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College of Fisheries
University of Washington
Seattle, Washington 98195

INDIAN ISLAND SALMONID OUTMIGRATION MONITORING STUDY

by

Dennis D. Moore, Bruce P. Snyder, and Ernest O. Salo

FINAL REPORT

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INDIAN ISLAND SALMONID OUTMIGRATION MONITORING STUDY

(Final Report for the Period January through July 1977)

INTRODUCTION

Previous salmonid outmigration studies (Schreiner 1977) indicate that, prior to 1977, 10-15 million hatchery incubated juvenile salmon from the Hoodsport (Washington Department of Fisheries) and Quilcene (U.S. Fish and Wildlife Service) hatcheries migrated from Hood Canal each spring and summer. Current Washington Department of Fisheries (WSDF) estimates indicate a threefold increase of chum salmon (*Oncorhynchus keta*) from hatcheries migrating from Hood Canal in 1977 (personal communication).

The U.S. Navy is in the process of relocating its conventional ordinance mission from NAVTORPSTA, Bangor Annex, to the existing naval activity at NAVTORPSTA, Keyport, Indian Island Annex. Indian Island Annex is approximately 4 km (2.5 mi) southeast of Port Townsend, Washington (Fig. 1). In part, the project consists of construction of a two-berth ammunition loading pier and wharf (900 x 115 ft and 750 x 60 ft) which would extend 300-1,000 ft into Port Townsend Bay from Walan Point (Figs. 1 and 2).

It is known that Pacific cod (*Gadus macrocephalus*) migrate into Port Townsend Bay in winter months (December-March) and spawn in the waters adjacent to Walan Point (WSDF, personal communication). The impact of munitions dock construction on spawning Pacific cod was studied by Karp and Miller (1977). The salmonid study was initiated to obtain baseline data on the migratory behavior of juvenile salmonid fry in waters adjacent to Walan Point. The objectives of this salmonid study were to: 1) Sample seasonally to determine the species composition and timing of outmigration; and 2) assess the effect of ongoing construction on the outmigration pattern of the salmonids at the Indian Island Annex. This biweekly, general survey was conducted in conjunction with intensive juvenile salmonid outmigration studies at Bangor Annex on Hood Canal, Washington, located approximately 27 km southeast of Indian Island (Schreiner 1977; Bax, in progress).

METHODS AND MATERIALS

All stations were sampled by beach seine and townet using boats based at the University's research vessel KUMTUKS, moored at Bangor Annex during the spring of 1977. The University of Washington's Big Beef Creek Fish Research Station near Seabeck was used as a base for the study.

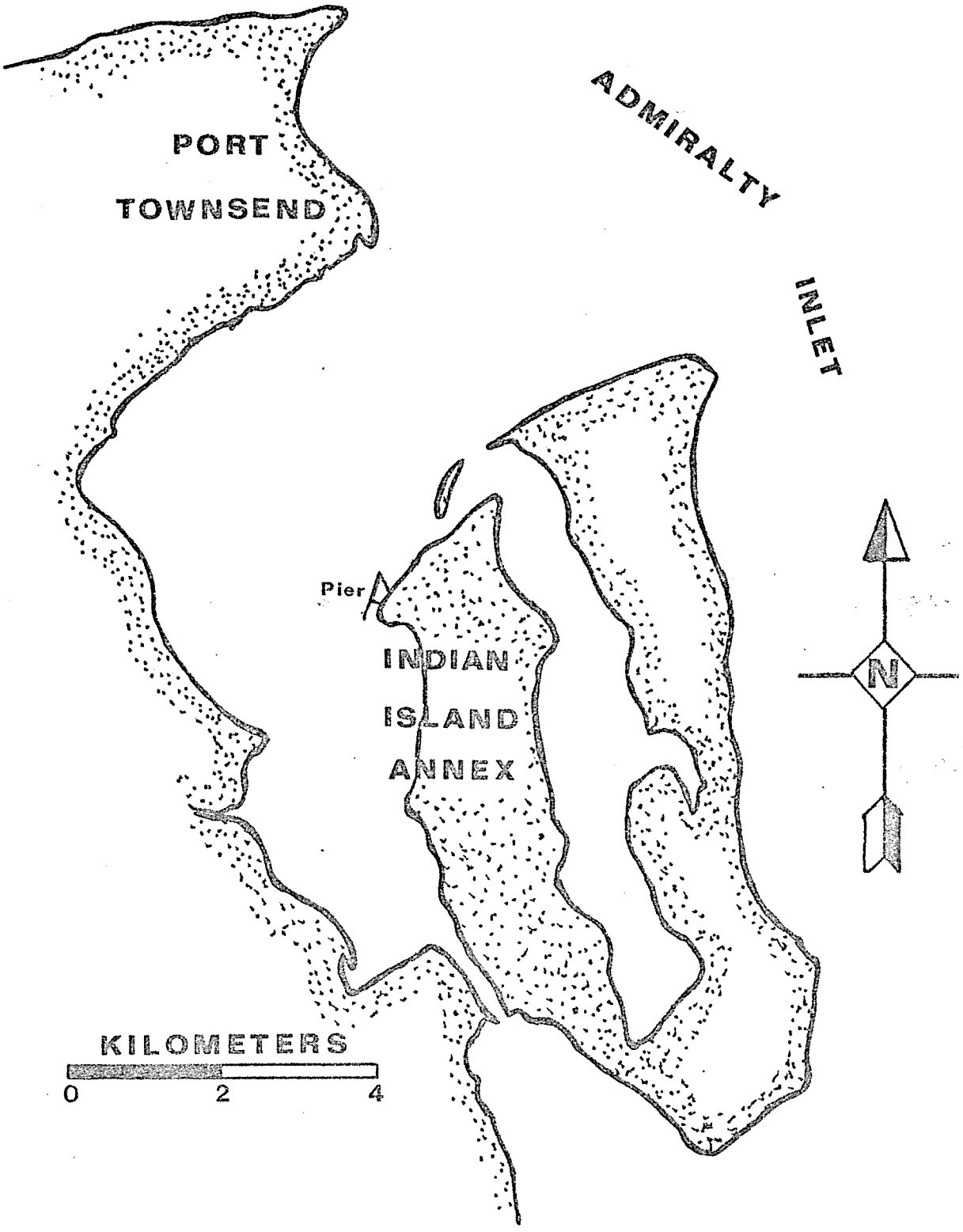
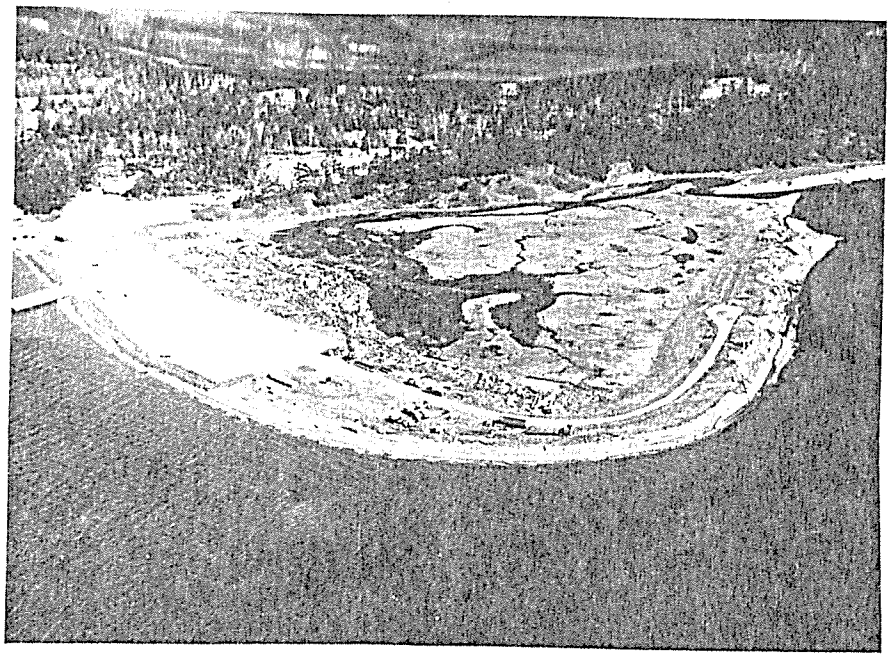


Fig. 1. Location of Indian Island Annex and proposed pier.

March 1977



April 1977

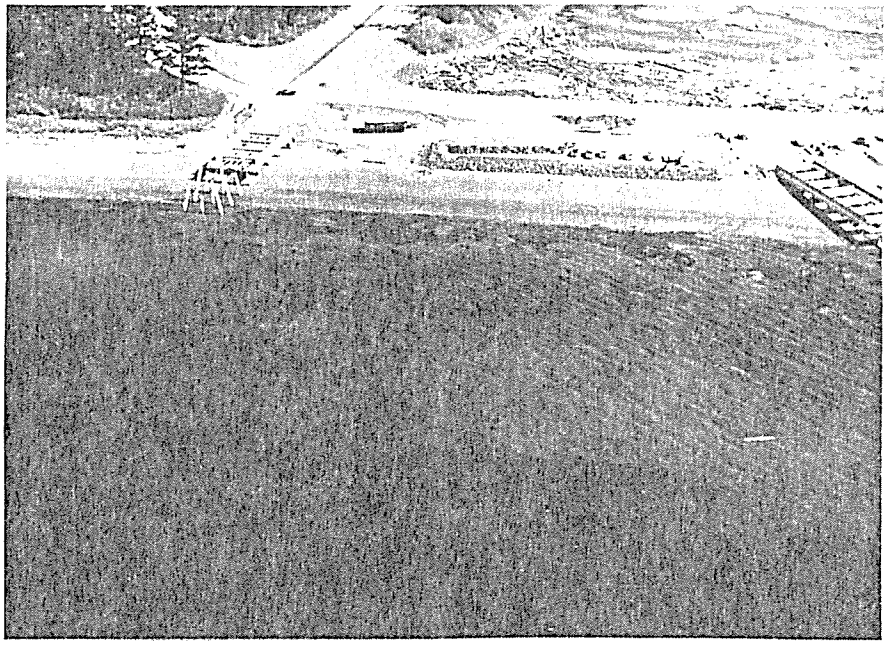


Fig. 2. Aerial photos taken March and April 1977 at Walan Point and initial pier construction.

Nearshore Sampling

Four nearshore stations were selected for study at Indian Island (Fig. 3). Aerial surveys conducted in March and April 1977 were used to evaluate each site for accessibility, substrate types, and currents.

Table 1 lists locations and descriptions of each site. Figure 4 displays beach seine stations added after January 20.

Nearshore stations were sampled January 20 utilizing a 10-m x 2-m beach seine of 6-mm stretch mesh. The seine was hauled parallel to shore for 30.5 m (100 ft) and from a depth of 1.5 m by one man on each end to the shoreline.

