AN ABSTRACT OF THE THESIS OF

Lisa T. Erman for the degree of Master of Science

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Title: Impacts of Dredged Material Disposal on Estuarine Benthic Macrofaunal Communities in Coos Bay, Oregon

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Abstract approved: ______________________________
Dr. Michael C. Mix

Hopper dredge disposal of coarse grained sediment was investigated between May and September, 1986, at a designated disposal area, Site G, in Coos Bay, Oregon. The objectives of the study were to: (a) identify and describe the benthic macrofaunal community structure at Site G during May and September, 1986; (b) analyze May and September sediments at the site to determine possible differences in percent organics, sediment grain size, and volatile solids; and (c) determine if there were correlations between sediment parameters and the macrofaunal community structure. Three stations were located within the disposal site and eight stations were located within the surrounding area.

Differences in sediment physical characteristics were not significant between seasons, although median grain size tended to be slightly finer in September. Furthermore, Stations 4,7, and 2 contained a higher percentage of gravels in May than at other stations or in September. Differences in sediment parameters among stations were few. There was no apparent relationship between depth and other sediment parameters. Differences in grain size distribution, organic

content, percent fines, and depth were thus not sufficient to account for differences in community structure among stations or between cruises.

Diversity, taxa richness, and numbers of individuals increased significantly in September. There was no significant difference in evenness between May and September. There were no significant correlations of community composition parameters and depth. Stations contained within Site G did not show consistent patterns or differences in diversity, richness, overall abundance, or evenness from other stations or between cruises.

Organisms obtained at Site G were those typically found in high energy, coarse grained environments. Two of these species, *Mediomastus californiensis* and *Spiophanes bombyx*, increased in abundance in September. Increases in several species were consistent with seasonal variations that have been described in other studies. Many juveniles were obtained in the September samples. This finding could be indicative of seasonal recruitment or recolonization following a disturbance.

Based on the information and data collected, it is unclear as to whether or not changes in community structure and composition were due to disturbance by disposal activities or to seasonal environmental and biological influences. Since increases in species abundance, richness and diversity occurred, detrimental effects related to disposal of 11,632 m^3 of coarse grained sediment at Site G were not apparent.

Impacts of Dredged Material Disposal on Estuarine Benthic Macrofaunal Communities in Coos Bay, Oregon

by

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Much appreciation is extended to the faculty, staff, and fellow graduate students of the Department of General Science for their encouragement, advice, patience and definitely humor. Many thanks to Keith King for his helpful suggestions, advice on graphics and especially his many "WORK CHECKS".

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INTRODUCTION

Sediment deposition occurs in many Oregon harbors and channels due to both constant influx of suspended sediments and low current activity. As a result, maintenance dredging is employed to ensure navigable entrance channels and harbors. However, such dredging causes mechanical or hydraulic disturbance to the substrate. Hopper dredges, for example, use suction pipes and dragheads to remove a layer of sediment from the bottom. The material is subsequently transported and dropped at a designated disposal site (Bray, 1979). This process may alter bottom stability, disrupt existing sediments, and consequently affect the associated benthic fauna (Slotta et al., 1973).

The need for maintenance dredging and the environmental problems associated with it are addressed in environmental statutes. The National Environmental Policy Act (NEPA,1969), Federal Water Pollution Control Act Amendments (P.L. 92-500, 1972) and Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532) all deal specifically with the disposal of dredged materials. These acts give the U.S. Environmental Protection Agency (EPA) and the Army Corps of Engineers (ACE) responsibility for designating, managing, and evaluating disposal sites (Bradley, 1976; Webb and Holmes, 1976; Kamlet, 1976). According to established criteria, no unacceptable adverse effects on the marine ecosystem, human health, or marine resources are permissible; nor are persistent or permanent effects due to dumping of dredged materials permitted (Federal Register, 1977).

In most studies of dredging effects, benthic infauna have been used to monitor and assess the environmental impacts of disposed material for a number of reasons: (1) these organisms are considered to be good disturbance indicators since many are relatively long-lived, sessile, and have limited mobility (Slotta et al., 1973; Synder, 1976; Hancock et al., 1977); (2) since many benthic organisms depend on sediments for food, a change in substrate composition can be crucial to their survival (Hancock et al., 1977; Rhoads et al., 1978); and (3) benthic infauna are a food source for juvenile, demersal, and migratory fish (Parr, 1974; Arntz, 1978).

Depending on the compatibility of the dredged materials to the disposal site substrate, the sediment grain size and chemistry may be altered so that the benthic community is affected. Finer fractions of the dredged materials may remain in suspension during the disposal process and be transported further from the disposal site than the coarser fraction. As a result, coarse sands may be increased at the disposal site. For example, an accumulation of coarse sand and gravel was detected at an offshore disposal site located in Yaquina Bay, Oregon (U.S. Army Corps of Engineers, 1985).

In contrast, dredged materials may be finer than the native substrate, resulting in increased fines at the disposal area. Higher organic levels are generally associated with finer sediments. Organic materials more readily adhere to the finer particles (Hancock et al., 1980; Felstul, 1987; Rhoads and Young, 1970; Boucot, 1981). Higher organic levels may be beneficial as food for the organisms present.

Deposit feeders rely on organics and microbes associated with them as a food source (Rhoads et al., 1978). The pelagic larvae of some deposit feeders can settle only when the microbial population on the sediment particles is sufficient. Yet, if the organic concentration is too high, an oxygen demand may be created as decomposers consume available oxygen (Pearson, 1975). Fewer species can tolerate reduced oxygen levels so that a reduction in diversity can occur (Pearson, 1975). With increased products from organic breakdown, larval settlement can be affected (Rhoads et al., 1978). An increase in fines may also clog or damage the gills and feeding structures of suspension feeders, nonmotile deposit feeders, and larval forms. Therefore, when studying benthic infauna, their feeding habits and reproductive strategy should be observed.

Other possible deposition impacts include burial, smothering, and toxic effects from exposure to polluted sediments. Species which can burrow quickly or which do not need to maintain surface contact are least affected. In fact, these organisms can become reestablished within a few weeks (Parr, 1974). McCauley et al. (1977) found that after an initial decrease in infaunal abundances following disposal, populations returned to their original levels within 7 days. Thus, the benthic organisms modes of locomotion and location within the substrate may also be of importance when considering the impacts of disposed materials.

The major objective of this study was to investigate the effects of hopper dredge disposal of coarse grained material between May and September, 1986, at a disposal area (Site G) in Coos Bay, Oregon. In order to assess such impacts, the community structure of benthic organisms both before and after disposal was determined. The specific objectives of the study were to:

a. identify and describe the distribution and abundance of benthic macrofaunal communities at the disposal site "G" during May and September, 1986;

b. compare benthic macrofaunal communities both before and after disposal, as well as communities between stations, by use of community structure measures such as abundance, diversity, and analyses of species composition (cluster analysis);

c. analyze pre- and post-disposal sediments at the site to determine possible differences in percent organics, sediment grain size, and volatile solids; and,

d. determine if there were correlations between sediment parameters and the macrofaunal community structure.

Another rationale for studying the benthic infauna at Site G was that the disposal site had been considered for flow lane disposal of dredged material pipelined from the Charleston small boat basin. Studies conducted at Site G could be used to establish a data base for future surveys and impact studies.

