ESTUARINE RESTORATION AND SALMONID UTILIZATION OF A PREVIOUSLY DYKED SLOUGH IN THE ENGLISHMAN RIVER ESTUARY, VANCOUVER ISLAND, BRITISH COLUMBIA

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ABSTRACT

Tutty, B.D., B.A. Raymond and K. Conlin. 1983. Estuarine Restoration and Salmonid Utilization of a Previously Dyked Slough in the Englishman River Estuary, Vancouver Island, British Columbia. Can. Ms Rep. Fish Aquat. Sci. 1689:vii + 51 p.

Tidal inundation of the northern portion of the Englishman River estuary ceased as a result of the construction of a sea dyke in 1969. This dyke was breached on March 27, 1979. Reactivation of 87 acres of slough was expected to provide significant estuarine rearing area for salmonids and other fish species. A series of fish trapping and benthic surveys was undertaken in 1979 to assess whether salmonids did utilize the reactivated estuary. Significant numbers of rearing chum moved into the slough and were capured during the April and May period. Their stomach contents appeared most representative of the epibenthos found there. A significant feature of the study was that chum fry appeared to rear longer and grow larger in the slough than in the adjacent estuary. Adult chum salmon have been observed spawning in groundwater upwelling areas in the upper portion of the reactivated slough. These factors indicate that with further study this estuarine restoration technique may be valuable enhancement tool.

Key Words: salmonid, rearing, estuary, enhancement, benthos.

RÉSUMÉ

Une digue a été construite en 1969 afin d'empêcher les marées d'inonder la partie nord marécaqeuse des veys estuariens de la rivière Englishman. Le 27 mars 1982, une trouée de 10 mètres de large a été pratiquée dans la digue, comme project de mise en valeur des salmonidés. Ce project visait à la création de nouveaux habitats pour l'élevage des salmonidés et d'autres espèces par suite de l'inondation du marécage estuarien à mer haute, sur 87 acres. On a effectué une série de piégeages de poissons et d'échantillonnages du benthos pour évaluer l'utilisation de l'estuaire par les salmonidés. Il a été établi que les alevins de saumons ketas en ont fait une utilisation importante en avril et mai 1979, et les proies retrouvées dans les contenus stomacaux étaient surtout des invertébrés faisant partie de l'épibionte de l'estuaire remis en état.

Mots-clés: salmonidés, estuaire, benthos, croissance, mise en valeur.

1.0 INTRODUCTION

The Englishman River estuary located at Parksville, Vancouver Island, B.C. was the location of a habitat restoration program to tidally reactivate a previously dyked estuarine slough habitat in the northern portion of what is known as the Englishman River Flats (Plate 1). A sea dyke had been constructed in 1969 that cut off the slough from tidal action rendering it a small freshwater pond with a lens of saltwater at the bottom. On March 27, 1979 a 10 meter wide section of the dyke was excavated so that inundation would occur over an 87 acre area at a 16.0 ft tide (H.W.M.) and 130 acres at 18.3 ft tide (H.H.W.M.).

The knowledge of the importance of estuarine habitat for rearing chum salmon (Oncorhynchus keta) has gradually evolved (e.g., Mason 1974; Healey 1979; Sibert 1979). Delayed seaward movement from estuaries may be of adaptive survival value to chum fry when there is sufficient prey and available rearing habitat.

The main purpose of this study was to document the restoration of the slough and to ascertain whether any juvenile salmonids gained access to and utilized this new habitat. If salmonids were found in this new habitat, it was thought that this approach might be a

PLATE 1: Infrared photograph of the Englishman River Flats and reactivated slough area with a bridge spanning the breach in the dyke, August 1979.

2.0 METHODS

2.1 Field Methods - Beach Seine and Trapping Procedures

Netting with a ninety-foot beach seine was conducted in the freshwater slough pond inside the dyke on March 22, 1979, and in the Englishman River estuary adjacent to the slough on the outside of the dyke at high tide. Samples of all salmonid specimens captured during the program were preserved in 10% formalin, and lengths and weights were measured. Scales were taken from all coho salmon juveniles captured in the slough pond inside the dyke on March 22, 1979.

On March 27, 1979 the dyke was breached during low tide by removing a 10 meter wide portion, Plate 2. Tidal inundation commenced thereafter on the first rising tide, Plate 3.

Fish trapping surveys were conducted at the slough entrance commencing March 28, 1979 with two (2' x 3') inclined plane traps (Plate 4) and a 10 foot deflection fence section of 1/4" galvanized mesh. This system of deflecting screen and the floating salmon fry traps were used to determine relative abundance of salmonids migrating in and out of the slough. In addition, an innovative modified fyke net with a floating live box was tested,

PLATE 2: Breaching the dyke at low tide, March 27, 1979

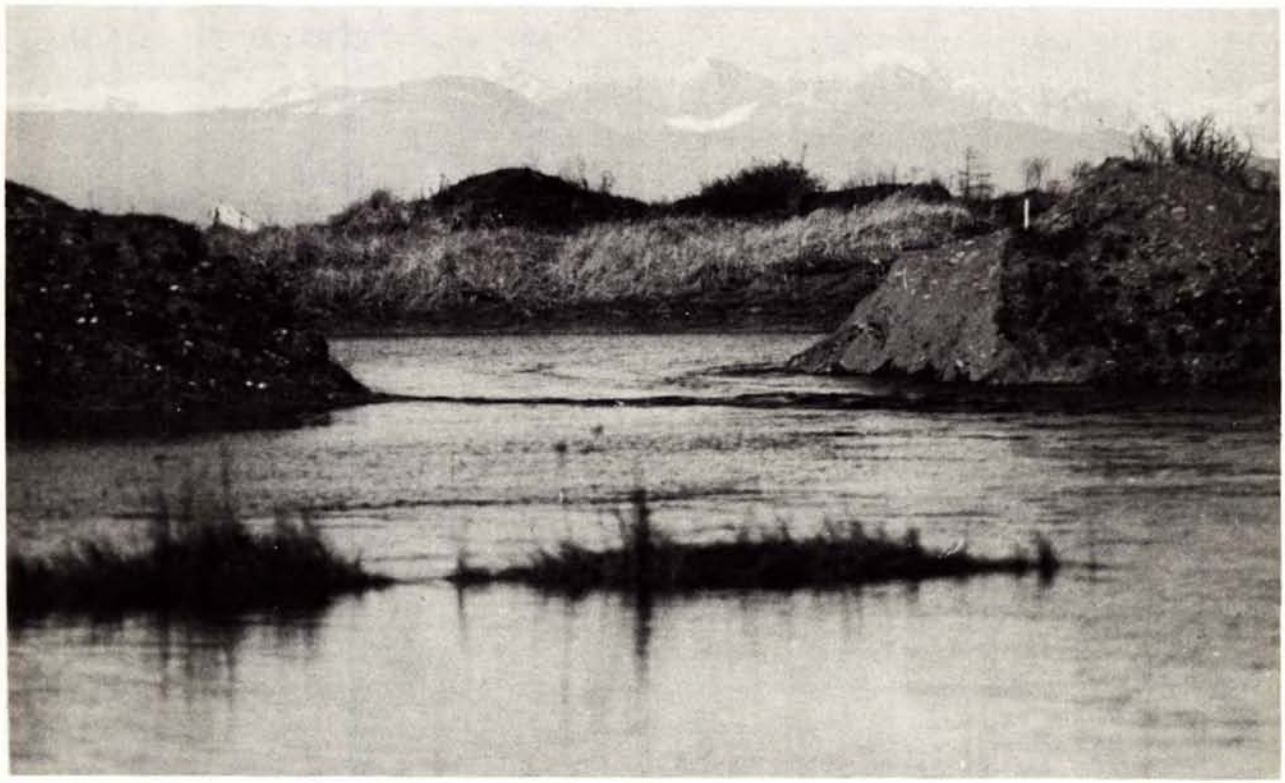

PLATE 3: Inundation commenced on the next rising tide, March 27, 1979

PLATE 4: 2 x 3 Inclined plane trap fishing the inflow flooding into the reactivated slough

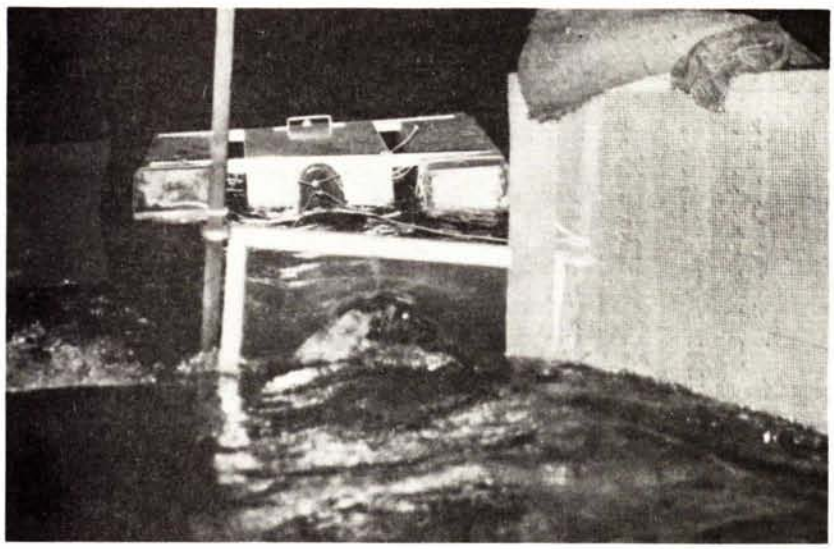

PLATE 5: Modified fyke net trap with a floating live box fishing the flow flooding into the reactivated slough at night

Plates 5 and 6. These trapping techniques are described in a separate report by Conlin and Tutty (1979).

Netting with a 25 foot marquisette beach seine was conducted in the slough pond at low water commencing May 3, 1979. Seining adjacent to the dyke and beach front area in the estuary was conducted April 19, May 27 and May 28, 1979. Hand seining was conducted in the slough June 25, July 27, August 25, September 17, November 17, 1979 and March 18, 1980.

2.2 Field Methods - Benthos and Salmon Stomach Samples

2.2.1 Ekman Grab Samples

Ekman grab samples of 0.0228 m^2 were collected by wading out into shallow water and forcing the grab into the sediment to a depth of approximately 10 cm. Three replicates were collected at two sites inside the slough on March 22, April 10 and May 17, 1979. Three samples were collected immediately outside the slough on March 22, 1979 before the dyke was breached. Samples were preserved in 10% formaldehyde buffered with sodium borate.

2.2.2 Epibenthic Tows

Samples of epibenthic invertebrates were collected by towing a 30 cm wide epibenthic sled 10 meters along the bottom during periods

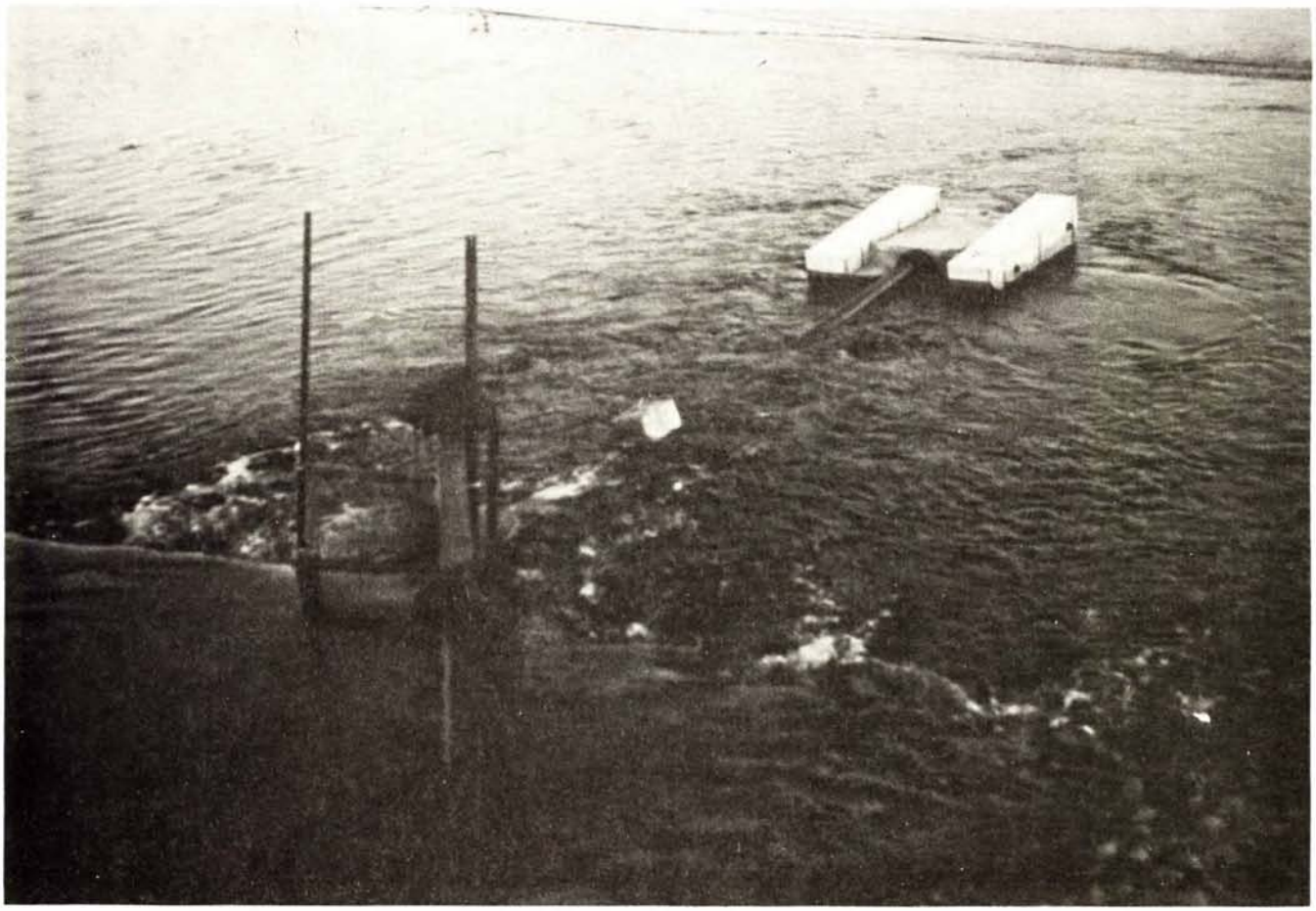

PLATE 6 : Modified fyke net with floating live box

of low light intensity. Mesh size of the net on the sled was 0.500 mm. Two replicates were collected at each of two sites - immediately outside the slough on March 2, 1979 and in the pond inside the slough on March 22, April 10 and May 17, 1979. Samples were preserved in buffered 10% formaldehyde.

