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NEARSHORE COMMUNITY STUDIES OF NEAH BAY, WASHINGTON

by

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FINAL CONTRACT REPORT

to

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Director

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PREFACE

The study was conducted by FRI research staff scientists and graduate students. Co-principal investigators Charles A. Simenstad and Ronald M. Thom were responsible for the design and management of the study and for the final synthesis and interpretation of the results. Karen A. Kuzis was the project leader, responsible for field sampling operations and analysis of the principal data, the fishes and motile macroinvertebrates. Jeffery R. Cordell managed all laboratory processing and associated data collection and conducted the epibenthos and zooplankton components of the study. David K. Shreffler was principally responsible for conducting the collection and processing of the benthic infaunal samples. Organization of this report reflects the study objectives and components (Section 1.2) and the following responsibilities of the authors:

(1) Fishes and motile macroinvertebrates—Karen A. Kuzis and Charles A. Simenstad;

(2) Epibenthos and Pelagic Zooplankton—Jeffery R. Cordell and Charles A. Simenstad;

(3) Benthic Infaunal Macroinvertebrates—Charles A. Simenstad and David K. Shreffler;

(4) Marine Macrophytes—Ronald M. Thom; and

(5) Trophic Relationships—Charles A. Simenstad and Jeffery R. Cordell.

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1.0 INTRODUCTION

This volume describes a one-year study by Fisheries Research Institute (FRI), University of Washington (UW), of the structure and community interactions of marine biota in Neah Bay. Neah Bay is an enclosed embayment at the southwestern entrance to the Strait of Juan de Fuca, on the northwest corner of Washington State (Fig. 1.1).

This assessment was initiated in response to a proposed suite of projects to develop intertidal and subtidal areas of the Bay for log export shipping and commercial fishing boat moorage (see Section 1.2). These projects have the potential to disrupt or eliminate areas of benthic marine habitat, much of which is characterized by macrophytic vegetation. Nearshore marine and estuarine habitats such as eelgrass, kelps and other macroalgae, and emergent salt marsh plants are presumed to be vital to many economically important fishes and macroinvertebrates. However, quantitative evidence indicating that these "macrophyte habitats" enhance growth and survival or otherwise account for high production of exploited populations is generally lacking. As a consequence, the significance of loss or degradation of macrophyte habitats with regard to importance to associated biota is theoretical.

Pressures for similar development of estuarine and nearshore marine shorelines in the Pacific Northwest, particularly in the Puget Sound region, are intense and increasing. Approximately 700 Department of Fisheries hydraulic permits and 1,000 Department of Ecology shoreline management permits are processed annually in Washington State alone (pers. com., D. Phinney, WDF and W. Alkire, WDOE). Although any challenge to these developments by resource managers often results in litigation and demands for mitigation, there is neither solid evidence for habitat protection nor data for optimal design of mitigation projects. This suggests the need for scientific information on the functional roles which macrophyte habitats play in the life histories and ecology of fishes and macroinvertebrates. It was in this context that the study described herein was conducted, and the data generated used to evaluate the implications to fisheries and other marine resources of potential loss or disruption of macrophytic habitats in Neah Bay.

At the time of the initiation of this study, a related proposal for similar development of Clallam Bay, the next community eastward along the Straits from Neah Bay, was to be included in the sampling design. However, this proposal was deleted early in the study and only limited samples and data were collected (see Section 3.2).

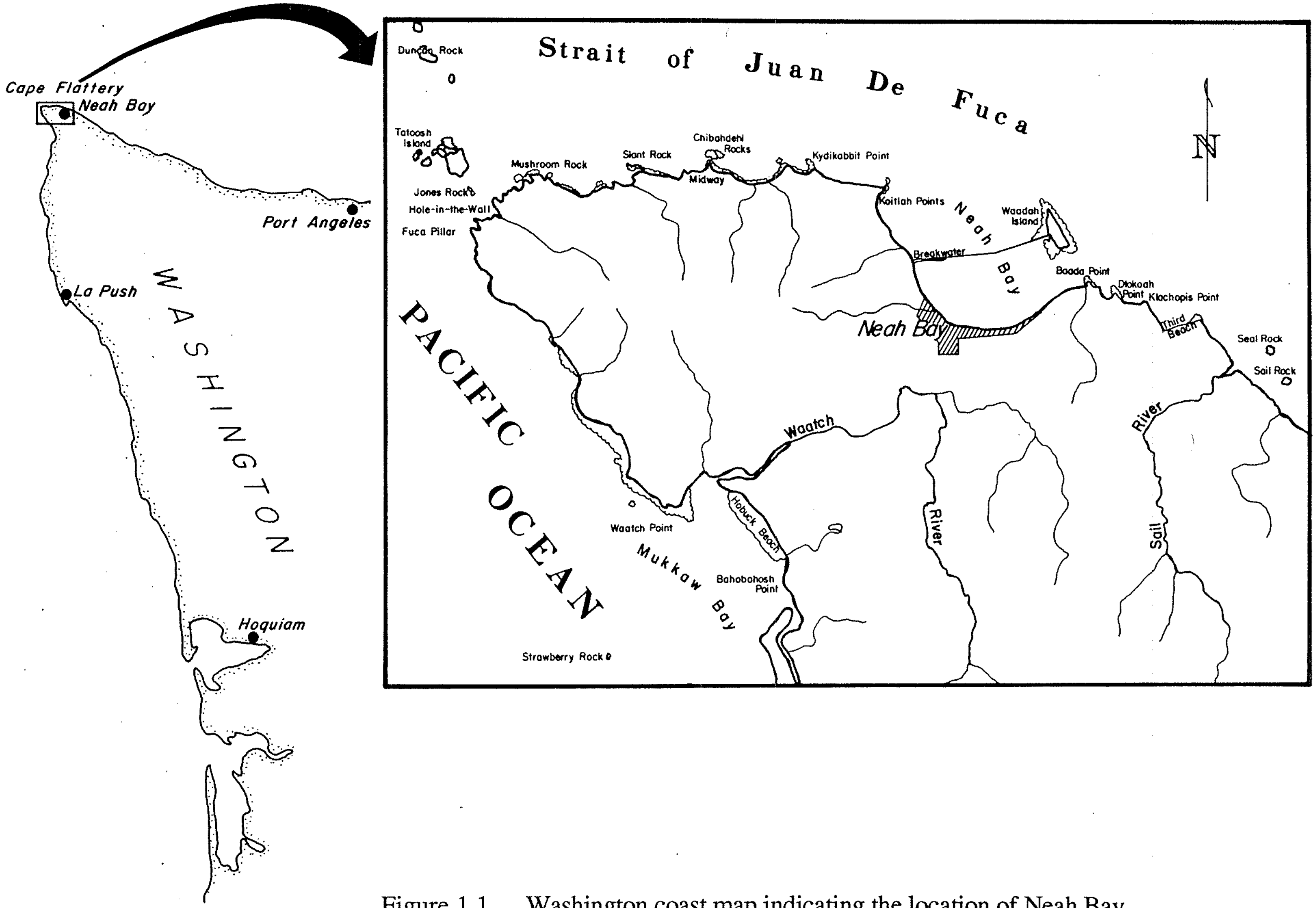

Figure 1.1 Washington coast map indicating the location of Neah Bay.

1.1 Proposed Shoreline/Nearshore Development of Neah Bay

1.1.1 Log Ship Channel

The Makah Indian Tribe has proposed to construct a public, deep- draft ship channel, principally for export of logs from Neah Bay. The proposed log shipment channel would bisect Neah Bay in an east to west direction, with the entrance to the channel approximately midpoint between the land masses of Baadah Point (on the mainland) and Waadah Island (Fig. 1.2). The channel is proposed to be 1,533 m long, 100 m wide, and dredged to a depth of approximately -12-m mean lower low water (MLLW). A 305-m square turning basin would be situated at the west end of the channel. Initial dredging would generate approximately 497,000 m^3 of dredged material, and rock blasting for construction dredging would be required to achieve the desired depths in some portions of the channel.

In addition to the navigation channel development, the proposed project would involve an associated log sorting area, log dump and log boom moorage in the Bay and reconstruction or upgrade of local highways and roads to accommodate increased log truck traffic. This study did not address any of the issues involved with these aspects of the project.

1.1.2 Small Boat Basin

The Makah Indian Tribe has also proposed to construct a small public boat basin which would provide a safe, protected year-round basin for permanent wet moorage of Indian and non-Indian commercial fishing boats and transient recreational pleasure boats. Three possible sites have been selected for evaluation (Fig. 1.3). The proposed marina (Fig. 1.4) would include a rubblemound breakwater ~300 m long with a top elevation of +6 m MLLW, and a 30-m to 50- m wide moorage basin entrance channel dredged to a depth of -5 m MLLW to accommodate recreational craft and commercial fishing boats. Associated with the moorage basin would be an adjacent 76-m long and 50-m wide turning basin dredged to -5 m MLLW and an adjoining 200-m long and 23-m to 30-m wide moorage access channel dredged to depths between -4 and -5 m MLLW. Initial construction was estimated to entail dredging of approximately 7,650 m^3 of material.

1.2 Objectives and Organization of Studies

In the context of the proposed shoreline and nearshore development projects in Neah Bay, the Fisheries Research Institute evaluated the functions and relative importance of nearshore macrophyte habitats in the region. The overall objectives of this study were as follows:

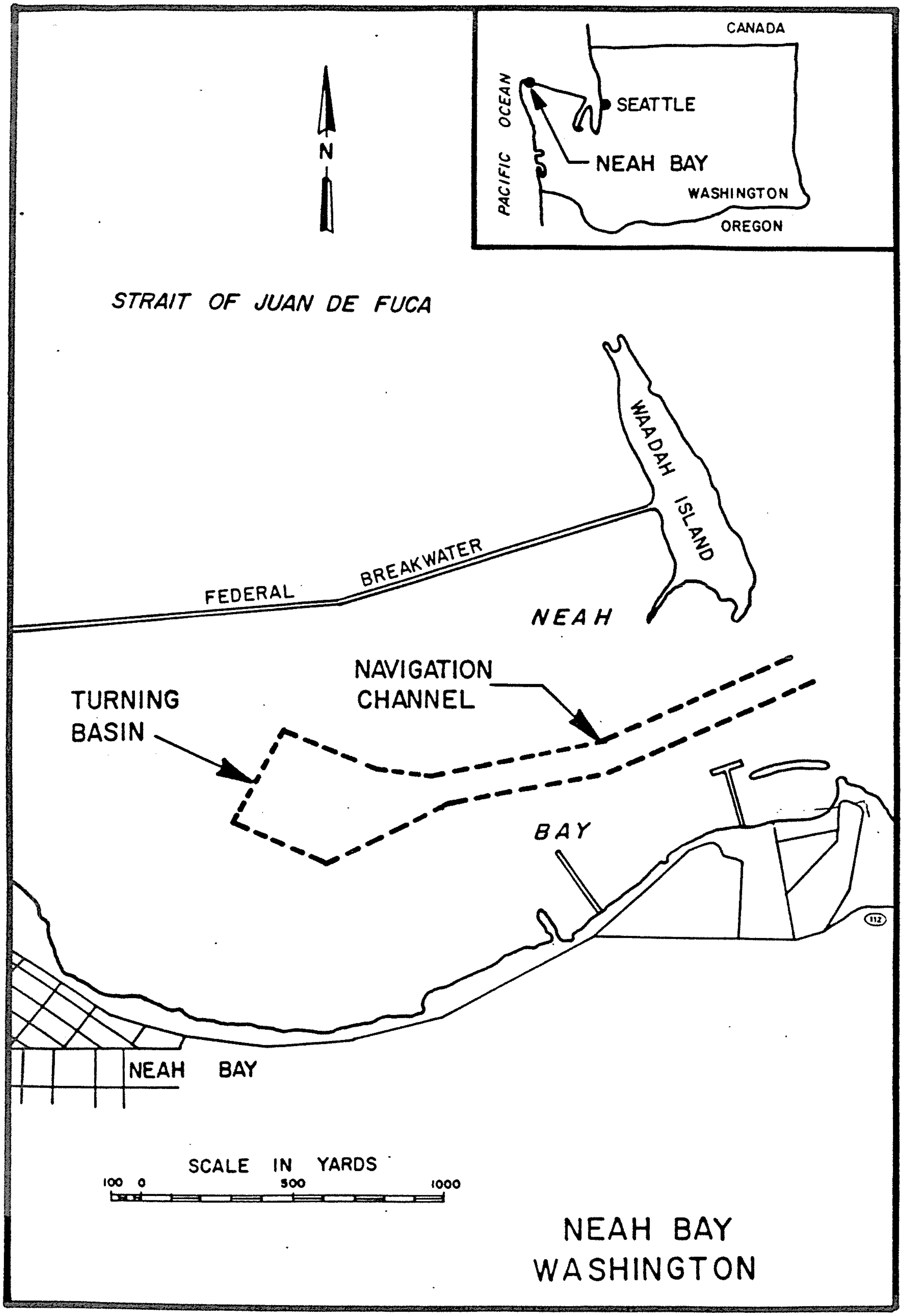

Figure 1.2. Location of proposed deep-draft ship channel in Neah Bay, Washington.

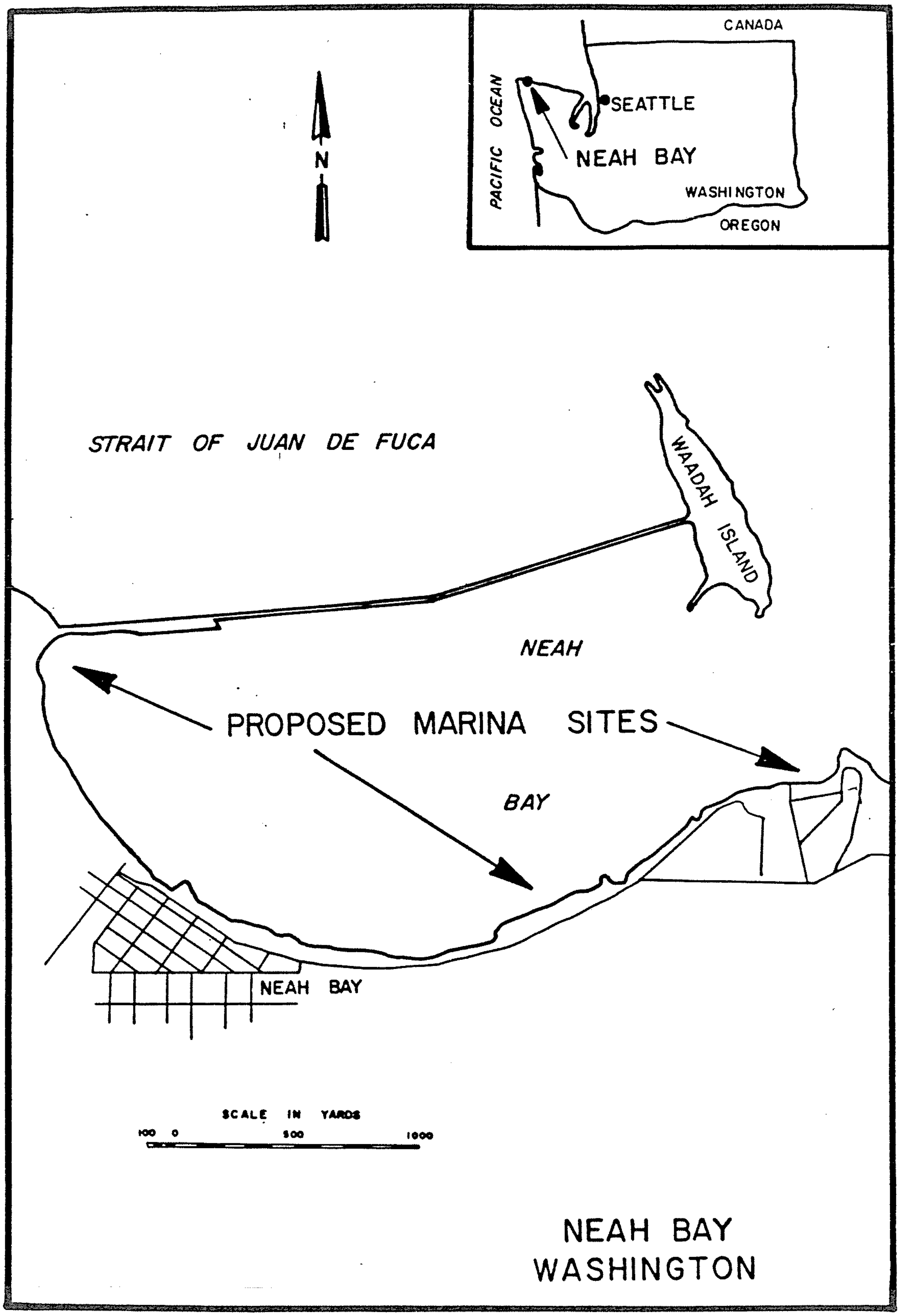

Figure 1.3. Proposed sites for a commercial fishing boat marina in Neah Bay, Washington.

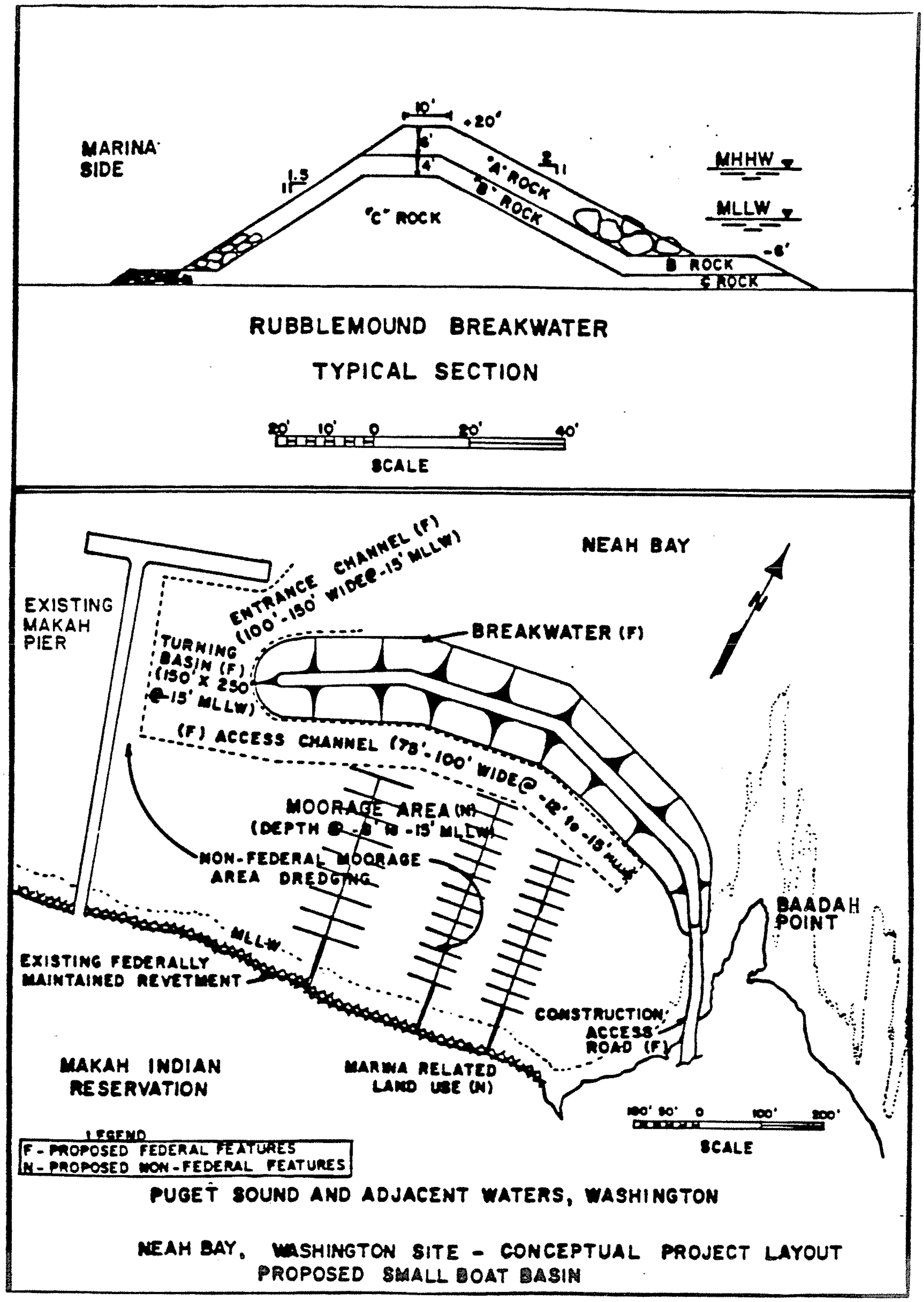

Figure 1.4. Conceptual design of commercial fishing boat marine in Neah Bay, Washington.

(1) compare fish and invertebrate assemblage structure† and standing stock† between macrophyte† habitats and non-macrophyte (unvegetated) habitats in the areas of Neah Bay;
(2) evaluate the function of these macrophyte habitats as critical refuge, food resources, and reproduction (spawning) habitat of economically and ecologically important fishes and macroinvertebrates;
(3) document seasonal variation in structure, standing stock, production† and function of macrophyte habitats;
(4) evaluate functional contributions of macrophyte communities to adjacent, non-macrophyte habitats; and
(5) hypothesize and estimate consequences to nearshore communities of macrophyte habitat loss and/or degradation in habitat quality.

The study was organized around five basic components: (1) fishes and motile macroinvertebrates; (2) epibenthos and pelagic zooplankton; (3) benthic infaunal macroinvertebrates; (3) macrophytes; and, (4) ecological interactions.

1.2.1 Fish and Motile Macroinvertebrate Assemblages

The objectives of investigations of fish and motile macroinvertebrate assemblages associated with macrophyte and other nearshore habitats of Neah Bay were to determine:

(1) species life history and composition, density and standing crop of discrete demersal and pelagic assemblages;
(2) temporal (seasonal) and spatial (habitat) variability in assemblage structure† and standing stock;† and
(3) ecological importance and value of study region to economically important fishes.

1.2.2 Epibenthos and Pelagic Zooplankton Assemblages

Objectives of studies of associated invertebrates assemblages were to determine:

(1) species/life history and composition, density and standing crop of discrete benthic, epibenthic, and pelagic invertebrate assemblages;
(2) temporal (seasonal) and spatial (habitat) variability in assemblage structure and standing stock; and
(3) ecological importance of study region to Dungeness crab and pandalid shrimp.

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†See glossary (Appendix 5.1) for definition of these and subsequent terms and acronyms.

1.2.3 Macrophyte Assemblages

Objectives of studies of macrophyte assemblages were to determine:

(1) species and relative standing stock of macrophyte assemblages;
(2) temporal (seasonal) and spatial (habitat) variability in assemblage structure and standing stock; and
(3) assemblage primary production.

1.2.4 Ecological Interactions

A synthesis of the ecological relationships among the fish and macroinvertebrate fauna and macrophyte habitats was undertaken to determine:

(1) principal faunal and floral associations;
(2) temporal (seasonal) and spatial (habitat) variability in these ecological associations;
(3) status of study area assemblages relative to comparable communities from other areas of the Straits of Juan de Fuca and Puget Sound; and
(4) potential impact of construction and operation of proposed navigation and harbor facilities on primary production, structure, standing stock, and ecological associations of local marine communities.

1.3 Previous Studies of Neah Bay

The only studies of marine fish within Neah Bay proper that we are aware of are those describing the distribution and abundance of juvenile salmonids conducted by the U.S. Fish and Wildlife Service and Makah tribe between May and August 1984 (U.S. Fish and Wildlife Service and Makah Tribe 1985). No quantitative information was found on motile macroinvertebrates, pelagic zooplankton, epibenthic and benthic infauna. An unpublished memorandum (NMFS, James Bybee, Sept. 13, 1984) reported qualitative observations on macroinvertebrates, fishes and macrophytes observed during a SCUBA dive in the vicinity of Evans Mole (see Fig. 2.1); it was noteworthy that dense *Ulva* accumulations on the bottom at that time precluded extensive observations.

Chemical and structural analyses were conducted on sediments from four locations in the mid-bay navigational channel (Pacific Northwest Laboratory, Battelle, Marine Research Laboratory 1984). These studies showed that Neah Bay sediments were uncontaminated, while sediments in Clallam Bay to the east indicated some hydrocarbon contamination.

As a separate but related component of environmental studies of Neah Bay, investigators from Cascadia Research Collective conducted an extensive survey of the distribution, abundance, natural history and behavior of marine mammals in the southwestern region of the Strait of Juan de Fuca, with particular emphasis on Neah Bay proper (Calambokidis et al. 1987). Calambokidis et al. found reported almost 800 sightings of ten marine mammal species from both boat and aerial surveys. Harbor seals (*Phoca vitulina richardsi*) were the most commonly seen marine mammals, followed by California (*Zalophus californianus*) and northern sea lions (*Eumetopias jubatas*). Occurrences of gray whales (*Eschrichtius robustus*) and a sea otter (*Enhydra lutris*) in the study area were of particular interest and study because of their endangered or threatened status.

Two prior studies of intertidal communities have been conducted on the exposed shores of Waadah Island. Rigg and Miller (1949) provided the first descriptions of intertidal zonation patterns in this area and Dayton (1971) included a site on Waadah Island in his insightful examination of rocky intertidal community ecology.

2.0 METHODS AND MATERIALS

2.1 Description of Study Area and Intensive Research Sites

Neah Bay is a semi-enclosed embayment with very little freshwater input. Three small creeks, Agency, Halfway and Village, drain into the Bay. In the summer months, total flow from all three creeks is less than one cubic foot per second (U.S. Fish and Wildlife Service and Makah Tribe 1985). Sampling was done at all of the proposed marina sites, Baadah Point, Evans Mole and the old Crown Zellerbach log storage area (hereafter referred to as the "Crown Z" site), in the proposed navigation channel and turning basin areas (Fig. 2.1).

2.1.1 Baadah Point

The Baadah Point site is characterized by a small, moderately sloping sand beach on the eastern side, with a wall of rip-rap along the western three quarters of the beach. The eastern portion of the beach is formed by the Point proper, which is primarily sandstone strata. The maximum depth at the Baadah Point site at mean high water is approximately 4.5 m MLLW. The substrate is predominantly sand with scattered rocks and rubble. There are patches of *Zostera marina* which are thicker on the eastern section of the site; in addition, thick patches of *Ulva* form in the summer.

2.1.2 Evans Mole

Evans Mole has a shallow sloping beach which forms a shallow ledge at mean low water level and is located immediately west of a rip rap groin (Fig. 2.1). Water depth at this site is approximately 4.5 m at high tide. The substrate is coarse sand and gravel with thin scattered patches of *Zostera marina*; in summer months, thick patches of *Ulva* occur near shore in the eastern portion of the site.

2.1.3 Crown Z

The Crown Z site has an upper intertidal zone formed of a steep rip rap breakwater which grades into a shallow sloping beach of soft silty mud. Scattered rocks and decomposing wood chips cover the bottom near the old log boom area, with a sand beach to the south. Water depth at this site averages about 4 m at mean high water. Scattered rocks in muddy areas provide a substrate for *Fucus* and *Ulva*. Sandy portions of the site to the west have patches of seagrasses, *Zostera marina* and *Zostera japonica* scattered throughout.

2.1.4 Navigation Channel/Turning Basin

Subtidal sites located in the proposed navigation channel and turning basin were 7 m and 8 m MLLW deep. The substrate is similar at both sites, consisting of silty sand with scattered rocks and thick patches of tubeworms and diatoms.

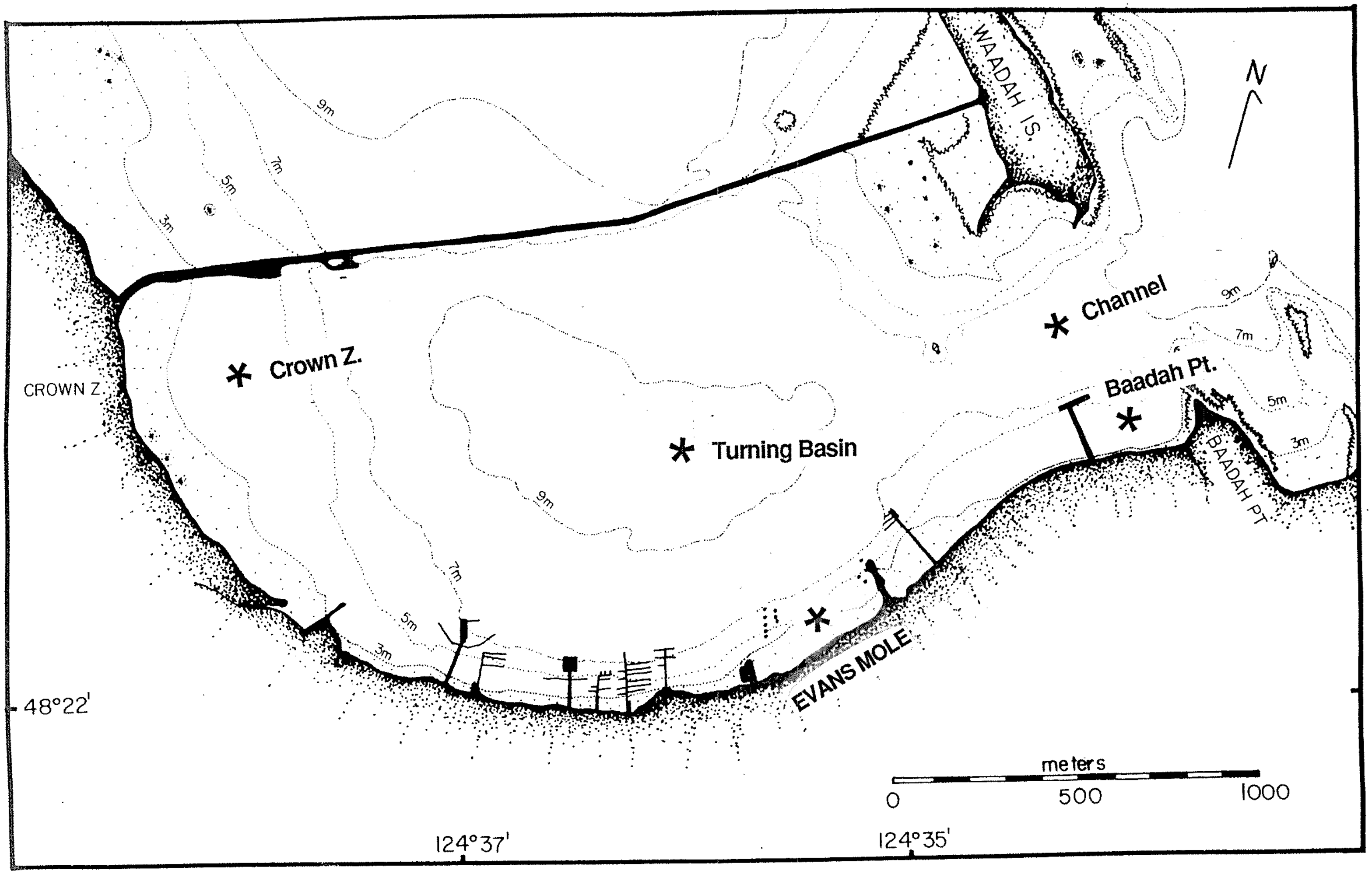

Figure 2.1. Neah Bay study area indicating the locations of the intensive sampling sites, during 1986-87.

2.2 Chronology of Surveys

Surveys for fish and motile macroinvertebrates, epibenthos and pelagic zooplankton, benthic infauna, and macroalgae occurred during daylight hours except for those restricted to low tide series, which occurred at night during certain sampling periods (September-March).

2.2.1 Fish and Motile Macroinvertebrates

Intensive sampling occurred in the months of May, July, September and January (Table 2.1a). The initial sampling trip in May focused on sampling the Baadah Point and Crown Z sites. The Evans Mole site was added in July. Otter trawl and SCUBA sampling also started in July. The beach seine site at Crown Z was added in July at the request of the Army Corps of Engineers and the underwater (SCUBA) transect at Crown Z was moved to the head of the Bay at the same time.

2.2.2 Epibenthos and Pelagic Zooplankton

Epibenthos and pelagic zooplankton occurred concurrently with fish (Table 2.1b).

2.2.3 Benthic Infauna

Benthic sampling occurred during two periods, grab samples between 4 and 17 August and air lift suction samples between 23 August and 26 September 1986.

2.2.4 Macroalgae

Transect sampling for macrophyte assemblage structure and standing stock was conducted on six occasions: 28 April; 21-23 May; 24 June; 18- 19 July; 15-17 September 1986; and 28 January 1987. Primary productivity experiments were conducted on 29 April, 23 May, 24 June, 18 July, and 16 September 1986, and 29 January 1987.

2.3 Sampling Methodology

2.3.1 Environmental Conditions and Habitat Characterization

Surface temperature. The surface water temperature was measured to the nearest 0.5°C with a mercury thermometer whenever sampling was performed.

Bay mapping. In September, a total of nine underwater transects were surveyed across the Bay using SCUBA with the aid of Teckna underwater scooters or free swimming at a constant speed (Fig. 2.2). A compass was mounted on the scooter or on a small slate held in front of the diver so that a constant course could be maintained. Each dive was timed using a pressure-sensitive bottom timer. The time was noted whenever habitat changes occurred or significant features were observed. The observations were later plotted on a chart using the proportion of time until the observation was made versus the total time of the dive.

Table 2.1. Fish (a) and epibenthos and zooplankton (b) collections (number of replicated samples) in Neah Bay, Washington, May 1986-April 1987; epibenthos and plankton collections at Neah Bay, 1986; gear types were P = 0.5 m plankton net, E = 0.1 m^2 plankton pump, and M = 0.016 m^2 plankton net.

a. Gear type		1986		1987	
Site (reps.)	May	July	September	January	March
1. Beach Seine					
Baadah Point	3	3	3	3	3
Evans Mole		3	3	3	3
Crown Z			2	2	2
2. Purse Seine					
Baadah Point	3	3	3	3	
Evans Mole	3	3	3	3	
Crown Z	3	3	3	3	
3. SCUBA					
Baadah Point		3	3	1	3
Evans Mole		3	2	2	3
Crown Z		3	3	1	3
4. Otter Trawl					
Channel		3	3	3	3
Turning Basin		3	3	3	3
Crown Z		3	3	3	2

b.	May	July	September
Baadah Point, Subtidal	P	P	P,E
Baadah Point, 0.0 m		M	M
Evans Mole	P	P,M	P,M
Crown Zellerbach dock	P,M	P,M	
Head of Bay, *Zostera marina*			P,M
Head of Bay *Z. japonica*		M	

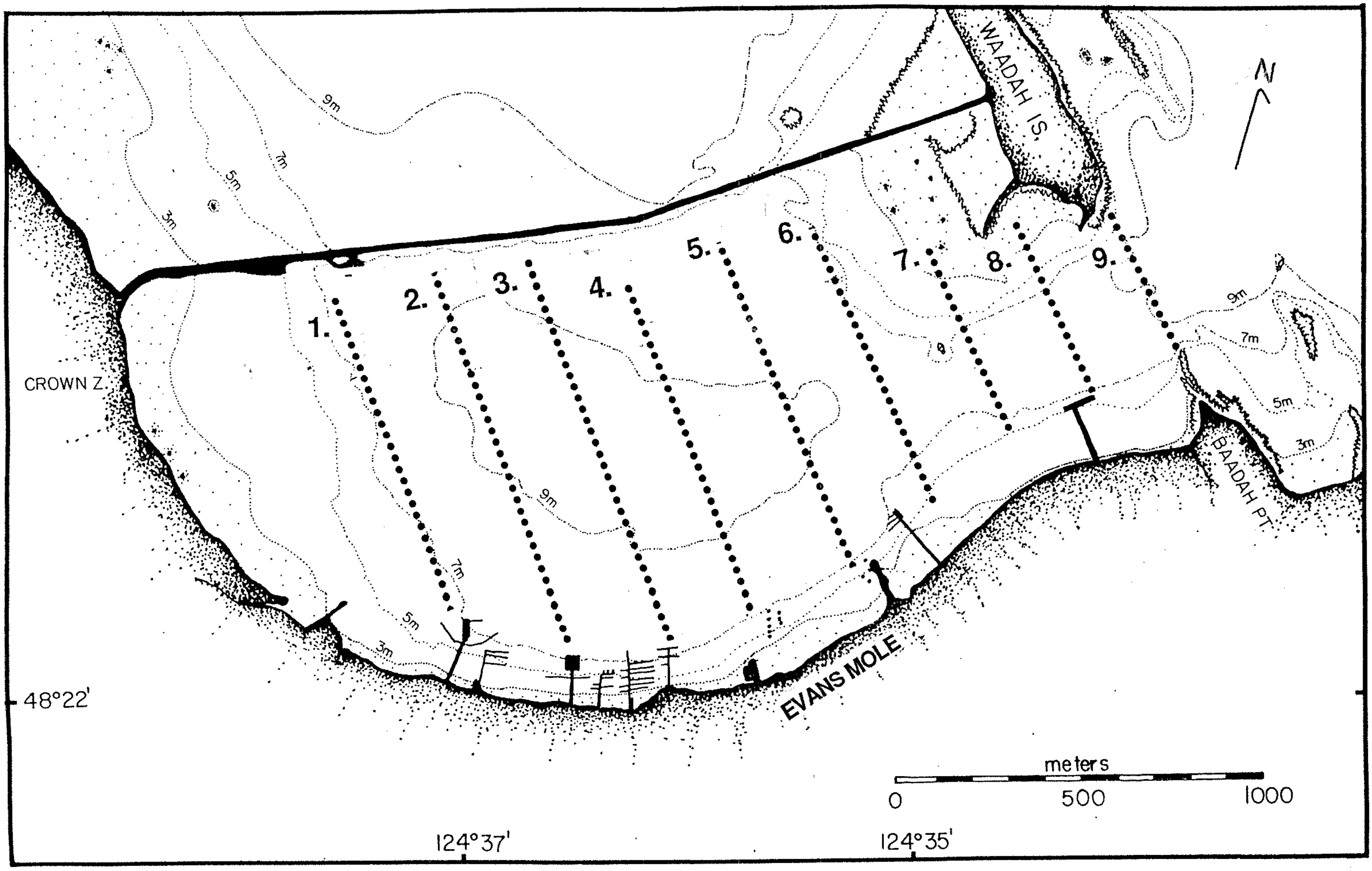

Figure 2.2. Map of the Neah Bay study area indicating location of SCUBA transects used to map Neah Bay benthic habitat distributions.

2.3.2 Fish and Motile Macroinvertebrate Sampling

In order to sample the different habitats within Neah Bay, a variety of sampling gear was employed at the three study sites. Fishes occurring in shallow, nearshore areas were sampled using a sinking beach seine. Neritic fishes were sampled with the purse seine. An otter trawl was used to sample demersal fishes in the deeper portions of the bay. Underwater transects were also surveyed to sample intermediate areas not well sampled by other gear types.

Beach Seining. Nearshore demersal fishes were sampled at Baadah Point, Evans Mole and Crown Z (Figure 2.1), using a 37-m sinking beach seine. The net consisted of two 18-m wings made of 3-cm mesh with a 2-m x 2.4-m x 2.3-m bag made of 6-mm mesh. Sets were made at low tide as close to slack water as possible. An outboard powered boat was used to set the net 30-m from shore and parallel to the beach. Once the net was in place, two-person teams situated about 40-m apart on shore hauled the net in at a rate of about 10 m min^{-1} (meters/minute*). When the net was approximately 10-m from shore, the teams moved closer together until they were about 10-m apart, after which hauling the net up onto the beach was completed. The area sampled was estimated to be 520 m^2.

The beach at Baadah Point was large enough for only two non-overlapping hauls; in order to get three replicates, two non-overlapping hauls were conducted on one day and a single haul was done the next. The Evans Mole beach was large enough for 3 non-overlapping hauls and all beach seines at this site were done on the same day. The Crown Z site only had a very small patch of beach suitable for beach seining, only one non-overlapping set could be done at this site. For a replicate, seining was conducted on two consecutive days.

Purse Seining. A 58-m, fine mesh purse seine was used to sample neritic fishes at Baadah Point, Evans Mole and Crown Z (Fig. 2.1). The wing of the net was 12.7-mm stretch mesh and the bunt 6.4-mm square mesh. The net was set from a 5-m outboard powered boat in "round haul" fashion. It took approximately 15 minutes to set, purse, and haul the net in by hand. Three consecutive sets were made at each site. Sample area and volume were estimated at 268 m^2 and 835 m^3,respectively. Currents and wind frequently distorted the shape of the net, thus affecting the area and volume actually sampled.

Demersal Trawling. Demersal fish were sampled at the channel, turning basin and Crown Z sites (Fig. 2.1) with a 4.9-m 'trynet' trawl. The body and codend of the net were constructed of 1.9-cm mesh. In addition, the codend of the net was lined with 0.5-cm mesh woven nylon. The net was deployed from a moving boat and held near the surface until the doors of the net spread

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*The scientific notation of the reciprocal, e.g., m^{-1}, m^{-2}, m^{-3}, is used throughout to denote "per", and is equivalent to /m, /m^2, and /m^3, respectively.

open. The net was then allowed to descend to the bottom with enough line to guarantee a minimum scope of 4:1. Tows lasted 5 minutes at a speed of 1.0 to 2.0 m sec^{-1}. Sample area and volume were estimated at 750 m^2 and 375 m^3, respectively.

Underwater Transect Surveys. Quantitative observations were made along underwater transects at Baadah Point, Evans Mole and Crown Z (Fig. 2.3). Transect lines were marked every meter along a 0.5-cm polypropylene line with flags at each five and ten meter mark; the lines were anchored to the bottom using rebar and cinder blocks at 50-m intervals. At Baadah Point, the two inside lines (T1 and T2) were 265-m long and the outside line (T3) was 235-m long. The lines at Crown Z and Evans Mole were 100-m long. Dives were made only when visibility exceeded 1 m; visibility was determined by the number of meter marks the diver could see along the line. One to two marks was defined as poor, two to three as minimal, three to five as good and more than five marks was defined as excellent. Two divers swam the transect simultaneously at a rate of approximately 10 m min^{-1}, counting all fish and crabs within 1 m of the line, and stopping every 10 m to record the counts. Each transect was repeated three times within a week, with a minimum of an hour between replicates. In the summer months, a thick layer of *Ulva* covered the bottom at Baadah (T1 and T2) and at Evans Mole. This layer was sometimes a meter thick and made sampling difficult. Percentage algal cover was estimated for each 10-m portion of the line.

Lingcod spawning within the Bay was monitored beginning in early March. A series of six survey dives were made along the rocky portions of Baadah Point, the south-east portions of the breakwater and the south end of Waadah Island looking for any evidence of nesting lingcod.

Preservation and Processing of Samples. Large fish and macroinvertebrates from beach seine and trawl collections were placed in labeled plastic bags and processed as soon as possible after collection. Processing entailed identifying the fish to species and life history stage, weighing (to nearest 0.1 g) and measuring (to nearest mm), checking the sex and stage of maturity and, if time allowed, making qualitative notes on the stomach contents. Smaller fish and invertebrates were preserved in 10% seawater-buffered formalin immediately after collection. These samples were stored for a minimum of seven days to allow for uniform shrinkage. The samples were then sorted to species and life history stage, enumerated and weighed. If there were less than 25 of a given species, each individual was weighed and measured. If there were more than 25, a subsample of 25 individuals was selected randomly and these were individually weighed and measured and the weight of the total catch was estimated.

2.3.3 Epibenthos and Pelagic Zooplankton Sampling

Epibenthic organisms were collected with one of two epibenthic pumps, depending on water depth. In subtidal eelgrass at Baadah Point and off the end of the Crown Z dock, where water

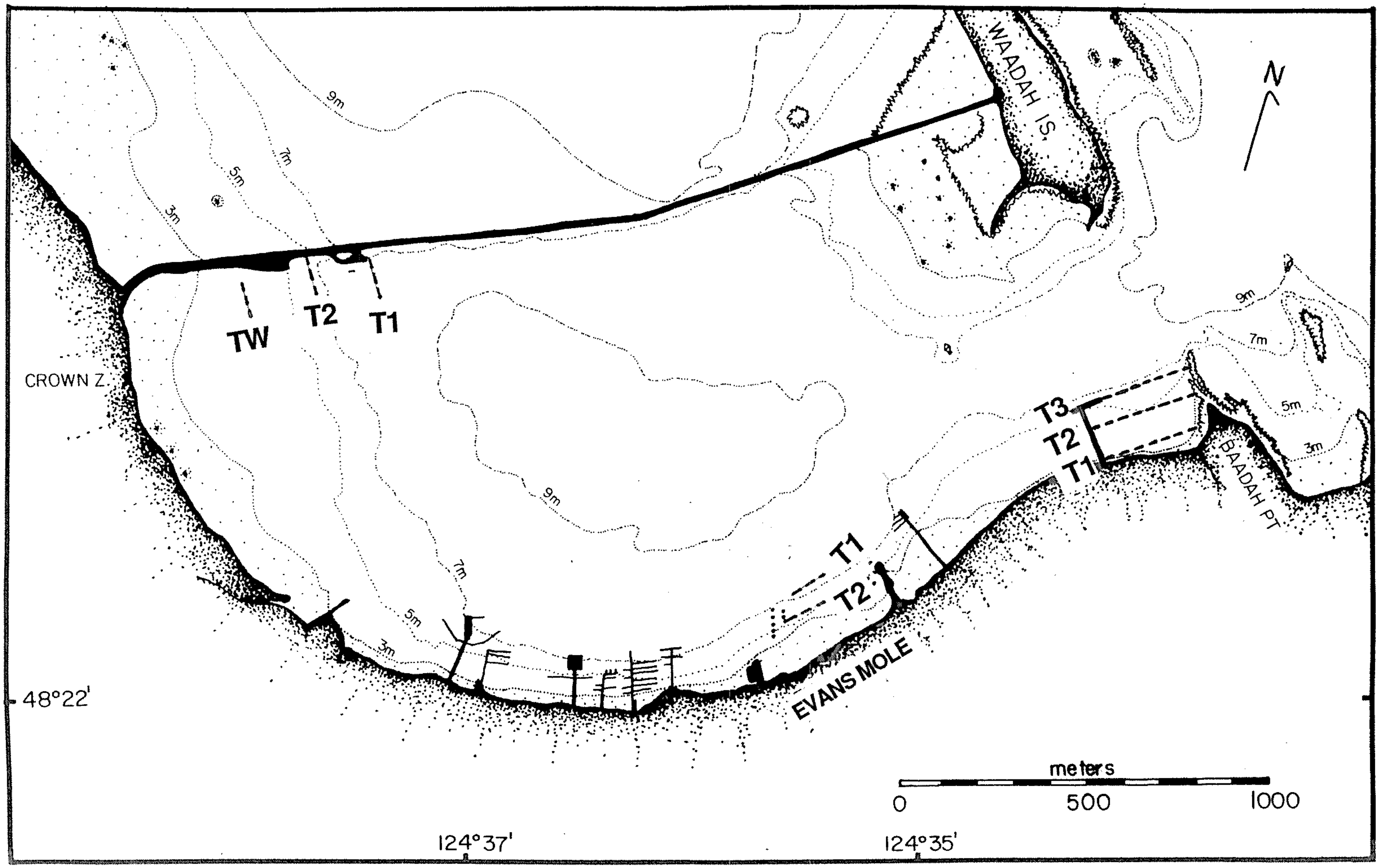


Figure 2.3. Map of Neah Bay study area indicating the locations of the SCUBA transects for quantitative fish observations, 1986-87.

depth exceeded one meter, a plankton pump which was developed to sample epibenthic zooplankton in the Columbia River estuary was utilized (Simenstad, 1984). This gasoline engine-powered pump system sampled 0.25 m of the water column over 0.1 m^2 of the bottom (Figure 2.4). Approximately 150 L of water were filtered unless there was an indication of sand being lifted from the substrate, in which case pumping was terminated in order to avoid contamination by infaunal organisms. A single 0.253-mm mesh net was used to filter the epibenthic organisms. Five replicate samples from adjacent, similar epibenthic areas were taken.

In the remaining intertidal sample sites, a similar but considerably smaller pump system was used (Figure 2.5). This system, which utilizes a battery-powered water pump, samples the near-bottom water column over 0.016 m^2 of the bottom. Outflow from the pump was filtered in the field through a sieve of 0.146-mm mesh.

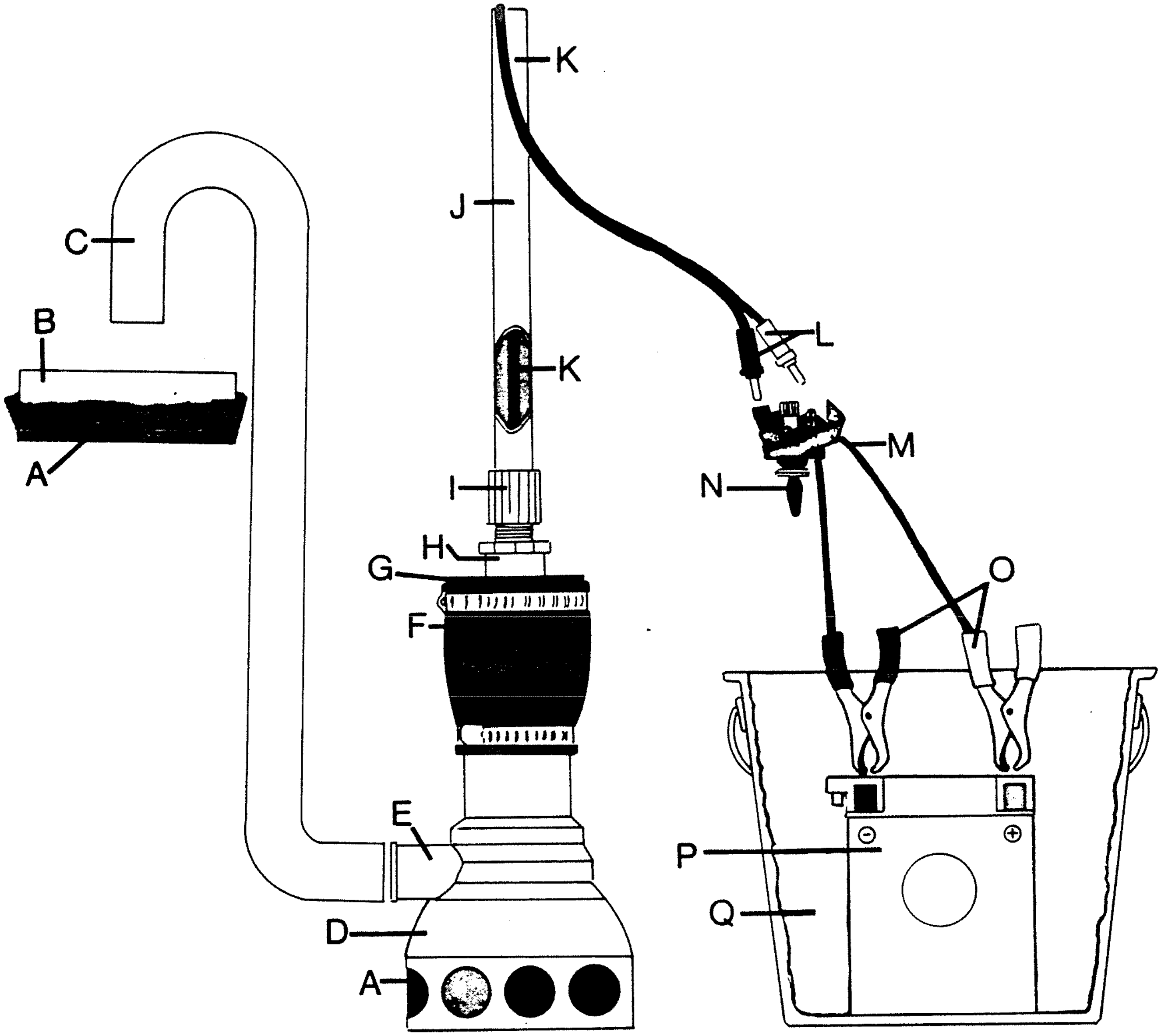
Water column zooplankton were collected with a 0.5-m plankton net constructed of 0.333 mm mesh. The net was slowly lowered cod-end down until it rested on the bottom in 3-5 m of water. After one minute, the net was pulled to the surface, sampling the water column from bottom to surface.

All epibenthic and water column samples were washed from cod-end buckets or sieves using filtered water from the sample location and poured into plastic sample jars, and were preserved with 10% buffered formalin. In the laboratory, organisms were sorted into convenient taxonomic groups using a dissecting microscope. Each group was then further sorted into individual taxa and these taxa were identified as far as possible. In general, adult crustaceans were identified to genus or species, and crustacean larvae and other organisms were identified to order. Organisms were also identified as to general life history stage (i.e., adult, juvenile, egg-bearing female, larva, etc.).

2.3.4 Benthic Infaunal Macroinvertebrates Sampling

Sampling of benthic macroinvertebrate infauna in subtidal habitats of Neah Bay was designed to accomplish two discrete objectives: (1) characterize the distribution and standing stock of infaunal assemblages in a synoptic survey of the Bay; and, (2) evaluate the composition and standing stock of deep-burrowing bivalves in more detail at the intensive study sites. Methods adopted for sampling and analyzing subtidal benthic macroinvertebrate infauna assemblages in Neah Bay were based on the protocol recommended by Tetra Tech Inc. (1987).

Synoptic Benthic Survey (van Veen grab). A modified van Veen bottom grab was deployed from a 5.6-m boat to sample an area of 0.025 m^2 at 39 preselected sites within Neah Bay (Fig. 2.6). The grab was lowered to the bottom in the locked-open position at a rate of approximately 0.3 m sec^{-1} until it impacted the bottom and, with the jaws closed, was raised at approximately the same rate. Once the grab was securely on board, the sediment sample was inspected to ensure that



A. .25 mm mesh screen
B. pvc collecting sieve
C. clear plastic hose
D. sampling cylinder (height = 10.3 cm, diameter = 14.8 cm)
E. rule c 1500 electric bilge pump
F. 3"x3" nohub
G. 1½"x3" reducer
H. 1"x1½" reducer
I. 1" female adaptor
J. 1" pvc handle (elongated or shortened for sampling at various depths)
K. cord
L. connectors
M. duct tape
N. switch
O. battery clips
P. 12 volt motorcycle battery
Q. holding bucket

Figure 2.4. Schematic of epibenthic suction pump; the sampling cylinder and screens are measured in centimeters, all other measurements are in inches.

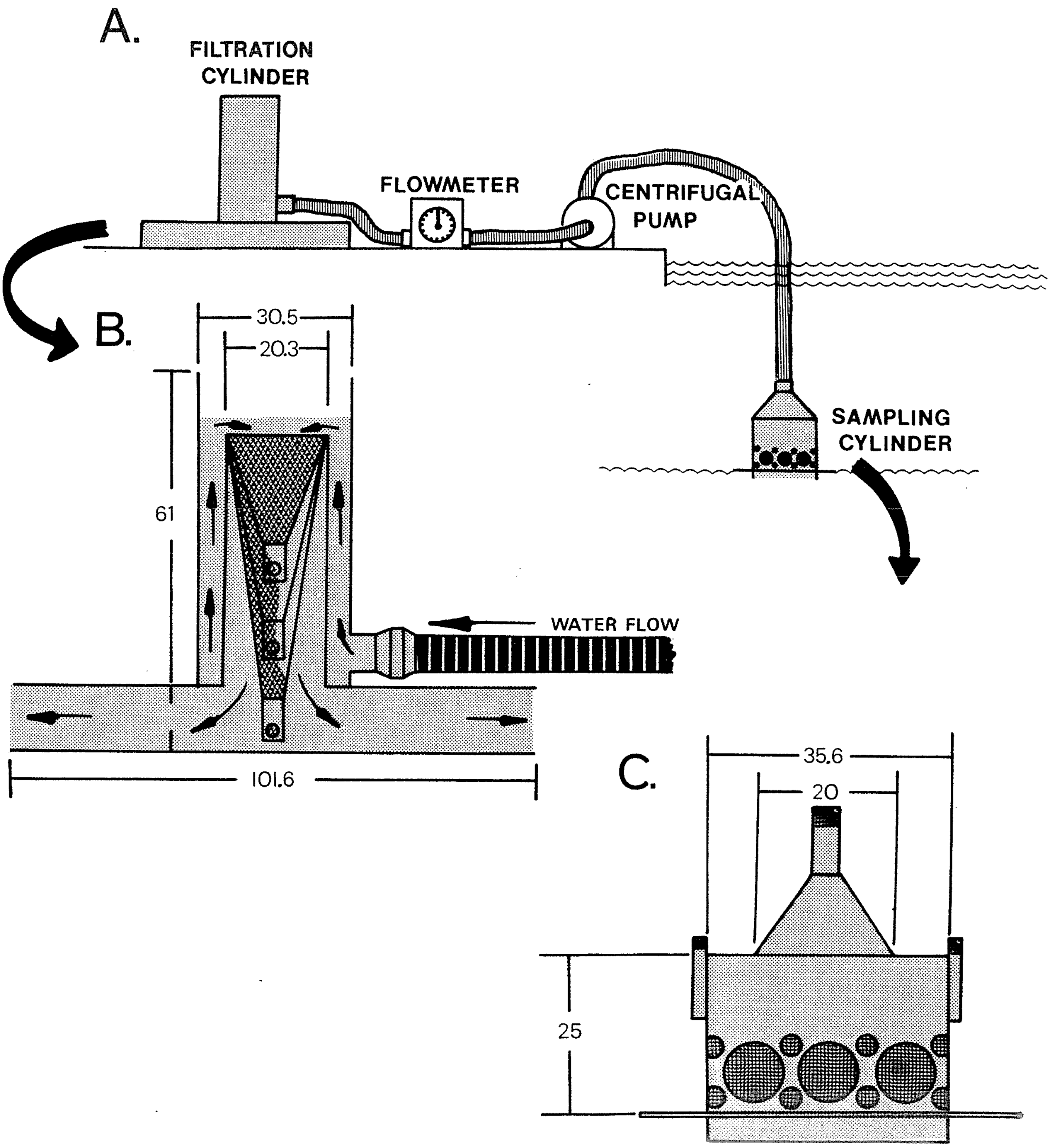


Figure 2.5. Suction pump utilized to quantitatively sample epibenthic organisms at subtidal sites in Neah Bay, Washington, May 1986-January 1987.

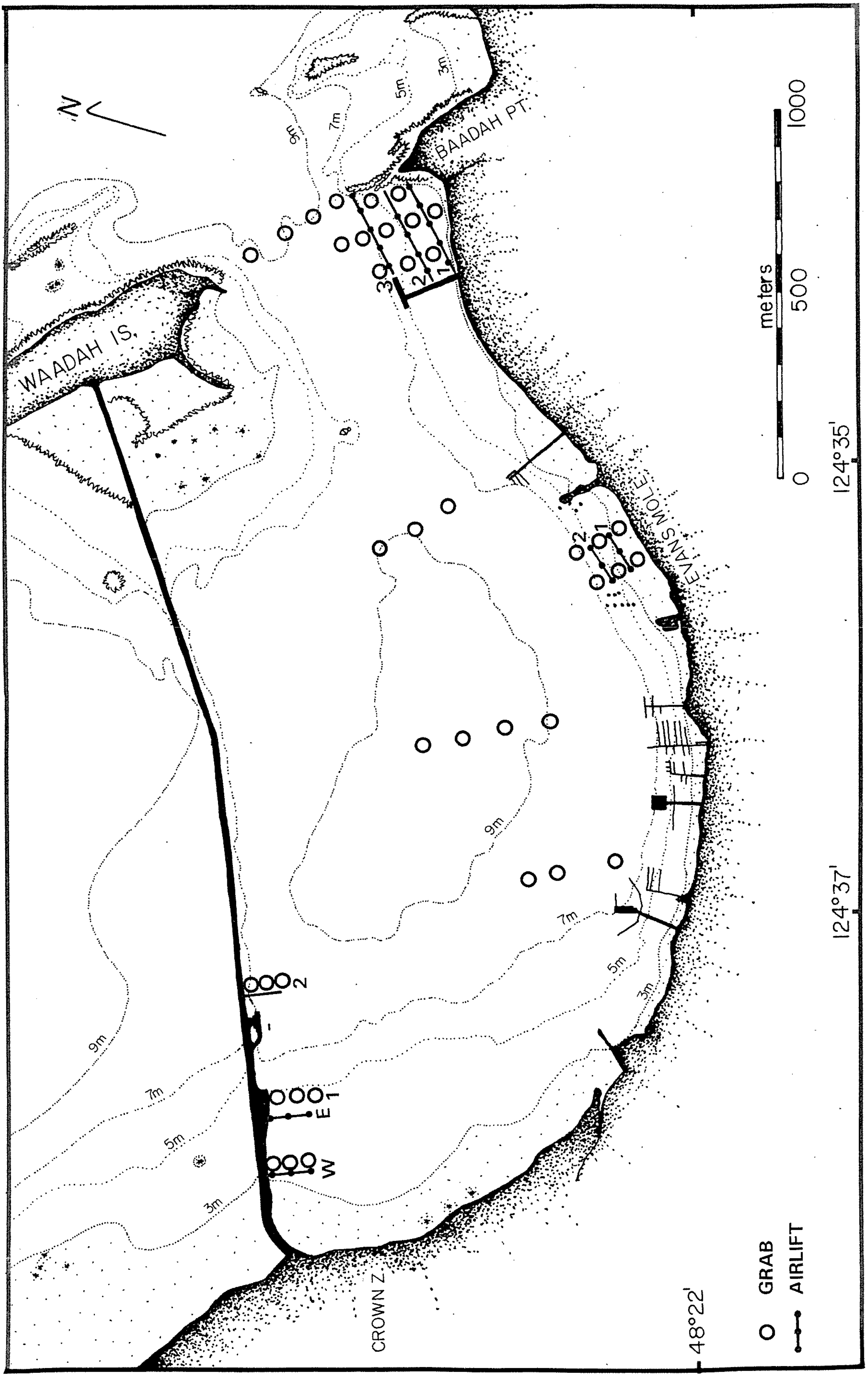


Figure 2.6. Location of synoptic benthic survey (Van Veen grab) and site-specific bivalve survey (airlift suction) stations and transects in Neah Bay, August-September 1986.

five designated sample criteria were satisfied (Tetra Tech, Inc. 1987). Gross characteristics of the surficial sediment and the vertical profile were then recorded for each sample judged acceptable. In addition, environmental conditions, including (1) air temperature (C), (2) water temperature (C), cloud cover (%), wind speed (knots) and direction, visibility (km), and precipitation, were recorded.

After the qualitative characteristics of the sample had been recorded, the entire sample was washed through a 6-L bucket fitted with a 1.0-mm mesh screen in the bottom. Any sediment remaining inside the grab was flushed through the sieve using a squirt bottle. Sieving was accomplished by rapidly raising and lowering the bucket into the surface water; swirling the bucket also facilitated the sieving. Once sieving was completed, and all sediment <1 mm had been passed thorough the sieve, the sample was transferred to a labelled 4-L PVC jar and preserved in 10% borax-buffered formalin with rose bengal stain added. The screen was carefully picked with forceps to remove any infaunal organisms not dislodged by water pressure from a squirt bottle. After fixation, the jars were inverted several times to ensure adequate penetration of the preservative throughout the sample. The samples were transported to Seattle for laboratory analysis.