METHODS

Site Description

The study area, disposal Site G, is located at River Mile 1.3 on the south side of the Coos Bay entrance channel, Oregon (Figures 1 and 2). It has an average depth of 11.5 m (38 feet) and dimensions of 61 by 303 m (200 by 1000 feet). Site G is located in an hydraulically active, highly dynamic region. The mean tidal range is 2.04 m at Charleston and 1.58 m at the mouth (Hancock et al., 1980; WRRI-19-I, 1973). Maximum ebb and flood tides have been recorded as 3.6 m/sec and 1.8 m/sec, respectively, with an average tidal current velocity of 1.0 m/sec (WRRI-19-I, 1973). For most of the year, the Coos estuary is classified as well mixed (Burt and McAllister, 1959).

A navigation channel 10.7 m deep is maintained to River Mile 15, located near Isthmus Slough. In order to maintain a navigable depth of 12.2 m within the entrance channel, an average of 650,000 m^3 of sediment is dredged annually; 344,000 m^3 from mile 1 to 12 and 383,000 m^3 from mile 12 to 15 are removed as well (Sollitt et al., 1984). Generally, the dredged material is deposited at sea. Sediments disposed offshore are of marine origin and are, for the most part, clean, fine sands (Hancock et al., 1980). Presently, dredged materials are disposed at 60 m depths offshore at disposal Site H, which is currently being monitored and evaluated.

Disposal Site G has been used for emergency disposal during inclement weather when dredges are unable to cross the entrance bar. The International Port of Coos Bay has also been authorized to use

Site G for flow lane disposal of fine grained, highly organic materials dredged from the Charleston small boat basin. The permit allows the removal of 7600 m^3 of sand and silt annually over 5 years by hydraulic pipeline dredge. Although the dredging and disposal did not occur at this site as planned in 1986, it may be an important factor in benthic community structure.

Sampling Plan

Two cruises, I and II, were conducted on May 13 and September 22, 1986, respectively. Relief disposal had not occurred for at least 10 months at Site G, prior to the first sample collection. The second collection occurred after disposal of 11,632 m^3 of dredged materials at Site G (646 m^3 on May 21-22 and 10,986 m^3 during June 5-26, 1986).

Ten sample stations were located within the Coos Bay channel area. Stations 4,7, and 8 were within Site G (Figure 2). Station location data (latitude, longitude, and depth) are shown in Tables 1 and 2.

Benthic Macrofauna

Five replicate box cores with a biting area of 0.096 m^2 were obtained at each of the ten stations. To collect macrofauna, each core sample was sieved through a 0.5 mm screen. Material retained on the screen was fixed in a buffered 10% formalin-seawater solution. After 72 hours, samples were rewashed to remove the formalin solution, placed in 70% isopropanol, and stained with rose bengal so that sorting and identification could take place. Organisms were

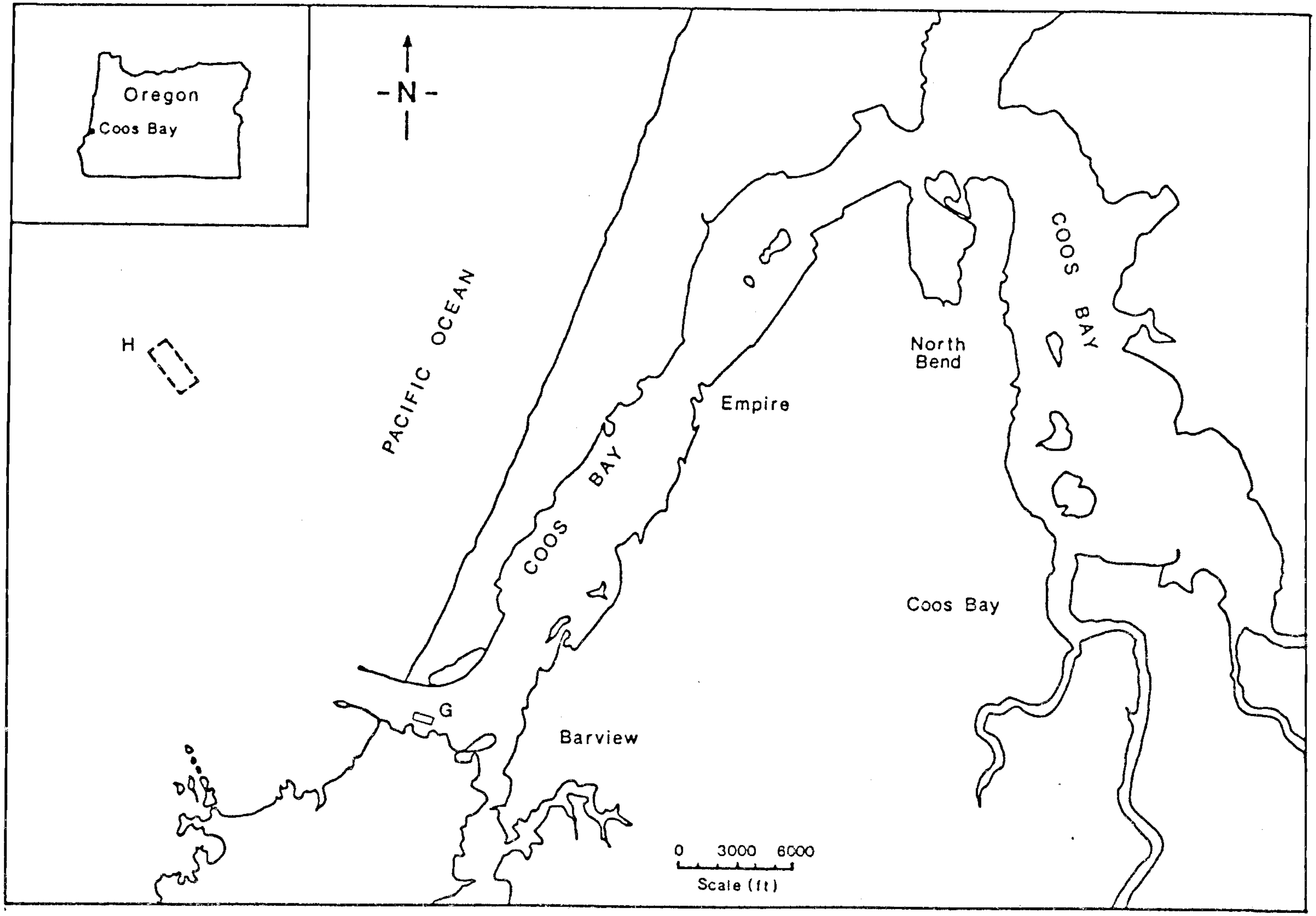

Figure 1. Map of Coos Bay estuary.