2.2.3 Fish Stomach Samples

Where possible, 10 salmon of each species were preserved from beach seine samples inside and outside the slough from each sampling period for analysis of stomach contents. Fish were preserved in buffered 10% foraldehyde.

2.3 Laboratory Methods

2.3.1 Ekman Grab Samples

Samples were sieved through 2.0 mm, 0.5 mm and 0.25 mm screens in series. Macrofauna were retained on the 2 mm and 0.5 mm screens and meiofauna on the 0.25 mm screen. Samples were stained with rose begal dye to facilitate sorting of invertebrates which were identified to the lowest possible taxa.

Sample size necessitated sorting and identifying only a portion of the invertebrates in each sample. Samples were subsampled by volume - meiofauna samples using a wide-mouthed pipette and macrofauna samples (excluding large organisms retained on 2.0 mm screen) using a Folsom plankton splitter.

2.3.2 Epibenthic Tows

Epibenthic samples were treated in the same manner as macrofauna samples.

2.3.3 Fish Stomach Samples

Salmon preserved during the study were measured for fork length and preserved weight, and analysed for stomach contents. Prey organisms were identified to the lowest possible taxa, and whole animals were sorted into 1 mm size categories. Size of prey organism was used to calculate wet weight using the following formula, and constant values were determined by Dr. J. Sibert, Pacific Biological Station, Department of Fisheries and Oceans.

$$\text{Weight (mg)} = A \times \text{Length (mm)}^B$$

It should be understood that this formula yields only a rough estimate of weight, but was used because numerical abundance of prey items over-estimates the importance of small organisms in the diet, and weighing prey items was not possible.

3.0 RESULTS

3.1 Trap and Net Captures of Salmon Juveniles

The total number of chum captured entering the slough was 578, and leaving the slough was 167. Salmonids captured inside the slough totalled 1,359 chum, 29 coho and 14 chinook. Five coho and one chinook were captured leaving the slough. Salmonids captured outside the slough totalled 105 chum and 4 chinook. The total number of salmon captured during all trapping and netting surveys was 2,262 (Table 1). The population characteristics of these samples are contained in Table 2. The percent relative frequency histograms of chum salmon weights for the selected populations examined are contained in Figures 1 (a) to (e).

At the start of the program on March 22, 1979 and prior to breaching the dyke, seining of the freshwater slough pond revealed that a population of rearing coho smolts had gained access into the slough probably through a partially obstructed 6" drainage culvert that passed under the dyke, Plates 7 and 8. The

TABLE 1: ENGLISHMAN RIVER ESTUARY COMBINED TRAP AND BEACH SEINE CAPTURES

	Immigrants into Slough			Residing in Slough*			Emigrants from Slough			Residing Outside Slough*		
	Chum	Coho	Chinook	Chum	Coho	Chinook	Chum	Coho	Chinook	Chum	Coho	Chinook
22/03/79	0	0	0	-	20	-	0	0	0	68	-	-
28/03/79	3	0	0	-	-	-	2	0	0	-	-	-
06/04/79	0	0	0	-	-	-	2	0	0	-	-	-
19/04/79	136	0	0	-	-	-	9	1	0	3	-	-
02/05/79	78	0	0	-	-	-	27	1	0	-	-	-
03/05/79	361	0	0	350	6	-	115	3	0	-	-	-
17/05/79	0	0	0	1,009	2	11	12	0	1	34	-	3
28/05/79	-	-	-	0	1	3	-	-	-	0	-	1
25/06/79	-	-	-	0	0	0	-	-	-	-	-	-
27/07/79	-	-	-	0	0	0	-	-	-	-	-	-
25/09/79	-	-	-	0	0	0	-	-	-	-	-	-
17/10/79	-	-	-	0	0	0	-	-	-	-	-	-
14/11/79	-	-	-	0	0	0	-	-	-	-	-	-
18/03/80	-	-	-	0	0	0	-	-	-	-	-	-
TOTALS	578			1,359	29	14	167	5	1	105		4

* Beach seined.

TABLE 2: SALMONID POPULATION CHARACTERISTICS

		Immigrants into Slough								Residing in Slough								Emigrants from Slough								Residing outside Slough							
		Length (cm.)				Weight (gm.)				Length (cm.)				Weight (gm.)				Length (cm.)				Weight (gm.)				Length (cm.)				Weight (gm.)			
	Dates	N.	$\bar{X}$	S.D.	Var.	N.	$\bar{X}$	S.D.	Var.	N.	$\bar{X}$	S.D.	Var.	N.	$\bar{X}$	S.D.	Var.	N.	$\bar{X}$	S.D.	Var.	N.	$\bar{X}$	S.D.	Var.	N.	$\bar{X}$	S.D.	Var.	N.	$\bar{X}$	S.D.	Var.
CHUM	22/03/79	-	-	-	-	-	-	-	-	0	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	23	3.61	.24	.05	23	.39	.09	.01
	28/03/79	3	3.5	0	0	3	.28	.02	.00	-	-	-	-	-	-	-	-	2	3.55	.21	.02	2	.29	.07	.00	-	-	-	-	-	-	-	-
	06/04/79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3.67	.31	.06	3	.31	.09	.01	-	-	-	-	-	-	-	-
	19/04/79	38	3.63	.11	.01	38	.31	.03	.00	10	4.09	.52	.24	10	.54	.24	.05	9	3.56	.16	.02	9	.31	.03	.00	3	3.63	.06	.00	3	.34	.03	.00
	02/05/79	30	3.68	.16	.02	30	.38	.06	.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	03/05/79	-	-	-	-	-	-	-	-	30	4.03	.41	.17	30	.53	19	.04	30	3.78	.23	.05	30	.39	.08	.01	-	-	-	-	-	-	-	-
	17/05/79	0	-	-	-	0	-	-	-	60	3.85	.33	.11	60	.44	16	.03	12	3.84	.43	.17	12	.42	.02	.04	30	4.16	.55	.29	30	.61	.27	.07
	28/05/79	-	-	-	-	-	-	-	-	0	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-
	25/06/79									0																							
	27/07/79									0																							
	25/09/79									0																							
	17/10/79									0																							
	14/11/79									0																							
	18/03/80																																
COHO	22/03/79	-	-	-	-	-	-	-	-	20	11.07	2.02	3.86	20	18.18	8.5	68.64																
	28/03/79									-																							
	06/04/79									-																							
	19/04/79	-	-	-	-	-	-	-	-	0								1	7.9	.00	.00	1	5.53	.00	.00								
	02/05/79									0																							
	03/05/79	-	-	-	-	-	-	-	-	4	8.0	.74	.42	4	5.84	1.45	1.58																
	17/05/79									0																							
	28/05/79									0																							
	25/06/79									0																							
	27/07/79									0																							
	25/09/79									0																							
	17/10/79									0																							
	14/11/79									0																							
	18/03/80																																
CHINOOK	22/03/79									0																							
	28/03/79									0																							
	06/04/79									0																							
	19/04/79									0																							
	02/05/79									0																							
	03/05/79									0																							
	17/05/79	-	-	-	-	-	-	-	-	10	4.74	.28	.07	10	1.19	.30	.08	1	4.2	0	0	1	.686	0	0	1	5.7	0	0	1	1.914	0	0
	28/05/79	-	-	-	-	-	-	-	-	3	5.53	.38	.1	3	1.99	.36	.09	-	-	-	-	-	-	-	-								
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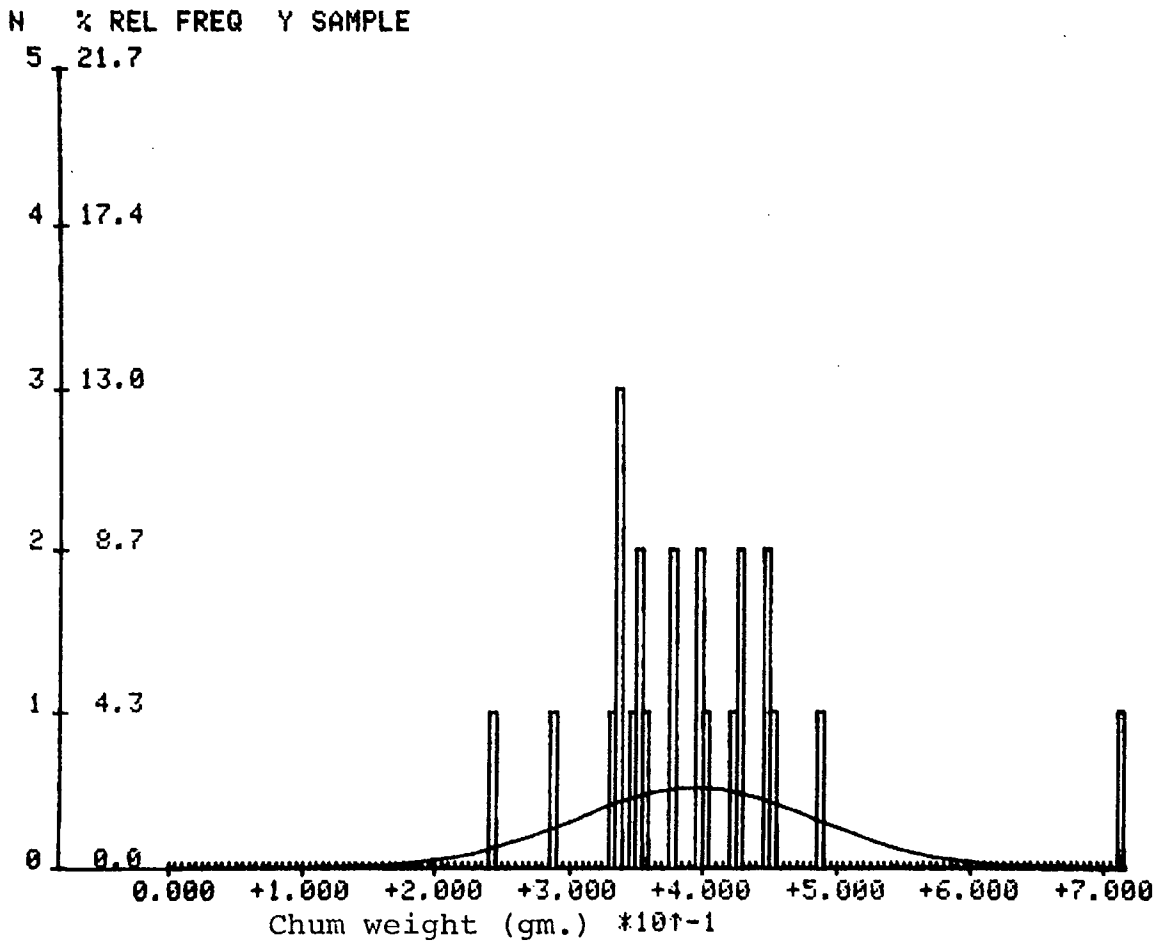


FIGURE 1(A): Frequency histogram of weight - for chum fry captured March 22, 1979 in the Englishman River estuary.

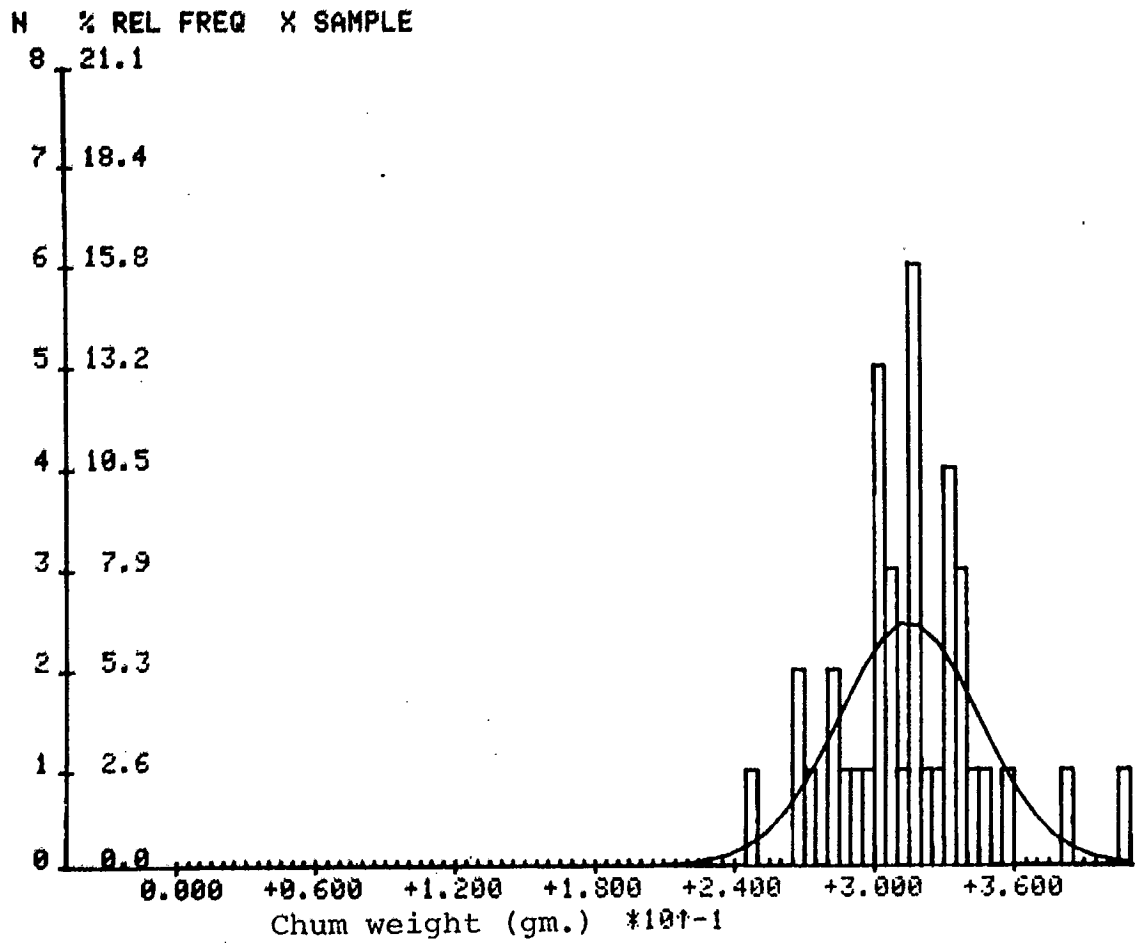


FIGURE 1(B): Frequency histogram of weight - for chum fry April 22, 1979 entering slough.

