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SERIE HAVUNDERSØKELSER

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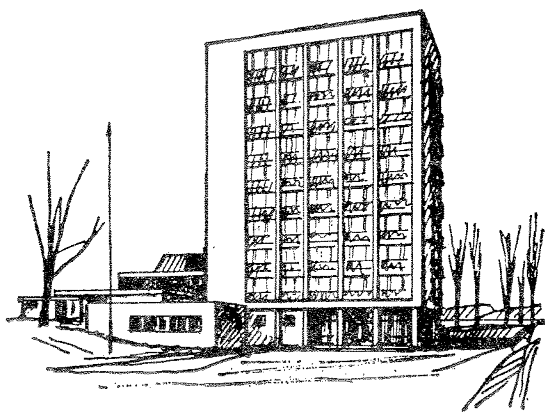

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A Quantitative Study of Benthic Infauna in Puget Sound,

WASHINGTON, USA, IN 1963–1964

BY
ULF LIE
Department of Oceanography,
University of Washington, Seattle,
Washington, USA

With a section on polychaetes by
KARL BANSE, KATHARINE D. HOBSON AND FREDERIC H. NICHOLS

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I. INTRODUCTION

A. Purpose of the present investigation

In 1962 the Department of Oceanography, University of Washington, planned to start benthic investigations in the Northeast Pacific Ocean, but as the Department was inexperienced in the field of benthos research it was felt that a pilot study in Puget Sound would be necessary. The pilot study would be particularly concerned with sampling problems, processing of material, and spatial and seasonal variability. Methods and concepts of modern synecology, such as statistical methods for delimiting communities and the concept of species diversity, have received little attention from benthos researchers, and one of the objectives therefore has been to test the validity and applicability of some of these methods. It was realized that future studies of the dynamics of productivity and energetics of benthic communities would have to be limited to the dominant species population. One of the objectives of the present investigation therefore has been to determine which species are the most important and to compile ecological and biological information about those species.

B. Literature review

1. Review of concepts and methods

A truly quantitative study of the bottom fauna is a product of this century, and is mainly attributed to the invention of a quantitative sampler, the Petersen grab (PETERSEN and JENSEN 1911). The advantage of grabs over the dredges that had been used in the last century is that they enable the scientist to enumerate faunistic parameters, such as standing crop or numbers per unit area of the bottom. It is then possible to make meaningful comparisons among areas, and with careful sampling even to estimate the rate of secondary production on the bottom. The application of these methods in fishery research is obvious, and it was the goal of PETERSEN and his co-workers to evaluate the feeding grounds of demersal fishes and to determine the relationships between benthos and fish production. These ideas were adopted by fishery investigators, primarily in northern Europe, and a number of studies were instigated during the first four decades of this century aiming at the benthos-fish production relationships. However, when PETERSEN (1913, 1915, 1918) applied the concept of communities to the study of benthos, a wider group of marine ecologists whose primary concern was the study of synecology became interested in the benthic fauna. The concept of community is one of the most important theories in plant and animal synecology, but considerable controversy exists as to the interpretation of the associations. Two distinctly different viewpoints are advocated (FAGER 1963), and the point of argument is whether the communities are fundamental ecological units (biocoenoses) with considerable biological self-regulation of composition, or if they are assemblages of organisms whose presence at any habitat is governed only by the ecological tolerances of the various species.

PETERSEN regarded his communities as convenient statistical units for mapping the benthos, but some of his followers tended to regard the PETERSEN communities as biocoenoses. However, THORSON (1957) stressed that if the communities were to be seen as biocoenoses, all the species and their interactions would have to be studied; and BODENHEIMER (1958) stated that the concept of the superorganismic biocoenosis is an intuitive hypothesis, which at present is in the domain of philosophy rather than science.

The existence of benthic communities has been accepted by most benthos scientists, but LINDROTH (1935) and STEPHEN (1933, 1934) rejected the concept of communities for benthos because they were not able to demonstrate distinct boundaries between the communities, and they indicated a gradual change in the fauna from one environmental extreme to another without discontinuities of distribution. This line of thought has been further developed by forest ecologists (BRAY and CURTIS 1957, BROWN and CURTIS 1952, CURTIS and McINTOSH 1951, WHITTAKER 1951, 1952, 1956, 1967), who claim that species populations are distributed along environmental gradients "individualistically", i.e., with bell-shaped abundance curves whose modes reflect the most favourable conditions for the species along the gradient. The composition of the assemblages of organisms at any point along the gradient is then governed by the ecological tolerances of the composite species populations to the environmental parameter, and the assemblages constitute a "continuum" from one environmental extreme to another.

PETERSEN realized the importance of environmental parameters for the distribution and maintenance of benthic communities, but he did not elaborate on these points. MOLANDER (1928b) emphasized the importance of temperature and salinity, while he considered bottom types to be of less importance. However, British benthos scientists (FORD 1923, DAVIS 1925, JONES 1950) considered the physical properties of the bottom to be the main factors for the distribution of benthic communities, and JONES' classified communities based on the bottom types. THORSON (1957) argued that such classifications would have little predictive power, because there are factors other than the physical properties of the sediments that affect the fauna. The fauna will give more information about the environment than the sediments about the fauna, and the animals themselves must therefore be the starting point for ecological studies.

Attempts have been made to subdivide the benthic fauna into more or less logical groups and to concentrate the study on one or more of these groups. PETERSEN (1918) divided the fauna into infauna and epifauna. The infauna was the fauna living in the substrate and epifauna was fauna living attached to or otherwise associated with inanimate matter such as rocks, wooden debris, etc. However, PETERSEN did not specify where motile forms such as amphipods, brachyurans, and nudibranchs would belong, while REMANE (1940), SANDERS (1956) and THORSON (1957) included the latter groups in the epifauna.

A further subdivision of the infauna was suggested by MARE (1942). The fauna retained by a 1-mm screen was called macrofauna, the fauna sieved through a 1-mm screen but retained by a 0.1-mm screen was called meiofauna, and the fauna sieved through a 0.1-mm screen was called microfauna. The separation of the fauna into size classes is unfortunate because a species may belong to different categories in the course of its development, and the question arises whether there is a choice of screens that would be biologically preferable to MARE's method. REISH (1959) sieved benthic samples from muddy bottom through a series of Tyler screens ranging in mesh size from 4.7 mm to 0.15 mm. The 1-mm screen would have sampled about 95% of the standing crop, 86% of the number of species, but only 25% of the number of specimens. The choice of screens should depend on the objectives, but also on the structure of the communities. One may therefore have to use screens with different mesh size for different communities.

2. Subtidal investigations from the west coast of the United States

The first attempt to describe benthic communities from the west coast of the United States was made by SHELFORD and TOWLER (1925). However, their work may hardly be considered quantitative, since their sampling procedures are obscure, numbers and weights are not given, and the conclusions about dominance and their choice of characterizing species probably would not satisfy modern students of communities.

SHELFORD (1935) continued his study of the Friday Harbor region and his approach was considerably more quantitative than that of SHELFORD and TOWLER's study. However, the study was based on single samples, and JONES (1961) noticed that conclusions were drawn for approximately 1000 km^2 based on 35 samples. Also, in inshore waters such as the Friday Harbor region, the mosaic pattern of the environment prevents reliable predictions, and it is doubtful whether the PETERSEN concept of communities is applicable to fjord conditions of this kind (THORSON 1957).

A more detailed study of a small soft-bottom area (about 7500 m^2) in the vicinity of the Friday Harbor Marine Laboratories was made by WISMER and SWANSON (1935). Ten replicate samples were taken with the PETERSEN grab at each of 15 stations within the small area, and additional samples were taken with dredge and trawl.

A very extensive study of the benthos off the coast of southern California was made in 1952-1954 (HARTMAN 1955, BARNARD, HARTMAN, and JONES 1959), yielding considerable information on taxonomy and ecology of a large number of benthic organisms.

More limited in scope and area was JONES's (1961) study of the benthic fauna off Point Richmond, California, but his report is exceptionally well written with a large number of ideas and results. JONES sampled monthly both with an Ekman grab and corers at four permanent stations.

The only benthic survey in Puget Sound proper was made by WENNEKENS (1959). The study was semiquantitative; the material was sampled with an anchor-dredge, and very scanty information is given on numbers and biomass of the various species or communities. The main objective of the study was to determine the relationship between the distribution of benthic communities and the environment.

C. Area and environment

1. Topography and sedimentology

Puget Sound is located in the northwestern part of the State of Washington, extending southward about 90 miles from the Strait of Juan de Fuca. The sound is characterized by a number of channels, sounds, and inlets. It is naturally separated from the Strait of Juan de Fuca and is divided into two major basins by two sills. The northern basin reaches a depth of about 250 m and the southern basin about 100 m. The topography of Puget Sound is primarily a result of glaciation, and the surface geology is characterized as glacial tills and moraines with bedrock rarely occurring along the shores.

The bottom sediments of Puget Sound are derived from river transport, shore erosion, and erodion of submarine banks. The sediment types are a very soft silty clay on the basin floors, from fine sand to gravel on the slopes, and boulders and gravel in the narrows and on the sills where the current is particularly strong (WENNEKENS 1959). No detailed study has been made on the rate of sedimentation in Puget Sound. Naturally, there is considerable deposition immediately off the major rivers, and the rate of denudation of the area that supplies sediments to the sound indicates an average sedimentation rate of 0.4 mm/yr (ANON. 1953).

2. Hydrography

The hydrography of Puget Sound has been studied since 1932 and the results have been published in a number of reports (BARNES and COLLIAS 1954a, 1954b, 1954c, 1956a, 1956b, 1956c, COLLIAS, DERMODY, and BARNES 1962, COLLIAS and BARNES 1964).

Hydrographic data were not collected simultaneously with the benthos. However, Drs. G.C. ANDERSON and K. BANSE have collected hydrographic data at two permanent stations since September 1963 in connection with a study of phytoplankton production in Puget Sound. The plankton stations are located close to the benthos sections (Figure 1) and therefore the hydrographic data have also been considered valid for the benthos stations. Temperature, salinity, and oxygen for the benthos stations have been determined from comparable depths at the primary production stations.

The water in Puget Sound is characterized by small vertical gradients in physical and chemical parameters and small seasonal and annual variations.

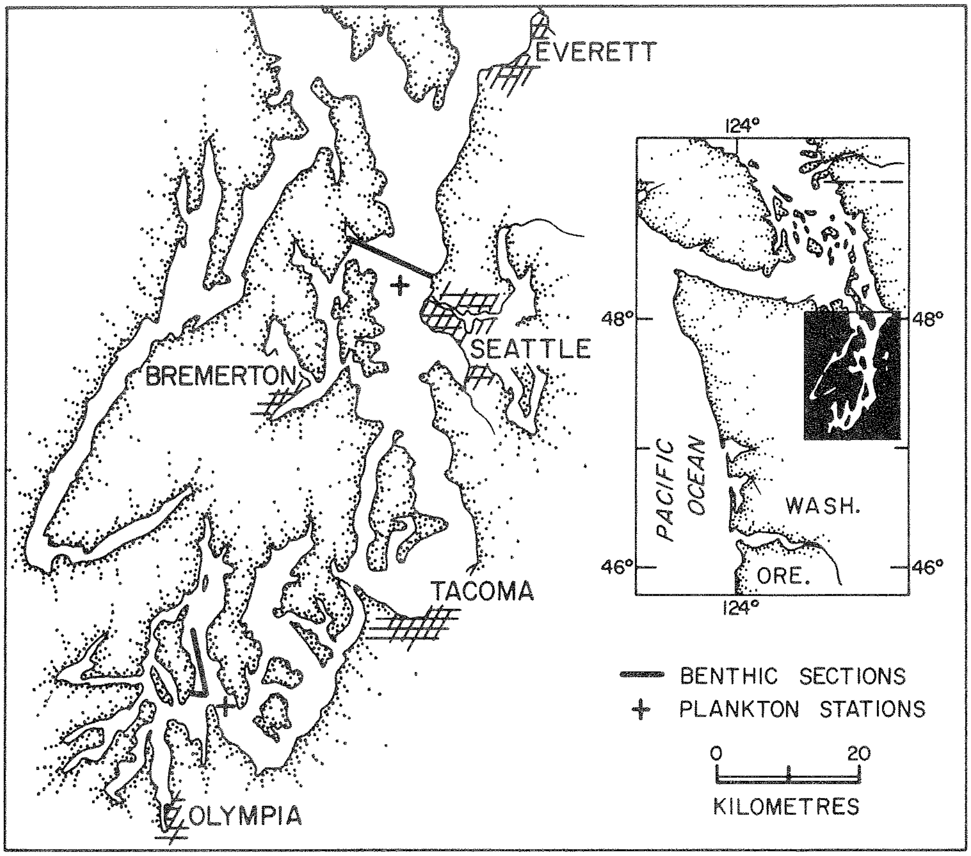

Figure 1. Benthos sections and phytoplankton productivity stations in Puget Sound.

Cold, salt, ocean water entering the Strait of Juan de Fuca as a deep current is thoroughly mixed over the sill between the outer and inner parts of the strait (HERLINVEAUX and TULLY 1961). The mixed water flows as a deep current into Puget Sound through Admiralty Inlet. This water mass is again mixed with less saline waters of the upper strata over the sills in Puget Sound because of the strong tidal currents.

The tides in Puget Sound are of a semidiurnal mixed type with large differences between succeeding low tides. The average diurnal tide range is about 3.3 m. The tidal currents are very strong in the sounds and narrows, up to 7.2 knots in the Tacoma Narrows, with the average velocity in the deeper and wider parts of the sound considerably lower. Normally there is a net outflow at the surface and a net inflow in the deeper layers, but occasionally there is a net outflow

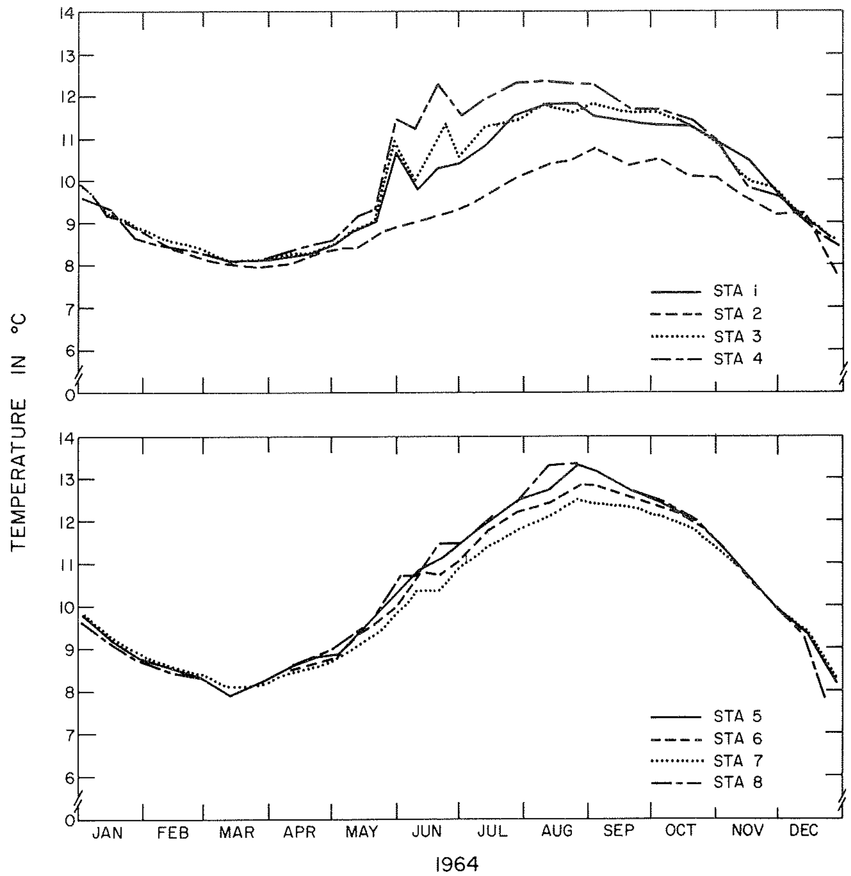

Figure 2. Bottom temperatures at the benthos stations during 1964.

at all depths. The topography and the strong tidal currents result in a good mixing of the water masses, reflected in the vertical distribution of hydrographic parameters such as temperature, salinity, and oxygen.

Figure 2 shows the temperature variations at the various benthos stations through 1964 as determined from the data collected at the primary production stations. The similarity between the stations ranging from about 12 to 70 m in depth was striking; only the deepest station (about 200 m) had summer temperatures 2.3°C below the rest of the stations. The annual temperature amplitudes at the benthos stations ranged from about 8 to 11°C at the deepest station, to about 8 to 13.5°C at station 8 in Case Inlet.

The same similarity among the stations was also evident in the salinity distribution. The salinities at the deepest station were from 1 to 1.5 $^{o}/oo$ higher than at station 8 in Case Inlet. The seasonal amplitudes were also extremely small: from 29.44 to 30.82 $^{o}/oo$ at the deepest station and from 28.04 to 29.73 $^{o}/oo$ at station 8.

Comparisons with earlier studies of the hydrography of Puget Sound show that the data from 1964 are representative for the average conditions in the sound and that the annual variations are small.

3. Phytoplankton production

The primary production of Puget Sound has not been studied as thoroughly as the hydrography over the years, but since September 1963 a detailed study has been made at two permanent stations, as mentioned above. The daily carbon fixation during the period March-October 1964 fluctuated about a mean level of 1-2 g/day. At the productivity station off Seattle during the period May-August there were enormous variations within short time intervals, with maximum values reaching as high as 4-7 g/day. Because of these peaks there was a distinct difference in the total primary production between the two productivity stations. In Case Inlet the annual production was 268 g of carbon per m^2 compared to 459 g off Seattle.

II. MATERIAL AND METHODS

A. Choice of stations

Our work in Puget Sound was considered a pilot study, and knowledge of the fauna in Puget Sound per se was not our main objective; therefore we decided to work extensively on permanent stations rather than to make a survey of the sound. The permanent stations were chosen in order to cover the widest possible range of the two environmental parameters that show large variations in the sound, depth and sediment type. To ensure real subtidal conditions, sampling was never made in water shallower than 10 m. Bottom types unsuitable for sampling with grabs (boulders, rocky bottoms) were avoided.

Stations were located in both main basins in Puget Sound (Figure 1) in order to test the generality of conclusions about the faunal distribution in relation to environmental factors. Four stations were on a section across Puget Sound off Seattle and four in Case Inlet in the southern part of the Sound. Figure 1 shows the location of the sections, and Figures 3 and 4 show the stations in relation to the bottom topography on the sections across Puget Sound off Seattle and Case Inlet. Station 5, which was located southwest of the main section in Case Inlet, is therefore not included in Figure 4. The environment at the various stations and the validity of the sampling is discussed below.

B. Description of stations

1. Station 1 (47°41'33"N, 122°24'18'W)

The station was located close to the beach off Golden Gardens in Seattle. The mean sampling depth over all seven cruises was 23 m, ranging from 15 to 36 m. The tidal currents were strong and the ship swung as much as 180° when anchored. A depth variation from 15 to 21 m could therefore occur between replicate samples. The fact that the substrate was of a mixed type with large amounts of debris (pieces of wood, bottles, etc.), together with the difficult current and wind conditions, made the sampling less efficient than at most of the other stations.

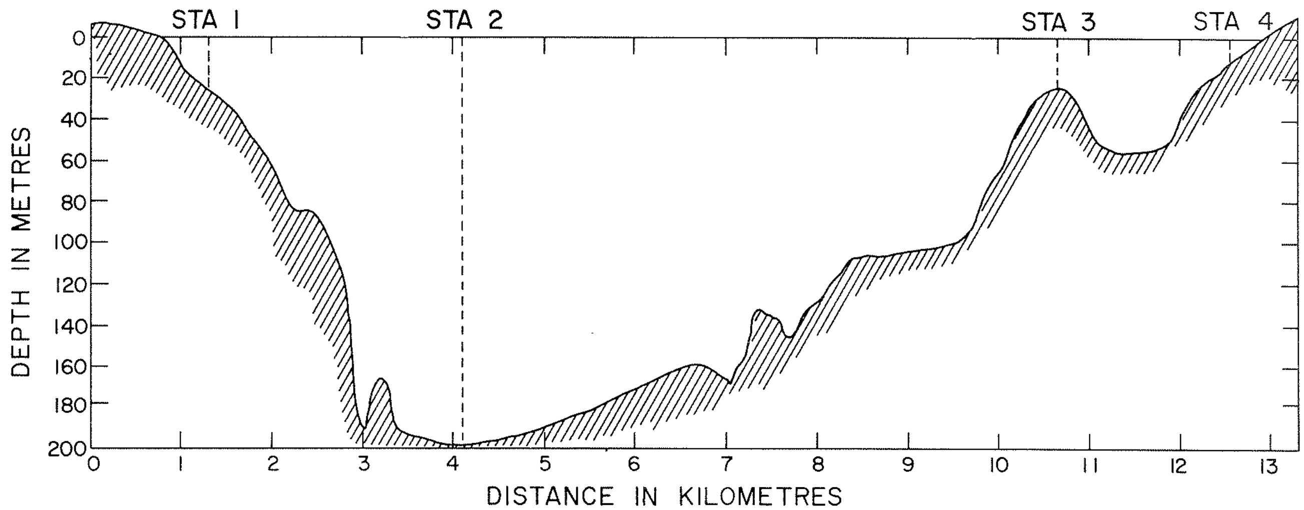

Figure 3. Depth profile along the benthos section off Seattle.

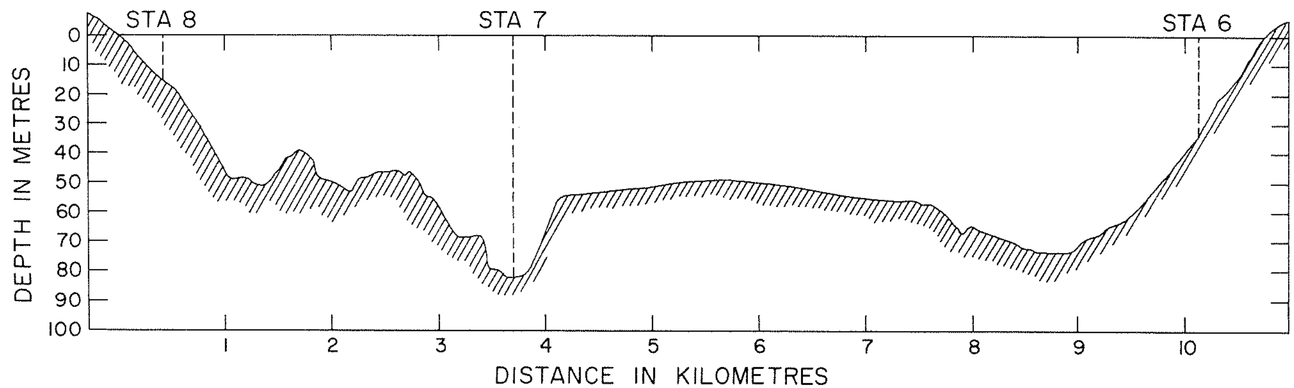

Figure 4. Depth profile along the benthos section in Case Inlet.

2. Station 2 ($47^{O}42'16''N$, $122^{O}26'24''W$)

This station was located in the middle of the large mud flat that forms the bottom of the deep basin in Puget Sound. The average depth was 195 m, ranging from 172 to 210 m. The station was easily recognized by the bottom type, a fine soft mud, and by the presence of the heart urchin Brisaster townsendi. The ship was not anchored during the sampling at this station, but if the ship drifted into a sediment type where a handful of sand was left on the screens after sieving, the heart urchins were no longer present in the samples. These samples were discarded and the ship was taken back to the correct position. The faunal parameters suggest that the station was very efficiently sampled.

3. Station 3 ($47^{O}44'04''N$, $122^{O}31'53''W$)

This station was located on top of a knoll-like elevation in the middle of Port Madison across Puget Sound from Seattle. The average depth was 22 m, varying only from 20 to 25 m. The sediment type was a fine sand mixed with shell fragments, and there were no particular problems in sampling.

4. Station 4 ($47^{O}44'31''N$, $122^{O}32'41''W$)

The station was located close to a partly submerged log at the beach in Port Madison. The average depth was 12 m, ranging from 10 to 18 m. The bottom type was a fine sand mixed with a fair amount of silt and occasionally wood debris. There were no particular sampling problems at station 4.

5. Station 5 ($47^{O}10'48''N$, $122^{O}50'00''W$)

This station was located southwest of Johnson Point in Case Inlet in southern Puget Sound. The average depth was 22 m, ranging from 15 to 36 m. The bottom was rather uneven and the sediments consisted of a coarse shell-sand heavily mixed with fairly large rocks. The bottom type together with very strong currents made sampling very difficult and relatively inefficient. However, no extreme variability in faunal parameters among replicate samples or among seasons could be demonstrated.

6. Station 6 ($47^{O}10'40''N$, $122^{O}48'48''W$)

The station was located close to the lighthouse at Johnson Point and therefore was always easy to find. The average depth was 34 m, ranging from 32 to

40 m. The substrate was of a very mixed type with high amounts of mud, sand, and gravel. Occasional strong currents affected the sampling efficiency as the ship swung up to 180° when anchored.

7. Station 7 (47°13'20"N, 122°49'36"W)

This station was located where the softest bottom in Case Inlet could be found, about half way between Johnson Point and Heron Island. The average depth was 70 m, ranging from 47 to 89 m. The station was very difficult to find, but the sediment type, a soft mud, was easily recognized. If while sampling the ship drifted into a sediment type with more sand, the sampling was stopped and the ship was taken back to its original position. Owing to these sampling problems, the data from this station are probably less reliable than from most of the other stations.

8. Station 8 (47°15'10"N, 122°50'06"W)

This station was located off the beach at the southern tip of Heron Island in Case Inlet. The average depth was 16 m, ranging from 10 to 21 m. The bottom type was a fine sand, occasionally mixed with shell fragments. There were no particular sampling problems.

C. Choice of sampler and sampling procedures

The main breakthrough in quantitative benthos research followed the invention of the Petersen bottom grab (PETERSEN and JENSEN 1911). Since then several improvements in grab samplers have been made, and the grab most commonly used in benthic research today is probably the van Veen grab. The efficiency of the van Veen grab has been tested against the Petersen grab (THAMDRUP 1938, URSIN 1954) and the van Veen grab was the more efficient. McINTYRE (1954) found the Smith-McIntyre grab to be more efficient than the van Veen grab. Because the Smith-McIntyre grab could not be obtained when the present study was started, it was decided to do the sampling with a 0.1-m^2 van Veen grab weighing about 33 kg.

A study of the sampling efficiency and digging characteristics of the van Veen grab (LIE and PAMATMAT 1965) shows that this grab is devoid of some of the inadequacies normally attributed to grabs. The grab made a rectangular rather than a semicircular cut into the bottom and the so-called depth differential effect (LONGHURST 1958) in sampling the fauna inhabiting different depths in the substrate therefore did not occur. The grab also gave good sampling replication, and it was suggested that the grab collected more than 90% of the specimens and at least 50% of the biomass. Naturally, the scarcity of large and deep-digging specimens makes predictions about the biomass dubious, but it may safely be assumed that the major part of the community energetics takes place in the layer of the substrate that is efficiently sampled by the van Veen grab.

The ship was always anchored during sampling and the grab was lowered with a constant speed of 2 m/sec. The content of the grab when sampling on the six sand-bottom stations was immediately emptied into a sediment measuring device (LIE and PAMATMAT 1965) and the amount of sediment was determined. The grab was always filled to its maximum capacity (20 litres) when sampling on the two mud-bottom stations (stations 2 and 7)

D. Number of samples

Grab sampling is similar to quadrat sampling in terrestrial ecology (LONGHURST 1959), and the problems are to ensure randomness of the samples and to sample a minimum area that will adequately represent the fauna of the community. Though PETERSEN himself was well aware of the danger of taking too few samples (PETERSEN 1918), many of his followers collected single samples or duplicates only, and conclusions about the numbers and biomass of the benthos per square metre were obtained by multiplication. As the "standard unit" for sampling of benthos in depths from 0-200 m, THORSON (1957) suggested 0.1 m^2. This was criticized by LONGHURST (1964), who has suggested 0.5 m^2 as a representative area, sampled by five replicate samples with a 0.1-m^2 grab (LONGHURST 1959). Clearly, the size of the minimum area depends largely on the problems at hand; a different area must be sampled to adequately collect the biomass rather than the majority of the specimens, and a different area again is required to sample all the species present.

Preliminary sampling in Puget Sound in 1962 showed such large variations in faunistic parameters from duplicate samples that ten replicate samples per station were arbitrarily collected in 1963, and a study was made to determine how many samples would be necessary for an adequate description of the faunal assemblages.

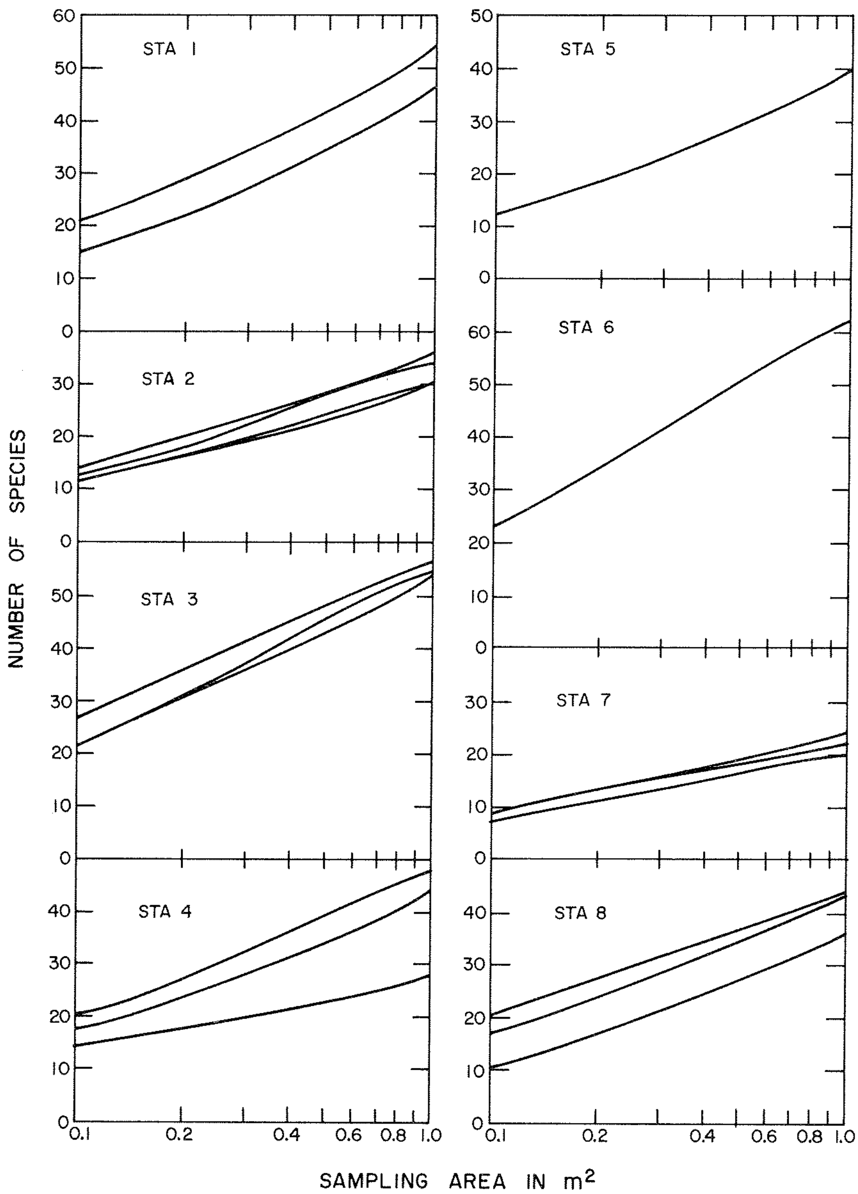

Figure 5. Estimated number of species in ten replicate samples.

The standard way of determining whether or not the species in a community are adequately sampled has been to study the cumulative plot of species recruited with increased sampling (HOLME 1953, JONES 1956, LONGHURST 1959). The samples should be randomized before plotting; but unless the number of replicate samples is high, randomization will not completely remove the variability due to sampling errors. The best plot seems to be the average of all the possible cumulative plots that can be made of replicates, and a method for determining this average curve has been developed by GAUFIN et al. (1956). The method estimates the average probability of finding a species in any particular $\underline{K} \leq \underline{n}$ samples but in none of the previous samples, provided the species occurs in the set of $\underline{n}$ samples. The average probability multiplied with the total number of species in the set of $\underline{n}$ samples gives the average number of species contributed by each of the samples, and cumulative plotting gives a curve that represents the average rate of discovery of species by adding replicate samples. The curve can be used for conclusions only for the $\underline{n}$ samples it is based on, and extrapolating to determine the total number of species in a community is not valid. However, the slope at the upper end of the curve is an indication of whether there are still many undiscovered species in the community.

Figure 5 shows the average cumulative plot of species versus number of samples following GAUFIN et al. for the cruises when 10 replicate samples were collected. Common to all of the curves is the fact that they are fairly steep at the upper end even with ten replicate samples. About 3% of the total number of species was found only in the tenth sample. However, these last-found species are rare in numbers and may partly be stray specimens from other habitats or communities.

According to Figure 5, from 75% to 85% of the species found in ten samples will be sampled in five samples at the stations in Puget Sound. However, since in all communities there is some degree of dominance of a small number of species, the more important question would be how many samples were necessary to sample the dominant species. Three to four samples would be sufficient for collecting the species that together made up 95% of the total number of specimens. Consequently, the number of replicate samples during the sampling program in 1964 was reduced to five samples per station. This was considered sufficient for an adequate description of the biomass and number of organisms of the faunal assemblages, and for data on ecology and biology of the important species. Table 1 shows the number of samples collected at each station during the investigation.

Table 1

Sampling dates, number of replicate samples, and depths at the eight permanent benthos stations in Puget Sound

Date	Replicate samples	Depth range (m)	Date	Replicate samples	Depth range (m)
Station 1			Station 5		
27 Feb 1963	10	15-21	12 Feb 1963	10	34-37
30 Apr	3	16-24	3 May	5	17-30
2 Aug	9	24-25	30 July	6	17-22
27 Nov	10	20-26	7 Nov	9	19-21
18 Feb 1964	5	20-22	13 Feb 1964	5	15-16
3 Apr	5	26-30	23 Apr	5	17-17
7 Aug	5	33-36	28 July	5	18-18
Station 2			Station 6		
25 Feb 1963	10	172-197	13 Feb 1963	6	32-40
21 May	10	175-182	3 May	5	36-40
1 Aug	10	210-210	30 July	10	34-38
27 Nov	10	195-210	7 Nov	9	35-37
18 Feb 1964	5	210-210	13 Feb 1964	5	34-35
3 Apr	5	200-210	23 Apr	5	34-34
2 Aug	5	210-216	28 July	5	35-36
Station 3			Station 7		
27 Feb 1963	10	21-22	13 Feb 1963	10	52-62
29 Apr	10	17-17	3 May	5	80-84
1 Aug	10	20-22	29 July	10	48-55
18 Nov	10	25-26	7 Nov	10	50-79
17 Feb 1964	5	23-23	13 Feb 1964	5	85-85
4 Apr	5	24-25	23 Apr	6	84-85
7 Aug	6	22-24	28 July	6	85-89
Station 4			Station 8		
9 Jan 1963	10	12-18	13 Feb 1963	10	9-21
29 Apr	10	10-12	3 May	6	10-11
2 Aug	9	13-14	29 July	10	11-12
18 Nov	10	10-10	7 Nov	10	12-17
17 Feb 1964	5	12-12	13 Feb 1964	5	16-18
4 Apr	5	12-16	23 Apr	5	13-16
7 Aug	5	13-13	28 July	5	16-17

E. Sieving

The present investigation is a study of the macrofauna (MARE 1942). All the samples have been sieved through a stainless steel screen with 1 mm mesh size. During the first three cruises the samples were also sieved through 3-mm and 10-mm screens, but it was time saving and the number of damaged specimens decreased when only the 1-mm screen was used. During the last four cruises all the material left on the 1-mm screen was brought back to the laboratory for sorting. All the samples were preserved in 5-10% formaldehyde buffered with $Na_2B_4O_7$.

F. Laboratory methods

1. Sediment particle size analysis

Subsamples were taken from 75 of the grab samples for a particle size analysis. The subsampling was made by pushing a polyethylene tube of 50 mm diameter through a door on top of the grab, thus taking out a core of the sediments. The subsample was homogenized before the analysis. The 36 sediment samples taken in January-February and April-May 1963 were given a detailed treatment following standard procedures (KRUMBEIN and PETTIJOHN 1938). Cumulative percents of the weights were determined for every full phi-size of the gravel and sand fractions, and for every half phi-size for the silt and clay fractions. In an additional 39 sediment samples collected in November 1963 the silt and clay fractions were lumped and labelled "mud". Their percentage of the total weight was determined by wet sieving through a 4-phi screen, evaporating the fluid, and weighing the residue. The weight percentages of every full phi-size of the gravel and sand fractions were determined by dry sieving as normally. From the analysis of the samples from November 1963 mean particle sizes could not be calculated.

2. Sorting and identification of fauna

In the laboratory small portions from the collecting jars were put in white photographic trays with freshwater and the specimens were picked up with a pair of forceps under a magnifying lamp. The sorting was done by several student helpers and a certain variance might be expected from the varying degree of accuracy of the sorters. However, the difference when samples were sorted twice by different sorters never exceeded 1% of the total number of organisms.

The present study is an investigation of the infauna in the wider sense. The species excluded from the study are those living attached to hard surfaces (Hydroida, Anthozoa, Cirripedia, Archaeogastropoda (Acmea spp.) and Tunicata), or boring (Teredo spp., Limnoria spp.). A few Limnoria lignorum were recorded when found on the screens after sieving. The specimens may have left wooden debris on the screens or may have been free-living at the time of sampling. The epifauna described above were excluded because sampling efficiency of these groups differs significantly from that of the infauna. The distribution and density of the epifauna are not merely biological phenomena but are dependent upon the more or less scattered distribution of rocks and wooden debris on the relatively uniform substrate.

Polychaetes, crustaceans, lamellibranchs, and echinoderms were the dominant groups both in numbers and standing crop, and consequently most of the effort was focussed on these groups. The rest of the fauna was grouped and labelled "miscellaneous" and given a rather cursory treatment both in regard to identification and enumeration (Appendix I, page 518). However, the sipunculid Golfingia pugettensis was so important both in numbers and weight that it was included among the dominant species (page 394).

The crustaceans, lamellibranchs, and echinoderms were identified and counted in all samples, while the polychaetes could be identified and counted from the samples from January-February and April-May 1963.

The polychaetes were identified by K. BANSE, K.D. HOBSON, and F.H. NICHOLS; the lamellibranchs by D.S. KISKER.

3. Size measurements and weighings

Length measurements were made for all the "numerically dominant species" (page 367), except the polychaetes, the sipunculid Golfingia pugettensis, and the vermiform holothurian Leptosynapta clarki. The last species were often broken during sampling or more or less contracted during preservation, making measurements meaningless. The crustaceans, the ophiuran Amphiodia urtica, and most of all the lamellibranchs were measured by an ocular micrometer in a dissecting microscope, while the heart urchin Brisaster townsendi and some of the larger lamellibranchs were measured in millimetres with a vernier caliper. The crustaceans were measured from the tip of the rostrum to the end of the urosome, the lamellibranchs were measured from anterior to posterior end, and the largest width perpendicular to the axis through the mouth and the anus was measured on Brisaster townsendi. Specifics about size measurements of Amphiodia urtica are given on page 481. In the size-frequency diagrams (example, Figure 20, page 406) the sizes were plotted as micrometer divisions, with a double scale on the abscissa for converting into millimetres.

Wet weights of the numerically dominant species were determined after blotting on filter paper. The wet weights would change rapidly with the time of blotting until an asymptote was reached after 5-10 min. All the material was therefore blotted for 10 min before weighing. The samples had been preserved from three months to three years before weighing. Polychaetes and other tube-building species were removed from the tubes, but the lamellibranchs were weighed with the shells on. The dry weights were determined after drying in an oven at 95°C until constant weight was obtained (4-8 hours).

The numerically dominant species of crustaceans, lamellibranchs, and echinoderms (except Leptosynapta clarki) were weighed in size-classes in order to determine the size-weight relationships. From the size-weight relationships the total wet weight and dry weight of the various species were determined by multiplication with the size-frequency diagrams. For the smaller size-classes several specimens were weighed in each size-class, while the larger specimens were weighed individually. Polychaetes, the sipunculid Golfingia pugettensis, and the holothurian Leptosynapta clarki were not measured and therefore the size-weight relationships could not be determined. For these species the total weight per sample has been determined.

Specimens of the numerically dominant species were burned in a muffle furnace to determine the ash content. The samples were placed in the furnace at 200°C and in the course of $8\frac{1}{2}$ hours the temperature was raised to 500°C. At this temperature the samples were left for 16 hours and then transferred to a dessicator for cooling before weighing.

4. Electronic data processing

A programme was designed for the IBM 7094 computer by Mrs. L.S. OLUND to compute the most important parameters of the species populations and the faunal assemblages. The parameters for the species populations included means, variances, standard deviations, and indices of dispersion (page 337). The computations were made both on raw data and on log (x + 1) transformations. Two indices of diversity (page 351) and a measure of redundancy for each sampling date for the various faunal assemblages were also programmed. Polychaetes were not included in the electronic data processing.

III. RESULTS AND DISCUSSION

A. Performance of the 0.1 m^2 van Veen grab

1. Repeatability

The normal procedure for studying the ability of gear to make reliable replicates, i.e., its repeatability, is to collect a number of samples from a limited area and to study the sampling variability in faunal indices such as biomass or number of specimens. However, the results obtained by this method will be more influenced by the patchiness of the fauna than by the inherent repeatability of the sampler itself. The present study has therefore been made on the grab's ability to make good replicates of volumes of sediment, bypassing the problem of patchiness of the fauna.

As mentioned above (page 249), there is no variability in the volume of sediment at the mud stations. Table 2 shows the mean volume of sediment obtained at the various sand stations on the different dates. The coefficient of variation $\underline{V}$ = 100 (standard deviation/mean volume) indicates the repeatability of the sampler; good replication gives a low coefficient of variation. There is some variation in mean amount of sediment at the various stations through the sampling period. The trend indicates that the coefficient of variation decreases with increasing volume of sediment, but the correlation is not statistically significant.

The two main factors causing large variability in the grab sampling are probably bad weather and inexperienced crew (URSIN 1954, LIE and PAMATMAT 1965). There is a tendency of decreasing coefficients of variation through the sampling period as shown in Figure 6. The heavy line for the mean coefficient of variation indicates the effect of experience, but even in the last cruise coefficients as high as 18 and 27% were recorded. Stations 3 and 4 are located close to each other (Figure 2) and the effect of weather could be expected to be similar on these two stations. The two broken lines in Figure 6 show that these two stations have about the same fluctuations in the coefficient of variation, indicating that although sampling experience certainly decreases the sampling variability, the weather will have a much more serious effect and will cause large variations even with an experienced crew.

Table 2

Volume of sediments in litres obtained in the 0.1-m^2 van Veen grab at the six sand-bottom stations in Puget Sound from January-February 1963 to July-August 1964

	Mean volume	Range of variation	Standard deviation	Coefficient of variation (%)	Number of samples
Station 1					
27 Feb 1963	3.23	1.5- 5.2	1.309	40.52	10
30 Apr	4.96				3
2 Aug	3.93	1.8- 5.3	1.136	28.90	9
27 Nov	4.84	3.0- 6.0	1.101	22.75	10
18 Feb 1964	3.72	2.8- 4.5	0.542	14.57	5
3 Apr	5.20	4.0- 6.5	0.787	15.14	5
7 Aug	6.20	5.0- 8.0	1.112	17.94	5
Station 3					
27 Feb 1963	7.60	6.0- 9.0	0.965	12.70	10
29 Apr	5.43	2.0- 7.0	1.465	26.98	10
1 Aug	7.03	5.7- 9.5	1.235	17.57	10
18 Nov	6.95	5.2- 9.5	1.160	16.69	10
17 Feb 1964	7.88	4.7-11.0	2.015	25.57	5
4 Apr	5.36	4.0- 6.8	0.958	17.87	5
7 Aug	5.92	4.0- 8.2	1.596	26.96	6
Station 4					
9 Jan 1963	8.48	6.0-10.7	1.592	18.77	10
29 Apr	7.13	4.5-12.0	2.045	28.68	10
2 Aug	8.15	7.3- 8.8	0.542	6.72	9
18 Nov	4.96	4.2- 6.5	0.713	14.38	10
17 Feb 1964	5.10	3.8- 6.5	1.035	20.29	5
4 Apr	6.00	5.5- 6.2	0.276	4.60	5
7 Aug	8.26	6.8- 9.2	0.941	11.39	5
Station 5					
12 Feb 1963	4.29	1.7- 7.0	1.823	42.49	10
3 May	4.46	2.8- 5.8	1.153	25.85	5
30 July	3.50	2.2- 5.3	1.066	30.46	6
7 Nov	6.63	5.0- 8.8	1.196	18.04	9
13 Feb 1964	5.30	5.0- 6.0	0.412	7.77	5
23 Apr	5.04	4.5- 5.7	0.403	8.00	5
28 July	5.86	4.5- 7.5	0.997	17.01	5

Table 2 (continued)

	Mean volume	Range of variation	Standard deviation	Coefficient of variation (%)	Number of samples
Station 6					
13 Feb 1963	3.41	1.5- 5.0	1.158	33.96	6
3 May	9.00	7.5-11.0	1.366	15.18	5
30 July	8.83	7.5-11.0	1.567	17.75	10
7 Nov	7.77	5.0- 9.4	1.356	17.45	9
13 Feb 1964	5.00	3.5- 6.2	1.018	20.36	5
23 Apr	7.20	6.5- 8.2	0.653	9.07	5
28 July	8.60	8.0- 9.2	0.415	4.83	5
Station 8					
13 Feb 1963	4.50	2.0- 6.5	1.434	31.87	10
3 May	7.51	5.8-10.5	1.697	22.60	6
29 July	8.40	7.0-10.5	1.126	13.41	10
7 Nov	6.90	5.2- 8.5	0.959	13.90	10
13 Feb 1964	5.88	4.5- 7.8	1.102	18.74	5
23 Apr	7.24	5.0-11.8	2.379	32.86	5
28 July	8.18	7.2- 8.7	0.591	7.23	5

Table 3

Volume of sediments in litres obtained with the 0.1-m^2 van Veen grab and the 0.1-m^2 Smith-McIntyre grab at station 1, 7 August 1964

	Mean volume	Range of variation	Standard deviation	Coefficient of variation (%)
Smith-McIntyre Grab	4.87	3.8-5.8	0.707	14.5
van Veen grab	6.34	4.8-8.0	2.118	33.4

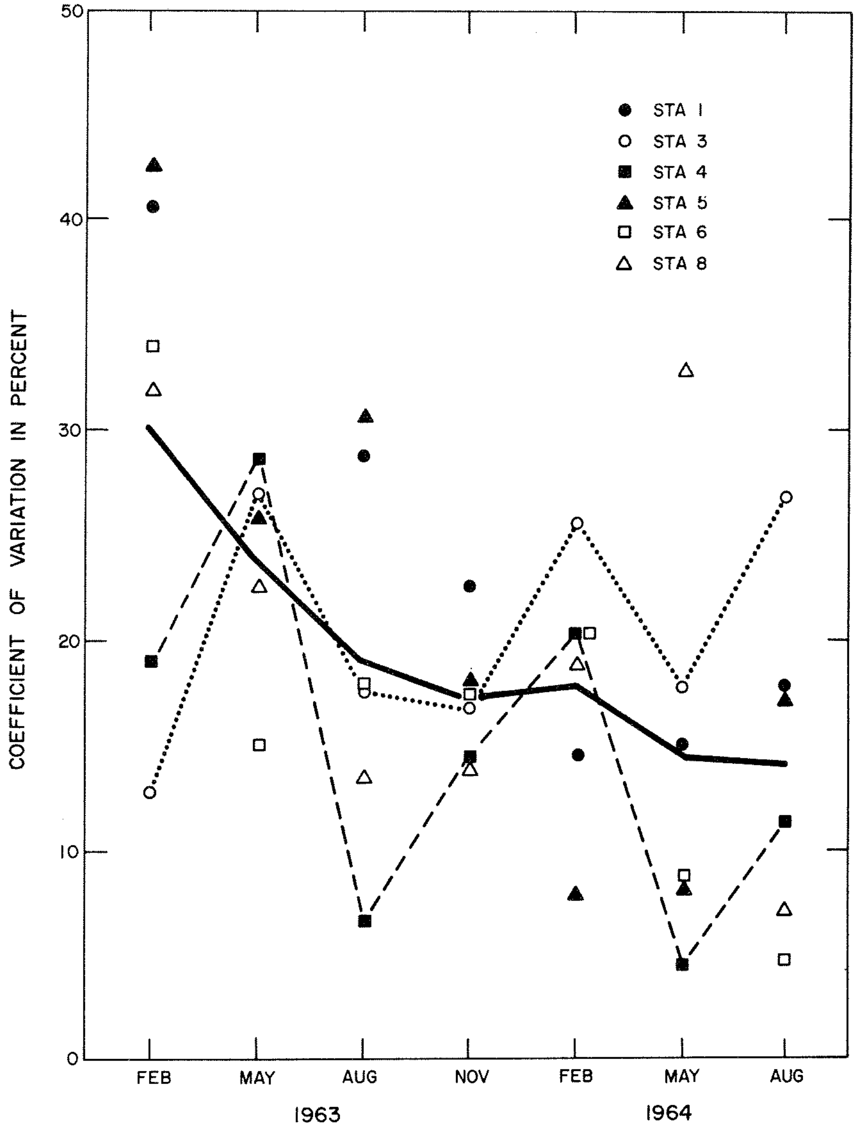

Figure 6. Coefficient of variation of mean sediment volumes from replicate grab samples during the investigated period. Heavy line represents the average, broken lines connect observations at stations 3 and 4.

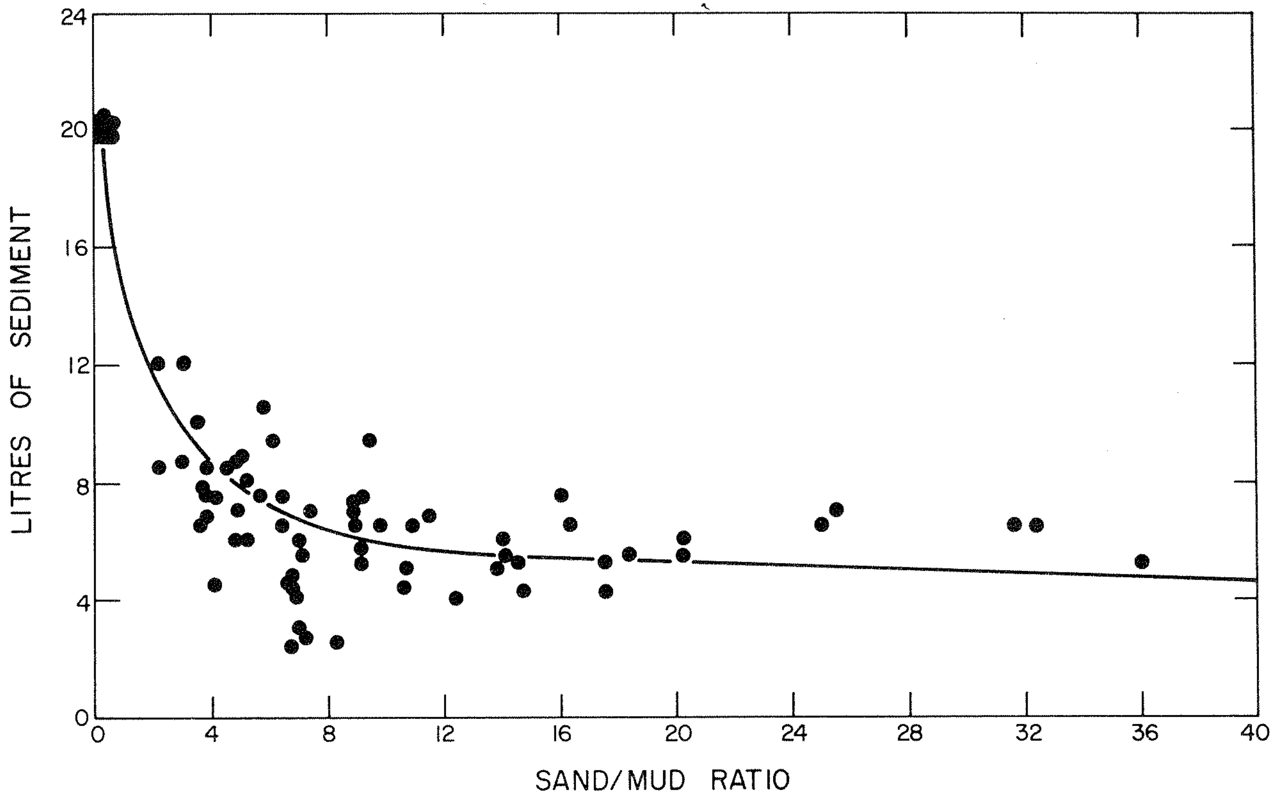

Figure 7. Volume of sediments in the grab with varying sand/mud ratio of the sediments.

The coefficient of variation reveals the variation in depth of penetration of the grab (LIE and PAMATMAT 1965). A mean value of about 15% with an experienced crew sampling on sand stations, with a mean volume of sediment of 6 litres, indicates that the average penetration of the grab is from about 5 to 7 cm. Since the vast majority of the fauna is concentrated in the upper 4-5 cm of the substrate, the effect of the sampling variability on the fauna is considerably less than the coefficient of variation, and probably negligible.

2. Sampling efficiency

Given a constant impact speed, the volume of sediment obtained by the grab is a function of the texture of the substrate. The sediment volume was correlated to the "hardness" of the sediment as measured by the sand/mud ratios from Table 4, (page 264). There was not a good correlation (Figure 7); other factors such as bad weather, strong currents, and rocks and wooden debris on the bottom are probably strongly influencing the results.

There is considerable evidence from the literature that by far the greatest portion of the benthic macrofauna is found in the upper 4-5 cm (JOHANSEN 1927, MOLANDER 1928a, SANDERS 1960, JONES 1961, LIE and PAMATMAT 1965). If a horizontal cut is assumed (LIE and PAMATMAT 1965, GALLARDO 1965), 1 cm of

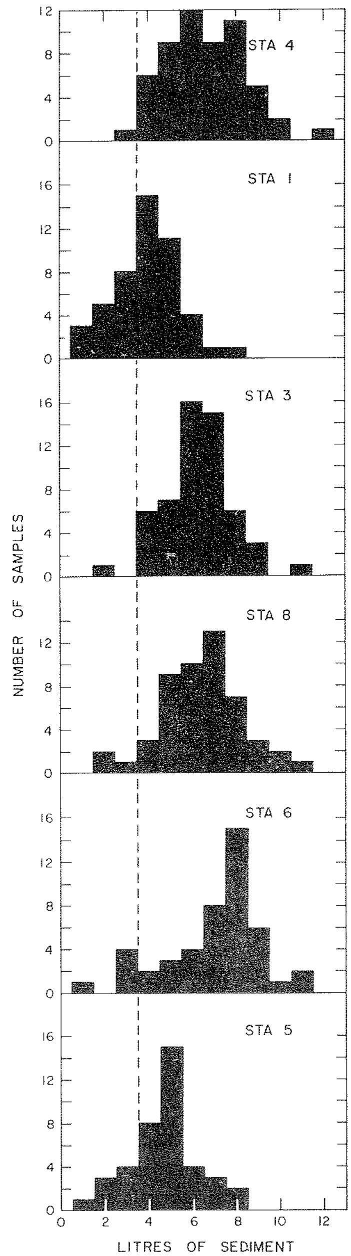

Figure 8. Volume of sediments in the grab samples at the sand bottom stations during the investigated period.

penetration of the 0.1 m^2 van Veen grab will result in 1 litre of sediment. To assure good representation of the fauna, a digging depth of at least 4 cm should be ascertained. This is always the case on muddy bottom, and Figure 8 shows that only 12.3% of the samples from sandy bottoms contained less than 4 litres. The mean for the sand samples was 6.26 litres, with 95% confidence limits from 5.73-6.79 litres. More than half of the samples with less than 4 litres of sediment were collected during the first cruise when sampling experience was low.

3. Comparison of the van Veen and the Smith-McIntyre grabs

McINTYRE (1954) studied the difference in catching power between the van Veen grab and the Smith-McIntyre grab. He found that the Smith-McIntyre grab consistently gave larger volumes of sediment than the van Veen grab. However, the litre amount he obtained seems surprisingly small for the sediment types he referred to (3.2 litres on mud, 3.25 and 2.25 on muddy sand). On similar bottom types in Puget Sound the van Veen grab sampled 20 litres and about 10 litres.

In the summer of 1964 ten replicate samples each were taken with a Smith-McIntyre grab and a van Veen grab at station 1. One of the virtues of the Smith-McIntyre grab is that sampling can be done in rough weather (McINTYRE 1954). The comparison in Puget Sound was therefore made on a day when there were fairly strong winds and currents at station 1. The coefficient of variation (Table 3) was much lower for the Smith-McIntyre grab, which supports McINTYRE's view that the grab is superior to others for sampling in bad weather. However, the van Veen grab gave higher volumes of sediments, and a test of the significance of sediment volumes from the two series of data showed that the volumes in the van Veen grab were significantly higher on the 95% level of probability.

This comparison indicates that the Smith-McIntyre grab is better for use in offshore waters than the van Veen grab, while the latter grab seems to dig deeper. Furthermore, the van Veen grab does not make a semicircular cut into the bottom and is therefore well suited for quantitative sampling (LIE and PAMATMAT 1965). The digging characteristics of the Smith-McIntyre grab (GALLARDO 1965) indicate that the cut is not completely horizontal, particularly on soft bottoms. However, WIGLEY (1967) found that the shock-wave associated with the Smith-McIntyre grab had less severe effects on the sampling than that associated with the van Veen grab.

B. The substrate at the stations

There is considerable evidence from the benthos literature (LINDROTH 1935, JONES 1950, BUCHANAN 1958, LONGHURST 1958, SANDERS 1958) that the physical properties of the substrate are important for the structure and distribution of benthic communities. The result of the particle size analysis from Puget Sound is shown in Table 4. The stations can be ranked according to coarseness of the sediments, but the ordination cannot be based on any single parameter (BUCHANAN 1958) partly because of bimodality in the distribution of the size classes and partly because sampling errors did not affect the various stations equally. The amount of gravel at stations 5 and 6 is definitely underestimated in Table 4. At these two stations there were large pebbles and rocks ranging up to 10 cm diameter, and these were not quantitatively collected by our method of subsampling (page 253).

Stations 2 and 7 stand out as very different from the other stations in their high percentage of silt and clay. Therefore, if the ordination of the stations is from finest to coarsest substrate, station 2 will be ranked first with station 7 as its nearest neighbour. Station 4 would be ranked next, based on its relatively high mud content, its low content of gravel and coarse sand, and its low mean particle size. Stations 1 and 3 are about equally similar to station 4 and their ranking is therefore not obvious. However, station 1 has been ranked first mainly based on the location of the mode of the sand fraction. Station 8 has been ranked next to station 3 although according to Table 4 it was not distinctly different from station 6. However, the lack of difference is due to subsampling problems at station 6 as described above. Station 5 had definitely the coarsest substrate of the eight stations in Puget Sound. Based on the data in Table 4 and sampling experience, the stations may be ranked according to increasing coarseness of the substrate in the following manner as shown in Figure 9; stations 2, 7, 4, 1, 3, 8, 6, 5.

In November 1963 there was a distinct change in the sediment type at station 4 (Table 4). The change was mainly reflected in a decrease of the mud fraction, but also in a slight change of the mode of the sand fraction towards the coarser part. This apparent change in the substrate was also reflected in the amount of sediments taken by the grab (Table 2) and in the faunal composition (page 285). However, the conditions gradually returned to normal, and by August 1964 the conditions were as in the spring of 1963. The change in the sediment type cannot be explained according to navigational errors because the sampling at station 4 was always made within about 20 m distance from an anchored log.

Table 4

Particle-size analysis by percent weight of sediments from the eight benthos stations in Puget Sound in 1963

	Gravel >2.0 mm	Very coarse sand 2.0-1.0 mm	Coarse sand 1.0-0.5 mm	Medium sand 0.5-0.25 mm	Fine sand 0.25-0.125 mm	Very fine sand 0.125-0.0625 mm	Silt 0.0625-0.0313 mm	Clay <0.0313 mm	Silt and clay	Sand/ mud	Mean particle size (mm)
Station 1											
27 Feb	0.47	0.20	0.75	9.36	49.16	33.41	5.12	1.54	6.66	14.03	0.135
	7.63	4.47	6.60	17.63	33.93	17.24	9.56	2.94	12.50	7.00	0.220
	0.00	0.07	0.36	4.75	20.41	48.56	20.83	5.01	25.84	2.87	0.087
30 Apr	0.09	1.31	1.98	8.96	42.30	32.41	9.84	3.11	12.95	6.72	0.125
	0.33	0.19	0.78	11.59	45.68	28.73	10.16	2.54	12.70	6.87	0.130
Mean	1.70	1.24	2.09	10.46	38.30	32.07	11.10	3.03	14.13	7.50	0.139
27 Nov	0.01	0.39	1.65	7.67	43.96	31.58			14.62	5.83	
	0.49	0.90	2.57	10.57	42.31	30.93			12.24	7.17	
	0.45	0.59	1.93	10.86	46.15	29.77			10.26	8.75	
	0.92	2.32	3.67	8.93	41.93	32.37			9.86	9.14	
	1.17	2.21	3.38	9.18	41.98	32.12			10.23	8.77	
	1.29	0.47	1.72	8.61	44.83	30.13			12.95	6.72	
Mean	0.72	1.15	2.49	9.30	43.53	31.15			11.69	7.73	
Station 2											
25 Feb	0.00	0.03	0.07	0.11	0.57	7.93	60.09	31.21	91.30	0.10	0.0075
	0.00	0.07	0.10	0.13	0.64	8.49	58.43	32.14	90.57	0.10	0.0068
	0.00	0.15	0.19	0.19	0.56	5.80	56.12	37.01	93.13	0.07	0.0065

Table 4 (continued)

Station 2 (continued)											
25 Feb	0.00	0.11	0.16	0.35	0.94	5.11	64.04	28.02	92.06	0.09	0.0073
	0.00	0.07	0.10	0.21	0.60	3.81	58.90	36.32	95.22	0.05	0.0065
	0.00	0.08	0.07	0.08	0.23	2.39	58.15	38.99	97.14	0.03	0.0058
Mean	0.00	0.09	0.12	0.18	0.59	5.59	59.28	33.95	93.24	0.07	0.0067
Station 3											
27 Feb	0.00	0.48	1.07	14.87	42.32	27.68	10.18	3.39	13.57	6.37	0.135
	0.00	0.17	1.20	14.19	39.41	28.08	12.40	4.55	16.95	4.90	0.123
	0.00	0.35	1.16	14.11	38.45	29.15	11.42	5.36	16.78	4.96	0.123
	0.00	0.00	0.77	14.66	39.79	27.84	11.29	5.64	16.93	4.91	0.122
Mean	0.00	0.25	1.05	14.46	39.99	28.19	11.32	4.74	16.06	5.28	0.126
18 Nov	0.34	0.61	3.30	17.56	53.58	12.06			12.55	7.03	
	0.74	0.43	3.80	18.78	55.87	10.62			9.75	9.26	
	0.44	0.39	3.47	19.19	56.28	10.94			9.28	9.78	
	0.04	0.35	3.58	19.88	53.81	10.50			11.83	7.45	
	0.62	0.53	3.79	20.75	54.27	9.93			10.11	8.85	
	0.19	0.84	4.41	19.88	55.35	10.46			8.88	10.89	
	0.00	0.66	3.74	19.19	55.80	10.76			9.85	9.15	

Table 4 (continued)

Station 3 (continued)											
18 Nov	0.77	0.44	3.24	18.84	56.55	10.02			10.14	8.86	
	0.00	0.24	4.32	23.89	52.74	9.21			9.58	9.44	
Mean	0.35	0.50	3.74	19.77	54.92	10.50			10.22	8.97	
Station 4											
9 Jan	0.10	0.13	1.49	12.21	24.09	37.09	21.25	3.64	24.89	3.02	0.115
	1.95	0.05	0.38	3.65	25.84	42.86	21.69	3.57	25.26	2.96	0.090
	0.01	0.06	0.22	3.27	37.53	40.92	15.90	2.10	18.00	4.56	0.105
	0.45	0.08	0.43	5.17	43.86	30.26	17.82	1.93	19.75	4.06	0.108
	0.00	0.25	0.26	2.25	45.33	30.18	18.34	3.41	21.75	3.60	0.100
	0.02	0.11	0.49	4.19	38.70	35.84	17.64	3.02	20.66	3.84	0.108
Mean	0.42	0.11	0.55	5.12	35.89	36.19	18.77	2.95	21.72	3.67	0.104
18 Nov	0.03	0.04	0.50	14.93	39.11	40.20			5.18	18.30	
	0.03	0.03	0.37	12.93	70.28	10.97			5.40	17.53	
	0.00	0.04	0.43	12.92	67.97	12.07			6.34	14.74	
	0.00	0.00	0.44	13.11	67.94	12.19			6.32	17.53	
	0.00	0.00	0.34	14.64	71.96	9.99			3.07	31.58	
	4.02	0.18	0.92	11.63	62.22	12.36			8.66	10.55	

Table 4 (continued)

Station 4 (continued)											
18 Nov	1.06	0.07	0.50	13.93	66.30	11.38			6.75	13.82	
	0.06	0.03	0.39	13.60	67.36	12.12			6.45	14.50	
Mean	0.65	0.05	0.49	13.46	64.14	15.16			6.02	17.32	
Station 5											
12 Feb	3.07	3.76	32.81	40.98	9.61	1.20	4.68	3.38	8.56	10.68	0.400
	1.65	2.46	25.62	44.20	11.11	1.11	7.75	6.12	13.87	6.21	0.300
	16.13	7.05	14.28	42.35	11.21	0.94	3.93	3.51	7.44	12.44	0.660
Mean	7.15	4.42	24.24	42.51	10.64	1.08	5.45	4.50	9.96	9.78	0.433
Station 6											
2 May	2.24	6.48	16.25	32.11	18.03	4.45	14.26	6.18	20.44	3.89	0.184
	12.79	5.35	8.81	21.73	14.41	4.61	26.73	5.56	32.29	2.10	0.260
Mean	7.52	5.92	12.53	26.92	16.22	4.53	20.50	5.87	26.32	3.00	0.222
7 Nov	9.33	3.79	13.15	31.57	25.12	3.10			13.95	6.15	
	6.59	4.98	14.81	28.62	20.17	3.65			21.19	3.72	
	22.16	4.00	13.52	26.07	17.15	2.74			14.36	5.95	
	8.36	3.79	13.24	29.66	20.65	3.73			20.56	3.86	
	30.63	11.50	0.49	23.19	15.45	2.63			16.10	5.21	

Table 4 (continued)

Station 6 (continued)											
7 Nov	18.68	4.95	11.94	26.62	21.88	3.00			13.44	6.44	
	6.73	6.46	17.84	29.56	18.42	3.19			17.83	5.06	
	11.43	4.25	16.08	35.21	21.18	1.68			10.17	8.84	
Mean	14.24	5.47	12.63	28.81	20.00	2.97			15.95	5.65	
Station 7											
13 Feb	0.33	0.15	0.49	1.01	2.09	14.99	57.82	23.13	80.95	0.24	0.100
	0.08	0.19	0.31	1.10	1.66	7.93	59.57	29.15	88.72	0.13	0.0072
	0.12	0.23	0.09	0.43	2.26	8.34	60.60	27.93	88.53	0.13	0.0085
Mean	0.18	0.19	0.30	0.85	2.00	10.42	59.33	26.73	86.07	0.17	0.0085
Station 8											
13 Feb	2.60	4.11	15.66	47.93	23.57	1.42	2.67	2.05	4.72	20.20	0.330
	19.88	13.15	12.32	25.20	14.46	4.16	7.14	3.70	10.84	8.22	0.570
	0.17	2.51	15.15	50.63	22.32	2.59	4.16	2.46	6.62	14.10	0.300
	17.27	9.82	9.47	27.25	17.77	3.18	9.59	5.65	15.24	5.56	0.400
3 May	4.84	4.09	13.48	39.59	28.03	2.00	5.97	1.99	7.96	11.56	0.320
	10.95	11.83	10.93	26.47	20.57	3.23	11.40	4.62	16.02	5.24	0.320

Table 4 (continued)

Station 8 (continued)											
3 May	12.00	10.15	11.62	28.44	19.29	3.69	10.21	4.61	14.82	5.75	0.350
Mean	9.67	7.95	12.66	35.07	20.86	2.90	7.31	3.58	10.89	10.09	0.370
7 Nov	3.96	2.44	7.68	44.65	33.74	4.54			3.00	32.38	
	7.24	4.62	8.03	41.15	32.64	2.47			3.85	24.98	
	8.96	3.30	8.07	40.56	34.08	2.01			3.02	32.13	
	8.89	3.97	7.52	38.54	32.97	2.33			5.78	16.31	
	14.09	5.15	6.58	33.70	32.11	2.49			5.88	16.02	
	6.72	3.07	6.27	39.56	35.44	4.22			4.72	20.20	
	3.24	2.45	7.04	43.65	37.53	2.31			3.78	24.47	
	3.62	1.69	8.14	47.67	34.88	1.54			2.46	36.03	
Mean	7.09	3.34	7.42	41.19	34.15	2.74			4.06	25.44	

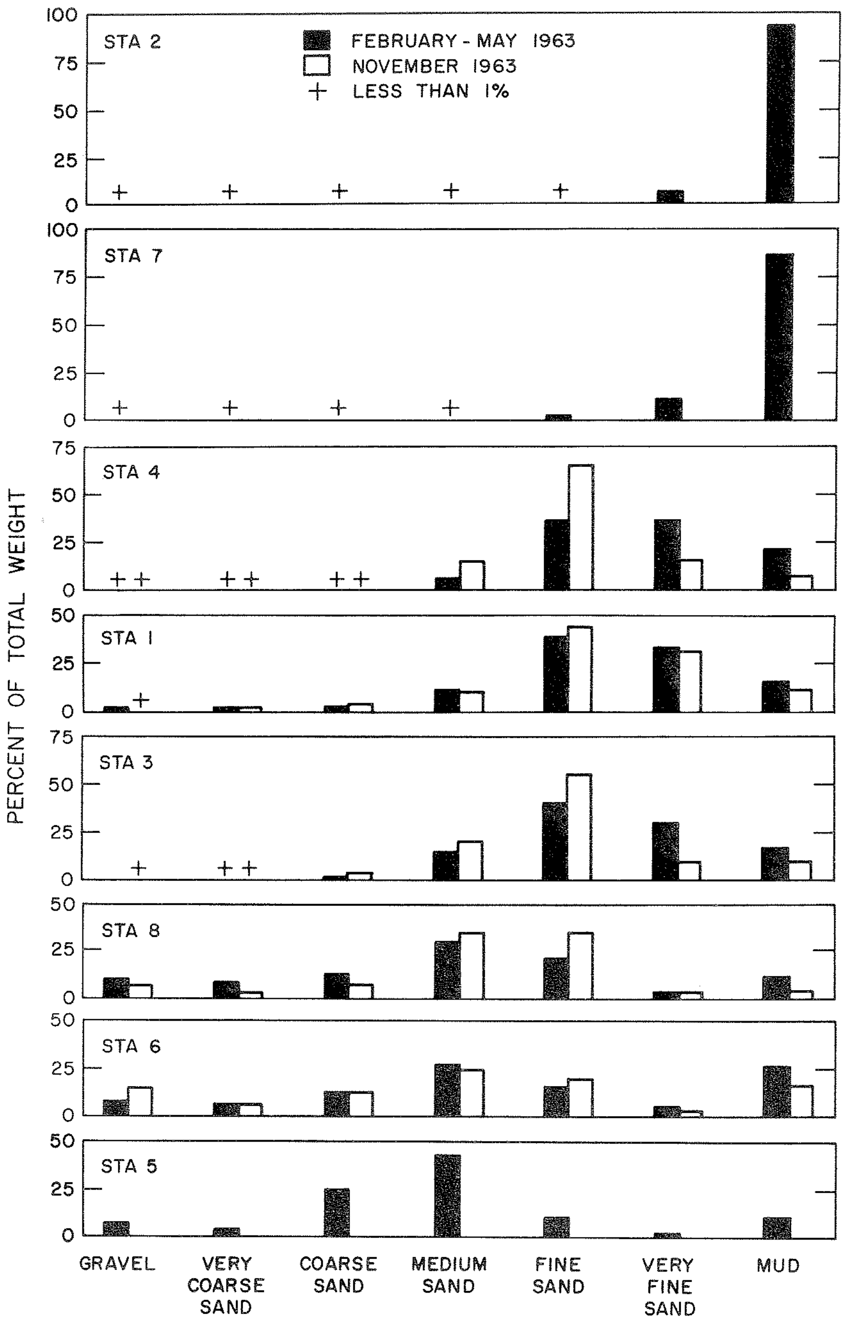

Figure 9. Distribution of grain-size fractions at the stations in February-May and November 1963.

