CAMPBELL RIVER FORESHORE BIOPHYSICAL INVENTORY

MARCH 1983

by

B. WADDELL AND S. MARKOWSKI
(JOB CREATION PROJECT)

prepared for

WATER USE UNIT
HABITAT MANAGEMENT DIVISION
DEPARTMENT OF FISHERIES AND OCEANS
VANCOUVER, B.C.
V6E 2P1

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* Excludes organisms greater than 9.5 mm^2 or with calcareous shells.

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Acknowledgements

This project was the combined efforts of the Federal Fisheries (Habitat Management Division, Water Use Unit) staff and participants of the FEBAP Project #567. We would like to thank all those involved with this study.

The project was designed by several staff in the foreshore group of the Water Use Unit. K. Conlin and R. Russell initially directed Water Use Unit staff with the field work before turning the project over to the FEBAP program. S. Hamilton and R. McNaughton then supervised the field work which was carried out by the following people: B. Clarke, D. DuPuis, D. Englund, C. Franks, T. Hamilton, P. Jespersen, and S. Quintrell. The lab analysis was initially organized by U. Orr and was carried out by K. Burke, G. Gainer, M. Graham, L. Grenier, J. McNicol, J. Tuytel and F. Williams.

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Brenda Waddell (Project Manager)
Steve Markowski (Lab Supervisor)

1. INTRODUCTION

The Campbell River area has long been known as a fishing capital. It serves as an important operations base for the commercial fishing industry and is noted for its recreational fishing. The marine foreshore is heavily utilized by salmon fry from Quinsam Hatchery and by wild stocks from Campbell River and other coastal rivers. Along with the increasing popularity of the area, however, there has been an increase in development. The marine foreshore north of Campbell River, including Duncan Bay and Menzies Bay, is subject to increasing industrial development pressure while the southern foreshore is subject to urbanization, including proposals for hotel and marina construction. Most of these proposals involve foreshore filling and dredging of the intertidal areas.

To date, very little biophysical habitat information has been collected in the Campbell River foreshore area. In order to augment existing biophysical information, a program was undertaken in spring and summer 1982 to assess benthic productivity and juvenile salmonid presence and utilization of the foreshore area. In addition, resource mapping of substrate composition and aquatic vegetation was undertaken. Laboratory analysis of samples of zooplankton, benthic invertebrates, fish and fish stomach contents followed the field program.

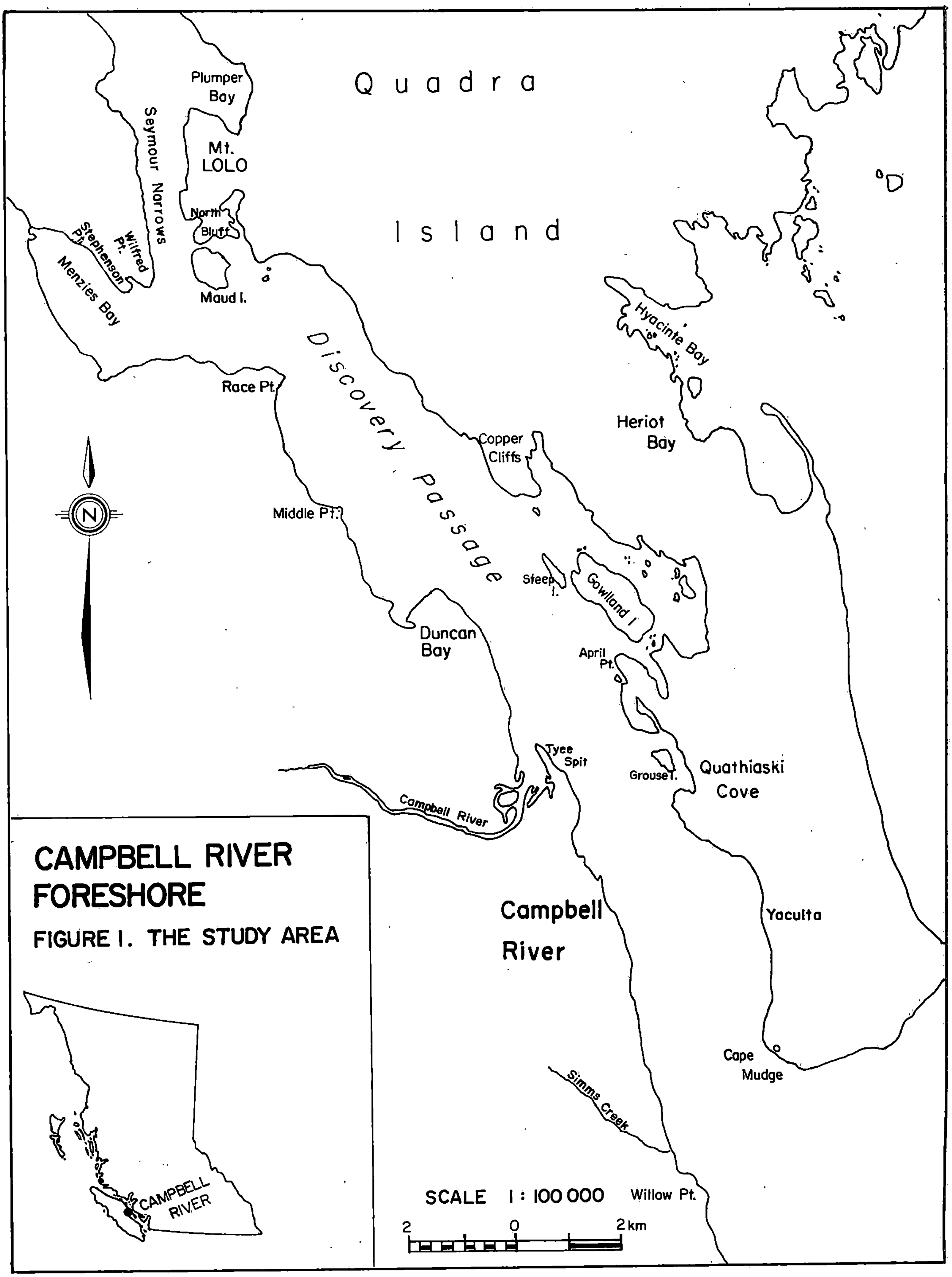
The purpose of this study was to enable the Department of Fisheries and Oceans to identify productive foreshore areas requiring habitat protection/management efforts, and to help direct planners and/or developers to less environmentally sensitive areas.

2. STUDY AREA

The community of Campbell River is located on the east coast of central Vancouver Island and the Campbell River flows into the southern end of Discovery Passage. The estuary is protected from the open northern waters of the Strait of Georgia by Quadra Island. (See Figure 1.)

For the purpose of this report, the study area extended from Willow Point to Seymour Narrows including Menzies Bay, but excluded the Campbell River estuary. The Quadra Island foreshore was also surveyed along this portion of Discovery Passage (Seymour Narrows to Cape Mudge).

Strong tidal streams occur in Discovery Passage with speeds of up to 10 knots (18 km/hr) (CBA Engineering Ltd., 1980). Seymour Narrows is particularly hazardous, with its treacherous eddies,



CAMPBELL RIVER FORESHORE

FIGURE I. THE STUDY AREA

intensive turbulence and strong tidal currents, which may exceed 15 knots (27 Km/hr.) (Bell and Thompson, 1977).

The Campbell River drains an area of 1,741 km^2 southwest of the town, and is the third largest river on Vancouver Island. The Quinsam River flows into the Campbell River 3 km upstream from the estuary, and drains an area of 280 km^2 (CBA Engineering Ltd., 1980). The Quinsam Hatchery is located on the Quinsam River approximately 1.5 km upstream from where it joins the Campbell River. The five species of Pacific salmon, steelhead and cutthroat trout, and Dolly Varden char are all found in the Campbell/Quinsam River system. Sockeye salmon are present in the system only in low numbers. In addition to wild fish, the hatchery released approximately 765,500 chinook fry, 71,500 chum fry, 1,280,000 coho smolts, 5,294,000 pink fry and 17,500 steelhead smolts in the spring of 1982.

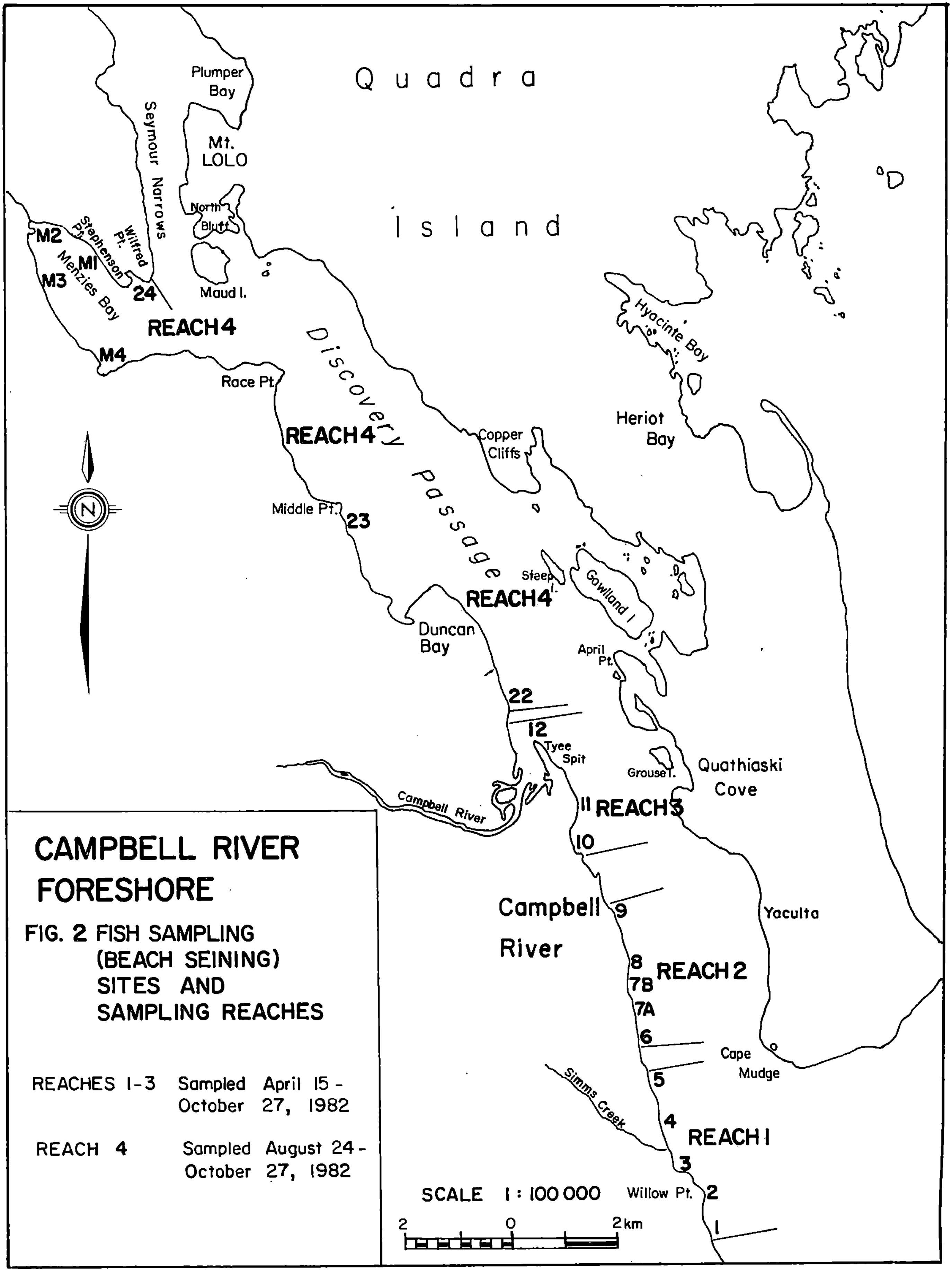
3 METHODS AND MATERIALS

3.1 Beach Seine and Benthic Site Selection and Study Design

Sites within the study area were selected for a variety of reasons. Beach seine Sites 1 to 7A and 8 to 11 were previously selected by the Habitat Management Division in conjunction with another study (Raymond et al., in prep.) and the Water Use Unit added Sites 7B and 12 to these. Sites 22 to 24 correspond to sites currently being studied by Dr. C. Levings (Fisheries Research Branch, West Vancouver Laboratory). Sites M1 to M4 were located in Menzies Bay and were selected by the Water Use Unit to observe whether this area served as a long-term rearing area for juvenile salmonids. See Figure 2 and Table 1 for site locations (See also Figure 2A). All of these sites were beach seined to determine fish utilization.

Table 1 Site Locations for the Campbell River Foreshore Study

Site #	
1	South of Willow Point (launching ramp)
2	Willow Point
3	South of Simm's Creek
4	Island Inn
5	Shoreline Motel (launching ramp)
6	Austrian Chalet
7A	Bay South of Hidden Harbour
7B	Hidden Harbour
8	Anchor Inn
9	South of Sewer
10	North of Ferry Berth
11	Indian Cemetery

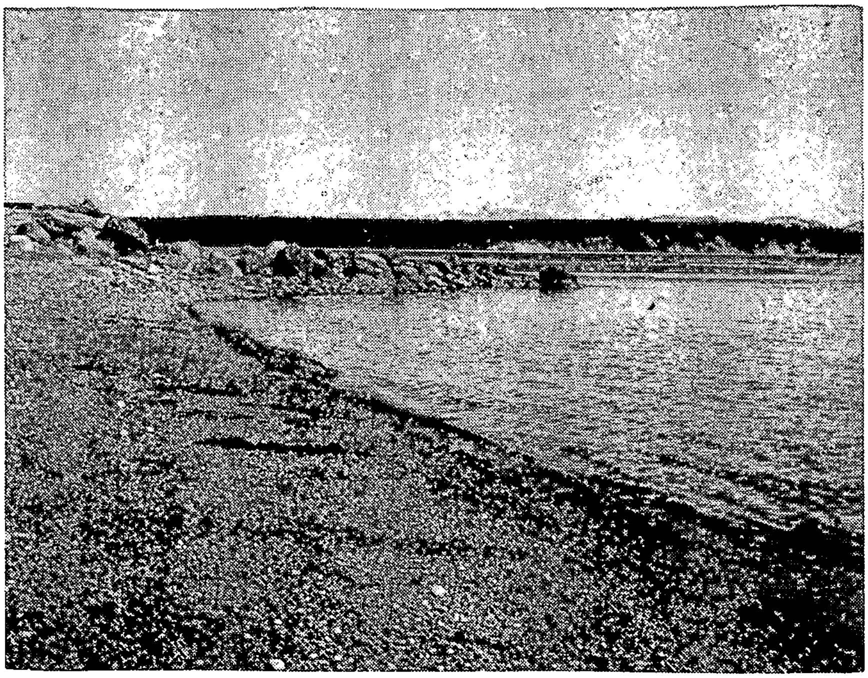


CAMPBELL RIVER FORESHORE

FIG. 2 FISH SAMPLING (BEACH SEINING) SITES AND SAMPLING REACHES

REACHES 1-3	Sampled April 15 - October 27, 1982
REACH 4	Sampled August 24 - October 27, 1982

Figure 2A



(i) Site 1

(ii) Site 3

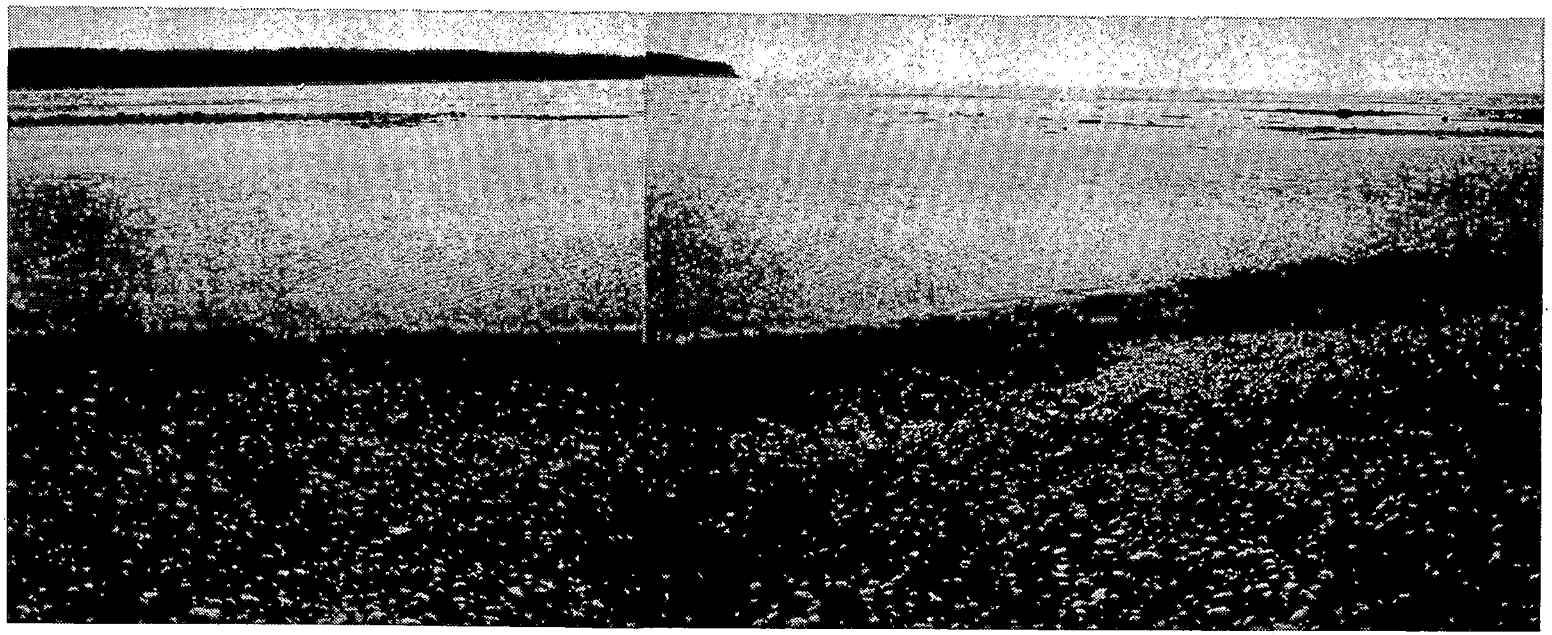
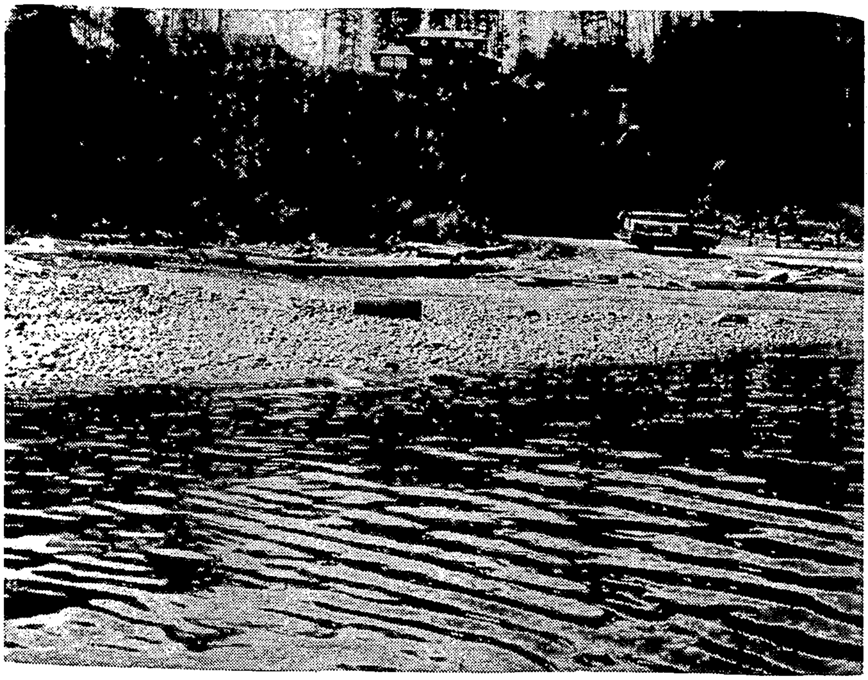
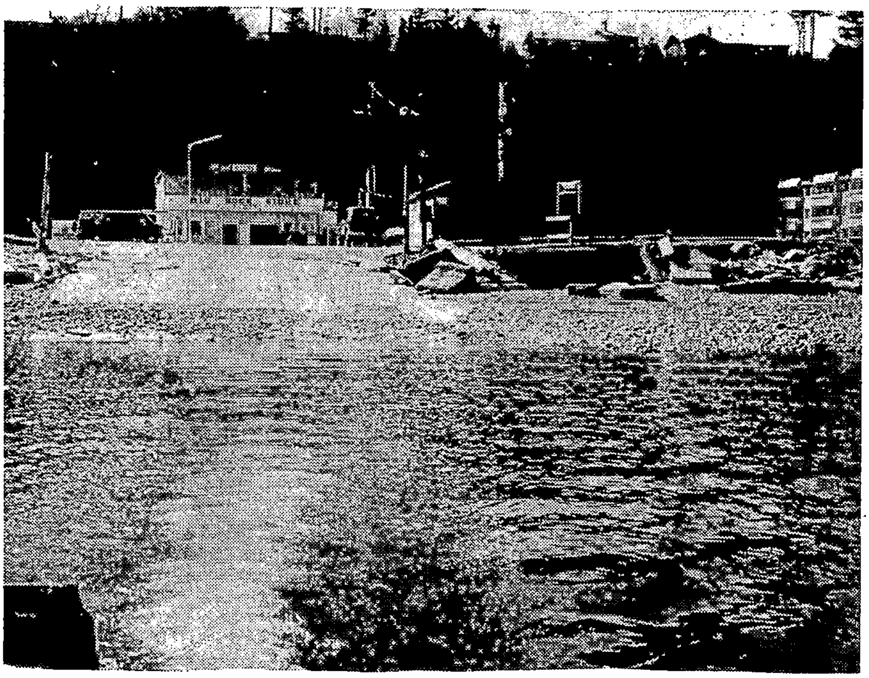


Figure 2A
(iii) Site 3

Figure 2A

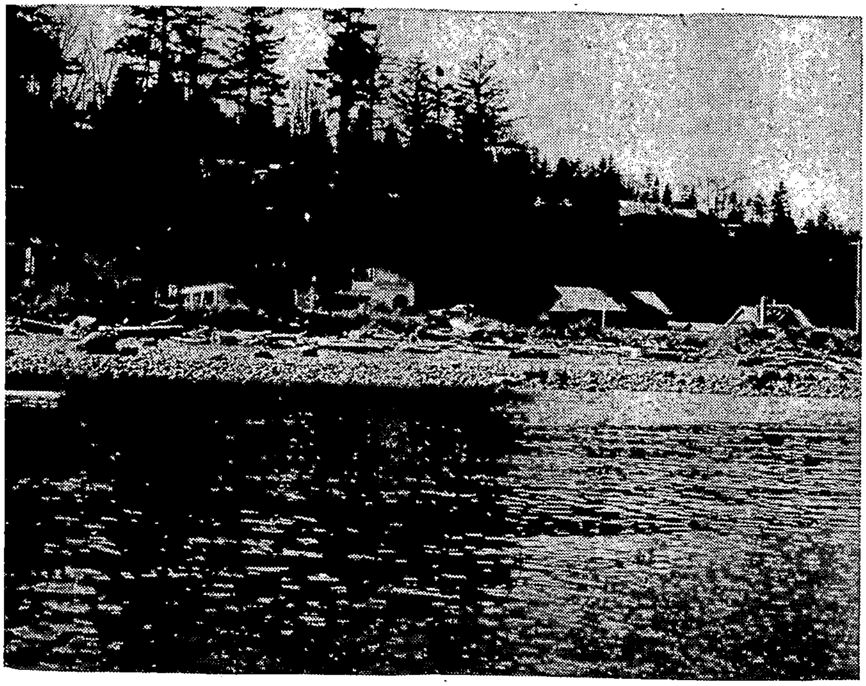


(vi) Site 4

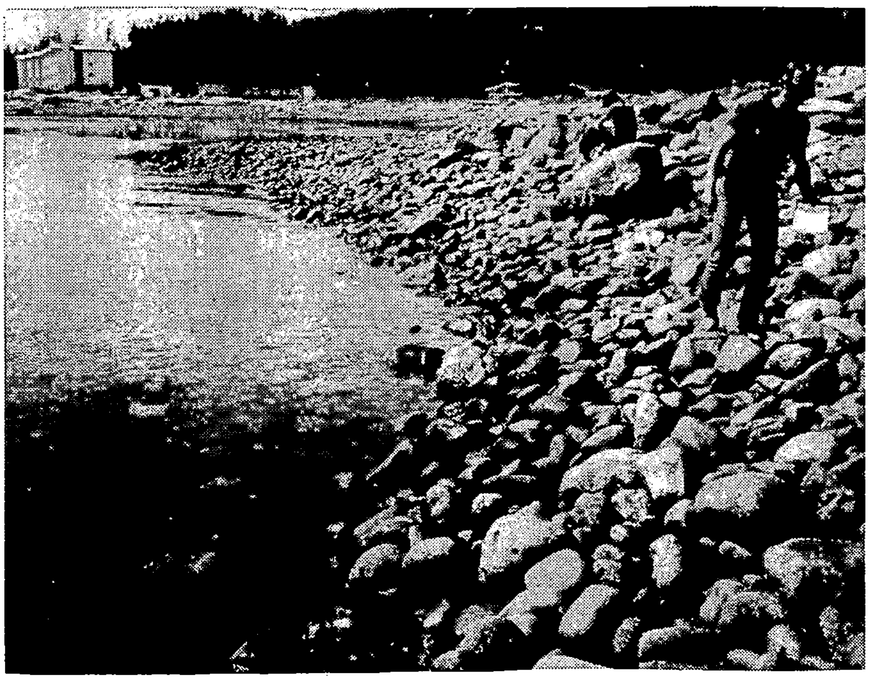


(v) Site 5

Figure 2A



(vi) Site 6



(vii) Site 7A

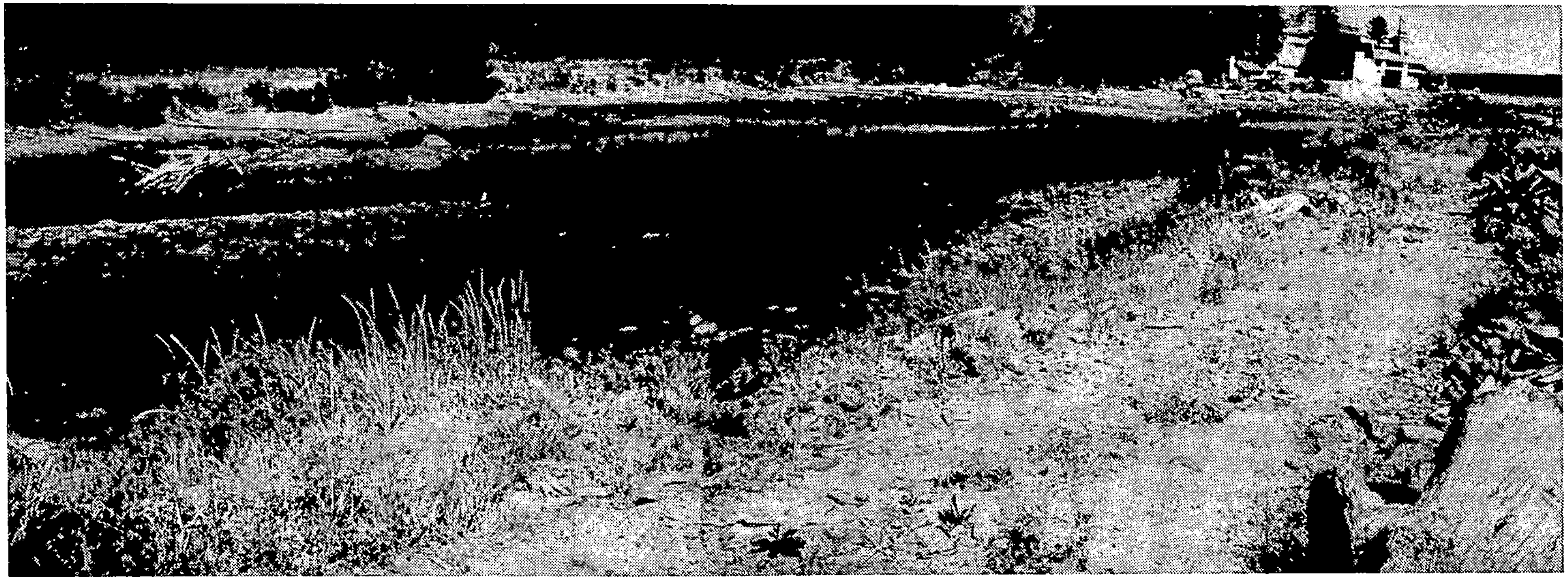
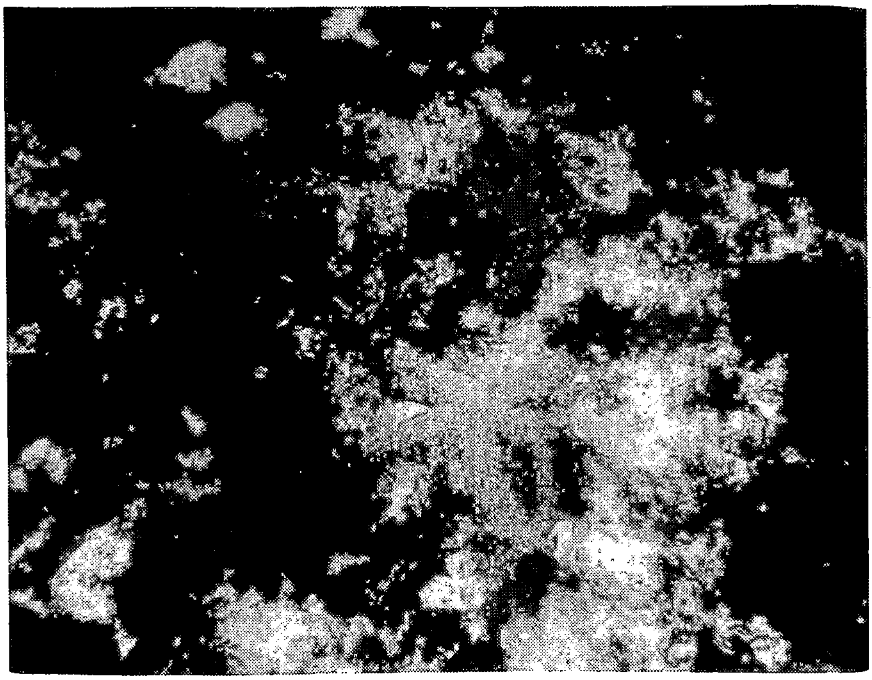
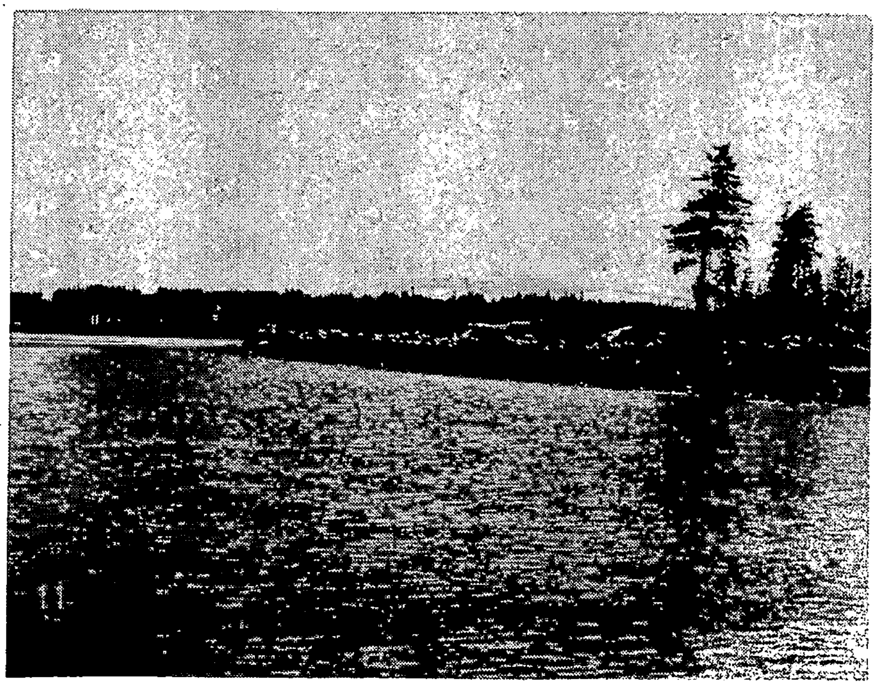


Figure 2A
(viii) Site 7B

Figure 2A



(x) Between Sites 10 and 11 (underwater)



(x) Site 11

12	Tip of Tyee Spit
22	Painter's Lodge
23	Middle Point
24	Nymphe Cove
M1	Menzies Bay
M2	Menzies Bay
M3	Menzies Bay
M4	Menzies Bay

Of the above-mentioned sites, three benthic sampling sites were selected to be representatives of three broad types of habitat characteristic of the area. These were:

(1) Site 3 (sand/fine gravel);

(2) Site 7A (cobble/boulder);

(3) Site 11 (coarse gravel/cobble).