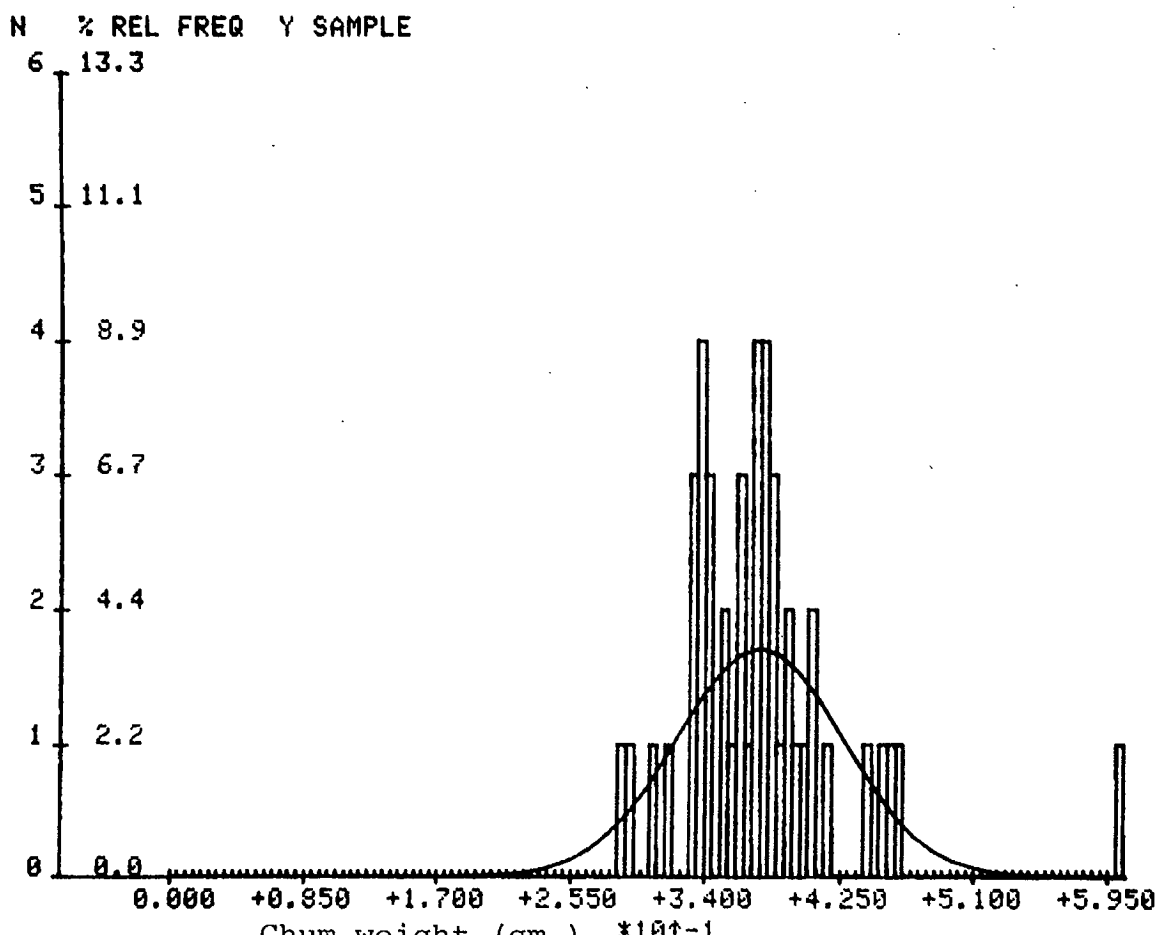


FIGURE 1(C): Frequency histogram of weight - for chum fry May 3, 1979 entering slough.

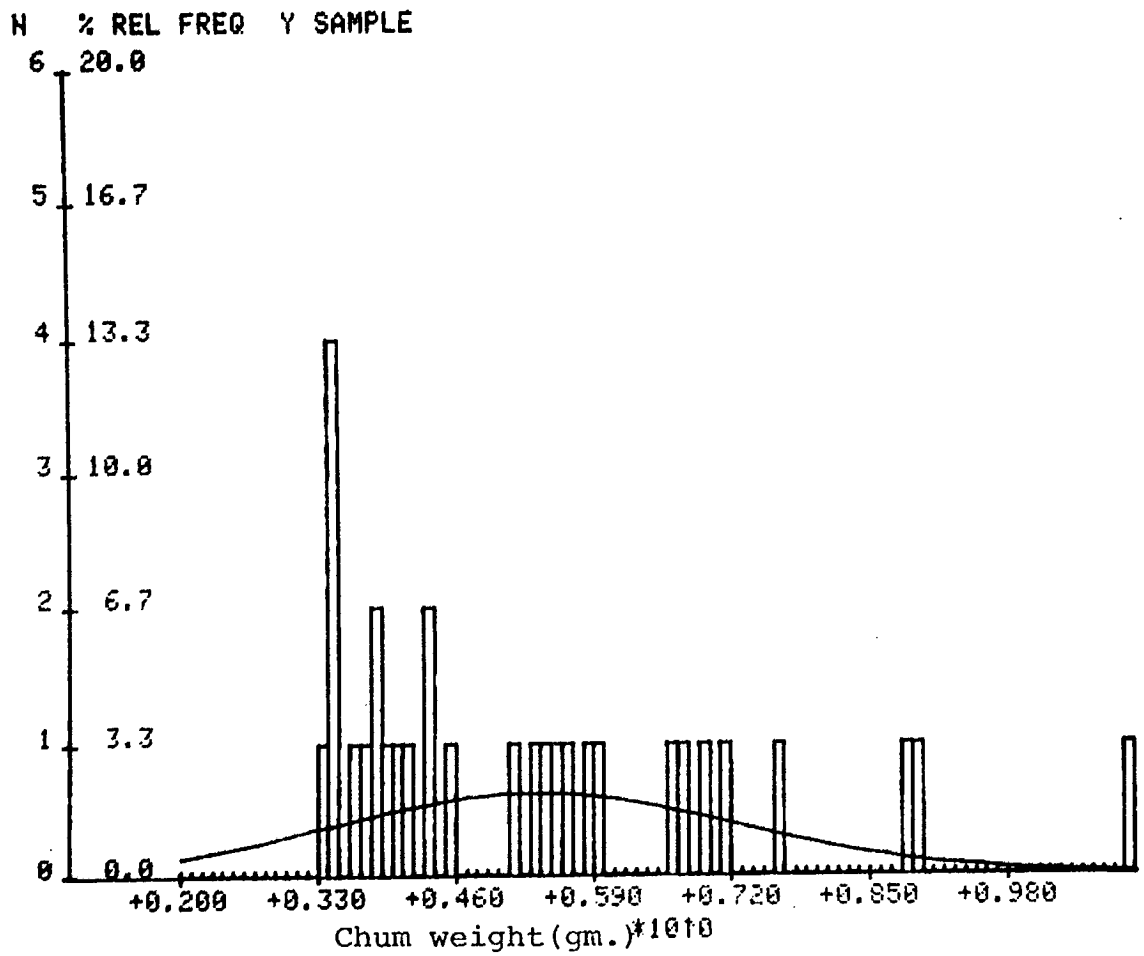


FIGURE 1(D): Frequency histogram of weight - for chum fry May 3, 1979 residing in slough.

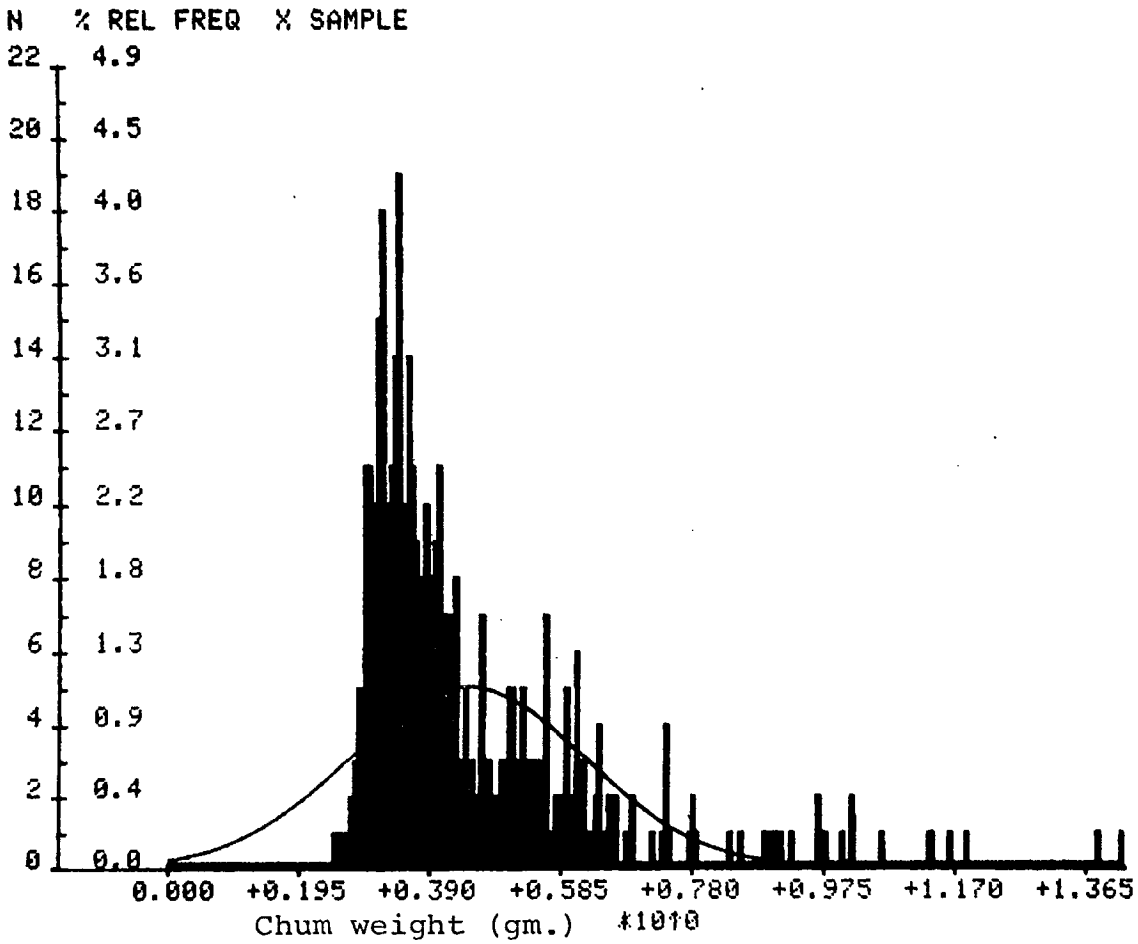


FIGURE 1(E): Frequency histogram of weight for chum fry May 17, 1979 residing in slough.

coho samples (20) provided a relative length frequency histogram indicating at least two cohorts with separate freshwater life histories, Figure 2, which was later confirmed through scale pattern interpretation, Table 3. Of the 20 coho sampled, 4 were age 2+, 12 were aged 1+ and 4 were considered unreadable.

Juvenile salmonids were not captured entering the slough on March 28 and April 18, 1979 after the dyke was breached, altough some chum fry were found rearing outside in the estuary adjacent to the slough on March 22, 1979. The trapping operations were not efficient. An estimate of only 1 to 3% of the total tidal inflow and outflow could be sampled by the trapping technique. Whether the chum fry were distributed evenly throughout the water column, or were concentrated during a certain inflow period is therefore not known. When the chum fry were observed entering the inclined plane trap, they oriented upstream against the current flow displaying an avoidance reaction. The operation of the 2 x 3 inclined plane traps was limited only to those periods when depths of approximately 1 foot and currents greater than one foot per second occurred; regular trap adjustments were necessary to compensate for the changing tidal amplitude and velocity acting on the inclined plane. Due to these difficulties, it was not possible to determine total populations movement to and from the slough.

PLATE 7: View at high tide of submerged access culvert under the dyke that provided passage of coho into the slough prior to the dyke being breached at this location.

PLATE 8: View at low tide of Plate 7.