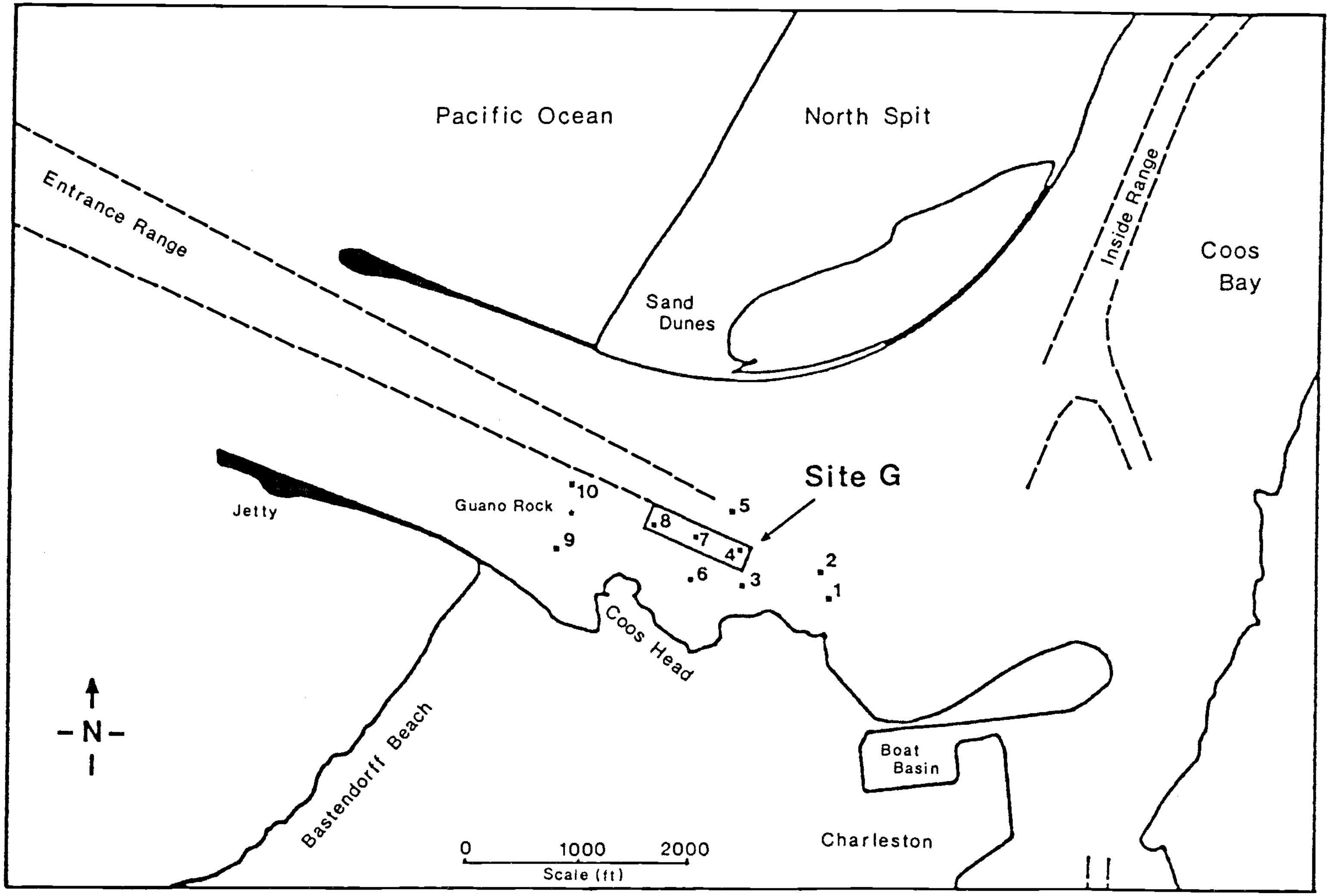

Figure 2. Map of Coos Bay entrance channel showing station locations.

Table 1. Station locations at disposal Site G, Coos Bay, Oregon, May 13, 1986.

Station	Latitude	Longitude	Depth
CBG-1	43 21.0	124 19.4	7.0
CBG-2	43 21.2	124 19.5	9.7
CBG-3	43 21.1	124 19.6	7.6
CBG-4	43 21.2	124 19.5	13.0
CBG-5	43 21.2	124 19.5	16.7
CBG-6	43 21.1	124 19.7	6.4
CBG-7	43.21.2	124 19.6	12.4
CBG-8	43 21.2	124 19.7	9.4
CBG-9	43 21.2	124 20.0	6.4
CBG-10	43 21.3	124 19.9	12.1

Depth-------meters
Latitude----north
Longitude---west

Table 2. Station locations at disposal Site G, Coos Bay, Oregon, September 22, 1986.

Station	Latitude	Longitude	Depth
CBG-1	43 21.05	124 19.34	9.7
CBG-2	43 21.05	124 19.36	7.3
	43 21.05	124 19.36	7.0
CBG-3	43 21.05	124 19.48	7.6
	43 21.05	124 19.49	8.2
CBG-4	43 21.19	124 19.47	12.7
	43 21.19	124 19.50	12.1
CBG-5	43 21.21	124 19.53	16.7
	43 21.23	124 19.55	16.4
CBG-6	43 21.22	124 19.70	6.1
	43 21.21	124 19.74	6.1
CBG-7	43 21.21	124 19.75	12.7
	43 21.21	124 19.75	13.3
CBG-8	43 21.22	124 19.74	9.4
	43 21.22	124 19.79	10.6
CBG-9	43 21.17	124 19.87	7.0
	43 21.17	124 19.92	7.3
CBG-10	43 21.23	124 19.98	13.6
	43 21.27	124 20.02	13.6

Depth-------meters
Latitude----north
Longitude---west

identified to the lowest possible taxon. Macrofauna were identified by various taxonomists contracted by the Army Corps of Engineers.

Sediment Analyses

A sixth box core was taken at each station for sediment analyses. Samples were collected by hand, placed in zip-locked plastic bags, and stored on ice. Subsequent analyses by the Army Corps of Engineers' Materials Lab (Troutdale, Oregon) were done for sediment grain size, volatile solids, and percent organics. Sediment analyses were conducted in accordance with the following ASTM designations: 421-58, 422-63, 2487-69 (American Society for Testing and Materials, 1985). To measure the sediment organic content, percent volatile solids were determined as weight loss upon ignition at 550 °C. Sediment grain size was determined with a hydrometer and sieves (see Appendix A, Table A-1).

Water Quality

A Hydrolab surveyor instrument was used to take in situ measurements of temperature, conductivity, pH, and depth at surface-, mid- and bottom-depths at four stations: CBG 1,2,6, and 10. Measurements, taken periodically (approximately every hour) within the study area, included changes during flood and ebb tides.

To determine dissolved oxygen (DO) levels, a water bottle sampler was used to take samples at surface-, mid- and bottom-depths. Samples, taken at three stations (CBG 4,8,9), were fixed with manganous sulfate and alkaline iodide solutions for later analysis by the Winkler method. A Hach automatic titrator was used in the analysis.

Data Analysis

Community composition parameters such as species diversity, species richness, abundance and evenness were used for spatial and temporal comparisons of communities. Other procedures included correlation and cluster analyses. The various analyses used in this study are discussed in Appendix B.

