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EPIBENTHIC ZOOPLANKTON ASSEMBLAGES  
AT SELECTED SITES ALONG THE STRAIT OF JUAN DE FUCA

by

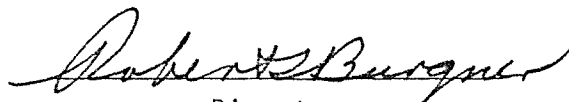
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COMPLETION REPORT

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## ABSTRACT

A survey of epibenthic zooplankton characterizing shallow sublittoral habitats along the Strait of Juan de Fuca was conducted in August 1978 in conjunction with coincident nearshore fish collections at the same sites. Approximately 235 taxa of invertebrate epifauna were identified in the 28 samples from 17 microhabitats distributed over the seven sampling sites; amphipods, polychaetes, gastropods, isopods, and copepods dominated the taxonomic composition. The total mean density was  $51.0 \times 10^3 \pm 75.5 \times 10^3$  organisms/m<sup>3</sup>; the total mean standing crop was  $1.98 \pm 2.66$  g/m<sup>3</sup>. Over three-quarters of the density was composed of harpacticoid copepods and they dominated the biomass composition at two sites. Sandy substrates with dense eelgrass beds, located at Port Williams and Beckett Point, had the highest diversity, density, and standing crop of any of the 17 microhabitats sampled; more exposed, wave swept sites such as Twin Rivers and Kydaka Beach typically had the least developed epifauna community. Gammarid amphipod assemblages were not numerically prominent but often composed a high proportion of the total standing crop, especially in the rocky tidepool habitats sampled at Slip Point, and are known to be important as prey for nearshore fishes and shorebirds in the region. Herbivorous amphipods which nestle or live in tubes on macroalgae were the prevalent life history forms. This survey, although constituting only a short-term series of collections, indicated that previous evaluations of the diversity, density, and standing crop of epibenthic invertebrates have been significantly underestimated.

## I. INTRODUCTION

Since 1974 the Washington State Department of Ecology (DOE) and NOAA-MESA Puget Sound Project Office have been conducting biological baseline studies in north Puget Sound and the Strait of Juan de Fuca on the potential effects of increased petroleum transport and refining activities in the region. These studies have focused principally on littoral and shallow sublittoral benthos, nearshore fish and macro-invertebrate assemblages, offshore phytoplankton and zooplankton assemblages, and nearshore food web structure (Gardner 1978; Mar. Ecosyst. Analy. Prog. 1978). One of the main objectives was to provide information on the trophic relationships and food web structure of the biotic communities most vulnerable to pollution or which could be involved in transfer or bioaccumulation of petroleum hydrocarbons.

The nearshore fish and food web investigations by Fisheries Research Institute (FRI) have indicated that epibenthic zooplankton are significant prey resources for the majority of nearshore fishes (Miller et al. 1977, in press; Simenstad et al. 1977, 1979; Cross et al. 1978) and also for many seabirds and shorebirds (Simenstad et al. 1979). The community structure and abundance of epibenthic zooplankton were not well documented in these studies, however, due to the initial emphasis on sampling infaunal and sessile organisms (Nyblade 1977, 1978; Smith and Webber 1978; Smith 1979; Webber 1979). The importance of epibenthic zooplankton as principal components of the region's food webs, responsible for the important transfer of detrital carbon to higher trophic levels, requires that this critical data gap be addressed—especially if we are to understand how trophic relationships between economically or ecologically important fish and their prey resources are affected by pollution.

As an addition to the MESA studies in the Strait of Juan de Fuca, in spring 1978, FRI was contracted to conduct a single survey of epi-

benthic zooplankton at seven established MESA sampling locations. The objective was to describe and quantify the epibenthic zooplankton assemblages occurring in representative nearshore habitats of the Strait of Juan de Fuca. Tasks included: 1) sampling the epibenthos at the seven sites, using an epibenthic suction pump sampler, coincident with the nearshore fish collections conducted by beach seine at these sites in August 1978; 2) documenting the taxonomic composition, density, and standing crop of epibenthic zooplankton per cubic meter in representative microhabitats occurring at each site. The following report describes that survey, the microhabitats found and sampled, and the composition and abundance of epibenthic zooplankton found in each microhabitat.

## II. MATERIALS AND METHODS

### II-A. Study Sites and Sampling Description

Epibenthic zooplankton<sup>1</sup> sampling was conducted at seven locations along the southern shore of the Strait of Juan de Fuca (Fig. 1). These locations were the same as those sampled for nearshore fish and macro-invertebrates for the MESA biological baseline studies, May 1976 to January 1979 (Simenstad et al. 1977; Cross et al. 1978; Miller et al. in press). Sampling occurred during the same week as the August fish collections (18-23 August 1978). Sites were chosen to represent all types of nearshore habitats along the strait, from the protected embayment with eelgrass meadows at Beckett Point, to the exposed rocky tidepool habitat at Slip Point. Miller et al. (in press) provides a detailed description of the habitats at the seven sites. As a preliminary step, a SCUBA diver surveyed the area routinely sampled for nearshore fish (with 37-m beach seine) in order to report on the variety of shallow sublittoral microhabitats represented. Microhabitats were selected according to depth, substrate type, and size, and the forms and density of macroalgae and rooted vegetation present. In the rocky littoral habitat, six tidepools between the 0.0-m and +1.2-m tide levels were sampled. Table 1 itemizes the 17 unique, duplicated (except for tidepool) collections, representative microhabitats, environmental conditions at the time of sampling, and the sample characteristics. Characteristics of the six tidepools sampled at Slip Point are indicated in Table 2.

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<sup>1</sup>While epibenthic zooplankton were the focus of this sampling design and the predominant forms in the collections, some truly benthic forms such as bivalves and gastropods were also sampled. We have included these in the epibenthic category for the sake of convenience only.

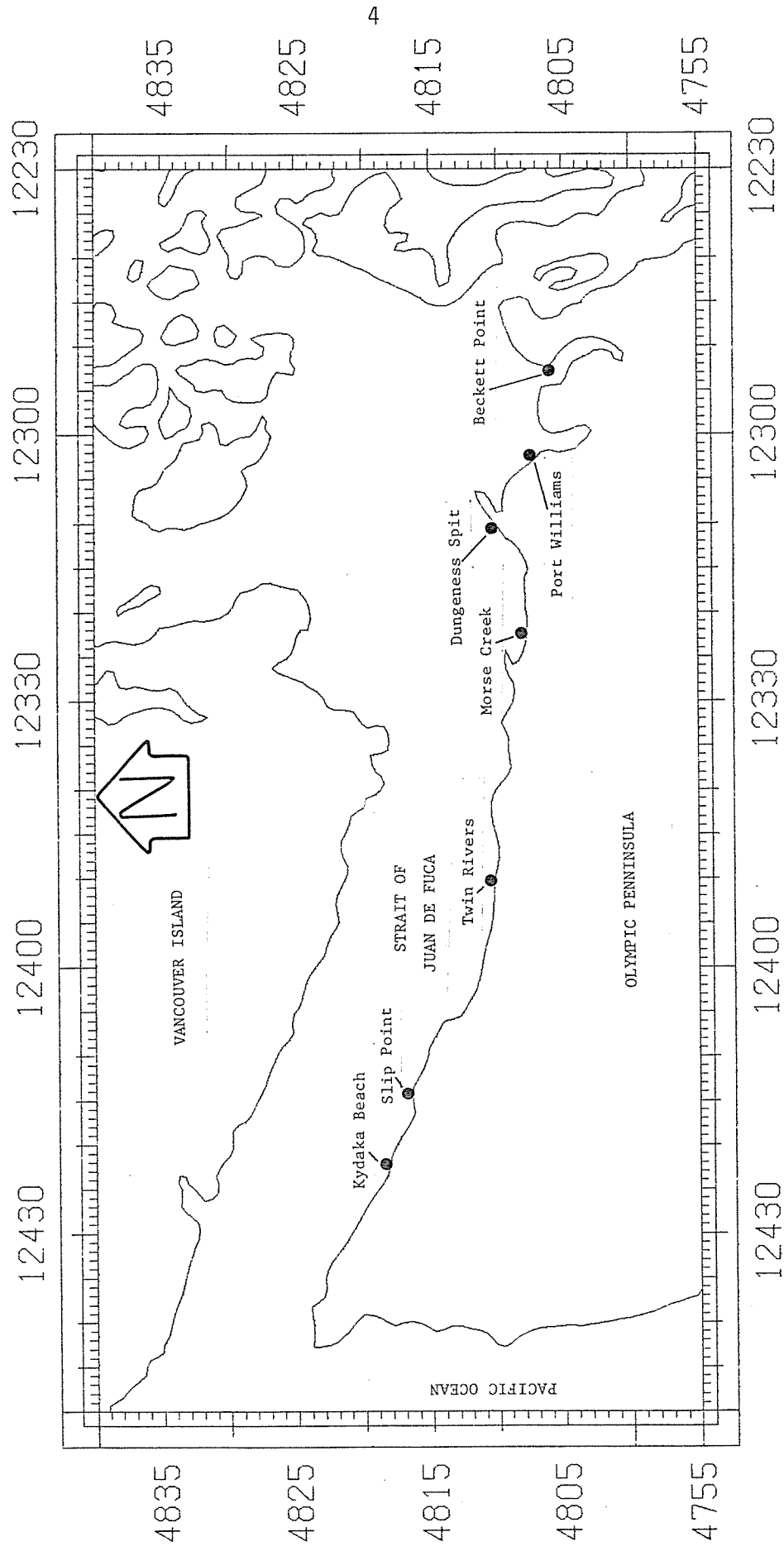


Fig. 1 Locations of epibenthic zooplankton sampling sites along the southern shore of the Strait of Juan de Fuca.

Table 1. Sampling and environmental characteristics associated with 17 epibenthic zooplankton collections made at 7 locations along the Strait of Juan de Fuca.

DATE	LOCATION	STATION NO.	MICROHABITAT	REPLICATE NO.	SAMPLE NO.	COLL. TIME P.S.T.	VOLUME M <sup>3</sup>	TIDE HT.	TIDE STAGE	H <sub>2</sub> O °C	AIR °C	SECCHI M
18 Aug 78	Slip Point	02061	Tidepool	1	1	0818	.08	-0.4	2	10.9	12.2	
"	Slip Point	02061	Tidepool	1	2	0853	.04	-0.3	3	11.1		
"	Slip Point	02061	Tidepool	1	4	0913	.06	-0.2	3	11.3		
"	Slip Point	02061	Tidepool	1	5	0936	.10	0.0	3	11.4		
"	Slip Point	02061	Tidepool	1	3	1015	.08	0.2	3	11.4		
"	Slip Point	02061	Tidepool	1	6	1035	.07	0.5	3	11.5		
18 Aug 78	Kydaka	02055	Sand	1	1	1255	.20	1.6	3	11.0	13	
"	Kydaka	02055	Sand	2	2	1258	.20	1.6	3			
18 Aug 78	Twin Rivers	02053	Sand	1	1	1453	.13	2.0	4	12.3	14.0	
"	Twin Rivers	02053	Sand	2	2	1456	.13	2.0	4			
22 Aug 78	Beckett Point	02045	Sand	1	1	1307	.20	0.6	2	12.6	12.5	7.0
"	Beckett Point	02045	Sand	2	2	1310	.20	0.6	2			
"	Beckett Point	02045	1-m Felgrass	1	3	1326	.20	0.6	3			
"	Beckett Point	02045	1-m Felgrass	2	4	1329	.20	0.6	3			
"	Beckett Point	02045	0.3m Sparse Felgrass	1	5	1343	.20	0.7	3			
"	Beckett Point	02045	0.3m Sparse Felgrass	2	6	1346	.20	0.7	3			
22 Aug 78	Port Williams	02023	Clean coarse sand	1	1	1533	.20	0.9	3	11.0	13.2	7.0
"	Port Williams	02023	Clean coarse sand	2	2	1536	.20	0.9	3			
"	Port Williams	02023	4-m Felgrass w/ Coarse Sand	1	3	1550	.20	1.0	3			
"	Port Williams	02023	Coarse Sand	2	4	1556	.20	1.0	3			
23 Aug 78	Dungeness Spit	02021	Coarse sand, gravel	1	1	1330	.20	0.8	2	10.5	11.8	2.75
"	Dungeness Spit	02021	Coarse sand, gravel	2	2	1340	.20	0.8	2			
23 Aug 78	Morse Creek	02016	Sand	1	1	1545	.20	1.3	3	10.0	11.9	6.0
"	Morse Creek	02016	Sand	2	2	1550	.20	1.3	3			
"	Morse Creek	02016	Cobble	1	3	1606	.20	1.3	3			
"	Morse Creek	02016	Cobble	2	4	1610	.20	1.3	3			
"	Morse Creek	02016	Sand with Cobble	1	5	1620	.20	1.3	3			
"	Morse Creek	02016	Sand with Cobble	2	6	1623	.20	1.3	3			

Table 2. Microhabitat characteristics of 6 tidepools sampled for epibenthic zooplankton at Slip Point, a rocky littoral site on the southern shore of the Strait of Juan de Fuca.

Tidepool No.	Tide level (m)	Dimensions	Bottom substrate	Epiphyta, epifauna
1	+0.01	2.0m x 0.8m x 5.0 cm	Shell fragments, pebbles	<i>Costarium</i> sp., <i>Ulva</i> sp., <i>Hedophyllum</i> sp.
2	0.00	1.9m x 0.5m x 8.0 cm	Shell fragments, pebbles	<i>Codium</i> sp., <i>Alaria</i> sp., <i>Hedophyllum</i> sp.
3	+0.34	1.0m x 1.4m x 8.0 cm	Bedrock, pebbles	Coralline algae, <i>Phyllospadix</i> sp.
4	+1.07	1.3m x 0.5m x 7.0 cm	Bedrock, pebbles, shell fragments	Unident. short brown alga, <i>Mytilus</i> sp.
5	+1.01	1.5m x 0.9m x 13.0cm	Bedrock, pebbles, shell fragments	Unident. short brown alga, <i>Ulva</i> sp., <i>Mytilus</i> sp.
6	+1.19	1.2m x 0.4m x 14.0cm	Bedrock, shell fragments	<i>Mytilus</i> sp.

## II-B. Sampling of Epibenthic Zooplankton

### II-B-1. Epibenthic Sampling Pump

Our suction pump for sampling epibenthic zooplankton was a modification of an earlier design (Burgner et al. 1969) adapted specifically for effective, quantitative sampling of epibenthic prey organisms of juvenile fish, especially juvenile salmonids (Miller et al. 1977; Simenstad and Kinney 1978). The pump system consisted of a self-priming, gasoline-powered, 5.1-cm centrifugal pump which drew water and associated plankters through a 25.4-cm conical expander into a 5.1-cm flexible PVC hard suction hose (Fig. 2). Once through the pump, the water sample passed through a sealed-register, totalizing flowmeter into a double stainless steel cylinder in which two nested conical nets were suspended. The nets were of 0.505-mm and 0.209-mm mesh sizes with area/aspect ratios of 1:2.54 and 1:5.3, respectively. The epibenthic organisms were retained in standard net buckets with window screen of appropriate mesh size.