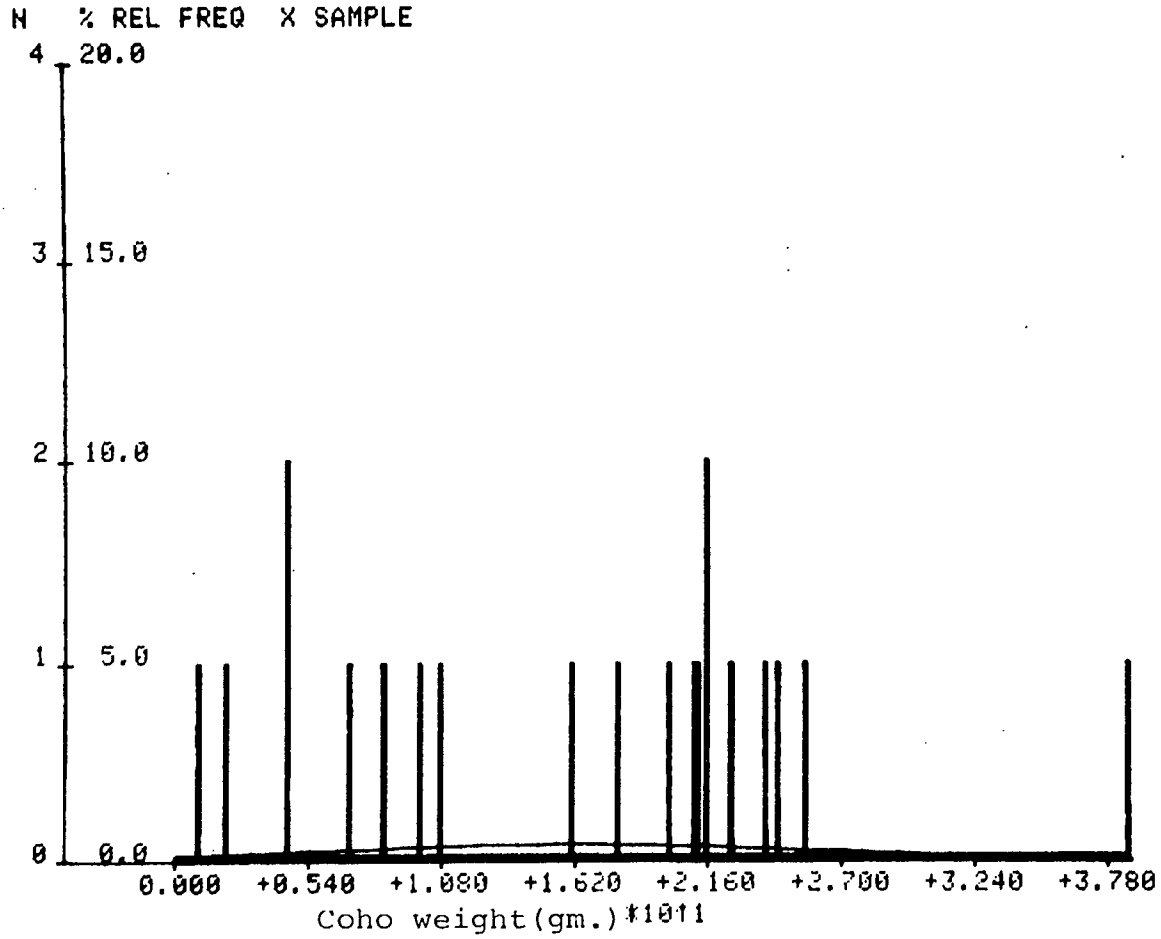


FIGURE 2: Frequency histogram of weight - for coho captured residing in slough.

TABLE 3: SCALE INTERPRETATION OF COHO POPULATION REARING MARCH 22, 1979 in ENGLISHMAN RIVER SLOUGH

Scale No.	Length(cm.)	Weight(gm.)	Age	Scale Patterns
1	12.7	25.2	1+	I(A)
2	11.6	20.0	2+	IV
3	12.4	24.4	1+	I(B)
4	13.0	25.5	1+	I(A)
5	14.9	38.6	2+	III
6	11.0	17.9	1+	I(A)
7	12.6	23.9	R	R
8	12.3	21.5	1+	I(A)
9	11.9	22.5	1+	I(B)
10	12.2	21.5	1+	I(B)
11	11.9	21.2	1+	I(B)
12	10.9	16.1	(1+)R	R
13	9.4	9.92	1+	II
14	9.5	10.7	R	R
15	7.1	4.5	1+	II
16	11.8	21.0	1+	I(B)
17	11.6	19.2	2+	IV
18	7.5	4.59	1+	II
19	8.9	8.44	2+	IV
20	8.2	7.04	R	R

AGE COMPOSITION

	Number	Age	%
	12	1+	75.0
	4	2+	25.0
Readable Total	16		100.0%

I(A) Indistinct annulus formation, with wide-spaced cuculi, and some evidence of spring growth. A mid-summer stress is apparent.

I(B) Stressed approximately to mid-first summer then moving to the estuary to overwinter. Annulus and good spring (+) growth showing. Generally poorer growth than I(A).

II River-reared entirely, well-defined annulus and appearing to have just entered estuary. Some scales show spring growth.

III Age 2+ remaining in a less productive area for two years before migrating. Two well-defined annuli and no spring growth.

IV Similar to III except all first year growth stunted. Good first annulus then appears to move into estuary for second year. Wider spaced cuculi and some spring growth. Second annulus just forming on edge.

As a result of the limited suitability of inclined plane traps operating under these conditions, other trapping methods were explored. Initial observations suggested that chum fry may have immigrated into the slough at the initial tide turn and emigrated from the slough at the last stage of the ebbing tide; however, this was not consistently observed. An alternative fyke net trap and floating live box was fabricated and installed on May 2, 3 and 17, 1978 in an effort to obtain larger sample sizes and better understand fry movement patterns. This trapping apparatus captured chum fry and coho smolts when water velocity ranged between 1.0 and 1.5 feet per second. The trap was considered to be a satisfactory technique for low flow and debris-free situations in estuary channels and streams (Conlin and Tutty, 1979). This trapping operation indicated that substantial numbers of chum and some coho juveniles moved out of the slough during the last stages of slough draining.

By May 3, 1979 the capture data suggested a greater number of chum fry were caught entering the slough than leaving. It was believed that fry were probably remaining in the slough for more than one tide cycle. On May 3, 1979 a single 25 foot seine net was hauled through the slough pond at low tide and resulted in the capture of 350 chum fry and 6 coho smolts. This data and the wide size range observed implied that the slough was harbouring

substantial numbers of fry. On May 17, 1979 the slough pond was again seined at low tide and 1,009 chum, 2 coho smolts and 11 chinook juveniles were captured.

3.2 Chum Salmon Growth Estimates

There were no means to quantify the duration of rearing chum fry residency in the slough since no mark/recapture programs were undertaken. Similarly, growth rates could not be directly determined. However, Figure 1 indicates that there was a wide size range of chum fry in the slough May 3 and May 17. This suggests a prolonged period of slough rearing and growth for substantial numbers of the fry.

3.3 Chum Salmon Rearing Duration Estimates

An estimate of rearing duration can be made between April 19 and May 17, 1979 by comparing the mean weights of chum fry samples April 19, May 3 and May 17, 1979. The estimated growth rates ranged between 6% to 13% body weight/day. If this rate is regressed against the mean weight of the largest chum cohort (1.15 gm (n=10, S.D.15 var. 02)) found May 17 and the mean incoming chum size (.35 gm), a rearing duration from 20 to as much as 40 days can be postulated for some of the larger fry.

The average slough residence period in the Nanaimo estuary was found to be from about 0 to 9 days (healey 1979). It is possible however that these larger chum fry were from other watersheds and did not originate from the Englishman River.

3.4 Invertebrate Surveys

3.4.1 Ekman Grab Samples

Results of the analysis for invertebrates of Ekman grab samples are presented in Tables 4 and 5.

On March 22, 1979, the numbers of individuals of meiofauna found in lower slough samples were approximately three times those found in samples collected outside the slough and in the middle of the slough above the influence of salt water. Abundance of meiofauna increased in the lower slough but decreased in the middle slough from March 22 to May 17. Foraminifera, Nematoda and Oligochaeta were the numerically dominant taxa in the lower slough; Nematoda, Harpacticoida and Ostracoda were dominant in the mid-slough, and Nematoda, Oligochaeta and Harpacticoida were dominant outside the slough.

TABLE 4: NUMBERS OF INDIVIDUALS PER METER^2 IN MEIOFAUNA SAMPLES

TAXA	OUTSIDE SLOUGH 22 MAR.	LOWER SLOUGH 22 MAR.	LOWER SLOUGH 19 APR.	LOWER SLOUGH 17 MAY	MID SLOUGH 22 MAR.	MID SLOUGH 19 APR.	MID SLOUGH 17 MAY
FORAMINIFERA		385,185	697,036	1,018,518	59,259		4,444
HYDROIDA				10,370			
TURBELLARIA	6,666	14,815	13,333	22,963			
PELECYPODA				741			
NEMATODA	156,296	303,703	423,703	483,703	351,110	43,333	29,333
OLIGOCHAETA	160,000	530,370	271,111	288,148		7,407	12,741
POLYCHAETA							
Malacoceros sp. (?)						370	
Manayunkia aestuarina	13,481	2,963	2,222	20,000		370	593
AMPHIPODA							
Eogammarus confervicolus	741						
Corophium spp. (juvenile)	1,481		2,963	14,815			
TANAIDACEA	741	2,963		3,704			
HARPACTICOIDA	86,815	85,926	128,148	164,444	72,593	30,370	16,000
OSTRACODA	45,185	16,296	63,704	44,444	29,630	36,296	36,444
INSECTA LARVA	741					1,481	593
COLLEMBOLA	741						
ACARI	889	7,407					
INVERTEBRATE EGGS	13,185	139,259	108,148	84,444		7,037	3,556
TOTAL	486,962	1,488,887	1,710,368	2,156,294	512,592	126,661	99,704

TABLE 5: NUMBERS OF INDIVIDUALS PER METER^2 IN MACROFAUNA SAMPLES

TAXA	OUTSIDE SLOUGH	LOWER SLOUGH			MID SLOUGH		
	22 MAR.	22 MAR.	19 APR.	17 MAY	22 MAR.	19 APR.	17 MAY
TURBELLARIA		474	5,156	3,200			356
NEMERTEA	89	15	59				
GASTROPODA			119				
PELECYPODA				119			
Macoma inconspicua	30						
Mya arenaria	119						
Mytilus edulis	15						
OLIGOCHAETA	39,111	68,340	30,222	93,778	2,193	6,104	19,156
POLYCHAETA							
Abarenicola pacifica			74	133			
Capitella capitata	74			193		59	356
Eteone sp.	474			30			
Manayunkia aestuarina	5,378	11,556	15,467	1,067	30	178	489
Nereis (Neanthes) limnicola				15			
Polydora kempi japonica	281						30
Polydora ligni			59	326			148
Polydora quadrilobata			889	252			
Pygospio elegans	340		593	237			
Scolelepis squamatus(?)				15			
Spio filicornis			178	30			
NEPHTYIDAE (UNIDENT.)			119				
SPIONIDAE (UNIDENT.)			59	237			
DECAPODA							
Crangon nigricauda			119				
Hemigrapsus oregonensis		7					
AMPHIPODA							
Ampithoe sp.	15						
Eogammarus confervicolus	4,519	740	15,674	4,178		89	
Corophium spp. (juv.)	681	356	5,215	33,556			237
C. insidiosum	3,985	533		474	70		
C. salmonis	2,726	444	133	607			
C. spinicorne	3,541	696	10,222	5,333			15

TABLE 5: NUMBERS OF INDIVIDUALS PER METER^2 IN MACROFAUNA SAMPLES (cont'd.)

TAXA	OUTSIDE SLOUGH 22 MAR.	LOWER SLOUGH 22 MAR.	LOWER SLOUGH 19 APR.	LOWER SLOUGH 17 MAY	MID SLOUGH 22 MAR.	MID SLOUGH 19 APR.	MID SLOUGH 17 MAY
CUMACEA	15						
TANAIDACEA	800	12,014	1,481	2,607			
MYSIDACEA			15				
HARPACTICOIDA	296		474	9,007	474	237	3,437
OSTRACODA	226	2,489	3,437	4,978	16,355	45,511	64,237
INSECTA LARVAE	134	519	2,222		1,008	2,030	2,045
INSECTA PUPAE		119			30	30	
COLLEMBOLA	74						
ACARI	15						
INVERTEBRATE EGGS		178		2,607	119		119
FISH EGGS	15						
STAGHORN SCULPIN	15						
TOTAL	62,968	98,480	91,986	162,979	20,279	54,238	90,625

On March 22 macroinvertebrates were most abundant in samples from the lower slough - 98,480 individuals per square meter compared with 62,968 outside the slough and 20,279 in the middle of th slough. Abundance of macrofauna increased both in the lower and middle slough from March 22 to May 17. The following changes in composition of the macroinvertebrate taxa of the lower slough were evident from March 22 to April 19 during which time the dyke was breached:

i. increase in the abundance and diversity of the polychaete fauna

ii. increase in the abundance of Eogammarus confervicolus from 740 per m^2 on March 22 to 15,674 per m^2 on April 19

iii. increase in the abundance of Corophium spinicorne adults from 696 per m^2 on March 22 to 10,222 per m^2 on April 19.

The middle slough site was characterized on March 22 by a very fine, highly organic sediment which smelled strongly of hydrogen sulphide. As a result of currents surging through the breached dyke after April 19 carrying suspended silts, the substrate at the middle slough site was noted to be sandy and the surrounding vegetation coated with fine silt.

3.4.2 Epibenthic Tows

Results of the analysis of epibenthic tows are presented in Table 6. On March 22 the abundance of epibenthic invertebrates inside and outside the slough were comparable but gammarid amphipods were more numerous outside the slough. Numbers of epibenthos inside the slough increased from 6,878 in two tows on March 22 to 37,246 in two tows on May 17.

3.5 Fish Stomach Samples

3.5.1 Chum

The taxonomic composition of the diet of chum salmon is presented in Figure 3. Harpacticoida, gammarid amphipods (Eogammarus sp. and Corophium spp.) and Diptera were the most important items in the diet of chum salmon captured inside the slough. Corophium spp. increased in importance in the diet on May 16-17 the importance of Diptera larvae in the diet decreased while Diptera pupae increased in importance.