Within ten days, the samples were washed on a 0.495-mm sieve underneath a ventilated fume hood and transferred from the formalin solution to 60% isopropanol. When sorting, successive, small amounts of the sample were placed in a plastic petri dish and the stained organisms were removed using forceps. Each petri dish of material was sorted twice, first with the naked eye and again under a dissecting microscope, to ensure that all organisms (stained and unstained) were removed. At a minimum, organisms were sorted into the following major taxonomic groups: (1) Annelida; (2) Mollusca; (3) Arthropoda; and, (4) Echinodermata. Whenever possible, identifications were made to lower taxonomic levels. The sorted organisms were counted and weighed (g blotted wet weight to 1 mg) and placed into separate, labelled vials, one for each major taxa. All the vials for a particular sample were labelled internally and externally and secured with a rubber band for later resorting and quality control checks.

Site-specific Infaunal Bivalve Survey (air lift suction pump). Air lift suction sampling was used specifically to assess assemblages of deep-burrowing bivalves. The sampling device was a 2-m section of PVC pipe equipped with a high-pressure valve and regulator at the suction end and a 0.5-mm mesh bag at the collection end.

While using SCUBA, a diver lowered and manipulated the sampling device to evacuate the sediment and organisms within a 0.25 m^2 weighted quadrat placed along the established underwater fish transect lines (Fig. 2.6). Six collections were made at both the Crown Z and Evans Mole (control) sites, including three samples along each transect line at 0 m, 50 m, and 100 m. Fifteen samples were collected at the Baadah Point site, including five along each of the transect lines at 40 m, 80 m, 120 m, 160 m, and 200 m. The depth to which the suction sampler was allowed to penetrate the bottom ranged from 12 cm to 25 cm, depending upon the coarseness and compaction of the sediment but remained constant along a given transect line.

Following the collection of each sample, the diver turned off the sampler, surfaced, and handed the collection bag to the boat tender. As the diver descended with a new collection bag, the boat tender sieved the sample and placed it in a labelled 4-L PVC jar and added 10% borax-buffered formalin and rose bengal stain. Processing and sorting of organisms were identical to the grab sample protocol (see previous section) with the exception that only the bivalves were retained and identified from the samples.

2.3.5 Macrophyte Community Sampling Transects

Quantitative sampling of the benthic assemblages was conducted along transects at each site (Table 2.2). The transects were positioned perpendicular to the edge of the water and extended over the entire intertidal zone (i.e., from above the distribution of benthic marine organisms down to approximately -2 ft MLLW). Three transects were established at Baadah Point. Transect BP1 and BP2 were directed southwest into Neah Bay, and transect BP3 was directed in a northeasterly direction away from Neah Bay. The transects spanned representative portions of the rocky intertidal zone at Baadah Point. The shoreward heads of transects BP1 and BP2 were 49.5 m apart. Transects BP2 and BP3 shared a common head. The transect heads and the direction of the transects were marked by driving 5-cm nails into the rocky substrata to which were tied bright red plastic flagging. Two transects (CZ1, CZ2) were established on the rip rap seawall at Crown Zellerbach. CZ1 was located 5m east of the eastern end of the old Crown Z dock. CZ2 was established approximately 30 m west of the west end of the dock. The direction and shore base and seaward end points for each transect were recorded and were used to reposition the transects during subsequent samplings. A single transect, HB1, was established over the cobble field located at the west end of the Bay. Stakes were driven into the sand/mud substrata to mark the transect location.

Transects were also established in the shallow subtidal zone for quantifying fish populations (Fig. 2.3). The occurrence of seaweeds and fish populations were recorded along these transects. The methods employed to sample these latter transects are described in section 2.3.2.

Assemblage Composition and Standing Stock. A tape measure was extended along a transect, and stretched taunt between the upper and lower ends of the transect. Due to the major crevices in the rocky substrata at Baadah Point, the tape was suspended as much as 1.5 m above the substrata. Stations were located at 1-m intervals along each transect. A plexiglass quadrat containing 50 randomly distributed points (2-mm dia.) within an area of 0.1 m^2 was placed at each station. The

Table 2.2. Description of macroalgae sampling transects, Neah Bay, Washington.

Site	Transect number	Location of the shore base point (SBP)	Angle of transect from SBP	Transect length	No. of stations	Elevation range	Date established	Months sampled
Baadah Point	BP1	On rocks immed. below tower on point	230° mag.	35 m	35	+10 to -2 ft	28 Apr. 1986	AP,MY,JE JL,SE,JR
Baadah Point	BP2	On top of rock benth 49.5m from BP1	239	35	35	+10 to -2 ft	28 Apr. 1986	AP,MY,JE, JL,SE,JR
Baadah Point	BP3	Same as BP2	35	35	35	+10 to -2 ft	28 Apr. 1986	MY,JE,JL, SE,JR
Crown Zellerbach Dock	CZ1	At apex of rip rap wall 5 m east from end of dock	122	10	10	+14 to -1 ft	23 May 1986	MY,JE,JL
Crown Zellerbach Dock	CZ2	Apex of rip rap wall that is directly across dike road from broken wood pilings. The pilings are 33.5 m west of shoreward tip of wood bumper at west end of dock	150	10	10	+14 to -1 ft	23 May 1986	MY,JE,JL, SE
Head of Bay	HB1	Spans cobble field at NW corner of Bay near jetty. SBP is 62 m off old telephone pole located on west side of dike road. Angle from pole to SBP is 100° mag.	65	35	35	+1 to +0 ft	16 Sep. 1986	SE,JR

species of plant or animal underlaying each point and the number of points overlaying each species was recorded. In addition, species occurring within the 0.1 m^2 area, but not under a point, were recorded as present. Bare substrata within the quadrat was scored exactly the same way. Scores were converted to percent cover by multiplying each score by two. Species and substrata types recorded as present, were given a cover value of 0.1%. Notes on the conditions of the biota and physical factors (e.g., logs) within the quadrat and near the transects were also taken. Specimens of species difficult to identify in the field were collected and identified in the laboratory later using appropriate taxonomic literature.

Difficulty in seeing the points on the plexiglass quadrat during night sampling in January required use of a line-intercept method. The tape measure was stretched along the transect as before. The animal or plant taxon or substrata type that occurred under each 10-cm mark along the line was given a score of one. For data analysis, 10 marks were grouped within each meter segment of the transect to yield 35 samples along Baadah Point transects and the Head of the Bay transect as before.

The elevation of each station was determined by first measuring the relative height among stations along a transect using a hand level, and then recording the position of the location of the waterline at a station or stations along the transect and the time of the observation. The sea level elevation was calculated from sea level predictions for Neah Bay (U.S. Department of Commerce 1985). Measurements were checked on several days to minimize daily variations in sea level from predicted levels.

Primary Productivity. O_2 flux in light bottle incubations were used to estimate net primary productivity of seaweeds. Specimens of the major taxa of algae occurring along the transects were carefully collected and kept cool. Water from just offshore of Baadah Point was collected in a clean 19-L carboy. Portions or entire specimens of each species were placed in 300-ml biological oxygen demand (BOD) bottles which were filled with seawater. Following a period (ca., 30 min) of equilibration, the initial dissolved oxygen (DO) was measured to the nearest 0.01 mg L^{-1} using a YSI digital oxygen meter and probe. The time of the measurement was also recorded. The bottles were capped, and placed in water at ambient sea temperature and light and allowed to incubate for one to three hours. Final DO was measured following the incubation period. Following final DO measurements, the seaweeds were extracted from the BOD bottles, and the surface area of the thallus recorded using a grid of points on a plastic sheet (Littler 1979). The specimens were placed in labelled plastic bags and frozen for transport to laboratory facilities at the University of Washington. Weight of the specimens was determined after drying at 80° for 24 to 48 hours. Calculations of net primary productivity and respiration were made using the formulas in Littler and Arnold (1980) with a photosynthetic quotient of 1.00. Productivity of the assemblage was calculated by converting mean percent cover values for a taxon to area covered in cm^2 m^{-2} and multiplying this latter value by the mean productivity rate per cm^2 of thallus for the taxon. Finally, these latter individual values were summed for each site to yield a combined assemblage productivity rate for the site.

2.3.6 Ecological Relationships

When occurring in sufficient numbers, subsamples of juvenile salmonids, baitfish (Pacific herring, northern anchovy, smelts, Pacific sand lance), hexagrammids (lingcod and greenlings), English sole, gadids (walleye pollock, Pacific cod), and juvenile rockfish were retained from the catches and preserved in buffered 10% formalin for stomach contents analyses at a later date.

Preserved specimens of between five and ten fish, depending upon size range, were analyzed quantitatively for stomach contents composition. Individual stomachs were processed using standardized techniques (Terry 1977) which documented stomach fullness and contents digestion, and the frequency of occurrence, numerical, and gravimetric composition of all food items as sorted by taxonomic (species, if possible), life history stage, and parts categories.

2.3.7 Data Management and Analysis

All field collection and laboratory data were recorded on standardized (FRI estuarine-coastal marine fish/zooplankton formats) forms which utilize the format #100 series of the National Oceanographic Data Center (NODC). This format system has been utilized in almost all FRI sampling in Puget Sound and coastal estuaries since 1976, which provides for a widely comparable data base. The system also utilizes the NODC taxonomic code, a ten-digit code which enables encoding of all organisms to any phylogenetic level and life history stage. All field data was entered by an experienced data entry operator and verified automatically at the time of entry.

Tabulation and basic statistical description of the fish catch, epibenthos and pelagic zooplankton, and predator stomach contents data were produced using FRI computer programs (CATCHSUM, SUPERPLANKTON and GUTBUGS/IRI, respectively, which run on the UW's Cyber 150-750 mainframe computer) specifically developed for NODC-formatted data. CATCHSUM and SUPERPLANKTON (Simenstad and Swanson 1984) output reports densities and standing crops of both individual taxa/life history stages and total organisms in areal terms as numbers m^{-2} and g m^{-2}, respectively. Mean, range and standard deviation for density and standing crop figures were also tabulated. SUPERPLANKTON also calculates the percent composition by abundance and biomass for each taxon/life history stage of epibenthic or planktonic organism.

Summarized data was analyzed further on either the Cyber mainframe or on a microcomputer using commercial statistical software. Graphic presentation was generated using the commercial graphics programs *Chart* and *MacDraw* on an Apple Macintosh or *Statgraphics* on an IBM or compatible microcomputer.

Assemblage structure was examined quantitatively using agglomerative hierarchical classification (clustering) of density data using the Bray-Curtis dissimilarity measure (Bray and Curtis 1957; Boesch 1973) and group average sorting. Collections (samples from habitats and microhabitats) constituted the entities and species densities the attributes. Similarities among sampling sites were determined using transformed ($\ln[X_{ij} + 1]$) data and taxa assemblages clustered using standardized (X_{ij}/X_{ik}) data. The coincidence among site (including discrete habitat/microhabitat samples) and taxa clusters was illustrated in two-way nodal constancy plots (Williams and Lambert 1961; Lambert and Williams 1962; Noy-Meir 1971; Boesch 1973; Beals 1984), where constancy (i.e., the relative degree of site group and taxa cluster coincidence) is expressed as $C_{ij} = a_{ij}/[n_i n_j]$) and a_{ij} is the number of occurrences of taxa i in site cluster j and n_i and n_j are the numbers of entities in the respective clusters.

Fish prey categories were ranked using a modified Index of Relative Importance (IRI; Pinkas et al. 1971; Cailliet 1977) computed for prey_i as, IRI_i = % frequency occurrence of prey_i (% abundance_i of total prey abundance + % biomass_i of total prey biomass). The comparative importance of each prey taxa in a sample was expressed as the percentage of the sum of n IRI values (%ΣIRI) in the sample ($\text{IRI}_i/\Sigma\text{IRI}_{i=1 \text{ to } n}$). Although relative parameters, these indices of prey utilization mediate biases resulting from varying stages of digestion among samples and the influence of unrepresentative prey which may have otherwise been numerically or gravimetrically prominent. Similarities in fish diet composition, based on % IRI were evaluated using the Percent Similarity Index (PSI), which is calculated by summing the smallest %IRI of each prey taxa pair between two samples being compared (Cailliet and Barry 1979).

Field data from macrophyte transect sampling were recorded in waterproof field books. The field books were photocopied after each field trip, and the copies were stored at the Nearshore Ecology Laboratory at FRI. Quantitative data were stored on computer files using IBM-compatible computer software (Lotus, Statgraphics). The software and file configuration facilitates statistical analysis and graphics production.

3.0 RESULTS

3.1 Neah Bay Environment

3.1.1 Temperature

Surface water temperatures within Neah Bay were very consistent between sites, never varying more than one degree centigrade; no site was consistently higher or lower than the others. In May and July, temperatures ranged from 11 to 12°C; in September, from 10 to 10.5°C; and, in January, from 8.0 to 8.5°C.

3.1.2 Habitat Mapping

The benthic portion of the Bay was found to be comprised of four distinct habitat types (Fig. 3.1). The largest habitat type was characterized by silty sand with scattered patches of tubeworms (Sabellidae and diatoms). Anaerobic areas covered with sulfur bacteria and garbage were also present. Two areas were dominated by sand and support high densities of macrophytes. One of these areas, located on the Waadah Island side of the Bay, also contained scattered boulders with attached laminarians and other kelps along with scattered patches of *Zostera* and *Ulva*. The other sandy habitat had scattered boulders with attached *Ulva* ; *Zostera* was also present in discrete patches. The fourth habitat consisted of silt with a heavy covering of wood chips and debris and there were large areas covered with sulfur bacteria indicating anaerobic conditions. This latter habitat was located in the vicinity of the Crown Z dock (Fig. 3.1).

3.2 Fish and Motile Macroinvertebrates

3.2.1 Nearshore Demersal Fishes (Beach Seine)

Composition. Over 40 species of fish were collected at Baadah Point, nearly twice the number of species that were observed at any of the other sites (Table 3.1). Numerical composition at Baadah Point was generally more diverse than at the other sites, especially in July when no one species predominated and 26 species were represented (Fig. 3.2). Pacific sand lance accounted for 26% of the total standing crop (g wet m^{-2}) of fish captured at Baadah Point, followed by starry flounder (21%) and Pacific staghorn sculpin (12%). At Evans Mole, the total standing crop was dominated by Pacific staghorn sculpins (44%), surf smelt (22%), and starry flounder (16%). Shiner perch accounted for 73% of the standing crop of fishes collected at Crown Z, followed by Pacific staghorn sculpins (16%).

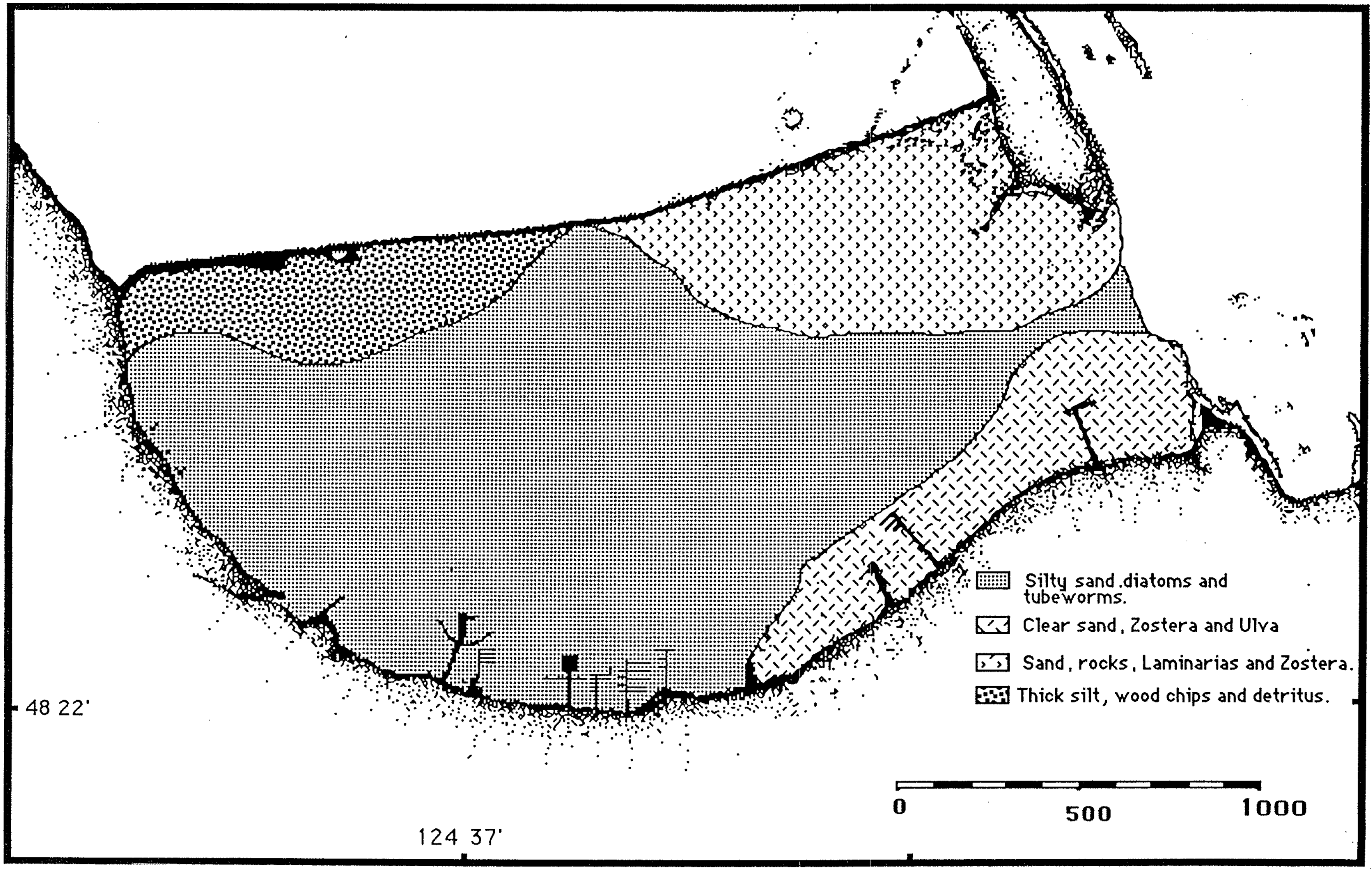


Fig. 3.1. Map of the Neah Bay study area indicating distribution of basic benthic habitats.

Table 3.1. Fish species captured in beach seines at Neah Bay, Washington, May 1986-March 1987; BP = Baadah Point, EM = Evans Mole, and CZ = Crown Z sampling sites; latin binomials for common fish names are listed in Appendix 5.2.

Species-Common name	Site		
1. American shad	-	EM	-
2. Pacific herring	BP	EM	CZ
3. Northern anchovy	BP	-	-
4. Chum salmon	BP	EM	-
5. Chinook salmon	BP	EM	CZ
6. Coho salmon	BP	EM	-
7. Surf smelt	BP	EM	CZ
8. Whitebait smelt	BP	-	-
9. Northern clingfish	BP	-	-
10. Pacific tomcod	BP	-	-
11. Walleye pollock	BP	-	-
12. Tube-snout	BP	-	CZ
13. Bay pipefish	BP	-	-
14. Brown rockfish	BP	-	-
15. Copper rockfish	BP	-	-
16. Kelp greenling	BP	EM	-
17. Coralline sculpin	-	EM	-
18. Rosylip sculpin	BP	-	-
19. Silverspotted sculpin	BP	EM	-
20. Sharpnose sculpin	-	EM	CZ
21. Buffalo sculpin	BP	EM	-
22. Red Irishlord	BP	-	-
23. Pacific staghorn sculpin	BP	EM	CZ
24. Great sculpin	BP	EM	-
25. Saddleback sculpin	BP	-	-
26. Tidepool sculpin	BP	EM	CZ
27. Padded sculpin	BP	-	-
28. Fluffy sculpin	-	-	CZ
29. Cabezon	BP	EM	-
30. Manacled sculpin	BP	-	-
31. Tubenose poacher	BP	-	-
32. Warty poacher	BP	-	-
33. Pacific spiny lumpsucker	BP	-	-
34. Tidepool snailfish	BP	-	-
35. Slipskin snailfish	BP	-	-
36. Slimy snailfish	BP	-	-
37. Shiner perch	-	-	CZ
38. Striped seaperch	BP	EM	-
39. Penpoint gunnel	BP	EM	-
40. Cresent gunnel	BP	EM	-
41. Saddleback gunnel	-	EM	-
42. High cockscomb	BP	-	CZ
43. Pacific sand lance	BP	EM	-
44. Speckled sanddab	BP	EM	-
45. English sole	BP	EM	CZ
46. Starry flounder	BP	EM	CZ
47. Sand sole	BP	EM	-
Total occurrence	40	24	11

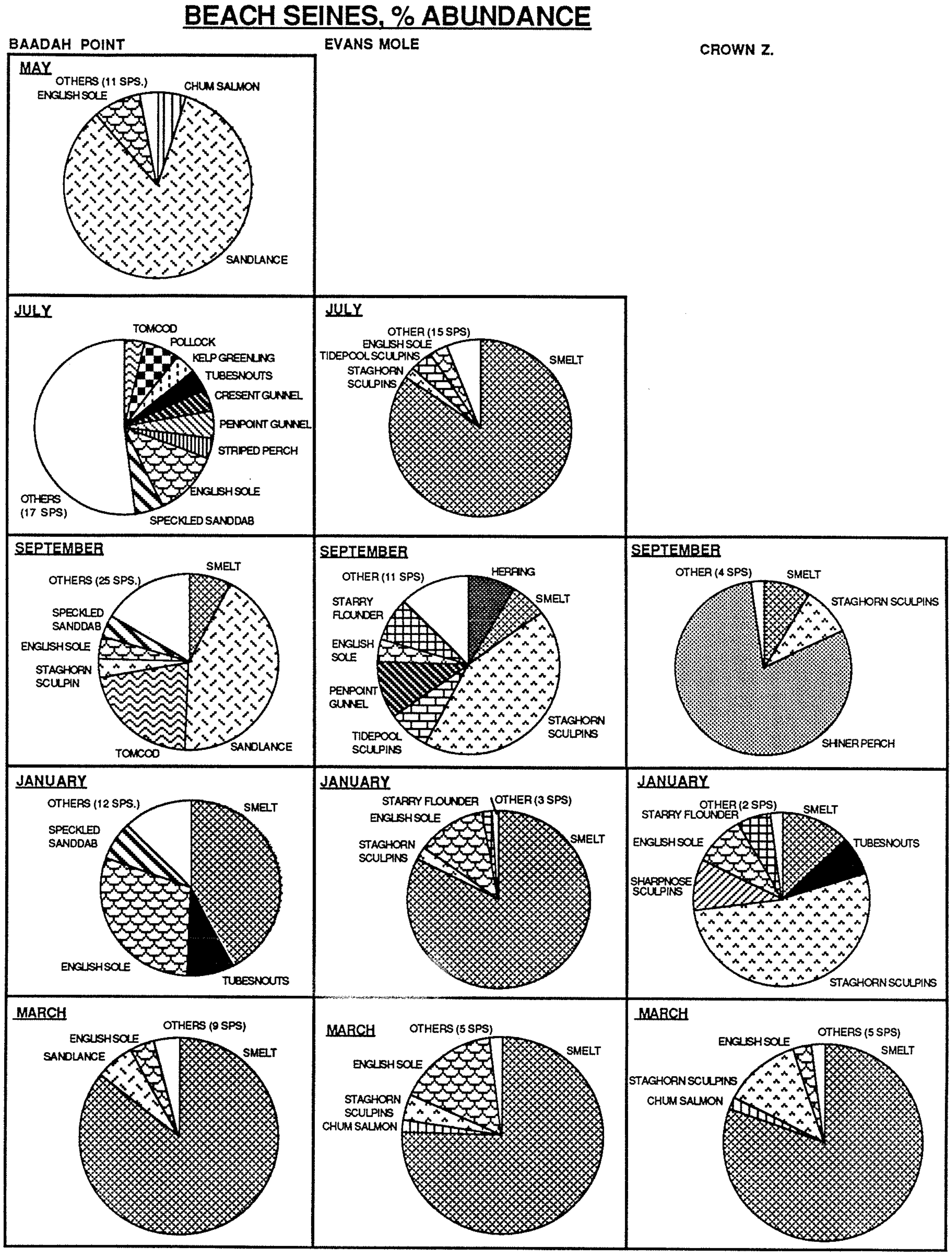


Figure 3.2. Composition (% abundance) of fish species captured in beach seines at three Neah Bay intensive study sites in 1986-87.

Standing stock. Mean standing crop of fishes sampled in the beach seine decreased at all sites from September to January and subsequently increased in March (Fig. 3.3). Comparison of the standing crop among sites was difficult because all sites were not sampled every season.

3.2.2 Pelagic Fishes (Purse Seines)

Composition. Similar to the results of the beach seine collections, more fish species were collected at Baadah Point than at the other sites (Table 3.2); four of the species caught (asterisks, Table 3.2) were caught in a single haul which accidently hit the bottom, thereby accounting for the presence of demersal pleuronectids (flatfish) in the samples. Either Pacific herring and surf smelt, though seldom both (with the exception of Crown Z in May) dominated the numerical composition of the fish fauna (Fig. 3.4). The data for January were not plotted because very few fish were caught (one tube-snout at Baadah, one surf smelt and one Pacific staghorn sculpin at Evans Mole and no fish at Crown Z). Surf smelt and Pacific herring, representing 51% and 16% of the total standing crop, respectively, predominated at Baadah Point; at Evans Mole, surf smelt represented 26% and Pacific herring 53%; and, at Crown Z, surf smelt predominated, representing 87% and Pacific herring 7%.

Standing stock. Extensive variability in mean standing crop among sites and dates suggested that the distribution of pelagic fishes in the Neah Bay was not strongly influenced by site characteristics (Fig. 3.5). In January, the total standing crop of pelagic fishes in the Bay was negligible.

3.2.3 Mid-Bay Demersal Fishes (Demersal Trawl)

Composition. Fish species richness at the mid-channel site was much higher than at the turning basin or Crown Z sites (Table 3.3). Speckled sanddab and English sole predominated numerically at the mid-channel and turning basin sites (Fig. 3.6). On the basis of standing crop, however, rock sole, kelp greenlings and red Irish lords dominated the composition at the mid-channel site, representing 26%, 23% and 23%, respectively. One large lingcod accounted for 8% of the biomass. At Turning Basin, English sole accounted for 30% of the biomass, followed by speckled sanddabs. Two large spotted ratfish accounted for 63% of the biomass. Only four fish per species were collected at the Crown Z site in July and September, and only four spotted ratfish were collected in March.

Standing stock. Trawl collections at the site closest to the mouth of the Bay had a higher mean standing crop than those further back in the Bay. The standing crop at Crown Z was higher than the other two sites only in March (Fig. 3.7).

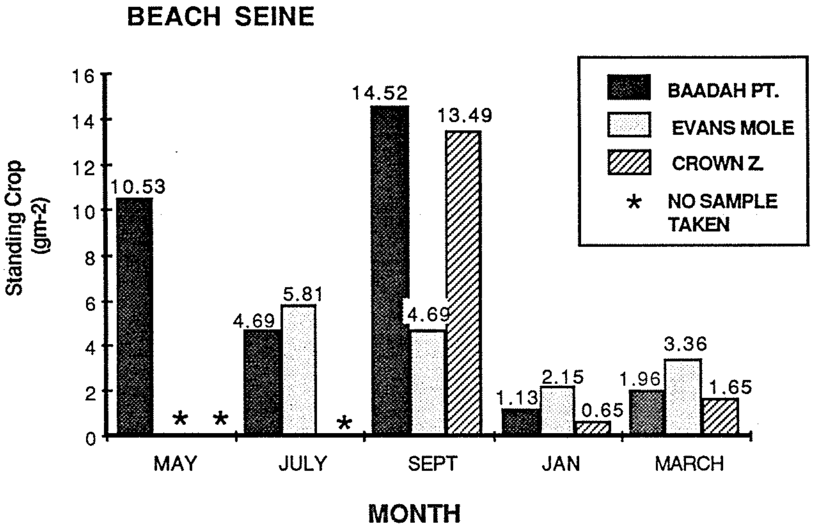


Figure 3.3. Standing crop (g m^{-2}) of fishes estimated from beach seine collections at intensive study sites in Neah Bay, 1986-87.

Table 3.2. Fish species captured in purse seines at Neah Bay, Washington, May 1986-March 1987; BP = Baadah Point, EM = Evans Mole, and CZ = Crown Z sampling sites; latin binomials for common fish names are listed in Appendix 5.2.

Species-Common name	Site		
1. American shad	-	EM	-
2. Pacific herring	BP	EM	CZ
3. Northern anchovy	-	EM	CZ
4. Pink salmon	BP	-	CZ
5. Chum salmon	BP	EM	-
6. Coho salmon	BP	EM	CZ
7. Chinook salmon	-	EM	CZ
8. Surf smelt	BP	EM	CZ
9. Pacific cod	BP	-	-
10. Tube-snout	BP	-	-
11. Copper rockfish	BP	-	-
12. Black rockfish	BP	-	-
13. Kelp greenling	BP	-	-
14. Lingcod	BP	-	CZ
15. Rosylip sculpin	BP	-	-
16. Pacific staghorn sculpin	BP	EM	-
17. Manacled sculpin	BP*	-	-
18. Tubenose poacher	BP*	-	-
19. Pacific sand lance	BP*	-	-
20. Speckled sanddab	BP*	-	-
21. Starry flounder	BP*	-	-
Total occurrences	18	8	7

*Species caught in a single seine which hit bottom.

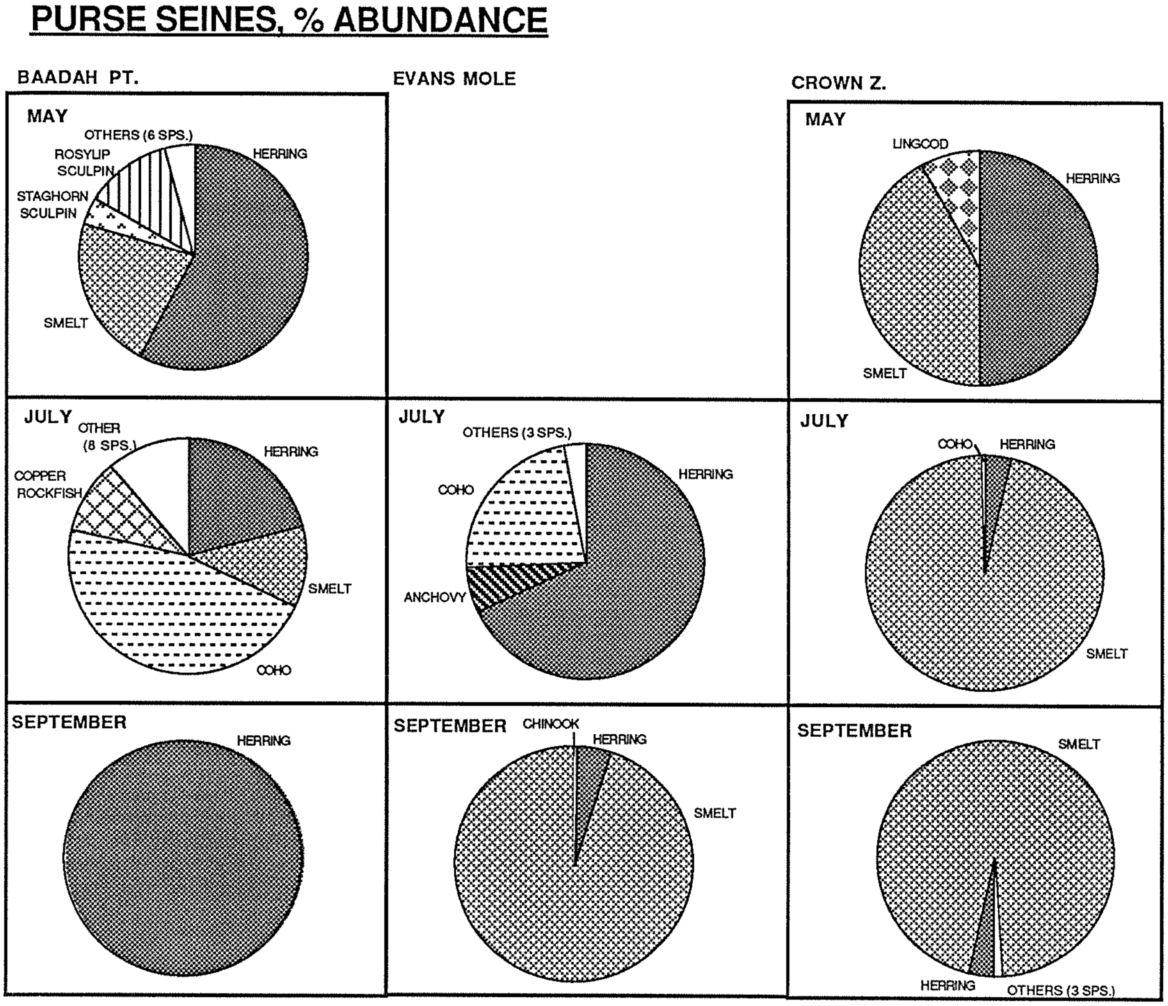


Figure 3.4. Composition (% abundance) of fish species captured in purse seine collections at three Neah Bay intensive study sites, 1986-87; January samples are not included because only four fish were caught in the nine samples.

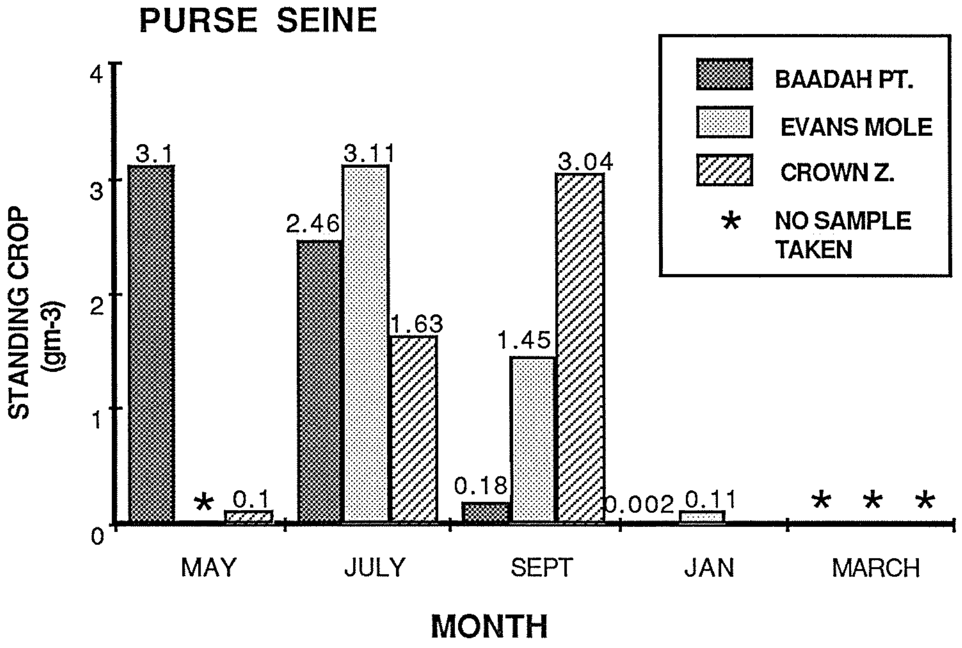


Figure 3.5. Standing crop (g m^{-3}) of fishes estimated from purse seine collections at intensive study sites in Neah Bay, 1986-87.

Table 3.3. Fish species captured in otter trawls at Neah Bay, Washington, May 1986-March 1987; CH = Mid-channel, TB = Turning Basin, CZ = Crown Z sampling sites; latin binomials for common fish names are listed in Appendix 5.2.

Species-Common name			Site	
1.	Spotted ratfish	-	TB	CZ
2.	Pacific cod	CH	-	-
3.	Pacific tomcod	-	TB	CZ
4.	Walleye pollock	-	TB	-
5.	Copper rockfish	CH	-	-
6.	Quillback rockfish	CH	-	-
7.	Kelp greenling	CH	-	-
8.	Lingcod	CH	TB	CZ
9.	Padded sculpin	CH	-	-
10.	Scaleyhead sculpin	CH	-	-
11.	Smoothhead sculpin	CH	-	-
12.	Rosylip sculpin	CH	-	-
13.	Buffalo sculpin	CH	-	CZ
14.	Red Irish lord	CH	-	-
15.	Brown Irish lord	CH	-	-
16.	Sailfin sculpin	CH	-	-
17.	Roughback sculpin	CH	-	-
18.	Staghorn sculpin	-	-	CZ
19.	Tidepool sculpin	-	-	CZ
20.	Bonyhead sculpin	-	TB	-
21.	Cabezon	CH	-	-
22.	Sturgeon poacher	CH	TB	-
23.	Pacific spiny lumpsucker	CH	-	-
24.	Speckled sanddab	CH	TB	-
25.	Rock sole	CH	-	-
26.	English sole	CH	TB	-
27.	Curlfin sole	CH	-	
Total occurrences		21	8	5

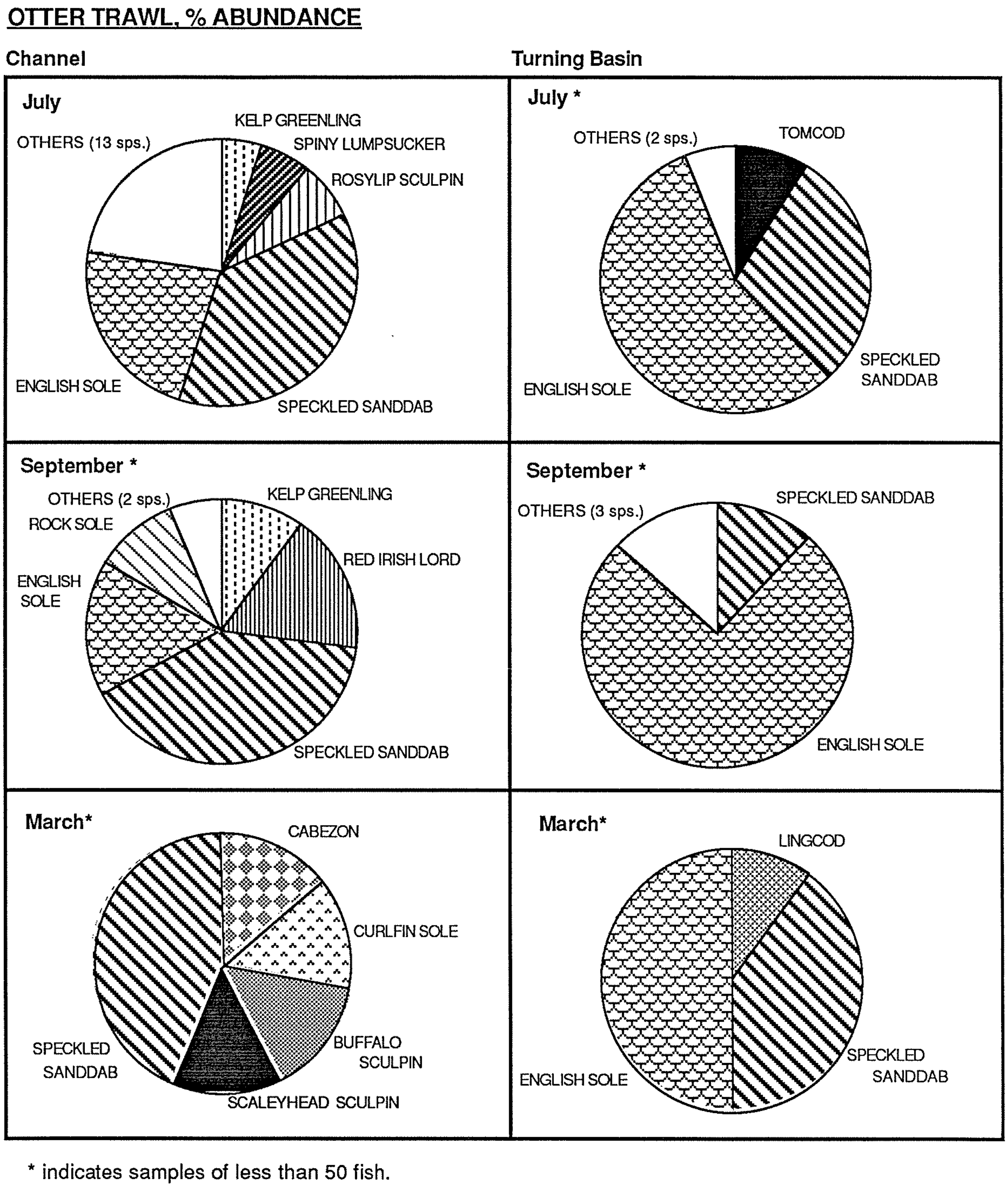


Figure 3.6. Composition (% abundance) of fish species captured in otter trawl collections at three Neah Bay intensive study sites, 1986-87 (Crown Zellerbach samples are not included because non-significant numbers of fish were caught).

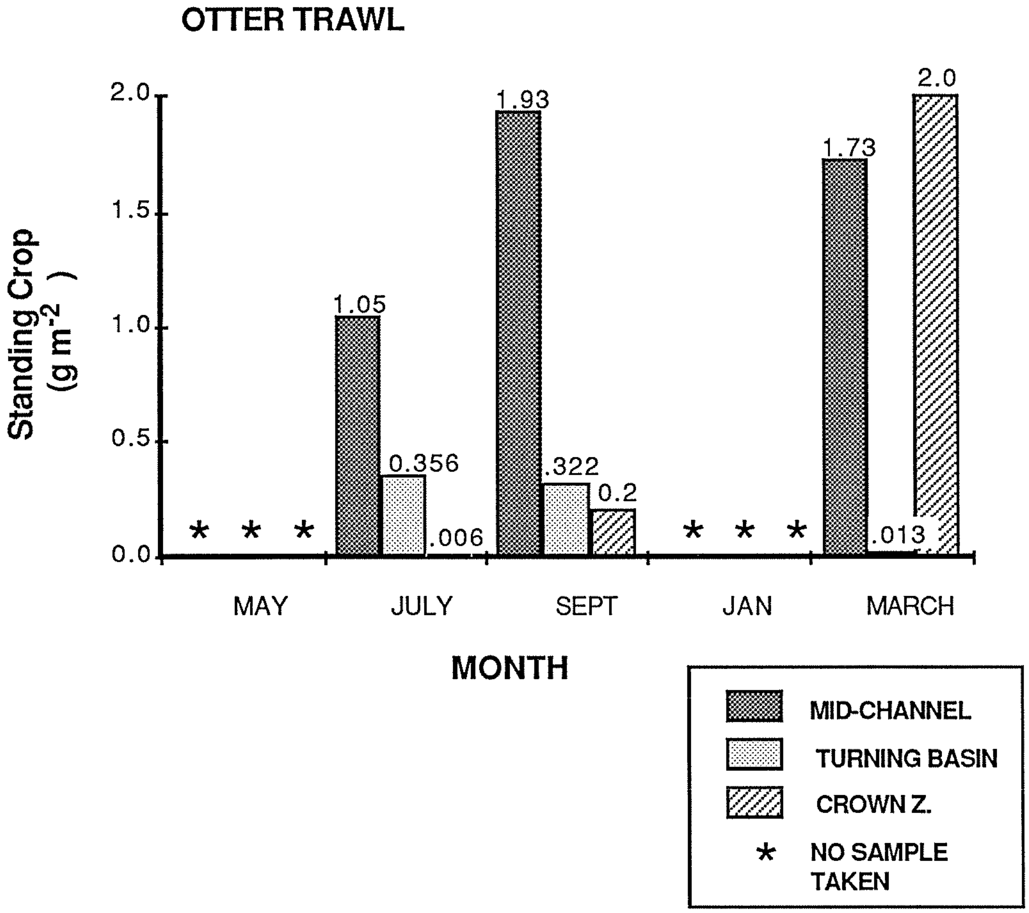


Figure 3.7. Standing crop (g m^{-2}) of fishes estimated from otter trawl collections at three Neah Bay intensive study sites in 1986-87.

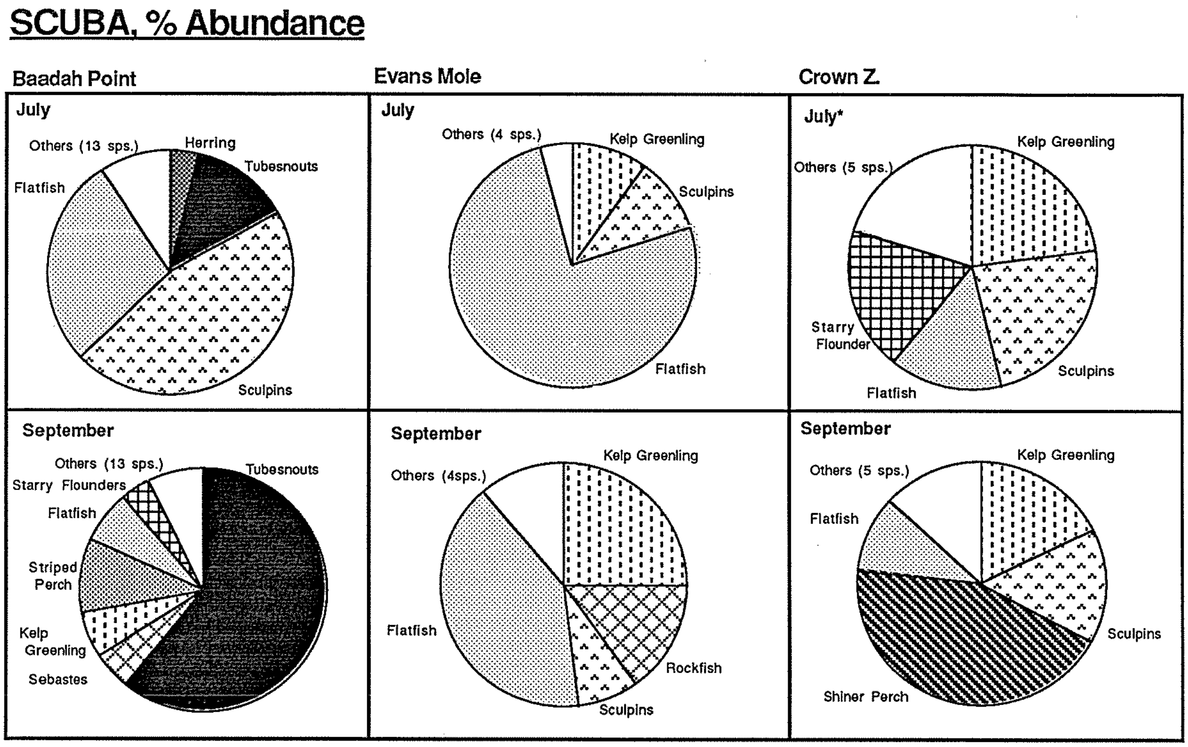


Figure 3.8. Composition (% abundance) of fish species observed along SCUBA transects at three Neah Bay intensive study sites, 1986-87. January and March samples were not plotted because very few fish were observed.

3.2.4 Nearshore Reef Fishes (SCUBA Observations)

Composition. There were more species observed along the subtidal transects at Baadah Point than at any of the other subtidal sites (Table 3.4). A somewhat different species composition was evidenced using the SCUBA transects than was documented from the other methods (Table 3.4). At Baadah Point, sculpins, flatfish and kelp greenling represented numerically 33%, 25%, and 4% of the fish observations, respectively. At Evans Mole, sculpins represented 22% of the observed fish numbers, flatfish 67%, and kelp greenling 13%. Crown Z observations were dominated by the same three groups; sculpins (22%), flatfish (12%) and kelp greenling (20%). Comparison of flatfish abundance between sites was tenuous, however, because of the varying amounts of coverage by *Ulva*.

In September, a strong easterly storm (characteristic of winter weather) disrupted our sampling. At Baadah Point, two replicates were completed before the storm and one after; at Crown Z, one replicate was completed before the storm and two after; and, at Evans Mole, one sample was completed before and one after the storm (visibility after the storm was poor at this site so a third replicate was not done). Mean fish density declined from July to September at Baadah and Evans Mole and increased at Crown Z (Fig. 3.9).

The January sampling also occurred during bad weather allowing only limited observations. No fish were observed along the inside transect line at Baadah Point and only one kelp greenling and one starry flounder were observed along the second transect line. At Evans Mole, two replicates were completed and only four starry flounders were observed. One replicate was conducted at Crown Z and no fish were observed along either transect. One dive was conducted along the third transect line in poor visibility during which no fish were observed.

There were very few fish observed in March. Five juvenile flatfish, two starry flounder and a single tube-snout were observed at Baadah Point. A group of sea lions was feeding on fish carcasses dumped off the Marine Harvest pier near the transects and they may have scared off or eaten any large fish or crabs in the area; these observations should be considered biased. At Evans Mole, ten starry flounder and three juvenile flatfish were observed and, at Crown Z, there were four starry flounder and one sculpin.

Macrophyte cover. The middle transect at Baadah Point (T2) had the highest macrophyte cover and the outside transect (T3) had the lowest (Table 3.5). The amount of cover increased from July to September but changed drastically after the storm in September. Thereafter, the thick cover of *Ulva* at Baadah Point disappeared and was replaced by a mixed conglomerate of debris consisting of all varieties of macrophytes that had been torn off of the rocks. At the same time,

Table 3.4. Total numbers of fishes observed during underwater transect observations, Neah Bay, Washington, May 1986-March 1987; latin binomials for common fish names are listed in Appendix 5.2.

Species-Common name	Baadah Point	Evans Mole	Crown Z
1. Big skate	1	-	-
2. Pacific herring	100	-	1+
3. Salmonid spp.	4	-	-
4. Gadid spp.	9	-	-
5. Tube-snout	875	1	2+
6. Rockfish spp.	99	8	-
7. Quillback rockfish	-	2	-
8. Kelp greenling	152	29	17
9. Lingcod	13	-	1
10. Cottid spp.	1137	20	16
11. *Artedius* spp.	-	-	1+
12. Buffalo sculpin	8	1	-
13. *Hemilepidotus* spp.	3	-	1+
14. Red Irish lord	1	-	-
15. Staghorn sculpin	-	1	1
16. Great sculpin	-	1	-
17. Fluffy sculpin	-	-	1
18. Sailfin sculpin	2	1	-
19. Tubenose poacher	3	-	-
20. Shiner perch	-	-	27+
21. Striped seaperch	86	-	-
22. Pricklebacks	1	-	1
23. Mossheaded warbonnet	-	-	1+
24. Gunnels	1	2	1+
25. Penpoint gunnel	10	1	1+
26. Cresent gunnel	2	1	1
27. Pacific sand lance	5	-	-
28. Flatfish	756	140	10
29. Rock sole	1	-	-
32. Starry flounder	86	13	9

+indicates species seen only after September storm.

large amounts of *Nereocystis*, *Macrocystis* and smaller alga accumulated on the bottom at the Crown Z site, presumably transported there by the storm action.

Distribution. At Baadah Point, there were some clear associations between certain groups of fishes and areas they seemed to prefer. Approximately 90% of the juvenile rockfish and 70% of the gadid observations were made along the middle transect, where the highest macrophyte cover occurred. In contrast, 97% of the unidentified sculpins occurred along the outside transect.

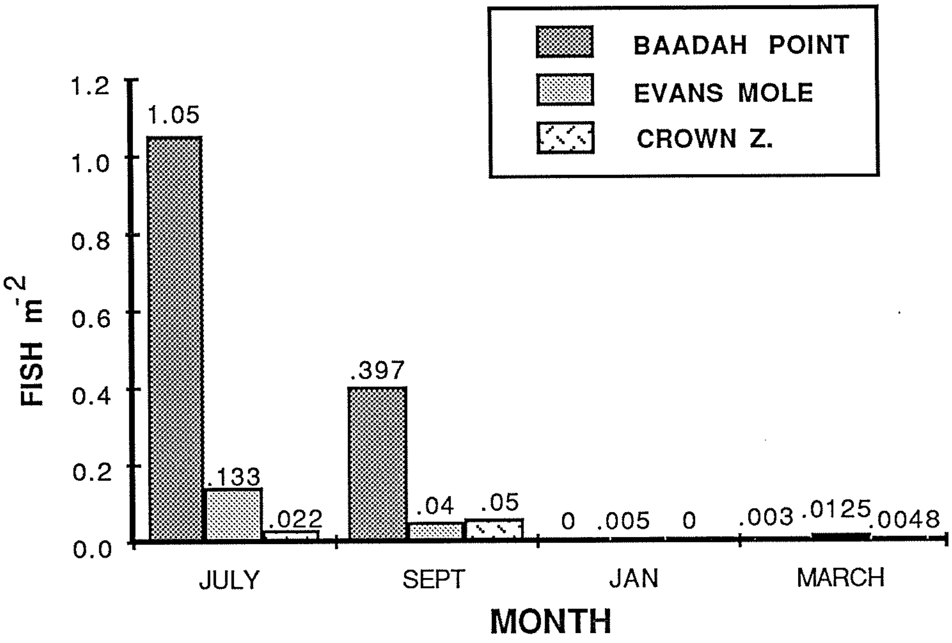


Figure 3.9. Fish densities (FISH m^{-2}) observed along SCUBA transects at three intensive study sites in Neah Bay, 1986-87.

Table 3.5. Cover of subtidal macrophytes estimated along SCUBA transects at Baadah Point9nd Evans Mole, Neah Bay, 1986.

Baadah Point		Ulva	Zostera	Laminaria
July	T1	69%	23%	-
	T2	73%	56%	-
	T3	-	-	Scattered
September	T1	60%*	30%	-
	T2	80%**	62%	-
	T3	15%	8%	Scattered

Evans Moll		*Ulva*/*Laminaria* mix
July	T1	40%
	T2	20%
September	T1	60%
	T2	20%

3.2.5 Life History Stages, Population Structure, Growth and Reproduction of Key Groups

Seven key groups with potential economic value were identified on the basis of significant representation in the samples. These included baitfish, salmonids, gadids, rockfish, hexagrammids, flatfish and macroinvertebrates.

Baitfish. Baitfish or forage fishes occurring during the study included: American shad, Pacific herring, northern anchovy, surf smelt, whitebait smelt and Pacific sand lance. Pacific herring, surf smelt and Pacific sand lance were the only species which occurred consistently in significant numbers to indicate population structure. Herring occurred in all purse seines in May, July and September; surf smelt occurred in almost all the purse seines and beach seines and accounted for most of the biomass sampled.

Most of the herring and surf smelt in the samples were post-larval or juvenile fish (Fig. 3.10-3.11). A few adults of both species occurred at Baadah Point in July and at Crown Z in March. More than one recruitment event appears to have contributed to the herring caught in the Bay. Given the multimodal size distributions, it would appear that several different cohorts of juvenile herring were continuously moving into Neah Bay but that a smaller proportion either resided for a longer period, and occurred subsequently at Evans Mole and Crown Z, or lower numbers of larger fish enter the Bay later (Fig. 3.10). For instance, while the early recruits (20-40 mm) evident in May appeared to be strongly represented at Evans Mole and Crown Z through September, large recruits (presumably yearlings) immigrated into the Bay between May and June but had emigrated by September. If the mode shifts of the early recruits corresponds to growth of that cohort, it would appear that growth was rapid during the late spring (e.g., approximately 20 mm month^{-1}) but slowed during the summer (approx. 10 mm month^{-1}).

Size frequency distributions of surf smelt suggested a more contracted spawning event adjacent to or in Neah Bay (Fig. 3.11). Adults (120-190 mm) were present at Baadah Point in May and July. One size mode of juveniles persisted at all sites from May through September, perhaps originating from the local adults in the Bay. Growth of the most prominent surf smelt cohort (mode) also appeared to decrease between spring and summer, from approximately 10 mm month^{-1} to 5 mm month^{-1}. The occurrence of smaller postlarvae and juveniles in January and March 1987 indicated that local spawning may occur during this period.

Sand lance occurred primarily at Baadah Point. On several occasions a few individuals occurred in beach seine collections at Evans Mole and Crown Z. Baitfish spawning was never observed directly in Neah Bay.

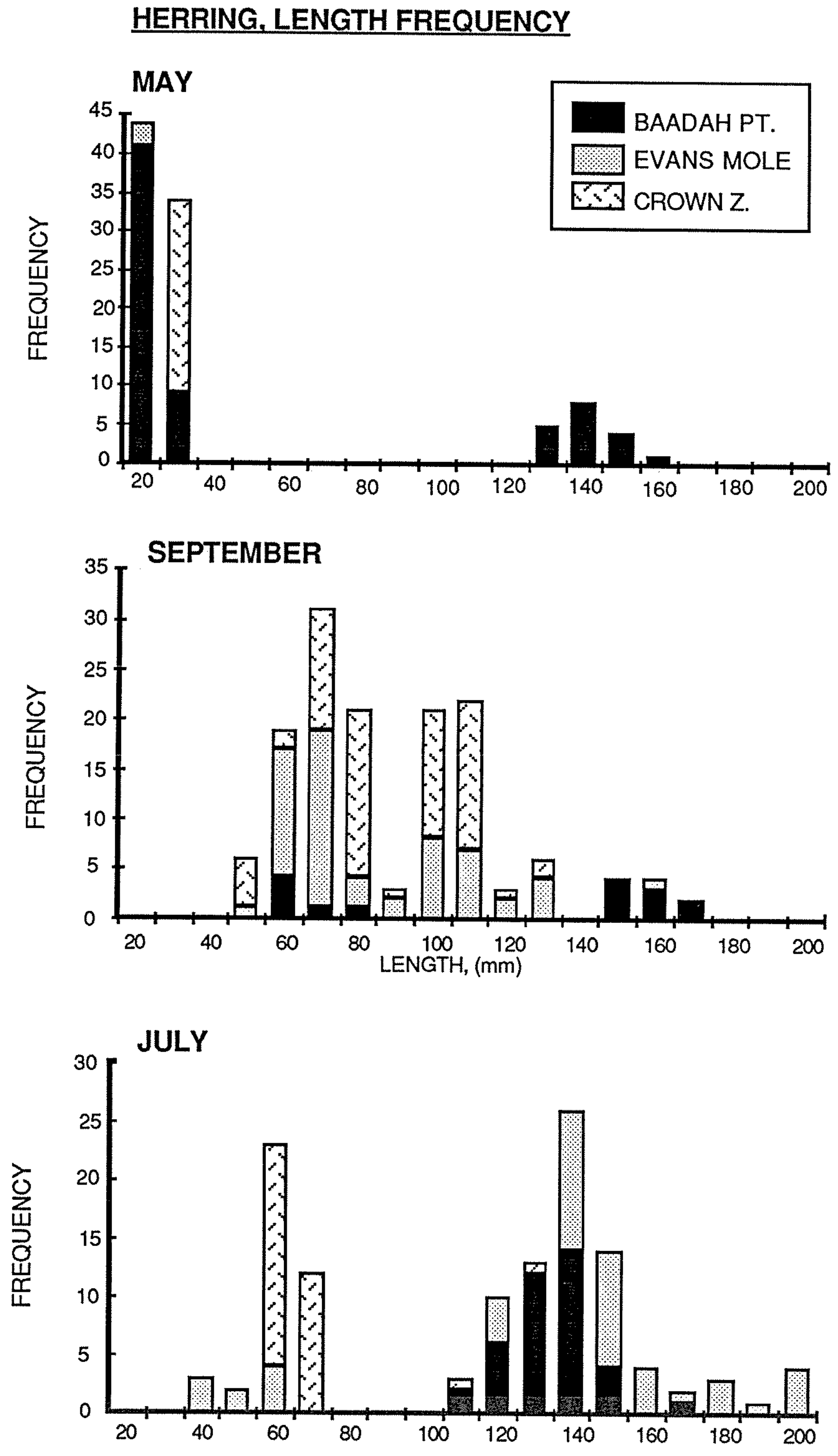


Figure 3.10. Length-frequency plots of Pacific herring captured in purse seine and beach seine samples at three Neah Bay intensive study sites, 1986 (no herring were taken in 1987 samples).

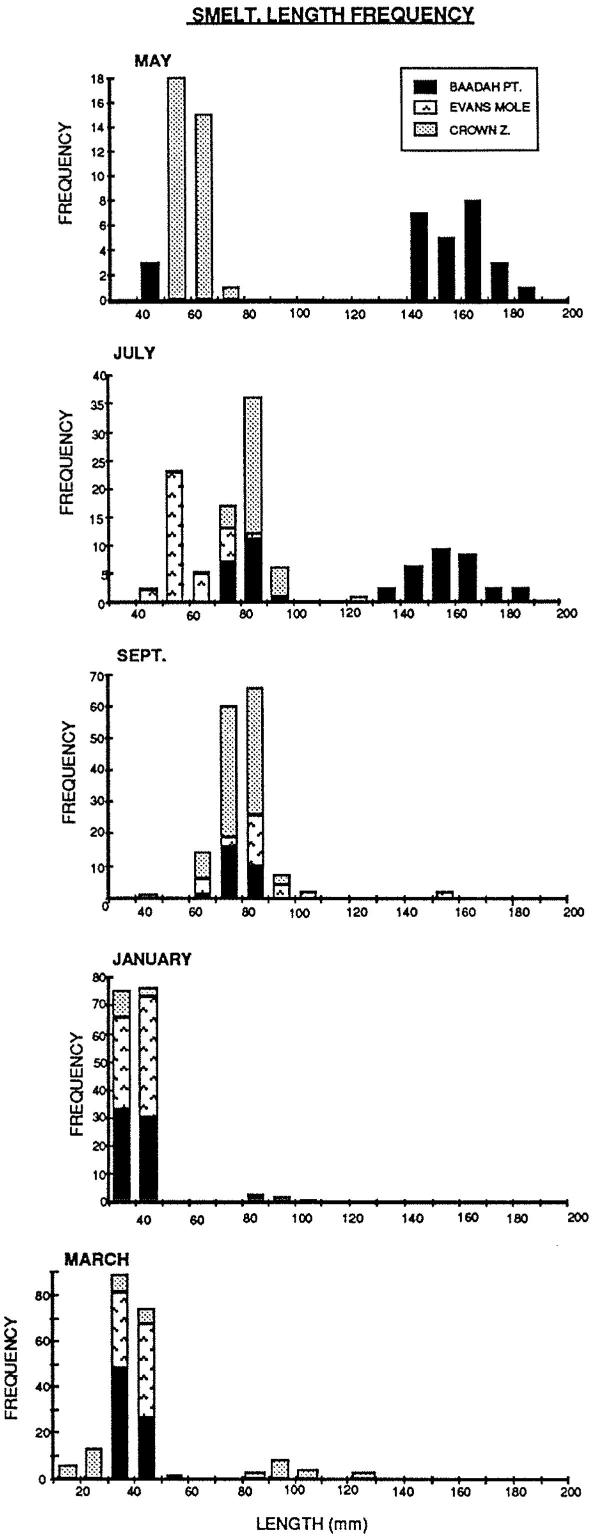


Figure 3.11. Length-frequency plots of surf smelt captured in purse seine and beach seine collections at three Neah Bay intensive study sites, 1986-87.