At these sites benthic samples, zooplankton samples and salmonid stomach samples were obtained concurrently with the fish sampling. This was to determine differences between the three habitats in terms of overall community structure, species differences, standing crop and juvenile salmonid utilization.

The study area was divided into four reaches in order to group the fish sampling data. In this way differences in salmonid presence in terms of distance from the estuary may be determined. Reaches 1, 2 and 3 refer to the study area south of the estuary whereas the area north of the estuary is encompassed by Reach 4. Reaches 1, 2 and 3 each include one of the sites sampled for benthos.

Reach #	Beach Seine Sites	Benthic Sampling Sites
1	1 - 5	3
2	6 - 9	7A
3	10 - 12	11
4	22 - 24 & M1 - M4	-

3.2 Substrate Mapping

The foreshore in the entire study area was examined at low tide and its substrate composition was recorded. A modified Wentworth scale, as described in Table 2, was used to classify the different substrate types.

Table 2 - Modified Wentworth Scale

Code	Description	Size Range (mm)	Size Range (inches)
1	Silt - Clay	0.62	
2	Sand	0.62- 2	

3	Pea Gravel Fine Gravel Medium Gravel	2 - 16	0.1- 0.6
4	Coarse Gravel Very Coarse Gravel	16 - 64	0.6- 2.5
5	Small Cobble	64 - 125	2.5- 5
6	Large Cobble	125 - 250	5 - 10
7	Boulder	250+	10+
8	Bedrock		

3.3 Vegetation Mapping

Distribution and density of aquatic vegetation was mapped over the entire study area by visual observations from a boat and from the foreshore at low tide. Low level false colour infrared photographs (Integrated Resources Photography Ltd.) (altitude 2,500 ft., scale 1:5,000) flown at 1400 hr. July 22, 1982 at an approximate 1.2 m tide (based on Campbell River tide tables) were also used as an aid to mapping the area from Willow Point to Painter's Lodge (north of the Campbell River estuary).

Kelp bed densities were noted using the following relative scale:

D1 - Sparse

D2 - Moderate

D3 - Dense

D4 - Extremely Dense

3.4 Zooplankton Sampling

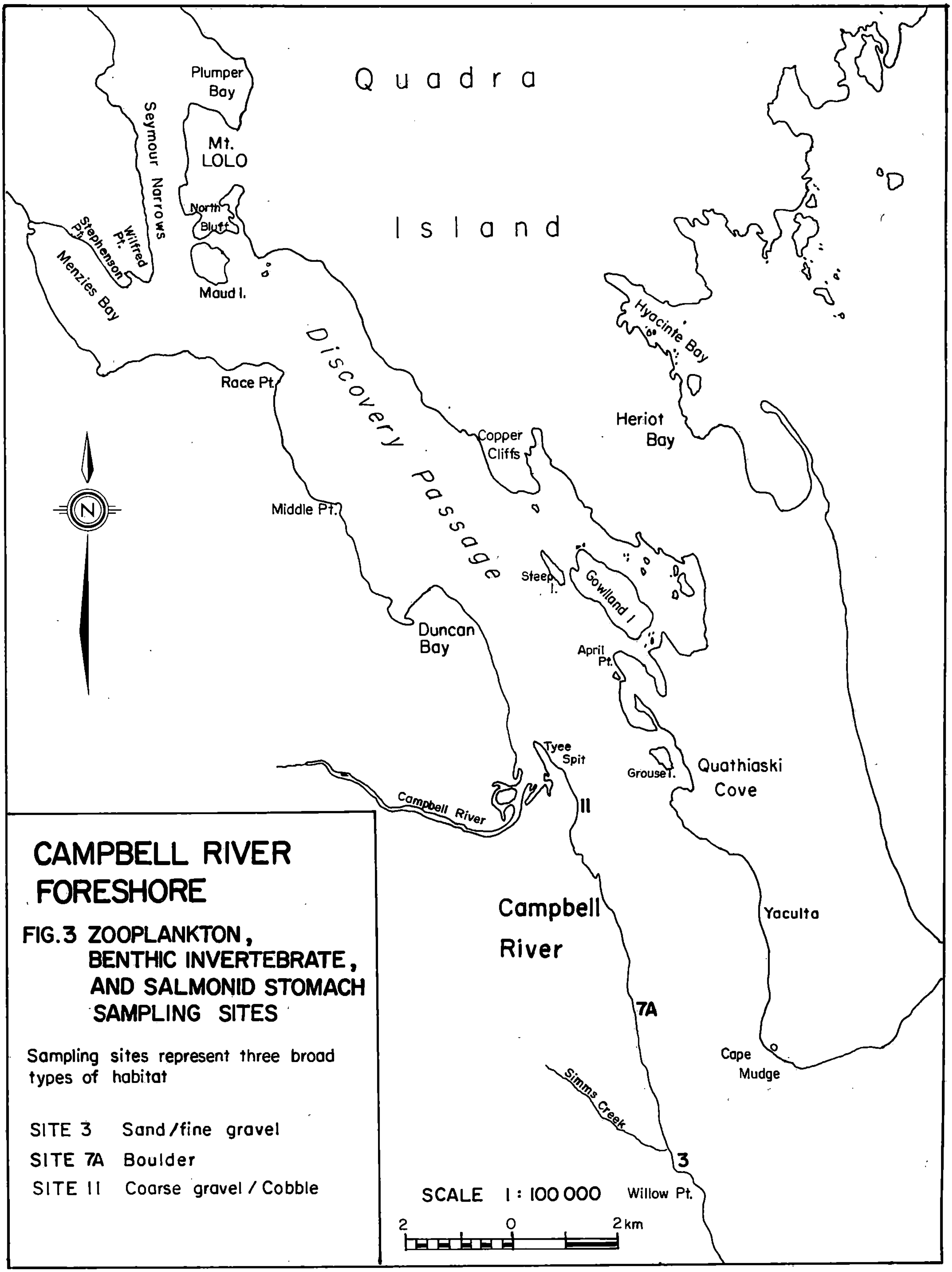
Zooplankton samples were collected at Sites 3, 7A and 11 (see Figure 3) in April, May and June, 1982 (concurrent with benthic sampling). A Miller drift sampler with a 250 μm mesh collecting bag and a 12 cm diameter opening was towed horizontally for five minutes, 50 cm below the water surface. Although the volume of water sampled was not measured, the speed of the boat and the sampling time was the same for all of the samples.

Invertebrate samples were preserved in 80% isopropyl alcohol and analyzed at the DFO West Vancouver Laboratory. For lab analysis procedure, refer to Section 3.5.2.

3.5 Benthic Invertebrate Sampling

3.5.1 Field Methods

Benthic samples were collected during three sampling periods in the spring of 1982 (April, May and June) at Sites 3, 7A and 11 (as previously mentioned).



CAMPBELL RIVER FORESHORE

FIG. 3 ZOOPLANKTON, BENTHIC INVERTEBRATE, AND SALMONID STOMACH SAMPLING SITES

Sampling sites represent three broad types of habitat

SITE 3 Sand/fine gravel
SITE 7A Boulder
SITE 11 Coarse gravel / Cobble

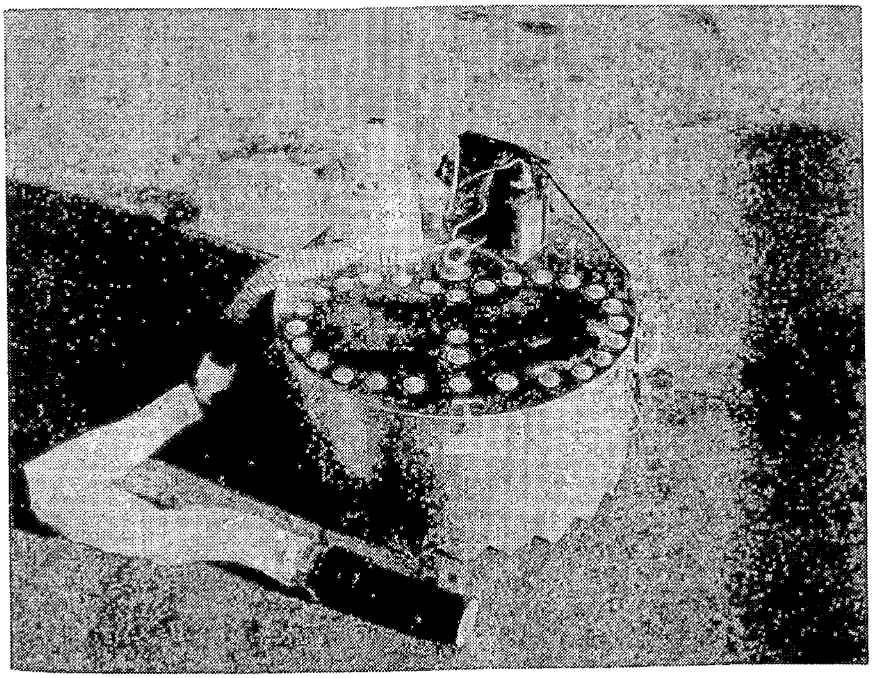
At each site, two sampling zones were established, one at the extreme low tide zone and a second at the mid tide level. Five replicate samples were collected from the two zones at each of the three sites, during the three sampling periods. Samples were collected in water depths varying from 0.3 to 1.3 meters (1 to 4 feet).

A Galen suction sampler was used to collect both the benthic and epibenthic fauna (sampler area = 0.164 m^2). The sediment encompassed by the sampler was stirred to an approximate depth of ten cm in order to send the invertebrates into suspension. A battery powered immersible bilge pump attached to the sampler drew the suspended invertebrates into a 250 μm mesh nytex collecting bag with an attached plastic jar (see Figure 3A). Encrusting taxa, such as mussels, barnacles, etc., if present, were not scraped from enclosed rocks. Therefore, the actual standing crops may be greater than the results indicate. To standardize sampling effort all samples were collected for a two minute pumping period. The samples were then preserved in 80% isopropyl alcohol and sent to the DFO lab in West Vancouver for analysis.

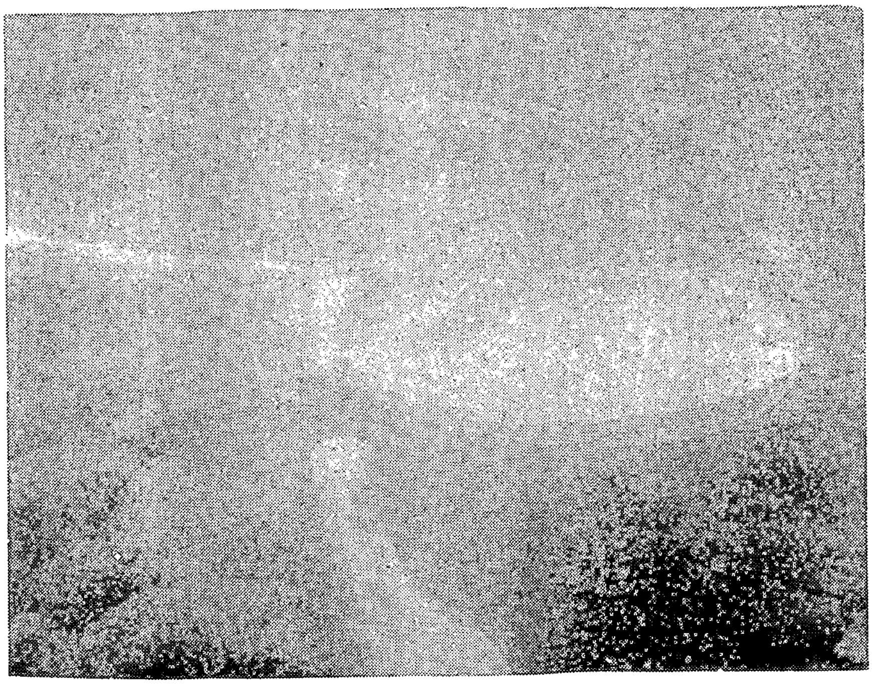
3.5.2 Laboratory Methods

To facilitate sorting of fauna from debris, all invertebrate samples were stained with rose bengal for at least 24 hours prior to

Figure 3A The Galen Invertebrate Sampler



(i) on land



(ii) underwater

analysis. To eliminate any incidental organisms smaller than the Galen sampler's mesh collecting bag or the Miller sampler's mesh, benthic and plankton samples were poured through a 250 μm sieve. When a large amount of sediment was present invertebrates were separated from the rest of the sample by elutriation, a process where the sample was placed in a shallow pan and agitated and flushed with a stream of water. This allowed all material less dense than the sediment, (ie. benthic invertebrates) to be floated out of the pan and into a collecting beaker. This was repeated several times for each sample, so that losses were less than 5 percent.

All of the benthic samples collected from Site 3 and all of the plankton samples collected in June were analyzed completely. However, because of high invertebrate densities, all other benthic and plankton samples were subsampled using a method developed by Dr. H. Mundie (Fisheries Research Branch, Pacific Biological Station, Nanaimo). This technique involved distributing a sample evenly over a collection of vials in the bottom of a large bucket filled with water and randomly selecting a statistically valid number of vials for analysis. This method is described in Appendix Ia.

For the method of calculation of the benthic standing crop, refer to Appendix Ib. The total number of invertebrates$\cdot m^2$ was the standard unit used for comparative purposes.

Four of the five sample replicates were dried and weighed for the determination of biomass expressed as $g \cdot m^{-2}$. Invertebrates important as fish food such as gammarid amphipods, harpacticoid copepods, and cyclopoid copepods were weighed separately from the rest of the organisms present in each sample. Shelled organisms and animals which could not pass through a $9.5mm^2$ sieve were excluded from the biomass measurements. A series of analysis of variance tests (ANOVA's) were conducted comparing invertebrate densities and biomass between the three sites and between the two tidal zones during each of the three time periods. In addition, ANOVA's were conducted to assess significant changes in densities at each specific site over time. When a significant difference was recorded the Student Neuman Keuls multiple range test was utilized to specify which sites or sampling periods were significantly different.

3.6 Fish Sampling

3.6.1 Field Methods

Fish sampling was concentrated in the area between Willow Point and Tyee Spit (see Figure 2, Sites 1 - 12). Sampling was not performed at Site 8 because the substrate was unsuitable for beach seining. Sampling was initiated in mid-April, 1982 and continued to mid-October, 1982. Sampling north of the estuary (Figure 2, Sites 22 - 23, M1 - M4) commenced in late August, 1982 and continued until mid-October, 1982. Sampling was conducted once a month from April through July, 1982 and approximately once a week from August through October, 1982.

During each sampling period, two replicate samples were obtained at each site using a 15 m (50 ft.) by 2 m (6 ft.) beach seine (1/8" mesh bunt and 1/4" mesh wings). Seining was conducted at high tide because the substrate was more suitable at this level. Most of the high tides occurred at night.

Beach seining was also conducted at Sites 3, 7A and 11 (Figure 3) concurrently with all benthic sampling in order to collect salmonids for stomach analysis. These fish were preserved in 10% formalin and analyzed in the lab.

3.6.2 Laboratory Methods

The preserved fish were rinsed with fresh water and blotted dry. Fork lengths were measured to the nearest millimeter and body weights were measured to the nearest milligram.

Scale samples were taken from a few chinook and coho salmon and analyzed by the DFO scale lab (1090 West Pender, Vancouver) to determine age.

Stomach samples were taken from 10 fish of each species collected at each specific site and collecting period (unless fewer were available). The stomach region extending from the esophagus to the pyloric caeca was removed and stored in 80% isopropyl alcohol.

Prior to analysis, each full stomach was placed on a damp filter paper and suction dried for a period of two minutes in order to obtain a standard moisture content. The stomach was then weighed on a Mettler electronic balance. Following this, the food contents were removed and the empty stomach was reweighed in order to obtain the weight of the stomach contents.

All food items were measured to the nearest millimeter. Most were identified to the order level. Amphipods were identified to the species level whenever possible.

To obtain the biomass of the invertebrate orders, food items were grouped to order, dried at a temperature of 90°C for 24 to 96 hours and then weighed. Digested material which could not be identified was not weighed. Indices of relative importance (I.R.I.) of each food item were then calculated according to the formula:

$$I.R.I = (\%N + \%W)\%FO$$

where %N = percent by number

%W = percent by dry weight

%FO= percent frequency of occurrence.

(from Pinkas et al. 1971)

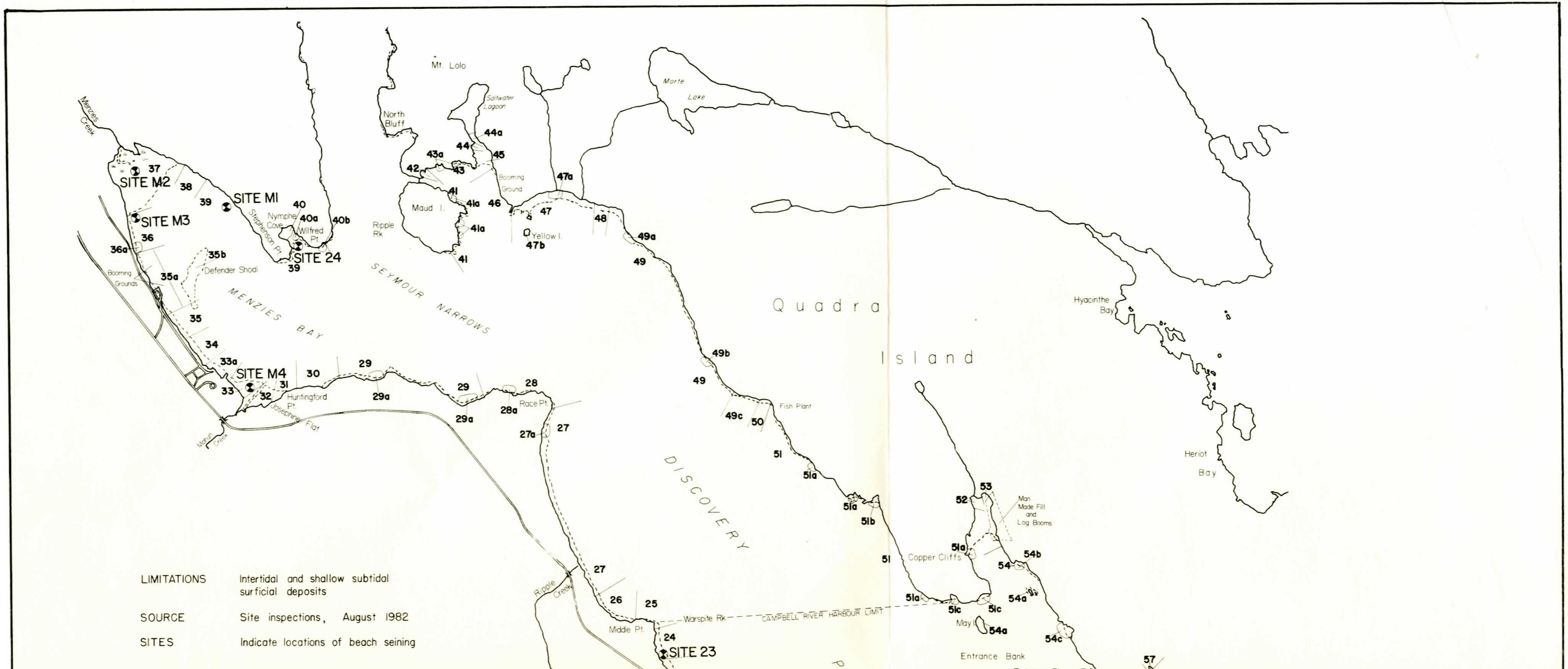
This method of stomach analysis does not take into account varying rates of digestion and evacuation among different taxa. Soft bodied animals such as annelids can be expected to be digested at a much faster rate than harder bodied crustacea. Bias can therefore be expected to favor harder bodied prey items.

Fish stomachs were initially preserved in 10% formalin, then later transferred to 80% isopropanol. In both formalin and isopropanol soluable materials such as lipids will dissolve out of the organisms into solution (Gonor et al. 1978). Therefore, dry weights for preserved samples will be less than for unpreserved samples.

4. RESULTS

4.1 Substrate Composition

Substrate composition is a major factor in determining the floral



LIMITATIONS Intertidal and shallow subtidal surficial deposits

SOURCE Site inspections, August 1982

SITES Indicate locations of beach seining

SITES Indicate locations of beach seining

1000 0 1000 4000

SCALE IN METRES

SECTION	1. SILT-CLAY	2. SAND	3. FINE GRAVEL	4. COARSE GRAVEL	5. SMALL COBBLE	6. LARGE COBBLE	7. BOULDER	8. BEDROCK
	MODIFIED WENTWORTH SCALE (%)							
1	-	-	25	25	25	25	-	-
2	5	-	-	-	-	10	10	75
3	-	5	-	-	20	25	30	20
4	-	15	20	30	30	5	-	-
5	-	25	20	15	10	5	15	10
6	-	-	5	15	20	30	30	-
7	-	-	5	15	75	-	5	-
8	-	-	-	5	5	40	50	-
9	-	-	5	15	10	60	10	-
10	-	-	5	5	5	40	45	-
11	-	-	100	-	-	-	-	-
12	-	-	5	10	15	-	70	-
13	100	-	-	-	-	-	-	-
14	-	-	5	10	15	40	30	-
15	-	10	25	65	-	-	-	-
16	-	-	15	85	-	-	-	-
17	-	60	-	5	5	10	20	-
18	-	20	20	20	20	20	-	-
19	-	-	-	-	-	-	100*	-
20	-	100	-	-	-	-	-	-
21	-	60	-	-	-	-	-	40
22	-	50	15	20	10	5	-	-
23	-	5	5	5	25	40	20	-
24	-	90	10	-	-	-	-	-
25	-	-	-	-	-	-	-	100
26	-	-	-	-	10	70	20	-
27	-	10	-	5	10	15	60	-
27a	-	-	100	-	-	-	-	-
28	-	-	-	-	-	-	10	90
28a	-	-	100	-	-	-	-	-
29	-	-	-	5	10	5	80	-
29a	-	-	20	80	-	-	-	-
30	-	-	-	-	5	25	70	-
31	-	80	-	-	-	-	20	-
32	-	90	-	-	-	-	10	-
33	-	15	20	50	10	5	-	-
33a	35	-	10	25	25	5	-	-
34	-	15	20	20	20	20	5	-
35	-	12.5	12.5	15	10	20	30	-
35a	-	-	5	5	25	35	30	-
35b	100	-	-	-	-	-	-	-
36	-	75	5	5	5	5	5	-
36a	-	20	20	10	10	10	30	-
37	-	75	15	10	-	-	-	-
38	-	50	25	5	5	-	15	-
39	-	-	-	-	-	-	15	85
40	95	-	-	-	-	5	-	-
40a	-	7.5	7.5	15	30	20	20	-
40b	-	-	-	-	-	-	-	100
41	-	-	-	-	-	-	-	100
41a	-	-	-	5	15	40	40	-
42	-	-	20	30	30	15	5	-
43	-	-	-	-	-	-	-	100
43a	-	-	-	5	15	40	40	-
44	40	-	10	10	15	5	20	-
44a	-	100	-	-	-	-	-	-
45	-	-	10	5	5	40	40	-
46	-	-	-	-	-	-	-	100
47	-	-	-	5	30	30	35	-
47a	-	20	40	40	-	-	-	-
47b	-	-	-	-	-	-	-	100
48	-	20	40	40	-	-	-	-

SECTION	1. SILT-CLAY	2. SAND	3. FINE GRAVEL	4. COARSE GRAVEL	5. SMALL COBBLE	6. LARGE COBBLE	7. BOULDER	8. BEDROCK
	MODIFIED WENTWORTH SCALE (%)							
49	-	-	5	10	20	40	25	-
49a	-	5	15	10	35	35	-	-
49b	-	-	10	15	70	5	-	-
49c	-	-	-	-	-	-	-	100
50	-	-	25	50	10	10	5	-
51	-	-	-	-	-	-	20	80
51a	-	-	-	-	-	-	100	-
51b	-	10	35	35	10	5	5	-
51c	-	-	10	10	20	20	40	-
52	12.5	12.5	5	-	15	15	20	20
53	50	50	-	-	-	-	-	-
54	-	-	-	-	-	-	20	80
54a	-	-	-	-	-	-	-	100
54b	-	5	15	10	35	35	-	-
54c	-	45	15	15	15	-	10	-
55	-	30	-	15	15	15	25	-
56	-	-	-	-	-	5	5	90
57	-	75	12.5	12.5	-	-	-	-
58	-	5	5	-	-	30	60	-
58a	-	-	-	-	-	-	-	100
59	-	75	5	5	5	5	5	-
60	-	15	15	-	-	20	50	-
61	-	-	-	-	-	-	-	100
62	-	90	-	-	-	5	5	-
62a	-	30	10	10	10	20	20	-
62b	-	-	-	-	-	10	10	80
63	-	30	30	30	10	-	-	-
64	-	100	-	-	-	-	-	-
65	-	50	10	-	40	-	-	-
66	-	-	-	-	-	10	10	80
66a	-	50	-	20	20	5	5	-
66b	-	-	-	-	-	10	10	80
67	-	25	25	25	25	-	-	-
68	-	5	5	5	25	35	25	-
69	-	-	-	-	-	-	20	80
70	-	10	40	40	5	-	5	-
71	-	-	-	-	-	-	-	100
72	-	-	10	30	20	20	20	-
73	-	5	5	30	40	10	10	-
74	95	-	-	-	5	-	-	-
75	-	-	-	-	-	-	-	100
75a	-	-	-	-	-	10	10	80
75b	-	-	20	20	20	20	20	-
75c	-	-	-	-	-	-	100	-
75d	-	-	10	35	-	20	35	-
76	-	60	5	15	15	5	-	-
77	-	-	-	-	-	-	-	100
78	-	-	15	30	10	25	20	-
79	-	-	-	-	-	-	25	75
79a	-	50	-	20	20	5	5	-
80	-	-	-	-	-	-	-	100
81	-	-	-	10*	10*	40	40	-
82	-	75	5	5	5	5	5	-
83	-	-	-	-	-	-	20	80
84	-	5	5	5	20	30	35	-
85	-	-	40	40	5	5	5	5
86	-	5	7.5	7.5	-	40	40	-
87	-	-	30	35	35	-	-	-
88	-	10	15	5	5	15	50	-
89	-	-	-	15	15	35	35	-
90	-	-	10	20	25	40	5	-

* Man - made Fill

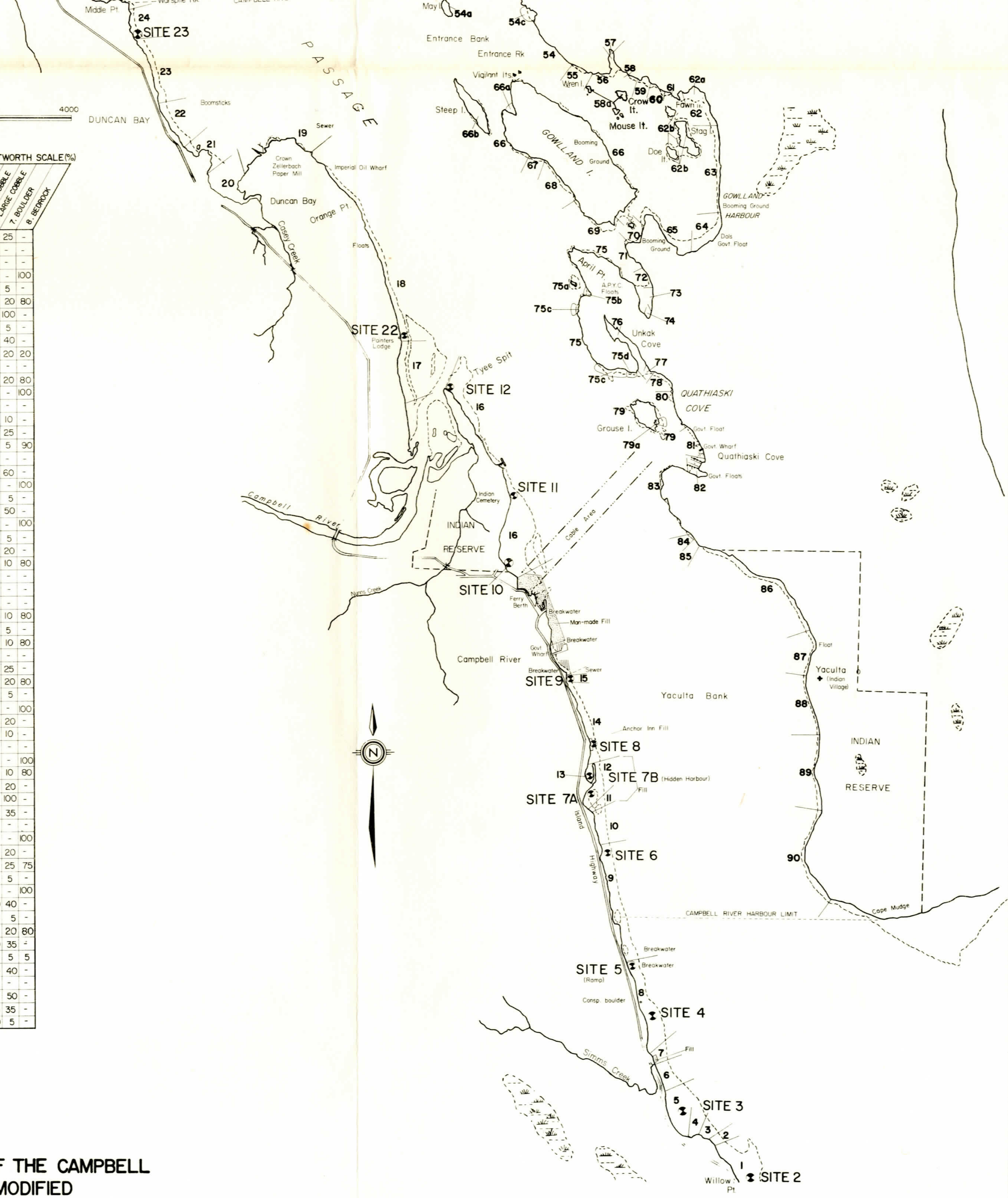


FIGURE 4 - SUBSTRATE COMPOSITION (%) OF THE CAMPBELL RIVER FORESHORE USING THE MODIFIED WENTWORTH SCALE

and faunal composition of a foreshore biological community. The destruction or removal of a particular substrate type means the elimination of the particular associated vegetation and invertebrates. Therefore, substrate composition is a valuable indicator of foreshore productivity.