Sampling February 17 was accomplished with a 10-m seine and a 37-m (120-ft) beach seine deployed from the bow of a 5-m (16.5-ft) flat-bottomed skiff. The 37-m seine has 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. 5). This seine, adjusted to float, was set 30 m from shore and was drawn perpendicular to shore and closed at 10 m, causing the catch to be funneled into the bag. Juvenile salmonids and predator species were subsampled, bottled, and put on ice.

This beach seine technique has been used for nearshore studies in Puget Sound by University of Washington Fisheries Research Institute (FRI) as well as by researchers from National Oceanic and Atmospheric Administration (NOAA) Marine Ecosystem Analysis (MESA) Program (Schreiner 1977).

Beginning March 1, nearshore sampling was completed with the 37-m seine exclusively.

Nearshore visual surveys were conducted from June 2-July 21 by skiff with one observer using polarized glasses and a mechanical counter. Surveys were conducted along 3-14 transects per day of 5-8 min duration each, and from 2-30 m from shore. Visual surveys were more effective along shoreline areas versus piers because of a tendency of juveniles to sound beneath the surface (Schreiner 1977).

Offshore Sampling

Offshore sampling was begun April 1, 1977, using a surface townet 15 m long with a 3.1-m x 6.1-m net opening and with mesh sizes grading from 76 mm at the opening to 6 mm at the bag (Fig. 6). The net was towed between the University's 11.4-m (38-ft) diesel-powered TENAS and a 7.8-m (26-ft) motor whaler with an inboard diesel engine. Towing speed was kept at 0.9 m per sec (3 ft/sec) and at 10-min intervals towing halted and crewmen in an outboard skiff pursed the cod end and removed

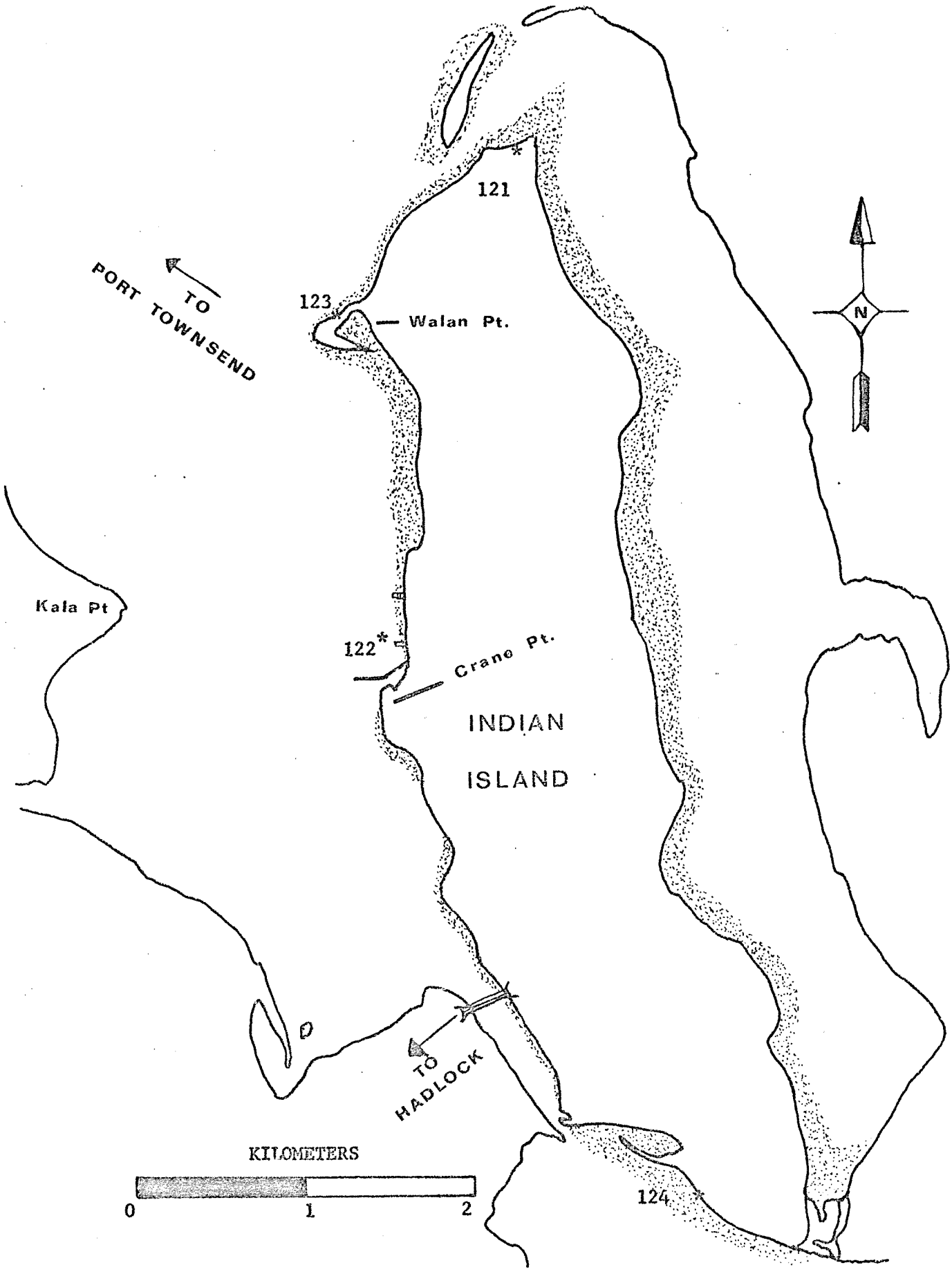


Fig. 3. Beach seine sampling sites utilized in January 1977, Indian Island, Washington.

Table 1. Location and description of beach seine sites used at Indian Island, Washington, 1977

Number and station name	Location	Slope	Substrate	Vegetation
1. 126 Sand Spit	Mid-spit, Outer shoreline	Gentle	Sand, sand, cobble	Thin patches of eelgrass (*Zostera marina*)
2. 123, North Walan Point	100-m North of Walan Point	Moderate	Sand	Thin patches of eelgrass (*Zostera marina*)
3. 127, South Walan Point	50-m S.E. of Walan Point	Moderate	Sand	Sparse beds of green algae (*Ulva* sp.)
4. 122, North Crane Point	5-m North of Crane Point launching	Gentle	Sand, small cobble	Moderate green algae beds (*Ulva* sp.)
5. 128, South Crane Point	200-m South of Crane Point pier	Moderate	Sand, small to medium cobble	Moderate green algae beds (*Ulva* sp.)
6. 129, South Kala Point	10-m South of Kala Point tip	Moderate	Sand	Bare
7. 131, North Kala Point	10-m North of Kala Point tip	Moderate	Sand small pebble	Sparse green algae (*Ulva* sp.)
8. 130, South Canal North	100-m North of black channel marker, south end, Port Townsend Canal	Gentle	Sand	Bare
9. 132, South Canal South	150-m South of red channel marker, Southend Port Townsend Canal	Gentle	Sand	Moderate green algae beds (*Ulva* sp.)
10. 124	.75-km S.E. of black channel marker at south entrance of Port Townsend Canal	Gentle	Sand	Thin eelgrass (*Zostera marina*) and thin green algae beds (*Ulva* sp.)
11. 121, Indian Island North	250-m East of South tip of sand bar off Northern Indian Island	Moderate	Sand and small pebble	Thin patches eelgrass (*Zostera marina*)
12. 125, State Park ramp	15-m Southeast of boat ramp at Ft. Flagler	Moderate	Medium to large cobble	Rock algae ??

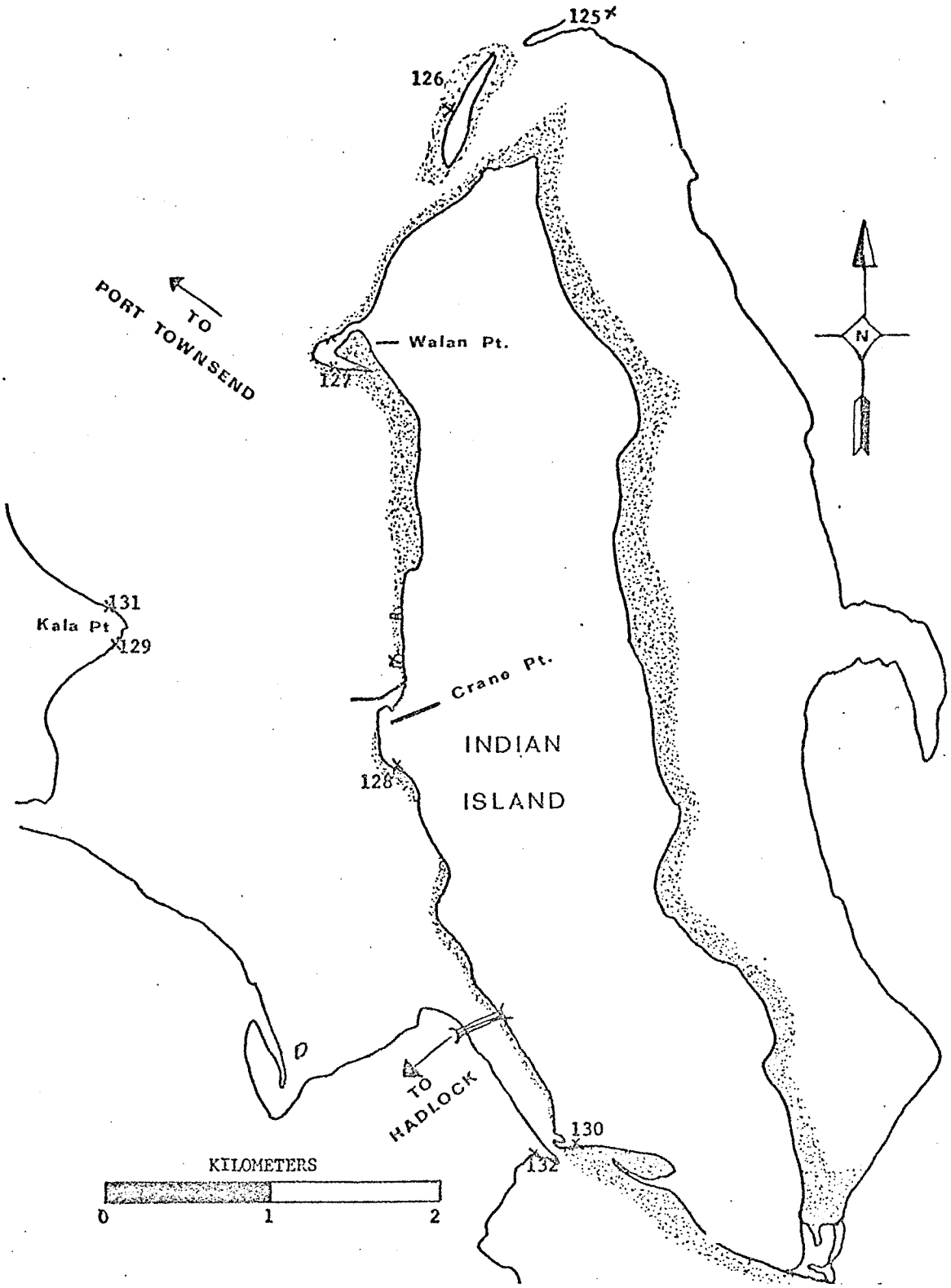
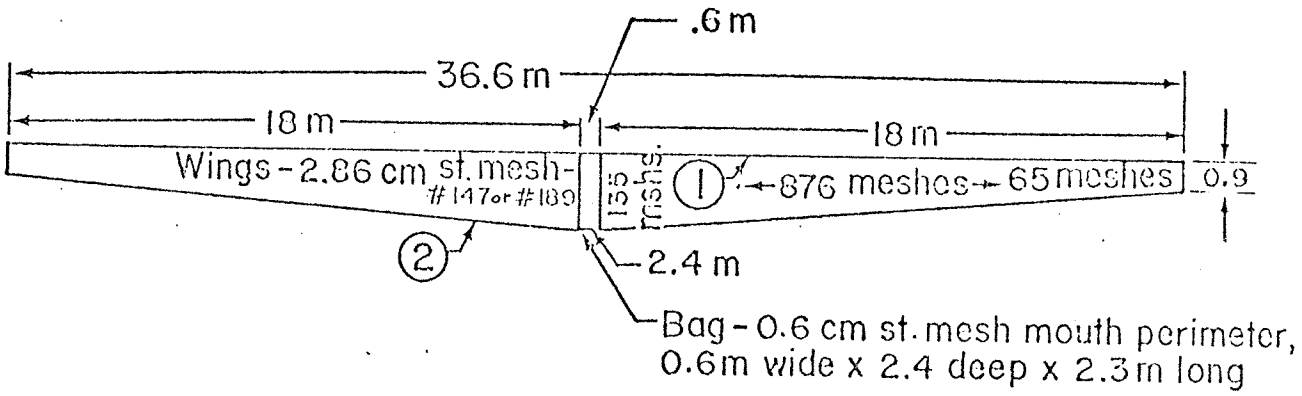