Salmonids. Four species of juvenile Pacific salmon occurred: chum, coho, chinook and pink. Chums were collected at all sites in May and July 1986 and March 1987. Coho and pink were captured in July and were more abundant at the Baadah Point end of the Bay. Chinook occurred at all sites in September (Table 3.6). No juvenile salmon were captured during sampling in winter (January) 1987.

Gadids. Juvenile Pacific cod, walleye pollock and Pacific tomcod were captured at Baadah Point or the mid-channel trawl site (Table 3.7). Tomcod were caught in the May, July and September samples; pollock and cod occurred only in the July samples. There were no gadids in the January or March collections.

Rockfishes. Four species of rockfish were represented in the Neah Bay: quillback, brown, copper and black. In May, a single post-larval black rockfish was captured in a Baadah Point purse seine. In July, a sub-adult quillback rockfish and a juvenile copper rockfish were collected in an otter trawl sample in the channel. Subsequently, juvenile copper rockfish were the only rockfish that occurred in abundance. At Baadah Point, 21 juvenile copper rockfish (mean 22-36 mm TL) were captured in purse seine samples and eight (22-36 mm) in beach seine samples.

There were 19 juvenile copper rockfish (total lengths 45-58 mm) in September beach seine samples and one 56 mm copper rockfish occurred in an otter trawl sample in the channel. The density of juvenile copper rockfish estimated from the July and September Baadah Point beach seine collections was 0.012 fish m^{-2}. During the same period, the density of juvenile rockfishes observed with SCUBA along transect T2 at Baadah Point was 0.050 fish m^{-2}, nearly five times higher than the beach seine estimate. Because of the difficult identification of post larval and early juvenile rockfishes, all of the juveniles caught were verified in the laboratory. Underwater identification of the juvenile rockfish along the SCUBA transects was impossible, but it is conceivable that different species may occur at different depths. Nonetheless, the density of juvenile rockfish was greater at the second Baadah Point transect than anywhere else in the bay. No rockfish were captured or observed in either the January or March collections.

Hexagrammids. Both lingcod and kelp greenling were captured or observed in Neah Bay. Most were juveniles although some adult kelp greenling were captured in the beach seines and adults of both were observed at Baadah Point during SCUBA transect observations.

In May, pelagic juvenile lingcod were captured in purse seine samples. Twenty-four lingcod (total lengths from 48 to 61 mm) were caught at Crown Z and six (total lengths 48 to 56 mm) were captured at Baadah Point. In July, two lingcod (131 mm, 374 mm) were captured in the channel and one (131 mm) at the Crown Z otter trawl collections.

Table 3.6. Summary of juvenile salmon densities (fish/100 m^{-2}) in beach seine and purse seine collections in Neah Bay, Washington, May 1986-March 1987; fork length in mm in parentheses.

Site	Month May	 July	 September	 January	 March
A. Chum Salmon (regular type) and Pink Salmon (bold type)					
Baadah Pt:					
Beach Seine;	114(20-70)	**1(83-84)**	-	-	4(12-76)
Purse Seine;	-	2(80-120)	-	-	-
Evans Mole:					
Beach Seine;	-	1(87)	-	-	17(11-72)
Purse Seine;	-	2(81-95)	-	-	-
Crown Z:					
Beach Seine;	-	-	-	-	25(10-76)
Purse Seine;	-	1	-	-	-
B. Coho Salmon (regular type) and Chinook Salmon (bold type)					
Baadah Pt:					
Beach Seine;	-	2(84-116)	**2(89-121)**	-	-
Purse Seine;	-	38(142-164)	-	-	-
Evans Mole:					
Beach Seine;	-	1(92)	**1(196)**	-	-
Purse Seine;	-	19(142-164)	**1(173-230)**	-	-
Crown Z:					
Beach Seine;	-	-	**1(126)**	-	-
Purse Seine;	-	1(144)	**2(173-230)**	-	-

Table 3.7. Summary of gadid fish density (fish/100 m^{-2}) in beach and purse seine and otter trawl collections in Neah Bay, Washington, May 1986-March 1987; fork length in mm.

Site	Month May	 July	 September	 January	 March
Baadah Pt:					
Beach Seine;	-	pollock; 40(59-67)	-	-	-
	-	tomcod; 88(59-83)	tomcod; 224(63-126)	-	-
Purse Seine;	tomcod; <1(35)	-	-	-	-
Channel:					
Otter Trawl;	-	pollock; <1(64)	-	-	-
	-	cod; <1(64)	-	-	-
	-	tomcod; <1(43-85)	-	-	-

No lingcod were collected in the September or January. On August 31, nine large lingcod (500-1000 mm) were observed between T1 and T2 and about 30 m seaward from the rocks of the Point. SCUBA divers speared seven of these and we were able to sample them. All were males ranging in size from 710 mm to 930 mm. Qualitative stomach contents analyses indicated that they had been feeding on juvenile kelp greenling, gadids and Pacific sand lance. No lingcod were observed on subsequent dives later that week, and no lingcod were observed during the spawning survey dives in March.

In May, thirteen pelagic kelp greenling (52-59 mm TL) were captured in purse seine samples at Baadah Point. In July, two large greenling (74 and 227 mm) were included in the Baadah Point purse seine sample which hit the bottom, and 39 juvenile greenling (63-121 mm) occurred in the beach seine collections. At Evans Mole at the same time, 36 juvenile greenling (65-112 mm) were captured by beach seine, and three juveniles (62-71 mm), four adult males (202-237 mm) and one adult female (211 mm) were caught in the channel during otter trawling.

In September, ripening females were collected in the beach seines at Baadah Point. Included in these collections were four females with eggs (254-403 mm), two males (231, 235 mm), and 35 juveniles (82-163 mm). At Evans Mole, six juvenile kelp greenling (104 -133 mm) were also captured in the beach seine collections. In the otter trawl sampling in the channel, three kelp greenling (178,202,431 mm) were captured; the largest was a gravid female. Three kelp greenling (102, 114, 320 mm) were captured in January and there were no kelp greenling in March samples.

Underwater observations at Baadah Point indicated that the density distribution of kelp greenling decreased from shallow to deep water (Fig. 3.12). Kelp greenling were also observed along the transects at Crown Z, although none were captured in the beach seine collections there.

Flatfish. Juvenile English sole were the most common of the five species of flatfish collected. Densities from beach seine collections decreased from May to September and then increased in January and March as young-of-the-year began to settle in the Bay (Fig. 3.13). A comparison of length frequency distributions of English sole captured in beach seine and trawl collections suggested that larger sole occurred at the deeper (trawl) sampling sites, and that several recruitment events were evidenced by young-of-the-year appearing in January, March and May (Fig. 3.14). There were very few fish over 100 mm and no fish over 140 mm in the samples, implying that English sole emigrate from the Bay after rearing for one to two years.

Except for one fish taken at Evans Mole in September, speckled sanddab appeared in only Baadah Point beach seine collections and otter trawls collections in the channel. Fish captured in beach samples were smaller than those in the otter trawl samples (Fig. 3.16).

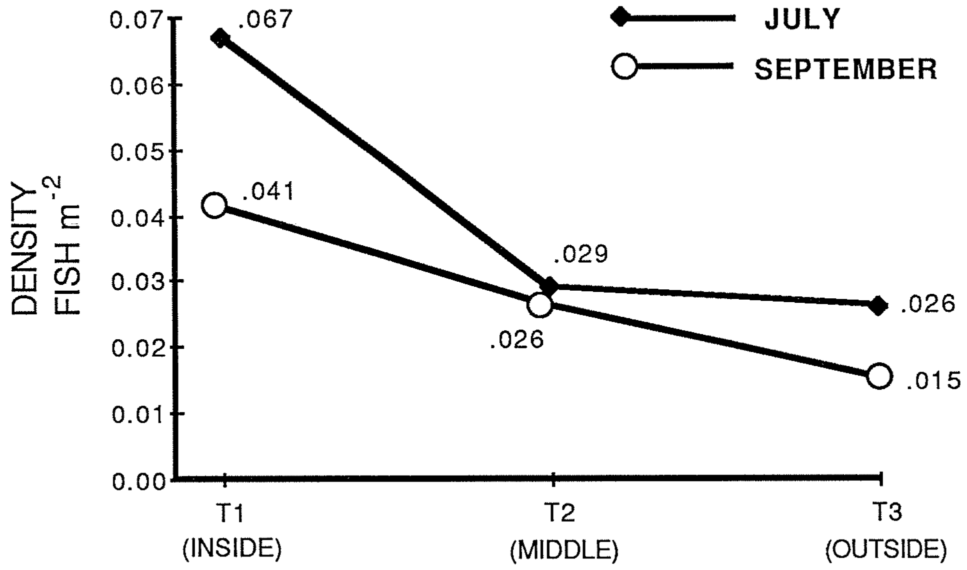


Figure 3.12. Density (fish m^{-2}) of kelp greenling observed during SCUBA transects at Baadah Point, Neah Bay, 1986.

Starry flounder occurred at all beach seine sites during all sampling periods. Length frequency distributions indicated that young-of-the-year appeared at the Evans Mole and Crown Z sites in July and September (Fig. 3.16). The incidence of protracted frequencies of larger, presumably older juveniles at Baadah Point in May in the absence of young-of-the-year at that site also implies that recruitment may occur further inside the Bay and the fish move progressively toward the mouth as they grow. Surprisingly, there were no starry flounder in any of the trawl collections.

Sand sole occurred in only three beach seine samples. A 149 mm sand sole was captured at Baadah Point in May. In January, seven (20-71 mm) were captured at Baadah Point and one (47 mm) at Evans Mole.

Rock sole were caught during trawling in the channel; four (38-231 mm) in July and three (148-372 mm) in September. In addition, one rock sole was observed during SCUBA observations along T3 (the deep transect) at Baadah Point.

3.2.6 Motile Macroinvertebrates

Dungeness crab and pandalid shrimp were the two motile macroinvertebrate taxa of potential economic value which appeared to utilize the Bay on a regular basis. Dungeness crab occurred in beach seine samples and were observed during SCUBA observations at all three of the study sites. Crab densities increased from March to September, presumably with settlement and or recruitment into the Bay (Fig. 3.17). In January, all the crabs sampled at Baadah Point were juveniles.

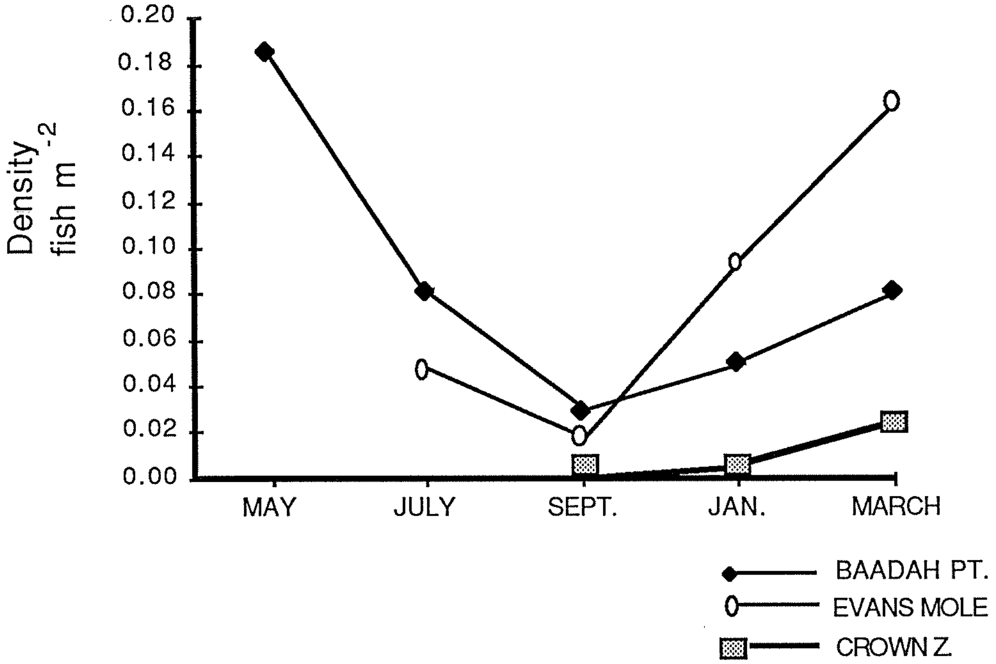


Figure 3.13. Density of English sole captured in beach seine samples at three intensive study sites in Neah Bay, Washington, 1986-87.

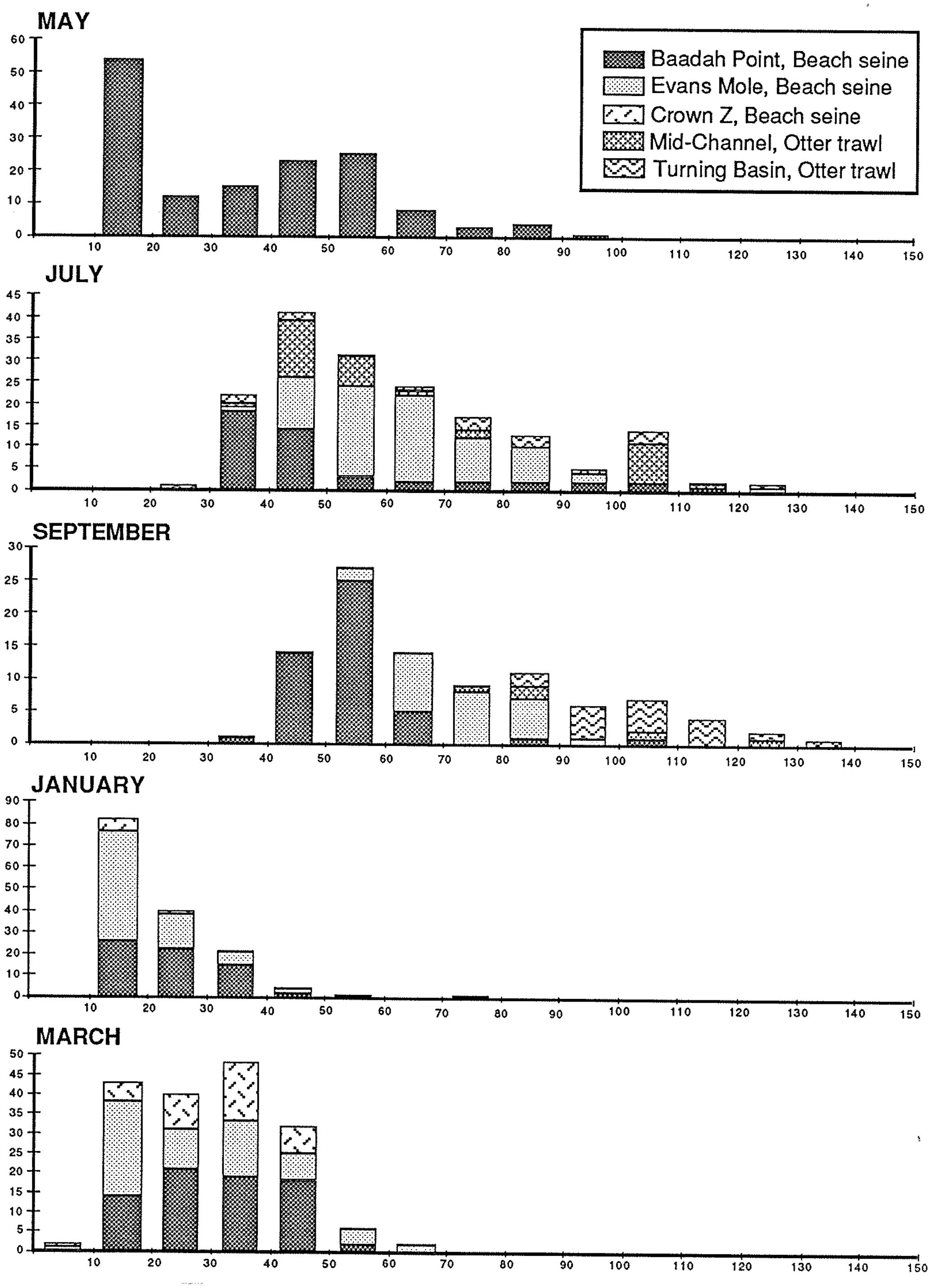


Figure 3.14. Length frequency plots of English sole captured in beach seine and otter trawl collections at Neah Bay intensive study sites, 1986-87.

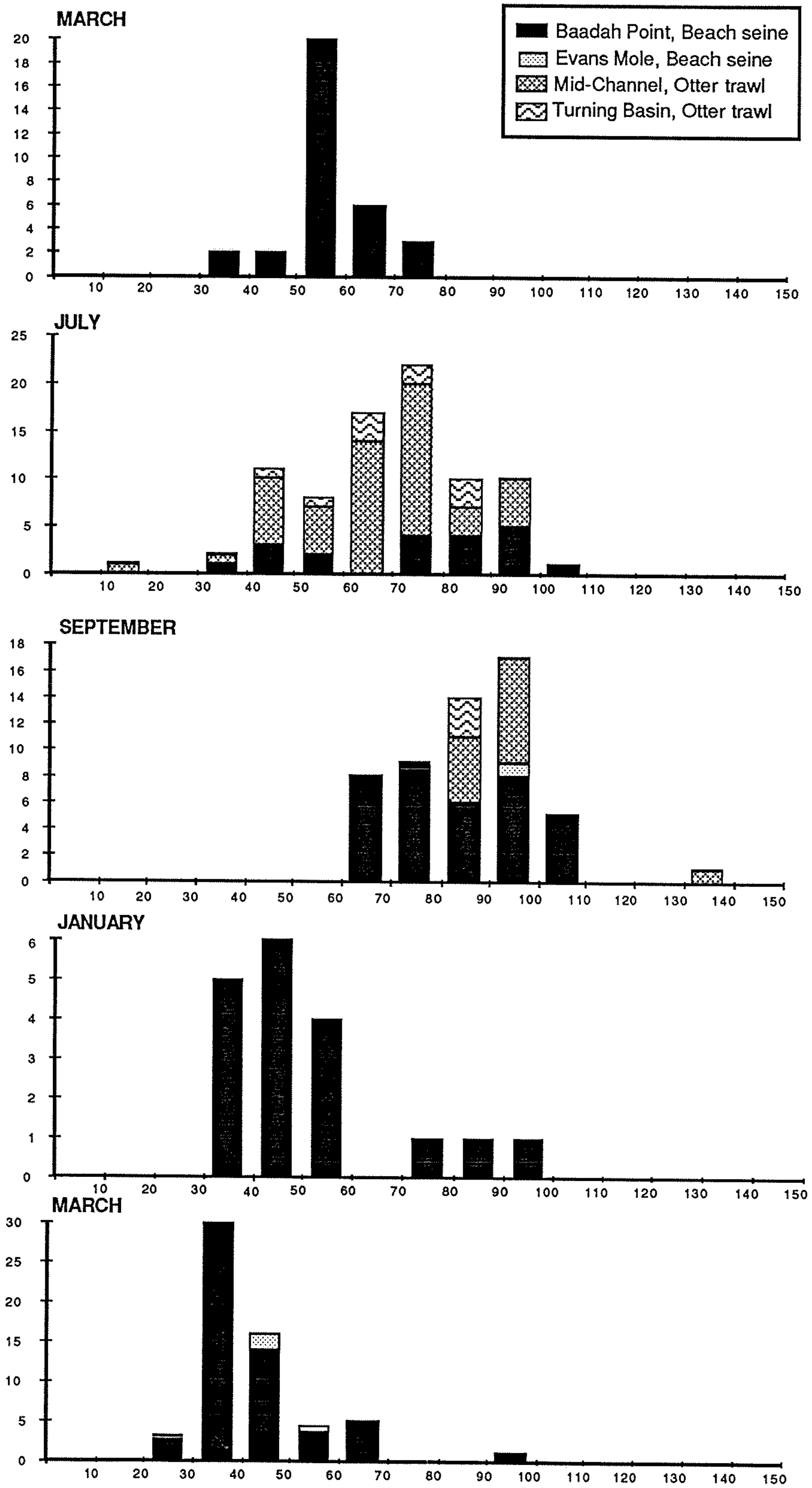
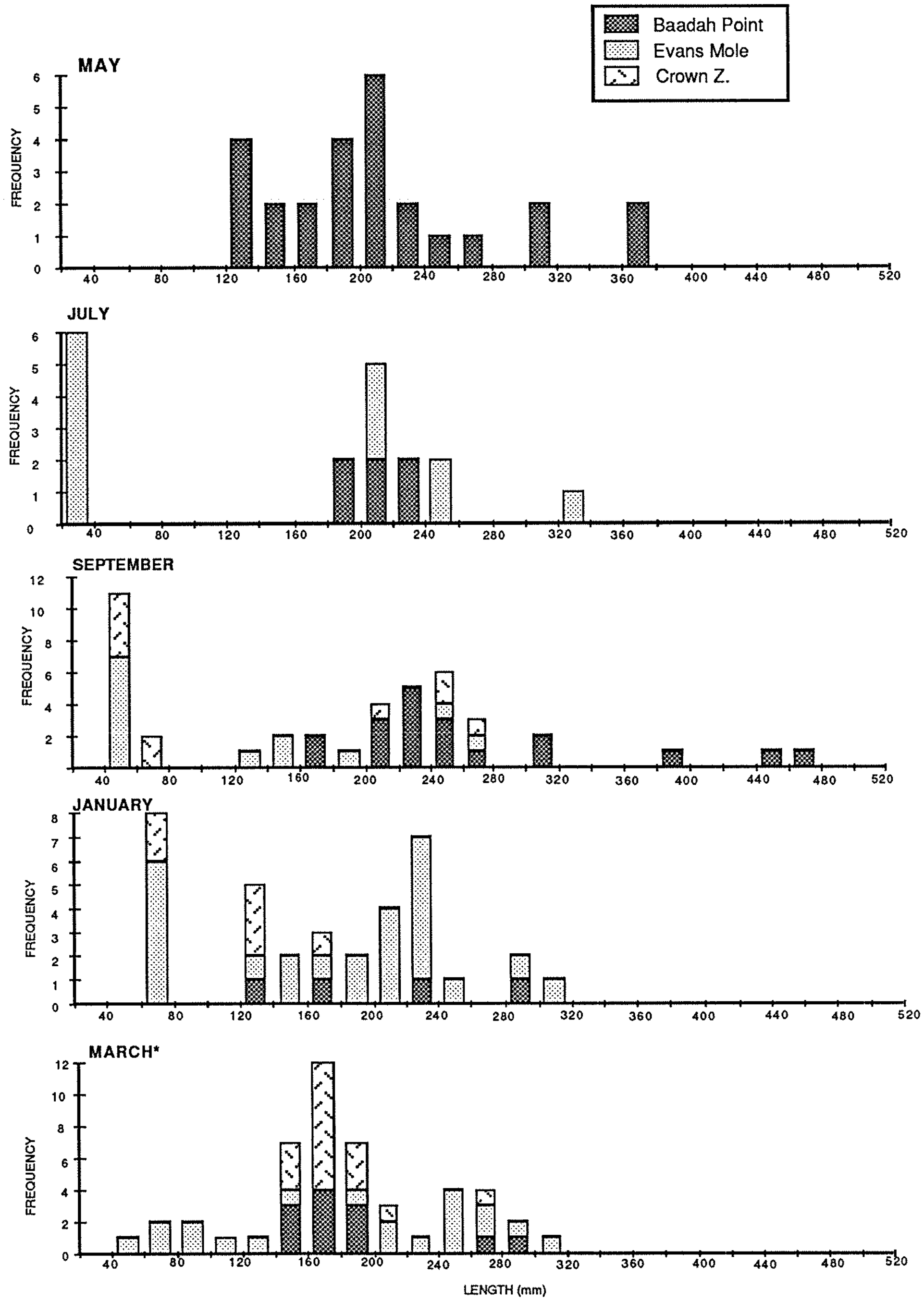


Figure 3.15. Length-frequency plots of speckled sanddabs captured in beach seine and otter trawl samples at Neah Bay intensive study sites, May 1986-March 1987.



* two large Starry flounder (total lengths 615 & 674) were caught at Evans Mole.

Figure 3.16. Length-frequency plots of starry flounder captured in beach seine collections at three Neah Bay intensive study sites, 1986-87.

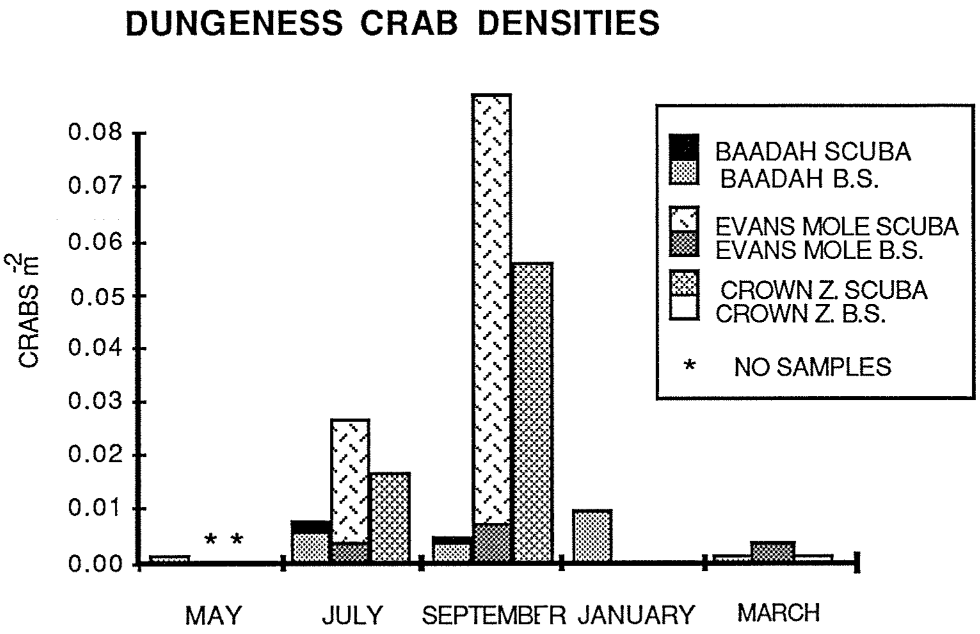


Figure 3.17. Dungeness crab densities (crabs m^{-2}) in SCUBA and beach seine samples at three Neah Bay intensive study sites, 1986-87.

Coon-striped shrimp (*Pandalus danae*) and spot prawns (*P. platyceros*) were the two economically important species of pandalid shrimp collected in abundance in the Bay. However, July and September were the only months when the shrimp were large enough to be sampled in significant numbers. There were some small shrimp in the May and March samples but at that time they were too small to be adequately sampled by the sampling gear. Coon-striped shrimp densities were highest at the mouth of the Bay and very few shrimp occurred within the bay (Fig. 3.18). Densities of spot prawn at the deeper sites decreased between July and September coincident with increased densities at shallower sites, which suggested immigration by the prawns into shallow water habitats of the Bay.

3.3 Epibenthos and Pelagic Zooplankton

3.3.1 Epibenthos

Composition. Harpacticoid copepods were the predominant organisms at all sites except near the Crown Zellerbach dock. Harpacticoids comprised from 55% of the numerical composition at Baadah Point 0.0 m to 83% at Baadah Point subtidal *Z. marina* (Fig. 3.19). In contrast at the Crown Zellerbach dock site the numerical composition was not dominated by any single taxa/group. Instead, dominance at this site was shared by unidentified invertebrate eggs (22%),

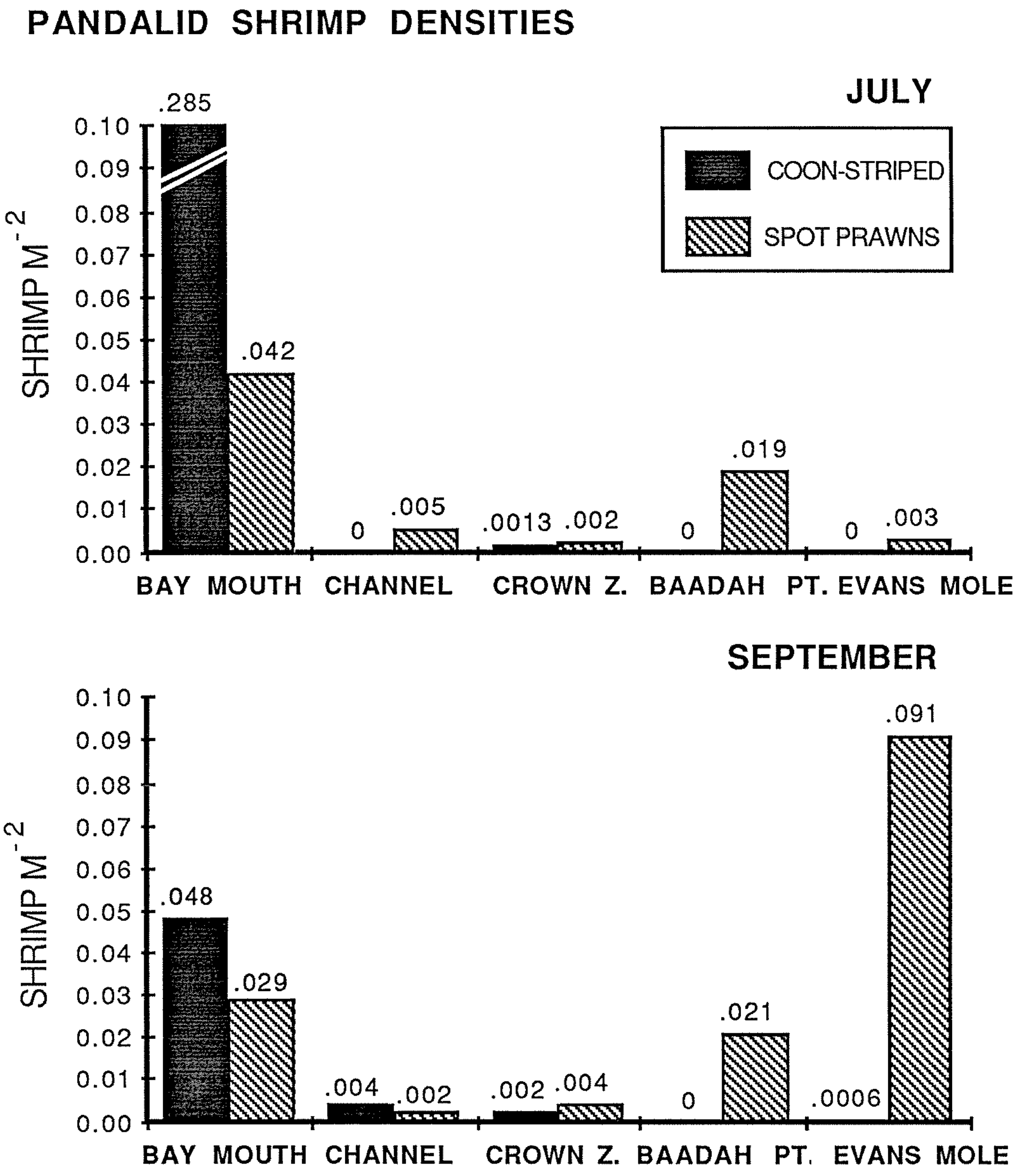


Figure 3.18. Pandalid shrimp densities (shrimp m^{-2}) at Neah Bay otter trawl and beach seine sites, 1986-87.

EPIBENTHOS, % ABUNDANCE

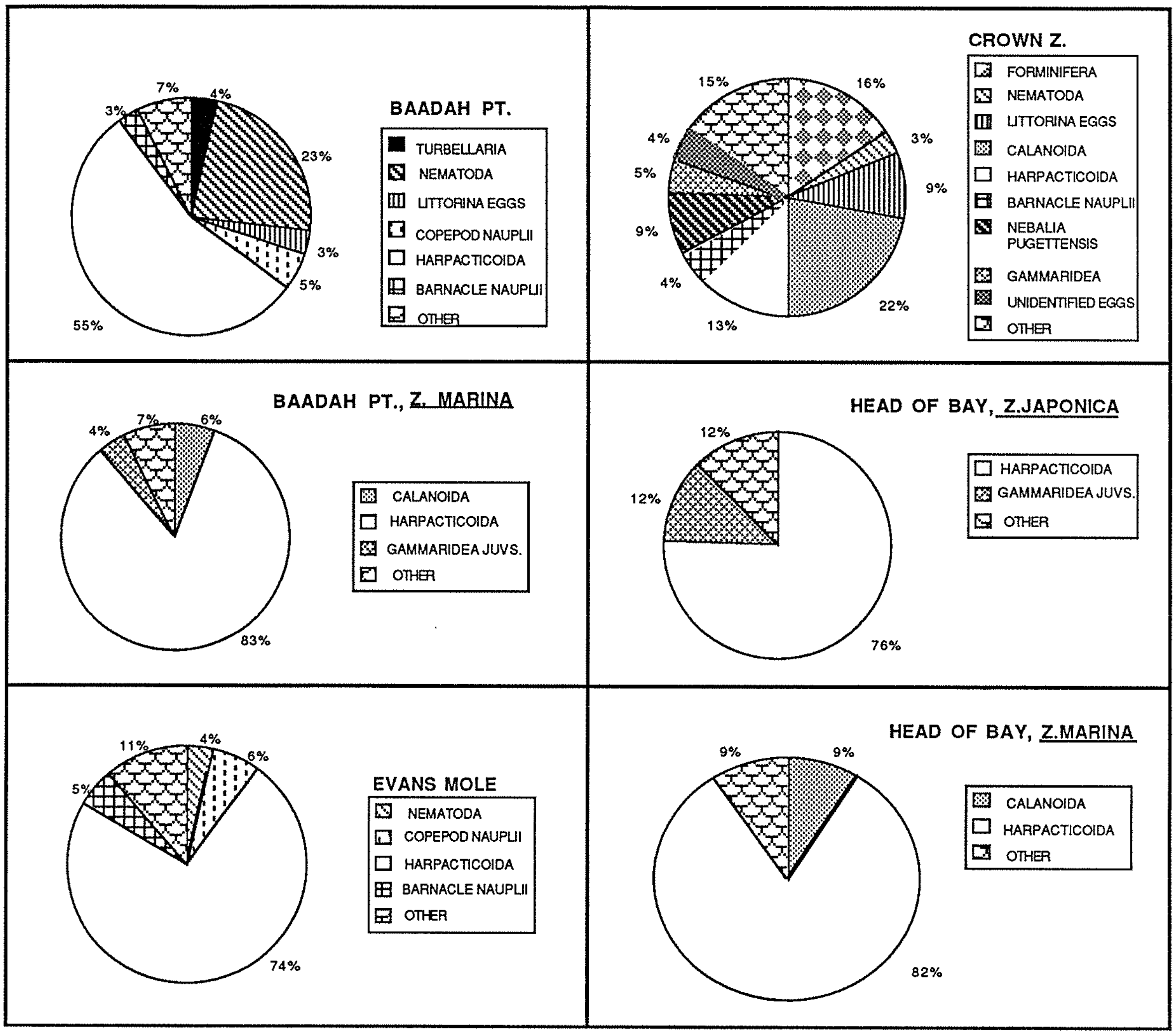


Figure 3.19. Numerical composition (%) of major epibenthic taxa/groups at six sites in Neah Bay, Washington, May 1986-Sept. 1987; all sites combined.

foraminifera (16%), harpacticoids (13%), *Littorina* snail egg cases (9%), and the anaerobic-tolerant leptostracan *Nebalia pugettensis* (9%).

Site- and date-specific composition at the finest taxonomic resolution possible (Table 3.8) indicated that the predominant epibenthic harpacticoids were:

1. *Tisbe* spp. in July at Baadah Point 0.0 m sand and the Crown Zellerbach dock; and in September in the eelgrass beds at the head of the bay;
2. *Zaus* sp. and *Harpacticus spinulosus* in July at Evans Mole;
3. *Harpacticus spinulosus* and *Huntemmania jadensis* in September at Evans Mole; and
4. *Diosaccus spinatus* and *Amonardia perturbata* in September at Baadah Point subtidal *Z. marina* beds.

Density. Density of epibenthic organisms ranged from 653 individuals m^{-2} at the Baadah Point subtidal *Zostera marina* bed in September to 165,625 individuals m^{-2} at the head of the bay *Z. marina* bed in September (Figure 3.20). The Crown Zellerbach dock site appeared to have considerably fewer epibenthic organisms than other sites (except for the single sampling of Baadah Point subtidal eelgrass).

3.3.2 Pelagic Zooplankton

Composition. Numerical composition of zooplankton by major taxonomic groups at the different sites in Neah Bay was marked by several apparent trends (Figure 3.21):

1. harpacticoid copepods were prominent at Baadah Point and at the head of the bay (38% and 43%, respectively), but scarce at the Crown Zellerbach dock and at Evans Mole (3% and 6%);
2. calanoid copepods were abundant at the head of the bay and Evans Mole (49% and 31%);
3. barnacle nauplii were relatively numerous at the Crown Zellerbach dock and Evans Mole (47% and 36%); and,
4. crab zoeae occurred in moderate numbers at all sites except the head of the bay.

Further analysis of these data by site, date and to the finest taxonomic resolution possible (Table 3.9) indicated that:

1. harpacticoid copepods occurred in the water column mainly in July at Baadah Point and in the single September sampling at the head of the bay, and were represented primarily by *Zaus* spp., *Tisbe* spp., and *Diosaccus spinatus*;
2. *Acartia* spp. were the dominant calanoid copepods;
3. *Cancer* zoeae (*C. magister*, *C. productus* and *C. gracilis*) were relatively abundant in May but did not include Dungeness crab;

Table 3.8. Major (those comprising 5% or more numerically) epibenthos taxa/groups by site and date in Neah Bay, Washington, May 1986-September 1987; an asterisk indicates epibenthic harpacticoid copepods.

Month	Site	Taxa/group	Numerical %
May	Crown Zellerbach Dock		
		Foraminifera	36
	Baadah Point (0.0 m sand)	*Tisbe* spp.*	24
		*Diosaccus spinatus**	8
		Copepod nauplii	9
		Zaus sp.*	6
	Crown Zellerbach Dock	*Acartia* sp. (calanoid copepod)	24
		Tisbe spp.*	18
		Nebalia pugettensis	13
		Unidentified eggs	7
	Evans Mole	*Zaus* sp.*	22
		*Harpacticus spinulosus**	12
		Copepod nauplii	10
		Barnacles nauplii	18
September	Baadah Point (0.0 m sand)	Nematodes	33
		Ectinosomatidae*	9
		*Harpacticus spinulosus**	8
		*Amonardia perturbata**	7
	Evans Mole	*Harpacticus spinulosus**	22
		*Huntemmania jadensis**	10
		*Ameira longipes**	9
		Mesochra sp.*	9
		Nematodes	8
	Head of Bay *Zostera marina*	Ectinosomatidae*	21
		Harpacticoid copepodids*	13
		Tisbe spp.*	12
		*Dactylopodia vulgaris**	9
	Baadah Point subtidal *Z. marina*	*Diosaccus spinatus**	44
		*Amonardia perturbata**	20
		Zaus sp.*	7

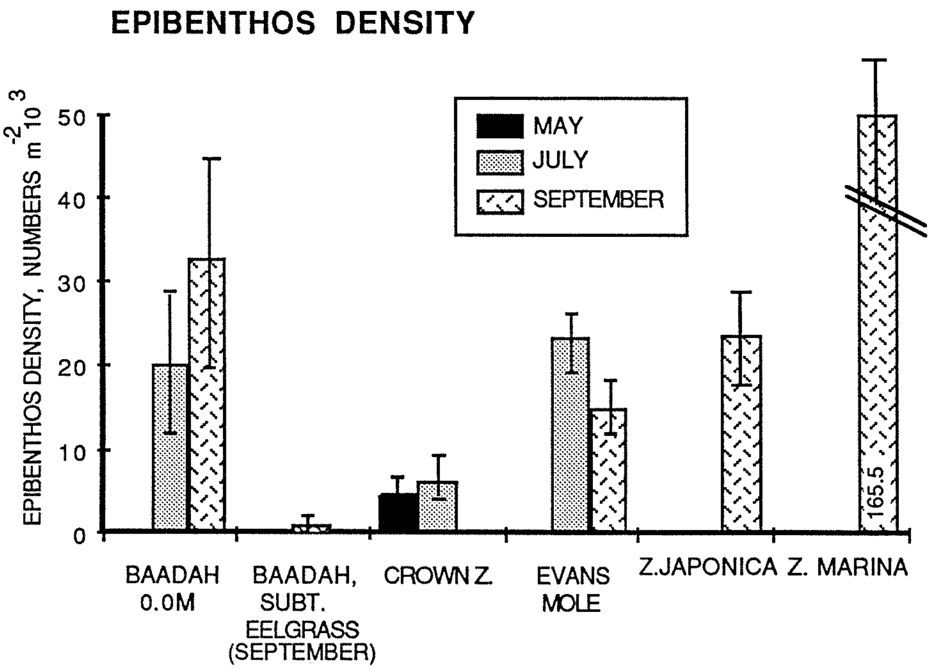


Figure 3.20. Density (no. m^{-2} 10^3) of all epibenthic organisms on three dates at six sites in Neah Bay, Washington, March 1986-Sept. 1987.

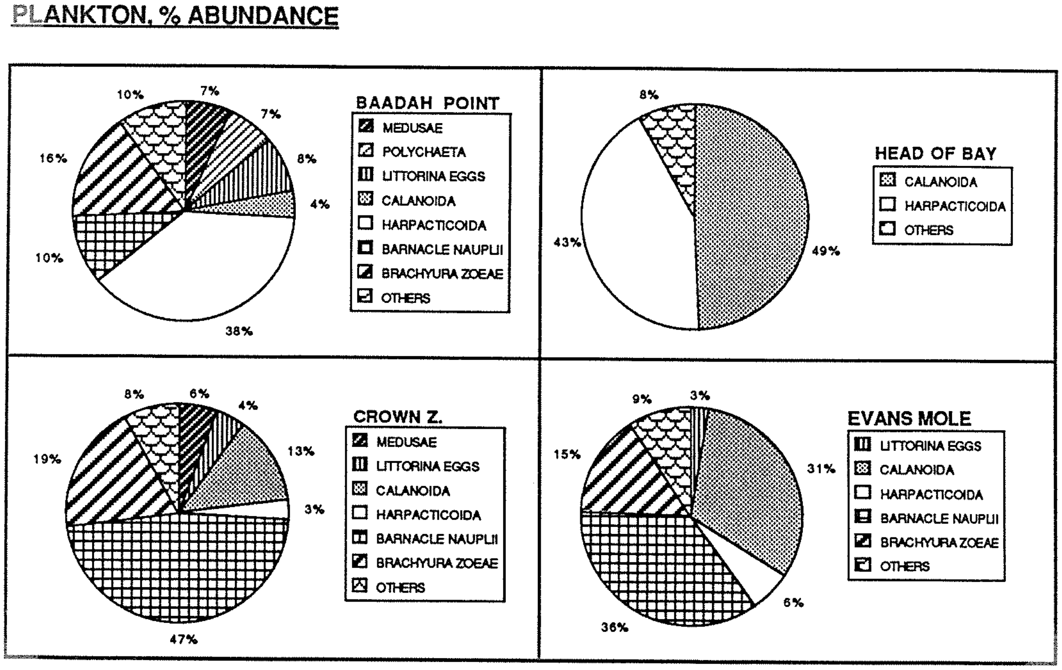


Figure 3.21. Numerical composition (%) of major zooplanktonic taxa/groups at four sites in Neah Bay, Washgton, May 1986-January 1987; all dates combined.

Table 3.9. Major zooplankton taxa/groups (those comprising 10% or more numerically) by site and date in Neah Bay; an asterisk indicates epibenthic harpacticoid copepods. an asterisk indicates epibenthic harpacticoid copepods.

Month	Site	Taxa/group	Numerical %
May	Baadah Point	Medusae	21
		Barnacle nauplii	20
		Cancer zoeae (not including *C. magister*)	13
	Crown Zellerbach Dock	Medusae	18
		Barnacle nauplii	27
		Cancer zoeae (not including *C. magister*)	11
July	Baadah Point	*Zaus* sp.*	31
		Tisbe spp.*	29
	Crown Zellerbach Dock	Barnacle nauplii	57
	Evans Mole	*Acartia* sp. (calanoid copepoed)	46
		Acartia longiremis	21
		Barnacle nauplii	30
September	Baadah Point	*Nereis* sp. juveniles (polychaete worm)	36
		Littorina (snail) eggs	17
	Head of Bay	*Acartia* sp.	46
		Tisbe spp.*	18
		*Diosaccus spinatus**	19
	Evans Mole	Barnacle nauplii	47
		Pinnotherid crab zoeae	25

4. barnacle nauplii were abundant at one or more sites on all sampling dates; and,
5. fish larvae were rare and included cottids, pricklebacks, and northern clingfish, while larvae of commercially or recreationally important species were comparatively absent.

Density. Zooplankton densities ranged from 17.0 organisms m^{-3} in September at Baadah point to 95.6 organisms m^{-3} in the vicinity of the *Zostera marina* bed at the head of the Bay, also in September (Fig. 3.22). With this latter exception, zooplankton densities were highest in July.

3.4 Benthic Infaunal Invertebrates

3.4.1 Composition

Synoptic benthic survey. A diverse fauna of crustaceans and polychaete annelids dominated the subtidal benthic samples from the synoptic survey of Neah Bay (Table 3.10, Fig. 3.23). Of the fifteen taxa categorizing the benthic grab samples, nine were crustaceans and three were

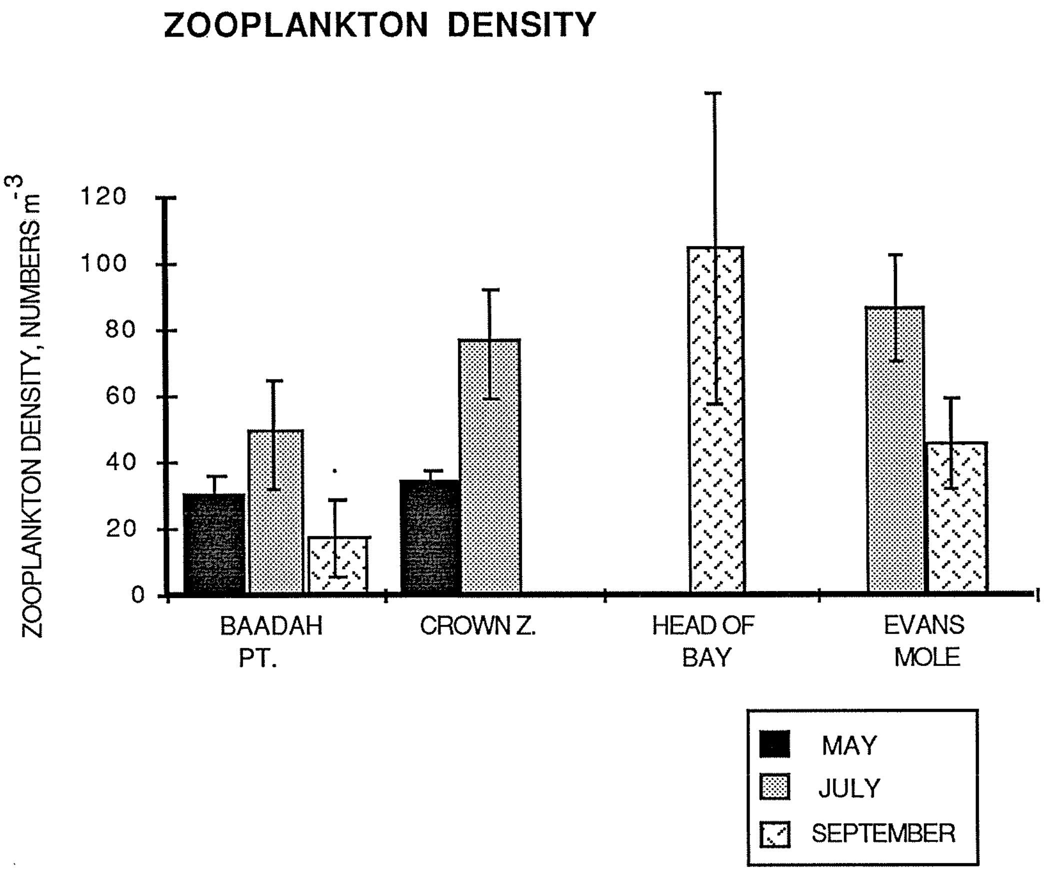


Figure 3.22. Density (no. m^{-3}) of all water-column zooplankton on three dates at four sites in Neah Bay, Washington, May 1986-Sept. 1986.

molluscs. Numerically, gammarid amphipods, polychaete annelids, and bivalves were the more prominent benthic taxa. Tanaids constituted a large proportion of the total faunal density in several regions. Polychaetes and bivalves were the most prominent taxa on the basis of biomass, although gammarid amphipods and nemerteans predominated at several sites due primarily to the occurrence of a few large individuals.

Site-specific infaunal bivalve survey. Eleven taxa of infaunal bivalves were identified from the airlift samples at the three intensive study sites (Table 3.11; Fig. 3.24); due to their small size, two taxa were not identifiable. At both the Baadah Point and Evans Mole sites, *Tellina* sp. and/or *Transennella tantilla* were the more abundant bivalves; *Transennella* generally dominated the bivalve assemblage at Baadah Point, while *Tellina* was more abundant at Evans Mole. *Macoma* sp. were also common at Evans Mole (Transect #1) and at Crown Z (Transect #1). Among the other, less prominent taxa, *Parvilucina* sp., *Mysella* sp., *Clinocardium nuttalli*, and *Protothaca staminea* seldom accounted for more than 10% of the total density and were occurred relatively

Table 3.10. Density (top, organisms m^{-2}) and standing crop (bottom/bold, preserved wet weight g^{-2}) of benthic macroinvertebrate infauna in eight subtidal regions of Neah Bay, Washington, August-September, 1986; see Section 3.1 for description of subtidal habitats and Fig. 2.6 for sampling site location.

Region Taxa	Baadah Point	Evans Mole	Crown Z	Head of Bay	Bay Mouth	East Channel	Turning Basin	West Basin
Nemertea		8.0						
	25.0							
Annelida								
Polychaeta	323.6	1192.0	1173.3	266.7	80.0	1266.7	1390.0	1106.7
	13.6	**23.1**	**33.3**	**13.0**	**262.3**	**55.1**	**74.6**	**85.5**
Moleusca								
Archaeoastropoda						13.3		
(limpets)						**1.7**		
Meso-/Neogastropoda	8.0							
(snails)	0.6							
Prosobranchia	2749.1	144.0	193.3	213.3	546.7	1213.3	200.0	80.0
(bivalves)	**36.1**	**6.3**	**7.0**	**28.6**	**14.3**	**32.3**	**31.9**	**11.0**
Crustacea								
Leptostraca	160.0	88.0	646.7	173.3		13.3		13.3
	1.0	**0.8**	**1.9**	**0.4**		**<0.1**		**<0.1**
Cumacea	43.6					106.7		
	0.3					**0.2**		
Tanaidacea	378.2	448.0	2973.3	240.0	146.7	480.0		40.0
	0.3	**0.2**	**5.2**	**0.3**	**0.1**	**0.6**		**<0.1**
Isopoda	3.6							
	0.2							
Amphipoda								
Gammaridea	4167.3	4552.0	2193.3	286.7	906.7	2973.3	510.0	506.7
	12.5	**12.3**	**3.9**	**0.5**	**0.2**	**9.8**	**3.2**	**1.6**
Caprellidea	32.7	16.0	6.7				10.0	
	0.1	**<0.1**	**0.1**				**<0.1**	
Decapoda								
Caridea	7.3			26.7				
(shrimp)	**5.6**			**8.7**				
Anomura		8.0			40.0			
(hermit crabs)		**0.1**			**11.0**			
Brachyura	3.6	48.0	266.7	26.7	66.7	93.3	50.0	146.7
(true crabs)	**5.2**	**2.3**	**0.7**	**3.3**	**5.9**	**2.3**	**0.6**	**1.9**

Table 3.10. Density (top, organisms m^{-2}) and standing crop (bottom/bold, preserved wet weight g^{-2}) of benthic macroinvertebrate infauna in eight subtidal regions of Neah Bay, Washington, August-September, 1986; see Section 3.1 for description of subtidal habitats and Fig. 2.6 for sampling site location - cont'd.

Region Taxa	Baadah Point	Evans Mole	Crown Z	Head of Bay	Bay Mouth	East Channel	Turning Basin	West Basin
Echinodermata								
Ophiuroidea	3.6				13.3			
(brittlestars)	<0.1				0.1			
Site mean	7872.7	6512.0	7453.3	1233.3	1800.0	6160.0	2160.0	1893.3
	74.8	**70.7**	**52.2**	**54.8**	**293.8**	**102.1**	**110.4**	**100.1**

uniformly at all Baadah Point and Evans Mole sites. Of the two unidentifiable taxa, Type A included two individuals from the 120 m point along Transect 3, Baadah Point, and Type B occurred in both transects at Crown Z, and was the dominant taxa at Transect #2 there.

During underwater observations and sampling at both the Evans Mole and Baadah Point sites, the siphons of horse clams, *Tresus capax*, were visible and were considered to be relatively abundant. However, the depth of penetration of the air lift suction sampler was not sufficient to remove these deep-burrowing clams.

3.4.2 Standing stock

Synoptic benthic survey. Mean macroinvertebrate infauna densities in the eight regions of Neah Bay were comparatively similar, between ~1200 and ~7900 organisms m^{-2} (Table 3.10, Fig. 3.23) despite the differences in taxonomic composition. Highest densities (~6500-~7800 m^{-2}) were recorded at the three shallow subtidal, intensive study sites at Baadah Point, Evans Mole, and Crown Z. The lowest densities occurred at the shallow subtidal sites at the head of the Bay (~1200 m^{-2}) and at the mouth of the Bay (~1800 m^{-2}). Intermediate densities were found at deeper subtidal sites in the regions of the proposed turning basin and navigation channel.

Standing crop did not mirror the density patterns, primarily due to the differences in taxa composition in the different regions. Standing crop over all eight regions averaged between 52.2 and 293.8 g m^{-2}. Standing crop of shallow subtidal benthos was relatively constant between ~50 and 75 g m^{-2}, approximately half of that of the deeper regions (~100 to ~110 g m^{-2}). The highest standing crop (293.8 g m^{-2}) occurred at the mouth of the Bay, but was due almost entirely to the occurrence of a large tube-worm (sabellid) mass in one grab sample.

Site-specific infaunal bivalve survey. Density distributions of deep-burrowing bivalves showed considerable among- and within-site variation (Fig. 3.25). Similar to total community

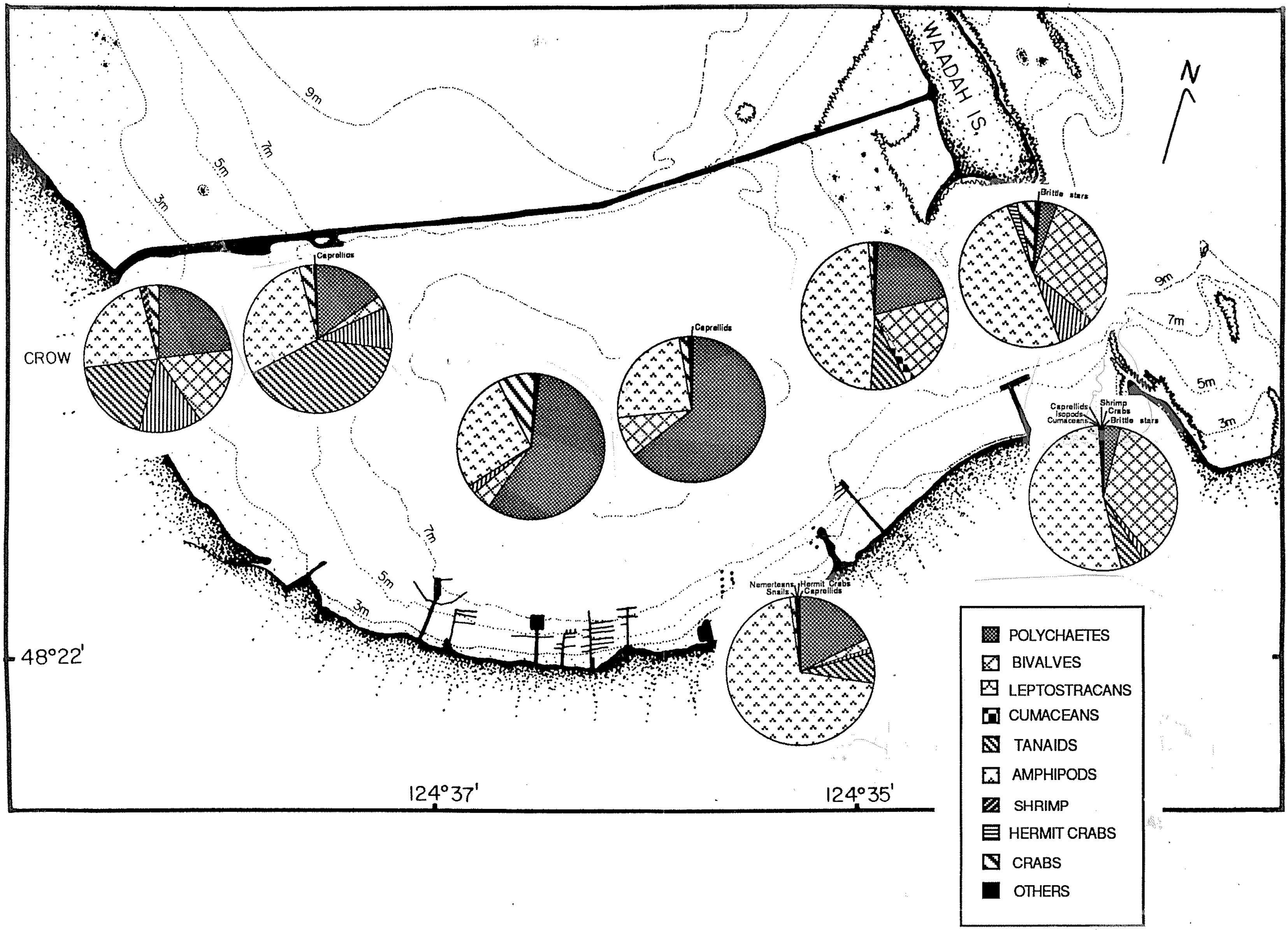


Figure 3.23. Numerical composition (%) of benthic infaunal macroinvertebrates in subtidal habitats of Neah Bay, Washington, August-September 1986.

Table 3.11. Density (top, organisms m^{-2}) and standing crop (bottom/bold, preserved wet weight g m^{-2}) of bivalve taxa at three sites in Neah Bay, Washington, August-September 1986.

Site	Baadah Point			Evans Mole		Crown Z	
Taxa Transect	1	2	3	1	2	1	2
Moleusca							
Bivalvia							
Lucinidae							
Parvilucina sp.	0.4	7.0	31.1	1.8	6.7		
	<0.1	**0.2**	**0.4**	**0.1**	**1.3**		
Montacutidae							
Mysella sp.	9.2	29.0	164.9	29.8	6.7	2.0	
	1.1	**2.1**	**7.0**	**3.5**	**0.1**	**<0.1**	
Cardiidae							
Clinocardium sp.	1.2	8.0	5.6	2.2		1.3	
	<0.1	**0.1**	**2.9**	**<0.1**		**0.3**	
Solenidae							
Siliqua patula		1.0	0.4				
		0.2	0.1				
Tellinidae							
Macoma sp.	1.2	7.0	7.2	52.9	4.0	18.7	
	0.3	**0.3**	**0.3**	**7.8**	**0.7**	**11.2**	
Tellina sp.	31.6	167.0	170.5	68.0	17.3		
	0.6	**7.6**	**4.0**	**1.6**	**0.4**		
Veneridae							
Transennella tantilla	65.2	749.0	1117.5	11.1	8.0	1.3	1.3
	0.7	**7.6**	**10.1**	**<0.1**	**0.1**	**<0.1**	**0.2**
Protothaca staminea	0.4	4.0	25.1	0.9	5.3		
	0.6	**0.3**	**1.4**	**0.2**	**1.1**		
Hiatellidae							
Hiatella sp.			5.6				
			0.1				
Type A			0.4				
			0.2				
Type B						1.3	5.9
						0.1	**2.6**
Transect total	110.0	988.0	1714.0	167.1	48.0	24.0	6.7
	2.8	**19.1**	**29.4**	**13.3**	**3.7**	**11.4**	**2.8**
Site total	937.3			107.6		15.3	
	19.6			**6.8**		**5.3**	

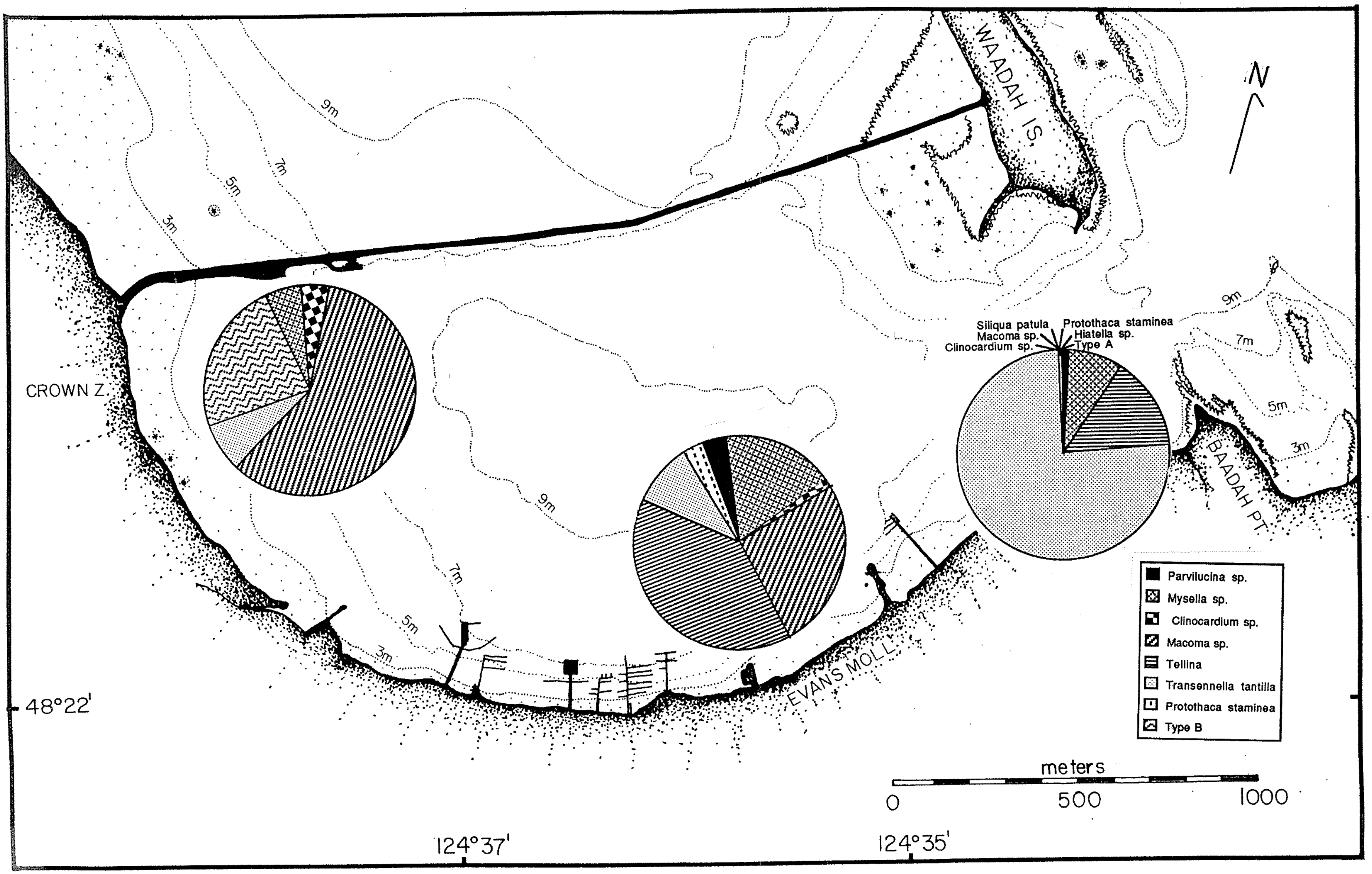


Figure 3.24. Numerical composition (%) of infaunal bivalves at three intensive study sites in Neah Bay, Washington, August - September 1986.