RESULTS AND DISCUSSION

Sediment Physical Characteristics

Table 3 contains the sediment parameters measured for all stations in May and September. Median grain size (D50) estimates were derived from grain size distribution curves composed of fractional weight per particle diameter size. Figures 3-12 are histograms of the percent of sediment retained in each grain size class (see Appendix A, Table A-1 for grain size classification). Median grain size differed at most by 0.15 mm among most stations and between sampling dates, although sediments tended to be slightly finer in September than in May (Figure 13). Differences were more pronounced at Stations 2 and 7. In May, these stations contained 35% and 49% gravel, respectively (Figure 14). Large shell fragments (Station 7) and large rocks (Station 2) accounted for the high gravel percentage. September sediments from both stations were less coarse, although Station 7 sediments were 11% fine gravel. The other disposal site stations, 4 and 8, had no apparent differences in median grain size from other stations and no differences in physical characteristics by sample date. However, Station 4 did contain approximately 10% gravels in both May and September. The shell fragments and gravels found at Stations 4 and 7 in May could be remnants of previous disposal activities.

Differences in percent fines and percent organics, like grain size, were not pronounced between either stations or season (Table 3). At Station 3 differences ranged from 0 to approximately 2%

Table 3. Sediment physical characteristics and depth for ten stations in Coos Bay, Oregon for both May and September cruises, 1986.

Station	Depth (m)	Sediment Type	D50 (mm)	%Fines	%Organic
May					
MCBG-1	7.0	SP	0.356	0.0	0.6
MCBG-2	9.7	SP/Grav	0.446	0.2	0.7
MCBG-3	7.6	SP	0.278	0.0	0.7
MCBG-4	13.0	SP	0.340	0.0	0.8
MCBG-5	16.7	SP	0.321	0.1	1.0
MCBG-6	6.4	SP	0.315	0.1	0.8
MCBG-7	12.4	SP/Grav	18.300	0.2	0.7
MCBG-8	9.4	SP	0.350	0.1	0.6
MCBG-9	6.4	SP	0.279	0.3	0.7
MCBG-10	12.1	SP	0.320	0.1	0.8
September					
SCBG-1	9.7	SP	0.242	0.8	1.2
SCBG-2	7.1	SP	0.315	0.1	0.6
SCBG-3	7.9		0.178	12.8	2.5
SCBG-4	12.4	SP	0.290	0.3	0.8
SCBG-5	16.5	SP	0.321	0.1	0.8
SCBG-6L	6.1	SP	0.320	0.1	0.9
SCBG-6H	6.1	SP	0.310	0.0	1.1
SCBG-7	13.0	SP	0.357	0.1	0.8
SCBG-8	10.0	SP	0.365	0.0	0.6
SCBG-9	7.1	SP	0.221	0.1	0.9
SCBG-10	13.6	SP	0.342	0.4	0.9

Depth-----------meters
SP--------------poorly graded sand
Grav------------gravel
D50-------------median grain size
MCBG------------Coos Bay study Area G, May Cruise I
SCBG------------Coos Bay study Area G, September Cruise II