The substrate composition of the study area is presented in Figure 4.

The strong currents of Discovery Passage have a direct influence on the substrate composition of the study area. In general, areas exposed to the current consist mainly of bedrock and large boulders. The finer substrates (ie. silt, sand and gravel) are swept from the exposed areas and are deposited in the more sheltered areas.

From Willow Point (Sec.1) north to the sewer (Sec. 15) the surficial substrate consists generally of large cobble and boulders. The exceptions are the beach at Site 3 (Sec. 5), which consisted of sand in the lower intertidal and sandstone in the upper intertidal zone, and Hidden Harbour (Sec. 13), a very sheltered area comprised entirely of silt.

North of the sewer there has been a man-made fill (marine breakwaters) composed of large boulders. The substrate north of the ferry terminal to the tip of the Tyee Spit (Sec. 16) consists mostly of coarse gravel. The foreshore sampled south of Painter's Lodge (ie. the estuary; Sec. 17) consists generally of sand, whereas the area north of Painter's Lodge to Orange Point (Sec. 18) contains a mixture of sand, gravel and cobble. A man-made fill consisting of large boulders makes up the foreshore of the Crown Zellerbach Paper Mill (Sec. 19). Duncan Bay (Sec. 20) is composed of 100% sand and the foreshore north of this area to Huntingford Point (Sec. 30) consists of beaches with a mixture of sand, gravel, cobble and boulders. Bedrock exists at the more exposed areas of this stretch (ie. Middle Point and Race Point; Sec. 25 and 28).

The substrate of the Menzies Bay foreshore (Sec. 31 - 38) is generally of a finer consistency than the last stretch (Sec. 21-30). It is composed mostly of sand and gravel with some cobble and boulders near the booming grounds (Sec. 34 - 35a). The northeastern side of Menzies Bay and the outermost points of Nymphe Cove (Section 39 and 40b) consist of bedrock, but Nymphe Cove (Sec. 40) and Defender Shoal (Sec. 35b) consist almost entirely of silt.

The eastern side of Maud Island (Sec. 41) and the adjacent Quadra Island foreshore (Sec. 43 and 46) is comprised mostly of bed-rock. The western side of Maud Island was not surveyed. Boulders and large cobble dominate the stretch of Quadra Island foreshore that extends from the point opposite Yellow Island (Sec. 47) to north of the fish plant (Sec. 49). Bedrock again makes up a large proportion of the foreshore from the fish plant (Sec. 49c) to the southern point of Quathiaski Cove (Sec. 83) and most of the foreshore of the islands along the Quadra Island coastline.

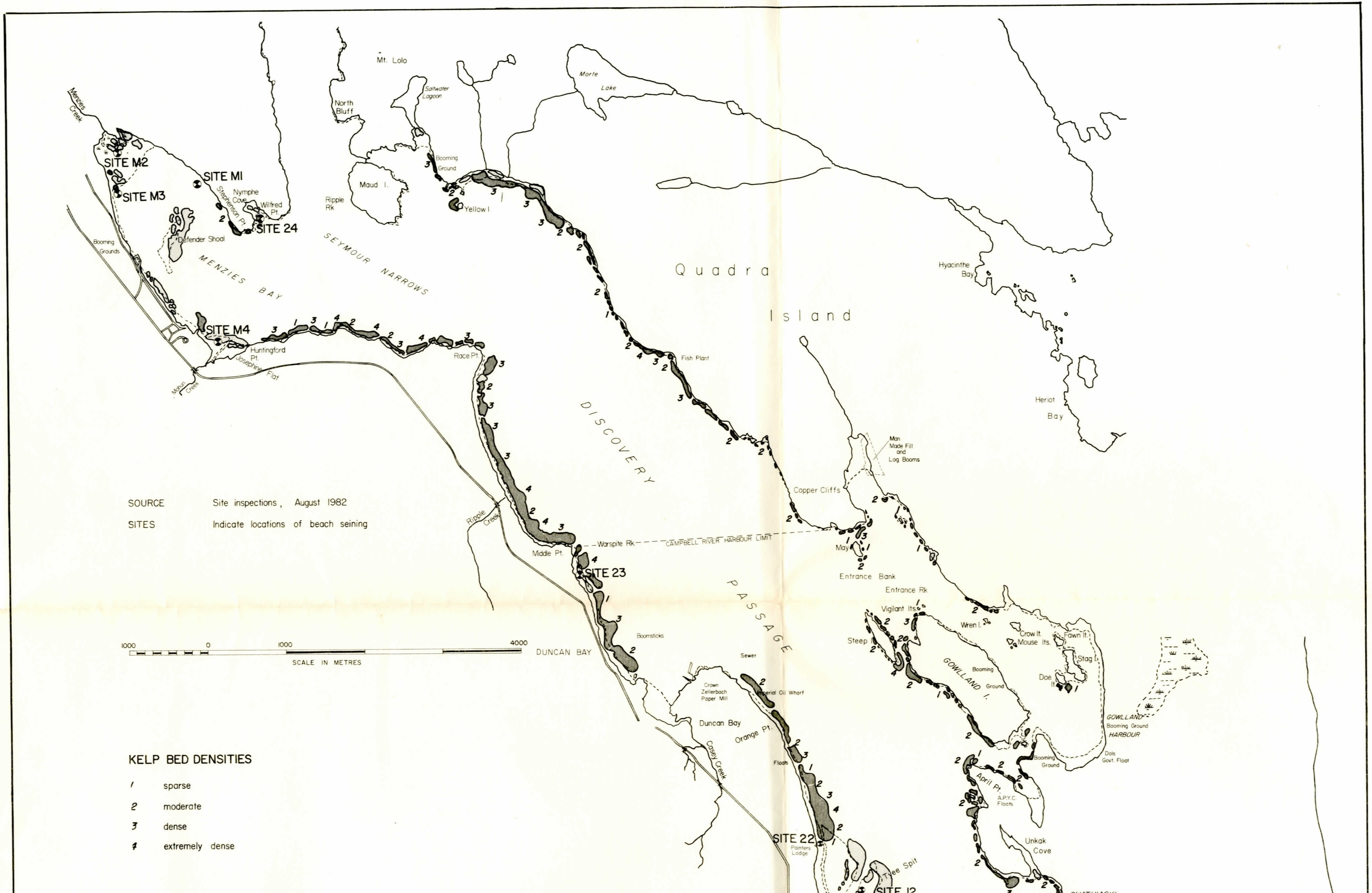
Most of the sheltered coves on Quadra Island within the study area (ex. Saltwater Lagoon - Sec. 44 and 44a; Gowlland Harbour - Sec. 62 - 65; Unkak Cove - Sec. 66; Quathiaski Cove - Sec. 82; and other smaller coves) have sandy or silty substrates. From the point south of Quathiaski Cove (Sec. 84) to Cape Mudge (Sec. 90) the foreshore consists of a mixture of gravel, cobble and boulders. The substrate was not examined beyond this point.

4.2 Vegetation Distribution

Foreshore vegetation communities including kelp and eelgrass beds are a major contributor to biological productivity as they are the main source of detritus (decayed organic matter) on which many of the nearshore food webs are based. Vegetation may also reduce currents and bind surface sediments reducing surface erosion and accumulating inorganic and organic material within the vegetation bed. The increased surface area provided by macroalgae and seagrasses support epiphytes (flora and fauna attached to the plants) which may exceed the biomass of the host plants (Odum, 1971). Microhabitats associated with holdfasts or rhizomes support an abundance of invertebrates. Finally, foreshore vegetation may provide a spawning substrate for Pacific herring and protection from predators for other fish species. For these reasons, vegetated foreshores are considered productive fish habitat for resident fish species and transient species such as juvenile salmon and herring (Dept. of Fisheries & Oceans, Habitat Management Division, Ucluelet Inlet Report, 1983).

Large kelp beds of the species Nereocystis luetkeana were found throughout most of the study area. Eelgrass beds (Zostera marina) were also found in several locations. Figure 5 shows the distribution of kelp and eelgrass beds and the relative densities of the kelp beds. (Note: Although two other kelp species occurred within the study area, Alaria sp. and Laminaria sp., only Nereocystis is shown in Figure 5. The other two species are noted in Figure 6.)

Nereocystis luetkeana, an annual kelp, may grow in waters up to 18 m deep, but is usually found from 7 - 9 m below zero tide level, attached to rocky bottoms. It is able to tolerate strong currents and exposure to surf. However, the holdfasts must attach to rocks of a size sufficiently large enough to withstand



Mt. Lolo
Menzies Creek
Saltwater Lagoon
North Bluff
Morte Lake
SITE M2
SITE M1
SITE M3
Nymphe Cove
Stephenson Pt.
Wilfred Pt.
SITE 24
Booming Ground
Maud I.
Ripple Rk
Yellow I.
Defender Shoal
Booming Grounds
SEYMOUR NARROWS
MENZIES BAY
Quadra
Island
Hyacinthe Bay
SITE M4
Huntingford Pt.
Josephine Flat
Mohun Creek
Race Pt.
Fish Plant
Heriot Bay
DISCOVERY
Man Made Fill and Log Booms
Copper Cliffs
SOURCE Site inspections, August 1982
SITES Indicate locations of beach seining
Ripple Creek
Warspite Rk
CAMPBELL RIVER HARBOUR LIMIT
Middle Pt.
May I.
SITE 23
Entrance Bank
Entrance Rk
PASSAGE
Vigilant Its.
Wren I.
Boomsticks
Steep I.
Crow It.
Mouse Its.
Fawn It.
Stag I.
1000 0 1000 4000
SCALE IN METRES
DUNCAN BAY
Sewer
GOWLLAND I.
Booming Ground
Doe It.
Crown Zellerbach Paper Mill
Imperial Oil Wharf
Duncan Bay
Orange Pt.
GOWLLAND Booming Ground HARBOUR
Casey Creek
Floats
Booming Ground
Dols Govt. Float
KELP BED DENSITIES
1 sparse
2 moderate
3 dense
4 extremely dense
April Pt.
A.P.Y.C. Floats
SITE 22
Painters Lodge
Unkak Cove
Tyee Spit
SITE 12

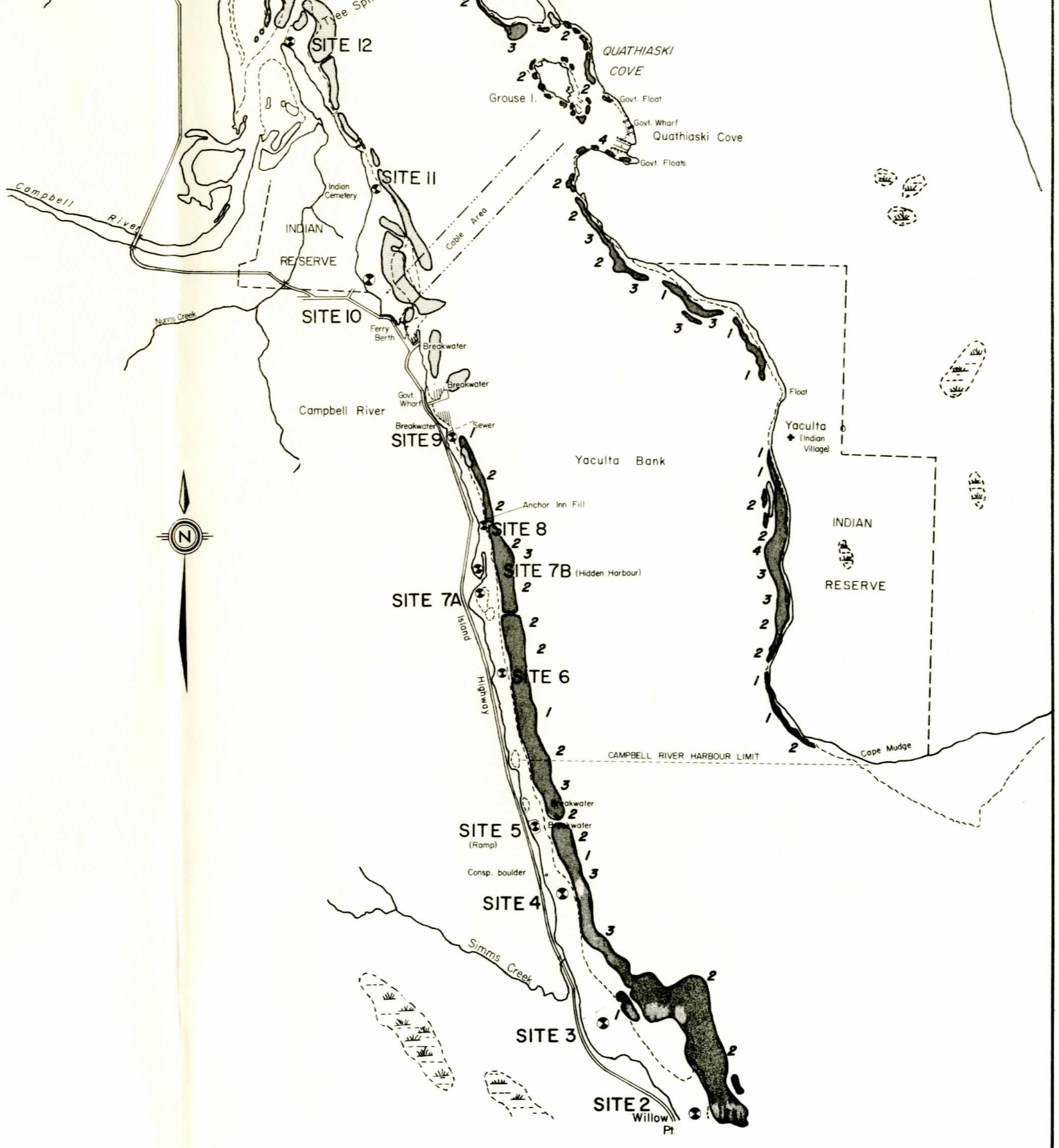


FIG 5 - KELP *(Nereocytis luetkeana)* AND
EELGRASS *(Zostera marina)* DISTRIBUTION

the stresses which waves can impose on these large plants (Dome Petroleum Ltd., 1981).

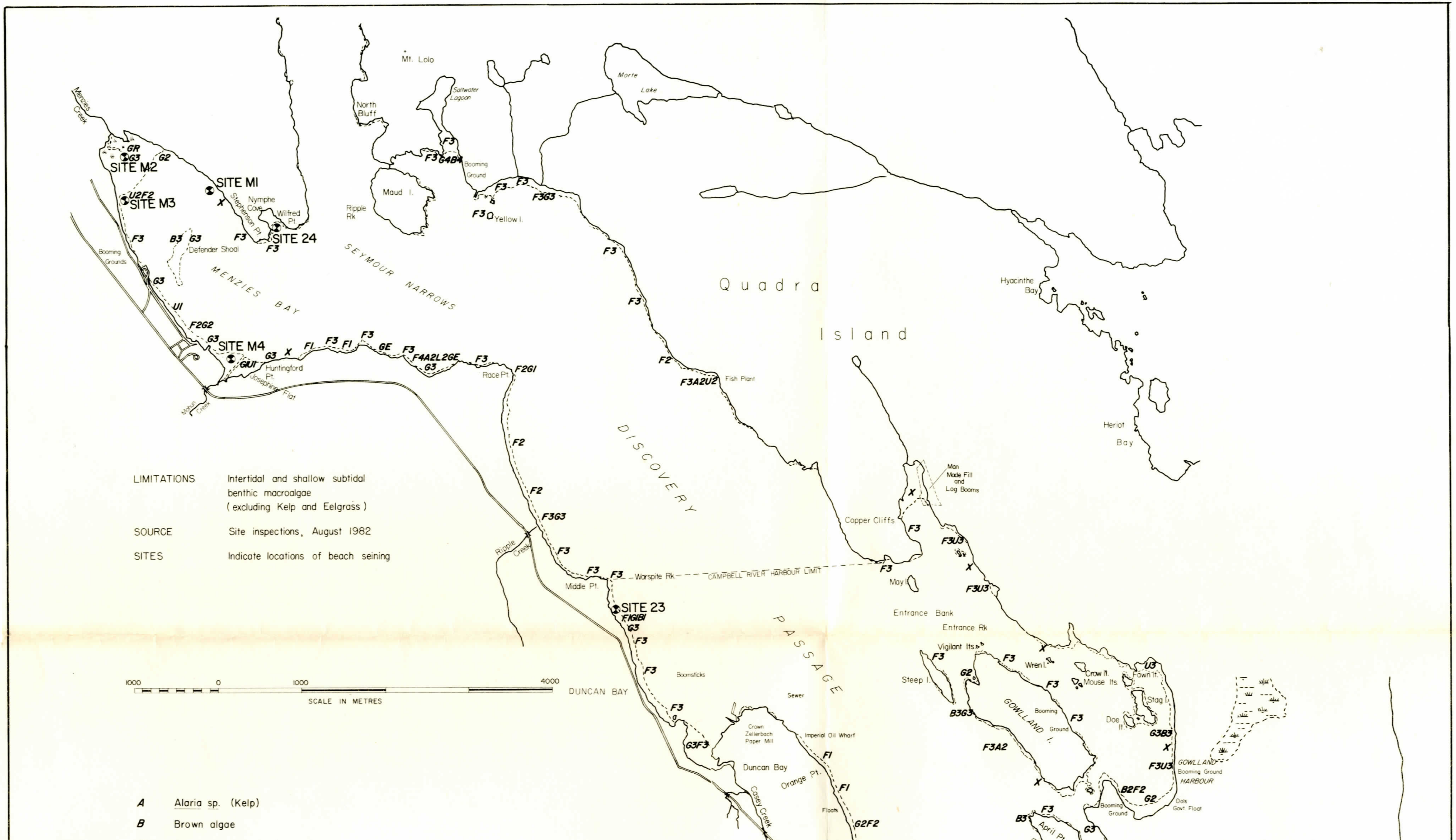
A very prominent, continuous strip of Nereocystis was observed to extend from Site 9 south to Willow Point and beyond. Another strip occurred slightly north of Painter's Lodge and continued northward to Orange Point. Both of these Nereocystis strips had several man-made pathways cut through them for boat access to public and private ramps. Another kelp strip began north of Duncan Bay and followed the coastline northward to the outer limits of Menzies Bay at Huntingford Point. Patches also occurred around Stephenson Point on the eastern side of Menzies Bay.

Maud Island vegetation was not surveyed. A long strip of individual kelp beds were observed along the Quadra Island coastline from the outer limits of Saltwater Lagoon south to the northern point of Gowlland Harbour. Most of these beds were smaller patches of kelp in relation to those found on the other side of Discovery Passage. Several small patches were also observed on the west side of Gowlland Island, around Steep and Grouse Islands, and south of Gowlland Harbour to the south side of Quathiaski Cove. From this point south to the lighthouse near Cape Mudge the beds became longer and wider. The vegetation was not examined beyond Cape Mudge.

In general, the eelgrass Zostera marina is most abundant in habitats characterized by salinities of 10.0 to 30.0 parts per thousand, temperatures of 10^0 to 20^0C, substrates of sand or silty sand, low exposure and in subtidal and very low intertidal zones (Campbell River, 1.2 to -4.0 meters). Desiccation of the plant, a function of tidal exposure and substrate type, determines the upper limit of Z. marina growth, while the lower limit is primarily controlled by light availability (Raymond et al., in prep.).

The most prominent eelgrass beds occurred near the Campbell River estuary, from the breakwaters north of Site 9 to Painter's Lodge (Site 22). Menzies Bay also had several large beds of eelgrass, especially on Defender Shoal. Small patches were also observed in Nymphe Cove, on the Quadra Island foreshore opposite Yellow Island and opposite Entrance Rock, in the entrances to Saltwater Lagoon and Unkak Cove, and south of Yaculta.

The presence and relative densities of aquatic vegetation other than Nereocystis and Zostera is displayed in Figure 6. (Note: In Figure 6, unidentified brown and green algae does not exclude Fucus and Ulva. Areas where observations of vegetation were not recorded are left with no vegetation designation (ie. blank) and areas which were void of vegetation were recorded as "x").


Mt. Lolo
Menzies Creek
North Bluff
Saltwater Lagoon
Morte Lake
Booming Ground
Maud I.
Ripple Rk
Yellow I.
SITE M1
SITE M2
SITE M3
SITE M4
SITE 23
SITE 24
Nymphe Cove
Stephenson Pt.
Wilfred Pt.
Defender Shoal
Booming Grounds
SEYMOUR NARROWS
MENZIES BAY
Quadra
Island
Huntingford Pt.
Josephine Flat
Mohun Creek
Race Pt.
Fish Plant
Hyacinthe Bay
Heriot Bay
Man Made Fill and Log Booms
Copper Cliffs
DISCOVERY PASSAGE
Warspite Rk.
CAMPBELL RIVER HARBOUR LIMIT
Middle Pt.
May I.
Entrance Bank
Entrance Rk
Vigilant Its.
Steep I.
Wren I.
Crow It.
Mouse Its.
Fawn It.
Stag I.
Doe It.
GOWLAND I.
GOWLLAND HARBOUR
Booming Ground
Dols Govt. Float
April Pt.
Ripple Creek
Boomsticks
Sewer
Crown Zellerbach Paper Mill
Imperial Oil Wharf
Duncan Bay
Orange Pt.
Casey Creek
Floats
DUNCAN BAY
1000 0 1000 4000
SCALE IN METRES
LIMITATIONS Intertidal and shallow subtidal benthic macroalgae (excluding Kelp and Eelgrass)
SOURCE Site inspections, August 1982
SITES Indicate locations of beach seining
A Alaria sp. (Kelp)
B Brown algae

B Brown algae

F Fucus sp. rockweed (Brown)

G Green algae

GE Green epiphyte (on Kelp stipes)

GR Grasses

L Laminaria sp. (Kelp)

U Ulva sp. (Green)

X Unvegetated open area

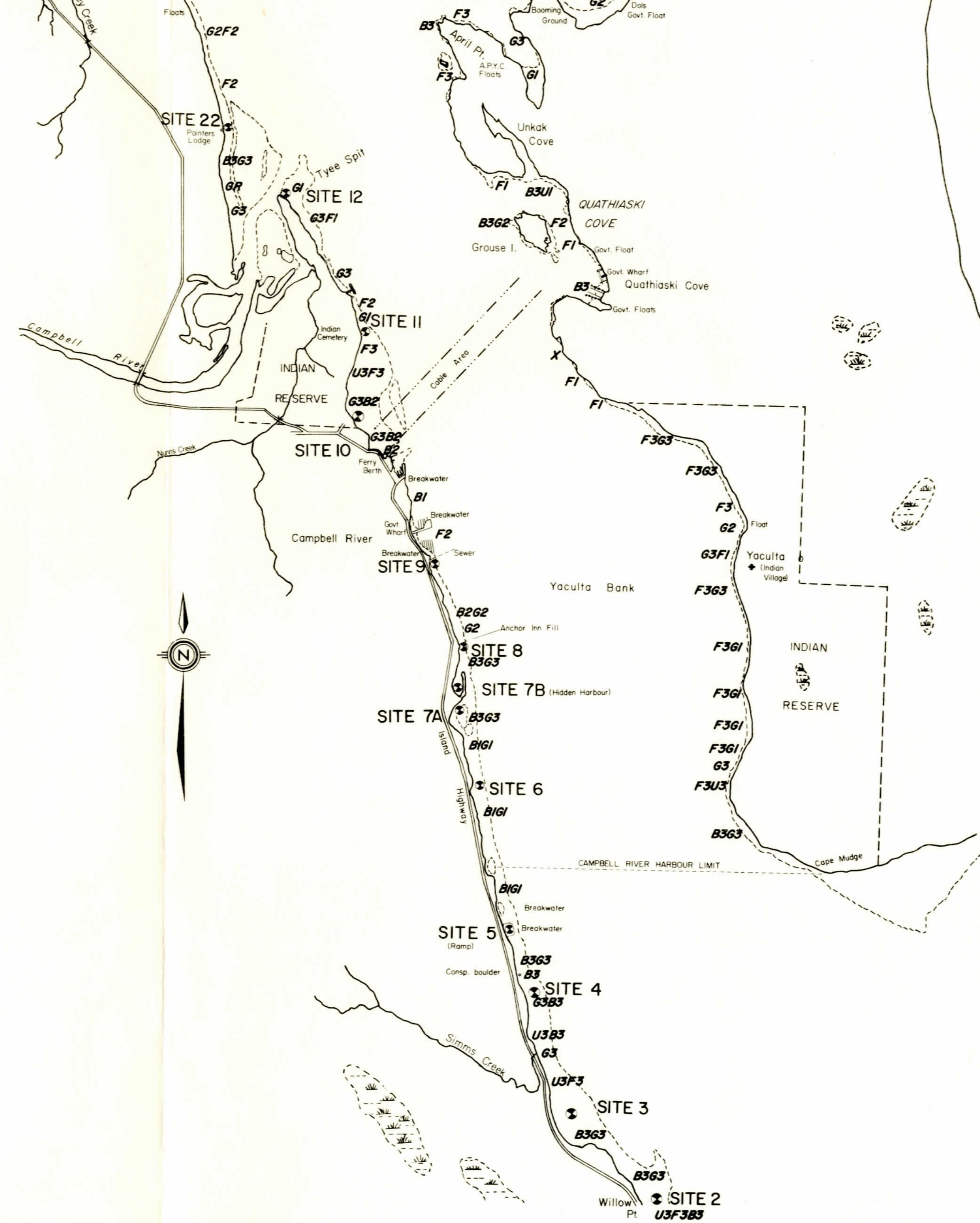
/ sparse

2 scattered, patchy

3 moderate

4 dense

FIG 6 - VEGETATION DISTRIBUTION
(excluding Kelp and Eelgrass)



Fucus sp. occurred on rocky substrate in the high intertidal zone over most of the study area. Ulva sp. was also common, occurring in the lower intertidal zones. Several species of red algae were also observed in many locations but were not recorded in the field notes. Species identification of the vegetation was not required for the purposes of this study. However, it was noted in the Campbell River Estuary Report (Bell and Thompson, 1977) that Chondrus, Enteromorpha, Porphyra, Iridaea and Petrocelis were observed as well as the genera noted in our study.

4.3 Zooplankton

Invertebrates which inhabit the water column, the zooplankton, are an important part of the neritic food web, as they transfer energy from the primary producers (phytoplankton) to the higher trophic levels (planktivorous fish). The calanoid copepod, a neritic invertebrate, is particularly important as a food source for Pacific herring and juvenile salmonids (Simenstad et al., 1979).

A list of all invertebrates found in plankton tows is given in Table 3.

TABLE 3 - LIST OF INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE PLANKTON TOWS IN APRIL, MAY AND JUNE, 1982

ORDER	FAMILY	GENUS SPECIES
Amphipoda	Caprellidae	
(Gammaridea)	Calliopiidae	_Calliopiella pratti_
	Pontogeniidae	_Accedomoera vagor_ _Pontogeneia rostrata_
(Hyperiidea)	Unknown	
Cirrepedia **	Cyprid Larvae	
Calanoida		
Decapoda		
Diptera	Chironomidae	
Insecta *		
Isopoda	(Cryptoniscan larvae)	
Nematoda▲		
Malacostraca **		
Osteicthyes *		
Polychaeta *		
Scyphozoa		

* Class
** Subclass
▲ Phylum

Figures 7, 8 and 9 show the distribution and abundance of the invertebrates found in the plankton samples collected in April, May and June, 1982 respectively. More detailed results may be found in Appendices II a, b and c.

The number of invertebrates/sample decreased by a factor of 10 in June from the two earlier samples. (Mean number of invertebrates per site $\approx 1.6 \times 10^2$ in April and May, and $\approx 1.6 \times 10^1$ in June.) In general, copepods were found to be numerically dominant in the plankton samples. Calanoid copepods were generally the dominant invertebrate in the April samples, whereas other copepods (harpacticoid and cyclopoid) appear to have dominated the samples collected in May and June. One exception to this rule is Site 11 in which the highest number of calanoid copepods were found in May. Note that only one sample was collected at each site during each sampling period.

The decline of zooplankton in June was probably due to a decline of a major food source, the phytoplankton. Cushing (1964) found that the decline of the spring bloom in the North Sea is closely related to overconsumption by *Calanus*, a calanoid copepod. With the decline of its major food source, *Calanus* populations also decline rapidly.

FIGURE 7. MEAN NUMBER OF INVERTEBRATES FOUND IN PLANKTON TOWS COLLECTED IN APRIL, 1982

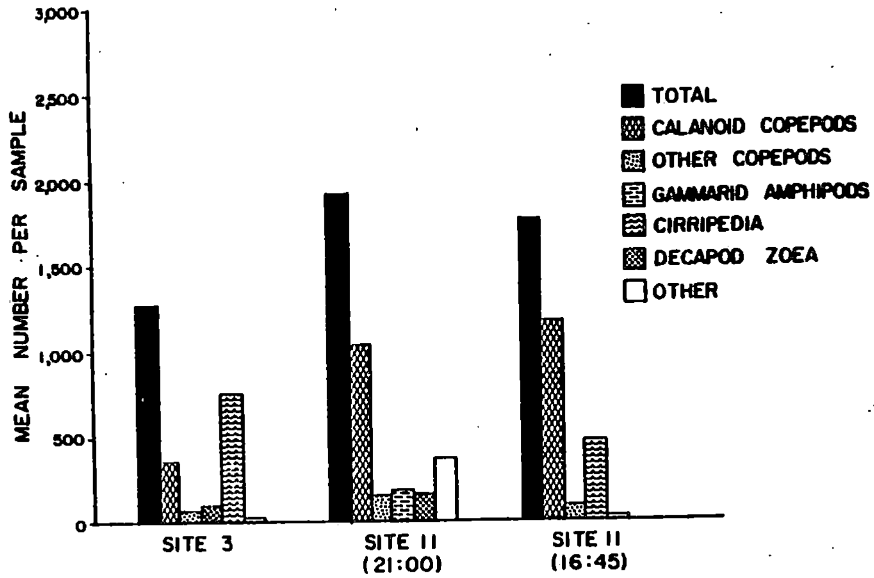


FIGURE 8. MEAN NUMBER OF INVERTEBRATES FOUND IN PLANKTON TOWS COLLECTED IN MAY 1982.