Table 3.12. Groups (clusters) of synoptic benthic survey stations in Neah Bay, Washington, August-September 1986; see Fig. 2.6 for station locations and Section 2.3.7 for description of numerical classification methodology.

Group	Number of stations	Stations characteristics
I	8	Deeper stations off Coast Guard dock, Crown Z and other deeper stations at Evans Mole and southwestern end of Bay
II	6	Baadah Point, principally outer two transect stations
III	6	Stations shallower than Group I throughout the Bay, including off Coast Guard Dock, in the southwestern corner and head of the Bay, the mouth of the Bay and at Baadah Point
IV	4	Deeper end of Crown Z transects, the southwestern corner and mouth of the Bay
V	6	Shallow stations at Crown Z, Baadah Point, Evans Mole and at the head of the Bay
VI	3	Turning Basin and at the head of the Bay
VII	6	Western end and central Turning Basin, Evans Mole

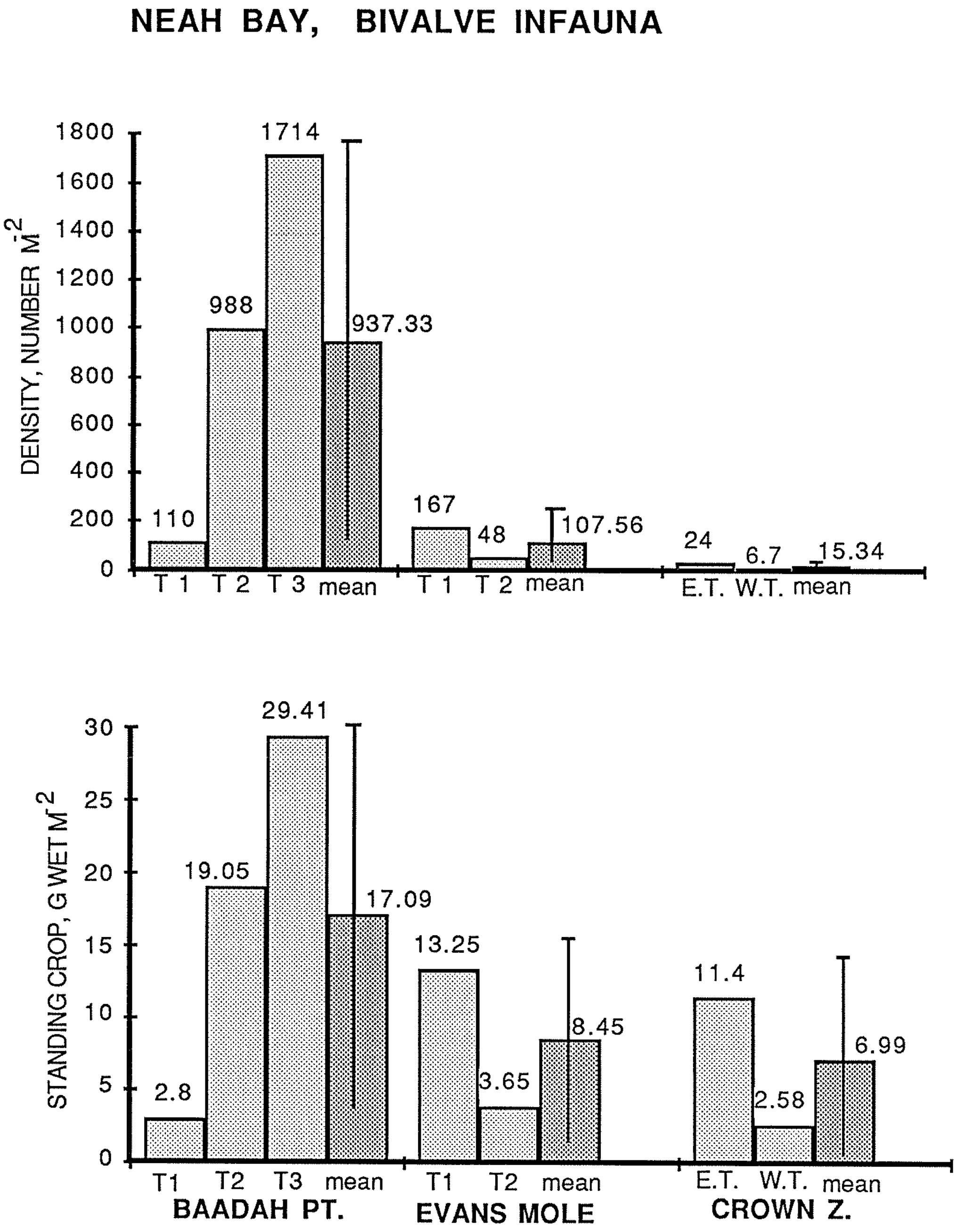


Figure 3.25. Density (no. m^{-2}) and standing crop (preserved g wet m^{-2}) of infaunal bivalves at three intensive study sites in Neah Bay, Washington, August-September 1986; see Figure 2.6 for transect (T) locations.

densities, the density of bivalves at Baadah Point was approximately nine times more (937.3 m^{-2}) than the average density at Evans Mole (107.6 m^{-2}). Bivalve density at Evans Mole was seven times higher than average bivalve density at Crown Z (15.3 m^{-2}). In addition, the average density along the transects at Baadah Point increased from 110 m^{-2} nearshore to 1714 m^{-2} offshore. In comparison, the trend at Evans Mole suggested higher density along the shallower transect. This contrast in the inshore-offshore, depth density patterns reflected primarily the inshore-offshore increase in *Transennella* density at Baadah Point compared to the inshore-offshore decrease in *Tellina* density at Evans Mole.

Similarities in *Transennella* and *Tellina* biomass resulted in approximately equivalent order in standing crop of bivalves at Baadah Point and Evans Mole. Although relatively few bivalve species were collected at Crown Z, this site had a standing crop (5.3 g m^{-2}) similar to the more diverse Evans Mole assemblage.

3.4.3 Assemblage Structure

Synoptic benthic survey. Numerical classification analysis was applied to the synoptic infauna data to help identify the major assemblage types in the Bay and to propose possible explanations for the factors responsible for the spatial patterns of the assemblages. This indicated that covarying depth and sediment structure affected infaunal assemblage. In particular, the stations groups did not appear to reflect directly the more broadly characterized benthic habitats (Fig. 3.1), suggesting perhaps more localized responses by the fauna to patchy habitats (mosaics) of sediments, diatoms and macroalgae, polychaete worm tubes, debris and detritus.

The taxa-site density data matrix was inverted and reanalyzed by clustering, producing taxa groups which could be identified with specific site clusters (habitats) in the Bay. This analysis indicated nine groups of benthic taxa distinguishable at the 0.65 level of dissimilarity (Fig. 3.27; Table 3.13). Five of the groups (II, III, IV, V, VI) were composed of only one taxa; two (I, IX) contained two taxa; and only one multi-taxa group (VII) was indicated. Caprellids (Group IV) and cumaceans (V), and polychaetes (VIII) and the three taxa in Group VII were closely associated (i.e., dissimilarity ≃0.70).

To illustrate which site clusters related to which species cluster, taxa groups I (bivalves and gammarid amphipods) and VIII (polychaete annelids) were both numerically prominent in all station groups (habitats). Group VII (crabs, tanaids, and leptostracans), which also included abundant organisms, were more concentrated in station groups I and III and, to a lesser extent, in V and VII (Fig. 3.28).

Although common to all habitats, relative differences in densities within common taxa groups also distinguished some station groups. For example: (1) densities of ≥69 bivalves and ≥80

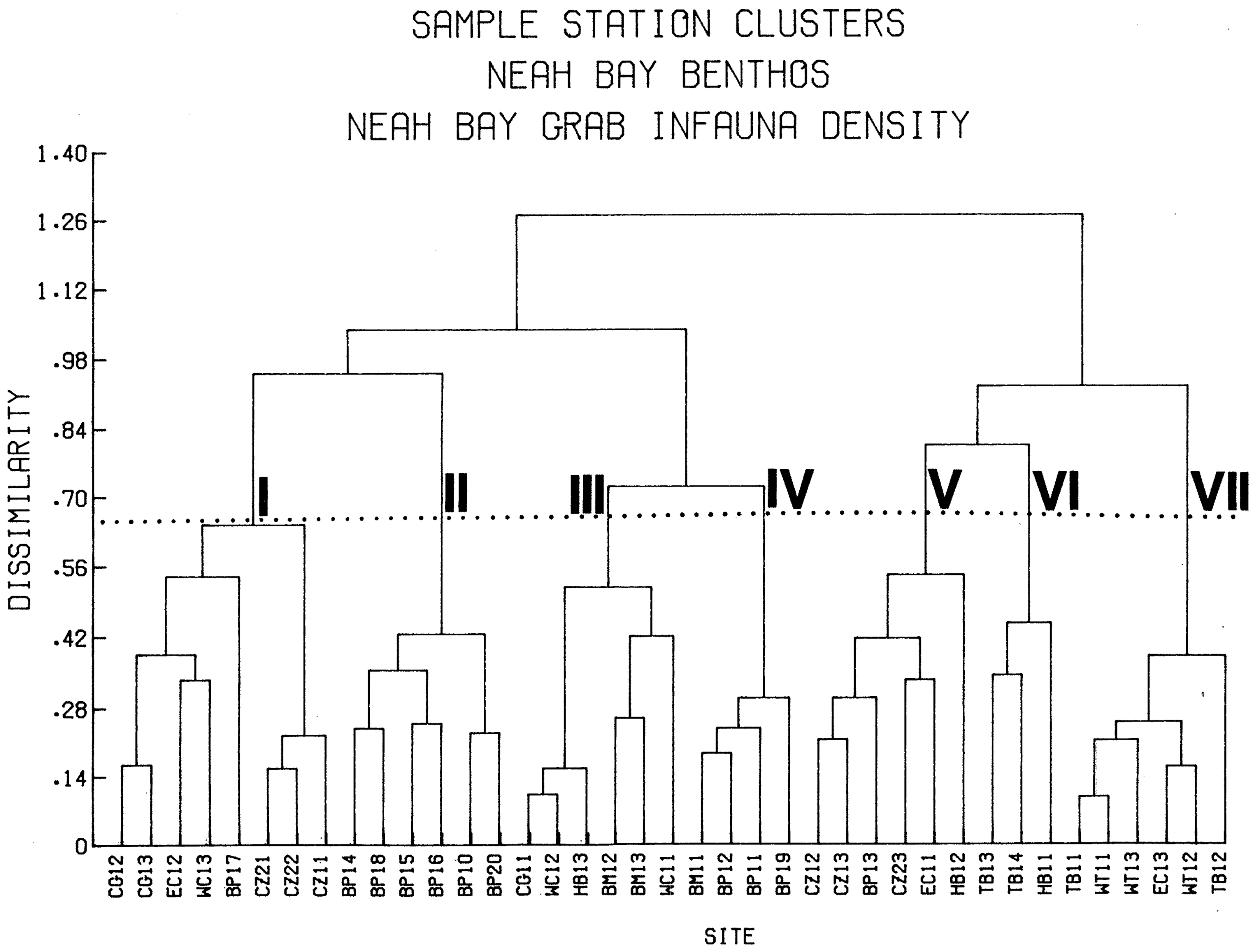


Figure 3.26. Cluster dendrogram of sampling site groups from synoptic benthic survey of Neah Bay, August-September 1986.

Table 3.13. Groups (clusters) of synoptic benthic survey taxa in Neah Bay, Washington, August-September 1986; see Table 3.12 for more detailed listing of taxa and their standing stocks and Section 2.3.7 for description of numerical classification methodology.

Group	Number of taxa	Taxa
I	2	Bivalves, gammarid amphipods
II	1	Shrimp
III	1	Isopods
IV	1	Caprellid amphipods
V	1	Cumaceans
VI	1	Hermit crabs
VII	3	Brachyuran crabs, tanaids, leptostracans
VIII	1	Polychaete annelids
IX	2	Gastropods, nemerteans

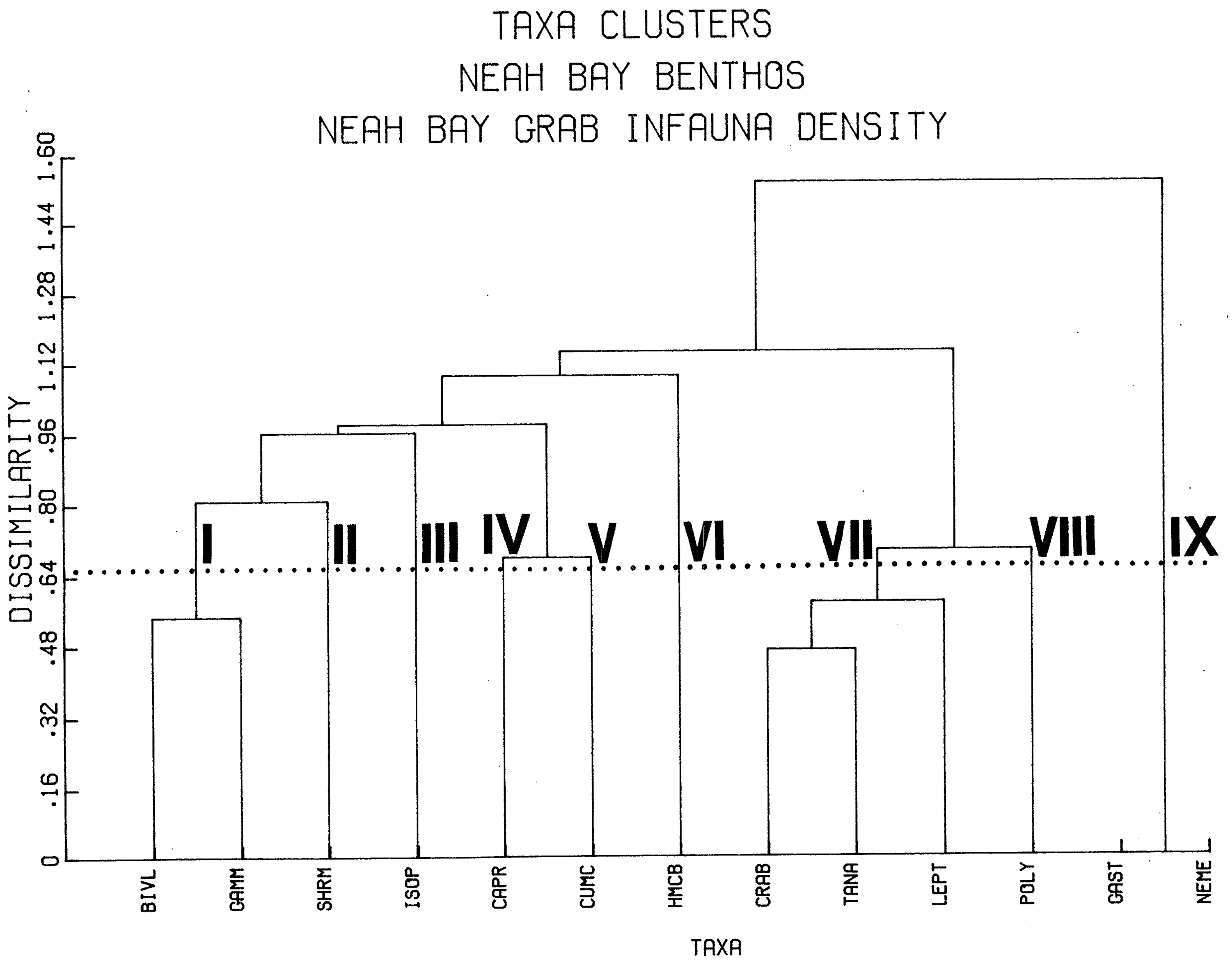
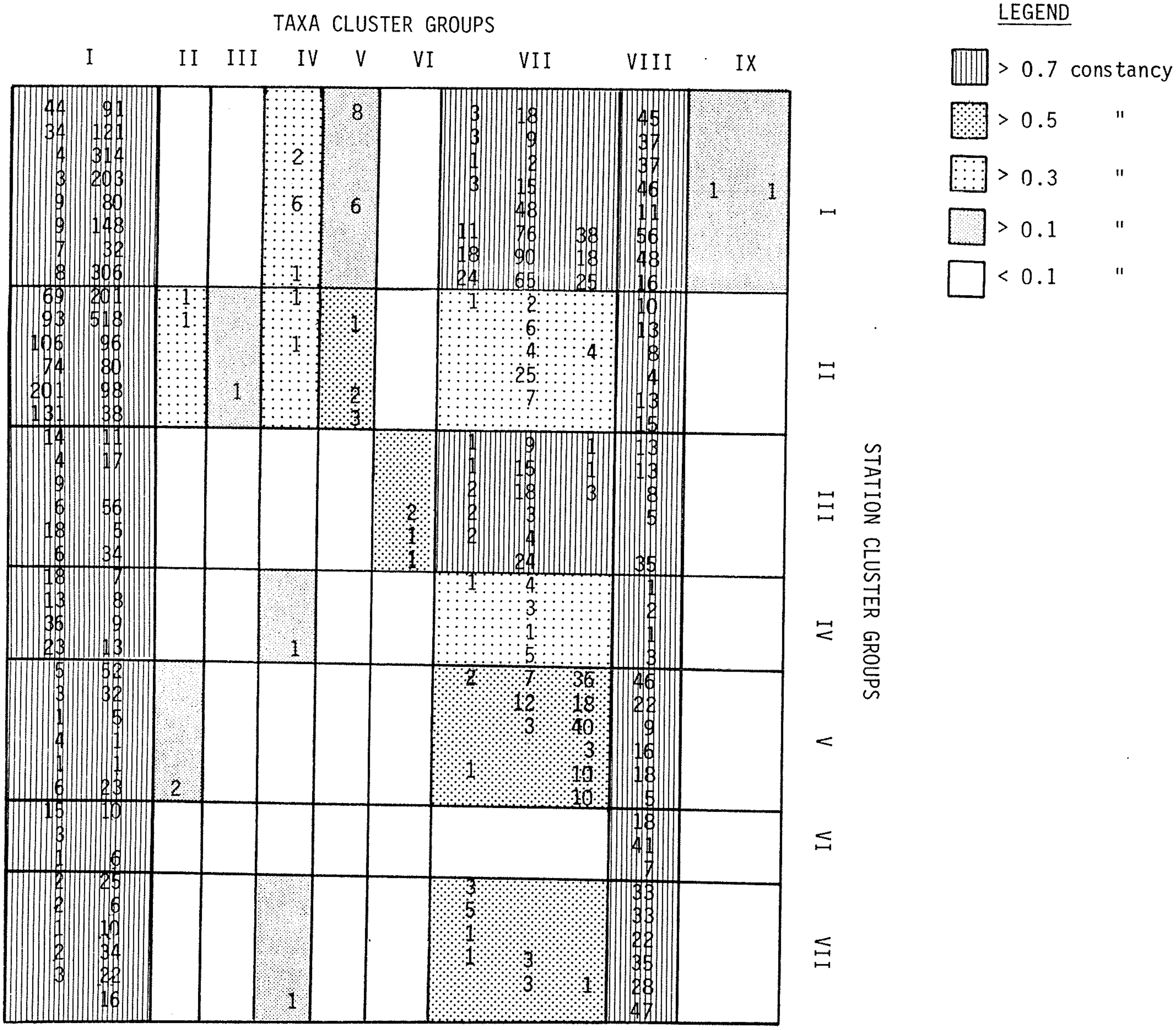


Figure 3.27. Cluster dendrogram of taxa groups from synoptic benthic surveys of Neah Bay, August-September 1986.



	I	II	III	IV	V	VI	VII	VIII	IX
I	44 91 34 121 4 314 3 203 9 80 9 148 7 32 8 306			2 6 1	8 6		3 18 3 9 1 2 3 15 48 11 76 38 18 90 18 24 65 25	45 37 37 46 11 56 48 16	1 1
II	69 201 93 518 106 96 74 80 201 98 131 38	1 1	1	1 1	1 2 3		1 2 6 4 4 25 7	10 13 8 4 13 15	
III	14 11 4 17 9 6 56 18 5 6 34					2 1 1	1 9 1 1 15 1 2 18 3 2 3 2 4 24	13 13 8 5 35	
IV	18 7 13 8 36 9 23 13			1			1 4 3 1 5	1 2 1 3	
V	5 52 3 32 1 5 4 1 1 1 6 23	2					2 7 36 12 18 3 40 3 1 10 10	46 22 9 16 18 5	
VI	15 10 3 1 6							18 41 7	
VII	2 25 2 6 1 10 2 34 3 22 16			1			3 5 1 1 3 3 1	33 33 22 35 28 47	

Figure 3.28. Nodal constancy diagram of station X taxa groups from synoptic benthic survey of Neah Bay, August-September 1986; numbers are density (no. m^{-2}) of organisms.

gammarid amphipods m^{-2} distinguished station group II (predominantly Baadah Point) from densities of ≤44 bivalves and ≥32 gammarid amphipods m^{-2} (station group I; ubiquitous shallow water group); (2) densities of ≥22 polychaete annelids m^{-2} distinguished station group VII from densities of ≤15 m^{-2} at group II; and, (3) tanaid densities averaging >40 m^{-2} in station group I were measurably different than densities of <15 m^{-2} at station group III. In other cases, the presence or absence of taxa groups accounted for station group differences. For example, the complete absence of taxa groups III (isopods), IV (caprellid amphipods), V (cumaceans), and VI (hermit crabs) distinguished station group V (ubiquitous shallow stations) and the presence of taxa groups II (shrimp), III, IV and V distinguished group II (Baadah Point).

Site-specific infaunal bivalve survey. Eight station groups were produced by the cluster analysis of bivalve density data (Fig. 3.29; Table 3.14). Many of these groups contained stations from transects at all three sites, suggesting that depth or substrate. Several groups (III, outer Baadah Point transect; V, east Crown Z; VIII, west Crown Z; IV, inner Evans Mole), however, were relatively distinct in their composition. Five taxa groups were identified, two of which (I, III) were formed of the more common, and often highly abundant, taxa (Fig. 3.30; Table 3.15).

Nodal constancy further substantiated the importance of taxa groups I and III (Fig. 3.31). The high densities of bivalves in these two groups appeared to be one of the more important factors characterizing outer transect at Baadah Point (station group III), as did the incidence of taxa group II. Although generally occurring in lower densities than along the outer transect at Baadah Point, taxa group III also typified the more diverse, shallow water stations at Baadah Point and Evans Mole (station groups I and IV). *Macoma* characterized a discrete, monospecific taxa group coincident with the finer sediment stations at Evans Mole and Crown Z east (station groups IV and V). A small, unidentified clam (Type A) was almost uniquely characteristic of the western transect at Crown Z.

3.5 Trophic Relationships

Food habits, as interpreted from IRI prey spectra, were interpreted for nearshore demersal and epibenthic fishes, i.e., those associated with the bottom habitats, as compared to pelagic (neritic) fishes, i.e., those occupying and feeding in the water column. Tabulations and statistical summaries of the raw data on fish stomach contents analyses and IRI plots, which form the basis of these synopses, are included in Appendix 7.3.

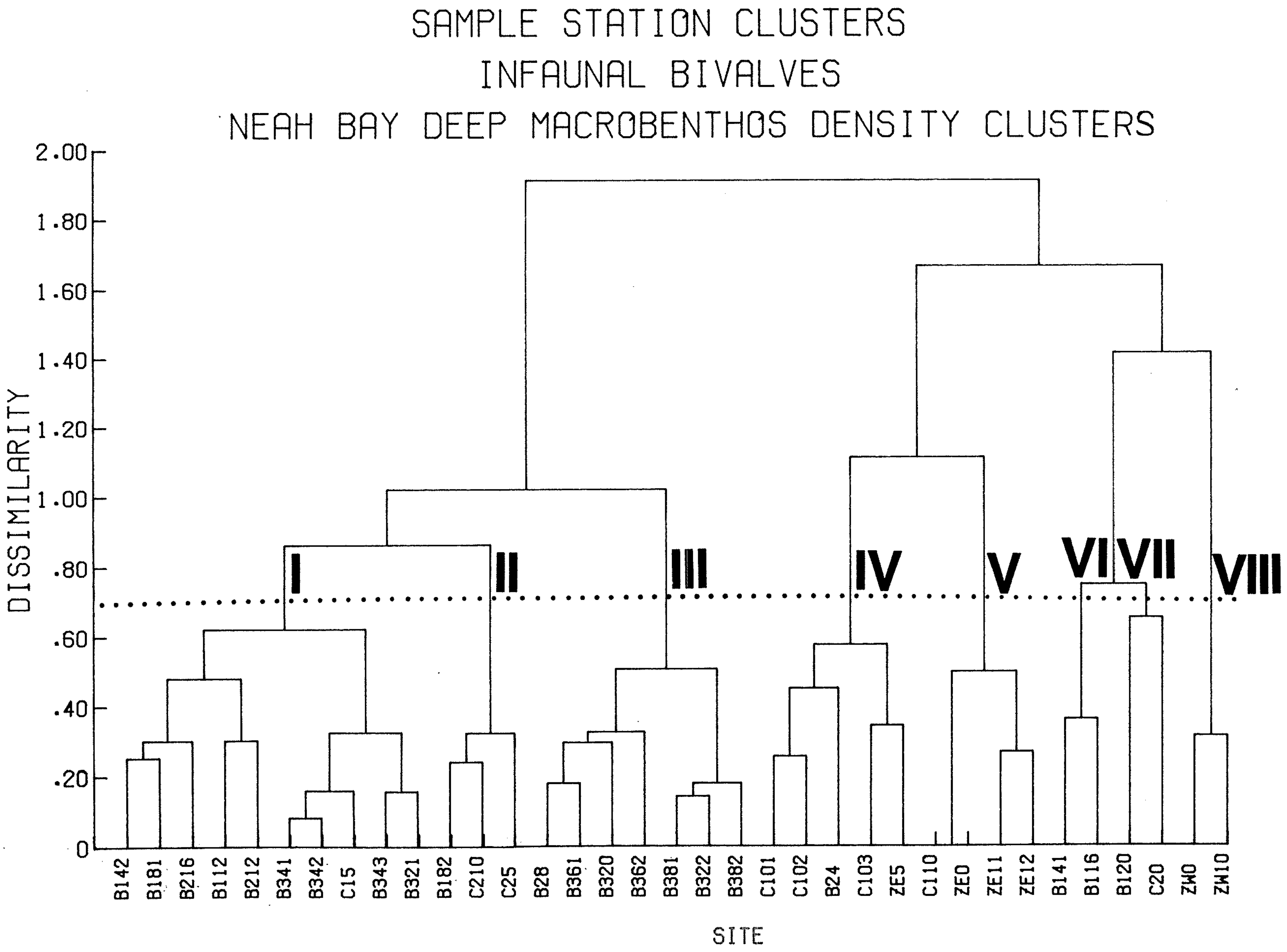


Figure 3.29. Cluster dendrogram of sampling site groups from site-specific infaunal bivalve survey in Neah Bay, August-September 1986

Table 3.14. Groups (clusters) of site-specific infaunal bivalve survey stations in Neah Bay, Washington, August-September 1986; see Fig. 2.6 for station locations and Section 2.3.7 for description of numerical classification methodology.

Group	Number of stations	Stations characteristics
I	10	Mixture of nine stations from all three Baadah Point transects and one inner (#1) Evans Mole station
II	3	Two Evans Mole outer (#2) transect stations and one inner Baadah Point transect station
III	7	Six stations from outer (#3) Baadah Point transect and one from middle Baadah Point transect
IV	5	Mixture of inner Evans Mole, middle Baadah Point and east Crown transect stations
V	4	East Crown Z transect stations and one inner Evans Mole station
VI	2	Inner Baadah Point transect
VII	2	Inner Baadah Point and outer Evans Mole transects
VIII	2	West Crown Z transect

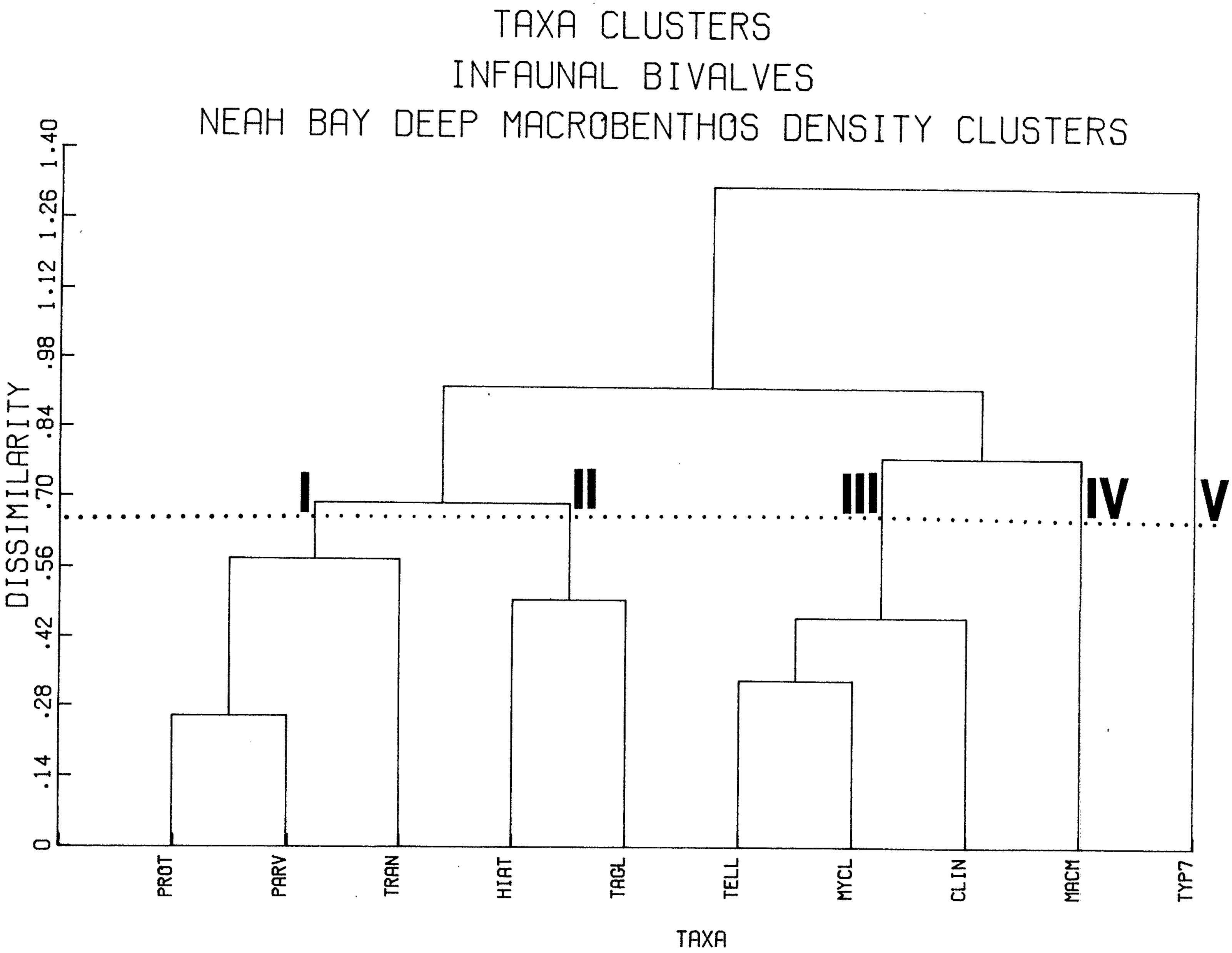


Figure 3.30. Cluster dendrogram of taxa groups from site-specific infaunal bivalve survey in Neah Bay, August-September 1986.

Table 3.15. Groups (clusters) of site-specific infaunal bivalve survey taxa in Neah Bay, Washington, August-September 1986; see Table 3.12 for more detailed listing of taxa and their standing stocks and Section 2.3.7 for description of numerical classification methodology.

Group	Number of taxa	Taxa
I	3	*Protothaca staminea*, *Parvilucina* sp., *Transennella tantilla*
II	2	*Hiatella* sp., *Siliqua patula*
III	3	*Tellina* sp., *Mysella* sp., *Clinicardium* sp.
IV	1	*Macoma* sp.
V	1	Type A

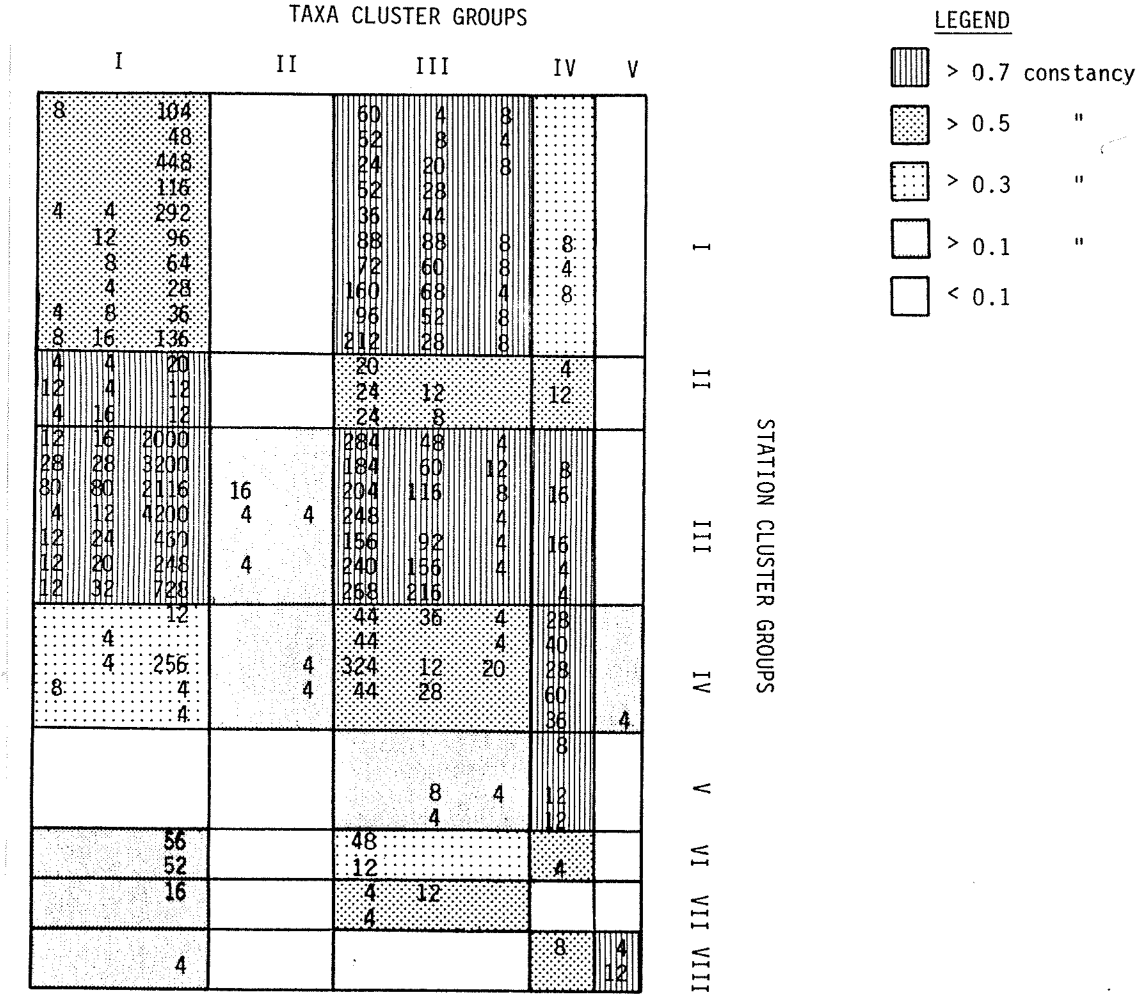


Figure 3.31. Nodal constancy diagram of station X taxa groups from site-specific infaunal bivalve survey in Neah Bay, August-September 1986.

3.5.1 Food Habits of Nearshore Demersal and Epibenthic Fishes

Chum salmon. Juvenile chum salmon <55-60 mm fork (FL) in size feed predominantly upon epibenthic organisms (Simenstad et al. 1982). Since these fish averaged 55 mm FL in size, we classified them as being in transition between epibenthic and pelagic habitats.

Twenty specimens originated from beach seine collections at Baadah Point during May and two from a purse seine collection at Baadah Point in July. The composite IRI prey spectrum (Table 3.16; Appendix 7.3) is dominated 80.2% by planktonic organisms, secondarily by benthic fauna (18.5%). The planktonic prey were predominantly fish (Pacific herring postlarvae and juveniles) and benthic prey were almost exclusively chironomid larvae.

Within these collections, the stomach contents of somewhat smaller individuals ($\bar{x}$ = 56.2 mm FL) captured in the beach seine collection in May was numerically dominated (64.9% of total number of prey) by chironomid larvae, but fish comprised the majority (93.3%) of the total prey biomass. In contrast, larger ($\bar{x}$ = 101 mm FL) fish captured in purse seine collections in July had fed on barnacle nauplii (99.6% of total number of prey) and unidentified fish (64.7% of total prey biomass). As a result, diet overlap as measured by PSI was low, 4.5%.

Walleye pollock. Five juvenile ($\bar{x}$ = 60.6 mm TL) walleye pollock were captured in a July beach collection at Baadah Point. Their diet was composed almost exclusively (95.7% ΣIRI) of epibenthic fauna, especially the cumacean *Diastylopsis tenuis* (61.4%) (Table 3.16, Appendix 7.3). Epibenthic harpacticoids (*Tisbe* sp., 13.4%; *Zaus* sp., 4.3%) and gammarid amphipods (*Photis* sp., 9.4%; *Ischyrocerus* sp., 2.2%) were the other prey of consequence.

Copper rockfish. Juvenile copper rockfish of the size captured during the July purse seine collections at Baadah Point ($\bar{x}$ = 27 mm TL) would be considered in transition between the larval/postlarval and early juvenile stages in pelagic habitats and the demersal habitats ultimately occupied as adults. The IRI prey spectrum of six fish (Table 3.16; Appendix 7.3) was almost exclusively dominated by epibenthic prey, of which the harpacticoid copepod *Tisbe* sp. was the principal component (85.5% ΣIRI).

English sole. Twenty-six juvenile English sole (41 to 92 mm TL) from beach seine collections at Baadah Point in May examined for prey composition ranged in size from 41 to 92 mm TL. The prey spectrum was equally divided between benthic and epibenthic prey (Fig. 3.16; Appendix 7.3). Indistinguishable juvenile bivalves were the predominant benthic prey (34.2% ΣIRI) and the cumacean *Diastylopsis tenuis* was the predominant epibenthic prey (42.6% ΣIRI).

3.5.2 Food Habits of Nearshore Pelagic Fishes

American shad. One adult American shad, captured at Evans Mole in a July purse seine collection, was included in the stomach contents analyses. Despite their presumed pelagic feeding

Table 3.16. Relative importance (% ΣIRI; see text) of prey taxa to nearshore demersal fishes, Neah Bay, Washington, May-September 1986.

Prey taxa	Predator Juvenile chum salmon	 Juvenile walleye pollock	 Juvenile copper rockfish	 Juvenile English sole
Benthos				
Polychaeta		2.7		9.6
Gastropoda		0.1		
Bivalvia				34.2
Ectinosomidae				0.2
Leptochelia dubia				0.1
Isopoda		<0.1		
Idotea sp.		0.1		
Caprellidea		<0.1		
Caprella sp.		0.1		
Decapoda-Brachyura			0.5	
Pinnotheridae			0.1	
Crangon sp.				0.3
Chironomidae-larvae	18.5			
(Subtotal)	(18.5)	(2.9)	(0.6)	(44.4)
Epibenthos				
Ostracoda		<0.1		
Euphilomedes carcharodontoa		0.9		
Harpacticoida	<0.1	2.2	1.4	1.6
Porcellidium sp.		<0.1		
Harpacticus sp.-*uniremis* group	0.1		0.5	0.2
Harpacticus sp.-*obscurus* group		0.1	2.3	
Zaus sp.	<0.1	4.3		
Tisbe sp.		13.4	85.5	0.2
Scutellidium sp.	0.3			
Amonardia perturbata		<0.1		
Dactylopodia sp.			0.1	
Parathalestris sp.		<0.1		
Diosaccus spinatus		0.1		
D. crassipes		0.1		
Cumacea				0.5
Lampropidae				0.2
Cumella vulgaris				0.2
Diastylopsis tenuis		61.4		42.6
Mysidacea			1.8	
Gammaridea	<0.1	2.6		0.5
Calliopiidae	0.2			

Table 3.16. Relative importance (% ΣIRI; see text) of prey taxa to nearshore demersal fishes, Neah Bay, Washington, May-September 1986 - cont'd.

Prey taxa	Predator			
	Juvenile chum salmon	Juvenile walleye pollock	Juvenile copper rockfish	Juvenile English sole
Epibenthos - cont'd.				
Pontogeneia cf. *rostrata*		0.5		
Ischyrocerus sp.		9.4	0.7	
I. anguipes				0.2
Synchelidium sp.		0.3		
S. shoemakeri		1.1		7.8
Protomedia sp.		<0.1		
Photis sp.		9.4		1.5
Hippolytidae			4.4	
(Subtotal)	(0.7)	(95.7)	(96.9)	(55.7)
Plankton				
Calanoida		<0.1	2.3	
Calanus sp.	0.1			
Centropages sp.		<0.1		
Acartia sp.		0.1		
Cyclopoida		0.1		
Oithona sp.		0.1		
Balanomorpha-larvae	12.3		0.1	
Pleocyemata-Caridea		<0.1		
Pinnotheridae		<0.1		
unident. fish	53.9			
Pacific herring	13.9			
(Subtotal)	(80.2)	(0.4)	(2.4)	(0.0)
Neuston				
Homoptera-Chcadoidea	0.1			
Collembola	0.1			
Aphididae	0.1			
Diptera	0.2			
(Subtotal)	(0.5)	(0.0)	(0.0)	(0.0)

behavior as later juveniles and adults, this fish had consumed exclusively the epibenthic harpacticoid *Diosaccus spinatus* (Appendix 7.3).

Pacific herring. Thirty-six young-of-the-year and yearling Pacific herring captured in purse seine collections at all three intensive study sites between May and July were examined for diet comparisons. The composite prey spectrum (Table 3.17; Appendix 7.3) was almost exclusively composed of planktonic prey; calanoid copepods (*Acartia*, *Centropages*), barnacle and fish larvae were prominent, contributing 42.3%, 39.5%, and 12.4% ΣIRI, respectively.

Prey spectra were further defined by collection date, sampling site, and fish size. At Baadah Point, young-of-the-year ($\bar{x}$ = 32.0 mm FL) captured in May were consuming calanoid copepod and barnacle nauplii and juvenile and adult calanoids (*Centropages*, *Acartia*) as compared to yearling ($\bar{x}$ = 148.7 mm FL) herring caught in July, which were feeding primarily on (unidentified) fish larvae and secondarily upon calanoids. As a result, PSI diet overlap was moderate, 38.4%. Young-of-the-year herring ($\bar{x}$ = 32.6 mm FL) captured at Crown Z in May had plankton-based similar diets to those at Baadah Point except for a larger contribution by larvaceans (*Oikopleura dioica*; 27.6% ΣIRI) and barnacle nauplii than calanoids. PSI diet overlap was higher (50.3%). In July, young-of-the-year ($\bar{x}$ = 72.4 mm FL) at Crown Z were consuming calanoids (*Acartia, Epilabidocera*) and barnacle nauplii, while similarly-sized fish at Evans Mole were feeding on calanoids (*Epilabidocera*) and the epibenthic harpacticoid *Diosaccus spinatus*; the resulting PSI prey overlap was 37.8%.

Northern anchovy. Adult northern anchovy examined for stomach contents originated from a beach seine collection at Baadah Point in May and from a purse seine collection at Evans Mole in July. The prey spectrum was almost exclusively dominated by phytoplankton (93.4% ΣIRI), with incidental contributions by harpacticoid copepods and barnacle nauplii (Table 3.17; Appendix 7.3). There was essentially no difference between diets of fish from the two collections.

Pink salmon. The stomach contents of four pink salmon were processed. One specimen was from a July purse seine collection at Evans Mole and three specimens were from the same collection series at Baadah Point. These fish were 79 to 91 mm FL in size, and should have been planktonic feeders at this stage in their outmigration to the North Pacific Ocean (Simenstad et al. 1982). The prey spectrum was remarkably diverse for the low sample size (Table 3.17; Appendix 7.3). Over 90% ΣIRI was composed of planktonic prey, primarily *Calanus* sp. and other calanoids (72.6% ΣIRI) and porcelain crab larvae. The limited sample sizes did not allow among-site comparisons for diet.

Coho salmon. Nine specimens of juvenile coho salmon 80 - 142 mm FL were analyzed from beach seine collections in July at Baadah Point (5 specimens) and Crown Z (1) and a beach seine collection at Baadah Point (3). The composite prey spectrum included predominantly planktonic

Table 3.17. Relative importance (% ΣIRI; see text) of prey taxa to nearshore pelagic fishes in Neah Bay, Washington, May-September 1986.

Predator Prey Taxa	Pacific herring	Northern anchovy	Juvenile pink salmon	Juvenile coho salmon	Surf smelt	Juvenile kelp greenling	Juvenile lingcod	Juvenile Pacific sand lance
Benthos								
Polychaeta	<0.1				3.3			
Gastropoda					0.1			
Caprella irregularis				0.2				
Diptera-Chironomidae-larvae			2.9					
(Subtotal)	(0.0)	(0.0)	(2.9)	(0.2)	(3.4)	(0.0)	(0.0)	(0.0)
Epibenthos								
Podon sp.	<0.1							
Euphilomedes carcharodontoa	0.1							
Harpacticoida	0.1	4.5	0.6		0.5			<0.1
Harpacticus sp.-*uniremis* group					0.2			<0.1
H. obscurus group	0.7				1.5			
Tisbe sp.					0.2			
Diosaccus spinatus	0.1				0.4			
Pleocyemata-Caridea								0.1
Diastylopsis tenuis				0.2				
Gammaridea						0.4		
Ampithoe sp.				0.2				
Hyalellidae				0.2				
Photis sp.				0.2				
Ischyrocerus sp.				6.0				
Jassa falcata				0.2				
Mysidacea			0.8		<0.1			1.1
Neomysis mercedis	0.4			0.2				
Alienacanthomysis macropsis				0.2				
Cumella vulgaris								<0.1
Acarina			0.3					
(Subtotal)	(1.4)	(4.5)	(1.7)	(7.4)	(2.8)	(0.4)	(0.0)	(1.6)
Plankton								
Unident. algae		93.4						
Unident. plants				0.2				
Hydrozoa-larvae			0.3					
Hydroida-larvae					0.1			
Gastropoda-larvae	0.1							
Calanoida	39.6	0.1	6.2		4.9	1.7	1.4	37.5
Calanus sp.	0.1		66.4		0.5	93.9	<0.1	3.4

Table 3.17. Relative importance (% ΣIRI; see text) of prey taxa to nearshore pelagic fishes in Neah Bay, Washington, May-September 1986 - cont'd.

Predator Prey Taxa	Pacific herring	Northern anchovy	Juvenile pink salmon	Juvenile coho salmon	Surf smelt	Juvenile kelp greenling	Juvenile lingcod	Juvenile Pacific sand lance
Plankton - cont'd.								
Paracalanus sp.					0.2			
Pseudocalanus sp.			0.9		0.1			0.2
Centropages sp.							0.5	1.5
C. abdominalis	0.1				<0.1			
Epilabidocera longipedata	0.1		0.8		0.2			
Acartia sp.	1.6				5.1		<0.1	1.6
A. longiremis	1.0				1.4		11.8	7.9
Cyclopoida	<0.1		0.3					
Corycaeus anglicus	0.1				0.1			
Balanomorpha-larvae	39.5	1.9	0.2	63.8		29.4		
Parathemisto pacifica			0.3					
Euphausiacea	<0.1				0.1			
Pleocyemata-Caridea-larvae	0.1				0.5			
Crangon sp.-larvae	0.3				0.6		36.0	
Decapoda-larvae	0.2				0.5	2.0	50.2	2.3
Decapoda-Brachyura-larvae	1.4	0.1	0.6		1.9	1.1		<0.1
Cancer sp.-larvae	0.1							
Anomura-larvae	0.1				4.0	1.0		
Paguridae-larvae	0.1				<0.1			
Porcellanidae-larvae	0.1		14.1	0.2	0.3			
Pinnitheridae-larvae	0.1				0.9			
Hemigrapsus sp.-larvae					<0.1			
Oikopleura dioica	0.9				8.3			
Chaetognatha								0.1
Unident. egg	0.2				0.4			0.1
Unident. fish	12.4		1.1	0.9				14.8
Clupea hargengus pallasi				68.6				
Ammodytes hexapterus				3.0				
(Subtotal)	(98.7)	(95.6)	(90.2)	(73.2)	(92.4)	(99.7)	(86.2)	(98.8)
Neuston								
Insecta			2.2	12.2				
Psocoptera			1.6					
Homoptera-Chcadoidea	0.2							
Collembola	0.3							

Table 3.17. Relative importance (% ΣIRI; see text) of prey taxa to nearshore pelagic fishes in Neah Bay, Washington, May-September 1986 - cont'd.

Predator Prey Taxa	Pacific herring	Northern anchovy	Juvenile pink salmon	Juvenile coho salmon	Surf smelt	Juvenile kelp greenling	Juvenile lingcod	Juvenile Pacific sand lance
Neuston - cont'd.								
Aphididae	0.2							
Diptera	0.3		0.3					
Diptera-Chironomidae				0.8				
Diptera-Brachycera				6.5				
Hymenoptera			0.3	0.2				
(Subtotal)	(1.0)	(0.0)	(4.4)	(19.7)	(0.0)	(0.0)	(0.0)	(0.0)

(73.2% ΣIRI) or neustonic (19.7% ΣIRI) prey. Pelagic forage fish (young-of-the-year herring and sand lance) were the dominant prey, supplemented by drift insects and, to a reduced extent, epibenthic amphipods (particularly *Ischycerus* sp.) (Table 3.17; Appendix 7.3).

Comparison of the diets of fish (116-142 mm FL) from the purse seine collection and those (80-99 mm FL) in a beach seine collection indicated minimal overlap. The larger, presumably more pelagic fish caught in the purse seine had consumed essentially all the forage fish identified in the composite diet spectrum. In contrast, neustonic and epibenthic prey dominated the diet of the beach seine-caught coho.

Chinook salmon. Two juvenile chinook salmon (119-147 mm FL) were captured in a purse seine collection at Baadah Point in July. The only identifiable prey in the stomach contents were two young-of-the-year herring (Appendix 7.3).

Surf smelt. On the basis of standing crop, surf smelt constituted the principal pelagic fish in Neah Bay. Twenty-six specimens were examined for stomach contents, originating from purse seine collections at both Baadah Point and Evans Mole in May and July. Planktonic prey such as barnacle larvae, larvaceans (*Oikopleura dioica*), calanoid copepods (*Acartia longiremis, Calanus* sp.), and decapod larvae (*Cancer* sp.) were most important (92.4% ΣIRI) to surf smelt feeding within the Bay (Table 3.17; Appendix 7.3). Benthic and epibenthic prey were minor constituents.

Diets differed among sites and dates but not among size classes. Smelt 54-65 mm FL captured at both Baadah Point and Crown Z in May fed primarily upon barnacle larvae, *Oikopleura dioica*, and calanoid copepods (*Acartia longiremis*), secondarily upon decapod larvae; PSI diet overlap was 40.2%. Larger (149-181 mm FL) smelt at Baadah Point, on the other hand, had fed more on decapod larvae such as *Cancer* sp. zoea; PSI diet overlap with the smaller smelt at Baadah was 33.4% and 14.5% with the fish from Crown Z. Similarly, smelt 75-126 mm FL caught at Baadah

Point and Crown Z in July had fed primarily upon barnacle larvae and calanoid copepods (again *Acartia* sp.); larvaceans were comparatively uncommon components. Diet overlap among these small smelt at the two sites was 79.44%. Larger smelt 162-180 mm FL at Baadah Point had a more diverse diet of decapod and shrimp larvae, calanoid and harpacticoid copepods; barnacles were not a significant constituent. Diet overlap with the small fish at Baadah Point was 15.2% and 13.2% with the small fish at Crown Z. It was noteworthy that an epibenthic harpacticoid, *Diosaccus spinatus*, was represented (as high as 17.5% ΣIRI) in the diets of both sizes of fish at both sites.

Kelp greenling. Five juvenile kelp greenling 53-59 mm TL captured in a purse seine collection at Baadah Point in May were analyzed for stomach contents. Their prey spectrum (Table 9.17; Appendix 7.3) was comparatively specific with 93.9% ΣIRI originating from the planktonic calanoid copepods, *Calanus* sp..

Lingcod. Stomach contents were examined from fifteen juvenile lingcod 48-59 mm FL captured in purse seine collections at Baadah Point and Crown Z in May. Planktonic prey, principally fish and sand shrimp (*Crangon* sp.) larvae and calanoid copepods, dominated the prey spectrum (Table 3.17; Appendix 7.3). Due to the contribution to the total prey biomass, fish were the dominant prey item; these were assumed to be planktonic, although the lack of any identifiable fish remains does not preclude their origin being other than the water column. Sand shrimp larvae and copepods (*Acartia longiremis*) constituted the majority of the numbers of prey consumed.

When the diets of juvenile lingcod were compared between the Baadah Point and Crown Z sites, the five fish collected at Baadah Point were found to have fed on pelagic *Acartia longiremis* (62.6% total prey abundance; 3.5% ΣIRI) and fish larvae (86.4% total prey biomass; 90.2% ΣIRI) while *Crangon* sp. (92.8% total prey abundance; 20.9% ΣIRI) and fish larvae (62.8% total prey biomass; 78.9% ΣIRI), presumably also planktonic, were the predominant prey at Crown Z.

Pacific sand lance. Ten Pacific sand lance 56-112 mm TL (yearling or older adults) were captured at Baadah Point in a May beach seine collection. Their diet was almost exclusively (98.8% ΣIRI) formed of planktonic prey, specifically calanoid copepods (*Acartia, Calanus, Centropages, Pseudocalanus*) and unidentified fish (though low in occurrence and numerical composition in the overall spectrum) (Table 3.17; Appendix 7.3).

3.6 Macrophytes

3.6.1 Assemblage Structure and Standing Stock

Profiles of the assemblage distributions along BP1, CZ1, HB1, and the site used for beach seining at the head of the bay (see section 3.0) illustrate the considerable differences among the sites. BP1 essentially consists of a high intertidal bench located between 0 and 25 m out from the shore base point, a wall, a lower intertidal bench centering on MLLW and another wall at about 40 m that extends to subtidal depths (Figure 3.32). Observations along subtidal transects showed that patches of *Nereocystis* with an understory of *Pterygophora* attached to rocky outcrops occurred in the subtidal zone between Baadah Point and the Coast Guard Dock. During summer, very thick masses of *Ulva* sp. occurred in this location. Masses of *Ulva* sp. were hauled up in beach seines and made subtidal observations of fish difficult during this period. The MLLW bench and deeper areas along the transect contained a rich assemblage of seaweeds; primarily the green alga *Ulva lactuca*, the red algae *Odonthalia floccosa*, *Iridaea cordata*, and the massive brown seaweeds *Costaria costata*, *Sargassum muticum*, *Egregia menziesii*, *Macrocystis integrifolia* and *Nereocystis luetkeana*. The upper intertidal bench was relatively sparsely covered by the green alga *Enteromorpha* spp. with some dense patches of the brown alga Fucus distichus located at the outer edge of the bench. Herbivorous gastropods of the genus *Littorina* were very abundant in some areas on the flat and were obviously grazing algae.

The steeply sloping rip rap habitat of CZ1, in contrast to BP transects, contained very little macrophytic algae (Fig. 3.32). Barnacles were abundant, along with small individuals of mussels (*Mytilus edulis*). The shallow subtidal zone was primarily mud with log debris. Individual plants of *Nereocystis* were occasional in the area. *Fucus* covered the mostly cobble habitat along HB1 (Fig. 3.32). Although a systematic transect for sampling was not established at the beach seine site located at the head of the Bay, observations revealed that a dense eelgrass (*Zostera marina*) meadow existed in the area at low intertidal elevations.

One taxon of seagrass, 67 taxa of algae and 23 taxa of animals were noted in the quadrat samples throughout the study period (Table 3.18). In addition, eelgrass (*Z. marina*) was recorded in the vicinity of the beach seine site at the head of the Bay. Data taken in September (Table 3.18) indicate substantial quantitative differences in the species composition and species standing stock among the sites. These data show that substantial differences existed among the sites during all sampling dates. Baadah Point consistently held the greatest number of algal taxa (Fig. 3.33), greatest total number of taxa (Fig. 3.34) and greatest mean vegetation cover (Fig. 3.34) of all the rocky sites. The assemblage parameter values for the head of the Bay transect were intermediate with respect to the other two sites.

Although substantial changes were seen in the presence and cover of certain species throughout the sampling period, total number of species and total mean algal cover were relatively stable throughout the year. The winter sampling showed only a slight reduction in number of algal taxa and algal cover as compared to the spring and summer samplings (Figs. 3.34, 3.35). The transects at Crown Zellerbach were covered with large logs during the January sampling, which

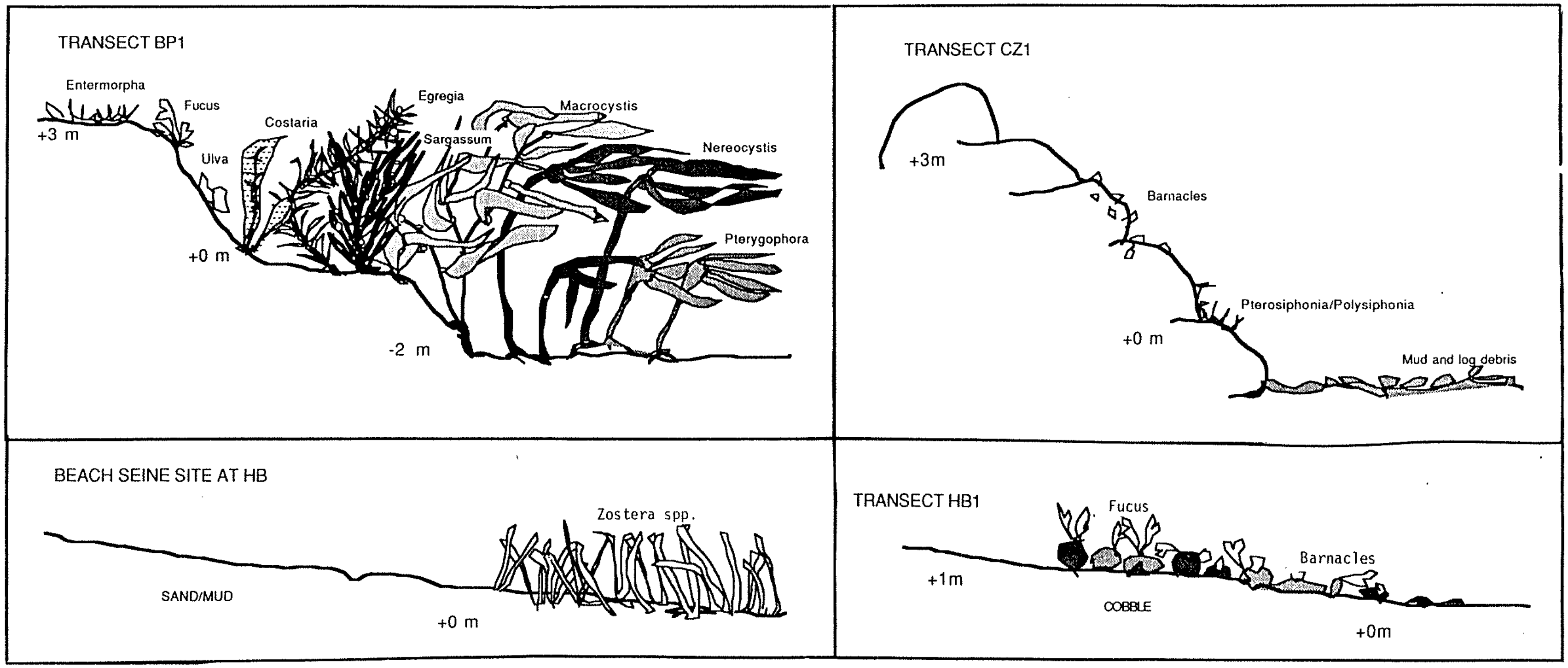


Figure 3.32. Generalized profiles of assemblages characterizing four intertidal sites in Neah Bay; transect elevations relative to MLLW.

Table 3.18. Mean percent cover of taxa and substrata at the three sites in September 1986. The entire taxa and substrata list for all samplings is given in the table; + = taxon noted at some time during the study, but not in September.

		Sites	
	Baadah Pt.	Crown Z.	Head of Bay
Substrata:			
Boulder		53.4	6.6
Cobble			
Gravel	1.3		
Gravel/shell	0.6		
Rock shelf	49.0		
Mud			54.0
Seagrass:			
Phyllospadix scouleri	1.0		
Seaweed:			
Ahnfeltia plicata	+		
Alaria marginata	2.9		
Bangia fuscopurpurea	+		
Bossiella sp.	0.8		
Ceramium sp.	+	+	
Cladophora sp.	0.2		
Codium fragile	+		
Colpomenia sp.	0.1		
Corallina officinalis	+		
C. vancouveriensis	<0.1		
C. sp.	+		
Costaria costata	+		
Cryptopleura sp.	+		
Delesseria decipiens	+		
diatom tuft or filament	3.8	+	
Dictyosiphon foeniculareus	<0.1		
Egregia menziesii	0.1		
encrusting red coralline	<0.1		
Endocladia muricata	0.3		
Enteromorpha intestinalis	0.2	+	0.2
E. linza		2.6	1.7
Fauchea sp.	+		
Fucus gardneri	12.1	+	24.5
Gelidium coulteri	0.8		
Gigartina exasperata	+		
G. papillata	0.5	0.4	
Grateloupia pinnata	+		
Halosaccion glandiforme	4.2		
Hedophyllum sessile	3.5		
Hildenbrandia sp.	+		

Table 3.18. Mean percent cover of taxa and substrata at the three sites in September 1986. The entire taxa and substrata list for all samplings is given in the table; + = taxon noted at some time during the study, but not in September - cont'd.