C. Composition of the faunal assemblages

1. Station 1 (Tables 5 and 6)

The fauna at this station was dominated by the two ostracods Euphilomedes carcharodonta and E. producta; the tanaid Leptochelia dubia; the polychaetes Lumbrineris californiensis, Platynereis bicanaliculata, Prionspio malmgreni, and Glycera capitata; and the lamellibranchs Mysella tumida and Axinopsida sericata. Table 6 shows that although there were considerable fluctuations in the abundances of the numerically dominant species during the period of investigation, their relative abundances as indicated by the rankings remained fairly constant.

The polychaetes Lumbrineris californiensis and Diopatra ornata, the ostracod Euphilomedes carcharodonta, and the sipunculid Golfingia pugettensis were the most important contributors to the standing crop but the fauna was characterized by an extremely low dominance in weight by any particular species.

2. Station 2 (Tables 7 and 8)

The dominant species at this station were the lamellibranchs Macoma carlottensis, Axinopsida sericata, and Nucula bellotii; the polychaetes Glycera capitata, Pectinaria californiensis, Pholoë minuta, Lumbrineris luti, Nephtys ferruginea, and Malmgrenia lunulata; the ostracod Euphilomedes producta; the cumacean Eudorella pacifica; and the echinoid Brisaster townsendi. The polychaete Travisia pupa, the holothurian Molpadia intermedia, the euchiuroid Nellobia eusoma, and an unidentified nemertea were conspicuous and frequently occurring members of the community although their numbers were rather low.

The fauna at station 2 revealed considerable fluctuation in abundance of numerically dominant species. This was particularly well demonstrated for Macoma carlottensis, which was reduced from 1119 to 32 individuals per square metre between February and August 1963. Similar reductions in numbers during the same period occurred also for Euphilomedes producta, Axinopsida sericata, Glycera capitata, Pholoë minuta, and Pectinaria californiensis. However, the numerically dominant species retained their relative abundances as demonstrated by their rankings (Table 8) in spite of the reduction of numbers.

The standing crop at station 2 was completely dominated by the echinoid Brisaster townsendi and the polychaetes Travisia pupa and Glycera capitata.

Table 5

Abundance of Polychaeta at station 1,
27 February (A) and 30 April (B) 1963

Species	A ($0.5 m^2$)	B ($0.3 m^2$)	Species	A ($0.5 m^2$)	B ($0.3 m^2$)
Gattyana cirrosa	1	0	Diopatra ornata	19	19
Harmothoë imbricata	0	1	Nothria sp.	7	14
Malmgrenia lunulata	0	1	Lumbrineris californiensis	69	70
Polynoida sp. I	1	0	Lumbrineris cruzensis	32	0
Pholoë minuta	5	1	Lumbrineris luti	5	2
Eteone sp. I	1	2	Lumbrineris sp. II	2	0
Eulalia bilineata	0	1	Lumbrineris sp.	1	0
Eulalia sanguinea	1	3	Notocirrus californiensis	5	1
Phyllodoce groenlandica	1	0	Haploscoloplos pugettensis	2	7
Phyllodoce williamsi	1	0	Aricidea lopezi	0	0
Phyllodoce (Anaitides) sp.	1	0	Aricidea sp.	1	0
Phyllodoce polynoides	1	0	Laonice cirrata	2	4
Phyllodoce sp.	1	0	Laonice sp. I	0	1
Phyllodocinae sp.	1	1	Paraspio sp. I	1	2
Micropodarke dubia	0	1	Polydora natrix	0	1
Ophiodromus pugettensis	1	1	Polydora caeca	0	1
Hesionidae indet.	5	0	Prionospio cirrifera	9	3
Exogone gemmifera	0	2	Prionospio malmgreni	40	29
Exogone lourei	1	3	Prionospio sp.	2	0
Pionosyllis sp.	1	0	Spionidae indet.	1	0
Syllis heterochaeta	0	1	Magelona sp.	0	1
Syllis harti	1	0	Phyllochaetopterus prolifica	1	2
Syllis sp.	0	1	Telepsavus costarum	1	0
Platynereis bicanaliculata	66	24	Caulleriella alata	4	2
Neptys caeca	1	0	Chaetozone setosa	6	16
Nephtys ferruginea	18	11	Tharyx multifilis	4	0
Glycera americana	1	2	Ammotrypane aulogaster	1	0
Glycera capitata	28	22	Armandia brevis	47	11
Glycinde picta	0	6	Capitellidae indet.	16	7
Glycinde sp. I	10	0	Axiothella rubrocincta	1	0
Goniada maculata	12	5	Clymenura columbiana	2	0

Table 5 (continued)

Species	A (0.5 m^2)	B (0.3 m^2)	Species	A (0.5 m^2)	B (0.3 m^2)
Euclymene zonalis	3	3	Ampharete gagarae	0	1
Praxillella gracilis	0	1	Melinna elisabethae	0	1
Maldanidae indet.	2	1	Amphitritinae sp. I	1	1
Owenia fusiformis	0	3	Terebellidae indet.	1	0
Sabellaria cementarium	0	1	Chone sp. I	0	1
Pectinaria granulata	5	7			

Table 6

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 1

	1963								1964					
	27 Feb		30 Apr		2 Aug		27 Nov		18 Feb		3 Apr		7 Aug	
	1.0 m^2		0.3 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	1367	1	446	1	543	1	1920	1	432	1	339	1	1146	1
Euphilomedes producta	20	8	35	3	295	2	144	3	18	6	106	2	637	2
Rutiderma rostrata	4	21	3	16	1	35	1	39	0		7	13	2	34
Cylindroleberis mariae	19	9	19	6	27	4	39	8	7	10	39	4	39	6
Leptostraca														
Epinebalia pugettensis	3	22	1	23	3	24	2	32	0		0		0	
Cumacea														
Diastylis pellucida	0		1	23	0		0		0		1	38	2	34
Diastylis alaskensis	1	33	1	23	8	14	24	12	2	21	0		3	29
Leptostylis villosa	0		0		0		0		0		2	31	2	34
Eudorella pacifica	0		0		0		1	39	1	25	0		2	34
Eudorellopsis biplicata	1	33	0		0		0		0		0		0	
Campylaspis canaliculata	2	24	0		1	35	1	39	0		2	31	2	34
Campylaspis (papillata) ?	1	33	0		1	35	0		0		3	25	4	28
Campylaspis sp. I	0		0		5	17	0		1	25	6	15	1	46
Isopoda														
Haliophasma geminata	2	24	0		0		2	32	1	25	3	25	0	
Limnoria lignorum	1	33	0		0		1	39	0		0		0	
Rocinela belliceps	0		0		0		0		0		1	38	0	

Table 6 (continued)

Species	1963								1964					
	27 Feb		30 Apr		2 Aug		27 Nov		18 Feb		3 Apr		7 Aug	
	$1.0\ m^2$		$0.3\ m^2$		$0.9\ m^2$		$1.0\ m^2$		$0.5\ m^2$		$0.5\ m^2$		$0.5\ m^2$	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Tanaidacea														
Leptochelia dubia	156	2	21	5	10	11	1103	2	116	2	65	3	120	3
Amphipoda														
Anonyx carinatus	0		1	23	0		0		0		0		0	
Aruga holmesi	0		0		0		1	39	0		3	25	0	
Hippomedon denticulatus	19	9	3	16	4	20	4	28	9	9	16	8	12	17
Orchomene decipiens	11	15	0		1	35	0		5	14	0		5	26
Pachynus barnardi	2	24	0		0		0		0		0		0	
Ampelisca compressa	0		0		0		0		0		0		2	34
Ampelisca cristata	1	33	0		0		0		0		0		0	
Ampelisca lobata	0		0		0		2	32	0		0		1	46
Ampelisca macrocephala	0		0		0		1	39	0		6	15	7	20
Byblis veleronis	14	12	3	16	24	6	91	4	23	3	18	7	35	7
Heterophoxus oculatus	6	18	5	12	7	15	40	7	5	14	23	6	20	10
Metaphoxus fultoni	7	16	0		5	17	39	8	2	21	9	12	52	4
Paraphoxus daboius	0		1	23	0		0		0		0		0	
Paraphoxus similis	0		0		2	29	0		0		0		0	
Paraphoxus variatus	5	19	0		1	35	0		6	13	0		0	
Stenothoidae indet.	0		2	21	0		0		0		0		0	
Monoculodes zernovi	2	24	0		0		6	24	0		2	31	1	46
Synchelidium rectipalmum	0		3	16	3	24	0		10	8	0		0	

Table 6 (continued)

	1963								1964					
	27 Feb		30 Apr		2 Aug		27 Nov		18 Feb		3 Apr		7 Aug	
	1.0 m^2		0.3 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Synchelidium shoemakeri	12	13	0		0		14	17	0		2	31	14	15
Westwoodilla caecula	5	19	3	16	35	3	27	11	1	25	4	21	16	12
Tiron biocellata	0		0		0		1	39	0		0		0	
Melphisana sp.	0		0		0		0		0		1	38	0	
Melita desdichada	17	11	4	14	17	8	8	20	5	14	1	38	1	46
Melita oregonensis	1	33	0		0		0		0		0		0	
Eurystheus thompsoni	1	33	0		0		2	32	0		0		0	
Photis brevipes	0		0		0		2	32	0		0		0	
Protomedeia sp.	0		0		0		1	39	0		0		0	
Corophium crassicorne	0		0		0		1	39	0		0		0	
Caprella sp.	1	33	1	23	2	29	0		0		0		0	
Natantia														
Decapoda natantia, juv.	2	24	5	12	12	9	22	13	1	25	3	25	3	29
Anomura														
Paguristes turgidus	0		0		0		0		0		1	38	0	
Pagurus sp., juv.	0		0		2	29	0		0		0		6	25
Brachyura														
Pinnixa schmitti	1	33	0		21	7	6	24	3	20	5	17	16	12
Lophopanopeus bellus	1	33	0		0		9	19	0		0		0	
Lophopanopeus diegenes	0		0		0		0		0		1	38	1	46

Table 6 (continued)

Species	1963								1964					
	27 Feb		30 Apr		2 Aug		27 Nov		18 Feb		3 Apr		7 Aug	
	1.0 m^2		0.3 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Brachyura (continued)														
Cancer sp., juv.	0		0		10	11	2	32	0		1	38	1	46
Oregonia gracilis	0		0		0		1	39	0		0		0	
Brachyura, megalopa	0		0		2	29	0		0		0		0	
PYGNOGONIDA														
Nymphon pixellae	0		0		0		1	39	0		0		0	
LAMELLIBRANCHIA														
Lucinoma annulatus	1	33	2	21	1	35	0		0		0		2	34
Parvalucina tenuisculptus	1	33	1	23	0		7	22	2	21	2	31	2	34
Axinopsida sericata	37	6	14	8	11	10	16	15	16	7	7	13	16	12
Clinocardium nuttalli	0		0		0		1	39	0		0		2	34
Nemocardium centifilosum	1	33	0		3	24	1	39	0		5	17	34	8
Compsomyax subdiaphana	1	33	0		0		0		0		0		1	46
Psephidia lordi	12	13	47	2	6	16	15	16	19	4	0		3	29
Macoma alaskana	0		1	23	0		1	39	0		1	38	7	20
Macoma calcarea	3	22	1	23	4	20	11	18	4	18	2	31	20	10
Macoma carlottensis	0		1	23	2	29	5	26	2	21	3	25	2	34
Macoma inconspicua	2	24	0		0		0		1	25	0		0	
Macoma yoldiformis	0		1	23	0		0		0		0		0	
Macoma spp., juv.	30	7	19	6	4	20	41	6	7	10	33	5	13	16

Table 6 (continued)

Species	1963								1964					
	27 Feb		30 Apr		2 Aug		27 Nov		18 Feb		3 Apr		7 Aug	
	1.0 m^2		0.3 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCIA (continued)														
Tellina buttoni	84	3	14	8	10	11	22	13	7	10	4	21	3	29
Nucula bellotii	2	24	0		3	24	8	20	4	18	4	21	7	20
Nuculana minuta	0		0		0		0		0		0		1	46
Yoldia seminuda	0		0		0		0		0		1	38	0	
Crenella columbiana	7	16	13	10	2	29	31	10	5	14	12	11	52	4
Musculus substriatus	0		0		1	35	0		0		3	25	2	34
Chlamys hericius	0		0		0		0		0		1	38	0	
Mysella tumida	82	5	23	4	25	5	43	5	19	4	0		5	26
Panomya arctica	0		0		0		0		0		1	38	7	20
Pandora filosa	1	33	0		0		1	39	1	25	0		1	46
Lyonsia pugetensis	0		0		0		3	29	0		0		32	9
Lamellibranchia indet.	83	4	9	11	4	20	2	32	1	25	14	9	1	46
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	0		0		1	35	3	29	0		5	17	0	
Amphipholis squamata	2	24	4	14	0		5	26	0		0		7	20
Ophiura lütkeni	2	24	1	23	0		7	22	0		2	31	3	29
Holothuroidea														
Chiridota laevis	0		0		0		0		0		5	17	2	34
Leptosynapta clarki	0		1	23	5	17	1	39	0		14	9	8	18
Pentamera spp.	0		0		3	24	3	29	1	25	4	21	8	18

Table 7

Abundance of Polychaeta at station 2, 25 February (A), 21 May (B), 1 August (C), and 27 November (D) 1963

Species	A (1.0 m^2)	B (1.0 m^2)	C (1.0 m^2)	D (1.0 m^2)
Antinoëlla macrolepida	0	2	5	1
Eunoë sp. I	1	2	0	2
Gattyana treadwelli	2	2	3	4
Gattyana sp.	0	1	0	0
Hesperonoë complanata	0	9	4	5
Malmgrenia lunulata	30	40	38	38
Pholoë minuta	37	8	1	2
Eteone sp. I	1	0	1	0
Eulalia levicornuta	0	0	0	2
Eulalia sp. I	0	1	1	1
Phyllodoce groenlandica	3	0	0	1
Phyllodoce multiseriata	0	0	1	0
Gyptis brevipalpa	1	0	2	0
Nephtys assignis	1	0	0	0
Nepthys cornuta	0	0	0	3
Nepthys ferruginea	33	27	14	12
Nepthys punctata	0	0	0	1
Glycera capitata	60	36	18	48
Glycera robusta	0	1	0	0
Glycera siphonostoma	0	5	0	0
Glycera sp.	1	0	0	0
Glycinde armigera	12	1	2	5
Goniada brunnea	7	4	2	4
Nothria sp.	17	13	8	14
Lumbrineris bicirrata	0	1	0	0
Lumbrineris cruzensis	0	0	1	0
Lumbrineris luti	34	22	25	37
Ninoe gemmea	2	4	2	1
Aricidea lopezi	2	0	0	1

Table 7 (continued)

Species	A (1.0 m^2)	B (1.0 m^2)	C (1.0 m^2)	D (1.0 m^2)
Paraonis ivanovi	22	4	0	15
Laonice cirrata	4	4	9	9
Laonice sp. I	1	0	0	0
Polydora caulleri	0	2	0	7
Prionospio cirrifera	4	4	1	13
Prionospio malmgreni	2	0	0	1
Prionospio sp.	1	0	0	0
Spiophanes berkeleyorum	0	0	1	0
Trochochaeta multisetosa	1	0	0	0
Spionidae indet.	2	0	0	1
Magelona sp.	0	0	1	0
Chaetozone setosa	13	5	1	6
Brada sachalina	1	4	5	2
Travisia pupa	4	2	3	1
Sternaspis fossor	0	1	2	0
Capitellidae indet.	26	52	19	21
Maldane glebifex	9	1	0	0
Praxillella affinis	1	6	1	0
Praxillella sp.	2	0	0	0
Macroclymene sp. I	0	0	10	29
Euclymeninae sp.	0	0	4	0
Pectinaria californiensis	39	33	10	94
Ampharete acutifrons	12	6	15	11
Ampharete gagarea	1	0	0	0
Neoamphitrite edwardsi	0	0	1	0
Pista cristata	0	0	0	1
Pista fasciata	1	1	1	1
Pista moorei	0	0	0	2
Terebellides stroemi	0	2	2	1
Terebellidae indet.	1	1	0	0
Polychaeta indet.	1	0	0	0

Table 8

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 2

	1963								1964					
	25 Feb		21 May		1 Aug		27 Nov		18 Feb		3 Apr		2 Aug	
Species	1.0 m^2		1.0 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	1	29	0		0		2	22	2	9	1	17	1	15
Euphilomedes producta	341	2	52	4	1	20	44	2	20	3	28	2	11	5
Cylindroleberis mariae	4	19	3	15	0		0		1	11	2	12	2	12
Cumacea														
Diastylis pellucida	1	29	2	23	1	20	0		0		1	17	0	
Diastylis alaskensis	0		0		0		0		0		0		1	15
Leptostylis villosa	2	23	0		0		0		0		0		0	
Eudorella pacifica	32	4	28	6	50	2	23	5	0		5	8	18	3
Eudorellopsis sp. I	13	8	5	10	9	10	4	16	1	11	5	8	1	15
Leucon sp. I	14	7	3	15	16	6	10	9	0		4	10	8	6
Isopoda														
Haliophasma geminata	1	29	0		1	20	0		1	11	1	17	5	10
Rocinela belliceps	1	29	1	26	0		1	28	0		0		0	
Amphipoda														
Anonyx carinatus	6	15	3	15	2	17	4	16	0		0		0	
Cyphocaris challengeri	0		0		0		0		1	11	0		0	
Orchomene pacifica	4	19	0		0		1	28	0		1	17	0	
Orchomene sp. I	0		1	26	1	20	0		0		0		0	
Ampelisca compressa	0		0		2	17	0		0		0		0	
Ampelisca macrocephala	8	12	3	15	7	11	2	22	3	6	2	12	1	15

Table 8 (continued)

Species	1963								1964					
	25 Feb 1.0 m^2		21 May 1.0 m^2		1 Aug 1.0 m^2		27 Nov 1.0 m^2		18 Feb 0.5 m^2		3 Apr 0.5 m^2		2 Aug 0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Byblis veleronis	0		0		0		1	29	0		0		0	
Heterophoxus oculatus	8	12	16	7	27	4	27	4	8	5	16	5	8	6
Paraphoxus oculatus	10	9	9	8	5	14	14	6	36	1	0		0	
Stenothoidae indet.	1	29	0		0		0		0		0		0	
Bathymedon sp.	0		0		7	11	7	13	0		0		8	6
Westwoodilla caecula	2	23	2	23	0		1	28	1	11	2	12	0	
Bruzelia tuberculata	8	12	4	14	7	11	10	9	0		2	12	3	11
Eusirus sp.	0		1	26	2	17	1	28	1	11	1	17	0	
Melita dentata	0		0		0		0		0		0		1	15
Melita desdichada	3	22	3	15	14	7	8	11	1	11	1	17	2	12
Eurystheus thompsoni	0		0		0		0		0		0		1	15
Dulichia sp.	10	9	1	26	1	20	0		0		4	10	0	
Natantia														
Decapoda natantia, juv.	0		0		0		2	22	0		0		0	
Anomura														
Axiopsis spinulicauda	0		0		1	20	3	20	3	6	0		0	
Callianassa sp., juv.	0		1	26	0		0		0		0		0	
Brachyura														
Pinnixa barnharti	6	15	5	10	22	5	3	20	1	11	0		2	12

Table 8 (continued)

Species	1963								1964					
	25 Feb		21 May		1 Aug		27 Nov		18 Feb		3 Apr		2 Aug	
	1.0 m^2		1.0 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA														
Lucinoma annulatus	3	22	8	9	1	20	1	28	0		1	17	1	15
Parvalucina tenuisculptus	2	22	0		0		2	22	1	11	0		0	
Adontorhina cyclia	5	18	0		0		4	16	3	6	7	7	6	9
Axinopsida sericata	57	3	104	2	12	8	13	7	2	9	21	4	16	4
Nemocardium centifilosum	4	19	3	15	0		2	22	0		0		0	
Macoma calcarea	1	29	0		0		0		0		0		0	
Macoma carlottensis	1119	1	651	1	32	3	259	1	27	2	57	1	43	1
Macoma inconspicua	2	23	0		0		1	28	0		0		0	
Acila castrensis	0		3	15	1	20	2	22	0		0		0	
Nucula bellotii	27	6	55	3	3	15	12	8	0		1	17	0	
Yoldia ensifera	0		0		1	20	0		0		0		0	
Yoldia scissurata	2	23	0		1	20	0		0		0		0	
Yoldia thraciaeformis	3	22	2	23	1	20	1	28	1	11	1	17	1	15
Clinocardium nuttalli	0		1	26	0		0		0		0		0	
Mysella tumida	1	29	0		0		0		0		0		0	
Pandora filosa	9	11	5	10	3	15	4	16	1	11	2	12	1	15
Lamellibranchia indet.	0		0		0		7	13	0		0		0	

Table 8 (continued)

Species	25 Feb 1.0 m^2		21 May 1.0 m^2		1 Aug 1.0 m^2		27 Nov 1.0 m^2		18 Feb 0.5 m^2		3 Apr 0.5 m^2		2 Aug 0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	6	15	3	15	0		0		1	11	8	6	0	
Amphipholis squamata	0		0		0		5	15	0		0		0	
Echinoidea														
Brisaster townsendi	30	5	50	5	63	1	43	3	16	4	27	3	27	2
Holothuroidea														
Molpadia intermedia	2	23	5	10	11	9	8	11	1	11	0		1	15
Pentamera sp.	0		0		0		1	28	0		0		0	

3. Station 3 (Tables 9 and 10)

The faunal assemblage at station 3 was dominated by the amphipod Byblis veleronis; the ostracods Euphilomedes carcharodonta and E. producta; the polychaetes Prionospio pinnata, Travisia brevis, and Trichobranchus glacialis; and the lamellibranchs Crenella columbiana, Axinopsida sericata, and Psephidia lordi.

There are indications from the faunal composition that the data from April 1963 differ considerably from those of the other sampling dates, possibly resulting from navigational errors. The results from April 1963 at station 3 must therefore be considered with some caution. However, the relative abundance of the numerically dominant species varied considerably throughout the period of investigation (Table 10).

The most important contributors to the standing crop were the polychaetes Travisia brevis and Laonice cirrata, and the lamellibranch Macoma calcarea, but the community was characterized by a low degree of dominance in weight.

4. Station 4 (Tables 11 and 12)

The fauna at station 4 was dominated by the lamellibranchs Axinopsida sericata, Nucula bellotii, and Mysella tumida; the polychaetes Nephtys ferruginea, Platynereis bicanaliculata, and Prionospio malmgreni; the ostracod Euphilomedes carcharodonta; the amphipod Paraphoxus variatus; and the brachyuran Pinnixa schmitti.

In November 1964 there was a distinct change in the sediment type at station 4 (see page 263), which resulted in a significant reduction in the number of species (see page 332). Simultaneously there was a reduction in the abundances of the numerically dominant species, particularly soft-bottom species such as Eudorella pacifica, Euphilomedes producta, and Macoma carlottensis. However, the numerically dominant species retained their relative abundances as indicated by their ranking throughout the period of investigation (Table 12).

The polychaetes Nephtys ferruginea, Diopatra ornata, Haploscoloplos pugettensis, and Platynereis bicanaliculata; the brachyuran Pinnixa schmitti; the lamellibranch Nucula bellotii; and the ophiurid Amphiodia urtica were the most important contributors to the standing crop, but there was not a high degree of dominance in weight by any of the species.

Table 9

Abundance of Polychaeta at station 3, 27 February (A) and 29 April (B) 1963

Species	A (0.5 m²)	B (0.5 m²)	Species	A (0.5 m²)	B (0.5 m²)
Gattyana cirrosa	0	1	Goniada maculata	2	3
Harmothoë imbricata	1	1	Diopatra ornata	1	0
Lagisca multisetosa	0	1	Nothria sp.	10	1
Lepidonotus squamatus	0	1	Lumbrineris bicirrata	3	3
Malmgrenia lunulata	3	3	Lumbrineris californiensis	11	2
Polynoidae sp. I	1	0	Lumbrineris cruzensis	1	1
Peisidice aspera	1	8	Lumbrineris limicola	19	0
Pholoë minuta	1	1	Lumbrineris luti	0	1
Eteone sp. I	2	1	Lumbrineris sp.	0	3
Eulalia bilineata	1	2	Notocirrus californiensis	3	1
Eulalia sanguinea	0	3	Dorvillea pseudorubrovittata	1	0
Phyllodoce castanea	1	1	Stauronereis sp.	1	1
Phyllodoce polynoides	3	0	Haploscoloplos pugettensis	6	2
Phyllodoce sp.	2	0	Phylo felix	1	0
Phyllodocinae sp. I	1	0	Aricidea lopezi	6	4
Phyllodocinae sp. II	1	0	Paraonis ivanovi	3	0
Phyllodocinae indet.	0	1	Laonice cirrata	16	1
Ophiodromus pugettensis	1	0	Laonice sp. I	0	4
Pilargis berkeleyae	2	1	Paraspio sp. I	8	3
Odontosyllis phosphorea	5	5	Polydora caeca	1	1
Syllis heterochaeta	3	0	Prionospio malmgreni	10	10
Syllis sp. I	0	3	Prionospio pinnata	34	0
Syllis harti	9	0	Spiophanes berkeleyorum	4	1
Nereis sp. II	0	1	Magelona sp.	63	4
Nereis sp. III	0	1	Mesochaetopterus taylori	0	1
Platynereis bicanaliculata	3	1	Phyllochaetopterus prolifica	2	5
Nephtys caeca	0	1	Telepsavus costarum	1	3
Nephtys ferruginea	67	17	Caulleriella alata	1	1
Glycera americana	1	1	Chaetozone setosa	6	9
Glycera capitata	18	3	Chaetozone sp. I	0	4
Glycinde armigera	5	4	Tharyx sp. I	12	2
Glycinde sp. II	0	1	Tharyx secundus sp. II	5	0

Table 9 (continued)

Species	A $(0.5 m^2)$	B $(0.5 m^2)$	Species	A $(0.5 m^2)$	B $(0.5 m^2)$
Tharyx sp.	11	2	Melinna elisabethae	2	0
Flabelligera sp. I	1	0	Asabellides littoralis	0	1
Ammotrypane aulogaster	1	0	Schistocomus hiltoni	1	0
Travisia brevis	25	0	Artacama conifera	1	0
Sternaspis fossor	2	0	Lanassa venusta	1	0
Capitellidae indet.	86	4	Neoamphitrite robusta	0	2
Axiothella rubrocincta	0	1	Pista cristata	0	3
Clymenura columbiana	4	1	Pista sp. I	0	1
Euclymene zonalis	5	0	Pista sp.	1	0
Isocirrus longiceps	10	0	Polycirrus sp. I	0	1
Nichomache lumbricalis	0	2	Polycirrus sp.	2	4
Petaloproctus tenuis	0	1	Proclea graffi	2	0
Rhodine bitorquata	2	0	Terebellides stroemi	2	0
Maldanidae indet.	0	1	Trichobranchus glacialis	21	0
Owenia fusiformis	0	1	Terebellidae indet.	3	7
Idanthyrus armatus	0	1	Laonome kröyeri	0	1
Sabellaria cementarium	0	1	Potamilla oculata	0	1
Pectinaria granulata	6	2	Potamilla reniformis	0	1
Pectinaria californiensis	1	0	Sabella media	0	5
Ampharete arctica	1	0	Sabellidae indet.	0	1
Ampharete gagerea	4	4	Polychaeta indet.	0	3

Table 10

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 3

Species	1963								1964					
	27 Feb		29 Apr		1 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	24	10	50	3	383	1	194	2	8	11	20	3	87	2
Euphilomedes producta	278	1	0		277	2	245	1	28	3	18	4	105	1
Rutiderma rostrata	0		0		1	50	1	45	2	26	1	27	2	43
Cylindroleberis mariae	1	40	0		0		0		0		0		0	
Leptostraca														
Epinebalia pugettensis	1	40	2	47	3	38	0		0		0		7	24
Cumacea														
Diastylis alaskensis	6	24	0		14	22	4	25	0		1	27	11	16
Diastylopsis dawsoni	1	40	0		0		0		0		0		0	
Leptostylis villosa	4	29	0		0		0		0		0		0	
Eudorella pacifica	18	12	1	55	3	38	6	21	0		0		6	27
Eudorellopsis biplicata	0		0		1	50	1	45	0		0		2	43
Campylaspis canaliculata	0		0		1	50	0		0		0		0	
Campylaspis (papillata) ?	0		0		0		0		1	36	1	27	1	50
Campylaspis sp. I	0		0		0		0		0		0		1	50
Isopoda														
Haliophasma geminata	4	29	0		4	35	3	36	3	21	4	14	5	31

Table 10 (continued)

Species	1963								1964					
	27 Feb		29 Apr		1 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Tanaidacea														
Leptochelia dubia	0		4	33	0		4	25	0		1	27	3	36
Leptognathia longiremis	0		0		0		4	25	1	36	0		9	18
Amphipoda														
Anonyx carinatus	0		0		4	35	0		0		0		0	
Anonyx sp. I	0		1	55	0		0		0		0		0	
Aruga holmesi	0		2	47	1	50	0		0		0		0	
Hippomedon denticulatus	10	16	16	19	5	32	17	10	2	26	2	22	6	27
Opisa tridentata	2	36	1	55	0		1	45	0		1	27	1	50
Orchomene decipiens	0		0		0		1	45	2	26	0		0	
Prachynella lodo	1	40	0		0		1	45	0		0		0	
Ampelisca compressa	0		35	6	3	38	2	39	0		1	27	0	
Ampelisca cristata	0		18	10	0		0		0		0		0	
Ampelisca lobata	2	36	6	29	21	17	4	25	7	12	0		39	8
Ampelisca macrocephala	14	13	0		14	22	9	15	2	26	4	14	24	10
Byblis veleronis	88	2	73	1	58	5	55	3	58	1	32	1	71	3
Heterophoxus oculatus	8	21	50	3	14	22	5	22	7	12	8	9	22	11
Metaphoxus fultoni	6	24	0		0		2	39	0		0		0	
Paraphoxus daboius	0		0		0		0		0		0		3	36
Paraphoxus robustus	0		0		2	46	0		0		0		3	36

Table 10 (continued)

Species	1963								1964					
	27 Feb		29 Apr		1 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Paraphoxus similis	0		0		0		1	45	0		0		0	
Paraphoxus spinosus	0		0		0		1	45	0		0		0	
Paraphoxus variatus	0		14	21	0		4	25	0		10	7	1	50
Monoculodes zernovi	0		0		0		0		0		1	27	0	
Synchelidium rectipalmum	0		3	41	0		0		0		0		0	
Synchelidium shoemakeri	0		0		0		0		0		2	22	0	
Westwoodilla caecula	9	18	7	27	24	15	4	25	0		1	27	6	27
Parapleustes pugettensis	0		4	33	0		0		0		0		0	
Melphisana sp.	0		0		0		2	39	0		0		1	50
Eusirus sp.	1	40	0		0		0		0		1	27	0	
Eurystheus thompsoni	0		2	47	0		0		0		4	14	16	13
Photis brevipes	0		14	21	1	50	0		0		0		0	
Protomedeia sp.	1	40	0		3	38	8	18	0		0		3	36
Ischyrocerus sp.	0		4	33	0		0		0		0		0	
Ericthonius brasiliensis	0		2	47	0		0		0		0		0	
Ericthonius hunteri	0		0		35	11	9	15	3	21	0			6
Dulichia arctica	0		5	30	0		0		0		0		0	
Dulichia tuberculata	0		2	47	0		0		0		0		0	
Caprella sp.	0		0		0		0		0		0		2	43

Table 10 (continued)

Species	1963								1964					
	27 Feb		29 Apr		1 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Natantia														
Decapoda *natantia*, juv.	0		2	47	31	12	17	10	5	16	3	17	46	5
Anomura														
Callianassa sp., juv.	0		0		1	50	2	39	0		1	27	0	
Pagurus sp., juv.	0		1	55	2	46	0		3	21	0		2	43
Petrolisthes eriomerus	0		0		0		1	45	0		0		0	
Brachyura														
Pinnixa schmitti	33	5	4	33	51	6	28	7	7	12	5	13	30	9
Pinnotheres concharum	0		2	47	0		0		2	26	1	27	0	
Lophopanopeus bellus	0		3	41	11	26	2	39	12	9	0		0	
Lophopanopeus diegenes	0		0		0		0		0		0		7	24
Cancer sp., juv.	3	34	2	47	40	9	1	45	0		0		14	14
Hyas lyratus	0		0		0		1	45	1	36	0		8	20
Oregonia gracilis	1	40	7	27	20	18	0		4	17	3	17	1	50
Scyra acutifrons	0		0		0		0		0		1	27	1	50
Brachyura, megalopa	0		0		5	32	0		0		0		0	
LAMELLIBRANCHIA														
Lucinoma annulatus	4	29	4	33	3	38	5	22	3	21	1	27	6	27
Parvalucina tenuisculptus	1	40	0		12	25	4	25	2	26	1	27	2	43
Adontorhina cyclia	9	18	0		17	19	12	13	1	36	8	9	8	20

Table 10 (continued)

Species	1963								1964					
	27 Feb		29 Apr		1 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA (continued)														
Axinopsida sericata	40	4	4	33	66	4	40	5	7	12	16	5	8	20
Thyasira gouldii	1	40	0		1	50	0		0		0		0	
Clinocardium fucanum	0		11	24	0		0		1	36	0		0	
Nemocardium centifilosum	20	11	3	41	23	16	13	12	1	36	0		21	12
Compsomyax subdiaphana	1	40	0		0		0		0		0		0	
Humilaria kennerleya	0		3	41	0		0		0		0		0	
Protothaca tenerrima	1	40	0		0		0		2	26	0		0	
Psephidia lordi	1	40	43	5	140	3	34	6	29	2	30	2	56	4
Macoma alaskana	26	8	71	2	27	13	20	9	18	5	10	7	4	33
Macoma calcarea	27	7	0		42	8	23	8	13	7	2	22	4	33
Macoma carlottensis	31	6	3	41	36	10	9	15	16	6	6	11	2	43
Macoma inconspicua	6	24	20	9	9	27	0		1	36	1	27	1	50
Macoma irus	0		0		1	50	0		0		0		0	
Macoma yoldiformis	8	21	1	55	3	38	1	45	1	36	1	27	3	36
Macoma spp., juv.	1	40	8	26	25	14	4	25	0		2	22	5	31
Tellina buttoni	0		0		0		2	39	0		0		1	50
Semele rubropicta	0		0		0		0		4	17	0		0	
Solen cicarius	0		0		0		0		0		0		1	50

Table 10 (continued)

Species	1963								1964					
	27 Feb		29 Apr		1 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	$1.0\ m^2$		$1.0\ m^2$		$1.0\ m^2$		$1.0\ m^2$		$0.5\ m^2$		$0.5\ m^2$		$0.5\ m^2$	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA (continued)														
Acila castrensis	0		14	21	0		1	45	0		0		0	
Nucula bellotii	26	8	0		15	21	11	14	2	26	6	11	2	43
Nuculana cellulita	0		0		0		0		1	36	0		0	
Nuculana minuta	6	24	4	33	7	28	7	20	2	26	3	17	7	24
Crenella columbiana	47	3	5	30	49	7	53	4	22	4	14	6	40	7
Modiolus modiolus	0		1	55	0		0		0		0		0	
Musculus substriatus	1	40	1	55	0		1	45	2	26	0		0	
Chlamys hericius	1	40	5	30	1	50	0		4	17	3	17	3	36
Pododesmus cepio	0		1	55	0		0		0		0		0	
Mysella tumida	1	40	3	41	1	50	4	25	1	36	0		0	
Mactra californica	0		0		2	46	0		0		0		0	
Mya arenaria	2	36	25	7	3	38	0		4	17	1	27	3	36
Mya truncata	2	36	0		0		0		0		0		0	
Panomya ampla	1	40	0		0		0		0		0		0	
Panomya arctica	1	40	0		0		0		0		0		1	50
Pandora filosa	11	15	0		4	35	8	18	0		1	27	8	20
Lyonsia pugetensis	0		0		16	20	3	36	0		0		12	15
Cuspidaria oldroydi	3	34	0		3	38	3	36	1	36	3	17	4	33
Lamellibranchia indet.	0		1	55	2	46	0		0		2	22	0	

Table 10 (continued)

Species	1963								1964					
	27 Feb		29 Apr		1 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	$1.0\ m^2$		$1.0\ m^2$		$1.0\ m^2$		$1.0\ m^2$		$0.5\ m^2$		$0.5\ m^2$		$0.5\ m^2$	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	10	16	0		0		4	25	1	36	0		0	
Amphipholis squamata	4	29	16	19	5	32	0		0		0		1	50
Ophiura lütkeni	9	18	4	33	7	28	5	22	3	21	0		1	50
Holothuroidea														
Leptosynapta clarki	13	14	25	7	6	30	4	25	13	7	0		9	18
Pentamera spp.	5	28	10	25	6	30	1	45	10	10	0		11	16

Table 11

Abundance of Polychaeta at station 4,
9 January (A) and 29 April (B) 1963

Species	A (0.5 m²)	B (1.0 m²)	Species	A (0.5 m²)	B (1.0 m²)
Harmothoë imbricata	5	2	Lumbrineris californiensis	9	45
Malmgrenia lunulata	12	9	Lumbrineris cruzensis	16	4
Polynoidae sp. I	5	2	Lumbrineris limicola	1	0
Pholoë minuta	20	24	Lumbrineris luti	44	139
Eteone sp. I	14	17	Lumbrineris sp.	0	2
Eulalia sanguinea	0	5	Notocirrus californiensis	1	2
Eulalia sp. I	1	0	Stauronereis rudolphi	0	9
Phyllodoce groenlandica	1	3	Stauronereis sp.	0	1
Phyllodoce (Anaitides) sp.	0	1	Haploscoloplos pugettensis	9	72
Gyptis brevipalpa	5	15	Phylo felix	1	0
Micropodarke dubia	0	4	Aricidea lopezi	6	3
Ophiodromus pugettensis	4	15	Aricidea ramosa	3	0
Pilargis berkeleyae	0	1	Paraonis lyra	1	0
Syllis heterochaeta	2	0	Paraonis ivanovi	18	0
Syllis sp. I	17	5	Apistobranchus ornatus	15	0
Syllis harti	11	9	Laonice cirrata	2	1
Micronereis nanaimoensis	0	3	Paraspio sp. I	5	0
Nereis sp. II	0	7	Polydora natrix	0	4
Nereis sp. IV	0	1	Polydora caeca	5	9
Nereis sp.	0	2	Prionospio cirrifera	13	25
Platynereis bicanaliculata	87	86	Prinospio malmgreni	59	26
Nephtys ferruginea	101	299	Prionospio pinnata	9	14
Sphaerodoridium sphaerulifer	3	2	Spiophanes berkeleyorum	1	3
Glycera americana	4	9	Spionidae indet.	3	2
Glycera capitata	16	14	Magelona spp.	25	2
Glycinde armigera	1	1	Mesocheatopterus taylori	1	0
Glycinde picta	6	33	Chaetozone setosa	6	3
Glycinde sp. I	1	0	Tharyx multifilis	3	6
Goniada maculata	1	4	Flabelligera sp. I	1	0
Diopatra ornata	2	7	Scalibregma inflatum	0	3
Nothria sp.	14	9	Ammotrypane aulogaster	5	4
Lumbrineris bicirrata	5	3	Armandia brevis	5	6

Table 11 (continued)

Species	A ($0.5 m^2$)	B ($1.0 m^2$)	Species	A ($0.5 m^2$)	B ($1.0 m^2$)
Travisia brevis	1	0	Artacama conifera	0	1
Capitellidae indet.	126	52	Lanassa venusta	1	0
Clymenura columbiana	5	0	Lysilla pacifica	1	8
Euclymene zonalis	34	95	Pista cristata	0	3
Isocirrus longiceps	1	0	Polycirrus spp.	3	1
Praxillella affinis	1	0	Streblosoma bairdi	0	2
Praxillella gracilis	30	7	Trichobranchus glacialis	1	0
Rhodine bitorquata	5	0	Terebellidae indet.	7	8
Maldanidae indet.	3	2	Chone bimaculata	2	1
Ampharete gagarea	4	0	Megalomma splendida	2	0
Melinna elisabethae	1	1	Polychaeta indet.	2	2

Table 12

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 4

	1963								1964					
	9 Jan		29 Apr		2 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	175	4	97	5	649	2	1512	1	229	1	53	3	249	2
Euphilomedes producta	216	3	6	17	243	3	1	23	11	9	9	11	139	3
Cylindroleberis mariae	1	39	4	20	4	28	0		1	21	0		0	
Leptostraca														
Epinebalia pugettensis	2	30	0		0		18	11	4	13	0		2	30
Cumacea														
Diastylis paraspinulosa	0		1	31	0		0		0		0		0	
Diastylis pellucida	0		1	31	0		0		0		0		0	
Diastylis alaskensis	1	39	32	13	16	17	7	14	4	13	3	18	6	18
Diastylopsis dawsoni	0		0		0		1	23	0		0		0	
Eudorella pacifica	147	5	6	17	101	7	1	23	2	18	4	16	28	9
Lamprops quadriplicata krasheninnikovi	0		1	31	0		0		0		0		0	
Isopoda														
Haliophasma geminata	3	27	0		3	31	2	20	2	18	6	14	2	30
Tanaidacea														
Leptochelia dubia	46	11	34	12	13	18	49	8	3	16	10	8	0	

Table 12 (continued)

	1963								1964					
	9 Jan		29 Apr		2 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	$1.0\ m^2$		$1.0\ m^2$		$0.9\ m^2$		$1.0\ m^2$		$0.5\ m^2$		$0.5\ m^2$		$0.5\ m^2$	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda														
Anonyx carinatus	4	25	0		0		0		0		1	24	0	
Hippomedon denticulatus	0		2	22	0		0		6	10	3	18	2	30
Opisa tridentata	2	30	0		0		0		0		0		0	
Prachynella lodo	3	27	0		2	36	0		0		0		2	30
Ampelisca brevisimulata	0		0		2	36	0		0		0		0	
Ampelisca compressa	0		3	22	3	31	5	16	0		0		0	
Ampelisca lobata	0		0		1	43	0		4	13	2	20	4	23
Ampelisca macrocephala	0		0		0		0		0		1	24	3	26
Byblis veleronis	6	18	7	15	2	36	2	20	0		2	20	4	23
Heterophoxus oculatus	2	30	1	31	2	36	0		0		0		2	30
Paraphoxus similis	0		1	31	0		0		0		0		0	
Paraphoxus variatus	62	8	146	2	67	9	541	2	184	2	47	2	24	10
Westwoodilla caecula	41	13	54	9	21	15	9	12	6	10	5	15	9	14
Pontogeneia rostrata	0		3	22	0		0		0		1	24	0	
Melita dentata	1	39	0		0		0		0		0		0	
Melita desdichada	3	27	2	26	3	31	0		0		0		0	
Aoroides columbiae	6	18	0		0		0		0		0		0	
Photis brevipes	1	39	92	7	1	43	0		0		0		0	

Table 12 (continued)

	1963								1964					
	9 Jan		29 Apr		2 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Protomedeia spp.	0		198	1	22	14	96	6	2	18	10	8	60	7
Amphithoe sp.	2	30	1	31	0		3	19	0		0		0	
Ischyroceros sp.	0		0		0		2	20	0		0		0	
Dulichia arctica	1	39	6	17	2	36	0		0		4	16	0	
Caprella sp.	0		0		0		0		0		0		4	23
Natantia														
Decapoda natantia, juv.	2	30	2	26	8	22	0		0		1	24	9	14
Anomura														
Callianassa sp., juv.	0		0		8	22	0		0		0		0	
Pagurus sp., juv.	1	39	0		0		0		0		0		0	
Petrolisthes eriomerus	0		0		1	43	0		0		0		0	
Brachyura														
Pinnixa schmitti	230	2	95	6	878	1	21	10	44	5	71	1	263	1
Cancer sp., juv.	5	23	1	31	45	12	7	14	1	21	0		6	18
Hyas lyratus	1	39	0		3	31	0		0		0		0	
Brachyura, megalopa	0		0		56	10	0		0		0		0	
LAMELLIBRANCHIA														
Lucinoma annulatus	7	17	1	31	10	19	0		0		0		2	30
Parvalucina tenuisculptus	2	30	3	22	5	25	0		1	21	0		3	26

Table 12 (continued)

Species	1963								1964					
	9 Jan		29 Apr		2 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA (continued)														
Axinopsida sericata	380	1	90	8	241	4	103	5	33	6	17	7	77	6
Thyasira gouldii	1	39	0		1	43	0		0		0		0	
Clinocardium nuttalli	2	30	7	15	4	28	8	13	0		2	20	20	12
Nemocardium centifilosum	0		0		0		0		0		0		2	30
Compsomyax subdiaphana	6	18	0		1	43	1	23	0		0		6	18
Protothaca tenerrima	1	39	0		0		1	23	0		0		0	
Psephidia lordi	50	10	1	31	163	5	85	7	14	8	10	8	94	5
Macoma alaskana	2	30	1	31	1	43	0		0		0		2	30
Macoma calcarea	6	18	1	31	6	24	0		0		2	20	1	39
Macoma carlottensis	87	7	26	14	27	13	4	17	1	21	1	24	46	8
Macoma inconspicua	1	39	1	31	5	25	0		0		0		3	26
Macoma yoldiformis	5	23	2	26	9	20	0		0		0		5	22
Macoma spp., juv.	27	15	45	10	2	36	1	23	6	10	9	11	2	30
Tellina buttoni	31	14	106	4	21	15	241	3	87	3	34	5	8	16
Solen cicarius	0		2	26	0		0		0		1	24	0	
Nucula bellotii	94	6	45	10	156	6	26	9	16	7	23	6	106	4
Yoldia seminuda	0		1	31	3	31	0		0		0		1	39
Yoldia sp.	1	39	0		0		0		0		0		0	

Table 12 (continued)

Species	1963								1964					
	9 Jan		29 Apr		2 Aug		18 Nov		17 Feb		4 Apr		7 Aug	
	1.0 m^2		1.0 m^2		0.9 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA (continued)														
Crenella columbiana	6	18	0		9	20	1	23	0		0		3	26
Mysella tumida	46	11	133	3	50	11	138	4	59	4	43	4	16	13
Pandora filosa	0		0		4	28	0		0		0		8	16
Lyonsia pugetensis	0		0		2	36	1	23	0		0		6	18
Cuspidaria oldroydi	2	30	0		0		0		0		0		0	
Lamellibranchia indet.	0		0		5	25	0		0		0		0	
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	52	9	3	22	68	8	4	17	3	16	7	13	46	8
Amphipholis squamata	12	16	0		1	43	0		0		0		0	
Ophiura lütkeni	4	25	1	31	0		0		0		1	24	0	

5. Station 5 (Tables 13 and 14)

The faunal assemblage at this station was dominated by the amphipods Byblis veleronis and Heterophoxus oculatus, the brachyuran Lophopanopeus bellus, the polychaetes Laonice pugettensis and Peisidice aspera, the ophiurid Amphipholis squamata, the holothurian Leptosynapta clarki, and unidentified species of the genus Pentomera. No species of lamellibranchs was numerous at the station, but Semele rubropicta occurred regularly and contributed significantly to the standing crop because of its considerable size.

Table 14 shows that there was considerable variability in the relative abundances of the numerically dominant species throughout the period of investigation.

The brachyuran Lophopanopeus bellus, the lamellibranch Semele rubropicta the sipunculid Golfingia pugettensis, and the holothurians Leptosynapta clarki and Pentamera spp. contributed significantly to the total standing crop, but none of the polychaetes was particularly important.

6. Station 6 (Tables 15 and 16)

The fauna at this station was dominated by the polychaetes Lumbrineris californiensis, L. luti, Chaetozone setosa, and Peisidice aspera; the ostracod Euphilomedes carcharodonta; the amphipod Heterophoxus oculatus; and the holothurian Leptosynapta clarki.

Table 16 shows that there was considerable variability in the relative abundances of the numerically dominant species at station 6 throughout the period of investigation.

Although polychaetes contributed the majority of the number of species and number of specimens at station 6, none of the species was of any importance to the standing crop. The only species of importance were the lamellibranchs Semele rubropicta and Mya arenaria, and the sipunculid Golfingia pugettensis.

7. Station 7 (Tables 17 and 18)

The faunal assemblage at station 7 was dominated by the ophiurid Amphiodia urtica; the cumacean Eudorella pacifica; the ostracod Euphilomedes carcharodonta; the brachyuran Pinnixa barnharti; and the polychaetes Sigambra tentaculata, Glycera capitata, and Lepidasthenia berkeleyae.

Table 18 shows that there was a very high degree of stability in the relative abundances of the numerically dominant species through the investigated period.

Table 13

Abundance of Polychaeta at station 5,
12 February (A) and 3 May (B) 1963

Species	A ($0.5 m^2$)	B ($0.5 m^2$)	Species	A ($0.5 m^2$)	B ($0.5 m^2$)
Gattyana cirrosa	3	0	Hemipodus borealis	0	9
Gattyana sp. I	0	1	Diopatra ornata	0	1
Harmothoë imbricata	12	9	Nothria sp.	0	1
Malmgrenia lunulata	10	8	Lumbrineris bicirrata	1	0
Peisidice aspera	27	16	Lumbrineris californiensis	10	9
Pholoë minuta	4	23	Lumbrineris cruzensis	4	0
Eteone sp. I	0	1	Lumbrineris luti	0	1
Eulalia sp. II	0	1	Protodorvillea sp. I	0	5
Eulalia sanguinea	1	2	Stauronereis sp.	2	0
Eulalia macroceros	0	4	Haploscoloplos pugettensis	5	10
Eulalia sp. I	1	0	Laonice sp. I	33	23
Mystides borealis	0	1	Prionospio cirrifera	0	2
Phyllodoce williamsi	4	2	Prionospio malmgreni	15	14
Phyllodocidae indet.	0	2	Rhynchospio arenicola	0	3
Gyptis brevipalpa	0	1	Spio filicornis	1	1
Micropodarke dubia	2	93	Magelona spp.	2	1
Ophiodromus pugettensis	2	2	Caulleriella alata	13	2
Autolytus sp.	0	1	Caulleriella sp. I	0	1
Eusyllis blomstrandi	3	6	Chaetozone setosa	11	1
Odontosyllis phosphorea	0	1	Chaetozone sp. I	15	10
Pionosyllis uraga	19	107	Chaetozone sp.	1	0
Syllis heterochaeta	3	0	Macrochaeta clavicornis	0	6
Syllis (Langerhansia) sp.I	1	3	Pherusa neopapillata	6	4
Syllis (Typosyllis) sp. I	0	1	Scalibregma inflatum	1	0
Syllidae indet.	0	1	Armandia brevis	3	1
Nereis sp. III	3	1	Capitellidae indet.	5	8
Platynereis bicanaliculata	1	1	Euclymene zonalis	8	10
Nephtys caecoides	3	0	Nichomache lumbricalis	2	0
Nephtys ferruginea	1	0	Notoproctus pacificus	3	0
Nephtys sp.	0	1	Ampharete acutifrons	1	2
Glycera americana	1	5	Schistocomus hiltoni	1	0
Glycera capitata	13	22	Amphitritinae sp.	0	3

Table 13 (continued)

Species	A (0.5 m^2)	B (0.5 m^2)
Pista moorei	1	0
Polycirrus spp.	3	0
Terebellides stroemi	1	1
Chone sp. I	0	6
Polychaeta indet.	1	0

Table 14

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 5

	1963								1964					
	12 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.5 m^2		0.6 m^2		0.9 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	0		0		6	9	0		0		1	22	0	
Cumacea														
Diastylis pellucida	0		0		0		0		0		0		1	24
Diastylis alaskensis	0		0		0		4	16	0		11	8	11	5
Lamprops carinata	0		0		0		0		0		2	19	3	19
Isopoda														
Haliophasma geminata	0		0		0		0		0		0		3	19
Rocinela belliceps	2	21	0		0		3	19	0		0		0	
Amphipoda														
Anonyx sp. I	2	21	2	15	3	15	3	19	1	16	0		0	
Aruga holmesi	0		1	20	0		0		0		0		0	
Aristias pacificus	4	12	0		1	24	0		0		0		0	
Hippomedon denticulatus	1	25	0		0		2	25	4	6	1	22	11	5
Lepidecreum eoum	1	25	0		0		0		0		0		0	
Orchomene decipiens	1	25	0		0		3	19	0		0		0	
Ampelisca compressa	10	8	5	10	0		8	10	3	8	3	16	7	12
Ampelisca cristata	1	25	1	20	0		5	14	1	16	14	7	28	2

Table 14 (continued)

Species	1963								1964					
	12 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.5 m^2		0.6 m^2		0.9 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Ampelisca lobata	1	25	0		0		1	30	0		1	22	0	
Ampelisca macrocephala	4	12	0		0		0		0		0		0	
Ampelisca pugetica	5	9	2	15	0		8	10	2	11	3	16	0	
Byblis veleronis	17	6	73	2	82	2	30	5	3	8	24	4	4	14
Heterophoxus oculatus	37	4	9	8	1	24	52	2	15	2	43	1	1	24
Paraphoxus spinosus	0		1	20	0		0		0		0		0	
Stenothoidae indet.	1	25	1	20	21	6	0		1	16	0		0	
Monoculodes zernovi	0		0		0		0		0		0		1	24
Synchelidium rectipalmum	5	9	2	15	3	15	25	6	2	11	1	22	9	7
Westwoodilla caecula	0		0		0		0		0		6	11	1	24
Tiron biocellata	25	5	11	7	3	15	19	8	2	11	11	8	1	24
Parapleustes pugettensis	0		9	8	3	15	0		0		0		0	
Melphisana sp.	0		1	20	0		1	30	0		1	22	0	
Rhacotropis inflata	0		0		1	24	0		0		0		0	
Pontogeneia melanophthalma	0		0		1	24	0		0		0		0	
Melita dentata	3	17	1	20	6	9	2	25	0		0		0	
Melita oregonensis	0		0		6	9	0		0		0		0	
Maera danae	1	25	1	20	2	22	0		0		0		0	

Table 14 (continued)

Species	1963								1964					
	12 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.5 m^2		0.6 m^2		0.9 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Eurystheus thompsoni	3	17	4	11	0		3	19	0		0		0	
Photis brevipes	0		3	13	7	8	3	19	1	16	1	22	0	
Protomedeia sp.	0		0		0		0		0		0		9	7
Ischyroceros sp.	0		0		1	24	0		0		2	19	1	24
Ericthonius brasiliensis	0		0		0		0		0		0		4	15
Ericthonius hunteri	2	21	0		3	15	4	16	2	11	1	22	0	
Dulichia tuberculata	0		14	6	3	15	0		0		4	13	0	
Caprella sp.	0		41	3	65	3	1	30	0		4	13	36	1
Natantia														
Decapoda natantia, juv.	2	21	0		53	4	18	9	0		0		8	10
Anomura														
Callianassa sp., juv.	0		0		1	24	0		0		0		0	
Pagurus sp., juv.	0		1	20	1	24	1	30	5	5	2	19	0	
Petrolisthes eriomerus	0		0		3	15	0		0		0		0	
Brachyura														
Pinnixa schmitti	4	12	0		0		4	16	0		0		4	15
Lophopanopeus bellus	91	1	96	1	163	1	103	1	10	3	10	10	9	7
Cancer sp., juv.	0		0		10	7	0		0		0		0	

Table 14 (continued)

Species	1963								1964					
	12 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.5 m^2		0.6 m^2		0.9 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Brachyura (continued)														
Hyas lyratus	0		1	20	4	12	3	19	1	16	0		1	24
Oregonia gracilis	3	17	1	20	1	24	2	25	1	16	0		3	19
Scyra acutifrons	1	25	0		0		0		0		0		0	
PYCNOGONIDA														
Nymphon pixellae	0		0		1	24	1	30	0		0		0	
LAMELLIBRANCHIA														
Clinocardium fucanum	1	25	0		0		1	30	0		0		4	15
Protothaca tenerrima	1	25	0		0		0		0		0		0	
Psephidia lordi	0		0		0		1	30	0		0		0	
Saxidomus giganteus	1	25	1	20	0		1	30	0		0		0	
Macoma inconspicua	1	25	1	20	0		2	25	1	16	2	19	5	14
Semele rubropicta	5	9	2	15	1	24	2	25	4	6	4	13	0	
Nuculana cellulita	1	25	0		0		0		0		0		0	
Glycymeris subobsoleta	1	25	3	13	0		1	30	1	16	0		0	
Kellia suborbicularia	1	25	0		0		0		0		0		0	
Mysella tumida	0		0		0		0		1	16	18	5	2	22
Mya arenaria	4	12	1	20	0		7	12	1	16	0		0	
Panomya arctica	4	12	0		0		0		0		0		0	

Table 14 (continued)

	1963								1964					
	12 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	$1.0\ m^2$		$0.5\ m^2$		$0.6\ m^2$		$0.9\ m^2$		$0.5\ m^2$		$0.5\ m^2$		$0.5\ m^2$	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA (continued)														
Lyonsia pugetensis	0		1	20	0		0		3	8	6	11	7	12
Lamellibranchia indet.	0		0		0		0		0		1	22	0	
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	0		0		0		6	13	0		0		2	22
Amphipholis squamata	91	1	19	4	23	5	50	3	1	16	40	2	8	10
Holothuroidea														
Chiridota laevis	3	17	0		4	12	5	14	2	11	3	16	0	
Leptosynapta clarki	43	3	17	5	2	22	31	4	37	1	36	3	15	4
Molpadia intermedia	0		4	11	0		0		0		0		0	
Pentamera spp.	15	7	2	15	4	12	21	7	8	4	17	6	16	3

Table 15

Abundance of Polychaeta at station 6,
13 February (A) and 2 May (B) 1963

Species	A ($0.5 m^2$)	B ($0.5 m^2$)	Species	A ($0.5 m^2$)	B ($0.5 m$
Aphrodite sp. I	0	1	Glycera capitata	15	16
Gattyana cirrosa	5	5	Glycinde sp. I	2	0
Harmothoë fragilis	1	0	Goniada maculata	2	4
Harmothoë imbricata	4	0	Diopatra ornata	2	6
Harmothoë multisetosa	0	1	Nothria sp.	0	1
Malmgrenia lunulata	3	6	Lumbrineris bicirrata	15	22
Polynoidae indet.	1	0	Lumbrineris californiensis	25	49
Peisidice aspera	47	42	Lumbrineris cruzensis	14	12
Pholoë minuta	1	0	Lumbrineris luti	22	23
Eteone sp. I	1	2	Arabella semimaculata	0	1
Eulalia bilineata	2	1	Driloneris sp. I	0	2
Eulalia sanguinea	1	0	Notocirrus californiensis	0	2
Eulalia sp.	1	0	Protodorvillea sp. I	0	2
Phyllodocinae sp.	0	1	Stauronereis sp.	0	1
Gyptis brevipalpa	0	1	Haploscoloplos pugettensis	17	9
Micropodarke dubia	0	1	Aricidea lopezi	1	3
Ophiodromus pugettensis	1	2	Aricidea ramosa	2	0
Sigambra tentaculata	1	1	Paraonis ivanovi	5	10
Pilargis berkeleyae	0	2	Laonice cirrata	0	4
Eusyllis blomstrandi	0	1	Laonice sp. I	3	6
Exogone sp.	0	1	Paraspio sp. I	1	3
Odontosyllis phosphorea	1	2	Polydora natrix	0	1
Pionosyllis uraga	0	2	Polydora caeca	0	1
Pionosyllis sp.	3	0	Prionospio cirrifera	3	0
Syllis sp. I	7	1	Prionospio malmgreni	5	20
Syllis armillaris	0	1	Prionospio pinnata	1	2
Nereis sp. II	0	2	Prionospio sp.	1	0
Nereis sp. III	4	7	Spiophanes berkeleyorum	3	10
Nereis sp.	0	1	Magelona spp.	14	51
Platynereis bicanaliculata	2	0	Telepsavus costarum	0	3
Nephtys ferruginea	3	4	Caulleriella alata	4	7
Glycera americana	1	4	Chaetozone spinosa	0	1

Table 15 (continued)

Species	A ($0.5 m^2$)	B ($0.5 m^2$)	Species	A ($0.5 m^2$)	B ($0.5 m^2$)
Chaetozone setosa	21	52	Petaloproctus tenuis	0	1
Chaetozone sp. I	1	6	Rhodine bitorquata	0	7
Tharyx multifilis	0	2	Maldanidae indet.	0	1
Tharyx sp. I	1	3	Idanthyrsus armatus	1	0
Tharyx sp.	1	3	Amage anops	4	11
Pherusa neopapillata	3	2	Ampharete gagarea	2	8
Scalibregma inflatum	0	1	Amphicteis mucronata	4	3
Ammotrypane aulogaster	0	1	Schistocomus hiltoni	1	1
Armandia brevis	1	0	Ampharetidae indet.	0	1
Capitellidae indet.	16	32	Lanassa venusta	0	2
Axiothella rubrocincta	0	1	Pista fasciata	0	1
Euclymene zonalis	0	3	Polycirrus sp.	0	1
Isocirrus longiceps	1	0	Thelepus japonicus	1	0
Maldane glebifex	1	0	Terebellides stroemi	4	2
Maldanella robusta	0	1	Trichobranchus glacialis	0	1
Notoproctus pacificus	3	2	Terebellidae indet.	5	1

Table 16

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 6

Species	1963								1964					
	13 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	0.6 m^2		0.5 m^2		1.0 m^2		0.9 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	3	11	0		53	5	44	2	67	1	24	1	3	22
Euphilomedes producta	3	11	0		16	12	1	41	0		0		1	30
Cylindroleberis mariae	0		0		1	48	0		0		0		0	
Cumacea														
Diastylis pellucida	0		3	15	0		0		0		0		0	
Diastylis alaskensis	1	19	2	20	32	9	19	11	2	20	6	16	6	11
Isopoda														
Haliophasma geminata	0		0		0		0		1	26	0		0	
Tanaidacea														
Leptognathia longiremis	0		0		4	28	1	41	0		1	29	0	
Amphipoda														
Hippomedon denticulatus	0		0		0		0		1	26	0		0	
Opisa tridentata	0		0		1	48	0		0		0		0	
Orchomene decipiens	1	19	0		2	42	0		3	17	0		3	22
Ampelisca compressa	1	19	21	2	59	3	3	25	1	26	2	24	5	17
Ampelisca lobata	0		2	20	4	28	27	6	15	3	11	9	0	
Ampelisca macrocephala	0		1	31	1	48	0		0		0		0	

Table 16 (continued)

	1963								1964					
	13 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	$0.6\ m^2$		$0.5\ m^2$		$1.0\ m^2$		$0.9\ m^2$		$0.5\ m^2$		$0.5\ m^2$		$0.5\ m^2$	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Ampelisca pugetica	3	11	2	20	3	34	12	15	1	26	0		6	11
Byblis veleronis	3	11	5	12	8	21	16	12	10	5	8	13	5	17
Heterophoxus oculatus	22	1	13	3	78	2	55	1	15	3	22	2	43	1
Metaphoxus fultoni	0		1	31	4	28	1	41	0		1	29	0	
Paraphoxus robustus	0		0		0		0		0		1	29	0	
Paraphoxus similis	0		1	31	3	34	1	41	0		0		6	11
Stenothoidae indet.	0		2	20	2	42	0		0		1	29	2	25
Pardalisca tenuipes	0		0		1	48	0		0		0		0	
Monoculodes zernovi	0		0		5	26	2	33	0		0		0	
Synchelidium rectipalmum	0		0		0		1	41	0		0		0	
Westwoodilla caecula	0		2	20	11	16	1	41	1	26	3	21	0	
Tiron biocellata	5	5	0		2	42	4	23	0		0		2	25
Eusirus sp.	0		0		1	48	0		0		0		0	
Pontogeneia melanophthalma	0		0		1	48	0		0		0		0	
Maera danae	0		0		1	48	0		0		0		0	
Aoroides columbiae	0		0		3	34	0		0		0		0	
Eurystheus thompsoni	0		0		10	18	26	8	16	2	13	6	2	25
Protomedeia sp.	0		0		0		4	23	0		1	29	0	

Table 16 (continued)

Species	1963 13 Feb 0.6 m^2 N	R	3 May 0.5 m^2 N	R	30 July 1.0 m^2 N	R	7 Nov 0.9 m^2 N	R	13 Feb 0.5 m^2 N	R	23 Apr 0.5 m^2 N	R	28 July 0.5 m^2 N	R
Amphipoda (continued)														
Ericthonius hunteri	2	15	7	8	99	1	16	12	8	7	1	29	18	5
Dulichia tuberculata	0		0		0		0		0		1	29	0	
Caprella sp.	1	19	1	31	7	23	0		0		13	6	2	25
Natantia														
Decapoda natantia, juv.	0		2	20	6	24	16	12	6	10	3	21	3	22
Anomura														
Callianassa sp., juv.	0		1	31	3	34	3	25	2	20	0		0	
Pagurus sp., juv.	4	8	1	31	10	18	10	17	6	10	5	17	4	20
Brachyura														
Pinnixa schmitti	0		6	10	11	16	9	19	3	17	9	12	6	11
Pinnotheres concharum	1	19	0		1	48	1	41	1	26	0		0	
Pinnotheres taylori	0		0		2	42	0		0		0		0	
Lophopanopeus bellus	5	5	10	5	37	6	27	6	4	13	10	11	17	7
Cancer sp., juv.	0		0		0		1	41	1	26	1	29	0	
Hyas lyratus	0		0		1	48	0		0		1	29	1	30
Oregonia gracilis	1	19	0		1	48	1	41	3	17	1	29	1	30
PYCNOGONIDA														
Nymphon pixellae	0		0		0		2	33	0		0		0	

Table 16 (continued)