### II-B-2. Sampling Procedure

Stations east of Port Angeles (Beckett Point, Port Williams, Dungeness Spit, and Morse Creek) were sampled from the FRI 7.9-m whaleboat MONTY PYTHON anchored on site. Stations west of Port Angeles (Twin Rivers, Slip Point, and Kydaka Beach) were sampled from the beach. A SCUBA diver randomly (within microhabitat) placed a 0.25-m<sup>2</sup> (area) sampling cylinder (Fig. 3), equipped with screened ports and a mesh cover (both 0.209-mm), securely on the bottom and then proceeded to "vacuum" the bottom area within by moving the expander cone systematically 10 cm above the surface (Fig. 4). This distance was maintained by a ring (which contacted the surface) extending from the expander cone (Fig. 3). Two nested nets were dropped into place within the sampling tank and removed after 200 liters had been filtered. Organisms retained in the nets were removed and preserved in 5% seawater-buffered formalin in labelled PVC jars. Sampling was repeated for each microhabitat at each sampling location after placing the sampling cylinder on a similar area of bottom nearby.

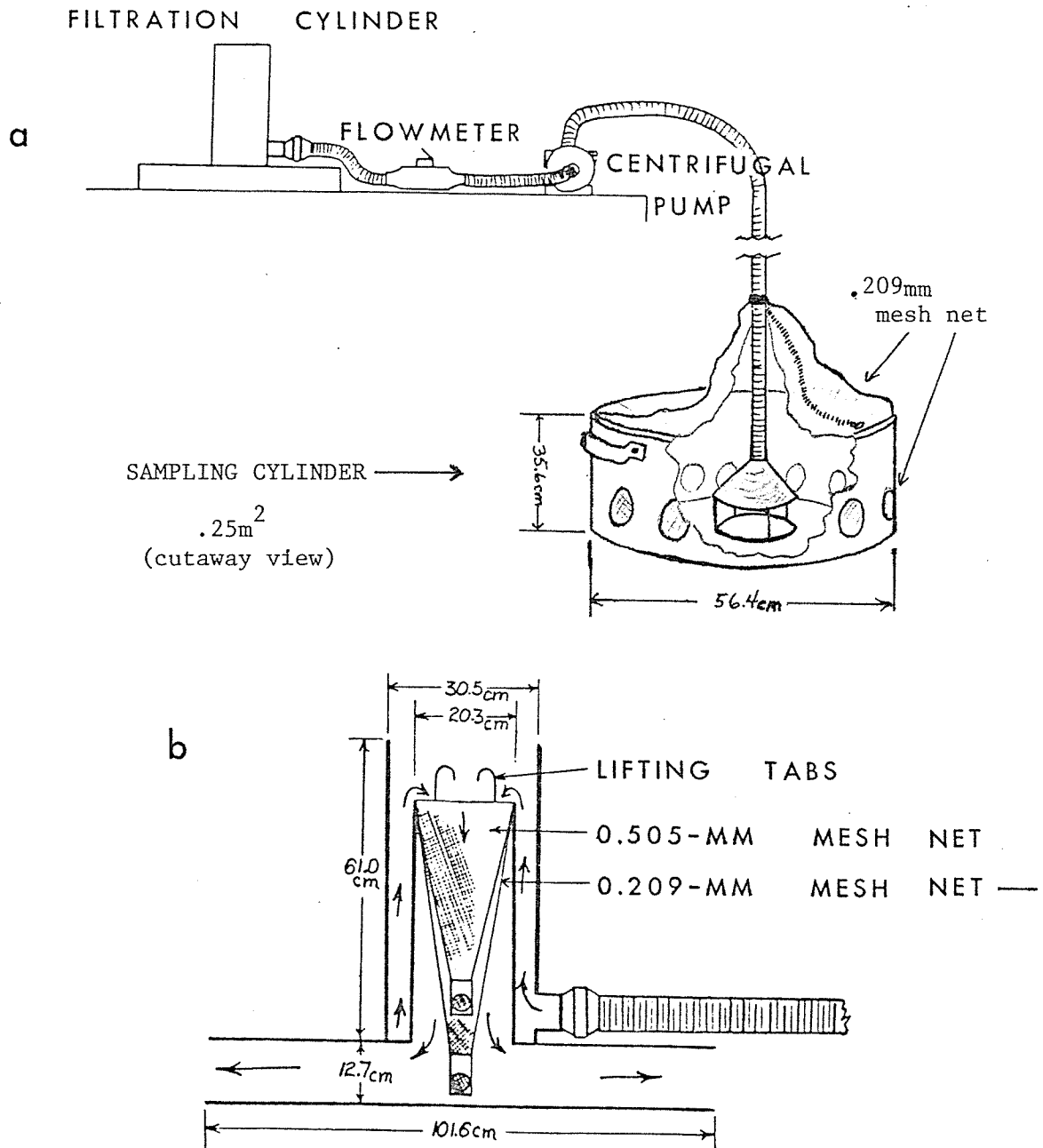


Fig. 2. Components of epibenthic suction-pump sampling system (a) and construction detail of filtration cylinders (b).

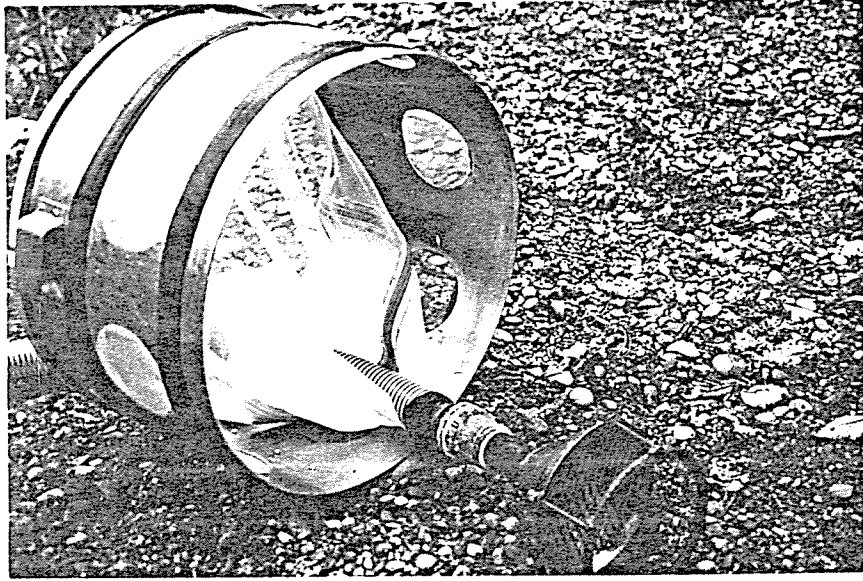


Fig. 3. The 0.25-m<sup>2</sup> sampling cylinder which, when placed on the bottom, is designed to prevent emigration and immigration of plankters. The expander cone end of the suction hose is also visible.

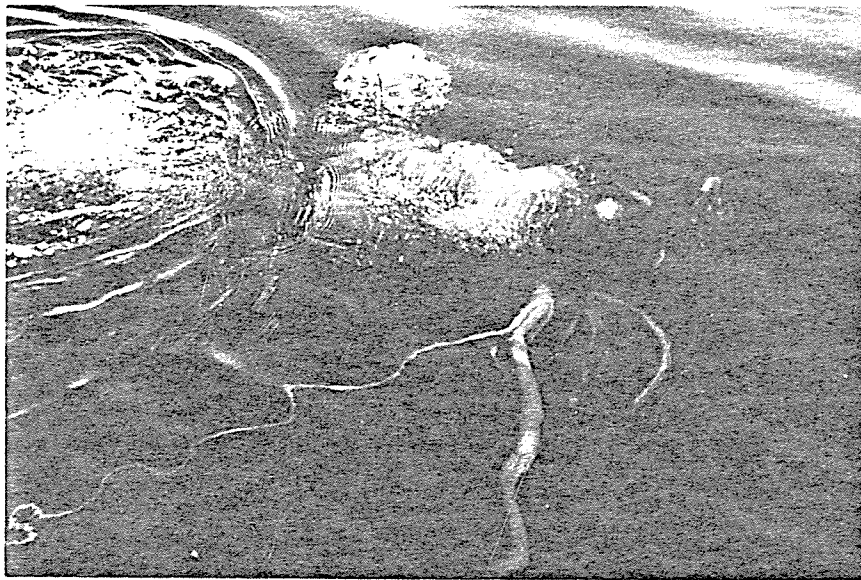


Fig. 4. SCUBA diver operating epibenthic plankton pump in shallow sub-littoral waters along Strait of Juan de Fuca. Suction hose enters from bottom center of photograph.

Water temperatures were measured by mercury thermometer held in the pumped water.

### II-C. Processing of Epibenthic Zooplankton Samples

After at least 5 days of fixation, zooplankton samples were rinsed, transferred with field tags to vials, and preserved in a 45% isopropanol, 5% propylene glycol solution. The smaller (0.209-mm) fractions were dyed with rose bengal at that time.

Organisms retained in each replicate 0.505-mm net sample were identified, enumerated, and weighed to the nearest 0.001 g in full. The 0.209-mm fractions of each replicate required panning to remove sand, and subsampling to accommodate very large numbers of organisms. Subsampling was performed using a stoppered 10-cc syringe with a 2-mm orifice, and a 250-cc flask. The complete sample was placed in the flask and filled to the 200-cc level with preservative. When the contents were settled, the syringe was inserted and slowly filled with fluid. The fluid was then forcibly expelled back into the flask to agitate the sample and each of five 2-cc subsamples was quickly withdrawn.

All epibenthic organisms except harpacticoid copepods were identified to species wherever possible given the state of the art of taxonomy and available reference material. Identification of gammarid amphipods to species was verified by, or in the case of rare species, accomplished by, Craig Staude at the University of Washington's Friday Harbor Laboratories. Characteristic habitats and feeding types of the gammarid amphipods were also defined by Mr. Staude.

### II-D. Data Management

All data were recorded directly in NODC #100 data format, except for raw data from the laboratory processing which were recorded in an NODC-

compatible format designed specifically for computerized analysis of the epibenthic zooplankton data. This form included the following: species code, life history stage, count, wet weight, sample and subsample volumes, collection time and gear, tide stage and height, total sample wet and dry weight. All organisms were identified by the NODC taxonomic code which permits coding to any phylogenetic level.

Tabulation and basic statistical analyses of the data were performed using a computer program package specifically developed for the NODC-format zooplankton data. This program tabulates the plankton collections by various gear codes, sites, and collection periods. Given species, life history stage, number, and wet weight, the program then adjusts the data to a standard sample volume and computes the density and biomass per cubic meter by taxon and life history stage. Finally, the program calculates the percent composition by abundance and biomass, as well as standard diversity indices for the total composition. Since the structure of the NODC taxonomic code allows truncation of the code by 2, 4, and 6 digits to standardize the organisms by genus, family, and class, respectively, the FRI program is designed to operate at any one of these truncation levels and can produce tables either on each life history stage or on pooled life history stages (except eggs) per taxon.

#### II-E. Statistics

Shannon-Wiener diversity index for both numerical and biomass data (see Pielou 1975) was used to describe the array of epibenthic organisms composing distinct samples or pooled groups of samples:

$$H' = \sum_{i=1}^s (p_i \ln_2 p_i)$$

where  $p_i$ 's are ratios of the number or biomass of taxon  $i$  to the total sample abundance or biomass.

## III. RESULTS

III-A. Species Composition

Approximately 235 taxa of epibenthic invertebrates were identified from the 28 samples (Appendix Table A-1). The majority of the taxa were composed of amphipoda (22.6%), polychaeta (20.3%), gastropoda (11.5%), isopoda (8.8%), and copepoda (8.3%), although this is partly biased by complete identification of amphipods and lack of identification of some copepods. The greatest number of taxa was found in the dense eelgrass meadow at Port Williams (99 taxa), two tidepools at Slip Point (61, 60), and the dense eelgrass microhabitat at Beckett Point (59); the lowest number (20) occurred in the 1.07-m level tidepool at Slip Point.

All sites and microhabitats had a fairly high species richness of gammarid amphipods, the highest being found in the dense eelgrass and bare sand microhabitats at Port Williams (21 and 14 taxa, respectively) and the +0.34-m level tidepool at Slip Point (12). The sand/cobble microhabitat at Morse Creek provided only one species of gammarid amphipod (Calliopiella pratti).<sup>2</sup> The sand and dense eelgrass habitat at Beckett Point, the sand habitats at Morse Creek and Dungeness Spit, and the 0.00-m and +1.07-m level tidepools at Slip Point had five or less species. Specific distribution of amphipods appeared to vary according to microhabitat and location. Melita desdichata, Paraphoxus spinosus, and Aoroides columbiae were most commonly encountered in the Slip Point tidepools. Amphithoe sp., Accedomoera vagor, Pontogeneia rostrata, and Ischyrocerus sp. were collected principally east of Port Angeles.

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<sup>2</sup>Calliopiella pratti has recently been reclassified as Paracalliopiella pratti.

Among the polychaetes, the nereids (especially Platynereis bicanelliculata) mainly occurred in the fine-grained-sediment habitats at Beckett Point and Port Williams. The eunicid Lumbrinereis sp. was found only in the Slip Point tidepools. Some unidentified spionids were restricted to sand or sand/cobble habitats at Beckett Point, Port Williams, Morse Creek, and Kydaka Beach. Many of the identified spionids, including Spiophanes sp., were most common in the Slip Point tidepool habitats.

The mesogastropod Lacuna sp. was the prevalent gastropod and was most conspicuous at the four sites east of Port Angeles. Acmaeids such as Notoacmaea persona, the trochid Lirularia lirulatus, littorine snails, and the snail Mitrella sp. mostly occurred in samples from the Slip Point tidepools. Unidentified juvenile bivalves were most prevalent at the three eastern sites but also occurred at Slip Point.

Harpacticoid copepods were prominent at all locations and in all habitats. Calanoid copepods, although normally neritic or planktonic in nature, were present at all sites. Some species (especially Paracalanus parvus and Pseudocalanus minutus) were conspicuous at the exposed sites of Morse Creek, Kydaka Beach, and Twin Rivers. Surprisingly, the highly exposed sites at Slip Point and Dungeness Spit had few calanoids. Cyclopoid copepods (Corycaeus sp., Oithana sp.) were especially common at Morse Creek but were present at all sites except Slip Point. Mysids (three species of Acanthomysis, and Holmesiella anomala, and Neomysis mercedis) were almost entirely restricted to exposed sand habitats at Morse Creek, Dungeness Spit, and Twin Rivers. Cumaceans (especially Cumella sp.) were present at all sites but were fairly rare at Beckett Point and Morse Creek. The tanaid Leptocheilia dubia was present only at sites east of Port Angeles and only in sand or sand/eelgrass habitats. The isopods were a very diverse group but were not common except at Slip Point, where Exosphaeroma media and asellid isopods (Munna sp.) appeared frequently. Craidean shrimp, especially Hippolyte clarki, were common only at Beckett Point and Port Williams.