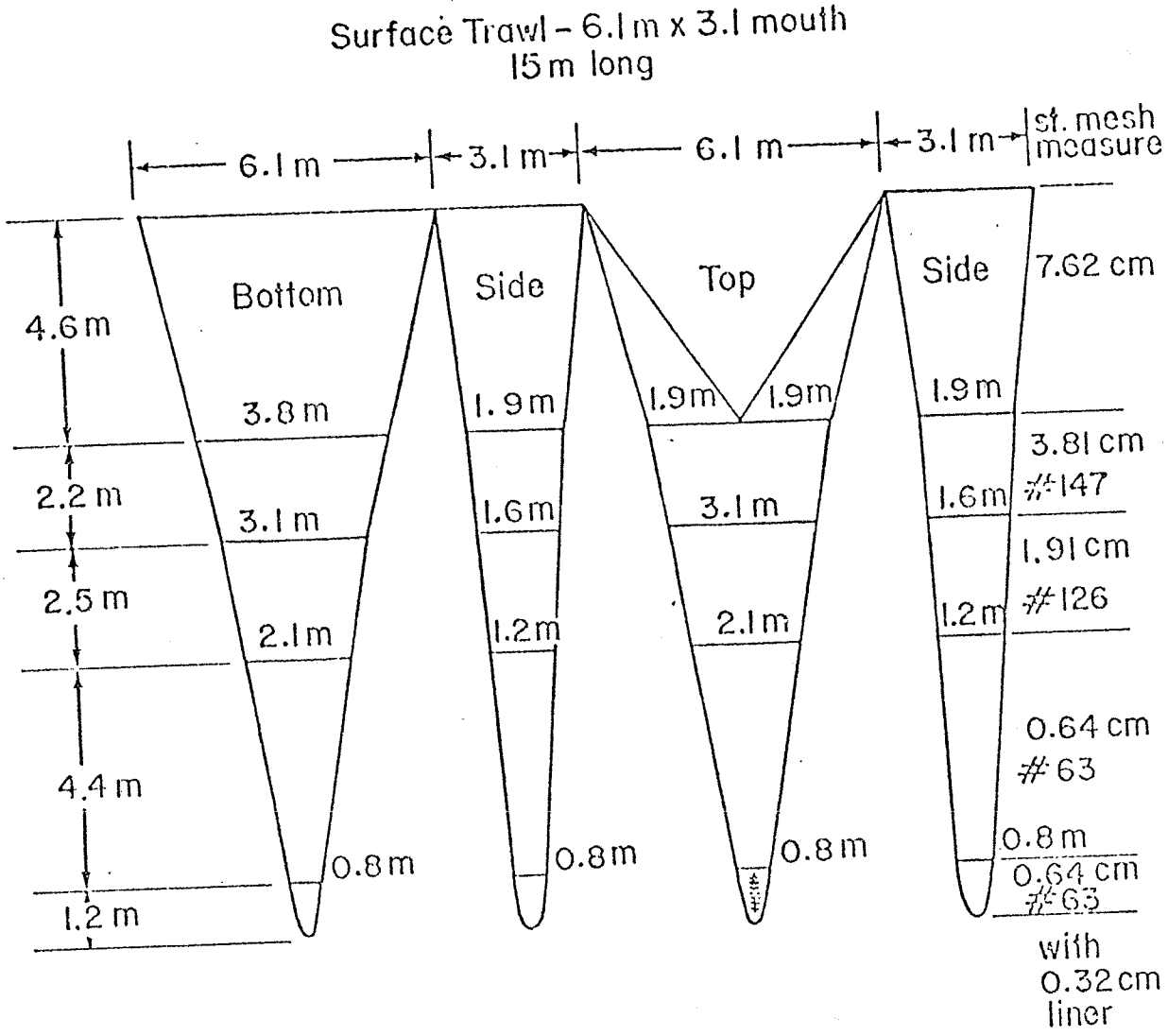
Fig. 4. Beach seine sampling sites added after January 20, 1977, Indian Island, Washington.



(1) 3.8 cm x 6.4 cm float every 6th hanging; convert to floating seine with seven 12.7 x 27.9 cm "T" floats.

(2) 113.4 g lead every 2nd hanging.

Fig. 5. Convertible beach seine utilized during nearshore surveys, January-July 1977, Indian Island, 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, April-July 1977, Indian Island, Washington.

all specimens. This technique allowed continuous sampling of the transect pattern, with each transect covering about 0.54 km (0.33 mi) (Fig. 7). Specimens were transported live in 19-liter (5-gal) plastic buckets to the TENAS and subsampled.

Specimen Analysis

A maximum of 100 chum salmon migrants per beach seine or tow (10 min) was subsampled. The fish were killed by narcotizing in MS-222 (tricaine methane sulfonate) and were preserved on ice with beach seine samples and returned to the laboratory for processing the following morning. A representative sample of coho (*Oncorhynchus kisutch*) and chinook (*O. tshawytscha*) smolts and other juvenile chum predator species was injected with 10-percent formalin and bottled for stomach analysis.

Fork lengths (tip of snout to fork of tail) were taken to the nearest mm and group weights recorded on a Mettler 1200 electrobalance to the nearest 0.01 g for each 5-mm increment.

Environmental Data Analysis

During the preliminary sampling phase (January-March) environmental conditions were monitored at nearshore stations 5-10 m from shore, and at offshore townet transects April-July. Water temperature, salinity, and conductivity were taken at a depth of 1 m with a Kahlsico electrodeless induction salinometer. Water transparency was measured with a 15-cm (6-in) Secchi disc (black and white quadrant type). Tides, currents, sea state, and weather conditions were also monitored.

RESULTS AND DISCUSSION

Catch Per Unit Effort (CPUE)

Because of the survey-type study, the significance of the CPUE is limited to an indication of routes of migration; however, the timing of the peak of migration is evident.

CPUE values were computed by the formula:

$\frac{C+}{f+}$ where C equals catch, f equals sampling effort, and + is a point in time (Ricker 1968, 1975).

Chum

Juvenile chum salmon were the most abundant salmonids observed during sampling from January-July 1977 (Fig. 8, Appendix 1). Juvenile chum captured January 20 had yolk sac conditions of slit to medium yolk,

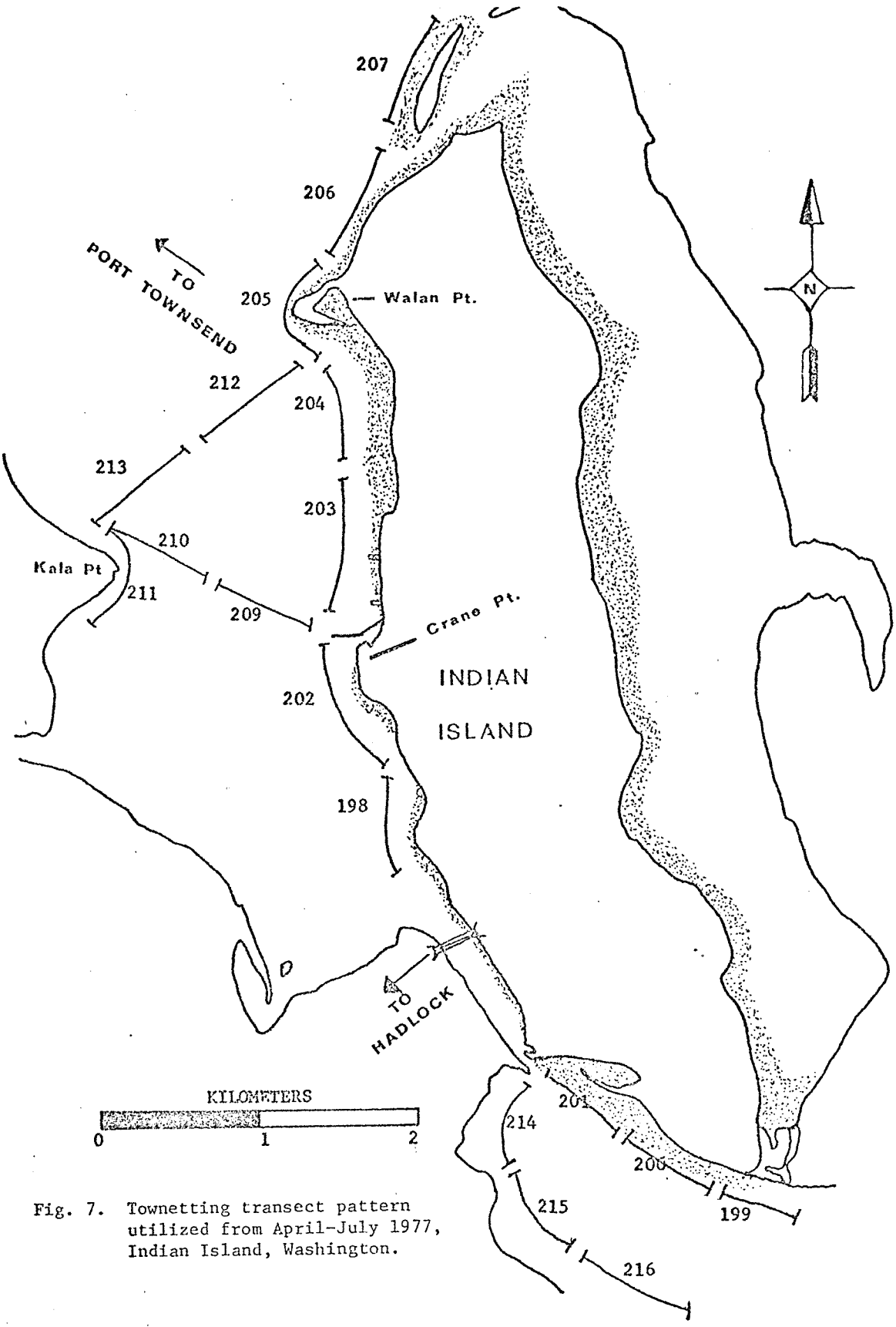


Fig. 7. Townetting transect pattern utilized from April-July 1977, Indian Island, Washington.