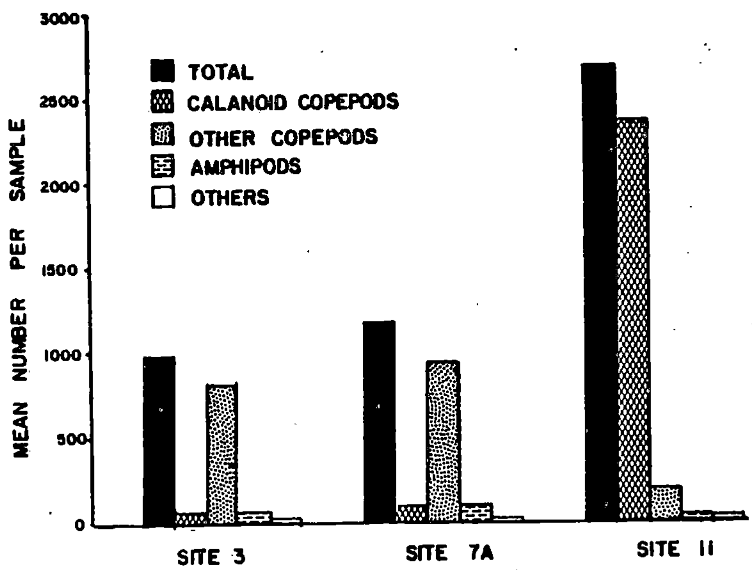
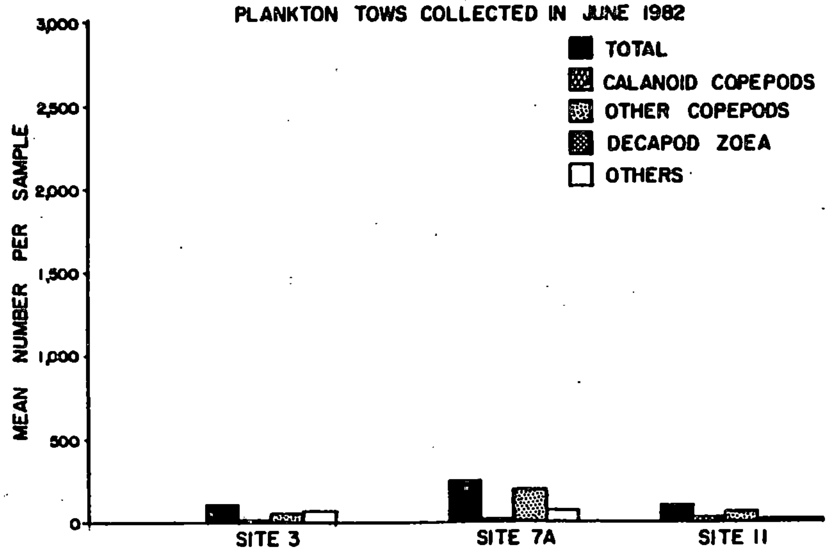


FIGURE 9. MEAN NUMBER OF INVERTEBRATES FOUND IN PLANKTON TOWS COLLECTED IN JUNE 1982



4.4 Benthic Invertebrates

Benthic invertebrates inhabit the surface of the aquatic substrate (epifauna) and the sediment proper (infauna). Many feed on bacteria trapped in the sediment and detritus (decayed organic matter) derived from algae and macrophytes. Similar to the zooplankton, benthic invertebrates transfer energy from the primary producers to the higher trophic levels (fish). Gammarid amphipods and harpacticoid copepods, the major detritivorous crustaceans found in the benthos, are important in juvenile salmonid diets. (Simenstad et al., 1979; Sibert et al., 1979).

A list of all invertebrates found in the benthic samples is shown in Table 4. Although invertebrates other than those found in the benthic and zooplankton samples were not surveyed for the purpose of this study, a few common taxa were observed. For example, barnacles and mussels were observed on the rocky shores. In the open sandy areas amongst the eelgrass beds south of the estuary (between Sites 10 and 11) there were dense populations of sanddollars. The starfish _Pisaster ochraceous_ was observed in between Sites 10 and 11, above the eelgrass beds (Figure 2Aix). Other invertebrates inhabitating Discovery Passage near Campbell River are mentioned in the Campbell River Estuary Report (Bell and Thompson, 1977).

TABLE 4 - LIST OF INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES IN APRIL, MAY AND JUNE, 1982

ORDER	FAMILY	GENUS SPECIES
Acarina		
Amphipoda	Ampithoidae	Amphithoe simulans Amphithoe lacertosa Amphithoe sp.
	Aoridae	Aoroides columbiae
	Calliopiidae	Calliopiella pratti Calliopius laeviusculus
	Caprellidae	Caprella alaskana Caprella laeviuscula
	Corophiidae	Corophium sp.
	Gammaridae	Melita sp.
	Hyalidae	Hyale plumulosa Hyale frequens Allorchestes angustus
	Ischyroceridae	Ischyrocerus sp.
	Pontogeniidae	Pontogeneia rostrata Paramoera mohri Accedomoera vagor
	Photidae	Photis brevipes
	Pleustidae	Pleustes depressa Pleusirus secorrus
	Phoxocephalidae	Paraphoxus spinosus
	Podoceridae	Podocerus cristatus
	Oedicerotidae	Synchelidium shoemakeri
	Talitridae	
	Gammaridea ..	
Anthozoa *		
Archaeogastropoda		
Asteroidea *		
Bivalvia ▲	Cardiidae	Clinocardium nuttalli
	Mytilidae	

TABLE 4 (con't)

ORDER	FAMILY	GENUS SPECIES
Cirripedia **		
Copepoda **	Calanoida .	
	Cyclopoida .	
	Harpacticoida .	
Cumacea		Cumella sp. Lamprops sp.
Decapoda	Grapsidae	Hemigrapsus oregonensis Hemigrapsus nudus
	Majidae	Pugettia producta Pugettia richii Mimulus foliatus
	Paguridae	Pagurus sp.
	Caridea ■	Crangon sp.
	Brachyura ■	
	Hippolytidae	Heptacaspus brevirostris
Diptera	Chironomidae	
	Nematocera ..	
Echinoidea		
Gastropoda *		
Insecta *		
Isopoda	Idoteidae	Idotea sp.
	Janiridae	Janira sp.
	Bopyridae	
	Munnidae	Munna sp.
	Sphaeromatidae	Gnorimosphaeroma sp.
Malacostraca **		

TABLE 4 (con't)

ORDER	FAMILY	GENUS SPECIES
Nematoda▲		
Nemertea		
Nudibranchia		
Oligochaeta *		
Ostracoda **		
Ophiuroidea **		
Nemertinea▲		
Mesogastropoda	Naticidae	Polinices lewesii
Osteichthyes *	Cottidae	
	Stichaeidae	
Polychaeta * (Site 7A only)	Arabellidae	Arabella sp.
	Capitellidae	Capitella capitata
	Chrysopetalidae	Paleanotus bellis Paleanotus sp.
	Dorvilleidae	Dorvillea sp.
	Glyceridae	Hemipodus borealis
	Goniadidae	
	Hesionidae	
	Lumbrineridae	
	Nereidae	Platynereis bicaniculata Nereis sp.
	Nerillidae	
	Onuphidae	Onuphis sp.
	Opheliidae	Armandia brevis
	Phyllodocidae	Eteone sp. Phyllodoce castanea
	Polynoidae	

TABLE 4 (con't)

ORDER	FAMILY	GENUS SPECIES
	Siglionidae	
	Spionidae	Malacocerus glutaeus Spio sp.
	Syllidae	Brania brevipharyngea Eusyllinae + Exogone sp. Syllis sp. Trypanosyllis sp.
	Terebellidae	
	Errantia ..	
	Aphroditoidea o	
Sipuncula ▲		
Tanaidacea	Paratanaidae	Leptochelia dubia
	Tanaidae	Anatanais normani

* Class
** Subclass
▲ Phylum
.. Suborder
. Order
■ Section
o Super Family
\+ Subfamily

Figures 10, 11 and 12 display the dominant invertebrates and show numbers found in the benthic samples collected in April, May and June, 1982 respectively. Appendices III a, b and c and d give more detailed results. Figures 13, 14 and 15 display the biomass results of the dominant invertebrates in April, May and June respectively; more detailed results are in Appendix IIIe. Appendix IIIf summarizes the results of the analyses of variance.

T-tests comparing invertebrate abundances revealed that consistent differences did not occur between the mid and low intertidal zones.

Harpacticoid copepods, cyclopoid copepods, and gammarid amphipods were the numerically predominant organisms present in the benthos. These taxa also formed the major portion of the biomass present at all three sites, except at the Site 7A mid tidal zone (large cobble/boulder site), where most of the biomass was composed of the shore crab Hemigrapsus sp. Other taxa consistently present in relatively small numbers at all benthic sites were cumacea, nematoda, oligochaeta, ostracoda, and polychaeta.

Except for the Site 7A mid tidal zone, total numbers of invertebrates increased from April to June at all three sites.

FIGURE 10

APRIL 1982
CAMPBELL RIVER
FORESHORE

MEAN NUMBER OF INVERTEBRATES PER METER SQUARED IN BENTHIC SAMPLES

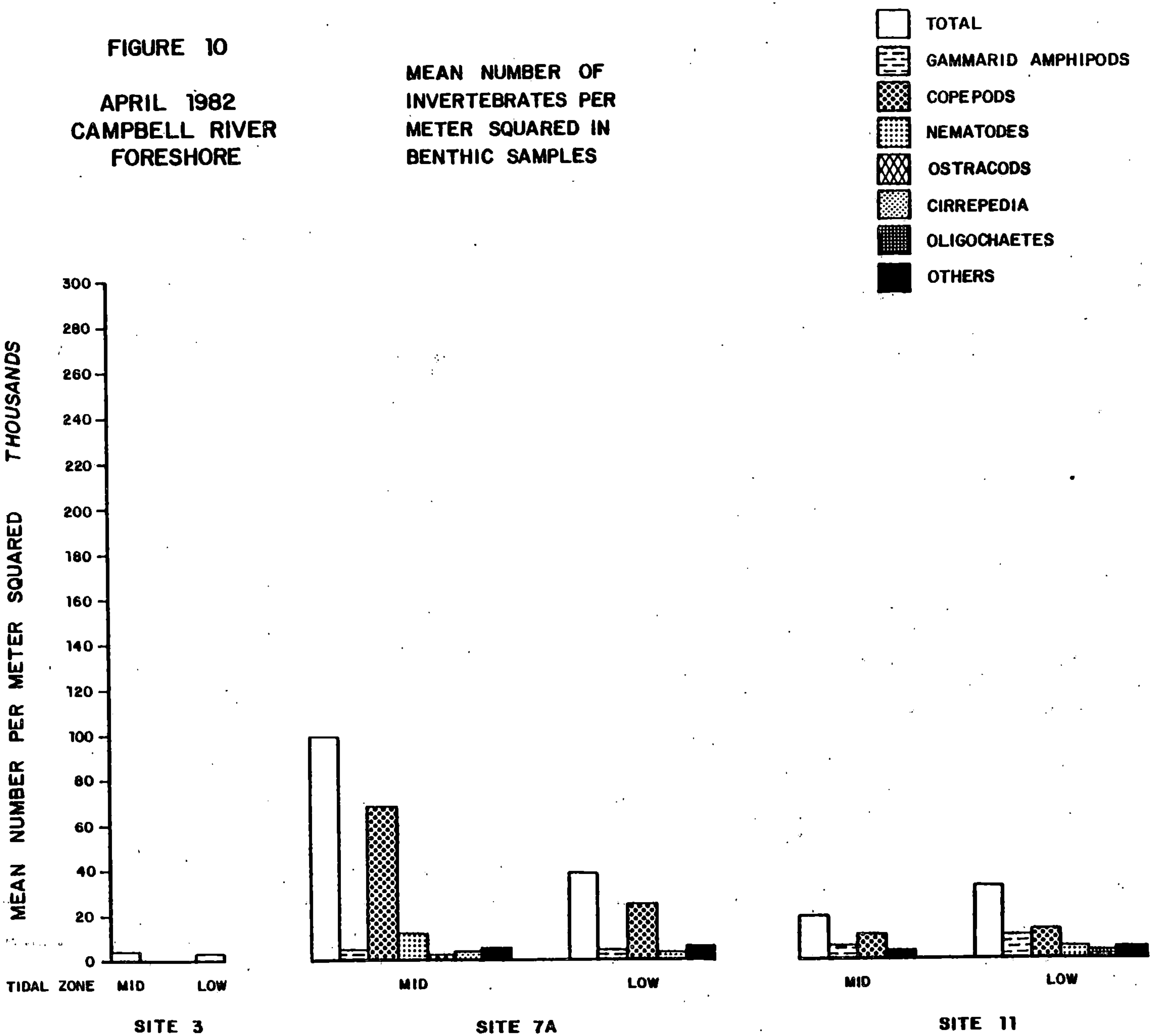


FIGURE 11

MAY 1982
CAMPBELL RIVER
FORESHORE

MEAN NUMBER OF INVERTEBRATES PER METER SQUARED IN BENTHIC SAMPLES

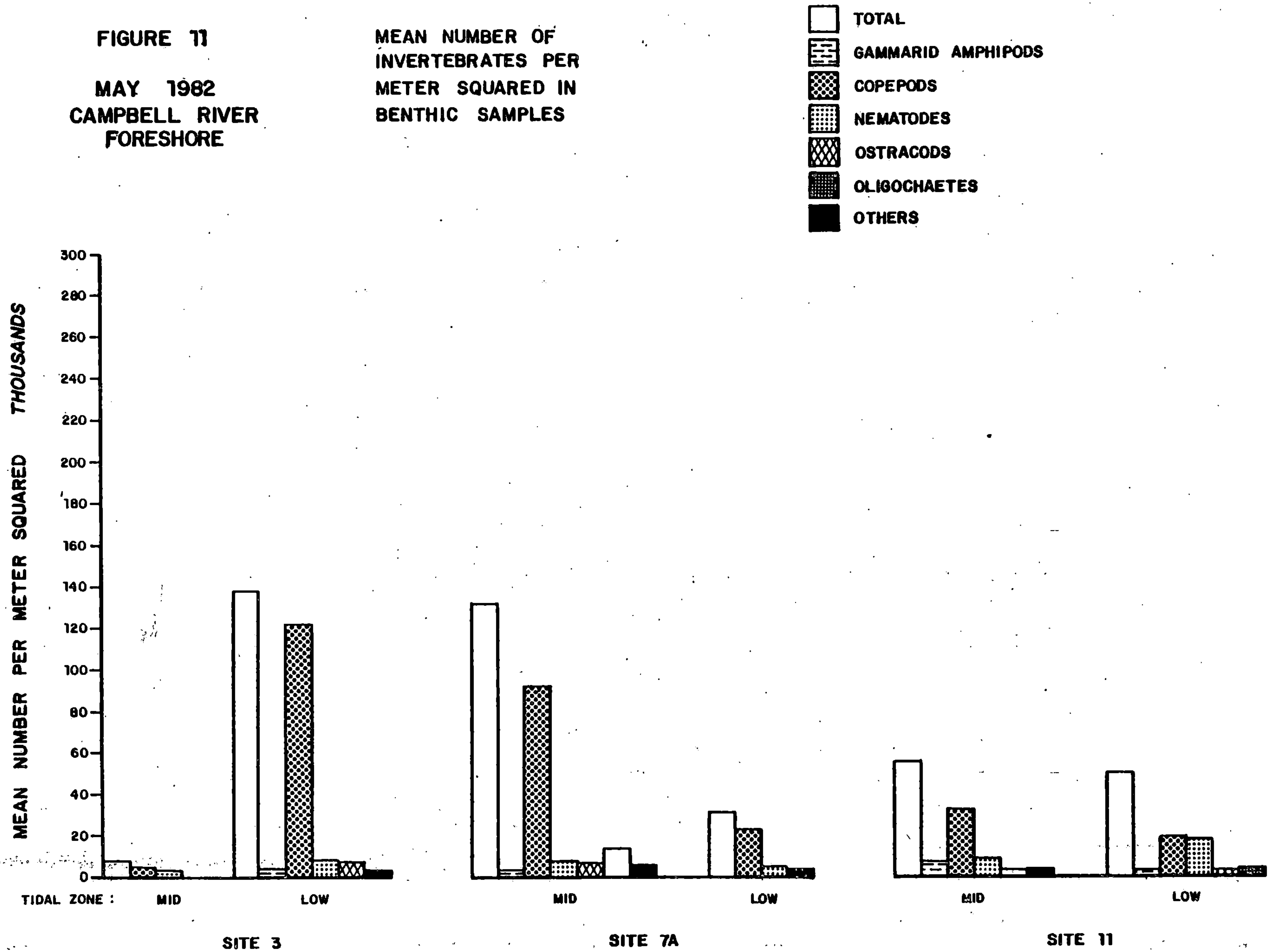


FIGURE 12

JUNE 1982
CAMPBELL RIVER
FORESHORE

MEAN NUMBER OF INVERTEBRATES PER METER SQUARED IN BENTHIC SAMPLES

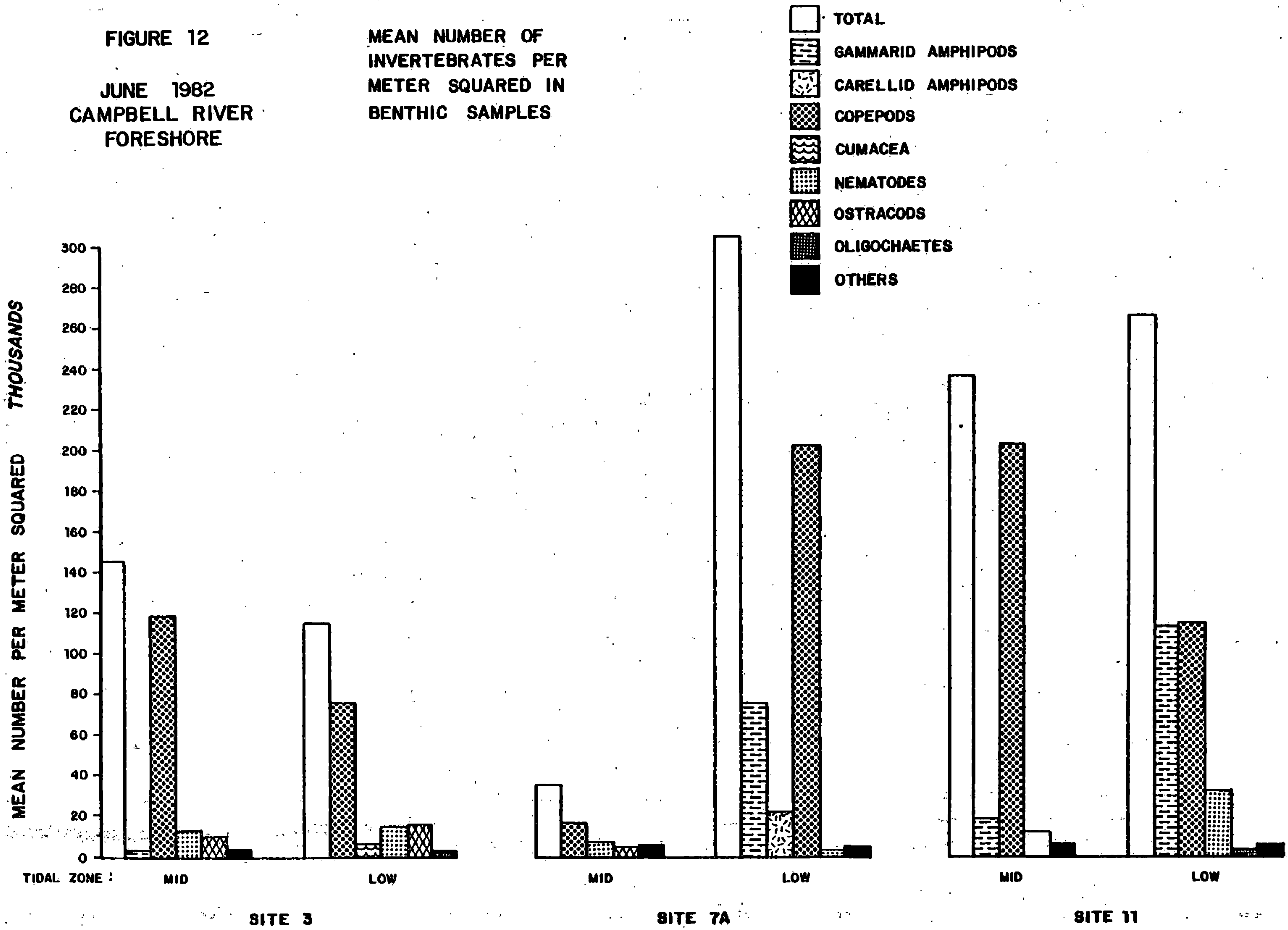


FIGURE 13

APRIL 1982
CAMPBELL RIVER
FORESHORE

MEAN WEIGHT OF INVERTEBRATES PER METER SQUARED IN BENTHIC SAMPLES *

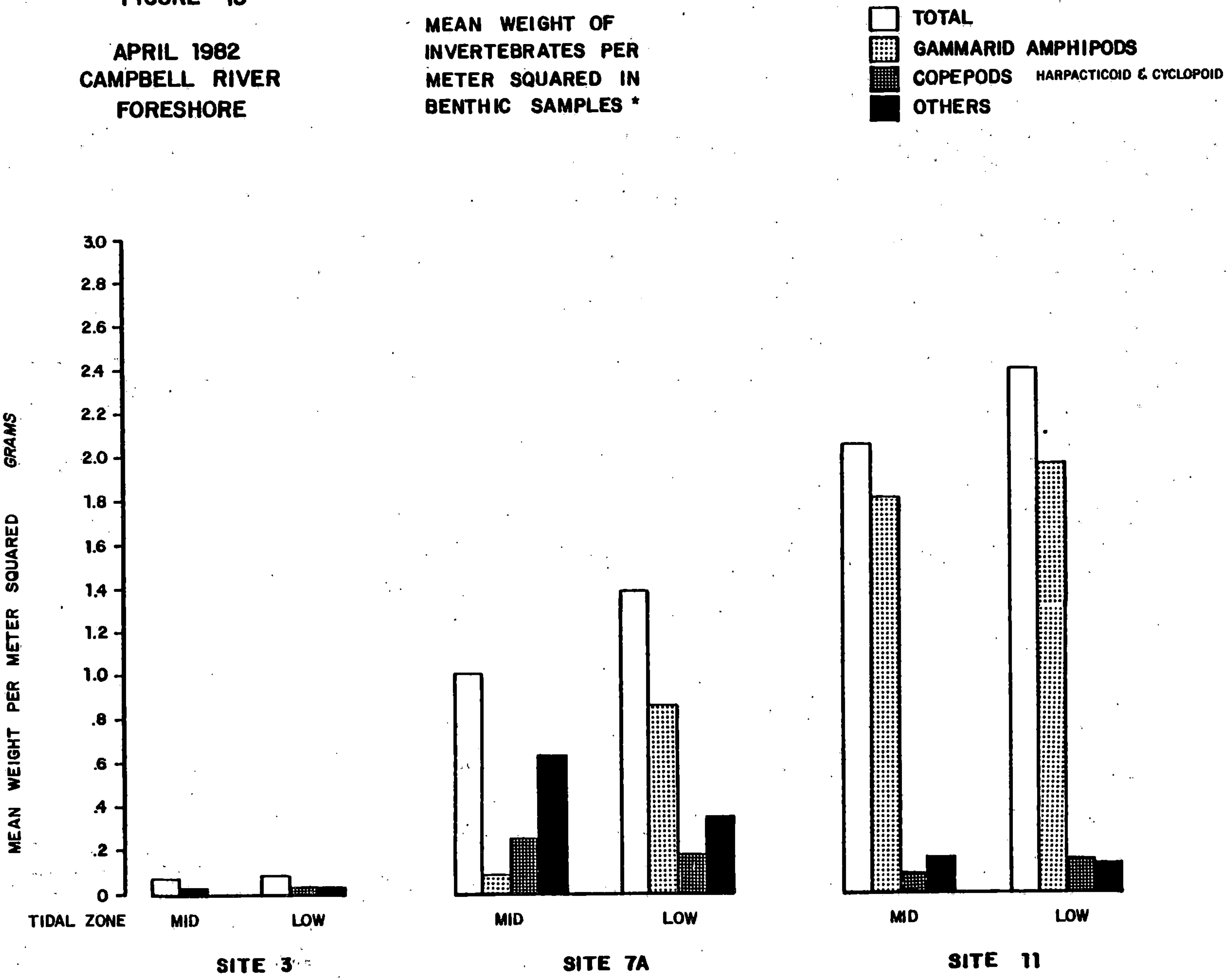


FIGURE 14

MAY 1982
CAMPBELL RIVER
FORESHORE

MEAN WEIGHT OF INVERTEBRATES PER METER SQUARED IN BENTHIC SAMPLES *

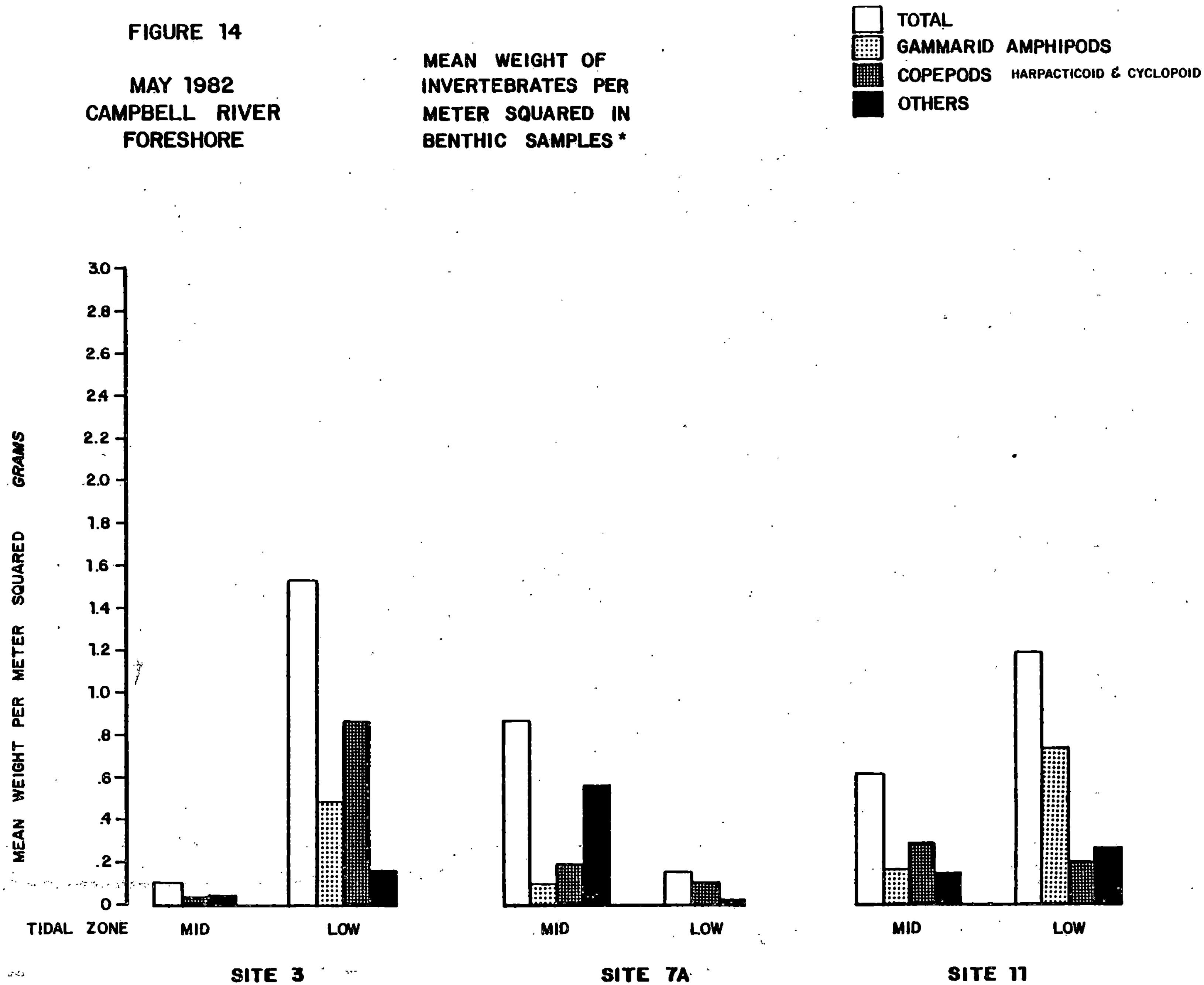
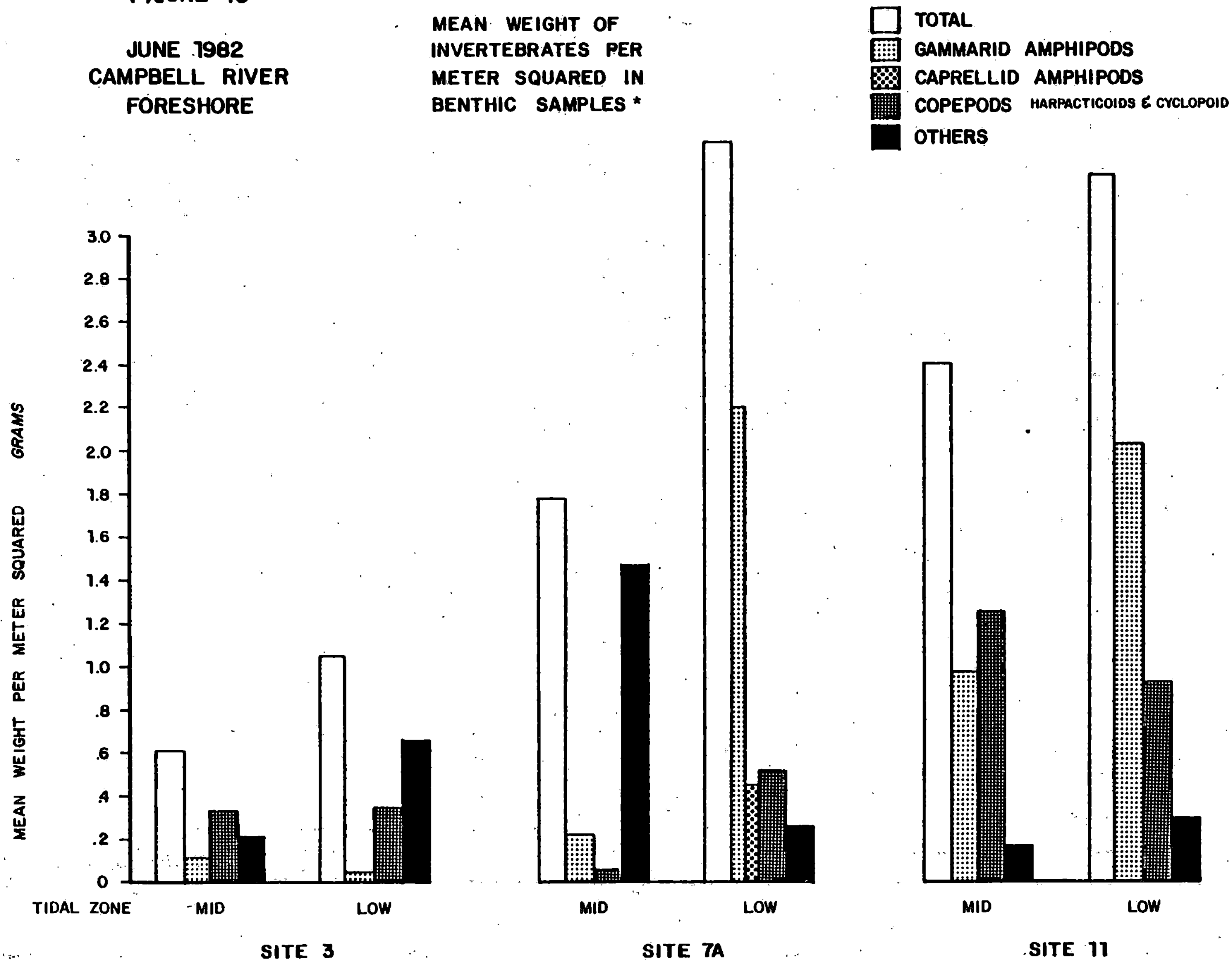


FIGURE 15

JUNE 1982
CAMPBELL RIVER
FORESHORE

MEAN WEIGHT OF INVERTEBRATES PER METER SQUARED IN BENTHIC SAMPLES *



Total biomass* significantly increased from April to June at both the mid and low intertidal zones at Site #3.

In April, the highest densities of benthic invertebrates occurred at Site 7A (large cobble/boulder site) and Site 11 (coarse gravel/small cobble site), invertebrates at the Site 7A mid station being most abundant, (ave. 98,486/m^2). Biomass totals were greatest at Site 11, with gammarid amphipods accounting for most of the weight.