The ophiuroid Amphipholis squamata was the only echinoderm collected in the pump samples and it was found only in Slip Point tidepools.

### III-B. Density

The total mean density ( $\pm 1$  s.d.) of epibenthic organisms<sup>3</sup> at the seven sites was  $51,039 \pm 75,481$  organisms/m<sup>3</sup>, with a coefficient of variation (standard deviation-to-mean ratio) of 1.48. Harpacticoid copepods composed 76.1% of the mean total density and were many orders of magnitude denser than the other most abundant organisms--the cumacean Cumella sp. (3.5%), harpacticoid eggs (3.1%), ostracods (2.3%), crustacean eggs (2.0%), the amphipod Calliopiella pratti (1.7%), the nereid polychaete Platynereis bicanaliculata (1.1%), and nematodes (1.1%) (Appendix Table A-2).

Densities at the various sites were quite variable, however, both in actual density and in the numerical contribution by specific groups (Fig. 5, Appendix Tables A-3-9). The highest mean density was Port Williams ( $177,490 \pm 127,796$  organisms/m<sup>3</sup>), the lowest at Twin Rivers ( $3,077 \pm 403$  organisms/m<sup>3</sup>). There was a general increase in density with the increased protection characterizing sites on the eastern end of the strait.

Even with the variability in densities, harpacticoid copepods numerically dominated the taxonomic composition at all sites, ranging from 37.9% at Kydaka Beach to 80.9% at Port Williams. Only at Twin Rivers and Kydaka Beach did harpacticoids compose less than 70% of the total number of organisms. Other numerically predominant organisms included crustacean and harpacticoid eggs (7.9 - 5.6% and 5.1 - 1.5%, respectively), calanoid

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<sup>3</sup>Including eggs and egg cases.

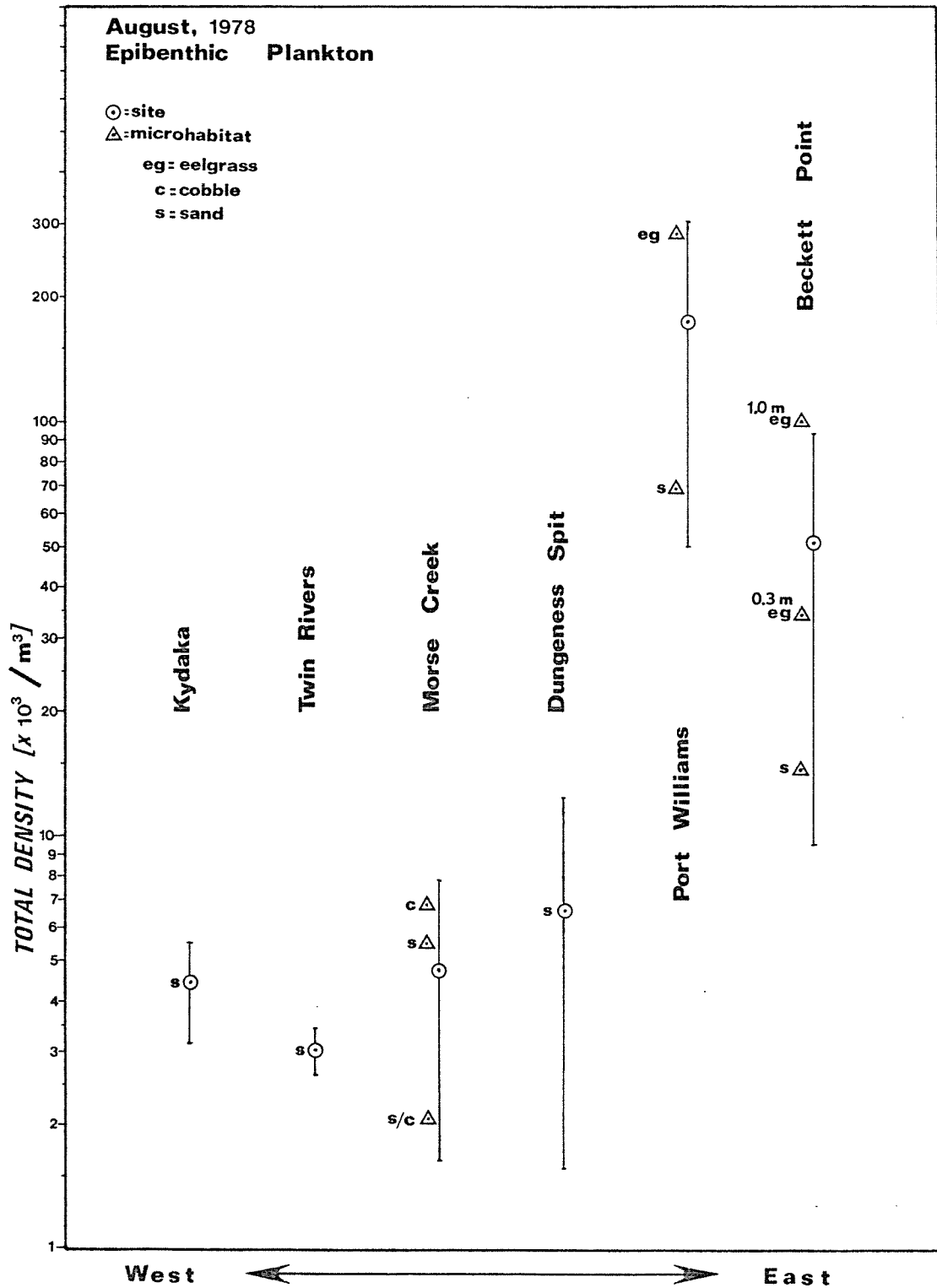


Fig. 5. Total density ( $E/m^3$ ) of epibenthic zooplankton at 6 nearshore sites along the Strait of Juan de Fuca. Mean densities in 11 microhabitats are designated by triangles; means and standard deviations at sites are designated by circles and vertical lines, respectively. Note log scale on ordinate.

copepods (Paracalanus parvus, 6.0 - 1.1%; Eurytemora hirundoides, 1.0%; Pseudocalanus minutus, 12.3%), cyclopoid copepods (Oithona sp., 3.4 - 1.8%), cumaceans (Cumella sp., 6.7 - 1.6%; Lampropidae, 7.1%), ostracods (4.5 - 1.2%), gammarid amphipods (Calliopiella pratti, 6.5%, and Aoroides columbiae, 2.9% at Slip Point; Hyale sp., 2.5%, and Gammaridae, 2.5% at Twin Rivers; and Monoculodes sp., 1.7% at Dungeness Spit), polychaete annelids (Platynereis bicanaliculata, 4.8% at Beckett Point; Spionidae, 16.7% at Kydaka Beach), and copepod nauplii (16.7 - 1.1%). In general, the majority of the sites showed a true epibenthic community, except Morse Creek where typically neritic calanoid and cyclopoid copepods accounted for over 21% of the total mean density of organisms sampled.

Estimates of epifauna density in the 17 microhabitat collections illustrate even more dramatic differences, which account for much of the variation of the pooled estimates (Table 3). Over  $8.85 \times 10^5$  organisms per cubic meter were sampled in the dense eelgrass meadow in the fine sand habitat at Port Williams. The next highest estimate ( $1.0 \times 10^5/\text{m}^3$ ) originated in the dense eelgrass meadow at Beckett Point. Slip Point tidepools at the +0.01, 0.00, and +0.34-m tide levels had slightly lower densities, between  $0.8$  and  $1.0 \times 10^4$ . The lowest total density estimates, in the range between  $1.0 \times 10^3$  and  $1.0 \times 10^4$ , occurred in all three microhabitat collections at Morse Creek and the single microhabitats at Twin Rivers, Kydaka Beach, and Dungeness Spit. Variation within the microhabitat was least evident in the 0.3-m eelgrass sample at Beckett Point (coeff. var. = 0.03), and sand/cobble habitat at Morse Creek (0.05), and the 1-m eelgrass sample at Port Williams (0.10). Highest variation was at Dungeness Spit (0.92), the cobble habitat at Morse Creek (0.74), and the sand sample at Beckett Point (0.59).

Based on density, percentage composition also varied within microhabitats (Appendix Table A-10). The proportional representation of harpacticoid copepods declined with increasing density of eelgrass, coincident with increased contributions by polychaete annelids, crustacean

Table 3. Density and standing crop of epibenthic zooplankton at 17 microhabitats of 7 sites along the Strait of Juan de Fuca, August 1978. Coefficient of variation is in parentheses.

Site	Microhabitat	Density		Standing crop	
		$(\bar{X} \pm 1 \text{ s.d.}, \#/\text{m}^3)$	$(\bar{X} \pm 1 \text{ s.d.}, \text{g}/\text{m}^3)$	$(\bar{X} \pm 1 \text{ s.d.}, \#/\text{m}^3)$	$(\bar{X} \pm 1 \text{ s.d.}, \text{g}/\text{m}^3)$
Beckett Point	Sand	14,673 $\pm$ 8,630	(0.59)	0.17 $\pm$ 0.01	(0.05)
	0.3-m eelgrass	38,308 $\pm$ 1,092	(0.03)	1.70 $\pm$ 0.17	(0.10)
	1-m eelgrass	100,283 $\pm$ 28,146	(0.28)	4.63 $\pm$ 1.87	(0.40)
Port Williams	Coarse sand	69,248 $\pm$ 36,490	(0.53)	1.54 $\pm$ 1.04	(0.68)
	1-m eelgrass	285,665 $\pm$ 28,348	(0.10)	9.25 $\pm$ 0.32	(0.04)
Dungeness Spit	Coarse sand	6,618 $\pm$ 6,071	(0.92)	0.21 $\pm$ 0.18	(0.82)
Morse Creek	Sand	5,445 $\pm$ 884	(0.16)	0.10 $\pm$ 0.01	(0.11)
	Cobble	6,833 $\pm$ 5,052	(0.74)	0.16 $\pm$ 0.10	(0.61)
	Sand/cobble	2,053 $\pm$ 103	(0.05)	0.07 $\pm$ 0.01	(0.11)
Twin Rivers	Sand	3,077 $\pm$ 403	(0.13)	0.28 $\pm$ 0.12	(0.44)
Slip Point	Tidepool #1	92,700		4.94	
	Tidepool #2	91,825		4.01	
	Tidepool #3	83,213		4.50	
	Tidepool #4	13,883		0.72	
	Tidepool #5	43,580		2.24	
	Tidepool #6	28,886		1.57	
Kydaka Beach	Sand	4,483 $\pm$ 1,170	(0.26)	0.13 $\pm$ 0.01	(0.03)
Total		51,039 $\pm$ 75,481	(1.48)	1.98 $\pm$ 2.66	(1.34)

eggs, and caridean and hippolytid shrimp. At Port Williams, on the other hand, the proportional representation of harpacticoid copepods increased with the presence of dense eelgrass concurrent with a dramatic decline in the contribution by cumaceans. The composition of the cobble microhabitat at Morse Creek was dramatically different from that of the bare sand and sand/cobble microhabitats, mainly because of the lack of calanoid copepods in the former collection. While taxonomic composition did not vary dramatically among the six tidepools sampled there were notable differences: the maximum proportion of the total contributed by gammarid amphipods (15.4%) occurred in the +0.34-m level tidepool; the highest proportion contributed by polychaete annelids (11.6%) was at the +1.01-m level; and nematodes were most prevalent (4.7% - 9.3%) in the higher level tidepools associated with the Mytilus barnacle community.

Based on density, maximum taxonomic diversity occurred at Kydaka Beach ( $H' = 3.26$ ) and Twin Rivers ( $H' = 3.05$ ) (Table 4). Minimum diversity generally occurred at the denser, eelgrass-associated collections at the eastern end of the strait. Among the epibenthic fauna in the Slip Point tidepools, the highest numerical diversity occurred in the higher-level tidepools.

### III-C. Standing Crop

The mean total standing crop of epibenthic organisms at the seven sites was approximately  $2 \text{ g/m}^3$  ( $1.98 \pm 2.66 \text{ g/m}^3$ ), with a coefficient of variation of 1.34. Despite their small size, harpacticoid copepods composed the highest proportion (27.2%) of the mean total standing crop, followed by the shrimp Hippolyte clarki (12.2%). The gastropod Lacuna sp., gammarid amphipods, limpets, and cumaceans were also prominent. The rank order of mean standing crop values at the seven sites generally mirrored the density values, except for the three western sites where Twin Rivers values were highest (Fig. 6, Appendix Tables A-3-9). Maximum mean

Table 4. Taxonomic diversity (Shannon-Wiener index,  $H'$ ) of epibenthic zooplankton at 17 microhabitats at 7 sites along the Strait of Juan de Fuca, August 1978.