	Sites		
	Baadah Pt.	Crown Z.	Head of Bay
Seaweed:			
Iridaea cordata	1.4		
0. heterocarpa	+		
Kallymenia sp.	+		
Laminaria saccharina	+		+
Laurencia spectabilis	+		
Leathesia difformis	+	+	
Macrocystis integrifolia	1.9		
Melobesia mediocris	+		
Microcladia sp.	0.1		
"*Monostroma*" complex	+		
Nereocystis luetkeana	+		
Odonthalia floccosa	<0.1		
Petalonia fascia	+	3.4	
Petrocelis sp.	0.2		
Pikea robusta	+		
Polyneura latissima ?	+		
Polysiphonia sp.	0.5	+	
Porphyra miniata	+		
P. spp.	+		
Prionitis sp.	+		
Pterosiphonia bipinnata	0.5	+	
Pterygophora californica	+		
Ptilota sp.	+		
Ralfsia sp.	0.5	+	
Rhodomela larix	0.8		
Sargassum muticum	+		
Scytosiphon lomentaria	+	+	
Spongomorpha sp.	+		
Ulva expansa	+		
U. sp.	6.0	+	0.2
Unidentified brown crust	+		
Unidentified brown turf	+		
Unidentified green filament	+		
Unidentified green turf	+		
Unidentified spongy red	+		
Invertebrates:			
Anthopleura elegantissima	0.4		
Balanus glandula	3.0	+	12.5
Bryozoa	+		
Collisella digitalis	<0.1	+	
C. strigatella	<0.1	0.1	

Table 3.18. Mean percent cover of taxa and substrata at the three sites in September 1986. The entire taxa and substrata list for all samplings is given in the table; + = taxon noted at some time during the study, but not in September - cont'd.

	Sites		
	Baadah Pt.	Crown Z.	Head of Bay
Invertebrates:			
Cthamalus dalli	3.2	0.1	
Littorina scutulata	0.1	0.1	
L. sitkana	0.2	+	
Mopalia sp.	+	+	
Mytilus californianus	<0.1		
M. edulis	+	+	<0.1
Notoacmaea pelta	+		
N. persona	0.1	0.1	
N. scutum	<0.1	+	<0.1
N. sp.	+		
Nucella emarginata	<0.1	+	
Pagurus sp.	<0.1		
Pink sponge	+		
Sabellid polychaete	+		
Semibalanus cariosus	0.1	40.6	<0.1
Strongylocentrotus purpuratus	+	+	
Urticina sp.		+	

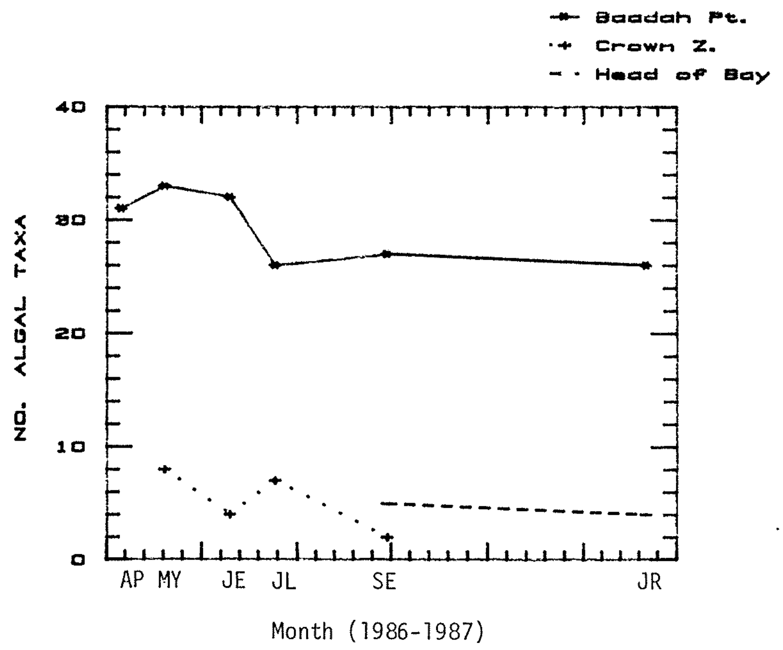


Figure 3.33. Algal species richness at three intensive study sites in Neah Bay, April 1986-January 1987.

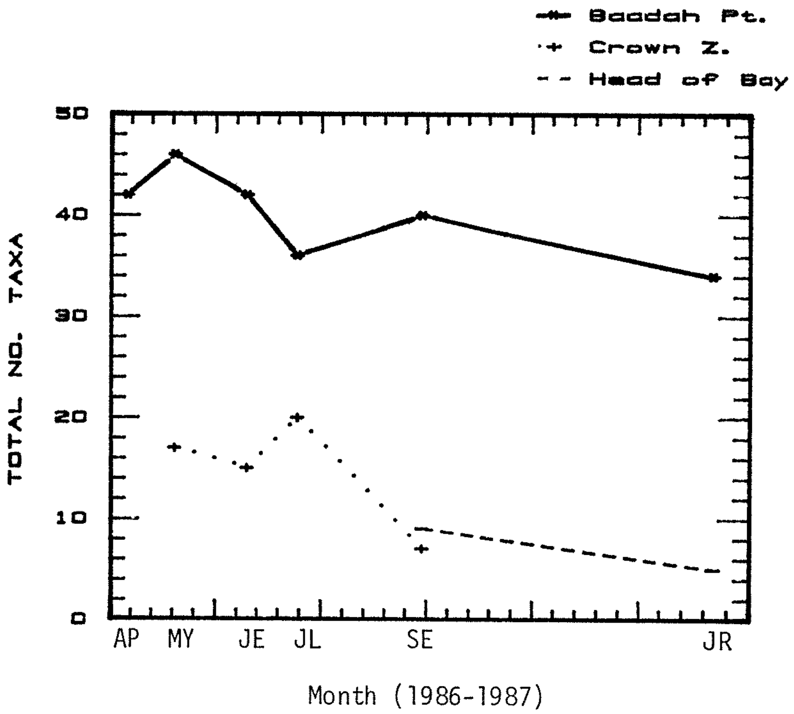


Figure 3.34. Total species richness at three intensive study sites in Neah Bay, April 1986-January 1987.

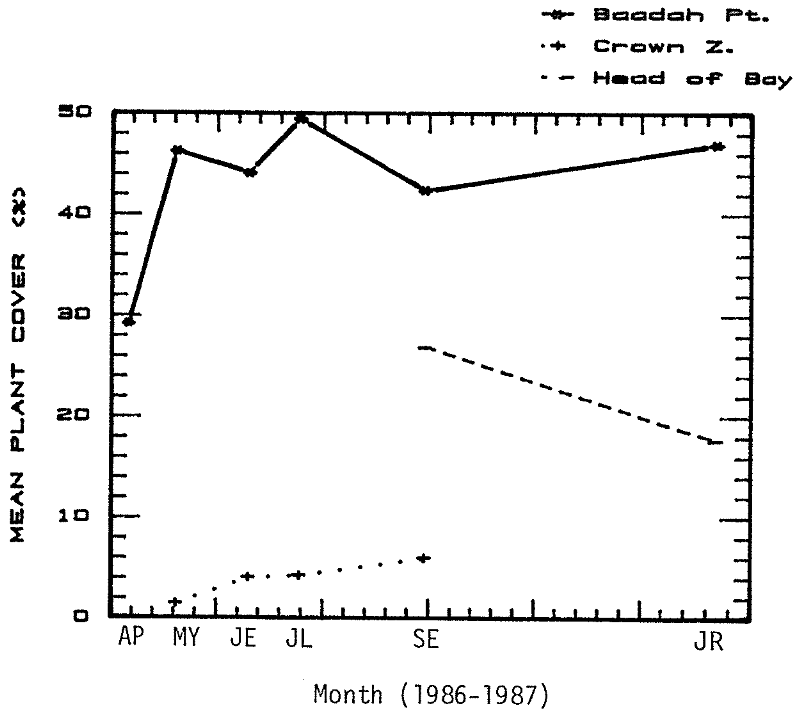


Figure 3.35. Mean plant cover (%) at three intensive study sites in Neah Bay, April 1986-January 1987.

indicates that the low species richness and cover at this site may be related to this significant winter disturbance.

3.6.2 Primary Productivity

Net primary production (i.e., NPP rates weighted by species standing stock) at Baadah Point was dominated by *Ulva lactuca*, *Fucus distichus*, *Egregia menziesii*, *Odonthalia floccosa*, *Rhodomela larix*, *Sargassum muticum*, and *Enteromorpha intestinalis*. In contrast, major primary producers at CZ and HB were the filamentous red alga *Pterosiphonia bipinnata* and *F. distichus*, respectively. The NPP rates for species that were abundant during at least three sampling periods are shown in Table 3.19. It is noteworthy that January rates were not appreciably different from spring and summer rates. NPP was consistently much greater at Baadah Point as compared to the other sites during all samplings (Figure 3.36). Total assemblage NPP, like standing stock, did not exhibit a substantial decline in winter. No estimates of standing stock or NPP were made for the eelgrass meadow at the head of the Bay. However, *Z. marina* shoots were dense and exceeded 0.5 m in length. Meadows of similar density and shoot size show NPP rates on the order of 1000 g C m^{-2} $year^{-1}$ (Kentula 1982). In comparison, our estimate of annual NPP for the Baadah Point algal assemblage is 116 g C m^{-2}. This latter value was calculated by first estimating NPP in months without data by straight line interpolation. Next, the hourly rates were multiplied by 6 hrs day^{-1} to yield daily rates. (This may be a conservative number. However, corrections are easily made when appropriate data are made available.) The daily rates were then multiplied by the number of days in each month to yield monthly rates. Finally, the monthly rates were summed to give the annual rate.

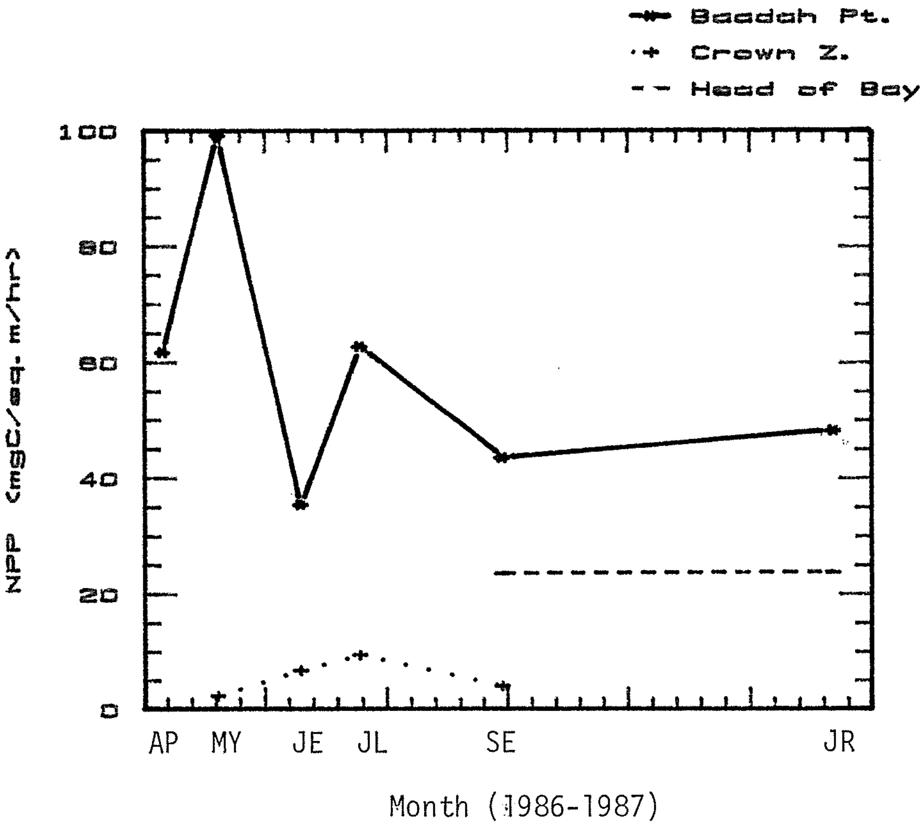


Figure 3.36. Net primary productivity at three intensive study sites in Neah Bay, April 1986-January 1987.

Table 3.19 Mean percent cover and net primary productivity (NPP) for algal taxa along three transects in Neah Bay, Washington; dates of data collecting were 21-23 May 1986 for BP1 and CZ1 and 16 September 1986 for HB1; - = not measured.

	Mean percent cover %			Net primary productivity (mg C m^{-2} hr^{-1})		
	BP1	CZ1	HB1	BP1	CZ1	HB1
Fucus distichus	8.4		20.4	14.70		35.75
Egregia menziesii	5.4			13.01		
Odonthalia floccosa	4.1		7.88			
Enteromorpha intestinalis	3.8		0.2	2.89		0.17
Ulva lactuca	2.9		<0.1	61.13		0.45
Costaria costata	2.6			-		
Sargassum muticum	1.8			3.11		
Rhodomela larix	1.2			3.67		
Hedophyllum sessile	1.0			0.98		
Iridaea cordata	0.9			0.61		
Alaria marginata	0.9			1.02		
Macrocystis integrifolia	0.1			0.05		
Monostroma spp.	0.1			0.06		
Gigartina papillata	<0.1		0.4	0.04		0.84
Red encrusting coralline	<0.1			-		
Corallina officinalis	<0.1			0.06		
Petrocelis middendorfii	<0.1			-		
Grateloupia californica	<0.1			-		
Porphyra miniata	<0.1			-		
Gigartina exasperata	<0.1			-		
Halosaccion glandiforme	<0.1			0.01		
Pikea robusta	<0.1			-		
Leathesia difformis	<0.1	<0.1		-		
Cryptopleura sp.	<0.1			-		
Prionitis lanceolata	<0.1			-		
? Fauchea sp.	<0.1			-		
Pterosiphonia bipinnata		2.8			5.74	
Enteromorpha linza			1.7			1.28

4.0 DISCUSSION

4.1. Comparisons of Faunal Assemblage Structure and Standing Stock at Intensive Study Sites

As a generality, Baadah Point was found to be the most diverse, productive, and structurally and biologically complex site within Neah Bay. Beach seine and purse seine collections at Baadah Point consistently contained more fish species than samples at the other sites and the mid-channel otter trawl samples near the mouth of the Bay had a higher species diversity than trawl samples from other sites. Baadah Point generally supported the highest density of fishes, although fish standing crop at Baadah was often lower than at Evans Mole (e.g., Fig. 3.3). Adult herring, gadids, adult lingcod and adult greenling occurred only in Baadah Point beach seines or mid-channel trawl collections. In addition, Pacific sand lance, juvenile pink and chum salmon, rockfish, sand sole and speckled sanddabs were all more common at Baadah Point.

Evans Mole also supported a diverse assemblage of fishes but the majority of these were pelagic bait- or forage fishes and juvenile coho and chinook salmon, which were generally distributed more homogenously in the bay. In addition, the Evans Mole fish assemblage was characterized by demersal species—staghorn and other sculpins, English sole and starry flounders—which also appear to be distributed ubiquitously within the bay. Crown Z exhibited patterns in fish assemblages structure and standing stock similar to Evans Mole but with even lower diversity.

In addition to the structured sampling during this study, we watched and interviewed Makah fishermen fishing marine setnets adjacent to the Marine Harvest pier parallel to the beach at Baadah Point and off Evans Mole beach. Nets set off Baadah Point regularly captured large king salmon, large cabezon (*Scorpaenichthys marmoratus*), some skates (Rajidae) and several white sturgeon (*Acipenser transmontanus*), while the nets set at Evans Mole only occasionally caught king salmon and cabezon (they had been set at that site because it was convenient for the fisherman). These large fish were probably too evasive for our sampling methods.

Fish species richness was generally higher in Neah Bay than was reported for many sites further east along the Strait of Juan de Fuca during the 1976-1979 MESA studies,* which averaged between 5 and 20 species at most sites (Miller et al. 1980; Long (1983). Only Beckett Point (Discovery Bay) had fish species richness approaching the 47 species collected in collections at Baadah Point; the Evans Mole collections, at 29 species, was also higher than normal for the

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*MESA studies included beach seine (directly comparable) and tow-net (surface trawl, indirectly comparable to purse seine) collections; no demersal trawling was conducted.

MESA sites; and, Crown Z collections (20 species) were approximately average for the time of the year encompassed. Notable differences in fish fauna in Neah Bay compared to the MESA collections to the east included the absence of redtail surfperch (*Amphistichys rhodoterus*) and longfin smelt (*Spirinchus thaleichthys*) among the numerically prominent species and the increased occurrence and abundance of juvenile salmon, surf smelt, Pacific sand lance, speckled sanddab, and Pacific tomcod. As might be expected, fish assemblage composition was most similar between the Neah Bay sites and Kydaka Beach, the closest (most westerly) MESA site. Standing stock, as compared by standing crop (g m^{-2}), was also generally higher in Neah Bay than measured at the MESA sites. Mean standing crop in beach seine collection at Neah Bay between May and September ranged between 4.7 and 14.5 g m^{-2} (Fig. 3.3), while most of the MESA sites during spring and summer 1976-1979 had standing crops below 5 g m^{-2}; only Twin Rivers (~9-~18 g m^{-2}) and Beckett Point (~10-~12 g m^{-2}) were comparable. Although comparisons of the two different sampling methods may be less dependable, standing crop estimates of pelagic fishes caught in Neah Bay with the purse seine were generally at least an order of magnitude greater than the MESA collections conducted with a tow net. The Neah Bay pelagic fish standing crops between May and September averaged 1.88 g m-2 and 75% were between ~1.5-~3.0 g m^{-3} (Fig. 3.5); the MESA tow-net standing crops, in contrast, were typically below 0.25 g m^{-3}, except for catches at Dungeness Spit and Beckett Point which ranged as high as ~0.3 to ~1.0 g m^{-3}.

It should be noted, however, that the MESA fish sampling occurred at a constant sampling frequency and included a significant portion of winter, night-time collections, which included low catches and many exclusively nocturnal taxa, respectively; our collections were concentrated during the spring and summer and were almost entirely diurnal. The absence of some species in the Neah Bay collections may also relate to the proximity of spawning concentrations, e.g., which may be at a greater distance, as in the case of longfin smelt.

Motile macroinvertebrates occurred in somewhat dissimilar patterns. Dungeness crab appeared in higher densities at Evans Mole, generally 0.5 denser than at Crown Z and up to an order of magnitude denser than at Baadah Point (Fig. 3.17). Coon-striped shrimp densities were higher near the Bay mouth, adjacent to Baadah Point, while spot prawns were abundant at both Baadah Point and Evans Mole, depending upon the month of collection (Fig. 3.18). Dungeness crab densities in Neah Bay, which reached a maximum near 0.01 m^{-2} in September, were representative of the densities found between August and October at the MESA sites, which ranged between 0.06 and 0.10 m^{-2} at Kydaka Beach, Twin Rivers (the maximum), Dungeness Spit, Morse Creek and Point Williams.

The density of epibenthic organisms tended to be correlated more with intertidal macrophytes (eelgrass, *Zostera marina* and *Z. japonica*) than sites, but was higher in unvegetated (except for macroalgae) intertidal sites at Evans Mole than Baadah Point in July, and higher at Baadah Point than any other site but the *Z. marina* site at Crown Z in September (Fig. 2.1). The MESA studies also produced a relatively comparable sampling of epibenthic organisms at sites to the east along the Strait of Juan de Fuca in August 1979 (Simenstad et al. 1980). In general, harpacticoid copepods were more prominent, and polychaete annelids as gastropods less so, in the Neah Bay collections as compared to the MESA collections; this may relate more to differences in the sampling methodology than to differences in epibenthos assemblages. Except for the samples from Crown Z and a subtidal eelgrass sample at Baadah, which were below 10,000 organisms m^{-3}, epibenthos density was higher (10,000-50,000 m^{-3}) than was found at the non-eelgrass habitat MESA sites (Kydaka Beach, Twin Rivers, Morse Creek, Dungeness Spit; <10,000 m^{-3}) but comparable to slightly lower than the highest densities found in sand-eelgrass habitats at Port Williams and Beckett Point (~100,000-300,000 m^{-3}). The contribution of eelgrass to epibenthos diversity and standing stock is, apparently, a consistent phenomenon among both the MESA and our Neah Bay habitats.

Pelagic zooplankton was particularly more dense at sites further inside the Bay than Baadah Point (Fig. 3.22), principally due to the presence of calanoid copepods. We know of no comparable nearshore pelagic zooplankton collections in the Strait of Juan de Fuca with which to compare the Neah Bay assemblage composition and standing stock.

In addition to relatively unique benthos assemblages at Baadah Point (Section 3.4.3), the standing stock of benthic organisms was highest at Baadah Point (Table 3.10) and, in particular, infaunal bivalves were considerably more dense at this site (Fig. 3.25).

We have described several differences in the habitats distributed among the three sites, including benthic structure and the presence and character of macrophyte assemblages. In many instances, these characteristics can explain differences in fish, macroinvertebrate, epibenthic and pelagic zooplankton assemblages. Specifically, there is a strong association between faunal diversity and substrate and macrophyte heterogeneity (including floral diversity) both among and within sites (see Section 4.2). However, a combination of unrelated physiochemical factors may also influence faunal assemblage structure: (1) proximity to the mouth of the bay (and exogenous populations and food); (2) circulation, especially convergences (fronts), gyres, etc.; (3) reduced exposure to summer winds and waves; and (4) water and sediment quality. We cannot exclude the potential effects of these factors in the absence of any true controls within physiochemically-homogeneous realms of the intensive study sites (e.g., statistically rigorous sampling of fauna with and without certain habitat characteristics such as seaweeds, kelps or seagrasses, hard rock vs. unconsolidated substrate, etc.). The difference between epibenthos and plankton assemblages typifies the differential effects of habitat and physical factors. While the standing stock and diversity of epibenthic crustaceans (e.g., harpacticoid copepods) appeared to be enhanced by the presence of intertidal seagrasses, planktonic zooplankton (e.g., barnacle larvae, calanoid copepods) was most abundant in the interior of Neah Bay, where currents were found to be slower (0.06-0.20 s^{-1}) and more cyclic (unpublished, 1986 U.S. Army Corp. Engineers circulation study) than off Baadah Point (0.25 m s^{-1}). This condition would entrain organisms or, at least, reduce population depletion by advection. Detailed studies of circulation, such as the complex current patterns around Baadah Point, which could also entrain larvae and detrital food material, would be required to clarify the role of circulation in faunal community structure at specific sites.

Another example of physiochemical effects on faunal structure is the prominence of *Nebalia* at the head of the Bay, possibly reflecting oxygen-deficient conditions in the fine surface sediments in that region.

4.2 Relationship Among Macrophyte Habitats and Fish and Macroinvertebrate Assemblages

Given the lack of distinct, dichotomous differences in the presence and absence of macrophyte habitats among our intensive sampling sites in Neah Bay, our data do not illustrate explicit relationships between macrophyte habitats and fish and motile macroinvertebrate assemblages. Baadah Point had the highest macrophyte cover and the highest fish diversity, but rockfish were the only species whose density appeared to be influenced by the amount of macrophyte cover. Juvenile rockfish density was five times higher along the Baadah Point transect with the highest macrophyte cover; in addition, the only juvenile rockfish observed at the Crown Z site were swimming around a raft of *Nereocystis* after the September storm. The thick macrophyte growth at Baadah Point and Evans Mole provided obvious cover, food and protection for all of the juvenile fishes who utilized these sites but there was no apparent correlation between the amount of macrophyte cover and the density of any of the other fish species.

There was coincidental evidence, however, in support of the importance of benthic macrophytes to enhancing fish diversity. Underwater transect observations conducted in September before and after the first significant easterly storm found significant changes in the macrophyte and fish distributions within the bay. The strong easterly weather pattern typical of winter weather subjected Baadah point to strong wind and wave action which scoured the bottom of macrophytic cover (*Ulva*). After the September storm, macrophyte cover and fish density were drastically reduced at Baadah Point while fish species uncommon to Crown Z were observed there associated rafts of loose *Nereocystis* and other alga. The same pattern was still evident during the January and March sampling periods, although in March new algal growth was evident at Baadah Point.

4.3 Neah Bay Habitat Utilization by Economically Important Fishes and Macroinvertebrates

Almost all of the fishes sampled in this study were juveniles; only greenling, sculpins, perch, sand lance, gunnels and starry flounders occurred regularly as adults during the course of the study. Thus, except for the relatively rare, large species captured by the Makah setnet fishermen (and unsampled in our studies), the direct utilization of Neah Bay by marketable fishes was minimal over the course of these studies. Dungeness crab, pandalid shrimp, and several species of clams (*Protothaca staminea*, *Clinocardium nuttallii* and *Tresus capax*) however, were documented or known to occur (i.e., *Tresus* at Evans Mole) in abundances sufficient to harvest, although not at a high rate of exploitation (e.g., recreational).

Juvenile fishes, on the other hand, dominated the fish fauna at Neah Bay. Neah Bay appears to provide "nursery" habitat for several demersal fishes, such as kelp greenling, English sole, speckled sanddab and starry flounder, which either actively move into the Bay as juveniles or are passively advected and entrained there as larvae. More often than not, these occurred in highest density at Baadah Point. Pelagic fishes, such as the bait- or forage fishes (herring, smelt, sand lance) and salmonids, also appeared extensively in Neah Bay as juveniles but showed virtually no site specificity and often occurred at all three sites during an intensive sampling period. Adult smelt were an exception and they only occurred in samples from Baadah Point.

Dungeness crabs appeared to move around within the Bay. The highest densities were in the July and September samples at Evans Mole and Crown Z. In January, the only crabs sampled were juveniles/sub-adult crabs in Baadah Point beach seines suggesting this site is the entry and/or nursery area for young Dungeness crabs entering the Bay.

Pandalid shrimp also appeared to utilize the Bay as a rearing ground. Juvenile shrimp, too small to be adequately sampled, appeared in the May and March samples. Shrimp in the July and September samples were adults and sub-adults. Coon-striped shrimp preferred the deeper water trawl sites, while spot prawns occurred at both deep and shallow sites. Densities of both species were highest near the mouth of the bay.

4.4 Factors Affecting Structure and Standing Stock of Epibenthos and Pelagic Zooplankton Assemblages

The most striking result of the plankton data presented here is the contrast between the Baadah Point and the collections at the Head of Bay, where epibenthic/epiphytic harpacticoid copepods such as *Zaus*, *Tisbe*, and *Diosaccus spinatus* predominated, and the Evans Mole and Crown Zellerbach dock sites, where more truly planktonic animals (e.g., barnacle nauplii, calanoid copepods, and crab zoeae) were most abundant. The most plausible explanation for the abundance of epibenthic harpacticoids at Baadah Point and the Head of the Bay is the proximity of these sites to macrophytes, i.e., *Zostera marina* at the Head of the Bay and *Z. marina* and macroalgae at Baadah Point. The relative abundance of these animals in the plankton indicates that they are being actively transported from the macrophytes and substrate into the water column. If this is the case, these suspended harpacticoid copepods may represent a food resource for juvenile fish utilizing Neah Bay.

The "inner bay" sites, i.e., Crown Zellerbach dock, Head of the Bay, and Evans Mole also had relatively high abundances of planktonic barnacle larvae and the calanoid copepods *Acartia* spp. on one or more sample dates. In particular, barnacle nauplii were abundant at one or more location on every sample date. Unlike the case with harpacticoid copepods, the exact source of these animals is unknown; they may either be transported into Neah Bay from outside, or be products of populations residing within the bay. Regardless of their origin, however, they may also represent forage resources for planktonic feeding fish.

Most of the epibenthic habitats which were sampled during this study appear to support populations of harpacticoid copepods which are known to be prey resources of nearshore fishes such as shiner perch and pipefish (i.e., *Diosaccus spinatus, Amonardia perturbata,* and *Zaus* sp.; Simenstad and Cordell, unpublished data) and juvenile salmon (i.e., *Tisbe* spp.; Cordell, 1986). The only exception was off of the Crown Zellerbach dock, where anoxic conditions were indicated by the low-oxygen tolerant *Nebalia pugettensis.* Abundances of epibenthic harpacticoids were particularly high in September in the vicinity of thick *Zostera marina* beds at the head of the Bay. Surprisingly, relatively low abundances were found on the *Z. marina* at Baadah Point.

The difference in epibenthic organism abundances between Baadah Point and the head of the Bay may be due to the differing physical characteristics of these two sample sites. Baadah Point is subject to much higher wave energy, and the *Z. marina* at this site is located deeper than at the head of the Bay. The bed at the head of the Bay extends well into the intertidal. The *Z. marina* bed at Baadah Point may therefore be less suitable habitat than that at the head of the Bay because (1) it may have less growth and turnover of epiphytes which afford cover and nourishment to epibenthic harpacticoids; (2) the eelgrass blades themselves may be torn up and lost faster; and (3) the harpacticoid copepods and other essentially nonmotile epibenthic organisms may be scoured by wave and current action into the water column, where they are transported away or consumed by predators.

While non-Dungeness Cancer (*C. productus* and *C. gracilis*) and pinnotherid crab larvae were common in Neah Bay plankton samples, Dungeness crab (*C. magister*) larvae did not occur in the zooplankton or epibenthos during this study. Fish larvae were encountered only rarely in the zooplankton samples, and did not include commercially important species; families/species of fish larvae found included Cottidae (sculpins), Stichaeidae (pricklebacks) and *Gobiesox meandricus* (northern clingfish).

4.5 Distribution and Standing Stock of Benthic Infauna Assemblages

From the taxonomically-coarse results of the synoptic survey, it is evident that the common taxa of benthic infauna are distributed ubiquitously throughout Neah Bay, and that any differences in the benthos among various areas of the Bay are expressed in their standing stock. Two taxa groups were extremely common at most stations: (1) bivalves and gammarid amphipods (group I, Fig. 3.27) and (2) polychaete annelids (group VIII). Another group composed of epibenthic crustaceans—crab, tanaids, and leptostracans—(group VII) were abundant at approximately half the sampling stations. Areal differences in the distribution of these fundamental groups may be summarized as: (1) bivalves, gammarids and polychaetes were all comparatively dense at Baadah Point (station group II, Fig. 3.26); (2) they were all abundant, at a reduced density and lower representation by bivalves, with the crustacean group in shallow stations throughout the Bay (station group I); and (3) the crustacean group, especially tanaids, was also represented in deeper stations (station group III).

Other groups of infauna were rare and generally did not characterize any discrete region of Neah Bay. The absence of infauna groups other than bivalves, gammarids and polychaetes was notable, however, at three stations (station group VI) in the turning basin and the head of the bay. The complete absence of gastropods and nemerteans except at one station at Evans Mole is also notable.

Although taxa groups and standing stocks did not exactly correlate with the distribution of basic habitats (Fig. 3.1), it was evident that stations exhibiting the highest diversity of taxa groups and standing stock tended to be located in shallow water. These stations were generally confined to Baadah Point and the area described as clear sand with *Zostera* and *Ulva* macrophyte patches. The only exception to this generalization was the higher than average densities of group II taxa (crabs, tanaids, leptostracans) at three of the Crown Z stations. The deeper, central region of the Bay characterized as silty sand with diatoms and wormtubes (Fig. 3.1) had generally lower benthic diversity and, as a result, was numerically dominated by polychaete annelids (Fig. 3.23).

Grain size analyses of selected benthic samples from Baadah Point and the turning basin and navigational channel (Battelle, Marine Research Laboratory 1984) indicated that the substrate composition at Baadah Point is predominantly sand (98.1%). Except for the south side of the turning basin, which is also sandy (80.0%) with silt and clay, the navigation channel grades from 80.8% to ~46.0% sand, and from 12.3% to ~40.0% gravel between the mouth of the bay to the western end of the turning basin. Silt and clay composition are highest (12.2% and 8.1%, respectively) in the north margin of the turning basin, closest to the Crown Z intensive study site. Finally, it is important to note that the available resources did not permit identification of these taxa to the species level and that the results of similar numerical classification of such finer resolution data might be different and, potentially, less ambiguous.

Both assemblage structure and standing stocks of bivalves sampled at the intensive study sites were more discrete. Baadah Point was dominated by *Transennella tantilla*, which became progressively denser offshore; *Tellina* sp., *Macoma* sp., and *Mysella* sp. were more prominent than *Transennella* at Evans Mole; and *Macoma* and an undescribed taxa (type A) dominated at Crown Z (Fig. 3.24). Standing stocks decreased from the mouth to the head of the bay (Fig. 3.25), as did the proportion representation of suspension-feeding taxa to deposit- feeders. While sediment composition is the likely factor in structuring the composition of the assemblages, it is probable that the differences in standing stock reflect the relatively higher turnover in particulate food particles for these suspension feeders at the mouth of the Bay. This suggests that at Baadah Point water-column primary production is highest and the dominant source of organic carbon to the benthic bivalve assemblages and that detritus is the dominant source of organic carbon at the west end of the bay. This may relate, as well, to the higher zooplankton (phytoplankton grazers) densities in the central region of the Bay and to the depositional pattern of macrophyte debris and detritus accreting at the west end.

Economically important bivalves actually sampled during these benthic studies were limited to the littleneck clam *Protothaca staminea* and, to a lesser extent, the cockle *Clinocardium nuttallii*. In both cases, however, densities were low (25 m-2) and the animals were small. Thus, only the horseclam, *Tresus capax*, which was observed to be abundant, but not sampled, in the vicinity of both Evans Mole and Baadah Point represents the only viably harvestable bivalve resource in the study area.

4.7 Trophic Relationships between Fish and Epibenthic and Zooplanktonic Prey Assemblages

Differences in predator-prey relationships among the intensive study sites is presumed to occur primarily among the epibenthic- or benthic-feeding fishes because their prey resources are more localized than the pelagic fishes, which utilize the more ephemeral zooplankton. Among the economically important fishes examined for stomach contents, none of the nearshore demersal species were captured at sites other than Baadah Point. In itself, this pattern of differential distribution within the Bay suggests that the availability of prey resources to these particular fish species potentially restricts much of their occurrence, at least for the purposes of feeding, to Baadah Point and similar habitats. This is best illustrated by the overlap in composition and standing stock of epibenthic/benthic harpacticoid copepods, gammarid amphipods and cumaceans at Baadah Point and in the stomach contents of juvenile walleye pollock, copper rockfish and English sole which occurred there (Table 3.16). Whether prey availability actually explains lower standing stock of these fishes at the other sites in the bay is open to conjecture, as many of these prey taxa appeared abundantly in *Zostera* habitats at the head of the bay. As was discussed earlier, many factors may combine to affect fish distribution and abundance among the three study areas.

Differences in the diets of pelagic fishes commonly found at the three study sites were examined for young-of-the-year Pacific herring, surf smelt and lingcod. Despite their presumably transient movements around the Bay, diets often differed significantly among similar collections of these fish at different sites, e.g. herring at Baadah Point and Crown Z in May and lingcod at Baadah Point and Crown Z. Some of these differences may be attributable to real differences in the distribution of the common prey within the Bay. For instance, many of the calanoid copepod taxa (i.e., *Acartia, Centropages, Calanus, Epilabidocera*) and barnacle larvae, which are important prey (Table 3.17), appear to be denser within the Bay, where their populations may be concentrated by increased retention times and lower circulation. However, these pelagic prey, as well as the other prominent taxa- decapod larvae-typically occur in dense patches, which would result in the manner of variation observed in these data.

Macrophytic habitats such as the *Zostera* spp., patches at Baadah Point and the head of the Bay represent both direct and indirect sources of fish prey resources. Direct support originates in the unique associations between seagrasses, seaweeds and kelps and prey organisms such as epibenthic harpacticoid copepods and gammarid amphipods. These taxa are typically quite different in behavior, morphology, and ecology from benthic forms and, due to their swimming movements off the substrate, are somewhat more available to foraging fish. Our own and related research on the epibenthos and fish predators upon these assemblages in other areas of Puget Sound and coastal Washington has identified a number of these taxa, some of which appear prominently in the diets of fishes in Neah Bay (Phillips 1984; Simenstad and Eggers 1981; Thom et al. 1984, 1986; C. Simenstad and J. Cordell, unpubl.). The harpacticoids *Tisbe* sp., *Zaus* sp., *Dactylopodia* sp., and *Diosaccus spinatus* and gammarids *Ischyrocerus anguipes, Jassa falcata, Syncheidium schoemakeri*, and *Photis* sp. which occur, often prominently, in the diets of juvenile walleye pollock and juvenile copper rockfish for instance, are characteristic of seagrass and other habitats with epiphytic diatoms and other microalgal growth. Although epiphytes are also common on kelps, no information on their associated epibenthic fauna is available. Other epibenthic taxa, such as the cumacean *Diastylopsis tenuis*, is probably associated more with the sand substrate which typifies seagrass habitats, although this may be, in and of itself, a consequence of the eelgrass plants.

Indirectly, eelgrass and other macrophytes also support epibenthos and other detritivores by the production of detritus. Given the observed transport of detritus, much of it detached eelgrass blades and *Ulva*, from the mouth to the head of the bay, highly productive macrophyte habitats such as surround Baadah Point may actually sustain the production of the dense detritivores such as tanaids, leptostracans (e.g., *Nebalia*) and bivalves (e.g., *Macoma* sp.) which occupy the Crown Z area at the head of the bay.

Certain prey may have originated exogenously to Neah Bay, either in the terrestrial system surrounding it or in the adjacent marine environs. Specifically, the chironomid (Dipteran, midge) larvae which occurred in the diets of juvenile chum salmon were assumed to occur in marsh habitats not present in the Bay. In that these fish were probably migrating along the shore of the Straits before entering the Bay, through predominantly marine sand-gravel beach or rocky kelp bed habitats, these prey presumably originated from wetland habitats upland and were transported into the Bay via stream discharges.

4.8 Comparisons of Macrophyte Assemblages and Net Productivity

The biota occupying rocky shallow water marine substrata are the most visible features of these habitats in the Pacific Northwest and elsewhere. The assemblages on the Pacific coast of Washington State are dominated in cover by sessile animals such as acorn barnacles (*Balanus* spp.) and mussels (*Mytilus* spp.), and kelps and other seaweeds. Typically, these nearshore habitats have an associated pelagic fauna consisting of several species of fish; many of recreational or commercial value (Simenstad et al. 1979). Although the association between the rocky bottom assemblage and the pelagic assemblage is well-known, quantification of the parameters responsible for the linkage has not been studied in the region. Factors that may be responsible include increased food supply from higher primary production, increased habitat diversity, and increased protection from predation.

Neah Bay contains a significant coverage of rocky and soft substrata upon and within which occurs macrophyte-dominated assemblages. Studies on the macrophytes in the Bay have been limited to the seaward portions of Waadah Island (Rigg and Miller 1949, Dayton 1971). Rigg and Miller visited the region during 1936- 1938, and distinguished eight algal-dominated intertidal zones. They stated that the intertidal life in the vicinity of Neah Bay was remarkably interesting in its richness and diversity. Our research focused on characterizing several parameters of the assemblages that may be important driving forces responsible for fish-benthos coupling. Structural parameters included species standing stock (as percent cover), total macrophyte standing stock, and species richness. In addition, net primary productivity was measured as an indication of the magnitude of a fundamental ecological process of the benthic shallow water assemblages. Assemblage structure and primary productivity show significant variations seasonally in the Northwest (Thom 1987). These variations result in changes in the physical habitat and food availability in the nearshore system, which can have significant effects on the fauna. Therefore, the temporal dynamics in system structure and productivity were documented.

The parameters and sampling strategy selected allowed an analysis of the alternative sites with regard to the assemblage diversity, species composition, habitat diversity, and production of organic matter. As stated above, all of these parameters may have direct importance in determining the numbers, types and sizes of fish occupying a nearshore area.

There were major differences in rocky intertidal assemblages at the three sites studied. Baadah Point represents a rocky outcrop with a species-rich, abundant and productive seaweed-dominated habitat. In contrast, sites at the Crown Zellerbach dock and at the head of the Bay had fewer species and a generally less abundant algal flora. The Crown Zellerbach site was particularly depauperate in seaweeds, only containing relatively small taxa. The cobble field at the head of the Bay had more algal species, with greater standing stocks and productivity as compared to Crown Zellerbach. Of note was the unsampled but relatively dense stand of eelgrass located immediately south of the site at the Head of the Bay. This bed was within the area sampled by beach seine.

Substrata differences, exposure to currents, and present and historical levels of disturbance may explain differences among the sites. Baadah Point is a stable rocky outcrop located at the mouth of Neah Bay. By its location, the Point receives frequent inputs of nutrient rich, relatively cold water from the adjacent Straits by tidal action. On flooding tides, intense eddies form in this embayment, which indicates that water from the Straits is being trapped. Fine sediments, which would tend to scour the benthic community on the rocks are probably not an important factor due to the sheerness of the outcrop. We noted on several occasions that the water in the embayment immediately west of the point was generally clearer as compared to the other sites. Much of the space, especially in the lower tidal elevations, is dominated by perennial taxa. Our observations suggest that the community is relatively undisturbed by sediment movement and has a relatively high rate of input of nutrient rich water. These latter conditions would promote the development of a stable seaweed dominated community as occurred at Baadah Point. In contrast, the water at the head of the Bay is more turbid and probably relatively less influenced by inputs of nutrient rich water from the Straits. Due to the proximity of cliffs and a small freshwater stream at the head end of the Bay, sediments are finer and cover a much greater proportion of the bottom. There are no rocky outcrops analogous to Baadah Point in this region, therefore, disturbance by shifting sediment has a relatively greater role in regulating assemblage structure. The HB1 transect reflected a condition typical of cobble fields located in shallow, quiet embayments in Puget Sound and elsewhere. The lack of an algal dominated assemblage on the stable rip rap wall at Crown Z dock presents an anomalous situation. It may be that increased turbidity, lower tidal exchange, log bashing in winter and lingering effects of log storage and debris in the immediate vicinity explain the depauperate condition of the assemblage. Subtidal observations showed that much log debris remained on the muddy bottom immediately offshore of the transect.

4.9 Evaluation of the Potential Impact of Development on Nearshore Communities in Neah Bay

4.9.1 Direct Loss of Habitat

Direct habitat loss could potentially result from both of the development proposals for Neah Bay: (1) the subtidal benthic area to be dredged for the deep-draft navigational channel, which we estimated from the planning documents to involve approximately 313,500 m^2 of the central region of the Bay (Fig. 1.2); and (2) the intertidal and shallow subtidal areas involved for the rubblemound breakwater and dredged moorage basin, entrance channel, turning basin, and access channel, which we estimated to involve approximately 7,000 m^2 and 25,000 m^2, respectively (Fig. 1.4). In both cases, these areas would be substituted, after an unknown period of recruitment and succession, by fish, mobile macroinvertebrate, epibenthos and benthos assemblages characteristic of deeper water communities; in one case, i.e., construction of a rubblemound breakwater, a large proportion of this area would be removed as intertidal-shallow subtidal habitat and only a small area would remain as highly-altered, steeply-sloped riprap shore.

Deepening of the central region of the Bay for the deep-draft channel would probably not result in an overall change in the Bay's primary production potential, as circulation would not be measurably affected to the point that water column production would be decreased (see Section 4.9.4, below); if anything, increased residence time would likely increase phytoplankton and zooplankton production. Although we did not measure benthic primary production in these habitats, we assume sediment microalgae production to be negligible because of the depths and did not find any evidence of significant macroalgal production in the region. Secondary benthic production, however, would probably shift qualitatively to a less diverse, polychaete-dominated assemblage characteristic of deeper, finer sediment habitats (i.e., taxa group VIII, Fig. 3.27; station group VII, Fig. 3.26; Figs. 3.23 and 3.28) and potentially a decrease in production, as indicated by the differences in standing crop (an gross index of production, although the ratio of standing crop:production varies according to taxa) between the turning basin and the other, shallower sites along the present channel (Table 3.10). The decreased current velocities at the entrance and eastern region of the bay would also promote increased deposition by both fine sediment and detritus further east than the turning basin (section 4.9.4, below), thus also extending the deposit-feeding taxa assemblages.

However, loss and disruption of habitat by dredging and filling for the marina would plausibly result in significant loss of diversity and production of macrophyte, demersal fish, mobile macroinvertebrate, epibenthos, and benthos diversity and production, with the magnitude dependent upon the site chosen. Comparison of diversity and productivity, or indices of productivity (density, standing crop) of the three sites indicate the stark difference among the three intensive study sites (Table 4.1). Except for one index (i.e., Dungeness crab density along SCUBA transects), Baadah Point is measurably more diverse and productive than the other two sites and, but for a few instances, Evans Mole is similarly superior to Crown Z and the head of the Bay. In some important cases, these differences are extreme, as in the 18:2.5:1 ratio of demersal fish density among the three sites and the order of magnitude difference in macrophyte diversity between Baadah Point and Crown Z.

Obviously, the potential consequences of habitat loss at Baadah are paramount. In addition, several more qualitative aspects of that site enhance this quantitative evaluation, including presence of: (1) the only significant kelp (*Nereocystis*) and *Zostera marina* beds; (2) high *Ulva* production;

Table 4.1. Relative ranking (ratios) of biotic assemblages at three sites (Baadah Point:Evans Mole:Crown Z/Head of Bay) proposed for marina development in Neah Bay, Washington; index measures averaged over all sampling periods (seasonally) and nd = no data.

Index	Assemblage				
	Macrophytes	Demersal fish	Dungeness crab	Epibenthos	Benthos
Diversity	10:nd:1	2.4:1.4:1*			1.7:1.4:1*** 2:1.4:1****
Density		18.0:2.5:1**	4:3:1* 1:27:18**	5.5:5.0:1	1.8:1.5:1*** 2.4:1.2:1****
Standing crop		1.6:1:1.3			1.4:1.3:1*** 3.7:1.3:1****
Productivity	5:nd:1				

* beach seine
** SCUBA
*** synoptic benthic survey
**** site-intensive bivalve survey

(3) the only hard rock substrate intertidal; and (4) the majority of all adult rockfish and lingcod observations. Evans Mole, in addition to being generally more diverse and productive than Crown Z and the head of the bay, is the site of high Dungeness crab densities and also appears to maintain high densities of horse clams.

4.9.2 Short-term Effects of Dredging and Filling

The short-term or indirect effects of the dredging and filling operations could, but would not necessarily, include: (1) release of toxicants from benthic sediments along the navigation channel and within the marina location; (2) increased turbidity during dredging and (3) modification of other natural environmental characteristics (e.g., sound, light) which results in abnormal modification of fish and macroinvertebrate behavior.

Turbidity and sound effects would be manifested principally in behavioral changes in pelagic fishes. In the absence of any associated toxicity, most of these fish (except for truly planktonic larvae) would actively avoid regions of abnormally high turbidity and underwater sound. If the dredging and related operations were to occur between March and October, and depending upon the areal extent of the impacted zone, this could result in exclusion of pelagic fishes from planktonic food resources. This could be especially deleterious during dredging operations at the mouth of the bay, which could effectively close off the Bay to any immigration or emigration during the periods of operation.

4.9.3 Effects of Underwater Explosions

While the specific design of the underwater demolition required to deepen the entrance to the navigation channel has not been developed, the U.S. Army Corps of Engineer's Foundations and Materials Section (William Bailey) has provided some initial estimates and comments (unpubl. memo, 14 November 1986). This communication described the operation as including:

(1) an air cannon to be towed behind a boat to chase fish away;
(2) a charge of not greater than 3 lbs.; and
(3) a blasting depth of 5 feet.

A survey of much of the existing literature on the effects of explosions and other sources of shock waves on fish (see Appendix 7.4 for the accompanying references) indicated that there are five general determinants of the effects: (1) characteristics and nature of the shock wave produced and the zone of influence, which is determined extensively by depth; (2) the physiological and behavioral characteristics of the fish; and (3) the location of the fish within the zone of influence, which is often related to the season and diel period of detonation. These studies synthesize a wide variety of underwater shock wave sources, including explosives, air guns used in seismic exploration, underground nuclear tests, and structured experiments. An accepted generalization is that organisms with air spaces, specifically fishes with air bladders, are the most susceptible, and eggs, larvae, and postlarvae-early juveniles are also sensitive. Among the fishes with air bladders, there are two forms: (1) those possessing an open pneumatic duct between the air bladder and the alimentary canal, termed physostomous fishes; and (2) those without the pneumatic duct, termed the physoclistous fishes. We have concentrated on fishes of these two physiological forms because the majority of the shock wave effects literature is directed toward these fishes, and because comparatively minimal effects have been found for invertebrates and fishes without such air spaces.

The shock waves from these various sources assumes approximately the same form but differ in certain properties which are important to determining the impact on aquatic resources, i.e., pressure distribution, wave acceleration, peak over- and underpressures, rise time, and boundary effects, which is often collectively described as the "impulse." While the synergistic effect of these wave characteristics on fish mortality has not often been studied rigorously, recent experimental research has generated workable models which can be used to evaluate potential *in situ* fish kills from specific projects. Most of these quantitative studies have focused on the effects upon physoclistous fishes.

Two shock wave characteristics are most important, the maximum pressure levels (psi) developed above and below ambient, and the rise time or wave frequency, i.e., the time it takes to develop peak over- and underpressures. The negative pressure wave or rarefaction develops through reflection of the wave at the surface and the bottom; at the surface, however, rarefaction is truncated by the effect of cavitation (formation of small gas bubbles which limits the negative pressure potential at the surface, termed the "surface cutoff"). These pressure extremes are affected by size and type of the explosive source, distance from the source bathymetry and the elastic properties of the bottom. Peak pressures decline exponentially with distance from the source, with the rate of decay also decreasing with distance. Rise time is essentially a function of the source.

Relative to experiences with *in situ* explosion effects, the wave forms produced by high velocity explosives, which produce high pressure extremes with short rise times, have been found to be the most deleterious. As a result, explosives such as TNT, nitrocarbonitrate (NCN) and pentolite tend to have rise times of 1-3 msec (for 5-lb charge), as compared to slower burning (e.g., black powder) explosives, with rise times of 6-7 msec, and much longer rise times for natural seismic and underground nuclear shock waves, e.g., 70 msec for the latter (Simenstad 1974). Although not stated, we assume that the detonation of the hard rock substrate in Neah Bay will involve a high velocity explosive; adoption of any other explosive source with longer rise times will make these predictions overestimates.

Many examples of documented fish kills from underwater explosive charges exist and provide some indication of the pressure limits on fish mortality within the sphere of the conditions anticipated at Neah Bay. Coker and Hollis (1950) indicated that the lethal radius for a variety of fish (menhaden, *Brevoortia tyrannus*, being the most numerous) was estimated to be 50 m from a 5-lb charge. A 5-lb charge of dynamite or NCN has been shown to generate lethal overpressures for physostomous fishes such as Pacific sardine (*Sardinops caerulea*) 100 to 150 feet from the source (218-138 psi) and northern anchovy (distance unknown, 43 psi) and to physoclistous fishes such as jacksmelt (*Atherinopsis californiensis*) 61 feet from the source (163 psi) (Hubbs and Rechnitzer 1953; Hubbs et al. 1960; Rulifson and Schoning 1963). In general, burial of the charge at increasing depths in the bottom decreased the general lethal effect, but the effect upon fish mortality appears to be ineffectual for burial depths <10 m (Paterson and Turner 1968).

More recent experimental research, however, has produced more quantitative, predictable models of fish damage and mortality from shock waves based on the theory of bubble (air bladder) oscillation and including the effects of cavitation (Gaspin 1975,; Gaspin et al. 1976; Goertner 1978). Using these estimating procedures, contours of (>50%) fish mortality have been predicted for physoclistous fishes such as spot (*Leiostomus xanthurus*) 18-cm long (comparable to rockfish species encountered near Baadah Point in Neah Bay) over a range of distances from the explosive charge and fish depth. Fish size does effect their survival at various depths, as larger fish have higher survival at shallow depths (because, in part, the larger air bladder does not have time to respond completely) while survival is lower for larger fish in deep waters. The estimation procedure requires approximation of the pressure-time signature, which requires precise information on the charge characteristics. For example, a 5-lb charge of pentolite would produce a maximum pressure of approximately 774 psi with a shock wave decay constant of 0.12 msec to a fish 10 m away from the source of the explosion; the two dimensional pressure envelope would then be determined over different depth strata and distances from the explosion, taking into consideration surface cut-off phenomenon and cavitation (Goertner 1978). This is an elaborate computational procedure which would require more precise information on explosive location, size, depth, etc. for estimating the pressure-time signature for Neah Bay. As a first approximation for the purposes of this report, however, we can scale back Goertner's (1978) calculations of >50% spot mortality for a 32 kg pentolite charge at 9 m depth as an exponential function of the charge weight, i.e., approximately 35% of the maximum pressure at the same distance from the explosion, although surface cut-off and cavitation may produce a somewhat different pressure distribution over depth with the smaller explosion. Using a comparable decrease in the same bubble/air bladder oscillation parameter, we would predict that the extent of the >50% mortality envelope might be approximately 75 to 80 m from the explosion at 5 to 10 m depth.

If the detonation took place approximately equidistant between Waadah Island and Baadah Point, the distance would be ~250 m to each. Thus, most of the large or commercially/ recreationally important physoclistous fishes documented to occur at the Baadah Point intensive study site (copper rockfish, Pacific tomcod) would probably be out of the >50% lethal envelope, and the physostomous (e.g., Pacific salmon) and non-air bladder fishes (e.g., lingcod, kelp greenling) at that site would be even less affected (to an inknown degree). Physoclistous and, to a lesser extent, physostomous pelagic fishes in the water column at the entrance to the Bay, however, would be subjected to higher mortalities. In particular, juvenile smelt, Pacific herring, Pacific sand lance and juvenile salmon, if present, would suffer mortalities depending upon the distance to the explosion. Although the air gun method might be utilized effectively to scare these fishes outside of the lethal pressure range, these fish are rapid-swimming, schooling fishes and might easily return to the area within short periods of time. A potential approach to reduce or eliminate this potential impact would be to limit detonations to a period between November and January, when (as indicated by the January purse seine collections) fish densities are at their extreme minimum and larvae and juveniles have not yet recruited to the Bay. Beach seine and SCUBA transect sampling in January also indicated that the nearshore demersal fishes at Baadah Point were similarly depleted at the same time.

Ultimately, with further, more detailed information on the type and placement of the explosives to be used in Neah Bay, a more accurate picture of the depth-distance mortality envelope can be generated and more detailed predictions of potential fish kills can be made.

4.9.4 Long-term Impacts on Circulation, Sedimentation, and Biotic Production

Placement and long-term operation of the proposed facilities could predictably result in significant changes in circulation and sedimentation within the bay, and an accompanying shift in biotic assemblages and production. Given the surface area of Neah Bay, relative to the ~200,000 m^{-3} of sediment to be removed during construction of the navigational channel, the tidal prism of the bay would probably not be significantly altered. Tidal current velocities, however, would probably be decreased from their present levels and the retention time of water within the Bay increased. As a result, accretion of fine sediments and detritus would increase in the Bay and the areas of fine sediment habits (Fig. 3.1) expand with a concomitant loss of coarser substrate (sand, gravel, rock) habitats. Decreased tidal velocities could also result in decreased transport of detritus into the Bay, although much of that appears to be tied to storm events and surface-generated (wind) transport, which would be theoretically unaffected. Therefore, as long as the Bay remains enclosed by the breakwater, circulation will be influenced principally by the cross sectional area, and any impacts evaluated through the effects of changing that area.

5.0 SUMMARY AND CONCLUSIONS

The fundamental findings of these studies may be summarized as the following:

(1) Among the three intensive study sites, Baadah Point is the most diverse and productive for all the benthic, epibenthic or demersal assemblages examined—nearshore demersal fishes, motile macroinvertebrates, epibenthos, benthos, and macroalgae; Evans Mole is somewhat less diverse and productive; and, Crown Z and the region at the head of the bay is the most depauperate and least productive except where eelgrass persists.

(2) Pelagic fish and zooplankton assemblages are generally ubiquitous through the Bay, with some indication that zooplankton production of certain taxa of calanoid copepods may be enhanced in the western end of the Bay due to the greater residence time of the water column in the closed end of the Bay.

(3) In comparison to the MESA study sites to the east, Neah Bay was found to have equivalent or higher species richness and standing stock of nearshore demersal and pelagic fishes and epibenthos.

(4) The composition and standing stock of epibenthic organisms were related more directly to macrophyte habitats (e.g., *Zostera marina* and *Z. japonica*) than to intensive study sites.

(5) Relatively unique benthos assemblages were found associated with differences in depth and substrate and with the proximity to the entrance to the Bay; as result, Baadah Point was also distinguished by relatively unique assemblages of general benthic taxa and specific benthic bivalves.

(6) Although there were indications of associations between fish assemblage structure and diversity with macrophyte habitats such as eelgrass and kelp beds and other seaweed accumulations (e.g., Ulva) these data did not provide conclusive evidence.

(7) There was, however, considerable overlap among the distribution and standing stock of benthic and epibenthic prey organisms with the benthic- and epibenthic-feeding fishes which were found associated with the macrophyte-rich habitats at Baadah Point.

(8) No populations of commercially or recreationally harvestable fishes were found to be uniquely utilizing Neah Bay for spawning, although adult lingcod and rockfish were observed at the entrance and could have utilized the Baadah Point area for reproduction. Rather, Neah Bay appears to be a major nursery or rearing area for bait- or forage fishes—herrings, smelts, and sand lance—and other fish species (e.g., English sole) which either actively move or are passively advected into the bay as postlarvae and early juveniles. Several large fishes generally unavailable to our sampling gear (cabezon, sturgeon, halibut)

were reported to occur incidentally in commercial fishing nets near our intensive study sites but there was no indication that they were numerous or common.

(9) The greatest potential for long-term environmental impacts resulting from the developments proposed for Neah Bay rests with the direct habitat losses and changes represented by the plan for a rubblemound breakwater-protected marina, estimated to involve alteration of 32,000 m^2 of intertidal and shallow subtidal habitat. Site location will be the primary determinant of the total impact to biotic diversity and production, presumably a lower impact with siting at Crown Z and the head of the bay as compared to Baadah Point and Evans Mole. Significant changes in benthic and epibenthic production will result in all cases. Construction of the deep-draft navigation channel, involving dredging and underwater demolition, could have a comparatively minimal long-term impact if conducted under certain conditions during the seasons of low fish abundance.

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7.0 APPENDICES

7.1 Glossary of Acronyms and Terms

Acronyms

EHHW	extreme higher high water
ELLW	extreme lower low water
EPA	(U.S.) Environmental Protection Agency
FRI	Fisheries Research Institute
MESA	Marine Ecosystem Analysis (Program), sponsored by National Oceanographic and Atmospheric Administration 1976-1979
MLLW	mean lower low water
USFWS	U.S. Fish and Wildlife Service
UW	University of Washington

Terms

allochthonous	exogenous material, herein referring to organic matter such as detritus, originating from outside the study area in which it is found
anadromous	fishes which spend most of their life cycle at sea but migrate from saltwater to fresh waters to spawn
autochthonous	endogenous material, herein referring to organic matter such as detritus, which originates within the area of study
autotrophic	capable of manufacturing food (synthesizing organic compounds) from inorganic constituents; typically photosynthetic plants
benthic	associated with the seabed substrate
benthos	organisms which live within or on the seabed
biomass	total organic mass of organisms or matter (e.g., detritus) at a given time
chlorophyll	green pigments identified from their spectral properties as chlorophylls a, b, and c, important in process of photosynthesis
community	the total assemblage of organisms, plant and animal, inhabiting a given area
consumers	heterotrophic organisms which obtain their nutrition from particulate organic matter
density	number (e.g., of animals or plants) found within a unit (space area or volume) of water, substrate, etc.
diel	through the (24-hr) day-night cycle
diurnal	pertaining to organisms which are active during daylight

detritus	fragments of detached or degraded organic and inorganic material, usually settleable
diversity	variety of taxa within a given association of organisms; usually includes both species richness and evenness terms
epibenthos	organisms which live in benthic boundary layer at interface between seabed and water column; can also apply to motile macroinvertebrates which live on seabed
facultative	capability of organism to live under varying conditions, e.g., can tolerate variable water quality, utilize different food resources, etc.
food chain	sequence of organisms on successive trophic levels within a community through which energy is transferred by heterotrophic processes
food web	network of interconnected food chains
forage fish	small, usually prolific, schooling species, which are important as food for secondary consumers
habitat	a specific type of place (biotope) that is occupied by an organism, population, or community
herbivore	organisms which feed on plant material
intertidal	zone between highest (EHHW) and lowest (ELLW) tides
macro-	organisms or materials visible to the unaided eye; usually applied to fauna which are retained on a 0.500-mm sieve
macrophyte	any plant that is visible with the naked, unaided eye
meio-	between macro- and micro- in size; usually defined as fauna which pass through a 1-mm sieve but retained on a 0.60-mm sieve
micro-	organisms and material invisible to the unaided eye; usually defined as fauna passing through a 0.60-mm to 0.1-mm sieve
neuston	organisms associated with, or dependent upon, the surface film (air-water interface) of bodies of water
nocturnal	pertaining to organisms which are active at night
obligate	constrained to a limited range of environmental conditions, as fauna restricted to narrow salinity or temperature ranges or selected food resources
planktonic	organisms or material suspended in water column; usually defines fauna with relatively low or no powers of locomotion
predator	animal that consumers other animals; secondary or tertiary (trophic level) consumers
primary productivity	total potential rate of incorporation of energy or organic matter generated by an individual, population or community of autotrophic organisms
producers	autotrophic organisms
respiration	chemical and physical reactions by living organisms in which energy and nutrients in foods are made available for use; oxygen is used and carbon dioxide and water are produced during this process

standing crop	biomass of organisms per unit space, area or volume
standing stock	general term describing quantity, including both density and standing crop, of organisms per unit space
secondary productivity	total potential rate of incorporation of energy or organic matter generated by an individual, population or community of consumer (heterotrophic) organisms
sessile	organisms which are attached to substrate and not free to move about
subtidal	zone extending from lower end of intertidal zone (ELLW) to outer edge of continental shelf at a depth of about 200 m or, under some definitions, to the lower extent of photic zone
trophic	pertaining to nutrition; as in trophic level, that position in food web in which organisms secure food in same general manner

For further definition of these and other terms, see:

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7.2 Fish Species List and Overall Occurrence

Occurrence of all fish species caught during 1986-87 Neah Bay community study; BP = Baadah Point, EM = Evans Mole, CZ = Crown Zellerbach, MC = Mid-Channel, TB = Turning Basin; nomenclature according to Robins et al. (1980).