Outside the slough, Diptera was by far the most important taxa in the diet of chum on all dates except March 22 when Collembola were eaten in large numbers. As was observed inside the slough,

TABLE 6: NUMBER OF INDIVIDUALS IN 2-10 METER X 30 cm. EPIBENTHIC TOWS

TAXA	OUTSIDE SLOUGH 22 MAR.	INSIDE SLOUGH 22 MAR.	19 APR.	17 MAY
TURBELLARIA		60	208	1,056
NEMERTEA	16			
GASTROPODA		8		
Littorina scutulata	12			
PELECYPODA	9			32
Mya arenaria	54			
Mytilus edulis	1			
TUNICATA				
Oikopleura vanhoffeni			32	
OLIGOCHAETA	314	4,189	7,036	13,868
POLYCHAETA				
Eteone sp.	16			1
Manayunkia aestuarina	656	772	1,363	3,642
Nereis (Neanthes) limnicola				3
Polydora ligni		2		
P. quadrilobata				33
Pygospio elegans	16			2
Spio filicornis			16	
DECAPODA				
CRAB ZOEA	8			
Hemigrapsus oregonensis	4			1
AMPHIPODA				
Ampithoe sp.	1			
Eogammarus confervicolus	1,831	440	1,904	6,086
Corophium spp. (juveniles)	763	79	1,056	10,850
C. insidiosum	340	13		192
C. salmonis	193			
C. spinicorne	265	74	81	598
Ischyrocerus sp.	8			
Pontogeneia sp.			16	

TABLE 6: NUMBER OF INDIVIDUALS IN 2-10 METER X 30 cm. EPIBENTHIC TOWS (cont'd.)

TAXA	OUTSIDE SLOUGH 22 MAR.	INSIDE SLOUGH 22 MAR.	19 APR.	17 MAY
ISOPODA				
Gnorimosphaeroma oregonensis	28	10	43	14
CUMACEA	56		113	
TANAIDACEA	320	875	466	679
MYSIDACEA - JUVENILE			416	
Neomysis mercedis	27		65	4
CIRRIPEDA - ADULT			544	14
NAUPLIUS	16			
COPEPODA, CALANOIDA			178	
INSECTA LARVAE	154	352	3,805	34
INSECTA PUPAE			197	96
INSECTA NYMPHS			16	
ACARI	24			
INVERTEBRATE EGGS	576			
FISH EGGS	1			3
FISHES	24	4	1	38
TOTAL	5,833	6,878	17,556	37,246

DIET KEY

1 Anisogammarus sp.
2 Corophium spp.
3 Harpacticoida
4 Diptera Adults
5 Diptera Pupae
6 Diptera Larvae
7 Collembola
8 Mysid Juveniles
9 Insecta Adults
10 Invertebrate Eggs
11 Neomysis mercedis
12 Chum Salmon

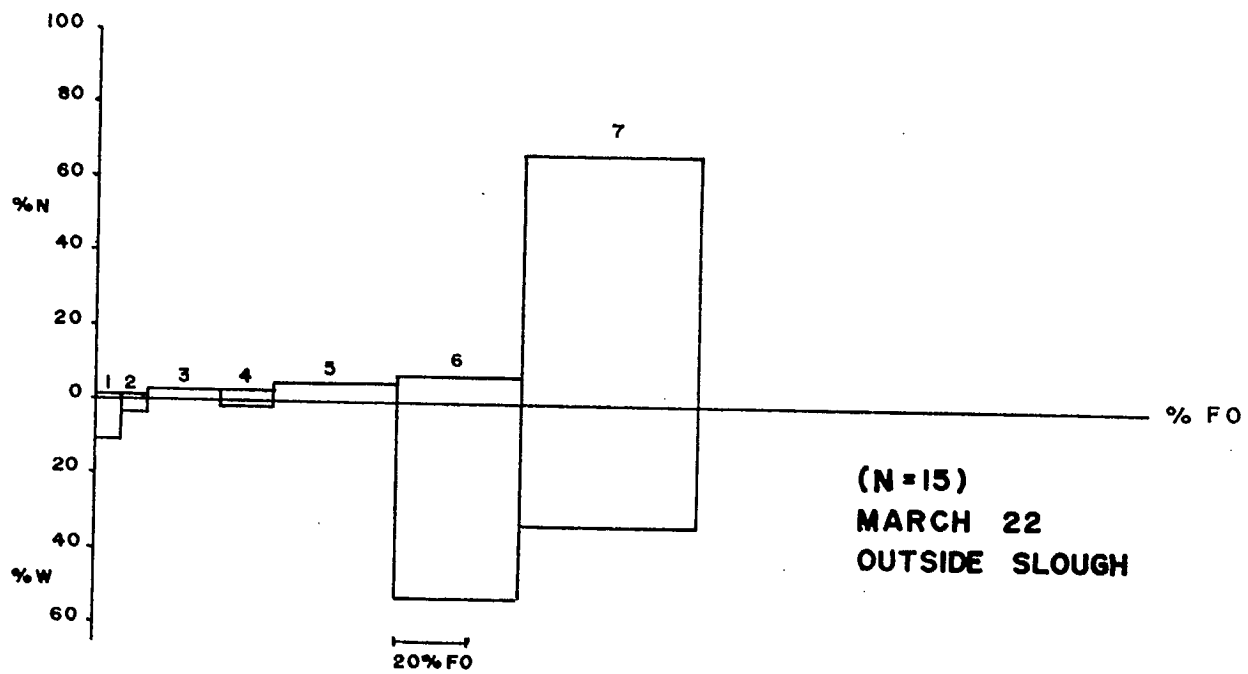
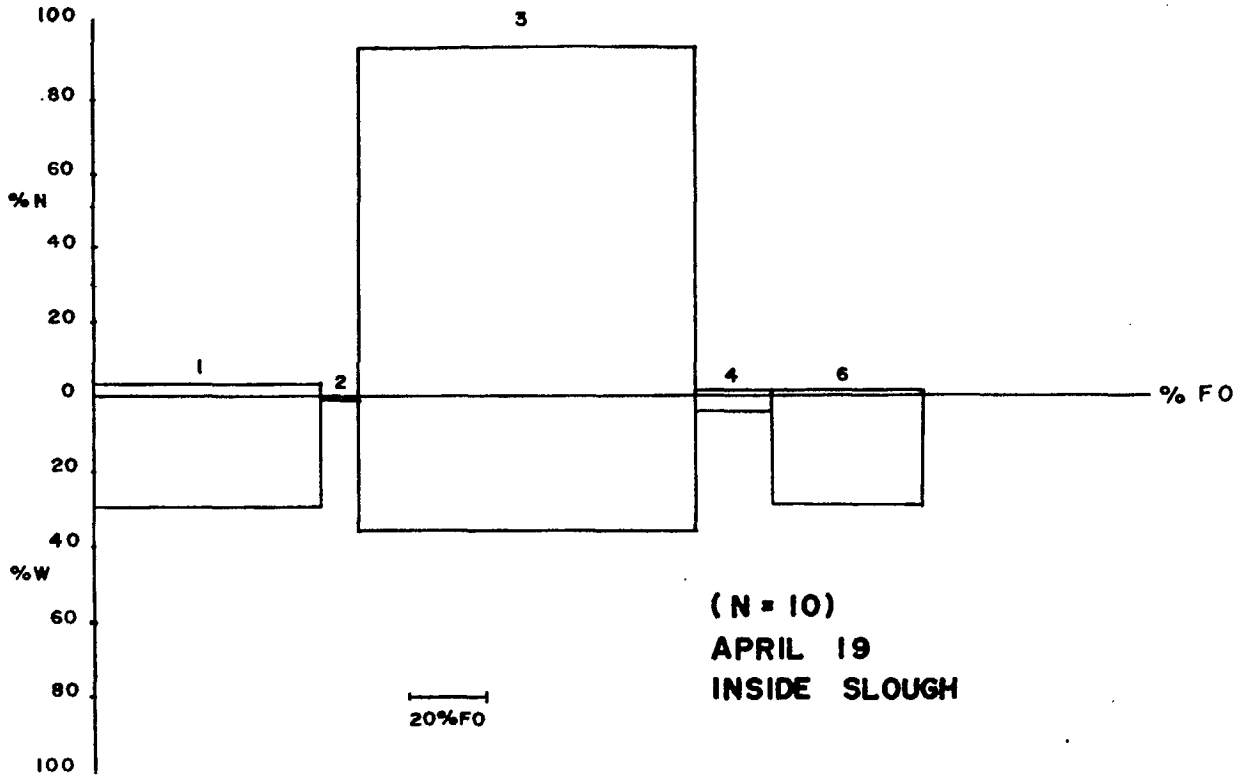


FIGURE 3: Index of Relative Importance diagrams for more common prey items in the diet of chum salmon at the Englishman River estuary, 1979. (% number and % wet weight vs. % frequency occurrence)



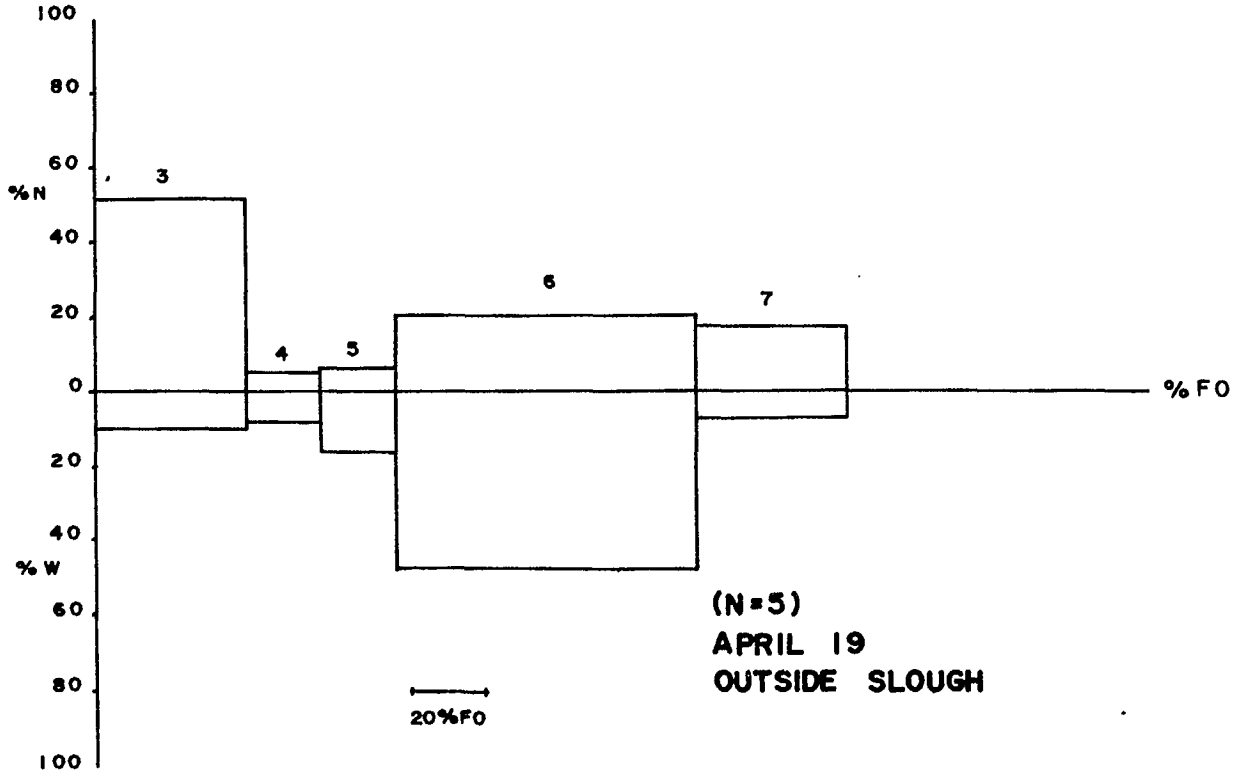
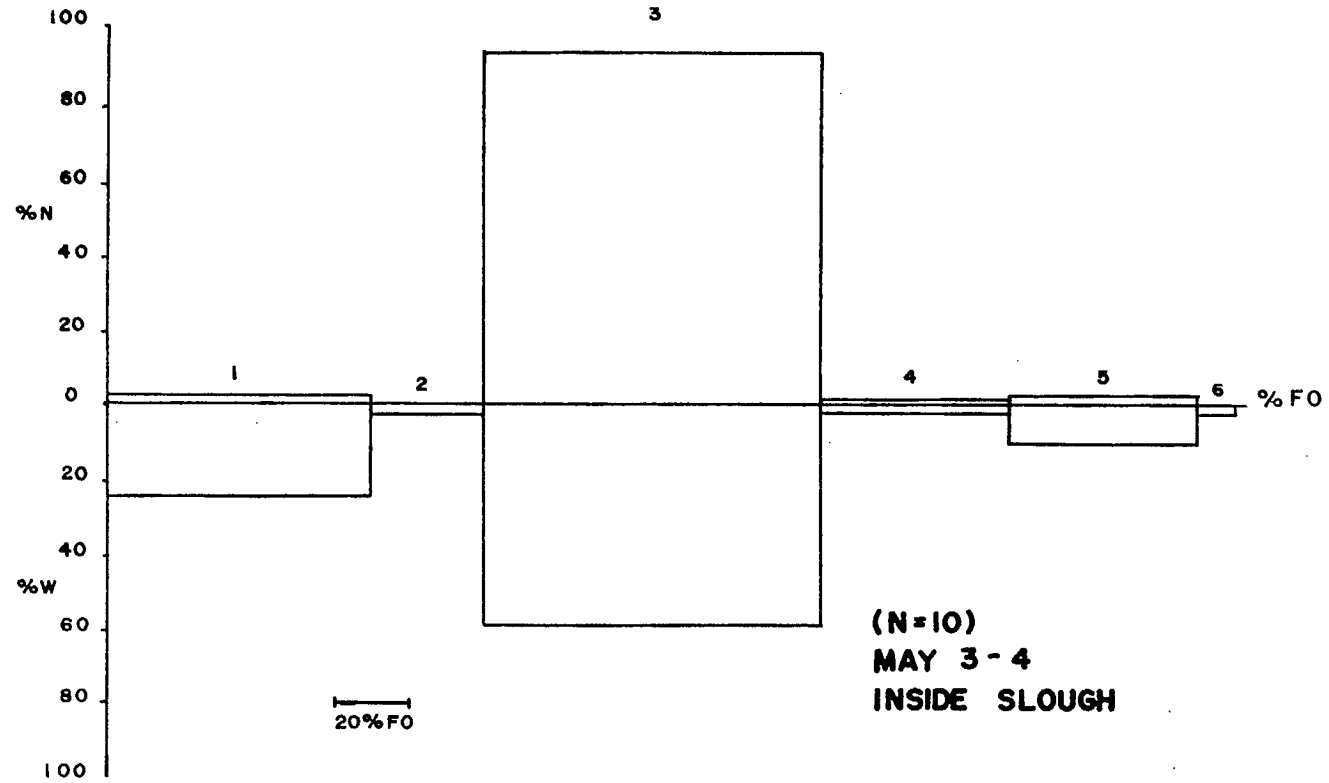


FIGURE 3: (cont'd.)