Site	Microhabitat	Shannon-Wiener diversity index, $H'$	
		Abundance	Biomass
Beckett Point	Sand	1.41	4.30
	0.3-m eelgrass	1.88	2.65
	1-m eelgrass	1.73	2.29
	Coarse sand	1.49	2.31
	1-m eelgrass	1.27	2.94
Dungeness Spit	Coarse sand	2.29	4.14
Morse Creek	Sand	2.05	4.01
	Cobble	0.68	4.03
	Sand/cobble	2.29	3.56
Twin Rivers	Sand	3.05	4.14
Slip Point	Tidepool #1	1.41	3.38
	Tidepool #2	1.87	3.80
	Tidepool #3	2.00	4.05
	Tidepool #4	1.29	2.97
	Tidepool #5	2.65	4.07
	Tidepool #6	2.34	4.16
Kydaka Beach	Sand	3.26	4.40

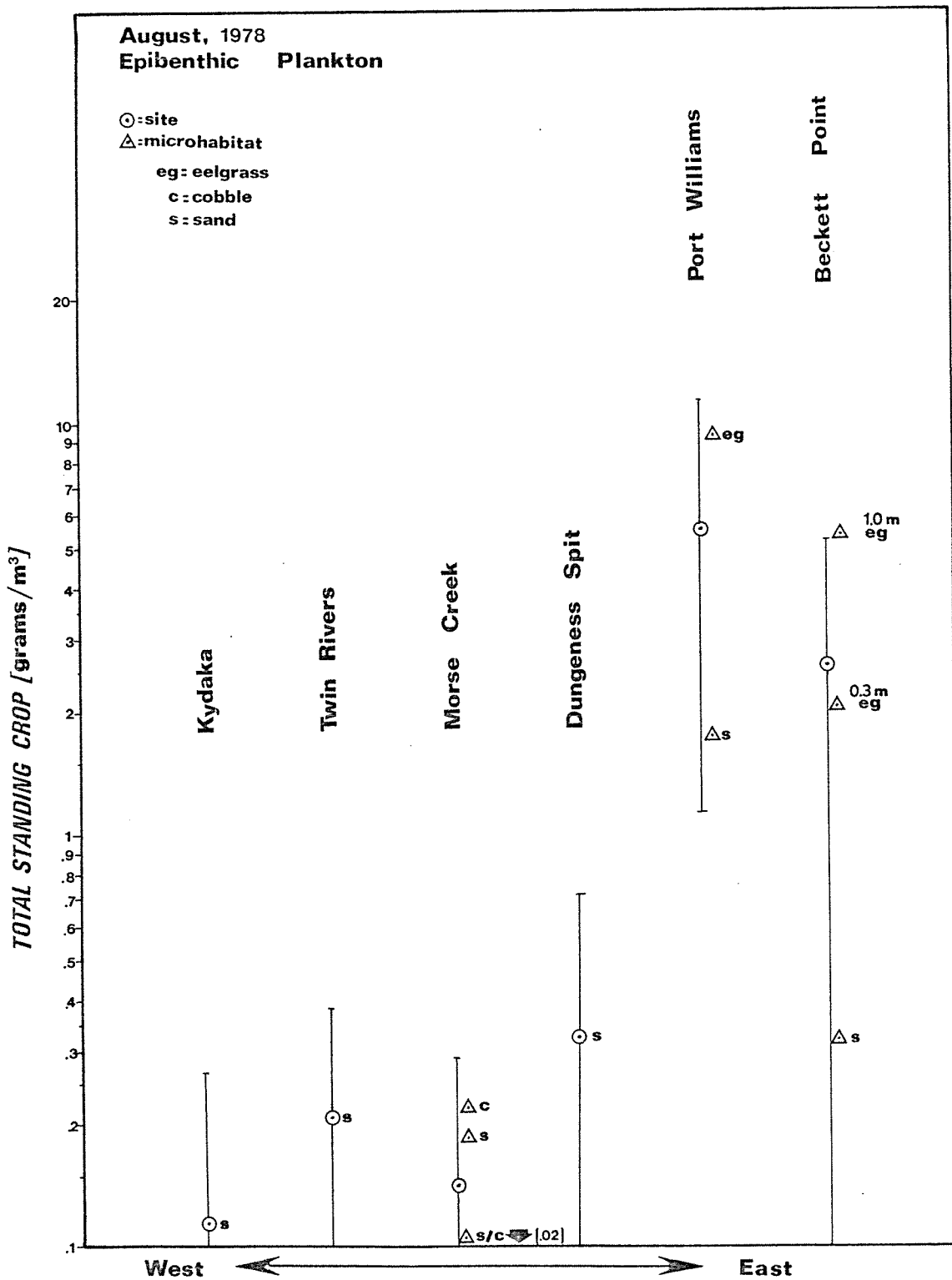


Fig. 6. Total standing crop ( $\text{g/m}^3$ ) of epibenthic zooplankton at 6 nearshore sites along the Strait of Juan de Fuca. Mean standing crops in 11 microhabitats are designated by triangles. Means and standard deviations at sites are designated by circles and vertical lines, respectively. Note log scale on ordinate.

standing crop occurred at Port Williams ( $5.217 \pm 4.470 \text{ g/m}^3$ ), the lowest at Kydaka Beach ( $0.127 \pm 0.004 \text{ g/m}^3$ ). As with density, the standing crop of epibenthic zooplankton generally increased from west to east.

The taxonomic composition of the organisms dominating the standing crop varied considerably. While harpacticoid copepods were quite prevalent (51.5% of mean standing crop) at Port Williams, they dominated at Morse Creek by only 9.3%, and at Beckett Point they were second in importance (25.7%) to Hippolyte clarki (47.3%). The gastropod Lacuna was most important at Dungeness Spit and ranked second and third at Port Williams and Beckett Point, respectively. The mysids Acanthomysis sculpta (30.0%) and A. nephrophthalma (7.1%) predominated at Twin Rivers while spionid polychaetes, crustacean eggs and nauplii, the calanoid copepod Paracalanus parvus, harpacticoids, and barnacle larvae were equally important (9.8%) at Kydaka Beach. In the rocky littoral tidepools at Slip Point, the gammarid amphipod Melita desdichata, the limpet Notoacmaea persona, and the ophiuroid Amphipholis squamata dominated the epibenthic fauna.

Variation among the 17 microhabitats was also more pronounced for standing crop than density but reflected the same general trends (Table 3, Appendix Table A-10). Maximum mean sample standing crop values were associated with the dense eelgrass meadows at Port Williams ( $9.25 \text{ g/m}^3$ ) and Beckett Point ( $4.63 \text{ g/m}^3$ ). Minimum values occurred at Morse Creek ( $0.07 - 0.16 \text{ g/m}^3$ ) and Kydaka Beach ( $0.13 \text{ g/m}^3$ ). Intermediate values were evidenced in the three lowest tidepools at Slip Point. Taxonomic diversity was in general inversely related to the mean standing crop values, illustrating the unproportional dominance of specific taxa in the more weighty samples.

Taxonomic composition based on standing stock changed dramatically between sites and between microhabitats within sites, and often differed from the density composition. In the protected embayment at Beckett Point (Discovery Bay) hippolytid shrimp and harpacticoid copepods domi-

nated the standing crop composition in the two eelgrass samples, while gammarid amphipods and gastropods predominated in the sample collected over bare sand. This was not consistent with the Port Williams composition, however, where gastropods were more prominent in the eelgrass bed fauna and hippolytid shrimp had higher proportional representation over coarse sand. Gammarid amphipods and gastropods composed over 65% of the standing crop in the cobble habitat at Morse Creek, while calanoid copepods, harpacticoid copepods, cyclopoid copepods, and mysids were the primary components of the standing crop over bare sand and sand/cobble habitats, suggesting that the sand substrate was the main factor diversifying the faunal composition at that site. While harpacticoid copepods and cumaceans had accounted for over 80% of the epifauna density at Dungeness Spit, standing crop composition was contributed by cumaceans, gastropods, polychaete annelids, and gammarid amphipods. Even though they represented less than 3% of the density, mysids composed over 43% of the standing crop at Twin Rivers and gammarid amphipods composed 10.1%. Calanoid copepods, harpacticoid copepods, barnacle larvae, spionid polychaetes, and gammarid amphipods contributed about equally to the standing crop.

Standing crop composition varied widely among the six tidepools sampled at Slip Point. Gastropods were prominent in the +0.01-m and the +1.19-m tidepools, polychaete annelids in all but the +1.07-m tidepool, ophiuroids in the +0.34-m and +1.01-m tidepool, and hippolytid shrimp in the +1.07-m tidepool. Gammarid amphipods were, however, consistently prominent members of the epifauna in all tidepools, composing between 20.5% (+1.01-m tidepool) and 35.0% (+1.07-m) of the mean standing crop. Lowest taxonomic diversity based on standing crop occurred in the +1.07-m tidepool ( $H' = 2.97$ ) while the maximum diversity occurred in the highest-level tidepool ( $H' = 4.16$ ).

III-D. Community and Trophic Structure of Gammarid Amphipods

Gammarid amphipods were prominent components of the epibenthic community at most sites, especially in terms of standing crop. But what is even more obvious is their role in the nearshore food web linkages leading to fishes and shorebirds (Simenstad et al. 1979). Of the 55 fish species identified as common residents of the nearshore habitats along the Strait of Juan de Fuca, 38% had diets in which gammarid amphipods composed over half of the IRI (Index of Relative Importance) of prey taxa; nine species (16%) had diets in which gammarids composed over 75% of the total IRI (Cross et al. 1978). Accordingly, the species determination of gammarids was pursued as far as possible given the state of the taxonomic literature. In addition, life history information in the form of feeding roles and habitat associations has been compiled for the predominant taxa by Craig Staude of the University of Washington's Friday Harbor Laboratories (Appendix B).

The sand and eelgrass habitats at Port Williams had the highest species richness (23 taxa) of gammarid amphipods, followed by the rocky littoral habitats at Slip Point (16) and the exposed gravel beach at Dungeness Spit (10). Minimum number of taxa (5) occurred at Twin Rivers and Kydaka Beach, both exposed, coarse sand habitats (Table 5). Specific associations with some sites was quite evident. Amphithoe sp., Calliopella pratti, Corophium sp., Accedomoera vagor, Pontogeneia sp., Photis sp., Protomedeia sp., Podoceropsis sp., Ischyrocerus sp., Lepidepcreum gurjanovae, and Paraphoxus sp. tended to be prominent at Port Williams. Only Aoroides columbiae and Pontogeneia rostrata were very common at Beckett Point. Monoculodes sp. was uniquely associated with Dungeness Spit and Mandibulophoxus gilesi reached its maximum estimated density at this site. Atylus sp. and Parallorchestes ochotensis were found in abundance only at Twin Rivers while Ischyrocerus sp. was moderately abundant there. The maximum mean densities and standing crop values estimated for any gammarid taxa at any site were for Calliopella pratti (3,854/m<sup>3</sup>, 0.05

Table 5. Occurrence of species and relative size of gammarid amphipods from 7 nearshore sites along the strait of Juan de Fuca, August 1978 (numbers in parentheses are mean wet weight in grams). Refer to test for description of habitats represented at each site.

Gammaridea	Beckett Point #/m <sup>3</sup> g/m <sup>3</sup>	Port Williams #/m <sup>3</sup> g/m <sup>3</sup>	Dungeness Spit #/m <sup>3</sup> g/m <sup>3</sup>	Morse Creek #/m <sup>3</sup> g/m <sup>3</sup>	Twin Rivers #/m <sup>3</sup> g/m <sup>3</sup>	Slip Point #/m <sup>3</sup> g/m <sup>3</sup>	Kydaka Beach #/m <sup>3</sup> g/m <sup>3</sup>
Ampeliscidae							
<u>Amphiloeus littoralis</u>		2.5 <0.000 (0.0001)					
<u>Gitanopsis vilordes</u>		26.3 0.002 (0.0001)					
Amphithodae							
<u>Amphithoe</u> sp.		7.5 0.005 (0.0007)				15.0 0.020 (0.0011)	
<u>A. simulans</u>		3.8 0.001 (0.0003)					
<u>A. lacertosa</u>	0.8 0.010 (0.0010)						
Aoridae							
<u>Aoroides columbiae</u>	66.7 0.024 (0.0009)	298.8 0.058 (0.0002)				1705.4 0.133 (0.0003)	
Atylidae							
<u>Atylus</u> sp.				0.8 <0.000 (0.0001)			
Calliopidae							
<u>Calliopius</u> sp.	0.8 0.010 (0.0020)				7.7 0.008 (0.0010)		
<u>Calliopiella pratti</u>	0.8 0.010 (0.0020)	188.7 0.080 (0.0004)	5.0 0.001 (0.0001)	0.8 <0.000 (0.0001)	3.8 <0.000 (0.0001)	3844.9 0.053 (<0.0000)	5.0 0.003 (0.0005)
Corophiidae							
<u>Corophium</u> sp.		127.5 0.007 (0.0001)				78.8 0.008 (0.0001)	
<u>C. baconi</u>		1.3 <0.000 (0.0001)					
Eusiridae							
<u>Accedomoera vagor</u>		76.3 0.005 (0.0001)					
<u>Pontogeneia</u> sp.	0.8 0.001 (0.0010)	57.6 0.014 (0.0002)	5.0 <0.000 (0.0001)	4.2 0.005 (0.0012)			

Table 5. Occurrence of species and relative size of gammarid amphipods from 7 nearshore sites along the Strait of Juan de Fuca, August 1978 (numbers in parentheses are mean wet weight in grams). Refer to text for description of habitats represented at each site - continued.

Gammaridea	Beckett Point #/m <sup>3</sup> g/m <sup>3</sup>	Port Williams #/m <sup>3</sup> g/m <sup>3</sup>	Dungeness Spit #/m <sup>3</sup> g/m <sup>3</sup>	Morse Creek #/m <sup>3</sup> g/m <sup>3</sup>	Twin Rivers #/m <sup>3</sup> g/m <sup>3</sup>	Slip Point #/m <sup>3</sup> g/m <sup>3</sup>	Kydaka Beach #/m <sup>3</sup> g/m <sup>3</sup>
<u>Ischyrocerus</u> sp.	2.5 <0.000 (0.0001)	508.8 0.042 (0.0001)	7.5 <0.000 (0.0003)	25.9 0.007 (0.0006)		2.1 <0.000 (0.0001) 3.3 <0.000 (0.0001)	
<u>Jassa falcata</u>							
Lysianassidae							
<u>Lepidepcreum gurjanovae</u>		1.3 <0.000 (0.0001)					
<u>Orchomene</u> sp.		1.3 <0.000 (0.0001)					
Oedicerotidae							
<u>Monoculodes</u> sp.			115.0 0.008 (0.0002)				
<u>Synchelidium</u> sp.							
<u>S. shoemakeri</u>		1.3 <0.000 (0.0001)		3.3 0.001 (0.0003)			
Phoxocephaliidae							
<u>Paraphoxus</u> sp.							
<u>P. spinosus</u>		22.5 0.004 (0.0001)				23.7 0.007 (0.0003)	2.5 <0.000 (0.0001)
<u>Mandibulophoxus gilesi</u>			37.5 0.008 (0.0002)	0.8 <0.000 (0.0001)			
Pleustidae							
<u>Parapleustes nautilus</u>						2.1 <0.000 (0.0001)	

Table 5. Occurrence of species and relative size of gammarid amphipods from 7 nearshore sites along the Strait of Juan de Fuca, August 1978 (numbers in parentheses are mean wet weight in grams). Refer to text for description of habitats represented at each site - continued.