Species	1963								1964					
	13 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	0.6 m^2		0.5 m^2		1.0 m^2		0.9 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA														
Lucinoma annulatus	0		1	31	0		0		0		1	29	0	
Parvalucina tenuisculptus	0		7	8	8	21	3	25	0		2	24	2	25
Adontorhina cyclia	0		0		1	48	1	41	0		1	29	0	
Axinopsida sericata	0		3	15	6	24	1	41	0		3	21	0	
Clinocardium fucanum	0		2	20	2	42	2	33	0		1	29	0	
Nemocardium centifilosum	0		3	15	26	10	1	41	0		0		19	4
Compsomyax subdiaphana	0		0		0		0		0		0		1	30
Protothaca tenerrima	0		0		1	48	1	41	0		1	29	0	
Psephidia lordi	0		0		0		2	33	1	26	1	29	0	
Macoma alaskana	1	19	0		2	42	1	41	2	20	4	19	0	
Macoma calcarea	0		0		3	34	2	33	0		0		0	
Macoma carlottensis	0		0		3	34	0		0		1	29	0	
Macoma inconspicua	2	15	2	20	5	26	7	20	8	7	1	29	6	11
Macoma irus	0		0		1	48	2	33	0		0		0	
Macoma yoldiformis	1	19	3	15	1	48	3	25	1	26	2	24	1	30
Macoma spp., juv.	1	19	1	31	4	28	3	25	0		5	17	1	30
Semele rubropicta	8	2	2	20	16	12	10	17	2	20	0		6	11
Nucula bellotii	1	19	0		1	48	0		0		1	29	0	

Table 16 (continued)

Species	1963								1964					
	13 Feb		3 May		30 July		7 Nov		13 Feb		23 Apr		28 July	
	0.6 m^2		0.5 m^2		1.0 m^2		0.9 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA (continued)														
Nuculana cellulita	1	19	0		0		0		0		0		1	30
Nuculana minuta	1	19	0		4	28	2	33	0		1	29	0	
Crenella columbiana	0		2	20	14	15	12	15	2	20	2	24	9	8
Mysella tumida	2	15	3	15	1	48	5	21	4	13	16	3	0	
Mya arenaria	4	8	13	3	36	7	33	4	7	9	4	19	5	17
Panomya arctica	0		0		3	34	2	33	0		2	24	4	20
Pandora filosa	0		0		1	48	3	25	0		0		0	
Lyonsia pugetensis	2	15	8	7	57	4	28	5	2	20	11	9	43	1
Lamellibranchia indet.	0		24	1	9	20	3	25	0		14	5	0	
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	4	8	5	12	15	14	5	21	4	13	12	8	7	9
Amphipholis squamata	5	5	6	10	17	11	40	3	10	5	15	4	7	9
Ophiura lütkeni	1	19	2	20	4	28	3	25	0		1	29	0	
Holothuroidea														
Leptosynapta clarki	8	2	10	5	36	7	24	9	5	12	7	14	39	3
Pentamera spp.	8	2	5	12	3	34	21	10	4	13	7	14	18	5

Table 17

Abundance of Polychaeta at station 7,
13 February (A), 3 May (B), 29 July (C), and 8 November (D) 1963

Species	A ($1.0 m^2$)	B ($0.5 m^2$)	C ($1.0 m^2$)	D ($1.0 m^2$)
Eunoë oerstedi	0	0	2	0
Eunoë sp. I	1	0	1	1
Gattyana treadwelli	1	1	5	3
Harmothoë imbricata	0	1	0	0
Lepidasthenia berkeleyae	1	4	29	10
Malmgrenia lunulata	0	1	0	0
Polynoidae sp. I	0	2	1	2
Peisidice aspera	0	2	0	0
Pholoë minuta	4	5	4	3
Sthenelais tertiaglabra	4	3	4	2
Eteone sp. I	0	1	0	0
Phyllodoce groenlandica	0	2	0	0
Gyptis brevipalpa	2	2	1	1
Sigambra tentaculata	40	4	31	17
Pilargis berkeleyae	2	0	3	1
Eusyllis sp.	0	2	0	0
Syllis heterochaeta	0	2	0	0
Syllis sp. I	0	1	0	0
Nereis sp. I	0	1	2	0
Nephtys assignis	0	1	0	0
Nephtys ferruginea	7	6	3	4
Nephtys sp.	1	0	0	0
Sphaerodoridium sphaerulifer	0	1	0	0
Glycera americana	0	2	0	0
Glycera capitata	31	11	19	22
Glycera robusta	2	0	0	0
Glycera siphonostoma	0	1	1	1
Glycinde armigera	1	0	0	0
Glycinde sp. I	0	0	0	1
Goniada brunnea	7	0	4	1
Diopatra ornata	1	11	0	0

Table 17 (continued)

Species	A ($1.0\,m^2$)	B ($0.5\,m^2$)	C ($1.0\,m^2$)	D ($1.0\,m^2$)
Nothria sp.	1	0	1	2
Lumbrineris bicirrata	0	1	1	0
Lumbrineris cruzensis	6	18	2	6
Lumbrineris luti	0	5	2	0
Lumbrineris sp. I	0	1	0	0
Lumbrineris sp.	1	0	3	0
Haploscoloplos pugettensis	0	9	0	0
Aricidea ramosa	5	2	4	1
Paraonis ivanovi	37	3	10	4
Laonice cirrata	11	6	25	8
Polydora natrix	0	0	1	0
Polydora caeca	0	2	2	2
Prionospio cirrifera	18	7	3	2
Prionospio malmgreni	1	3	1	5
Prionospio pinnata	11	0	3	4
Prionospio sp.	0	0	2	0
Spiophanes berkeleyorum	1	1	4	0
Spionidae indet.	2	0	0	0
Magelona spp.	0	3	1	0
Phyllochaetopterus prolifica	0	2	0	0
Chaetozone sp. I	1	0	0	0
Chaetozone setosa	0	0	1	0
Chaetozone gracilis	1	0	0	0
Tharyx sp. I	0	7	0	0
Pherusa neopapillata	0	1	0	0
Capitellidae indet.	5	1	7	2
Euclymeninae sp.	0	5	0	0
Isocirrus longiceps	0	2	0	0
Praxillella affinis	43	11	90	52
Praxillella gracilis	0	1	0	0
Rhodine bitorquata	0	4	0	0
Maldanidae indet.	0	2	0	0

Table 17 (continued)

Species	A ($1.0 m^2$)	B ($0.5 m^2$)	C ($1.0 m^2$)	D ($1.0 m^2$)
Sabellaria cementarium	0	7	0	0
Pectinaria californiensis	14	19	17	20
Pectinaria granulata	0	4	0	0
Amage anops	0	8	0	0
Ampharete gagarae	0	1	0	0
Schistocomus hiltoni	0	1	0	0
Scionella japonica	0	1	0	0
Neoamphitrite edwardsi	1	0	0	0
Pista fasciata	1	0	7	1
Polycirrus spp.	0	1	0	0
Terebellides stroemi	5	5	4	0
Thelepus japonicus	0	1	0	0
Terebellidae indet.	2	4	4	0
Potamilla myriops	1	0	0	0
Polychaeta indet.	0	0	0	1

Table 18

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 7

	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	$1.0\ m^2$		$0.5\ m^2$		$1.0\ m^2$		$1.0\ m^2$		$0.5\ m^2$		$0.6\ m^2$		$0.6\ m^2$	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	4	12	227	1	18	5	0		97	1	373	1	330	1
Euphilomedes producta	0		74	3	6	12	0		12	4	112	3	140	2
Cylindroleberis mariae	0		1	18	0		0		0		1	17	1	18
Cumacea														
Diastylis alaskensis	0		0		0		0		0		0		2	14
Eudorella pacifica	33	3	28	4	46	1	29	2	27	3	17	4	106	4
Eudorellopsis biplicata	0		18	5	0		0		0		3	9	1	18
Tanaidacea														
Leptognathia longiremis	0		1	18	0		0		0		0		0	
Amphipoda														
Opisa tridentata	0		0		0		0		0		1	17	1	18
Prachynella lodo	1	18	0		0		0		0		1	17	0	
Ampelisca compressa	0		1	18	0		0		0		0		0	
Ampelisca lobata	0		0		1	21	0		0		0		0	
Ampelisca macrocephala	0		0		0		0		0		3	9	3	11
Ampelisca pugetica	0		0		0		0		0		0		1	18
Heterophoxus oculatus	19	6	3	13	16	6	6	5	9	5	7	6	14	7

Table 18 (continued)

Species	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	$1.0\ m^2$		$0.5\ m^2$		$1.0\ m^2$		$1.0\ m^2$		$0.5\ m^2$		$0.6\ m^2$		$0.6\ m^2$	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Metaphoxus fultoni	0		1	18	0		0		0		0		0	
Stenothoidae indet.	0		5	7	0		0		0		0		0	
Synchelidium shoemakeri	0		1	18	0		0		0		0		0	
Westwoodilla caecula	0		1	18	0		0		0		0		0	
Pontogeneia melanophthalma	0		0		1	21	0		0		0		0	
Aoroides columbiae	0		0		0		0		0		0		2	14
Eurystheus thompsoni	0		9	6	0		1	16	0		0		0	
Photis brevipes	1	18	0		2	16	0		7	6	3	9	0	
Protomedeia sp.	5	11	5	7	8	9	3	11	2	8	8	5	48	5
Ischyroceros sp.	0		1	18	0		0		0		0		0	
Ericthonius hunteri	0		1	18	0		0		0		0		0	
Dulichia arctica	0		2	14	0		0		0		0		3	11
Natantia														
Decapoda natantia, juv.	0		0		3	13	0		0		0		0	
Anomura														
Callianassa sp., juv.	2	15	4	9	8	9	4	8	2	8	4	8	5	10
Brachyura														
Pinnixa barnharti	38	1	4	9	44	2	21	3	2	8	5	7	19	6
Pinnixa occidentalis	7	8	4	9	7	11	2	13	0		0		0	
Oregonia gracilis	0		1	18	0		0		0		0		0	

Table 18 (continued)

Species	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.5 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.6 m^2		0.6 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA														
Lucinoma annulatus	4	12	0		3	13	4	8	0		1	17	0	
Parvalucina tenuisculptus	38	1	2	14	11	8	19	4	0		0		2	14
Axinopsida sericata	21	5	0		19	4	0		0		1	17	8	9
Nemocardium centifilosum	0		0		0		0		1	13	2	14	0	
Compsomyax subdiaphana	2	15	0		0		2	13	0		0		0	
Macoma carlottensis	6	9	0		0		1	16	0		0		0	
Macoma yoldiformis	0		2	14	0		0		0		2	14	0	
Macoma spp., juv.	1	18	1	18	1	21	3	11	1	13	0		0	
Acila castrensis	1	18	0		0		0		1	13	1	17	0	
Nucula bellotii	33	3	4	9	3	13	6	5	2	8	3	9	14	7
Yoldia amygdalea	4	12	0		1	21	4	8	0		0		1	18
Yoldia scissurata	1	18	1	18	2	16	0		5	7	3	9	3	11
Yoldia seminuda	0		0		0		0		0		0		1	18
Yoldia thraciaeformis	2	15	0		2	16	2	13	1	13	1	17	1	18
Crenella columbiana	0		2	14	0		0		0		1	17	0	
Mysella tumida	6	9	1	18	16	6	5	7	2	8	2	14	2	14
Pandora filosa	0		0		1	21	0		0		0		0	
Thracia trapezoides	1	18	0		0		0		0		0		0	
Lamellibranchia indet.	0		1	18	2	16	0		0		1	17	0	

Table 18 (continued)

	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.5 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.6 m^2		0.6 m^2	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	15	7	202	2	38	3	42	1	49	2	293	2	122	3
Ophiura lütkeni	0		1	18	0		0		0		0		0	
Holothuroidea														
Molpadia intermedia	0		0		2	16	1	16	1	13	0		0	
Pentamera spp.	0		0		1	21	1	16	0		0		0	

Significant contributors to the standing crop were the polychaetes Diopatra ornata, Pectinaria californiensis, Laonice cirrata, and Glycera capitata; and the ophiurid Amphiodia urtica.

8. Station 8 (Tables 19 and 20)

The fauna at this station was dominated by the ostracod Euphilomedes carcharodonta; the amphipod Byblis veleronis; the ophiurid Amphiodia urtica; the holothurian Leptosynapta clarki; the lamellibranchs Mysella tumida and Psephidia lordi; and the polychaetes Lumbrineris californiensis, Prionospio malmgreni, and Haploscoloplos pugettensis. Other conspicuous members of the community were anomurans of the genus Pagurus, the sipunculid Golfingia pugettensis, the pennatulid Leioptilus guerneyi, and unidentified gastropods.

Table 20 shows that the fauna at station 8 was characterized by a considerable stability in the relative abundances of the numerically dominant species.

None of the species of polychaetes, but the ostracod Euphilomedes carcharodonta, the brachyuran Lophopanopeus bellus, the holothurian Leptosynapta clarki, the ophiurid Amphiodia urtica, and the sipunculid Golfingia pugettensis were significant contributors to the standing crop.

D. Number of species and specimens

1. Seasonal variations in numbers

Absence of significant seasonal variations in abundance of benthic organisms has repeatedly been reported (BLEGVAD 1925, STEVEN 1930, JONES 1952), and the general explanation has been that the benthic infauna species have a life span of several years, which tends to reduce the seasonal variations. Sampling variability may also obscure the true seasonal variations.

The alleged absence of seasonal variations in number of specimens seems strange, particularly in boreal and arctic waters where the spatfall for most of the species occurs during the summer. However, for detection of seasonal variations a sufficiently fine screen must be used to retain the young shortly after spatfall.

In 1963 ten replicate samples were generally collected at the benthos stations in Puget Sound, and in 1964 only five replicates were taken (page 251). Figure 5, page 250, shows the rate of discovery of species with increasing number of replicates

Table 19

Abundance of Polychaeta at station 8,
13 February (A) and 3 May (B) 1963

pecies	A (0.5 m²)	B (0.5 m²)	Species	A (0.5 m²)	B (0.5 m²)
attyana cirrosa	1	0	Nothria sp.	1	0
armothoë imbricata	1	12	Lumbrineris bicirrata	2	0
epidasthenia berkeleyae	1	0	Lumbrineris californiensis	32	214
almgrenia lunulata	5	15	Lumbrineris cruzensis	10	4
eisidice aspera	7	13	Lumbrineris luti	5	2
holoë minuta	7	3	Protodorvillea sp. I	0	2
thenelais tertiaglabra	1	0	Stauronereis japonica	0	1
aleanotus bellis	0	7	Haploscoloplos pugettensis	19	42
teone sp. I	2	8	Orbiniidae indet.	0	1
ulalia sanguinea	0	2	Paraonis ivanovi	4	0
hyllodoce groenlandica	1	1	Laonice cirrata	0	1
hyllodoce williamsi	1	10	Laonice sp. I	0	4
hyllodoce castanea	1	1	Paraspio sp. I	1	0
hyllodoce polynoides	1	0	Polydora caeca	0	28
yptis brevipalpa	1	1	Prionospio cirrifera	0	5
icropodarke dubia	0	17	Prionospio malmgreni	20	40
phidromus pugettensis	1	9	Prionospio pinnata	1	0
phiodromus sp.	0	2	Spiophanes berkeleyorum	2	2
ilargis berkeleyae	1	6	Spionidae indet.	0	1
yllis sp. I	1	11	Magelona spp.	22	64
ereis sp. II	0	3	Phyllochaetopterus prolifica	0	1
ereis sp. III	1	8	Mesochaetopterus taylori	1	0
latynereis bicanaliculata	1	9	Telepsavus costarum	0	4
ephtys caecoides	1	0	Caulleriella alata	8	3
ephtys ferruginea	5	3	Chaetozone setosa	6	9
lycera americana	3	10	Chaetozone sp. I	0	3
lycera capitata	7	8	Tharyx sp. I	1	2
lycera siphonostoma	1	0	Tharyx sp.	1	0
lycinde picta	0	8	Pherusa neopapillata	3	4
lycinde sp. I	7	0	Scalibregma inflatum	0	1
oniada maculata	1	1	Armandia brevis	2	2
iopatra ornata	2	0	Travisia brevis	2	0

Table 19 (continued)

Species	A ($0.5 m^2$)	B ($0.5 m^2$)	Species	A ($0.5 m^2$)	B ($0.5 m
Capitellidae indet.	4	20	Ampharete gagarae	2	4
Axiothella rubrocincta	0	1	Pista cristata	1	2
Clymenura columbiana	1	0	Polycirrus sp.	0	3
Euclymene zonalis	0	1	Terebellides stroemi	2	0
Euclymeninae sp.	1	0	Lanassa venusta	1	0
Maldanidae indet.	1	0	Terebellidae indet.	1	0
Pectinaria granulata	12	2			

Table 20

Abundance (N) and rank (R) of Crustacea, Lamellibranchia, and Echinodermata at station 8

	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.6 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
Species	N	R	N	R	N	R	N	R	N	R	N	R	N	R
CRUSTACEA														
Ostracoda														
Euphilomedes carcharodonta	214	1	118	4	4396	1	341	1	216	2	190	1	1197	1
Euphilomedes producta	1	23	0		0		0		0		1	29	1	33
Cumacea														
Diastylis pellucida	0		2	25	0		0		0		0		0	
Diastylis alaskensis	0		0		17	12	1	34	0		1	29	7	17
Isopoda														
Haliophasma geminata	0		0		1	36	0		0		5	14	0	
Tanaidacea														
Leptochelia dubia	0		17	12	8	21	22	9	1	17	24	5	2	28
Amphipoda														
Hippomedon denticulatus	0		0		10	18	1	34	2	13	0		0	
Orchomene decipiens	7	11	1	31	0		2	30	0		0		0	
Ampelisca compressa	0		1	31	0		0		1	17	0		0	
Ampelisca cristata	0		0		5	25	0		0		0		1	33
Ampelisca lobata	0		0		3	30	0		2	13	3	20	2	28
Ampelisca macrocephala	1	23	0		0		0		0		0		0	
Ampelisca pugetica	4	18	6	18	0		3	24	0		0		0	

Table 20 (continued)

Species	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	$1.0\ m^2$		$0.6\ m^2$		$1.0\ m^2$		$1.0\ m^2$		$0.5\ m^2$		$0.5\ m^2$		$0.5\ m^2$	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Amphipoda (continued)														
Byblis veleronis	12	8	18	10	42	8	51	6	9	5	23	7	21	11
Heterophoxus oculatus	23	4	58	5	3	30	9	18	4	8	23	7	4	21
Paraphoxus heterocuspidatus	0		2	25	0		25	8	0		0		0	
Paraphoxus obtusidens	2	21	0		0		0		0		0		0	
Paraphoxus robustus	5	16	2	25	2	33	5	22	0		0		10	13
Paraphoxus similis	0		38	7	0		22	9	2	13	5	14	6	18
Paraphoxus spinosus	0		0		1	36	0		0		0		0	
Paraphoxus tridentatus	1	23	0		0		0		0		0		0	
Paraphoxus variatus	0		0		29	9	0		0		0		0	
Stenothoidae indet.	0		1	31	0		0		0		0		0	
Monoculodes zernovi	0		0		0		0		0		5	14	1	33
Synchelidium rectipalmum	0		0		0		1	34	0		0		0	
Synchelidium shoemakeri	0		0		1	36	0		0		0		0	
Westwoodilla caecula	0		21	9	19	11	6	20	1	17	5	14	9	16
Tiron biocellata	1	23	0		0		0		0		0		0	
Pontogeneia rostrata	0		0		2	33	0		0		0		0	
Melita dentata	1	23	0		0		0		0		0		0	
Melita desdichada	0		0		1	36	1	34	0		0		0	

Table 20 (continued)

Species	1963 13 Feb 1.0 m^2 N	R	3 May 0.6 m^2 N	R	29 July 1.0 m^2 N	R	7 Nov 1.0 m^2 N	R	1964 13 Feb 0.5 m^2 N	R	23 Apr 0.5 m^2 N	R	28 July 0.5 m^2 N	R
Amphipoda (continued)														
Dexamonica reduncam	0		3	24	0		0		0		0		0	
Aoroides columbiae	1	23	0		25	10	4	23	0		0		5	20
Eurystheus thompsoni	0		0		0		4	23	1	17	0		0	
Photis brevipes	0		2	25	7	22	3	24	0		1	29	1	33
Protomedeia sp.	1	23	1	31	52	6	7	19	0		4	18	4	21
Amphitoe sp.	0		0		0		1	34	0		0		0	
Corophium crassicorne	1	23	47	6	166	4	18	11	3	10	39	4	105	4
Ericthonius hunteri	0		4	20	0		0		0		0		0	
Dulichia arctica	0		1	31	0		0		0		3	20	0	
Caprella sp.	0		10	15	0		0		1	17	3	20	3	24
Natantia														
Decapoda natantia, juv.	1	23	4	20	14	16	18	11	1	17	0		2	28
Anomura														
Callianassa sp., juv.	0		0		10	18	1	34	1	17	1	29	0	
Pagurus sp. juv.	17	7	16	13	47	7	60	4	10	4	24	5	6	18
Brachyura														
Pinnixa schmitti	6	12	5	19	7	22	6	20	1	17	3	20	10	13
Lophopanopeus bellus	19	5	32	8	1	36	10	17	0		2	25	0	

Table 20 (continued)

Species	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.6 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Brachyura (continued)														
Cancer sp., juv.	1	23	0		0		3	24	0		1	29	0	
Oregonia gracilis	0		0		1	36	1	34	0		0		0	
LAMELLIBRANCHIA														
Lucinoma annulatus	0		0		1	36	0		0		0		2	28
Parvalucina tenuisculptus	6	12	1	31	9	20	15	14	3	10	12	10	4	21
Axinopsida sericatus	0		0		3	30	0		1	17	1	29	1	33
Clinocardium nuttalli	0		0		16	14	1	34	0		0		10	13
Compsomyax subdiaphana	0		0		0		0		1	17	0		0	
Psephidia lordi	18	6	14	14	658	2	57	5	7	7	11	11	192	2
Macoma alaskana	1	23	0		0		3	24	0		1	29	1	33
Macoma carlottensis	0		1	31	0		0		0		1	29	0	
Macoma inconspicua	4	18	4	20	5	25	17	13	2	13	0		2	28
Macoma yoldiformis	10	10	7	16	5	25	12	15	1	17	4	18	38	7
Macoma spp., juv.	1	23	4	20	2	33	2	30	0		11	11	56	6
Tellina buttoni	0		0		0		3	24	1	17	0		0	
Semele rubropicta	5	16	0		0		1	34	0		0		0	
Solen cicarius	0		0		1	36	0		0		0		0	
Nucula bellotii	6	12	2	25	16	14	3	24	4	8	2	25	15	12

Table 20 (continued)

Species	1963								1964					
	13 Feb		3 May		29 July		7 Nov		13 Feb		23 Apr		28 July	
	1.0 m^2		0.6 m^2		1.0 m^2		1.0 m^2		0.5 m^2		0.5 m^2		0.5 m^2	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
LAMELLIBRANCHIA (continued)														
Yoldia seminuda	1	23	0		6	24	0		0		0		1	33
Crenella columbiana	3	20	1	31	12	17	12	15	8	6	21	9	29	10
Mysella tumida	12	8	141	2	180	3	175	3	16	3	71	3	64	5
Mya arenaria	2	21	0		5	25	1	34	0		1	29	3	24
Pandora filosa	1	23	1	31	0		0		1	17	0		3	24
Lyonsia pugetensis	1	23	0		4	29	2	30	0		2	25	30	9
Cuspidaria oldroydi	0		0		0		0		0		1	29	0	
Lamellibranchia indet.	0		2	25	0		0		0		0		0	
ECHINODERMATA														
Ophiuroidea														
Amphiodia urtica	192	2	169	1	153	5	224	2	251	1	144	2	146	3
Amphipholis squamata	6	12	7	16	17	12	46	7	3	11	3	20	36	8
Holothuroidea														
Leptosynapta clarki	76	3	130	3	0		2	30	0		7	13	0	
Pentamera spp.	1	23	18	10	0		0		0		2	25	3	24

at the various stations. From these curves one may find a factor for each station which, multiplied by the number of species in five samples, gives an estimate of the number of species in ten replicate samples. At station 1 this factor was 1.24; at station 2, 1.20; at station 3, 1.17; at station 4, 1.20; at station 5, 1.25; at station 6, 1.19; at station 7, 1.16; and at station 8, 1.20. The number of species found in five replicate samples during 1964 was multiplied by these factors to make the data comparable to the number of species found in 1963. When the number of samples was neither ten nor five (Table 1), the corresponding conversion factors were determined from Figure 5.

There was considerable stability in the number of species at the various stations during the investigated period and no seasonal trend is revealed (Table 21). The highest number of species occurred at stations 3 and 6 where the substrate was of a mixed type, and the lowest numbers at stations 2 and 7 where the bottom type was a fairly uniform mud.

At station 4 there was a sudden drop in the number of species from August to November 1963, coinciding with a distinct change in the sediment type at the station (page 263). However, throughout the rest of the period of the investigation the number of species gradually increased, and by August 1964 the number was as high as before November 1963. The relatively large variations in number of species at stations 1 and 6 during the period were probably caused by the particular sampling problems (page 245) and the heterogeneity of the environment (page 247).

The lack of seasonal variations in number of species is probably due to the small seasonal variations in the hydrographic parameters as discussed on pages 241 to 244.

The species appearing only in the last five of ten replicate samples were assumed to be rare, and the total number of specimens per square metre has therefore been calculated from the number of specimens in five samples by multiplying by a factor of 2 (Table 21), although the number of specimens may be slightly underestimated by this method. The table shows that there was considerable variation in the number of specimens at the various benthos stations in Puget Sound during the period of investigation. The number of specimens was particularly high at stations 1, 4, and 8, owing to the high abundance of ostracods at these stations (Tables 6, 12, and 20). The number of specimens from the various sampling dates at each station were converted to percentage of the total number of specimens from the station during the period of investigation (Figure 10). Although there is a considerable variability, there seems to be a distinct seasonal

Table 21

Number of specimens (N) and species (S) of Crustacea, Lamellibranchia, and Echinodermata per square metre at the benthos stations in Puget Sound (asterisk * indicates figures based on fewer than 10 samples)

	Stations															
	2		7		4		1		3		8		6		5	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
Jan-Feb 1963	1749	37	245	23	1789	48	2036	47	836	56	666	38	180*	35*	399	39
Apr-May	1034	32	1218*	36*	1270	45	2343*	49*	626	56	1550*	46*	372*	46*	666*	43*
July-Aug	306	31	262	26	3247*	52*	1916*	43*	1565	59	5963	43	764	64	830*	38*
Nov	535	37	156	19	2891	30	3747	55	912	58	1202	44	578*	57*	481*	39*
Feb 1964	266*	28*	442*	20*	1446*	29*	1474*	53*	646*	55*	1072*	36*	438*	40*	226*	33*
Apr	402*	30*	1443*	29*	766*	36*	1586*	60*	476*	52*	1322*	46*	510*	57*	546*	38*
July-Aug	340*	30*	1411*	27*	2552*	49*	4788*	68*	1382*	74*	4066*	47*	610*	43*	430*	38*

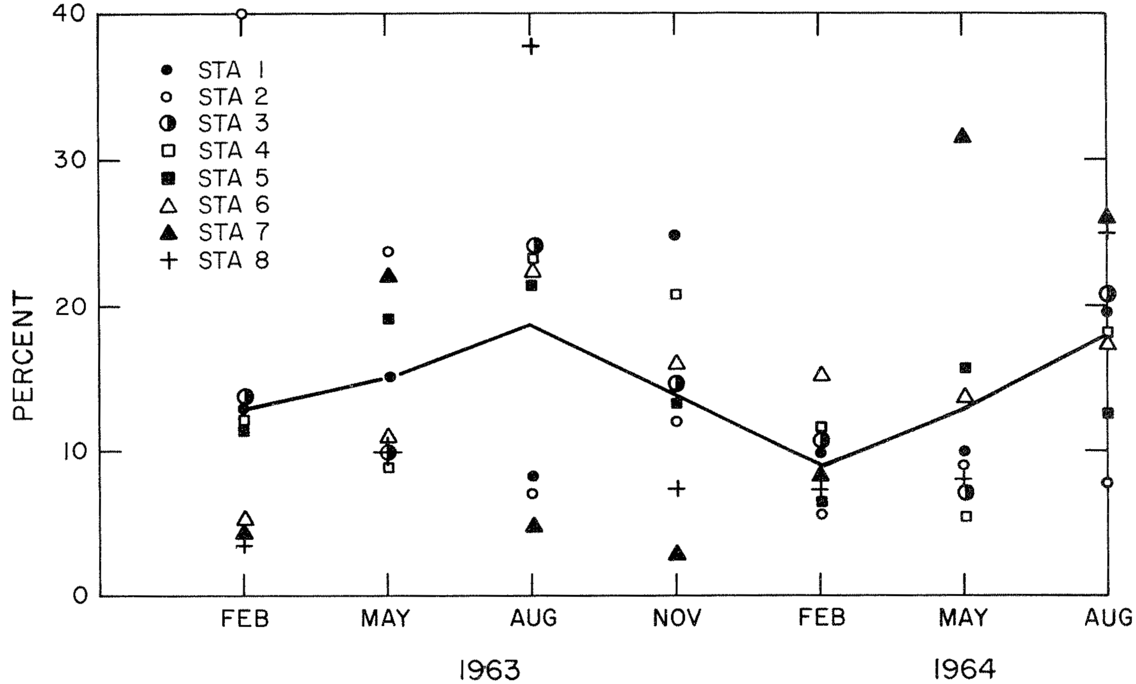

Figure 10. Number of specimens at each station as percentage of total number of specimens collected at that station. Heavy line represents mean for all stations.

trend in the number of specimens as represented by the heavy line for the mean figures for each sampling date. The seasonal variations in the number of specimens were particularly obvious at stations 3, 4, 6, and 8. The minima occurred in late winter or spring and the maxima during the summer, and there was a difference of about 100% between maxima and minima. However, both the difference between maxima and minima and the time of their occurrence is clearly a function of both screen size and time interval between sampling dates.

2. Distribution of taxonomic groups in relation to sediments

Table 21 showed that both number of species and number of specimens was highest at stations with substrate dominated by fine sand, and decreased with finer and coarser sediments. Similar findings for filter-feeders from Buzzards Bay were demonstrated by SANDERS (1958). The relative proportion of the major taxonomic groups at the various stations in January-February and April-May, when polychaetes also were counted and identified, are shown in Table 22. The stations are arranged in order from the finest (station 2) to the coarsest (station 5) substrate, according to Figure 9. The polychaetes comprised about 49-70% of the number of species, crustaceans about 16-30%, echinoderms about 2-6%, and lamellibranchs about 9-23%. There was a gradual increase in number of species of polychaetes from soft to hard bottom, the opposite trend was revealed for the lamellibranchs, while crustaceans and echinoderms showed no significant trend in relation to sediment types.

Table 22 also shows the relative proportion of the total number of specimens of the major taxonomic groups. The most significant features are that the number of echinoderms was highest on the stations with the coarsest sediment, and the proportion of crustaceans is particularly high at the sand-bottom stations. The proportion of polychaetes seemed to increase towards the coarser bottom types. The proportion of lamellibranchs decreases heavily towards the coarser bottom types, and this phenomenon was also reflected in the absolute number of specimens.

3. Patchiness of numerically dominant species

Patchiness is a parameter of the species population with considerable significance in quantitative ecology. The patchiness estimated from random samples of a community may be a function of active aggregation or a result of inherent sampling deficiencies. The effect of the sample sizes and the spacing of replicate samples in relation to patchiness is discussed in detail in GREIG-SMITH (1964).

Tabell 22

Number of species (S) and specimens (N) per square metre of Polychaeta, Crustacea, Lamellibranchia, and Echinodermata in January-February (A) and April-May (B) 1963

Stations

		2				7				4				1			
		S	%	N	%	S	%	N	%	S	%	N	%	S	%	N	%
Polychaeta	A	35	48.61	379	17.81	34	59.65	237	49.17	85	62.96	1646	47.92	68	59.13	910	31.23
	B	33	50.77	304	21.90	66	65.35	414	25.37	64	58.72	1157	47.69	71	59.17	980	29.50
Crustacea	A	21	29.17	468	21.99	9	15.79	110	22.82	26	18.52	894	26.03	30	25.22	1724	59.16
	B	19	29.23	143	10.30	24	23.76	784	48.04	26	23.85	800	32.98	26	21.67	1841	55.42
Lamellibranchia	A	13	18.06	1243	58.41	13	22.81	120	24.89	20	16.30	850	24.75	15	13.04	274	9.40
	B	9	15.38	833	63.62	10	8.91	28	1.75	17	15.60	466	19.20	19	15.83	481	14.48
Echinodermata	A	3	4.17	38	1.79	1	1.75	15	3.11	3	2.22	45	1.31	2	2.61	6	0.21
	B	3	4.62	58	4.20	2	1.98	406	24.88	2	1.83	4	1.60	4	3.33	20	0.60

Stations

		3				8				6				5			
		S	%	N	%	S	%	N	%	S	%	N	%	S	%	N	%
Polychaeta	A	60	52.63	892	51.62	66	63.46	454	40.54	68	64.76	622	77.36	56	59.57	510	56.11
	B	80	58.82	342	35.40	67	63.21	1318	45.96	90	66.17	1016	73.20	65	60.19	888	57.14
Crustacea	A	22	19.30	484	28.01	20	19.23	320	28.57	17	17.14	97	12.06	25	26.60	277	24.97
	B	31	22.79	338	34.99	24	22.64	700	24.41	22	16.17	166	11.96	29	24.22	562	36.16
Lamellibranchia	A	26	22.81	306	17.71	14	13.46	71	6.34	12	12.38	41	5.10	10	8.51	20	2.20
	B	21	15.44	231	23.91	11	10.38	300	10.46	18	13.23	150	10.81	9	8.33	20	1.29
Echinodermata	A	6	5.26	46	2.66	4	3.85	275	24.55	6	5.71	44	5.47	5	5.32	152	16.72
	B	4	2.94	55	5.69	4	3.77	550	19.18	6	4.41	56	4.03	5	4.63	84	5.40

When sampling is done from a surface ship, the spatial distribution of subtidal benthic infauna is estimated from the variability in counts from replicate samples. An exact description of the patchiness may be ascertained using samplers of various sizes and by spacing the samples in a grid or some other nonrandom way. However, although this method may be recommended for studies of single-species populations, its laboriousness prevents its use in any large-scale synecological analysis.

The frequency of sample counts of replicate samples of randomly distributed populations will conform to a Poisson distribution, in which the ratio between variance and mean is unity. This ratio, which is known as the coefficient of dispersion, indicates evenness of distribution when lower than unity, with ratios larger than one indicating some degree of patchiness. However, as discussed by URSIN (1960), there is a relationship between the variance and the mean, so that when the mean is small the ratio will always be close to unity. The degree of patchiness as measured by the coefficient of dispersion is therefore dependent upon the mean, i.e., a function of sample size.

The negative binomial distribution has found wide application in biology (BLISS and FISHER 1953), and one of the parameters $k = \bar{x}^2/(s^2 - \bar{x})$, where $\bar{x}$ is mean abundance and s^2 is the variance, has frequently been used as a measure of patchiness. This parameter is independent of sample size (TAYLOR 1953) and therefore preferable to the coefficient of dispersion as a measure of nonrandomness of distribution.

The parameter k has been calculated for all species of Crustacea, Lamellibranchia, and Echinodermata from the Puget Sound material. The parameter is useful only for measuring overdispersion, and since for most of the species the variance often was equal to or smaller than the mean, it was not possible to calculate an average value for k for comparing the patchiness of different species. The ranking listed in Table 23 showing the numerically dominant species of Crustacea, Lamellibranchia, and Echinodermata in decreasing order of patchiness is based on the proportion of observations indicating randomness or underdispersion ($k \leq 0$). The table is based on values of k for means larger than one and with more than 90% efficiency of the estimate (ANSCOMBE 1949). The parameter k decreases with increasing patchiness, and Table 23 shows that nearly the same ranking of the numerically important species would have resulted from the increasing proportions of values of k between 0 and 5. The reciprocity of the rankings based on frequency of observations indicating randomness or underdispersion and the highest degree of overdispersion suggests that the ranking list

Table 23

Ranking list of numerically important species of Crustacea, Lamellibranchia and Echinodermata according to proportions of observations indicating random or even distribution

Species	Random or underdispersed $k \leq 0$	Overdispersed $k > 10$	$5 < k < 10$	$0 < k < 5$	Number of observations
Semele rubropicta	4	0	0	0	4
Brisaster townsendi	6	1	0	0	7
Macoma calcarea	4	0	0	2	6
Mya arenaria	3	1	1	2	7
Nucula bellotii	9	3	2	5	19
Heterophoxus oculatus	16	7	2	11	36
Macoma alaskana	3	1	0	3	7
Crenella columbiana	7	4	2	6	19
Pinnixa schmitti	7	2	1	11	21
Axinopsida sericata	10	5	5	9	29
Amphiodia urtica	8	1	3	13	25
Byblis veleronis	9	7	5	10	31
Macoma carlottensis	3	3	3	6	15
Lophopanopeus bellus	4	3	2	8	17
Eudorella pacifica	4	2	1	12	19
Euphilomedes producta	6	4	4	15	29
Mysella tumida	4	2	5	11	22
Psephidia lordi	4	3	1	15	23
Leptosynapta clarki	3	5	5	9	22
Euphilomedes carcharodonta	3	8	10	17	38
Leptochelia dubia	1	3	1	10	15
Paraphoxus variatus	0	3	0	8	11

has some biological significance. One would have to seek explanations for the ranking list from the knowledge of the ecology and biology of the composite species, but unfortunately practically nothing is known about most of the species on the list. However, it may be more than coincidence that the nine species with the highest degree of patchiness all have some degree of viviparity or brood-protection. After being released from the females, the offspring of these species may conceivably settle close together and form patches as dense as their niche-requirements will permit. Species with planktonic larvae, on the other hand, would be expected to reveal a more random distribution in a homogeneous environment. Similarly in plant ecology, overdispersion has been explained according to prevalence of vegetative reproduction (CLAPHAM 1936, WHITFORD 1949).

E. Standing crop

1. Standing crop of benthic infauna

Total standing crop of macrobenthos is a parameter of doubtful significance in quantitative ecology, particularly because the samples include species highly different in age and size, and therefore any inference from the estimates of standing crop to productivity is apt to be erroneous (THORSON 1957).

Meiofauna outnumbers macrofauna in number of specimens by several orders of magnitude (SANDERS 1960, McINTYRE 1961, WIGLEY and McINTYRE 1964) and, furthermore, since meiofauna generally has higher metabolic rate per unit weight and shorter generation time, it may be questioned whether the productivity of macrofauna adequately represents the community productivity. However, the standing crop of the meiobenthos in SANDERS' study comprised only 3% of the macrobenthos, in McINTYRE's study from 6.6 to 28.0%, and in WIGLEY and McINTYRE's study 4.2%. The low standing crop and the fact that a certain part of the meiofauna constitutes juvenile stages of macrofauna lead to the conclusion that the macrofauna is responsible for the major part of the level-bottom productivity (THORSON 1966).

In the present study, total weights as a rule are not available, but the standing crop of the dominant species populations has been estimated for each season. To determine which proportion of the total standing crop the important species comprise and partly to compare standing crop data from Puget Sound with data from other areas, the total standing crop was determined for the samples collected in August 1964. Epifauna (particularly coelenterates) and gastropods were removed from the samples before weighing. The wet weights of the major taxonomic groups were determined, and the data were converted into data for dry organic matter by conversion factors derived from studies of the wet weight/organic matter relationships for the numerically dominant species. For polychaetes, crustaceans, and lamellibranchs, the mean conversion factors were 0.133, 0.150, and 0.055, respectively. For echinoderms the factor 0.122 was used for ophiurids, 0.076 for holothurians, and 0.033 for echinoids. For "miscellaneous groups" the factor 0.130 was used for sipunculids, 0.133 for nemertea (same as for polychaetes), and 0.055 for brachyopods (same as for lamellibranchs).

There was considerable stability among the replicates in the wet weights of polychaetes and crustaceans, while particularly the wet weights of echinoderms and miscellaneous groups varied drastically (Table 24). At stations 1, 2, 4, and 6 the total wet weight among replicates varied with a factor of less than 2, while at stations 3, 5, 7, and 8 the factor was about 4. It is obvious that attempting to estimate total standing crop of benthos from a small number of samples is not to be recommended. Mean figures determined from replicate samples are preferable, because they provide a measure of variability, but the variance is normally so high that even this approach has little predictive power.

A more meaningful comparison of the relative importance of the various taxonomic groups may be made when wet weights are converted to dry organic matter. Figure 11 shows that the polychaetes were generally the dominant group with from 37.8% of the total dry organic matter at station 5 to 82.3% at station 7. There was a clear tendency of decreasing relative importance of polychaetes towards harder sediment types. Crustaceans comprised from 1.9 to 12.7% of the total dry organic matter, and at the stations dominated by fine sand (stations 4, 3, 1, and 8) the crustaceans comprised more than 10%. Lamellibranchs comprised from 1.0% of the total dry organic matter at station 2 to 17.3% at station 4; there was no distinct trend among the stations in the relative proportion of the weight of lamellibranchs. On the average, the lamellibranchs comprised about 8-10% of the dry organic matter. Echinoderms generally accounted for about 6-9%, but at station 2 the echinoid Brisaster townsendi comprised 63.8% of the dry organic matter, and at station 5 the holothurians Pentamera spp. and Leptosynapta clarki comprised 41.4%. "Miscellaneous groups" comprised from 9.6 to 32.5% of the dry organic matter at stations 1, 3, 8, 6, and 5, owing particularly to the abundance of the sipunculid Golfingia pugettensis.

The relative proportions of the total weight attributed to the various taxonomic groups in Puget Sound were different from the results of HOLME (1953) from the English Channel, where Polychaeta comprised 26%, Crustacea 10%, Lamellibranchia 35%, and Echinodermata 18% of the total standing crop.

Seven of the stations in Puget Sound had from 8 to 12 grammes of dry organic matter per square metre, while station 2 had about 19 grammes (Figure 11). However, the major part of the standing stock at station 2 is made up of Brisaster townsendi, which probably has a very slow growth and high age. In terms of productivity, therefore, there seems to be little reason to distinguish among the benthos stations in Puget Sound.

HOLME (1953) found an average standing crop measured in dry weight and corrected for calcareous deposits, inorganic gut content, and sieving errors to be about 10 g/m^2. SANDERS (1956) compared the standing crop of macrofauna from Long Island Sound with data from earlier investigations from European waters, and found that the standing crop in Long Island Sound was considerably higher, about four to five times higher than in the English Channel as determined by HOLME (1953). SANDERS stressed the difficulties in comparisons resulting from different sampling techniques and different treatment of the samples.

The productivity of benthos is presumably related to the primary production of the water masses. In Long Island Sound, the annual primary production was 470 g C/m^2 (RILEY 1956), and at the two productivity stations in Puget Sound, 268 and 459 g C/m^2 (see page 244). The difference between Long Island Sound and Puget Sound in standing crop of macrofauna seems to be considerably greater than the difference in primary production; but unless the age structure and the metabolism of the benthos from the two areas are similar, the standing crop is a doubtful indicator for productivity (THORSON 1957).

2. Seasonal variation in standing crop

The large variability in standing crop from replicate samples (Table 24) tends to obscure seasonal trends. Much of the variability is caused by large and rare species, and it seems reasonable that any conclusions about seasonal variations must be based on species for which there are reliable estimates of abundance. Table 25 shows the ash-free dry weight of the numerically dominant species of Crustacea, Lamellibranchia, and Echinodermata through the investigated period. There were considerable differences among the cruises at the various stations, but there was no distinct seasonal trend. This is in contrast to the results of a benthos study during the period 1949-1960 in the German Bight by ZIEGELMEIER (1963). In two of the years the biomass (displacement volume) was higher in spring than in the autumn of the same year, but for the rest of the

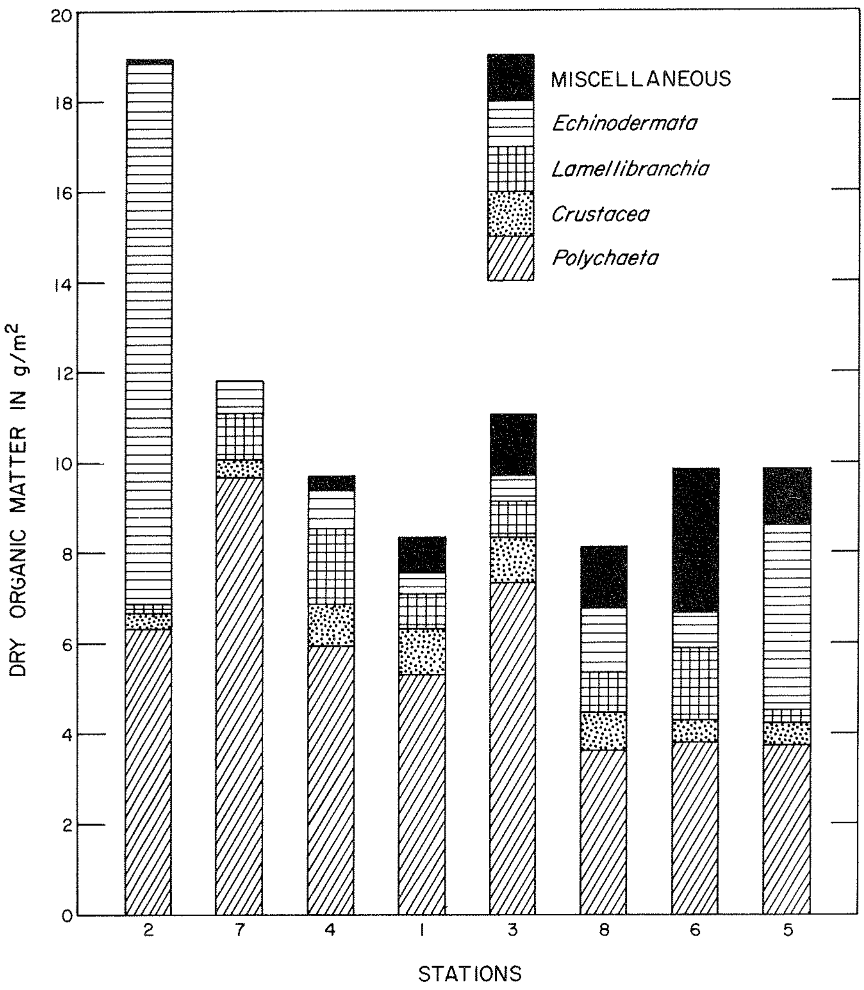

Figure 11. Standing crop as dry organic matter in grammes per square metre of the main taxonomic groups.

Table 24

Total standing crop and the standing crop of the major groups of benthic infauna in milligrammes per 0.1 square metre at the benthos stations in Puget Sound in July-August 1964

	Samples 1	2	3 Wet weights	4	5	6	Mean wet weight	Mean ash-free dry weight
Station 1								
Polychaeta	5140	4920	4650	2780	2350		3968	528
Crustacea	750	630	740	650	770		708	106
Lamellibranchia	995	948	1586	1322	2132		1397	77
Echinodermata	600	320	750	570	800		608	46
"Miscellaneous groups"	200	2090	570	120	40		604	80
Total standing crop	7685	8908	8296	5442	6092		7285	837
Station 2								
Polychaeta	3550	7970	5870	2590	3610		4718	627
Crustacea	50	1030	30	30	40		236	35
Lamellibranchia	490	220	160	436	320		325	18
Echinodermata	39280	36750	38590	23520	44640		36556	1206
"Miscellaneous groups"	10	20	90	20	60		40	5
Total standing crop	43380	45990	44740	26596	48670		41875	1891
Station 3								
Polychaeta	2620	4020	6450	11050	1320	7660	5520	734
Crustacea	490	1160	250	960	810	370	673	101
Lamellibranchia	1068	0	1721	2750	409	2721	1445	80
Echinodermata	3010	20	420	1530	250	0	872	65
"Miscellaneous groups"	210	600	20	2980	1770	10	932	124
Total standing crop	7398	5800	8861	19270	4559	10761	9442	1105
Station 4								
Polychaeta	4700	3490	3270	5770	5050		4456	593
Crustacea	370	420	600	740	810		588	88
Lamellibranchia	2321	5372	1123	4467	1975		3052	168
Echinodermata	1170	200	2020	780	1550		1144	86
"Miscellaneous grops"	50	1240	40	80	90		300	34
Total standing crop	8611	10722	7053	10837	9475		9540	969
Station 5								
Polychaeta	5220	1820	1110	1930	3920		2800	372
Crustacea	310	650	90	430	230		342	51
Lamellibranchia	40	1000	1065	224	269		520	29
Echinodermata	750	1320	19820	620	4620		5426	407
"Miscellaneous groups"	300	1020	1130	1920	320		938	124
Total standing crop	6620	5810	23215	5124	9359		10026	983
Station 6								
Polychaeta	3250	3580	2220	2000	3200		2850	379
Crustacea	510	350	230	340	190		324	49
Lamellibranchia	4454	3365	3364	1619	1072		2775	153
Echinodermata	950	1700	440	730	1090		982	73
"Miscellaneous groups"	1700	1080	3960	5050	190		2400	319
Total standing crop	10864	10075	10214	9759	5742		9331	973

Table 24 (continued)

Station 7								
Polychaeta	9830	7620	5020	2640	15500	3250	7310	972
Crustacea	110	240	290	390	320	280	272	41
Lamellibranchia	293	200	4900	84	536	3573	1598	88
Echinodermata	470	880	910	750	500	730	707	79
"Miscellaneous groups"	10	0	0	0	20	30	10	1
Total standing crop	10713	8890	11120	3864	16876	7863	9897	1181
Station 8								
Polychaeta	5600	1080	2520	2070	2320		2718	361
Crustacea	470	700	600	540	520		566	85
Lamellibranchia	3424	745	1950	830	1226		1635	89
Echinodermata	5050	280	360	320	330		1268	142
"Miscellaneous groups"	4280	100	170	170	370		1018	135
Total standing crop	18824	2905	5600	3930	4766		7205	812

Table 25

Ash-free dry weight in milligrammes per square metre of the numerically dominant species of Crustacea, Lamellibranchia, Echinodermata, and the sipunculid Golfingia pugettensis

	Stations							
	2	7	4	1	3	8	6	5
Jan-Feb 1963	13011	255	917	230	942	1223	1559	1876
Apr-May	11137	1535	319	344	735	2918	1227	2459
July-Aug	18520	421	963	345	1017	1584	2462	3162
Nov	10574	224	500	844	708	1126	2992	3803
Feb 1964	8378	357	293	569	1481	2198	289	2311
Apr	13012	1312	289	352	285	1524	1039	1220
July-Aug	12328	938	1035	1099	364	2960	2475	658

years the biomass in autumn was on the average 62.7% higher, ranging from 15.0 to 164.3%. However, contrary to the conditions in Puget Sound there were considerable seasonal variations in the temperatures in the German Bight.

The numerically dominant species of Crustacea, Lamellibranchia, and Echinodermata in August 1964 comprised on the average 53.86% of the total standing crop of the same taxonomic groups. For the various stations the percentages were: station 1, 48.0%; station 2, 97.9%; station 3, 14.7%; station 4, 30.3%; station 5, 11.2%; station 6, 90.0%; station 7, 45.1%; and station 8, 93.7%. Excluding Pentamera spp. from the dominant species caused the low percentage at station 5, while the cause at station 3 probably was the high diversity.

F. Similarity among the faunal assemblages

When communities are described by classical methods based on characteristic species (THORSON 1957), the similarities among the various communities cannot be measured quantitatively. Today there are mathematical methods for delimiting communities, which permit objective measurement of affinity. FAGER (1957) discussed a method for describing communities as recurring groups of species, and various multivariate analyses (GOODALL 1954, WILLIAMSON 1961, 1963, COLEBROOK 1964) have recently been widely used. The multivariate analyses seem advantageous to FAGER's method in that they are based on abundance of species rather than frequency of occurrence and the mathematics involved are parametric statistics rather than rank correlations.

Both the classical methods and the new mathematical methods are attempts to bring order out of a more or less chaotic mass of data resulting from extensive ecological surveys. The methods are hardly applicable, however, when the number of stations is small (SANDERS 1956), as was the case in the Puget Sound study. Regardless of method, the fauna from the eight permanent stations distributed in different environments would probably result in eight different communities. However, since the stations in Puget Sound were located in different environments, it is possible to use the data for a study of the similarity between the faunal assemblages as a function of abiotic parameters.

Simple mathematical equations for calculating the degree of similarity between communities based on co-occurrence of species from pairs of stations have been suggested by JACCARD (1908) and SØRENSEN (1948). However, the

Table 26

Order of stations according to (A) degree of similarity and (B) softness of substrate

	Stations							
(A) Similarity								
Jan-Feb 1963	2	7	4	3	1	8	6	5
Apr-May	2	7	4	1	8	3	6	5
July-Aug	2	7	4	3	1	8	6	5
Nov	2	7	4	3	1	8	6	5
Feb 1964	2	7	4	1	8	3	6	5
Apr	2	7	4	1	3	8	6	5
July-Aug	2	7	4	3	1	8	6	5
Average	2	7	4	1	3	8	6	5
Feb 1963 with Polychaeta	2	7	4	1	3	8	6	5
Five out of seven cruises	2	7	4	3	1	8	6	5
(B) Softness of substrate	2	7	4	1	3	8	6	5

parent distributions of these equations are unknown (LOOMAN and CAMPBELL 1960) and therefore the measured affinity between two stations cannot be tested for coincidence. LOOMAN and CAMPBELL suggested a method based on rank correlation methods (KENDALL 1962) in which the measured similarity can be tested for coincidence by chi-square. The coefficient of similarity, T, is based on the number of co-occurring species, and is calculated for all possible pairs within a set of stations.

The coefficient has been calculated for the stations in Puget Sound from each sampling date based on Crustacea, Lamellibranchia, and Echinodermata, and the stations have been arranged in a matrix according to the degree of similarity to station 2, which had the lowest affinity to the other stations. The order of the stations resulting from the arranged matrices from each sampling date is shown in Table 26. The index of similarity was also calculated from January-February 1963 with the Polychaeta included. The order of the stations as determined from the index of similarity is particularly interesting when viewed in relation to the order of the stations based on the particle size analysis of the sediments (Figure 9, page 270). Table 26 shows that the order is the same as for the average of the index of similarity.

Table 27

Number of cruises with significant affinity among faunal assemblages from the eight benthos stations in Puget Sound

	Stations							
Stations	2	7	4	1	3	8	6	5
2		3	0	0	0	0	0	0
7			3	0	1	0	1	0
4				6	4	6	0	0
1					2	3	2	0
3						2	4	0
8							5	1
6								5

The method for calculating the index of similarity among communities is based on the absence and presence of species, thus giving equal weight to abundant and rare species. Many of the rare species could be stray individuals that might not be typical or constant members of the communities, and it can be argued that part of the measured similarity between two neighbouring communities may be caused by contamination between the two. To reduce this source of error, the index of similarity was calculated based on the species that occurred in at least five out of the seven cruises at a station (Table 26, "five out of seven"). The resulting order is the same as the order based on sediment types except for stations 1 and 3.

The index of similarity measures observed affinity against expected coincidence, and the stations have been ordinated according to the number of cruises at which the affinity between any pair of stations was significant on the 95% level of probability (Table 27). Station 2 was placed first in the matrix partly because it represents an environmental extreme, and partly because it had the lowest number of significant affinities with other stations. The order of the stations is again the same as for the sediment types.

It may be objected that the measured affinity among communities is imperfect because it is based on absence and presence of species only, while communities also differ in the relative abundance of the various species, i.e. by the structure of the communities as represented by the numerically dominant species. The species of Crustacea, Lamellibranchia, and Echinodermata that were ranked as the ten most abundant through the investigated period at each station were

Table 28

The ten most abundant species at each of the benthos stations in Puget Sound from January-February 1963 to July-August 1964

Species	Stations 2	7	4	3	1	8	6	5
Macoma carlottensis	1							
Brisaster townsendi	2							
Axinopsida sericata	3		4	7	7			
Euphilomedes producta	4	5	8	2	2			
Eudorella pacifica	5	2						
Heterophoxus oculatus	6	6		9	9	9	1	6
Eudorellopsis sp. I	7							
Pandora filosa	8							
Ampelisca macrocephala	9							
Leucon sp. I	10							
Amphiodia urtica		1				2	9	
Euphilomedes carcharodonta		3	1	3	1	1	3	
Pinnixa barnharti		4						
Nucula bellotii		7	5					
Protomedia spp.		8	10					
Callianassa sp., juv.		9						
Mysella tumida		10	6		8	3		
Pinnixa schmitti			2	8				
Paraphoxus variatus			3					
Tellina buttoni			7					
Psephidia lordi			9	4		4		
Byblis veleronis				1	5	5		2
Crenella columbiana				4	10	10		
Macoma alaskana				6				
Macoma calcarea				10				
Leptochelia dubia					3			
Cylindroleberis mariae					4			
Macoma spp., juv.					6			

Table 28 (continued)

Species	Stations 2	7	4	3	1	8	6	5
Pagurus spp., juv.						6		
Corophium crassicorne						7		
Amphipholis squamata						8	2	2
Leptosynapta clarki							4	4
Lophopanopeus bellus							5	1
Lyonsia pugetensis							6	
Mya arenaria							7	
Ericthonius hunteri							8	
Pentamera spp.							10	5
Tiron biocellata								7
Synchelidium rectipalmum								8
Ampelisca compressa								9
Caprella spp.								10

arranged in a matrix according to the number of dominant species any pair of stations had in common (Table 28). Station 2 was placed first in the matrix because it represents an environmental extreme, and the resulting ordination of stations was again identical to the ordination based on the index of similarity, T, and sediment types (Table 26), except that stations 1 and 3 have changed place. However, the two stations are very similar in sediment type as mentioned above, and Table 28 shows that they also had many numerically dominant species in common.

It seems that the faunal assemblages at the various stations in Puget Sound are gradually changing from one environmental extreme to another, and the sediment type seems to be the overwhelmingly dominant environmental parameter. This may, however, be a phenomenon specific for Puget Sound, since the hydrographic parameters were relatively constant and similar at the various stations (page 243). The low degree of similarity of station 2 to other stations may in part be a function of its considerably greater depth.

G. Relationships between the faunal assemblages in Puget Sound and known benthic communities

For an adequate description of communities, fairly large areas of the bottom must be surveyed in order to be able to separate the general trend from local variability (THORSON 1957). The present study of benthic infauna therefore does not satisfy the requirements for a classical community analysis, but a comparison of the faunal assemblages in Puget Sound with known communities may give an indication of the classification of assemblages.

The fauna at stations 1, 3, 4, and 6 was not directly comparable to any of the communities listed in SPÄRCK (1935) or THORSON (1957). At all these stations the fauna was characterized by a lack of large and conspicuous species with definite importance to the total standing crop. Similarly, BARNARD and HARTMAN (1959) found it difficult to characterize the fauna from inshore sandy bottoms of southern California by important species.

A significant feature of the shallow-water sand-bottom stations was the numerical preponderance of ostracods, and at stations 1 and 8 they also contributed significantly to the total standing crop.

At station 5, which is characterized by a very coarse sand or gravel, the fauna was dominated by echinoderms and crustaceans (Tables 13 and 14), and there was little similarity to known benthic communities.

The fauna at station 2 was dominated numerically by the lamellibranchs Macoma carlottensis and Axinopsida sericata; the ostracod Euphilomedes producta; and the polychaetes Glycera capitata, Pectinaria californiensis, and Pholoë minuta. However, the standing crop was completely dominated by the echinoid Brisaster townsendi, and the polychaete Travisia pupa. Other important contributors to the standing crop were the holothurian Molpadia intermedia and the echiuroid Nellobia eusoma. The community thus has features in common with a Macoma-community (THORSON 1957), with a Brissopsis-community (PETERSEN 1915, 1918), and with the Listriolobus-community of BARNARD and HARTMAN (1959).

The European Amphiura-communities are replaced in the Pacific Ocean by various Amphiodia- (or Amphioplus-) communities (THORSON 1957), and BARNARD and ZIESENHENNE (1961) described an Amphiodia urtica-community that was widely distributed off the coast of southern California, associated with silty sand or sandy silt.

Amphiodia urtica was a dominant species both in numbers and standing crop at stations 7 and 8 in Puget Sound. The two stations were highly different in bottom types (Figure 9, page 270), and the codominants and subdominants were also different in the two assemblages. The fauna at station 7 was the most similar to the Amphiodia urtica-community described by BARNARD and ZIESENHENNE, but both assemblages may be considered facets of the Amphiodia urtica-mega-community.

The comparison above indicates that only three of the eight stations in Puget Sound show any resemblance to earlier described communities, and particularly that the fauna from the shallow water sand stations are lacking in similarity to other communities. These stations have, however, certain features in common. They are dominated by the ostracod Euphilomedes carcharodonta, amphipods of the families Ampeliscidae and Phoxocephalidae, the polychaete genera Lumbrineris and Prionospio, and the lamellibranchs Mysella tumida and Psephidia lordi. A survey of the inshore sandy bottoms in the eastern North Pacific Ocean might determine whether these assemblages represent a distinct benthic community.

H. Diversity

1. Indices of diversity as measurable parameters of communities

Number of species as a measure of the species diversity is a useful parameter for studies of communities (MacARTHUR 1965), but more information about the community would be contained in a parameter that also encompassed the number of specimens. The ratio between the number of specimens and the number of species is meaningless, partly because the measurement implies that the specimens are equally distributed among the species, and partly because the ratio would be strongly dependent on sample size and would be affected by sampling variability. If indices of diversity are to be meaningful parameters for communities, they must remain reasonably independent of sample size, provided a minimum area of the community has been sampled.

The indices of diversity may be separated into two distinct groups, one based on assumptions about a theoretical distribution of specimens among the species, and one "distribution free," i.e., based on observed rather than theoretical distribution of specimens among the species (WHITTAKER 1965). To the first group belongs the index d, which was suggested as an index of diversity by MARGALEF (1958). It is based on the assumption by GLEASON (1922) that there is a linear relationship between the number of species in a community and the logarithm of the sample area. The index $\underline{\alpha}$ (FISHER, CORBETT and WILLIAMS 1943), based on the assumption that the relationship between number of species and number of specimens in a community conforms to a logarithmic series, is another index of diversity belonging to the first group.

To the second group belong the indices derived from information theory (SHANNON and WEAVER 1963), which provide a method for calculating the degree of dominance (redundancy) in the communities.

Indices of diversity have been found to be practical tools for comparisons of communities (MARGALEF 1958, HAIRSTON 1959), for studies of niche-diversification among birds (MacARTHUR and MacARTHUR 1961), and for studies of geographic and seasonal variability (PATTEN 1962, WILLIAMS 1964). However, there are theoretical implications that the indices of diversity are also related to community evolution and succession (MARGALEF 1958), to environmental complexity and interspecific relations (WHITTAKER 1965), and to the stability of communities (MacARTHUR 1955). The stability of a community is dependent upon the number of pathways by which the energy may flow through the community; i.e., a high number of species in the various trophic levels stabilizes the community.

Two indices of diversity and a measure of redundancy have been calculated for the Puget Sound infauna. The indices were based on data on Crustacea, Lemellibranchia, and Echinodermata, and calculated for each sample and for pooled data from five and ten replicate samples. In addition, the indices of diversity from Januar-February and April-May 1963 with Polychaeta included is discussed on page 363.

2. MARGALEF's index of diversity

The index $\underline{d} = (S - 1)/\ln N$ (S = number of species, N = number of specimens) was suggested as an index of diversity by MARGALEF (1958), and used in a study of spatial heterogeneity and temporal succession of phytoplankton communities. One of the virtues of $\underline{d}$ as an index of diversity is that it is more sensitive to changes in the number of species than in number of specimens. MARGALEF considered indices of diversity derived from information theory to be theoretically superior, but the complexity of their calculations prevented their use. In a study of the distribution of letters in a Spanish text he found that the index $\underline{d}$ was a good approximation to the indices derived from information theory. The validity of comparing letters in a text and species in a community was criti-

Table 29

MARGALEF's index of diversity (d) at the stations

Dates		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	1963	3.7	3.3	5.5	4.9	7.0	4.8	6.5	5.0
Apr-May		3.9	4.4	5.4	4.9	6.8	5.0	6.9	5.7
July-Aug		4.0	3.4	5.6	5.0	6.5	4.7	7.9	5.2
Nov		4.8	3.9	2.9	5.1	7.7	5.1	8.0	6.1
Feb	1964	4.5	2.6	3.5	4.6	7.6	4.4	6.0	5.3
Apr		4.7	3.4	4.7	6.7	7.4	5.7	8.2	5.0
July-Aug		4.7	3.4	5.5	6.7	9.1	4.9	5.8	5.3
Mean		4.3	3.5	4.7	5.4	7.4	4.9	7.1	5.4
95% confidence limits, $\pm$:		0.43	0.52	1.02	0.82	0.78	0.37	0.93	0.37

cized by HAIRSTON (1959), who stated that the similarity between the two indices of diversity was merely coincidental.

The validity of d as an index of diversity depends on whether there exists a linear relationship between the number of species and the logarithm of the sampling area. Figure 5, page 250 shows that this was largely the case in the present material.

The variability in d calculated from pooled data from five replicate samples from the eight benthos stations in Puget Sound through the period of investigation is shown in Table 29. The sensitivity of d to changes in species numbers is demonstrated at station 4. In November 1963 there was a sudden decrease in the diversity at station 4, but the index gradually increased back to the normal level in August 1964. The change in diversity was correlated with a simultaneous change in the sediment composition at the station (see page 263) that made the number of species drop from 52 to 30, while the number of specimens changed relatively less, from 3247 to 2891. The change in the environment resulted in unfavorable conditions for the community and the rare species that were the least adapted became extinct. The index of diversity, d, seems therefore to be useful for describing the effect on the fauna by changes in the environment.

However, the index is not well suited for describing changes in the relative abundance of the species. At station 2 there was a significant decrease in the number of specimens, from 1749 to 306 from February to August 1963, caused by the decrease in the number of specimens of Macoma carlottensis from 1119 to 32. However, as the number of species during the same period changed from 37 to 31, the index of diversity remained practically unchanged (Table 29).

The highest diversity was measured at stations 3 and 6, the lowest at stations 2 and 7, while the rest of the stations did not differ significantly in diversity (Figure 12). Stations 2 and 7 represent a uniformly soft, silty substrate, which offers less diversified niches than stations 3 and 6, where the substrate was of a more mixed type. In general there seems to be a correlation between the index of diversity, d, and the complexity of the environment.

Ostracoda contributed significantly to the number of specimens particularly at stations 1 and 8 (average 67% and 39%, respectively) but the number of species identified in the Puget Sound material was only 4. When the index of diversity, d, was calculated without the ostracods, it changed only from 0.9 to 7.4%, again indicating that the index is unsuited for detecting important differences in the relative abundance of the species in a community.

3. The SHANNON-WIENER function as an index of diversity

The index

$$H = -\sum_{i=1}^{s} p_i \log_2 p_i$$

(p_i = proportion of the abundance of species i, s = number of species) has been used as an index of diversity by MacARTHUR and MacARTHUR (1961), MacARTHUR (1965), and PATTEN (1962).

As seen from the estimating equation, the index H is a sum of empirically observed integers. The requirement for its validity is that it represents an ergodic process, i.e., that the sequence of symbols produced by the process is always the same in statistical properties (SHANNON and WEAVER 1963). In synecological terms this means that the proportions of abundance of the various species must be relatively constant and adequately represented by the sample. Therefore, a certain minimum sample size must be ascertained in order to secure adequate representation of the community. Here H was calculated for single samples and for pooled data from five and ten replicate samples. The average increase in H between single samples and data from five samples was about 8%, and the difference between H from five and ten samples was about 4%. It therefore seems that the index of diversity H remained reasonably stable when the sampling area was 0.5 m^2 (five replicate samples).

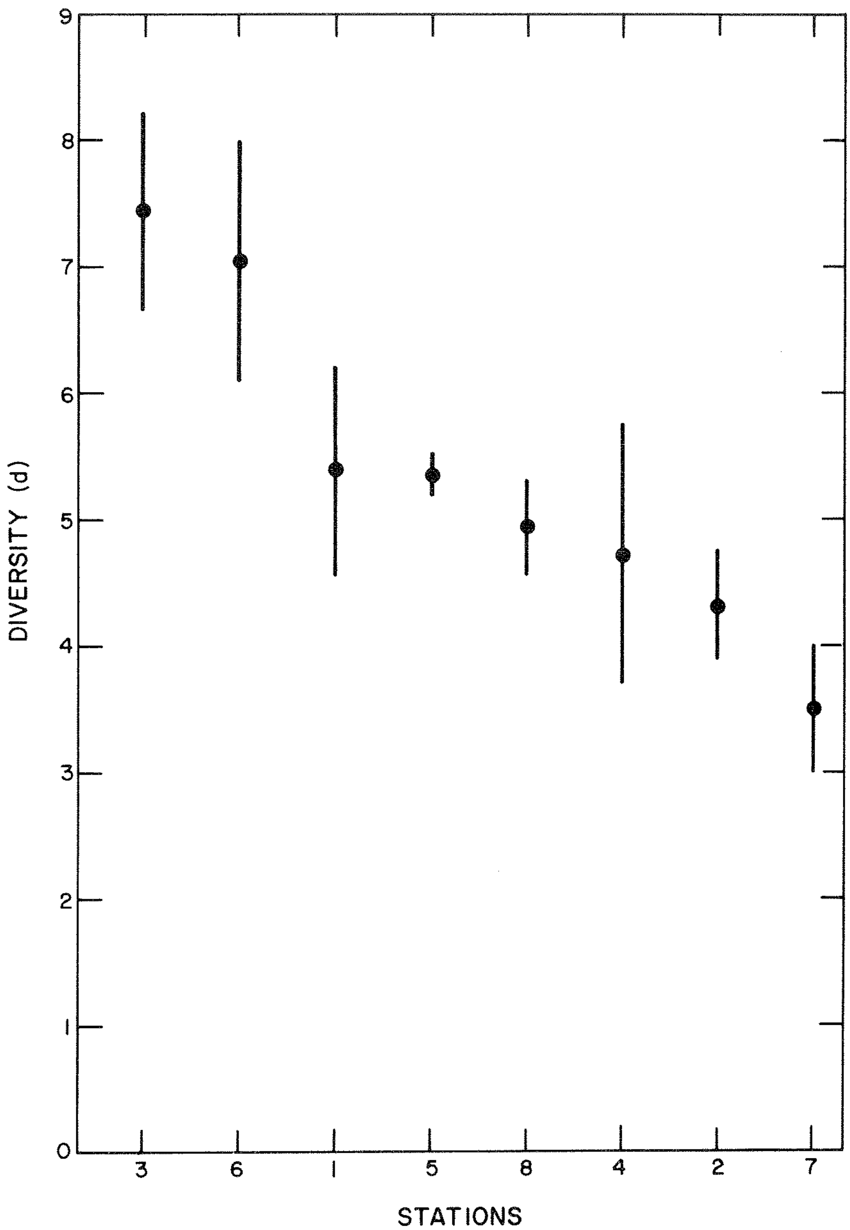

Figure 12. MARGALEF's index of diversity d. The plots represent means throughout the investigated period with an estimate of 95% confidence limits.