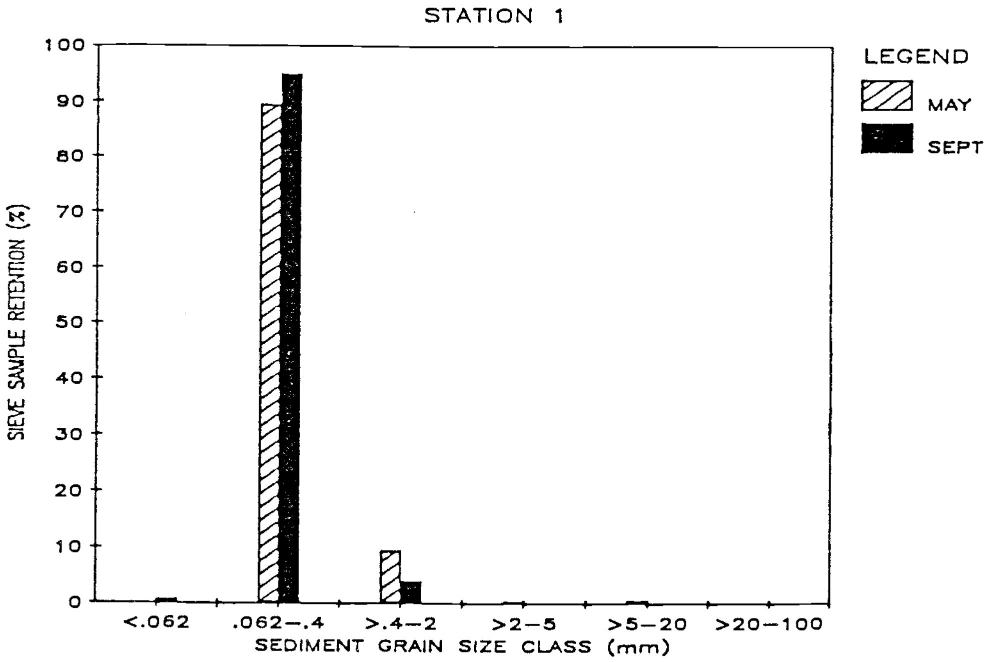

Figure 3. Classification of sediment obtained at Station 1

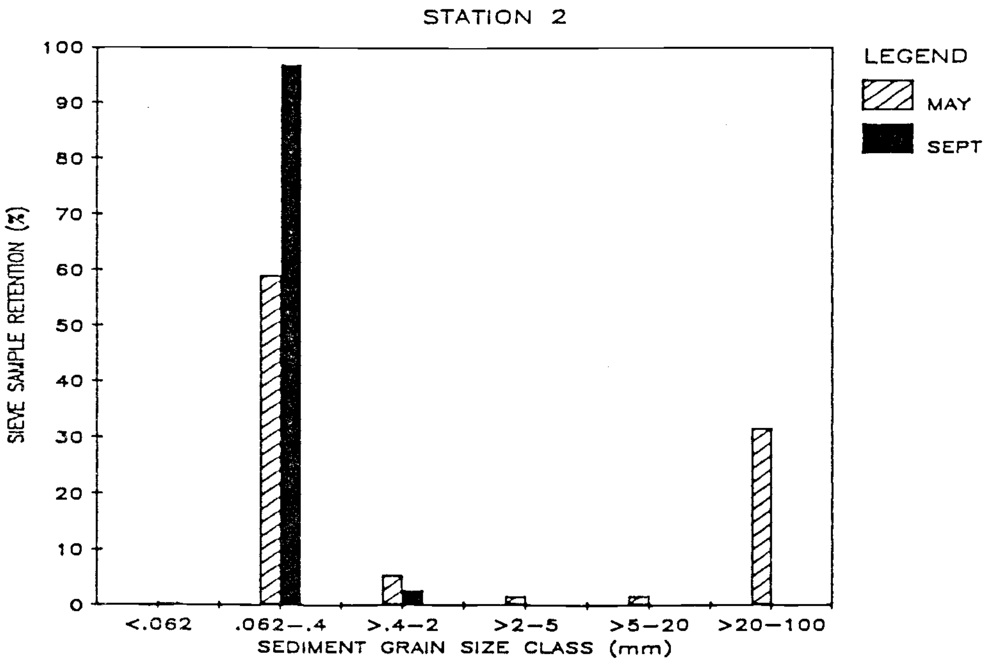

Figure 4. Classification of sediment obtained at Station 2

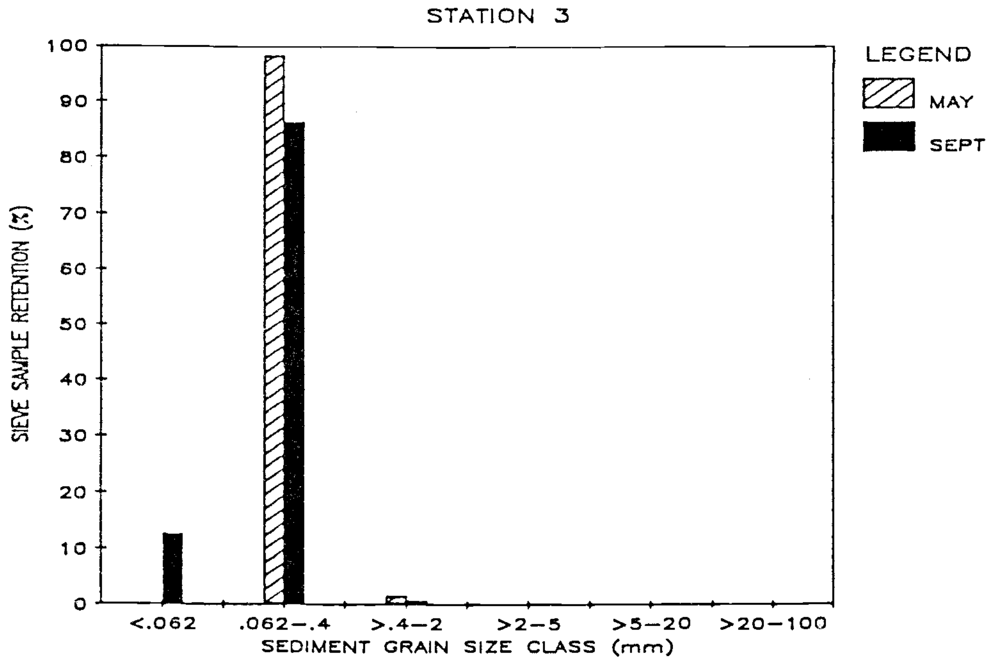

Figure 5. Classification of sediment obtained at Station 3

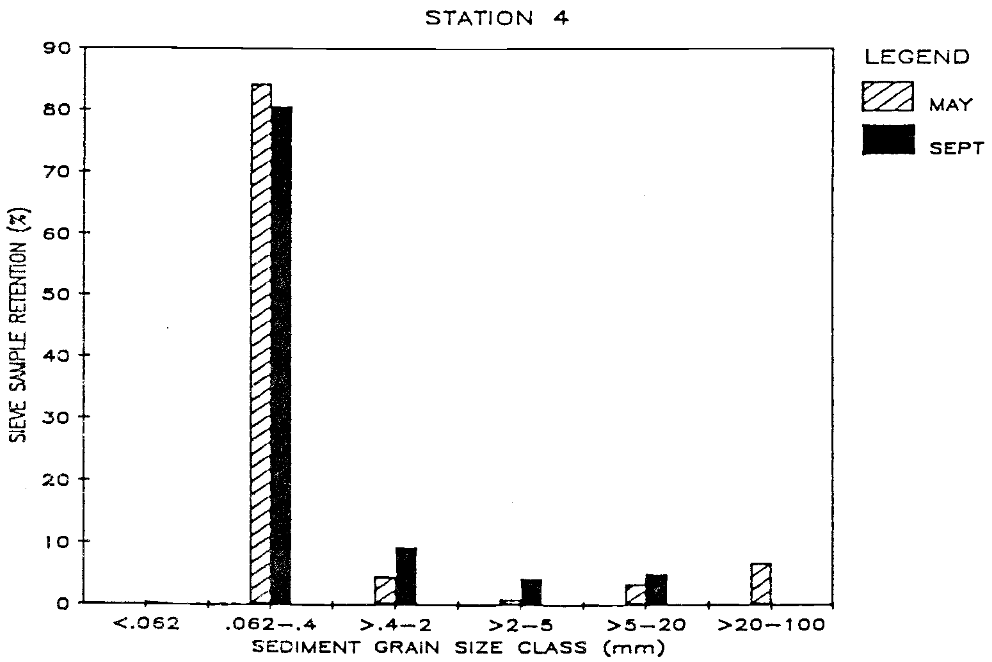

Figure 6. Classification of sediment obtained at Station 4

