	
May	5							.988		
	12				1.190	1.154				
	19									
	26				1.133	1.133		1.092	1.093	
June	2	1.161	1.210		1.008	1.059				
	9	1.059	1.067		1.063	1.053				
	16				1.001					
	23	1.015								
	30									
July	7									
	14									
	21				1.080					

Appendix Table 4. Comparison of weekly condition factor of juvenile salmon sampled with surface townet during the period from March 31 to July 23, 1976 - (continued)

TOWNET

		Station 22 Mid-Canal to Floral Pt.			Station 23 Brown Pt. to Mid-Canal			Station 24 Mid-Canal to Service Pier		
Month	Date	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
March	31									
April	7									
	14	.973	.941							
	21								1.092	
	28	1.204	1.178							
May	5	1.004								
	12	1.161								
	19				1.041			1.126	.991	
	26				1.193	1.144		1.067		
June	2				1.126	1.102				
	9									
	16									
	23							1.035	1.039	1.043
	30									
July	7									
	14									
	21									

Appendix Table 5. Comparison of weekly mean lengths of juvenile salmon sampled during the period from January 22 to July 23, 1976

		10 m beach seine						37 m beach seine						surface townet					
		Chum		Pink		Chinook		Chum		Pink		Chinook		Chum		Pink		Chinook	
Month	Date	mean (mm)	S.D.	mean (mm)	S.D.	mean (mm)	S.D.	mean (mm)	S.D.	mean (mm)	S.D.	mean (mm)	S.D.	mean (mm)	S.D.	mean (mm)	S.D.	mean (mm)	S.D.
January	21	38.7	1.6	34.1	1.2														
	28	41.8	2.4	37.8	2.0														
February	4	39.7	3.3																
	11	37.7	1.9																
	18							38.6	2.0	36.4	3.1								
March	3	39.2	1.8	39.5	2.3			41.5	3.2	43.0	3.0								
	10	40.8	2.0	41.5	3.2			38.8	1.4	39.9	4.7								
	24							38.1	2.5	47.2	4.3								
	31							40.4	2.2	36.3	4.2			34.2	1.5				
April	7							41.1	2.7	37.5	3.1			47.4	8.7	56.1	8.3		
	14							38.8	3.2	36.8	7.1			47.9	11.3	59.6	10.5		
	21							38.2	5.2	34.0	4.9			45.0	6.6	64.8	8.9		
	28							41.1	4.8	37.2	3.7			41.4	5.9	37.7	10.3		
May	5							50.4	7.6	44.0	9.9	64.0	0.0	56.1	6.6	65.8	17.9		
	12							51.9	7.5	45.1	7.1			59.3	12.3	74.5	27.6		
	19							57.6	9.7	51.1	9.5			61.4	6.4	59.8	5.4		
	26							53.4	11.4	54.7	7.8	83.5	3.5	64.2	6.8	62.9	5.4		
June	2							56.7	8.6	58.4	6.1	74.9	7.6	66.8	9.3	67.6	7.3	76.8	5.6
	9							58.7	9.7	65.1	6.2	88.9	9.4	64.9	10.6	67.9	6.8		
	16													66.6	8.6	71.3	7.9	81.9	6.7
	23							69.7	7.9	70.0	5.7	81.0	0.0	70.9	13.5	75.8	9.2	84.8	7.8
	30													71.8	10.9	88.4	10.9	84.0	10.6
July	7							82.4	11.4	75.0	0.0	89.3	10.0	77.1	8.9	89.0	0.0	90.3	7.9
	14													78.0	7.6			88.9	11.2
	21													104.1	25.2			97.1	12.8