In May, invertebrates were significantly more abundant at the Site 3 low tidal zone that either of the Site 7A or Site 11 low tidal zones. This was unusual because in general the Site 3 samples were devoid of vegetation and had low invertebrate densities in relation to Sites 7A and 11. However, the samples collected at Site 3 at the low tidal zone in May contained a great deal of eelgrass. It is not known whether the samples were taken in close proximity to a small patch of eelgrass or if this was drift vegetation, but it may partially explain the high invertebrate densities at Site 3. At the mid intertidal zones in May, invertebrates were most abundant at Site 7A and least abundant at Site 3.

* Excludes organisms greater than 9.5 mm^2 or with calcareous shells.

In June, Sites 7A and 11 tide low zones had greater numbers of invertebrates than the Site 3 low tide zone. At the mid intertidal zones invertebrates were most abundant at Site 11, with progressively less numbers at Site 3 and at Site 7A.

Epibenthic harpacticoid and cyclopoid copepods were the most abundant taxa numerically at all but one of the benthic stations, comprising from 34.7% to 85.5% of the invertebrate total. They also accounted for a sizeable portion of the biomass at each site. Abundance of epibenthic copepods increased at all sites from April to June reaching peak levels in June at Site 7A low tide (avg. $201{,}576 \cdot m^{-2}$), and Site 11 mid tide level (avg. $202{,}865 \cdot m^{-2}$). Copepod densities appeared to be related to the amount of algal debris present in the benthic samples.

Gammarid amphipods were much less abundant than the epibenthic copepods but still constituted a large portion of the biomass, particularly at Sites 7A and 11. At the Site 11 low tide station gammarid amphipods constituted the majority of the biomass in all three months. At Site 11 biomass due to gammarid amphipods did not sufficiently increase from April to June despite the fact that amphipods were far more abundant in June, indicating the recruitment of a large number of juveniles at the site. Twenty-two gammarid amphipod taxa were identified at the three sites. <u>Allorchestes angustus</u> was the most common amphipod present at

Site 3 while Pontogeneia sp., Calliopiella pratti, and Ischyrocerus sp. were the dominant species present at Site 7A. Accedomoera vagor, Pontogeneia sp., and Calliopiella pratti were most abundant at Site 11.

4.5 Fish

At least 26 species of fish were collected in the study area between April 14 and October 27, 1982 (Table 5). Included in the catches were chinook, chum, coho and pink salmon, pacific herring and coastal cutthroat trout. Appendix IVa gives the catch data for all fish species sampled from the Campbell River foreshore from April 15 to October 27, 1982. The Pacific Biological Station also carried out an extensive study, under the direction of Drs. C. Levings and C. McAllister, in the Campbell River area, concentrating on migration and rearing of hatchery fish stocks.

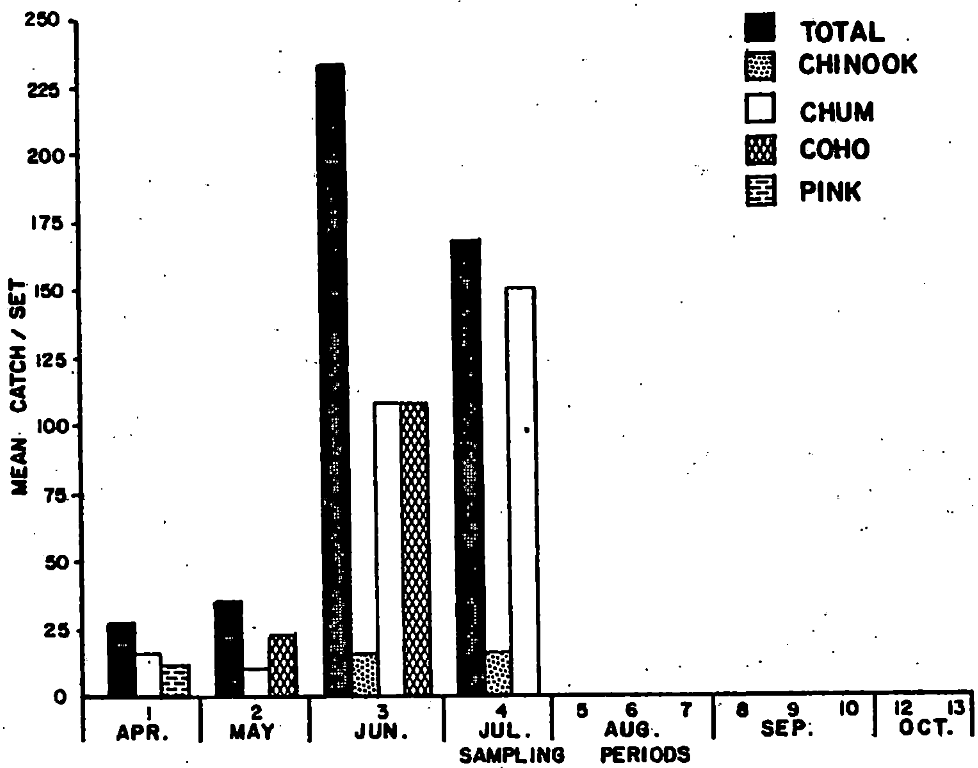
4.5.1 Timing and Distribution on the Foreshore

The timing of abundance of juvenile salmonids found in Reaches 1 - 4 is given in Figures 16 to 19 respectively; since beach seining was only undertaken once in each month of April, May, June and July, the data are incomplete and an accurate determination of the peak in migration from the estuary could not be obtained for any of the salmonid species.

TABLE 5 - SPECIES LIST OF FISH CAPTURED IN CAMPBELL RIVER FORESHORE BY BEACH SEINING IN APRIL - OCTOBER, 1982

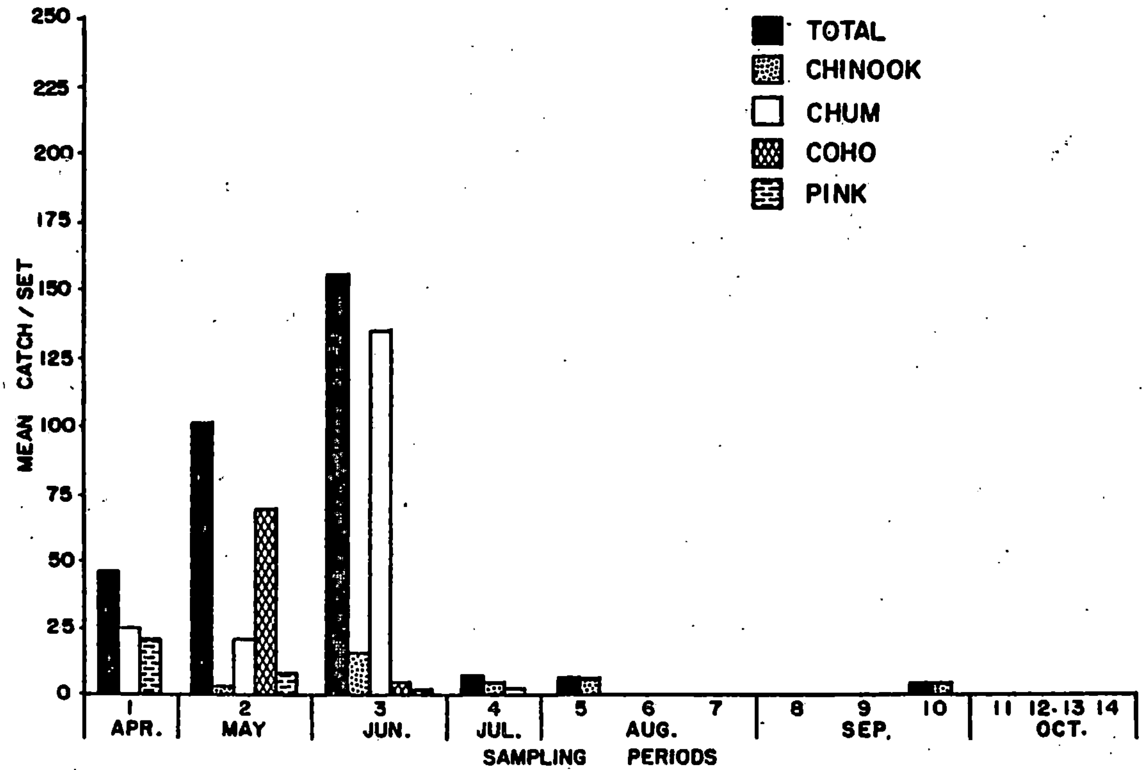
COMMON NAME	FAMILY	GENUS SPECIES
Pacific Herring	Clupeidae	Clupea harengus
Pink Salmon	Salmonidae	Oncorhynchus gorbuscha
Chum Salmon	Salmonidae	Oncorhynchus keta
Coho Salmon	Salmonidae	Oncorhynchus kisutch
Chinook Salmon	Salmonidae	Oncorhynchus tshawytscha
Coastal Cutthroat Trout	Salmonidae	Salmo clarki
Pacific Tomcod	Gadidae	Microgadus proximus
Threespine Stickleback	Gasterosteidae	Gasterosteus aculeatus
Bay Pipefish	Syngnathidae	Syngnathus griseolineatus
Shiner Perch	Embiotocidae	Cymatogaster aggregata
Striped Seaperch	Embiotocidae	Embiotoca lateralis
Unidentified Surfperch	Embiotocidae	Unknown
Unidentified Blenny	Stichaeidae	Unknown
Penpoint Gunnel	Pholidae	Apodichthys flavidus
Pacific Sand Lance	Ammodytidae	Ammodytes hexapterus
Unidentified Rockfish	Scorpaenidae	Unknown
Kelp Greenling	Hexagrammidae	Hexagrammos decagrammus
Buffalo Sculpin	Cottidae	Enophrys bison
Pacific Staghorn Sculpin	Cottidae	Leptocottus armatus
Tidepool Sculpin	Cottidae	Oligocottus maculosus
Unidentified Sculpin	Cottidae	Unknown
Smooth Alligatorfish	Agonidae	Anoplagonus inermis
Unidentified Liparis	Cyclopteridae	Unknown (2 sp.)
Unidentified Sanddab	Bothidae	Citharichthys sp.
Starry Flounder	Pleuronectidae	Platichthys stellatus
C-O Sole	Pleuronectidae	Pleuronichthys coenosus

FIGURE 16 SALMONID PRESENCE IN REACH 1



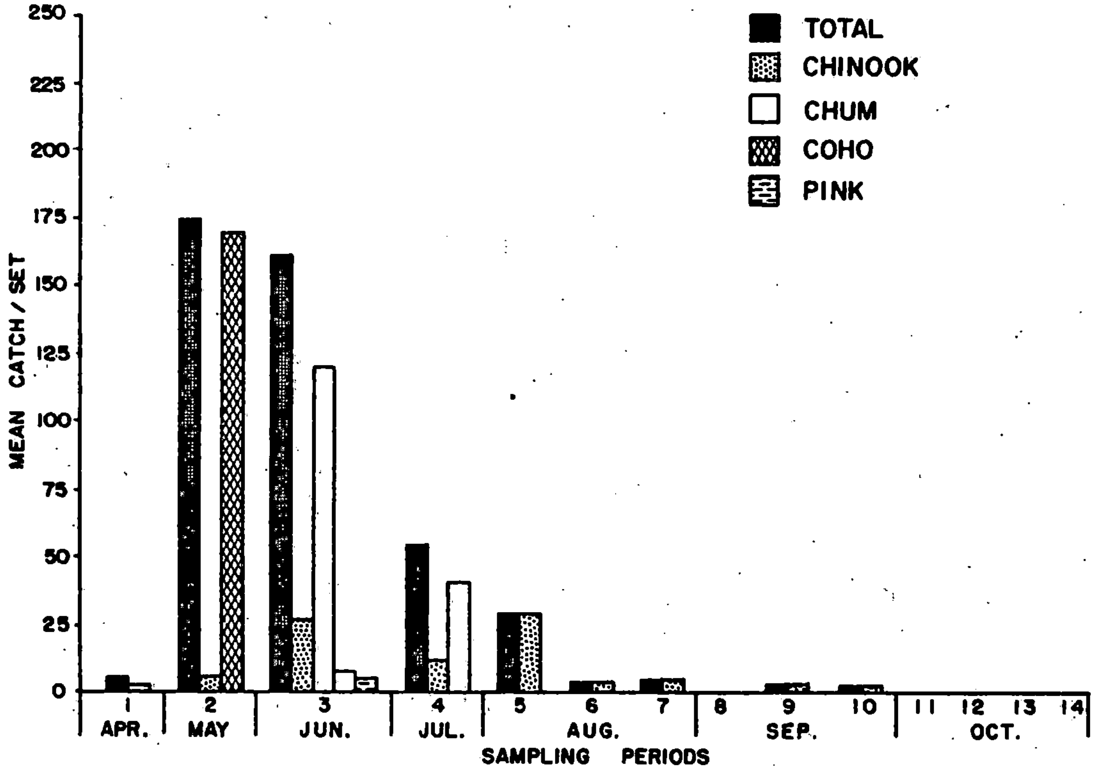
ANYTHING BELOW 2 FISH / CATCH IS NOT SHOWN

FIGURE 17 SALMONID PRESENCE IN REACH 2



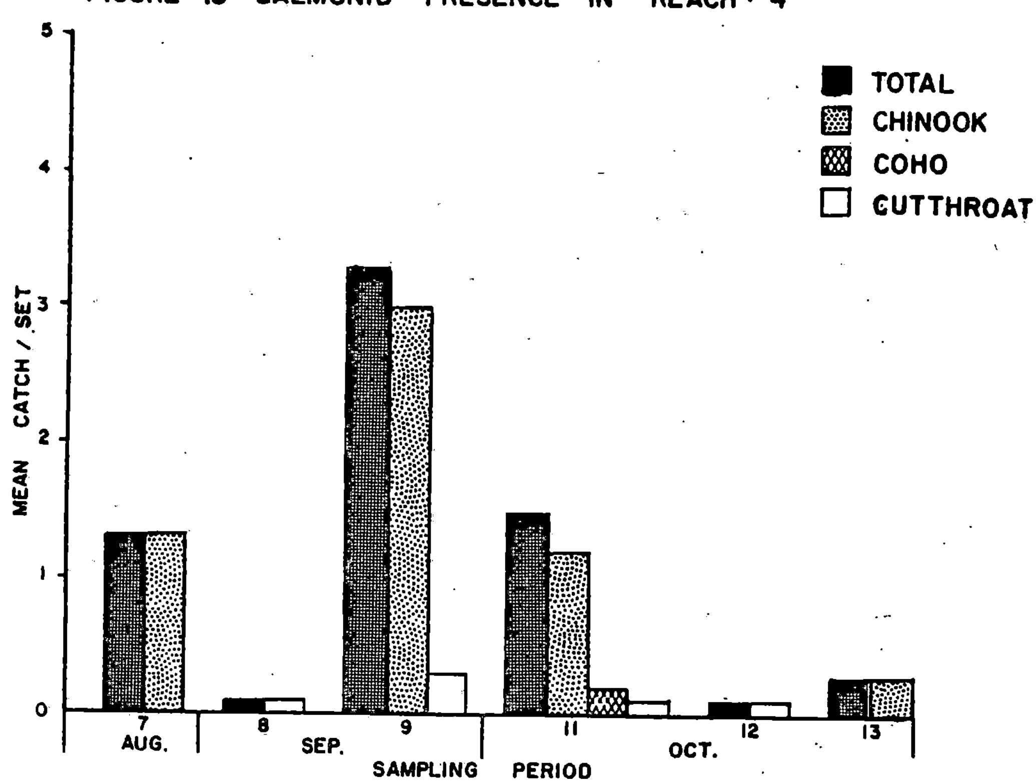
ANYTHING BELOW 2 FISH / CATCH IS NOT SHOWN

FIGURE 18 SALMONID PRESENCE IN REACH 3



ANYTHING BELOW 2 FISH / CATCH IS NOT SHOWN

FIGURE 19 SALMONID PRESENCE IN REACH 4



4.5.1.1 Chinook Salmon

Chinook salmon were abundant from the June 21 - 23 (14.4•set $^{-1}$) to the August 6 - 7, 1982 (11.1•set $^{-1}$) sampling periods in the overall southern foreshore (Sites 1 to 12). If each reach is examined individually however, the results appear quite different. The catch per unit effort (CPUE = #/beach seine set) was high in all three reaches during the June 21 - 23 sampling period (Reach 1 = 14.5•set $^{-1}$; Reach 2 = 15.2•set $^{-1}$; Reach 3 = 27.0•set $^{-1}$), and remained high in the July 6 - 7 sampling period in Reach 1 (16.8•set $^{-1}$) and Reach 3 (15.8•set $^{-1}$). The juvenile chinook were most abundant in the foreshore in Reach 3 during the August 6 - 7 sampling period (29.3•set $^{-1}$). This was directly due to the fact that the highest single catch (67•set $^{-1}$) was obtained at Site 12 (closest to the estuary) during this time period.

A total of approximately 765,500 juvenile chinook were released from the Quinsam Hatchery on six occasions between May 5 and July 7, 1982 (from summary of hatchery release data; Appendix IV b).

Only one hatchery chinook with a coded-wire nosetag was recovered in May from the foreshore, but several more were captured from June to September, 1982 (Appendix IVc).

Juvenile chinook were observed at all sampling sites in the southern foreshore at some time during the study. Unlike other salmonid species, chinook were still observed in the foreshore until mid-October, 1982 (end of sampling), although their numbers were very low (0.25 - 1.0•set $^{-1}$). After mid-September, 1982, most of the chinook observed were found in Menzies Bay.

Juvenile chinook scales were analyzed to determine age (Appendix IVd). Five chinook collected from Site 7B on June 21, 1982 were aged 0^{+}(fry of the year). The scales revealed an even, fast, smooth growth with low stress, indicating a hatchery type of growth.

4.5.1.2 Chum Salmon

Chum salmon were most abundant in the southern foreshore in the June sampling period (103.7• set $^{-1}$ for the overall southern foreshore; Reach 1 = 108.8•set $^{-1}$; Reach 2 = 134.6•set $^{-1}$; Reach 3 = 120.5•set $^{-1}$), and were rare in the August 6 - 9 sampling period (0.07•set $^{-1}$ overall). There was also a high catch per unit effort in the July sampling period in Reach 1 (150.8•set $^{-1}$). The largest single catch was obtained in Reach 2 at Site 9 during June (370•set $^{-1}$). Chum were observed throughout the southern foreshore at some point during the study (the northern foreshore was only examined during the fall).

Quinsam Hatchery released approximately 71,500 untagged juvenile chum on June 9, 1982. The marked increase in the chum catch in the foreshore during the June sampling period was probably highly influenced by this release.

4.5.1.3 Coho Salmon

Coho salmon were abundant in the southern foreshore in the May ($70.5 \bullet set^{-1}$) and June ($42.0 \bullet set^{-1}$) sampling periods. This corresponds to the Quinsam Hatchery's release of approximately 1,280,000 coho from May 18 to June 2, 1982 (Appendix IVb). Reaches 3 and 2 showed their highest CPUE's in the May sampling period ($168.5 \bullet set^{-1}$ and $68.3 \bullet set^{-1}$ respectively), whereas Reach 1 did not reach a peak in abundance until the June sampling period ($108.0 \bullet set^{-1}$). Coho were not observed in the foreshore after June 21 - 23, 1982 in Reaches 2 and 3, and were rare in Reach 1 in the July sampling period ($0.8 \bullet set^{-1}$). This indicates that the coho were probably travelling in large schools and moving quickly through the estuary and shallower foreshore areas. However, stomach samples indicate that the coho did utilize the food resources of the area.

Coho were observed in all areas of the southern foreshore during some time in the study. The highest single catch was obtained at

Reach 1, Site 1 in the June sampling period (430•set $^{-1}$). A few wild stock coho were observed in the foreshore in the April sampling period, but only in Reach 3 (0.9•set $^{-1}$).

Scale samples were analyzed and juvenile coho from Sites 7A and 11 collected on April 16 and May 26-27, 1982 were found to be aged 1^+ (overwintered in freshwater, including hatchery fish). The scales revealed that those coho captured at Site 11 on May 27, 1982 had an even, fast, smooth growth with low stress, indicating a hatchery type of growth situation.

4.5.1.4 Pink Salmon

The highest CPUE'S for pink salmon in the foreshore were obtained in the April sampling period (9.69•set^{-1} in the overall southern foreshore). However, beach seining should have commenced prior to this, and been undertaken more frequently to increase the accuracy in the determination of the peak migration from the estuary. The numbers were low in Reach 3 in April (1.6•set^{-1}) and higher in Reach 2 and 1 (21.8 • set^{-1} and 11.1 • set^{-1} respectively), which indicates the majority of the pinks may have already migrated from the estuary by this time. The number of juvenile pink decreased in the May sampling period and were non-existent in Reach 3 at this time. However, the mean catch was 4.5 • set^{-1} in Reach 3 during the June sampling period.

Similar results were observed in 1980 (Raymond *et al.*, in prep.) and it was suggested that these were possibly fish from another river system.

Juvenile pinks were found in all areas sampled in April. The highest single catch was in Reach 2, at Site 7A in the April sampling period ($56 \bullet set^{-1}$).

Quinsam Hatchery released approximately 3,478,000 pinks from March 23 to April 20, 1982, and another 60,000 on April 30, 1982.

4.5.2 Length Distribution

4.5.2.1 Chinook Salmon

The length distribution of juvenile chinook salmon collected in the study area between April 14 and October 27, 1982 is given in Appendix Va and shown in Figure 20.

In April there was a small size range for juvenile chinook, their sizes varying from 35 to 45 mm standard length (avg. 41 mm). These data represent wild stocks only since the first hatchery release was not until May 5, 1982.

FIGURE 20 LENGTH DISTRIBUTION OF CHINOOK SALMON SAMPLED IN THE CAMPBELL RIVER FORESHORE

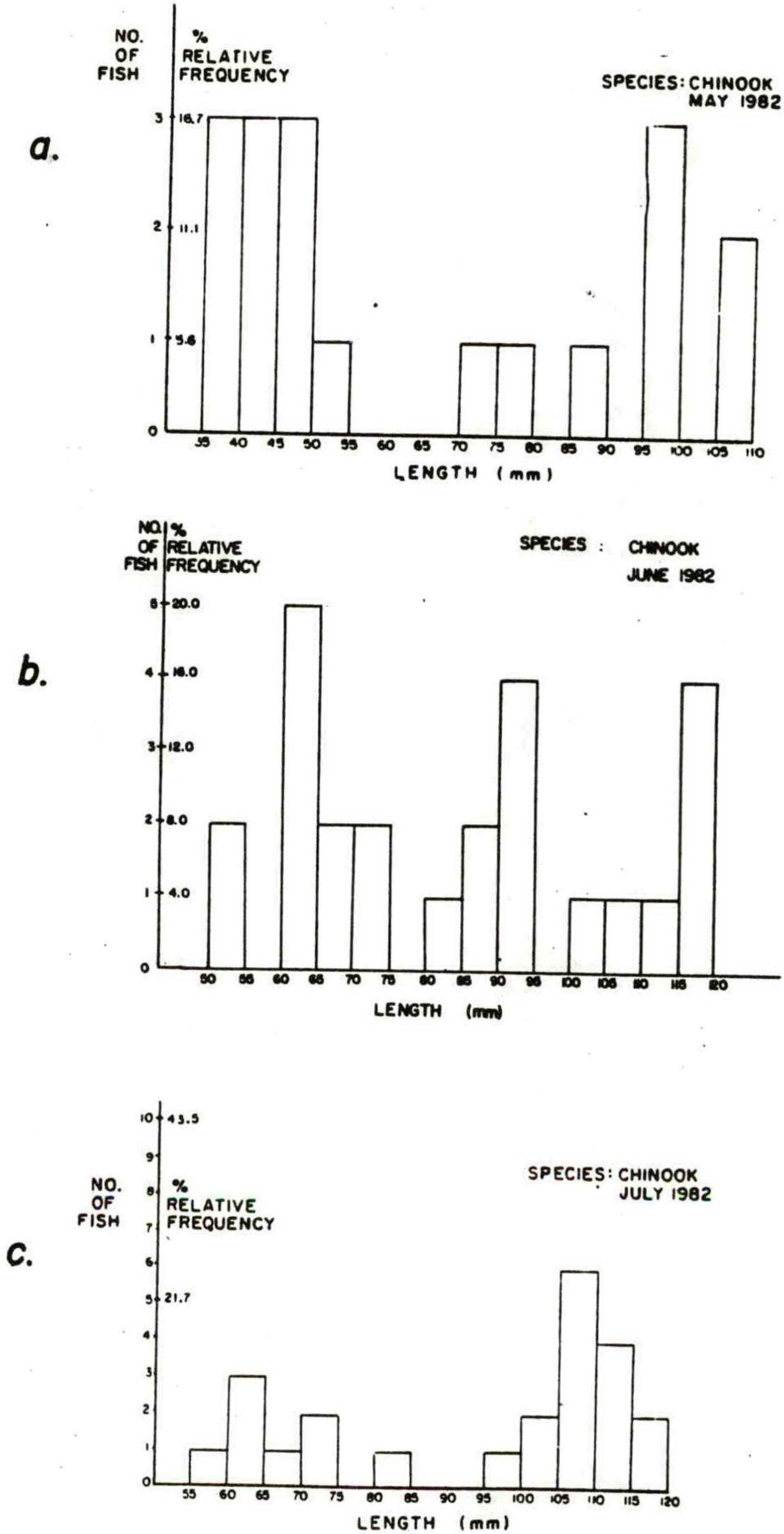
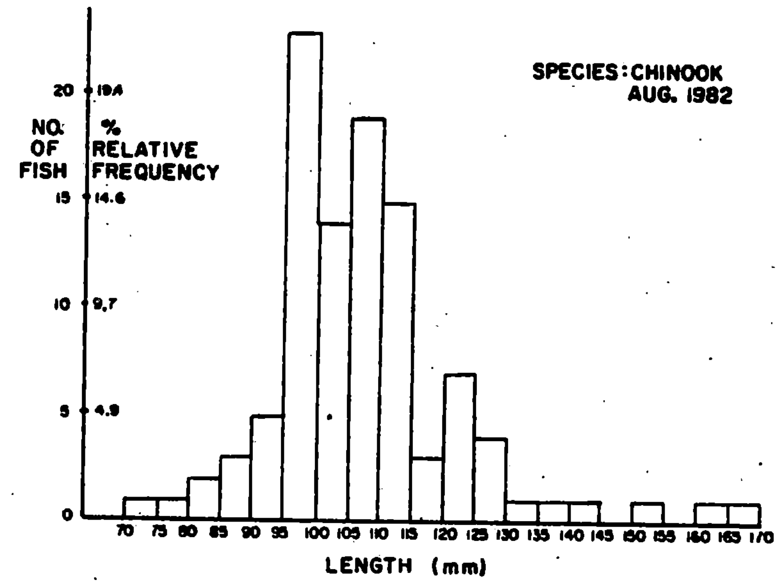
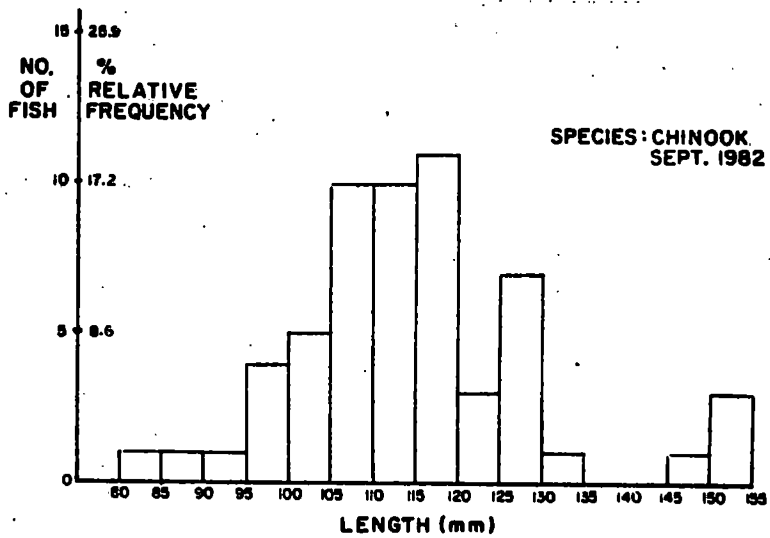


FIGURE 20 CONTINUED

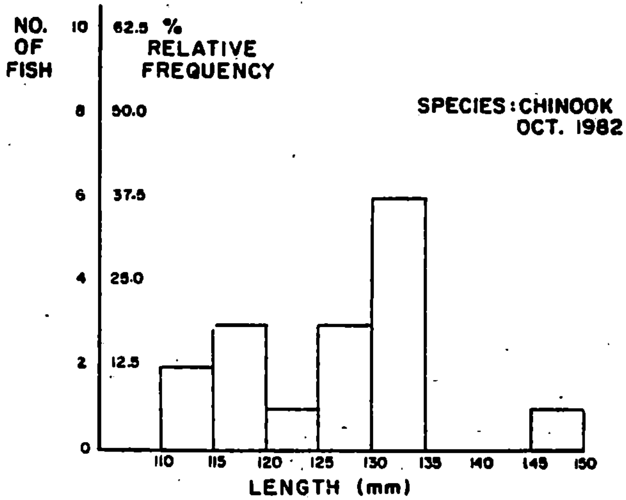
d.



e.



f.



The size range increased in May with standard lengths of 35 to 109 mm (avg. 67.3 mm). There was a large variation in the sizes which formed more than one size class rather than a normal distribution. Since the Quinsam Hatchery released chinook in May, the size classes may represent both hatchery and wild populations.

In June the lengths varied from 50 to 119 mm (avg. 85.7 mm) and were similar to the July data (55 to 119 mm) (avg. 95.9 mm). As in May, the lengths of juvenile chinook captured in June and July do not appear to fit a normal distribution pattern. The Quinsam Hatchery released juvenile chinook on six different occasions between May 5 and July 7, so the length data were probably comprised of wild stocks and hatchery fish from several different releases.

In August the chinook lengths varied from 70 to 169 mm (avg. 107.9 mm). At this time there appears to be a normal length distribution, indicating only a single population of fish was sampled. The majority of larger hatchery fish may have left the estuary and foreshore so that those remaining in August were mainly the wild stocks.

The lengths of the juvenile chinook captured in September varied from 80 to 154 mm (avg. 115.3 mm), whereas the lengths in October varied from 110 to 149 mm (avg. 127.3 mm). The data from these two months again suggest a normal distribution, indicating a "single" population of chinook was present in the foreshore at these times.