Gammaridea	Beckett Point #/m <sup>3</sup> g/m <sup>3</sup>	Port Williams #/m <sup>3</sup> g/m <sup>3</sup>	Dungeness Spit #/m <sup>3</sup> g/m <sup>3</sup>	Morse Creek #/m <sup>3</sup> g/m <sup>3</sup>	Twin Rivers #/m <sup>3</sup> g/m <sup>3</sup>	Slip Point #/m <sup>3</sup> g/m <sup>3</sup>	Kyudaka Beach #/m <sup>3</sup> g/m <sup>3</sup>
<u>Pontogeneia rostrata</u>	14.1 0.050 (0.0011)	908.8 0.347 (0.0004)		6.6 0.004 (0.0004)		2.1 <0.000 (0.0001)	5.0 0.003 (0.0005)
Gammaridae					76.9 0.008 (0.0001)	2.1 <0.000 (0.0001)	
<u>Maera simile</u>							2.5 0.005 (0.0020)
<u>Megaluropus longimerus</u>				1.7 0.002 (0.0010)		344.3 0.458 (0.0017)	
<u>M. desdichata</u>							
Haustoriidae							
<u>Eohaustorius washingtonianus</u>			7.5 0.003 (0.0003)			12.5 0.001 (0.0001)	5.0 0.001 (0.0001)
<u>Kajuna</u>						6.3 <0.000 (<0.0000)	
Hyalidae		75.0 0.002 (<0.0000)					
<u>Allorchestes angustus</u>					19.2 0.004 (0.0002)		
<u>Hyalé</u> sp.					76.9 0.008 (0.0001)		
<u>H. rubra</u>		1.3 <0.000 (H. frequens) (0.0001)		0.8 0.001 (0.0010)		27.1 0.019 (0.0008)	2.5 0.005 (0.0010)
<u>Parallorchestes ochotensis</u>		1.3 <0.000 (0.0001)		3.3 0.006 (0.0018)			
Isaeidae							
<u>Photis</u> sp.	66.7 0.005 (0.0001)	103.8 0.005 (0.0001)	50.0 0.005 (0.0010)			139.6 0.010 (0.0001)	
<u>P. brevipes</u>		2.5 0.008 (0.0030)					
<u>Protomedea</u> sp.		7.5 0.001 (0.0002)					
<u>Podocerospis</u> sp.		525.1 0.057 (0.0001)	2.5 <0.000 (0.0018)				
Ischyroceridae		25.0 0.002 (0.0001)					

g/m<sup>3</sup>) and Aoroides columbiae (1,705/m<sup>3</sup>, 0.13 g/m<sup>3</sup>) in Slip Point tidepools. The maximum within-tidepool density was 7,875/m<sup>3</sup> C. pratti and 4,025/m<sup>3</sup> A. columbiae in the 0.00 level tidepool. The largest amphipods and those probably most subject to fish and bird predation included Photis brevipes, Calliopiella pratti, and Calliopius sp.

Based on the classification in the literature of feeding types, herbivores amphipods predominated over detritivores and suspension feeder (Table 6). Suspension feeders occurred only at Dungeness Spit and Port Williams. Similarly, the principal habitat association was that involving forms which nestle on macroalgae or live in tubes attached to the algae. Inquilinous and sediment-associated forms were rare and truly epibenthic forms were the least common.

Table 6. Feeding mode and habitat associations of gammarid amphipods at 7 nearshore sites along the Strait of Juan de Fuca.

	Beckett Point	Port Williams	Dungeness Spit	Morse Creek	Twin Rivers	Slip Point	Kydaka Beach
<b>A. <u>Feeding mode</u></b>							
Herbivores	4	11	2	5	2	6	3
Detritivores	3	5	2	1	1	2	
Detritivores, burrowing deposit feeders		4	1	1		2	
Suspension feeders		1	2				
Unknown, presumed detritivores	1	3	2	3	2	4	1
<b>B. <u>Habitat association</u></b>							
Algal associated	7	13	5	5	5	10	3
Inquilinous, incl. commensal & epibiotic	1	3		1		1	1
Sediment associated		3	3	2		2	1
Epibenthic		1		2			

## IV. DISCUSSION

Comparable quantitative studies of shallow sublittoral epibenthic organisms are generally lacking in the available literature, although information describing the importance of these organisms as prey resources for nearshore fishes is abundant (Bregnballe 1961; Feller and Kaczynski 1975; Fuse 1962; Hatanaka and Iizuka 1962; Kikuchi 1966, 1974; Kikuchi and Peres 1977; Kitamori and Kobayashi 1958; Larsen 1936; Marsh 1973; Thayer et al. 1975). Kikuchi (1974) documented the importance of eelgrass beds as habitat for epibenthic macrofauna and the fish that feed on them. He provided density estimates of  $8,020/m^2$  (well protected muddy bottom) to  $13,918/m^2$  (less protected sandy bottom) in an eelgrass bed in Tomioka Bay, Japan (a 0.5-mm sieve mesh screen was used). Our epibenthic pump sampling cylinder encompassed an area of  $0.25 m^2$  and filtered approximately 1.56X the water volume of the sampling cylinder; therefore, an approximate correction factor of 2.5 could be applied to our volumetric density and standing crop estimates to arrive at equivalent surface area estimates. Thus, the density of epibenthic fauna in the thick eelgrass meadow at Port Williams would be approximately  $>.1 \times 10^5/m^2$ , or 51X the maximum value determined by Kikuchi.

Williams et al. (1968) used a Clark-Bumpus sampler to determine the taxonomic composition and standing crop of zooplankton in shallow estuaries near Beaufort, NC. Converting their volumetric estimates to gravimetric values provides estimates of standing crop ranging from 0.002 to  $0.46 g/m^3$ , approximately 25% of the mean standing crop values estimated for habitats along the Strait of Juan de Fuca. They also calculated standing crop for other studies conducted in shallow water marine environments along the East Coast of the United States (Williams et al. 1968, Table 3); these estimates varied between 0.14 and  $0.95 g/m^3$  (Stickney 1959; Barlow 1955; Conover 1961; Woodmansee 1958; Hopkins 1966).

The discrepancies between these density and standing crop figures may be due to the difference between the more traditional sampling techniques and the epibenthic plankton pump used in our study. Our pump is a stationary sampler which filters the water column adjacent to a unit surface area of the bottom, where towed nets and vehicles integrate the water column over multiple microhabitats and are less effective in eelgrass or kelp. Towed samplers have recognized biases associated with differential avoidance by zooplankters that respond to projected shock waves. The pump system also has certain biases which can produce overestimates of density and standing crop, e.g., the pump may be withdrawing infaunal organisms from the sediment. There was also a problem associated with the estimation of the actual volume of water contained within the sampling cylinder (containing organisms) versus the replacement water drawn (and filtered) into the cylinder. As mentioned, this may account for an approximately 1.56X overestimate factor.

Densities of epibenthic harpacticoid copepods, numerically predominant at all sites and in all habitats, averaged  $38,795 \pm 62,621/\text{m}^3$  (Appendix Table A-2) and reached a maximum of  $239,825 \pm 38,042/\text{m}^3$  in the thick eelgrass meadow at Port Williams. Corrected to surface area and adjusted for the biases previously discussed, this estimate ( $613,952/\text{m}^2$ ) is significantly higher than maxima reported for interstitial and infaunal harpacticoids on littoral and shallow sublittoral beaches nearby:  $285,800/\text{m}^2$  in the Nanaimo River estuary (Kask and Sibert 1976) and  $272,200/\text{m}^2$  on Puget Sound beaches (Feller 1977)--and of similar habitats in other regions:  $388,000/\text{m}^2$  in Scotland (McIntyre and Murison 1973) and  $200,000/\text{m}^2$  in Denmark (Muus 1967). They are also much higher than maxima estimated from epibenthic-sled sampling of the Nanaimo River estuary ( $9,500/\text{m}^2$ ) (Sibert et al. 1977) and in Puget Sound ( $9,200/\text{m}^2$ ) (Feller and Kaczynski 1975; Simenstad and Kinney, 1979); epibenthic pump samples 5 cm and 30 cm from the bottom in the Nanaimo estuary provided estimates comparable to

the sled sampling (J. Sibert, personal communication).

Although it is probable that opposing biases explain some of the differences in these estimates of epibenthic organisms, it is clear that our appraisal of the diversity, magnitude, and probably production of the epibenthos in shallow sublittoral and littoral habitats is sorely deficient. The importance of epibenthic fauna in the nearshore food webs demands that these communities be studied and quantified in much greater detail.

## V. CONCLUSIONS AND RECOMMENDATIONS

Our survey of nearshore epibenthic zooplankton conducted along the Strait of Juan de Fuca in August 1978 has indicated that previous evaluations of the diversity, density, and standing crop of these assemblages have been underestimated. The few other estimates of density and standing crop of epibenthic organisms from this region and similar regions have typically been several orders of magnitude lower.

Approximately 235 taxa of invertebrate epifauna were identified in 28 samples from 17 littoral and shallow sublittoral microhabitats at seven sites. Amphipods, polychaetes, gastropods, isopods, and copepods dominated the taxonomic composition. The total mean density ( $\pm 1$  s.d.) of epibenthic organisms at the seven sites was  $51,039 \pm 75,481$  organisms/m<sup>3</sup>, with a coefficient of variation of 1.48; the total mean standing crop was  $1.98 \pm 2.66$  g/m<sup>3</sup>. Over three-quarters of the density was composed of harpacticoid copepods, which themselves averaged  $38,795 \pm 62,621$ /m<sup>3</sup> with a maximum of  $239,825 \pm 38,042$ /m<sup>3</sup> in a thick eelgrass meadow habitat. Although harpacticoid copepods numerically dominated the density composition at all seven sites, they dominated the biomass composition at only two.

The sandy, dense eelgrass meadow microhabitat at Port Williams, a relatively protected area at the mouth of Sequim Bay, had the highest diversity, density, and standing crop of any of the 17 microhabitats sampled. The more exposed, wave-swept sites at Twin Rivers and Kydaka Beach generally had the least developed epifauna community. Within-site differences were often great, especially where bare-sand microhabitats were compared to diverse and abundant eelgrass and macrophytic algae microhabitats, which typically account for several-fold increases in the density and standing crop of epibenthic zooplankton.

Gammarid amphipods, which we examined in detail because of their importance as prey for nearshore fishes and shorebirds, were not prominent numerically, but often composed a high proportion of the total standing crop of epifauna, especially in the rocky tidepools sampled at Slip Point. The eelgrass microhabitats at Port Williams, however, exhibited the highest species richness of gammarid amphipods. The common gammarids which contributed most to the density and standing crop values were Calliopiella pratti, Aoroides columbiae, Pontogeneia rostrata, and Ischyrocerus sp. Herbivorous amphipods which nestle on macroalgae or live in tubes attached to the algae were the prevalent life history forms.

From comparison with the few other studies of epibenthic zooplankton communities in this region and similar regions, it is apparent that our estimation of their diversity and magnitude is quite incomplete. There is also the possibility that the habitats along the Strait of Juan de Fuca actually exhibit much more developed, productive communities than those which have been sampled in Puget Sound and the Strait of Georgia. It is more likely, however, that the traditional methods used in quantifying epifauna have generally underestimated the real composition, density, and standing crop of these communities. This fact, and the recently recognized importance of epifauna to nearshore food webs, suggests that more surveys and ecological studies should be focused on these communities. The study described here took place during the period of only 1 week, and the results can hardly be considered representative of the population structure and standing stock throughout the year. It is possible, in fact, that the communities may be even more developed in spring, typically the period of reproductive activity and population expansion in zooplankton taxa. Thorough understanding of the role of epifauna in the nearshore ecosystem will thus require extensive seasonal sampling in each of the major nearshore habitats and their distinguishable microhabitats.

The dramatic differences in density and standing stock also indicate major differences in the nutrient regimes and bioenergetics associated with different microhabitats. Obviously, the specific increase in epifauna documented in microhabitats associated with eelgrass and macroalgae is related not only to the increased diversity in the physical habitat but also to the potential increase in dissolved organics and detritus (production and/or entrapment) immediately available to the epifaunal organisms. The processes which account for these energy conversions and linkages at the lower end of the food web must be examined in quantitative in situ and experimental investigations before we can understand the overall operation of nearshore ecosystems, much less predict the effect of extreme perturbations on the biotic communities.

## VI. ACKNOWLEDGMENTS

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## VII. LITERATURE CITED

- Barlow, J. P. 1955. Physical and biological processes determining the distribution of zooplankton in a tidal estuary. *Biol. Bull.* 109(2):211-225.
- Bregnballe, F. 1961. Plaice and flounder as consumers of the microscopic bottom fauna. *Neddr. Danm. Fisk. og Havunders.* 3:133-182.
- Burgner, R. L., K. K. Chew, J. S. Isakson, O. A. Mathisen, P. A. Lebednik, R. E. Norris, C. E. O'Clair, M. M. Peck, C. A. Simenstad, P. N. Slattery, and G. J. Tutmark. 1969. Research program on marine ecology and oceanography, Amchitka Island, Alaska. *Ann. Progr. Rep.*, July 1, 1968 - June 30, 1969. *Fish. Res. Inst. Coll. Fish., Univ. Washington, to Battelle Mem. Inst., Columbus, Ohio, BMI-171-128.*
- Conover, R. J. 1961. A study of Charlestown and Green Hill ponds, Rhode Island. *Ecology* 42:119-140.
- Cross, J. N., K. L. Fresh, B. S. Miller, C. A. Simenstad, S. N. Steinfort, and J. C. Fegley. 1978. Nearshore fish and macro-invertebrate assemblages along the Strait of Juan de Fuca including food habits of the common nearshore fish; report of two years of sampling. *Ann. Rep. to NOAA, MESA Puget Sound Office. Univ. Washington, Fish. Res. Inst. FRI-UW- 7718. [Also NOAA Tech. Mem. ERL MESA-32. 188 pp.]*
- Feller, R. J. 1977. Life history and production of meiobenthic harpacticoid copepods in Puget Sound. Ph.D. Dissertation, Univ. Washington, Seattle. 249 pp.

- Feller, R. J., and V. W. Kaczynski. 1975. Size selective predation by juvenile chum salmon (Oncorhynchus keta) on epibenthic prey in Puget Sound. J. Fish. Res. Board Can. 32(8):1419-1429.
- Fuse, S. 1962. The animal community in the Zostera belt. Physiol. Ecol., Kyoto 11:1-22. [In Japanese, English summary.]
- Gardner, F., ed. 1978. North Puget Sound baseline program, 1974-1977. Washington State Dep. Ecology, Olympia, Washington. 81 pp. + app. A-P.
- Hatanaka, M., and K. Iizuka. 1962. Studies on the fish community of the Zostera area. I. The ecological order for feeding in the fish group related to the dominant species. Bull. Japan. Soc. Sci. Fish. 28:5-16. [In Japanese, English summary.]
- Hopkins, T. L. 1966. The plankton of the St. Andrew Bay system, Florida. Publ. Inst. Mar. Sci., Texas 11:12-64.
- Hurtubia, J. 1973. Trophic diversity measurement in sympatric predatory species. Amer. Nat. 100:419-424.
- Kask, B. A., and J. Sibert. 1976. Preliminary observations on the meiofauna of the Nanaimo estuary. Fish. and Mar. Serv. Data Rep. 14, Pac. Biol. Sta. Nanaimo, B.C., Canada.
- Kikuchi, T. 1974. Japanese contributions on consumer ecology in eelgrass (Zostera marina L.) beds, with special reference to trophic relationships and resources in inshore fisheries. Aquaculture 4:145-160.
- Kikuchi, T., and J. M. Peres. 1977. Consumer ecology of seagrass beds. Pages 147-193 in C. P. McRoy and C. Herffferich, eds.

Seagrass ecosystems: A scientific perspective. Marcel Dekker, New York.