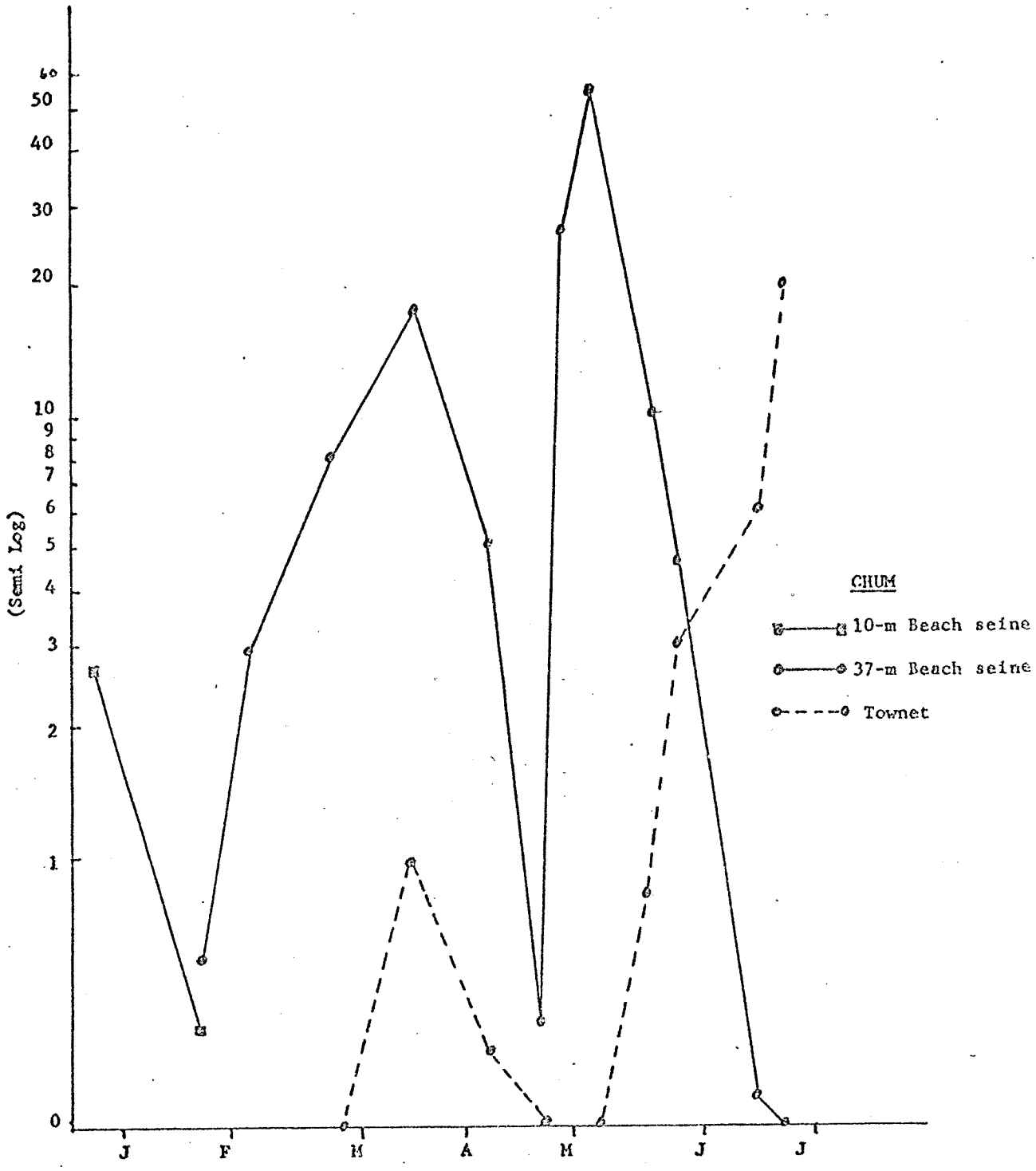


Fig. 8. Catch per unit effort of chum salmon by week at Indian Island, Washington, 1977.

which may indicate an origin from a local feeder stream. Fry of these conditions were captured until March. The peaks of migration as defined by beach seining occurred in mid-April and early June, and the townet peak was developing in late July. The 1977 Hood Canal CPUE is compared in Fig. 9. Beach seine catch peaks occurred in early March, early May, and early June, and townet peaks occurred early May and mid-June.

The early beach seine peak at Bangor was reflected at Indian Island more than 1 month later, presumably because of the migration past Indian Island of fish of Hood Canal origin. This was also indicated by the size of the fish and the speed of migration. The major beach seine catch for both Indian Island and Bangor occurred in early June; the largest number counted (600) by visual survey was made on June 3 along transect 198 (Table 2).

Earlier researchers state that juvenile chum salmon spend the initial phase of their saltwater residence in nearshore zones (Gerke and Kaczynski 1972; Bakkala 1970; Schreiner 1977), and that they gradually emigrate offshore as lengths and condition factors increase. Steady downward CPUE for nearshore areas after the June peak is contrasted by a steady upswing catch curve for townetting after early June, suggesting fry movement offshore, or from the system.

Catch data (Appendices 2 and 3) indicate more than 50 percent of all chums were caught at the south end of Indian Island on both ebb and flood tides. There is some indication of schooling of fishes before they enter the swift currents of Port Townsend Canal.

Distribution of catch success ($\geq$ one juvenile chum) was computed for sites that were sampled routinely throughout the season (Table 3). The Indian Island sampling scheme was divided into three geographical areas (Fig. 10), with two sampling sites per area for each sampling method. Percentage of success was computed for each site and averaged for each location. East and west locations had relatively equal success ratios, signifying no preference for either shoreline. The differences among east, west, and south were not statistically significant (chi squares) and more sampling effort is required to substantiate any differences.

Fry Condition

The condition factors were computed for individual chum fry, using the equation:

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

where W is the weight in grams, and L is the length in millimeters (Ricker 1968).

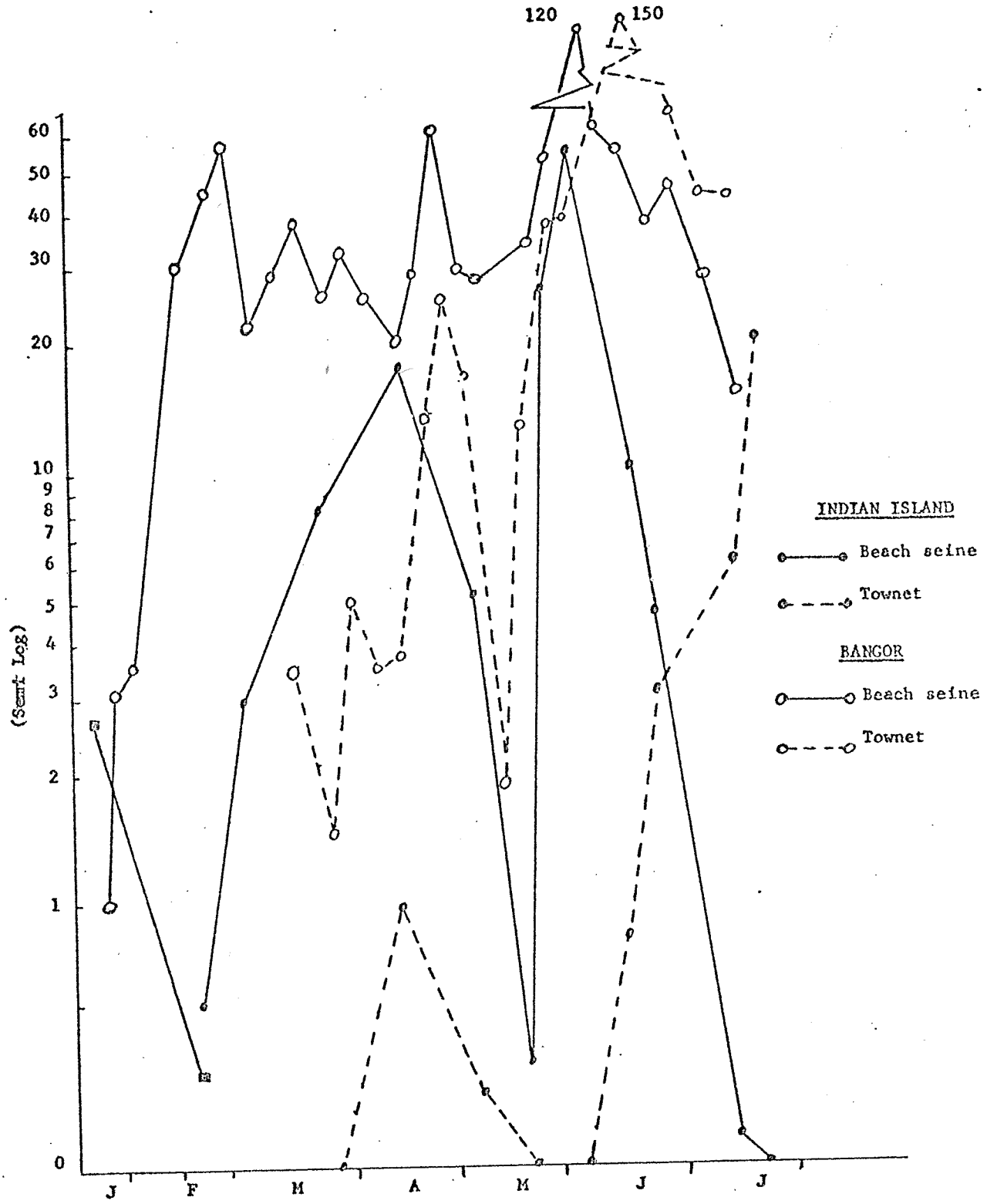


Fig. 9. Catch per unit effort Indian Island vs. Bangor by week. January-July 1977.