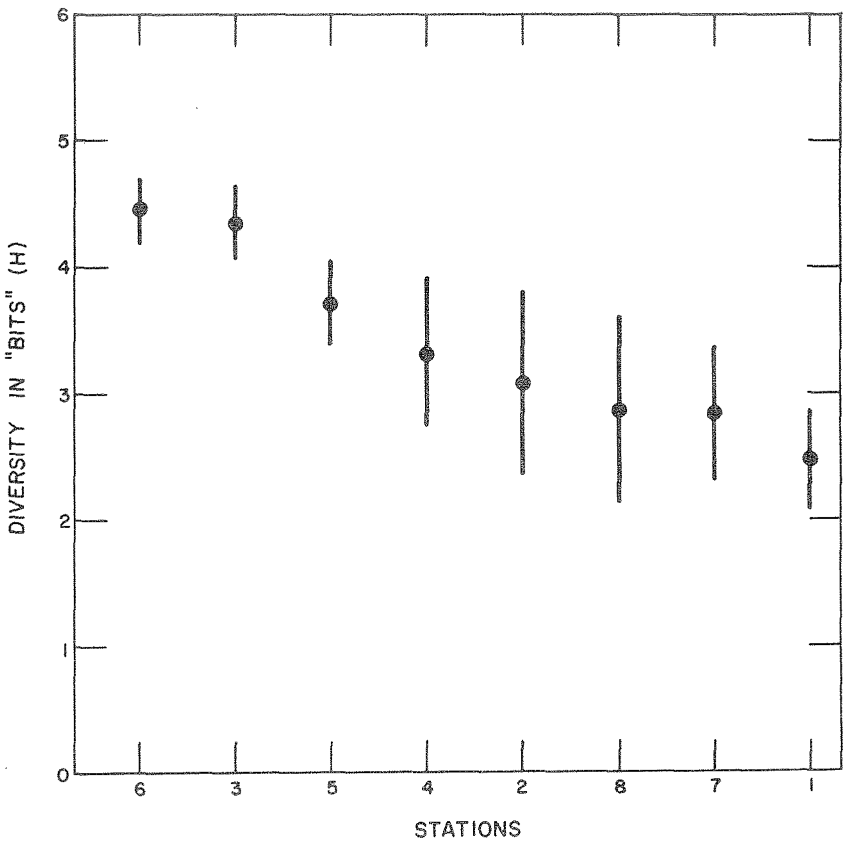

Figure 13. The SHANNON-WIENER function H. The plots represent means throughout the investigated period with an estimate of 95% confidence limits.

Stations 6 and 3 had considerably higher values than the other stations (Figure 13), and these high indices of diversity were both a function of high numbers of species and low degree of dominance of the most important species.

Here H is the amount of information per individual measured in "bits" of information (PATTEN 1962), and the index varies both with changes in the number of species and with changes in the relative abundance of the species. Therefore, when the number of specimens of Macoma carlottensis at station 2 decreased, there was a sharp increase in H (Table 30). When the change in environment occurred at station 4 in November 1963, there was a simultaneous decrease in H, probably resulting more from changes in the relative proportions of dominant species than from a decrease in the number of species (Table 31).

Table 30

The SHANNON-WIENER function (H) at the stations

Dates	Stations 2	7	4	1	3	8	6	5
Jan-Feb 1963	1.9	3.3	3.7	2.0	4.1	3.4	4.4	3.6
Apr-May	2.1	2.5	3.5	2.3	4.5	3.7	4.6	3.4
July-Aug	3.6	3.5	3.3	2.7	4.2	1.7	4.5	3.2
Nov	3.7	3.4	2.4	2.2	4.0	3.3	4.6	4.0
Feb 1964	3.2	2.5	2.9	2.4	4.5	2.1	4.0	3.6
Apr	3.5	2.0	3.8	3.2	4.4	3.5	4.8	4.0
July-Aug	3.6	2.7	3.7	2.6	4.8	2.4	4.2	4.2
Mean	3.1	2.8	3.3	2.5	4.4	2.9	4.4	3.7
95% confidence limits, ±:	0.70	0.53	0.48	0.38	0.09	0.71	0.26	0.41

Table 31

Changes in abundances of the most abundant species at station 4 from August to November 1963

Species	August	November
Pinnixa schmitti	878	21
Euphilomedes carcharodonta	649	1512
Euphilomedes producta	243	1
Axinopsida sericata	242	103
Psephidia lordi	163	85
Nucula bellotii	156	26
Eudorella pacifica	101	1

Although there was a significant increase in the abundance of Paraphoxus variatus, Mysella tumida, and Tellina buttoni in November, Euphilomedes carcharodonta comprised more than 55% of the total number of organisms, and the overwhelming dominance of the latter species caused the change in diversity.

When the index $\underline{H}$ was calculated with the ostracods excluded, the information content per individual at stations 1 and 8 increased with 37.2 and 26.5%, respectively, while at the other stations where the ostracods were of minor importance the index changed from 0.2 to 2.0%. The ostracods were among the smallest species collected, and if the mesh size of the screen had been 2 mm instead of 1 mm, practically all the ostracods would have been lost. This indicates that sampling procedures heavily affect the index of diversity, $\underline{H}$. Unless identical sampling techniques have been used, the levels of diversity cannot be compared. In studies of benthos, the fauna is arbitrarily separated into epifauna or infauna, macrofauna, meiofauna or microfauna, and the sampling efficiency of species within each group may vary. It is therefore doubtful whether the measured diversity would yield significant information about environment complexity, succession, stability, and community evolution.

4. Redundancy

Redundancy is defined as the part of the total information that is not determined by free choice but by statistical properties governing the relative abundances of the species (SHANNON and WEAVER 1963). The redundancy of the Puget Sound infauna has been calculated from the formulas given by MARGALEF (1958):

$$\underline{R}_{\underline{E}} = 100\left(1 - \frac{\log(N!/\prod_{i=1}^{s} N_i!)}{\log N!}\right)$$

The redundancy in percent is one minus the relative entropy multiplied by 100. The relative entropy is the ratio between the observed information content and the maximum information the system could contain. The relative entropy is therefore the degree of randomness of the system, and the redundancy is conversely the degree of nonrandomness or the level of organization. In the course of succession of communities, more intense relations between the species are established and more efficient species replace less efficient species (MacARTHUR 1955), and in a climax community each niche is occupied by one species. This leads to loss of information and increased redundancy (PATTEN 1962), and the redundancy therefore becomes a measure of the successional stage of the community.

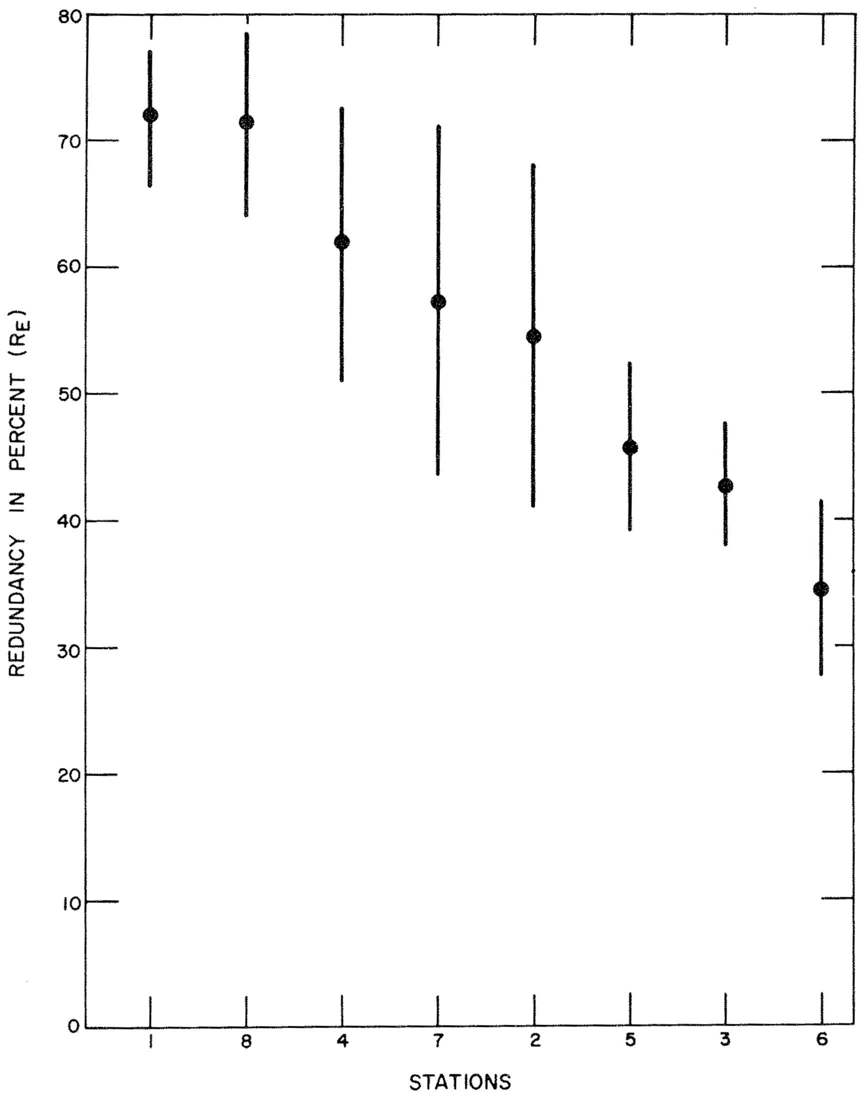

Figure 14. Redundancy $\underline{R}_{\underline{E}}$. The plots represent means throughout the investigated period with an estimate of 95% confidence limits.

Table 32

Redundancy (R_E) at the stations

Dates	Stations 2	7	4	1	3	8	6	5
Jan-Feb 1963	78.8	45.4	57.7	78.2	46.2	66.3	22.3	42.9
Apr-May	72.6	68.9	40.3	72.9	38.5	63.0	29.5	53.7
July-Aug	43.9	41.8	64.5	66.3	48.8	83.0	39.3	57.6
Nov	44.5	39.5	74.5	77.6	48.6	67.3	33.6	42.0
Feb 1964	48.1	63.1	70.8	71.3	38.9	78.8	42.7	40.7
Apr	48.5	76.9	62.0	62.3	36.8	65.3	32.5	44.4
July-Aug	45.0	66.4	63.1	73.7	40.9	76.0	41.7	38.6
Mean	54.5	57.4	61.8	71.8	42.7	71.4	34.5	45.7
95% confidence limits, ± :	13.60	13.78	10.88	5.34	4.69	7.17	6.77	6.58

Stations 3 and 6, which had the highest species diversity measured both by d and H, also had the lowest redundancy (Figure 14), which demonstrates that the high diversity was to a certain degree determined by the low level of dominance of a small number of species. Stations 1, 8, and 4, which had the highest redundancy, are recognized by the numerical dominance of the ostracod Euphilomedes carcharodonta.

At station 2 (Table 32) there was a sharp decrease in redundancy when the numerically dominant species Macoma carlottensis was reduced in numbers (see page 462). The resulting low redundancy was maintained throughout the period of investigation, which may indicate that the niche originally occupied by Macoma carlottensis remained empty.

The redundancy calculated when the ostracods were excluded resulted in a decrease at stations 1 and 8 of 34.4 and 28.0%, respectively, and an increase of 3.1 to 13.6% at the other stations. The limitations of the usefulness of the SHANNON-WIENER function as an index of diversity for benthos as discussed above are also applicable to the redundancy.

5. Comparisons of indices of diversity

FISHER, CORBETT and WILLIAMS (1943) found that the relationships between species and specimens in a community followed a logarithmic series, and the relationship was expressed by the formula $S = \alpha \ln (1 - N/a)$. The slope of

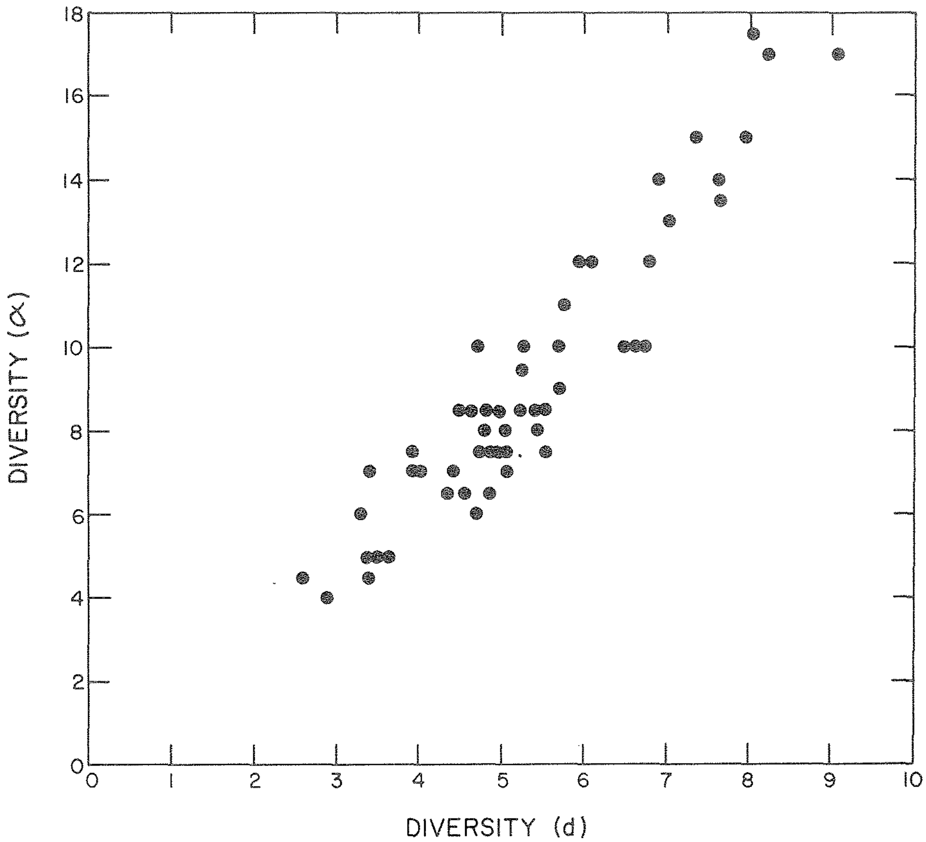

Figure 15. Comparison of MARGALEF's index of diversity d and FISHER, CORBETT and WILLIAM's α.

the logarithmic curve was measured by the parameter α, which was called the index of diversity. WILLIAMS (1964) showed that when the number of specimens is much higher than the number of species, the logarithmic curve approximates a straight line, and the number of species then becomes a function of the logarithm of the number of specimens, i.e., of sample size as suggested by GLEASON (1922). The index of diversity, d, was based on GLEASON's assumption. When d is plotted against α taken from WILLIAMS (1964, figure 126, page 311) for the present stations, the relationship between the two indices of diversity, as expected from WILLIAMS' considerations, is rectilinear and the difference between the two is only a matter of units (Figure 15). The variability in Figure 15 is probably due to the difficulty in extracting accurate values of α

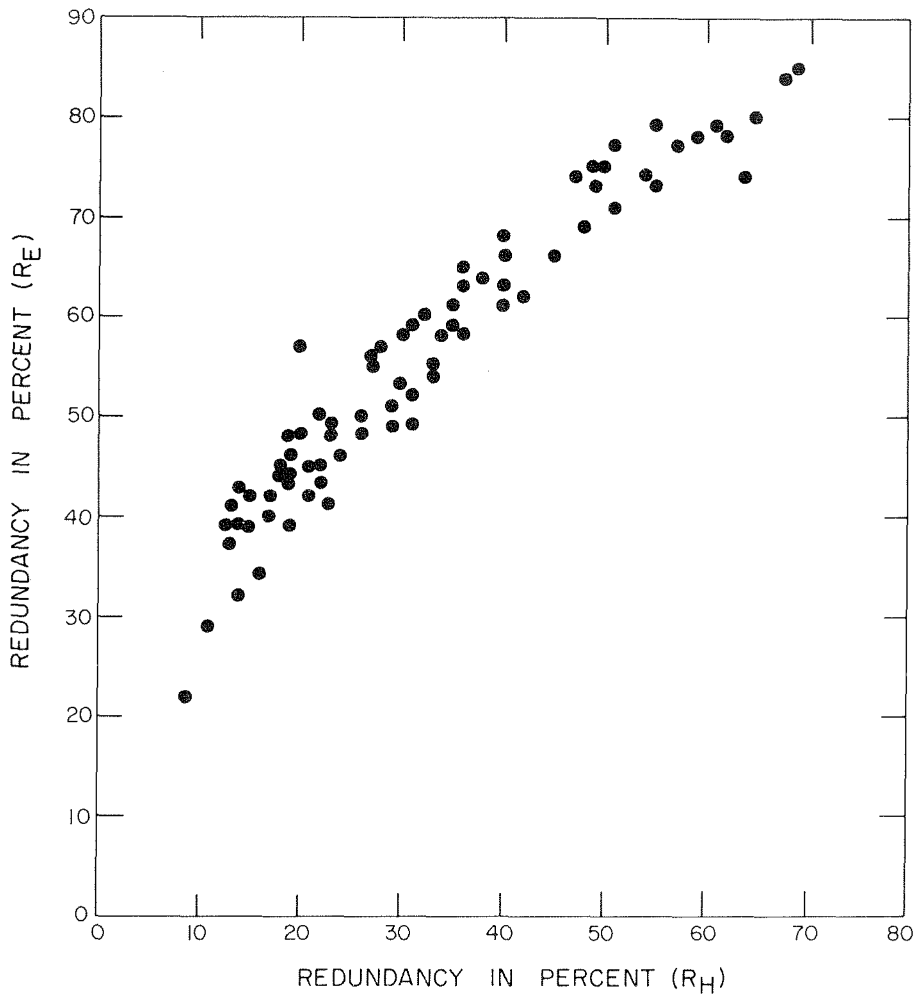

Figure 16. Comparison of redundancy calculated by MARGALEF's equations ($\underline{R}_{\underline{E}}$) and from the SHANNON-WIENER function ($\underline{R}_{\underline{H}}$).

from WILLIAMS's figure. There is therefore no reason to distinguish between $\underline{d}$ and $\underline{\alpha}$ as indices of diversity, but $\underline{d}$ has the advantage of being easier to compute.

Redundancy, $\underline{R}_{\underline{E}}$, in the present paper was calculated according to formulas presented in MARGALEF (1958). This method is extremely cumbersome if the numbers of species and specimens are large. Redundancy may be computed more easily from the SHANNON-WIENER function by the equation: $\underline{R}_{\underline{H}} = 100(1 - \underline{H}/\log_2 S)$. Figure 16 shows a plot of values of redundancy calculated by both methods. There is an obvious correlation but it does not seem to be rectilinear.

The properties of the indices of diversity d and H were discussed on pages 352 to 358. MARGALEF (1958) stated that d was a good approximation to H, but this was true only when diversity was high (Figure 17). High diversity as measured by H results from a low degree of dominance, which corresponds to d where all the species have the same effect on the index of diversity. However, when the degree of dominance is high and H is low, the difference between the two indices of diversity consequently becomes greater.

6. Indices of diversity with polychaetes included

The evaluation of the indices of diversity and their application to studies of the structure of benthic communities in the present paper has been based on data on Crustacea, Lamellibranchia, and Echinodermata, because complete identification and counting of the Polychaeta were not performed for all the cruises. However, as the polychaetes comprised about 49 to 70% of the number of species and about 18 to 76% of the number of organisms (Table 22, page 336), obviously the diversity of the infauna depends to a considerable degree on the polychaetes. Table 33 shows the indices of diversity d and H and the redundancy for the benthic infauna collected during January-February and April-May 1963 calculated with and without the polychaetes.

The index d increased with a mean factor of 2.3 in January-February and with 2.4 in April-May when the polychaetes were included; the range of the factor was from 1.9 to 3.0. The ranking of the stations according to the size of d changed slightly when the polychaetes were included, but the rank correlation coefficient (KENDALL 1962) in January-February was 0.71 (significant at 98% level of probability) and 0.82 in April-May (significant at 99% level of probability). The increase in d was expected, since the index is more sensitive to changes in number of species than in number of specimens.

The index H varied considerably less, with a mean factor of 1.4 in both seasons with a range from 1.2 to 1.8. The index H varies both with the number of species and the degree of dominance, and the relatively small change indicates that the level of dominance did not change significantly. The ranking of the stations did not change at all in January-February when the polychaetes were included, and in April-May the rank correlation coefficient was 0.96, which is significant beyond the 99% level of probability.

The mean redundancy decreased by about 5% when the polychaetes were

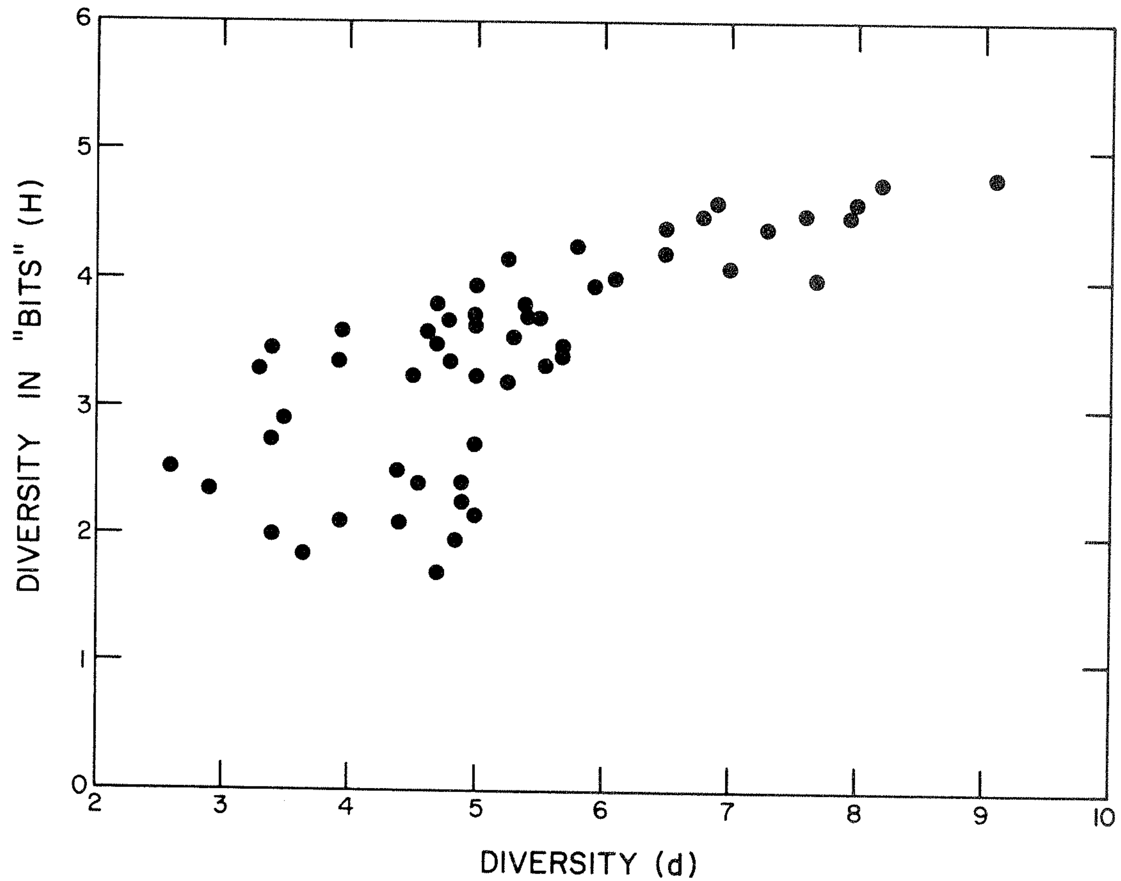

Figure 17. Comparison of MARGALEF's index of diversity d and the SHANNONWIENER function H.

Table 33

MARGALEF's index of diversity (d), the SHANNON-WIENER function (H), and the redundancy (R_E) at the benthos stations in Puget Sound in January-February and April-May 1963, calculated with (A) and without (B) the polychaetes

	d				H				R_E			
	Jan-Feb		Apr-May		Jan-Feb		Apr-May		Jan-Feb		Apr-May	
Stations	A	B	A	B	A	B	A	B	A	B	A	B
2	9.1	4.8	8.9	4.5	3.0	2.0	4.0	2.2	73.5	79.2	57.5	74.7
7	8.9	4.0	13.0	4.4	4.9	3.6	4.1	2.5	40.0	47.6	61.8	68.9
4	14.9	5.5	13.7	6.0	5.0	3.7	5.0	3.9	51.4	57.7	50.5	56.7
1	12.2	4.9	11.0	4.9	3.6	2.0	3.8	2.2	68.5	78.2	62.5	72.9
3	14.3	7.0	17.8	6.8	5.2	4.1	5.8	4.5	27.2	46.3	38.2	38.5
8	13.0	4.8	12.7	5.0	4.6	3.4	4.9	3.7	52.5	66.3	50.4	55.5
6	14.5	6.5	17.2	6.9	5.6	4.4	5.7	4.6	36.5	22.3	40.4	29.5
5	12.1	5.0	12.8	5.7	5.1	3.7	4.8	3.4	42.3	42.9	50.0	53.7

included, which again demonstrates the similarity in dominance between the polychaetes and the nonpolychaetes. However, at station 6 in February there was a 64% increase and in May a 37% increase in the redundancy. At this station there were nine polychaetes among the ten most abundant species in February and eight in May.

The ranking of the stations based on redundancy when polychaetes were included remained nearly unchanged. The rank correlation coefficient in January-February was 0.89 and in April-May 0.96, and both coefficients were significant on the 99% level of probability.

IV. THE NUMERICALLY DOMINANT SPECIES

A. Selection of dominant species

Many aspects of the dynamics of communities will have to be explained through detailed studies of the component species populations. Most animal communities are so complex and rich in species that it is necessary to make a choice of the species that supposedly are most important to the communities and make them subject to detailed analysis. The importance of the species can be determined in terms of abundance, biomass, energetics (productivity), or by the effect the various species have on the success of other species, i.e., on the contribution through competition or predation to community structure. In the present study there was no other means of distinguishing between species than by the relative abundances. As a general rule the species that contributed about 70% of the total number of organisms at a station were considered the numerically dominant species. Because of taxonomic problems the polychaetes Capitellidae indet. and Magelona spp., and the holothurians Pentamera spp. were excluded in spite of both high numbers and significant contributions to the standing crop. The ophiurid Amphipholis squamata was also excluded from the list of dominant species owing to its minute size, its fragility, and supposedly low content of organic matter. On the other hand the polychaete Travisia pupa and the lamellibranchs Mya arenaria and Semele rubropicta were included because of their high frequency of occurrence and significant contributions to the standing crop at some stations.

The important polychaetes were selected from the cruises in January-February and April-May 1963 when the polychaetes were completely identified and counted, while the crustaceans, lamellibranchs, echinoderms, and the sipunculid Golfingia pugettensis were selected from a consideration of their importance throughout the investigated period. The numerically dominant species consisted of 30 polychaetes, nine crustaceans, ten lamellibranchs, three echinoderms and one sipunculid, and together they comprised from 60.5 to 89.5% (average 74.4%) of the total number of specimens at the various stations during the first two cruises in 1963.

Aspects of the biology and ecology of the numerically dominant species compiled in part from the Puget Sound benthos investigations and in part from pertinent literature are discussed below.

B. Biological and ecological information about the numerically dominant species

1. Harmothoë imbricata (LINNÉ)

This polychaete of the family Polynoidae has a circumpolar distribution and has been found in the eastern Pacific Ocean from the Arctic to California. The species is particularly abundant in littoral and shallow waters but has been recorded from intertidal down to about 3650 m. It may be free-living or commensal with the polychaetes Thelepus crispus and Diopatra ornata (PETTIBONE 1953) and with several Terebellidae and Chaetopteridae (FAUVEL 1923). Harmothoë imbricata is recorded from combinations of shells, rocks, mud, and sand (PETTIBONE 1953).

Harmothoë imbricata was not very abundant in the present material but occurred in highest numbers at the stations with coarse bottom types (Table 34). The species did not contribute significantly to the total standing crop at any of the stations.

The dry weight of H. imbricata comprised on the average 18.80% of the wet weight with 95% confidence limits ± 2.39; the organic matter of one sample comprised 88.87% of the dry weight.

2. Lepidasthenia berkeleyae PETTIBONE

This species of the family Polynoidae is distributed in the Northeast Pacific Ocean from Vancouver Island to Puget Sound on muddy bottoms from 63 to 126 m (PETTIBONE 1953).

In Puget Sound Lepidasthenia berkeleyae occurred regularly on station 7 but not at the other soft-bottom station (station 2). The species was also found in one of the samples from station 8 (Table 35). Lepidasthenia berkeleyae is a commensal with Praxillella affinis pacifica (PETTIBONE 1953). Also the latter species occurred in significant numbers only at station 7 (Table 60, page 392).

The dry weight of L. berkeleyae comprised 14.51% of the wet weight, with 95% confidence limits ± 1.36; the organic matter of one sample comprised 93.83% of the dry weight. Lepidasthenia berkeleyae contributed a significant part of the standing crop at station 7 (Table 35).

Table 34

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Harmothoë imbricata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	10	0	2	2	8	24
	W			269.4		34.2	17.0	25.8	336.4
	A			54.6		6.4	3.2	4.6	57.8
Apr-May	N	0	2	2	3	2	24	0	18
	W		25.8	2.5	50.9	21.5	49.5		23.4
	A		2.3	0.5	8.5	3.6	8.3		3.9

None at stations 2 and 7 in July-August and November

Table 35

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Lepidasthenia berkeleyae in 1963. Weights in milligrammes

		February	May	July	November
Station 7	N	20	8	29	10
	W	967.3	1722.1	2354.5	1174.2
	A	131.7	234.4	320.4	159.8
Station 8	N	2	0		
	W	16.5			
	A	2.3			

The species did not occur at any of the other stations

3. Malmgrenia lunulata (DELLE CHIAJE)

This polychaete of the family Polynoidae is distributed from the Arctic to the Azores in the Atlantic Ocean and from Vancouver Island to Galapagos in the Eastern Pacific Ocean. Malmgrenia lunulata occurs from the intertidal down to about 865 m (PETTIBONE 1953), particularly on silty and mixed bottoms (HARTMAN 1961).

The distribution of M. lunulata at the benthos stations in Puget Sound (Table 36) cannot be explained according to sediment types. The highest numbers occurred at the softest station, but the species was also quite abundant at the three stations with the coarsest bottom material (stations 8, 6, and 5). Malmgrenia lunulata is known to be a commensal with the holothurian Brisaster townsendi (PETTIBONE 1953), which occurred only at station 2 where M. lunulata was most abundant (Table 108, page 495).

The dry weight of M. lunulata comprised 17.26% of the wet weight with 95% confidence limits ± 0.96; the organic matter of one sample comprised 92.40% of the dry weight. The species was of some importance to the standing crop at station 2 (Table 36).

4. Peisidice aspera JOHNSON

This species of the family Polydontidae is distributed in the Northeast Pacific Ocean from Alaska to Galapagos in depths from intertidal to about 335 m. In dredgings from about 20 to 190 m Peisidice aspera occurred in various combinations of mud, sand, gravel, rocks, and shells, and in the intertidal on pilings and red algae (PETTIBONE 1953).

In Puget Sound the species was limited to the stations with coarse substrate (Table 37).

The dry weights comprised 24.23% of the wet weights with 95% confidence limits ± 1.75. The organic matter from four samples comprised from 80.08 to 90.98% of the wet weight with a mean of 84.54%.

The wet weight and ash-free dry weight of P. aspera at the benthos stations are shown in Table 37. BANSE and HOBSON (in press) studied the intestinal content of four specimens. Three specimens had empty intestines and the fourth had a few sand grains. The latter finding and the relatively low organic content is a weak indication that P. aspera may be a deposit feeder. The species was of some importance to the standing crop at station 6.

Table 36

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Malmgrenia lunulata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	30	0	14	0	6	10	6	20
	W	421.7		67.8		16.8	51.4	35.6	107.8
	A	63.7		12.0		4.0	8.4	6.0	18.6
Apr-May	N	40	2	7	0	6	30	12	16
	W	647.3	3.6	83.8		40.5	159.9	1294.6	231.1
	A	103.5	1.4	13.4		6.5	25.6	207.1	37.0
July-Aug	N	38	0						
	W	831.0							
	A	132.9							
Nov	N	40	0						
	W	645.5							
	A	103.2							

Table 37

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Peisidice aspera in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	0	0	2	14	94	54
	W					22.0	28.2	210.6	89.4
	A					5.2	7.0	49.6	18.8
Apr-May	N	0	4	0	0	16	26	84	32
	W		31.8			28.9	60.9	264.3	38.9
	A		7.9			5.6	11.8	51.3	7.5

None at stations 2 and 7 in July-August and November 1963

5. Pholoë minuta (FABRICIUS)

This species of the family Sigalionidae is circumpolar and distributed in the Northeast Atlantic Ocean from the Arctic to France, and in the Northwest Atlantic Ocean it has been recorded off New England. In the Northwest Pacific Ocean Pholoë minuta has been found in the Japan Sea, and in the Northeast Pacific Ocean from the Arctic to central California. The species has been found in depths from low water to about 2260 m in various combinations of mud, sand, gravel, stones, and rocks (PETTIBONE 1953).

The species was ubiquitous in the present material and Table 38 does not indicate any trend in the abundance in relation to sediment types.

The dry weight of P. minuta comprised 17.43% of the wet weight with 95% confidence limits ± 0.88; the organic matter of one sample comprised 91.43% of the dry weight. The species was not important in the wet weight or organic matter at any of the Puget Sound benthos stations (Table 38).

6. Sigambra tentaculata (TREADWELL)

This species of the family Pilargiidae has been found in the Northwest Atlantic Ocean from New England to South Carolina and Florida, and in the Pacific Ocean off central and and southern California (HARTMAN 1961, 1965a, PETTIBONE 1966). Sigambra tentaculata is recorded in depths from intertidal to 5000 m.

In Puget Sound the species occurred regularly at station 7, which is dominated by soft sediments, and occasionally at station 6 (Table 39).

The dry weight comprised 15.93% of the wet weight with 95% confidence limits ± 1.61; the organic matter of one sample comprised 90.34% of the dry weight. Sigambra tentaculata was not an important contributor to the standing crop at stations 6 and 7 (Table 39).

7. Pionosyllis uraga IMAJIMA

This species of the family Syllidae is previously recorded from Central Japan in depths from 40 to 150 m (IMAJIMA 1966). In Puget Sound the species was found at the stations dominated by gravelly sediments (Table 40).

The dry weight of P. uraga comprised 27.58% of the wet weight with 95% confidence limits ± 11.41. The organic matter from three samples comprised from 94.87 to 95.12% of the dry weight with a mean of 94.99%. This high percentage of organic matter indicates that the species may be carnivorous.

Table 38

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Pholoë minuta in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	37	4	20	10	2	14	2	8
	W	111.4	3.1	59.0	23.4	8.0	37.4	8.6	16.2
	A	17.7	0.6	10.2	4.6	1.8	6.6	1.2	2.4
Apr-May	N	8	10	48	3	2	6	0	46
	W	13.2	10.0	58.7	10.4	7.5	17.6		92.8
	A	2.1	1.6	9.4	2.3	1.0	3.3		15.3
July-Aug	N	1	4						
	W	0.9	4.3						
	A	0.1	0.7						
Nov	N	2	3						
	W	7.1	5.6						
	A	1.3	0.9						

Table 39

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Sigambra tentaculata in 1963. Weights in milligrammes

		February	May	July	November
Station 6	N	2	2		
	W	3.7	5.6		
	A	0.5	0.8		
Station 7	N	40	8	30	17
	W	101.0	19.8	63.1	43.4
	A	14.5	2.9	9.1	6.4

The species did not occur at any of the other stations

Table 40 shows that P. uraga was of little importance for the standing crop at the benthos stations in Puget Sound.

8. Platynereis bicanaliculata (BAIRD)

This species of the family Nereidae is distributed all over the North Pacific Ocean (USHAKOV 1955). In the Northeast Pacific Ocean Platynereis bicanaliculata has been recorded from intertidal down to about 35 m (from unpublished records of C. and E. BERKELEY deposited in the U.S. National Museum).

In Puget Sound P. bicanaliculata was found on all the stations except the mud bottom stations (Table 41), and the species was particularly abundant at stations 4 and 1, which were dominated by fine sand with 15 to 20% silt and clay (see Table 4, page 264).

The dry weight of P. bicanaliculata comprised 15.45% of the wet weight with 95% confidence limits ± 1.22; the organic matter of one sample comprised 82.91% of the dry weight.

The species was of considerable importance to the standing crop at station 4 and of some importance also at station 1 (Table 41).

9. Nephtys ferruginea HARTMAN

This species of the family Nephtyidae is distributed from Vancouver Island to Peru (BERKELEY and BERKELEY 1958), and also recorded from Chile (HARTMAN-SCHRÖDER 1965). Nephtys ferruginea has been found in depths down to about 400 m in silty and mixed sediments (HARTMAN 1961).

In Puget Sound the species had a ubiquitous distribution, but was particularly abundant at stations with substrate dominated by fine sand (Table 42).

The dry weight of N. ferruginea comprised 11.36% of the wet weight with 95% confidence limits ± 0.83; the organic matter of one sample comprised 76.15% of the dry weight. Generally the genus Nephtys is considered to be carnivorous (CLARK 1962), but SANDERS (1956, 1960) found that Nephtys incisa was a non-selective deposit feeder. The amount of organic matter in the present material is surprisingly low for a carnivore and may be an indication of inorganic remains in the intestines. Other errant polychaetes in Puget Sound (Harmothoe imbricata, Lepidasthenia berkeleyae, Pholoe minuta, and Sigambra tentaculata) have organic matter comprising from about 89 to 94% of the dry weight, which seems more compatible with carnivorous feeding. BANSE and HOBSON (in press) found only empty intestines on N. ferruginea in Puget Sound, which may indicate carnivorous feeding; but NICHOLS (1968) found some inorganic remains in the intestines of

Table 40

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Pionosyllis uraga in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	0	0	0	0	0	38
	W								21.7
	A								4.1
Apr-May	N	0	0	0	0	0	0	4	214
	W							4.2	226.6
	A							0.9	41.9

None at stations 2 and 7 in July-August and November 1963

Table 41

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Platynereis bicanaliculata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	174	132	6	2	4	2
	W			2674.8	706.0	274.6	11.8	21.0	92.4
	A			433.6	118.8	164.6	2.0	3.4	17.8
Apr-May	N	0	0	86	80	2	18	0	0
	W			2858.0	238.1	1.0	419.7		
	A			366.1	30.5	0.1	53.8		

None at stations 2 and 7 in July-August and November 1963

N. ferruginea but few animal remains. This finding, together with the low organic content in the present material, suggests deposit feeding.

Table 42 shows the wet weight and ash-free dry weight of N. ferruginea at the Puget Sound benthos stations. The species is of considerable importance to the standing crop at stations 4, 1, and 3.

10. Glycera capitata OERSTED

This species of the family Glyceridae is widely distributed in the Arctic, North and South Atlantic, Mediterranean, Antarctic, at Japan, and in the Northeast Pacific from Alaska to Mexico (PETTIBONE 1963). Glycera capitata has been recorded on sand with gravel and calcarious algae (FAUVEL 1923) and in mixed to silty mud (HARTMAN 1960) in depths from shallow water to slope of continental shelf (HARTMAN 1961).

Glycera capitata was ubiquitous in Puget Sound (Table 43), occurring in comparable abundance at all the stations ranging from fine mud (station 2) to gravelly sand (station 5).

The dry weight comprised 13.68% of the wet weight with 95% confidence limits ± 0.53; the organic matter of one sample comprised 91.91% of the dry weight. Glycerids are generally considered to be deposit feeders (SANDERS et al. 1962), but most of their observations on Glycera dibranchiata revealed empty intestines. Also BANSE and HOBSON (in press) found largely empty intestines of G. capitata from Puget Sound. The very high organic content found in the present material indicates empty intestines, and the low variability in the mean dry weight percentages indicates that empty intestines was the general rule. KLAWE and DICKIE (1957) found that G. dibranchiata did not grow during the summer, and SANDERS et al. (1962) suggested that this might explain the high frequency of empty intestines in their material collected during the summer of 1959. However BANSE and HOBSON (in press) found empty intestines also during winter. KLAWE and DICKIE (1957) found that indigestible material in Glyceridae is regurgitated, which may explain the high frequency of empty intestines.

Glycera capitata was of some importance to the standing crop at stations 2, 7, and 1 (Table 43).

11. Lumbrineris bicirrata TREADWELL

This species of the family Lumbrineridae is distributed from Puget Sound to western Mexico in sandy silt down to about 360 m (HARTMAN 1947, 1961).

Table 42

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Nepthys ferruginea in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	33	7	202	36	134	10	6	2
	W	306.9	175.4	1444.8	645.8	1515.4	48.6	40.2	36.8
	A	49.5	26.3	237.6	106.6	271.8	7.8	5.0	6.4
Apr-May	N	27	12	299	36	34	6	8	0
	W	265.1	41.0	3060.4	1560.6	561.0	77.1	37.0	
	A	33.0	4.9	381.3	194.5	69.9	9.6	4.6	
July-Aug	N	14	3						
	W	137.5	80.1						
	A	17.1	10.0						
Nov	N	12	4						
	W	165.4	162.1						
	A	20.6	20.2						

Table 43

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Glycera capitata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	60	31	32	56	36	14	30	26
	W	2695.0	1578.3	655.4	377.6	692.6	425.8	957.2	609.4
	A	375.4	210.9	69.8	58.4	101.4	57.8	114.2	88.4
Apr-May	N	36	22	14	73	6	16	32	44
	W	1729.6	1191.2	932.9	373.7	1097.3	424.1	540.7	377.9
	A	212.9	146.6	114.8	46.0	135.1	52.2	66.6	46.5
July-Aug	N	18	19						
	W	1636.0	1027.1						
	A	201.4	126.4						
Nov	N	48	22						
	W	3486.6	1689.4						
	A	429.2	208.0						

Lumbrineris bicirrata was not particularly abundant at any of the stations in Puget Sound, and there was no significant trend in its abundance in relation to sediment types (Table 44).

The dry weight comprised 16.23% of the wet weight with 95% confidence limits ±1.66; the organic matter of one sample comprised 86.49% of the dry weight. The species of the genus Lumbrineris are generally considered to be deposit feeders (BANSE and HOBSON in press), but the organic content in the present material is higher than could be expected if there were a significant fraction of inorganic matter in the intestines. However, BANSE and HOBSON found that most of the intestines were empty and those that were not empty contained only inorganic matter. The high frequency of empty intestines may account for the high percentage of organic matter in the present material.

Table 44 shows that L. bicirrata was not particularly important in wet weight or organic matter at any of the Puget Sound benthos stations.

12. Lumbrineris californiensis HARTMAN

This species has been recorded off southern California on sandy and muddy bottoms in depths from about 10 to 400 m (HARTMAN 1947, 1961).

In Puget Sound Lumbrineris californiensis occurred on stations with substrate from muddy sand (station 4) to gravel (station 5), but not on stations dominated by silt and clay (Table 45).

The dry weight on the average comprised 16.36% of the wet weight with 95% confidence limits ± 1.15; the organic matter of one sample comprised 85.43% of the dry weight. Also for this species BANSE and HOBSON (in press) found mostly empty intestines, which may account for the high organic content of this alleged deposit feeder.

The wet weight and ash-free dry weight of L. californiensis as shown in Table 45 indicate that the species is of some importance to the standing stock at most sand-bottom stations in Puget Sound.

13. Lumbrineris cruzensis HARTMAN

This species is found in fine mud at about 40 m depth off Vancouver Island (BERKELEY and BERKELEY 1948), and in fine silt with much detritus on shallow water off southern California (HARTMAN 1960).

In Puget Sound Lumbrineris cruzensis occurred on all the stations (Table 46) and in higher numbers at stations with sandy or gravelly bottoms than in fine silt.

Table 44

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Lumbrineris bicirrata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	10	0	6	4	30	2
	W			2335.4		39.0	69.8	423.6	51.6
	A			391.6		4.6	10.6	64.2	8.6
Apr-May	N	1	2	3	0	6	0	44	0
	W	30.8	114.3	154.0		289.2		387.5	
	A	4.3	16.0	21.4		40.4		53.9	
July-Aug	N	0	1						
	W		1210.4						
	A		169.2						

None at stations 2 and 7 in November 1963

Table 45

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Lumbrineris californiensis in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	18	138	22	64	50	18
	W			113.4	1323.4	316.0	517.2	290.0	229.8
	A			21.4	218.2	57.8	89.8	44.0	42.8
Apr-May	N	0	0	45	233	4	428	98	18
	W			449.1	1589.8	20.1	5561.0	1084.5	202.7
	A			62.8	222.3	2.8	777.4	151.6	28.3

None at stations 2 and 7 in July-August and November 1963

The dry weight of L. cruzensis comprised 20.85% of the wet weight with 95% confidence limits ± 2.68; the organic matter of one sample comprised 88.84% of the dry weight. The high percentage of organic matter may also be explained for this species by high frequency of empty intestines. Lumbrineris cruzensis does not appear to be important for the standing stock at any of the stations (Table 46).

14. Lumbrineris luti BERKELEY and BERKELEY

This species is known only from the Vancouver Island region, where it occurred in dense mud on depths from about 20 to 40 m (BERKELEY and BERKELEY 1948).

The distribution of Lumbrineris luti in Puget Sound is not readily explained by sediment preference (Table 47). The highest abundance occurred at station 4 where the substrate is characterized as muddy sand, but it also had a rather high abundance at station 6 where the sediment consisted of a gravelly sand. However, the substrate at station 6 had also a rather high percentage of mud (silt and clay), about 16 to 26%. This species was regularly abundant at one of the soft-bottom stations (station 2) but not at the other (station 7). Except for the low abundance of the species at station 7, Table 47 indicates that L. luti is associated with sediments with a high mud fraction.

The dry weight of L. luti on the average comprised 17.86% of the wet weight with 95% confidence limits ± 1.12; the organic matter of one sample comprised 91.32% of the dry weight.

Even at the stations with a relatively high abundance the species does not seem to be of any importance for the standing crop (Table 47).

15. Haploscoloplos pugettensis PETTIBONE

This species of the family Orbiniidae is distributed from Alaska to western Mexico and has also been recorded from Japan. Haploscoloplos pugettensis has been found in depths from intertidal to about 530 m on soft bottoms (HARTMAN 1950, IMAJIMA and HARTMAN 1964).

In Puget Sound H. pugettensis was associated with sandy sediments ranging from muddy sand (station 4) to gravel (station 5), while it was nearly absent at the soft-bottom stations (Table 48).

The dry weight comprised 21.43% of the wet weight with 95% confidence limits ± 3.01; the organic matter of one sample comprised 56.52% of the dry weight. The low content of organic matter indicates deposit feeding.

Table 46

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Lumbrineris cruzensis in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	6	32	64	2	20	28	8
	W		40.3	37.4	121.8	17.2	20.0	127.6	17.8
	A		7.6	5.6	24.4	3.4	3.4	16.8	3.8
Apr-May	N	0	32	4	0	2	8	24	0
	W		200.5	44.0		3.2	8.8	88.3	
	A		32.5	7.1		0.6	1.4	14.3	
July-Aug	N	1	2						
	W	1.7	33.0						
	A	0.3	5.3						
Nov	N	0	5						
	W		31.3						
	A		5.1						

Table 47

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Lumbrineris luti in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	34	0	88	10	0	10	44	0
	W	231.3		497.2	20.0		25.6	154.8	
	A	28.8		91.8	4.8		4.4	23.8	
Apr-May	N	20	10	139	7	2	4	46	2
	W	118.9	129.2	605.7	16.4	2.1	52.2	155.8	4.3
	A	19.4	21.1	98.8	2.3	0.4	8.5	25.4	0.7
July-Aug	N	25	2						
	W	281.6	23.2						
	A	45.9	3.8						
Nov	N	37	0						
	W	312.3							
	A	50.9							

H. pugettensis was obviously of some importance to the standing stock at stations 1 and 8 (Table 48).

16. Laonice cirrata (SARS) ?

This species of the family Spionidae is distributed in the Arctic, North Atlantic, and Mediterranean Seas (USHAKOV 1955). In the eastern Pacific Ocean Laonice cirrata has been reported from western Canada to southern California (HARTMAN 1961), and in Chile (HARTMAN-SCHRÖDER 1965). BANSE and HOBSON (in press) consider the present species as different from the European species.

In Puget Sound L. cirrata was found on soft-bottom stations and on fine sand while it seemed to avoid coarse sediments (Table 49).

The dry weight comprised 12.58% of the wet weight with 95% confidence limits ± 1.10; the organic matter of one sample comprised 72.48% of the dry weight. The low content of organic matter indicates deposit feeding.

Laonice cirrata appeared to be of some importance to the standing crop at stations 2, 7, 1, and 4 (Table 49).

17. Laonice sp. I

This species occurred on the stations dominated by sandy and gravelly sediments with the highest abundance at station 5, which had the coarsest substrate (Table 50).

The dry weight of Laonice sp. I comprised 14.65% of the wet weight with 95% confidence limits ± 1.62. The organic matter from four samples comprised from 75.47 to 86.47% of the dry weight with a mean of 79.48%.

Table 50 shows the wet weight and ash-free dry weight of Laonice sp. I at the various stations, and the species seemed to be of some importance for the standing crop at station 5.

18. Prionospio cirrifera WIRÉN

This species is distributed in all Arctic seas from the Chukchi to the Barents Sea, in the Sea of Okhotsk and from Alaska to southern Oregon (USHAKOV 1955). It has also been found in southern California (HARTMAN 1961), and in western Sweden and Portugal (SÖDERSTRÖM 1920).

In Puget Sound P. cirrifera occurred with the highest abundance at the stations dominated by fine sand, but it was also regularly found at the mud-bottom stations (Table 51).

Table 48

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Haploscoloplos pugettensis in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	18	8	12	38	34	10
	W			72.2	523.8	56.4	564.4	392.2	383.4
	A			13.2	146.0	12.4	116.8	64.4	80.8
Apr-May	N	0	18	72	23	4	84	18	18
	W		197.6	93.6	847.6	94.5	2427.9	247.6	391.9
	A		21.0	9.9	89.9	10.0	257.6	26.2	41.6

None at stations 2 and 7 in July-August and November 1963

Table 49

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Laonice cirrata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	4	11	4	4	32	0	0	0
	W	467.5	2921.6	81.9	446.8	2108.8			
	A	53.1	340.1	4.6	79.0	409.8			
Apr-May	N	4	12	1	10	2	2	8	0
	W	176.9	1564.0	136.1	2396.1	176.8	252.2	67.8	
	A	16.1	142.5	14.8	218.3	16.1	23.0	6.2	
July-Aug	N	9	25						
	W	3884.9	8625.0						
	A	351.9	767.2						
Nov	N	9	8						
	W	3610.1	4149.2						
	A	328.9	378.0						

Table 50

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Laonice sp. I in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	1	0	0	0	0	0	6	66
	W	2.0						56.3	1208.8
	A	0.2						5.9	126.2
Apr-May	N	0	0	0	3	8	8	12	46
	W				7.6	281.3	195.6	154.8	799.9
	A				0.8	29.4	20.4	16.2	83.5

None at stations 2 and 7 in July-August and November 1963

Table 51

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Prionospio cirrifera in 1963. Weights in milligrammes (Plus + indicates insignificant)

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	4	18	26	18	0	0	6	0
	W	0.6	6.4	5.2	2.6			12.6	
	A	0.1	1.1	1.0	0.6			1.8	
Apr-May	N	4	14	25	10	0	10	0	4
	W	0.8	7.2	3.6	6.4		1.5		2.3
	A	0.1	0.9	0.5	0.9		0.2		0.3
July-Aug	N	1	3						
	W	0.2	0.7						
	A	+	0.1						
Nov	N	13	2						
	W	4.2	1.1						
	A	0.5	0.2						

The dry weight comprised 16.26% of the wet weight with 95% confidence limits ± 1.77; the organic matter comprised 80.90% of the dry weight. Members of the genus Prionospio are considered deposit feeders (see P. pinnata) and the organic content therefore seems high.

Table 51 shows the wet weight and the ash-free dry weight of P. cirrifera at the benthos stations in Puget Sound, and it is obvious that the species is of no importance for the standing crop of infauna at any of the stations.

19. Prionospio malmgreni CLAPARÈDE

This species has a worldwide distribution on sandy and muddy bottoms (FAUVEL 1923), and it has been recorded from western Canada to California (HARTMAN 1961). Prionospio malmgreni occurred in high abundance at all the bottom types ranging from muddy sand (station 4) to gravel (station 5), while it was very scare at the mud-bottom stations 2 and 7 (Table 52).

The dry weight comprised 17.06% of the wet weight with 95% confidence limits ± 1.10; the organic matter comprised 75.11% of the dry weight. The relatively low organic content indicates deposit feeding.

In spite of the high abundance at various stations, P. malmgreni did not appear to be of definite importance to the standing crop at any of the stations (Table 52).

20. Prionospio pinnata EHLERS

This species is distributed in the Atlantic and Indian Oceans, at Japan, and from western Canada to Chile (HARTMAN-SCHRÖDER 1965). Off southern California Prionospio pinnata occurred in highest abundance in olive-green mud on shelf and slope depths (HARTMAN 1960).

The distribution of Prionospio pinnata at the benthos stations in Puget Sound cannot be explained according to sediment types (Table 53).

The dry weight comprised 15.07% of the wet weight with 95% confidence limits ± 1.08; the organic matter of four samples comprised from 72.50 to 81.50% of the dry weight, with a mean of 77.30%. The relatively low organic content indicates deposit feeding, and BANSE and HOBSON (in press) classified the species as a selective deposit feeder in agreement with EHLERS (1901).

Prionospio pinnata seemed to be of some importance for the standing crop at station 4 (Table 53).

Table 52

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of <u>Prionospio malmgreni</u> in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	2	1	118	80	20	40	10	30
	W	0.9	0.6	105.0	255.8	30.0	144.6	54.4	35.6
	A	0.1	0.1	16.6	45.6	5.8	21.0	7.4	7.4
Apr-May	N	0	6	26	97	20	80	40	28
	W		18.2	40.7	593.9	41.6	282.8	93.9	87.4
	A		2.3	5.2	74.8	5.3	35.6	11.8	5.6
July-Aug	N	0	1						
	W		0.5						
	A		0.1						
Nov	N	1	5						
	W	1.0	26.8						
	A	0.1	3.4						

Table 53

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of <u>Prionospio pinnata</u> in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	11	18	0	68	2	2	0
	W		996.9	478.4		739.2	146.8	2.0	
	A		117.9	56.6		87.5	17.4	0.2	
Apr-May	N	0	0	14	0	0	0	4	0
	W			1309.0				78.3	
	A			154.9				9.3	
July-Aug	N	0	3						
	W		477.7						
	A		56.5						
Nov	N	0	3						
	W		774.4						
	A		91.6						

21. Caulleriella alata (SOUTHERN) ?

This species of the family Cirratulidae is known from the Atlantic, from Alaska to western Mexico and Chile, and from the Subantarctic islands (HARTMANN-SCHRÖDER 1962). In California Caulleriella alata occurred in mixed sediments on shallow sublittoral seabottoms (HARTMAN 1961).

Table 54 shows that in Puget Sound C. alata was found on the stations dominated by sandy or gravelly sediments.

The dry weight comprised 21.74% of the wet weight with 95% confidence limits ± 6.09; organic matter from three samples comprised from 60.00 to 73.68% of the dry weight with a mean of 67.67%.

Table 54 shows that C. alata was of little importance for the standing crop at the Puget Sound benthos stations.

22. Chaetozone setosa MALMGREN

This species of the family Cirratulidae is distributed both in the Atlantic and Pacific Oceans in the littoral zone and is associated with silty sediments (HARTMAN 1961). Chaetozone setosa also has been recorded in depths of about 2400 m (PETTIBONE 1954), and 4436 m (HARTMAN 1965b).

In Puget Sound C. setosa occurred on all stations, but in highest abundance at the sand-bottom stations (Table 55).

The dry weight comprised 14.74% of the wet weight with 95% confidence limits ± 1.66; the organic matter of four samples comprised from 60.10% to 90.30% of the dry weight, with a mean of 78.80%. BANSE and HOBSON (in press) classified C. setosa as a selective deposit feeder.

C. setosa was of little importance to the standing crop at any of the stations (Table 55).

23. Chaetozone sp. I

This species occurred only at the very coarse substrates in Puget Sound (Table 56), and it was numerically dominant only at station 5.

The dry weight comprised 36.67% of the wet weight with 95% confidence limits ± 8.33. The organic content of two samples was 81.31 and 86.32% of the dry weight, respectively, and this relatively low organic content may indicate deposit feeding with nearly empty intestines.

Table 56 shows that Chaetozone sp. I was not an important contributor to the standing crop at the Puget Sound benthos stations.

Table 54

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Caulleriella alata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	0	8	2	16	8	26
	W				17.3	3.5	69.6	3.9	15.8
	A				1.9	0.4	7.8	0.4	1.8
Apr-May	N	0	0	0	7	2	24	14	4
	W				15.3	5.4	112.8	42.2	3.6
	A				1.7	0.6	12.4	4.6	0.4

None at stations 2 and 7 in July-August and November 1963

Table 55

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Chaetozone setosa in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	13	0	12	12	12	12	42	22
	W	4.8		16.2	45.5	20.8	36.4	118.6	40.2
	A	0.6		1.9	5.3	2.4	4.8	15.2	9.4
Apr-May	N	5	0	3	50	18	18	104	2
	W	3.3		4.1	87.7	19.7	56.8	209.9	2.0
	A	0.4		0.5	10.2	2.3	6.6	24.3	0.3
July-Aug	N	1	1						
	W	4.8	2.6						
	A	0.5	0.3						
Nov	N	6	0						
	W	4.1							
	A	0.5							

24. Armandia brevis (MOORE)

This species of the family Opheliidae is distributed from Alaska to Mexico (BERKELEY and BERKELEY 1952), and it has been found in shallow water on algal growth on rocks in California (HARTMAN 1947).

In Puget Sound Armandia brevis occurred on substrates ranging from silty sand to gravelly sand (Table 57). The species was among the numerically dominant species only at station 1.

The dry weight comprised 16.34% of the wet weight with 95% confidence limits ± 2.09; the organic matter of one sample comprised 63.95% of the dry weight. The low organic content indicates that A. brevis is a deposit feeder.

Table 57 shows that A. brevis was of little importance to the standing crop at the Puget Sound benthos stations.

25. Travisia pupa MOORE

This species of the family Opheliidae is distributed from Alaska to southern California (HARTMAN 1961), and at Vancouver Island it was found in depths from about 40 to 400 m (BERKELEY and BERKELEY 1952).

In Puget Sound Travisia pupa was found only at the deepest stations with the softest substrate (Table 58). The species was not among the numerically dominant species, but it was one of the most important contributors to the standing crop at station 2.

The dry weight comprised 14.80% of the wet weight with 95% confidence limits ± 2.94; the organic matter of one sample comprised 80.62% of the dry weight.

26. Euclymene zonalis (VERRILL)

This species of the family Maldanidae is reported from the Vancouver Island region at an intertidal sandflat and in depths of about 45 to 55 m (BERKELEY and BERKELEY 1952).

In Puget Sound Euclymene zonalis was associated with fine sand, being rare or absent both on muddy and gravelly bottoms (Table 59).

The dry weight comprised 22.90% of the wet weight with 95% confidence limits ± 3.16; the organic matter of four samples comprised from 31.6 to 53.0% of the dry weight, with a mean of 41.0%. The low organic content indicates deposit feeding.

Euclymene zonalis was of some importance to the standing crop at station 4 (Table 59).

Table 56

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Chaetozone sp. I in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	0	0	0	0	2	30
	W							11.1	26.8
	A							1.8	4.1
Apr-May	N	0	0	0	0	8	6	12	20
	W					2.5	40.4	13.3	18.7
	A					0.4	6.4	2.1	3.1

None at stations 2 and 7 in July-August and November 1963

Table 57

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Armandia brevis in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	10	94	0	4	2	6
	W			20.4	105.4		31.8	3.0	33.4
	A			3.0	22.0		5.8	0.6	5.6
Apr-May	N	0	0	6	36	0	4	0	2
	W			74.3	308.2		39.0		15.4
	A			12.1	32.1		4.1		1.6

None at stations 2 and 7 in July-August and November 1963

Table 58

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Travisia pupa in 1963. Weights in milligrammes

		February	May	August	November
Station 2	N	4	2	3	1
	W	16175.5	10883.2	17523.3	6104.9
	A	1890.9	1231.4	2048.5	713.7

The species did not occur at any of the other stations

Table 59

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Euclymene zonalis in 1963. Weights in milligrammes (Plus + indicates insignificant)

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	68	6	10	0	0	0
	W			1256.1	16.8	53.1			
	A			118.0	1.6	5.0			
Apr-May	N	0	0	95	10	0	2	4	0
	W			2019.9	44.6		0.3	10.4	
	A			189.7	4.1		+	1.0	

None at stations 2 and 7 in July-August and November 1963

27. Praxillella affinis pacifica BERKELEY

This subspecies of Praxillella affinis is distributed from western Canada to southern California in sandy silt on the shelf and slope (HARTMAN 1961).

In Puget Sound the species was definitely associated with silty bottoms (Table 60), occurring regularly and in high abundance at station 7, where it wàs of considerable importance for the standing crop.

The dry weight comprised 14.80% of the wet weight with 95% confidence limits ± 0.75; the organic matter of four samples comprised from 56.4 to 81.3% of the dry weight, with a mean of 68.20%. The low content of organic matter indicates deposit feeding.

28. Praxillella gracilis (SARS)

This species is distributed from the Arctic and North Atlantic to the Mediterranean and the Persian Gulf (FAUVEL 1923), and from Western Canada to southern California (BERKELEY and BERKELEY 1952). Praxillella gracilis is reported from sandy silts on shelf and slope (HARTMAN 1961) and from abyssal depths (HARTMAN 1965b). In Puget Sound the species was associated with silty sand and it was of some importance to the standing crop at station 4 (Table 61).

The dry weight comprised 24.60% of the wet weight with 95% confidence limits ± 9.90; the organic matter of two samples comprising 58.04 and 59.13% of the dry weight. The low content of organic matter indicates that this species is a deposit feeder.

29. Pectinaria californiensis HARTMAN

This species of the family Pectinariidae is recorded from California, where it is common on muddy flats, sitting with posterior end of tubes slightly above top of sediment (HARTMAN 1947).

In Puget Sound Pectinaria californiensis was strongly associated with soft, muddy bottoms (Table 62), and it was of some importance to the standing crop at stations 2 and 7.

The dry weight comprised 17.87% of the wet weight with 95% confidence limits ± 1.56; the organic matter of one sample comprised 28.51% of the dry weight. The low content of organic matter indicates deposit feeding.

Table 60

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Praxillella affinis in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	1	43	2	0	0	0	0	0
	W	32.0	10280.6	15.3					
	A	3.2	1037.3	1.5					
Apr-May	N	6	20	0	0	0	0	0	0
	W	96.4	5880.8						
	A	9.7	593.4						
July-Aug	N	1	90						
	W	459.1	30944.6						
	A	46.3	3122.3						
Nov	N	0	52						
	W		14220.9						
	A		1434.9						

Table 61

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Praxillella gracilis in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	60	0	0	0	0	0
	W			2560.8					
	A			324.1					
Apr-May	N	0	2	7	3	0	0	0	0
	W		959.5	692.2	37.4				
	A		128.6	92.8	4.6				

None at stations 2 and 7 in July-August and November 1963

30. Pectinaria granulata (LINNÉ)

This species is distributed throughout the Arctic seas from the Chuckhi Sea to Greenland, and in the northwestern Pacific Ocean (USHAKOV 1955). In the northeastern Pacific Pectinaria granulata has been found from Alaska to Mexico (HARTMAN 1941). Pectinaria granulata has been recorded in combinations of mud, sand, gravel, and rocks in depths from intertidal to about 340 m (PETTIBONE 1954).

In Puget Sound P. granulata was associated with sediments dominated by very fine sand, fine sand, and medium sand, while both muddy and gravelly bottoms seemed to be avoided (Table 63), and the species was not an important contributor to the standing crop at any of the stations.

The dry weight comprised 37.32% of the wet weight with 95% confidence limits ± 7.79; the organic matter of one sample comprised only 14.70% of the dry weight. The low organic content indicates deposit feeding and high amounts of inorganic materials in the intestines.

31. Golfingia pugettensis FISHER

Golfingia pugettensis is a sipunculid originally described by FISHER (1952) from Dogfish Bay in Puget Sound and from San Juan Island, where it occurred on sandy mud.

In Puget Sound, G. pugettensis occurred on all stations except the softest (station 2), and the highest abundances were found on the sand-bottom stations 8, 6, and 3 (Table 64). There was no significant seasonal pattern in the abundance. Sipunculids are filter feeders or deposit feeders, which normally inhabit rather hard bottoms, avoiding loose mud or shifting sand (FISHER 1952).

After preservation the specimens of G. pugettensis appeared more or less contracted and therefore length measurements were not made. However, there seemed to be considerably larger individuals at stations 5 and 6 than at the other stations.

The wet weight and dry weight of G. pugettensis was determined for each sample, and the organic matter of two samples comprised 77.50 and 77.78%, respectively, of the dry weight. The dry weights could therefore be converted to organic matter by multiplying by a conversion factor of 0.7764, and Table 65 shows the wet weights and organic matter of G. pugettensis at the benthos stations in Puget Sound during the period of investigation. There were considerable fluctuations in the weight from one cruise to another, but the species contributed

Table 62

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Pectinaria californiensis in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	39	14	0	0	2	0	0	0
	W	922.2	2826.3			65.8			
	A	241.8	372.9			15.8			
Apr-May	N	33	38	0	0	0	0	0	0
	W	2075.3	7940.1						
	A	105.6	404.1						
July-Aug	N	10	17						
	W	600.9	5439.5						
	A	30.6	276.9						
Nov	N	94	20						
	W	2826.7	2359.4						
	A	143.9	111.9						

Table 63

Abundance (N), wet weight (W), and ash-free dry weight (A) per square metre of Pectinaria granulata in 1963. Weights in milligrammes

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	N	0	0	0	10	12	24	0	0
	W				487.4	372.0	118.9		
	A				27.6	20.1	9.7		
Apr-May	N	0	8	0	23	4	4	0	0
	W		269.6		1437.5	373.3	56.7		
	A		14.8		78.9	20.5	3.1		

None at stations 2 and 7 in July-August and November 1963

Table 64

Abundance per square metre of Golfingia pugettensis

	Stations 2	7	4	1	3	8	6	5
Jan-Feb 1963	0	4	11	1	17	0	16	0
Apr-May	0	2	10	10	1	24	2	0
July-Aug	0	9	7	3	14	39	5	0
Nov	0	0	0	11	11	36	19	15
Feb 1964	0	0	0	4	32	154	20	6
Apr	0	4	2	0	8	98	32	8
July-Aug	0	0	2	6	6	134	12	2

Table 65

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Golfingia pugettensis

		Stations 2	7	4	1	3	8	6	5
Jan-Feb	W	0	9.8	561.1	2.4	536.8	0	4044.5	0
1963	A	0	1.3	93.4	0.3	77.0	0	626.2	0
Apr-May	W	0	32.4	1128.7	73.8	13.9	804.5	1350.3	0
	A	0	3.8	182.2	9.9	1.7	98.3	151.0	0
July-Aug	W	0	97.0	285.2	688.7	412.9	359.4	4422.9	0
	A	0	11.5	40.5	105.8	49.9	34.8	606.9	0
Nov	W	0	0	0	878.2	262.0	487.9	11997.2	15262.1
	A	0	0	0	145.4	31.2	66.8	1630.9	2243.2
Feb	W	0	0	0	2037.4	3110.6	3222.1	321.3	5642.7
1964	A	0	0	0	293.5	491.7	442.2	29.4	879.6
Apr	W	0	9.9	27.6	0	104.8	1356.7	3532.3	26.2
	A	0	1.2	5.6	0	12.4	148.0	491.0	3.4
July-Aug	W	0	0	111.1	1130.2	127.2	7380.8	8867.0	9.4
	A	0	0	12.9	159.4	12.7	981.1	1263.1	1.2

significantly to the total standing crop at stations 1, 3, 8, 6, and 5. The high biomass, in spite of lower abundance, at stations 5 and 6 compared with that at station 8 again indicates that the specimens at stations 5 and 6 were generally larger than at the other stations.

32. Euphilomedes carcharodonta (V. Z. SMITH)

This ostracod of the family Cypridinidae was originally described by SMITH (1952) from British Columbia and recorded from the same area by POULSEN (1962).

Euphilomedes carcharodonta was very abundant in Puget Sound, where it occurred at all stations, but was particularly numerous at the shallow stations with a substrate dominated by fine sand. The species seemed to avoid the very soft (station 2) and very hard bottoms (station 5) (Table 66). At the six stations where E. carcharodonta occurred regularly, it was ranked first in numerical importance at three, second at one, and third at two, and was definitely the most abundant of the infauna species in Puget Sound. At the stations where E. carcharodonta was numerous there was a distinct seasonal fluctuation in abundance, with maxima occurring in July-August and minima in April-May.