1.	Big Skate, *Raja binoculata* Girard 1854	BP				
2.	Spotted Ratfish *Hydrolagus colliei* (Lay & Bennett 1839)					TB
3.	American Shad, *Alosa sapidissima* (Wilson 1812)		EM			
4.	Pacific Herring, *Clupea harengus pallasi* Valenciennes 1847	BP	EM	CZ		
5.	Northern Anchovy, *Engraulis mordax* Girard 1854	BP	EM	CZ		
6.	Pink Salmon, *Oncorhynchus gorbuscha* (Walbaum 1792)	BP	EM			
7.	Chum Salmon, *Oncorhynchus keta* (Walbaum 1792)	BP	EM			
8.	Coho Salmon, *Oncorhynchus kisutch* (Walbaum 1792)	BP	EM	CZ		

9.	Chinook Salmon, *Oncorhynchus tshawytscha* (Walbaum 1792)	BP	EM	CZ		
10.	Surf Smelt, *Hypomesus pretiosus* (Girard 1855)	BP	EM	CZ		
11.	Whitebait Smelt, *Allosmerus elongatus* (Ayres 1854)	BP				
12.	Northern Clingfish, *Gobiesox meandricus* (Girard 1858)	BP				
13.	Pacific Cod, *Gadus macrocephalus* Tilesius 1810	BP			MC	
14.	Pacific Tomcod, *Microgadus proximus* (Girard 1854)	BP				TB
15.	Walleye Pollock, *Theragra chalcogramma* (Pallas 1811)	BP				TB
16.	Tube-snout, *Aulorhynchus flavidus* Gill 1861	BP	EM	CZ		
17.	Bay Pipefish, *Syngnathus leptorhynchus* Girard 1854	BP				
18.	Shiner Perch, *Cymatogaster aggregata* Gibbons 1854			CZ		
19.	Striped Seaperch, *Embiotoca lateralis* Agassiz 1854	BP	EM			
20.	High Cockscomb, *Anoplarchus purpourescens* Gill 1861	BP		CZ		
21.	Mosshead Warbonnet, *Chirolophis nugator* (Jordan & Williams 1895)			CZ		
22.	Penpoint Gunnel, *Apodichthys flavidus* Girard 1854	BP	EM	CZ		
23.	Cresent Gunnel, *Pholis laeta* (Cope 1873)	BP	EM	CZ		
24.	Saddleback Gunnel, *Pholis ornata* (Girard 1854)		EM			
25.	Pacific Sand Lance, *Ammodytes hexapterus* Pallas 1811	BP	EM			
26.	Brown Rockfish, *Sebastes auriculatus* Girard 1854	BP				
27.	Copper Rockfish, *Sebastes caurinus* Richardson 1854	BP			MC	
28.	Quillback Rockfish, *Sebastes maliger* (Jordan & Gilbert 1880)	EM	MC			
29.	Black Rockfish, *Sebastes melanops* Girard 1856	BP				

30.	Kelp Greenling, *Hexagrammos decagrammus* (Pallas 1810)	BP	EM	CZ	MC	
31.	Lingcod, *Ophiodon elongatus* Girard 1854	BP		CZ	MC	
32.	Padded Sculpin, *Artedius fenestralis* Jordan & Gilbert 1882				MC	
33.	Scalyhead Sculpin, *Artedius harringtoni* (Starks 1896)				MC	
34.	Smoothhead Sculpin, *Artedius lateralis* (Girard 1854)				MC	
35.	Bonyhead Sculpin, *Artedius notospilotus* Girard 1854					TB
36.	Coralline Sculpin, *Artedius corallinus* Girard 1854		EM			
37.	Rosylip Sculpin, *Ascelichthys rhodorus* Jordan & Gilbert	BP			MC	
38.	Silverspotted Sculpin, *Blepsias cirrhosus* (Pallas 1811)	BP	EM			
39.	Roughback Sculpin, *Chitonotus pugentensis* (Stiendachner 1877)				MC	
40.	Sharpnose Sculpin, *Clinocottus acuticeps* (Gilbert 1895)		EM	CZ		
41.	Buffalo Sculpin, *Enophrys bison* (Girard 1854)	BP	EM	CZ	MC	
42.	Red Irish Lord, *Hemilepidotus hemilepidotus* (Tilesius 1810)	BP			MC	
43.	Brown Irish Lord, *Hemilepidotus spinosus* (Ayres 1855)				MC	
44.	Pacific Staghorn Sculpin, *Leptocottus armatus* Girard 1854	BP	EM	CZ		
45.	Great Sculpin, *Myoxocephalus polycanthocephalus* (Pallas 1811)	BP	EM			
46.	Sailfin Sculpin, *Nautichthys oculufasciatus* (Girard 1857)	BP	EM		MC	
47.	Tidepool Sculpin, *Oligocottus maculosus* Girard 1856	BP	EM	CZ		
48.	Saddleback Sculpin, *Oligocottus rimensis* (Greely 1901)	BP				
49.	Fluffy Sculpin, *Oligocottus snyderi* Greely 1901			CZ		
50.	Cabezon, *Scorpaenichthys marmoratus* (Ayres 1854)	BP	EM			

51.	Manacled Sculpin, *Synchirus gilli* Bean 1889	BP				
52.	Sturgeon Poacher, *Argonus acipenserinus* Tilesius 1811				MC	TB
53.	Warty Poacher, *Occella verrucosa* (Lockington)	BP				
54.	Tubenose Poacher, *Pallasina barbata* (Steindachner 1877)	BP				
55.	Pacific Spiny Lumpsucker, *Eumicrotremus orbis* (Gunther 1861)	BP			MC	
56.	Tidepool Snailfish, *Liparis florae* (Jordan & Starks 1895)	BP				
57.	Slipskin Snailfish, *Liparis fucensis* Gilbert 1895	BP				
58.	Slimy Snailfish, *Liparis mucosus* Ayres 1855	BP				
59.	Speckled Sanddab *Citharichthys stigmaeus* Jordan & Gilbert 1882	BP	EM	CZ	MC	TB
60.	Rock Sole, *Pleuronectes* (*Lepidopsetta*) *bilineata* (Ayres 1855)	BP			MC	
61.	English Sole, Pleuronectes (*Parophrys*) *vetulus* Girard 1854	BP	EM		MC	TB
62.	Starry Flounder, *Platichthys stellatus* (Pallas 1811)	BP	EM	CZ		
63.	Sand Sole *Psettichthys melanostictus* Girard 1854	BP	EM			
	Total Species/Sampling Site	47	29	20	19	7

7.3 Fish Stomach Contents Analyses IRI Summaries

The following tabulations and diagrams delineate the composition of the diets of nearshore demersal and pelagic fishes caught in Neah Bay, May-July 1986; they are arranged as discussed in the text (Section 3.5)

```
STOMACH ANALYSIS                                                        PAGE  1
****************
   SPECIES  8755010202-ONCORHYNCHUS KETA                        CHUM SALMON

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ---------------------------------------------------------------------------
                     86JY17          P 1          02116         2         1440
                     86MY21          B 1          02116        17         1730
                     86MY21          B 2          02116         3         1845

LIFE HISTORY STAGE
                     22 JUVENILE
                     ---
TOTAL SAMPLE SIZE    22


NUMBER OF EMPTY STOMACHS          0
PERCENTAGE OF EMPTY STOMACHS        .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)      22


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                             MEAN    RANGE    S.D.
                            -------------------------
CONDITION FACTOR              4.8    2.-6.     1.1
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR              4.6    4.-5.      .5
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT         .14    NEG.-
   (GRAMS)                             .71     .15
TOTAL CONTENTS ABUNDANCE    287.3     2.0-
   (NUMBERS)                         5618.0 1191.2
NO. PREY CATEGORIES           3.5     1.-
   (PER STOMACH)                        9.     2.4
LENGTH                       60.2    36.-
   (MM)                                119.  20.58
WEIGHT                       3.13    .43-
   (GRAMS)                            17.80   3.87
PCT RATIO OF CONTENTS        5.92    .09-
   WT TO PREDATOR WT                  13.62   3.12

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM       LIFE                   NUMBER          *          BIOMASS             *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN    RANGE  S.D. *   TOTAL   MEAN   RANGE   S.D. *  MEAN   S.D.  * ABUN-          NORM.
  PARTS CODE       STAGE  OCCUR                            *                               *               * DANCE BIOMASS BIOMASS
-----------------------------------------------------------------------------------------------------------------------------------

HYDROZOA                         1     .0     1-      .2       .00     .00   NEG.-     .00   .0001 .0000       .02     .00     .00
                C-J/A NOSEX  4.5                1                            NEG.
POLYCHAETA                       1     .0     1-      .2       .02     .00   .02-      .00   .0160 .0000       .02     .51     .61
                C-J/A NOSEX  4.5                1                              .02
CALANOIDA                        2     .1     2-      .4       .00     .00   .00-      .00   .0005 .0000       .03     .03     .04
                C-J/A NOSEX  4.5                2                              .00
```

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STOMACH ANALYSIS                                                     PAGE  2
****************
   SPECIES  8755010202-ONCORHYNCHUS KETA                 CHUM SALMON
PREY ORGANISM       LIFE                 NUMBER           *             BIOMASS              *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN    RANGE   S.D.  *   MEAN  S.D.  *  ABUN-           NORM.
  PARTS CODE       STAGE  OCCUR                           *                                  *               *  DANCE BIOMASS BIOMASS
 ---------------------------------------------------------------------------------------------------------------------------------
CALANUS SP.                        8      .4    4-    1.2        .00    .00    .00-     .00    .0005 .0000       .13    .13    .15
               A-JUV+ADULT   9.1                  4                              .00
CALANUS SP.                        1      .0    1-     .2        .00    .00   NEG.-     .00    .0001 .0000       .02    .00    .00
               F-COPEPODID   4.5                  1                             NEG.
HARPACTICOIDA                      3      .1    1-     .5        .00    .00   NEG.-     .00    .0001 .0000       .05    .01    .01
               7-JUVENILE    9.1                  2                             NEG.
HARPACTICOIDA                      3      .1    3-     .6        .00    .00   NEG.-     .00    .0000 .0000       .05    .00    .00
                -UNKNOWN     4.5                  3                             NEG.
HARPACTICUS SP.                    1      .0    1-     .2        .00    .00   NEG.-     .00    .0001 .0000       .02    .00    .00
               7-JUVENILE    4.5                  1                             NEG.
HARPACTICUS SP.-UNIREMIS GROUP     4      .2    4-     .9        .00    .00   NEG.-     .00    .0000 .0000       .06    .00    .00
               A-JUV+ADULT   4.5                  4                             NEG.
HARPACTICUS SP.-UNIREMIS GROUP    14      .6   14-    3.0        .00    .00    .00-     .00    .0001 .0000       .22    .06    .08
               C-J/A NOSEX   4.5                 14                              .00
ZAUS SP.                           1      .0    1-     .2        .00    .00   NEG.-     .00    .0001 .0000       .02    .00    .00
               8-ADULT       4.5                  1                             NEG.
ZAUS SP.                           1      .0    1-     .2        .00    .00   NEG.-     .00    .0001 .0000       .02    .00    .00
               A-JUV+ADULT   4.5                  1                             NEG.
ZAUS SP.                           4      .2    4-     .9        .00    .00   NEG.-     .00    .0000 .0000       .06    .00    .00
               C-J/A NOSEX   4.5                  4                             NEG.
SCUTELLIDIUM SP.                  27     1.2    3-    5.1        .00    .00   NEG.-     .00    .0000 .0000       .43    .01    .01
               7-JUVENILE    9.1                 24                             NEG.
SCUTELLIDIUM SP.                  14      .6   14-    3.0        .00    .00   NEG.-     .00    .0000 .0000       .22    .00    .00
               A-JUV+ADULT   4.5                 14                             NEG.
BALANOMORPHA                    5600   254.5 5600- 1193.9        .02    .00    .02-     .00    .0000 .0000     88.61    .51    .61
               2-NAUPLIUS    4.5               5600                              .02
IDOTEIDAE                          1      .0    1-     .2        .00    .00    .00-     .00    .0010 .0000       .02    .03    .04
               C-J/A NOSEX   4.5                  1                              .00
GAMMARIDEA                         3      .1    1-     .5        .00    .00   NEG.-     .00    .0001 .0000       .05    .01    .01
               7-JUVENILE    9.1                  2                             NEG.
GAMMARIDEA                         1      .0    1-     .2        .00    .00   NEG.-     .00    .0001 .0000       .02    .00    .00
               C-J/A NOSEX   4.5                  1                             NEG.
CALLIOPIIDAE                       6      .3    6-    1.3        .00    .00    .00-     .00    .0003 .0000       .09    .06    .08
               7-JUVENILE    4.5                  6                              .00
CALLIOPIIDAE                       9      .4    9-    1.9        .01    .00    .01-     .00    .0011 .0000       .14    .32    .38
               C-J/A NOSEX   4.5                  9                              .01
HYALE SP.                          3      .1    3-     .6        .00    .00    .00-     .00    .0003 .0000       .05    .03    .04
               7-JUVENILE    4.5                  3                              .00
ISCHYROCERUS SP.                   3      .1    3-     .6        .00    .00    .00-     .00    .0003 .0000       .05    .03    .04
               A-JUV+ADULT   4.5                  3                              .00
PARATHEMISTO PACIFICA              1      .0    1-     .2        .00    .00   NEG.-     .00    .0001 .0000       .02    .00    .00
               C-J/A NOSEX   4.5                  1                             NEG.
DECAPODA                           3      .1    1-     .5        .00    .00   NEG.-     .00    .0001 .0000       .05    .01    .01
               3-ZOEA        9.1                  2                             NEG.
ANOMURA                            1      .0    1-     .2        .00    .00    .00-     .00    .0010 .0000       .02    .03    .04
               3-ZOEA        4.5                  1                              .00
PORCELLANIDAE                      2      .1    2-     .4        .00    .00   NEG.-     .00    .0000 .0000       .03    .00    .00
               3-ZOEA        4.5                  2                             NEG.
INSECTA                            4      .2    4-     .9        .01    .00    .01-     .00    .0015 .0000       .06    .19    .23
               8-ADULT       4.5                  4                              .01
COLLEMBOLA                         3      .1    3-     .6        .00    .00   NEG.-     .00    .0000 .0000       .05    .00    .00
               A-JUV+ADULT   4.5                  3                             NEG.
COLLEMBOLA                         4      .2    2-     .6        .00    .00    .00-     .00    .0005 .0000       .06    .06    .08
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                     C-J/A NOSEX    9.1                2                            .00
PLECOPTERA                                1    .0     1-     .2      .00    .00   NEG.-     .00   .0001 .0000     .02    .00    .00
                     6-LARVA        4.5                1                           NEG.
PSOCOPTERA                                2    .1     2-     .4      .00    .00    .00-     .00   .0015 .0000     .03    .10    .11
                     8-ADULT        4.5                2                            .00
HOMOPTERA-CICADOIDEA                      2    .1     1-     .3      .00    .00   NEG.-     .00   .0001 .0000     .03    .01    .01
                     7-JUVENILE     9.1                1                           NEG.
HOMOPTERA-CICADOIDEA                      3    .1     1-     .5      .00    .00   NEG.-     .00   .0001 .0000     .05    .01    .01
                     C-J/A NOSEX    9.1                2                           NEG.
APHIDIDAE                                 3    .1     1-     .5      .00    .00   NEG.-     .00   .0003 .0003     .05    .04    .04
                     8-ADULT        9.1                2                            .00
APHIDIDAE                                 2    .1     2-     .4      .00    .00   NEG.-     .00   .0000 .0000     .03    .00    .00
                     C-J/A NOSEX    4.5                2                           NEG.
DIPTERA                                   6    .3     2-     .9      .01    .00    .00-     .00   .0011 .0005     .09    .19    .23
                     8-ADULT        9.1                4                            .00
DIPTERA                                   1    .0     1-     .2      .00    .00    .00-     .00   .0030 .0000     .02    .10    .11
                     C-J/A NOSEX    4.5                1                            .00
NEMATOCERA                                1    .0     1-     .2      .00    .00   NEG.-     .00   .0001 .0000     .02    .00    .00
                     8-ADULT        4.5                1                           NEG.
DIPTERA-CHIRONOMIDAE                     21   1.0     4-    2.7      .01    .00    .00-     .00   .0003 .0002     .33    .16    .19
                     8-ADULT       13.6               11                            .00
DIPTERA-CHIRONOMIDAE                    226  10.3    45-   23.0      .05    .00    .01-     .01   .0002 .0001    3.58   1.57   1.87
                     9-LR+JV+AD    18.2               78                            .02
DIPTERA-CHIRONOMIDAE                    210   9.5     2-   31.8      .08    .00    .00-     .01   .0007 .0006    3.32   2.50   2.97
                     A-JUV+ADULT   18.2              145                            .05
DIPTERA-BRACHYCERA                        1    .0     1-     .2      .00    .00    .00-     .00   .0030 .0000     .02    .10    .11
                     8-ADULT        4.5                1                            .00
OSTEICHTHYES                             42   1.9     1-    4.1     1.13    .05    .01-     .15   .0251 .0274     .66  36.10  42.91
                     6-LARVA       22.7               12                            .64
OSTEICHTHYES                              1    .0     1-     .2      .09    .00    .09-     .02   .0890 .0000     .02   2.86   3.39
  1-UNIDENT.         A-JUV+ADULT    4.5                1                            .09
OSTEICHTHYES                              2    .1     2-     .4      .09    .00    .09-     .02   .0440 .0000     .03   2.82   3.36
                     C-J/A NOSEX    4.5                2                            .09
TELEOSTEI                                34   1.5     4-    3.2      .46    .02    .01-     .05   .0126 .0055     .54  14.67  17.43
                     6-LARVA       22.7               11                            .15
CLUPEA HARENGUS PALLASI                  32   1.5     3-    3.7      .65    .03    .11-     .07   .0266 .0190     .51  20.83  24.75
                     6-LARVA       18.2               14                            .25
INORGANIC                                 1    .0     1-     .2      .00    .00   NEG.-     .00   .0001 .0000     .02    .00    .00
                     C-J/A NOSEX    4.5                1                           NEG.
UNIDENTIFIED MATERIAL                                                .49    .03    .00-     .03                         15.86
                                                                                   .09

TOTAL NUMBER OF PREY CATEGORIES   49

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS       .89
                                             BIOMASS      2.34
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS               .87
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STOMACH ANALYSIS                                                PAGE  2
****************
   SPECIES: 8755010202-ONCORHYNCHUS KETA                 CHUM SALMON

            INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
            USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
            ******************************************

                                    FREQ   NUM.   GRAV.   PREY    PERCENT
          PREY ITEM                 OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
   ----------------------------     -----  -----  -----   ------  ---------

  DIPTERA-CHIRONOMIDAE              50.00   7.23   5.03   613.3    18.54
  OSTEICHTHYES                      27.27    .71  49.66  1373.7    41.54
  TELEOSTEI                         22.73    .54  17.43   408.4    12.35
  HOMOPTERA-CICADOIDEA              18.18    .08    .02     1.7      .05
  CLUPEA HARENGUS PALLASI           18.18    .51  24.75   459.2    13.89
  COLLEMBOLA                        13.64    .11    .08     2.6      .08
  CALANUS SP.                       13.64    .14    .16     4.1      .12
  APHIDIDAE                         13.64    .08    .05     1.7      .05
  DIPTERA                           13.64    .11    .34     6.2      .19
  HARPACTICOIDA                     13.64    .09    .01     1.5      .04
  ZAUS SP.                          13.64    .09    .01     1.5      .04
  SCUTELLIDIUM SP.                  13.64    .65    .01     9.0      .27
  GAMMARIDEA                        13.64    .06    .01     1.0      .03
  DECAPODA                           9.09    .05    .01      .5      .02
  HARPACTICUS SP.-UNIREMIS GROUP     9.09    .28    .08     3.3      .10
  CALLIOPIIDAE                       9.09    .24    .46     6.3      .19
  BALANOMORPHA                       4.55  88.61    .61   405.5    12.26

    PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
    COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
    (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

       PERCENT DOMINANCE INDEX,              .79    .34               .26
       SHANNON-WEINER DIVERSITY              .78   1.92              2.26
       EVENNESS INDEX,                       .15    .38               .45
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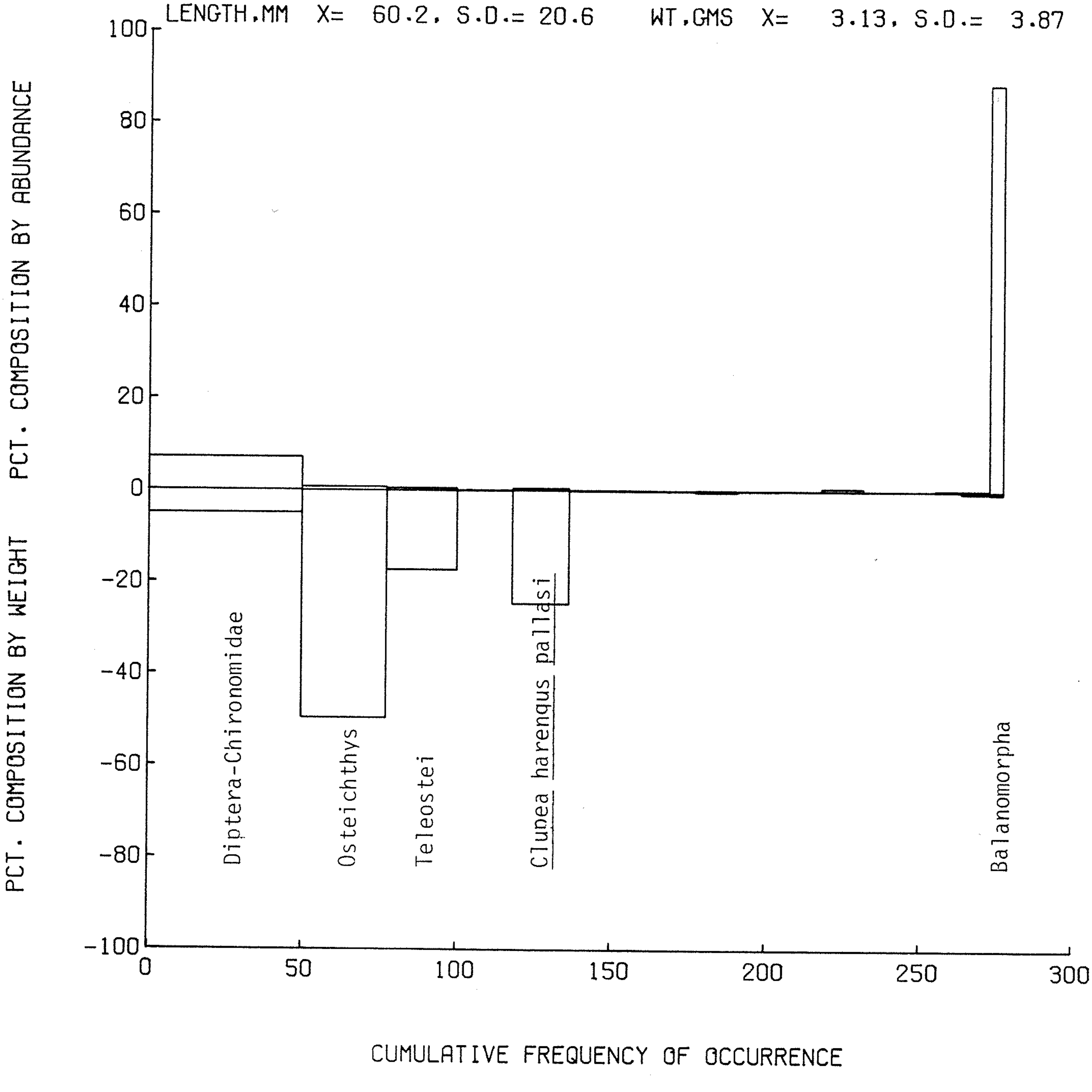
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL
PREDATOR 8755010202 - ONCORHYNCHUS KETA
(CHUM SALMON) ADJUSTED SAMPLE SIZE = 22



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STOMACH ANALYSIS                                                     PAGE  1
****************
   SPECIES  8791030701-THERAGRA CHALCOGRAMMA            WALLEYE POLLOCK

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 -------------------------------------------------------------------------
                       86JY18          B 1           02116           5            700

LIFE HISTORY STAGE
                        5 JUVENILE
                      ---
TOTAL SAMPLE SIZE       5


NUMBER OF EMPTY STOMACHS         0
PERCENTAGE OF EMPTY STOMACHS      .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)      5


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                            MEAN     RANGE     S.D.
                           -------------------------
CONDITION FACTOR             5.2     4.-6.      .8
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR             4.8     4.-5.      .4
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT        .07     NEG.-
   (GRAMS)                              .13     .05
TOTAL CONTENTS ABUNDANCE   183.2      5.0-
   (NUMBERS)                        282.0   104.9
NO. PREY CATEGORIES         11.8      5.-
   (PER STOMACH)                      21.      6.1
LENGTH                      60.6      52.-
   (MM)                               65.     5.13
WEIGHT                      1.95     1.40-
   (GRAMS)                           2.48      .42
PCT RATIO OF CONTENTS       3.24     .36-
   WT TO PREDATOR WT                 5.04     1.97

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM       LIFE                     NUMBER             *           BIOMASS                *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE   S.D.  *     TOTAL    MEAN     RANGE    S.D.  *   MEAN   S.D.  *  ABUN-          NORM.
  PARTS CODE       STAGE  OCCUR                             *                                      *                *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------------------------
POLYCHAETA                        3     .6     1-      .9        .03     .01     .00-       .01     .0138 .0187        .33    8.20   10.01
               C-J/A NOSEX  40.0                2                                  .03
GASTROPODA                        1     .2     1-      .4        .00     .00     .00-       .00     .0020 .0000        .11     .59     .72
               C-J/A NOSEX  20.0                1                                  .00
OSTRACODA                         1     .2     1-      .4        .00     .00     NEG.-      .00     .0001 .0000        .11     .03     .04
               C-J/A NOSEX  20.0                1                                NEG.
EUPHILOMEDES CARCHARODONTOA       4     .8     1-     1.3        .01     .00     .00-       .00     .0023 .0009        .44    2.34    2.86
               8-ADULT      40.0                3                                  .01
CALANOIDA                         1     .2     1-      .4        .00     .00     NEG.-      .00     .0001 .0000        .11     .03     .04
               F-COPEPODID  20.0                1                                NEG.
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STOMACH ANALYSIS                                                          PAGE  2
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   SPECIES  8791030701-THERAGRA CHALCOGRAMMA            WALLEYE POLLOCK
PREY ORGANISM      LIFE               NUMBER              *          BIOMASS                  *  AVE. BIOMASS*     PERCENTAGES
                 HISTORY FREQ  TOTAL  MEAN   RANGE   S.D. *    TOTAL   MEAN    RANGE    S.D.  *   MEAN  S.D. *  ABUN-            NORM.
  PARTS CODE      STAGE  OCCUR                            *                                   *              *  DANCE BIOMASS BIOMASS
-----------------------------------------------------------------------------------------------------------------------------------
CENTROPAGES SP.                      2     .4    2-       .9       .00     .00   NEG.-     .00    .0000 .0000        .22     .03     .04
               A-JUV+ADULT  20.0                   2                             NEG.
ACARTIA SP.                          4     .8    4-      1.8       .00     .00   NEG.-     .00    .0000 .0000        .44     .03     .04
               A-JUV+ADULT  20.0                   4                             NEG.
HARPACTICOIDA                       12    2.4    1-      4.3       .00     .00   NEG.-     .00    .0001 .0001       1.31     .09     .11
               8-ADULT      60.0                  10                             NEG.
PORCELLIDIUM SP.                     1     .2    1-       .4       .00     .00   NEG.-     .00    .0001 .0000        .11     .03     .04
               8-ADULT      20.0                   1                             NEG.
HARPACTICUS SP.-OBSCURUS GROUP       4     .8    4-      1.8       .00     .00   NEG.-     .00    .0000 .0000        .44     .03     .04
               8-ADULT      20.0                   4                             NEG.
ZAUS SP.                            49    9.8    1-      9.1       .00     .00   NEG.-     .00    .0000 .0000       5.35     .41     .50
               8-ADULT     100.0                  24                              .00
ZAUS SP.                             6    1.2    6-      2.7       .00     .00   NEG.-     .00    .0000 .0000        .66     .03     .04
               L-EGG-C FEM  20.0                   6                             NEG.
TISBE SP.                           93   18.6    1-     19.0       .01     .00   NEG.-     .00    .0001 .0000      10.15    1.49    1.82
               8-ADULT      80.0                  46                              .00
TISBE SP.                           70   14.0   70-     31.3       .00     .00    .00-     .00    .0000 .0000       7.64     .59     .72
               A-JUV+ADULT  20.0                  70                              .00
AMONARDIA PERTURBATA                 2     .4    2-       .9       .00     .00   NEG.-     .00    .0000 .0000        .22     .03     .04
               8-ADULT      20.0                   2                             NEG.
PARATHALESTRIS SP.                   1     .2    1-       .4       .00     .00   NEG.-     .00    .0001 .0000        .11     .03     .04
               8-ADULT      20.0                   1                             NEG.
CYCLOPOIDA                           4     .8    4-      1.8       .00     .00   NEG.-     .00    .0000 .0000        .44     .03     .04
               8-ADULT      20.0                   4                             NEG.
OITHONA SP.                          1     .2    1-       .4       .00     .00   NEG.-     .00    .0001 .0000        .11     .03     .04
               8-ADULT      20.0                   1                             NEG.
OITHONA SP.                          1     .2    1-       .4       .00     .00   NEG.-     .00    .0001 .0000        .11     .03     .04
               F-COPEPODID  20.0                   1                             NEG.
DIASTYLOPSIS TENUIS                515  103.0  100-     62.8       .17     .03    .02-     .02    .0003 .0001      56.22   49.52   60.44
               A-JUV+ADULT  80.0                 167                              .06
ISOPODA                              1     .2    1-       .4       .00     .00   NEG.-     .00    .0001 .0000        .11     .03     .04
               L-EGG-C FEM  20.0                   1                             NEG.
IDOTEA SP.                           2     .4    2-       .9       .00     .00    .00-     .00    .0005 .0000        .22     .29     .36
               7-JUVENILE   20.0                   2                              .00
GAMMARIDEA                           1     .2    1-       .4       .00     .00    .00-     .00    .0030 .0000        .11     .88    1.07
  1-UNIDENT.   8-ADULT      20.0                   1                              .00
GAMMARIDEA                          11    2.2    4-      3.2       .00     .00    .00-     .00    .0002 .0001       1.20     .59     .72
               A-JUV+ADULT  40.0                   7                              .00
GAMMARIDEA                           8    1.6    8-      3.6       .01     .00    .01-     .00    .0009 .0000        .87    2.05    2.50
               C-J/A NOSEX  20.0                   8                              .01
PONTOGENEIA SP. CF ROSTRATA          3     .6    3-      1.3       .00     .00    .00-     .00    .0010 .0000        .33     .88    1.07
               A-JUV+ADULT  20.0                   3                              .00
PONTOGENEIA SP. CF ROSTRATA          1     .2    1-       .4       .00     .00    .00-     .00    .0010 .0000        .11     .29     .36
               C-J/A NOSEX  20.0                   1                              .00
PHOTIS SP.                          59   11.8    7-     13.9       .03     .01    .00-     .01    .0005 .0001       6.44    9.38   11.44
               A-JUV+ADULT  80.0                  36                              .02
PROTOMEDEIA SP.                      1     .2    1-       .4       .00     .00   NEG.-     .00    .0001 .0000        .11     .03     .04
               7-JUVENILE   20.0                   1                             NEG.
ISCHYROCERUS SP.                    17    3.4    3-      3.8       .00     .00    .00-     .00    .0003 .0001       1.86    1.17    1.43
               A-JUV+ADULT  60.0                   9                              .00
ISCHYROCERUS SP.                     4     .8    4-      1.8       .00     .00    .00-     .00    .0003 .0000        .44     .29     .36
               C-J/A NOSEX  20.0                   4                              .00
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STOMACH ANALYSIS                                                        PAGE  3
****************
   SPECIES  8791030701-THERAGRA CHALCOGRAMMA            WALLEYE POLLOCK

PREY ORGANISM       LIFE               NUMBER        *           BIOMASS              * AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN    RANGE    S.D. *  MEAN  S.D. * ABUN-            NORM.
  PARTS CODE       STAGE  OCCUR                           *                                 *              * DANCE BIOMASS BIOMASS
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SYNCHELIDIUM SP.                   6    1.2     6-    2.7        .00     .00    .00-      .00   .0002 .0000      .66    .29    .36
               A-JUV+ADULT  20.0                 6                                 .00
SYNCHELIDIUM SP.                   1     .2     1-     .4        .00     .00    NEG.-     .00   .0001 .0000      .11    .03    .04
               C-J/A NOSEX  20.0                 1                                NEG.
SYNCHELIDIUM SHOEMAKERI           10    2.0    10-    4.5        .00     .00    .00-      .00   .0002 .0000     1.09    .59    .72
               A-JUV+ADULT  20.0                10                                 .00
SYNCHELIDIUM SHOEMAKERI           12    2.4    12-    5.4        .00     .00    .00-      .00   .0003 .0000     1.31    .88   1.07
               C-J/A NOSEX  20.0                12                                 .00
CAPRELLIDEA                        1     .2     1-     .4        .00     .00    NEG.-     .00   .0001 .0000      .11    .03    .04
               C-J/A NOSEX  20.0                 1                                NEG.
CAPRELLA SP.                       1     .2     1-     .4        .00     .00    .00-      .00   .0020 .0000      .11    .59    .72
               C-J/A NOSEX  20.0                 1                                 .00
PLEOCYEMATA-CARIDEA                1     .2     1-     .4        .00     .00    NEG.-     .00   .0001 .0000      .11    .03    .04
               3-ZOEA       20.0                 1                                NEG.
PINNOTHERIDAE                      1     .2     1-     .4        .00     .00    NEG.-     .00   .0001 .0000      .11    .03    .04
               3-ZOEA       20.0                 1                                NEG.
UNIDENTIFIED MATERIAL                                            .06     .02    .00-      .01                         18.08
                                                                                .03

TOTAL NUMBER OF PREY CATEGORIES   39

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS       2.59
                                             BIOMASS       2.31
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS               2.50
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STOMACH ANALYSIS                                                PAGE  2
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   SPECIES: 8791030701-THERAGRA CHALCOGRAMMA              WALLEYE POLLOCK

           INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
           USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
           *****************************************

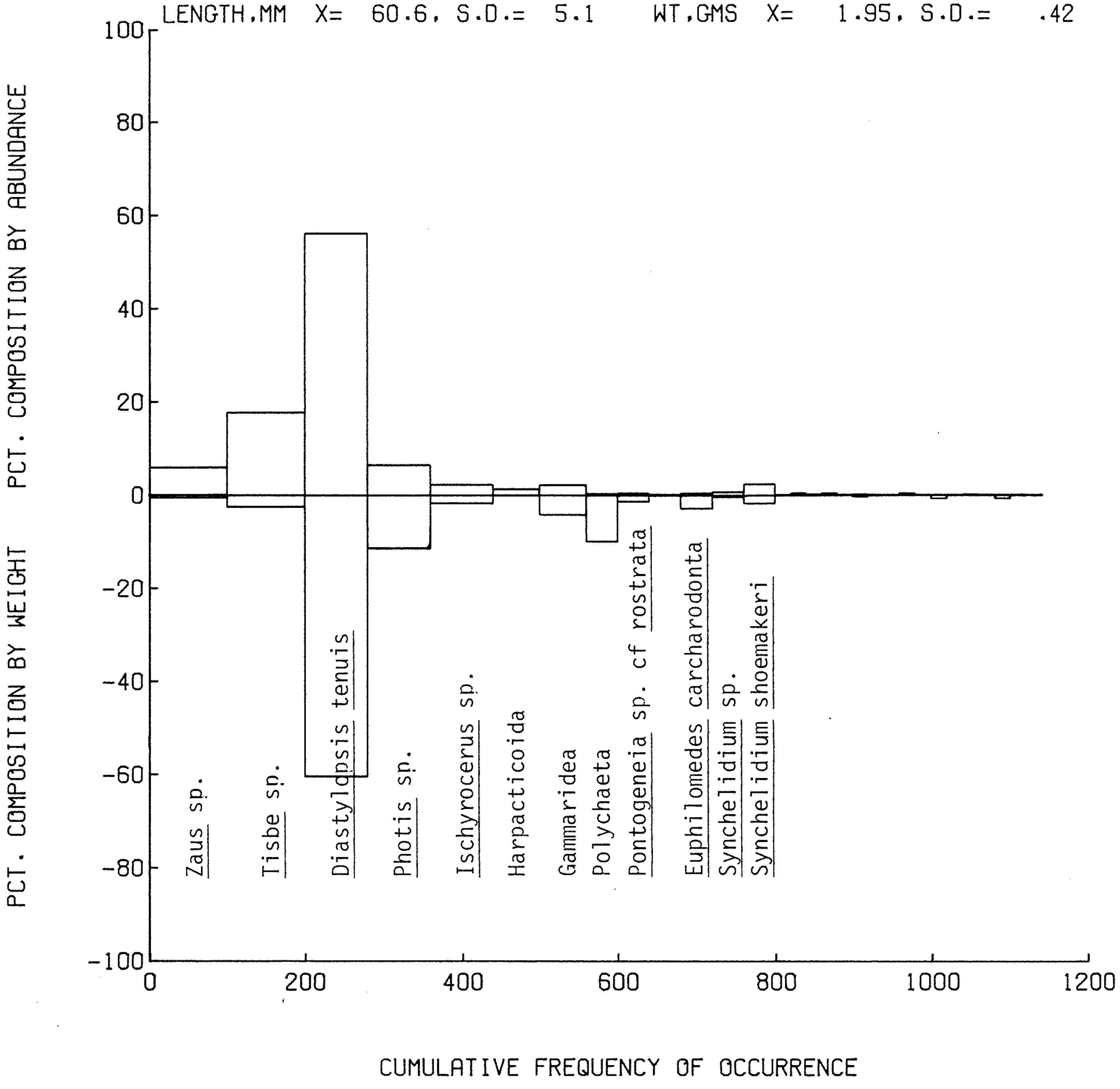
                                  FREQ   NUM.   GRAV.  PREY     PERCENT
        PREY ITEM                 OCCUR  COMP.  COMP.  I.R.I.   TOTAL IRI
 ---------------------------      -----  -----  -----  ------   ---------

 ZAUS SP.                        100.00   6.00    .50   650.5      4.28
 TISBE SP.                       100.00  17.79   2.54  2033.5     13.37
 DIASTYLOPSIS TENUIS              80.00  56.22  60.47  9335.0     61.39
 PHOTIS SP.                       80.00   6.44  11.45  1431.2      9.41
 ISCHYROCERUS SP.                 80.00   2.29   1.79   326.5      2.15
 HARPACTICOIDA                    60.00   1.31    .11    85.0       .56
 GAMMARIDEA                       60.00   2.18   4.29   388.6      2.56
 POLYCHAETA                       40.00    .33  10.02   413.8      2.72
 PONTOGENEIA SP. CF ROSTRATA      40.00    .44   1.43    74.7       .49
 OITHONA SP.                      40.00    .22    .07    11.6       .08
 EUPHILOMEDES CARCHARODONTOA      40.00    .44   2.86   132.0       .87
 SYNCHELIDIUM SP.                 40.00    .76    .39    46.3       .30
 SYNCHELIDIUM SHOEMAKERI          40.00   2.40   1.79   167.6      1.10
 PARATHALESTRIS SP.               20.00    .11    .04     2.9       .02
 CYCLOPOIDA                       20.00    .44    .04     9.4       .06
 CENTROPAGES SP.                  20.00    .22    .04     5.1       .03
 ACARTIA SP.                      20.00    .44    .04     9.4       .06
 ISOPODA                          20.00    .11    .04     2.9       .02
 IDOTEA SP.                       20.00    .22    .36    11.5       .08
 OSTRACODA                        20.00    .11    .04     2.9       .02
 PORCELLIDIUM SP.                 20.00    .11    .04     2.9       .02
 HARPACTICUS SP.-OBSCURUS GROUP   20.00    .44    .04     9.4       .06
 PROTOMEDEIA SP.                  20.00    .11    .04     2.9       .02
 GASTROPODA                       20.00    .11    .72    16.5       .11
 CALANOIDA                        20.00    .11    .04     2.9       .02
 AMONARDIA PERTURBATA             20.00    .22    .04     5.1       .03
 CAPRELLIDEA                      20.00    .11    .04     2.9       .02
 CAPRELLA SP.                     20.00    .11    .72    16.5       .11
 PLEOCYEMATA-CARIDEA              20.00    .11    .04     2.9       .02
 PINNOTHERIDAE                    20.00    .11    .04     2.9       .02

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX,              .36    .39                .41
      SHANNON-WEINER DIVERSITY             2.31   2.18               2.05
      EVENNESS INDEX,                       .47    .44                .42
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL
PREDATOR 8791030701 - THERAGRA CHALCOGRAMMA
(WALLEYE POLLOCK) ADJUSTED SAMPLE SIZE = 5
LENGTH,MM X= 60.6, S.D.= 5.1 WT,GMS X= 1.95, S.D.= .42



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STOMACH ANALYSIS                                                   PAGE  1
****************
   SPECIES  8826010108-SEBASTES CAURINUS                 COPPER ROCKFISH

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ---------------------------------------------------------------------------
                      86JY17          P 1           02116            6          1440

LIFE HISTORY STAGE
                        6 JUVENILE
                      ---
TOTAL SAMPLE SIZE       6


NUMBER OF EMPTY STOMACHS          0
PERCENTAGE OF EMPTY STOMACHS       .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)       6


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                             MEAN    RANGE    S.D.
                          -------------------------
CONDITION FACTOR              5.2    1.-7.    2.1
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR              3.7    1.-5.    1.8
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT         .01    NEG.-
   (GRAMS)                             .02     .01
TOTAL CONTENTS ABUNDANCE     49.8      .0-
   (NUMBERS)                         144.0    54.2
NO. PREY CATEGORIES           4.8      1.-
   (PER STOMACH)                        7.     2.4
LENGTH                       27.0     24.-
   (MM)                                31.    2.61
WEIGHT                        .30     .19-
   (GRAMS)                             .44     .08
PCT RATIO OF CONTENTS        1.91     .33-
   WT TO PREDATOR WT                  3.65    1.15

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM      LIFE                    NUMBER          *           BIOMASS             * AVE. BIOMASS*      PERCENTAGES
                 HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN    RANGE    S.D. *  MEAN   S.D. * ABUN-           NORM.
  PARTS CODE      STAGE  OCCUR                           *                                  *              * DANCE BIOMASS BIOMASS
---------------------------------------------------------------------------------------------------------------------------------

CALANOIDA                         8   1.3    3-     2.2       .00     .00   NEG.-     .00   .0000 .0000      2.68     .74     .90
               2-NAUPLIUS   33.3                5                                NEG.
CALANOIDA                         5    .8    1-     1.0       .00     .00   NEG.-     .00   .0001 .0000      1.67    1.11    1.35
               F-COPEPODID  50.0                2                                NEG.
HARPACTICOIDA                     2    .3    2-      .8       .00     .00   NEG.-     .00   .0000 .0000       .67     .37     .45
               6-LARVA      16.7                2                                NEG.
HARPACTICOIDA                     4    .7    2-     1.0       .00     .00   NEG.-     .00   .0000 .0000      1.34     .74     .90
               F-COPEPODID  33.3                2                                NEG.
HARPACTICUS SP.-OBSCURUS GROUP   12   2.0    4-     3.3       .00     .00   NEG.-     .00   .0000 .0000      4.01     .74     .90
               8-ADULT      33.3                8                                NEG.
```

```
STOMACH ANALYSIS                                                     PAGE  2
****************
   SPECIES  8826010108-SEBASTES CAURINUS                 COPPER ROCKFISH

PREY ORGANISM       LIFE                 NUMBER           *             BIOMASS             *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN   RANGE    S.D. *   MEAN  S.D. *  ABUN-           NORM.
  PARTS CODE       STAGE  OCCUR                           *                                 *              *  DANCE BIOMASS BIOMASS
-----------------------------------------------------------------------------------------------------------------------------------

HARPACTICUS SP.-OBSCURUS GROUP      1    .2     1-     .4        .00    .00   NEG.-     .00    .0001 .0000        .33    .37    .45
               C-J/A NOSEX   16.7                 1                            NEG.
HARPACTICUS SP.-UNIREMIS GROUP      3    .5     1-     .8        .00    .00   NEG.-     .00    .0001 .0000       1.00    .74    .90
               8-ADULT       33.3                 2                            NEG.
TISBE SP.                           4    .7     4-    1.6        .00    .00   NEG.-     .00    .0000 .0000       1.34    .37    .45
               8-ADULT       16.7                 4                            NEG.
TISBE SP.                         222  37.0     8-   51.3        .01    .00   NEG.-     .00    .0000 .0000      74.25  40.96  50.00
               A-JUV+ADULT   66.7               133                             .01
DIOSACCUS SPINATUS                  1    .2     1-     .4        .00    .00   NEG.-     .00    .0001 .0000        .33    .37    .45
               8-ADULT       16.7                 1                            NEG.
DACTYLOPODIA SP.                    1    .2     1-     .4        .00    .00   NEG.-     .00    .0001 .0000        .33    .37    .45
               8-ADULT       16.7                 1                            NEG.
DACTYLOPODIA CRASSIPES              1    .2     1-     .4        .00    .00   NEG.-     .00    .0001 .0000        .33    .37    .45
               8-ADULT       16.7                 1                            NEG.
BALANOMORPHA                        1    .2     1-     .4        .00    .00   NEG.-     .00    .0001 .0000        .33    .37    .45
               2-NAUPLIUS    16.7                 1                            NEG.
MYSIDACEA                          27   4.5     27-  11.0        .00    .00    .00-     .00    .0000 .0000       9.03   3.69   4.50
               7-JUVENILE    16.7                27                             .00
ISCHYROCERUS SP.                    2    .3     2-     .8        .00    .00    .00-     .00    .0005 .0000        .67   3.69   4.50
               C-J/A NOSEX   16.7                 2                             .00
HIPPOLYTIDAE                        1    .2     1-     .4        .01    .00    .01-     .00    .0070 .0000        .33  25.83  31.53
               7-JUVENILE    16.7                 1                             .01
DECAPODA-BRACHYURA                  3    .5     1-     .8        .00    .00   NEG.-     .00    .0001 .0000       1.00    .74    .90
               3-ZOEA        33.3                 2                            NEG.
PINNOTHERIDAE                       1    .2     1-     .4        .00    .00   NEG.-     .00    .0001 .0000        .33    .37    .45
               3-ZOEA        16.7                 1                            NEG.
UNIDENTIFIED MATERIAL                                            .00    .00    .00-     .00                            18.08
                                                                                .00

TOTAL NUMBER OF PREY CATEGORIES   18

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        1.65
                                             BIOMASS        2.10
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                 1.53
```

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STOMACH ANALYSIS                                              PAGE  2
****************
   SPECIES: 8826010108-SEBASTES CAURINUS                COPPER ROCKFISH

            INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
            USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
            *********************************************

                                     FREQ   NUM.   GRAV.  PREY    PERCENT
         PREY ITEM                   OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
   ----------------------------      -----  -----  -----  ------  ---------

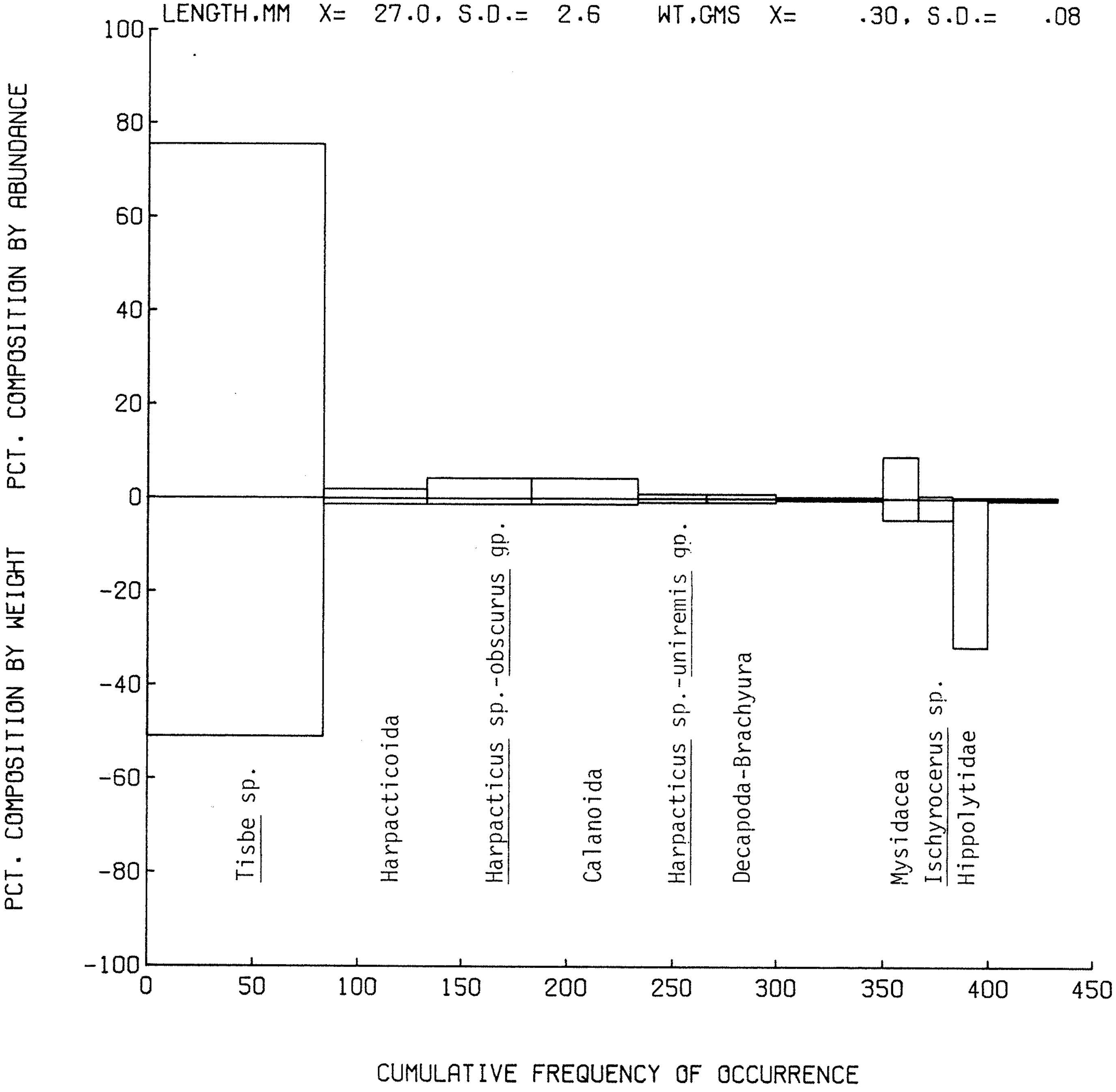
  TISBE SP.                          83.33  75.59  50.91 10541.2   85.54
  HARPACTICOIDA                      50.00   2.01   1.36   168.5    1.37
  HARPACTICUS SP.-OBSCURUS GROUP     50.00   4.35   1.36   285.6    2.32
  CALANOIDA                          50.00   4.35   1.36   285.6    2.32
  HARPACTICUS SP.-UNIREMIS GROUP     33.33   1.00    .91    63.7     .52
  DECAPODA-BRACHYURA                 33.33   1.00    .91    63.7     .52
  DACTYLOPODIA SP.                   16.67    .33    .45    13.1     .11
  DACTYLOPODIA CRASSIPES             16.67    .33    .45    13.1     .11
  BALANOMORPHA                       16.67    .33    .45    13.1     .11
  MYSIDACEA                          16.67   9.03   4.55   226.3    1.84
  ISCHYROCERUS SP.                   16.67    .67   4.55    86.9     .71
  HIPPOLYTIDAE                       16.67    .33  31.82   535.9    4.35
  DIOSACCUS SPINATUS                 16.67    .33    .45    13.1     .11
  PINNOTHERIDAE                      16.67    .33    .45    13.1     .11

    PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
    COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
    (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

       PERCENT DOMINANCE INDEX,              .58    .37                .74
       SHANNON-WEINER DIVERSITY             1.47   1.98               1.01
       EVENNESS INDEX,                       .39    .52                .27
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8826010108 - SEBASTES CAURINUS
(COPPER ROCKFISH) ADJUSTED SAMPLE SIZE = 6
LENGTH,MM X= 27.0, S.D.= 2.6 WT,GMS X= .30, S.D.= .08



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STOMACH ANALYSIS                                                  PAGE  1
****************
   SPECIES: 8857041301-PAROPHRYS VETULUS                  ENGLISH SOLE

FROM COLLECTIONS:  FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                   --------------------------------------------------------------------------
                     86MY21         B 1          02116          24          1730
                     86MY21         B 2          02116           2          1845

LIFE HISTORY STAGE:
                     26 JUVENILE
                    ---
TOTAL SAMPLE SIZE:   26


NUMBER OF EMPTY STOMACHS:        0
PERCENTAGE OF EMPTY STOMACHS:     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY):    26


PREY CODES ARE TRUNCATED BY 0 DIGITS
DATA FORMAT = S240.33B

                           MEAN    RANGE    S.D.
                         -------------------------
CONDITION FACTOR            2.8    1.-6.     1.9
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR            3.1    1.-5.     2.0
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT       .02    NEG.-
   (GRAMS)                            .13    .03
TOTAL CONTENTS ABUNDANCE   14.0       .0-
   (NUMBERS)                        57.0    17.8
NO. PREY CATEGORIES         3.7      1.-
   (PER STOMACH)                     10.     3.0
LENGTH                     64.1     41.-
   (MM)                              92.   14.87
WEIGHT                     3.07     .65-
   (GRAMS)                          8.99    1.98
PCT RATIO OF CONTENTS       .79     .01-
   WT TO PREDATOR WT                2.88     .92

NOTE: LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM        LIFE                NUMBER           *          BIOMASS             *  AVE. BIOMASS*       PERCENTAGES
                   HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN    RANGE   S.D. *   MEAN  S.D. *  ABUN-          NORM.
                    STAGE  OCCUR                            *                                *             *  DANCE BIOMASS BIOMASS
----------------------------------------------------------------------------------------------------------------------------------

POLYCHAETA                         27   1.0     1-    2.3         .05    .00   NEG.-     .00   .0023 .0027     7.40   9.09  14.13
                            30.8                 10                                .02
BIVALVIA                          127   4.9     1-    9.4         .07    .00   NEG.-     .00   .0006 .0004    34.79  13.60  21.14
                            42.3                 43                                .02
HARPACTICOIDA                      14    .5     1-    1.1         .00    .00   NEG.-     .00   .0001 .0000     3.84    .14    .21
                            26.9                  5                              NEG.
ECTINOSOMIDAE                       4    .2     1-     .5         .00    .00   NEG.-     .00   .0001 .0000     1.10    .06    .09
                            11.5                  2                              NEG.
```

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STOMACH ANALYSIS                                             PAGE  2
****************
   SPECIES: 8857041301-PAROPHRYS VETULUS                ENGLISH SOLE
PREY ORGANISM       LIFE              NUMBER           *            BIOMASS            *  AVE. BIOMASS*      PERCENTAGES
                 HISTORY FREQ  TOTAL  MEAN    RANGE  S.D. *     TOTAL   MEAN    RANGE    S.D. *   MEAN  S.D.  *  ABUN-             NORM.
                  STAGE  OCCUR                             *                                 *                *  DANCE BIOMASS BIOMASS
------------------------------------------------------------------------------------------------------------------------------------

HARPACTICUS SP.-UNIREMIS GROUP  4    .2     1-    .6         .00    .00    NEG.-     .00    .0002 .0002      1.10    .22     .34
                        7.7                  3                              .00
ZAUS SP.                        1    .0     1-    .2         .00    .00    NEG.-     .00    .0001 .0000       .27    .02     .03
                        3.8                  1                             NEG.
TISBE SP.                       4    .2     1-    .5         .00    .00    NEG.-     .00    .0001 .0000      1.10    .06     .09
                       11.5                  2                             NEG.
CUMACEA                         8    .3     1-   1.0         .00    .00    NEG.-     .00    .0002 .0001      2.19    .41     .64
                       11.5                  4                              .00
LAMPROPIDAE                     2    .1     1-    .3         .00    .00    NEG.-     .00    .0021 .0028       .55    .81    1.25
                        7.7                  1                              .00
DIASTYLOPSIS TENUIS            78   3.0     1-   4.6         .14    .01     .00-     .01    .0016 .0013     21.37  27.36   42.52
                       46.2                 17                              .05
CUMELLA VULGARIS                5    .2     1-    .6         .00    .00    NEG.-     .00    .0001 .0000      1.37    .06     .09
                       11.5                  2                             NEG.
LEPTOCHELIA DUBIA               2    .1     1-    .3         .00    .00    NEG.-     .00    .0001 .0000       .55    .04     .06
                        7.7                  1                             NEG.
GNORIMOSPHAEROMA SP.            1    .0     1-    .2         .00    .00    NEG.-     .00    .0001 .0000       .27    .02     .03
                        3.8                  1                             NEG.
GAMMARIDEA                      7    .3     1-    .7         .00    .00    NEG.-     .00    .0001 .0001      1.92    .26     .40
                       15.4                  3                              .00
AMPELISCA AGASSIZI              1    .0     1-    .2         .00    .00     .00-     .00    .0010 .0000       .27    .20     .31
                        3.8                  1                              .00
ATYLUS SP.                      2    .1     2-    .4         .00    .00     .00-     .00    .0005 .0000       .55    .20     .31
                        3.8                  2                              .00
CALLIOPIIDAE                    1    .0     1-    .2         .00    .00    NEG.-     .00    .0001 .0000       .27    .02     .03
                        3.8                  1                             NEG.
GAMMARIDAE                      2    .1     2-    .4         .00    .00    NEG.-     .00    .0000 .0000       .55    .02     .03
                        3.8                  2                             NEG.
GAMMARIDAE                      1    .0     1-    .2         .00    .00    NEG.-     .00    .0001 .0000       .27    .02     .03
                        3.8                  1                             NEG.
PHOTIS SP.                     13    .5     1-   1.8         .02    .00     .00-     .00    .0016 .0004      3.56   3.54    5.51
                       11.5                  9                              .01
ISCHYROCERUS ANGUIPES           4    .2     1-    .6         .00    .00     .00-     .00    .0012 .0012      1.10    .59     .92
                        7.7                  3                              .00
SYNCHELIDIUM SP.                2    .1     2-    .4         .00    .00    NEG.-     .00    .0000 .0000       .55    .02     .03
                        3.8                  2                             NEG.
SYNCHELIDIUM SHOEMAKERI        50   1.9     1-   7.3         .02    .00    NEG.-     .00    .0003 .0003     13.70   4.02    6.24
                       26.9                 37                              .01
PHOXOCEPHALIDAE                 1    .0     1-    .2         .00    .00    NEG.-     .00    .0001 .0000       .27    .02     .03
                        3.8                  1                             NEG.
EUCARIDA                        1    .0     1-    .2         .00    .00     .00-     .00    .0030 .0000       .27    .59     .92
                        3.8                  1                              .00
CRANGON SP.                     1    .0     1-    .2         .02    .00     .02-     .00    .0150 .0000       .27   2.95    4.59
                        3.8                  1                              .02
DIPTERA-CHIRONOMIDAE            2    .1     2-    .4         .00    .00    NEG.-     .00    .0000 .0000       .55    .02     .03
                        3.8                  2                             NEG.
```

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STOMACH ANALYSIS                                                     PAGE  3
****************
   SPECIES: 8857041301-PAROPHRYS VETULUS                    ENGLISH SOLE

UNIDENTIFIED MATERIAL                                            .18    .02    .00-     .02                            35.65
                                                                               .05


TOTAL NUMBER OF PREY CATEGORIES   27

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        3.06
                                             BIOMASS        2.52
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                2.91
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STOMACH ANALYSIS                                                    PAGE  2
****************
   SPECIES: 8857041301-PLEURONECTES (PAROPHRYS) VETULUS  ENGLISH SOLE

              INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
              USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
              *********************************************

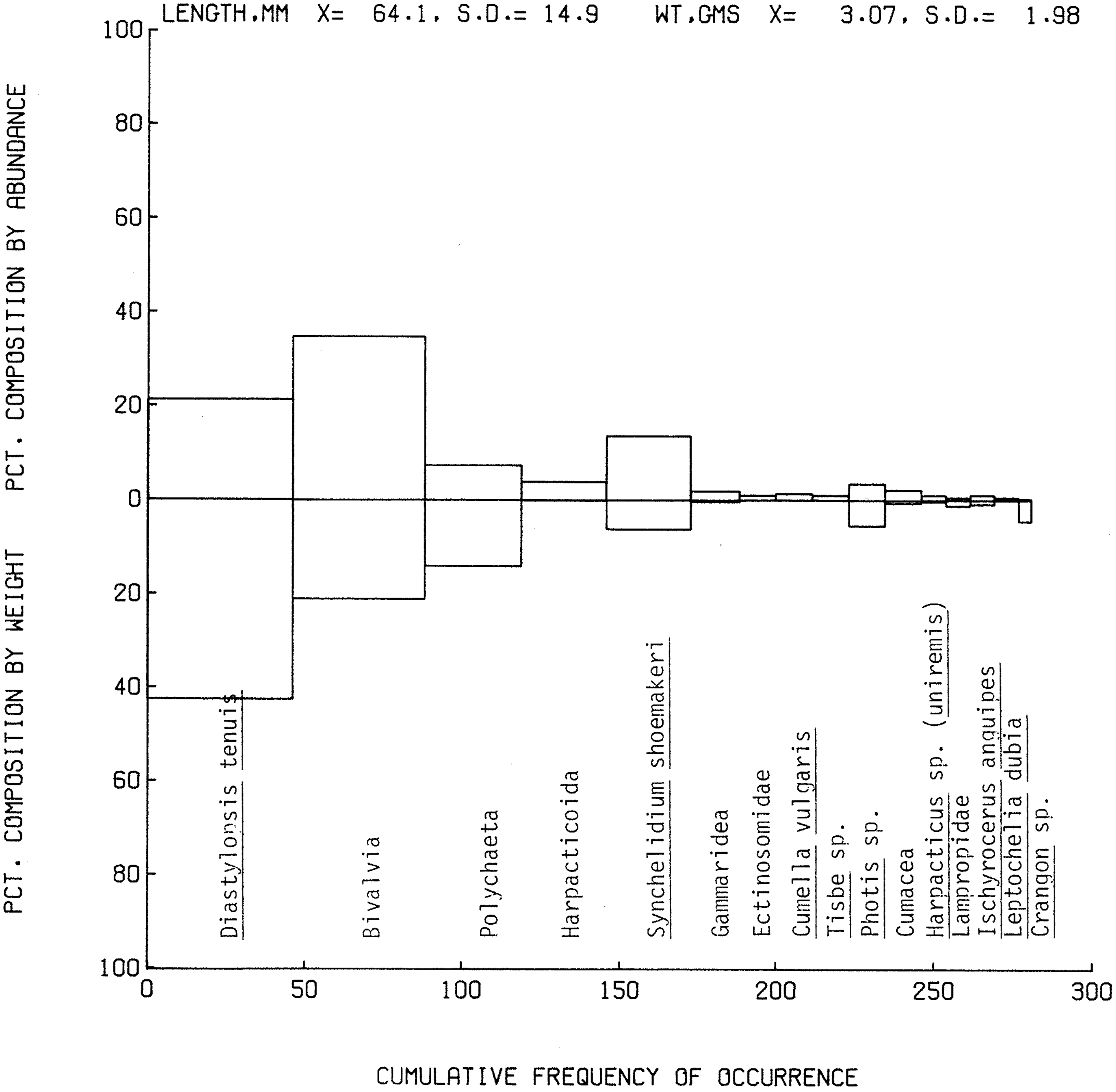
                                    FREQ   NUM.   GRAV.  PREY    PERCENT
           PREY ITEM                OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
  ----------------------------      -----  -----  -----  ------  ---------

  DIASTYLOPSIS TENUIS               46.15  21.37  42.52  2948.8    42.57
  BIVALVIA                          42.31  34.79  21.14  2366.4    34.16
  POLYCHAETA                        30.77   7.40  14.13   662.5     9.56
  HARPACTICOIDA                     26.92   3.84    .21   109.0     1.57
  SYNCHELIDIUM SHOEMAKERI           26.92  13.70   6.24   536.8     7.75
  GAMMARIDEA                        15.38   1.92    .40    35.6      .51
  ECTINOSOMIDAE                     11.54   1.10    .09    13.7      .20
  CUMELLA VULGARIS                  11.54   1.37    .09    16.9      .24
  TISBE SP.                         11.54   1.10    .09    13.7      .20
  PHOTIS SP.                        11.54   3.56   5.51   104.6     1.51
  CUMACEA                           11.54   2.19    .64    32.7      .47
  HARPACTICUS SP.-UNIREMIS GROUP     7.69   1.10    .34    11.0      .16
  LAMPROPIDAE                        7.69    .55   1.25    13.9      .20
  ISCHYROCERUS ANGUIPES              7.69   1.10    .92    15.5      .22
  LEPTOCHELIA DUBIA                  7.69    .55    .06     4.7      .07
  CRANGON SP.                        3.85    .27   4.59    18.7      .27

    PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
    COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
    (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

       PERCENT DOMINANCE INDEX,              .20    .25              .31
       SHANNON-WEINER DIVERSITY             3.06   2.52             2.10
       EVENNESS INDEX,                       .64    .53              .44
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION ESOLE
PREDATOR 8857041301 - PAROPHRYS VETULUS
(ENGLISH SOLE) ADJUSTED SAMPLE SIZE = 26
LENGTH,MM X= 64.1, S.D.= 14.9 WT,GMS X= 3.07, S.D.= 1.98



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STOMACH ANALYSIS                                                    PAGE  1
****************
   SPECIES  8747010101-ALOSA SAPIDISSIMA                  AMERICAN SHAD

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ------------------------------------------------------------------------
                     86JY17          P 1          02118          1          1545

LIFE HISTORY STAGE
                      1 ADULT
                    ---
TOTAL SAMPLE SIZE     1


NUMBER OF EMPTY STOMACHS        0
PERCENTAGE OF EMPTY STOMACHS     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)      1


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                              MEAN    RANGE    S.D.
                           -------------------------
CONDITION FACTOR               2.0    2.-2.     .0
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR               2.0    2.-2.     .0
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT          .01     .01-
   (GRAMS)                               .01    .00
TOTAL CONTENTS ABUNDANCE      10.0    10.0-
   (NUMBERS)                            10.0     .0
NO. PREY CATEGORIES            1.0      1.-
   (PER STOMACH)                          1.     .0
LENGTH                       150.0    150.-
   (MM)                                 150.    .00
WEIGHT                       37.07   37.07-
   (GRAMS)                             37.07    .00
PCT RATIO OF CONTENTS          .03     .03-
   WT TO PREDATOR WT                     .03    .00

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM       LIFE               NUMBER          *           BIOMASS              *  AVE. BIOMASS*       PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE   S.D. *    TOTAL   MEAN    RANGE    S.D. *   MEAN  S.D. *  ABUN-              NORM.
  PARTS CODE       STAGE  OCCUR                            *                                  *             *  DANCE BIOMASS BIOMASS
-----------------------------------------------------------------------------------------------------------------------------------

DIOSACCUS SPINATUS              10  10.0    10-      .0        .00     .00   NEG.-    .00    .0000 .0000    100.00     .83 100.00
                 A-JUV+ADULT 100.0            10                              NEG.
UNIDENTIFIED MATERIAL                                          .01     .01    .01-    .00                             99.17
                                                                              .01

TOTAL NUMBER OF PREY CATEGORIES     1

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS          .00
                                             BIOMASS          .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                  .00
```