Table 2. Indian Island shoreline visual counts of chum fry during June and July 1977

Date	Species	Transect numbers 215	214	211	207	206	205	204	203	202	201	200	198	Total	Sky condition	Sea state
6/2	# Chum				0	0	0	0	0	0		0	35	35	Overcast	Wavelets Sm. - Lg.
6/3	# Chum			0	0								600	600	Overcast	Moderate waves
6/16	# Chum			0	1	5	10		1	1	0	0	6	24	Clear	Small wavelets
6/17	# Chum	1	0		0	0	0	0	0	25			0	26	Clear	Ripples
6/24	# Chum		0	5	0	0	1	0	0	0	0	0	0	6	Partly cloudy	Small wavelets
7/14	# Chum				10	0	0	1	1	3	0	0	0	30 3	48	Overcast	Large wavelets
7/15	# Chum		0	0	0	0	0	0	0	0	0	0	0	0	Overcast	Ripples
7/21	# Chum			0	0	0	0	0	0	0	0	0	0	0	Overcast	Ripples small
Totals		1	0	5	11	5	10	3	4	26	0	0	674	739		

Table 3. Distribution of catch success for 1977, Indian Island, Washington

	Beach seine						Townet					
	West		East		South		West		East		South	
Station:	123	127	129	131	130	132	204	205	211	213	200	201
X sampled:	14	9	8	6	11	9	14	16	9	8	8	10
X success:	4	2	4	0	4	4	5	4	3	2	3	3
% success:	28.5	22.2	50	00	36.3	44.4	35.2	25	33.3	25	375	30
Mean % success:	25.4		25		40.3		30		29.1		33.7	

(Successful catch means $\geq$ 1 chum salmon).

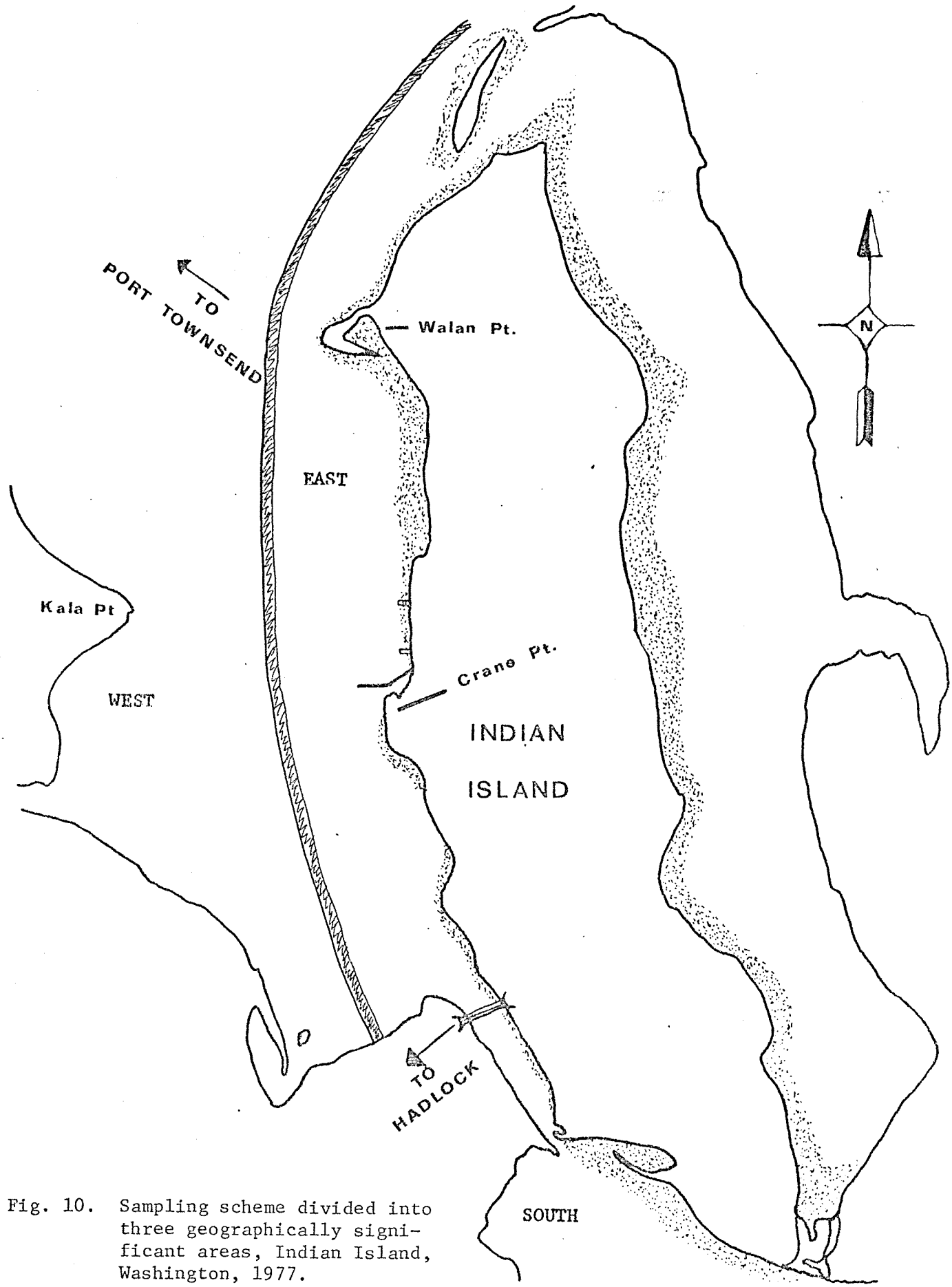


Fig. 10. Sampling scheme divided into three geographically significant areas, Indian Island, Washington, 1977.

"Weekly mean condition factors" (Fig. 11) indicates a steady increase in fry condition until early June. Lower mean conditions prior to June correlate with fry recruitments occurring during that period. Weekly mean length and standard deviation (Fig. 12, Appendix 4) indicate recruitment until May, which was also true for Hood Canal catches in 1975 and 1976 (Schreiner 1977) and 1977 (Bax, in progress). Townet mean lengths for Indian Island were significantly higher than nearshore means after early June. Hood Canal catches indicate the same trend starting as early as March. This size-dependent distribution of chum fry is a common observation. After attaining lengths of 45 to 50 mm (Hood Canal--Gerke and Kaczynski 1972), 50 to 60 mm (Puget Sound--Feller 1974), the fry enter deeper estuarine waters (offshore).

Hatchery Influence

In 1977, Hood Canal hatcheries released 18.6 million juvenile chum salmon, with the majority released in April, May, and June (Fig. 13, Table 4). Hatcheries involved include: Quilcene National Fish Hatchery; Hoodsport State Hatchery; George Adams State Hatchery; and University of Washington Big Beef Creek Research Hatchery.

The University of Washington and WSDF conducted chum spray-marking studies in 1977 (Whitmus, personal communication). Approximately 890,000 juvenile chum were spray-marked with fluorescent pigment from February 21 to June 5 and released at either Hoodsport, Big Beef Creek, or Bangor (Table 5). Migration patterns were studied between release sites and the mouth of Hood Canal.

The first marked chum recapture at Indian Island occurred on April 1 at Crane Point. It was one of 3,000 fluorescent spray-marked chum released February 21 at Bangor Annex. Spray-marked chum were again recaptured at Indian Island from the April 20 and June 5 releases from the Hoodsport Hatchery.

Marked chum were recovered 8-16 days after release (Table 5) depending on release location. Data indicate chum were outmigrating from 3-6 km per day, although a group released March 27 at Big Beef Creek were recovered 19 hr later, approximately 30.8 km north.

Infrequent sampling effort prevents extrapolation from the total of six chum recovered from 890,000 marked-released fish from Hood Canal, except that a small percentage do indeed utilize the Oak Bay-Port Townsend Bay water system.

Coho and Chinook

Coho were observed in offshore areas at Indian Island in early April and nearshore areas in late May, with fish present in late July (Fig. 14). Chinook were observed in June and July, mainly in offshore

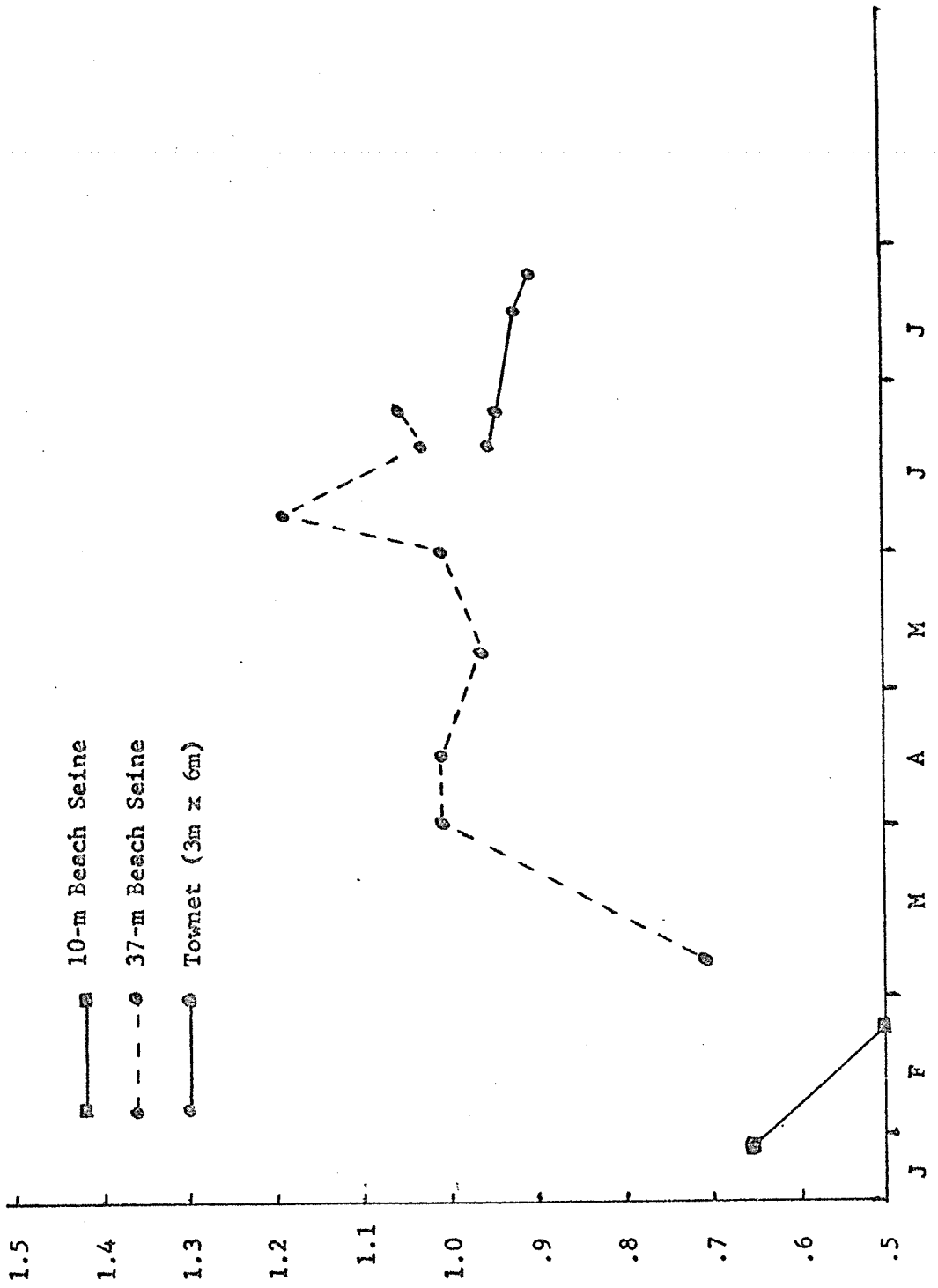


Fig. 11. Indian Island weekly chum salmon condition factor (all stations) 1977.