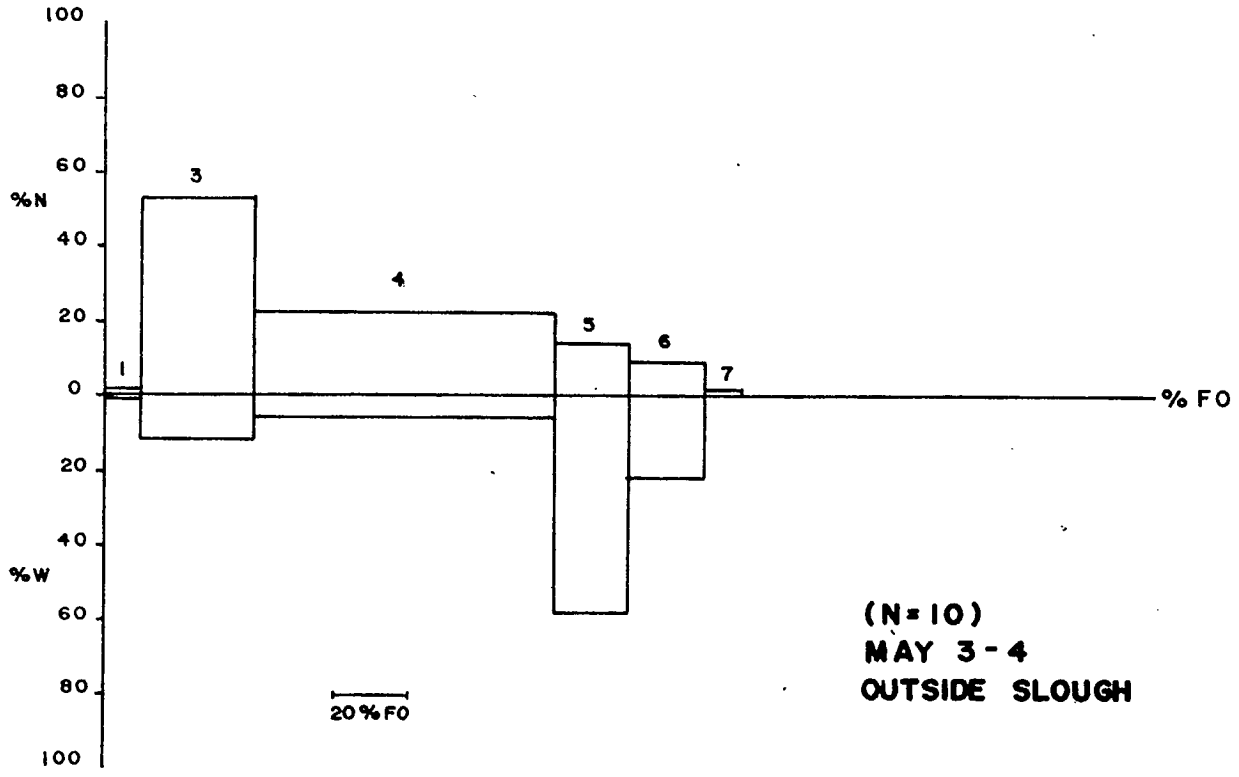


FIGURE 3: (cont'd.)

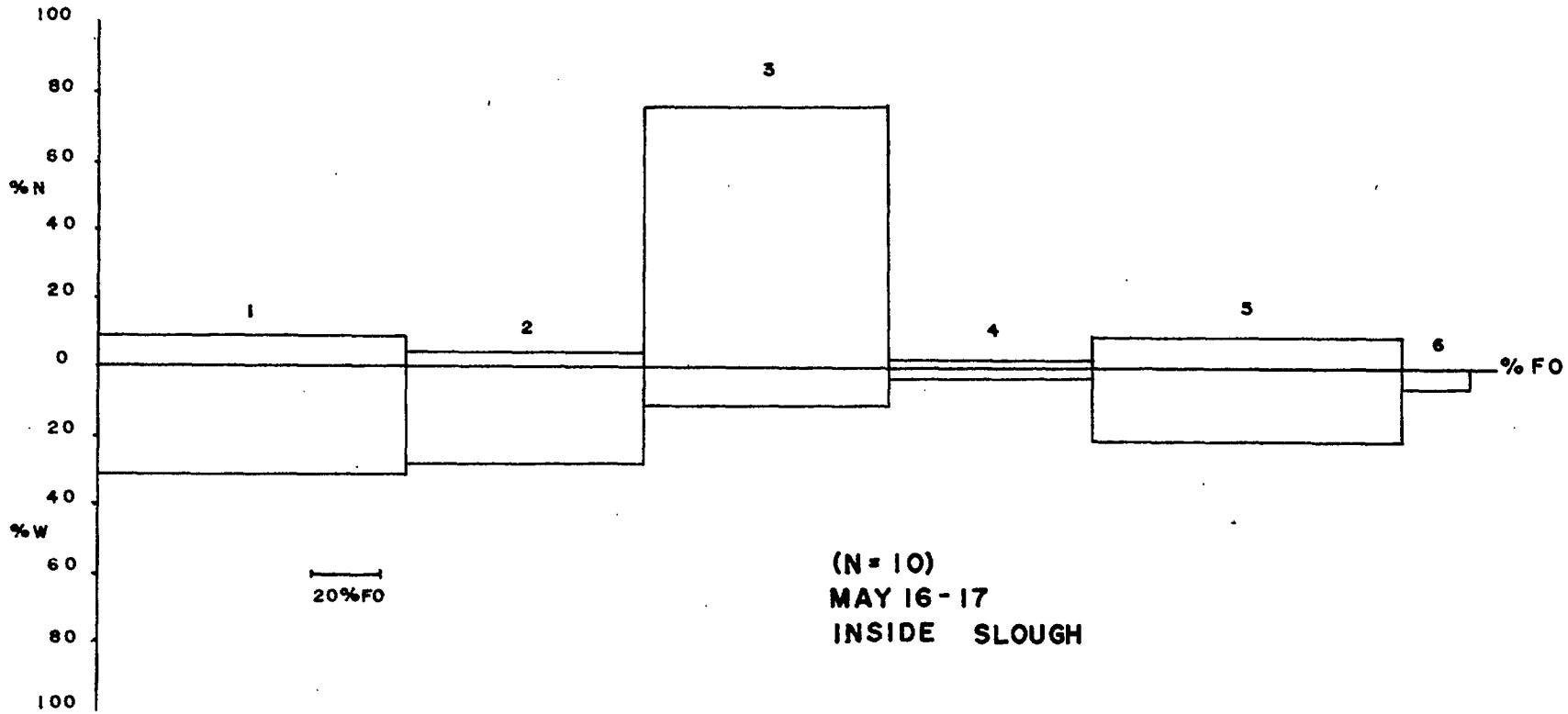


FIGURE 3: (cont'd.)

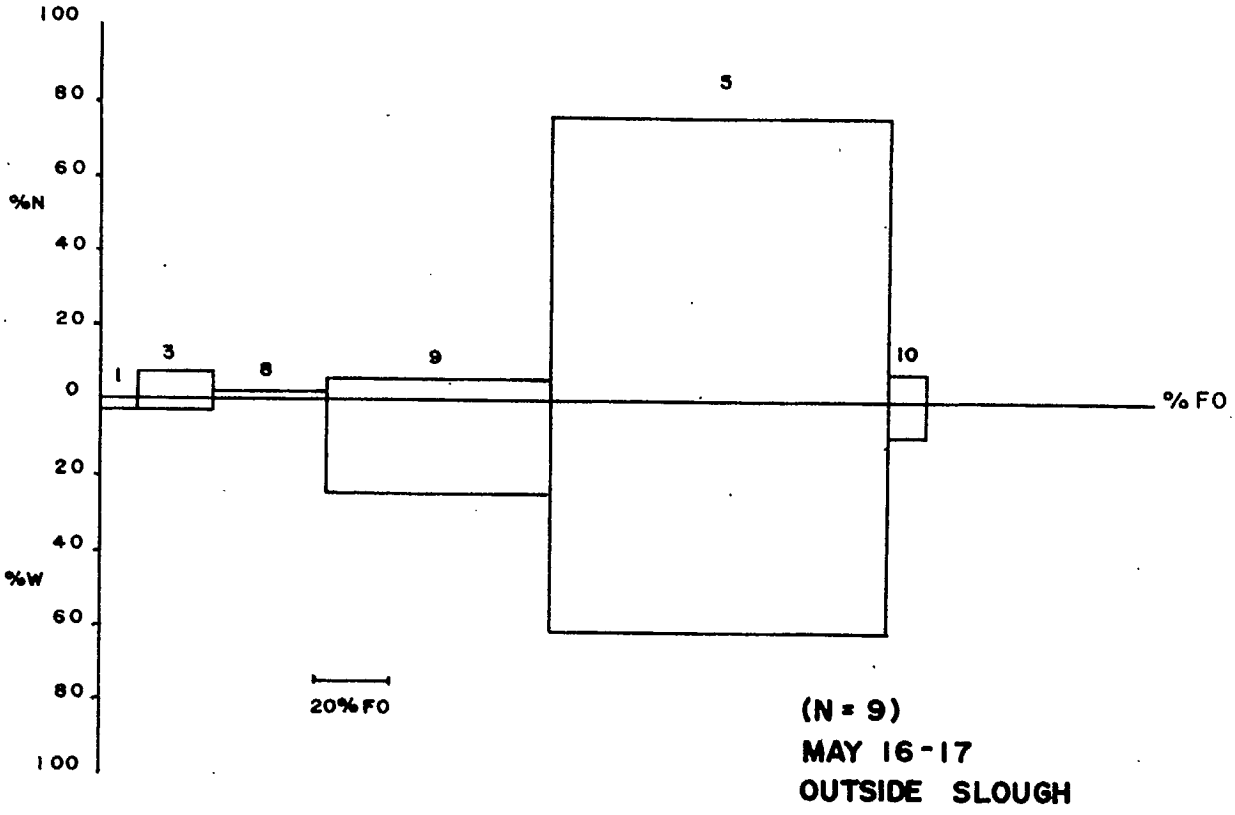


FIGURE 3 : (cont'd.)

Diptera larvae decreased in importance in the diet with time concurrent with a corresponding increase in importance of Diptera pupae.

The size composition of the diet of chum salmon is presented in Figure 4, and the size of chum salmon preserved for stomach content analysis is graphed in Figure 5. Size range of chum salmon in the laboratory sample and their prey did not appreciably change between March 22 and May 16-17.

3.5.2 Chinook

Taxonomic and size compositions of the diet of chinook salmon are presented in Figures 6 and 7. Nineteen chinook fry were collected in beach seines on the Englishman River estuary in May. As a result, stomachs were grouped only for diet analysis. By weight, the diet was comprised almost exclusively of Neomysis mercedis although numerically Harpacticoida and Diptera pupae were also important diet items.

3.5.3 Coho

For the purpose of stomach content analysis, coho salmon were grouped into those caught before the dyke was breached (March 22) and those caught after the dyke was breached (May). All coho

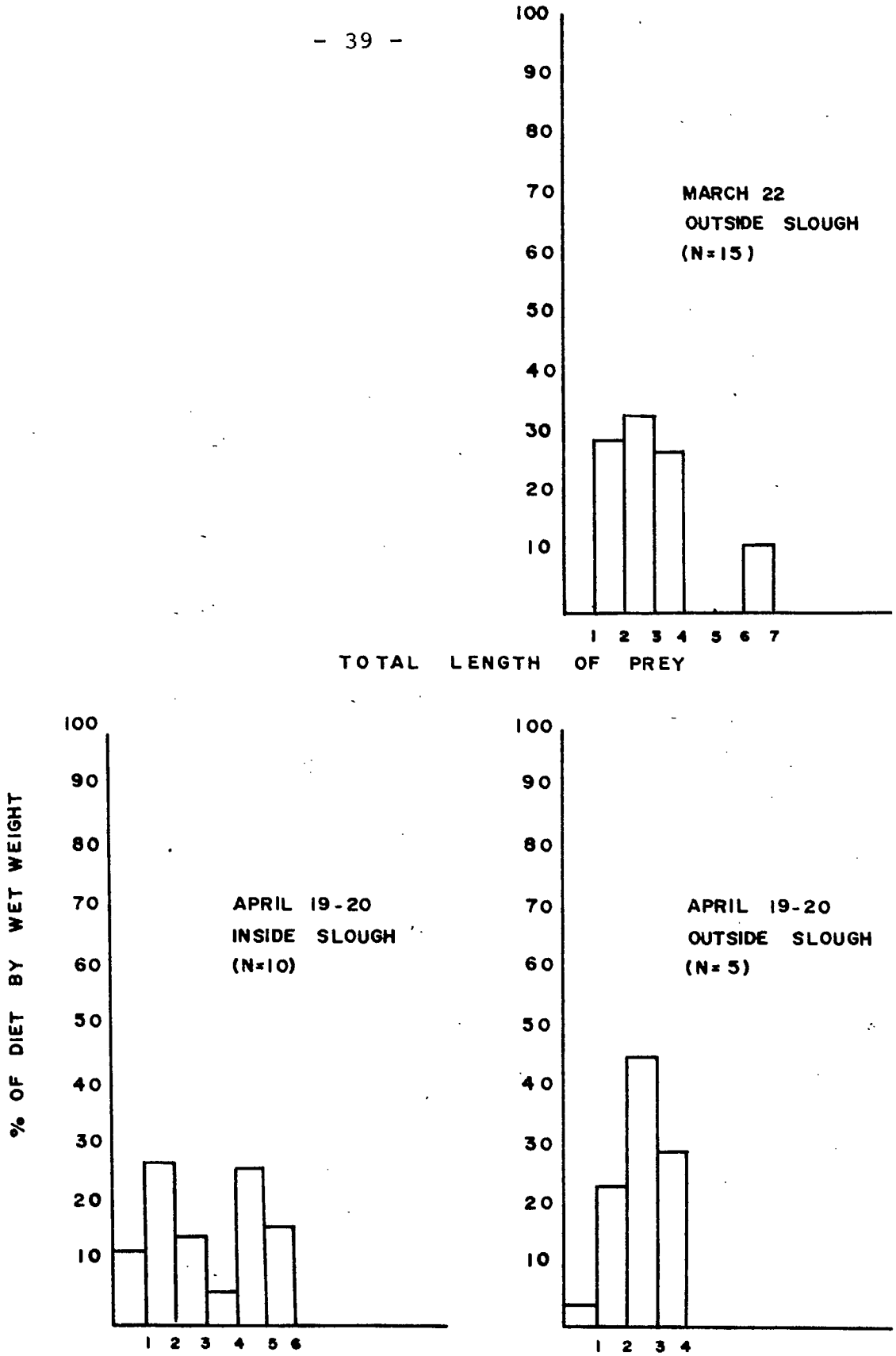


FIGURE 4: Size (total length in mm.) composition of chum salmon diet at Englishman River estuary, 1979.