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STOMACH ANALYSIS                                                   PAGE  2
****************
   SPECIES: 8747010101-ALOSA SAPIDISSIMA                 AMERICAN SHAD

             INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
             USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
             ******************************************

                                 FREQ   NUM.   GRAV.  PREY    PERCENT
          PREY ITEM              OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
  --------------------------     -----  -----  -----  ------  ---------

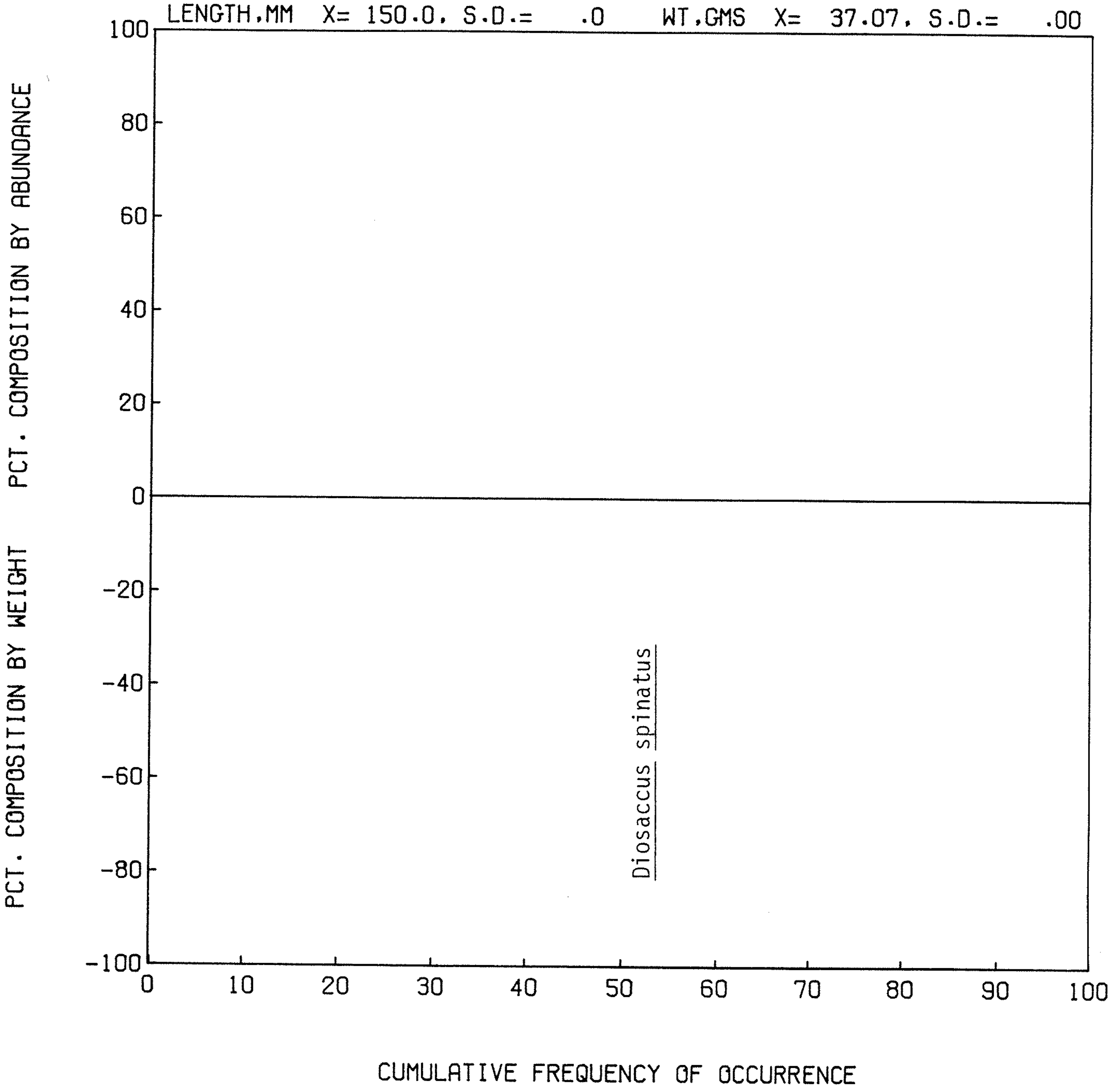
 DIOSACCUS SPINATUS             100.00 100.00 100.00 20000.0   100.00

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX,          1.00   1.00              1.00
      SHANNON-WEINER DIVERSITY           .00    .00               .00
      EVENNESS INDEX,                      I      R                  I
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8747010101 - ALOSA SAPIDISSIMA
(AMERICAN SHAD) ADJUSTED SAMPLE SIZE = 1
LENGTH,MM X= 150.0, S.D.= .0 WT,GMS X= 37.07, S.D.= .00



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STOMACH ANALYSIS                                                  PAGE  1
****************
   SPECIES  8747010201-CLUPEA HARENGUS PALLASI          PACIFIC HERRING

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ------------------------------------------------------------------------
                      86JY17          P 3          02118           1          1625
                      86JY17          P 1          02118           3          1545
                      86MY21          P 2          02116           5          1528
                      86MY21          P 3          02117           5          1408
                      86JY17          P 3          02117           9          1405
                      86JY17          P 1          02118           2          1545
                      86JY17          P 1          02116           2          1440
                      86JY17          P 2          02116           4          1440

LIFE HISTORY STAGE
                     10 LARVA
                      9 JUVENILE
                      8 ADULT
                      4 JUVENILE/ADULT, SEXUAL MATURITY UNKNOWN
                    ---
TOTAL SAMPLE SIZE    31


NUMBER OF EMPTY STOMACHS        0
PERCENTAGE OF EMPTY STOMACHS     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)     31


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                           MEAN    RANGE    S.D.
                         -------------------------
CONDITION FACTOR            3.8    1.-7.     2.0
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR            2.9    1.-5.     1.5
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT       .04    NEG.-
   (GRAMS)                           .30     .06
TOTAL CONTENTS ABUNDANCE   99.5     .0-
   (NUMBERS)                       1112.0  242.4
NO. PREY CATEGORIES         4.3     1.-
   (PER STOMACH)                     10.     2.9
LENGTH                     93.5     29.-
   (MM)                             206.   58.75
WEIGHT                    18.60     .12-
   (GRAMS)                         87.46   24.52
PCT RATIO OF CONTENTS       .81     .00-
   WT TO PREDATOR WT                2.15     .68

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.
```

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STOMACH ANALYSIS                                                  PAGE  2
****************
   SPECIES  8747010201-CLUPEA HARENGUS PALLASI          PACIFIC HERRING

PREY ORGANISM      LIFE                 NUMBER              *          BIOMASS               *  AVE. BIOMASS*      PERCENTAGES
                HISTORY FREQ  TOTAL  MEAN   RANGE   S.D. *     TOTAL   MEAN    RANGE    S.D. *   MEAN  S.D. *  ABUN-           NORM.
  PARTS CODE     STAGE  OCCUR                            *                                   *              *  DANCE BIOMASS BIOMASS
---------------------------------------------------------------------------------------------------------------------------------

POLYCHAETA                       2     .1     1-     .2        .00     .00   NEG.-     .00   .0001 .0000       .06     .02     .05
               C-J/A NOSEX   6.5                1                              NEG.
PODON SP.                        4     .1     1-     .3        .00     .00   NEG.-     .00   .0001 .0000       .13     .03     .09
               C-J/A NOSEX  12.9                1                              NEG.
EUPHILOMEDES CARCHARODONTOA      4     .1     4-     .7        .01     .00   .01-      .00   .0018 .0000       .13     .60    1.65
               C-J/A NOSEX   3.2                4                              .01
CALANOIDA                      150    4.8     1-   12.7        .00     .00   NEG.-     .00   .0000 .0000      4.87     .10     .28
               2-NAUPLIUS   38.7               68                              NEG.
CALANOIDA                     1068   34.5     1-   99.7        .02     .00   NEG.-     .00   .0000 .0000     34.64    1.85    5.08
               A-JUV+ADULT  32.3              456                              .01
CALANOIDA                       19     .6     3-    2.4        .00     .00   NEG.-     .00   .0001 .0002       .62     .36     .99
               C-J/A NOSEX   9.7               13                              .00
CALANOIDA                       43    1.4     1-    4.4        .00     .00   NEG.-     .00   .0000 .0000      1.39     .03     .09
               F-COPEPODID  12.9               20                              NEG.
CALANUS SP.                      1     .0     1-     .2        .00     .00   .00-      .00   .0010 .0000       .03     .09     .24
               C-J/A NOSEX   3.2                1                              .00
PARACALANUS SP.                  7     .2     7-    1.3        .00     .00   NEG.-     .00   .0000 .0000       .23     .01     .02
               A-JUV+ADULT   3.2                7                              NEG.
CENTROPAGES ABDOMINALIS         11     .4     1-     .9        .00     .00   NEG.-     .00   .0001 .0000       .36     .04     .12
               A-JUV+ADULT  16.1                4                              NEG.
CENTROPAGES ABDOMINALIS          1     .0     1-     .2        .00     .00   NEG.-     .00   .0001 .0000       .03     .01     .02
               C-J/A NOSEX   3.2                1                              NEG.
EPILABIDOCERA SP.                1     .0     1-     .2        .00     .00   NEG.-     .00   .0001 .0000       .03     .01     .02
               8-ADULT       3.2                1                              NEG.
EPILABIDOCERA SP.               11     .4     4-    1.4        .00     .00   NEG.-     .00   .0000 .0000       .36     .02     .05
               A-JUV+ADULT   6.5                7                              NEG.
EPILABIDOCERA LONGIPEDATA       35    1.1    11-    4.7        .00     .00   .00-      .00   .0001 .0000      1.14     .26     .71
               A-JUV+ADULT   6.5               24                              .00
ACARTIA SP.                    152    4.9     6-   15.9        .01     .00   NEG.-     .00   .0000 .0000      4.93     .61    1.68
               A-JUV+ADULT  12.9               76                              .00
ACARTIA SP.                      1     .0     1-     .2        .00     .00   NEG.-     .00   .0001 .0000       .03     .01     .02
               C-J/A NOSEX   3.2                1                              NEG.
ACARTIA SP.                      6     .2     6-    1.1        .00     .00   NEG.-     .00   .0000 .0000       .19     .01     .02
               F-COPEPODID   3.2                6                              NEG.
ACARTIA LONGIREMIS              70    2.3     1-    5.0        .00     .00   NEG.-     .00   .0000 .0000      2.27     .09     .24
               A-JUV+ADULT  32.3               21                              NEG.
HARPACTICOIDA                   18     .6     2-    2.9        .00     .00   NEG.-     .00   .0000 .0000       .58     .02     .05
               C-J/A NOSEX   6.5               16                              NEG.
HARPACTICOIDA                    1     .0     1-     .2        .00     .00   NEG.-     .00   .0001 .0000       .03     .01     .02
               F-COPEPODID   3.2                1                              NEG.
HARPACTICUS SP.-OBSCURUS GROUP 181    5.8     9-   24.0        .00     .00   NEG.-     .00   .0000 .0000      5.87     .10     .28
               A-JUV+ADULT   9.7              128                              .00
ZAUS SP.                         4     .1     4-     .7        .00     .00   NEG.-     .00   .0000 .0000       .13     .01     .02
               8-ADULT       3.2                4                              NEG.
DIOSACCUS SPINATUS               3     .1     1-     .3        .00     .00   NEG.-     .00   .0001 .0000       .10     .03     .07
               8-ADULT       9.7                1                              NEG.
DIOSACCUS SPINATUS               8     .3     8-    1.4        .00     .00   NEG.-     .00   .0000 .0000       .26     .01     .02
               A-JUV+ADULT   3.2                8                              NEG.
CYCLOPOIDA                       2     .1     1-     .2        .00     .00   NEG.-     .00   .0001 .0000       .06     .02     .05
               8-ADULT       6.5                1                              NEG.
CORYCAEUS ANGLICUS               6     .2     2-     .8        .00     .00   NEG.-     .00   .0000 .0000       .19     .02     .05
               C-J/A NOSEX   6.5                4                              NEG.
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STOMACH ANALYSIS                                                         PAGE  3
****************
   SPECIES  8747010201-CLUPEA HARENGUS PALLASI           PACIFIC HERRING
PREY ORGANISM       LIFE                   NUMBER             *         BIOMASS              *  AVE. BIOMASS*     PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN    RANGE   S.D. *    TOTAL   MEAN    RANGE    S.D. *   MEAN   S.D. *  ABUN-          NORM.
  PARTS CODE       STAGE  OCCUR                              *                                  *              *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------------

CORYCAEUS ANGLICUS                    4    .1      4-      .7       .00     .00    NEG.-      .00    .0000 .0000       .13     .01     .02
                  F-COPEPODID   3.2                 4                               NEG.
OITHONA SP.                           1    .0      1-      .2       .00     .00    NEG.-      .00    .0001 .0000       .03     .01     .02
                  F-COPEPODID   3.2                 1                               NEG.
BALANOMORPHA                       1090  35.2      1-   106.2       .02     .00    NEG.-      .00    .0000 .0000     35.36    1.88    5.15
                  2-NAUPLIUS   38.7               424                               .01
BALANOMORPHA                          1    .0      1-      .2       .00     .00    NEG.-      .00    .0001 .0000       .03     .01     .02
                  6-LARVA       3.2                 1                               NEG.
BALANOMORPHA                         25    .8      1-     3.3       .00     .00    NEG.-      .00    .0001 .0000       .81     .04     .12
                  E-CYPRIS     16.1                18                               NEG.
GNORIMOSPHAEROMA SP.                  1    .0      1-      .2       .00     .00    .00-       .00    .0020 .0000       .03     .17     .47
                  C-J/A NOSEX   3.2                 1                               .00
EUPHAUSIACEA                          3    .1      1-      .4       .00     .00    NEG.-      .00    .0001 .0000       .10     .02     .05
                  6-LARVA       6.5                 2                               NEG.
EUPHAUSIIDAE                          6    .2      6-     1.1       .00     .00    NEG.-      .00    .0000 .0000       .19     .01     .02
                  6-LARVA       3.2                 6                               NEG.
PLEOCYEMATA-CARIDEA                   1    .0      1-      .2       .00     .00    NEG.-      .00    .0001 .0000       .03     .01     .02
                  3-ZOEA        3.2                 1                               NEG.
CRANGON SP.                          20    .6      5-     2.8       .00     .00    NEG.-      .00    .0000 .0000       .65     .02     .05
                  6-LARVA       6.5                15                               NEG.
PORCELLANIDAE                         4    .1      4-      .7       .00     .00    .00-       .00    .0003 .0000       .13     .09     .24
                  3-ZOEA        3.2                 4                               .00
DECAPODA-BRACHYURA                   39   1.3      1-     4.0       .00     .00    NEG.-      .00    .0001 .0000      1.27     .32     .87
                  3-ZOEA       25.8                22                               .00
DECAPODA-BRACHYURA                    1    .0      1-      .2       .00     .00    NEG.-      .00    .0001 .0000       .03     .01     .02
                  4-MEGALOP     3.2                 1                               NEG.
PINNOTHERIDAE                         6    .2      1-      .7       .00     .00    NEG.-      .00    .0001 .0000       .19     .03     .07
                  3-ZOEA        9.7                 4                               NEG.
OIKOPLEURA DIOICA                    68   2.2      1-     6.1       .00     .00    NEG.-      .00    .0000 .0000      2.21     .06     .17
                  C-J/A NOSEX  22.6                25                               NEG.
OSTEICHTHYES                          1    .0      1-      .2       .21     .01    .21-       .04    .2060 .0000       .03   17.76   48.63
                  7-JUVENILE    3.2                 1                               .21
OSTEICHTHYES                          3    .1      3-      .5       .14     .00    .14-       .02    .0453 .0000       .10   11.72   32.11
  1-UNIDENT.      C-J/A NOSEX   3.2                 3                               .14
UNIDENTIFIED MATERIAL                                               .74     .05    .00-       .02                             63.48
                                                                                   .09

TOTAL NUMBER OF PREY CATEGORIES    43

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        2.72
                                             BIOMASS        2.14
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                2.68
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STOMACH ANALYSIS                                              PAGE  2
****************
   SPECIES: 8747010201-CLUPEA HARENGUS PALLASI          PACIFIC HERRING

             INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
             USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
             *****************************************

                                  FREQ   NUM.   GRAV.  PREY     PERCENT
          PREY ITEM               OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
   ---------------------------    -----  -----  -----  ------  ---------

  CALANOIDA                       58.33  32.97   4.37  2177.9    39.56
  BALANOMORPHA                    50.00  34.99   7.60  2129.7    38.69
  DECAPODA-BRACHYURA              30.56   1.39   1.10    76.1     1.38
  ACARTIA LONGIREMIS              27.78   1.80    .16    54.5      .99
  OIKOPLEURA DIOICA               22.22   1.95    .28    49.6      .90
  CENTROPAGES ABDOMINALIS         16.67    .31    .10     6.8      .12
  ACARTIA SP.                     16.67   4.08   1.20    88.1     1.60
  PODON SP.                       11.11    .10    .07     1.9      .03
  CRANGON SP.                     11.11    .85    .69    17.1      .31
  HARPACTICOIDA                   11.11    .51    .07     6.4      .12
  PINNOTHERIDAE                   11.11    .21    .07     3.0      .05
  DIOSACCUS SPINATUS              11.11    .28    .07     3.9      .07
  OSTEICHTHYES                    11.11    .18  61.34   683.5    12.42
  DECAPODA                         8.33    .69    .84    12.8      .23
  PLEOCYEMATA-CARIDEA              8.33    .15    .68     6.9      .13
  EPILABIDOCERA SP.                8.33    .31    .05     3.0      .05
  PORCELLANIDAE                    8.33    .18    .51     5.8      .10
  HARPACTICUS SP.-OBSCURUS GROUP   8.33   4.65    .20    40.4      .73
  CANCER SP.                       8.33    .77   2.64    28.4      .52
  CALANUS SP.                      8.33    .10    .35     3.7      .07
  CORYCAEUS ANGLICUS               8.33    .26    .05     2.6      .05
  GASTROPODA                       8.33    .26    .35     5.0      .09
  UNIDENTIFIED EGG                 8.33    .10   1.19    10.7      .20
  EPILABIDOCERA LONGIPEDATA        5.56    .90    .49     7.7      .14
  POLYCHAETA                       5.56    .05    .03      .5      .01
  ANOMURA                          5.56    .05    .66     3.9      .07
  EUPHAUSIACEA                     5.56    .08    .03      .6      .01
  CYCLOPOIDA                       5.56    .05    .03      .5      .01
  CIRRIPEDIA                       2.78  10.91   4.62    43.1      .78
  NEOMYSIS MERCEDIS                2.78    .03   8.57    23.9      .43
  EUPHILOMEDES CARCHARODONTOA      2.78    .10   1.15     3.5      .06
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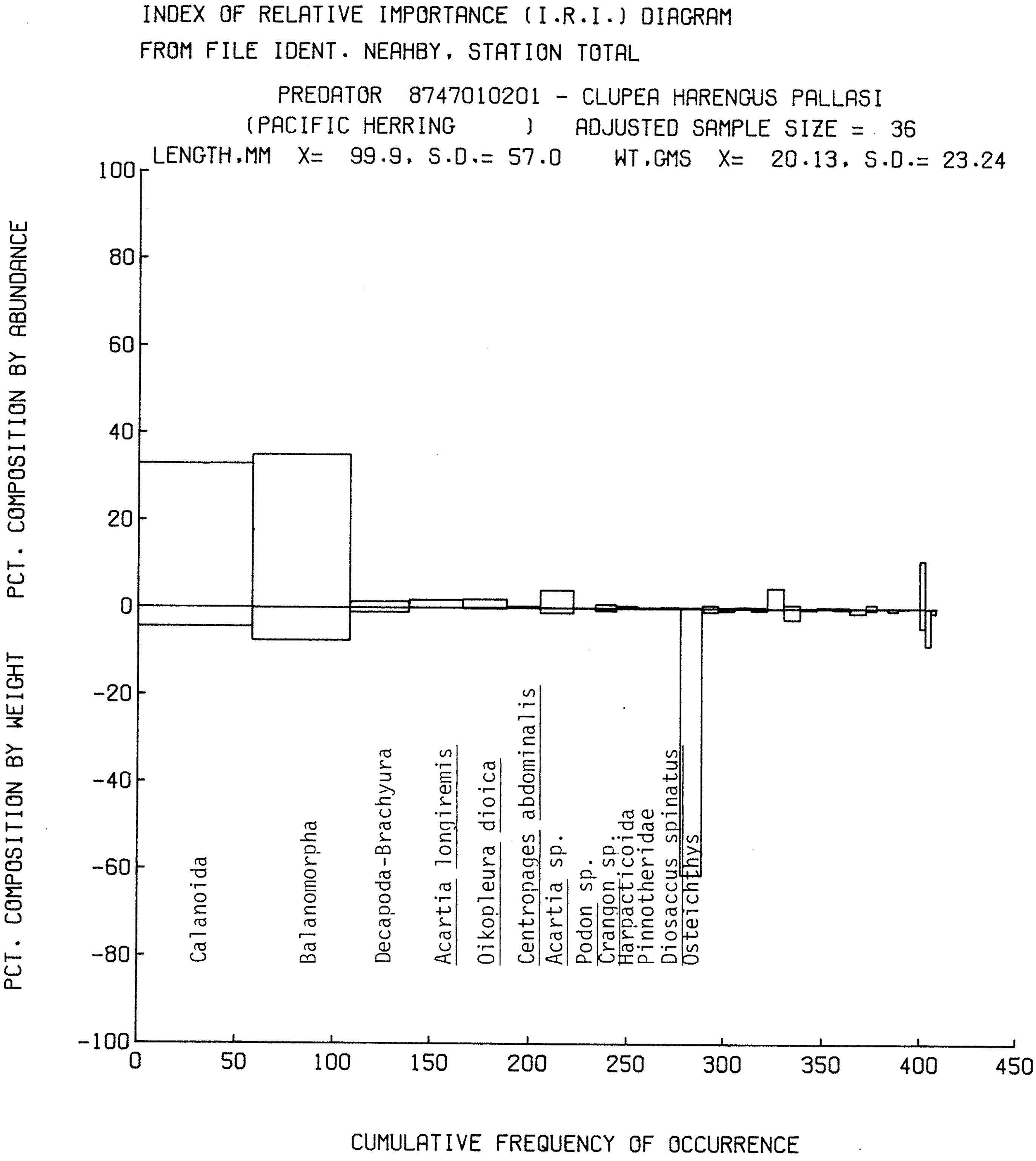

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL
PREDATOR 8747010201 - CLUPEA HARENGUS PALLASI
(PACIFIC HERRING) ADJUSTED SAMPLE SIZE = 36
LENGTH,MM X= 99.9, S.D.= 57.0 WT,GMS X= 20.13, S.D.= 23.24

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STOMACH ANALYSIS                                              PAGE  1
****************
   SPECIES: 8747020101-ENGRAULIS MORDAX                 NORTHERN ANCHOVY

FROM COLLECTIONS:  FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 -------------------------------------------------------------------------
                      86MY22          B 2           02116          11          1845

LIFE HISTORY STAGE:
                    11 JUVENILE/ADULT, SEXUAL MATURITY UNKNOWN
                   ---
TOTAL SAMPLE SIZE:  11


NUMBER OF EMPTY STOMACHS:        0
PERCENTAGE OF EMPTY STOMACHS:     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY):    11


PREY CODES ARE TRUNCATED BY 0 DIGITS
DATA FORMAT = S240.33B

                             MEAN    RANGE    S.D.
                           -------------------------
CONDITION FACTOR              3.4    3.-5.      .7
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR              5.0    5.-5.      .0
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT         .07     .03-
   (GRAMS)                             .25     .07
TOTAL CONTENTS ABUNDANCE      1.5     1.0-
   (NUMBERS)                           2.0      .5
NO. PREY CATEGORIES           1.5     1.-
   (PER STOMACH)                        2.      .5
LENGTH                      103.9     83.-
   (MM)                                121.  11.20
WEIGHT                       9.33    5.92-
   (GRAMS)                           15.00    3.45
PCT RATIO OF CONTENTS         .70     .45-
   WT TO PREDATOR WT                   1.69     .38

NOTE: LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM        LIFE                NUMBER              *           BIOMASS              *  AVE. BIOMASS*        PERCENTAGES
                   HISTORY FREQ  TOTAL  MEAN   RANGE   S.D.  *    TOTAL    MEAN     RANGE    S.D. *   MEAN  S.D. *  ABUN-            NORM.
                    STAGE  OCCUR                             *                                    *              *  DANCE BIOMASS BIOMASS
--------------------------------------------------------------------------------------------------------------------------------------------

HARPACTICOIDA                       1     .1     1-     .3        .16     .01     .16-     .05    .1600 .0000      6.25  16.41  16.47
                            9.1                   1                                  .16
CIRRIPEDIA                          1     .1     1-     .3        .00     .00    NEG.-     .00    .0001 .0000      6.25    .01    .01
                            9.1                   1                                 NEG.
BALANOMORPHA                        2     .2     1-     .4        .00     .00    NEG.-     .00    .0001 .0000     12.50    .02    .02
                           18.2                   1                                 NEG.
DECAPODA-BRACHYURA                  1     .1     1-     .3        .00     .00    NEG.-     .00    .0001 .0000      6.25    .01    .01
                            9.1                   1                                 NEG.
UNIDENTIFIED ALGAE                 11    1.0     1-     .0        .81     .07     .03-     .07    .0737 .0707     68.75  83.18  83.49
                          100.0                   1                                  .25
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STOMACH ANALYSIS                                                    PAGE  2
****************
   SPECIES: 8747020101-ENGRAULIS MORDAX                  NORTHERN ANCHOVY

PREY ORGANISM      LIFE                NUMBER             *           BIOMASS               *  AVE. BIOMASS*      PERCENTAGES
                 HISTORY FREQ  TOTAL  MEAN    RANGE  S.D. *    TOTAL    MEAN     RANGE    S.D. *   MEAN  S.D. *  ABUN-              NORM.
                  STAGE  OCCUR                            *                                    *             *  DANCE BIOMASS BIOMASS
-----------------------------------------------------------------------------------------------------------------------------------

UNIDENTIFIED MATERIAL                                              .00      .00     .00-      .00                              .37
                                                                                    .00


TOTAL NUMBER OF PREY CATEGORIES    5

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        1.50
                                             BIOMASS         .65
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                1.15
```

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STOMACH ANALYSIS                                           PAGE  2
****************
   SPECIES: 8747020101-ENGRAULIS MORDAX              NORTHERN ANCHOVY

            INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
            USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
            *********************************************

                                FREQ   NUM.   GRAV.   PREY    PERCENT
        PREY ITEM               OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
  ----------------------------  -----  -----  -----  ------  ---------

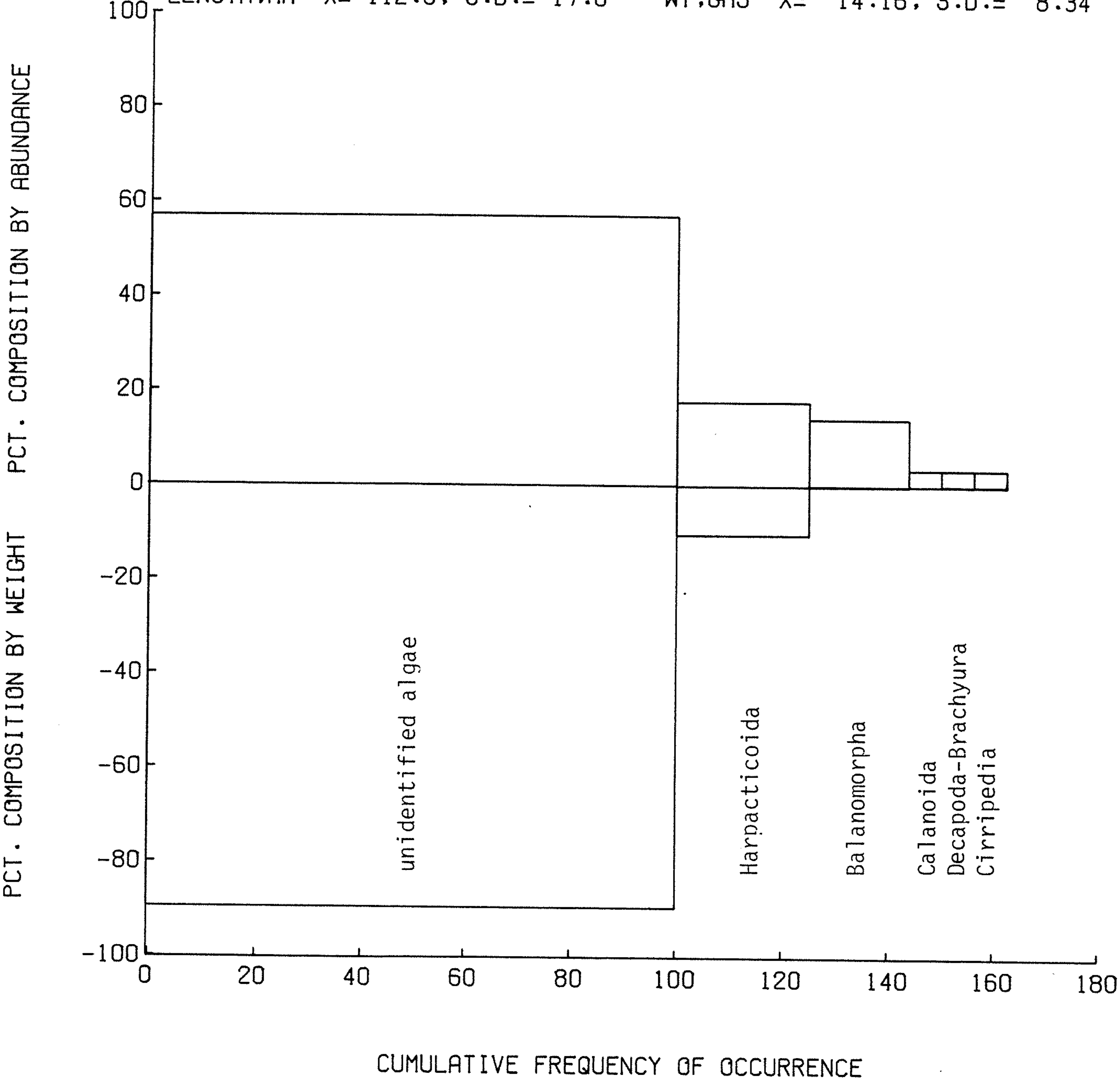
 UNIDENTIFIED ALGAE            100.00  57.14  89.52 14666.7    93.36
 HARPACTICOIDA                  25.00  17.86  10.44   707.4     4.50
 BALANOMORPHA                   18.75  14.29    .02   268.2     1.71
 CALANOIDA                       6.25   3.57    .01    22.4      .14
 DECAPODA-BRACHYURA              6.25   3.57    .01    22.4      .14
 CIRRIPEDIA                      6.25   3.57    .01    22.4      .14

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX,            .38    .81                .87
      SHANNON-WEINER DIVERSITY           1.82    .49                .43
      EVENNESS INDEX,                     .70    .19                .17
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8747020101 - ENGRAULIS MORDAX
(NORTHERN ANCHOVY) ADJUSTED SAMPLE SIZE = 16
LENGTH,MM X= 112.6, S.D.= 17.0 WT,GMS X= 14.16, S.D.= 8.34



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                                                                              PAGE  1
STOMACH ANALYSIS
****************
   SPECIES  8755010201-ONCORHYNCHUS GORBUSCHA            PINK SALMON

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ----------------------------------------------------------------------------
                    86JY17          P 1           02118          1           1545
                    86JY17          P 1           02116          3           1440

LIFE HISTORY STAGE
                      4 JUVENILE
                    ---
TOTAL SAMPLE SIZE     4


NUMBER OF EMPTY STOMACHS        0
PERCENTAGE OF EMPTY STOMACHS     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)      4


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                           MEAN     RANGE    S.D.
                        -------------------------
CONDITION FACTOR            4.0     2.-6.    1.8
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR            2.5     1.-4.    1.3
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT       .06     NEG.-
   (GRAMS)                            .16     .07
TOTAL CONTENTS ABUNDANCE   40.5      .0-
   (NUMBERS)                        122.0    55.6
NO. PREY CATEGORIES         5.5      1.-
   (PER STOMACH)                      8.     3.3
LENGTH                     83.8     79.-
   (MM)                              91.     5.12
WEIGHT                     5.61     4.73-
   (GRAMS)                           7.82    1.48
PCT RATIO OF CONTENTS       .85      .04-
   WT TO PREDATOR WT                 2.01     .85

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM       LIFE                  NUMBER            *            BIOMASS              *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE   S.D. *     TOTAL   MEAN    RANGE    S.D. *   MEAN  S.D. *  ABUN-           NORM.
  PARTS CODE       STAGE  OCCUR                            *                                   *              *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------------

HYDROZOA                             1     .3     1-     .5        .00     .00    NEG.-     .00    .0001 .0000        .62     .04     .11
               C-J/A NOSEX  25.0                  1                                NEG.
ACARINA                              1     .3     1-     .5        .00     .00    NEG.-     .00    .0001 .0000        .62     .04     .11
               C-J/A NOSEX  25.0                  1                                NEG.
CALANOIDA                            4    1.0     4-    2.0        .00     .00    NEG.-     .00    .0000 .0000       2.47     .04     .11
               A-JUV+ADULT  25.0                  4                                NEG.
CALANOIDA                            3     .8     1-    1.0        .00     .00    NEG.-     .00    .0001 .0000       1.85     .09     .23
               C-J/A NOSEX  50.0                  2                                NEG.
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STOMACH ANALYSIS                                                    PAGE  2
****************
   SPECIES  8755010201-ONCORHYNCHUS GORBUSCHA          PINK SALMON
PREY ORGANISM      LIFE              NUMBER           *         BIOMASS            * AVE. BIOMASS*      PERCENTAGES
                HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN    RANGE    S.D. *  MEAN  S.D. *  ABUN-              NORM.
  PARTS CODE      STAGE  OCCUR                          *                                  *             *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------------

CALANUS SP.                    103  25.8   103-   51.5        .08     .02     .08-     .04   .0007 .0000      63.58   33.63   85.91
               8-ADULT     25.0             103                                 .08
PSEUDOCALANUS SP.                3    .8     3-    1.5        .00     .00    NEG.-     .00   .0000 .0000       1.85     .04     .11
               8-ADULT     25.0               3                                NEG.
EPILABIDOCERA LONGIPEDATA        1    .3     1-     .5        .00     .00     .00-     .00   .0010 .0000        .62     .45    1.15
               8-ADULT     25.0               1                                 .00
HARPACTICOIDA                    2    .5     2-    1.0        .00     .00    NEG.-     .00   .0000 .0000       1.23     .04     .11
               C-J/A NOSEX 25.0               2                                NEG.
CYCLOPOIDA                       1    .3     1-     .5        .00     .00    NEG.-     .00   .0001 .0000        .62     .04     .11
               C-J/A NOSEX 25.0               1                                NEG.
MYSIDACEA                        1    .3     1-     .5        .00     .00     .00-     .00   .0010 .0000        .62     .45    1.15
               C-J/A NOSEX 25.0               1                                 .00
PARATHEMISTO PACIFICA            1    .3     1-     .5        .00     .00    NEG.-     .00   .0001 .0000        .62     .04     .11
               C-J/A NOSEX 25.0               1                                NEG.
PORCELLANIDAE                   20   5.0     1-    9.3        .00     .00    NEG.-     .00   .0001 .0000      12.35    1.39    3.55
               3-ZOEA      50.0              19                                 .00
DECAPODA-BRACHYURA               2    .5     2-    1.0        .00     .00    NEG.-     .00   .0000 .0000       1.23     .04     .11
               3-ZOEA      25.0               2                                NEG.
INSECTA                          6   1.5     6-    3.0        .00     .00     .00-     .00   .0002 .0000       3.70     .45    1.15
               8-ADULT     25.0               6                                 .00
PSOCOPTERA                       2    .5     2-    1.0        .00     .00     .00-     .00   .0010 .0000       1.23     .90    2.29
               8-ADULT     25.0               2                                 .00
DIPTERA                          1    .3     1-     .5        .00     .00    NEG.-     .00   .0001 .0000        .62     .04     .11
               8-ADULT     25.0               1                                NEG.
DIPTERA-CHIRONOMIDAE             7   1.8     7-    3.5        .00     .00     .00-     .00   .0003 .0000       4.32     .90    2.29
               8-ADULT     25.0               7                                 .00
HYMENOPTERA                      1    .3     1-     .5        .00     .00    NEG.-     .00   .0001 .0000        .62     .04     .11
               8-ADULT     25.0               1                                NEG.
OSTEICHTHYES                     2    .5     2-    1.0        .00     .00     .00-     .00   .0005 .0000       1.23     .45    1.15
               1-EGG       25.0               2                                 .00
UNIDENTIFIED MATERIAL                                         .14     .05     .02-     .03                            60.85
                                                                              .08

TOTAL NUMBER OF PREY CATEGORIES   19

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        2.18
                                             BIOMASS        1.04
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                1.98
```

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STOMACH ANALYSIS                                                   PAGE  2
****************
   SPECIES: 8755010201-ONCORHYNCHUS GORBUSCHA           PINK SALMON

           INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
           USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
           *********************************************

                                  FREQ   NUM.   GRAV.   PREY     PERCENT
      PREY ITEM                   OCCUR  COMP.  COMP.   I.R.I.   TOTAL IRI
  ----------------------------    -----  -----  -----   ------   ---------

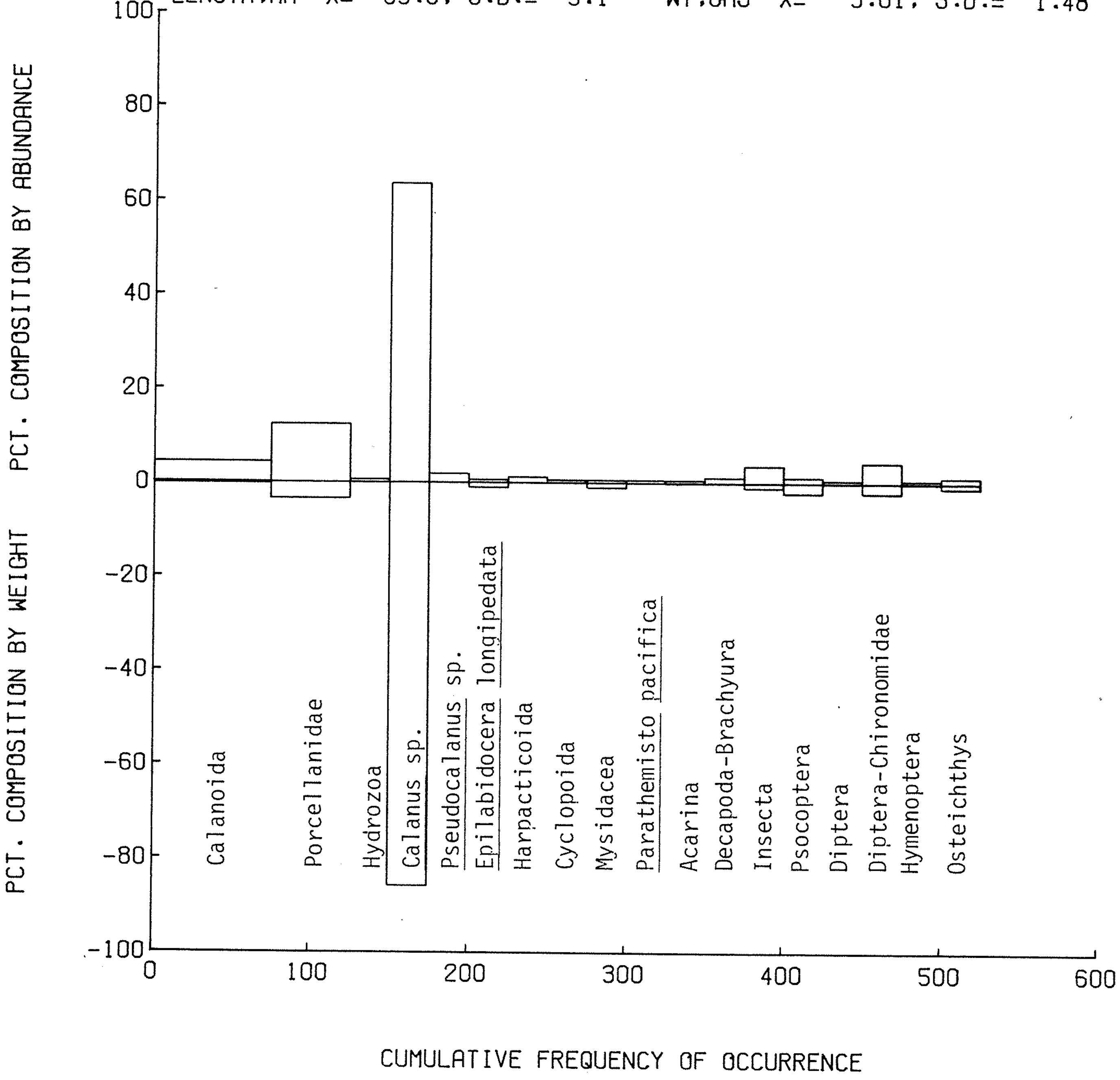
 CALANOIDA                        75.00   4.32    .34    349.8      6.21
 PORCELLANIDAE                    50.00  12.35   3.55    794.8     14.12
 HYDROZOA                         25.00    .62    .11     18.3       .32
 CALANUS SP.                      25.00  63.58  85.91   3737.3     66.37
 PSEUDOCALANUS SP.                25.00   1.85    .11     49.2       .87
 EPILABIDOCERA LONGIPEDATA        25.00    .62   1.15     44.1       .78
 HARPACTICOIDA                    25.00   1.23    .11     33.7       .60
 CYCLOPOIDA                       25.00    .62    .11     18.3       .32
 MYSIDACEA                        25.00    .62   1.15     44.1       .78
 PARATHEMISTO PACIFICA            25.00    .62    .11     18.3       .32
 ACARINA                          25.00    .62    .11     18.3       .32
 DECAPODA-BRACHYURA               25.00   1.23    .11     33.7       .60
 INSECTA                          25.00   3.70   1.15    121.2      2.15
 PSOCOPTERA                       25.00   1.23   2.29     88.1      1.57
 DIPTERA                          25.00    .62    .11     18.3       .32
 DIPTERA-CHIRONOMIDAE             25.00   4.32   2.29    165.3      2.94
 HYMENOPTERA                      25.00    .62    .11     18.3       .32
 OSTEICHTHYES                     25.00   1.23   1.15     59.5      1.06

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX,            .43    .74                .47
      SHANNON-WEINER DIVERSITY           2.14   1.03               1.89
      EVENNESS INDEX,                     .51    .25                .45
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8755010201 - ONCORHYNCHUS GORBUSCHA
(PINK SALMON) ADJUSTED SAMPLE SIZE = 4
LENGTH,MM X= 83.8, S.D.= 5.1 WT,GMS X= 5.61, S.D.= 1.48



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STOMACH ANALYSIS                                                    PAGE  1
****************
   SPECIES  8755010203-ONCORHYNCHUS KISUTCH           COHO SALMON

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ---------------------------------------------------------------------------
                     86JY17          P 3           02117           1           1405
                     86JY17          P 1           02116           5           1440
                     86JY18          B 1           02116           3            700

LIFE HISTORY STAGE
                      9 JUVENILE
                    ---
TOTAL SAMPLE SIZE     9


NUMBER OF EMPTY STOMACHS        0
PERCENTAGE OF EMPTY STOMACHS     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)      9


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                           MEAN    RANGE    S.D.
                         --------------------------
CONDITION FACTOR            4.2    2.-6.     1.7
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR            4.7    3.-5.      .7
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT       .82    NEG.-
   (GRAMS)                           2.01     .70
TOTAL CONTENTS ABUNDANCE   13.4     1.0-
   (NUMBERS)                        90.0    28.8
NO. PREY CATEGORIES         3.0      1.-
   (PER STOMACH)                      13.     3.9
LENGTH                    116.1     80.-
   (MM)                             142.   21.49
WEIGHT                    23.03    6.58-
   (GRAMS)                          42.04  11.66
PCT RATIO OF CONTENTS      3.27      .07-
   WT TO PREDATOR WT                 5.83   2.13

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM       LIFE                  NUMBER            *            BIOMASS              *  AVE. BIOMASS*        PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE   S.D.  *     TOTAL   MEAN    RANGE    S.D. *   MEAN   S.D. *  ABUN-             NORM.
  PARTS CODE       STAGE  OCCUR                             *                                   *               *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------------------

CIRRIPEDIA                        1     .1     1-      .3         .00     .00    NEG.-     .00   .0001 .0000       .83     .00     .00
               C-J/A NOSEX  11.1                1                                 NEG.
ALIENACANTHOMYSIS MACROPSIS       1     .1     1-      .3         .00     .00    .00-      .00   .0020 .0000       .83     .03     .03
               C-J/A NOSEX  11.1                1                                  .00
NEOMYSIS MERCEDIS                 1     .1     1-      .3         .02     .00    .02-      .01   .0180 .0000       .83     .24     .25
               8-ADULT      11.1                1                                  .02
```

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STOMACH ANALYSIS                                           PAGE  2
****************
   SPECIES  8755010203-ONCORHYNCHUS KISUTCH            COHO SALMON

PREY ORGANISM       LIFE                 NUMBER          *           BIOMASS            *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN   RANGE  S.D. *  MEAN  S.D. *  ABUN-         NORM.
  PARTS CODE       STAGE  OCCUR                             *                             *              *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------

DIASTYLOPSIS TENUIS             1    .1    1-     .3       .00    .00   .00-    .00  .0030 .0000      .83    .04    .04
              8-ADULT     11.1              1                              .00
AMPITHOE SP.                    1    .1    1-     .3       .03    .00   .03-    .01  .0310 .0000      .83    .42    .43
              8-ADULT     11.1              1                              .03
HYALELLIDAE                     1    .1    1-     .3       .00    .00   .00-    .00  .0010 .0000      .83    .01    .01
              8-ADULT     11.1              1                              .00
PHOTIS SP.                      1    .1    1-     .3       .00    .00   .00-    .00  .0010 .0000      .83    .01    .01
              8-ADULT     11.1              1                              .00
ISCHYROCERUS SP.               20   2.2    1-    6.3       .01    .00   .00-    .00  .0013 .0010    16.53    .18    .18
              8-ADULT     22.2             19                              .01
JASSA FALCATA                   1    .1    1-     .3       .00    .00   .00-    .00  .0010 .0000      .83    .01    .01
              8-ADULT     11.1              1                              .00
CAPRELLA IRREGULARIS            1    .1    1-     .3       .00    .00   .00-    .00  .0030 .0000      .83    .04    .04
              L-EGG-C FEM 11.1              1                              .00
PORCELLANIDAE                   1    .1    1-     .3       .00    .00   .00-    .00  .0010 .0000      .83    .01    .01
              3-ZOEA      11.1              1                              .00
INSECTA                         4    .4    1-    1.0       .01    .00   .00-    .00  .0023 .0009     3.31    .11    .11
              8-ADULT     22.2              3                              .01
INSECTA                        35   3.9   35-   11.7       .09    .01   .09-    .03  .0026 .0000    28.93   1.25   1.28
              A-JUV+ADULT 11.1             35                              .09
DIPTERA-CHIRONOMIDAE            5    .6    5-    1.7       .00    .00   .00-    .00  .0004 .0000     4.13    .03    .03
              A-JUV+ADULT 11.1              5                              .00
DIPTERA-BRACHYCERA             21   2.3    1-    6.6       .05    .01   .01-    .02  .0037 .0019    17.36    .71    .72
              8-ADULT     22.2             20                              .05
HYMENOPTERA                     1    .1    1-     .3       .00    .00   .00-    .00  .0020 .0000      .83    .03    .03
              8-ADULT     11.1              1                              .00
OSTEICHTHYES                    1    .1    1-     .3       .29    .03   .29-    .10  .2940 .0000      .83   3.99   4.08
              C-J/A NOSEX 11.1              1                              .29
CLUPEA HARENGUS PALLASI         2    .2    2-     .7       .14    .02   .14-    .05  .0695 .0000     1.65   1.89   1.93
  1-UNIDENT.  7-JUVENILE  11.1              2                              .14
CLUPEA HARENGUS PALLASI        19   2.1    3-    2.7      5.44    .60   .88-    .77  .2913 .0613    15.70  73.88  75.57
              7-JUVENILE  44.4              6                             2.01
AMMODYTES HEXAPTERUS            2    .2    2-     .7      1.09    .12  1.09-    .36  .5465 .0000     1.65  14.83  15.17
              7-JUVENILE  11.1              2                             1.09
PLANTS AND PLANT PARTS          1    .1    1-     .3       .00    .00   .00-    .00  .0040 .0000      .83    .05    .06
               -UNKNOWN   11.1              1                              .00
UNIDENTIFIED MATERIAL                                      .16    .03   .00-    .04                         2.24
                                                                           .11

TOTAL NUMBER OF PREY CATEGORIES   21

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        3.10
                                             BIOMASS        1.26
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                2.80
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STOMACH ANALYSIS                                                    PAGE  2
****************
   SPECIES: 8755010203-ONCORHYNCHUS KISUTCH             COHO SALMON

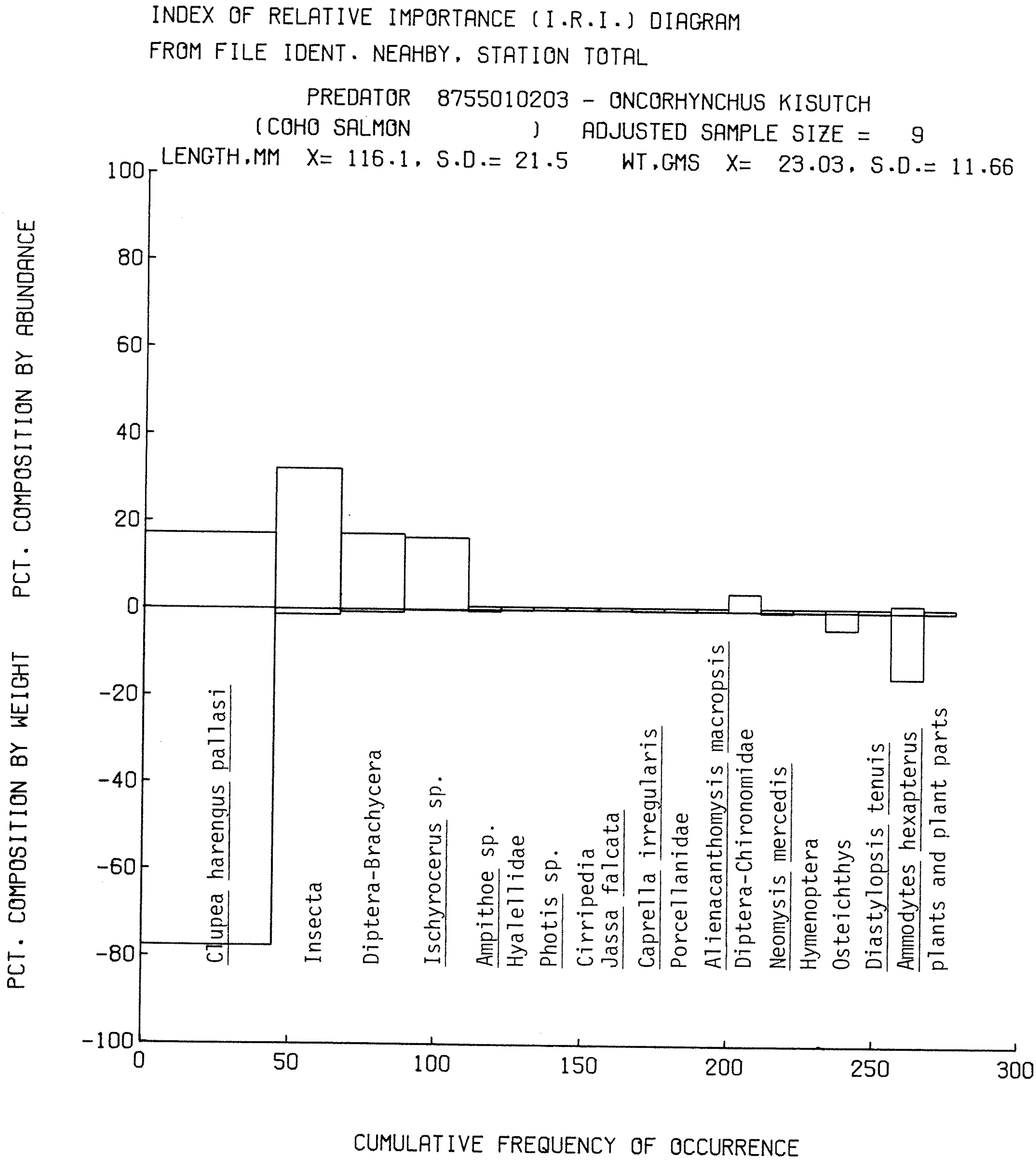
           INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
           USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
           *******************************************

                                   FREQ   NUM.   GRAV.   PREY    PERCENT
        PREY ITEM                  OCCUR  COMP.  COMP.   I.R.I.  TOTAL IRI
  ----------------------------     -----  -----  -----   ------  ---------

 CLUPEA HARENGUS PALLASI           44.44  17.36  77.50   4215.7    68.61
 INSECTA                           22.22  32.23   1.39    747.1    12.16
 DIPTERA-BRACHYCERA                22.22  17.36    .72    401.7     6.54
 ISCHYROCERUS SP.                  22.22  16.53    .18    371.3     6.04
 AMPITHOE SP.                      11.11    .83    .43     14.0      .23
 HYALELLIDAE                       11.11    .83    .01      9.3      .15
 PHOTIS SP.                        11.11    .83    .01      9.3      .15
 CIRRIPEDIA                        11.11    .83    .00      9.2      .15
 JASSA FALCATA                     11.11    .83    .01      9.3      .15
 CAPRELLA IRREGULARIS              11.11    .83    .04      9.6      .16
 PORCELLANIDAE                     11.11    .83    .01      9.3      .15
 ALIENACANTHOMYSIS MACROPSIS       11.11    .83    .03      9.5      .15
 DIPTERA-CHIRONOMIDAE              11.11   4.13    .03     46.2      .75
 NEOMYSIS MERCEDIS                 11.11    .83    .25     12.0      .19
 HYMENOPTERA                       11.11    .83    .03      9.5      .15
 OSTEICHTHYES                      11.11    .83   4.08     54.5      .89
 DIASTYLOPSIS TENUIS               11.11    .83    .04      9.6      .16
 AMMODYTES HEXAPTERUS              11.11   1.65  15.17    186.9     3.04
 PLANTS AND PLANT PARTS            11.11    .83    .06      9.8      .16

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX,               .19    .63                .49
      SHANNON-WEINER DIVERSITY              2.86   1.13               1.69
      EVENNESS INDEX,                        .67    .27                .40
```



INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8755010203 - ONCORHYNCHUS KISUTCH
(COHO SALMON) ADJUSTED SAMPLE SIZE = 9
LENGTH,MM X= 116.1, S.D.= 21.5 WT,GMS X= 23.03, S.D.= 11.66

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STOMACH ANALYSIS                                                  PAGE  1
****************
   SPECIES  8755010206-ONCORHYNCHUS TSHAWYTSCHA         CHINOOK SALMON

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ------------------------------------------------------------------------
                     86JY17          P 3           02118           2          1625

LIFE HISTORY STAGE
                     2 JUVENILE
                    ---
TOTAL SAMPLE SIZE    2


NUMBER OF EMPTY STOMACHS        0
PERCENTAGE OF EMPTY STOMACHS     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)      2


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                            MEAN    RANGE    S.D.
                         -------------------------
CONDITION FACTOR             4.5    2.-7.    3.5
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR             3.0    1.-5.    2.8
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT        .51     .04-
   (GRAMS)                            .97     .66
TOTAL CONTENTS ABUNDANCE     1.0     .0-
   (NUMBERS)                          2.0     1.4
NO. PREY CATEGORIES          1.0     1.-
   (PER STOMACH)                       1.      .0
LENGTH                     133.0    119.-
   (MM)                              147.   19.80
WEIGHT                     33.58   21.73-
   (GRAMS)                          45.42   16.75
PCT RATIO OF CONTENTS       2.28     .09-
   WT TO PREDATOR WT                 4.48    3.11

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM      LIFE               NUMBER           *           BIOMASS              *  AVE. BIOMASS*      PERCENTAGES
                 HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN    RANGE    S.D. *   MEAN   S.D. *  ABUN-            NORM.
  PARTS CODE      STAGE  OCCUR                          *                                  *              *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------------

CLUPEA HARENGUS PALLASI           2    1.0     2-    1.4        .97     .49     .97-     .69    .4870 .0000    100.00  96.15 100.00
           7-JUVENILE    50.0                   2                                 .97
UNIDENTIFIED MATERIAL                                           .04     .04     .04-     .00                            3.85
                                                                                 .04

TOTAL NUMBER OF PREY CATEGORIES    1

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        .00
                                             BIOMASS        .00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                .00
```

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STOMACH ANALYSIS                                                    PAGE  2
****************
   SPECIES: 8755010206-ONCORHYNCHUS TSHAWYTSCHA         CHINOOK SALMON

              INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
              USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
              ********************************************

                                  FREQ   NUM.   GRAV.  PREY     PERCENT
        PREY ITEM                 OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
   ----------------------------   -----  -----  -----  ------  ---------