4.5.2.2 Chum Salmon

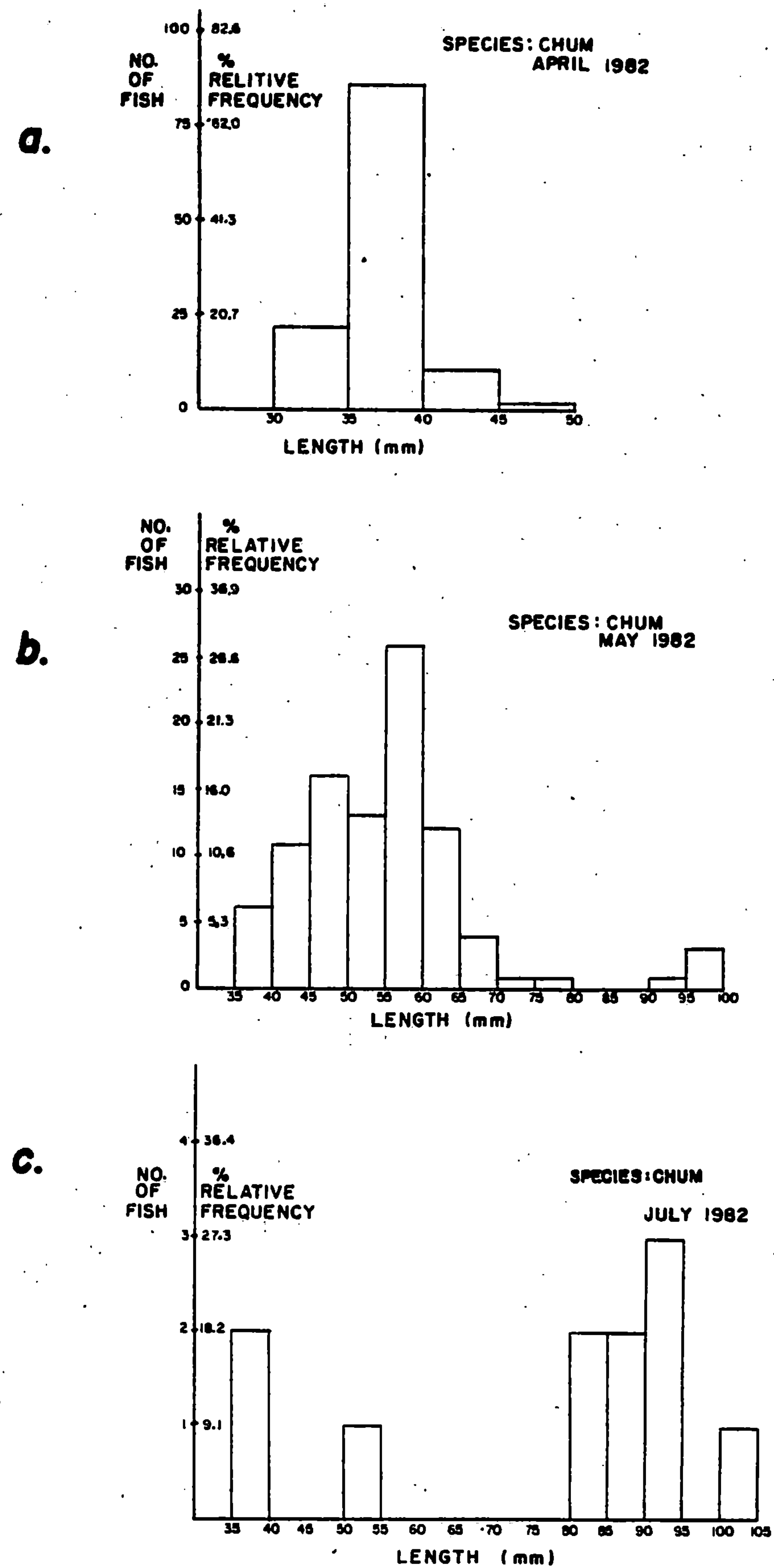
The length distribution of juvenile chum salmon collected in the study area between April 14 and July 7, 1982 is given in Appendix Vb and shown in Figure 21.

In April the size range of juvenile chum was very small. The lengths varied from 30 to 49 mm for 121 sampled fish, of which 71% were between 35 and 39 mm(ave. 38.2mm). By May the size range increased with standard lengths of 35 to 99mm (ave. 57.1 mm). The data for these two months appear to fit a normal distribution and were represented only by wild stocks (hatchery chum were not released until June 9, 1982).

Although the length data collected in June and July was minimal, (ie. low number of fish available), the size distribution was quite variable, and probably represented both wild and hatchery populations.

FIGURE 21 LENGTH DISTRIBUTION OF CHUM SALMON

SAMPLED IN THE CAMPBELL RIVER FORESHORE



4.5.2.3 Coho Salmon

The length distribution of juvenile coho salmon collected in the study area between April 14 and July 7, 1982 is given in Appendix Vc and shown in Figure 22.

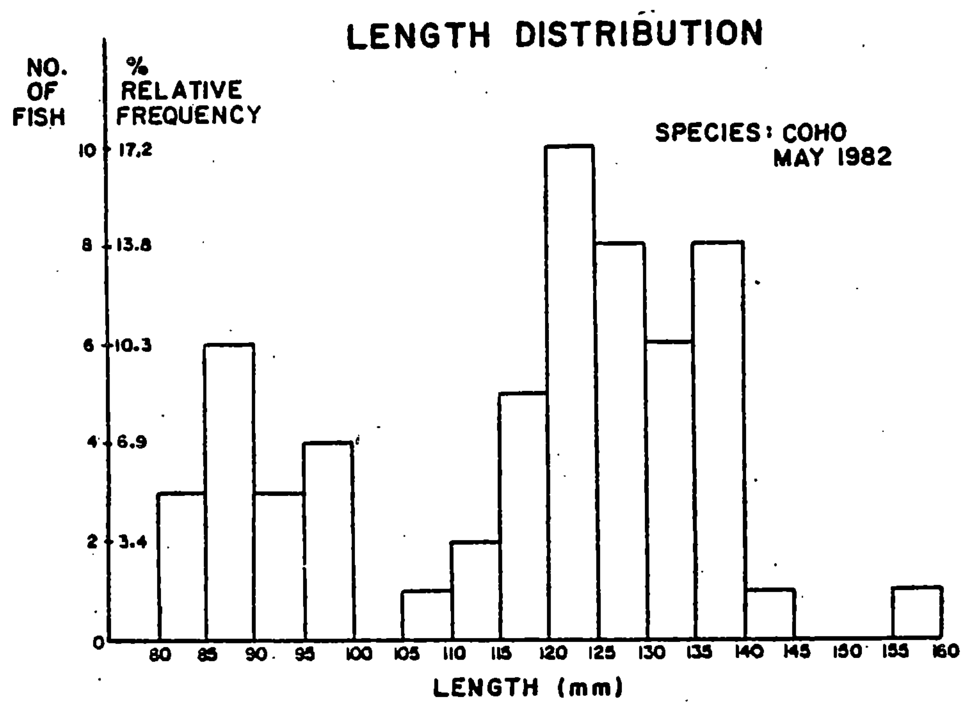
The lengths of five coho captured in April varied from 100 to 134 mm (avg. 118.6 mm). In May, however, the lengths ranged from 80 to 159 mm (avg. 119.1 mm) with an irregular distribution. The apparent size classes may indicate that more than one population of coho was sampled. During this period four different hatchery releases took place (between May 18 and June 2) and coho sampled from the foreshore during May probably originated from both hatchery and wild stocks. Additionally, scale analysis was performed on sixteen juvenile coho captured in May (Appendix IVd) and results indicated they all had growth patterns typical of a hatchery environment. Their lengths ranged from 120 to 144 mm, which is on the larger end of the length distribution scale (See Figure 22).

In June the range of lengths was smaller than in May and varied from 75 to 124 mm (97.9 mm), but only 13 fish were measured. Only 2 coho were captured in July.

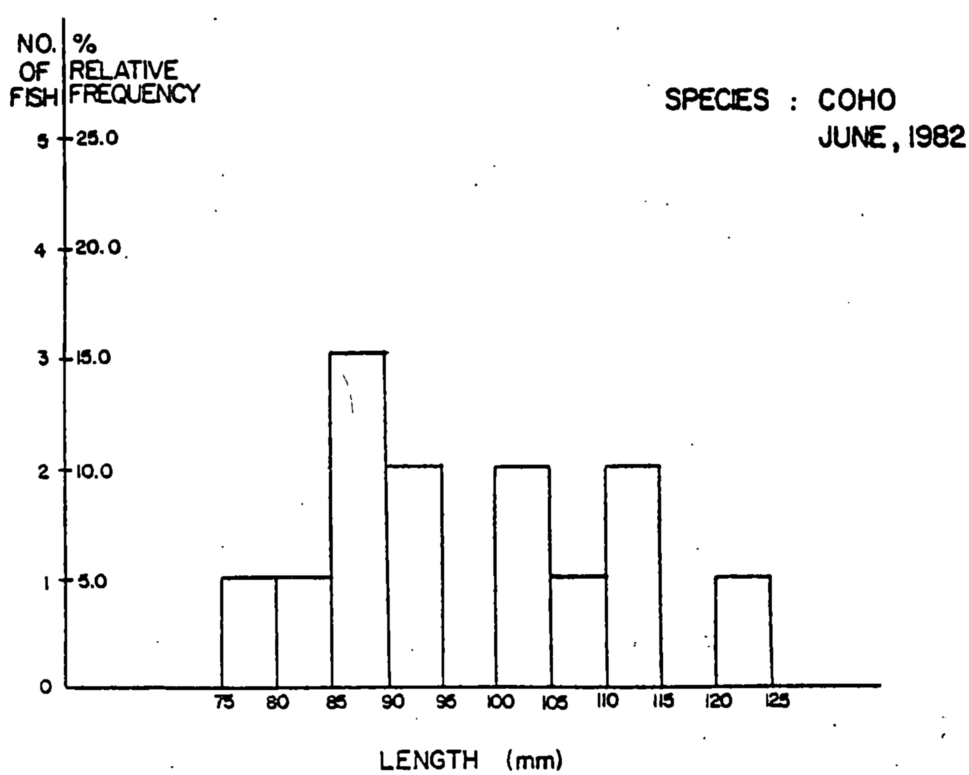
FIGURE 22 LENGTH DISTRIBUTION OF COHO SALMON

SAMPLED IN CAMPBELL RIVER FORESHORE

a.



b.



4.5.2.4 Pink Salmon

The length distribution of juvenile pink salmon collected in the study area between April 14 and June 23 is given in Appendix Vd and shown in Figure 23.

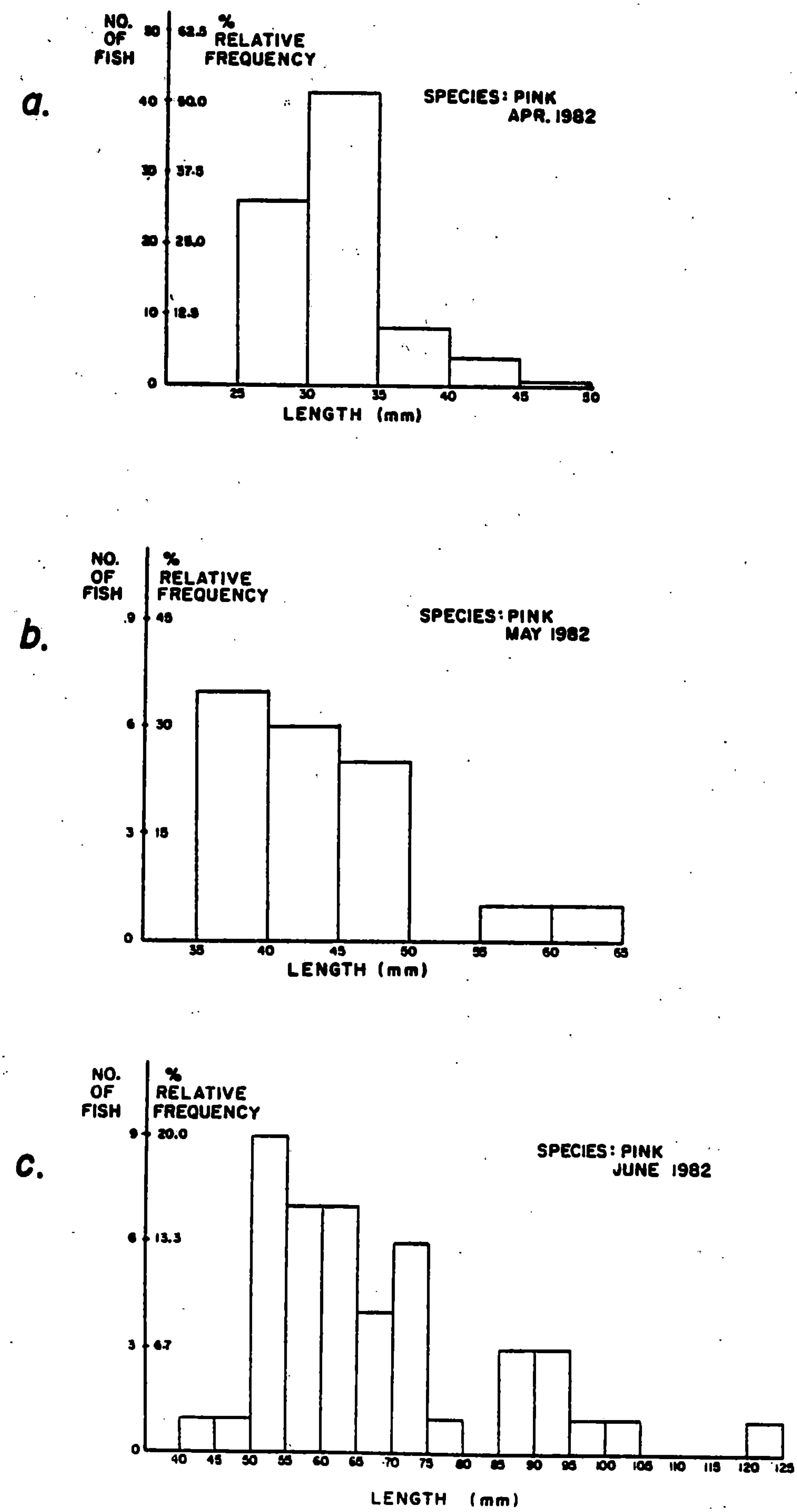
The lengths of 80 juvenile pinks sampled in April ranged from 25 to 49 mm (avg. 33.3 mm) and the distribution appears to be normal. In May the lengths ranged from 35 to 64 mm (avg. 46.3; from 20 sampled fish) whereas in June the lengths varied from 40 to 124 mm (avg. 68.6 mm; from 45 sampled fish).

It is difficult to determine from the graphs alone the type of distribution pattern that exists for juvenile pinks in May and June. The Quinsam hatchery released pink from March 23 to April 20, and on April 30, 1982. The data may be representative of wild or hatchery fish alone or of a combination of these. As suggested previously, the fish sampled in June may be from another river system because of the increase in numbers from May to June (see Section 4.5.1.4).

4.5.3 Juvenile Salmon Stomach Contents

A list of all the invertebrate taxa identified in the juvenile salmon stomachs sampled between April 14 and June 23, 1982 is

FIGURE 23 LENGTH DISTRIBUTION OF PINK SALMON SAMPLED IN THE CAMPBELL RIVER FORESHORE



shown in Table 6. Appendix VIa shows the stomach contents found in each salmon species collected in April, May and June at Sites 3, 7A and 11. Figures 24 to 26 display the same information.

Harpacticoid and cyclopoid copepods, calanoid copepods, gammarid amphipods, and juvenile chironomids were the dominant food items consumed by all four species of salmon utilizing the foreshore area. Chironomids were an important component of the diet only at Site #3 in June, when their percent Indices of Relative Importance (%I.R.I.) values were high for the three salmonid species caught at the site (Chinook avg. 65.6%, Chum avg. 56.9%, and Pink avg. 50.2%). At all other sites and times the dominant food items were calanoid copepods, gammarid amphipods, harpacticoid and cyclopoid copepods. (Refer to Appendix VI). In June, chinook and coho juveniles began selecting larger prey items such as mysids, decapod megalops, and fish larvae. These prey items often comprised the major portion of the total biomass consumed.

Juvenile chinook salmon stomachs were sampled only at Site 7A in May and at all sites in June. The chinook caught in May at Site 7A fed on relatively equal numbers of gammarid amphipods, calanoid copepods and epibenthic harpacticoid and cyclopoid copepods.

TABLE 6 - LIST OF INVERTEBRATES FOUND IN SALMONID STOMACHS FROM THE CAMPBELL RIVER FORESHORE IN APRIL, MAY AND JUNE, 1982

ORDER	FAMILY	GENUS SPECIES	STAGE
Acarina			
Amphipoda (Gammaridea)	Aoridae	Aoroides columbiae	
	Ampithoidae	Ampithoe sp.	
	Calliopiidae	Calliopiella pratti Calliopius laeviuscula	
	Hyalidae	Hyale sp.	
	Photidae	Photis brevipes	
	Pontogeniidae	Accedamoera vagor Paramoera mohri Pontogeneia rostrata	
	Phoxocephalidae	Paraphoxus spinosus	
	Ischyroceridae	Ischyrocerus sp.	
	Corophiidae	Corophium sp.	
	Gammaridae	Eogammarus sp.	
	Talitridae	Orchestia sp.	
Amphipoda (Caprellidea)	Caprellidae		
Amphipoda (Hyperidea)		Parathemisto sp. Primno sp.	
Cirrepedia			cyprid larvae nauplius
Copepoda **	Calanoida		
	Harpacticoida		
	Cyclopoida		

TABLE 6 - (Con't)

ORDER	FAMILY	GENUS SPECIES	STAGE
Cumacea		*Cumella* sp.	
Decapoda			Zoea larvae
	Brachyura °		Megalops larvae
Diptera (Nematocera)	Chironomidae		Pupae Adult Larvae
Euphausiacea?			
Gastrapoda			
Homoptera			
Insecta *			Adult
Isopoda			Cryptoniscan larvae
Malacostraca **			
Mysidacea			
Nematoda			
Oligochaeta			
Ostracoda (Pelagic Form)			
Osteicthyes (Fish)			
Polychaeta	Syllidae		
	Nereidae		
Tanaidaicea			
Thysanoptera			

* Class
** Subclass
° Section

FIGURE:24 -MEAN NUMBER OF INVERTEBRATES PER FISH IN STOMACH SAMPLES COLLECTED IN APRIL, 1982.

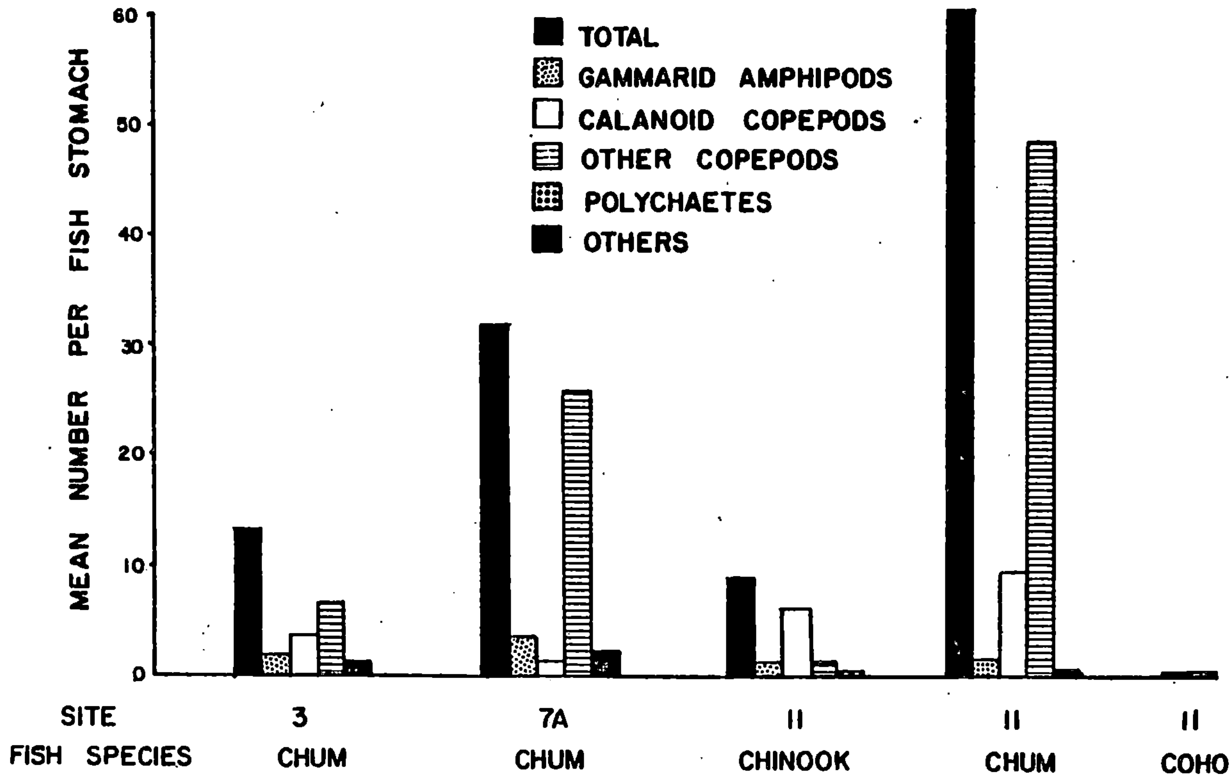


FIGURE:25 -MEAN NUMBER OF INVERTEBRATES PER FISH IN STOMACH SAMPLES COLLECTED IN MAY, 1982.

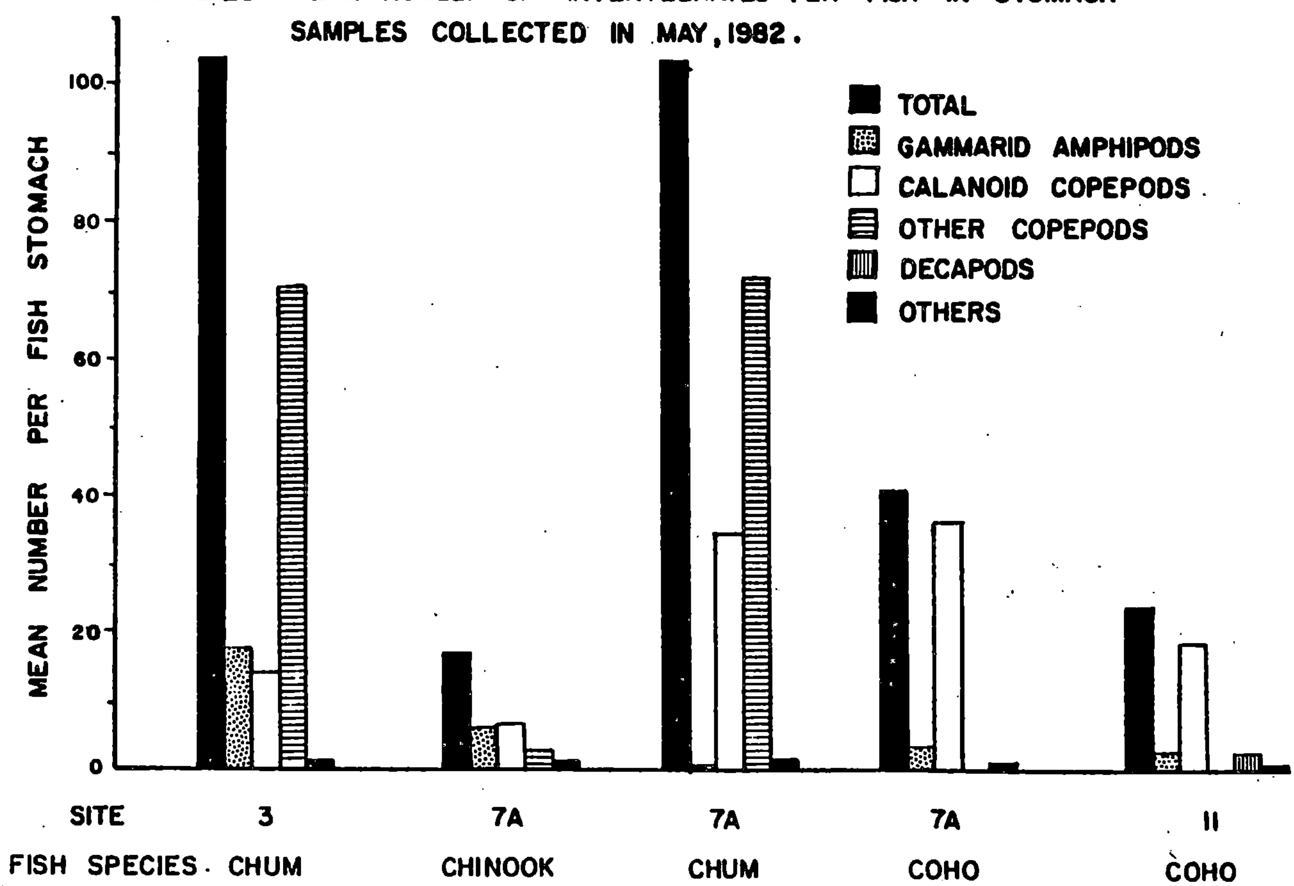
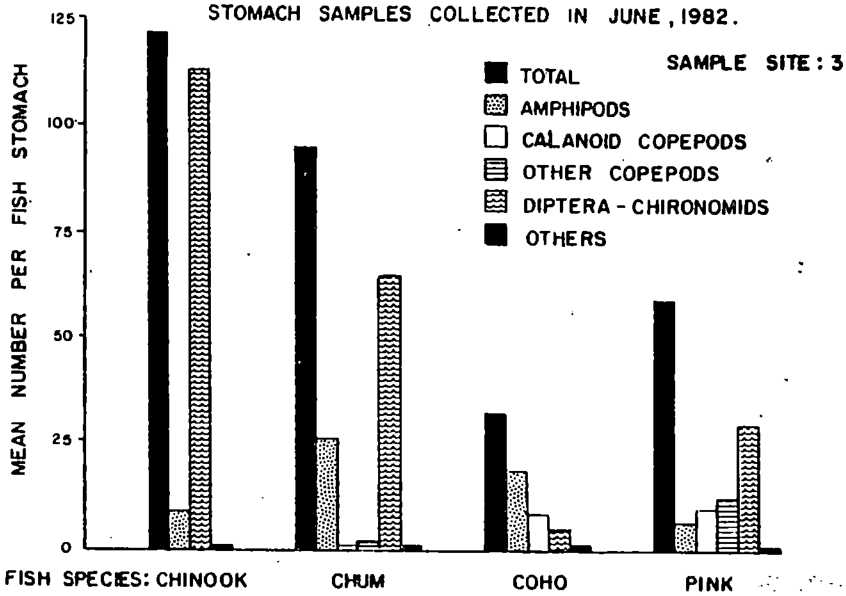
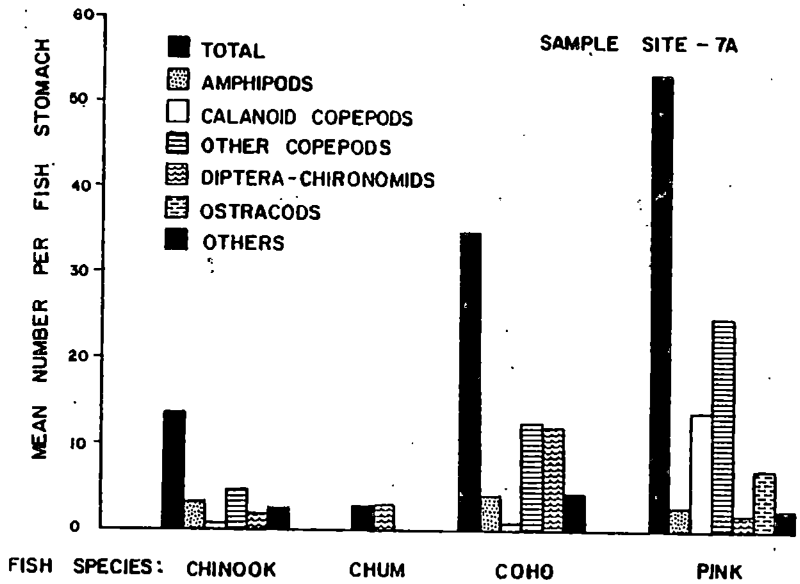
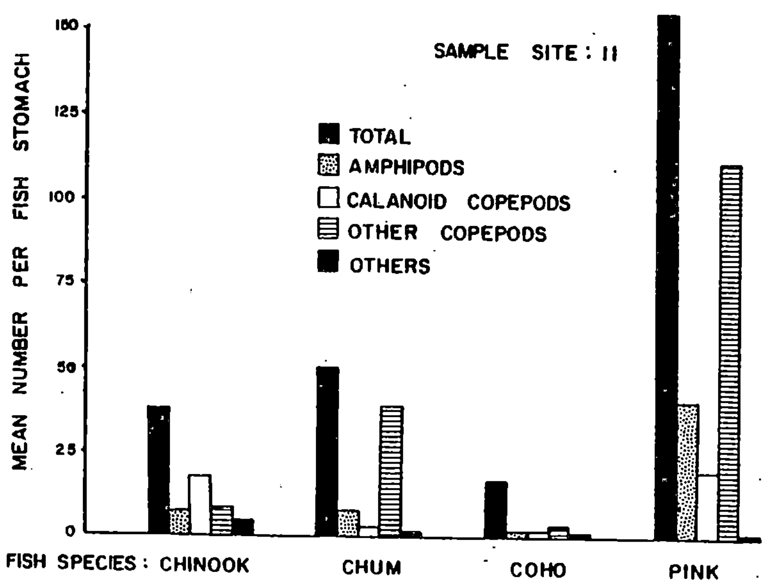


FIGURE:26 - MEAN NUMBER OF INVERTEBRATES PER FISH IN STOMACH SAMPLES COLLECTED IN JUNE, 1982.







In June, the chinook exhibited a wide variation in the types of food consumed between the three sites. As mentioned previously, the single chinook caught at Site 3 fed exclusively on juvenile chironomids and gammarid amphipods. At Site 7A gammarid amphipods and epibenthic copepods were the dominant food items, while fish larvae, calanoid copepods and mysids were of secondary importance. Calanoid copepods were the most important food item at Site 11 followed by gammarid amphipods, and harpacticoid and cyclopoid copepods.

Chum I.R.I. values indicated that calanoid, harpacticoid and cyclopoid copepods were the most important prey items during all three months at all sites. Gammarid amphipods were utilized more in June than in the preceeding two months.

Juvenile coho fed primarily on calanoid copepods in May (only collected at Sites 7A and 11) and on relatively equal numbers of gammarid amphipods, mysids, calanoid copepods and epibenthic harpacticoid and cyclopoid copepods in June (only collected at Site 11).

Juvenile pink salmon stomachs were only sampled in June. At Sites 7A and 11 calanoid copepods were the most important prey items (ie. had the highest I.R.I. values), followed by harpacticoid and cyclopoid copepods. Juvenile chironomids were the dominant food items consumed at Site 3.

The data collected in this study were similar to other studies undertaken in marine nearshore areas of Puget Sound where it was shown that epibenthic detritivores, particularly harpacticoid copepods and gammarid amphipods are the dominant prey items consumed by pink and chum salmon fry during the spring months (Feller et al., 1975; Kaczynski et al., 1973).

5. DISCUSSION

It was observed in our study that the upper reaches of sandy areas in the Campbell River foreshore did not usually support vegetation. In comparison, the lower intertidal zone of sandy areas often supported eelgrass (Figures 4 and 5). Larger substrates (such as cobble and boulder), have greater stability and supported common intertidal algae such as Fucus and Ulva (Figures 4 and 5). Boulders in subtidal areas support larger vegetation, such as kelp (Figures 4 and 5).

There are many large, extensive kelp beds in the study area and where these are absent, other algal mats, eelgrass beds, or mudflats generally exist (Figure 5). These habitats have the potential to support large populations of detritivores, in particular harpacticoid copepods and gammarid amphipods, which are major food items for juvenile salmonids (Simenstad, 1979). Vegetated areas also offer a protective habitat for juvenile fishes and a spawning habitat for herring. This indicates, therefore, that the majority of the Campbell River foreshore may be considered productive fish habitat. Of all the vegetated areas, Simenstad (1979) has indicated that eelgrass is one of the most productive nearshore habitats.

Zooplankton populations especially calanoid copepods, were abundant in the water column in April and May, but declined drammatically in June (Figures 7, 8 and 9). One explanation for the trend is offered by Cushing (1964), who observed that Calanus, a calanoid copepod, overconsumed its major food source, phytoplankton. The decline of phytoplankton populations resulted in the subsequent decline of Calanus populations.