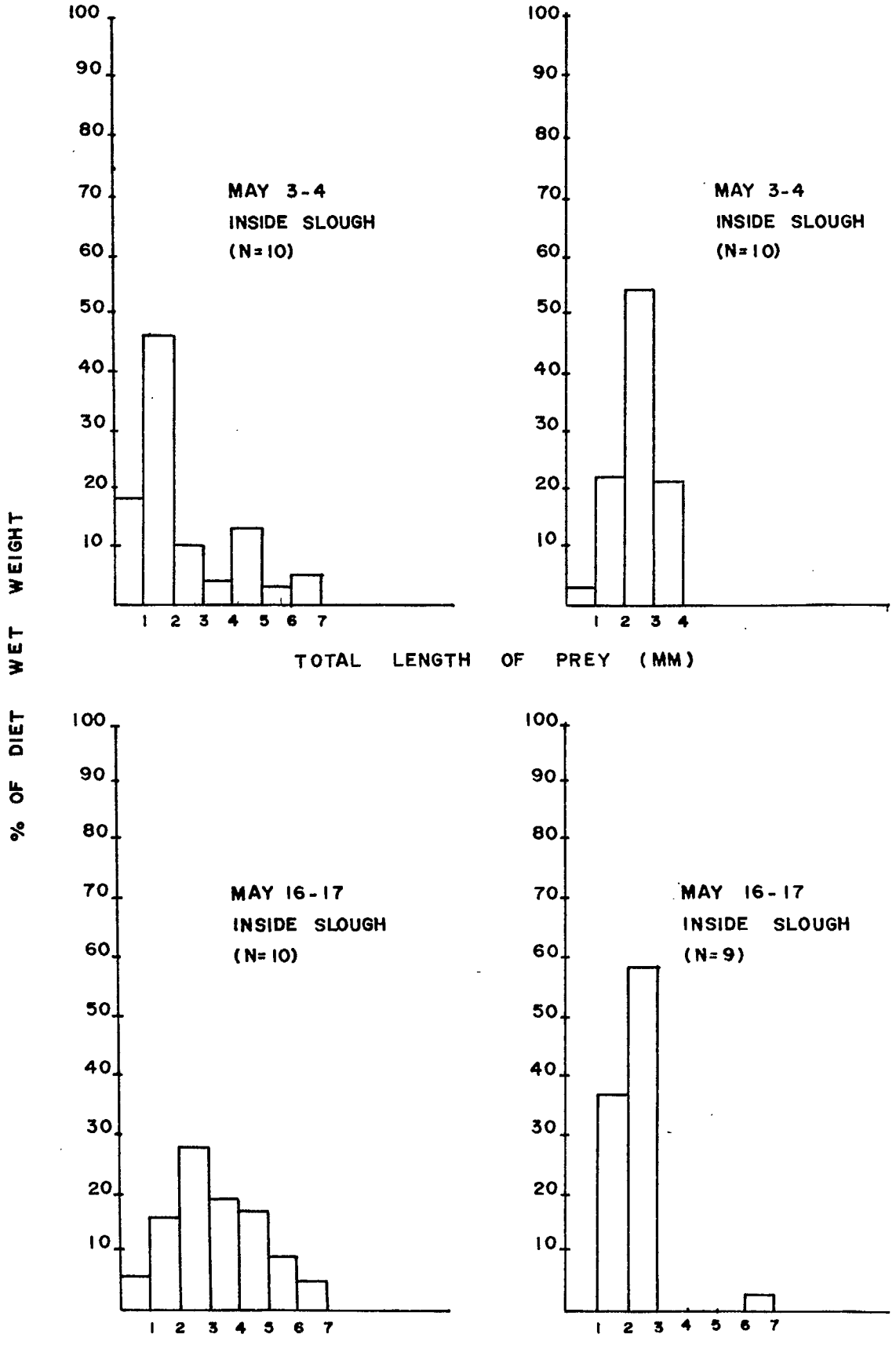


FIGURE 4: (cont'd.)

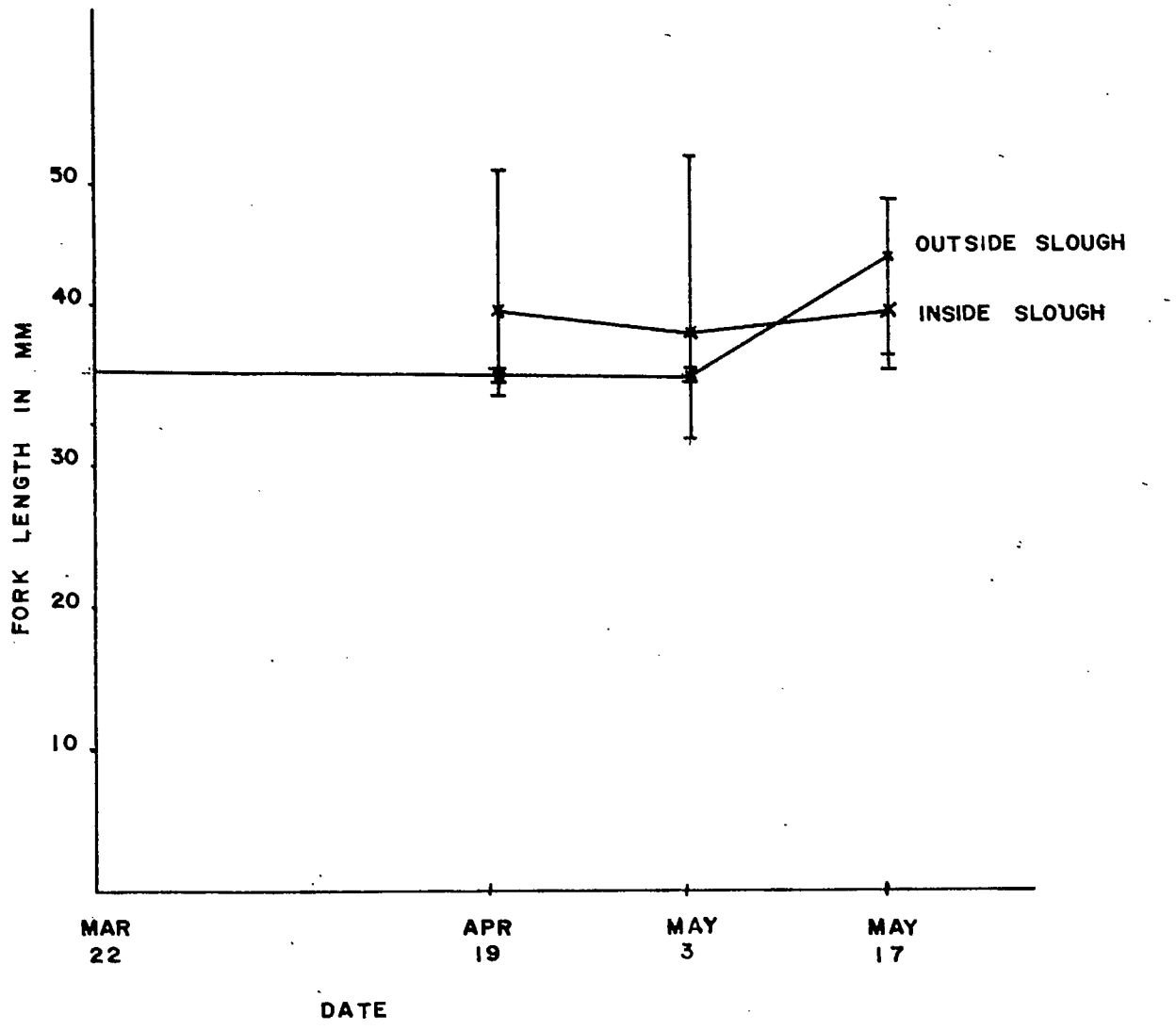


FIGURE 5: Mean fork length of chum salmon sampled for stomach content analysis.

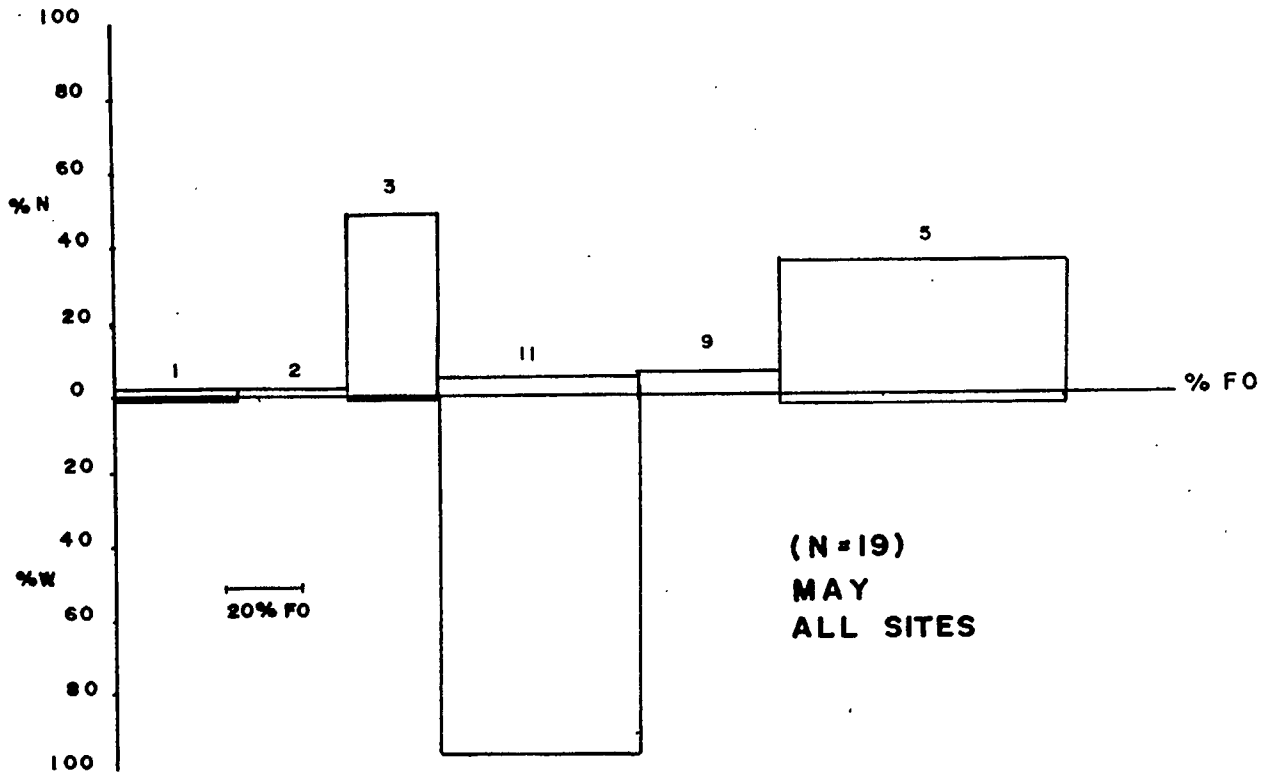


FIGURE 6 : Index of Relative Importance diagram for more common prey items in the diet of chinook salmon at the Englishmán River estuary, 1979.