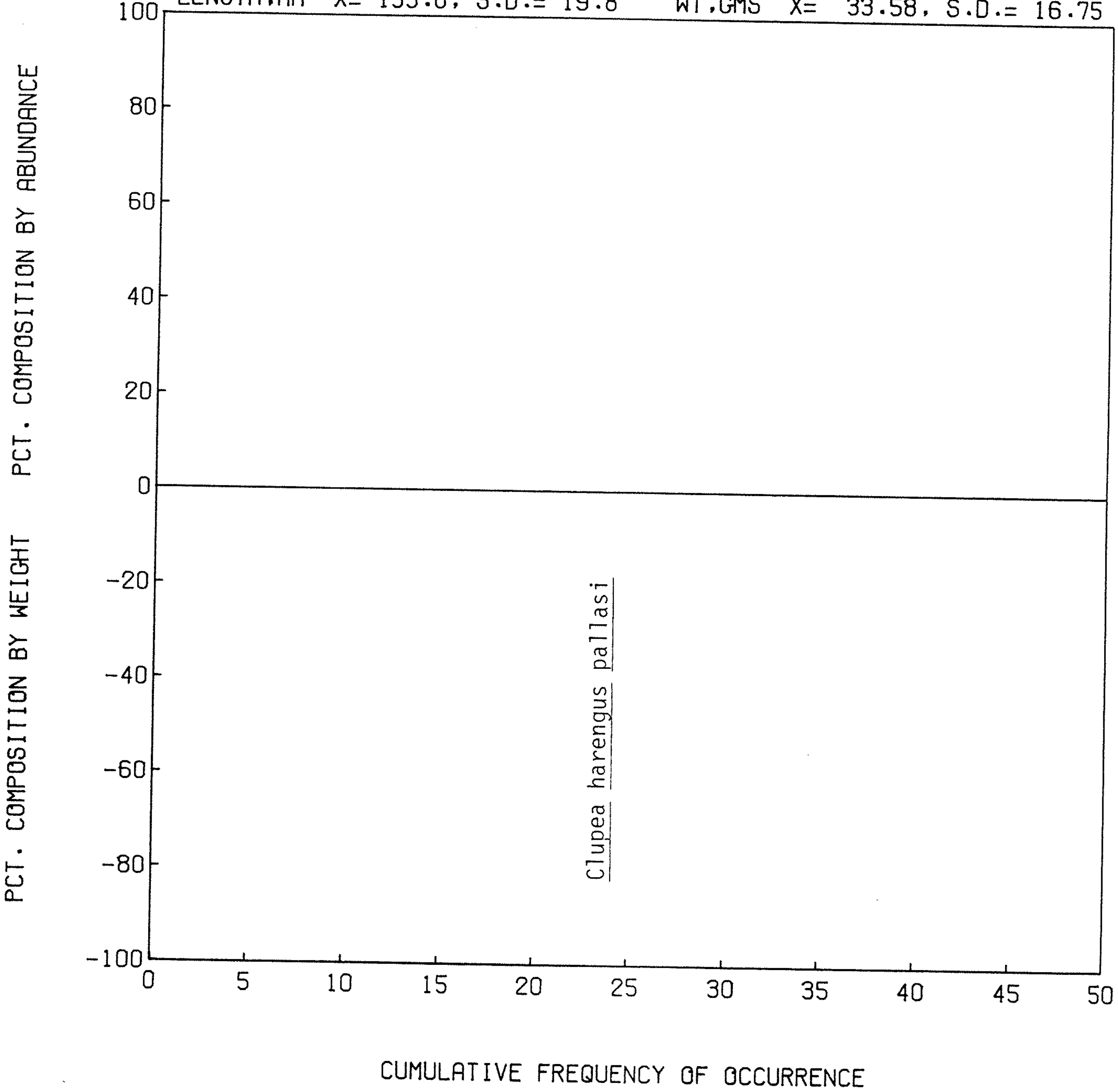
  CLUPEA HARENGUS PALLASI         50.00 100.00 100.00 10000.0   100.00

    PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
    COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
    (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

       PERCENT DOMINANCE INDEX,             1.00   1.00             1.00
       SHANNON-WEINER DIVERSITY             .00    .00              .00
       EVENNESS INDEX,                        I      I                I
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8755010206 - ONCORHYNCHUS TSHAWYTSCHA
(CHINOOK SALMON) ADJUSTED SAMPLE SIZE = 2
LENGTH,MM X= 133.0, S.D.= 19.8 WT,GMS X= 33.58, S.D.= 16.75



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STOMACH ANALYSIS                                                PAGE  1
****************
   SPECIES  8755030101-HYPOMESUS PRETIOSUS              SURF SMELT

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ---------------------------------------------------------------------------
                     86MY21          P 1          02116            3           1458
                     86MY21          P 2          02117            5           1348
                     86JY17          P 3          02117            5           1405
                     86JY17          P 1          02116            5           1440
                     86MY21          P 1          02116            5           1458
                     86JY17          P 1          02116            1           1440
                     86JY17          P 2          02116            2           1440

LIFE HISTORY STAGE
                     18 JUVENILE
                      8 ADULT
                     ---
TOTAL SAMPLE SIZE    26


NUMBER OF EMPTY STOMACHS         0
PERCENTAGE OF EMPTY STOMACHS    .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)     26


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                             MEAN    RANGE    S.D.
                            --------------------------
CONDITION FACTOR              3.7    2.-6.    1.1
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR              3.0    2.-5.     .9
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT         .12    NEG.-
   (GRAMS)                             .60    .17
TOTAL CONTENTS ABUNDANCE    238.9    1.0-
   (NUMBERS)                         796.0  284.0
NO. PREY CATEGORIES           9.4      1.-
   (PER STOMACH)                       18.    5.0
LENGTH                      104.6    54.-
   (MM)                               181.  47.67
WEIGHT                      18.64    1.05-
   (GRAMS)                           67.54  23.52
PCT RATIO OF CONTENTS         .85     .05-
   WT TO PREDATOR WT                  1.94    .61

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.
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STOMACH ANALYSIS                                                      PAGE  2
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   SPECIES  8755030101-HYPOMESUS PRETIOSUS               SURF SMELT
PREY ORGANISM       LIFE                 NUMBER           *             BIOMASS              *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN     RANGE   S.D. *   MEAN S.D.  *  ABUN-           NORM.
  PARTS CODE       STAGE  OCCUR                           *                                  *              *  DANCE BIOMASS BIOMASS
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HYDROIDA                             1    .0    1-      .2       .01     .00    .01-       .00    .0090 .0000         .02    .30   2.93
               8-ADULT        3.8                 1                               .01
POLYCHAETA                         306  11.8    1-    29.1       .01     .00    NEG.-      .00    .0000 .0000        4.93    .32   3.16
               C-J/A NOSEX   42.3               112                               .01
AUTOLYTUS SP.                        1    .0    1-      .2       .00     .00    .00-       .00    .0010 .0000         .02    .03    .33
               C-J/A NOSEX    3.8                 1                               .00
GASTROPODA                           1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               7-JUVENILE     3.8                 1                              NEG.
GASTROPODA                           5    .2    1-      .8       .00     .00    NEG.-      .00    .0002 .0001         .08    .04    .36
               C-J/A NOSEX    7.7                 4                               .00
EVADNE SP.                           2    .1    2-      .4       .00     .00    NEG.-      .00    .0000 .0000         .03    .00    .03
               C-J/A NOSEX    3.8                 2                              NEG.
PODON SP.                            3    .1    3-      .6       .00     .00    NEG.-      .00    .0000 .0000         .05    .00    .03
               C-J/A NOSEX    3.8                 3                              NEG.
CALANOIDA                            7    .3    3-     1.0       .00     .00    NEG.-      .00    .0000 .0000         .11    .01    .07
               2-NAUPLIUS     7.7                 4                              NEG.
CALANOIDA                            2    .1    1-      .3       .00     .00    NEG.-      .00    .0001 .0000         .03    .01    .07
               8-ADULT        7.7                 1                              NEG.
CALANOIDA                          245   9.4    1-    13.9       .01     .00    NEG.-      .00    .0001 .0001        3.94    .47   4.69
               A-JUV+ADULT   46.2                48                               .00
CALANOIDA                            1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               C-J/A NOSEX    3.8                 1                              NEG.
CALANUS SP.                          1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               8-ADULT        3.8                 1                              NEG.
CALANUS SP.                          7    .3    3-     1.0       .00     .00    NEG.-      .00    .0000 .0000         .11    .01    .07
               A-JUV+ADULT    7.7                 4                              NEG.
CALANUS SP.                          1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               C-J/A NOSEX    3.8                 1                              NEG.
CALANUS SP.                         28   1.1    3-     2.7       .00     .00    NEG.-      .00    .0001 .0001         .45    .08    .75
               F-COPEPODID   19.2                12                               .00
CALANUS CRISTATUS                    1    .0    1-      .2       .00     .00    .00-       .00    .0020 .0000         .02    .07    .65
               A-JUV+ADULT    3.8                 1                               .00
EUCALANUS BUNGII                     1    .0    1-      .2       .00     .00    .00-       .00    .0010 .0000         .02    .03    .33
               A-JUV+ADULT    3.8                 1                               .00
PARACALANUS SP.                     22    .8    1-     2.2       .00     .00    NEG.-      .00    .0001 .0000         .35    .05    .46
               8-ADULT       19.2                10                               .00
PARACALANUS SP.                      8    .3    8-     1.6       .00     .00    NEG.-      .00    .0000 .0000         .13    .00    .03
               A-JUV+ADULT    3.8                 8                              NEG.
PARACALANUS PARVUS                   1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               8-ADULT        3.8                 1                              NEG.
PSEUDOCALANUS SP.                    9    .3    1-     1.0       .00     .00    NEG.-      .00    .0001 .0000         .14    .01    .13
               8-ADULT       15.4                 4                              NEG.
PSEUDOCALANUS SP.                    1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               C-J/A NOSEX    3.8                 1                              NEG.
AETIDEIDAE                           1    .0    1-      .2       .00     .00    .00-       .00    .0020 .0000         .02    .07    .65
               C-J/A NOSEX    3.8                 1                               .00
CENTROPAGES SP.                      2    .1    2-      .4       .00     .00    NEG.-      .00    .0000 .0000         .03    .00    .03
               A-JUV+ADULT    3.8                 2                              NEG.
CENTROPAGES ABDOMINALIS              1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               8-ADULT        3.8                 1                              NEG.
CENTROPAGES ABDOMINALIS              1    .0    1-      .2       .00     .00    NEG.-      .00    .0001 .0000         .02    .00    .03
               A-JUV+ADULT    3.8                 1                              NEG.
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STOMACH ANALYSIS                                                   PAGE  3
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   SPECIES  8755030101-HYPOMESUS PRETIOSUS             SURF SMELT
PREY ORGANISM       LIFE                 NUMBER          *         BIOMASS              * AVE. BIOMASS*       PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *   TOTAL   MEAN    RANGE    S.D. *  MEAN  S.D. *  ABUN-             NORM.
  PARTS CODE       STAGE  OCCUR                          *                                  *             *  DANCE BIOMASS BIOMASS
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CENTROPAGES ABDOMINALIS          4     .2     1-      .6      .00     .00   NEG.-      .00   .0001 .0000      .06     .01     .07
                 F-COPEPODID  7.7              3                             NEG.
EPILABIDOCERA LONGIPEDATA       36    1.4     8-     4.1      .00     .00   NEG.-      .00   .0001 .0001      .58     .10    1.01
                 A-JUV+ADULT 11.5             16                              .00
ACARTIA SP.                      4     .2     1-      .6      .00     .00   NEG.-      .00   .0001 .0000      .06     .01     .07
                 8-ADULT      7.7              3                             NEG.
ACARTIA SP.                    477   18.3     2-    49.8      .02     .00   NEG.-      .00   .0000 .0000     7.68     .63    6.25
                 A-JUV+ADULT 30.8            239                              .01
ACARTIA CLAUSI                  24     .9    24-     4.7      .00     .00    .00-      .00   .0000 .0000      .39     .03     .33
                 A-JUV+ADULT  3.8             24                              .00
ACARTIA LONGIREMIS               3     .1     3-      .6      .00     .00   NEG.-      .00   .0000 .0000      .05     .00     .03
                 7-JUVENILE   3.8              3                             NEG.
ACARTIA LONGIREMIS               1     .0     1-      .2      .00     .00   NEG.-      .00   .0001 .0000      .02     .00     .03
                 8-ADULT      3.8              1                             NEG.
ACARTIA LONGIREMIS             200    7.7     1-    35.8      .01     .00   NEG.-      .00   .0000 .0000     3.22     .30    3.03
                 A-JUV+ADULT 15.4            183                              .01
HARPACTICOIDA                    2     .1     2-      .4      .00     .00   NEG.-      .00   .0000 .0000      .03     .00     .03
                 8-ADULT      3.8              2                             NEG.
HARPACTICOIDA                   23     .9     1-     2.0      .00     .00   NEG.-      .00   .0000 .0000      .37     .02     .23
                 C-J/A NOSEX 26.9              8                             NEG.
HARPACTICOIDA                   37    1.4     5-     6.3      .00     .00   NEG.-      .00   .0000 .0000      .60     .01     .07
                 F-COPEPODID  7.7             32                             NEG.
HARPACTICUS UNIREMIS             1     .0     1-      .2      .00     .00   NEG.-      .00   .0001 .0000      .02     .00     .03
                 8-ADULT      3.8              1                             NEG.
HARPACTICUS SPINULOSUS           1     .0     1-      .2      .00     .00   NEG.-      .00   .0001 .0000      .02     .00     .03
                 8-ADULT      3.8              1                             NEG.
HARPACTICUS SP.-OBSCURUS GROUP 346   13.3     2-    61.1      .00     .00   NEG.-      .00   .0000 .0000     5.57     .14    1.40
                 8-ADULT     15.4            312                              .00
HARPACTICUS SP.-OBSCURUS GROUP  38    1.5    38-     7.5      .00     .00    .00-      .00   .0000 .0000      .61     .03     .33
                 A-JUV+ADULT  3.8             38                              .00
HARPACTICUS SP.-UNIREMIS GROUP  39    1.5     1-     7.0      .00     .00   NEG.-      .00   .0001 .0000      .63     .14    1.37
                 8-ADULT     11.5             36                              .00
TISBE SP.                       14     .5     1-     2.4      .00     .00   NEG.-      .00   .0001 .0001      .23     .01     .10
                 8-ADULT     11.5             12                             NEG.
TISBE SP.                       17     .7     8-     2.3      .00     .00   NEG.-      .00   .0000 .0000      .27     .01     .07
                 A-JUV+ADULT  7.7              9                             NEG.
TISBE SP.                        1     .0     1-      .2      .00     .00   NEG.-      .00   .0001 .0000      .02     .00     .03
                 C-J/A NOSEX  3.8              1                             NEG.
TACHIDIUS TRIANGULARIS           1     .0     1-      .2      .00     .00   NEG.-      .00   .0001 .0000      .02     .00     .03
                 8-ADULT      3.8              1                             NEG.
DIOSACCUS SPINATUS              23     .9     1-     3.3      .00     .00   NEG.-      .00   .0001 .0001      .37     .07     .72
                 8-ADULT     11.5             16                              .00
DIOSACCUS SPINATUS               2     .1     2-      .4      .00     .00   NEG.-      .00   .0000 .0000      .03     .00     .03
                 A-JUV+ADULT  3.8              2                             NEG.
DIOSACCUS SPINATUS              19     .7    19-     3.7      .00     .00    .00-      .00   .0002 .0000      .31     .10     .98
                 L-EGG-C FEM  3.8             19                              .00
DACTYLOPODIA VULGARIS            8     .3     8-     1.6      .00     .00    .00-      .00   .0001 .0000      .13     .03     .33
                 8-ADULT      3.8              8                              .00
CYCLOPOIDA                       4     .2     4-      .8      .00     .00   NEG.-      .00   .0000 .0000      .06     .00     .03
                 8-ADULT      3.8              4                             NEG.
CORYCAEUS ANGLICUS               4     .2     4-      .8      .00     .00   NEG.-      .00   .0000 .0000      .06     .00     .03
                 A-JUV+ADULT  3.8              4                             NEG.
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STOMACH ANALYSIS                                                 PAGE  4
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   SPECIES  8755030101-HYPOMESUS PRETIOSUS              SURF SMELT
PREY ORGANISM        LIFE              NUMBER           *           BIOMASS              * AVE. BIOMASS*    PERCENTAGES
                   HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *   TOTAL  MEAN    RANGE   S.D. *  MEAN  S.D. * ABUN-        NORM.
  PARTS CODE        STAGE  OCCUR                            *                              *              * DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------

CORYCAEUS ANGLICUS                5    .2    1-    .6       .00    .00   NEG.-     .00   .0001 .0000      .08    .01    .10
               C-J/A NOSEX  11.5                2                          NEG.
CORYCAEUS ANGLICUS                4    .2    4-    .8       .00    .00   NEG.-     .00   .0000 .0000      .06    .00    .03
               F-COPEPODID   3.8                4                          NEG.
LICHOMOLGIDAE                     1    .0    1-    .2       .00    .00   NEG.-     .00   .0001 .0000      .02    .00    .03
               C-J/A NOSEX   3.8                1                          NEG.
BALANOMORPHA                   2416  92.9    1-  149.4      .06    .00   NEG.-     .00   .0000 .0000    38.90   2.10  20.87
               2-NAUPLIUS   80.8              460                          .01
BALANOMORPHA                    445  17.1    1-   87.1      .01    .00   NEG.-     .00   .0001 .0001     7.16    .27   2.64
               3-ZOEA        7.7              444                          .01
BALANOMORPHA                     33   1.3    1-    3.0      .00    .00   NEG.-     .00   .0000 .0000      .53    .02    .20
               E-CYPRIS     23.1               12                          NEG.
MYSIDACEA                        12    .5    1-    1.7      .00    .00   NEG.-     .00   .0000 .0000      .19    .01    .10
               6-LARVA      11.5                8                          NEG.
GAMMARIDEA                        1    .0    1-    .2       .00    .00   NEG.-     .00   .0001 .0000      .02    .00    .03
               7-JUVENILE    3.8                1                          NEG.
PARATHEMISTO PACIFICA             1    .0    1-    .2       .00    .00   NEG.-     .00   .0001 .0000      .02    .00    .03
               C-J/A NOSEX   3.8                1                          NEG.
METACAPRELLA ANOMALA              1    .0    1-    .2       .00    .00   .00-      .00   .0010 .0000      .02    .03    .33
               C-J/A NOSEX   3.8                1                          .00
EUPHAUSIACEA                     32   1.2   32-    6.3      .00    .00   NEG.-     .00   .0000 .0000      .52    .00    .03
               3-ZOEA        3.8               32                          NEG.
EUPHAUSIACEA                      4    .2    4-    .8       .00    .00   NEG.-     .00   .0000 .0000      .06    .00    .03
               6-LARVA       3.8                4                          NEG.
DECAPODA                          6    .2    2-    .7       .00    .00   NEG.-     .00   .0004 .0003      .10    .07    .68
               3-ZOEA       11.5                2                          .00
DECAPODA                          2    .1    1-    .3       .00    .00   .00-      .00   .0010 .0000      .03    .07    .65
               4-MEGALOP     7.7                1                          .00
DECAPODA                         19    .7    2-    2.6      .00    .00   NEG.-     .00   .0000 .0000      .31    .01    .10
               6-LARVA      11.5               13                          NEG.
PLEOCYEMATA-CARIDEA              17    .7    1-    2.2      .00    .00   NEG.-     .00   .0002 .0001      .27    .10   1.01
               3-ZOEA       11.5               10                          .00
PLEOCYEMATA-CARIDEA               6    .2    1-    .6       .00    .00   NEG.-     .00   .0003 .0005      .10    .04    .42
               6-LARVA      15.4                2                          .00
CRANGON SP.                       2    .1    2-    .4       .00    .00   .00-      .00   .0005 .0000      .03    .03    .33
               4-MEGALOP     3.8                2                          .00
CRANGON SP.                      31   1.2    2-    4.1      .01    .00   NEG.-     .00   .0004 .0004      .50    .27   2.64
               6-LARVA      15.4               20                          .00
ANOMURA                           1    .0    1-    .2       .00    .00   NEG.-     .00   .0001 .0000      .02    .00    .03
               3-ZOEA        3.8                1                          NEG.
PAGURIDAE                         2    .1    1-    .3       .00    .00   NEG.-     .00   .0006 .0006      .03    .04    .36
               4-MEGALOP     7.7                1                          .00
PORCELLANIDAE                    24    .9    1-    3.1      .01    .00   NEG.-     .00   .0003 .0002      .39    .27   2.64
               3-ZOEA       11.5               13                          .01
DECAPODA-BRACHYURA               90   3.5    1-    5.7      .01    .00   NEG.-     .00   .0001 .0003     1.45    .26   2.60
               3-ZOEA       50.0               24                          .01
MAJIDAE                           1    .0    1-    .2       .00    .00   .00-      .00   .0010 .0000      .02    .03    .33
               4-MEGALOP     3.8                1                          .00
CANCER SP.                       28   1.1    1-    4.1      .06    .00   NEG.-     .01   .0019 .0022      .45   1.85  18.33
               3-ZOEA       23.1               21                          .04
XANTHIDAE                         2    .1    2-    .4       .00    .00   NEG.-     .00   .0000 .0000      .03    .00    .03
               3-ZOEA        3.8                2                          NEG.
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STOMACH ANALYSIS                                                 PAGE  5
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   SPECIES  8755030101-HYPOMESUS PRETIOSUS              SURF SMELT

PREY ORGANISM       LIFE               NUMBER            *        BIOMASS              *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL    MEAN    RANGE    S.D. *  MEAN  S.D. *  ABUN-              NORM.
  PARTS CODE       STAGE  OCCUR                           *                              *              *  DANCE BIOMASS BIOMASS
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PINNOTHERIDAE                    68    2.6     1-    7.7       .01     .00    NEG.-      .00    .0001 .0000       1.09     .18    1.82
              3-ZOEA       30.8                36                                .00
GRAPSIDAE                         1     .0     1-     .2       .00     .00    NEG.-      .00    .0001 .0000        .02     .00     .03
              3-ZOEA        3.8                 1                               NEG.
HEMIGRAPSUS SP.                   6     .2     3-     .8       .00     .00    NEG.-      .00    .0000 .0000        .10     .01     .07
              3-ZOEA        7.7                 3                               NEG.
APHIDIDAE                         1     .0     1-     .2       .00     .00    NEG.-      .00    .0001 .0000        .02     .00     .03
              8-ADULT       3.8                 1                               NEG.
NEMATOCERA                        1     .0     1-     .2       .00     .00    NEG.-      .00    .0001 .0000        .02     .00     .03
              8-ADULT       3.8                 1                               NEG.
SAGITTA SP.                       1     .0     1-     .2       .00     .00    NEG.-      .00    .0001 .0000        .02     .00     .03
              C-J/A NOSEX   3.8                 1                               NEG.
OIKOPLEURA SP.                  304   11.7    85-   45.4       .00     .00    .00-       .00    .0000 .0000       4.89     .13    1.30
              C-J/A NOSEX   7.7               219                                .00
OIKOPLEURA DIOICA               636   24.5     1-   48.6       .01     .00    NEG.-      .00    .0000 .0000      10.24     .30    2.96
              C-J/A NOSEX  61.5               196                                .00
OSTEICHTHYES                      1     .0     1-     .2       .01     .00    .01-       .00    .0130 .0000        .02     .43    4.23
              C-J/A NOSEX   3.8                 1                                .01
TELEOSTEI                         1     .0     1-     .2       .00     .00    .00-       .00    .0010 .0000        .02     .03     .33
              6-LARVA       3.8                 1                                .00
UNIDENTIFIED EGG                 17     .7     1-    2.4       .01     .00    NEG.-      .00    .0007 .0011        .27     .30    2.96
              1-EGG        11.5                12                                .01
UNIDENTIFIED MATERIAL                                         2.74     .13    .01-       .18                           89.93
                                                                              .58

TOTAL NUMBER OF PREY CATEGORIES   89

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        3.51
                                             BIOMASS        4.38
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                3.48
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STOMACH ANALYSIS                                                  PAGE  2
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   SPECIES: 8755030101-HYPOMESUS PRETIOSUS              SURF SMELT

            INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
            USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
            ******************************************

                                    FREQ   NUM.   GRAV.  PREY     PERCENT
        PREY ITEM                   OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
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  BALANOMORPHA                      88.46  46.59  27.58  6561.8    63.79
  OIKOPLEURA DIOICA                 61.54  10.24   2.81   803.3     7.81
  CALANOIDA                         57.69   4.11   4.55   499.1     4.85
  DECAPODA-BRACHYURA                50.00   1.45   2.47   196.1     1.91
  POLYCHAETA                        42.31   4.93   3.00   335.3     3.26
  HARPACTICOIDA                     38.46   1.00    .31    50.3      .49
  ACARTIA SP.                       38.46   7.74   6.00   528.6     5.14
  CALANUS SP.                       34.62    .60    .83    49.5      .48
  PINNOTHERIDAE                     30.77   1.09   1.73    87.0      .85
  PLEOCYEMATA-CARIDEA               26.92    .37   1.36    46.6      .45
  DECAPODA                          26.92    .43   1.36    48.3      .47
  ACARTIA LONGIREMIS                23.08   3.28   2.94   143.6     1.40
  CANCER SP.                        23.08    .45  17.41   412.1     4.01
  PARACALANUS SP.                   23.08    .48    .46    21.9      .21
  TISBE SP.                         23.08    .52    .19    16.2      .16
  HARPACTICUS SP.-OBSCURUS GROUP    19.23   6.18   1.64   150.4     1.46
  PSEUDOCALANUS SP.                 19.23    .16    .15     6.1      .06
  CORYCAEUS ANGLICUS                19.23    .21    .15     7.0      .07
  CRANGON SP.                       19.23    .53   2.81    64.3      .63
  DIOSACCUS SPINATUS                15.38    .71   1.64    36.1      .35
  CENTROPAGES ABDOMINALIS           15.38    .10    .12     3.4      .03
  PORCELLANIDAE                     11.54    .39   2.50    33.4      .32
  MYSIDACEA                         11.54    .19    .09     3.3      .03
  EPILABIDOCERA LONGIPEDATA         11.54    .58    .96    17.7      .17
  HARPACTICUS SP.-UNIREMIS GROUP    11.54    .63   1.30    22.2      .22
  GASTROPODA                        11.54    .10    .37     5.4      .05
  UNIDENTIFIED EGG                  11.54    .27   2.81    35.6      .35
  HEMIGRAPSUS SP.                    7.69    .10    .06     1.2      .01
  OIKOPLEURA SP.                     7.69   4.89   1.24    47.2      .46
  EUPHAUSIACEA                       7.69    .58    .06     4.9      .05
  PAGURIDAE                          7.69    .03    .34     2.9      .03
  HYDROIDA                           3.85    .02   2.78    10.8      .10

  OSTEICHTHYES                       3.85    .02   4.02    15.5      .15

    PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
    COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
    (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

       PERCENT DOMINANCE INDEX,              .25    .12              .42
       SHANNON-WEINER DIVERSITY             3.08   4.01             2.29
       EVENNESS INDEX,                       .52    .68              .39
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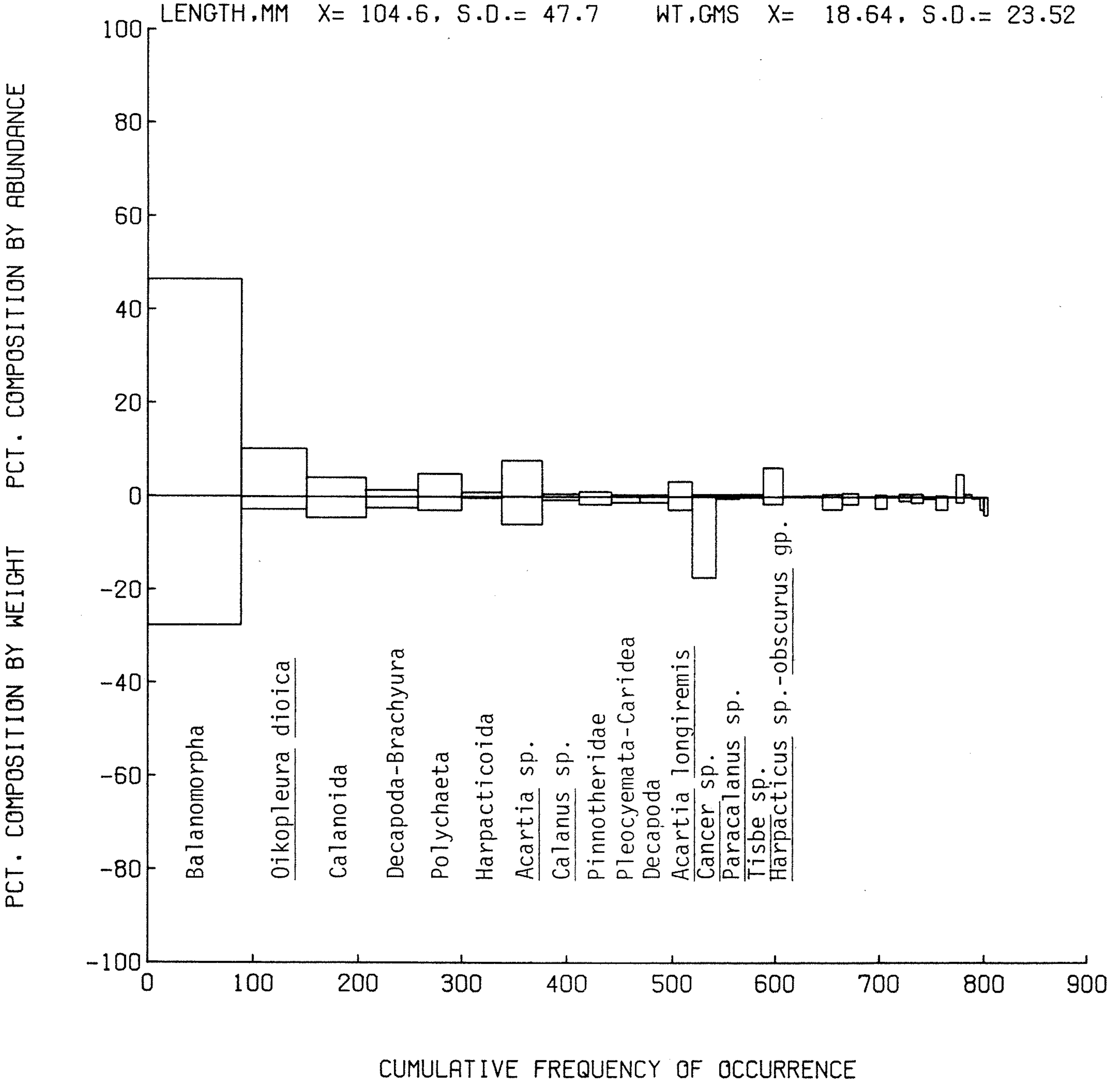
INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL
PREDATOR 8755030101 - HYPOMESUS PRETIOSUS
(SURF SMELT) ADJUSTED SAMPLE SIZE = 26
LENGTH,MM X= 104.6, S.D.= 47.7 WT,GMS X= 18.64, S.D.= 23.52



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STOMACH ANALYSIS                                                   PAGE  1
****************
   SPECIES: 8827010101-HEXAGRAMMOS DECAGRAMMUS          KELP GREENLING

FROM COLLECTIONS:  FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                  ------------------------------------------------------------------------
                      86MY21          P 2           02116       *****           ****

LIFE HISTORY STAGE:
                        5 JUVENILE
                      ---
TOTAL SAMPLE SIZE:      5


NUMBER OF EMPTY STOMACHS:         0
PERCENTAGE OF EMPTY STOMACHS:    .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY):     5


PREY CODES ARE TRUNCATED BY 0 DIGITS
DATA FORMAT = S240.33B

                           MEAN     RANGE     S.D.
                         -------------------------
CONDITION FACTOR            5.6    4.-7.      1.1
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR            4.6    3.-5.       .9
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT       .02     .01-
   (GRAMS)                            .04      .01
TOTAL CONTENTS ABUNDANCE   23.4    16.0-
   (NUMBERS)                          32.0     6.9
NO. PREY CATEGORIES         2.0     1.-
   (PER STOMACH)                       3.       .7
LENGTH                     55.6    53.-
   (MM)                                59.    2.61
WEIGHT                     1.44    1.09-
   (GRAMS)                            1.73     .28
PCT RATIO OF CONTENTS      1.59     .96-
   WT TO PREDATOR WT                  2.92     .80

NOTE: LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM      LIFE             NUMBER             *          BIOMASS             *  AVE. BIOMASS*      PERCENTAGES
                 HISTORY FREQ  TOTAL  MEAN   RANGE   S.D. *   TOTAL   MEAN    RANGE    S.D. *  MEAN   S.D. *  ABUN-            NORM.
                  STAGE  OCCUR                             *                                *              *  DANCE BIOMASS BIOMASS
------------------------------------------------------------------------------------------------------------------------------------

CALANOIDA                        10   2.0    10-    4.5        .00     .00    .00-      .00    .0002 .0000      8.55    1.79    3.27
                         20.0                  10                                .00
CALANUS SP.                      91  18.2    10-   13.0        .05     .01    .01-      .01    .0006 .0001     77.78   45.54   83.47
                         80.0                  31                                .02
GAMMARIDEA                        1    .2     1-     .4        .00     .00    .00-      .00    .0010 .0000       .85     .89    1.64
                         20.0                   1                                .00
DECAPODA                          8   1.6     8-    3.6        .00     .00    .00-      .00    .0005 .0000      6.84    3.57    6.55
                         20.0                   8                                .00
ANOMURA                           2    .4     1-     .5        .00     .00   NEG.-      .00    .0006 .0006      1.71     .98    1.80
                         40.0                   1                                .00
```

```
STOMACH ANALYSIS                                                        PAGE  2
****************
   SPECIES: 8827010101-HEXAGRAMMOS DECAGRAMMUS          KELP GREENLING
PREY ORGANISM      LIFE               NUMBER          *           BIOMASS             *  AVE. BIOMASS*      PERCENTAGES
                 HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *    TOTAL   MEAN    RANGE    S.D. *  MEAN  S.D. *  ABUN-             NORM.
                  STAGE  OCCUR                           *                                  *             *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------------

DECAPODA-BRACHYURA              5   1.0     5-    2.2         .00     .00    .00-     .00    .0004 .0000      4.27    1.79    3.27
                       20.0                   5                                .00
UNIDENTIFIED MATERIAL                                          .05     .01    .00-     .01                            45.45
                                                                              .02

TOTAL NUMBER OF PREY CATEGORIES     6

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS        1.20
                                             BIOMASS        1.00
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                1.11
```

```
STOMACH ANALYSIS                                                 PAGE  3
****************
  SPECIES: 8827010101-HEXAGRAMMOS DECAGRAMMUS         KELP GREENLING

           INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
           USING FILEID= NEAHBY, STATION= KPGRN FOR PLOT
           *********************************************

                                  FREQ   NUM.   GRAV.  PREY     PERCENT
         PREY ITEM                OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
  ----------------------------    -----  -----  -----  ------  ---------

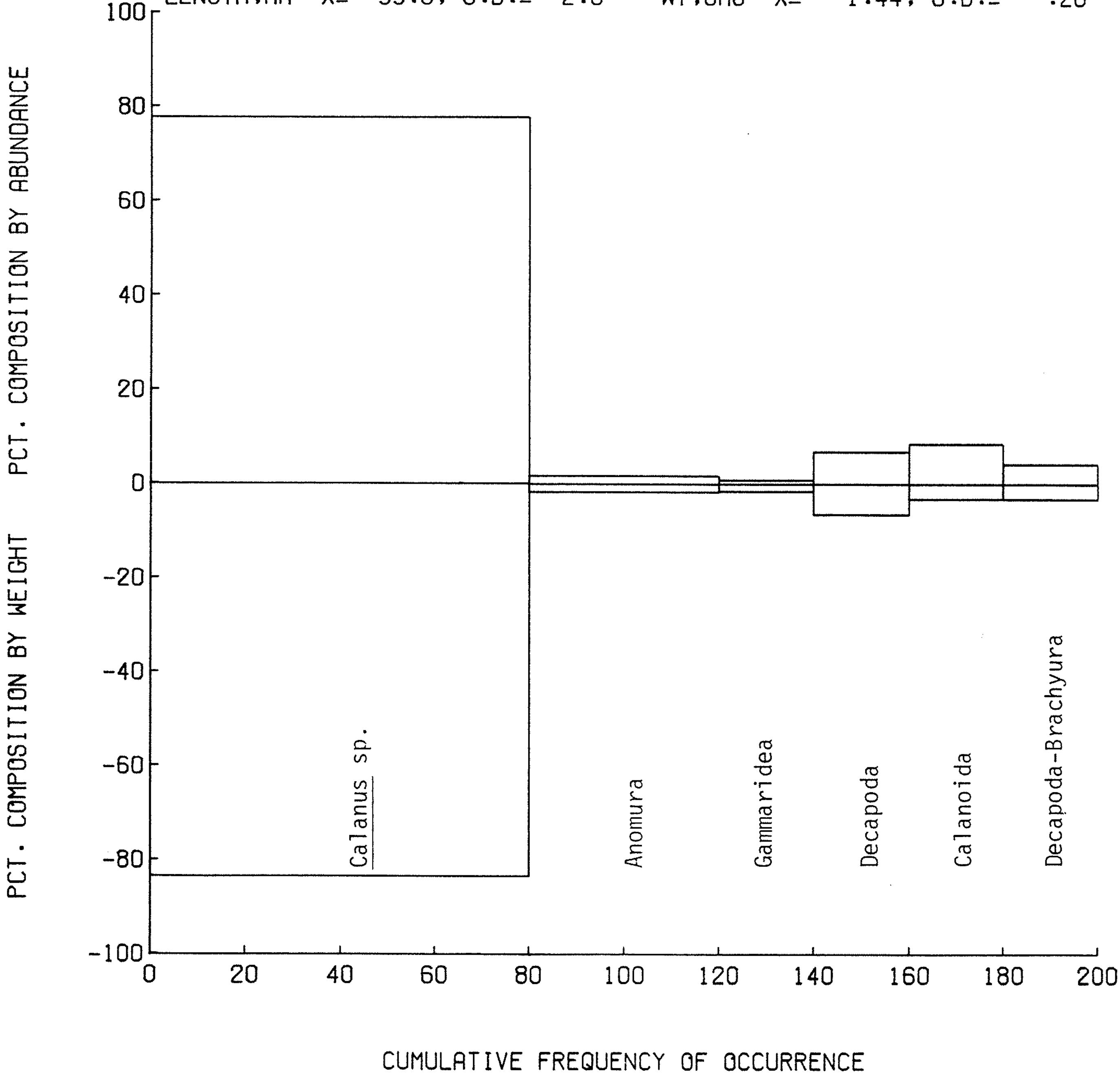
 CALANUS SP.                      80.00  77.78  83.47 12899.8    93.85
 ANOMURA                          40.00   1.71   1.80   140.4     1.02
 GAMMARIDEA                       20.00    .85   1.64    49.8      .36
 DECAPODA                         20.00   6.84   6.55   267.7     1.95
 CALANOIDA                        20.00   8.55   3.27   236.4     1.72
 DECAPODA-BRACHYURA               20.00   4.27   3.27   150.9     1.10

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX,              .62    .70                .88
      SHANNON-WEINER DIVERSITY             1.20   1.00                .47
      EVENNESS INDEX,                       .47    .39                .18
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8827010101 - HEXAGRAMMOS DECAGRAMMUS
(KELP GREENLING) ADJUSTED SAMPLE SIZE = 5
LENGTH,MM X= 55.6, S.D.= 2.6 WT,GMS X= 1.44, S.D.= .28



```
STOMACH ANALYSIS                                                          PAGE  1
****************
   SPECIES  8827010201-OPHIODON ELONGATUS               LINGCOD

FROM COLLECTIONS   FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ------------------------------------------------------------------------
                     86MY21          P 2          02116          5          1528
                     86MY21          P 1          02117          5          1458
                     86MY21          P 2          02117          5          1458

LIFE HISTORY STAGE
                     15 JUVENILE
                    ---
TOTAL SAMPLE SIZE    15


NUMBER OF EMPTY STOMACHS        0
PERCENTAGE OF EMPTY STOMACHS     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY)     15


PREY CODES TRUNCATED BY 0 DIGITS
LIFE HISTORY STAGES ARE  UNPOOLED
DATA FORMAT = S240.33B

                            MEAN    RANGE    S.D.
                           -------------------------
CONDITION FACTOR             4.3    1.-7.    2.0
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR             4.2    1.-5.    1.7
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT        .04    NEG.-
   (GRAMS)                            .07     .02
TOTAL CONTENTS ABUNDANCE    24.5     .0-
   (NUMBERS)                        74.0    29.3
NO. PREY CATEGORIES          2.6     1.-
   (PER STOMACH)                      6.     1.6
LENGTH                      53.3     48.-
   (MM)                              59.    3.37
WEIGHT                       .83     .52-
   (GRAMS)                          1.34     .22
PCT RATIO OF CONTENTS       4.55     .09-
   WT TO PREDATOR WT                9.84    2.93

NOTE  LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM       LIFE                     NUMBER            *              BIOMASS              *  AVE. BIOMASS*     PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE   S.D.  *    TOTAL   MEAN    RANGE    S.D.  *   MEAN   S.D.  * ABUN-          NORM.
  PARTS CODE       STAGE  OCCUR                             *                                   *                * DANCE BIOMASS BIOMASS
-----------------------------------------------------------------------------------------------------------------------------------------

CALANOIDA                         29    1.9     1-     5.1         .00     .00   NEG.-     .00    .0001 .0000      7.90     .22     .25
               A-JUV+ADULT  20.0                18                                 .00
CALANUS SP.                        2     .1     2-      .5         .00     .00    .00-     .00    .0005 .0000       .54     .18     .21
               A-JUV+ADULT   6.7                 2                                 .00
CENTROPAGES SP.                    6     .4     1-      .6         .00     .00   NEG.-     .00    .0001 .0000      1.63     .09     .10
               A-JUV+ADULT  33.3                 2                                NEG.
```

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STOMACH ANALYSIS                                                PAGE  2
****************
   SPECIES  8827010201-OPHIODON ELONGATUS             LINGCOD

PREY ORGANISM       LIFE               NUMBER          *            BIOMASS              *  AVE. BIOMASS*      PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN    RANGE   S.D. *    TOTAL    MEAN    RANGE     S.D. *   MEAN   S.D. *  ABUN-              NORM.
  PARTS CODE        STAGE  OCCUR                               *                                   *                *  DANCE BIOMASS BIOMASS
--------------------------------------------------------------------------------------------------------------------------------------------------

ACARTIA SP.                          2     .1     2-      .5        .00      .00   NEG.-       .00    .0000 .0000        .54      .02      .02
              A-JUV+ADULT    6.7                  2                                   NEG.
ACARTIA LONGIREMIS                 122    8.1     1-    18.4        .01      .00   NEG.-       .00    .0001 .0001      33.24     1.69     1.92
              A-JUV+ADULT   40.0                 58                                   .00
CRANGON SP.                        190   12.7     1-    21.0        .06      .00   NEG.-       .00    .0006 .0004      51.77    10.90    12.44
              6-LARVA       66.7                 63                                   .02
OSTEICHTHYES                        16    1.1     1-     1.3        .41      .03    .01-       .02    .0331 .0187       4.36    74.56    85.06
              6-LARVA       66.7                  4                                   .06
UNIDENTIFIED MATERIAL                                               .07      .01    .00-       .01                               12.34
                                                                                    .02

TOTAL NUMBER OF PREY CATEGORIES    7

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS         1.69
                                             BIOMASS          .74
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS                 1.64
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STOMACH ANALYSIS                                                   PAGE  2
****************
   SPECIES: 8827010201-OPHIODON ELONGATUS               LINGCOD

            INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
            USING FILEID= NEAHBY, STATION= TOTAL FOR PLOT
            ******************************************

                                     FREQ   NUM.   GRAV.  PREY     PERCENT
          PREY ITEM                  OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
  ---------------------------        -----  -----  -----  ------  ---------

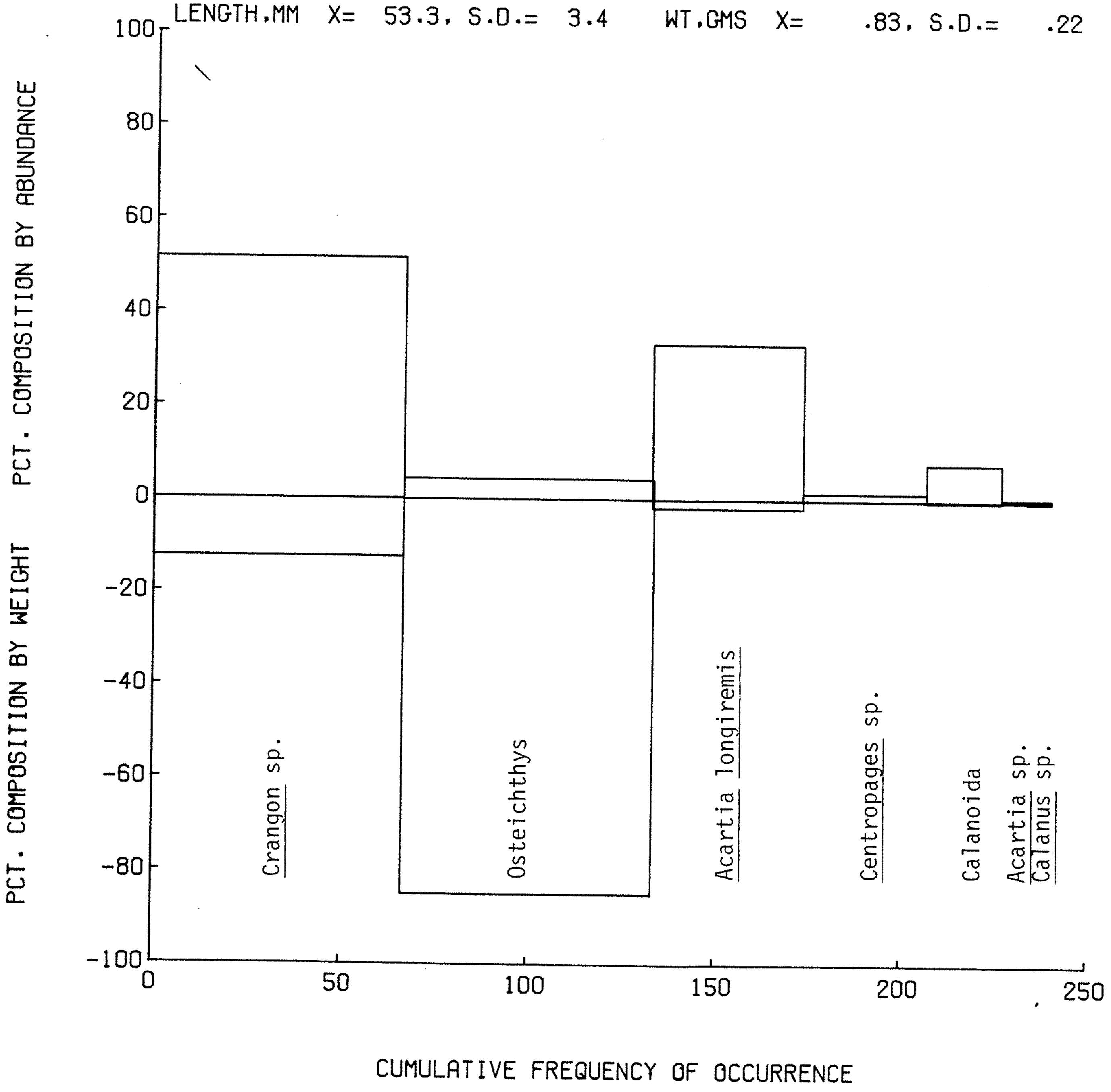
  CRANGON SP.                        66.67  51.77  12.44  4280.6    36.04
  OSTEICHTHYES                       66.67   4.36  85.06  5961.2    50.19
  ACARTIA LONGIREMIS                 40.00  33.24   1.92  1406.7    11.84
  CENTROPAGES SP.                    33.33   1.63    .10    57.9      .49
  CALANOIDA                          20.00   7.90    .25   163.0     1.37
  ACARTIA SP.                         6.67    .54    .02     3.8      .03
  CALANUS SP.                         6.67    .54    .21     5.0      .04

    PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
    COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
    (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

       PERCENT DOMINANCE INDEX,              .39    .74                .40
       SHANNON-WEINER DIVERSITY             1.69    .74               1.53
       EVENNESS INDEX,                       .60    .26                .54
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8827010201 - OPHIODON ELONGATUS
(LINGCOD) ADJUSTED SAMPLE SIZE = 15



```
STOMACH ANALYSIS                                                   PAGE  1
*****************
   SPECIES: 8645010101-AMMODYTES HEXAPTERUS              PACIFIC SAND LANCE

FROM COLLECTIONS:  FILE ID.    SAMPLE NO.  STATION LOC. NO. SPECIMENS  COLLECTION TIME (PST)
                 ----------------------------------------------------------------------
                     86MY21          B 1          02116          10         1730

LIFE HISTORY STAGE:
                     10 JUVENILE/ADULT, SEXUAL MATURITY UNKNOWN
                    ---
TOTAL SAMPLE SIZE:   10


NUMBER OF EMPTY STOMACHS:        0
PERCENTAGE OF EMPTY STOMACHS:     .00
ADJUSTED SAMPLE SIZE(STOMACHS CONTAINING PREY):     10


PREY CODES ARE TRUNCATED BY 0 DIGITS
DATA FORMAT = S240.33B

                           MEAN     RANGE     S.D.
                         --------------------------
CONDITION FACTOR            4.1     3.-6.      1.2
   (1-7, EMPTY-DISTENDED)
DIGESTION FACTOR            3.1     2.-5.      1.0
   (1-5, COMPLETE-NONE)
TOTAL CONTENTS WEIGHT       .07     NEG.-
   (GRAMS)                            .20      .07
TOTAL CONTENTS ABUNDANCE  104.1      3.0-
   (NUMBERS)                        324.0    124.2
NO. PREY CATEGORIES         4.9       2.-
   (PER STOMACH)                       8.      2.1
LENGTH                     84.2      56.-
   (MM)                              112.    23.25
WEIGHT                     2.67      .40-
   (GRAMS)                           5.50     2.23
PCT RATIO OF CONTENTS      2.46      .69-
   WT TO PREDATOR WT                 4.80     1.37

NOTE: LENGTH AND WEIGHT STATISTICS ARE BASED ON THE TOTAL SAMPLE, INCLUDING EMPTY STOMACHS.

PREY ORGANISM        LIFE                   NUMBER              *           BIOMASS            * AVE. BIOMASS*      PERCENTAGES
                   HISTORY FREQ  TOTAL  MEAN   RANGE   S.D.  *     TOTAL   MEAN    RANGE    S.D. *   MEAN   S.D. * ABUN-           NORM.
                    STAGE  OCCUR                             *                                   *             * DANCE BIOMASS BIOMASS
------------------------------------------------------------------------------------------------------------------------------------------

CALANOIDA                         260   26.0     2-    37.4         .05     .00   NEG.-      .01    .0002 .0003     24.98    6.84   14.28
                           80.0                116                                   .03
CALANUS SP.                        28    2.8     2-     4.6         .01     .00   NEG.-      .00    .0003 .0002      2.69    1.05    2.19
                           60.0                 15                                   .00
PSEUDOCALANUS SP.                  12    1.2    12-     3.8         .00     .00    .00-      .00    .0001 .0000      1.15     .15     .31
                           10.0                 12                                   .00
CENTROPAGES SP.                    14    1.4     1-     2.0         .00     .00   NEG.-      .00    .0001 .0001      1.34     .35     .74
                           60.0                  6                                   .00
CALANOIDA                          77    7.7    77-    24.3         .00     .00    .00-      .00    .0001 .0000      7.40     .59    1.23
                           10.0                 77                                   .00
```

```
STOMACH ANALYSIS                                              PAGE  2
****************
   SPECIES: 8845010101-AMMODYTES HEXAPTERUS             PACIFIC SAND LANCE
PREY ORGANISM       LIFE              NUMBER           *          BIOMASS              *  AVE. BIOMASS*     PERCENTAGES
                  HISTORY FREQ  TOTAL  MEAN   RANGE  S.D. *   TOTAL   MEAN   RANGE   S.D. *  MEAN   S.D. *  ABUN-             NORM.
                   STAGE  OCCUR                            *                              *             *  DANCE BIOMASS BIOMASS
-------------------------------------------------------------------------------------------------------------------------------

ACARTIA SP.                     62   6.2    1-   19.3      .00    .00   NEG.-     .00   .0001 .0000    5.96     .46     .96
                          20.0                  61                          .00
ACARTIA LONGIREMIS             127  12.7    2-   26.2      .00    .00   NEG.-     .00   .0000 .0000   12.20     .64    1.33
                          50.0                  83                          .00
HARPACTICOIDA                    1    .1    1-     .3      .00    .00   NEG.-     .00   .0001 .0000     .10     .01     .03
                          10.0                   1                         NEG.
HARPACTICUS SP.-UNIREMIS GROUP   1    .1    1-     .3      .00    .00   NEG.-     .00   .0001 .0000     .10     .01     .03
                          10.0                   1                         NEG.
BALANOMORPHA                   403  40.3    1-   70.5      .01    .00   NEG.-     .00   .0000 .0000   38.71    1.67    3.49
                          60.0                 221                          .01
MYSIDACEA                        2    .2    2-     .6      .03    .00    .03-     .01   .0155 .0000     .19    4.58    9.56
                          10.0                   2                          .03
CUMELLA VULGARIS                 1    .1    1-     .3      .00    .00   NEG.-     .00   .0001 .0000     .10     .01     .03
                          10.0                   1                         NEG.
DECAPODA                        35   3.5    2-    7.5      .01    .00   NEG.-     .00   .0001 .0001    3.36     .77    1.60
                          40.0                  24                          .00
PLEOCYEMATA-CARIDEA              4    .4    4-    1.3      .00    .00   NEG.-     .00   .0000 .0000     .38     .01     .03
                          10.0                   4                         NEG.
DECAPODA-BRACHYURA               1    .1    1-     .3      .00    .00   NEG.-     .00   .0001 .0000     .10     .01     .03
                          10.0                   1                         NEG.
CHAETOGNATHA                     1    .1    1-     .3      .00    .00    .00-     .00   .0020 .0000     .10     .30     .62
                          10.0                   1                          .00
OSTEICHTHYES                    11   1.1    5-    2.3      .20    .02    .07-     .05   .0180 .0068    1.06   30.00   62.62
                          20.0                   6                          .14
UNIDENTIFIED EGG                 1    .1    1-     .3      .00    .00    .00-     .00   .0030 .0000     .10     .44     .93
                          10.0                   1                          .00
UNIDENTIFIED MATERIAL                                      .35    .04    .01-     .05                           52.08
                                                                         .15

TOTAL NUMBER OF PREY CATEGORIES   18

SHANNON-WEINER DIVERSITY INDEX (NORMALIZED)  NUMBERS       2.56
                                             BIOMASS       1.96
BRILLOUIN-S DIVERSITY INDEX BASED ON NUMBERS               2.51
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STOMACH ANALYSIS                                                       PAGE  3
****************
   SPECIES: 8845010101-AMMODYTES HEXAPTERUS              PACIFIC SAND LANCE

             INDEX OF RELATIVE IMPORTANCE (I.R.I.) TABLE
             USING FILEID= NEAHBY, STATION= SNDLC FOR PLOT
             *******************************************

                                  FREQ   NUM.   GRAV.  PREY     PERCENT
          PREY ITEM               OCCUR  COMP.  COMP.  I.R.I.  TOTAL IRI
  ----------------------------    -----  -----  -----  ------  ---------

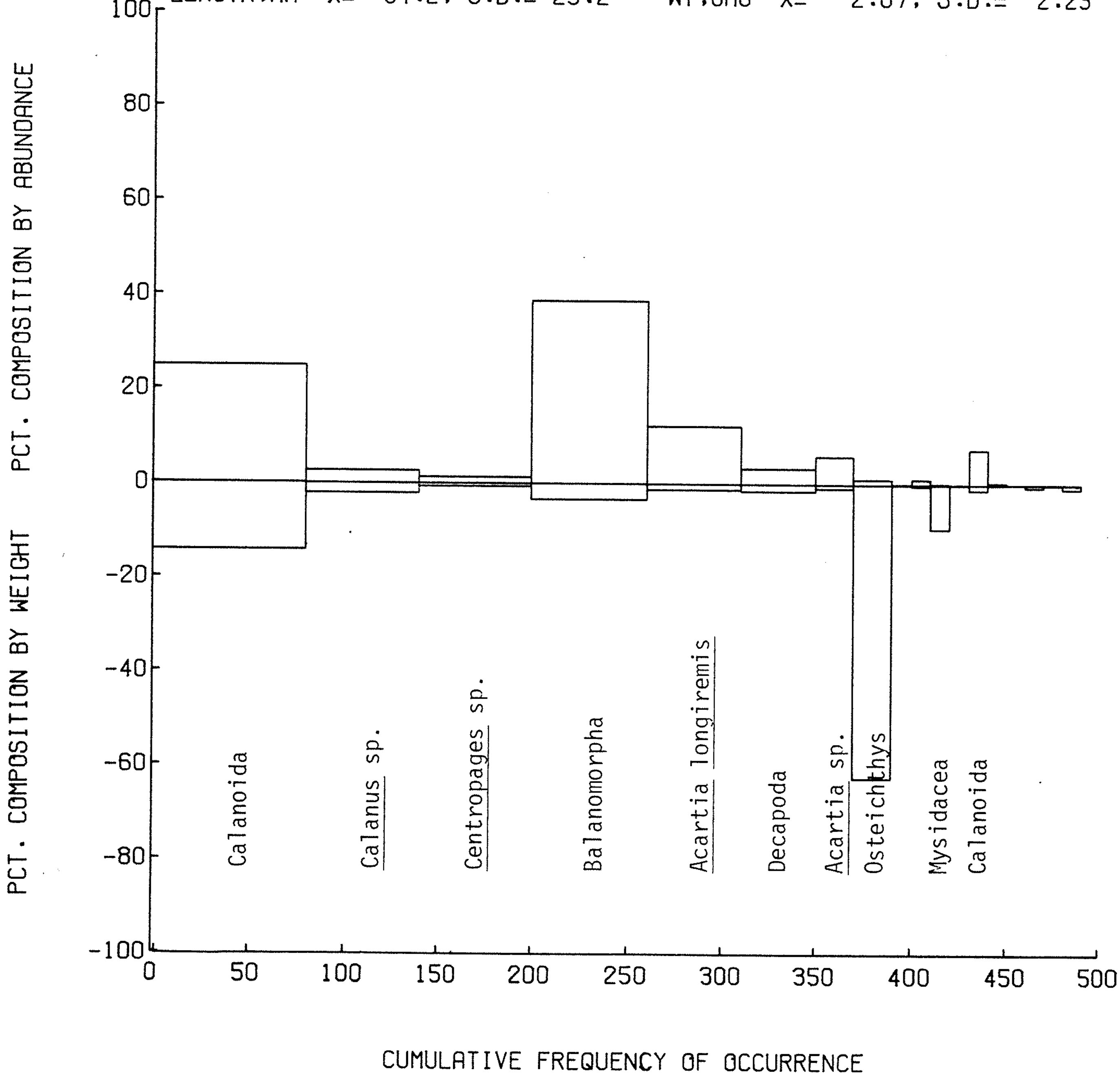
  CALANOIDA                       80.00  24.98  14.28  3140.6    36.51
  CALANUS SP.                     60.00   2.69   2.19   292.8     3.40
  CENTROPAGES SP.                 60.00   1.34    .74   125.1     1.45
  BALANOMORPHA                    60.00  38.71   3.49  2531.9    29.43
  ACARTIA LONGIREMIS              50.00  12.20   1.33   676.3     7.86
  DECAPODA                        40.00   3.36   1.60   198.6     2.31
  ACARTIA SP.                     20.00   5.96    .96   138.2     1.61
  OSTEICHTHYES                    20.00   1.06  62.62  1273.4    14.80
  HARPACTICUS SP.-UNIREMIS GROUP  10.00    .10    .03     1.3      .01
  PSEUDOCALANUS SP.               10.00   1.15    .31    14.6      .17
  MYSIDACEA                       10.00    .19   9.56    97.5     1.13
  CUMELLA VULGARIS                10.00    .10    .03     1.3      .01
  CALANOIDA                       10.00   7.40   1.23    86.3     1.00
  PLEOCYEMATA-CARIDEA             10.00    .38    .03     4.2      .05
  DECAPODA-BRACHYURA              10.00    .10    .03     1.3      .01
  CHAETOGNATHA                    10.00    .10    .62     7.1      .08
  HARPACTICOIDA                   10.00    .10    .03     1.3      .01
  UNIDENTIFIED EGG                10.00    .10    .93    10.2      .12

   PREY TAXA WITH FREQ. OCCUR. LESS THAN 5 AND NUMERICAL AND GRAVIMETRIC
   COMPOSITION BOTH LESS THAN 1 ARE EXCLUDED FROM THE TABLE AND PLOT
   (BUT NOT FROM CALCULATION OF DIVERSITY INDICES)

      PERCENT DOMINANCE INDEX,             .24    .42                .25
      SHANNON-WEINER DIVERSITY            2.56   1.96               2.41
      EVENNESS INDEX,                      .61    .47                .58
```

INDEX OF RELATIVE IMPORTANCE (I.R.I.) DIAGRAM
FROM FILE IDENT. NEAHBY, STATION TOTAL

PREDATOR 8845010101 - AMMODYTES HEXAPTERUS
(PACIFIC SAND LANCE) ADJUSTED SAMPLE SIZE = 10
LENGTH,MM X= 84.2, S.D.= 23.2 WT,GMS X= 2.67, S.D.= 2.23



7.4 Literature Review of Impacts of Underwater Explosions and Other Shock \Waves on Fishes and Macroinvertebrates

7.4.1 Introduction

In order to interpret the potential impact of underwater demolition required to construct the navigational channel in Neah Bay, a survey was conducted of published reports and literature on the effects of explosions and related shock waves on fishes and macroinvertebrates. While this review was somewhat extensive, permitting a thorough evaluation of the probable impact mechanisms, it should not be considered exhaustive by any means; there is an considerable body of literature from which to draw data pertinent to a particular shock wave situation and marine community.

Rapid pressure changes under water, generically considered "shock waves" in this synthesis, have been observed to affect aquatic life through a variety of causes, including subsistence fishing, biological sampling, demolitions for engineering, seismic surveys, weapons testing, underground nuclear tests, and within hydroelectric power turbines.

This literature search was based upon an earlier study of the pressure effects of shock waves from underground nuclear tests (see Simenstad 1974) and brought up to date through computer searches (e.g., Cambridge) of publications occurring since the earlier survey. Although the emphasis is specifically upon explosion-induced shock wave impacts upon marine fish and macroinvertebrates, citations are also included for: (1) basic physiological effects of pressure change; (2) characteristics and propagation of shock waves through water; (3) the physics of water and dissolved gases under pressure changes; (4) freshwater animals; and, (5) shock wave and pressure effects on mammals. However, the compilation of references for these secondary topics should not be considered as comprehensive. Furthermore, the survey did not directly address sublethal effects of shock waves and sound on the behavior of aquatic organisms because the projected impact of the underwater demolition in Neah Bay would not be persistent, and thus these short-term effects were presumed to be reversable. Neither were nonapplicable sources on air-borne (air blast) shock wave (other than those transmitted into water) effects considered.

7.4.2 Literature Cited

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Anderson, H. T., and P. S. Loken. 1968. Lung damage and lethality by underwater detonations. Acta Physiol. Scand. 72:6-14.

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