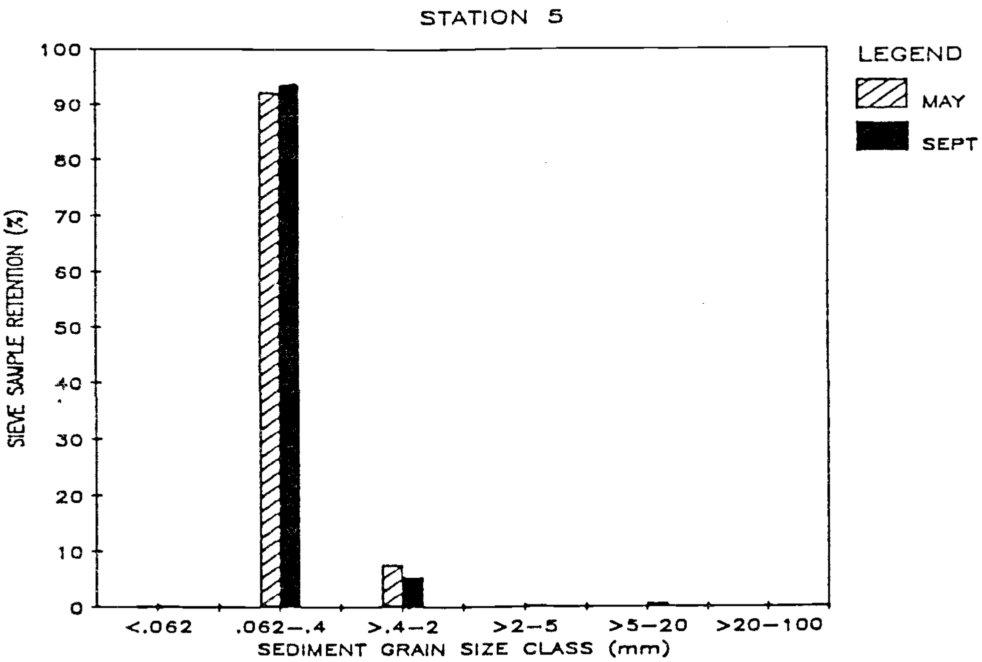

Figure 7. Classification of sediment obtained at Station 5

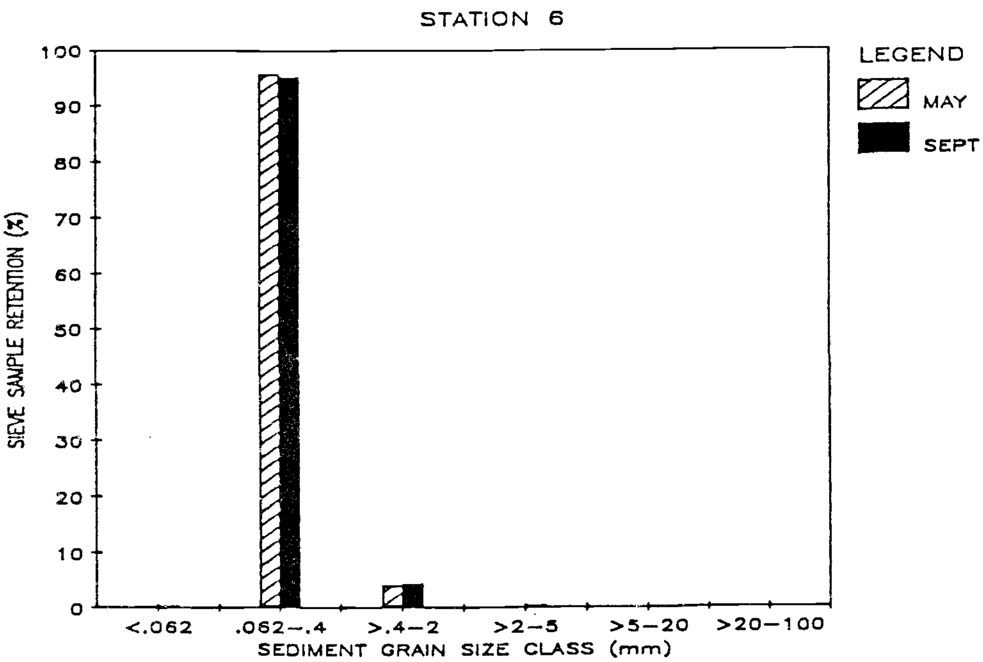

Figure 8. Classification of sediment obtained at Station 6

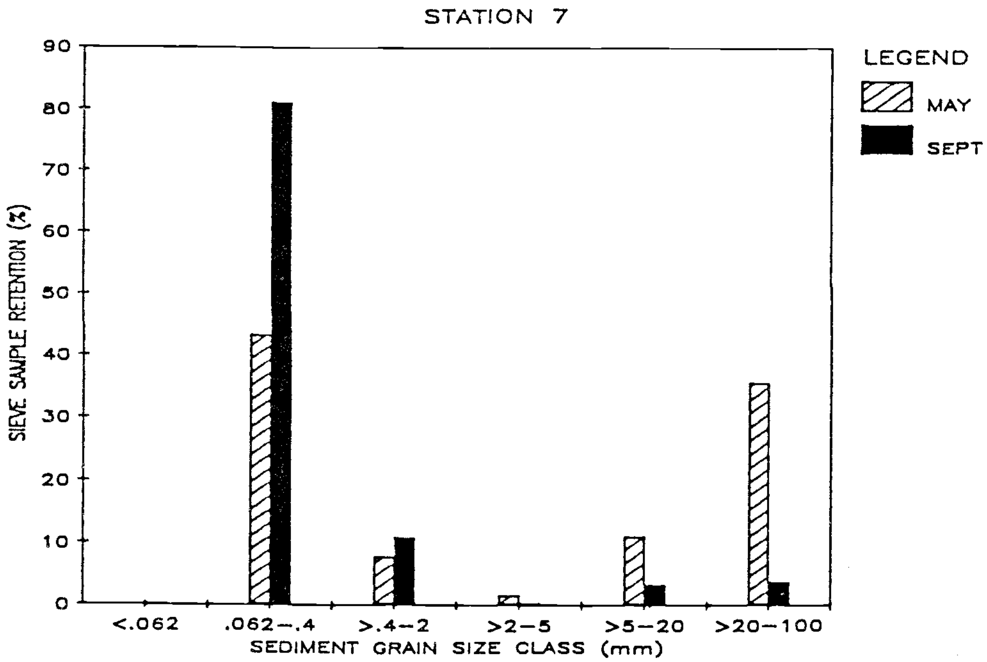

Figure 9. Classification of sediment obtained at Station 7

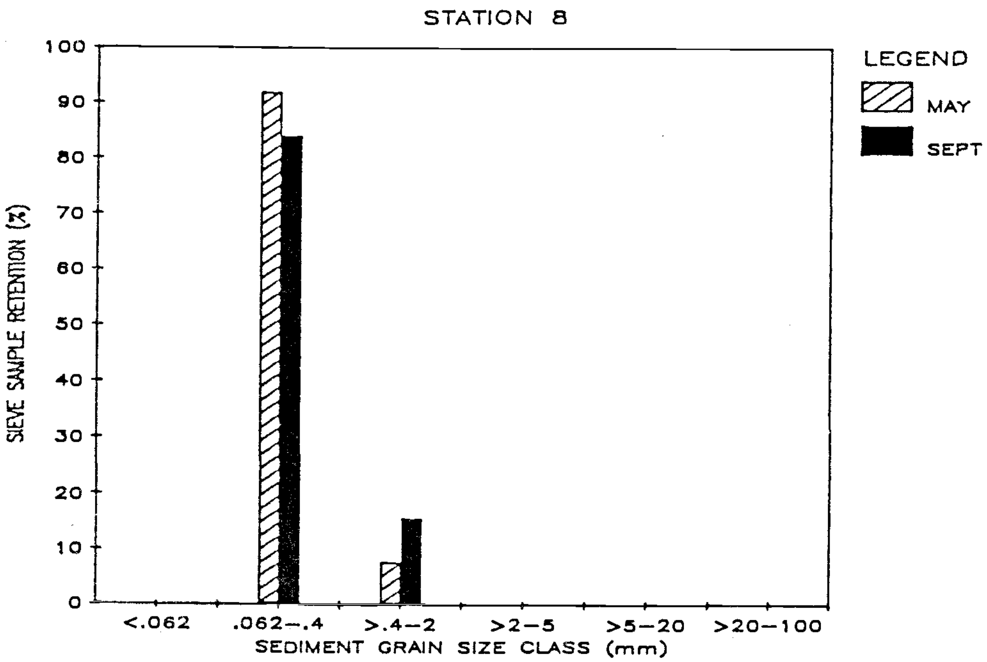