Euphilomedes carcharodonta revealed a high degree of patchiness, particularly during the seasons when abundance was high. The species had the third highest degree of patchiness of the numerically dominant species (Table 23, page 338). Ostracods are viviparous and a high degree of patchiness can therefore be expected.

Length measurements were made for all the E. carcharodonta in the present study, and Figure 18 shows the length-frequency diagrams at station 8. Three size classes can be clearly distinguished, with practically no overlap among the groups. The modes of the groups were at 1.50, 1.88, and 2.27 mm, and the same size classes were found at all stations. POULSEN (1962) reported males from 2.2 to 2.4 mm, and a female of 2.37 mm. FOWLER (1909) found that with each moult ostracods increased in size by a certain factor, and SKOGSBERG (1920) found this growth factor to be 1.23 for Philomedes globosus. The data for E. carcharodonta from Puget Sound indicate growth factors varying with size. Between the two smallest size groups the factor was 1.27, and between the two largest groups, 1.21.

SKOGSBERG (1920) could distinguish six free-living immature stages of P. globosus, while in Puget Sound only mature specimens and two immature stages were found. However, smaller larval stages would not be retained by the 1-mm

Table 66

Abundance (N) per square metre and rank (R) of <u>Euphilomedes carcharodonta</u>

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	1	29	4	12	175	4	1367	1	24	10	214	1	5	11	0	
Apr-May		0		434	1	97	5	1487	1	50	3	197	4	0		0	
July-Aug		0		18	5	721	2	543	1	383	1	4396	1	53	5	10	9
Nov		2	22	0		1512	1	1920	1	194	2	341	1	37	2	0	
Feb	1964	4	9	194	1	458	1	864	1	16	11	432	2	134	1	0	
Apr		2	17	621	1	106	3	678	1	40	3	380	1	48	1	2	22
July-Aug		2	15	482	1	498	2	2292	1	145	2	2394	1	6	22	0	

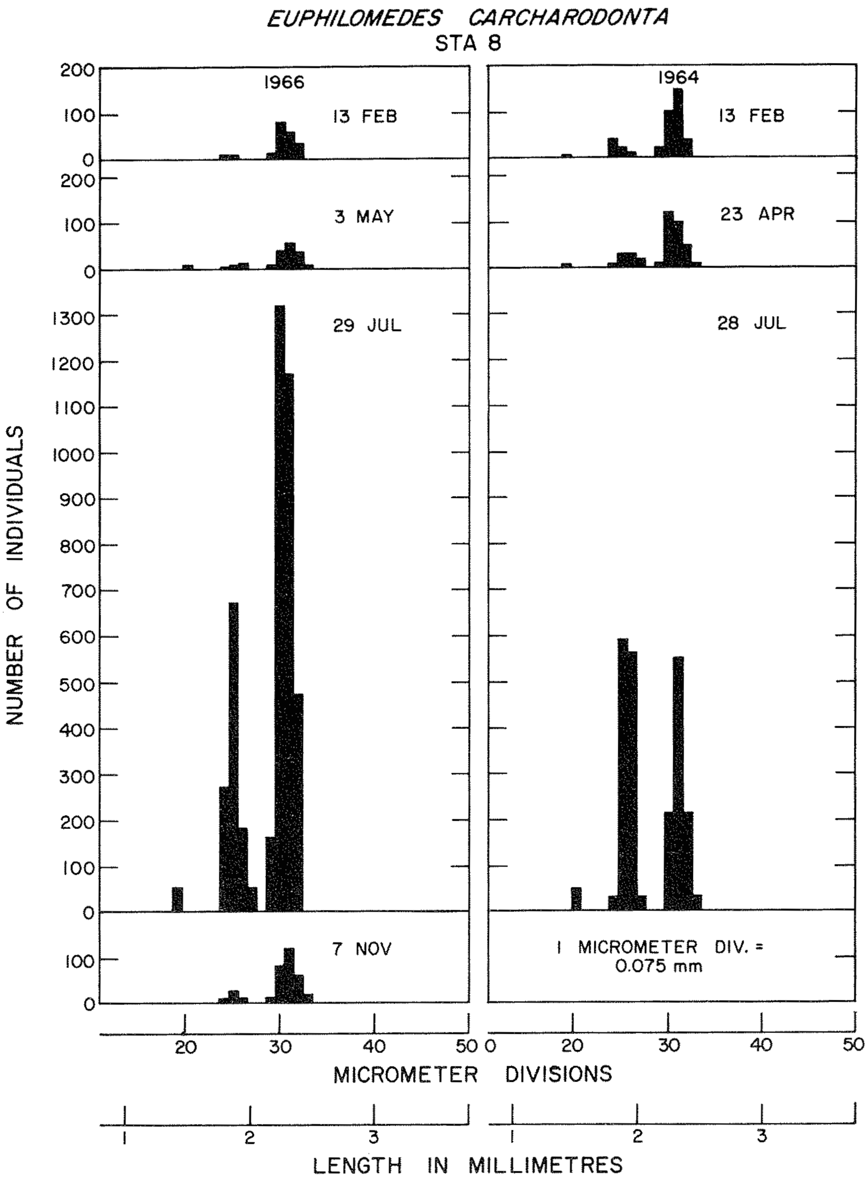

Figure 18. Size distribution of Euphilomedes carcharodonta at station 8.

Table 67

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of <u>Euphilomedes carcharodonta</u>

♀		Stations 2	7	4	1	3	8	6	5
Jan-Feb 1963	W	2.5	6.7	287.8	1577.1	37.0	267.5	12.8	0
	A	0.3	0.6	26.8	147.3	3.4	24.3	1.2	0
Apr-May	W	0	320.3	130.1	873.1	55.9	301.8	0	0
	A	0	33.5	11.9	84.8	5.9	28.0	0	0
July-Aug	W	0	19.5	729.4	978.4	255.7	5868.6	94.1	30.5
	A	0	1.9	70.4	92.6	24.9	565.7	9.1	3.0
Nov	W	2.7	0	1988.6	2415.2	249.1	369.7	60.5	0
	A	0.3	0	180.8	220.2	22.5	30.3	5.6	0
Feb 1964	W	5.4	182.0	613.7	1073.4	26.2	590.9	161.4	0
	A	0.7	17.2	55.1	100.0	2.4	54.7	15.1	0
Apr	W	2.7	479.3	137.4	850.2	53.6	448.1	59.2	1.3
	A	0.3	52.0	12.5	77.3	4.8	38.1	9.1	0.1
July-Aug	W	1.3	542.4	434.7	1487.6	112.0	2880.2	9.6	0
	A	0.1	56.1	44.0	149.8	12.1	285.8	0.8	0

screen. Figure 18 shows that mature specimens generally were more abundant than the immature, perhaps because the immature are more free-swimming than the mature specimens. MULLER (1894) stated that females of the genus <u>Philomedes</u> bit off their natatory bristles and were therefore not able to rise from the bottom, while the males were able to swim throughout their lives. This may in part explain the unequal sex ratio of <u>Euphilomedes carcharodonta</u> in the samples. The males generally comprised from 5 to 10% of the number of mature specimens, but during July-August they comprised from 20 to 50%.

From 20 to 30 specimens in each of the three size classes were weighed and the average wet weights and dry weights were determined. The wet weights per individual from the three size classes were 0.40, 1.34, and 2.54 mg, respectively, and the dry weights 0.08, 0.19, and 0.39 mg. The organic matter of a sample of <u>E. carcharodonta</u> comprised 63.1% of the dry weight, and the conversion factor from dry weight to organic matter was 0.631. The total wet weight and the weight of the organic matter of <u>E. carcharodonta</u> during the period of investigation was calculated by multiplying the number of organisms in the various size classes with the corresponding weights and the dry weight/organic matter conversion factor; the results are shown in Table 67. Because of its minute size, E. carcharodonta was not so important by weights as by numbers, but at stations 1 and 8 it contributed significantly to the total standing crop.

33. Euphilomedes producta POULSEN

This species was originally described from British Columbia by POULSEN (1962). Euphilomedes producta was the second most abundant ostracod in Puget Sound, and it occurred on somewhat deeper and softer bottoms than E. carcharodonta (Table 68). At stations 1, 2, and 3, E. producta had an overall rank of 2, 4, and 2, respectively, and at stations 1, 3, and 4, where the abundance was highest, there was a distinct seasonal trend, with maxima occurring in July-August and minima during January-February or April-May.

Table 23 shows that E. producta was among the numerically dominant species with the highest patchiness.

Euphilomedes producta showed nonoverlapping modes on the size frequency curves similar to E. carcharodonta, and Figure 19 shows the size frequency diagrams for the species at station 1. The three modes that occurred at all stations were 1.20, 1.50, and 1.80 mm, and the calculated growth factors between the groups were 1.25 and 1.20. One single female found by POULSEN (1962) near Nanaimo, British Columbia, measured 1.78 mm.

Euphilomedes producta is considerably smaller than E. carcharodonta and the two smaller size groups were definitely not quantitatively sampled. The males were generally rare, comprising from 0 to 5%; during July-August from 20 to 45%.

The weights of E. producta were determined as for E. carcharodonta. The average wet weight per individual in the various size classes was 0.12, 0.50, and 1.08 mg and the dry weights were 0.02, 0.06, and 0.16 mg. The organic matter comprised 65.4% of the dry weight and the conversion factor from dry weight to organic matter was 0.654. Total wet weight and organic matter was determined as for E. carcharodonta; the results are presented in Table 69, from which it is obvious that E. producta plays an insignificant part in the total standing crop at the benthos stations in Puget Sound.

Table 68

Abundance (N) per square metre and rank (R) of <u>Euphilomedes producta</u>

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	341	2	0		216	3	20	8	278	1	1	23	5	11	0	
Apr-May		52	4	148	3	6	17	117	3	0		0		0		0	
July-Aug		1	20	6	12	270	3	295	2	277	2	0		16	12	0	
Nov		44	2	0		1	23	144	3	245	1	0		1	41	0	
Feb	1964	40	3	24	4	22	9	36	6	56	3	0		0		0	
Apr		56	2	187	3	18	11	212	2	36	4	2	29	0		0	
July-Aug		22	5	190	2	278	3	1274	2	175	1	2	33	2	30	0	

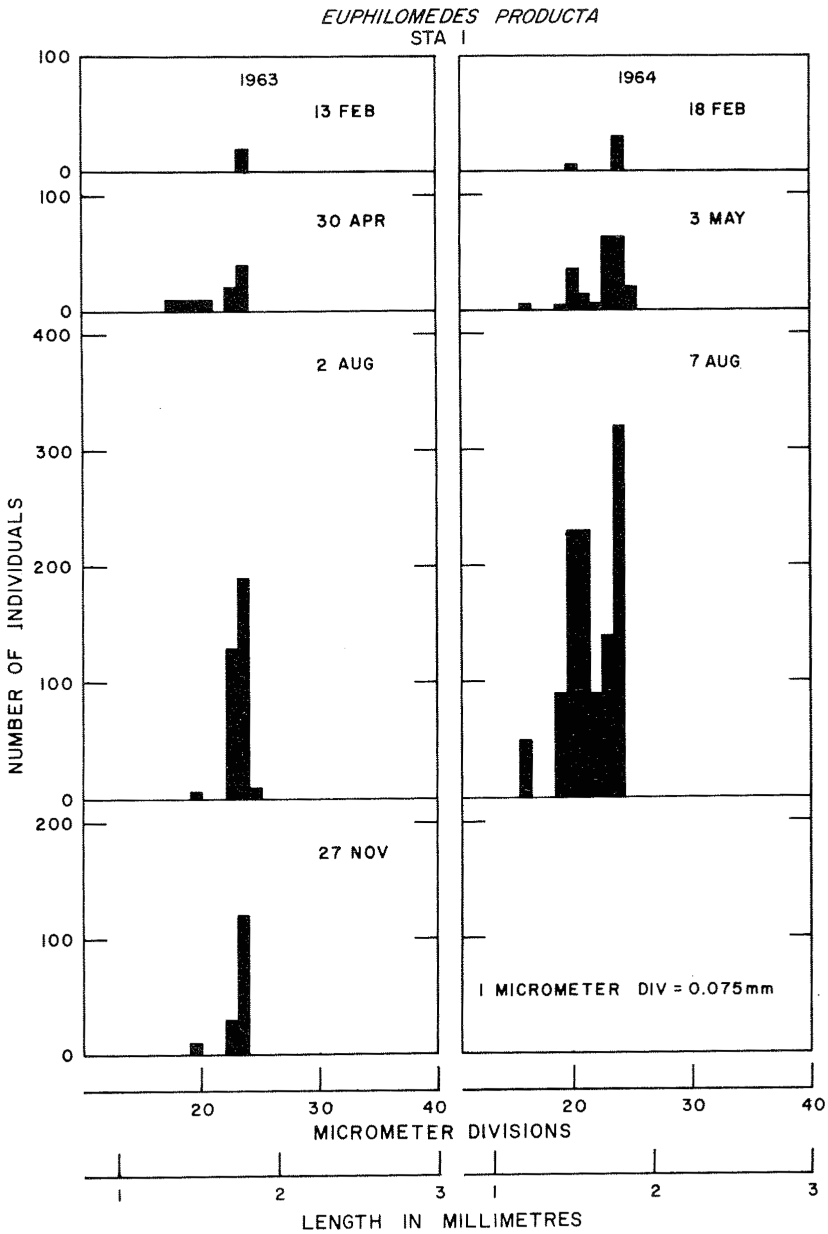

Figure 19. Size distribution of Euphilomedes producta at station 1.

Table 69

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Euphilomedes producta

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	155.8	0	97.5	10.6	137.5	0.5	3.0	0
1963	A	12.2	0	7.8	0.9	10.9	0.1	0.3	0
Apr-May	W	26.0	61.5	3.0	33.2	0	0	0	0
	A	2.0	5.1	0.3	2.9	0	0	0	0
July-Aug	W	0	3.0	116.8	185.1	118.1	0	13.2	0
	A	0	0.3	9.7	14.9	9.9	0	1.2	0
Nov	W	21.2	0	1.1	70.9	105.0	0	0.5	0
	A	1.7	0	0.1	5.6	8.4	0	0.1	0
Feb	W	18.0	12.0	11.0	15.5	22.7	0	0	0
1964	A	1.4	0.9	0.9	1.2	1.8	0	0	0
Apr	W	30.2	98.9	9.0	85.7	17.2	1.0	0	0
	A	2.2	8.0	0.7	6.9	1.4	0.1	0	0
July-Aug	W	10.1	113.1	104.6	603.1	79.4	1.0	1.1	0
	A	0.9	9.3	8.9	52.3	7.0	0.1	0.1	0

34. Paraphoxus variatus BARNARD

The species, which is an amphipod of the family Phoxocephalidae, was found by BARNARD (1960a) in coastal waters of southern California, in depths from 9 to 110 m, with 80% occurring at depths of less than 37 m. The sediments on the type locality were a sandy mud.

Paraphoxus variatus was not one of the regularly occurring species in Puget Sound (Table 70), but at station 4 it was occasionally numerous and definitely among the numerically important species. Table 70 indicates that P. variatus prefers a sandy substrate, and when the sediment changed from a muddy sand to fine sand at station 4, P. variatus was among the species that increased in numbers.

Paraphoxus variatus had the highest degree of patchiness of the numerically important species (Table 23, page 338). It must be emphasized, however, that as the species was abundant at one station only, the number of observations on patchiness was lower than for most other species.

Figure 20 shows the size frequency diagrams of P. variatus at station 4 during the period of investigation. The curves were unimodal, no change of the

Table 70

Abundance (N) per square metre and rank (R) of <u>Paraphoxus variatus</u>

Stations

	2		7		4		1		3		8		6		5	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb 1963	0		0		62	8	5	19	0		0		0		0	
Apr-May	0		0		146	2	0		14	21	0		0		0	
July-Aug	0		0		74	9	1	35	0		29	9	0		0	
Nov	0		0		541	2	0		4	25	0		0		0	
Feb 1964	0		0		368	2	12	13	0		0		0		0	
Apr	0		0		94	2	0		20	7	0		0		0	
July-Aug	0		0		48	10	0		2	50	0		0		0	

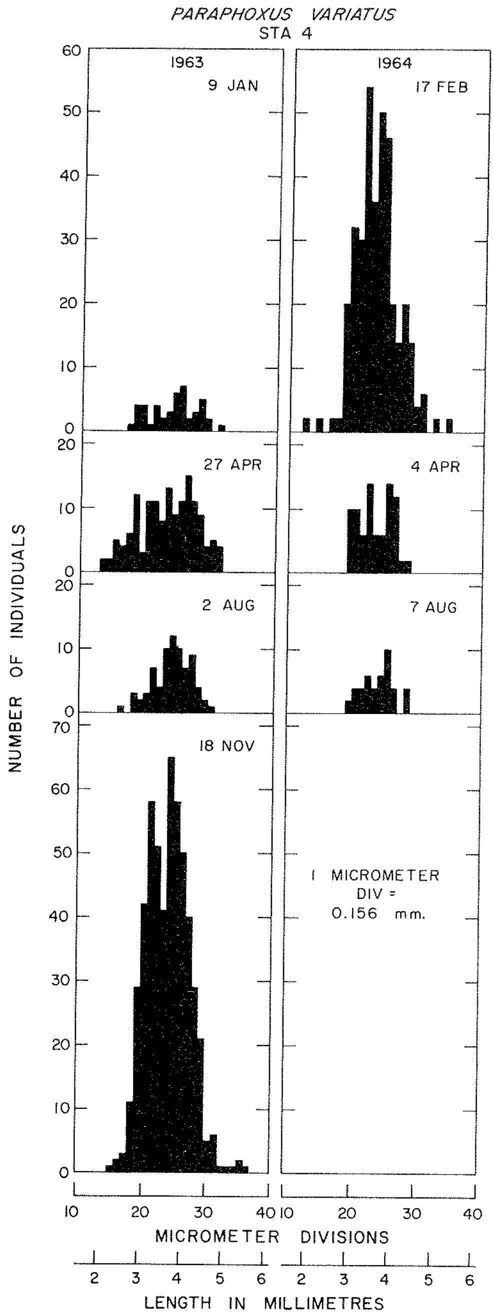

Figure 20. Size distribution of Paraphoxus variatus at station 4.

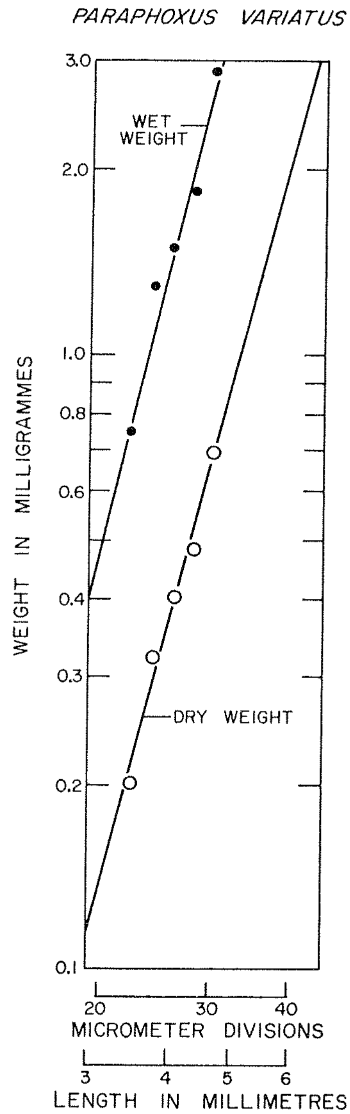

Figure 21. Weight/size curves for Paraphoxus variatus.

Table 71

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Paraphoxus variatus

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	60.6	7.5	0	0	0	0
1963	A	0	0	10.4	1.3	0	0	0	0
Apr-May	W	0	0	182.9	0	21.6	0	0	0
	A	0	0	31.2	0	3.7	0	0	0
July-Aug	W	0	0	101.8	1.7	0	58.4	0	0
	A	0	0	17.4	0.3	0	10.7	0	0
Nov	W	0	0	705.6	0	6.0	0	0	0
	A	0	0	120.5	0	1.0	0	0	0
Feb	W	0	0	398.8	23.8	0	0	0	0
1964	A	0	0	68.1	4.1	0	0	0	0
Apr	W	0	0	91.8	0	33.6	0	0	0
	A	0	0	15.7	0	5.7	0	0	0
July-Aug	W	0	0	54.4	0	4.2	0	0	0
	A	0	0	9.3	0	0.7	0	0	0

modes can be demonstrated, and there was no season with a significantly higher number of small individuals. This may indicate that a more or less continuous spawning took place.

The relationships between weights and sizes were found by weighing groups of 20 individuals from five size classes, and the mean weights for each size class were plotted (Figure 21). The dry weight comprised 25.24% of the wet weight, and two ash determinations showed that the ash made up 32.2 and 31.7% of the dry weight, respectively. This was a considerably higher ash content than found for any other nondecapod crustacean, and P. variatus was easily recognized in the samples by the heavily calcified exoskeleton.

The wet weights and the organic matter of P. variatus at the various stations during the period of investigation are shown in Table 71. The data were calculated from the size measurements and the weight/size curves in Figure 21. The dry weights were converted into organic matter by multiplying by 0.680. Table 71 shows that P. variatus occasionally was of some importance to the standing crop at station 4.

35. Heterophoxus oculatus (HOLMES)

This amphipod of the family Phoxocephalidae is distributed from Puget Sound to Panama (BARNARD 1960a). In southern California it occurred in depths from 18 to 1920 m, but generally from 94 to 183 m.

Heterophoxus oculatus was ubiquitous in Puget Sound, occurring with nearly the same abundance at all stations except station 4 (Table 72), where its ecological role may have been taken over by Paraphoxus variatus. The data in Table 72 gave no information about sediment preference for H. oculatus, and the variations in numbers during the period of investigation appear to be random fluctuations rather than seasonal variations. Heterophoxus oculatus was not very patchily distributed (Table 23, page 338), and in nearly half of the observations the species was randomly or evenly distributed.

The size frequency diagrams for the various stations gave no indication about growth and recruitment of H. oculatus. The data for all stations were graphed together and the resulting size frequency diagrams are shown in Figure 22. However, the diagrams still appeared unimodal and no significant changes of the modes indicating growth could be demonstrated. The explanation may be, as for Paraphoxus variatus, that there was a more or less continuous spawning all year round.

The size range of H. oculatus in the Puget Sound material was from 2.3 to 8.0 mm, and the modes on the size frequency diagrams ranged from 4.5 to 5.5 mm.

Wet weights and dry weights were determined for groups of 20 specimens from seven size classes, and the mean weights for each size class were graphed in Figure 23. The dry weights comprised 18.27% of the wet weight, and the organic matter of two samples was 90.0 and 89.4% of the dry weights, respectively.

The wet weights and dry weights were calculated from the size frequency diagrams and the weight/size curves in Figure 23, and the organic matter was found by multiplying the dry weights by 0.897 (Table 73). H. oculatus did not contribute significantly to the total standing crop at any of the benthos stations in Puget Sound.

36. Byblis veleronis BARNARD

This amphipod of the family Ampeliscidae is distributed along the coast of southern California and in the Gulf of California in depths of from 9 to 417 m (BARNARD 1954a). In a comparison between amphipod faunas from Newport Bay,

Table 72

Abundance (N) per square metre and rank (R) of Heterophoxus oculatus

		Stations															
		2		7		4		1		3		8		6		6	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	8	12	19	6	2	30	6	13	8	20	24	4	37	1	37	4
Apr-May		16	7	6	13	1	31	17	12	50	3	97	5	26	3	18	8
July-Aug		27	4	16	6	2	36	7	15	14	22	3	30	78	2	2	24
Nov		27	4	6	5	0		40	7	5	22	9	18	61	1	58	2
Feb	1964	16	5	18	5	0		10	14	14	12	8	8	30	3	30	2
Apr		32	5	12	6	0		46	6	16	9	46	7	44	2	86	1
July-Aug		16	6	26	7	4	30	40	10	37	11	8	21	86	1	2	24

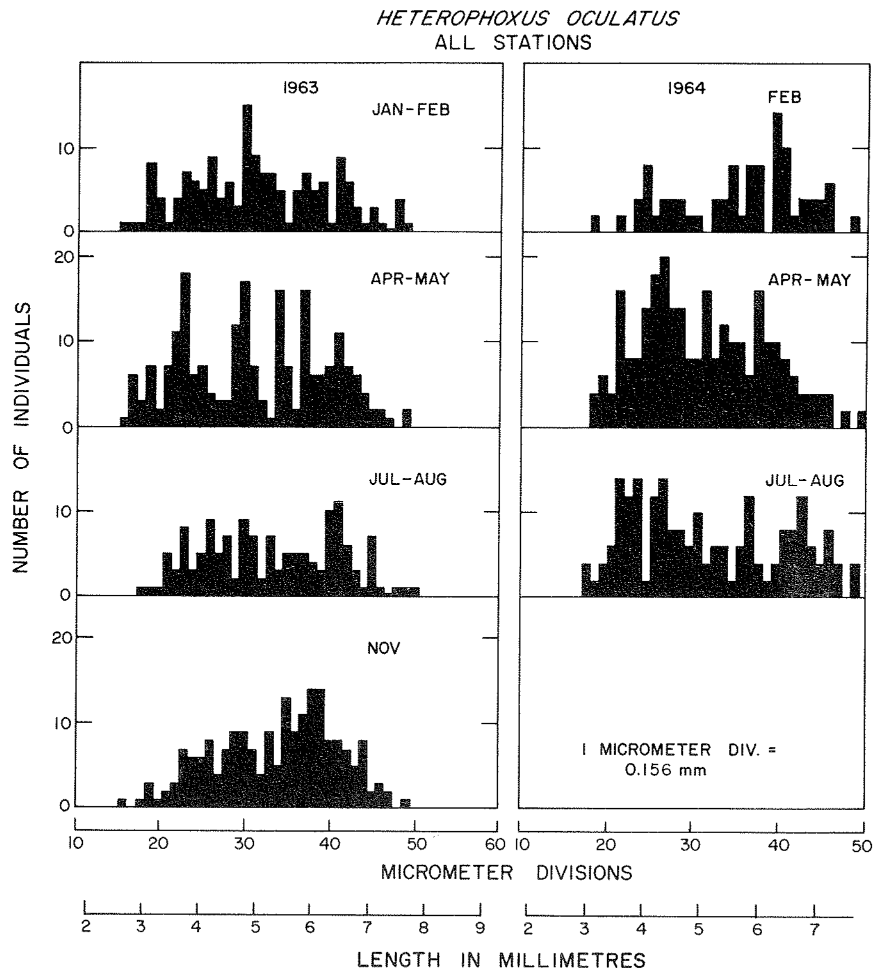

Figure 22. Size distribution of Heterophoxus oculatus Combined data for all stations.

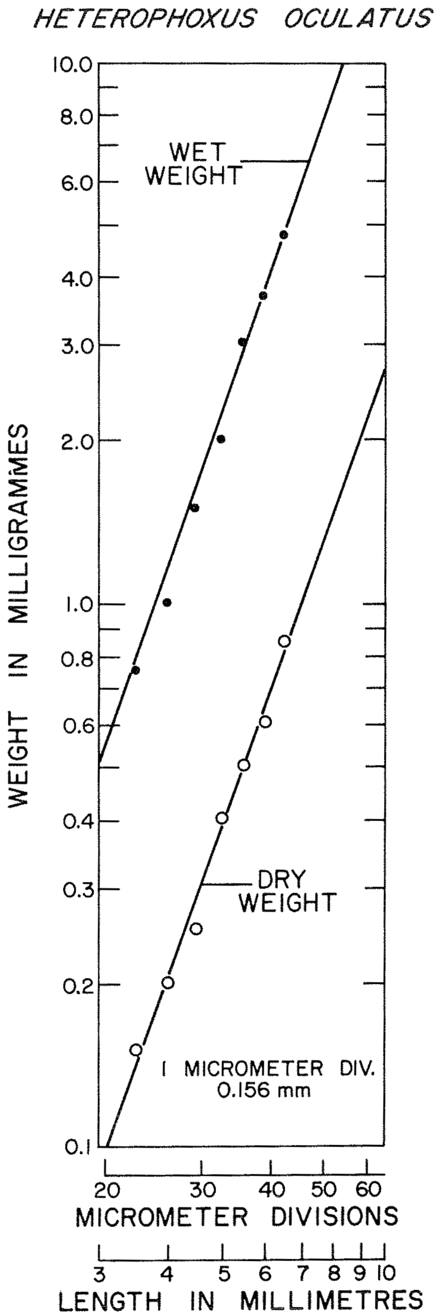

Figure 23. Weight/size curves for Heterophoxus oculatus.

Table 73

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Heterophoxus oculatus

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	21.4	85.8	5.4	10.4	21.2	45.2	95.6	96.6
	A	3.5	14.0	0.9	1.7	3.5	7.4	15.6	15.8
Apr-May	W	67.4	33.3	3.0	40.4	144.2	153.3	52.4	39.0
	A	11.0	5.4	0.5	6.6	23.5	25.0	8.6	6.4
July-Aug	W	37.4	51.9	6.3	27.8	38.0	13.7	167.1	5.2
	A	6.1	8.5	1.0	4.5	6.2	2.2	27.3	0.8
Nov	W	100.3	21.6	0	89.2	15.1	32.9	152.2	137.8
	A	16.4	3.5	0	14.6	2.5	5.4	24.8	22.5
Feb 1964	W	58.8	79.8	0	24.2	42.4	23.0	87.4	80.8
	A	9.6	13.0	0	3.9	6.9	3.8	14.3	13.2
Apr	W	106.2	16.8	0	113.4	39.6	127.0	101.4	174.7
	A	17.3	2.7	0	18.5	6.5	20.7	16.5	28.5
July-Aug	W	68.2	92.4	12.4	144.2	136.0	30.8	139.2	6.8
	A	11.1	15.1	2.0	23.5	22.3	5.0	22.7	1.1

California, and offshore benthos stations, BARNARD (1961) found a density of eight B. veleronis per square metre in the offshore samples and none in the Newport Bay samples.

In Puget Sound B. veleronis occurred at all stations but in very low abundance at the soft-bottom stations 2, 7, and 4 (Table 74). At stations 1, 3, and 8, the overall rank of B. veleronis through the period of investigation was 5, 1, and 5, respectively. There was no significant seasonal trend in abundance during the period of investigation.

Size-frequency diagrams for single stations did not clearly show the growth pattern of B. veleronis and the data for all stations were therefore lumped together (Figure 24). The diagrams are complex but appear to be generally of a bimodal type, and the location of the modes at the various dates were plotted (Figure 25). The growth curve appears to be rectilinear and the growth per year was approximately 7 mm. Byblis veleronis had a life span of about 2 years in Puget Sound. The size range was from 2.0 to 14.7 mm.

Wet weights were determined from 14 size groups of B. veleronis and dry weight from ten size groups. There were from seven to 15 specimens per size

Table 74

Abundance (N) per square metre and rank (R) of <u>Byblis veleronis</u>

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	0		0		6	18	14	12	88	2	12	8	5	11	17	6
Apr-May		0		0		7	15	10	16	73	1	30	10	10	12	146	2
July-Aug		0		0		2	36	24	6	58	5	42	8	8	21	137	2
Nov		1	29	0		2	20	91	4	55	3	51	6	18	12	33	5
Feb	1964	0		0		0		46	3	116	1	18	5	20	5	6	8
Apr		0		0		4	20	36	7	64	1	46	7	16	13	48	4
July-Aug		0		0		8	23	70	7	118	3	42	11	10	17	8	14

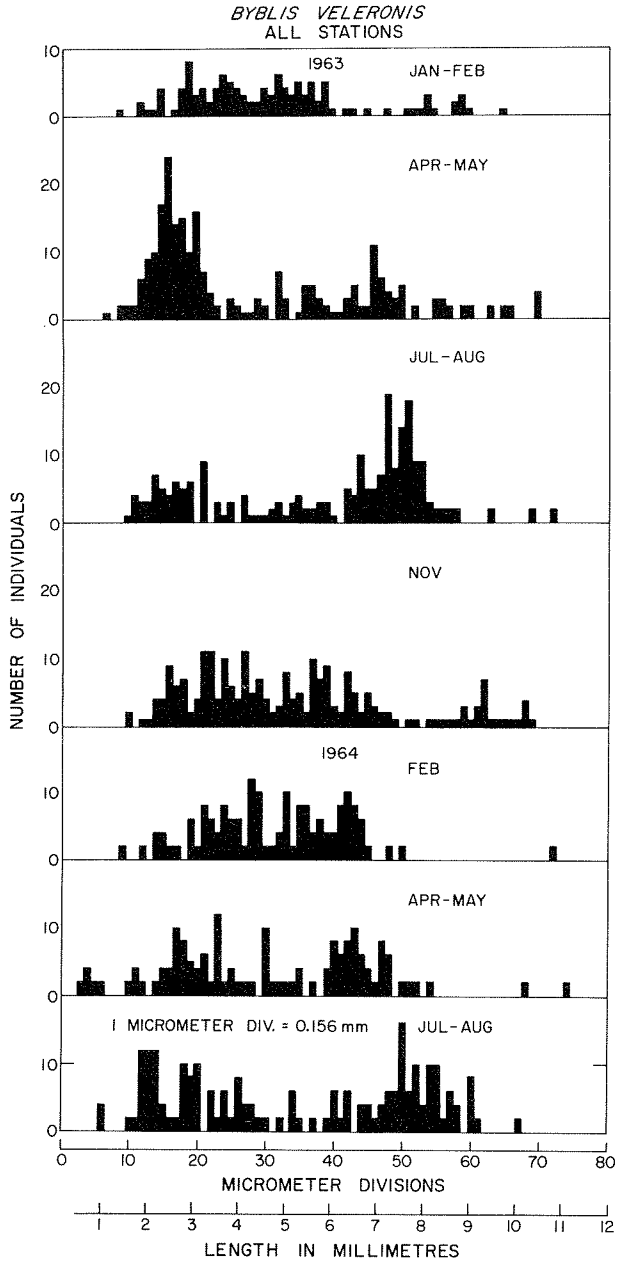

Figure 24. Size distribution of Byblis veleronis Combined data for all stations.

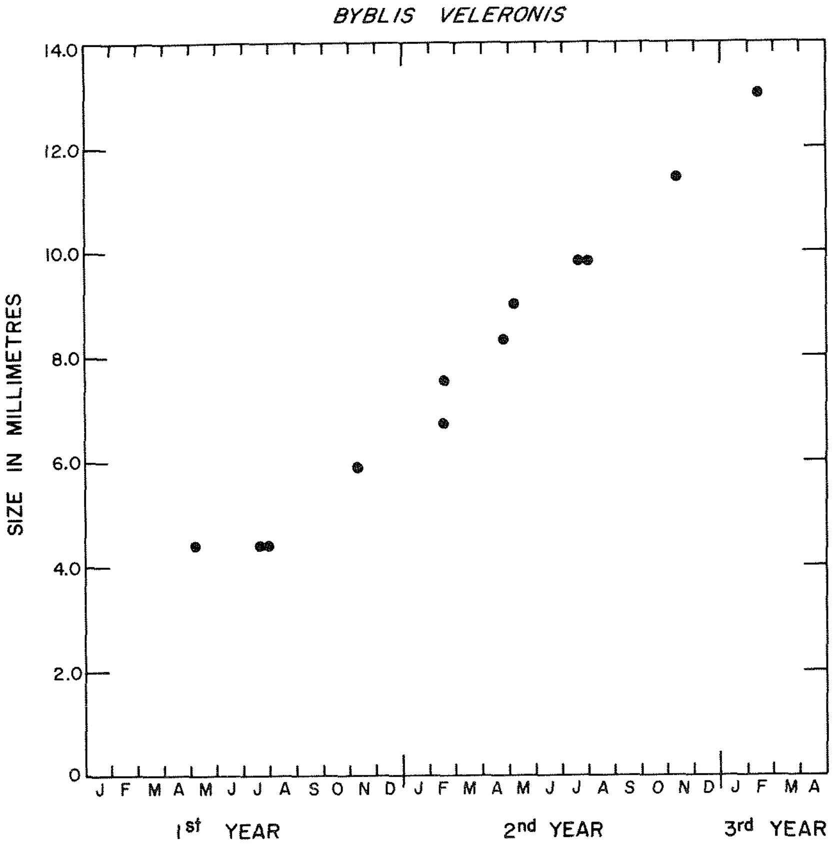

Figure 25. Growth curve for Byblis veleronis.

group and the mean weights for each group were plotted in Figure 26. The organic matter of two samples comprised 84.4 and 84.1% of the dry weight. The conversion factor from dry weight to dry organic matter was then 0.8425. From the length measurements, the weight/size curves in Figure 26 and the dry weight/organic matter conversion factor, the total wet weight, and the organic matter of B. veleronis at the benthos stations in Puget Sound during the period of investigation were calculated (Table 75). In spite of the high abundance, B. veleronis appears to be a rather insignificant contributor to the standing crop.

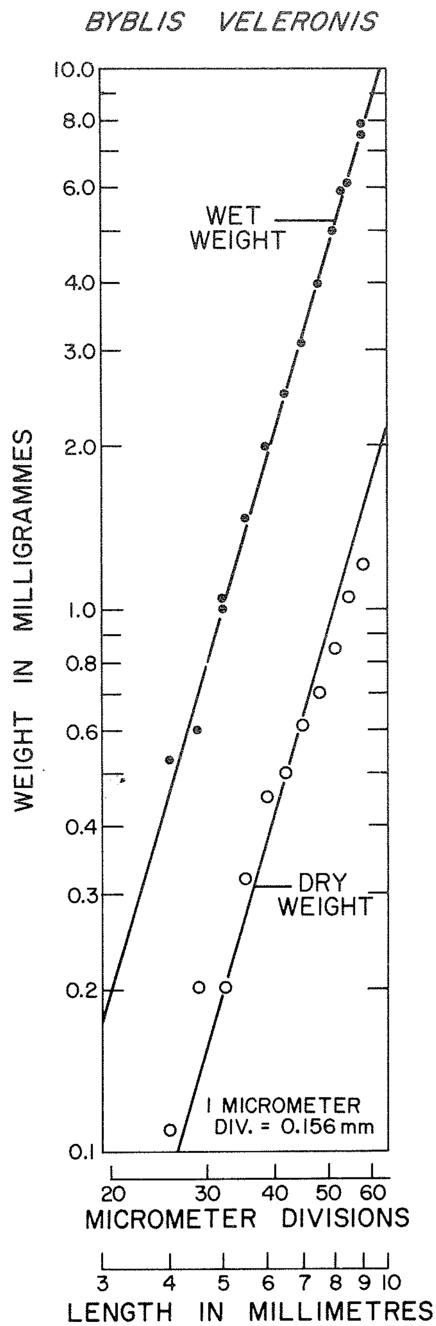

Figure 26. Weight/size curves for Byblis veleronis.

Table 75

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Byblis veleronis

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	2.9	18.0	101.3	5.8	2.3	49.5
1963	A	0	0	0.5	3.1	17.4	1.0	0.4	8.5
Apr-May	W	0	0	4.1	12.8	172.9	16.9	4.1	87.9
	A	0	0	0.7	2.2	29.7	2.9	0.7	15.1
July-Aug	W	0	0	5.2	20.4	138.5	16.3	7.6	208.9
	A	0	0	0.9	3.5	23.8	2.8	1.3	35.9
Nov	W	0	0	1.7	40.7	26.2	33.8	11.1	103.0
	A	0	0	0.3	7.0	4.5	5.8	1.9	17.7
Feb	W	0	0	0	28.5	59.9	11.6	11.6	11.1
1964	A	0	0	0	4.9	10.3	2.0	2.0	1.9
Apr	W	0	0	1.7	37.2	34.9	6.4	6.4	43.7
	A	0	0	0.3	6.4	6.0	1.1	1.1	7.5
July-Aug	W	0	0	2.9	89.6	130.3	7.6	7.6	15.1
	A	0	0	0.5	15.4	22.4	1.3	1.3	2.6

37. Leptochelia dubia KRÖYER

This tanaid of the family Tanaidae has a world-wide distribution, reported from Hawaii, Brazil, Puerto Rico, Bermuda, Jamaica, Ireland, the Red Sea, British Columbia (Canada), and Washington (U.S.A.) (HATCH 1947).

In Puget Sound the species was not found at stations with very fine or very coarse sediment, but was abundant at stations with fine sandy bottoms on shallow water (Table 76). According to HATCH (1947) Leptochelia dubia builds tubes of sand in the intertidal zone and down to about 46 m.

Leptochelia dubia carries its young in a brood pouch, which may be the reason for the very high degree of patchiness demonstrated in Table 23, page 338.

Figure 27 shows the length frequency diagrams for L. dubia at station 1. The diagrams appear to be unimodal, and as there was no significant change in the location of the modes, information concerning longevity and growth rate of L. dubia could not be extracted. The smallest specimen found in the samples was 1.7 mm, and the largest 5.7 mm. HATCH (1947) recorded a length of 4.75 mm for L. dubia.

Table 76

Abundance (N) per square metre and rank (R) of Leptochelia dubia

	Stations															
	2		7		4		1		3		8		6		5	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb 1963	0		0		46	11	156	2	0		0		0		0	
Apr-May	0		0		34	12	70	5	4	33	28	12	0		0	
July-Aug	0		0		14	18	10	11	0		8	21	0		0	
Nov	0		0		49	8	1103	2	4	25	22	9	0		0	
Feb 1964	0		0		6	16	232	2	0		2	17	0		0	
Apr	0		0		20	8	130	3	2	27	48	5	0		0	
July-Aug	0		0		0		240	3	5	36	4	28	0		0	

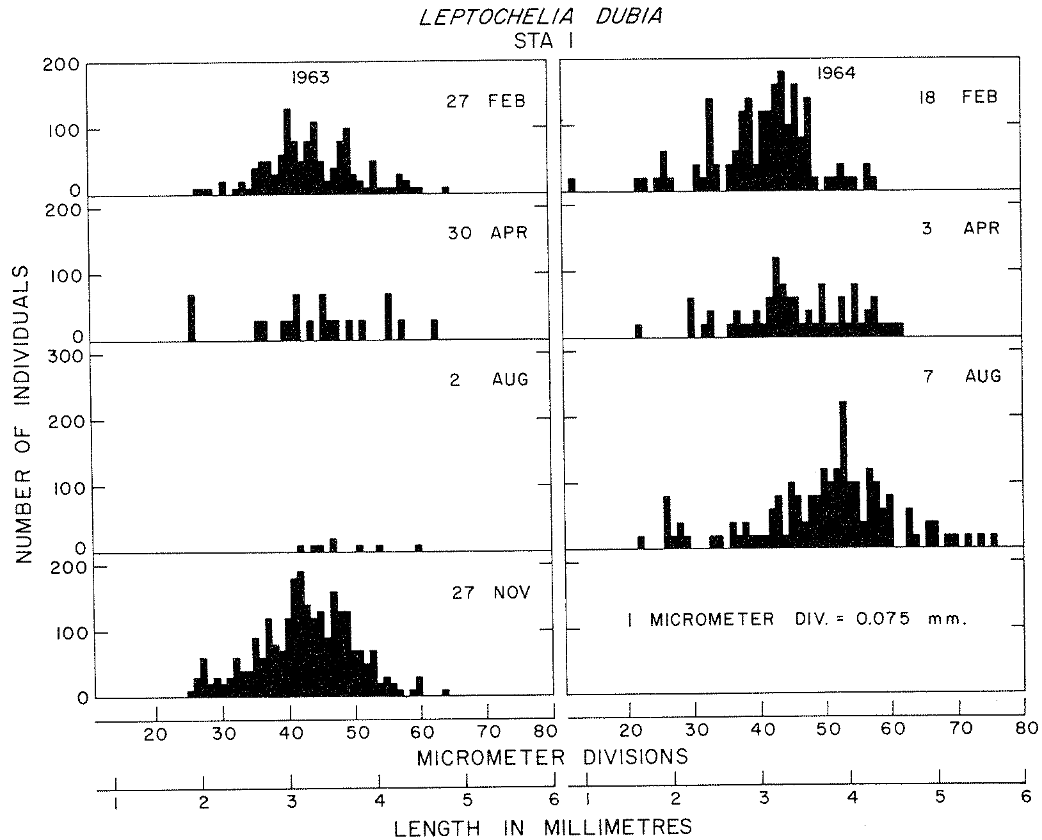

Figure 27. Size distribution of Leptochelia dubia at station 1.

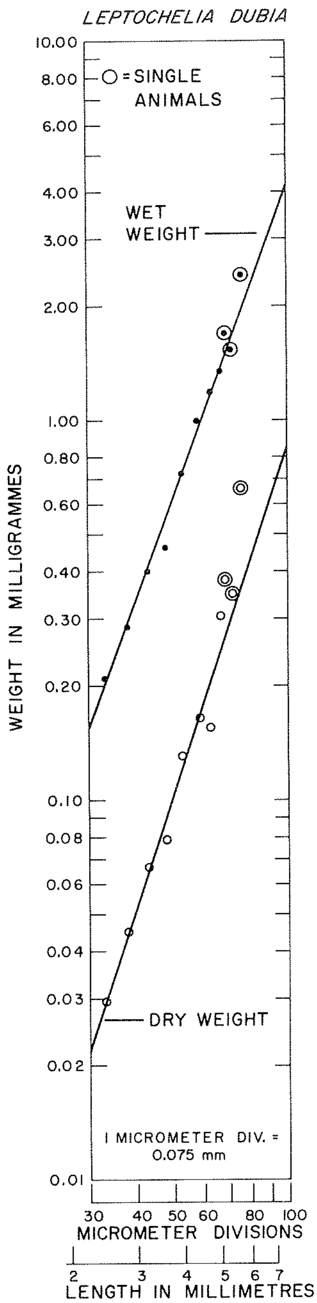

Figure 28. Weight/size curves for Leptochelia dubia.

Table 77

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Leptochelia dubia

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	0	0	21.4	106.2	0	0	0	0
	A	0	0	3.0	14.9	0	0	0	0
Apr-May	W	0	0	25.7	31.3	3.2	22.9	0	0
	A	0	0	3.6	4.4	0.4	3.2	0	0
July-Aug	W	0	0	8.0	8.1	0	5.1	0	0
	A	0	0	1.1	1.1	0	0.7	0	0
Nov	W	0	0	24.8	109.6	3.8	8.6	0	0
	A	0	0	3.5	15.3	0.5	1.2	0	0
Feb 1964	W	0	0	3.2	143.4	0	1.8	0	0
	A	0	0	0.5	20.1	0	0.3	0	0
Apr	W	0	0	16.2	113.0	1.9	40.2	0	0
	A	0	0	2.3	15.8	0.2	5.6	0	0
July-Aug	W	0	0	0	266.4	5.4	2.0	0	0
	A	0	0	0	37.3	0.8	0.3	0	0

Wet weights and dry weights were determined from 11 size classes of L. dubia and the weight/size curves are shown in Figure 28. From four to 22 specimens were weighed in each size class except for the three largest size classes, which contained single individuals. Eight of the 11 points on the curves in Figure 28 therefore represent mean weights and three points represent individual weights.

The organic matter was found to comprise 77.1% of the dry weight. From the size frequency diagrams, the weight/size curves in Figure 28, and the organic matter/dry weight conversion factor (0.771), the total wet weight and organic matter at the Puget Sound benthos stations during the period of investigation was calculated (Table 77). Leptochelia dubia was obviously of no importance to the total standing crop at the Puget Sound benthos stations.

38. Eudorella pacifica HART

This cumacean of the family Leuconidae was described by HART (1930) from British Columbia, Canada. BARNARD and GIVEN (1961) studied carapace dentation of a large number of Eudorella collected off southern California and found reason to regard the two species, E. pacifica and E. tridentata, originally described by HART (1930) to be the same. In southern California, E. pacifica was found on soft bottom in water deeper than 27 m and with a density of from 1.6 to 45 specimens per square metre.

The Eudorella found in Puget Sound were all of the E. pacifica type (HART 1930) and the species was strongly associated with soft sediment (Table 78). The change to coarser sediment at station 4 between August and November 1963 (page 263) had a severe effect on the abundance of E. pacifica. Table 78 does not reveal significant seasonal variability in abundance, partly because seasonal variations cannot be separated from random variability. Eudorella pacifica ranked number nine in patchiness of the numerically dominant species (Table 23, page 338).

Figures 29, 30, and 31 show length frequency distributions of E. pacifica at stations 2, 4, and 7. The material from single stations was too scanty to determine the growth of the species, but there was a distinct difference among the various stations in size distributions. At station 2 the sizes ranged from 4.1 to 5.6 mm, at station 4 from 3.2 to 4.5 mm, and at station 7 from 4.1 to 6.4 mm; multimodal frequency curves indicating different year classes were not significant at any of the stations. As the size differences among the stations might be parameters of the different populations rather than different year classes, studies of age distributions and growth patterns of E. pacifica from pooled data of all the stations is hardly justified.

Four size groups with from three to seven specimens in each group were weighed and the size/weight curves are shown in Figure 32. The dry weight comprised 17.2% of the wet weight, and the organic matter of one sample was 73.1% of the dry weight. Table 79 shows that Eudorella pacifica did not contribute significantly to the standing crop of benthos at any of the stations in Puget Sound.

39. Pinnixa schmitti RATHBUN

This species is a crab of the family Pinnotheridae found from Alaska to San Francisco Bay (RATHBUN 1918) in burrows of Upogebia sp. (WELLS 1928). RICKETTS and CALVIN (1952) reported that P. schmitti is a frequent commensal with Echiurus sp. and that young specimens occurred with terebellid worms.

HART (1940) found P. schmitti in British Columbia mostly on sand in tubes of the polychaete genus Amphitrite. In Puget Sound, P. schmitti occurred on all the shallow-water stations with sandy bottom types (Table 80). At the two soft bottom stations in deeper water, it had been replaced by P. barnharti and P. occidentalis (Tables 8 and 18, pages 281 and 320).

Table 78

Abundance (N) per square metre and rank (R) of _Eudorella pacifica_

	Stations															
	2		7		4		1		3		8		6		5	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb 1963	32	4	33	3	147	5	0		18	12	0		0		0	
Apr-May	28	6	56	4	6	17	0		1	55	0		0		0	
July-Aug	50	2	46	1	112	7	0		3	38	0		0		0	
Nov	23	5	29	2	1	23	1	39	6	21	0		0		0	
Feb 1964	0		54	3	4	18	2	25	0		0		0		0	
Apr	5	8	28	4	8	16	0		0		0		0		0	
July-Aug	18	3	168	4	56	10	4	34	10	27	0		0		0	

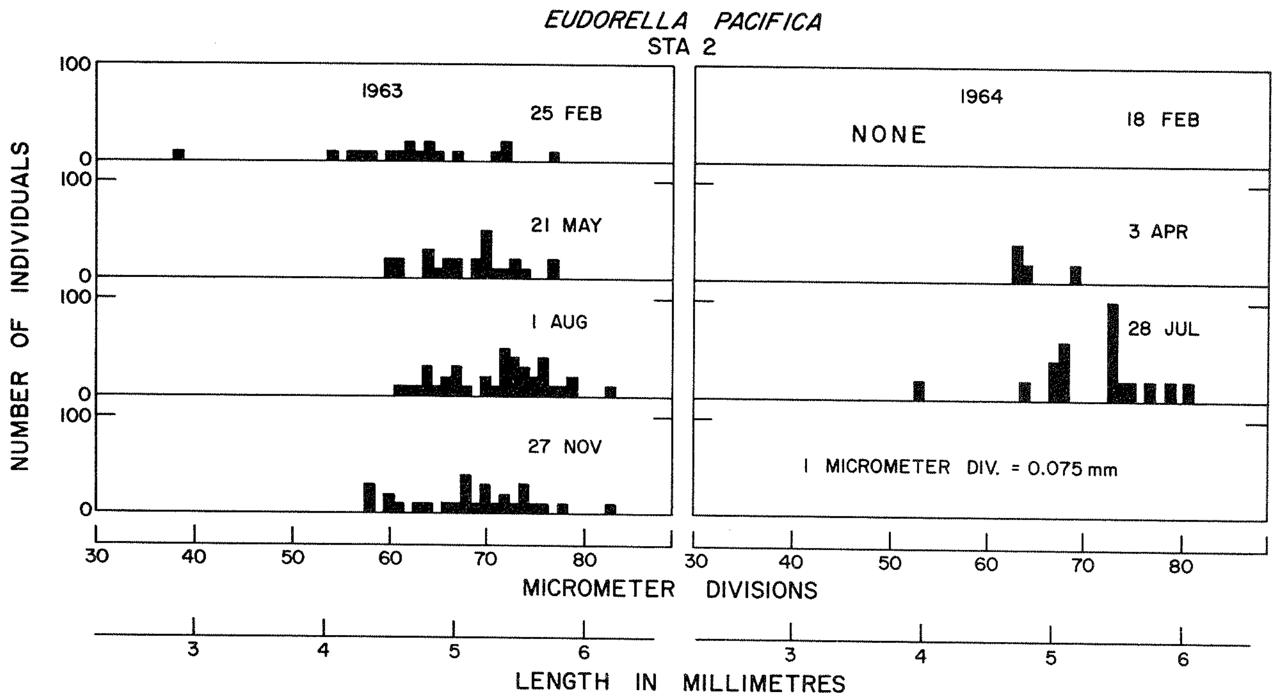

Figure 29. Size distribution of Eudorella pacifica at station 2.

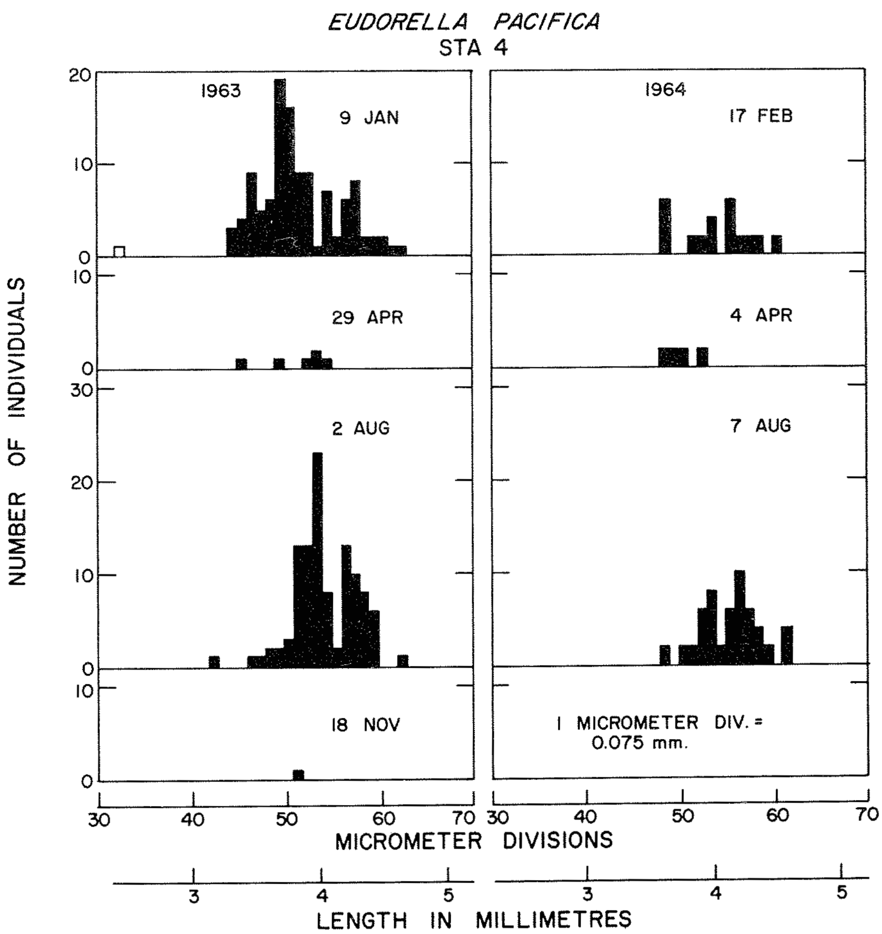

Figure 30. Size distribution of Eudorella pacifica at station 4.

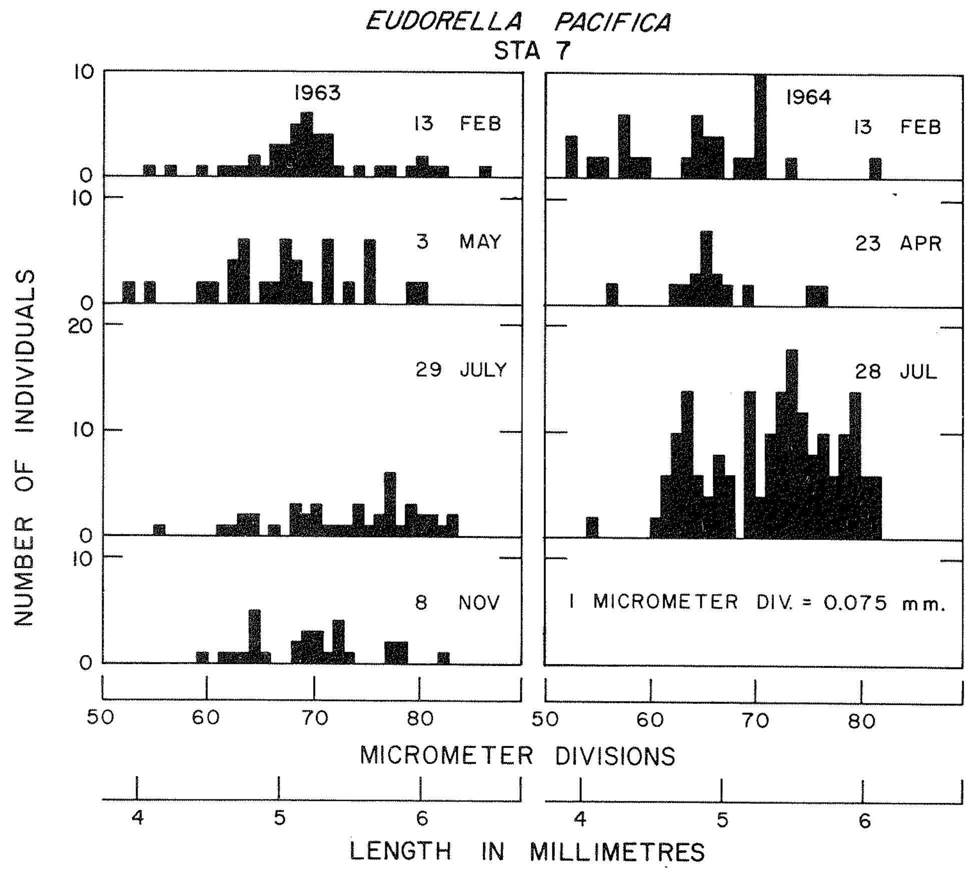

Figure 31. Size distribution of Eudorella pacifica at station 7.

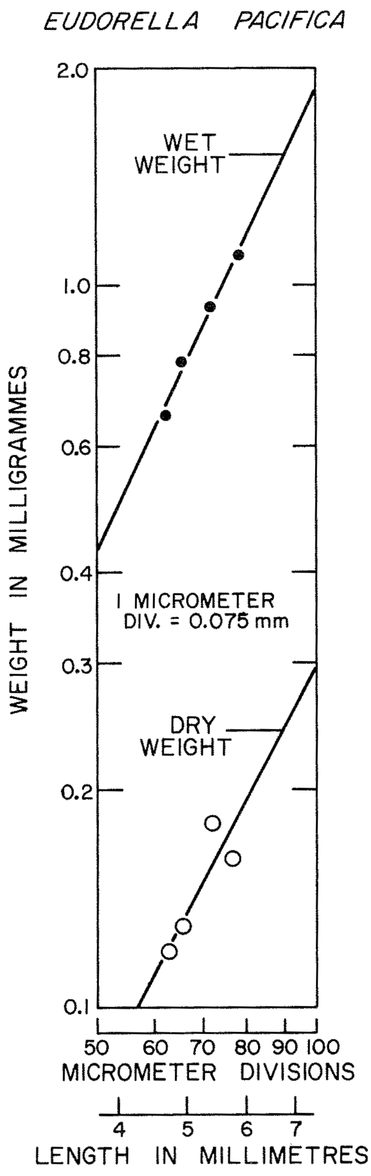

Figure 32. Weight/size curves for Eudorella pacifica.

Table 79

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Eudorella pacifica

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	17.4	29.2	76.4	0	12.3	0	0	0
1963	A	2.2	3.7	9.6	0	1.5	0	0	0
Apr-May	W	29.2	31.2	3.9	0	0.6	0	0	0
	A	3.7	3.9	0.5	0	0.1	0	0	0
July-Aug	W	48.4	30.5	78.8	0	2.1	0	0	0
	A	6.1	3.8	9.9	0	0.3	0	0	0
Nov	W	32.7	18.3	0.7	0.7	4.5	0	0	0
	A	4.1	2.3	0.1	0.1	0.6	0	0	0
Feb	W	0	27.6	2.1	1.8	0	0	0	0
1964	A	0	3.5	0.3	0.2	0	0	0	0
Apr	W	8.2	15.2	5.2	0	0	0	0	0
	A	1.0	1.9	0.7	0	0	0	0	0
July-Aug	W	42.1	129.4	42.2	2.4	6.0	0	0	0
	A	5.3	16.3	5.3	0.3	0.8	0	0	0

The sampling method in the present investigation prevented studies of the commensal relationships of P. schmitti, but neither Echiurus nor Upogebia was found in the samples. The grab may not have penetrated sufficiently deep to catch Upogebia, which is a deep burrowing species.

There was a distinct seasonality in the abundance of P. schmitti with the maxima occurring in the summer (Table 80). Compared with other species with brood-protection, P. schmitti had a remarkably low degree of patchiness (Table 23, page 338), but in this case the measured patchiness may in part be a function of the distribution of the commensal host species.

Table 80 shows that P. schmitti was particularly numerous at station 4 and Figure 33 shows the carapace width frequencies during the period of investigation at station 4 as representative of all stations. The smallest individuals were found in the summer samples, and therefore the young were probably released from the brood pouch during the summer. The size range of P. schmitti in the Puget Sound samples was from 1.4 to 5.4 mm. The size-frequency diagrams indicate that Pinnixa schmitti has a life span of a little more than two years, and by plotting the various

Table 80

Abundance (N) per square metre and rank (R) of Pinnixa schmitti

	Stations															
	2		7		4		1		3		8		6		5	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb 1963	0		0		230	2	1	33	33	5	6	12	0		4	12
Apr-May	0		0		95	6	0		4	33	8	19	12	10	0	
July-Aug	0		0		976	1	21	7	51	6	7	22	11	16	0	
Nov	0		0		21	10	6	24	28	7	6	20	10	19	4	16
Feb 1964	0		0		88	5	6	20	14	12	2	17	6	17	0	
Apr	0		0		142	1	10	17	10	13	6	20	18	12	0	
July-Aug	0		0		526	1	32	12	50	9	20	13	12	11	8	15

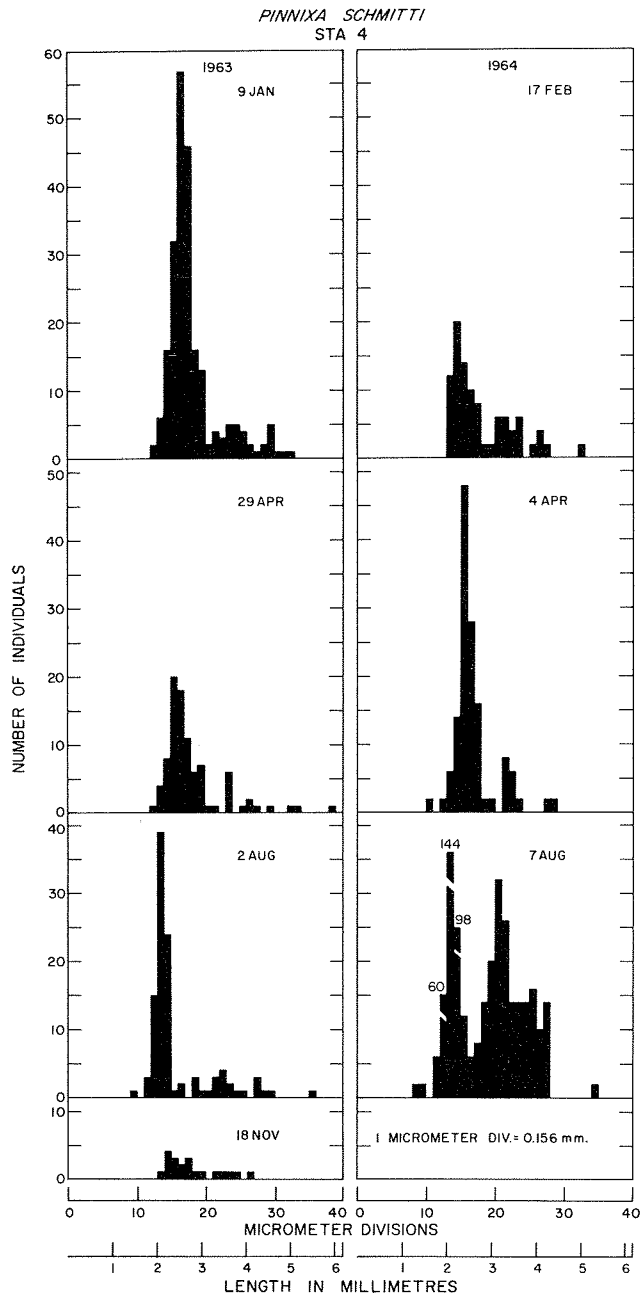

Figure 33. Size distribution of Pinnixa schmitti at station 4.

modes on the size-frequency diagrams from stations 3 and 4, a growth curve was established that indicated a growth rate of about 1.2 mm per year (Figure 34). HART (1940) found a similar size range of P. schmitti (males 5.0, females 4.5 mm) in British Columbia, while RATHBUN (1918) found males measuring 9.2 and females 8.5 mm in lower San Francisco Bay.

Sex could be determined on about 50% of the individuals of P. schmitti from the Puget Sound stations, and the sex ratio did not differ significantly from unity.

After screening and sorting, most of the specimens of P. schmitti had lost one or more of their appendages, and the number of complete animals was considered insufficient for estimating the weight/size relationships. Therefore each specimen with a complete set of appendages was weighed with and without the appendages. The weights without the appendages comprised 77.03% of the total weight with 95% confidence limits ± 2.89 and 60.98% (± 2.42) of the dry weight. The plots of wet weights and dry weight in Figure 35 are based on weights of single individuals without appendages, where the wet weights have been multiplied by 1.30 and the dry weights by 1.64 to obtain total weights. In three samples of P. schmitti the organic matter comprised from 48.4 to 55.5% of the dry weight, with an average of 52.0%. The content of organic matter was determined from the dry weights by multiplying by 0.52. Pinnixa schmitti contributed significantly to the standing crop at station 4, but was rather unimportant at the other stations (Table 81).

40. Lophopanopeus bellus (STIMPSON)

This species is a crab of the family Xanthidae occurring from Prince William Sound, Alaska to Monterey Bay, California (RATHBUN 1930), and WAY (1917) found the species in Puget Sound hidden under rocks on sandy bottoms.

In the present investigation, L. bellus was found on the hardest bottoms, with a significant decrease of abundance in increasingly softer sediments (Table 82). No seasonality in abundance could be detected and the species was ranked as number 7 in degree of patchiness of the numerically dominant species (Table 23, page 338).

Figure 36 shows the frequency of carapace width of L. bellus at station 5 during the period of investigation. The smallest specimens occurred in late summer, indicating that hatching had occurred during the summer. HART (1935) found that hatching of L. bellus in British Columbia occurred from May to August. The growth rate and life span of L. bellus cannot easily be extracted from Figure 36 because the modes of specimens older than about two years cannot be separated.

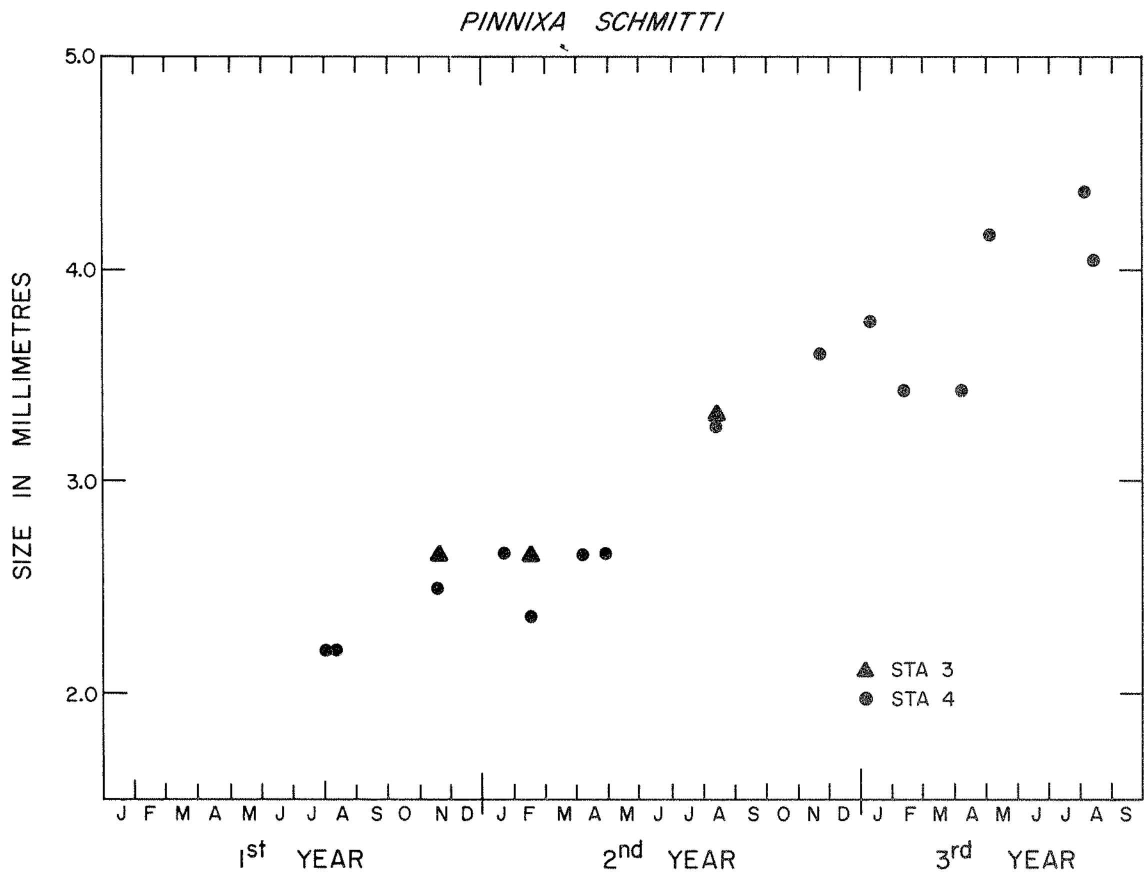

Figure 34. Growth curve for Pinnixa schmitti.