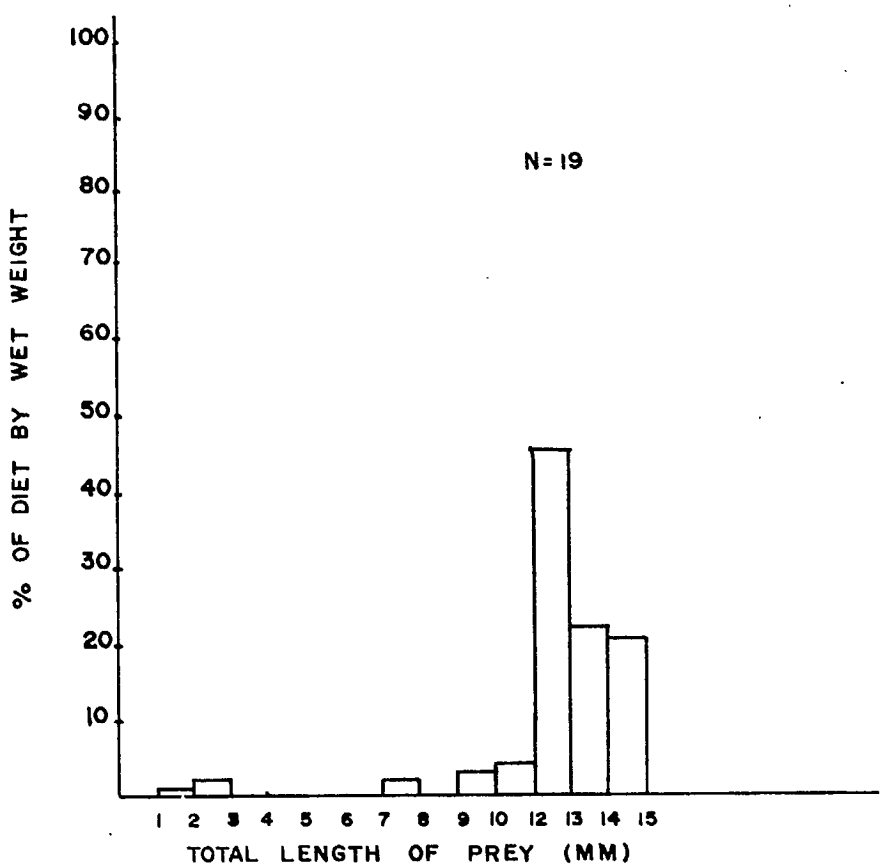


FIGURE 7.: Size (total length in mm.) composition of chinook salmon diet at Englishman River estuary, 1979.

were caught inside the slough. Taxonomic and size compositions of the diet of coho are presented in Figures 8 and 9. On March 22 gammarid amphipods (Eogammarus sp. and Corophium spp.) were the only important items in the diet of coho smolts. In May, after the dyke was breached, chum salmon made up the bulk of the coho diet but amphipods were still eaten in large numbers.

4.0 DISCUSSION AND SUMMARY

4.1 Chum

Juvenile chum salmon immediately entered the slough through the breached dyke. The relatively large number of chum fry found rearing in the slough during May 1979, combined with the wide size range of the chum population there, indicated that favourable rearing conditions existed. The sudden absence of any salmonid fry residing in the slough May 28, 1979 is most probably attributed to high water temperatures measured to be 20°C caused by exceptionally warm weather which occurred during the last week in May, 1979. A continuation of these elevated water temperatures prevailed through the summer sampling periods until September 25, 1979 when temperatures once again dropped to below 19°C.

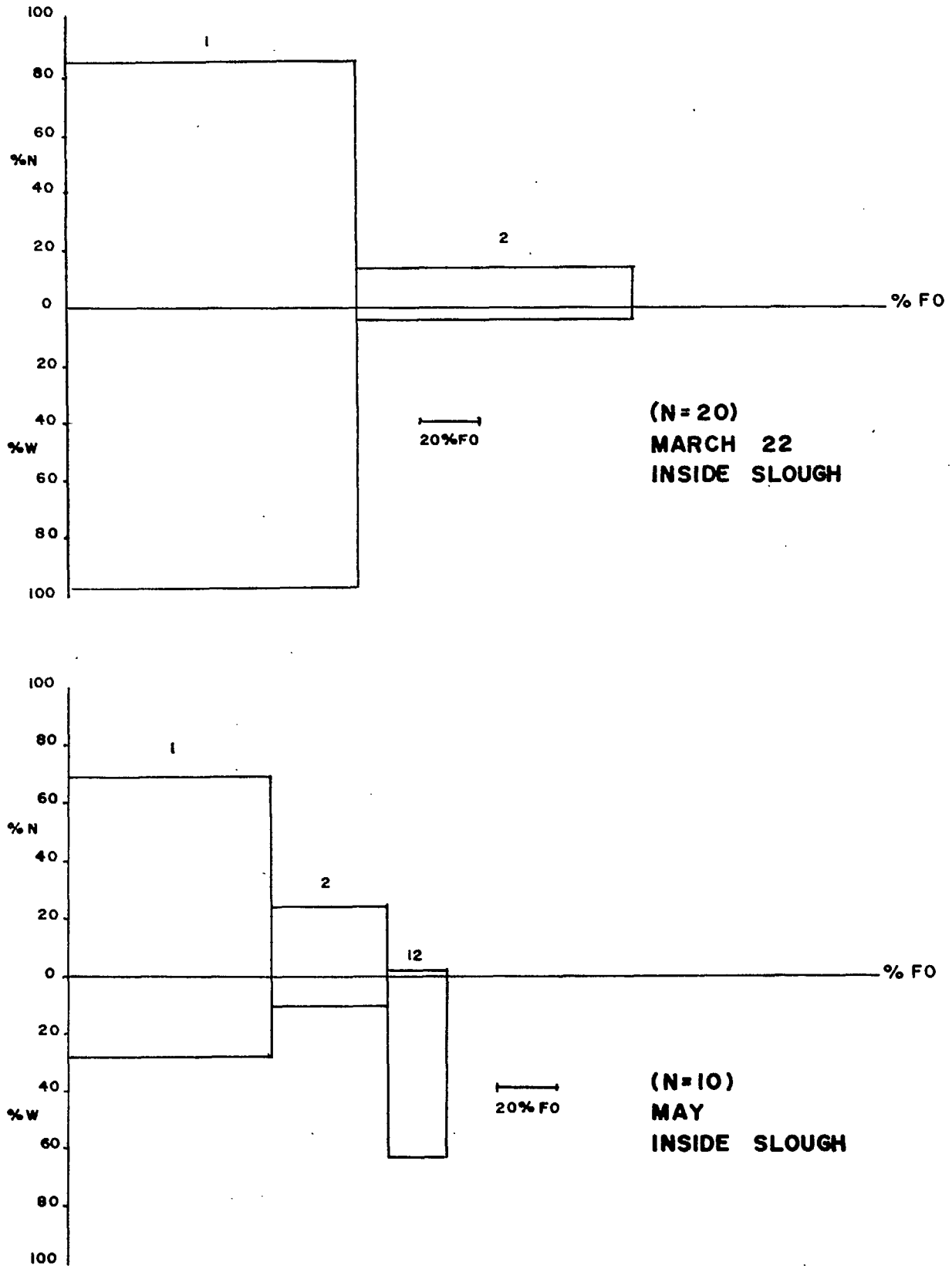


FIGURE 8: Index of Relative Importance diagrams for more common prey items in the diet of coho salmon at the Englishman River estuary, 1979.

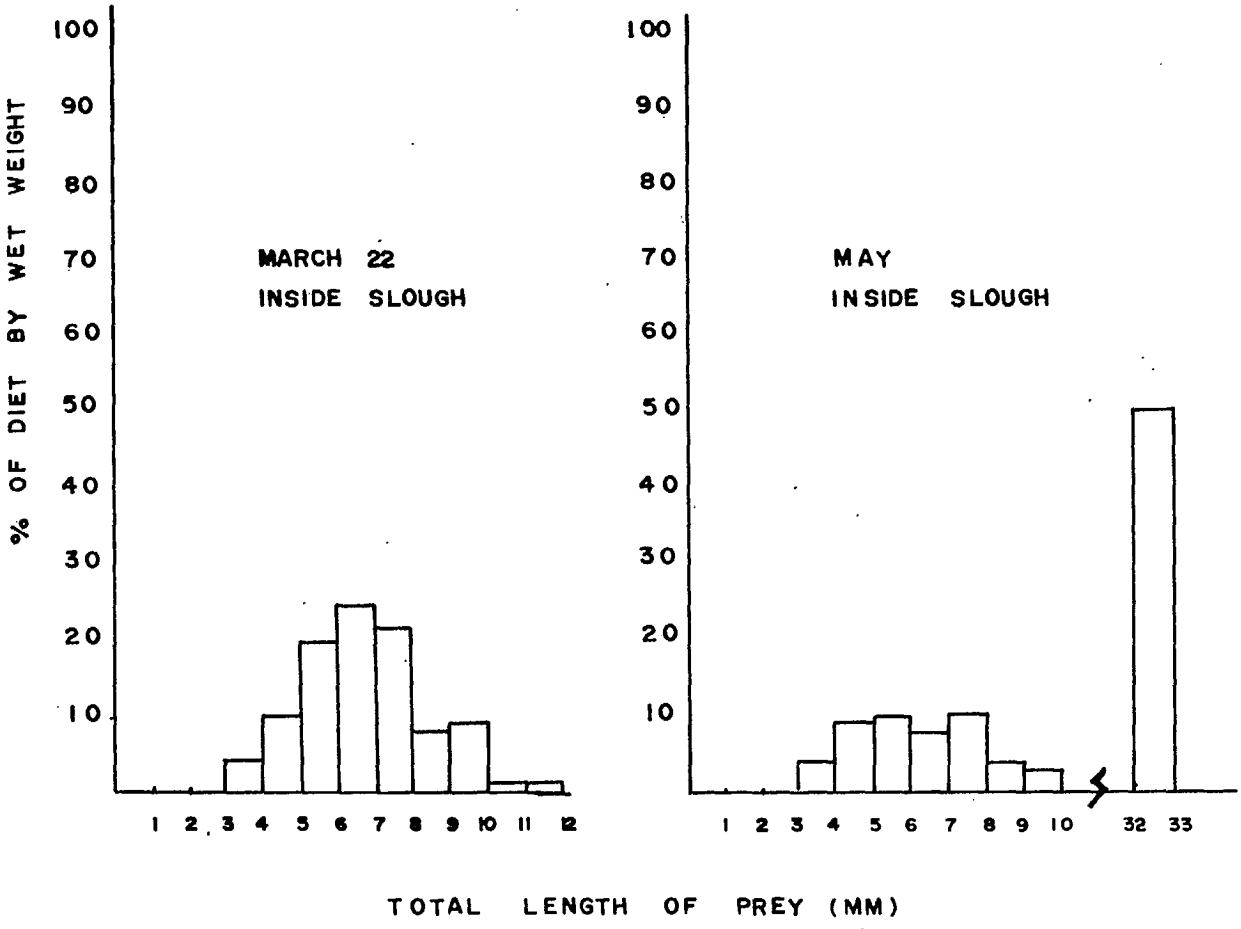


FIGURE 9: Size (total length in mm.) composition of coho salmon diet at Englishman River estuary, 1979.

Chikara (1979) has shown that short term estuarine rearing of juvenile chum salmon in Japan improves their survival to maturity and increases the proportion of older fish. The Englishman River chum stocks may benefit from the increase in available estuarine habitat created in 1979.

Historically, adult chum salmon were known to have spawned in the upper portion of the slough prior to the implacement of the sea dyke in 1969 (D. Gooderich, pers. comm.). Upwelling ground water seepage percolates into the upper reaches of the slough. Since 1979 several adult chum salmon have been observed spawning in the upper reaches of the reactivated slough (R. Kraft, pers. comm.).

4.2 Coho

Before the dyke was breached March 27, 1979 the slough was primarily a freshwater habitat with a small volume of tidal marine water flowing in through a partially clogged culvert in the dyke. Juvenile coho salmon had gained access to the slough, probably via the open culvert, and were found rearing in the slough March 22, 1979.

From scale interpretation of the coho juveniles found rearing in the slough, two distinct age classes and a variety of growth patterns were evident. Some age (1+) coho appeared to have grown rapidly in their first spring while rearing in the Englishman River, then a scale "stress" occurred during the summer period, which corresponds to the recurrent low summer flow period in the Englishman River. The fall period indicated normal growth is probably the period when the fish entered the slough to rear during the winter months. Scale patterns indicate that some (1+) coho probably entered the slough during the fall period while others arrived in the slough just prior to being captured March 22, 1979 (F.Y.E. Yole, pers. comm. Fisheries and Marine Service Scale Lab.).

Some juvenile coho aged (2+) appeared to have remained in the Englishman River for two years before entering the slough. Evidence of spring growth appeared on the scales of some of the (2+) fish captured in the slough indicating overwintering in the slough while other (2+) coho appeared to have recently arrived in the slough prior to their capture March 22, 1979 (F.Y.E. Yole, pers. comm.).

The variety of life histories of the two age groups of coho juveniles found in the slough is responsible for the wide size range discovered in that coho population.

The local fishery officer reported some 15 to 20 coho (mean/ length approximately 125 mm long) were captured in May 1980 in the extreme upper reaches of the reactivated slough (R. Kraft, pers. comm.).

4.3 Feeding and Benthic Invertebrates

Important diet items of juvenile salmon captured in the slough at the Englishman River estuary - Neomysis sp., Diptera, Eogammarus sp., Harpacticoida, Corophium spp. - are invertebrate taxa commonly eaten by juvenile salmon at other estuaries in British Columbia (Levy and Levings 1979; Healey 1979 and Goodman 1975).

Benthic and epibenthic invertebrate samples collected during this study indicate that the above taxa inhabit the slough; therefore, breaching the dyke allowed juvenile salmon, particularly chum to exploit a food source which was previously not available to them.

Numbers of benthic invertebrates collected in grab samples from the lower slough were comparable to results from other estuaries, Table 7.

The abundance of invertebrates in the lower slough increased considerably from March 22, 1979 to May 19, 1979.

(NUMBER/METER^2)

TAXA	ENGLISHMAN R. MAY 17	STURGEON BANKS FRASER R.[1] JUNE 5	BURRARD INLET MAPLEWOOD FLATS[2] FEB. 28	NANAIMO R.[3] YEARLY AVERAGE	SQUAMISH R.[4] MUD/LOWER MARSH
Corophium spp.	39,970	0-37,440	320-8060	-	396
Eogammarus confervicolus	4,178	960	0-3968	-	3800
Harpacticoid	164,444	-	-	245,000	-

1. Levings and Coustalin (1975)
2. Levings and McDaniel (1974)
3. Sibert (1979)
4. Levings (1978, MS)

TABLE 7: COMPARISON OF THE NUMBERS OF SOME BENTHIC INVERTEBRATES COMMON AT THE ENGLISHMAN RIVER ESTUARIES WITH NUMBERS FOUND AT OTHER ESTUARIES IN BRITISH COLUMBIA

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