Figure 10. Classification of sediment obtained at Station 8

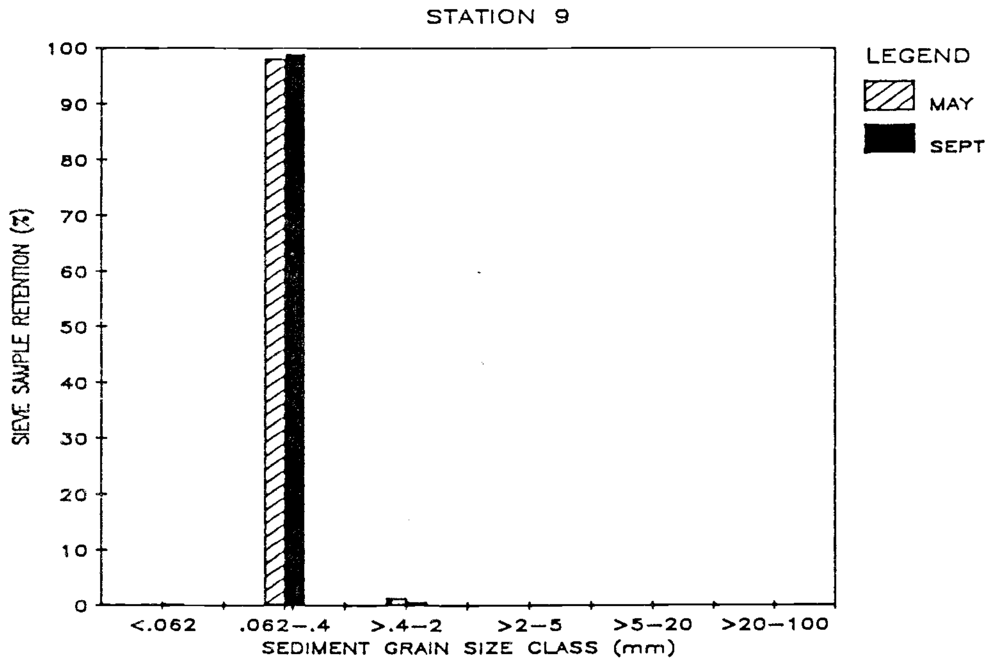

Figure 11. Classification of sediment obtained at Station 9

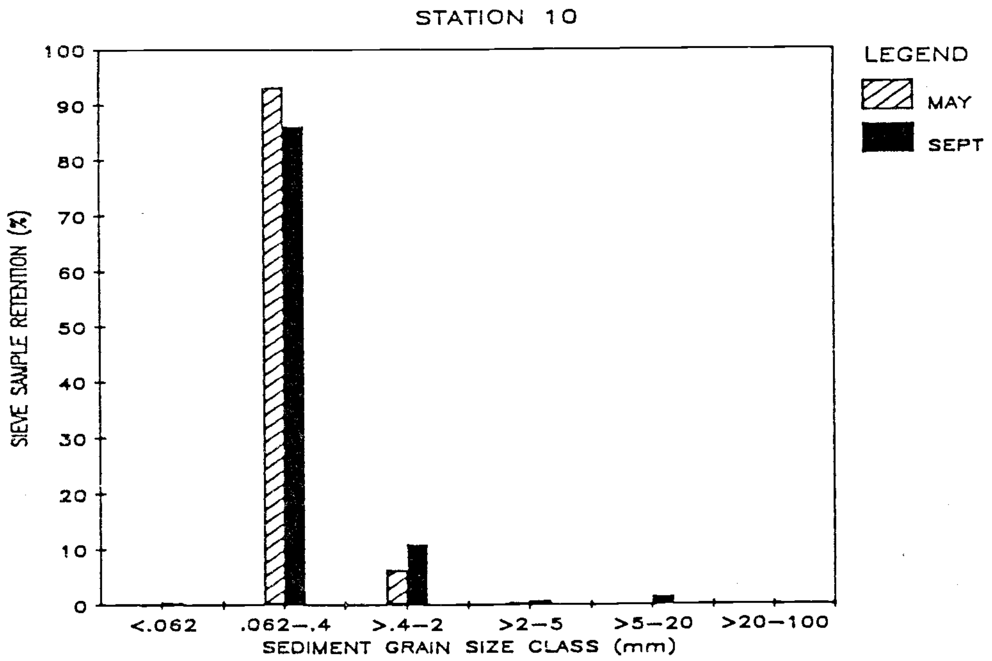

Figure 12. Classification of sediment obtained at Station 10

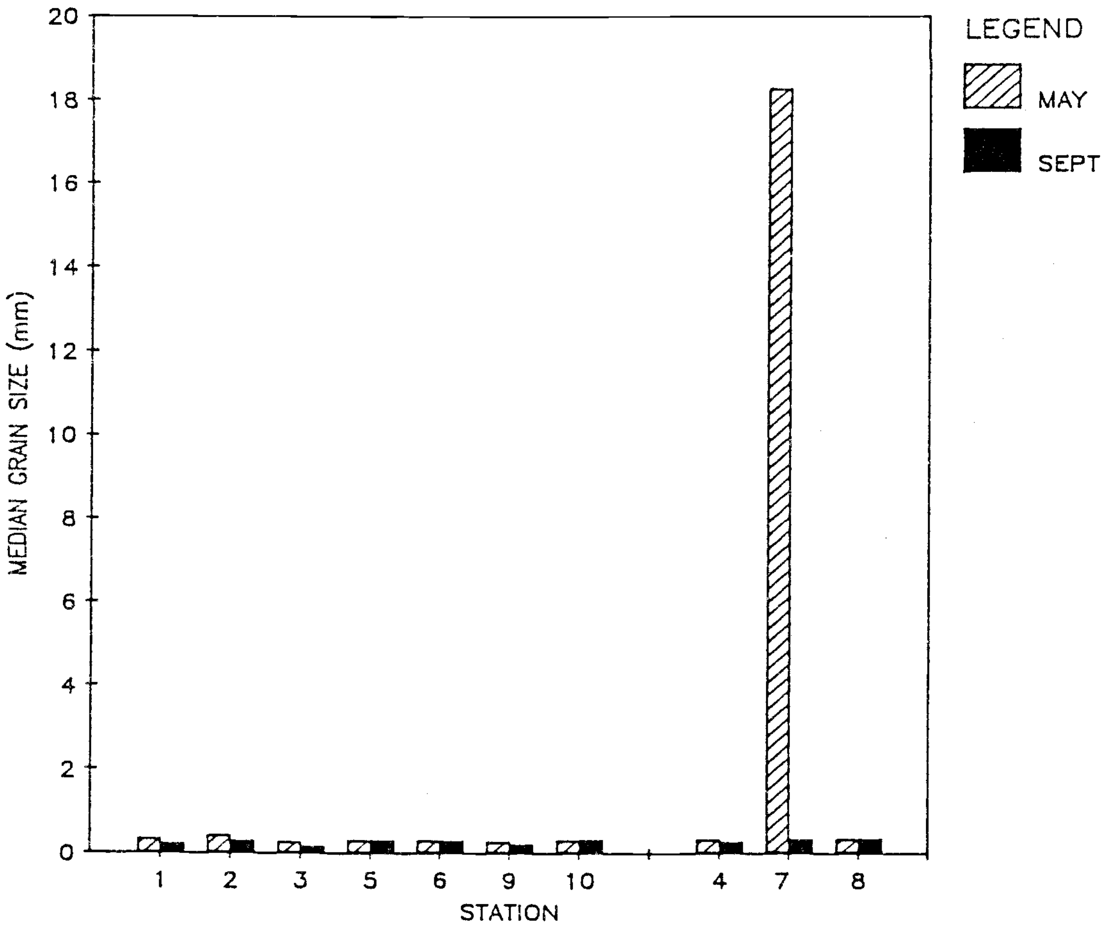

Figure 13. Sediment grain size at each station for May and September.