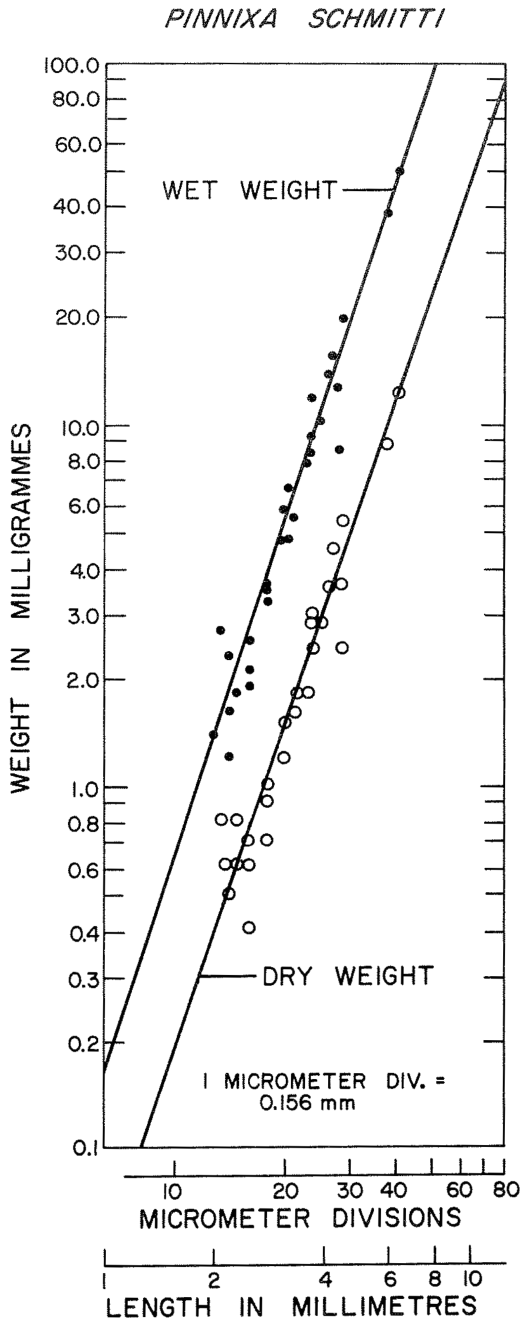

Figure 35. Weight/size curves for Pinnixa schmitti.

Table 81

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Pinnixa schmitti

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	1098.3	15.5	149.1	42.0	0	33.6
1963	A	0	0	147.3	2.1	20.0	5.6	0	4.5
Apr-May	W	0	0	483.9	0	151.5	64.8	127.4	0
	A	0	0	64.9	0	20.3	8.7	17.1	0
July-Aug	W	0	0	389.1	82.5	158.0	46.3	106.8	0
	A	0	0	52.2	11.1	21.2	6.2	14.3	0
Nov	W	0	0	95.2	31.2	165.8	48.1	94.3	40.4
	A	0	0	12.8	4.2	22.2	6.5	12.6	5.4
Feb	W	0	0	430.2	26.4	54.0	20.2	52.1	0
1964	A	0	0	57.7	3.5	7.2	2.7	7.0	0
Apr	W	0	0	571.3	125.0	92.8	54.3	136.0	0
	A	0	0	76.6	16.8	12.6	7.2	18.2	0
July-Aug	W	0	0	2200.2	246.2	171.2	164.3	118.4	64.9
	A	0	0	295.0	33.0	23.0	22.0	15.9	8.7

The size range was from 1.1 to 12.3 mm. If the growth rate during the first two years was maintained, the largest specimens found in the sample would be about five to six years old. RATHBUN (1930) reported males of 34.2 mm and HART (1940) found males of 22 and females of 30 mm, and it may therefore be that the grab was selectively catching the younger specimens in Puget Sound.

As with Pinnixa schmitti (page 432), Lophopanopeus bellus normally lost some of their appendages during sieving and sorting of the samples. The wet weight of L. bellus without appendages comprised 57.31% of the total wet weight with 95% confidence limits ± 2.61, and the dry weight without appendages comprised 46.87% (± 1.80) of the total dry weight. The wet weight of 44 specimens weighed without appendages was converted to total wet weight by multiplying by the conversion factor of 1.74, and the dry weight of 41 specimens was determined by multiplying by 2.13. The resulting weight/size curves are shown in Figure 37. The organic matter in nine samples of L. bellus averaged 47.56% of the dry weight, ranging from 56.83 to 44.91%. The organic matter was determined from the dry weight by multiplying by 0.475, and Table 83 shows the wet weight and organic matter of L. bellus at the benthos stations in Puget Sound during the

Table 82

Abundance (N) per square metre and rank (R) of <u>Lophopanopeus bellus</u>

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	0		0		0		1	33	0		19	5	8	5	91	1
Apr-May		0		0		0		0		3	41	53	8	20	5	192	1
July-Aug		0		0		0		0		11	26	1	36	37	6	272	1
Nov		0		0		0		9	19	2	39	10	17	30	6	114	1
Feb	1964	0		0		0		0		24	9	0		8	13	20	3
Apr		0		0		0		0		0		4	25	20	11	20	10
July-Aug		0		0		0		0		0		0		34	7	18	7

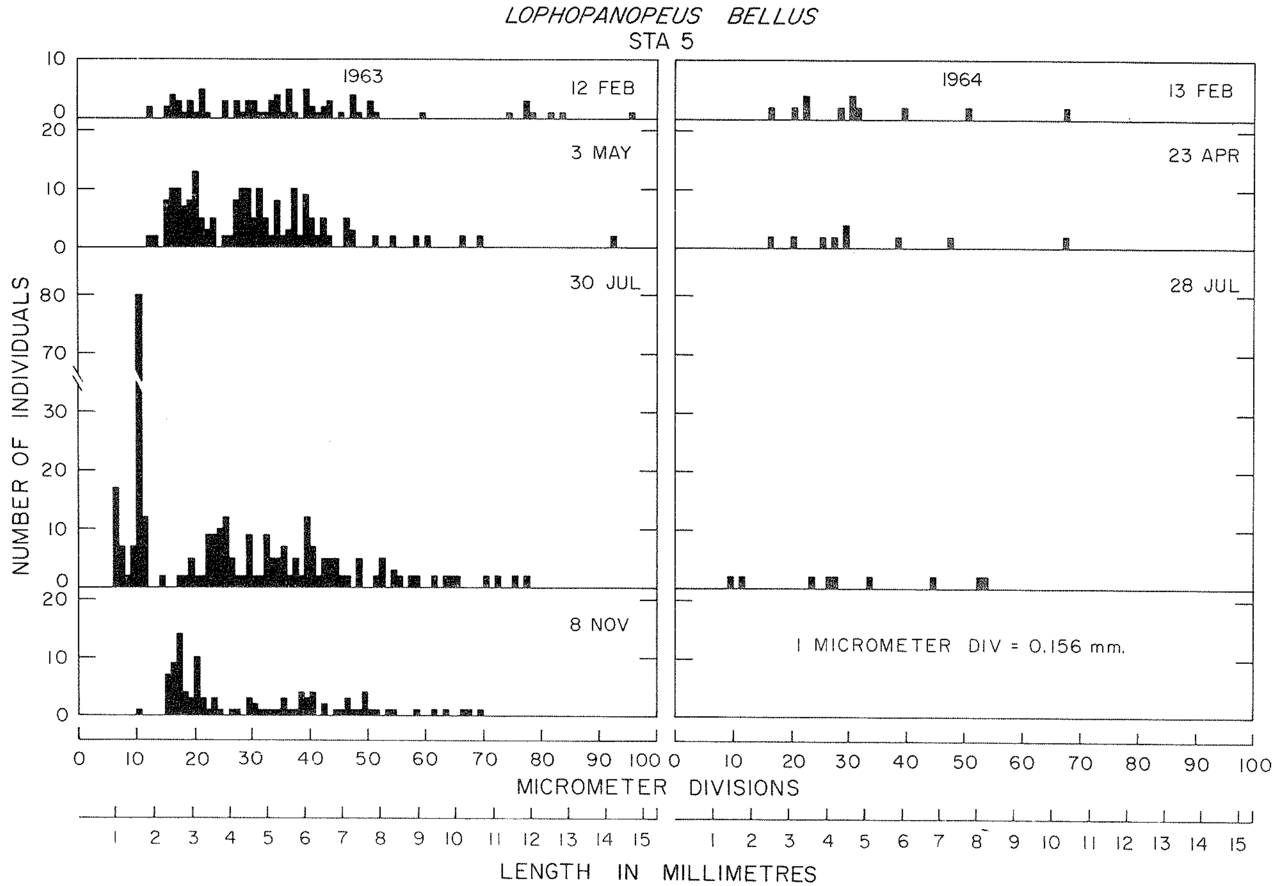

Figure 36. Size distribution of <u>Lophopanopeus bellus</u> at station 5 .

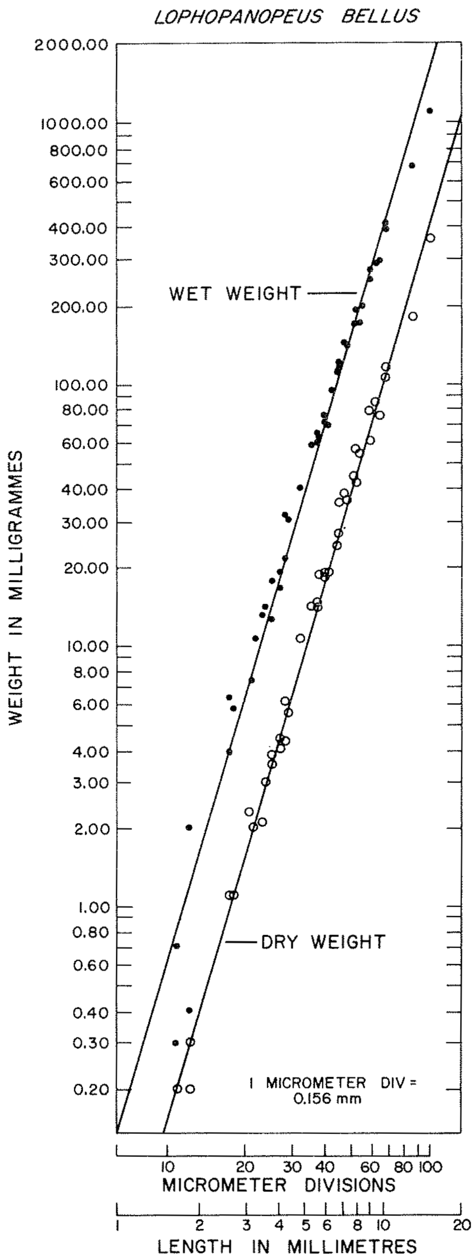

Figure 37. Weight/size curves for Lophopanopeus bellus.

Table 83

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Lophopanopeus bellus

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	0	66.0	0	941.3	510.8	10827.7
1963	A	0	0	0	8.9	0	126.2	68.5	1452.0
Apr-May	W	0	0	0	0	198.3	2468.7	1917.2	11926.8
	A	0	0	0	0	26.6	331.1	257.1	1599.4
July-Aug	W	0	0	0	0	906.1	79.0	4327.5	21645.9
	A	0	0	0	0	121.5	10.6	580.3	2902.7
Nov	W	0	0	0	918.0	146.0	665.0	2665.7	7570.6
	A	0	0	0	123.1	19.6	89.2	357.5	1015.2
Feb	W	0	0	0	0	1619.6	0	341.2	1940.6
1964	A	0	0	0	0	217.2	0	45.8	260.2
Apr	W	0	0	0	0	0	248.2	1848.2	1742.8
	A	0	0	0	0	0	33.3	247.8	233.7
July-Aug	W	0	0	0	0	0	0	3713.4	1398.4
	A	0	0	0	0	0	0	498.0	187.5

period of investigation. Owing to its considerable size, L. bellus contributed significantly to the standing crop of benthos at stations 5 and 6.

41. Nucula bellotii ADAMS

This species is a lamellibranch of the family Nuculidae, distributed from the Arctic Ocean to San Diego, California (OLDROYD 1924).

In Puget Sound Nucula bellotii occurred on all stations except station 5, but the species seems to prefer fine sand with a fairly high percentage of silt (Table 84. At station 4 where the species was particularly numerous, there seemed to be significantly higher abundance during summer than during any other season. Nucula bellotii had a rather low degree of patchiness, with nearly half of the observations indicating random or even distribution (Table 23, page 338).

Figure 38 shows the size frequency diagrams of the species at station 4 during the period of investigation. The species was not sufficiently abundant to yield significant information about longevity and growth. The size range of N. bellotii in Puget Sound was from 1.1 to 9.0 mm; OLDROYD (1924) reported a size of 6 mm for N. bellotii.

Table 84

Abundance (N) per square metre and rank (R) of <u>Nucula bellotii</u>

Stations

		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	27	6	33	3	94	6	1	24	26	8	6	12	2	19	0	
Apr-May		55	3	8	9	45	10	0		0		3	25	0		0	
July-Aug		3	15	3	13	173	6	3	24	15	21	16	14	1	48	0	
Nov		12	8	6	5	26	9	8	20	11	14	3	24	0		0	
Feb	1964	0		4	8	32	7	8	18	4	26	8	8	0		0	
Apr		2	17	5	9	46	6	8	21	12	11	4	25	2	29	0	
July-Aug		0		18	7	212	4	14	20	2	43	30	12	0		0	

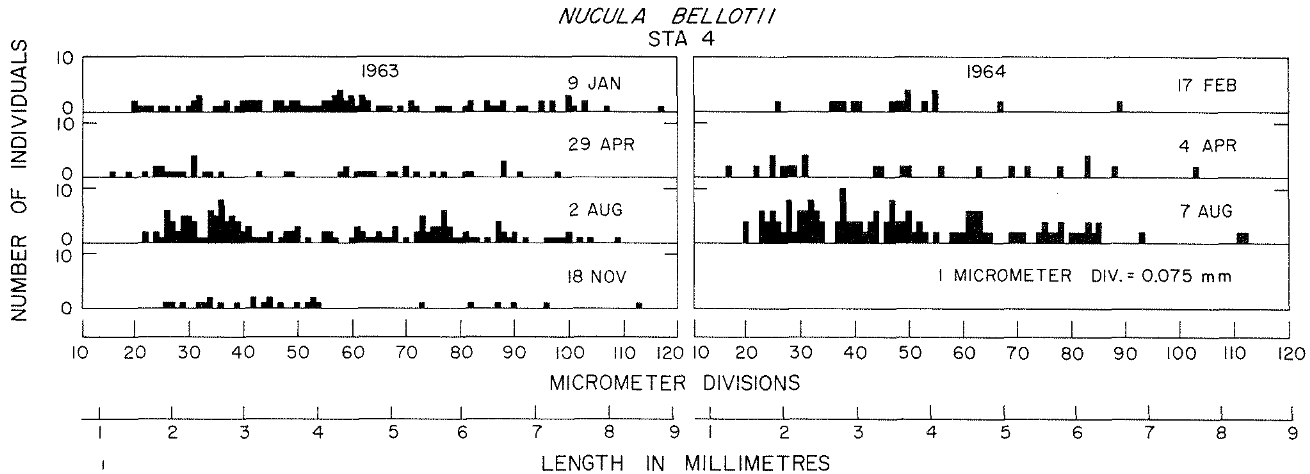

Figure 38. Size distribution of Nucula bellotii at station 4.

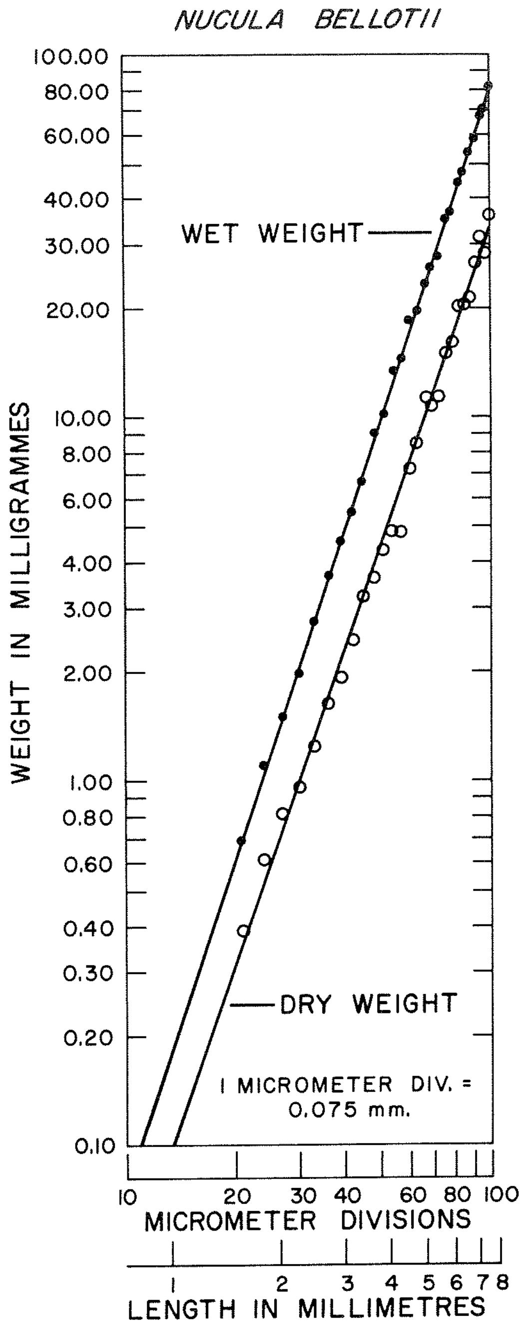

Figure 39. Weight/size curves for Nucula bellotii.

Table 85

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Nucula bellotii

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	412.1	671.4	2323.1	24.1	518.0	101.3	36.1	0
1963	A	34.0	55.4	191.7	2.0	42.7	8.4	3.0	0
Apr-May	W	893.4	141.4	741.0	0	0	43.0	0	0
	A	73.7	11.7	61.1	0	0	3.5	0	0
July-Aug	W	61.0	82.3	2567.0	64.0	312.1	261.4	19.0	0
	A	5.0	6.8	211.8	5.3	25.7	21.6	1.6	0
Nov	W	241.3	173.0	472.1	151.0	261.9	67.0	0	0
	A	19.9	14.3	38.9	12.5	21.6	5.5	0	0
Feb	W	0	100.4	358.9	184.3	61.3	129.7	0	0
1964	A	0	8.3	29.6	15.2	5.0	10.7	0	0
Apr	W	37.4	136.1	777.0	176.0	177.4	59.4	51.4	0
	A	3.1	11.2	64.1	14.5	14.6	4.9	4.2	0
July-Aug	W	0	396.1	3015.8	306.3	24.3	518.9	0	0
	A	0	32.7	248.8	25.3	2.0	42.8	0	0

Wet weights and dry weights were determined from 27 size classes of N. bellotii and the weight/size curves are presented in Figure 39. From four to 11 specimens were weighed in each size class, and the points on the curves in Figure 39 therefore represent mean weights.

The organic matter from 19 samples was found to comprise 19.31% of the dry weight with 95% confidence limits ±1.38 and 8.25% (±0.63) of the wet weight. From length measurements, the curves in Figure 39, and the organic matter/dry weight conversion factor (0.1931), the total wet weight and dry organic matter of N. bellotii at the various stations in Puget Sound during the period of investigation were calculated (Table 85). Nucula bellotii was occasionally of some importance to the total standing crop at station 4.

42. Crenella columbiana DALL

This lamellibranch of the family Mytilidae is distributed from the Aleutian Islands to San Diego, California (OLDROYD 1924).

Table 86 shows the abundance of Crenella columbiana at the Puget Sound

Table 86

Abundance (N) per square metre and rank (R) of <u>Crenella columbiana</u>

Stations

		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	0		0		6	18	7	16	47	3	3	20	0		0	
Apr-May		0		4	14	0		43	10	5	30	2	31	4	20	0	
July-Aug		0		0		10	20	2	29	49	7	12	17	14	15	0	
Nov		0		0		1	23	31	10	53	4	12	15	13	15	0	
Feb	1964	0		0		0		10	14	44	4	16	6	4	20	0	
Apr		0		2	17	0		24	11	28	6	42	9	4	24	0	
July-Aug		0		0		6	26	104	4	67	7	58	10	18	8	0	

Table 87

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Crenella columbiana

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	182.1	226.4	1545.4	750.0	0	0
1963	A	0	0	8.0	9.9	67.8	32.9	0	0
Apr-May	W	0	121.6	0	2479.0	510.7	145.2	128.2	0
	A	0	5.3	0	108.9	22.4	6.4	5.6	0
July-Aug	W	0	0	241.8	25.0	2551.4	394.7	418.6	0
	A	0	0	10.6	1.1	112.0	17.3	18.4	0
Nov	W	0	0	36.0	3536.9	2788.8	288.5	448.2	0
	A	0	0	1.6	155.3	122.4	12.7	19.7	0
Feb	W	0	0	0	250.2	1777.2	922.8	121.4	0
1964	A	0	0	0	11.0	78.0	40.5	5.3	0
Apr	W	0	0	0	608.6	670.4	2231.0	112.9	0
	A	0	0	0	26.7	29.4	97.9	5.0	0
July-Aug	W	0	0	161.4	4036.2	2594.0	4225.4	573.7	0
	A	0	0	7.1	177.2	113.9	185.5	25.2	0

benthos stations during the period of investigation. The species prefers sandy bottoms as found on stations 1, 3, and 8, and seems to avoid silty and gravelly bottoms. There was no significant seasonal trend in abundance, and Table 23, page 338 indicated a rather low patchiness, with half of the observations indicating random or even distribution.

Neither size measurements from single stations nor pooled data from all stations gave size-frequency diagrams from which information about longevity and growth could be ascertained. This was partly owing to the low abundance of the species and partly to the wide size range (from 1.2 to 10.2 mm). OLDROYD (1924) reported 16 mm as extreme length of C. columbiana.

Wet weights and dry weights were determined for 18 size classes of C. columbiana, and the weight/size curves are presented in Figure 40. From three to seven specimens were weighed in the seven smallest size classes, and for these classes mean weights were plotted. The remaining plots in Figure 40 represent weights of single specimens.

The organic matter from seven samples comprised 16.68% of the dry weight with 95% confidence limits ± 1.86 and 4.39% (± 0.58) of the wet weight. From the

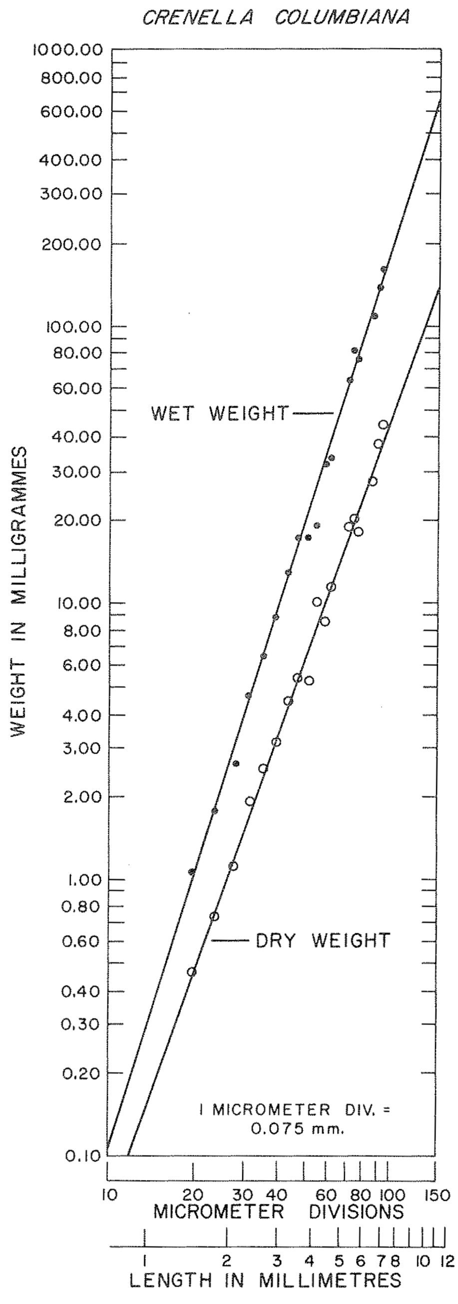

Figure 40. Weight/size curves for Crenella columbiana .

size measurements, the weight/size curves in Figure 40, and the organic matter/ dry weight conversion factor (0.1668), the total wet weight and dry organic matter of C. columbiana during the period of investigation were calculated (Table 87). During summer and autumn the species contributed significantly to the standing crop at stations 1, 3, and 8.

43. Psephidia lordi BAIRD

This lamellibranch of the family Veneridae is distributed from the Bering Sea to San Diego, California, and in Puget Sound (OLDROYD 1924).

In Puget Sound, P. lordi was particularly numerous at shallow-water stations with substrate dominated by fine sand, but avoided both silty and gravelly bottoms (Table 88). There was a distinct seasonal trend in its abundance with maxima occurring in summer and minima in winter and spring. Psephidia lordi has a viviparous mode of reproduction, and the species was ranked as number 6 in degree of patchiness among the numerically important species (Table 23, page 338).

Figure 41 shows the size frequency diagrams of P. lordi at station 8 during the period of investigation. The young are hatched during the summer and they appear in the samples in great numbers in August. The mortality was very high and in November the stock was heavily reduced. The size frequency distributions indicate that P. lordi in Puget Sound has a life span of about 1 to $1\frac{1}{2}$ years. Figure 41 shows that the modes of the frequency distributions changed during the period of investigation, and by plotting the modes against time the growth curve of the species may be determined. Figure 42 shows the plots of the modes at stations 3, 4, and 8, and indicates the growth curves at the various stations. The growth rate was highest at station 8, somewhat lower at station 4, and lowest at station 3, and there are indications that the differences in growth rate may be related to differences in temperature. Figure 2, (page 243) shows that station 8 had about 1°C higher temperature than station 4 from April to November when the growth rate was highest, and station 4 had about 1°C higher temperature than station 3.

The smallest individuals found in the samples were 1.5 mm and the largest 6.4 mm, although OLDROYD (1924) reported a length of 8.5 mm for P. lordi.

Wet weights and dry weights from 20 size classes of P. lordi were determined and Figure 43 shows the weight/size curves. From 12 to 30 individuals were weighed in each size class and the plots therefore represent mean weights.

Table 88

Abundance (N) per square metre and rank (R) of Psephidia lordi

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	0		0		50	10	12	12	1	39	18	6	0		0	
Apr-May		0		0		1	31	157	2	43	5	23	14	0		0	
July-Aug		0		0		181	5	6	16	140	3	658	2	0		0	
Nov		0		0		85	7	15	16	34	6	57	5	2	33	1	30
Feb	1964	0		0		28	8	38	4	58	2	14	7	2	26	0	
Apr		0		0		20	8	0		60	2	22	11	2	29	0	
July-Aug		0		0		188	5	6	29	93	4	384	2	0		0	

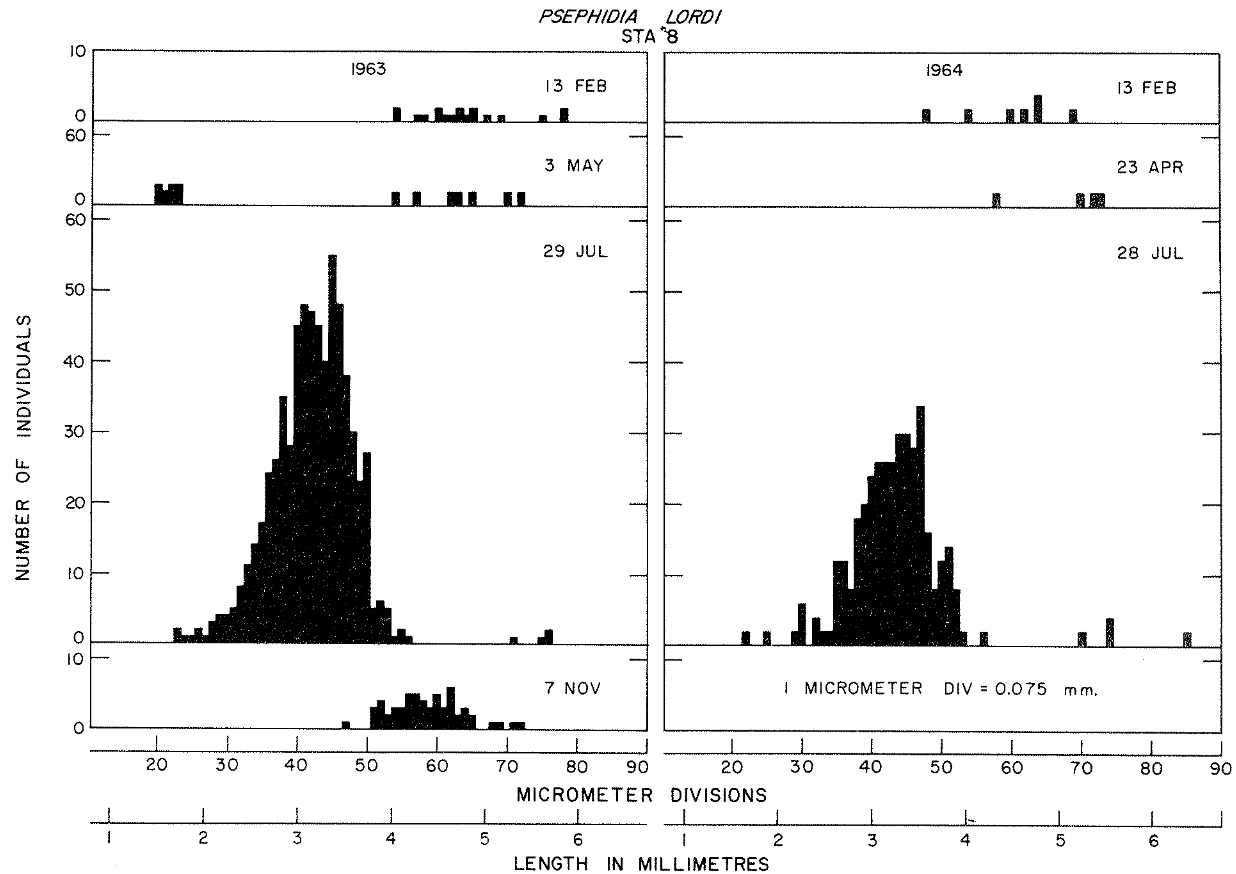

Figure 41. Size distribution of Psephidia lordi at station 8.

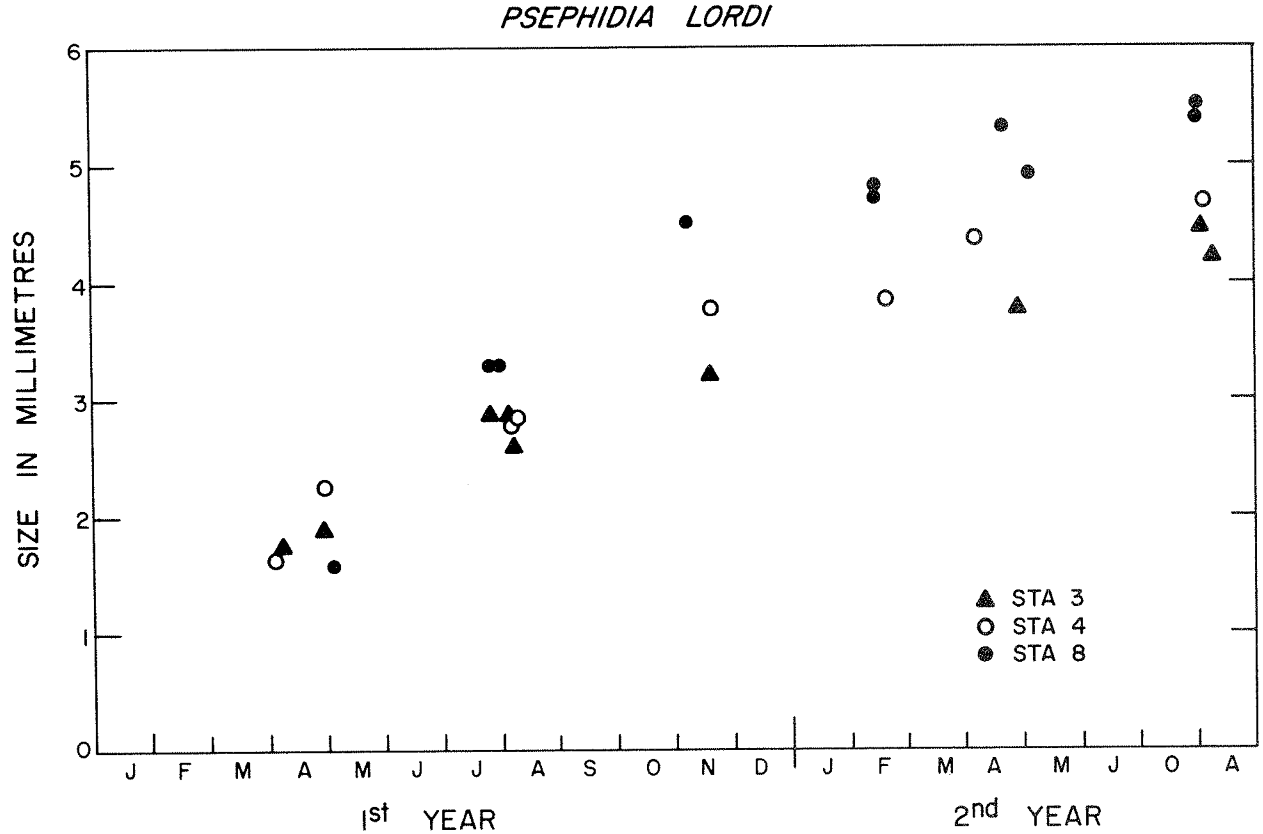

Figure 42. Growth curves for Psephidia lordi at stations 3, 4, and 8 .

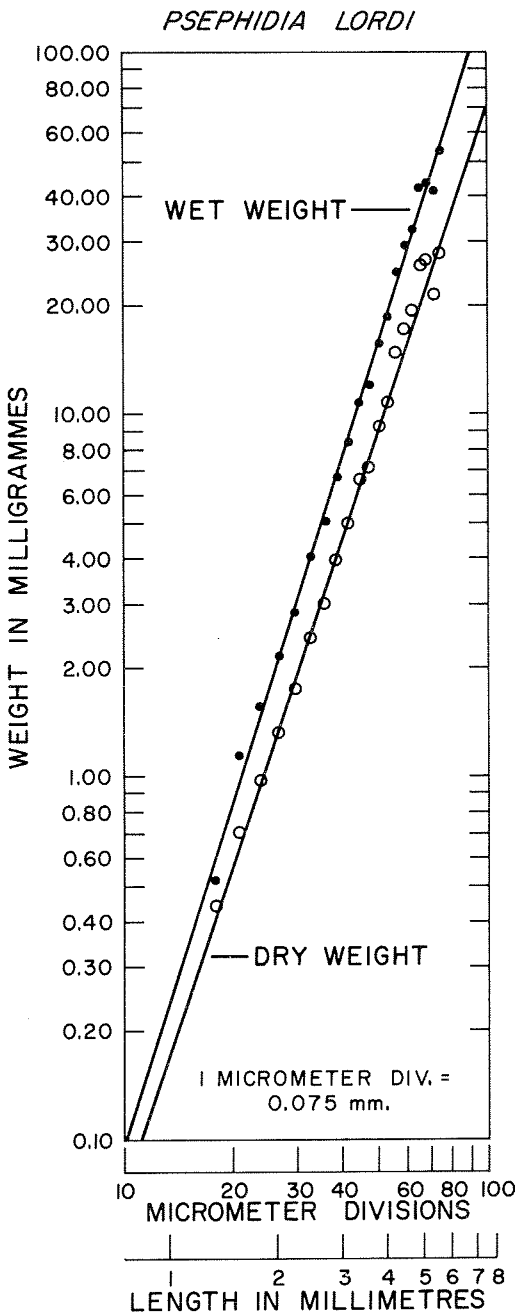

Figure 43. Weight/size curves for Psephidia lordi.

Table 89

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Psephidia lordi. (Plus + indicates insignificant)

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	315.8	75.8	6.3	588.4	0	0
1963	A	0	0	15.9	3.8	0.3	29.6	0	0
Apr-May	W	0	0	2.7	821.2	585.2	387.9	0	0
	A	0	0	+	41.3	29.4	19.5	0	0
July	W	0	0	980.1	31.6	1146.2	5765.2	0	0
	A	0	0	49.3	1.6	57.7	290.0	0	0
Nov	W	0	0	1007.5	80.0	327.0	1408.4	0	0
	A	0	0	50.7	4.0	16.5	70.8	0	0
Feb	W	0	0	282.1	239.4	710.8	374.8	0	0
1964	A	0	0	14.2	12.0	35.8	18.9	0	0
Apr	W	0	0	114.7	0	412.9	317.6	0	0
	A	0	0	5.8	0	20.8	16.0	0	0
July-Aug	W	0	0	1154.2	48.7	792.8	3840.0	0	0
	A	0	0	58.1	2.5	39.9	193.2	0	0

The organic content in 17 samples was found to comprise 8.54% of the dry weight, with 95% confidence limits ± 0.78 and 5.03% (± 0.43) of the wet weight.

Table 89 shows the wet weights and the dry organic matter of P. lordi at the benthos stations in Puget Sound during the period of investigation. The data are calculated from length measurements, the weight/size curves in Figure 43, and the organic matter/dry weight conversion factor (0.0854). At station 8, P. lordi contributed significantly to the standing stock in August 1963 and 1964.

44. Mysella tumida (CARPENTER)

This lamellibranch of the family Montacutidae is distributed from Shumagin Islands, Alaska, to San Diego, California (OLDROYD 1924).

In Puget Sound Mysella tumida had a distribution similar to that of Psephidia lordi, but it seemed to be more abundant both in softer and harder sediments (Table 90). There was no significant seasonal trend in the abundance of M. tumida. The species has a viviparous mode of reproduction and ranked as number 5 in degree of patchiness among the numerically important species (Table 23, page 338).

Table 90

Abundance (N) per square metre and rank (R) of Mysella tumida

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	1	29	6	9	46	11	82	5	1	39	12	8	3	15	0	
Apr-May		0		2	18	133	3	77	4	3	41	235	2	6	15	0	
July-Aug		0		16	6	56	11	25	5	1	50	180	3	1	48	0	
Nov		0		5	7	138	4	43	5	4	25	175	3	5	21	0	
Feb	1964	0		4	8	118	4	38	4	2	36	32	3	8	13	2	16
Apr		0		3	14	86	4	0		0		142	3	32	3	36	5
July-Aug		0		4	14	32	13	10	26	0		128	5	0		4	22

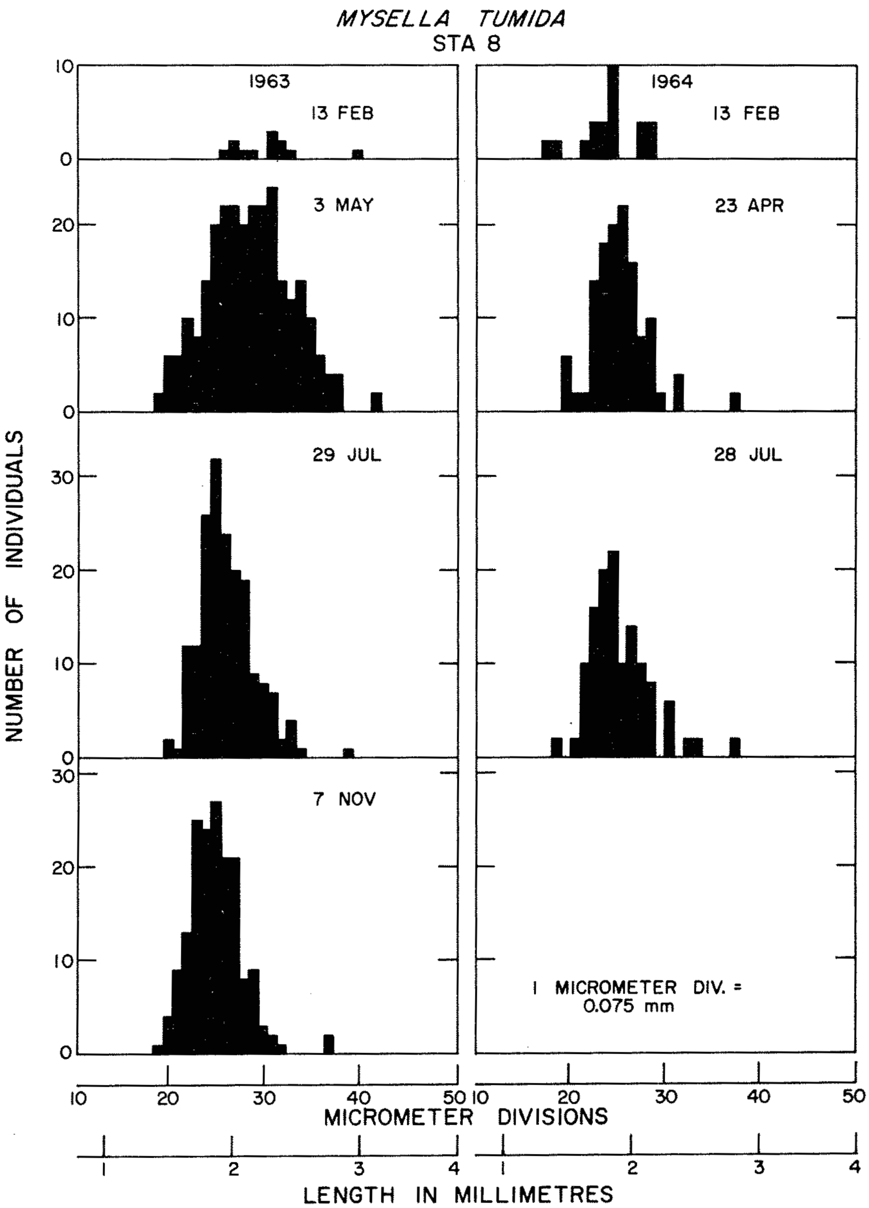

Figure 44. Size distribution of Mysella tumida at station 8.

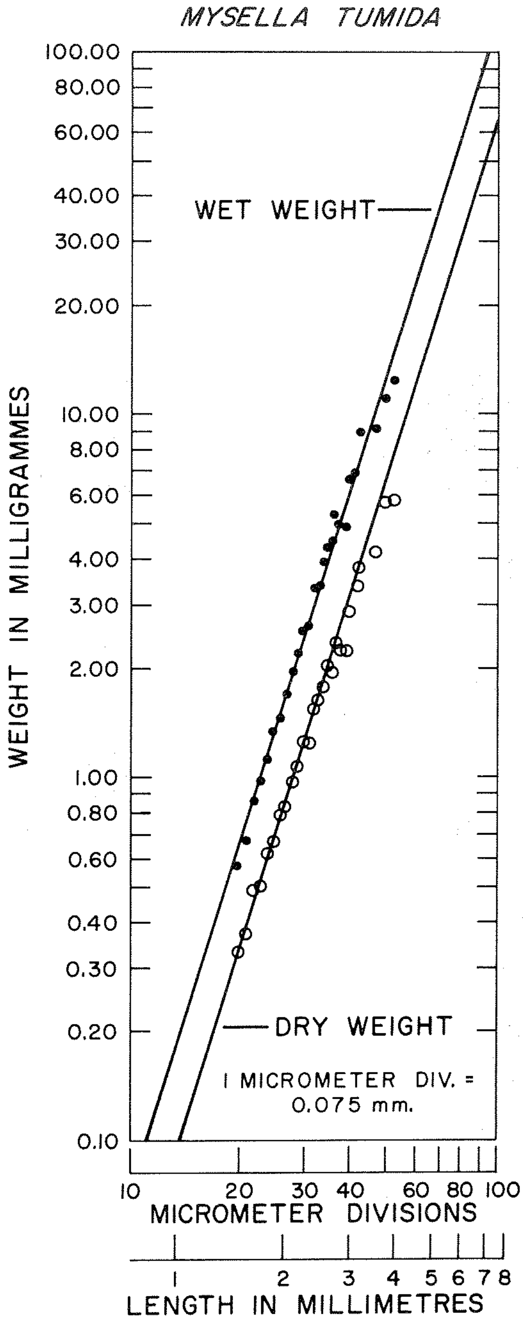

Figure 45. Weight/size curves for Mysella tumida.

Table 91

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Mysella tumida

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	2.4	21.4	67.3	140.1	3.1	33.0	7.1	0
	A	0.1	1.4	4.5	9.4	0.2	2.2	0.5	0
Apr-May	W	0	5.0	278.2	114.9	6.8	607.4	10.8	0
	A	0	0.3	18.8	7.7	0.5	40.9	0.7	0
July-Aug	W	0	42.9	104.2	55.0	2.4	300.9	2.6	0
	A	0	2.9	7.0	3.7	0.2	20.2	0.2	0
Nov	W	0	16.3	314.5	78.1	9.7	246.3	8.3	0
	A	0	1.1	21.2	5.3	0.7	16.6	0.6	0
Feb 1964	W	0	9.4	245.6	102.0	6.2	43.6	20.0	6.1
	A	0	0.6	16.6	6.9	0.4	2.9	1.3	0.4
Apr	W	0	8.0	129.0	0	0	200.6	81.6	76.3
	A	0	0.5	8.7	0	0	13.5	5.5	5.1
July-Aug	W	0	12.3	79.0	10.6	0	202.2	0	8.4
	A	0	0.8	5.3	0.7	0	13.6	0	0.6

Figure 44 shows the size frequency diagrams of M. tumida at station 8, and the figure is representative for the size frequency distributions at the other stations. The frequency distributions are unimodal and there appears to be no change in the modes of the distributions during the period of investigation, so no information concerning longevity and growth could be ascertained. The smallest individuals in the samples were 1.1 mm and the largest 3.0 mm, the same size as reported by OLDROYD (1924).

Wet weight and dry weight of 26 size classes of M. tumida were determined and the weight/size curves are shown in Figure 45. Ten to 15 specimens were weighed in each of the 21 smallest size classes, while the largest five size classes included single specimens only. Therefore the plots in Figure 45 represent mean weights for 21 of the size classes and individual weights for five of the size classes.

The organic matter from 18 samples comprised 15.84% of the dry weight with 95% confidence limits ± 2.37 and 6.75% (± 0.70) of the wet weight. From the size measurements, the weight/size curves in Figure 45, and the organic matter/dry weight conversion factor (0.1584), the wet weight and the organic matter of

M. tumida during the period of investigation were calculated (Table 91). The table shows that M. tumida was not an important contributor to the standing crop at the Puget Sound benthos stations.

45. Axinopsida sericata CARPENTER

This lamellibranch of the family Thyasiridae is distributed from the Aleutian Islands to California (OLDROYD 1924).

Table 92 shows the abundance of Axinopsida sericata at the Puget Sound stations during the period of investigation. The distribution of the species among the stations cannot be explained according to sediment type. It was common at all the stations off Seattle (stations 1, 2, 3, and 4) regardless of sediment type and depth, while it was scarce at all the stations in southern Puget Sound.

There was no significant seasonal trend in the abundance of the species, and it did not have a high degree of patchiness; about one-third of the observations indicated randomness or evenness of spatial distribution (Table 23, page 338).

Figure 46 shows the length frequencies of A. sericata at station 4 during the period of investigation. Two or three modes could be distinguished and the species appeared to have a life span of about two years. The growth curve is demonstrated in Figure 47. The smallest individuals (1.4 mm) appeared in samples in August, suggesting a spatfall during summer, and the largest individuals (about 4.9 mm) were found in spring or summer. OLDROYD (1924) reported a length of 5 mm for A. sericata.

Wet weights and dry weights were determined for 41 size classes of A. sericata. There were from ten to 17 specimens in each size class except for the five largest classes, which contained only one specimen. Thirty-six points on the curves in Figure 48 therefore represent mean weights per size class, while five points represent individual weights.

The organic matter from ten samples comprised 9.99% of the dry weight with 95% confidence limits ± 1.93 and 4.38% (± 0.72) of the wet weight. Table 93 shows the wet weight and dry organic matter of A. sericata at the benthos stations in Puget Sound during the period of investigation. The data are calculated from the length measurements, the weight/size curves in Figure 48, and the organic matter/dry weight conversion factor (0.0999). Axinopsida sericata was not an important contributor to the standing stock at any of the benthos stations in Puget Sound.

Table 92

Abundance (N) per square metre and rank (R) of Axinopsida sericata

	Stations 2 N	2 R	7 N	7 R	4 N	4 R	1 N	1 R	3 N	3 R	8 N	8 R	6 N	6 R	5 N	5 R
Jan-Feb 1963	57	3	21	5	380	1	37	6	40	4	0		0		0	
Apr-May	104	2	0		90	8	47	8	4	33	0		6	15	0	
July-Aug	12	8	19	4	269	4	11	10	66	4	3	30	6	24	0	
Nov	13	7	0		103	5	16	15	40	5	0		1	41	0	
Feb 1964	4	9	0		66	6	32	7	14	12	2	17	0		0	
Apr	42	4	2	17	34	7	14	13	32	5	2	29	6	21	0	
July-Aug	32	4	12	9	154	6	32	12	13	20	2	33	0		0	

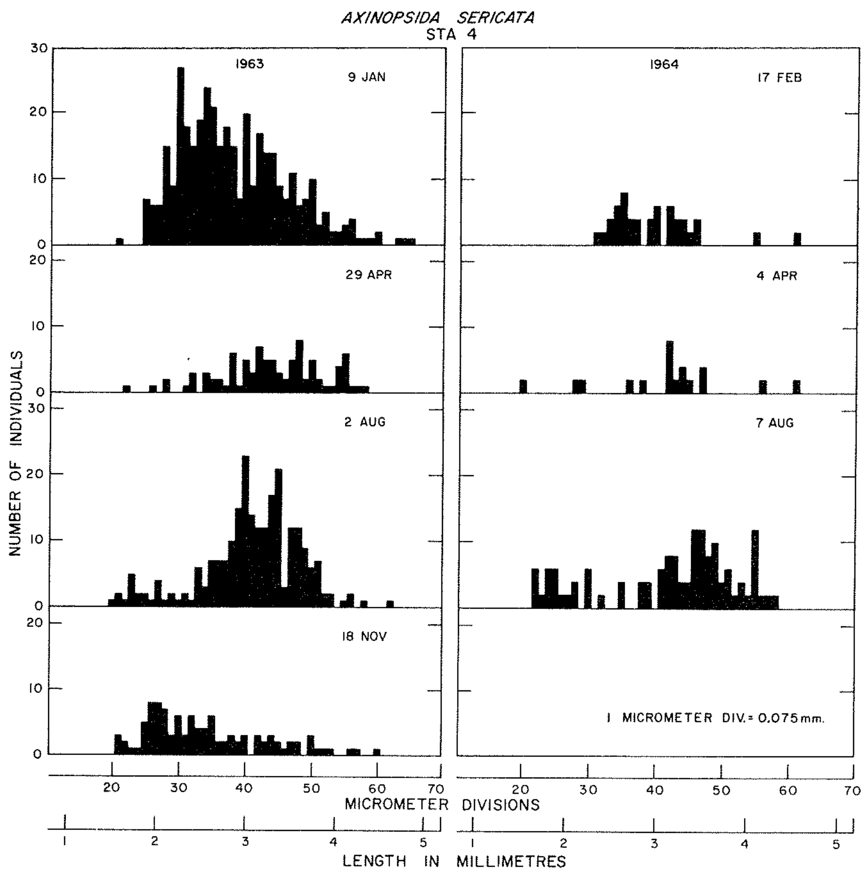

Figure 46. Size distribution of Axinopsida sericata at station 4.

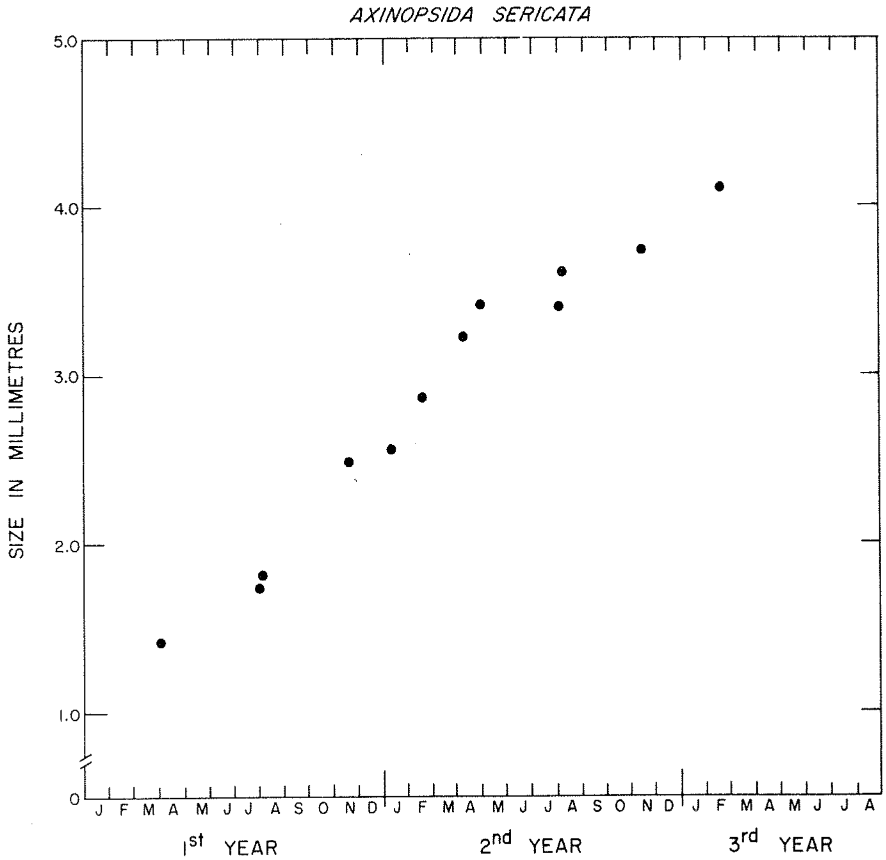

Figure 47. Growth curve for Axinopsida sericata.

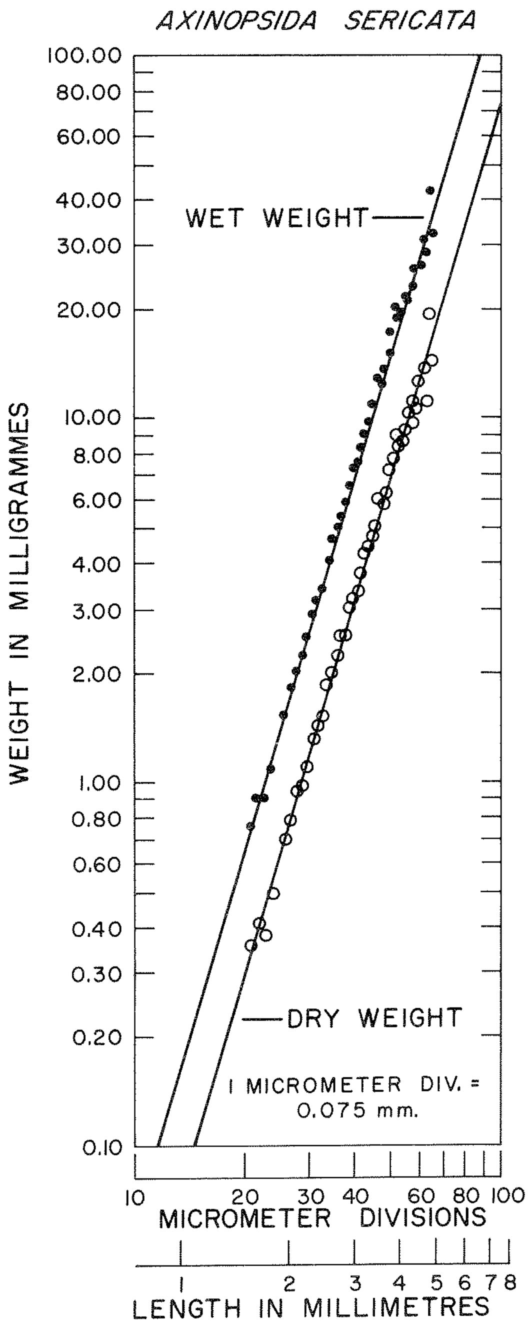

Figure 48. Weight/size curves for Axinopsida sericata.

Table 93

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Axinopsida sericata

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	403.0	173.0	2543.0	341.2	204.2	0	0	0
	A	17.6	7.6	111.4	14.9	8.9	0	0	0
Apr-May	W	861.4	0	931.6	412.0	23.5	0	55.3	0
	A	37.7	0	40.8	18.0	1.0	0	2.4	0
July-Aug	W	110.4	164.3	1959.6	100.4	473.4	31.3	46.8	0
	A	4.8	7.2	85.8	4.3	20.7	1.4	2.0	0
Nov	W	124.0	0	530.9	134.0	230.4	0	9.1	0
	A	5.4	0	23.6	5.9	10.1	0	0.4	0
Feb 1964	W	41.4	0	458.2	317.9	80.8	16.4	0	0
	A	1.8	0	20.1	13.9	3.5	0.7	0	0
Apr	W	374.1	18.2	311.8	151.6	183.2	19.3	48.2	0
	A	16.4	0.8	13.7	6.6	8.0	0.8	2.1	0
July-Aug	W	301.0	110.4	1561.8	844.0	91.8	16.8	0	0
	A	13.2	4.8	68.4	37.0	4.0	0.7	0	0

46. Macoma carlottensis (WHITEAVES)

The species is a lamellibranch of the family Tellinidae, distributed from the Arctic Ocean to Ballenas Lagoon in Lower California (OLDROYD 1924).

Table 94 shows the abundance of Macoma carlottensis at the Puget Sound benthos stations. The distribution cannot be completely explained according to sediment type alone, although the species seems to prefer fine sediments. However, as with Axinopsida sericata, the species seems to be restricted to the stations off Seattle, occurring on all stations there, while it was nearly nonexistent in southern Puget Sound. There was a heavy reduction in numbers at station 2 from February to August 1963, and at station 4 the species nearly disappeared when the sediment changed in November 1963 (see page 263). No seasonal trend in the abundance was evident, and M. carlottensis had a rather high degree of patchiness (Table 23, page 338).

Figure 49 shows the size frequency diagrams at station 2 during the period of investigation. The strong reduction in numbers is clearly demonstrated and seems to have been caused by the disappearance of the year classes in 1961 and

Table 94

Abundance (N) per square metre and rank (R) of <u>Macoma carlottensis</u>

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	1119	1	6	9	87	7	0		31	6	0		0		0	
Apr-May		651	1	0		26	14	3	23	3	41	2	31	0		0	
July-Aug		32	3	0		30	13	2	29	36	10	0		3	34	0	
Nov		259	1	1	16	4	17	5	26	9	15	0		0		0	
Feb	1964	54	2	0		2	21	4	21	16	6	0		0		0	
Apr		114	1	0		2	24	6	25	6	11	2	29	2	29	0	
July-Aug		86	1	0		34	8	4	34	2	43	0		0		0	

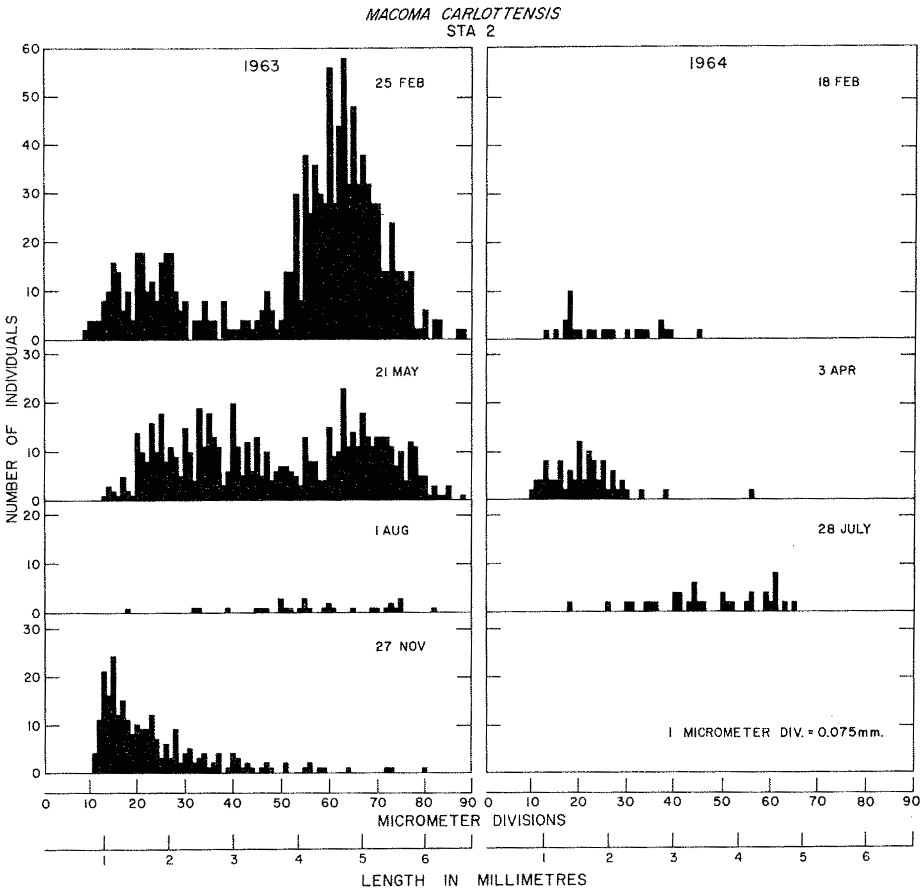

Figure 49. Size distribution of Macoma carlottensis at station 2.

Table 95

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Macoma carlottensis

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	78900.2	318.6	620.9	0	2816.0	0	0	0
	A	3621.5	14.6	28.5	0	129.3	0	0	0
Apr-May	W	36943.1	0	361.8	271.4	196.3	84.3	0	0
	A	1695.7	0	16.6	12.5	9.0	3.9	0	0
July-Aug	W	2580.6	0	1327.1	196.0	1619.1	0	208.0	0
	A	118.4	0	60.9	8.9	74.3	0	9.5	0
Nov	W	2301.8	18.2	156.0	273.1	516.4	0	0	0
	A	105.7	0.8	7.2	12.5	23.7	0	0	0
Feb 1964	W	421.2	0	91.4	312.4	844.0	0	0	0
	A	19.3	0	4.2	14.3	38.7	0	0	0
Apr	W	568.6	0	112.3	341.6	376.2	65.2	115.4	0
	A	26.0	0	5.2	15.7	17.3	3.0	5.3	0
July-Aug	W	2994.2	0	1131.0	216.1	86.0	0	0	0
	A	137.4	0	51.9	9.9	3.9	0	0	0

1962. In November 1963 a new year class was introduced, but the size-frequency diagram indicates that the majority of the specimens were yet too small to be retained by the 1-mm screen. The modes on the frequency curves occurring later than August 1963 are difficult to locate and a growth curve for M. carlottensis could therefore not be drawn. The smallest individuals occurring in the samples were 0.9 mm and the largest 6.8 mm, and the size diagrams indicate a life span of about 2 to $2\frac{1}{2}$ years.

From four to 11 specimens were weighed in each of 35 size classes and the points on the curves in Figure 50 therefore represent mean weights. The organic matter from nine samples comprised 15.41% of the dry weight with 95% confidence limits ± 2.53 and 4.59% (± 0.54) of the wet weight. From the size measurements, the curves in Figure 50, and the organic matter/dry weight conversion factor (0.1541), the wet weights and the organic matter at the Puget Sound benthos stations during the period of investigation were calculated (Table 95). Macoma carlottensis was one of the most important contributors to the total standing stock at station 2 in February and May 1963, but after the heavy reduction in numbers, the species played a rather insignificant part in the standing stock.

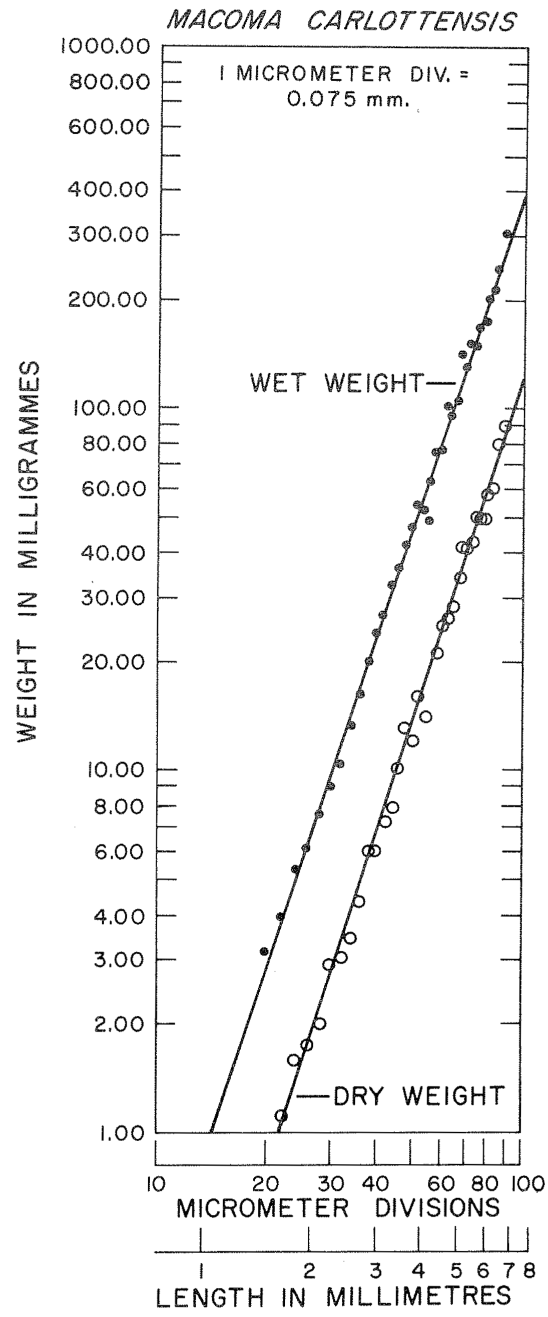

Figure 50. Weight/size curves for Macoma carlottensis.

47. Macoma alaskana DALL

This lamellibranch of the family Tellinidae is distributed from Alaska to Vancouver Island (OLDROYD 1924).

In Puget Sound Macoma alaskana occurred in low numbers at the sand stations but only at station 3 was it definitely among the numerically dominant species (Table 96). The material was too scanty for definite conclusions concerning seasonal patterns in abundance. The patchiness of M. alaskana was low, but the information about patchiness was based on seven observations only (Table 23, page 338).

The species was not sufficiently abundant to yield significant information about growth or longevity for M. alaskana. The size range in samples was from 3.0 to 17.8 mm.

Wet weights and dry weights were determined for single specimens from 36 size classes (Figure 51). The organic matter from 12 samples comprised 13.17% of the dry weight with 95% confidence limits ±1.83 and 5.26% (±0.40) of the wet weight. The organic matter/dry weight conversion factor was 0.1317, and from this factor, the length measurements, and the weight/size curves in Figure 51, the total wet weight and organic matter at the benthos stations in Puget Sound during the period of investigation were calculated (Table 97). Owing to its large size, M. alaskana was of some importance to the standing crop at station 3 in spite of rather low abundance.

48. Macoma calcarea GMELIN

This species of the family Tellinidea is distributed throughout the Arctic Ocean and in the Pacific Ocean south to Japan and Monterey Bay, California. In the Atlantic Ocean it occurs south of New York, the British Isles, and Denmark (MacGINITIE 1959).

Macoma calcarea occurred in low abundance at the sand stations 1, 3, and 4, but only at station 3 was the species abundant enough to be considered an important species (Table 98). The scarcity of the species prevents conclusions about sediment preference and seasonal patterns in abundance. The patchiness of M. calcarea was extremely low, with two-thirds of the observations indicating randomness or evenness of distribution (Table 23, page 338). However, the conclusions about patchiness are based on six observations only.