Harpacticoid and cyclopoid copepods, and gammarid amphipods had the highest densities and represented the largest proportion of the biomass at all three benthic sites (Figures 10, 11, 12, 13, 14 and 15). Other taxa consistently present in relatively small numbers at all benthic sites where cumacea, nematoda, oligochaeta, ostracoda and polychaeta (Appendix IIIa, b and c). The total number of benthic invertebrates generally increased from April to June. T-tests comparing benthic invertebrate abundances revealed that no consistent differences occurred between the mid and low intertidal zones.

Samples collected from Site 7A (large cobble/boulder site) and Site 11 (coarse gravel/small cobble site) typically had larger amounts of algae, whereas samples collected from Site 3 were usually devoid of any vegetation. Sites 7A and 11 each had a significantly denser population and larger biomass of benthic invertebrates most commonly consumed by juvenile salmonids than did Site 3. Therefore, invertebrate populations appear to be correlated to the amount of vegetation present at each site. This is further supported by the fact that when sampling was conducted at Site 3 in May in the low tide zone, there was a great deal of eelgrass collected and invertebrate numbers were extremely high, even significantly larger than Sites 7A and 11 during the same time period.

Benthic data were not collected in the high intertidal area during this study. Results from limited sampling in Hidden Harbour (Site 7B) (Habitat Management, unpublished data) indicate invertebrate densities from the high intertidal zone were less dense than in the mid and low intertidal zones. However, the scope of the sampling was limited, the study area fairly protected and not typical of the Campbell River foreshore, suggesting that a further study should be initiated. In particular, invertebrate densities should be more thoroughly compared at the three different tide heights, especially since most foreshore development involving fill would produce the most detrimental effects on the uppermost tidal area where sampling has currently been limited. The generally lower vegetation densities in the high intertidal zones indicate that invertebrate populations are probably less dense than in the lower zones, but this should be supported with data.

Juvenile chinook salmon were most abundant in the Campbell River foreshore from the June 21 - 23, 1982 (avg. $14.4 \cdot set^{-1}$) to the August 6 - 7, 1982 (avg. $11.1 \cdot set^{-1}$) sampling periods. Their average lengths were 85.7 mm in June, 95.9 mm in July and 107.9 mm in August (Appendix Va). Juveniles were observed in the foreshore until mid - October, 1982 (end of sampling), although their numbers were very low ($0.25 - 1.0 \cdot set^{-1}$). After mid-September, 1982 most of the chinook observed were found in Menzies Bay. In a study in the Nanaimo area from 1975 to 1977, Healey (1980a) observed that underyearling chinook began migrating from the rivers and estuaries into the foreshore in late May. In the same study, it was also observed that underyearling fish were more abundant than yearling fish and numbers remained high through the summer and fall.

Juvenile chum were most abundant in the June sampling period (avg. 103.7•set $^{-1}$) and were rare by the August 6 - 9 sampling period (avg. 0.07•set $^{-1}$). Healey (1980b) found that most chum in the Nanaimo area occupy water of one meter or less in depth until late May. Then most of the juvenile chum move away from the beaches into open water in May and June. In our study, the average length of juvenile chum was 57.1 mm in May and 63.9 in June (Appendix Vb).

Coho smolts were abundant in the foreshore in the May (avg. 70.5• set $^{-1}$) and June (avg. 42.0•set $^{-1}$) sampling periods. Results indicated that the coho were probably travelling in large schools and moved quickly through the estuary and along the shallower foreshore areas. The stomach samples indicated that they utilized the food resources of the foreshore area. The average length was 119.1 mm in May (Appendix Vc). Healey (1980b) also found that coho smolts enter Georgia Strait in May and June at an average length of 100 - 120 mm, and disperse rapdily throughout the strait.

The highest CPUE's for juvenile pink salmon in the foreshore was in the April 15 - 20 sampling period (avg. 9.7•set $^{-1}$). However, results may have been different if the sampling was undertaken more frequently throughout the study. The average length was 33.3 mm in April, 46.3 mm in May and 68.6 mm in June (no data for

July (Appendix Vd). Healey (1980b) observed that the offshore movement of juvenile pinks in late May was size dependent, with larger juveniles moving offshore first. Juveniles captured in the Fraser River plume averaged 34.6 mm in length in April, 62 mm at the beginning of June and 100 mm at the beginning of July (Phillips and Barraclough, 1978), and may therefore grow faster than the Campbell River pinks.

Harpacticoid and cyclopoid copepods, and gammarid amphipods had high percent indices of relative importance in the stomachs of juvenile chinook, chum, coho and pink salmon (Appendix VI). As previously mentioned, these taxa were also the most abundant invertebrates found in the intertidal benthos. These results along with other studies indicate that juvenile salmon are opportunistic feeders, feeding on the more abundant prey species in an area.

Calanoid copepods were also an important food item for all four salmon species. Although the percent I.R.I.'s for calanoid copepods fluctuated erractically between sites and between months, they were also an important food item for all four salmon species. All food items consumed by the juvenile salmon (except juvenile chironomids) were found either in the water column or in the intertidal benthos. Therefore the Campbell River foreshore plays an important role in the survival of juvenile salmon by providing essential food items.

There was also evidence that fish in the Campbell River foreshore occassionally relied on food produced in freshwater. In June at Site 3 juvenile chironomids were the dominant food item consumed by juvenile chinook, chum and pink salmon (Figure 26a). Since chironomid populations were extremely low in all benthic samples it seems likely that this source of food originated from Simm's Creek, located slightly north of Site 3. Therefore, drift insects from freshwater streams may provide a valuable food resource for juvenile salmon in late spring at some areas of the Campbell River foreshore.

This study has illustrated the importance of the Campbell River vegetated foreshore areas in terms of fish production. These areas provide not only protective cover for juvenile fish but supply optimum habitats for benthic and epibenthic invertebrates, which are essential juvenile salmon food items. This study has provided some insight as to where foreshore development will cause the most amount of damage to fish habitat.

6. CONCLUSIONS AND RECOMMENDATIONS

1. The sandy/fine gravel site (Site 3) did not support as much vegetation as the coarse gravel/small cobble site (Site 11) and large cobble/boulder site (Site 7A). Furthermore, the mid to high intertidal zone of the sandy /fine gravel site was devoid of vegetation (except some drift algae) and supported a significantly lower population of benthic invertebrates than the other two more vegetated sites. The sandy site was sampled in the low intertidal zone in May near a small eelgrass patch and it was found these samples were more productive than the other two sites during the same time period. We concluded that vegetated areas are more productive than non-vegetated areas in terms of providing a habitat for benthic and epibenthic invertebrates important in juvenile salmonid diets, such as harpacticoid and cyclopoid copepods and gammarid amphipods. The low intertidal zone generally had higher vegetation densities than the high-intertidal zone. We conclude that habitat protection/ management efforts should to applied to the vegetated foreshore areas of Campbell River.

2. Juvenile chinook, chum, coho and pink salmon all utilize the Campbell River foreshore for various periods of time on their migration from the estuary to deeper, open

waters. Juvenile chinook rear in Menzies Bay in the fall, but only in low numbers.

3. Main food items for juvenile chinook, chum, coho and pink salmon were found in the Campbell River foreshore area. Harpacticoid and cyclopoid copepods and gammarid amphipods were found in the intertidal benthos at all three substrate sites, while calanoid copepods were found in the water column. Juvenile chironomids, possibly entering the foreshore from freshwater streams (ex. Simm's Creek), were an important food item for juvenile chinook, chum and pink salmon at Site 3.

4. The biophysical data gathered give a general indication of the importance of each of the three different substrate types studied in terms of juvenile salmon utilization. These biophysical data were used as an aid in the development of the Ministry of Lands, Parks and Housing foreshore plan for the Campbell River area.

Since only one site of each substrate type was examined, this information may not be directly applied to other unstudied areas. Therefore, any review of development proposals affecting the foreshore should be accompanied by a thorough biological study of the area in question. Furthermore data collecting were limited in the high intertidal zones. All that is known is that the vegetation is generally sparser in this area than lower zones, and low vegetation usually indicates low benthic invertebrate populations. Since foreshore development, especially filling the intertidal section, is most likely to involve the high intertidal zone, further investigations should be carried out in this area to see if the above pattern exists here.

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APPENDICES

APPENDIX Ia - Invertebrate Subsampling Method

The following is a description of our invertebrate subsampling method which was developed by Dr. Mundie (Pacific Biological Station, Nanaimo):

First, each sample was passed through a 9.5 mm sieve in order to remove material which would not freely pass through the diameter of the vials. Fauna passing through the 9.5 mm sieve were retained for subsampling. Fauna retained by the sieve were sorted, counted, identified at least to the order level and later added to the total sample count (see Section 3.4.3 for calculations).

Ninety-three 25 mm diameter flat bottom shell vials were placed in a herring bucket with a bottom diameter of 26.5 cm. The bucket was then filled with water until the top of the water column stood approximately 25 cm above the tops of the vials. Eight mls of standard dishwashing detergent was added to the bucket water and gently stirred in to decrease the water's surface tension. The invertebrate sample was placed into a beaker and enough water was added to allow the sample to float freely. The sample was agitated and poured into the bucket. Simultaneously, another technician stirred the solution in the bucket in a figure eight fashion in order to randomly distribute the invertebrates throughout the water column. The invertebrates were allowed to settle for a period of at least four hours.

After the sample had settled, six* (or ten**) vials were randomly removed from the bucket. All invertebrates in these vials were sorted, counted and identified usually to the order level using a dissecting microscope. Amphipods, cumaceans, isopods, polychaetes*** and tanaids were identified to as far as was practical. Any organisms found floating on the water surface were skimmed off and added to the ¨9.5 mm fraction. Both the identified invertebrates and the remainder of the sample were then stored in 80% isopropyl alcohol. The total number of invertebrates m^{-2} was then determined using the calculations in Appendix Ib.

* The number Dr. Mundie gave as a statistically valid number of subsampling vials.

** Ten vials were used instead of six if there was a particularly low number of invertebrates present.

*** Only identifed for Site 7 samples due to lack of time.

APPENDIX Ib - Calculation of Benthic Standing Crop

Sample Area = 0.164 m^2 = 1/6.098 m^2

Vial Diameter = 22 mm

Bucket Diameter = 264 mm

Area of 1 vial = $(r)^2$ = $(11\ mm)^2$ = 380 mm^2

Area of Herring Bucket = $(r)^2$ = $(132\ mm)^2$ = 54,739 mm^2

Subsample Size

(6 vials) = 380/54,739 x 6 = 0.0416 = 1/24.01 = 4.16% of total sample

(10 vials) = 380/54,739 x 10 = 0.0694 = 1/14.41 = 6.94% of total sample

Number in Total Sample

(if 6 vials used) = (# in 6 vials) (24.01) + ("9.5 mm^2 fraction)

(if 10 vials used) = (# in 10 vials) (14.41) + ("9.5 mm^2 fraction)

Number in One Meter Squared

= (# in total sample) (6.098)

APPENDIX IIa - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE PLANKTON TOWS COLLECTED IN APRIL, 1982

INVERTEBRATE		April 20 (18:00) Site 3	April 20 (16:45) Site 11	April 20 (21:00) Site 11
Amphipoda	*Accedomoera vagor*	-	-	43
	Pontogenia rostrata	-	-	86
	Unidentified	-	-	57
Cirripedia	Cyprid larvae	749	456	-
Copepoda	Calanoida	331	1,176	1,037
	Parasitic	14	-	-
	Harpacticoid & Cyclopoid	58	96	144
Cumacea		14	-	-
Decapoda	Zoea larvae	101	24	158
Diptera	Chironomidae	14	-	-
Fish	larvae	-	-	14
Ostracoda		-	-	345
Polychaeta		-	-	14
Scyphozoa		-	-	14
Totals		1,281	1,752	1,912

APPENDIX IIb - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE PLANKTON TOWS COLLECTED IN MAY, 1982

INVERTEBRATE		May 27 (13:05) Site 3	May 27 (12:25) Site 7A	May 26 (13:00) Site 11
Amphipoda	Calliopiidae	44	29	-
	Gammaridea	28	86	44
	Hyperiidea	-	-	14
Cirripedia	Cyprid larvae	14	14	43
Copepoda	Calanoida	58	102	2,386
	Harpacticoid & Cyclopoid	838	952	202
	Nauplius larvae	-	14	-
Malacostraca	Unidentified	14	-	-
Totals		996	1,197	2,689

APPENDIX IIc - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE PLANKTON TOWS COLLECTED IN JUNE, 1982

INVERTEBRATE		June 22 (10:30) Site 3	June 22 (20:30) Site 7A	June 22 (19:50) Site 11
Amphipoda	Caprellidae	-	-	1
	Gammaridea	14	-	3
Cirripedia	Cyprid larvae	14	14	4
Copepoda	Calanoida	14	14	23
	Harpacticoid & Cyclopoid	43	202	50
	Naplius larvae	-	-	1
Decapoda	Zoea larvae	14	28	13
Insecta	larvae	-	-	2
Isopoda	Cryptoniscan larvae	-	14	-
Ostracoda		-	-	1
Malacostraca	Unidentified	-	-	1
Nematoda		14	-	-
Totals		113	272	99

APPENDIX IIIa - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES IN APRIL, 1982 (#/m^2)

(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Acarina		1		1,296		183	
Amphipoda	(Gammaridea)						
	Accedomoera vagor	-		-		2,566	
	Allorchestes angustus	36		1		110	
	Ampithoe sp.	-		33		-	
	Aoroides columbiae	-		444		-	
	Calliopiella pratti	5		2,111		293	
	Hyale sp.	-		-		439	
	Ischyrocerus sp.	-		-		38	
	Paramoera sp.	-		268		-	
	Paraphoxus spinosus	-		177		-	
	Photis brevipes	-		30		-	
	Pontogeneia sp.	-		455		523	
	Unidentified	38		528		2,752	
	Total	96	±70	4,077	±2,229	6,722	±2,891
Amphipoda	(Caprellidae)	-		-		37	
Anthozoa		-		410		-	
Bivalvia	Mytilidae	-		-		29	
	Unidentified	-		117		-	
Cirrepedia		211	±76	3,036	±2,463	996	±841
Copepoda		1,145	±965	69,567	±22,743	10,203	±6,177

APPENDIX IIIa (Cont'd)
(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Cumacea	*Cumella* sp.	56		1,761		73	
	Lamprops sp.	33		-		-	
Decapoda	*Hemigrapsus* sp.	-		32		37	
	Pugettia producta	-		-		1	
	Zoea larvae	1		-		-	
Echinoidea		-		29		-	
Gastropoda		-		59		-	
Isopoda	*Idotea* sp.	-		58		37	
	Munna sp.	-		29		-	
	Sphaeromatidae	-		-		2	
Nematoda		1,467	±1,050	13,345	±10,045	488	±485
Oligochaeta		7		29		227	
Ostracoda		250	±516	2,521	±851	331	±280
Polychaeta		30	±65	2,003	±1,722	367	±252
Tanaidacea	*Leptochelia* sp.	-		88		-	
Total		3,298	±1,493	98,486	±25,776	19,774	±10,180

APPENDIX IIIa - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES IN APRIL, 1982 (#/m^2)

(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Acarina		36		464		354	
Amphipoda	(Gammaridea)						
	Accedomoera vagor	-		-		130	
	Ampithoe sp.	-		29		58	
	Calliopiella pratti	-		265		60	
	Calliopius laeviusculus	-		1		30	
	Hyale sp.	-		29		-	
	Ischyrocerus sp.	-		-		88	
	Photis brevipes	-		60		29	
	Pleusirus secorrus	-		29		-	
	Pleustes depressa	-		29		29	
	Pontogeneia sp.	-		3,108		7,700	
	Unidentified	91		562		1,297	
	Total	91	±128	4,863	±1,698	9,456	±5,689
Amphipoda	(Caprellidae) Caprella sp.	-		64		29	
Anthozoa		-		29		-	
Asteroidea		-		29		29	
Bivalvia		46		60		176	
Cirrepedia		66		117		234	

APPENDIX IIIa (Cont'd)
(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Copepoda	Harpacticoida & Cyclopoida	1,533	±1,124	25,308	±18,787	12,141	±2,765
Cumacea	*Cumella* sp.	156		29		234	
	Lamprops sp.	29		–		–	
	Total	184		29		234	
Decapoda	*Hemigrapsus* sp.	–		29		–	
	Pugettia producta	–		2		–	
	Zoea larvae	–		–		29	
	Pugettia richii	–		1		–	
	Pagurus sp.	–		1		–	
Diptera	Chironomid larvae	60		–		–	
Echinoidea		–		–		59	
Gastropoda		0		1,032	±136	88	
Isopoda	*Munna* sp.	–		32		29	
	Unidentified	–		–		29	
Nematoda		443	±342	3,390	±2,131	4,210	±2,315
Oligochaeta		178	±188	539	±433	2,869	±1,645
Ostracoda		128	±126	1,273	±740	942	±815

APPENDIX IIIa (Cont'd)
(ii) LOW TIDAL ZONE

TAXA	SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Ophiuroidea	-		1		-	
Polychaeta	2	±5	2,023	±1,264	969	±530
Tanaidacea *Leptochelia* sp.	-		29		-	
Total	2,709	±1,489	39,519	±23,554	31,939	±3,105

APPENDIX IIIb - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES IN MAY, 1982 (#/m²)

(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Acarina		61		390		178	
Amphipoda	(Gammaridea)						
	Accedomoera vagor	-		-		2,089	
	Ampithoe sp.	-		146		3	
	Aoroides columbiae	-		874		3	
	Calliopiella pratti	-		1,323		1,430	
	Hyale sp.	-		-		40	
	Ischyrocerus sp.	-		-		49	
	Paraphoxus spinosus	-		98		-	
	Pleustes depressa	-		1		-	
	Pleusirus secorrus	-		30		-	
	Photis brevipes	-		-		38	
	Pontogeneia sp.	-		299		956	
	Synchelidium shoemakeri	-		1		-	
	Unidentified	30		797		4,188	
	Total	30	±68	3,633	±2,946	7,979	±4,655
Amphipoda	(Caprellidae) *Caprella* sp.	-		121		29	
Archaeogastropoda		-		85		-	
Bivalvia		-		-		1	
Cirrepedia		29		146		-	
Copepoda		4,558	±3,513	92,950	±21,849	32,768	±27,530

APPENDIX IIb (Cont'd)
(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Cumacea	*Cumella* sp.	-		1,905		60	
Decapoda	Brachyura	-		-		29	
	Hemigrapsus sp.	-		2		-	
	Mimulus foliatus	-		1		-	
	Pagurus sp.	-		58		-	
	Unidentified	-		-		60	
Diptera	Chironomid larvae	-		29		-	
Gastrapoda		29		292		267	
Isopoda	Bopyridae	-		1		-	
	Idotea sp.	-		29		-	
	Janira sp.	-		-		29	
	Munna sp.	-		761		176	
	Unidentified	-		2		-	
Nematoda		2,769	±1,848	8,033	±4,589	9,105	±6,086
Nemertea		-		1		-	
Oligochaeta		-		361		3,585	±2,246
Ostracoda		456	±338	7,389	±5,271	644	±382
Polychaeta		-		14,910	±24,954	909	±791

APPENDIX IIIb (Cont'd)
(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Tanaidacea	*Anatanais normani*					31	
	Leptochelia sp.	29		1,576		503	±419
Total		7,962	±3,589	132,655	±20,792	56,122	±39,150

APPENDIX IIIb - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES IN MAY, 1982 (#/m^2)

(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Acarina		1,287	±1,273	474		148	
Amphipoda	(Gammaridea)						
	Accedomoera vagor	59		-		32	
	Allorchestes angustus	207		-		-	
	Ampithoe sp.	59		-		29	
	Aoroides columbiae	-		-		529	
	Calliopiella pratti	-		-		644	
	Paramoera sp.	-		51		-	
	Photis brevipes	-		-		29	
	Pleusirus secorrus	49		-		-	
	Pleustes depressa	-		-		29	
	Pontogeneia sp.	117		-		617	
	Unidentified (juveniles)	2,728		102		1,520	
	Total	3,170	±4,322	166	±288	3,459	±1,405
Amphipoda	(Caprellidae) Caprella sp.	482	±1,077	8		-	
Archeogastropoda		-		29		-	
Asteroidea		-		-		29	
Bivalvia	Mytilidae	-		-		261	
	Unidentified	-		3		-	
Calanoida		-		5		-	

APPENDIX IIIb (Cont'd)
(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Cirrepedia		-		2		-	
Copepoda	Harpacticoida & Cyclopoida	121,590	±78,372	22,744	±2,291	19,234	±10,253
Cumacea	*Cumella* sp.	761	±598	-		29	
	Unidentified	-		6		-	
Decapoda	Brachyura	-		2		59	
	Heptacarpus brevirostris	-		-		7	
	Crangon sp.	-		-		1	
	Pagurus sp.	-		-		1	
Diptera	Chironomid larvae	89		152		-	
Echinoidea		-		-		29	
Gastropoda		29		122		440	
Isopoda	*Janira* sp.	-		-		29	
	Munna sp.	-		-		149	
	Cryptoniscan larvae	29		-		-	
	Unidentified	-		2		29	
Nematoda		5,481	±3,570	4,536	±2,843	18,675	±15,695
Oligochaeta		205		271		3,632	±3,333
Ostracoda		4,988	±2,920	1,866	±1,841	2,670	±1,426

APPENDIX IIIb (Cont'd)
(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Osteichthyes	Cottidae	6		–		–	
Polychaeta		176	±160	783	±230	973	±492
Sipuncula		–		–		29	
Tanaidacea	*Anatanais normani*	59		–		177	
	Leptochelia sp.	29		–		90	
	Unidentified	–		2		–	
	Total	88		2		267	
Total		138,376	±88,736	31,510	±5,149	50,151	±24,582

APPENDIX IIIc - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES IN JUNE, 1982 (#/m^2)

(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Acarina		470	±458	94		30	
Amphipoda	(Gammaridea)						
	Accedomoera vagor	-		-		1,405	
	Allorchestes angustus	1,205		135		-	
	Ampithoe sp.	-		-		88	
	Calliopiella pratti	-		280		3,162	
	Calliopius laeviusculus	-		-		88	
	Corophium sp.	-		-		29	
	Hyalidae	468		-		-	
	Hyale sp.	-		-		1,903	
	Ischyrocerus sp.	-		-		88	
	Melita sp.	-		-		88	
	Paramoera sp.	-		30		-	
	Paraphoxus spinosus	-		37		-	
	Pleusirus secorrus	-		29		-	
	Pleustes depressa	-		-		29	
	Pontogeneia sp.	-		1		7,201	
	Unidentified	879		184		4,084	
	Total	2,553	±3,521	697	±602	18,312	±13,232
Amphipoda	(Caprellidae) *Caprella* sp.	0		17		32	
Bivalvia	*Clinocardium nuttalli* Unidentified	117		1		T	
Cirrepedia		117		1,489		-	

APPENDIX IIIc - (Cont'd)
(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Copepoda		119,465	±67,325	16,416	±5,220	202,865	±44,969
Cumaceada	*Cumella* sp.	996		855		468	
Decapoda	*Hemigrapsus* sp.	-		1		-	
	Hemigrapsus oregonensis	-		278		-	
	Pagurus sp.	-		117		32	
Diptera	Chironomid larvae	266		230		-	
Gastropoda		-		64		116	
Isopoda	*Gnorimosphaeroma* sp.	-		-		1	
	Munna sp.	-		1		1	
	Unidentified	-		58		-	
Mesogastropoda	*Polinices lewesii*	-		1		-	
Nematoda		12,023	±5,961	7,820	±3,664	10,978	±5,457
Oligochaeta		1,083	±2,101	962	±910	2,232	±784
Osteichthyes	Cottidae	1		-		-	
Ostracoda		8,517	±6,604	4,928	±6,222	1,413	±824
Polychaeta		88	±196	735	±282	352	±267

APPENDIX IIIc (Cont'd)
(i) MID TIDAL ZONE

TAXA		SITE 3 #'S	S.D	SITE 7 #'S	S.D.	SITE 11 #'S	S.D.
Tanaidacea	*Anatanais normani*	-		-		59	
	Leptochelia dubia	1		-		29	
Total		145,579	±82,615	34,824	±14,025	237,408	±52,454

APPENDIX IIIc - INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES IN JUNE, 1982 (#/m²)

(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Acarina		324		95		117	
Amphipoda	(Gammaridea)						
	Accedomoera vagor	-		-		16,554	
	Allorchestes angustus	117		-		-	
	Ampithoe sp.	-		30		-	
	Aoroides columbiae	-		324		-	
	Corophium sp.	-		-		-	
	Calliopiella pratti	-		58,424		36,825	
	Hyalidae (juveniles)	-		1		-	
	Ischyrocerus sp.	130		1,827		293	
	Paraphoxus spinosus	-		1		-	
	Photis brevipes	-		-		790	
	Pleusirus secorrus	-		29		-	
	Pontogeneia sp.	2		11,208		20,421	
	Unidentified	213		2,796		37,592	
	Total	367	±389	74,953	±52,527	112,485	±65,238
Amphipoda	(Caprellidae)						
	Caprella alaskana	-		1,514		-	
	Caprella laeviuscula	-		4,309		-	
	Caprella sp.	-		17,243		121	
Asteroidea		-		29		-	
Bivalvia		36		-		-	

PPENDIX IIIc (Cont'd)
(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Cirrepedia		32		29		0	
Copepoda		75,266	±21,683	201,576	±95,826	114,657	±60,996
Cumacea	*Cumella* sp.	6,366	±2,764	1		120	
	Unidentified	-		1		146	
Decopoda	*Crangon* sp.	-		-		2	
	Heptacarpus sp.	-		-		2	
	Hippolytidae	-		-		29	
	Pugettia sp.	-		-		29	
	Unidentified	1		-		-	
Diptera	Chironomid larvae	88		-		-	
Echinoidea		-		-		1	
Gastropoda		58		1,357	±1,391	117	
Isopoda	*Munna* sp.	-		590		118	
	Unidentified	-		-		29	
Mysidacea		-		88		1	
Nematoda		14,122	±5,213	2,671	±2,253	32,206	±10,129
Oligochaeta		2,935	±3,532	38		3,477	±4,883
Ostracoda		15,484	±4,730	585	±401	1,880	±574

APPENDIX IIIc (Cont'd)
(ii) LOW TIDAL ZONE

TAXA		SITE 3 #'S	SITE 3 S.D	SITE 7 #'S	SITE 7 S.D.	SITE 11 #'S	SITE 11 S.D.
Polychaeta		677	+818	890	+518	656	+704
Tanaidacea	Anatanais normani	-		154		-	
	Leptochelia sp.	146		29		411	
	Unidentified	-		29		-	
	Total	146		212		411	
Total		115,882	+27,845	305,035	+123,658	266,713	+120,374

APPENDIX IIId - POLYCHAETES IDENTIFIED IN THE BENTHIC SAMPLES COLLECTED FROM SITE 7A IN CAMPBELL RIVER FORESHORE (#/m²)

FAMILY	GENUS SPECIES	April Mid	April Low	May Mid	May Low	June Mid	June Low
Aphroditoidea	Unidentified	6	-	-	-	-	-
Arabellidae	Unidentified	-	1	30	-	-	-
Capitellidae	*Capitella* sp.	-	-	-	-	58	-
Chrysopetalidae	*Paleanotus bellis*	-	29	-	-	-	-
	Paleanotus sp.	-	-	-	-	-	73
Dorvilleidae	*Dorvillea* sp.	-	5	-	-	-	38
	Unidentified	-	-	-	-	-	2
Glyceridae	*Hemipodus borealis*	-	-	-	-	1	-
Hesionidae	Unidentified	75	325	238	49	-	38
Lumbrineridae	Unidentified	3	-	-	-	-	-
Nereidae	*Nereis* sp.	-	-	-	-	176	-
	Platynereis bicaniculata	16	29	1	2	-	-
	Unidentified	6	-	-	-	200	-
Nerillidae	Unidentifed	-	-	-	-	59	-
Onuphidae	*Onuphis* sp.	-	47	-	-	-	-
Ophelidae	*Armandia brevis*	62	-	59	-	-	-
Phyllodocidae	*Phyllodoce castanea*	3	-	-	-	-	-
Polynoidae	Unidentified	53	427	117	49	1	-
Siglionidae	Unidentified	3	-	-	-	-	-
Spionidae	*Malacocerus glutaeus*	59	-	59	-	59	-
	Spio sp.	-	-	-	49	-	-
	Unidentified	362	-	29	-	-	-
Syllidae	*Brania brevipharyngea*	338	135	-	49	-	73
	Exogone sp.	12	547	59	392	-	40
	Syllis sp.	-	-	-	49	29	-
	Trypanosyllis sp.	34	29	-	-	-	-
	Unidentified	-	163	-	-	59	29
Terebellidae	Unidentified	9	-	-	-	17	-
Unidentified		168	206	30	305	-	651
Unidentified (juveniles)		-	-	14,349	-	-	-

APPENDIX IIIe - BIOMASS OF INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES (g/m^2)

		Gammarid Amphipods	Harpacticoid & Cyclopoid Copepods	Others*	Total*	OTHERS**	TOTAL**
APRIL							
SITE 3							
	MID	0.0126	0.0204	0.0368	0.0698	0.0000	0.0698
	LOW	0.0071	0.0340	0.0356	0.0767	0.0158	0.0925
SITE 7A							
	MID	0.0856	0.2421	0.6435	0.9712	0.0135	0.9847
	LOW	0.8563	0.1774	0.3476	1.3813	0.2923	1.6736
SITE 11							
	MID	1.8012	0.0841	0.1546	2.0399	0.6908	2.7307
	LOW	2.0467	0.1489	0.1948	2.3904	0.0000	2.3904
MAY							
SITE 3							
	MID	0.0121	0.0438	0.0465	0.1024	0.0000	0.1024
	LOW	0.4850	0.8604	0.1824	1.5278	0.0000	1.5278
SITE 7A							
	MID	0.0966	0.1939	0.5874	0.8779	0.5758	1.4537
	LOW	0.0150	0.1020	0.0290	0.1460	0.0598	0.2058
SITE 11							
	MID	0.1670	0.2981	0.1530	0.6181	0.0525	0.6706
	LOW	0.7261	0.1932	0.2615	1.1808	2.6223	3.8031

APPENDIX IIIe (Cont)- BIOMASS OF INVERTEBRATES FOUND IN CAMPBELL RIVER FORESHORE BENTHIC SAMPLES (g/m^2)

		Gammarid Amphipods	Harpacticoid & Cyclopoid Copepods	Others*	Total*	OTHERS**	TOTAL**
JUNE							
SITE 3							
	MID	0.1193	0.3315	0.1597	0.6105	0.0000	0.6105
	LOW	0.0472	0.3474	0.6614	1.0560	0.0000	1.0560
SITE 7A							
	MID	0.2261	0.0744	1.4832	1.7837	7.2745	9.0582
	LOW	2.1998	0.5254	0.6913	3.4165	0.5770	3.9935
SITE 11							
	MID	0.9751	1.2578	0.1785	2.4114	0.1394	2.5508
	LOW	2.0299	0.9289	0.3206	3.2794	0.0022	3.2816

* Excludes organisms greater than 9.5 mm or with calcareous shells

** Includes all organisms

APPENDIX IIIf Significant Differences in Numbers and Biomass Between Locations, Measured by One Way Analysis of Variance (ANOVA) and Subsequent Multiple Range Testing (.05). (Only significantly different sites are listed.)