- Kikuchi, T. 1966. An ecological study on animal communities of the Zostera marina belt in Tomioka Bay, Amakusa, Kyushu. Publ. Amakusa Mar. Biol. Lab. 1:1-106.
- Kitamori, R., and S. Kobayashi. 1958. The ecological study on "Moba" (Zostera marina area). 1. Phase of early summer. Bull. Naikai Reg. Fish. Res. Lab. 11:7-16.
- Larsen, K. 1936. The distribution of the invertebrates in the Dydsø Fjord, their biology and their importance as fish food. Rep. Danish Stat. 41.
- Marine Ecosystems Analysis Program (NOAA). 1978. The Puget Sound project: Description of research activities. 40 pp.
- Marsh, G. H. 1973. The Zostera epifaunal community in the York River, Virginia. Chesapeake Sci. 14:87-97.
- McIntyre, A. D., and D. J. Murison. 1973. The meiofauna of a flatfish nursery ground. J. Mar. Biol. Assoc. U.K. 53:93-118.
- Miller, B. S., C. A. Simenstad, L. L. Moulton, W. A. Karp, K. L. Fresh, F. C. Funk, and S. F. Borton. 1977. Puget Sound baseline program: Nearshore fish survey. Final Rep., July 1974-June 1977. Univ. Washington, Fish. Res. Inst. FRI-UW-7710.
- Miller, B. S., C. A. Simenstad, J. N. Cross, K. L. Fresh, and S. N. Steinfort. [In press]. Nearshore fish and macroinvertebrate assemblages along the Strait of Juan de Fuca including food habits of the common nearshore fish--final report of three years' sampling, 1976-1979. Rep. to MESA Puget Sound Project. Univ. Washington, Fish. Res. Inst.

- Muss, B. J. 1967. The fauna of Danish estuaries and lagoons: Distribution and ecology of dominating species in the shallow reaches of the mesohaline zone. *Meddelelser Fra Danmarks Fiskeri-Og Havundersogelser* 5:1-316.
- Nyblade, C. F. 1977. Baseline study program: North Puget Sound intertidal study (U.W.). Append. in F. Gardner, ed., North Puget Sound baseline program, 1974-1977. Washington State Dep. Ecology, Olympia, Washington.
- Nyblade, C. F. 1978. The intertidal and shallow subtidal benthos of the Strait of Juan de Fuca, spring 1976 - winter 1977. NOAA Tech. Mem. ERL MESA-26.
- Pielou, E. C. 1975. *Ecological diversity*. Wiley Interscience. 165 pp.
- Simenstad, C. A., and W. J. Kinney. 1978. Trophic relationships of outmigrating chum salmon in Hood Canal, Washington, 1977. Final Rep. Oct. 1, 1977 - March 31, 1978 to Washington State Dep. Fish., Univ. Washington, fish. Res. Inst. FRI-UW-7810. 75 pp.
- Simenstad, C. A., and W. J. Kinney. 1979. Selection of epibenthic plankton by outmigrating chum salmon in Hood Canal, Washington. Pages 243-289 in J. Mason, ed. Proc. 1978 Pink and Chum Salmon Workshop, March 1978, Parksville, B.C., Canada. Pac. Biol. Sta., Nanaimo, B.C., Canada.
- Simenstad, C. A., B. S. Miller, J. N. Cross, K. L. Fresh, S. N. Steinfort, and J. C. Fegley. 1977. Nearshore fish and macroinvertebrate assemblages along the Strait of Juan de Fuca including food habits of nearshore fish. Annu. Rep. to NOAA, Univ. Washington, Fish. Res. Inst. FRI-UW-7729, 159 pp. [Also NOAA Tech. Mem. ERL MESA-20.]

- Simenstad, C. A., B. S. Miller, C. F. Nyblade, K. R. Thornburgh, and L. J. Bledsoe. 1979. Food web relationships of northern Puget Sound and the Strait of Juan de Fuca--a synthesis of the available knowledge. Final Rep. NOAA/MESA Puget Sound Proj., Univ. Washington, Fish. Res. Inst. FRI-UW-7914. 334 pp.
- Sibert, J., B. A. Kask, and T. J. Brown. 1977. A diver-operated sled for sampling the epibenthos. Fish. & Mar. Serv. Tech. Rep. 738, Res. & Resour. Serv., Pac. Biol. Sta., Nanaimo, B.C., Canada.
- Smith, G. I., and H. H. Webber. 1978. A biological sampling program of intertidal habitats of northern Puget Sound. Rep. to Washington State Dep. Ecol., Baseline Study Program, North Puget Sound, by Western Washington Univ., Bellingham, Washington. 311+ pp.
- Smith, G. I. 1979. A quantitative sampling program of benthic communities in nearshore subtidal areas within the Rosario Strait region of northern Puget Sound, Washington State (1976). Appendix C in F. Gardner, ed. North Puget Sound baseline program, 1974-1977. Washington State Dep. Ecology, Olympia, Washington. 81 pp. + app.
- Stickney, A. P. 1959. Ecology of the Sheepscot River estuary. U.S. Fish Wildl. Serv., Spec. Sci. Rep.--Fish. 309. 21 pp.
- Thayer, G. W., S. M. Adams, and W. W. LaCroix. 1975. Structural and functional aspects of a recently established Zoster marina community. In L. E. Cronin, ed., Second Internat. Estuarine Research Conference, Myrtle Beach, SC, 15-18 October 1973. Academic Press, New York.
- Webber, H. H. 1979. The intertidal and shallow subtidal benthos of the west coast of Whidbey Island, spring 1977 to winter 1978. NOAA Tech. Mem. ERL MESA-37. 108 pp.

Williams, R. B., M. B. Murdoch, and L. K. Thomas. 1968. Standing crop and importance of zooplankton in a system of shallow estuaries. *Chesapeake Sci.* 9(1):42-51.

Woodmansee, R. A. 1958. The seasonal distribution of the zooplankton off Chicken Key in Biscayne Bay, Florida. *Ecology* 39(2):247-262.

APPENDIX A

Taxonomic composition, density, and standing crop of epibenthic zooplankton at seven nearshore sites, including 17 microhabitats, along the Strait of Juan de Fuca, August 1978















Appendix Table A2. Numerical and gravimetric composition of epibenthic zooplankton in nearshore environs of Strait of Juan de Fuca; all sites pooled.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%
Harpacticoida	38,795.0 ± 62,621.3	76.10	76.10	0.53 ± 1.32	27.19	27.19
Cumella sp.	1,761.9 ± 5,015.4	3.46	79.56	0.237 ± 0.64	12.2	39.39
Harpacticoid eggs	1,562.4 ± 2,204.2	3.06	82.62	0.106 ± 0.33	5.47	44.86
Ostracoda-Podocopa	1,175.5 ± 2,944.6	2.31	84.93	0.098 ± 0.24	5.05	49.91
Crustacean eggs	1,019.4 ± 3,755.0	2.00	86.93	0.071 ± 0.38	3.65	53.56
Calliopiella pratti	852.2 ± 2,248.8	1.67	88.60	0.069 ± 0.25	3.57	57.13
Platynereis				0.067 ± 0.23	3.47	60.6
bicanaliculata	579.1 ± 1,418.6	1.14	89.74	0.054 ± 0.19	2.76	63.36
Nematoda	575.3 ± 924.8	1.13	90.87	0.042 ± 0.07	2.16	65.52
				0.040 ± 0.04	2.04	67.56
				0.035 ± 0.10	1.83	69.39
				0.032 ± 0.15	1.66	71.05
				0.032 ± 0.12	1.66	72.71
				0.026 ± 0.12	1.33	74.04
				0.024 ± 0.05	1.22	75.26
				0.023 ± 0.08	1.20	76.46
				0.022 ± 0.08	1.13	77.59
				0.021 ± 0.05	1.10	78.69
Total	51,038.80 ± 75,481.10			1.98 ± 2.66		
Coeff. Var.	1.48			1.34		



Appendix Table A3. Numerical and gravimetric composition of epibenthic zooplankton in shallow sublittoral, sand/eelgrass habitat at Beckett Point, Strait of Juan de Fuca - continued.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1$ SD	%	Cum.%	$\bar{X} \pm 1$ SD	%	Cum.%
Harpacticoida	36,867.5 ± 28,260.7	72.17	72.17	1.023 ± 1.12	47.27	47.27
Crustacean eggs	4,046.7 ± 7,853.7	7.92	80.09	0.557 ± 0.61	25.73	73.00
Harpacticoid eggs	2,583.3 ± 2,338.7	5.06	85.15	0.132 ± 0.12	6.12	79.12
<u>Platynereis</u>						
<u>bicanaliculata</u>	2,467.5 ± 2,288.2	4.83	89.98	0.116 ± 0.26	5.35	84.47
Cyclopoida	683.3 ± 545.6	1.34	91.32	0.063 ± 0.14	2.93	87.40
<u>Paracalanus parvus</u>	583.3 ± 348.8	1.14	92.46	0.030 ± 0.07	1.39	88.79
				0.028 ± 0.07	1.31	90.10
				0.024 ± 0.03	1.12	91.22
Total	51,121.67 ± 41,669.05			2.27 ± 2.23		
Coeff. Var.	0.82			0.98		

Appendix Table A4. Numerical and gravimetric composition of epibenthic zooplankton in shallow sublittoral, mud/eelgrass habitat at Port Williams (Graysmarsh), Strait of Juan de Fuca.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%
Harpacticoida	143,530.0 ± 113,766.1	80.88	80.88	2.78 ± 2.61	51.49	51.49
Cumella sp.	11,860.0 ± 8,216.7	6.68	87.56	0.493 ± 0.84	9.13	60.62
Ostracoda-Podocopa	6,256.2 ± 5,995.0	3.53	91.09	0.435 ± 0.51	8.06	68.68
Harpacticoid eggs	4,507.5 ± 2,409.6	2.54	93.63	0.355 ± 0.44	6.57	75.25
Eurytemora						
<u>hirundooides</u>	1,825.0 ± 2,742.7	1.03	94.66	0.188 ± 0.23	3.47	78.72
				0.154 ± 0.19	2.85	81.57
				0.124 ± 0.09	2.29	83.86
				0.08 ± 0.09	1.48	85.34
				0.08 ± 0.09	1.48	86.82
				0.06 ± 0.05	1.11	87.93
				0.059 ± 0.08	1.09	89.02
				0.057 ± 0.08	1.06	90.08
Total	177,490.00 ± 127,796.05			5.22 ± 4.47		
Coef. Var.	0.72			0.86		

Appendix Table A5. Numerical and gravimetric composition of epibenthic zooplankton in shallow sublittoral, gravel-sand habitat at Dungeness Spit, Strait of Juan de Fuca.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%
Harpacticoida	4,665.0 ± 4,751.8	70.49	70.49	0.047 ± 0.06	22.81	22.81
Lampropidae	472.5 ± 441.94	7.14	77.63	0.030 ± 0.04	14.53	37.34
Ostracoda-Podocopa	300.0 ± 424.3	4.53	82.16	0.025 ± 0.04	12.00	49.34
Nematoda	155.0 ± 219.2	2.34	84.50	0.010 ± 0.0	5.04	54.38
Hydroida	150.0 ± 212.1	2.27	86.77	0.015 ± 0.0	7.32	61.70
Monoculodes sp.	115.0 ± 134.4	1.74	88.51	0.16 ± 0.0	3.72	65.42
Cumella sp.	107.5 ± 145.0	1.62	90.13			
Harpacticoida eggs	100.0 ± 141.4	1.51	91.34	0.15 ± 0.01	3.72	69.14
				0.005 ± 0.01	2.64	70.78
				0.005 ± 0.01	2.52	74.30
				0.005 ± 0.01	2.52	76.82
				0.005 ± 0.01	2.40	79.22
				0.005 ± 0.01	2.40	81.62
				0.005 ± 0.01	2.40	84.02
				0.005 ± 0.01	2.40	86.42
				0.005 ± 0.01	2.40	88.82
				0.005 ± 0.01	2.40	91.22
				0.005 ± 0.01	2.40	93.62
				0.005 ± 0.01	2.40	96.02
Total	6.617.50 ± 6,070.51			0.21 ± 0.18		
Coeff. Var.	0.920			0.82		

Appendix Table A6. Numerical and gravimetric composition of epibenthic zooplankton in shallow sublittoral, sand-cobble habitat at Morse Creek, Strait of Juan de Fuca.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%	$\bar{X} \pm 1 \text{ SD}$	%	Cum.%
Harpacticoida	3,412.5 ± 3,372.5	71.44	71.44	0.010 ± 0.00	9.31	9.31
<u>Pseudocalanus</u>						
minutus	589.2 ± 740.4	12.33	83.77	0.008 ± 0.02	6.91	16.22
<u>Paracalanus parvus</u>	287.5 ± 552.2	6.02	89.79	0.007 ± 0.01	6.31	22.53
<u>Oithona sp.</u>	83.3 ± 75.3	1.74	91.53	0.007 ± 0.01	6.01	28.54
<u>Calanoida nauplii</u>	50.8 ± 83.1	1.06	92.59	0.007 ± 0.01	6.01	34.55
<u>Parallorchestes</u>						
<u>ochotensis</u>				0.006 ± 0.01	5.26	39.81
<u>Paracalanus parvus</u>				0.005 ± 0.01	4.58	44.39
<u>Holmesiella anomala</u>				0.005 ± 0.01	4.50	48.89
<u>Accedomoera vagor</u>				0.005 ± 0.01	4.50	53.39
<u>Pontogeneia rostrata</u>				0.004 ± 0.01	3.83	57.22
<u>Calanoida nauplii</u>				0.003 ± 0.01	3.08	60.30
<u>Gastropod eggs</u>				0.003 ± 0.01	2.25	62.55
<u>Caprella laeviuscula</u>				0.003 ± 0.01	2.25	64.80
<u>Polychaeta</u>				0.002 ± 0.00	1.58	66.38
<u>Ostracoda-Podocopa</u>				0.002 ± 0.00	1.58	67.96
<u>Harpacticoid eggs</u>				0.002 ± 0.00	1.58	69.54
<u>Leptochelia dubia</u>				0.002 ± 0.00	1.58	71.12
<u>Nematoda</u>				0.002 ± 0.00	1.50	72.60
<u>Spionidae</u>				0.002 ± 0.00	1.50	74.12
<u>Rhynchospio sp.</u>				0.002 ± 0.00	1.50	75.62
<u>Mesogastropoda eggs</u>				0.002 ± 0.00	1.50	77.12
<u>Bivalvia</u>				0.002 ± 0.00	1.50	78.62
<u>Crustacea eggs</u>				0.002 ± 0.00	1.50	80.12
<u>Copepoda nauplii</u>				0.002 ± 0.00	1.50	81.62
<u>Eurytemora</u>						
<u>hirundoides</u>				0.002 ± 0.00	1.50	83.12
<u>Tegastidae</u>				0.002 ± 0.00	1.50	84.62
<u>Balanomorpha larvae</u>				0.002 ± 0.00	1.50	86.12
<u>Acanthomysis sculpta</u>				0.002 ± 0.00	1.50	87.62
<u>Lamprops sp.</u>				0.002 ± 0.00	1.50	89.12
<u>Megaluropus</u>						
<u>longerimerus</u>				0.002 ± 0.00	1.50	90.62
<u>Chaetognatha</u>				0.002 ± 0.00	1.50	92.12
				0.13 ± 0.06		
				0.508		
Total	4,778.33 ± 3,176.47					
Coef. Var.	0.660					