The abundance of the species was so low that the size-frequency diagrams did not reveal significant information about longevity or growth. The size range

Table 96

Abundance (N) per square metre and rank (R) of Macoma alaskana

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	0		0		2	30	0		26	8	1	23	2	19	0	
Apr-May		0		0		1	31	3	23	71	2	0		0		0	
July-Aug		0		0		1	43	0		27	13	0		2	42	0	
Nov		0		0		0		1	39	20	9	3	24	1	41	0	
Feb	1964	0		0		0		0		36	5	0		4	20	0	
Apr		0		0		0		2	38	20	7	2	29	8	19	0	
July-Aug		0		0		4	30	14	20	7	33	2	33	0		0	

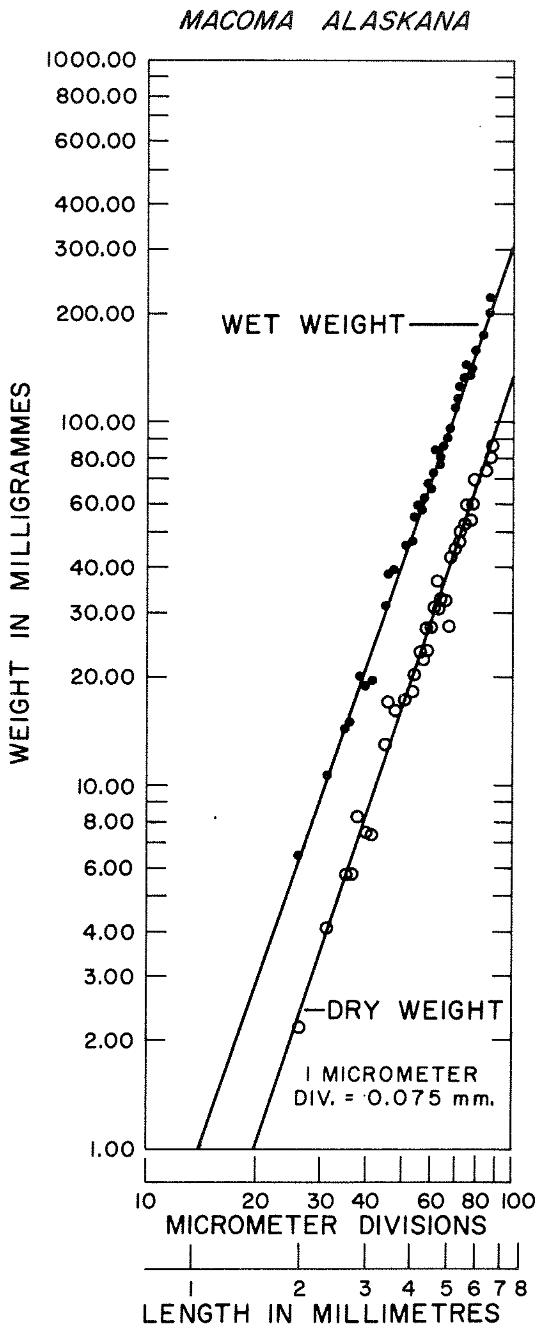

Figure 51. Weight/size curves for Macoma alaskana.

Table 97

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Macoma alaskana

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	0	0	142.0	0	3074.4	71.4	172.0	0
	A	0	0	7.5	0	161.7	3.8	9.0	0
Apr-May	W	0	0	76.3	240.0	5884.9	0	0	0
	A	0	0	4.0	12.6	309.5	0	0	0
July-Aug	W	0	0	91.4	0	2295.0	0	153.4	0
	A	0	0	4.8	0	120.7	0	8.1	0
Nov	W	0	0	0	87.1	2842.2	265.0	91.1	0
	A	0	0	0	4.6	149.5	13.9	4.5	0
Feb 1964	W	0	0	0	0	3575.0	0	368.0	0
	A	0	0	0	0	188.0	0	19.4	0
Apr	W	0	0	0	172.4	2561.3	174.2	671.3	0
	A	0	0	0	9.1	134.7	9.2	35.3	0
July-Aug	W	0	0	0	936.5	558.0	151.8	0	0
	A	0	0	0	49.3	29.4	8.0	0	0

in the samples was from 2.2 to 20.6 mm. MacGINITIE (1959) found M. calcarea at Point Barrow, Alaska, to range from 13.5 to 37 mm, with a maximum of 47.5 mm.

Wet weights and dry weights were determined for single individuals from 23 size classes of M. calcarea (Figure 52).

The organic matter from seven samples comprised 14.44% of the dry weight with 95% confidence limits ± 2.21 and 1.77% (± 0.71) of the wet weight. From the size measurements, the weight/size curves in Figure 52, and the organic matter/dry weight conversion factor (0.1444), the total wet weight and organic matter of M. calcarea at the Puget Sound benthos stations during the period of investigation was calculated (Table 99). As the species was fairly large, it was occasionally of some significance to the standing crop at station 3.

49. Semele rubropicta DALL

This lamellibranch of the family Semelidae is distributed from Forrester Island, Alaska, to Tijuana, Lower California (DALL 1921).

Table 98

Abundance (N) per square metre and rank (R) of Macoma calcarea

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	1	29	0		6	18	3	22	27	7	0		0		0	
Apr-May		0		0		1	31	3	23	0		0		0		0	
July-Aug		0		0		7	24	4	20	42	8	0		3	34	0	
Nov		0		0		0		11	18	23	8	0		2	33	0	
Feb	1964	0		0		0		8	18	26	7	0		0		0	
Apr		0		0		4	20	4	31	4	22	0		0		0	
July-Aug		0		0		2	39	40	10	8	33	0		0		0	

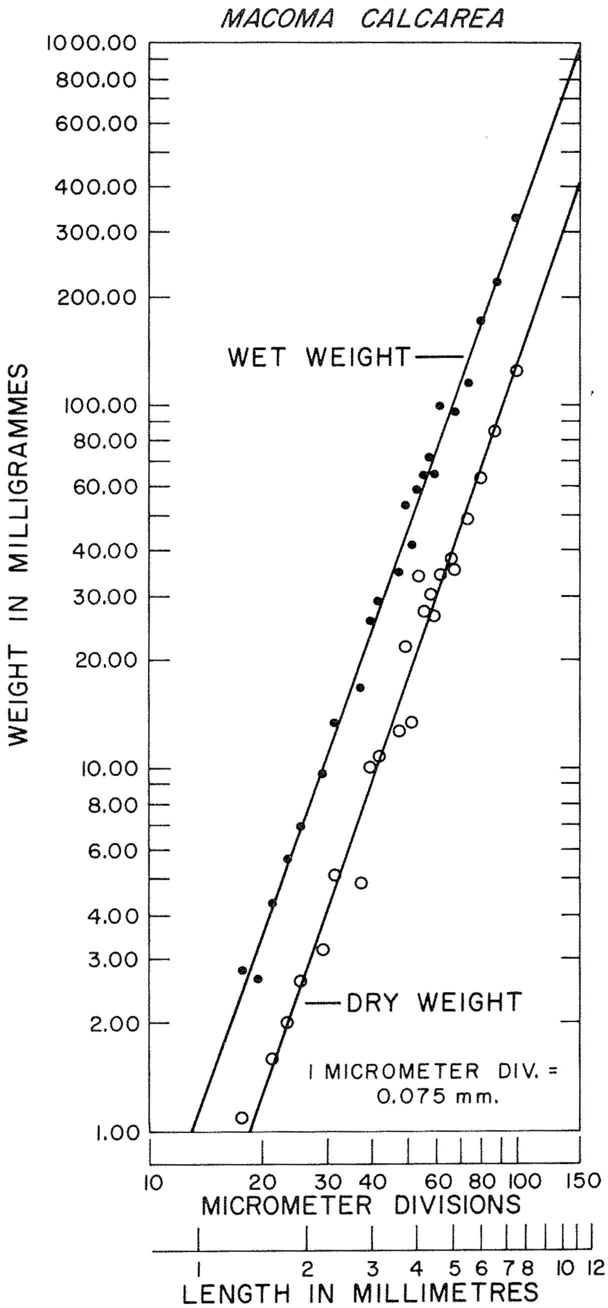

Figure 52. Weight/size curves for Macoma calcarea.

Table 99

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Macoma calcarea

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	36.4	0	236.0	161.0	3941.3	0	0	0
1963	A	2.1	0	13.6	9.3	227.4	0	0	0
Apr-May	W	0	0	48.3	124.8	0	0	0	0
	A	0	0	2.8	7.2	0	0	0	0
July-Aug	W	0	0	194.6	168.0	5698.5	0	123.0	0
	A	0	0	11.2	9.7	328.8	0	7.1	0
Nov	W	0	0	0	1493.0	3276.2	0	68.3	0
	A	0	0	0	86.1	189.0	0	3.9	0
Feb	W	0	0	0	1105.6	2012.0	0	0	0
1964	A	0	0	0	63.8	116.1	0	0	0
Apr	W	0	0	184.3	218.3	21.6	0	0	0
	A	0	0	10.6	12.6	1.2	0	0	0
July-Aug	W	0	0	81.0	5192.6	962.0	0	0	0
	A	0	0	4.7	299.6	55.5	0	0	0

In Puget Sound, Semele rubropicta was found at the stations with the coarsest sediment type (Table 100). The species was not particularly abundant at any of the stations, but because of its considerable size and high frequency of occurrence at stations 5 and 6, S. rubropicta was included among the numerically dominant species.

Because of the low abundance of the species, no information about growth, longevity, or seasonal variations in abundance is available. Table 23, page 338 indicates a very low degree of patchiness, but the conclusion is based on only four observations. The size range of S. rubropicta in the samples was from 6.0 to 33.7 mm.

Wet weight and dry weight was determined for 19 specimens from different size classes (Figure 53). The organic matter from ten samples comprised 7.34% of the dry weight with 95% confidence limits ± 0.41 and 3.89% (± 0.18) of the wet weight. The organic matter/dry weight conversion factor was 0.0734, and from this factor, the length measurements, and the weight/size curves in Figure 53, the total wet weight and organic matter of S. rubropicta at the benthos

Table 100

Abundance (N) per square metre and rank (R) of <u>Semele rubropicta</u>

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	0		0		0		0		0		5	16	13	2	5	9
Apr-May		0		0		0		0		0		0		4	20	4	15
July-Aug		0		0		0		0		0		0		16	12	2	24
Nov		0		0		0		0		0		1	34	11	17	2	25
Feb	1964	0		0		0		0		8	17	0		4	20	8	6
Apr		0		0		0		0		0		0		0		8	13
July-Aug		0		0		0		0		0		0		12	11	0	

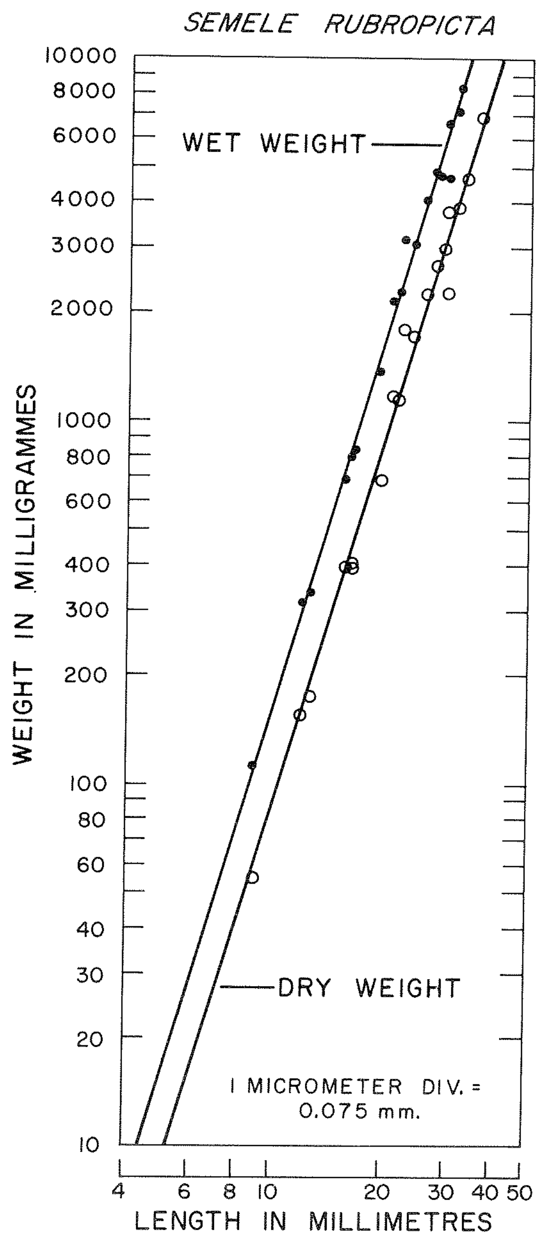

Figure 53. Weight/size curves for Semele rubropicta.

Table 101

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Semele rubropicta

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	0	0	0	0	0	4660.0	18199.6	6697.0
	A	0	0	0	0	0	181.3	708.0	260.5
Apr-May	W	0	0	0	0	0	0	16600.0	16000.0
	A	0	0	0	0	0	0	645.7	622.4
July-Aug	W	0	0	0	0	0	0	25605.0	5600.0
	A	0	0	0	0	0	0	996.0	217.8
Nov	W	0	0	0	0	0	960.0	20102.5	8160.0
	A	0	0	0	0	0	37.3	782.0	317.4
Feb 1964	W	0	0	0	0	4800.0	0	1450.0	18460.0
	A	0	0	0	0	186.7	0	56.4	718.0
Apr	W	0	0	0	0	0	0	0	19320.0
	A	0	0	0	0	0	0	0	751.5
July-Aug	W	0	0	0	0	0	0	8070.0	0
	A	0	0	0	0	0	0	313.9	0

stations in Puget Sound during the period of investigation was calculated (Table 101). The species was of considerable importance to the total standing stock at stations 5 and 6.

50. Mya arenaria LINNÉ

This lamellibranch of the family Myidae is distributed in the western part of the Atlantic Ocean from northern Norway to western France, and on the American east coast southwards to New York (JENSEN and SPÄRCK 1934). Mya arenaria from the Atlantic coast were transplanted into San Francisco Bay about 1865, and today the species is distributed from Alaska to Monterey, California (MacNEIL 1965).

In Puget Sound the species occurred at the stations with coarse sandy bottoms (Table 102). SANDERS et al. (1962) found M. arenaria intertidally in Barnstable Harbor, Massachusetts, in all the various sediment types present there. As the species was not particularly numerous at any of the stations, no information about longevity, growth, or seasonal variations in abundance is available. Table 23,

Table 102

Abundance (N) per square metre and rank (R) of Mya arenaria

	Stations															
	2		7		4		1		3		8		6		5	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb 1963	0		0		0		0		2	35	2	21	7	8	4	12
Apr-May	0		0		0		0		25	7	0		26	3	2	20
July-Aug	0		0		0		0		3	38	5	25	36	7	0	
Nov	0		0		0		0		0		1	34	37	4	8	12
Feb 1964	0		0		0		0		8	17	0		14	9	2	16
Apr	0		0		0		0		2	27	2	29	8	19	0	
July-Aug	0		0		0		0		5	36	6	24	10	17	0	

Table 103

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Mya arenaria

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	0	0	20.3	71.5	365.6	120.0
1963	A	0	0	0	0	1.3	4.5	23.1	7.6
Apr-May	W	0	0	0	0	268.0	0	669.2	59.6
	A	0	0	0	0	16.9	0	42.3	3.8
July-Aug	W	0	0	0	0	42.4	150.6	649.2	0
	A	0	0	0	0	2.7	9.5	41.0	0
Nov	W	0	0	0	0	0	34.0	716.0	364.3
	A	0	0	0	0	0	2.1	45.3	23.0
Feb	W	0	0	0	0	64.3	0	395.0	63.0
1964	A	0	0	0	0	4.1	0	25.0	4.0
Apr	W	0	0	0	0	49.0	63.0	822.0	0
	A	0	0	0	0	3.1	4.0	52.0	0
July-Aug	W	0	0	0	0	63.4	178.4	1900.0	0
	A	0	0	0	0	4.0	11.3	120.1	0

page 338 indicates a low degree of patchiness with half of the observations indicating randomness or evenness of distribution.

Mya arenaria ranged in size from 1.8 to 16.5 mm at the Puget Sound benthos stations.

Wet weights and dry weights were determined for single specimens from 26 size classes of M. arenaria (Figure 54). The organic matter from 11 samples comprised 16.05% of the dry weight with 95% confidence limits ± 1.83 and 6.32% (± 0.68) of the wet weight. From the length measurements, the weight/size curves in Figure 54, and the organic matter/dry weight conversion factor (0.1605), the total wet weight and dry organic matter of M. arenaria at the Puget Sound benthos stations during the period of investigation was calculated (Table 103). The species was not particularly important for the total standing crop of benthos at any of the Puget Sound benthos stations.

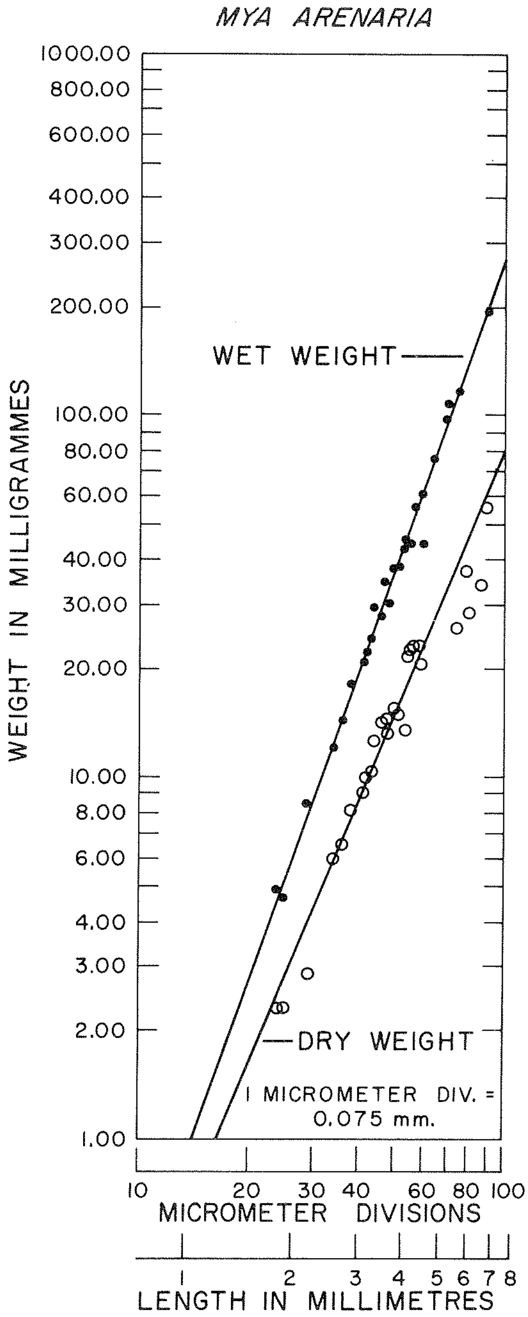

Figure 54. Weight/size curves for Mya arenaria.

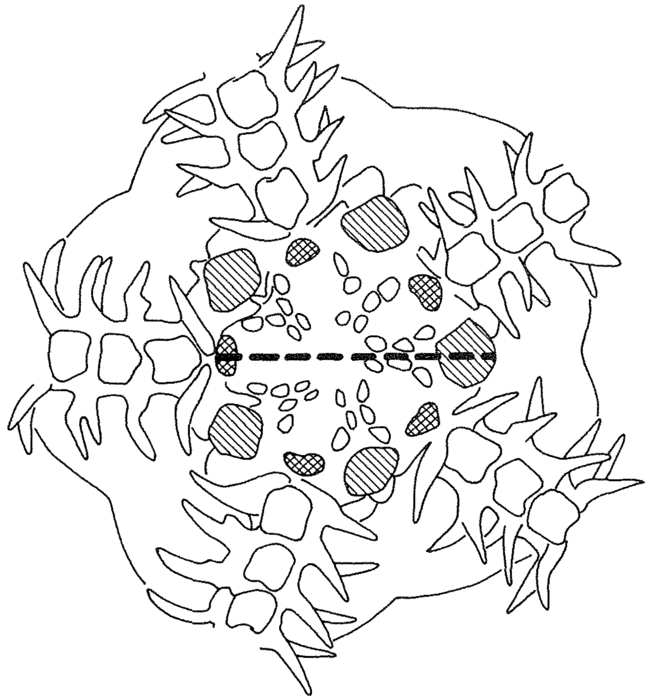

Figure 55. Ventral side of Amphiodia urtica. Broken line indicates "oral width".

51. Amphiodia urtica (LYMAN)

This ophiurid of the family Amphiuridae occurs from Alaska to California and is the most abundant and widespread species of the coastal shelves off Southern California (BARNARD and ZIESENHENNE 1961). The average density of Amphiodia urtica off Southern California was 422 specimens per square metre.

In Puget Sound, A. urtica occurred at all the stations, but it was particularly abundant at stations 7 and 8 (Table 104). BARNARD and ZIESENHENNE (1961) found the highest density of the species on bottoms with about 70% silt. However, station 7 had about 60% silt and station 8 had about 7% or less (Table 4,page 364) so the distribution of A. urtica among the benthos stations in Puget Sound cannot be explained according to sediment distributions.

Amphiodia urtica did not reveal a high degree of patchiness (Table 23, page 338); about one-third of the observations indicated randomness or evenness of spatial distribution.

Table 104

Abundance (N) per square metre and rank (R) of Amphiodia urtica

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	6	15	15	7	52	9	0		10	15	192	2	7	8	0	
Apr-May		3	15	404	2	3	22	0		0		282	1	10	12	0	
July-Aug		0		38	3	68	8	1	35	0		153	5	15	14	0	
Nov		0		42	1	4	17	3	29	4	25	224	2	6	21	7	13
Feb	1964	2	11	98	2	3	16	0		2	36	502	1	8	13	0	
Apr		16	6	488	2	7	13	10	17	0		288	2	24	8	0	
July-Aug		0		202	3	46	8	0		0		292	3	14	9	4	22

Arm lengths could not be used for studies of size distributions and growth because often the arms were all broken or in various degrees of regeneration. The disc diameter was also an inaccurate measure because the disc was often more or less expanded or pillow-shaped, probably as a function of preservation or physiological conditions. Therefore, all the specimens were measured from the outer end of an oral plate to the outer end of the opposite first arm plate (Figure 55), and this measurement is subsequently referred to as the oral width. Figures 56 and 57 show the oral width frequency histograms at stations 7 and 8 during the period of investigation. The diagrams are multimodal with a high degree of overlapping and the various modes are difficult to identify through the seasons. However, the 1963 year class could be traced fairly easily, and an attempt has been made to identify the modes of the other year classes as well. The locations of the various modes through the period of investigation are shown in Figure 58 and the plot indicates the growth curve for A. urtica. The growth rate of the oral width was about 0.25 mm per year, which corresponds to a disc diameter growth of about 0.53 mm per year (Figure 59). This compares favorably with the growth rate of two closely related European species, Amphiura chiajei and A. filiformis, which had disc diameter growth rates of 0.3 and 1.0 mm per year, respectively (BUCHANAN 1964).

An attempt was made to determine the relationship between wet weight and dry weight of A. urtica and the oral width. Four grab samples were emptied into tubs of seawater and the visible specimens of A. urtica were carefully removed from the sediments and preserved separately. The arms were studied under a dissecting microscope and arms that did not appear to have regenerated were cut off between the third and fourth joint, measured, and weighed (wet weight and dry weight). The oral width of the corresponding specimens was measured, and the relationship between arm length and oral width was linear (Figure 60). The discs stripped of arms were weighed, and Figure 61 shows disc weight in relation to oral widths, and arm weights in relation to arm lengths. The total wet weights and dry weights for A. urtica have been calculated by finding the disc weights from Figure 61 for each oral width class and adding to the disc weights five times the arm weights as determined from Figures 60 and 61. The resulting weight/oral width curves for A. urtica are shown in Figure 62. These weights are "ideal weights" since it is presumed that all arms are complete, which is rarely the case in nature.

The organic content from two samples comprised 29.17 and 27.57% of the dry weight, respectively. From the oral width measurements, the weight/oral

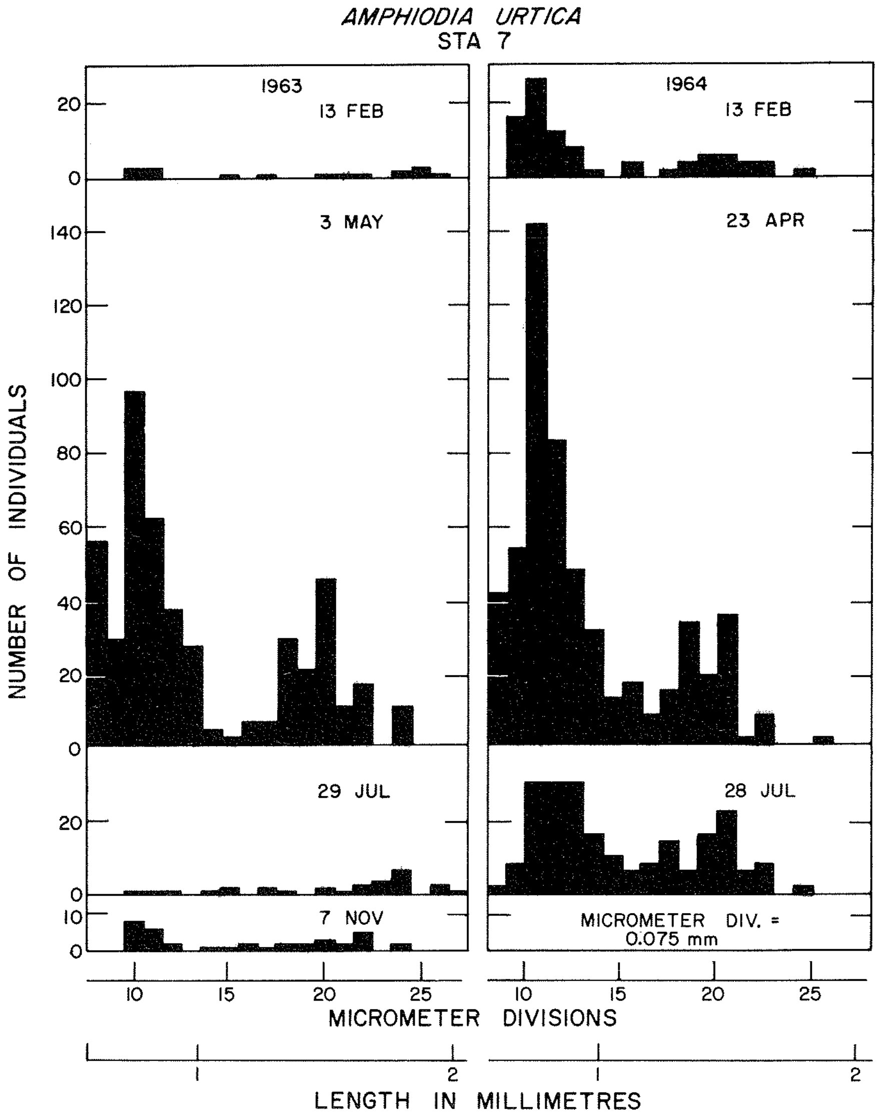

Figure 56. Oral width distribution of Amphiodia urtica at station 7.

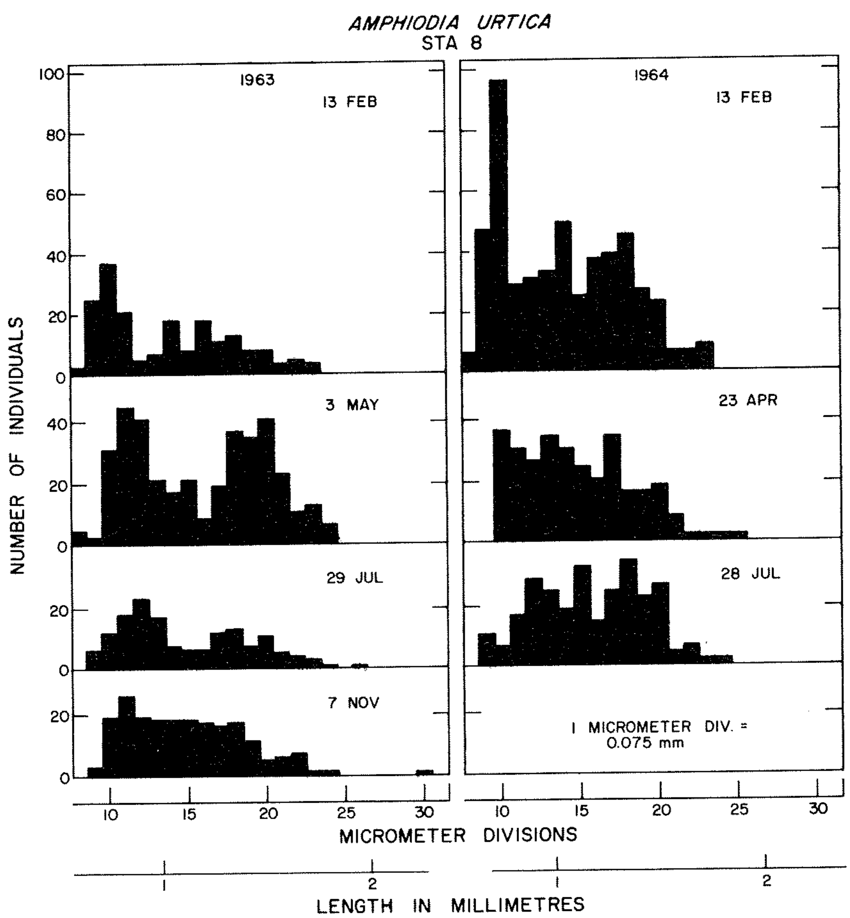

Figure 57. Oral width distribution of Amphiodia urtica at station 8.

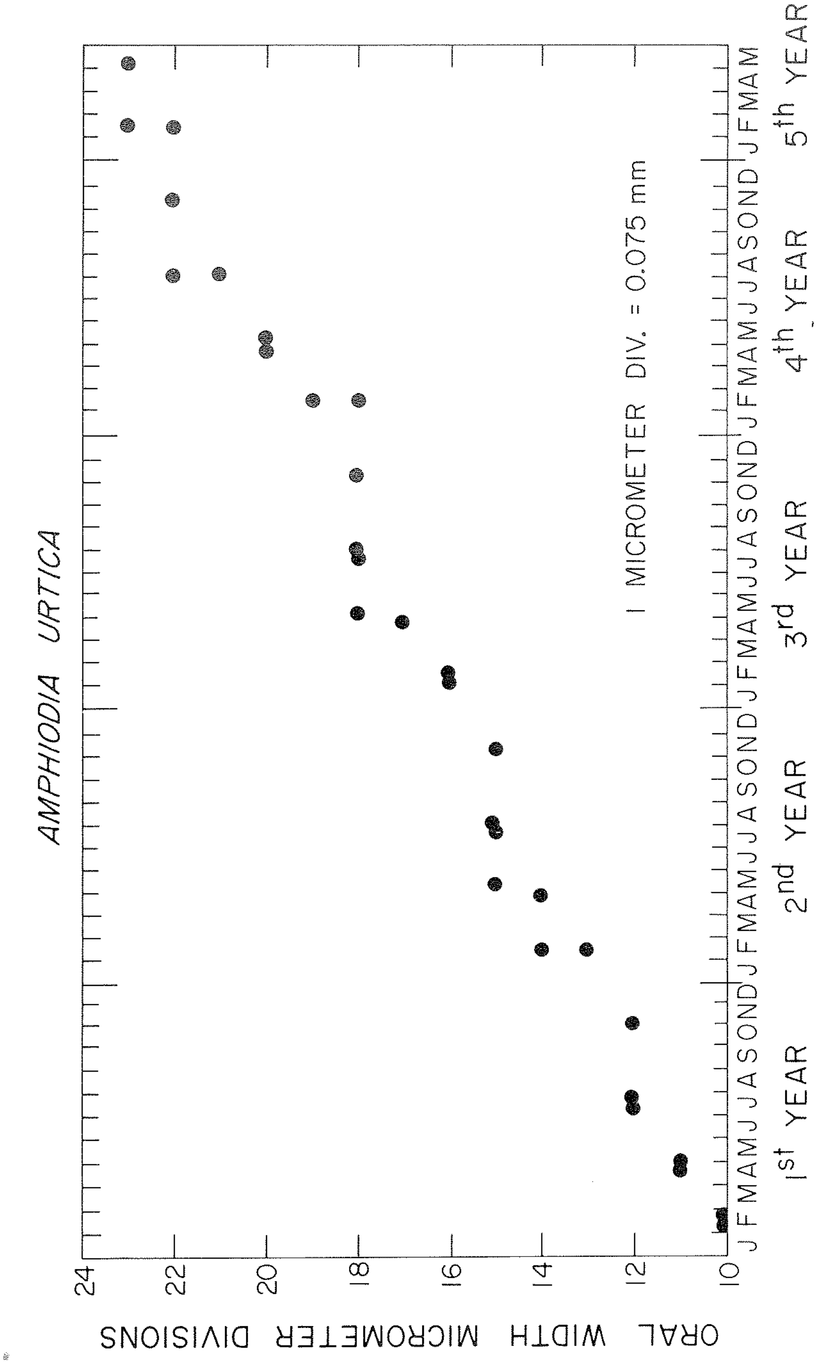

Figure 58. Growth curve for Amphiodia urtica.

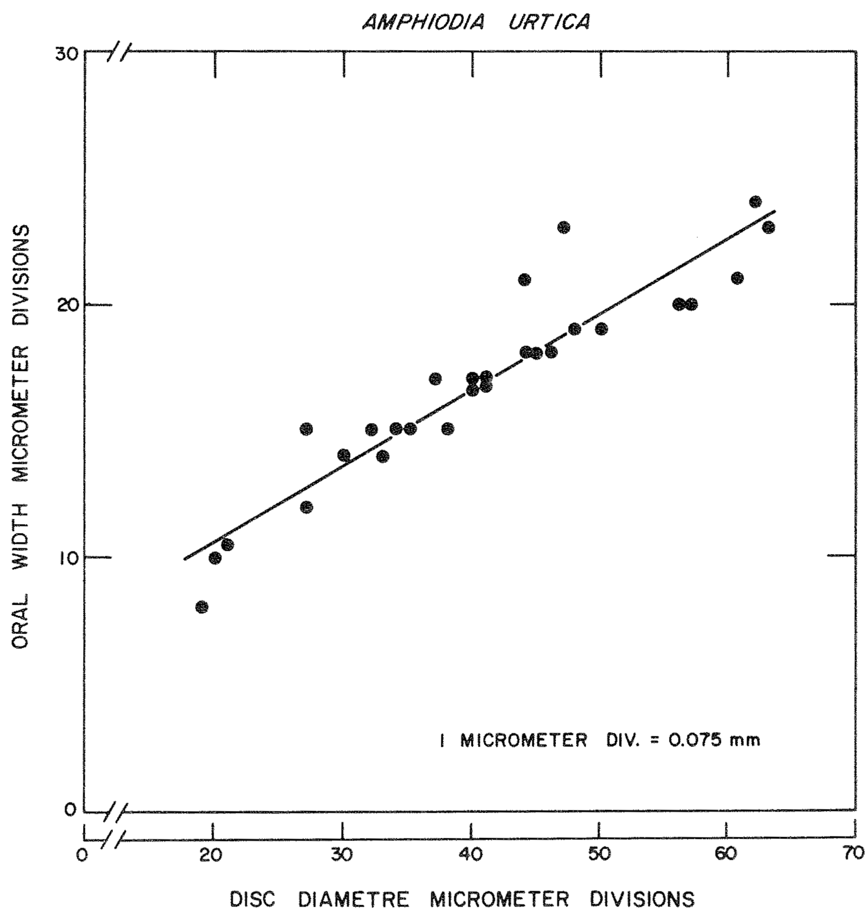

Figure 59. Relationship between oral width and disc diameter of Amphiodia urtica.

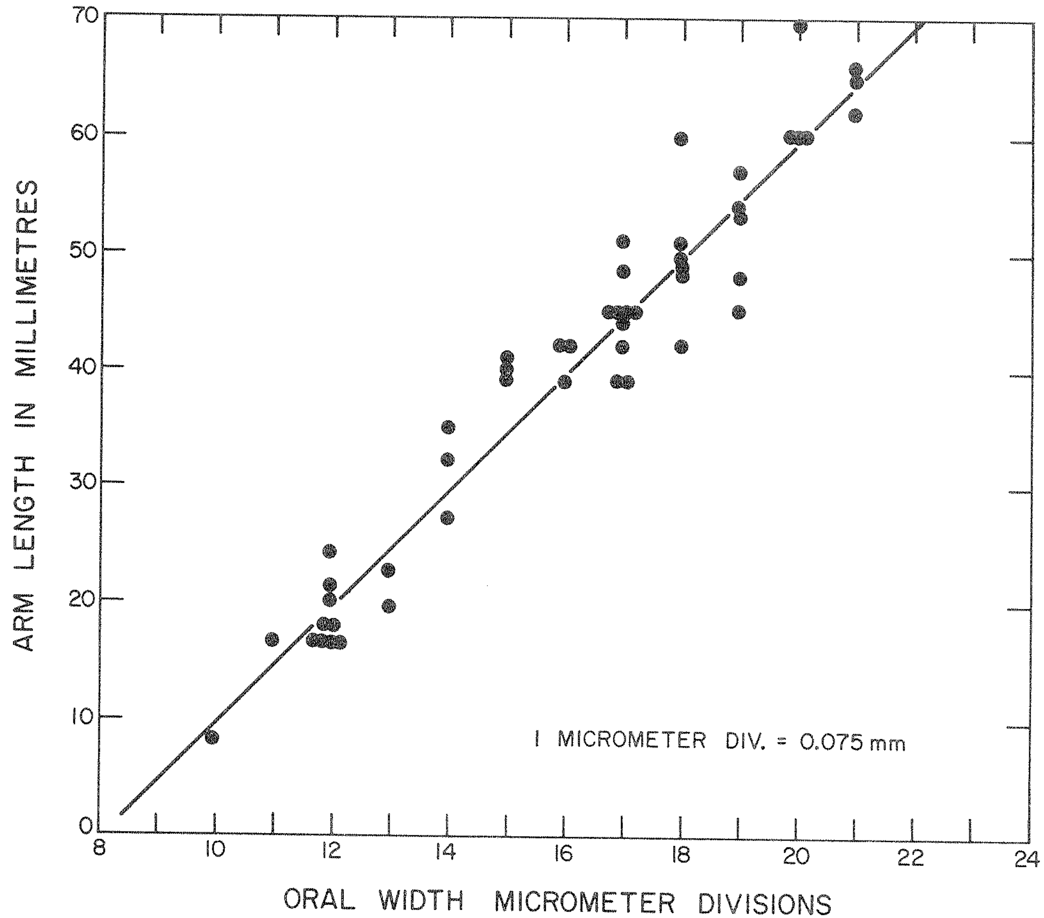

Figure 60. Relationship between oral width and arm length of Amphiodia urtica.

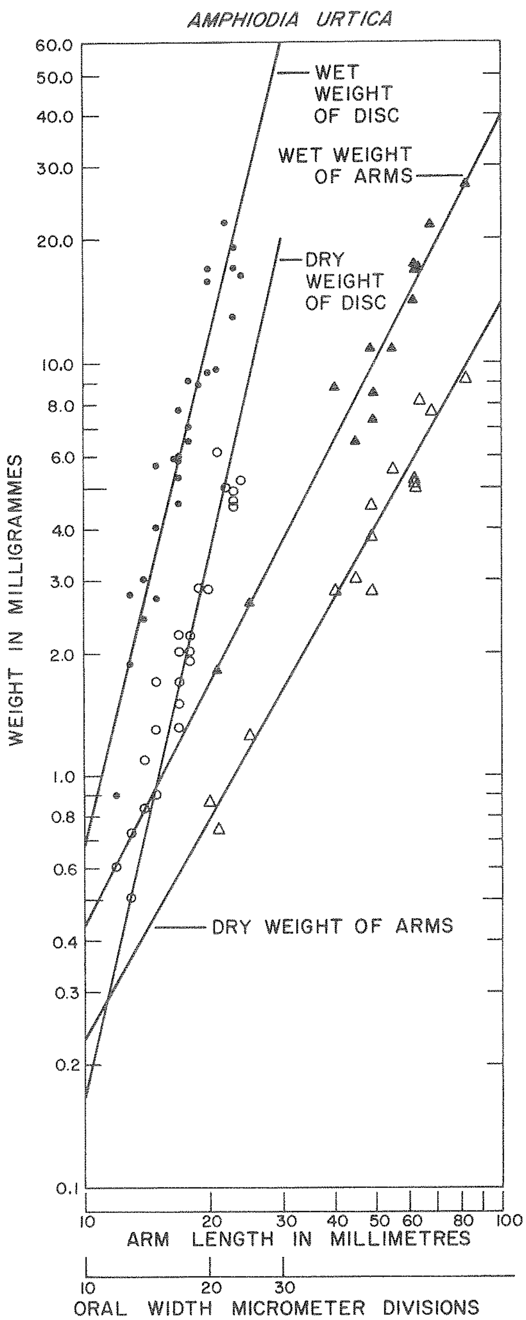

Figure 61. Disc weight/oral width and arm weight/arm length relationships for Amphiodia urtica.

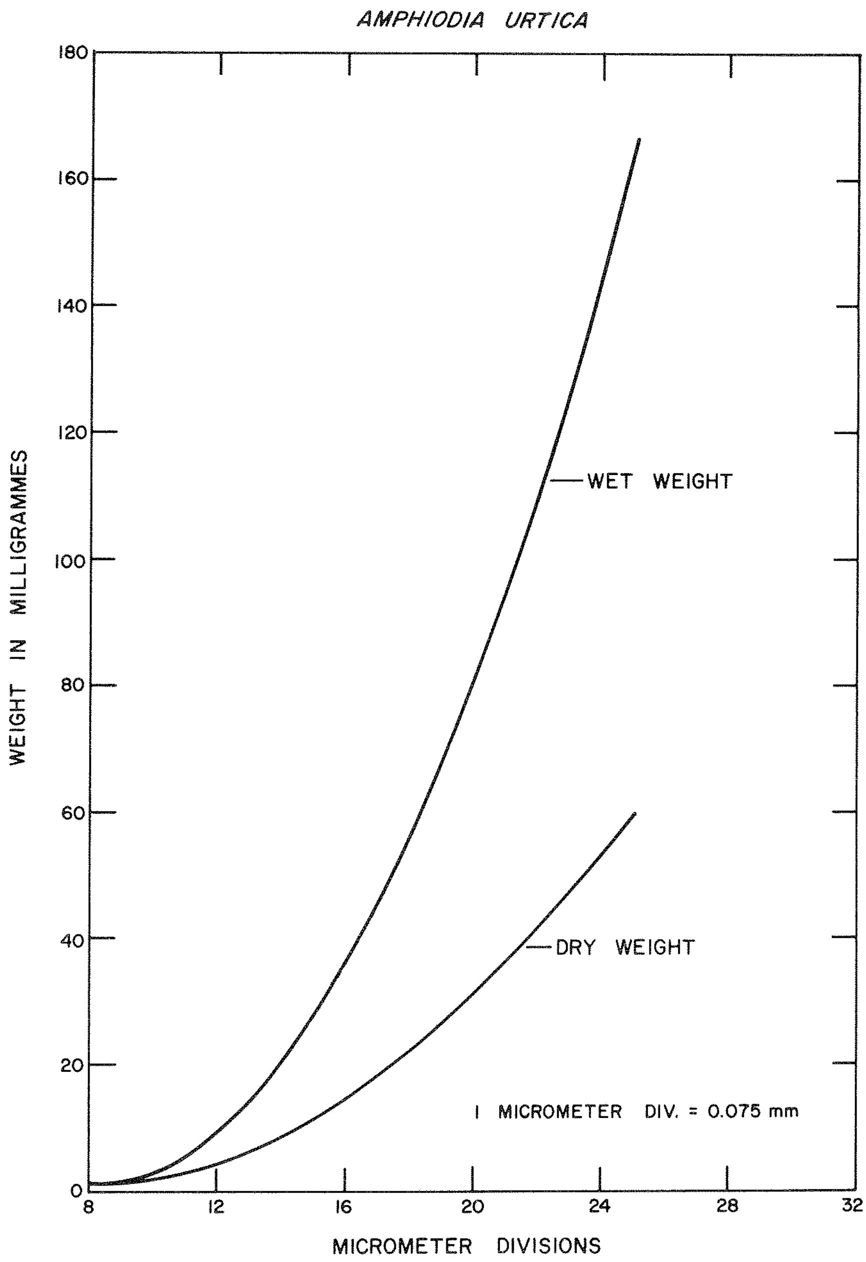

Figure 62. Weight/oral width curves for Amphiodia urtica.

Table 105

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Amphiodia urtica

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb 1963	W	336.0	1397.0	2104.0	0	731.0	5715.0	322.0	0
	A	37.7	156.7	236.1	0	82.0	641.2	36.1	0
Apr-May	W	288.0	13068.0	238.0	0	0	16801.0	560.0	0
	A	32.3	1466.2	26.7	0	0	1885.1	62.8	0
July-Aug	W	0	3367.0	2840.0	68.0	0	5261.0	700.0	0
	A	0	377.8	318.6	7.6	0	590.3	78.5	0
Nov	W	0	1800.0	342.0	184.0	311.0	6643.0	408.0	398.0
	A	0	202.0	38.4	20.6	34.9	745.3	45.8	44.7
Feb 1964	W	181.0	2792.0	231.0	0	131.0	14426.0	448.0	0
	A	20.3	313.3	25.9	0	14.7	1618.6	50.3	0
Apr	W	856.0	10992.0	594.0	560.0	0	9964.0	1064.0	0
	A	96.0	1233.3	66.6	62.8	0	1118.0	119.4	0
July-Aug	W	0	7152.0	1900.0	0	0	10774.0	784.0	263.0
	A	0	802.5	213.2	0	0	1208.8	88.0	29.5

width curves in Figure 62, and the dry weight/organic matter conversion factor (0.28), the total wet weight and organic matter of A. urtica for the Puget Sound benthos stations during the period of investigation have been calculated (Table 105). The species was of considerable importance to the total standing crop, particularly at stations 7 and 8, in spite of its low content of organic matter. However, because of its extremely slow growth rate, its importance to the community productivity is probably considerably less.

52. Leptosynapta clarki HEDING

There has been considerable controversy regarding the taxonomy of the holothurians of the family Synaptidae from the Pacific coast of North America. CLARK (1901) found that Leptosynapta inhaerens (MÜLLER) and L. albicans SELENKA were synonymous, and he gave preference to the name L. albicans. This view has largely prevailed since then, although the name L. inhaerens occasionally occurred in the literature (BUSH 1918, 1921). HEDING (1928) reexamined the taxonomy of the Synaptidae from the Northeast Pacific Ocean and maintained that there are two species, Leptosynapta albicans, and a species that resembled L. inhaerens but was regarded as a new species, Leptosynapta clarki. The latter species is probably the same as Leptosynapta inhaerens of BUSH (1918, 1921) and the L. albicans of CLARK (1901, 1907) and RICKETTS and CALVIN (1952). The species is known to be particularly abundant in the intertidal zone on sandy bottoms (RICKETTS and CALVIN 1952, BUSH 1918), and Table 106 shows the abundance of L. clarki at the benthos stations in Puget Sound during the period of investigation. The species autotomizes easily when disturbed, which made enumeration difficult. The data in Table 106 are counts of the anterior parts that carry tentacles. There was no significant seasonal pattern in abundance, and the table clearly shows that L. clarki prefers a rather coarse substrate.

Leptosynapta clarki had a very high degree of patchiness (Table 23, page 338), which may be related to its viviparous mode of reproduction.

Since the specimens break so easily, no information about size distribution or growth is available. Wet weights and dry weights were determined by weighing all the parts of L. clarki from each sample. The weights are rather inaccurate, partly because the specimens may have been cut in two during sampling and partly because the specimens showed highly varying amounts of inorganic materials in the digestive tract. For this reason there was also a high variability in the wet weight/dry weight relationships. The dry weight comprised from 10.45 to 50.25% of the wet weight with a mean of 26.05% and 95% confidence limits ± 3.25. The ash content from two samples comprised 57.10 and 84.79% of the dry weight. This high variability was probably due to varying amounts of inorganic matter in the digestive tract. Table 107 shows the wet weight and the weight of organic matter of L. clarki at the benthos stations in Puget Sound during the period of investigation. The organic matter has been calculated by multiplying the dry weights by the mean percentage of organic matter as determined from the two combusted samples, 0.2906. Table 107 shows that L. clarki contributed significantly to the total standing crop at station 5, but at stations 3, 8, and 6 the species could also occasionally be of some importance. However, the particular sampling problems and the highly varying amounts of inorganic matter reduce the significance of the weight determinations by a considerable degree.

53. Brisaster townsendi AGASSIZ

This species is an irregular echinoid of the family Schizasteridae distributed from southeastern Alaska to the Gulf of Panama in depths from 35 to 1900 m (MORTENSEN 1951).

Table 106

Abundance (N) per square metre and rank (R) of Leptosynapta clarki

		Stations															
		2		7		4		1		3		8		6		5	
		N	R	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Jan-Feb	1963	0		0		0		0		13	14	76	3	13	2	43	3
Apr-May		0		0		0		3	23	25	7	217	3	20	5	34	5
July-Aug		0		0		0		5	17	6	30	0		36	7	3	22
Nov		0		0		0		1	39	4	25	2	30	27	9	34	4
Feb	1964	0		0		0		0		26	7	0		10	12	74	1
Apr		0		0		0		28	9	0		14	13	14	14	72	3
July-Aug		0		0		0		16	18	13	18	0		78	3	30	4

Table 107

Wet weight (W) and ash-free dry weight (A) in milligrammes per square metre of Leptosynapta clarki

		Stations							
		2	7	4	1	3	8	6	5
Jan-Feb	W	0	0	0	0	1069.8	2778.4	420.8	1920.1
1963	A	0	0	0	0	88.4	154.1	67.5	126.9
Apr-May	W	0	0	0	350.3	2297.1	7195.5	416.1	2782.9
	A	0	0	0	24.6	234.5	461.2	32.6	211.4
July-Aug	W	0	0	0	1331.4	294.1	0	829.2	33.7
	A	0	0	0	68.9	16.7	0	58.7	1.3
Nov	W	0	0	0	15.8	233.7	147.5	787.7	2177.0
	A	0	0	0	1.7	27.6	16.2	56.7	114.3
Feb	W	0	0	0	0	946.2	0	226.1	3611.2
1964	A	0	0	0	0	72.6	0	17.8	433.7
Apr	W	0	0	0	989.9	64.5	20.7	351.8	2525.0
	A	0	0	0	58.2	6.4	2.4	26.4	189.8
July-Aug	W	0	0	0	588.1	192.2	0	1672.9	3891.3
	A	0	0	0	26.1	9.9	0	126.3	427.1

In Puget Sound, B. townsendi was found only at station 2, but since the species at this station was completely dominating in biomass (see page 341), had a high frequency of occurrence, and was fairly abundant, it was included among the numerically dominant species. Table 108 shows the abundance of B. townsendi per square metre at station 2 during the period of investigation. Table 108 indicates seasonal variations in abundance with minima in February. However, the size frequencies (Figure 63) did not indicate any seasonal pattern, and the species is probably not capable of performing significant migrations, which could explain the variations in abundance. Therefore, the difference in abundance between the dates is probably heterogeneity in distribution rather than seasonal variation. During the sampling at station 2, the ship was not anchored and was therefore permitted to drift a considerable distance during the sampling; because the station was located in the middle of the sound the exact location was more difficult to determine than at other stations. An analysis of variance (Table 109) showed that with 95% probability the differences in abundance of B. townsendi between sampling dates was larger than could be expected from random sampling.

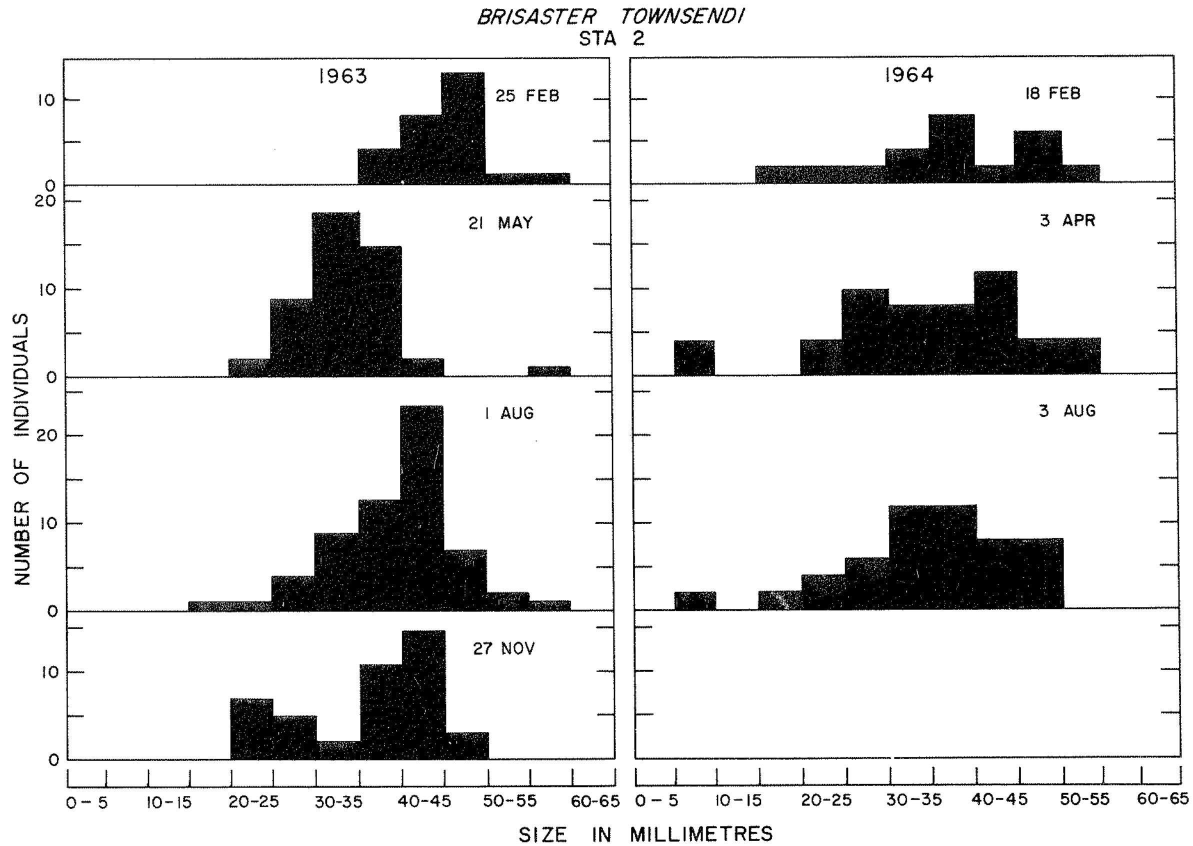

Figure 63. Size distribution of Brisaster townsendi at station 2.

Table 108

Abundance (N) per square metre and rank (R) of Brisaster townsendi at station 2

	1963				1964		
	Feb	May	Aug	Nov	Feb	Apr	Aug
N	30	50	63	43	32	54	54
R	5	5	1	3	4	3	2

Table 109

Analysis of variance of abundance of Brisaster townsendi at station 2 during the investigated period

Source of variation	Amount of variation	Degrees of freedom	Estimated variance
Between sampling dates	73.0	6	12.17
Within sampling dates	197.4	48	4.11
Total	270.4	54	

The differences in abundance as shown in Table 108 may therefore reflect a heterogeneity in the distribution at the large mud flat in central Puget Sound at about 200 m depth.

The size-frequency distributions of B. townsendi at station 2 during the period of investigation are shown in Figure 63. The most striking feature of the figure is the scarcity of small individuals. There were significant differences among the modes from the various sampling dates, but no growth pattern could be demonstrated. The differences in size distribution from the various sampling dates may, like the differences in abundance, be a function of a geographical heterogeneity. The predominance of large specimens is demonstrated in Figure 64, where all measurements of B. townsendi have been graphed together. Only 3.8% of the specimens were smaller than 20 mm, and 92.4% of the specimens measured from 20 to 50 mm. The size distribution indicates a very small recruitment and low mortality of the stock. The reason for the small recruitment may

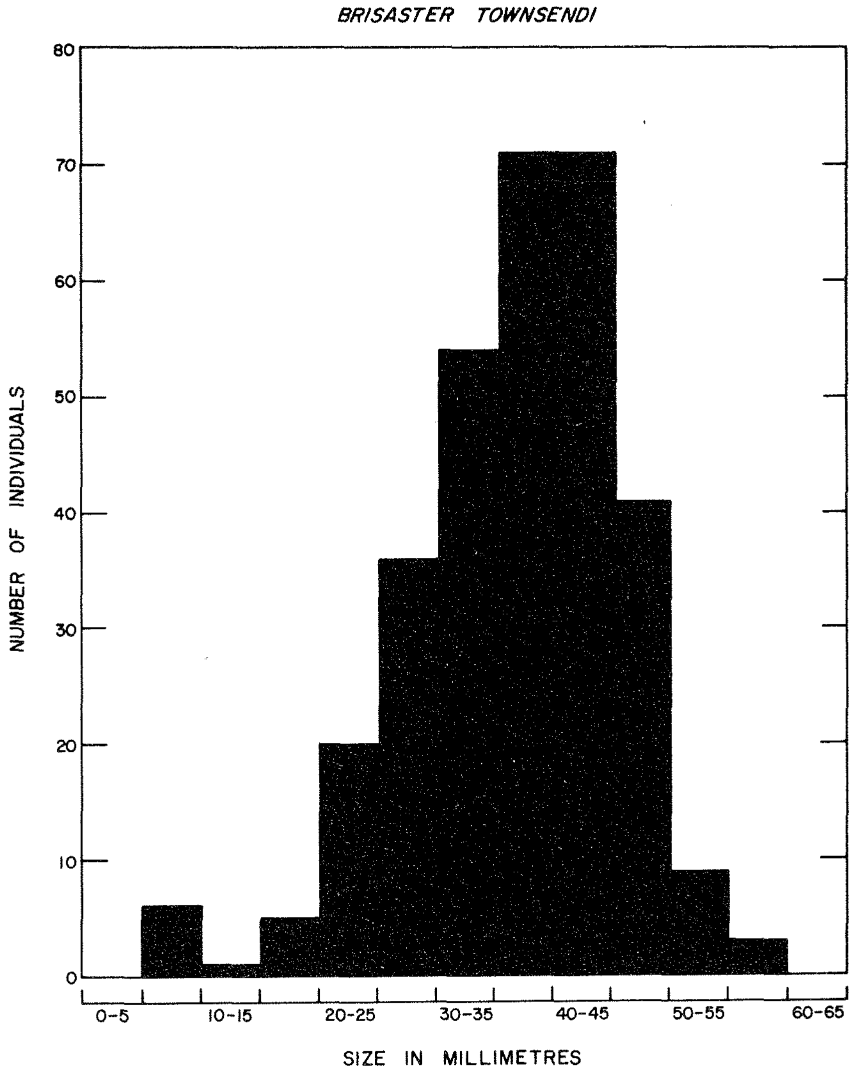

Figure 64. Size distribution of Brisaster townsendi at station 2 for combined data for all seasons.

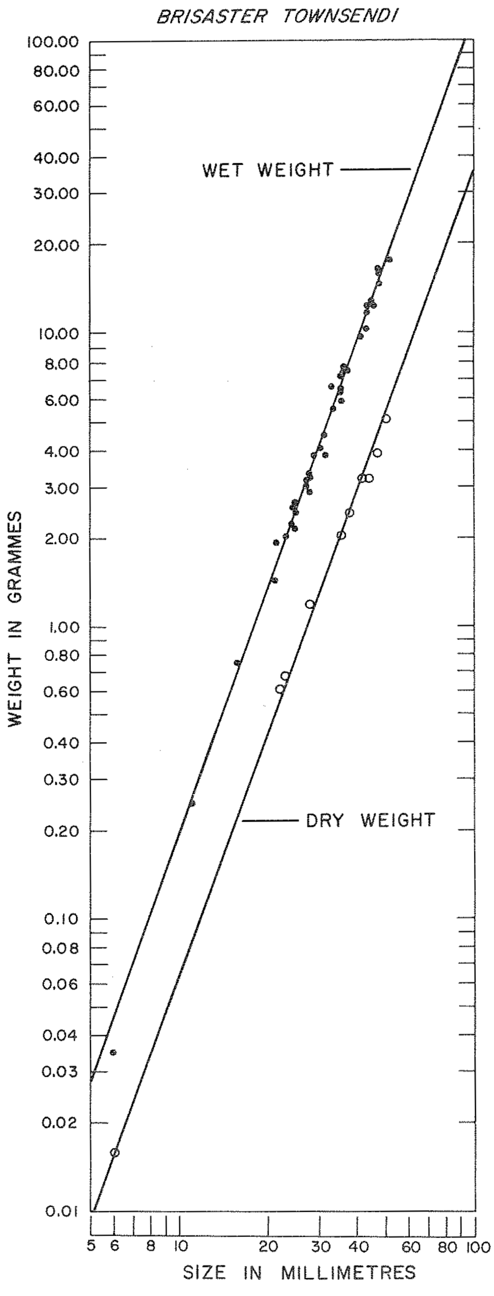

Figure 65. Weight/size curves for Brisaster townsendi.

Table 110

Wet weight (W) and ash-free dry weight (A) in grammes per square metre of Brisaster townsendi at station 2

	1963				1964		
	25 Feb	21 May	1 Aug	27 Nov	18 Feb	3 Apr	2 Aug
W	370.00	281.15	557.10	315.85	229.10	389.50	368.60
A	12.21	9.28	18.38	10.42	7.56	12.85	12.16

be that the niche requirements for B. townsendi were maximally utilized, and therefore the success of a recruit is dependent upon the removal of an already settled specimen. When resources are maximally utilized and the interspecific competition is low, a tendency toward even spatial distribution could be expected. Table 23 shows that B. townsendi had a very low degree of patchiness; in six out of seven observations the species had a nearly even distribution. This low patchiness does not contradict the statements above concerning heterogeneity of distribution. The mud flat appears to be more or less densely populated by B. townsendi, but at any point on the mud flat the species is nearly evenly dispersed regardless of abundance.

Wet weights were determined for 39 specimens and dry weights from ten specimens of various size groups (Figure 65). The organic matter of three specimens was 9.72, 10.50, and 11.70% of the dry weights, respectively.

From the size frequency curves in Figure 63, the weight/size curves in Figure 65, and the dry weight/organic matter conversion factor (0.11), the total wet weights and organic matter of B. townsendi for the various sampling dates at station 2 were calculated (Table 110). Brisaster townsendi dominated the standing crop at station 2, in spite of the low percentage of organic matter.

V. SUMMARY

1. Benthic samples were collected every three months from January-February 1963 to July-August 1964 at eight permanent stations in Puget Sound, Washington, U.S.A. Three to ten replicate samples (total 405 samples) were collected per station per sampling date with a 0.1 m^2 van Veen grab, the samples were sieved through a 1-mm stainless steel screen, and the material was preserved in 5 to 10% formaldehyde buffered with $Na_2B_4O_7$. The stations were located in substrates ranging from fine mud to gravelly sand on depths from about 12 to 200 m.

2. Subsamples were taken from 75 of the grab samples for a particle-size analysis of the sediments. All the crustaceans, lamellibranchs, and echinoderms were identified and counted, while the polychaetes were identified and counted from the first two cruises only. The size distributions, wet weights, dry weights, and ash-content of the numerically dominant species were determined. A computer program was designed to calculate various parameters of the species populations and various indices of diversity of the faunal assemblages.

3. The volume of sediments obtained by the grab when sampling on the sand bottom stations had a mean coefficient of variation of about 15%, which indicated a variability in penetration from 5 to 7 cm. The variability increased in bad weather. The mean volume of sediments at the sand-bottom stations was 6.26 litres, and 87.7% of the samples contained more than 4 litres. A comparison between the van Veen grab and the Smith-McIntyre grab showed that the former grab collected about 1.5 litres of sediment more than the latter, but the latter grab revealed much lower variability among replicate samples.

4. The substrate at stations 2 and 7 was classified as mud, while at the other six stations the substrate varied from muddy sand (station 4) to gravelly sand (station 5). Based on the sediment particle-size analyses the stations were ranked according to increasing coarseness of the substrate in the following manner: Station 2, 7, 4, 1, 3, 8, 6, and 5.

5. The composition of the fauna at the various stations is discussed. The sand-bottom stations are characterized by lack of species that were dominant by

weight. At most stations there was considerable constancy in the ranking of the numerically dominant species during the investigated period.

6. Significant seasonal variations in number of specimens, with maxima occurring in July-August and minima in January-February, were demonstrated. The average difference between maxima and minima was more than 100%. There was no seasonal variation in the number of species.

7. The polychaetes comprised 49 to 70%, the crustaceans 16 to 30%, the lamellibranchs 9 to 23%, and the echinoderms 2 to 6% of the total number of species at the various stations. There was an increase in the number of species of polychaetes from soft to hard bottoms, crustaceans and echinoderms showed no significant trend, while the number of species of lamellibranchs decreased from soft to hard bottoms. Similar features were demonstrated for the number of specimens of the various taxonomic groups.

8. Patchiness of the species was measured by the coefficient $\underline{k}$ from the negative binomial distribution on counts from replicate samples. The nine species with the highest patchiness out of 22 numerically dominant species of crustaceans, lamellibranchs, and echinoderms were all viviparous or had some degree of brood-protection.

9. Total standing crop was determined for the main taxonomic groups and for the total infauna in the samples from August 1964. The total wet weight between replicate samples varied with a factor of two at stations 1, 2, 4, and 6, and with a factor of about four at stations 3, 5, 7, and 8. There were only small differences in weights of polychaetes and crustaceans among the replicate samples but the weights of echinoderms and "miscellaneous groups" varied drastically. The polychaetes comprised 37.8 to 82.3%, the crustaceans 1.9 to 12.7%, the lamellibranchs 1.0 to 17.3%, the echinoderms 6.0 to 63.8%, and the "miscellaneous groups" 9.6 to 32.5% of the total standing crop. Station 2 had about 19 g and the rest of the stations from 8 to 12 g of dry organic matter per square metre. There was no significant seasonal variability in the standing crop of the numerically dominant species of Crustacea, Lamellibranchia, and Echinodermata during the investigated period.

10. The similarity among the faunal assemblages based on crustaceans, lamellibranchs, and echinoderms was measured by KENDALL's rank correlation coefficient. The stations were ordinated according to degree of similarity, and there was practically no difference among the ordinations from the various sampling dates. The average ordination of the stations from all seven sampling dates

was identical to the ordination based on the coarseness of the substrate. The same ordination was found when the rank correlation coefficient was calculated with the polychaetes included; and when only the species occurring at a station in at least five out of seven sampling dates were included, only two of the stations changed place on the ordination. An ordination of the stations based on the number of species with the highest abundance at the various stations was identical to the ordination based on the coefficient of correlation. The faunal assemblages therefore seem to represent a "continuum" from one environmental extreme to the other, with texture of the substrate as the overwhelmingly dominant environmental factor.

11. Only three of the eight faunal assemblages showed similarity to known benthic communities. The fauna from the shallow-water and sand-bottom stations had features in common and may represent facets of a North Pacific inshore sand-bottom community.

12. MARGALEF's index of diversity $\underline{d}$, the SHANNON-WIENER function $\underline{H}$, and a measure of redundancy $\underline{R}_{\underline{E}}$ were calculated for single samples and for pooled data from five and ten replicate samples. The index $\underline{d}$ was sensitive to changes in the number of species, while $\underline{H}$ and $\underline{R}_{\underline{E}}$ were more dependent upon the concentration of numerical dominance. The various indices did not vary extensively at each station, but there were significant differences among stations. The mean redundancy at the various stations varied from 34.5 to 71.8%. Excluding the ostracods, which were extremely abundant at some stations but contributed only four species, from the calculations resulted in nearly no change in the index $\underline{d}$, while $\underline{H}$ and $\underline{R}_{\underline{E}}$ changed radically. Including the polychaetes led to drastic changes in the index d, smaller changes in $\underline{H}$, and very small changes in $\underline{R}_{\underline{E}}$. This indicates that the complexity and level of organization was well described by the nonpolychaetes. Various indices of diversity were compared and discussed.

13. Aspects of the biology and ecology of the numerically dominant species, i.e., species that contributed about 70% of the total number of specimens at the various stations, are discussed. The numerically dominant species consisted of 30 polychaetes, nine crustaceans, ten lamellibranchs, three echinoderms, and one sipunculid. Particular attention is given to their geographic distribution, sediment preference, patchiness, growth, and weight-size relationships. The wet weight and ash-free dry weight contributions of the various species were calculated.

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VIII. APPENDIX I

"MISCELLANEOUS GROUPS"

The major part of the present paper deals with the four taxonomic groups Polychaeta, Crustacea, Lamellibranchia, and Echinodermata. The rest of the fauna, which for convenience was labeled "miscellaneous groups" (Table 111), was of less numerical importance and was therefore not subject to careful identification and enumeration. Occasionally the "miscellaneous groups" contributed significantly to the standing crop, but the most important contributors belonged to the epifauna and therefore were not included in the present study.

Counts of Virgularia sp. ?, Leioptilus guerneyi, and Nemertini (Table 111) are inaccurate because the organisms were often broken and the enumeration therefore difficult. No attempt was made to pick the epifauna off rocks and various debris, and the Anthozoa in Table 111 are specimens that were left on the screens after sieving. Gastropoda occurred at all stations and were fairly numerous at stations 4 and 8. However, the living specimens were not distinguished from the dead, empty shells, and their numbers have therefore not been listed in Table 111. The sipunculid Golfingia pugettensis was sufficiently important both in numbers and biomass to be included among the numerically dominant species (page 394).