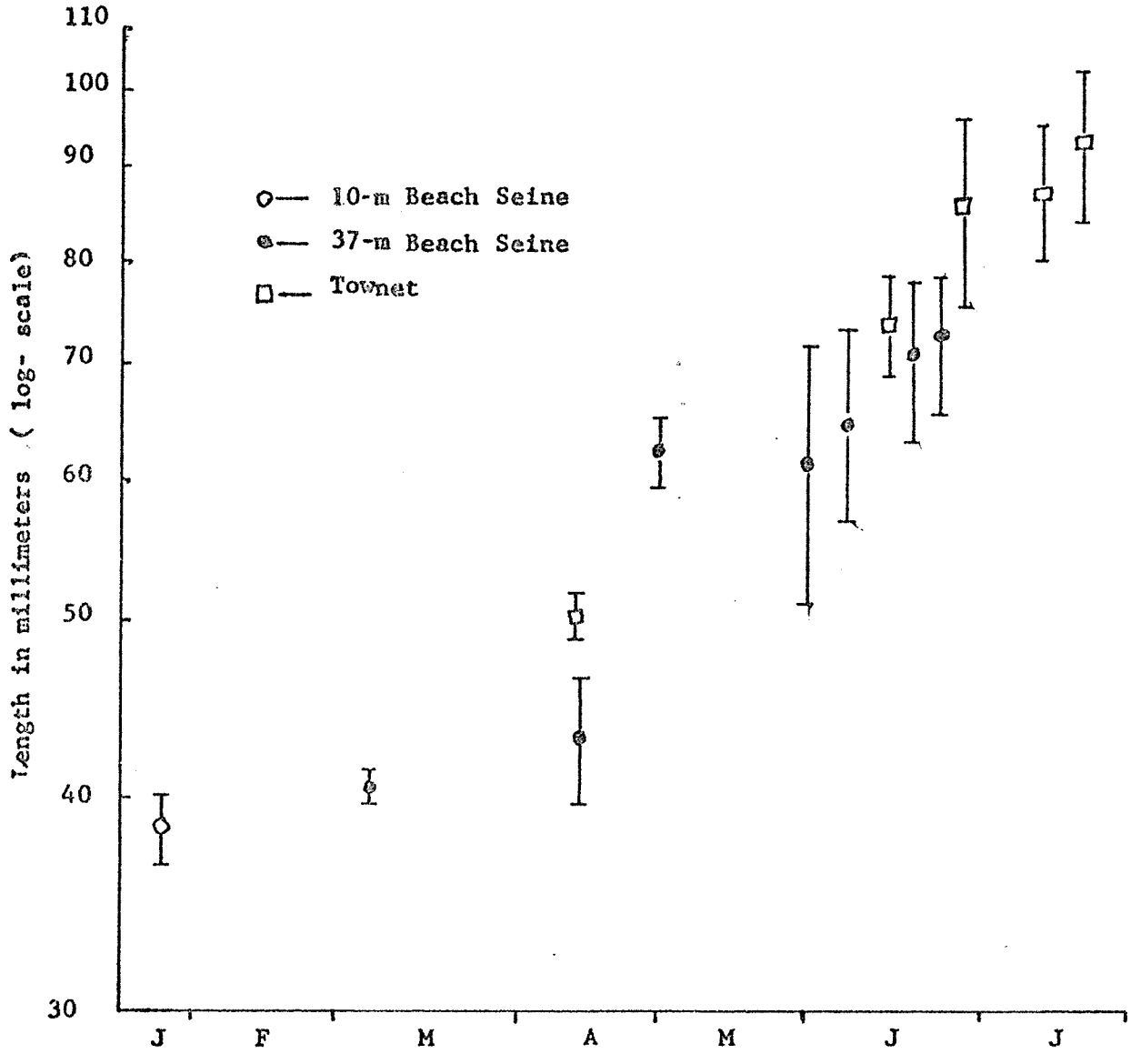


Fig. 12. Weekly mean length and standard deviation of chum salmon collected with all sampling methods from January 20 to July 21, 1977, Indian Island, Washington.

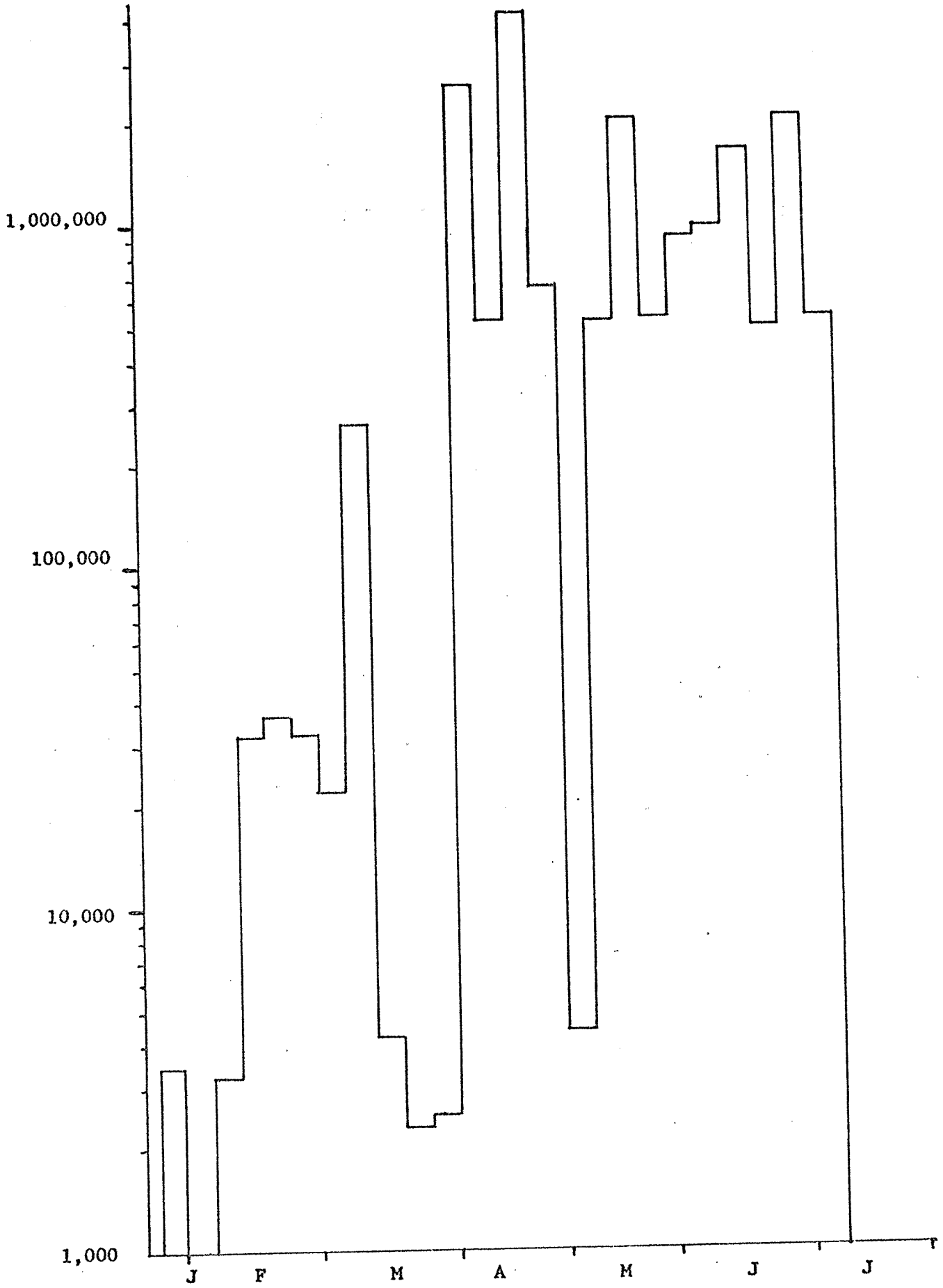


Fig. 13. Hood Canal Hatchery release of chum salmon by week, compiled data from Hoodsport, Quilcene, George Adams, and Big Beef Creek (University of Washington), 1977.

Table 4. Hood Canal Hatchery release of chum salmon by week, compiled data from Hoodsport, Quilcene, George Adams, and Big Beef Creek (University of Washington), 1977

Week		Total chum released
1	Jan. 2-8	153
2		635
3		3,385
4		966
5		3,210
6	Feb. 6-12	32,051
7		35,851
8		32,796
9		22,614
10	March 6-12	268,198
11		4,246
12		2,333
13		2,470
14	April 3-9	2,566,607
15		566,381
16		792,774
17		4,677,207
18	May 1-7	4,404
19		521,791
20		2,000,815
21		533,903
22		906,200
23	June 5-11	966,255
24		1,608,692
25		491,812
26		2,084,523
27	July 3-9	520,000

Table 5. Release of Hood Canal spray-marked chum, and recovered at Indian Island, Washington, 1977

Release site	Date released	Time	Number released	Color (mark)	Length (Mean) mm	Recovery date	Number collected	Length (mm)	Migration duration[4]
B.B.C.[1]	February 21	PM	50,206	Red	48.3				
B.B.C.		21 PM	20,492	Yellow	56.5				
Bangor[2]		21 AM	3,000	Blue	-	March 1	1	46 mm	8 days
B.B.C.	March	20 -	27,000	Red	57				
			7,000	Green	53				
B.B.C.		27	63,550	Orange	55				
B.B.C.	April	16	20,000	Orange	38				
		17	22,000	Blue	38				
		18	20,000	Green	38				
Hoodsport[3]		20	256,000	Red	-	May 6	4		16 days
Hoodsport	June	5	400,000	Orange	-	June 17	1	80 mm	12 days

[1]Big Beef Creek, University of Washington.

[2]Bangor Annex, University of Washington.
[3]Hoodsport Hatchery, State of Washington.
[4]Note: Indian Island to Bangor - 27 km,
to B.B.C. - 37 km,
to Hoodsport - 67 km.