Appendix Table A7. Numerical and gravimetric composition of epibenthic zooplankton in shallow sublittoral, sand habitat at Twin Rivers, Strait of Juan de Fuca.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1$ SD	%	Cum.%	$\bar{X} \pm 1$ SD	%	Cum.%
<u>Harpacticoida</u>	1,619.2±766.9	52.62	52.62	0.081±0.10	30.00	30.00
<u>Copepoda nauplii</u>	461.5±435.1	15.00	67.62	0.019±0.03	7.14	37.14
<u>Paracalanus parvus</u>	153.8±0.00	5.00	72.62	0.019±0.03	7.14	44.28
<u>Oligochaeta</u>	84.6±119.7	2.75	75.37	0.016±0.00	5.86	50.14
<u>Unidentified eggs</u>	84.6±97.9	2.75	78.12	0.015±0.00	5.71	55.85
<u>Pycnogonidae</u>	76.9±108.8	2.50	80.62	0.015±0.00	5.71	61.56
<u>Ostracoda-Podocopa</u>	76.9±108.8	2.50	83.12	0.008±0.01	3.00	64.56
<u>Oithona sp.</u>	76.9±108.8	2.50	85.62	0.008±0.01	3.00	67.56
<u>Balanomorpha larvae</u>	76.9±108.8	2.50	88.12	0.008±0.01	3.00	70.56
<u>Cumella sp.</u>	76.9±108.8	2.50	90.62	0.008±0.01	2.86	73.42
<u>Gammaridae</u>	76.9±108.8	2.50	93.12	0.008±0.01	2.86	76.28
<u>Hyalae sp.</u>	76.9±108.8	2.50	95.62	0.008±0.01	2.86	79.14
				0.008±0.01	2.86	82.00
				0.008±0.01	2.86	84.86
				0.008±0.01	2.86	87.72
				0.008±0.01	2.86	90.58
				0.008±0.01	2.86	93.44
Total	3,076.92±402.51			0.28 ±0.12		
Coeff. Var.	0.130			0.441		

Appendix Table A8. Numerical and gravimetric composition of epibenthic zooplankton in rocky littoral habitat (tidepools) at Slip Point, Strait of Juan de Fuca.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1$ SD	%	Cum.%	$\bar{X} \pm 1$ SD	%	Cum.%
Harpacticoida	42,415.1 ± 26,987.6	71.87	71.87	0.457 ± 0.34	15.26	15.26
<u>Calliopiella pratti</u>	3,844.8 ± 3,683.9	6.51	78.38	0.331 ± 0.81	11.05	26.31
Nematoda	1,826.5 ± 1,301.8	3.09	81.47	0.324 ± 0.49	10.81	37.12
<u>Aoroides columbiae</u>	1,705.5 ± 1,520.7	2.89	84.36	0.185 ± 0.20	6.17	43.29
<u>Harpacticoid eggs</u>	1,617.9 ± 1,879.0	2.74	87.10	0.150 ± 0.31	5.02	48.31
Ostracoda-Podocopa	684.3 ± 803.4	1.16	88.26	0.150 ± 0.23	5.01	53.32
Halacaridae	604.2 ± 649.3	1.02	89.28	0.132 ± 0.08	4.41	57.73
				0.103 ± 0.16	3.43	61.16
				0.100 ± 0.08	3.33	64.49
				0.083 ± 0.14	2.78	67.27
				0.077 ± 0.14	2.57	69.84
				0.059 ± 0.06	1.98	71.82
				0.054 ± 0.03	1.81	73.63
				0.039 ± 0.10	1.30	74.93
				0.039 ± 0.09	1.29	76.22
				0.033 ± 0.04	1.10	77.32
				0.032 ± 0.01	1.06	78.38
				0.032 ± 0.01	1.06	79.44
Total	59,228.77 ± 34,581.44			3.15 ± 1.77		
Coeff. Var.	0.580			0.564		

Appendix Table A9. Numerical and gravimetric composition of epibenthic zooplankton in shallow sublittoral, sand habitat at Kydaka Beach, Strait of Juan de Fuca.

Taxa	Density (No/m <sup>3</sup> )			Standing crop (g/m <sup>3</sup> )		
	$\bar{X} \pm 1$ SD	%	Cum.%	$\bar{X} \pm 1$ SD	%	Cum.%
Harpacticoida	1,700.0 ± 565.7	37.93	37.98	0.010 ± 0.0	9.83	9.83
Spionidae	750.0 ± 636.4	16.73	54.66	0.010 ± 0.0	9.83	19.66
Copepoda nauplii	750.0 ± 919.2	16.73	71.39	0.010 ± 0.0	9.83	29.49
Paracalanus parvus	250.0 ± 212.1	5.58	76.97	0.010 ± 0.0	9.83	39.32
Crustacean eggs	250.0 ± 70.7	5.58	82.55	0.010 ± 0.0	9.83	49.15
Nematoda	200.0 ± 282.8	4.46	87.01	0.010 ± 0.0	9.83	58.98
Oithona sp.	150.0 ± 212.1	3.35	90.36	0.005 ± 0.01	4.91	63.89
				0.005 ± 0.01	4.91	68.80
				0.005 ± 0.01	4.91	73.71
				0.005 ± 0.01	4.91	78.62
				0.005 ± 0.01	4.91	83.53
				0.005 ± 0.01	4.91	88.44
				0.003 ± 0.00	2.46	90.90
				0.003 ± 0.00	2.46	93.36
				0.003 ± 0.00	2.46	95.82
Total	4,482.5 ± 1,170.26			0.13 ± 0.00		
Coeff. Var.	0.260			0.033		

Appendix Table A10. Percent composition by abundance and biomass of epibenthic plankton in various microhabitats at 6 sites along the Strait of Juan de Fuca, August 1978.

	Beckett Point					
	Bare sand		0.3-m Eelgrass		1-m Eelgrass	
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	79.88	6.31	72.93	20.69	71.50	28.70
Calanoid copepods	4.45	9.16	2.09	1.18	0.45	0.23
Cyclopoid copepods	3.07	6.01	3.52	1.47	1.40	0.44
Bivalves	1.40	6.31	0.41	0.32	0.15	0.22
Gammarid amphipods	0.74	13.51	0.36	2.06	0.26	1.64
Asellotan isopods	0.02	0.15	0.59	0.30	0.41	0.50
Cumaceans	0.03	0.15	--	--	--	--
Hippolytid shrimp	0.03	6.01	0.60	51.55	0.68	50.14
Neogastropoda	0.05	12.01				
Gastropods	0.48	10.66	1.30	12.40	0.36	8.26
Spionid polychaetes	0.68	3.00	0.01	0.01	0.05	0.11
Polychaete annelids	0.49	3.90	6.59	1.09	5.21	7.84
Nematodes	2.83	6.16			0.30	0.22
Ostracods	1.02	6.01	1.44	0.60	0.81	0.34
Harpacticoid eggs	3.75	6.01	4.44	0.59	5.48	0.22
Caridean shrimp			1.31	0.29	0.00	0.01
Crustacean eggs					11.81	3.89
Tanaids	0.75	3.30	2.34	0.62	0.32	0.28
Shannon-Wiener Diversity Index (H')	1.41	4.30	1.88	2.65	1.73	2.29

	Port Williams			
	Coarse sand		1-m Eelgrass	
	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	68.23	35.73	84.07	54.31
Cumaceans	20.84	42.00	3.25	2.40
Ostracods	2.88	1.15	3.70	3.93
Hippolytid shrimp	0.03	10.54	0.00	2.27
Bivalves	0.12	1.82	0.16	1.17
Harpacticoid eggs	5.27	0.65	1.88	0.11
Gastropods	0.02	0.03	0.30	10.76
Calanoid copepods	0.43	0.96	1.45	0.43
Tanaids	0.37	0.49	0.59	0.89
Shannon-Wiener Diversity Index (H')	1.49	2.31	1.27	2.94

	Dungeness Spit	
	Coarse sand, gravel	
	Abundance	Biomass
Harpacticoid copepods	70.50	7.26
Cumaceans	10.17	23.89
Nematodes	2.35	2.46
Ostracods	4.53	2.34
Harpacticoid copepod eggs	1.51	2.34
Hydroids	2.27	2.34
Gastropods	0.53	22.37
Polychaete annelids	0.87	14.05
Gammarid amphipods	3.49	12.42
Caprellid amphipods	0.84	2.57
Calanoid copepods	0.76	2.34
Tanaids	1.06	2.46
Shannon-Wiener Diversity Index (H')	2.29	4.14

Appendix Table A10. Percent composition by abundance and biomass of epibenthic plankton in various microhabitats at 6 sites along the Strait of Juan de Fuca, August 1978. - continued.

	Morse Creek					
	Bare sand		Cobble		Sand and cobble	
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	53.35	16.19	92.28	6.28	52.62	14.19
Calanoid copepods	39.90	27.15	1.53	3.36	30.21	34.80
Mysids	0.24	15.92	0.04	0.15	0.24	10.14
Cyclopoid copepods	1.84	10.44	--	--	7.43	13.85
Cumaceans	0.05	0.26	0.25	3.21	--	--
Nematodes	0.92	5.22	--	--	--	--
Bivalves	0.92	5.22	--	--	--	--
Chaetognaths	0.92	5.22	--	--	--	--
Gammarid amphipods	0.38	3.91	1.83	44.41	0.12	0.34
Pinnotherid crabs	0.05	2.61	--	--	0.12	0.34
Gastropods	0.18	0.52	0.41	21.00	0.12	0.34
Caprellid amphipods	--	--	0.04	4.59	--	--
Polychaete annelids	--	--	0.73	3.06	--	--
Barnacle larvae	--	--	0.73	3.06	--	--
Crustacean eggs	--	--	0.73	3.06	--	--
Asellotan isopods	--	--	0.08	1.68	--	--
Idoteid isopods	--	--	0.04	1.53	--	--
Ostracods	--	--	--	--	2.56	7.09
Harpacticoid copepods	--	--	--	--	2.68	7.09
Spionid polychaetes	--	--	0.84	3.21	2.44	6.76
Tanaids	0.96	5.48	--	--	--	--
Shannon-Wiener Diversity Index (H')	2.05	4.01	0.68	4.03	2.29	3.56

	Kydaka Beach	
	Bare sand	
	Abundance	Biomass
Harpacticoid copepods	37.92	11.81
Copepod nauplii	16.73	7.87
Spionid polychaetes	16.74	11.81
Calanoid copepods	7.15	12.60
Barnacle larvae	3.35	11.81
Crustacean eggs	5.58	7.87
Nematodes	4.46	7.88
Harpacticoid eggs	2.23	3.94
Cyclopoid copepods	3.35	7.88
Epicaridean isopods	1.12	3.94
Gammarid amphipods	0.40	10.05
Shannon-Wiener Diversity Index (H')	3.26	4.40

	Twin Rivers	
	Bare sand	
	Abundance	Biomass
Harpacticoid copepods	42.63	8.44
Copepod nauplii	15.00	5.55
Calanoid copepods	5.12	5.69
Oligochaetes	2.75	2.91
Pycnogonids	2.50	2.77
Ostracods	2.50	2.77
Cyclopoid copepods	2.50	2.77
Barnacle nauplii	2.50	2.77
Mysids	2.48	43.12
Cumaceans	2.50	2.77
Gammarid amphipods	6.11	10.12
Unidentified eggs	2.74	3.05
Cnidarians	0.37	6.93
Shannon-Wiener Diversity Index (H')	3.05	4.14

Appendix Table A10. Percent composition by abundance and biomass of epibenthic plankton in various microhabitats at 6 sites along the Strait of Juan de Fuca, August 1978 - continued.

Microhabitat--algae and sessile inverts.:	Slip Point tidepools											
	1		2		3		4		5		6	
	Costarium, Ulva & Hedophyllum		Codium, Alaria, & Hedophyllum		Corralines, Phyllospadix		Undent. brown, Mytilus		Undent. brown, Ulva, Mytilus		No algae, Mytilus	
Volume:	0.080 m <sup>3</sup>	0.076 m <sup>3</sup>	0.076 m <sup>3</sup>	0.076 m <sup>3</sup>	0.112 m <sup>3</sup>	0.112 m <sup>3</sup>	0.046 m <sup>3</sup>	0.176 m <sup>3</sup>	0.176 m <sup>3</sup>	0.176 m <sup>3</sup>	0.067 m <sup>3</sup>	0.067 m <sup>3</sup>
Tide height:	+0.01 m	0.0 m	0.0 m	0.0 m	+0.34 m	+0.34 m	+1.07 m	+1.07 m	+1.07 m	+1.07 m	+1.19 m	+1.19 m
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Harpacticoid copepods	80.58	0.53	71.57	2.62	70.71	0.58	79.47	4.86	58.81	0.98	66.12	1.91
Gammarid amphipods	9.01	21.58	12.58	24.41	15.43	28.75	6.48	34.95	6.42	10.48	5.74	31.03
Ostracods	1.36	1.30	0.03	0.06	2.48	0.61	2.40	4.63	1.11	0.98	0.05	0.09
Harpacticoid eggs	2.43	0.51	5.45	1.25	--	--	--	--	3.67	0.89	2.97	1.81
Nematodes	1.39	0.53	2.91	1.31	0.68	0.58	7.32	4.86	9.32	0.94	4.70	1.91
Archaeogastropods	0.07	41.79	0.16	4.37	1.48	5.56	--	--	0.23	2.27	1.19	7.25
Brittlestars	--	--	0.36	25.26	0.36	25.26	--	--	0.62	32.14	0.05	5.44
Oligochaetes	0.80	6.58	0.65	4.37	0.02	0.03	0.24	0.23	0.57	1.32	0.40	0.91
Sphaeromatid isopods	0.09	3.29	0.22	13.73	0.20	3.92	0.12	0.23	0.37	9.82	0.05	0.09
Neogastropods	--	--	0.06	6.38	0.06	6.38	--	--	--	--	0.15	20.87
Pagurid crabs	0.08	0.51	0.03	1.67	0.03	1.67	--	--	--	--	0.05	4.54
Unidentified eggs	--	--	0.54	1.25	--	--	--	--	0.05	0.04	0.05	0.09
Idoteid isopods	--	--	0.08	2.23	0.08	2.23	--	--	0.02	0.45	0.05	0.91
Polychaete annelids	1.74	17.51	3.67	44.63	2.56	12.92	0.24	9.49	11.57	21.36	5.50	12.42
Anthozoans	0.03	1.01	--	--	--	--	--	--	--	--	--	--
Halacarid mites	0.82	0.53	0.54	1.25	2.12	0.58	--	--	1.38	0.89	--	--
Asellotan isopods	0.31	0.57	0.71	1.37	1.61	3.06	0.12	0.23	2.55	1.86	5.49	4.62
Mesogastropods	0.03	1.05	0.54	1.25	0.07	1.94	0.12	2.31	0.13	3.13	0.84	1.00
Cumaceans	0.08	0.25	0.03	0.06	0.81	1.11	0.24	0.23	0.18	0.89	2.08	1.91
Cirolanid isopods	--	--	0.02	1.67	0.02	1.67	--	--	--	--	--	--
Hippolytid shrimp	--	--	0.03	0.62	--	--	0.12	32.41	0.02	5.36	--	--
Gastropod eggs	0.01	0.03	0.08	0.28	0.08	0.28	2.40	4.63	0.05	0.04	0.05	0.09
Bivalves	0.33	0.56	0.11	0.12	0.07	0.06	--	--	0.25	3.12	2.97	1.81
Crustacean eggs	0.54	0.51	0.30	0.56	0.30	0.56	--	--	1.54	0.94	0.10	0.09
Shannon-Wiener Diversity Index (H')	1.41	3.38	1.87	3.80	2.00	4.05	1.29	2.97	2.65	4.07	2.34	4.16

APPENDIX B

Feeding Types and Habitats of Some Local Marine Amphipods

by  
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1979

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## Introduction

Gammaridean amphipods are an important faunal component of nearly all marine benthic ecosystems. However, a full understanding of their role within each community has been hampered by an incomplete knowledge of amphipod life history.