Table 111

Abundance per square metre of "Miscellaneous groups"

	1963				1964		
	Jan-Feb	Apr-May	July-Aug	Nov	Feb	Apr	July-Aug
Station 1							
Anthozoa	1	0	0	0	0	0	0
Leioptilus guerneyi	0	6	224	0	0	0	19
Nemertini	12	15	16	9	0	4	32
Golfingia pugettensis	1	10	3	11	4	0	6
Station 2							
Cerianthus sp.	0	0	0	2	0	4	0
Nemertini	3	20	19	4	10	28	12
Nellobia eusoma	1	13	0	3	2	0	4
Solenogastres	0	5	5	3	0	8	6
Station 3							
Leioptilus guerneyi	2	11	6	7	18	6	30
Cerianthus sp.	0	0	0	0	0	2	0
Nemertini	9	5	9	7	20	0	14
Brachiopoda	0	3	4	0	0	0	2
Golfingia pugettensis	17	1	14	11	32	8	6
Station 4							
Leioptilus guerneyi	9	2	0	0	0	0	6
Nemertini	20	14	1	19	4	10	22
Priapulus caudatus	0	0	0	0	0	0	2
Golfingia pugettensis	11	10	7	0	0	2	2
Station 5							
Anthozoa	37	3	10	4	4	4	8
Leioptilus guerneyi	1	0	0	6	2	0	0
Cerianthus sp.	0	0	0	1	0	0	0
Nemertini	8	8	6	25	36	32	74
Priapulus caudatus	0	0	1	0	0	0	0
Golfingia pugettensis	0	0	0	15	6	8	2
Brachiopoda	2	0	0	7	0	2	0

Table 111 (continued)

	1963				1964		
	Jan-Feb	Apr-May	July-Aug	Nov	Feb	Apr	July-Aug
Station 6							
Anthozoa	0	12	3	5	0	0	6
Leioptilus guerneyi	0	2	0	1	0	0	18
Cerianthus sp.	4	3	18	5	0	0	4
Nemertini	8	4	1	24	16	12	52
Golfingia pugettensis	16	2	5	19	20	32	12
Brachiopoda	0	4	0	0	0	0	12
Station 7							
Virgularia sp. ?	2	10	4	5	2	6	4
Cerianthus sp.	3	0	12	8	6	4	0
Nemertini	7	13	5	13	12	10	4
Priapulus caudatus	0	0	2	0	0	0	0
Golfingia pugettensis	4	2	9	0	0	4	0
Station 8							
Leioptilus guerneyi	3	16	12	9	4	34	22
Nemertini	0	59	14	22	22	10	4
Golfingia pugettensis	0	24	39	36	154	98	134
Solenogastres	0	0	0	0	0	2	0

IX. APPENDIX II

ANNOTATED LIST OF POLYCHAETES

Karl Banse[1], Katharine D. Hobson[2], and Frederic H. Nichols[1]

The collections discussed in this volume contained at least 191 species of polychaetes. Distinguished were 187 of which 158 could be named. Among these were 11 new species, and 29 new records for the waters of Washington and British Columbia. These, and 31 other forms of the collection, were discussed by BANSE and HOBSON (in press), BANSE and NICHOLS (in press), or will be treated in forthcoming papers by BANSE and NICHOLS. In the first-named paper, it was pointed out that the collection added 41 species (including an unnamed species) to the 394 benthic species known from the area; the addition seemed to reflect incomplete knowledge of the region rather than recent immigration.

Species were primarily identified from descriptions and keys for the local fauna (BERKELEY and BERKELEY 1948, 1952, mimeographed addenda; PETTIBONE 1953), for records from Oregon (HARTMAN and REISH 1950), California (HARTMAN 1961), and the western North Pacific (CHLEBOVICH 1961, IMAJIMA and HARTMAN 1964, USHAKOV 1955). Of other papers, the monographs on the collection of the Allan Hancock Foundation by HARTMAN (see HARTMAN 1961) were particularly useful. Because the sampling on eight stations provided about two-fifths of the polychaete species known from the waters of Washington and British Columbia, and because it supplied ecological knowledge for the first time for many of the species recorded previously from here, detailed taxonomic comments on the station lists seemed appropriate, even if species names cannot yet be provided.

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1. Department of Oceanography, University of Washington, Seattle, Washington 98105.

2. Systematics-Ecology Program, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.

The arrangement of families and the species nomenclature employed is that of HARTMAN (1959, 1965a), if not stated otherwise. To save space, the comments in the papers by BANSE and HOBSON (in press) and BANSE and NICHOLS (in press) are indicated by an asterisk and a double asterisk, respectively, after the names. For the species not so marked, descriptions can be found in BERKELEY and BERKELEY (1948, 1952) or PETTIBONE (1953, for scale worms) if no other synonyms are given. Provisional names like Anaitides sp. I usually refer to unidentified forms that clearly are different from the other species of that genus found by us but cannot be characterized fully. New species to be described elsewhere have been named in the same manner to avoid the creation of nomina nuda.

An almost complete set of identified specimens, excepting those that are marked by (^{o}) after the author name, has been deposited in the U. S. National Museum; another set, containing about a third of the species, has been given to the Burke Memorial Washington State Museum on the University of Washington campus.

APHRODITIDAE

Aphrodita sp. I

A single specimen is about 10 mm long and has 18 setigers. There is apparently no facial tubercle. The median tentacle resembles that of A. parva MOORE in being about three times as long as the prostomium and terminating in a knob. The eyes (two pairs ?) are situated on two small prominences at the anterior edge of the prostomium. The palps have small spinelets on their surface. The notosetae are of three types: (1) long capillary setae that form the dorsal feltage; (2) heavy amber protective setae with slender curved tips and very minute asperities (some of these setae may have terminal sheaths that are not pilose, (Figure 66a); (3) acicular setae with scalelike features on the convex edge. The first two setigers have bipinnate neurosetae that are spiraled at the tip. All setigers have about five stout neurosetae. These may have no teeth, or only basal spurs, but usually have two to six teeth near the end (Figure 66b). Only a few have distal sheaths.

Although this specimen resembles A. parva in its small size and in the length of the median tentacle, it differs in not having smooth palps, lacking pilose neurosetae, and having more than one tooth on many neurosetae. It also differs from A. japonica MARENZELLER, A. negligens MOORE, A. longipalpa ESSENBERG, A. refulgida MOORE, and A. falcifera HARTMAN, in having more

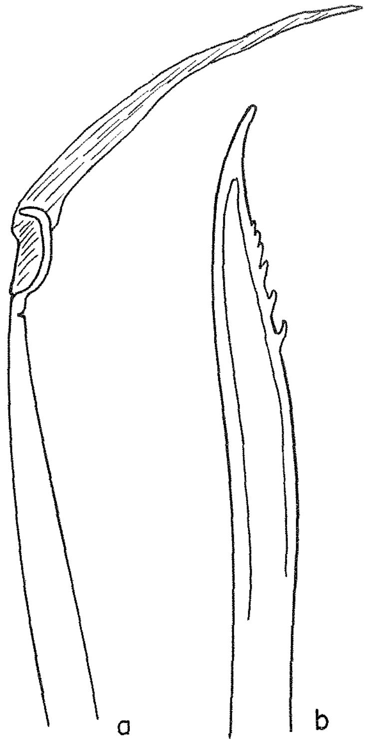

Figure 66. (Setae not drawn to scale) Aphrodita sp. I.
a, protective notoseta with terminal sheath. b, neuroseta.

than one tooth each on the neurosetae; it differs from these and A. castanea MOORE and A. armifera MOORE in having a very long median tentacle.

POLYNOIDAE

Antinoella macrolepida (MOORE)

syn. Antinoe macrolepida: BERKELEY and BERKELEY, 1948, p. 14.

Antinoe macrolepida: HARTMAN, 1959, p. 62.

Antinoella macrolepida: HARTMAN, 1960, p. 80.

Seven hauls from station 2 in August and November 1963 contained this species.

Two small specimens from two hauls from the same station of May and August 1963 were referred to the species with hesitation. Eye pigment is absent, but there are fairly well-marked cephalic peaks; otherwise, the animals conform to the description of the species, and are similar to our larger individuals. Possibly, the large anterior eyes, as figured by MOORE (1905) and USHAKOV (1958) develop late and distort the prostomium slightly so that the peaks become indistinct.

Eunoë oerstedi MALMGREN

syn. E. barbata MOORE fide PETTIBONE, 1954, p. 219.

Our specimens do not agree completely with the description by PETTIBONE (1953). The papillae on the median tentacle are fairly short. There are only a few macrotubercles on the elytra, similar to the Eunoë barbata ? described by HARTMAN (1939).

Eunoë sp. I*

A new species to be described by BANSE and Hobson.

Gattyana cirrosa (PALLAS)

A specimen with eggs was found in February 1963, on station 6.

Gattyana treadwelli PETTIBONE

Gattyana sp. I (°)

There is one small, pale, poorly preserved specimen of 5 mm length. The prostomium is bilobed and the cephalic horns are blunt. The elytra have no tubercles, but have long filiform papillae on the dorsal surface and around the margins. All notosetae are capillary. None of the neurosetae are capillary, most of them being unidentate with short spinous regions barely longer than the bare distal tips.

The form agrees with G. ciliata MOORE known from Puget Sound, except that the elytra of G. ciliata have many microtubercles and macrotubercles, in addition to papillae (PETTIBONE 1953).

Harmothoë fragilis MOORE*

Harmothoë imbricata (LINNÉ)

Hesperonoë complanata (JOHNSON)*

Hololepidella tuta (GRUBE) ?

syn. Polyeunoa tuta: BERKELEY and BERKELEY, 1948, p. 19; PETTIBONE, 1953, p. 54.

An anterior fragment with elytra may belong to this species. The notosetae are fine, as described by PETTIBONE (1953) for free-living individuals.

Lagisca multisetosa MOORE ? (°)

One damaged specimen probably belongs to this species.

Lepidasthenia berkeleyae PETTIBONE

Lepidasthenia longicirrata BERKELEY

syn. Lepidametria longicirrata: BERKELEY and BERKELEY, 1948, p. 19.

Lepidonotus squamatus (LINNÉ)

syn. L. caelorus MOORE fide: IMAJIMA and HARTMAN, 1964, p. 26.

Malmgrenia lunulata (DELLE CHIAJE)

We can distinguish four forms in our material, with a few intermediate specimens. These observations are not used in the present study. None is M. nigralba BERKELEY, included in M. lunulata by PETTIBONE (1953).

Polynoidae sp. I

A new genus and species to be described by NICHOLS.

POLYODONTIDAE

Peisidice aspera JOHNSON*

SIGALIONIDAE

Pholoë minuta (FABRICIUS)

syn. P. tuberculata: BERKELEY and BERKELEY, 1958, p. 22.

P. minuta: PETTIBONE, 1953, p. 77.

Two forms of the species seem to be present, with some intermediates. These observations are not used in the present study.

Sthenelais tertiaglabra MOORE

syn. S. articulata: BERKELEY and BERKELEY, 1948, p. 23.

S. tertiaglabra: HARTMAN, 1961, p. 10.

An individual collected on station 7 in July carried eggs.

CHRYSOPETALIDAE

Paleanotus bellis (JOHNSON)*

PHYLLODOCIDAE

Eteone sp. I

A small unidentified species that was found on all stations. One specimen has about half of the proboscis everted and no lateral papillae can be seen. The form of the dorsal and ventral cirri resembles that of E. longa FABRICIUS (Figure 67a). However, the setae are not quite the same as that figured by BERGSTRÖM (1914, Fig. 72D) in having some spines below the principal tooth (Figure 67b). A mature female is only 15 mm long with a greatest width of 0.35 mm (without feet). Since there are two species similar to E. longa reported from the area (E. pacifica HARTMAN and E. tuberculata TREADWELL) and E. californica HARTMAN can be expected, identification is uncertain. PETTI-

BONE (1954) has suggested that E. californica and E. tuberculata may be synonyms of E. longa.

Eulalia (Hypoeulalia) bilineata (JOHNSON) ?* (°)

Eulalia (Eulalia) levicornuta MOORE*

Eulalia (Eulalia) sp. I

There are two bright brownish-green specimens. The complete one is almost 4 cm long; its greatest width is about 0.6 mm (without parapodia). Possibly a dried specimen from station 3 belongs to the species too. Although the proboscis is not everted, the species appears to be a Eulalia s. str. The first tentacular segment is free from the prostomium and the second segment, and is dorsally fully developed. The ventral cirrus of the second segment is slightly flattened. The longest tentacular cirrus is about as long as the body is wide. Setae start on the third tentacular segment: The dorsal cirri are fairly large and the ventral cirri are subcordate and diverge from the foot. The tips of the shafts of the setae end in several fairly long teeth of which the middle tooth is slightly thicker than the others.

The form does not agree with any other Eulalia sp. known from the North Pacific on account of the shape of the dorsal cirri, the shape of the shafts of the bristles, and the absence of eyes.

Eulalia (Eulalia) sp. II (°)

There is a small complete specimen with 76 setigers, almost 3 mm long, with an extended proboscis of an additional 1.2 mm, and about 0.4 mm greatest width, without feet. There are four antennae, almost two-thirds the length of the prostomium. The fifth antenna inserts slightly anteriorly to the small eyes. The posterior margin of the prostomium is almost straight. All tentacular segments are free and dorsally visible; there are setae on the second segment and the ventral cirrus of this segment is slightly flattened. The tentacular cirrus of the third segment is the longest cirrus and reaches the 11th setiger. The proboscis is proximally densely covered with cylindrical papillae. Distally, however, the papillae are fewer, being two to three times their own diameter apart. The parapodia are rounded. The dorsal cirri of normal segments are lanceolate (Figure 67c), becoming relatively longer posteriorly. The tip of the shaft of the seta ends in a long tooth with small accessory teeth (Figure 67d). Theblades are quite short. Anal cirri have been lost. The color of the animal is pale yellow, with dark pigment in the dorsal intersegmental furrows.

The form is a true Eulalia sp. sensu BERGSTRÖM (1914). Among the local relatives, it resembles E. levicornuta in the shaft of its setae. However, the

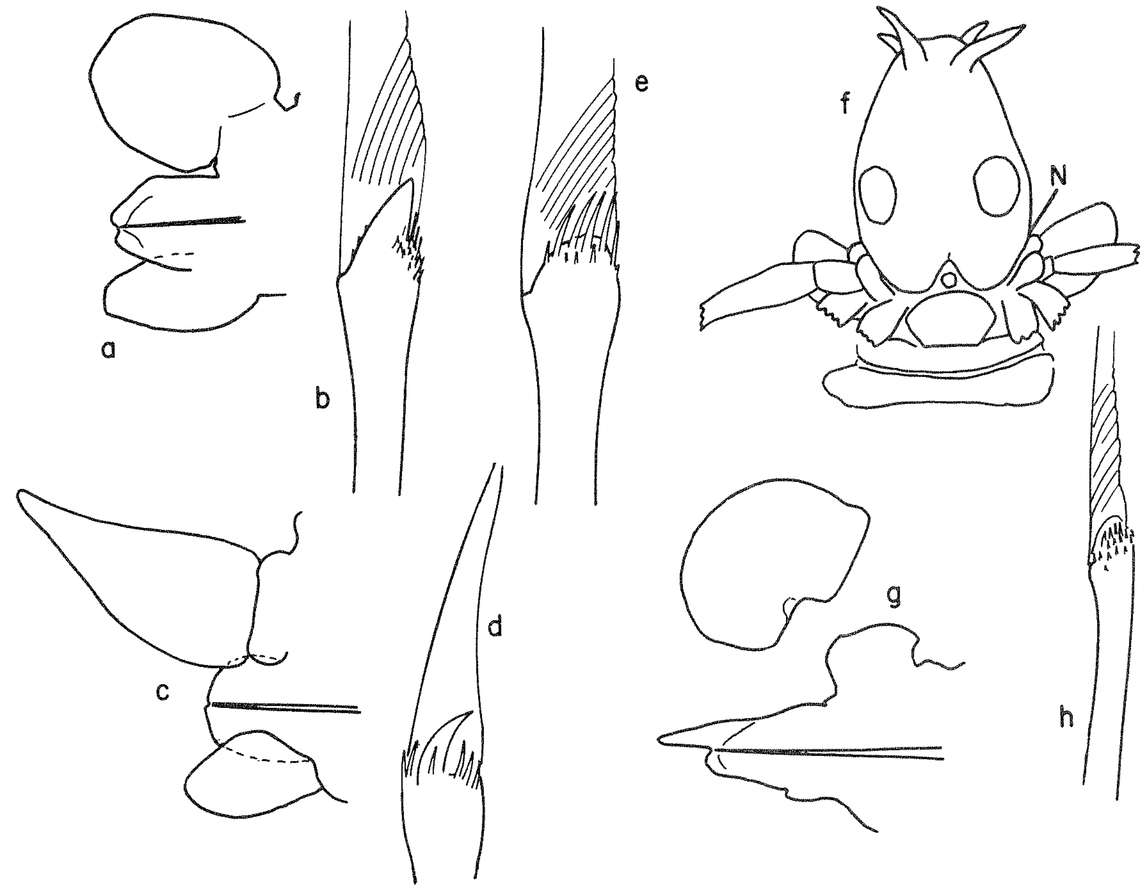

Figure 67. (Pictures not drawn to scale) Eteone sp. I. a, outline of 55th parapodium, setae omitted. b, detail of seta. Eulalia sp. II. c, outline of 32nd parapodium. d, detail of seta. Mystides borealis? e, detail of seta. Phyllodocinae sp. I. f, sketch of dorsal view of anterior end. N: Nuchal papilla. g, outline of 25th parapodium, with dorsal cirrus from 10th parapodium. h, detail of seta.

blades are short in the present form. Also, the cirri of Eulalia sp. II are more lanceolate and pointed than those of E. levicornuta.

Eulalia (Eumida) sanguinea OERSTED

All animals have dorsally broad green-brown bands across the middle of the segments. A specimen collected in April contains very numerous, not fully mature lens-shaped eggs of about 100 µ diameter and about half that thickness.

Eulalia (Pterocirrus) macroceros (GRUBE)**

Eulalia (Pterocirrus) sp. I*

A new species to be described by BANSE and HOBSON.

Mystides borealis THÉEL? (°)

One damaged specimen may represent this species. The prostomium is very small. The first and second segments are fused. The arrangement of the tentacular cirri seems to be $1 + S\frac{1}{1} + S\frac{0}{N}$. However, there is a distinct cirrophore on segment 3, and because the dorsal cirri are present on the next two segments (normal setigers) it is uncertain whether or not there has been a cirrus on the third segment. BERGSTRÖM (1914) has depicted the innervation of the dorsal tentacular cirrus on the third segment, which HARTMANN-SCHRÖDER (1963) has stated to be absent in Arctic material.

The end of the shaft of a seta is shown in Figure 67e. The seta does not agree with SOUTHERN's (1914) description of Irish material, nor with the similar figure by HARTMANN-SCHRÖDER (1963) for M. notialis EHLERS, thought to be synonymous with M. borealis.

Phyllodoce (Anaitides) groenlandica OERSTED

The pigment pattern of our specimens is not that of the subspecies orientalis ZACHS from the Far Eastern Seas and Chukchi Sea. Some specimens are included here without everted probosces, that have the typical rectangular dorsal and pointed ventral cirri, and three bars across the dorsum of median segments as our other specimens.

Phyllodoce (Anaitides) nr. multiseriata RIOJA*

Phyllodoce (Anaitides) williamsi HARTMAN*

Specimens without everted probosces but with the same form of dorsal and ventral cirri and the same color pattern as the readily identifiable individuals are included in the species lists under this name.

Phyllodoce (Genetyllis) castanea (MARENZELLER)

Two poorly preserved specimens are referred to this species with some hesitation. The prostomium is rounded-triangular, and broader than long. The proboscis is smooth. There is no nuchal papilla. The first segment is dorsally reduced; the tentacular formula appears to be $1 + S\frac{1}{1} + S\frac{1}{N}$. There is an acicula in the cirrophore of the dorsal tentacular cirrus of the third segment. This does not agree with the genus diagnosis by BERGSTRÖM (1914). Of the tentacular cirri, only the ventral cirrus on the second segment remains; it is filiform but possibly slightly flattened. The dorsal cirri have been lost. The lips of the parapodia are rounded and of equal length. The few remaining ventral cirri have rounded tips and are longer than the parapodia. The tips of the shaft of the setae are covered with numerous spines of equal width. MOORE (1909) reported one series of hairs for a specimen from California.

Phyllodoce (Paranaitis) polynoides (MOORE)

Phyllodocinae sp. I

There are two anterior fragments of about 10 mm length, representing a member of the subfamily Phyllodocinae BERGSTRÖM (1914) with a nuchal papilla (Figure 67f). There is a pair of pronounced nuchal organs on each side of the posterior part of the prostomium that are about as large as the cirriphores of the tentacular cirri. The probosces are not everted but the specimens are fairly transparent, and there are no obvious lateral proximal rows of papillae as in Anaitides. In one of the specimens the third segment is dorsally visible as an oval area behind the nuchal papilla (Figure 67f); in the other one, the fourth segment (first normal segment) appears to follow the prostomium. The ventral tentacular cirri of the second segment are flattened. All tentacular segments seem to be without parapodia and setae. The dorsal cirri are large and reniform. The supra-acicular lobes of the parapodia are elongated (Figure 67g). The ends of the shafts of the bristles are rounded, with many small teeth (Figure 67h).

Apart from the features of the anterior end, the species is characterized by the supra-acicular lobe, which rarely occurs outside the subgenus Sige of Eulalia.

Phyllodocinae sp. II (^{o})

One complete specimen of about 12 mm length, which belongs to the subfamily Phyllodocinae BERGSTRÖM (1914). Its oval prostomium is longer than wide, and is without a nuchal papilla or a fifth antenna. The paired antennae are about as long as the prostomium. The first and second segments are moderately well separated from each other ventrally, but the first segment cannot be seen dorsally. There are setae on the second segment. All tentacular cirri are filiform, their length being several times the width of the body. All dorsal cirri have been lost but the few remaining ventral cirri are oval and fairly thick. The tips of the shafts of the setae have many fine teeth of equal width, quite similar to those of our Phyllodoce (Genetyllis) castanea specimen; the blades are long.

Although the known characters of the animal point to the subgenus Genetyllis of Phyllodoce, the species is decidedly different from P. castanea from the same station and month because of the form of the prostomium and the length of the tentacular cirri.

HESIONIDAE

Gyptis brevipalpa (HARTMANN-SCHRÖDER)*

Micropodarke dubia (HESSLE)*

Ophiodromus pugettensis (JOHNSON)

syn. Podarke pugettensis: BERKELEY and BERKELEY, 1948, p. 56.

P. pugettensis: HARTMAN, 1959, p. 192.

HESSLE (1925) has suggested that Podarke is a synonym of Ophiodromus.

PILARGIDAE

Sigambra tentaculata (TREADWELL)*

Pilargis berkeleyae MONRO

SYLLIDAE

Autolytus sp. I (^{o})

There is one stolon that could not be identified.

Eusyllis blomstrandi MALMGREN*

Exogone gemmifera PAGENSTECHER (^{o})

Exogone lourei BERKELEY and BERKELEY

Odontosyllis phosphorea nanaimoensis BERKELEY

Pionosyllis uraga IMAJIMA*

Syllis (Langerhansia) heterochaeta MOORE

Syllis (Langerhansia) sp. I

This is a slim species when compared with the sympatric S. heterochaeta MOORE. The entrance to the pharynx is fairly soft, and terminates in 10 papillae. There is a distal dorsal tooth. The proventricle has 35 to 40 rows of papillae. All antennae and cirri are moniliform throughout, transparent, and without color. The median antenna has 20 to 21 articles, the lateral ones have eight or nine articles. The dorsal tentacular cirri have 10 to 15 articles, the ventral ones have seven or eight articles. The dorsal parapodial cirri are slender without marked tapering, and have 10 to 14 articles with little alternation of length. The tips of the setae characterizing the subgenus deviate considerably from those of S. heterochaeta and from S. cornuta RATHKE: the long compound spinigers are bidentate with a prominent secondary tooth (Figure 68a), which is

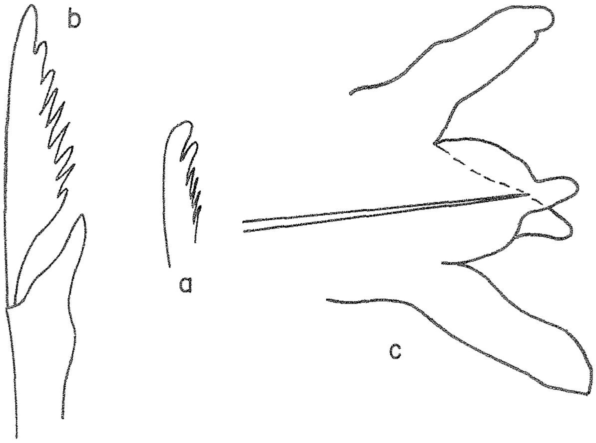

Figure 68. (Setae not drawn to scale) Syllis (Langerhansia) sp. I. a, tip of "Langerhansia" seta; the width is about 2 μ. b, blade of short compound seta. Glycinde sp. I. c, outline of 25th parapodium.

clearly distinguished from the distal serration of the cutting edge. Both teeth are rounded. The long spinigers of S. heterochaeta do not have such a clearly defined secondary tooth, and those of S. cornuta are distally tapered. These setae are present from the first setiger. All short compound setae are bidentate (Figure 68b).

Syllis (Typosyllis) armillaris (MÜLLER) (^{o})

Syllis (Typosyllis) harti BERKELEY and BERKELEY*

Syllis (Typosyllis) sp. I (^{o})

There is a poorly preserved specimen with 34 setigers, 3.3 mm length and 0.5 greatest width (without parapodia). Only one partially preserved dorsal cirrus, some ventral cirri but no antennae or tentacular cirri are left. The proventricle extends from the sixth to the 11th setiger. The species is none of the other Syllis spp. of the collection because of its compound setae; they have slender bidentate blades 30 to 40μ long, with 3 μ greatest width, which are slightly pectinated only at the base. Ten to 20 of these per foot are accompanied by a dorsal, fairly fine and very slightly serrated capillary. The animal is heavily pigmented with green-brown cells.

NEREIDAE

Micronereis nanaimoensis BERKELEY and BERKELEY

syn. M. variegata: BERKELEY and BERKELEY, 1948, p. 60.

Nereis (Nereis) spp. I-III

There are many immature specimens, usually about 1 cm long and mostly without everted probosces, which could not be properly identified. The tentacular cirri appear to be smooth. All species have notopodia with two well-separated ligulae that are conical, tapering to a fairly broad tip, and are not enlarged posteriorly. Notopodial homogomph falcigers begin at about the 20th setiger; blades have fairly rounded tips and almost smooth cutting edges.

Nereis (Nereis) sp. I

In paragnath group VI there is a single fairly large conical paragnath; groups VII and VIII form one line of dark paragnaths. The dorsal posterior tentacular cirri reach to about the 12th setiger. Heterogomph falcigers have short blades only.

Nereis (Nereis) sp. II

In paragnath group VI there is a single paragnath; groups VII and VIII form an irregular broad band of small amber paragnaths of equal size. The dorsal posterior tentacular cirri reach to the fourth to sixth setiger. There are heterogomph falcigers with both short and relatively long blades.

Nereis (Nereis) sp. III

Paragnath groups VII and VIII form one line of few fairly dark paragnaths. The dorsal posterior tentacular cirri reach to the 10th to 15th setiger. There are two kinds of heterogomph falcigers, as in Nereis sp. II. Found on four stations but not together with Nereis sp. I.

Nereis (Nereis) sp. IV (°)

A 7-cm-long heteronereid specimen, apparently a male, without the posterior end. Groups I and V are absent on the proboscis, group VI consists of five to six conical paragnaths in triangular arrangement and groups VII to VIII form a band of cones of equal size. The longest tentacular cirri reach the sixth to seventh setiger. The first six or seven notopodial cirri are thickened. Notopodial homogomph falcigers, shaped like those of Nereis spp. I-III, start at about the 40th setiger. The blades of heterogomph falcigers are of uniform intermediate length. The transformation of parapodia begins at about the 60th setiger only.

Platynereis bicanaliculata (BAIRD)*

NEPHTYIDAE

Nephtys assignis HARTMAN*

Nephtys caeca (FABRICIUS)

Nephtys caecoides HARTMAN ?

There are only a few specimens. An individual from station 5, haul 5, collected in February 1963 does not possess an interramal cirrus on the fourth setiger, although this character is typical for N. caecoides. Also, the parapodial lobes are more deeply incised than reported by HARTMAN (1938) for the species.

Nephtys cornuta BERKELEY and BERKELEY

Nephtys ferruginea HARTMAN*

By the time of identification, the characteristic pigmentation of the anterior segments had faded in most of the specimens. Where possible, the third parapodia were dissected to observe the presence of the interramal cirri. Also, the shape of the posterior neuropodial acicular lobes was studied. The shape of the interramal cirri was helpful when dissection was cumbersome or useless as with young or incomplete specimens; the cirri point mostly downward in the species. Very young specimens might have been misidentified (possible confusion with N. caecoides). However, N. ferruginea is by far the most common species of the genus in our material so that the possibility of this is not very great. The specimen counts in parentheses are of those samples where identifications have not been rechecked.

Nephtys punctata HARTMAN ?

Only one specimen that probably belongs to this species was found.

SPHAERODORIDAE

Sphaerodoridium sphaerulifer (MOORE)*

GLYCERIDAE

Glycera americana LEIDY

Glycera capitata OERSTED

Most specimens agree with HARTMAN's (1950) description in having no accessory process on the proboscidial ailerons, no ridges on proboscidial organs, triannulate segments, and one postsetal lobe. Some of our specimens, however, correspond to G. nana JOHNSON in having biannulate segments and shorter parapodial lobes. HARTMAN regards G. nana as a cold-water form of G. capitata on the basis of intergrades. Because several of our specimens seem to be intermediates (triannulate segmentation and short parapodial lobes), we have not distinguished between the two forms. The G. nana form occurs with G. capitata on stations 1 and 4 and alone on station 5. The intermediates come from stations 6 and 8.

Glycera robusta EHLERS

Glycera siphonostoma (DELLE CHIAJE)*

Hemipodus borealis JOHNSON

GONIADIDAE

Glycinde armigera MOORE

Glycinde picta BERKELEY

Glycinde sp. I

This form appears to be intermediate between G. armigera and G. picta and resembles the former in lacking ventral micrognaths. Parapodia are uniramous through the 27th or 28th setiger. The species resembles G. picta in having triangular or slightly obcordate presetal lobes (Figure 68c). No specimens have the probosces everted, but macrognaths and the dorsal micrognaths are visible through the body walls.

This species was found on five stations but co-occurred with G. picta only once (station 4, haul 10, January 1963). Also in this sample was a form resembling G. armigera except that the parapodia were uniramous through the 27th setiger.

Glycinde sp. II (^{o})

There is only one badly damaged specimen. No ventral micrognaths are present, and the parapodial change occurs at about the 40th setiger.

Goniada brunnea TREADWELL

Goniada maculata OERSTED*

ONUPHIDAE

Diopatra ornata MOORE

Nothria sp., near N. elegans (JOHNSON) and N. iridescens (JOHNSON) syn. Onuphis spp.: BERKELEY and BERKELEY, 1948, p. 90.

There are many specimens of two incompletely identified forms belonging to the genus Nothria. In this genus, HARTMAN (1944a) separates N. elegans from N. iridescens on the basis of the following characters: Nothria iridescens has only tridentate pseudocomposite hooks, ventral cirri are cirriform through six or seven segments, subacicular hooks are first present from the 13th to 15th setiger, and the intersegmental groove is darker than the segment. Nothria elegans has both bidentate and tridentate pseudocompound hooks, ventral cirri are cirriform through four or five setigers, subacicular hooks are first present from the 10th setiger, and the intersegmental groove is pale. Our specimens agree with both descriptions in lacking composite spinigers and having the branchiae begin on the first setiger. In addition, all anterior pseudocompound hooks are tridentate; ventral cirri are cirriform through the fifth setiger (occasionally fourth or sixth); the number of annulations on the tentacular ceratophores vary, usually being fewer than in N. iridescens and greater than in N. elegans. The two forms occur together only on station 4 in January. We distinguish them on the basis of three fairly constant, easily recognizable characters:

Form A: Subacicular hooks occur from the ninth setiger. The inner pair of tentacles is short, reaching to the fourth to ninth setiger. Gills on the 25th parapodium are thick (see BERKELEY and BERKELEY 1948).

Form B: Subacicular hooks occur from the 11th to 13th setiger. The inner pair of tentacles is long, reaching to the 13th to 25th setiger. Gills on the 25th parapodium are thin.

LUMBRINERIDAE

Lumbrineris bicirrata TREADWELL (^{o})

syn. L. bifurcata: BERKELEY and BERKELEY, 1948, p. 99.

Lumbrineris californiensis HARTMAN*

Lumbrineris cruzensis HARTMAN

Lumbrineris limicola HARTMAN ?

syn. L. limicola HARTMAN, 1944a, p. 161.

The specimens conform to HARTMAN's (1944a) description by the maxillary formula (1+1, 4+4, 1+1, 1+1), by having compound hooks, light aciculae, and prolonged postsetal lobes in posterior segments. They do not agree with L. limicola in the following respects: The noticeable notoacicular papillae described by HARTMAN are absent. There are fewer limbate setae and hooks in the first parapodium (three setae above, two or three compound hooks medially and three limbate setae below) whereas L. limicola has seven or eight setae, 12 hooks and five or six limbate setae. Compound hooks are present through 13 to 15 and not through about 44 setigers (HARTMAN 1944a). The average body width of our specimens is about 1.5 mm, as compared with 6 mm for HARTMAN's specimens.

The species would be new for Puget Sound. Presently it is known from California.

Lumbrineris luti BERKELEY and BERKELEY ?

There are many specimens that resemble L. luti in having simple hooded hooks present from the first parapodium, yellow aciculae, and an elongate postsetal lobe in the posterior parapodia. A complete individual from station 4, April 1963, conforms to BERKELEY's description of the maxillary formula of L. luti (1+1, 4+5, 1+2, 1+1) whereas the maxillary formula of our other specimens is 1+1, 4+4 to 5, 1+1 to 2, 1+1.

BERKELEY and BERKELEY (1945) suggested that L. luti may be a variety of L. brevicirra SCHMARDA (= L. impatiens CLAPARÈDE ?). Lumbrineris luti is similar in dentition to L. impatiens except its maxilla III has the formula 1+2 instead of 2+2. Some of our specimens are more darkly pigmented (brownish-red) than L. luti as described by BERKELEY and BERKELEY. None of our specimens could be identified as L. brevicirra because the few tails found with only moderately prolonged postsetal lobes are from very young animals.

Lumbrineris sp. I (°)

One individual from station 7, May 1963, differs from L. luti only in the maxillary formula (1+1, 5+4, 1+2, 2+3). The anterior hooks are simple, the aciculae are light, and the posterior parapodial lobes are elongated. It is possible that some specimens identified as L. luti may be Lumbrineris sp. I, since the only difference seems to be in the maxillary formula, which has not always been determined.

Lumbrineris sp. II (°)

There are two specimens. The body is about 1 mm wide including parapodia. The maxillary formula is 1+1, 5+4, 2+2, 2+2. There are light aciculae and simple hooks; the posterior parapodial lobes are not prolonged. Although a head is found in one haul and only a tail in another haul, they are presumed to be of the same species because the characters of neither correspond to any other species present at this station.

Ninoë gemmea MOORE

ARABELLIDAE

Arabella semimaculata (MOORE) ? (°)

A. semimaculata: HARTMAN, 1944a, p. 173.

As we have only a fragment, the identification is doubtful. The width, excluding parapodia, is 5 to 6 mm. The parapodial lobes are elongate and directed slightly dorsally and posteriorly. Coloration is dark and irridescent.

This species would be new for Washington. It is presently known from California.

Drilonereis sp. I (°)

A species that cannot yet be identified. The jaws do not match those of D. falcata MOORE, D. filum CLAPARÈDE, or D. nuda MOORE, known from California.

Notocirrus californiensis HARTMAN*

DORVILLEIDAE

Dorvillea pseudorubrovittata BERKELEY*

Protodorvillea sp. I**

A new species being described by BANSE and NICHOLS (in press).

Stauronereis japonica (ANNENKOVA)**

Stauronereis rudolphi (DELLE CHIAJE)

syn. S. rudolphi: PETTIBONE, 1961, p. 181.

Dorvillea rudolphii: BERKELEY and BERKELEY, 1948, p. 86.

D. rudolphi: HARTMAN, 1959, p. 349.

From the gut contents of our specimens, the species appears to be a deposit feeder, as stated by HEMPELMANN (1931).

ORBINIIDAE

Haploscoloplos pugettensis (PETTIBONE)

syn. H. elongata: BERKELEY and BERKELEY, 1952, p. 97.

Scoloplos pugettensis: PETTIBONE, 1957, p. 162.

Phylo felix KINBERG

syn. P. felix: HARTMAN, 1957, p. 262.

The specimen from station 3 agrees with the description by HARTMAN (1957) in that the branchiae begin on the fifth setiger; there are 19 thoracic segments, eight of which have hastate spears. The ventral fringe is present on segments 12 to 20; there are up to 11 lobes on a side in the ventral fringe. The specimen from station 4 differs only in having 23 thoracic segments, of which 12 have hastate spears. A ventral fringe is present on segments 12 to 22, and there are up to 18 lobes on a side in the ventral fringe.

PARAONIDAE

Aricidea (Aricidea) lopezi BERKELEY and BERKELEY ?

syn. A. lopezi: BERKELEY and BERKELEY, 1956, p. 542.

Our 12 specimens are similar to A. lopezi BERKELEY and BERKELEY in the following characters: The prostomium is trilobed. The median antenna, extending to the first to fourth setiger, but broken in some specimens, is narrow at the base and tip and a little wider in the middle. The thorax is inflated. There are up to 17 pairs of gills, beginning on the fourth setiger, but some specimens have none at all. The gills increase in length posteriorly and often taper to a threadlike tip and do not meet mid-dorsally. Dorsal cirri are long except on the first two or three setigers.

Our specimens differ from A. lopezi as described by BERKELEY and BERKELEY (1956) and HARTMAN (1960) in the form of the modified neuropodial setae. The hooked crotchets (Figure 69a) have a fine subapical hair and the fine hairlike extensions described for A. lopezi. The hooks compare with none so far described in the literature.

Aricidea (Aricidea) ramosa ANNENKOVA*

Paraonis (Paradoneis) lyra SOUTHERN*

Paraonis (Paraonis) ivanovi ANNENKOVA*

APISTOBRANCHIDAE

Apistobranchus ornatus HARTMAN*

SPIONIDAE

Laonice cirrata (SARS) ?*

Laonice sp. I*

A new species being described by BANSE and HOBSON (in press).

Paraspio sp. I*

A new species being described by BANSE and HOBSON (in press).

Polydora (Boccardia) natrix SÖDERSTRÖM ?

Each of our five specimens, up to 10 mm in length, has a bifurcate prostomium, four to six eyes, and a dorsal caruncle extending to the anterior portion of the third setiger. The first setiger has a well-developed notopodium, the notopodial lobe being at least half the size of that of the second setiger, and having several notosetae. The fifth setiger has some modified setae that are smooth and falcate; the second type of modified setae has spinelets at the tip which continue basally below the thickest region. The ventral hooks begin on the seventh setiger. Their main fang is usually at right angles to the shaft, as in P. polybranchia HASWELL, as described by SÖDERSTRÖM (1920) but not as in P. natrix. Neuropodial capillary setae persist through the posterior region.

Because of the nature of the notopodia on the first setiger, our specimens are referred to P. natrix only with doubt.

Polydora (Polydora) caeca (OERSTED) ?

There are about 50 specimens ranging from about 15 to 50 mm in length and up to 4 mm in width, but all are badly broken. The prostomium is strongly bifurcate, and usually with four eyes. It is not possible to determine the length of the dorsal sense organ. There are notosetae and a well-defined dorsal lamella on the first setiger. The modified setae (Figure 69b) on the fifth setiger number four to 11. The ventral hooks (Figure 69c) begin on the seventh setiger. The

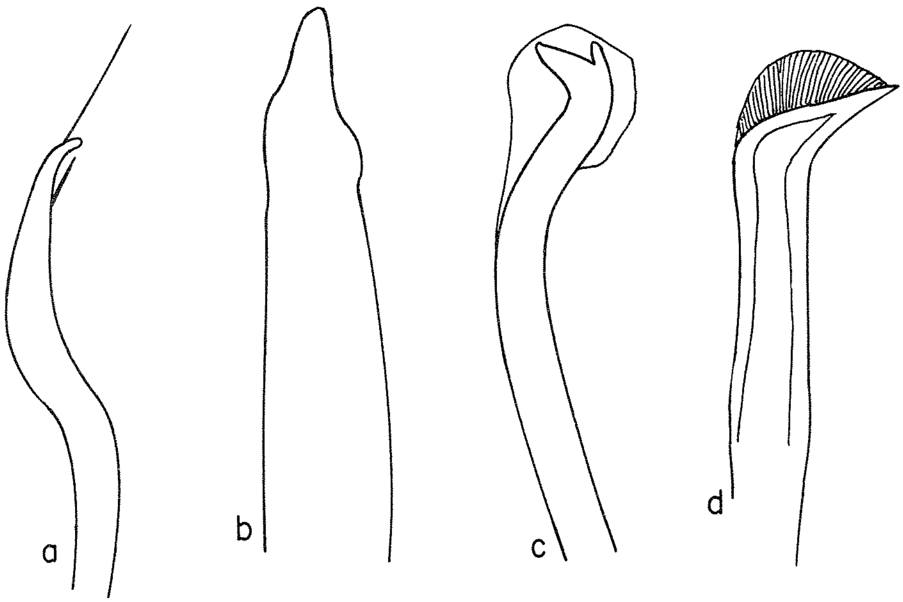

Figure 69. (Setae not drawn to scale) Aricidea lopezi? a. lower neuroseta. Polydora caeca? b, modified seta from fifth setiger. c, ventral hook from median setiger. Polydora caulleryi? d, modified seta from fifth setiger.

gills start on the eight setiger and are absent on one specimen on the last 30 to 40 segments. Posterior notopodia have about five short awl-shaped setae of about the same width as the longer capillary setae. One poorly preserved posterior end has a disklike pygidium. Intersegmental spots of pigment on the dorsum of small (15 mm long) specimens are similar to those in Fig. 42a of HANNERZ (1956).

Our specimens are unusually large for this species (up to 4 mm wide and 50 mm long). Since the dorsal sense organ cannot be clearly made out, our identification is somewhat uncertain.

Polydora (Polydora) caulleryi MESNIL ? (°)

syn. P. caulleryi PETTIBONE, 1954, p. 280.

We follow PETTIBONE (1954) who regards P. brachycephala HARTMAN as synonymous with P. caulleryi (see also FAUVEL 1927, and HARTMAN 1965b).

There are about 10 anterior fragments up to about 10 mm long. They agree with descriptions by FAUVEL (1927) and PETTIBONE (1954) of P. caulleryi. The prostomium is slightly incised, has no eyes and no occipital antenna. Notosetae are present on the first setiger. There is a dark V-shaped mark on the dorsum of many specimens just behind the first notopodium. The fifth setiger has six to nine falcate modified setae with pectinate tips (Figure 69d). Neuropodial hooks and gills begin on the seventh setiger.

Our identification is uncertain because of the absence of posterior ends.

Prionospio cirrifera WIRÉN

Prionospio malmgreni CLAPARÈDE

Prionospio pinnata EHLERS*

Rhynchospio arenincola HARTMAN

syn. R. arenincola: BANSE, 1963, p. 203.

Spio filicornis (MÜLLER)

Spiophanes berkeleyorum PETTIBONE

syn. S. berkeleyorum PETTIBONE, 1962, p. 78.

TROCHOCHAETIDAE

Trochochaeta multisetosa (OERSTED)*

MAGELONIDAE

Magelona spp.

According to a personal communication by Dr. M. L. JONES, the material contains two species that were not identified by us.

CHAETOPTERIDAE

Mesochaetopterus taylori POTTS

Phyllochaetopterus prolifica POTTS

Probably many tubes of this species have not been recognized by the sorters so that its abundance can be severely underestimated. The species occurred in large numbers on station 3 in October 1965.

Telepsavus costarum CLAPARÈDE

Our specimens resemble the description given by BERKELEY and BERKELEY (1952) except for the white glandular area on the ventral surface, which may be missing or may be on setigers 4-6, 5-9, 6-8, or 7-9. BERKELEY and BERKELEY describe it as being on the seventh and eight setigers. We are certain that our specimens are not Spiochaetopterus typicus SARS, the closest related form from this area.

CIRRATULIDAE

Caulleriella alata (SOUTHERN)*

Caulleriella sp. I

One short anterior fragment from station 5 of May 1963 is clearly not C. alata (regarding this species, see BANSE and HOBSON in press). Neuropodial acicular spines start on the third, notopodial spines on the eight setiger. There are some unidentate spines among the ordinary bifid ones. Since the unidentate spines are found between the latter ones, they cannot represent worn-off spines. Without dissection, it could not be made out whether either of the spines is winged.

Chaetozone setosa MALMGREN*

Chaetozone spinosa MOORE*

Chaetozone sp. I and II*

New species being described by BANSE and HOBSON (in press).

Macrochaeta clavicornis (SARS) ?

A new record to be described by BANSE.

Tharyx multifilis MOORE

Tharyx sp. I and II*

New species being described by BANSE and HOBSON (in press).

FLABELLIGERIDAE

Brada sachalina ANNENKOVA ?*

Flabelligera ? sp. I (°)

The two specimens are in such poor condition that only the bristles can be observed. There is a cephalic cage. The notopodia contain only annulated capillaries. In the neuropodia there are one or two pseudocomposite hooks per bundle, resembling those of F. infundibularis JOHNSON. Neither mucous sheath nor papillae can be detected.

Pherusa neopapillata HARTMAN ?

syn. P. neopapillata HARTMAN, 1961, p. 121.

Our 15 specimens are up to 40 mm long. The cephalic cage is conspicuous. The setae of the first setiger have widely spaced striations, as described by HARTMAN (1961) for the species. However, in many cases the tips of the ventral hooks (Figure 70a) appear to be more bent than those of P. neopapillata. The slenderest hooks (Figure 70b) are sigmoid and are similar to those described for P. papillata (HARTMAN 1961, pl. 24, Fig. 6). Individuals from station 8 have greatly twisted hooks, but resemble the other specimens in the above characters. The papillae are long and slender, often covered with sediment.

We refer our specimens with some doubt to P. neopapillata rather than to P. papillata although the latter species is the one to be expected in this area. P. neopapillata has been known from California (HARTMAN 1961).

SCALIBREGMIDAE

Scalibregma inflatum RATHKE

OPHELIIDAE

Ammotrypane aulogaster RATHKE

Armandia brevis (MOORE)

We accept the view of BERKELEY and BERKELEY (1941) that A. bioculata HARTMAN is a synonym of A. brevis, because our specimens are variable and have characters common to both forms. There are 29 setigers, with gills from the second to 27th or 28th setiger. Two to three eyes are found on the prostomium, and 11 pairs of circular eyespots occur on setigers 6-17. On the pygidial funnel are four to six dorsal and two sublateral papillae.

Travisia brevis MOORE*

Travisia pupa MOORE

syn. T. pupa: HARTMAN, 1961, p. 34.

STERNASPIDAE

Sternaspis fossor STIMPSON

Our specimens agree with the description for S. fossor STIMPSON of BERKELEY and BERKELEY (1952). They have seven segments between the

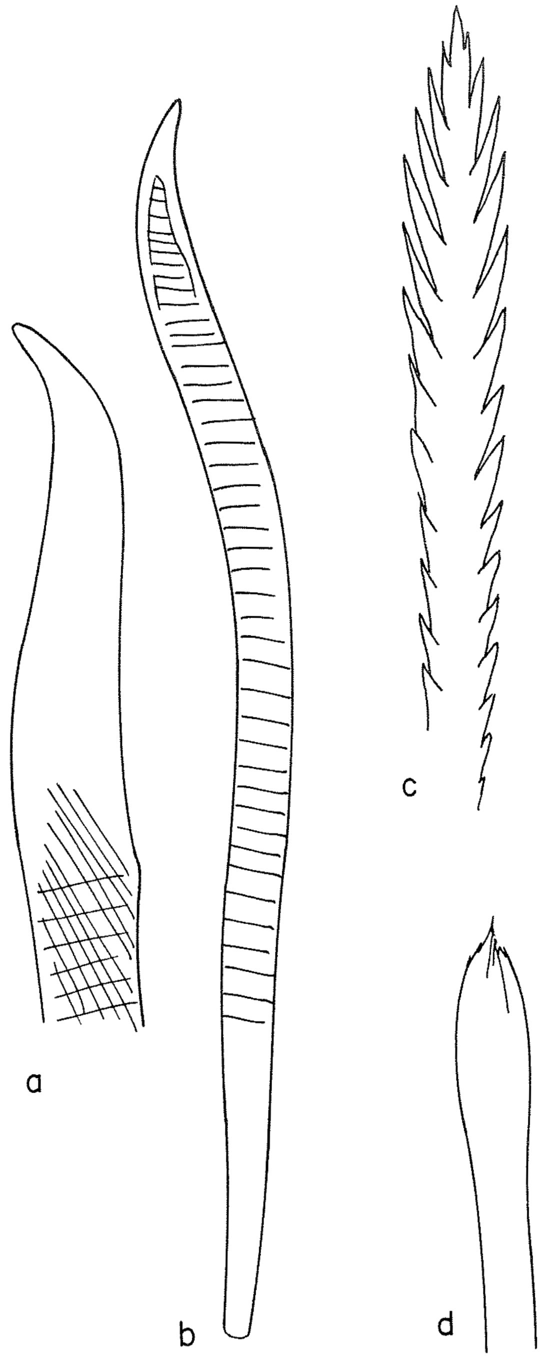

Figure 70. (Seta not drawn to scale) Pherusa neopapillata? a, typical neuropodial hook. b, slender neuropodial hook. Idanthyrsus armatus. c, outer opercular palea, d, dorsal thoracic palea.

genital pores and the caudal shield. There are 10 lateral bundles of setae arising on each side of the caudal plate, and five bundles arising on each side from the posterior margin of the plate. Apparently, the only difference between this species and S. scutata (RANZANI) is in the number of posterior setal bundles arising from the caudal shield (IMAJIMA and HARTMAN 1964). Some authors (PETTIBONE 1954, USHAKOV 1955) regard the two forms as the same species. Because our specimens coincide with the description of S. fossor, we retain this name.

CAPITELLIDAE

Capitellidae spp. (^{o})

There is more than one species of capitellids represented in our collection, but because identification was time consuming and extremely uncertain, all specimens in this family have been lumped.

MALDANIDAE

Axiothella rubrocincta (JOHNSON)

Clymenura columbiana (BERKELEY)

syn. Leiochone columbiana BERKELEY and BERKELEY (1952)

Young specimens occurred in February.

Euclymene cf. zonalis (VERRILL)

Numerous specimens of varying sizes are available, none of which is complete or mature, however. Similar to the description of E. zonalis by BERKELEY (1952), the anterior setigers tend to be stacked, particularly the third one into the fourth. There is a strong constriction preceding the pygidium (as in pl. V, Fig. 4 of VERRILL 1874), but there is no constriction on the seventh setiger as in E. droebachiensis (ARWIDSSON 1907). The form differs from the description of Euclymene zonalis BERKELEY and BERKELEY (1952) in having lateral notches on the cephalic rim. Acicular spines on the first setiger are fairly smooth but are toothed on the second and third setigers (the outline is between Fig. 308 of Axiothella cantenata and Fig. 312 of E. droebachiensis, ARWIDSSON 1907). There are two nonsetigerous posterior segments. The pygidial funnel carries 10 to 15 long cirri, the ventral one of which is not conspicuously larger than the others; between them are one, or occasionally two, short triangular cirri.

The species seems to be a nonselective deposit feeder. Small specimens from station 4 (mean grain size, 0.105 mm) had coarse material in their intestines, with many grains of 0.25 mm diameter.

Isocirrus longiceps (MOORE)*

Macroclymene sp. I*

Maldane glebifex GRUBE

Maldanella robusta MOORE

Nicomache lumbricalis (FABRICIUS)

Notoproctus pacificus (MOORE)

Petaloproctus tenuis borealis ARWIDSSON

Praxillella affinis pacifica BERKELEY*

Praxillella gracilis (SARS)

Rhodine bitorquata MOORE*

OWENIIDAE

Owenia fusiformis DELLE CHIAJE

HARTMAN (1959) considered O. occidentalis (JOHNSON) from Puget Sound a possible synonym of O. fusiformis. We accept this view.

SABELLARIIDAE

Idanthyrsus armatus KINBERG

Our two specimens have outer opercular paleae (Figure 70c) more clearly resembling those of I. ornamentatus CHAMBERLIN than those of I. armatus KINBERG (cf. CHAMBERLIN 1919, pl. 3 Fig. 3, and HARTMAN 1944c, pl. 31 Figs. 34 and 36), and possesses two pairs of dorsal nuchal hooks. The dorsal thoracic paleae, however, are paddle-shaped (Figure 70d) as in I. armatus, and not like those described by CHAMBERLIN (1919) for I. ornamentatus. The uncini have two rows of eight to nine teeth each. We note that there is a larger difference between the thoracic paleae of the two species than between the opercular paleae, and we consider our specimens to be I. armatus. Some authors (OKUDA 1938, PETTIBONE 1954) regard I. ornamentatus and I. armatus as the same species.

Sabellaria cementarium MOORE

PECTINARIIDAE

Pectinaria (Cistenides) granulata LINNÉ)*

syn. P. granulata: PETTIBONE, 1954, p. 312.

Pectinaria (Pectinaria) californiensis HARTMAN

syn. P. californiensis HARTMAN 1941, p. 333.

Our specimens disagree with P. californiensis in having 15 to 17 cephalic spines rather than 12 to 14, and thus approach P. belgica reported from Puget

Sound (BERKELEY and BERKELEY 1952). However, the scaphal hooks are curved, and there are five to six major teeth in the uncini as described for P. californiensis by HARTMAN (1944b). Pectinaria californiensis had not been recorded previously from this area.

AMPHARETIDAE

Amage anops (JOHNSON)

Ampharete acutifrons (GRUBE)*

Ampharete arctica MALMGREN

Ampharete gagarae USHAKOV*

Amphicteis mucronata MOORE

Asabellides lineata (BERKELEY and BERKELEY)

syn. Pseudosabellides lineata: BERKELEY and BERKELEY, 1952, p. 71.

Melinna elisabethae McINTOSH*

Schistocomus hiltoni CHAMBERLIN

syn. S. hiltoni: HARTMAN, 1955, p. 42.

TEREBELLIDAE

Artacama conifera MOORE

Lanassa venusta (MALM)**

Lysilla pacifica HESSLE** (^{0})

Neoamphitrite edwardsi (QUATREFAGES)*

Neoamphitrite sp.

A small Neoamphitrite specimen from station 3, haul 8, of April could not be identified because of poor preservation.

Pista cristata (MÜLLER)

Pista fasciata (GRUBE) sensu MARENZELLER*

Pista moorei BERKELEY and BERKELEY

Pista sp. I

One moderately well-preserved, incomplete specimen comes from station 3 (April). The animal is 2.6 cm long and has 17 thoracic and about 20 abdominal setigers. There is one pair of arborescent branchiae, apparently arising from the third segment. Large lappets on the peristomium (first segment) are situated lateroventrally, and laterally on the third segment. There seems to be a small lateral lappet on the fourth segment. Nephridial papilla are fairly clearly seen on the fourth and fifth segments and may be present also on the third.

Polycirrus spp. (^{0})

Members of this genus have been poorly preserved throughout. There is one specimen from station 3 (April) distinguished by hirsute capillary setae on 11 segments (Polycirrus sp. I). All the other animals have essentially smooth, winged notosetae (some with fine hairs along the wings) and are lumped, although there seem to be two species (one of them probably P. caliendrum CLAPARÈDE, on stations 3 and 4).

Proclea graffi (LANGERHANS)*

Scionella japonica MOORE*

Streblosoma bairdi (MALMGREN)

Thelepus japonicus MARENZELLER ?

syn. T. japonicus: IMAJIMA and HARTMAN, 1964, p. 350.

The identification of two incomplete specimens is doubtful. There are three pairs of gills, not truly coiled. The thoracic uncini are arranged in almost straight rows and have two (also three) teeth side by side above the main fangs, without any other teeth. They are distinctly different from a complete specimen collected on station 3 by F. H. N. in 1965 but agree with the description of T. setosus by IMAJIMA and HARTMAN (1964).

Amphitritinae sp. I (°)

Two small, poorly preserved specimens, which may not belong to the same species, come from station 1. Both have 17 setigers with smooth-winged capillary setae, which start on the fourth segment. There are one or two pairs of arborescent branchiae with a short stem. A marked dorsal fold as in Scionella does not seem to be present. Lateral lappets or ventral plates could not be made out. The uncini are arranged in two rows on some segments, facing each other, and have several rows of teeth above the main fang. They do not have handles as do Pista spp.

TRICHOBRANCHIDAE

Terebellides stroemi SARS

Trichobranchus glacialis MALMGREN

SABELLIDAE

Chone sp. I**

A new species being described by BANSE and NICHOLS (in press).

Laonome kröyeri MALMGREN

syn. L. kroyeri: BANSE, 1963, p. 204.

Megalomma splendida (MOORE)

Potomilla (Pseudopotamilla) myriops MARENZELLER*

Potamilla (Pseudopotamilla) occelata MOORE

syn. Pseudopotamilla occelata: BERKELEY and BERKELEY, 1952, p. 117.

Potamilla (Pseudopotamilla) reniformis (LINNÉ)

syn. Pseudopotamilla reniformis: BERKELEY and BERKELEY, 1952, p. 116.

Sabella media (BUSH)

syn. Demonax medius: BERKELEY and BERKELEY, 1952, p. 115.

We retain the species name used by BERKELEY and BERKELEY (1952) for one specimen from station 3. MONRO (1933) had suggested that the Alaskan S. media and the Japanese S. aulaconota MARENZELLER are junior synonyms of the Peruvian Demonax leucaspis KINBERG. This view was accepted by BERKELEY and BERKELEY (1941) and apparently also by USHAKOV (1955). HARTMAN (1942) kept Demonax medius separate from D. leucaspis, and IMAJIMA and HARTMAN (1964) retained D. aulaconota although with hesitation. CHLEBOVICH (1961) included Sabella media in S. aulaconota. The palps of our 16-mm-long specimen (without tentacular crown, about 12 mm) are more slender than figured by MONRO (1933), and relative to their width are about 50% longer than those of the material from Panama.

X. APPENDIX III

TAXONOMIC LISTING OF NONPOLYCHAETES

All the nonpolychaetes in the present material are listed taxonomically in Table 112. Dr. J.L. BARNARD (personal communication) considered the amphipods *Anonyx* sp. I and *Orchomene* sp. I new species. Three species of Cumacea were either new species or undescribed variations of other species. *Leucon* sp. I has characters in common with both *Leucon nasica* (KRÖYER) *s. str.* and *Leucon nasica orientalis* LOMAKINA, and its status is unknown. *Eudorellopsis* sp. I agrees with *Eudorellopsis integra* SMITH, except for a distinct tooth dorsally on the carapace, about one third from the pesudorostrum. *Campylaspis* sp. I is probably a new species.

Table 112

Taxonomic list of the nonpolychaetes with references for identification

Species	References
ANTHOZOA	
Pennatulacea	
Leioptilus guerneyi (GRAY)	KÜKENTHAL (1915)
Virgularia sp. ?	
Ceriantharia	
Cerianthus sp.	
Actinaria	
Actinaria indet.	
ECHIURIDA	
Nellobia eusoma FISHER	FISHER (1946)
SIPUNCULIDA	
Golfingia pugettensis FISHER	FISHER (1952)
PRIAPULIDA	
Priapulus caudatus LAMARCK	SHAPEERO (1962)
NEMERTINI	
Nemertini indet.	
SOLENOGASTRES	
Solenogastres indet.	
BRACHIOPODA	
Brachiopoda indet.	
CRUSTACEA	
Ostracoda	
Euphilomedes carcharodonta (V. Z. SMITH)	SMITH (1952)
Euphilomedes producta POULSEN	POULSEN (1962)
Rutiderma rostrata JUDAY	JUDAY (1907)
Cylindroleberis mariae BAIRD	JUDAY (1907)
Amphipoda	
Anonyx carinatus (HOLMES)	HURLEY (1963)
Anonyx sp. I	

Table 112 (continued)

Species	References
Aristias pacificus SCHELLENBERG	HURLEY (1963)
Aruga holmesi BARNARD	BARNARD (1955)
Cyphocaris challengeri STEBBING	GURJANOVA (1951)
Hippomedon denticulatus (BATE)	BARNARD (1954b)
Lepidecreum eoum GURJANOVA	GURJANOVA (1951)
Opisa tridenta HURLEY	HURLEY (1963)
Orchomene decipiens HURLEY	Do.
Orchomene pacifica (GURJANOVA)	BARNARD (1964a)
Orchomene sp. I	
Pachynus barnardi HURLEY	HURLEY (1963)
Prachynella lodo BARNARD	BARNARD (1964b)
Ampelisca brevisimulata BARNARD	BARNARD (1954a)
Ampelisca compressa HOLMES	BARNARD (1960b)
Ampelisca cristata HOLMES	BARNARD (1954a)
Ampelisca lobata HOLMES	Do.
Ampelisca macrocephala LILLJEBORG	Do.
Ampelisca pugetica STIMPSON	Do.
Byblis veleronis BARNARD	Do.
Heterophoxus oculatus (HOLMES)	BARNARD (1960a)
Metaphoxus fultoni (SCOTT)	BARNARD (1964a)
Paraphoxus daboius BARNARD	BARNARD (1960a)
Paraphoxus heterocuspidatus BARNARD	Do.
Paraphoxus obtusidens (ALDERMAN)	Do.
Paraphoxus oculatus (G. O. SARS)	Do.
Paraphoxus robustus HOLMES	Do.
Paraphoxus spinosus (HOLMES)	Do.
Paraphoxus tridentatus (BARNARD)	Do.
Paraphoxus variatus BARNARD	Do.
Stenothoidae indet.	
Pardalisca tenuipes G. O. SARS	SARS (1895)
Bathymedon sp.	
Monoculodes zernovi GURJANOVA	MILLS (1962)
Synchelidium rectipalmum MILLS	Do.

Table 112 (continued)

Species	References
Synchelidium shoemakeri MILLS	MILLS (1962)
Westwoodilla caecula (BATE)	Do.
Tiron biocellata BARNARD	BARNARD (1962b)
Bruzelia tuberculata G. O. SARS	SARS (1895)
Calliopius sp.	
Parapleustes pugettensis (DANA)	BARNARD and GIVEN (1960)
Melphisana sp.	
Eusirus sp.	
Rhacotropis inflata G. O. SARS	SARS (1895)
Pontogeneia melanophthalma GURJANOVA	GURJANOVA (1951)
Pontogeneia rostrata GURJANOVA	Do.
Melita dentata KRÖYER	SARS (1895)
Melita desdichada BARNARD	BARNARD (1962b)
Melita oregonensis BARNARD	BARNARD (1954b)
Maera danae (STIMPSON)	BARNARD (1962b)
Dexamonica reduncans BARNARD	BARNARD (1957)
Aoroides columbiae WALKER	BARNARD (1954b)
Eurystheus thompsoni (WALKER)	BARNARD (1959)
Photis brevipes SHOEMAKER	BARNARD (1962a)
Protomedeia sp.	
Amphithoe sp.	
Ischyrocerus sp.	
Corophium crassicorne BRUZELIUS	GURJANOVA (1951)
Ericthonius brasiliensis (DANA)	Do.
Ericthonius hunteri (BATE)	Do.
Dulichia arctica MURDOCH	Do.
Dulichia tuberculata BOECK	Do.
Dulichia sp.	
Caprella sp.	
Isopoda	
Haliophasma geminata MENZIES and BARNARD	MENZIES and BARNARD (1959)

Table 112 (continued)

Species	References
Limnoria lignorum RATHKE	HATCH (1947)
Rocinela belliceps STIMPSON	Do.
Tanaidacea	
Leptochelia dubia KRÖYER	HATCH (1947)
Leptognathia longiremis LILLJEBORG	Do.
Cumacea	
Diastylis paraspinulosa ZIMMER	LOMAKINA (1958)
Diastylis pellucida HART	Do.
Diastylis alaskensis CALMAN	Do.
Diastylopsis dawsoni SMITH	Do.
Leptostylis villosa G. O. SARS	Do.
Eudorella pacifica HART	Do.
Eudorellopsis biplicata CALMAN	Do.
Eudorellopsis sp. I	
Leucon sp. I	
Campylaspis canaliculata ZIMMER	ZIMMER (1936)
Campylaspis (papillata) LOMAKINA ?	LOMAKINA (1958)
Campylaspis sp. I	
Lamprops carinata HART	LOMAKINA (1958)
Lamprops quadriplicata krasheninnikovi DERZHAVIN	Do.
Leptostraca	
Epinebalia pugettensis CLARK	CLARK (1932)
Anomura	
Axiopsis spinulicauda (RATHBUN)	SCHMITT (1921)
Callianassa sp. juv.	
Paguristes turgidus (STIMPSON)	SCHMITT (1921)
Pagurus sp. juv.	
Petrolisthes eriomerus STIMPSON	HAIG (1960)
Brachyura	
Pinnixa barnharti RATHBUN	RATHBUN (1918)
Pinnixa occidentalis RATHBUN	Do.
Pinnixa schmitti RATHBUN	Do.

Table 112 (continued)

Species	References
Pinnotheres concharum (RATHBUN)	RATHBUN (1918)
Pinnotheres taylori RATHBUN	Do.
Lophopanopeus bellus (STIMPSON)	RATHBUN (1930)
Lophopanopeus diegenes RATHBUN	Do.
Cancer sp. juv.	
Hyas lyratus DANA	RATHBUN (1925)
Oregonia gracilis DANA	Do.
Scyra acutifrons DANA	Do.
PYCNOGONIDA	
Nymphon pixellae SCOTT	HEDGPETH (1941)
LAMELLIBRANCHIA	
Lucinoma annulata (REEVE)	MORRIS (1952)
Parvalucina tenuisculpta (CARPENTER)	OLDROYD (1924)
Adontorhina cyclia BERRY	BERRY (1947)
Axinopsida sericata CARPENTER	DALL (1901)
Thyasira gouldii (PHILLIPPI)	OLDROYD (1924)
Clinocardium fucanum (DALL)	Do.
Clinocardium nuttalli (CONRAD)	Do.
Nemocardium centifilosum (CARPENTER)	Do.
Compsomyax subdiaphana (CARPENTER)	Do.
Humilaria kennerleyi (CARPENTER)	Do.
Protothaca staminea (CONRAD)	Do.
Protothaca tenerrima (CARPENTER)	MORRIS (1952)
Psephidia lordi (BAIRD)	OLDROYD (1924)
Saxidomus giganteus (DESHAYES)	Do.
Macoma alaskana DALL	Do.
Macoma calcarea (GMELIN)	Do.
Macoma carlottensis (WHITEAVES)	GRANT and GALE (1931)
Macoma incongrua (vonMARTENS)	OLDROYD (1924)
Macoma inconspicua (BRODERIP and SOWERBY) (syn. M. baltica)	GRANT and GALE (1931)
Macoma yoldiformis CARPENTER	OLDROYD (1924)

Table 112 (continued)

Species	References
Macoma spp. juv.	
Tellina buttoni DALL	OLDROYD (1924)
Tellina sp., juv.	
Semele rubropicta DALL	OLDROYD (1924)
Solen sicarius GOULD	Do.
Acila castrensis (HINDS)	Do.
Nucula bellotii ADAMS	ADAMS (1856)
Nuculana cellulita (DALL)	OLDROYD (1924)
Nuculana minuta (FABRICIUS)	GOULD (1850)
Yoldia amygdalea VALENCIENNES	REEVE and SOWERBY (1873)
Yoldia seminuda DALL	OLDROYD (1924)
Yoldia traciaeformis (STORER)	Do.
Yoldia ensifera DALL	Do.
Yoldia sp.	
Glycymeris subobsoleta (CARPENTER)	OLDROYD (1924)
Crenella (Megacrenella) columbiana DALL	HABE and ITO (1965)
Modiolus modiolus (LINNÉ)	GOULD (1850)
Modiolus sp.	
Musculus substriatus (GRAY)	OLDROYD (1924)
Chlamys hericius (GOULD)	Do.
Pododesmus cepio (GRAY)	GRAY (1850)
Kellia suborbicularis (MONTAGU)	OLDROYD (1924)
Mysella tumida (CARPENTER)	Do.
Mactra californica CONRAD	Do.
Mya arenaria (LINNÉ)	MacNEIL (1965)
Mya truncata LINNÉ	OLDROYD (1924)
Panomya ampla DALL	MacGINITIE (1959)
Panomya arctica (LAMARCK)	Do.
Pandora filosa (CARPENTER)	OLDROYD (1924)
Lyonsia pugetensis DALL	Do.
Thracia trapezoides CONRAD	Do.
Cuspidaria oldroydi DALL	Do.

Table 112 (continued)

Species	References
Lamellibranchia indet.	
OPHIUROIDEA	
Ophiurae	
Amphiodia urtica (LYMAN)	NIELSEN (1932)
Amphipholis squamata (DELLE CHIAJE)	DYAKONOV (1954)
Ophiura lütkeni (LYMAN)	Do.
ECHINOIDEA	
Spatangoidea	
Brisaster townsendi (AGASSIZ)	MORTENSEN (1951)
HOLOTHUROIDEA	
Apoda	
Chiridota laevis FABRICIUS	BUSH (1918)
Leptosynapta clarki HEDING	HEDING (1928)
Dendrochirota	
Pentamera spp.	
Molpadia intermedia (LUDWIG)	DEICHMAN (1937)

ERRATA

Page 233, line 9: for "SEANNON-WIENER" read "SHANNON-WIENER"

" 243, line 8: for "2.3 ^{O}C" read "2-3 ^{O}C"

" 335, line 16: for "49-70%" read "49-66%"

" 360, bottom line: for " $S = \alpha \ln(1-N/a)$" read " $S = \alpha \ln(1-N/\alpha)$"

" 363, line 15, and page 499, line 7: for "49 to 70%" read "49 to 66%"

" 400, line 3: for "MULLER (1894)" read "MÜLLER (1894)"

" 412, second paragraph: for "at all stations but in very low abundance at the soft-bottom stations 2, 7, and 4 (Table 74)" read "at all stations except station 7, but in very low abundance at stations 2 and 4 (Table 74)"