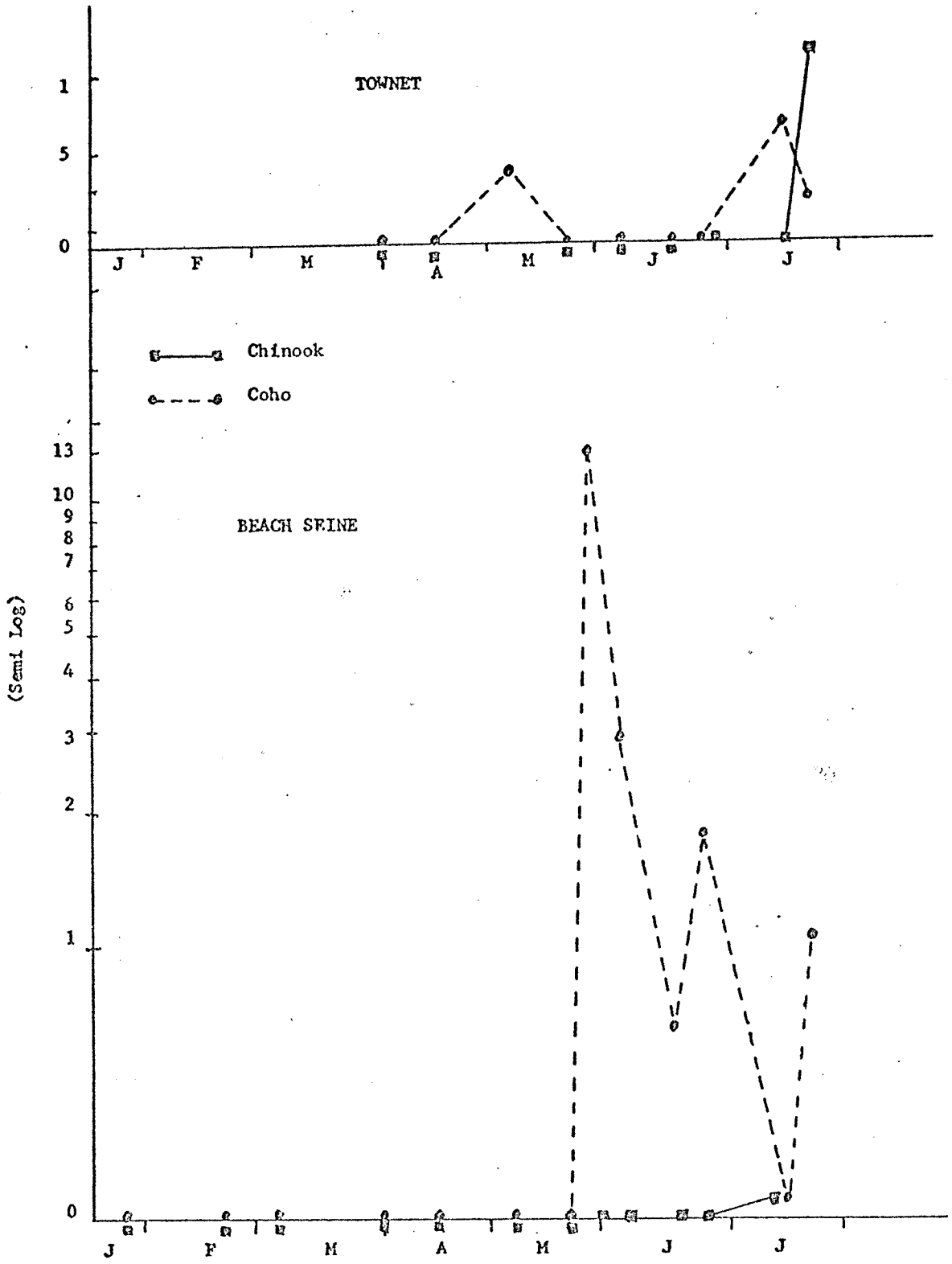


Fig. 14. Catch per unit effort of chinook and coho by week at Indian Island, Washington, 1977.

catches. Low catch frequency for coho and chinook prevents extrapolation of migration peaks. Schreiner (1977) suggests chinook migration peaks from late June to early July for Hood Canal.

Stomach analysis of coho, chinook, and other species that may prey on chums is displayed in Appendix 5. Stomach contents consisted mostly of invertebrates; no salmonids were found.

Construction Impact

Major construction work (pile driving) at Walan Point was conducted throughout the study period. No correlation can be seen between pile driving and CPUE values (Table 6) at sampling sites in the construction area. This may be due to the construction phase as pile driving was in the initial stage, although one of the busiest pile driving days (July 21, 16 piles) produced the largest offshore catch at transect 205 (within 50 m of the pier).

Environmental Data

The weekly mean environmental data are presented in Fig. 15 and Appendix 6. Mean weekly water temperature ranged from 7° C in March to 12.5° C in mid-July. Fry movement from the system is considered to be partially influenced by water temperature. Holland (1953) suggests chum outmigration requires a temperature range of 6.7°-13.3° C, with optimum being 10° C. Water temperatures reached the 10° C optimum in early June, which corresponds with the nearshore catch peak.

Surface salinities fluctuated from 32 ppt in March to 29.7 ppt in May. Daily fluctuations may be due in part to the surface tidal patterns in the study area. McGary's (1977) tidal current displays indicate that the study area is bathed in eddying currents on most tidal cycles as opposed to the adjacent, straight-line currents of Admiralty Inlet. Season mean salinity for all stations was 31.2 ppt, with standard deviation of .75 ppt. This indicates low freshwater mixing in the study area.

Water visibility ranged from 5.65 m in April to 3.4 m in June. Low daily measurements in the Walan Point area in June and July are partially influenced by wind velocity and direction. The predominant wind direction from the west caused wave-to-beach churning action which reduced visibility.

SUMMARY

1. Biweekly beach seine sampling was conducted from January 20 to July 21, 1977, at shoreline stations adjacent to Indian Island Annex.

Table 6. CPUE per day near Walan Point versus number of piles driven at pier site, Indian Island, Washington, 1977

Date	Number of piles driven	Transects			Station		Daily total
		204	205	206	123	127	
January 20	3	-	-	-	0	0	0
February 17	15	-	-	-	1/0[1]	0/1	2
March 1	0	-	-	-	3	9	12
April 1	0	0	0/0[2]	0/0	0	0	0
15	12	0/0	0	0	0	0	0
May 6	0	-	0/0	0/0	0	0	0
20	3	-	0	0	0	-	0
27	0	-	-	-	0	-	0
28	No data	-	-	-	-	29	29
June 2	2	0/0	0	0	-	0	0
3	2	-	0	0	-	-	0
16	8	-	0	0	-	27	27
17	3	0/0	0	0	9	-	9
24	No data	0/3	0/10	1	11	-	25
July 14	16	8/14	0/5	0	0	0	27
15	10	2/4	5	0	0	0	11
21	16	0	9	0/4	0	0	13

[1]Two values per day for beach seine means 10m first, 37m second.

[2]Two values per day for townet means transect was sampled twice.

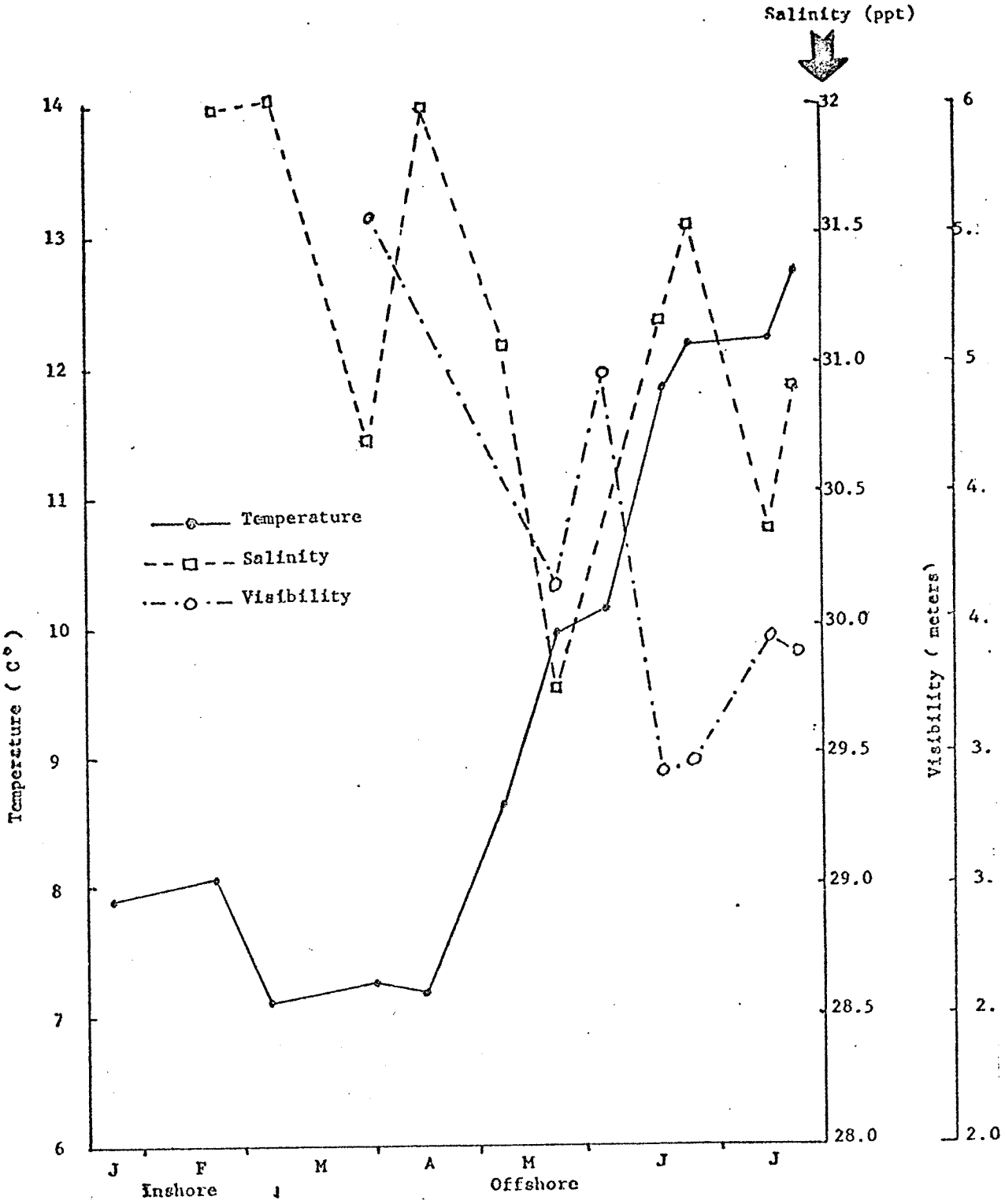


Fig. 15. Weekly mean environmental data for the period January 20 to July 21 1977, Indian Island, Washington.

2. Townetting surveys were conducted biweekly from April 1 to July 21, 1977, at transects adjacent to Indian Island Annex.

3. Juvenile chum salmon were the most abundant salmonids sampled between January and July, 1977. Nearshore catch peaks were detected in mid-April and early June and the offshore peak was developing in mid- to late July.