The objective of this paper is to define the feeding types and habitats of gammarid amphipods collected by Mr. Charles Simenstad of the Fisheries Research Institute. These species were taken in low intertidal and shallow subtidal waters along the Strait of Juan de Fuca and in Hood Canal, Washington.

The life history information is based on sparsely available literature, and serves to document the need for more research in this area. There are very few specific feeding observations for local fauna. Most have been extrapolated from close congeners or by generalization within a genus or family. For those species whose feeding types remain unknown the "best guess" would be detritivore. Enequist (1949) states that "practically all young amphipods appear to eat detritus, even those which as adults are phytophagous, predatory, or carrion feeders."

As might be expected from the above extrapolation process, the designated life history categories are at best provisional. Several of the citations suggest that many species exhibit more than one feeding and habitat type. Thus, species were assigned to the summary tables (Tables 1 and 2) under the most probable life history category on the basis of present information.

## Species list

Accedomoera vaqor Barnard

Possibly herbivore (detritivore) as Barnard (1964) reports for the closely related genus, Pontogeneia; nestling on algae (Barnard, 1975) and found in coarse sediment (Nyblade, unpub.).

Allorchestes anqusta Dana

Possibly herbivore (detritivore) as Barnard (1964) reports for the closely related genus, Hvale; nestling on algae (Barnard, 1975) but also found on and in cobbles and mixed sediment (Armstrong et al, 1976).

Amphilochnus litoralis Stout

Feeding type unknown; possibly a commensal, its hosts poorly known (Barnard, 1964 and 1975).

Ampithoe lacertosa Bate

An exclusive herbivore (Heller, 1968); builds an algal nest in algae (Barnard, 1964; Heller, 1968).

Ampithoe sp.

Herbivorous, but may accept meat (Heller, 1968); builds an algal nest in algae (Barnard, 1964; Heller, 1968).

Aoroides columbiae Walker

Detritivore (Enequist, 1949); tubicolous on algae or coarse sediment (Barnard, 1964 and 1975; Armstrong et al, 1976).

Atylus tridens (Alderman)

Feeding type unknown; nestling in algae (Barnard, 1975) but with a pelagic stage (Mills, 1961).

Calliopius sp. B

Possibly a detritivore (suspension feeder) (Enequist, 1949); probably nestling on algae as Barnard (1975) reports for Calliopius sp., c.f. laeviusculus.

Corophium sp.

Detritivore deposit-feeder, but also capable of suspension feeding (Hart, 1929; Enequist, 1950; Nicol, 1967); tubicolous, burrowing in sand or mud (C. acherusicum also tubicolous on algae) (Hart, 1929; Enequist, 1949; Barnard 1964 and 1975).

Eohaustorius washingtonianus (Thorsteinson)

Suspension feeder (Nicol, 1967; Bousfield, 1973; Dexter, 1978), however Dr. Peter Jumars (pers. comm.) reports a "sand licking" behavior; freely burrowing in sand (Barnard, 1975; Armstrong et al., 1976; Dexter, 1978).

Gitanopsis vilordes Barnard

Feeding type unknown; commensal in algae (Barnard, 1975).

Guernea sp. A

Other members of this family (Dexaminidae) are specialized detritivores, commensal in ascidians or sponges (Enequist, 1949).

Hyale frequens (Stout)

Herbivore (detritivore)(Barnard, 1964); nestling in algae (Barnard 1964 and 1975), but also found on cobbles and mixed sediment (Armstrong et al., 1976).

Ischyrocerus anguipes Kroyer

Phytophagous, possibly largely feeding on water-borne detritus (Enequist, 1949); tubicolous on algae (Barnard, 1975).

Jassa falcata (Montagu)

Enequist (1949) states that the family "Jassidae" is mostly phytophagous; tubicolous on algae and pilings (Barnard, 1975).

Lepidepcreum cf. gurjanovae Hurley

Enequist (1949) lists many members of the family Lysianassidae as burrowing, subsurface detritivores and borderline carrion feeders, while Barnard (1975) assumes most lysianassids are non-burrowing sediment feeders.

Maera simile (Stout)

Enequist (1949) reports that the related species, M. loveni, is a shallow burrowing, subsurface detritivore, while Barnard (1964, 1975) states that M. simile is a herbivore (detritivore) which nestles on algae.

Mandibulophoxus gilesi Barnard

Probably a subsurface detritivore as Enequist (1949) reports for other members of the family Phoxocephalidae; burrowing in shallow-water sand bottoms seaward of the surf zone (Barnard, 1975).

Megaluropus longimerus Schellenberg

Feeding type unknown; Bousfield (1973) reports members of this genus to be sand burrowing, while Barnard (1975) states that they nestle on algae, but are primarily neritic, nektonic, or demersal.

Melita californica AldermanMelita desdichada Barnard

Enequist (1949) characterizes the family Gammaridae as largely free-swimming and phytophagous-omnivorous. Limited observations by the

author suggest that local species of Melita are also phytophagous-omnivorous, but Barnard (1975) states that these species nestle in algae.

Metopella carinata (Hansen)

Feeding type unknown; Barnard (1975) reports other members of this family (Stenothoidae) to be commensal.

Monoculodes spinipes Mills

Monoculodes sp. E

Shallow burrowing detritivore (Enequist, 1949); Enequist (1949) states that members of the family Uedicerotidae move freely at the mud-water interface, while Barnard (1964) reports that they are possibly sediment burrowers.

Najna sp.

Possibly herbivorous; nestling on algae especially kelp (Barnard, 1964), while the author has frequently observed members of this species burrowing into the stipes of the alga, Alaria.

Orchestia traskiana Stimpson

Herbivorous on decaying algae (Carefoot, 1977); on rocky beaches and occasionally on sandy beaches with algae, under debris and boards in salt marshes (Bousfield, 1975).

Urchomene sp. A

Barnard (1964) lists this genus as "sediment feeding" while Thurston (1979) considers deep water members of this genus to be generalist-necrophagous feeders; epibenthic (Thurston, 1979), presumably non-burrowing but sediment related (Barnard, 1964).

Paracalliopiella cf. pratti (Barnard) (= Calliopiella)

Possibly a detritivore as Enequist (1949) reports for the closely related genus, Calliopiopus; nestling on algae (Barnard, 1975) but also found on mixed sediment (Armstrong et al, 1976).

Parallorchestes ochotensis (Brandt)

Herbivore (detritivore) (Barnard, 1964); nestling on algae (Barnard, 1964 and 1975).

Paraphoxus spinosus COMPLEX

As in Mandibulophoxus

Parapleustes nautilus Barnard

Feeding type unknown; nestling on algae (Barnard, 1975).

Photis brevipes ShoemakerPhotis sp.

Detritivore (Enequist, 1949); tubicolous on algae (Barnard, 1975).

cf. Podoceroopsis n. sp.

Possibly the same as Ischyrocercus anquipes with which it co-occurs.

Podocercus sp. (?cristatus (Thomson))

Enequist (1949) reports that members of the family Podoceridae are suspension feeders, using their antennae to filter detritus from the water; living among hydroids (Barnard, 1975).

Pontogeneia cf. rostrata Gurjanova

Barnard (1964) lists this genus as herbivore (detritivore); Barnard (1964 and 1975) states that members of this genus nestle on algae having little contact with the sediment, while Pamatmat (1966) reports it as burrowing in sediment.

Protomedeia sp. A (cf. zotea Barnard)

Detritivore (Enequist, 1949); burrowing in sediment, possibly tubicolous (Enequist, 1949).

Synchelidium shoemakeri Mills

As in Monoculodes.

Table 1. Provisional feeding types of some local gammaridean amphipods

Herbivores (including omnivores); \*= nearly exclusive herbivore

Accedomoera vagor  
 Allorchestes angusta  
 Ampithoe lacertosa\*  
 Ampithoe sp.\*  
 Hyale frequens  
 Ischyrocerus anguipes  
 Jassa falcata  
 Maera simile  
 Melita californica  
 Melita desdichada  
 Najna sp.\*  
 Orchestia traskiana\*  
 Parallorchestes ochotensis  
 cf. Podoceropsis n. sp.  
 Pontogeneia cf. rostrata

Detritivores; += burrowing deposit feeder

Aoroides columbiae  
 Calliopius sp. B  
 Corophium sp. +  
 Guerneia sp.  
 Lepidepcreum cf. gurjanovae  
 Mandibulophoxus gilesi +  
 Monoculodes spinipes  
 Monoculodes sp. E  
 Orchomene sp.  
 Paracalliopiella cf. pratti  
 Paraphoxus spinosus COMPLEX +  
 Photis brevipes  
 Protomedeia sp. A +  
 Synchelidium shoemakeri

Table 1, continued:

Suspension feeders

(Corophium sp.)

Eohaustorius washingtonianus

Podocerus sp.

Unknown (presumed detritivores)

Amphilocheus litoralis

Atylus tridens

Gitanopsis vilordes

Megaluropus longimerus

Metopella carinata

Parapleustes nautilus

Table 2. Provisional habitat types of some local gammaridean amphipods

<u>Algal Associated</u>	<u>Sediment Associated</u>
Accedomoera vagor	(Accedomoera vagor)
Allorchestes angusta	Corophium sp.
Ampithoe lacertosa	Eohaustorius washingtonianus
Ampithoe sp.	Lepidepecreum cf. gurjanovae
Aoroides columbiae	Mandibulophoxus gilesi
Atylus tridens	Monoculodes spinipes
Calliopius sp. B	Monoculodes sp. E
(Gitanopsis vilordes)	Orchestia traskiana
Hyale frequens	Orchomene sp.
Ischyrocercus anguipes	Paraphoxus spinosus COMPLEX
Jassa falcata	Protomedeia sp. A
Maera simile	Synchelidium shoemakeri
(Megaluropus longimerus)	<u>Pelagic</u> (epibenthic swimming)
Melita californica	(Atylus tridens)
Melita desdichada	Megaluropus longimerus
Najna sp.	(Orchomene sp. ?)
(Orchestia traskiana)	
Paracalliopiella cf. pratti	
Parallorchestes ochotensis	
Parapleustes nautilus	
Photis brevipes	
Photis sp.	
cf. Podoceroopsis n.sp.	
Pontogeneia cf. rostrata	
<u>Inquillinous</u> (incl. commensal and epibiotic)	
Amphilocheus litoralis	
Gitanopsis vilordes	
Guernea sp. A ?	
Metopella carinata	
Podocercus sp.	

## Literature cited

Armstrong, J.W., C.P. Staude, R.M. Thom, and K.K. Chew. 1976. Habitats and relative abundances of the intertidal macrofauna at five Puget Sound beaches in the Seattle area. *Syesis* 9: 277-290.

Barnard, J.L. 1964. Marine Amphipoda of Bahia de San Quintin, Baja California. *Pacific Nat.* 4: 55-139.

Barnard, J.L. 1975. Identification of gammaridean amphipods. In: R.I. Smith and J.T. Carlton (eds.), *Light's Manual: Intertidal Invertebrates of the Central California Coast*. Third Edition, pp. 314-366.

Bousfield, E.L. 1973. *Shallow-water Gammaridean Amphipoda of New England*. Comstock Pub., Ithaca, N.Y. 312 p.

Bousfield, E.L. 1975. List of Talitridae. In: R.I. Smith and J.T. Carlton (eds.), *Light's Manual: Intertidal Invertebrates of the Central California Coast*. Third Edition, pp. 363-364.

Carefoot, T. 1977. *Pacific Seashores: A Guide to Intertidal Ecology*. University of Washington Press, Seattle. 208 p.

Dexter, D.M. 1978. The infauna of a subtidal, sand bottom community at Imperial Beach, California. *Calif. Fish and Game* 64(4): 268-279.

Enequist, I. 1949. Studies on the soft-bottom amphipods of the Skagerrak. Zool. Bidrag. Uppsala, Bd. 28: 297-492.

Hart, T.J. 1929. Preliminary notes on the bionomics of the amphipod, Corophium volutator. J. Mar. Biol. Assoc. U.K. 16: 761-789.

Heller, S.P. 1968. Some aspects of the biology and development of Ampithoe lacertosa (Crustacea: Amphipoda). M.S. Thesis, University of Washington, 132p.

Mills, E.L. 1961. Amphipod crustaceans of the Pacific Coast of Canada, I. Family Atylidae. Bull. Nat. Mus. Canada 172: 13-33.

Nicol, J.A.C. 1967. The Biology of Marine Animals. Second Edition. Sir Isaac Pitman and Sons Ltd., London. 699 p.

Nyblade, C.F. Unpublished. North Puget Sound Intertidal Study. Friday Harbor Laboratories, University of Washington. Washington Dept. of Ecology Baseline Study. Final Report. April 1977.

Pamatmat, M.M. 1966. The ecology and metabolism of a benthic community on an intertidal sandflat (false Bay, San Juan Is., Washington). Ph.D. Dissertation, University of Washington, 243 p.

Thurston, M.H. 1979. Scavenging abyssal amphipods from the north-east Atlantic Ocean. Marine Biology 51: 55-68.