	LOW		MID	
	Total Numbers	Total Biomass*	Total Numbers	Total Biomass*
Invertebrate totals				
April	7A"3	11"3	7A"3	-
	11"3	7A"3	11"3	-
May	3"11	-	7A"11"3	-
	3"7A	-	-	-
	-	-	-	-
June	7A"3	-	11"3"7A	-
	11"3	-	-	-
Copepods (Harpacticoid and Cyclopoid)				
April	7A"3	-	7A"11	-
	-	-	7A"3	7A"3
May	3"7A	3"11	7"11"3	
	3"11	3"7A	-	-
June	7A"3	11"3	11"3"7	11"3
	-	-	-	11"7A
Gammarid Amphipods				
April	11"3	-	11"3	
	7A"3	-	7A"3	-
May	-	-	11"3	-
	-	-	-	-
June	11"3	-	11"7	-
	7"3	-	11"3	-

* Excludes organisms greater than 9.5 mm^2 or with calcareous shells.

APPENDIX IVa - CATCH DATA FOR ALL FISH SPECIES SAMPLED FROM THE CAMPBELL RIVER FORESHORE FROM APRIL 15 TO OCTOBER 27, 1982.

Abbreviations

PHER Pacific Herring, PK Pink Salmon, CM Chum Salmon, CO Coho Salmon, CK Chinook Salmon, CT Coastal Cutthroat Trout, TC Pacific Tomcod, TsSb Threespine Stickleback, BP Bay Pipefish, ShP Shiner Perch, StP Striped Seaperch, UP Unidentified Surfperch, UB Unidentified Blenny, PG Penpoint Gunnel, SL Pacific Sand Lance, URF Unidentified Rockfish, KGr Kelp Greenling, BSc Buffalo Sculpin, ShSc Pacific Staghorn Sculpin, TpSc Tidepool Sculpin, USc Unidentified Sculpin, Af Smooth Alligatorfish, ULp Unidentified Liparis, Sdab Unidentified Sanddab, SF Starry Flounder, COS C-O Sole,
UFf Unidentified Flatfish, (J) Juvenile, RCr Rock Crab, KC Kelp Crab Blank = Not Sampled.

Sampling Period (1982)	Site 1	Site 2	Site 3	Site 4	Site 5
April 20	1PK 1PHER(J) 2TpSc	1PK 27CM	8PK 3CM 5SL 1Sdab 1SF	25PK 30CM	20PK 2CM 1KGr(J)
	1PK 1CM 1KGr(J) 14StP 2SpSc 1TpSc		2Sdab 1TpSc 1SF 45CM 14PK		
May 26	12CO 1CK	2CO 2CM 2UP 2KGr	15CO 1CK 3CM 1Sc 1TC	20CM 8PK 1USc	81CO 3CK 25CM 4USc 30TC(J)
June 22			3CK 1CO 225CM 5PK 12USc		
June 23	50CK 430CO 190CM	1CK 1CO 16CM 17StP			4CK 4CM 1CT 4USc

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 1	Site 2	Site 3	Site 4	Site 5
July 6	1CO 2USc 100StP 1CK 103CM		33CK 1CO 250CM 1UP 1USc 1KGr		
Aug 6	1ShSc 2CK 34NF 1UP 2USc	47ShP 6USc 5ShP 5USc			
Aug 12	125SL 58UP 2USc 1KGr 2SL 103UP 8USc 1BP		36UP 4SF 6USc 88UP 7SF 13USc		
Aug 24	5USc 1Sdab 8UP 6USc 3UP		13USc 8Sdab 4USc 1Sdab 1UP		
Aug 31	2CK 6UP 3USc 1SL 5UP 4USc 1BP		3Sdab 2Sdab 3USc 1UP		
Sept 8			10ShP 1Sdab 3USc 2StP 1CK 3USc 2Sdab 6ShP 1StP		

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 1	Site 2	Site 3	Site 4	Site 5
Sept 13	2USc 4USc		Unable to Count USc present		
Oct 12	No catch No catch		No catch No catch		
Oct 19	No catch No catch		2UFf 1USc 7UFf		

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 6	Site 7A	Site 7B	Site 9	Site 10
Apr 15		60-70CM 60-70PK 7StP 2UCot			
Apr 20		15PK 20CM 1SF		8PK 3CM	1CO 1PK 2CM 4TpSc 1BSc 1KGr(J) 1RCr
May 25				2CK 46PK 126CM 16CK 240CO 4CM 2CT 2PHER(J)	
May 27		72CO 30USc 35TC	13CO 1CK 2CM 30UCot 3StP 4USc		
June 21		1CK 3PK 20CM 8USc			
June 22		6USc 1CK 1CO 72CM 1TsSb 18Sc 1KGr			

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 6	Site 7A	Site 7B	Site 9	Site 10
June 23	35CK 13CO 3CM 1KGr 4USc			10CK 5PK 370CM	
July 6		16CK 1KGr 2StP 5ShP 35USc 2CK 1CM 2KGr		1CK 7CM 10PHER(J) 10USc 1URF 1CK 2CM 1USc 3PHER 1SF	
Aug 6	No catch 7CK 1USc	4CK 13USc 3CK 6USc			
Aug 9				17CK 1CM 6CK 2USc	
Aug 12	6USc 1USc 10UP				
Aug 17		94UP 1SF 6USc 56UP 5SF		3CK 5USc 2CK 1USc	

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 6	Site 7A	Site 7B	Site 9	Site 10
Aug 24	1StP 3ShP 3ShP	4USc 1KGr 3ShP 1PG 4CK 14ShP 1USc 1PG 1UP	54ShP 10USc 55ShP 2USc		
Aug 31	No catch 2UP				
Sept 1		62USc 1ShP 39USc	5USc 3USc	6USc 1SL 3USc	
Sept 7		12USc 8USc 5StP 1Sab	2SF 6USc 46UP 12USc	1Sdab 7UP 7USc	
Sept 8	1CK No catch				
Sept 13	Not Seined	2USc 4USc	10UP 4USc 2UP		
Sept 14				No catch 20CK 2USc	
Oct 7	No catch No catch	No catch 1USc	No catch No catch	No catch No catch	
Oct 12	No catch No catch	No catch No catch	No catch No catch	No catch 5USc	
Oct 19	1UFf 1KGr No Catch	2PHER 2USc 1UP 1USc 1UB	2UFf 1UFf 1UFf	2USc 5USc	

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 11	Site 12	Site 22	Site 23	Site 24
Apr 16	1PK 2CM 9CO				
Apr 20	1CK 10PK 14CM 1BSc 25ULp 3SF				
May 25	214CO 7CK 1CM 1KGr 1TC	123CO 3CK 1CM			
June 22	40CK 16CO 9PK 240CM 1CT				
June 23		14CK 1CM 1USc			
July 7	13CK 144CM	33CK 8CM 61KGr 1SL 3USc			
	17CK 4CM	10CK 6USc 1KGr			

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 11	Site 12	Site 22	Site 23	Site 24
Aug 9	2CK — 1USc	67CK 1USc 1UP — 48CK			
Aug 17	1ST 1UP — 15CK 1PHER 2UP	No catch — No catch			
Aug 27	2USc — 14CK	5CK 1TsSb — 2TsSb			
Sept 1	2CK 1StP — No catch	No catch — No catch			2UP 2ShSc 157TpSc 6TsSb
Sept 7	4CK — 8CK 2ShP	1CK — 1USc		No catch — No catch	22CK 1USc 4Sdab — 2CK 1USc 3SF
Sept 14	No catch — No catch	10CK — 1CK 1USc			
Oct 7	1USc — 1USc	1CK 2TsSb — No catch		6SF 1USc — 3SF 4USC	3CK
Oct 12	No catch — 2TsSb	1USc — 1USc	No catch — No catch		

APPENDIX IVa - (Con't)

Sampling Period (1982)	Site 11	Site 12	Site 22	Site 23	Site 24
Oct 14			(North) 1UB 1BP 2USc 3UFf 1KC		
			(North) 6USc 1UFf 1COS 1UB 2KGr		
			6USc 4BP 6Af		
			6USc 1UP 2BP		
			(South) 17UP 3USc 2PG 5TC 2Af		
			(South) 22UP 1PG 1USc 1BP 3Af		
Oct 19	1USc	1USc		2SF 2USc	No Catch
	No catch	No catch		1USc	No catch
Oct 27		1CK 1BSc			
		2TsSb			

APPENDIX IVa - (Con't)

Sampling Period (1982)	M 1	M 2	M 3	M 4
Aug 25	4USc 26USc	1USc No catch	40USc 47USc	10CK 16Sdab 10USc 16USc 10Sdab
Sept 2	3TpSc 1TpSc	2USc 1USc	1CT No catch	6USc 2UFf 7USc 3UFf
Sept 9	30USc 10CK	1USc 1CK 2SF 4USc	16USc 1SF 1TsSb 3CT 6USc 1CK	10USc 8Sdab 4USc 2Sdab
Oct 8	3USc	7CK 4USc 1TsSb 2CO 3USc 2SF	5USc 1CT 1USc 1TsSb	1CK 4USc 5USc
Oct 13	1CT 1USc	6USc 6SF 2USc 1SF	1USc	2USc 1UFf 4USc 2UFf
Oct 20	1CK 2USc	15SF 1USc 4SF 4USc	2CK 2USc 7USc	3USc 3UFf 4UFf 1USc

APPENDIX IVb - QUINSAM HATCHERY JUVENILE SALMONID RELEASE DATA FOR 1982

Species	Brood Year	Release (1982)	# Marked	Total Released
Chinook	81	May 5	83,591	87,300
	81	May 14	49,802	180,173
	81	May 26	89,126	92,045
	81	June 4	49,953	258,233
	81	June 16	89,599	92,128
	81	July 7	53,670	55,585
			415,741	765,464
Chum	81	June 9	-	71,565
Coho	80	May 18	18,852	539,722
	80	To	19,050	220,139
	80	June 2	18,835	253,934
	80		19,501	266,554
			76,238	1,280,349
Pink	81	Mar 23 - Apr 20	60,525	3,353,867
	81	April 16	60,394	124,624
	81	April 30	60,146	124,376
			181,065	3,602,867

APPENDIX IVc - MARKED JUVENILE SALMONIDS CAUGHT IN THE CAMPBELL RIVER FORESHORE DURING THE STUDY (- = not measured)

Date (1982)	Site	Species	# Marked/ Total Caught	Length (mm)
May 25	12	Coho	9/123	125+
May 26	2	Coho	1/2	160
May 26	3	Coho	1/15	135
May 26	3	Chinook	1/1	80
May 26	5	Coho	7/81	125+
May 27	7A	Coho	8/72	-
June 22	7B	Coho?	3/9	89,94,118
June 22	7B	Chinook?	2/7	118, 117
June 22	11	Coho?	2/11	94, 141
June 23	2	Chinook	1/1	-
June 23	5	Chinook	3/4	-
June 23	6	Chinook	13/35	-
July 6	3	Chinook	2/33	-
July 6	7	Chinook	3/16	-
July 6	9	Chinook	1/1	85
July 7	11	Chinook	8/13	-
July 7	11	Chinook	8/17	115,104, 107,110, 105,109, 110,109
July 7	12	Chinook	1/33	-
Aug 17	11	Chinook	2/15	160,157
Sept 14	9	Chinook	1/20	-
Sept 14	12	Chinook	2/10	-

APPENDIX IV d - RESULTS OF SALMONID SCALE ANALYSIS FOR AGE

Species	Date	Site	Age	Number	Comments
Chinook	June 21/82	7B	0^+	5	Hatchery type growth
Coho	April 16/82	11	1^+	4	
			1^{+*}	1	* Estuary growth?
	May 26/82	11	1^+	3	
	May 27/82	7A	1^+	5	
	May 27/82	11	1^+	16	Hatchery type growth
	June 21/82	7B	0^+	1	Species uncertai

APPENDIX $\underline{\text{V}}$ a - LENGTH DISTRIBUTION OF CHINOOK SALMON SAMPLED IN THE CAMPBELL RIVER FORESHORE (BY MONTH)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
April	35 - 39	2	33.3
	40 - 45	4	66.7
Total April	$\bar{X}$ = 41.0	6	100.0
May	35 - 39	3	16.7
	40 - 44	3	16.7
	45 - 49	3	16.7
	50 - 54	1	5.5
	55 - 59	0	0.0
	60 - 64	0	0.0
	65 - 69	0	0.0
	70 - 74	1	5.5
	75 - 79	1	5.5
	80 - 84	0	0.0
	85 - 89	1	5.5
	90 - 94	0	0.0
	95 - 99	3	16.7
	100 - 104	0	0.0
	105 - 109	2	11.1
Total May	$\bar{X}$ = 67.3	18	99.9
June	50 - 54	2	8.0
	55 - 59	0	0.0
	60 - 64	5	20.0
	65 - 69	2	8.0
	70 - 74	2	8.0
	75 - 79	0	0.0
	80 - 84	1	4.0
	85 - 89	2	8.0
	90 - 94	4	16.0
	95 - 99	0	0.0
	100 - 104	1	4.0
	105 - 109	1	4.0
	110 - 114	1	4.0
	115 - 119	4	16.0
Total June	X = 85.7	25	100.0

APPENDIX V a (Cont'd)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
July	55 - 59	1	4.3
	60 - 64	3	13.0
	65 - 69	1	4.3
	70 - 74	2	8.7
	75 - 79	0	0.0
	80 - 84	1	4.3
	85 - 89	0	0.0
	90 - 94	0	0.0
	95 - 99	1	4.3
	100 - 104	2	8.7
	105 - 109	6	26.1
	110 - 114	4	17.4
	115 - 119	2	8.7
Total July	$\bar{X}$ = 95.9	23	99.8
August	70 - 74	1	1.0
	75 - 79	1	1.0
	80 - 84	2	1.9
	85 - 89	3	2.9
	90 - 94	5	4.9
	95 - 99	23	22.3
	100 - 104	14	13.6
	105 - 109	19	18.4
	110 - 114	15	14.6
	115 - 119	3	2.9
	120 - 124	1	6.8
	125 - 129	4	3.9
	130 - 134	1	1.0
	135 - 139	1	1.0
	140 - 144	1	1.0
	145 - 149	0	0.0
	150 - 154	1	1.0
	155 - 159	0	0.0
	160 - 164	1	1.0
	165 - 169	1	1.0
Total August	$\bar{X}$ = 107.9	103	100.2

APPENDIX V a (Cont'd)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
Sept.	80 - 84	1	1.7
	85 - 89	1	1.7
	90 - 94	1	1.7
	95 - 99	4	6.9
	100 - 104	5	8.6
	105 - 109	10	17.2
	110 - 114	10	17.2
	115 - 119	11	19.0
	120 - 124	3	5.2
	125 - 129	7	12.1
	130 - 134	1	1.7
	135 - 139	0	0.0
	140 - 144	0	0.0
	145 - 149	1	1.7
	150 - 154	3	5.2
Total Sept.	$\bar{X}$ = 115.3	58	99.9
Oct.	110 - 114	2	2
	115 - 119	3	3
	120 - 124	1	1
	125 - 129	3	3
	130 - 134	6	6
	135 - 139	0	0
	140 - 144	0	0
	145 - 149	1	6.3
Total Oct.	$\bar{X}$ = 127.3	16	100.2

APPENDIX V b - LENGTH DISTRIBUTION OF CHUM SALMON SAMPLED IN THE CAMPBELL RIVER FORESHORE (BY MONTH)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
April	30 - 34	22	18.2
	35 - 39	86	71.1
	40 - 44	11	9.1
	45 - 49	2	1.6
Total April	$\bar{X}$ = 38.2	121	100.0
May	35 - 39	6	6.4
	40 - 44	11	11.7
	45 - 49	16	17.0
	50 - 54	13	13.8
	55 - 59	26	27.7
	60 - 64	12	12.8
	65 - 69	4	4.3
	70 - 74	1	1.1
	75 - 79	1	1.1
	80 - 84	0	0.0
	85 - 89	0	0.0
	90 - 94	1	1.1
	95 - 99	3	3.2
Total May	$\bar{X}$ = 57.1	94	100.2
June	50 - 54	2	28.6
	55 - 59	0	0.0
	60 - 64	2	28.6
	65 - 69	0	0.0
	70 - 74	1	14.3
	75 - 79	2	28.6
Total June	$\bar{X}$ = 63.9	7	100.1

APPENDIX V b (Cont'd)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
July	35 - 39	2	18.2
	40 - 44	0	0.0
	45 - 49	0	0.0
	50 - 54	1	9.1
	55 - 59	0	0.0
	60 - 64	0	0.0
	65 - 69	0	0.0
	70 - 74	0	0.0
	75 - 79	0	0.0
	80 - 84	2	18.2
	85 - 89	2	18.2
	90 - 94	3	27.3
	95 - 99	0	0.0
	100 - 104	1	9.1
Total July	$\bar{X}$ = 77.7	11	100.1

APPENDIX V c - LENGTH DISTRIBUTION OF COHO SALMON SAMPLED IN THE CAMPBELL RIVER FORESHORE (BY MONTH)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
April	100 - 104	1	20.0
	105 - 109	0	0.0
	110 - 114	1	20.0
	115 - 119	2	40.0
	120 - 124	0	0.0
	125 - 129	0	0.0
	130 - 134	1	20.0
Total April	$\bar{X}$ = 118.6	5	100.0
May	80 - 84	3	5.2
	85 - 89	6	10.3
	90 - 94	3	5.2
	95 - 99	4	6.9
	100 - 104	0	0.0
	105 - 109	1	1.7
	110 - 114	2	3.4
	115 - 119	5	8.6
	120 - 124	10	17.2
	125 - 129	8	13.8
	130 - 134	6	10.3
	135 - 139	8	13.8
	140 - 144	1	1.7
	145 - 149	0	0.0
	150 - 154	0	0.0
	155 - 159	1	1.7
Total May	$\bar{X}$ = 119.1	58	99.8

APPENDIX V c (Cont'd)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
June	75 - 79	1	8.0
	80 - 84	1	8.0
	85 - 89	3	23.0
	90 - 94	2	15.0
	95 - 99	0	0.0
	100 - 104	2	15.0
	105 - 109	1	8.0
	110 - 114	2	15.0
	115 - 119	0	0.0
	120 - 124	1	8.0
Total June	$\bar{X}$ = 97.9	13	100.0
July	115 - 119	1	50.0
	120 - 209	0	0.0
	210 - 214	1	50.0
Total July		2	100.0

APPENDIX $\overline{\underline{V}}$ d - LENGTH DISTRIBUTION OF PINK SALMON SAMPLED IN THE CAMPBELL RIVER FORESHORE (BY MONTH)

Month 1982	Length Class (mm)	No. of Fish	% Relative Frequency
April	25 - 29	26	32.5
	30 - 34	41	51.3
	35 - 39	8	10.0
	40 - 44	4	5.0
	45 - 49	1	1.2
Total April	$\bar{X}$ = 33.3	80	100.0
May	35 - 39	7	35.0
	40 - 44	6	30.0
	45 - 49	5	25.0
	50 - 54	0	0.0
	55 - 59	1	5.0
	60 - 64	1	5.0
Total May	$\bar{X}$ = 46.3	20	100.0
June	40 - 44	1	2.2
	45 - 49	1	2.2
	50 - 54	9	20.0
	55 - 59	7	15.6
	60 - 64	7	15.6
	65 - 69	4	8.9
	70 - 74	6	13.3
	75 - 79	1	2.2
	80 - 84	0	0.0
	85 - 89	3	6.7
	90 - 94	3	6.7
	95 - 99	1	2.2
	100 - 104	1	2.2
	105 - 109	0	0.0
	110 - 114	0	0.0
	115 - 119	0	0.0
	120 - 124	1	2.2
Total June	$\bar{X}$ = 68.6	45	100.0

APPENDIX VI - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chinook Salmon
Site: 7A
Date: May 27, 1982
No of Replicates: 4
Mean Length: 39.8 mm
Mean Weight: 0.534 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	5.2	30.3	0.00038	34.7	75	4875	48.0
Calanoid Copepoda	6.3	36.8	0.00040	36.3	50	1876	18.5
Cyclopoid & Harpacticoid Copepoda	4.5	26.3	0.00012	10.9	75	2790	27.5
Unidentified Diptera adult	0.7	3.9	0.00008	7.0	25	273	2.7
Homoptera	0.2	1.3	0.00007	6.8	25	202	2.0
Oligochaeta	0.2	1.3	0.00005	4.3	25	140	0.4

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chinook Salmon
Site: 3
Date: June 22, 1982
No of Replicates: 1
Length: 52mm
Weight: 1.395 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	9.0	7.4	0.01365	61.3	100	6870	34.3
Chironomid Adults	40.1	35.5	0.00304	13.7	100	4920	24.6
Chironomid Larvae	19.7	17.4	0.00167	7.5	100	2490	12.4
Chironomid Pupae	44.9	39.7	0.00391	17.6	100	5730	28.6

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chinook Salmon
Site: 7A
Date: June 21, 1982
No of Replicates: 11
Mean Length: 103.2mm
Mean Weight: 11.078g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	3.8	26.9	0.00141	11.1	82	3116	29.8
Calanoid Copepoda	1.1	7.7	0.00015	1.2	64	570	54
Cyclopoid & Harpacticoid Copepoda	5.9	41.5	0.00003	0.2	73	3044	29.1
Caprellid Amphipoda	0.4	3.1	0.00007	0.5	18	65	0.6
Coleoptera	0.1	0.8	0.00018	1.4	9	20	0.2
Chironomid Larvae	2.2	15.4	0.00013	1.0	27	443	4.2
Chironomid Pupae	0.3	2.3	0.00004	0.3	18	47	0.4
Decapoda Zoea	0.8	5.4	0.00011	5.4	36	223	2.1
Fish larvae	0.7	4.6	0.00783	4.6	27	1804	17.2
Coleoptera larvae	0.3	2.3	0.00004	2.3	27	70	0.7
Isopoda	0.2	1.5	0.00021	1.5	18	58	0.6
Unid. Insecta Adult	0.7	4.6	0.00013	4.6	36	202	1.9
Mysidacea?	0.5	3.8	0.00219	3.8	36	763	7.3
Tanaidacea	0.3	2.3	0.00005	2.3	9	24	0.2
Others	0.1	0.8	0.00005	0.8	9	11	0.1

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chinook Salmon
Site: 11
Date: June 22, 1982
No of Replicates: 6
Mean Length: 95.2 mm
Mean Weight: 8.606 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	6.7	16.9	0.00029	4.2	100	2110	19.8
Calanoid Copeoda	4.1	10.4	0.00373	53.6	83	5312	49.9
Cyclopoid & Harpacticoid Copepoda	23.8	60.2	0.00020	2.8	33	2079	19.5
Decapoda Megalops	0.5	1.3	0.00144	20.3	17	367	3.4
Gastropoda	2.4	6.0	0.00019	2.7	33	287	2.7
Hyperid Amphipoda	1.4	3.5	0.00018	2.6	33	201	1.9
Insecta adult	0.2	0.4	0.00006	0.8	17	20	0.2
Mysidacea?	0.2	0.4	0.00081	11.6	17	204	1.9
Others	0.4	0.9	0.00007	0.9	33	59	0.6

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chum
Site: 3
Date: April 20, 1983
No of Replicates: 10
Mean Length: 39.7 mm
Mean Weight: 0.367 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	2.2	14.8	0.00004	11.9	70	1869	14.9
Calanoid Copeoda	3.6	25.0	0.00016	55.3	70	5621	44.7
Cyclopoid & Harpacticoid Copepoda	7.5	51.6	0.00004	14.2	70	4606	36.7
Chironomid Pupae	0.2	1.6	0.00027	9.2	20	216	1.7
Chironomid Adults	0.5	3.1	0.00028	9.5	20	252	2.0

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chum
Site: 7A
Date: April 14, 1982
No of Replicates: 11
Mean Length: 37.46 mm
Mean Weight: 3.368 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	3.1	9.6	0.00012	35.1	45	2012	14.2
Calanoid Copeoda	1.2	3.7	0.00003	9.7	36	482	3.4
Cyclopoid & Harpacticoid Copepoda	25.7	79.8	0.00011	32.7	100	11250	79.2
Cumacea	.2	0.6	0.00002	4.6	18	94	0.7
Decapoda (Zoea)	.5	1.4	0.00003	10.2	18	209	1.5
Fish (larvae)	.3	0.8	0.00002	4.6	9	104	0.7
Polychaeta	.9	2.8	0.00001	3.2	9	54	0.4

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chum
Site: 11
Date: April 16-20, 1982
No of Replicates: 10
Mean Length: 38.80 mm
Mean Weight: 3.547 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	1.6	2.6	0.00008	9.0	60	696	4.2
Calanoid Copeoda	9.9	16.2	0.00030	34.9	100	5110	31.1
Cyclopoid & Harpacticoid Copepoda	49.0	80.4	0.00042	50.1	80	10440	63.7
Decapoda (Zoea)	.4	0.7	0.00002	2.6	10	33	0.2
Unidentified Diptera adult	.4	0.7	0.00001	0.7	10	74	0.5
Mysidacea	.4	0.7	0.00002	2.7	10	34	0.2

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chum
Site: 3
Date: May 27, 1982
No of Replicates: 10
Mean Length: 51.80 mm
Mean Weight: 1.122 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	15.9	16.9	0.00014	8.1	80	2000	11.1
Calanoid Copeoda	13.2	14.1	0.00079	46.8	100	6090	33.9
Cyclopoid & Harpacticoid Copepoda	64.0	68.1	0.00070	41.1	90	9828	54.7
Cumacea	.3	0.3	0.00001	0.4	20	14	0.1
Unidentified Diptera adult	.5	0.5	0.00003	1.6	10	21	0.1

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chum
Site: 7A
Date: May 27, 1982
No of Replicates: 10
Mean Length: 62.40 mm
Mean Weight: 1.885 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	.2	0.4	0.00006	4.5	40	196	1.0
Calanoid Copeoda	17.0	31.7	0.00109	78.5	100	11020	56.9
Cyclopoid & Harpacticoid Copepoda	35.8	66.6	0.00018	12.6	100	7920	40.9
Cumacea	.2	0.3	0.00002	1.7	40	80	0.4
Gastropoda	.3	0.6	0.00001	0.8	40	56	0.3
Ispoda	.2	0.3	0.00003	1.9	40	88	0.5

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Chum
Site: 3
Date: June 22, 1982
No of Replicates: 1
Length: 53mm
Weight: 1.611 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	27.0	28.4	0.00392	45.8	100	7420	37.1
Calanoid Copeoda	1.0	1.1	0.00057	6.7	100	780	3.9
Cyclopoid & Harpacticoid Copepoda	2.0	2.1	0.00019	2.2	100	430	2.2
Unidentified Diptera adult	43.0	45.3	0.00162	18.9	100	6420	32.1
Unidentified Diptera larve	17.0	17.9	0.00063	7.4	100	2530	12.7
Unidentified Diptera pupae	5.0	5.3	0.00162	18.9	100	2420	12.1

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Coho
Site: 11
Date: April 16
No of Replicates: 4
Mean Length: 118.0 mm
Mean Weight: 12.860g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	0.3	100.0	0.00011	100.0	25	5000	100.0

Species: Coho
Site: 7A
Date: May 27, 1982
No of Replicates: 3
Mean Length: 88.3 mm
Mean Weight: 2.082 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	3.6	8.4	0.00065	6.1	33	2294	19.3
Calanoid Copeoda	37.3	88.2	0.00021	19.3	100	8820	74.3
Chironomid Adults	.3	0.8	0.00005	5.0	33	19	1.6
Decapoda Zoea	.7	1.7	0.00013	9.0	33	353	3.0
Oligochaeta	.3	0.8	0.00006	5.6	33	211	1.8

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Coho
Site: 11
Date: May 26-27, 1982
No of Replicates: 5
Mean Length: 132.4 mm
Mean Weight: 16.994g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	2.5	10.1	0.00087	41.7	40	2072	16.2
Calanoid Copepoda	19.5	78.1	0.00106	50.7	80	10304	80.7
Decapoda Zoea	2.3	9.3	0.00010	4.8	20	282	2.2
Insecta adult	.6	2.5	0.00006	2.8	20	106	0.8

Species: Coho
Site: 11
Date: June 22, 1982
No of Replicates: 6
Mean Length: 93.2 mm
Mean Weight: 7.212 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	1.8	23.4	0.00078	27.0	66.6	3357	35.8
Hyperid Amphipoda	.8	10.6	0.00025	8.5	16.7	319	3.4
Caprellid Amphipoda	.5	6.4	0.00003	1.0	16.7	124	1.3
Calanoid Copepoda	1.5	19.4	0.00019	6.7	66.6	1738	18.5
Cyclopoid & Harpacticocoid Copepoda	2.7	34.0	0.00006	2.0	50.0	1800	19.2
Mysidacea?	.5	6.3	0.00157	54.8	33.3	2035	21.7

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Pink
Site: 3
Date: June 22, 1982
No of Replicates: 12
Mean Length: 68.8 mm
Mean Weight: 4.827 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	3.9	6.4	0.00035	8.4	50	740	8.7
Hyperid Amphipoda	2.7	4.4	0.00051	12.2	25	415	4.9
Calanoid Copepoda	11.2	18.9	0.00123	29.6	42	2037	24.0
Cyclopoid & Harpacticoid Copepoda	13.9	23.1	0.00008	1.8	33	822	9.7
Chironomid Adults	8.9	14.8	0.00058	13.8	42	1201	14.1
Chironomid larvae	8.7	14.5	0.00052	12.5	50	1350	15.9
Chironomid pupae	9.4	15.7	0.00077	18.6	50	1715	20.2
Mysidacea?	0.5	0.9	0.00004	1.0	8	17	.2
Others	0.8	1.3	0.00009	2.2	58	203	2.4

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Pink
Site: 7A
Date: June 21, 23, 1982
No of Replicates: 19
Mean Length: 68.2 mm
Mean Weight: 3.089 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	1.2	2.3	0.00006	1.3	67	328	2.4
Hyperid Amphipoda	0.9	1.6	0.00005	1.0	56	146	1.1
Calanoid Copepoda	13.0	24.2	0.00389	83.6	78	8408	60.8
Cyclopoid & Harpacticoid Copepoda	19.8	36.9	0.00018	3.8	78	3175	23.0
Chironomid Adults	0.4	0.7	0.00003	0.6	11	14	0.1
Chironomid larvae	1.3	2.5	0.00006	1.2	44	163	1.2
Chironomid pupae	1.0	1.8	0.00009	1.9	44	163	1.2
Cirripedia	2.7	5.0	0.00002	0.4	33	178	1.3
Mysidacea?	0.4	0.7	0.00002	0.5	11	13	0.1
Oligochaeta	0.3	0.5	0.00001	0.2	22	15	0.1
Ostracoda	11.0	20.4	0.00024	5.1	33	842	6.1
Others	1.9	3.6	0.00001	0.2	100	380	2.7

APPENDIX VI (Cont) - DIETS OF JUVENILE SALMON COLLECTED FROM THE CAMPBELL RIVER FORESHORE AND THE INDICES OF RELATIVE IMPORTANCE (I.R.I.).

Species: Pink
Site: 11
Date: June 22, 1982
No of Replicates: 8
Mean Length: 71.0
Mean Weight: 2.928 g

Food Category	Number/ Stomach	% Numerical Composition	Weight/ Stomach	% Weight Composition	Frequency of Occurrence	Prey I.R.I.	% Total I.R.I.
Gammarid Amphipoda	1.0	0.7	0.00007	1.4	38	80	0.7
Hyperid Amphipoda	4.2	3.1	0.00047	10.2	50	665	5.5
Calanoid Copepoda	25.0	18.4	0.00295	64.0	75	6180	51.5
Cyclopoid & Harpacticoid Copepoda	105.4	77.5	0.00107	23.3	50	5040	42.0
Cumacea	0.1	0.1	0.00003	0.7	13	10	0.1
Others	0.3	0.2	0.00002	0.4	25	15	0.1