4. Coho were present in offshore areas in early April and nearshore areas in late May with fish present in late July.

5. Chinook were observed in June and July, mainly in offshore catches.

6. No apparent effect on the migration pattern was observed.

7. In conclusion, this study should be considered as a preliminary measure or survey of the occurrence of salmonids in the construction area. A full assessment of pier construction upon migrating juvenile salmon, if it is deemed necessary, would require more intensive sampling, particularly in the area of construction.

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APPENDICES

Appendix Table 1. Catch per unit effort for 1977, Indian Island, Washington

	Month	Date	Chum	Coho	Chinook
			TOWNET		
	April	1	0	0	0
		15	1.0	0	0
	May	6	.21	.21	0
		20	0	0	0
	June	3	0	0	0
		17	.84	0	0
		24	3.13	0	0
	July	15	6.27	.35	0
		21	20.69	.15	.54
			BEACH SEINE		
10-m beach seine	January	20	2.66	0	0
	February	17	.25;[1] .50	0	0
37-m beach seine	March	1	3.0	0	0
	April	1	8.33	0	0
		15	19.16	0	0
	May	6	5.33	0	0
		20	.33	0	0
		28	28.6	13.4	0
	June	3	55.0	3.0	0
		17	10.14	.57	0
		24	4.75	1.87	0
	July	15	.12	.06	.06
		21	0	.11	0

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

Appendix Table 2. 1977 townet data for Indian Island, Washington

Date	Transect 207	206	205	204	203	202	198	201	200	199	214	211	212	213	209	210	Total daily	Total weekly
4/1	0	0/0*	0/0*	0	0	0	0	0	0	0							0	0
4/15	0	0	0	0/0*	0/0*			0				0			0	11	11	11
5/6	0/0*	0/0*	0/0*			0	3	0	0	0		0	0	0			3	3
5/20	0	0	0			0	0	0			0	0	0	0			0	0
6/2	0	0	0	0/0*	0/0*	0	0	0	0								0	
6/3	0	0	0			0	0					0			0		0	
6/16	0	0	0		2	3	1	0	0			0	0	0/2*			8	21
6/17	0/0*	0	0	0/0*	10	3	0				0	0		0			13	
6/24	0	1	0/10*	0/3*	3	0	0/20*	0	2		0	10		0			47	47
7/14	1	0	0/5*	8/14*	20	4	3/8*	50	4								117	163
7/15	4	0	5	2/4*	4	1/8*	0	1	0		1	15		1			46	
7/21	1	0/4*	9	0	5/0*	18	0	219	5			8		0			269	269
Season totals	6	5	29	31	44	37	35	270	11	0	1	33	0	3	0	11	514	

*Two values per day per site means two tows per site that day.

Appendix Table 3. 1977 beach seine catch data for Indian Island, Washington

Date	Station												Totals daily	Totals weekly
	126	123	127	122	128	131	129	130	132	121	124	125		
1/20		0	0	16	0					0	0		16	16
2/17		1/0*		0/1*						0/1*	0/0*		3	3
3/1		3		9						0	0		12	12
4/1	47	0		0	3					0		0	50	50
4/15	0	0	0		43		2	70					115	115
5/6	0	0	0	0	0	0	0	48	0				48	48
5/20	0	0		0	0	0		2					2	2
5/27	0	0											0	143
5/28			29		78			36					143	
6/2	0		0		125		2	0	250				377	385
6/3									8				8	
6/16	24		27	8	7		10	0	0				76	142
6/17	0	9		15	17	0		0	25				66	
6/24	0	11		0	0	0	8	0	19				38	38
7/14	0	0	0	0	0		0	0	0				0	2
7/15	0	0	0	2	0	0	0	0	0				2	
7/21	0	0	0	0	0	0	0	0	0				0	0
Season totals	71	24	56	51	273	0	22	156	458	1	0	0	956	

*Two values per day per site means 10-m seine first, 37-m seine second.

Appendix Table 4. Indian Island weekly mean lengths and standard deviation of chum salmon collected with all sampling methods from January 20 to July 21, 1977

Date	Gear	Mean (mm)	SD
1/20	10-m beach seine	38.5	3.01
3/1	37-m beach seine	39.8	3.06
4/1	37-m beach seine	40.68	1.74
4/15	37-m beach seine	43.28	6.396
	Townet	50	1.09
5/6	37-m beach seine	62.60	1.85
5/28	37-m beach seine	60.80	10.89
6/3	37-m beach seine	65.01	8.66
6/17	37-m beach seine	70.2	8.299
	Townet	74.2	4.80
6/24	37-m beach seine	71.18	6.45
	Townet	85.95	11.01
7/15	Townet	87.66	8.638
7/21	Townet	93.73	8.96

Appendix Table 5. Stomach analysis for predator species collected at Indian Island, Washington, Spring 1977 (all stations)

Family	Genus - specie	Sample number	Comments and stomach contents
Salmonidae	*Oncorhynchus tshawytscha* Chinook salmon	1	Juvenile (F.L.[1] 14.0-cm) stomach full, 75 to 100 percent. Identifiable: 54 *Nereis* spp.
	O. kisutch Coho salmon	9	Juvenile (F.L. 9.5-cm to 17-cm) stomach empty to 50 percent full. Prey - Decapod zoea (+ mesalops); cumaceans; *neris* spp.; Harpacticoid copepods; gammarid amphipods; *Exosphaeroma media*, sand lance (in 3 coho)
Cottidae	*Leptocottus armatus* Staghorn sculpin	3	1 adult, 2 juveniles (T.L.[2] 20-cm, 13-cm, 11.5-cm) All stomachs 25 percent full with traces identifiable. All contained stomach parasites Trematodes and/or Nematodes Identifiable stomach contents - gammarid amphipods
	Scorpaenichthys marmoratus	2	Adult, stomach contents full to distended, 75 to 100 percent identifiable, includes: *Cancer productus; Telmessus cheiragonus, Pugettia gracilis*
Pleuronectidae	*Platicthys stellatus* Starry flounder	1	adult, stomach full, 50 to 75 percent identifiable, 10 *Cinocardium nuttalii;* 1 *Dendraster excentricus;* 1 *Hemigrapsus nudus;* 1 clam
Gadidae	*Gadus macrocephalus* Pacific cod	1	juvenile (T.L. 8-cm) stomach - trace with trace identifiable, 40 gammarid amphipods (various species)

Appendix Table 6. Weekly mean environmental data for 1977, Indian Island, Washington

Month	Date	Temp.	Sal.	Vis.	Month	Date	Temp.	Sal.	Vis.
		STATION 121					STATION 122		
Jan	1	7.9	-	-	Jan	1	-	-	-
Feb	17	8.0	31.8	-	Feb	17	8.0	32.4	-
Mar	1	7.1	32.4	-	Mar	1	7.0	31.9	-
		STATION 123					STATION 124		
Jan	1	7.9	-	-	Jan	1	-	-	-
Feb	17	8.0	32.8	-	Feb	17	8.1	31.3	-
Mar	1	7.0	32.3	-	Mar	1	7.1	31.6	-
		TRANSECT 198					TRANSECT 201		
April	1	7.6	30.7	6.0	April	1	7.4	29.9	6.5
	15	-	-	-		15	7.0	34.1	-
May	6	8.2	31.2	-	May	6	9.4	30.3	-
	20	10.0	29.4	4.5		20	9.5	29.1	4.5
June	3	10.6	-	5.0	June	3	10.5		5.0
	17	10.9	31.1	3.5		17	-	-	-
	24	12.0	31.2	-		24	12.0	33.7	4.5
July	15	11.75	30.0	4.5	July	15	12.6	30.3	5.0
	21	12.1	30.6	3.5		21	12.3	30.4	5.0
		TRANSECT 202					TRANSECT 203		
April	1	7.5	30.8	4.5	April	1	7.4	30.8	6.0
	15	-	-	-		15	7.2	32.1	-
May	6	8.2	31.0	-	May	6	-	-	-
	20	10.2	29.7	4.5		20	-	-	-
June	3	10.3		4.75	June	3	10.25		4.5
	17	11.5	32.25	3.5		17	11.9	31.5	3.75
	24	12.0	31.2	2.5		24	12.0	31.2	4.0
July	15	12.7	29.9	4.0	July	15	11.9	31.3	4.5
	21	12.3	30.8	3.5		21	12.4	31.1	3.75
		TRANSECT 204					TRANSECT 205		
April	1	7.4	31.0	5.0	April	1	7.4	31.0	5.0
	15	7.3	31.6	-		15	7.2	32.1	-
May	6	-	-	-	May	6	8.6	31.5	-
	20	-	-	-		20	10.0	30.5	3.0
June	3	10.1		5.0	June	3	9.9		5.0
	17	12.2	31.5	2.5		17	11.4	31.2	3.5
	24	12.3	31.4	3.25		24	12.0	31.5	
July	15	11.6	30.7	3.6	July	15	12.5	30.7	3.0
	21	12.3	31.0	4.0		21	12.4	30.9	4.0

Appendix Table 6. Weekly mean environmental data for 1977, Indian Island, Washington - Continued

Month	Date	Temp.	Sal.	Vis.	Month	Date	Temp.	Sal.	Vis.
	TRANSECT 206					TRANSECT 207			
April	1	7.3	30.75	-	April	1	7.2	30.8	-
	15	7.2	31.9	-		15	7.2	31.9	-
May	6	8.9	31.2	-	May	6	8.7	31.7	-
	20	10.2	30.1	4.0		20	10.0	29.9	4.0
June	3	9.9	-	5.3	June	3	9.9	-	5.3
	17	11.8	31.2	3.8		17	11.8	31.2	3.8
	24	12.5	31.0	3.5		24	12.5	31.0	3.5
July	15	12.4	30.6	3.5	July	15	12.4	30.6	3.5
	21	12.1	30.9	4.0		21	12.1	30.9	4.0
	TRANSECT 211					TRANSECT 213			
April	1	-	-	-	April	1	-	-	-
	15	7.2	31.5	-		15	-	-	-
May	6	8.5	31.3	-	May	6	8.5	31.2	-
	20	10.0	29.6	4.0		20	9.7	29.8	4.5
June	3	9.9	-	5.0	June	3	-	-	-
	17	13.2	30.9	3.25		17	11.9	29.7	3.5
	24	12.0	31.6	3.5		24	12.5	31.4	3.0
July	15	12.0	30.8	3.0	July	15	12.1	28.6	4.0
	21	13.3	31.0	3.0		21	13.1	31.3	4.0

WEEKLY MEAN FOR ALL SITES

Month	Date	Temp.	Sal.	Vis.
Jan	1	7.9	-	-
Feb	17	8.0	32.1	-
Mar	1	7.0	32.1	-
April	1	7.4	30.7	5.65
	15	7.2	32.2	-
May	6	8.6	31.2	-
	20	9.9	29.8	4.1
June	3	10.1	-	5.0
	17	11.9	31.2	3.4
	24	12.2	31.5	3.5
July	15	12.3	30.4	4.0
	21	12.5	30.9	3.9