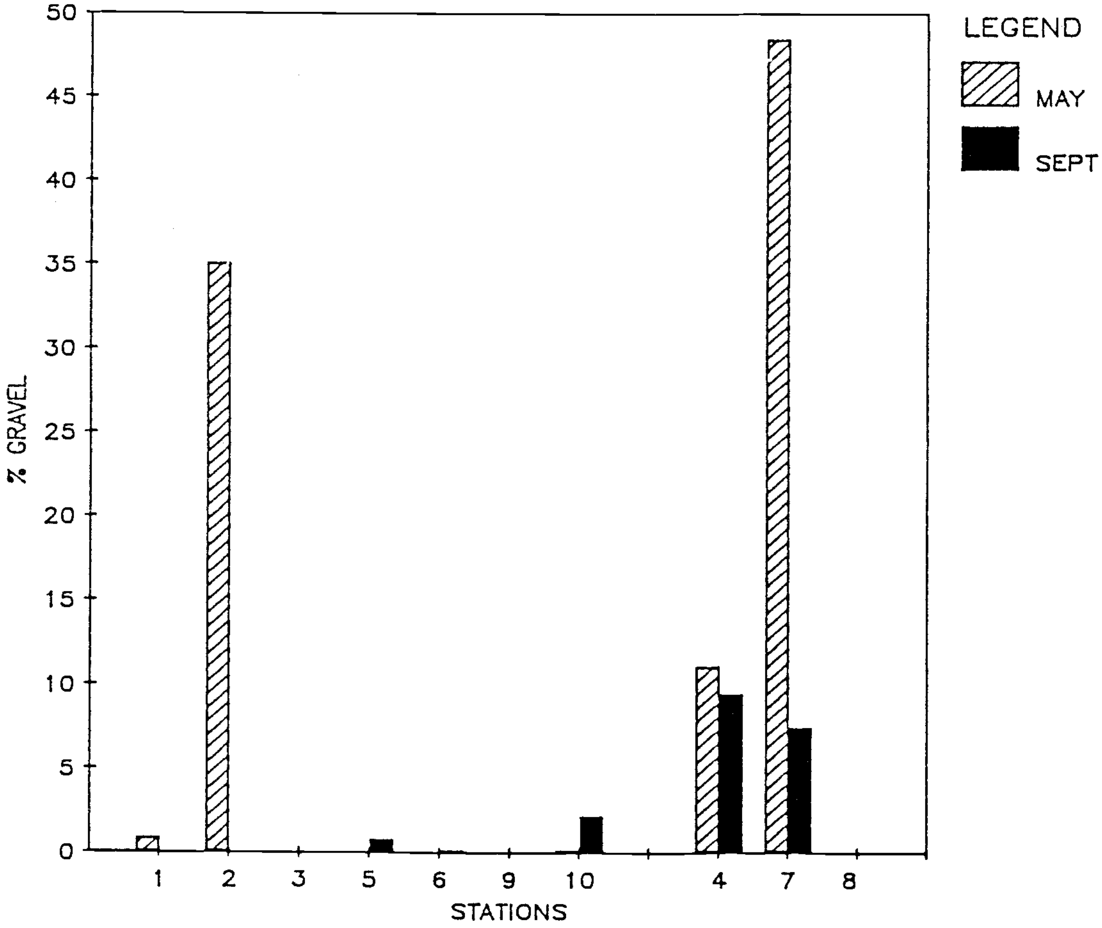

Figure 14. Sediment percent gravels at each station for May and September.

for organics and from 0 to 12% for percent fines. The ten stations had an average organic content of about 0.74% in May and a slightly higher average of 1% in September. Figure 15 depicts the organic content variations for all stations on the two sample dates. Figure 16 is a similar representation for percent fines, which varied from an average of 0.1% in May to 1.3% in September (or 0.2% if Station 3 is excluded). There appears to be no distinct differences in percent fines and organics between those stations within Site G (4,7,8) and the other locations, nor between sample dates. Station 3 is an exception, however, as percent fines increased by 12.8%. Table 4 contains the results of Student's t-tests of significance performed on May and September station data for median grain size, percent fines, percent organics, percent gravel, and depth. The tests confirmed that there were no significant differences in these parameters between the two sampling dates ($p > .05$).

Table 5 includes correlations among the various sediment parameters and correlations with depth. A high correlation existed between organics and fines in September ($r = .950$). However, this was not observed in May. Similarly, a weak negative correlation of grain size with percent fines and organics existed in September data ($r = -.680$ and $-.763$, respectively) but was lacking in May. The correlations observed in September were presumably due to the higher values of percent fines and organics found at Station 3 (Figure 17). Depth and percent organics showed a slight correlation in May ($r = .687$), yet overall, there was no apparent relationship between depth and other sediment parameters. This was not unexpected in view of the

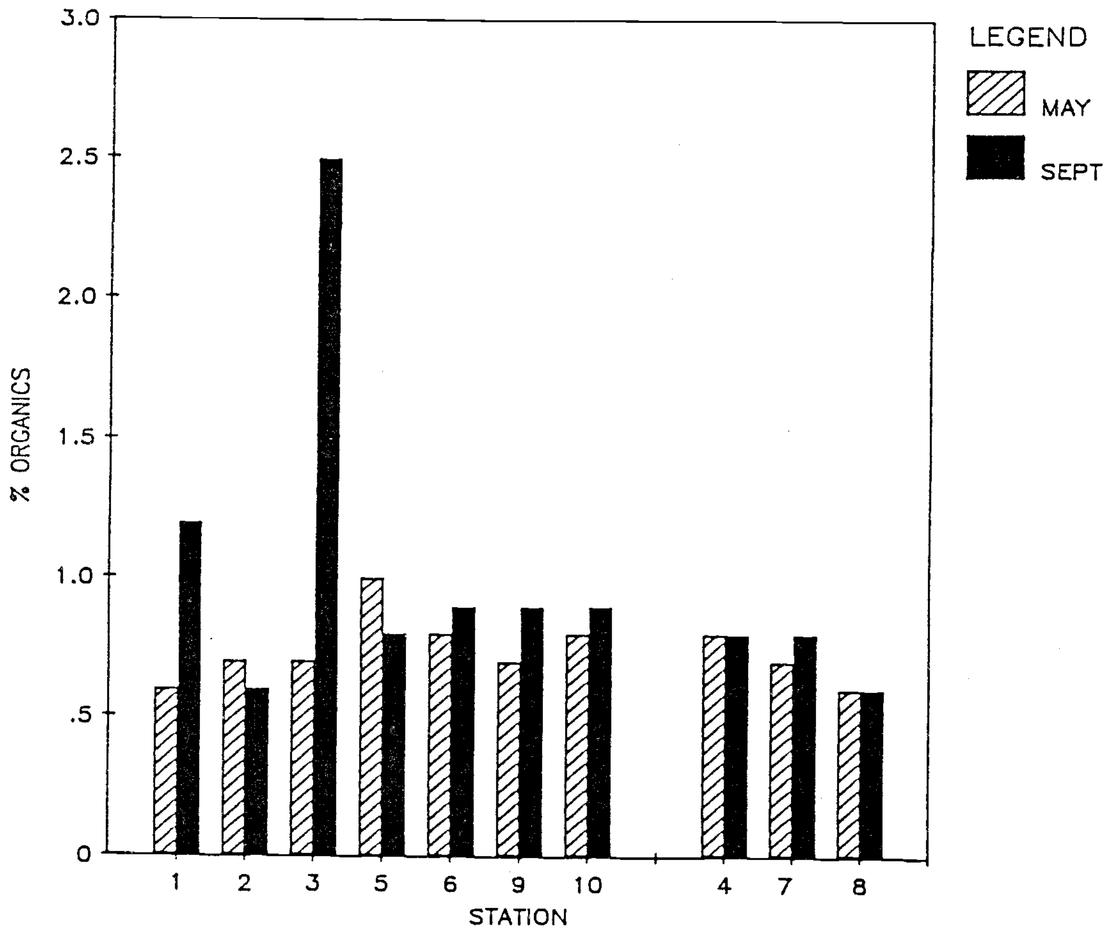

Figure 15. Sediment percent organics at each station for May and September.

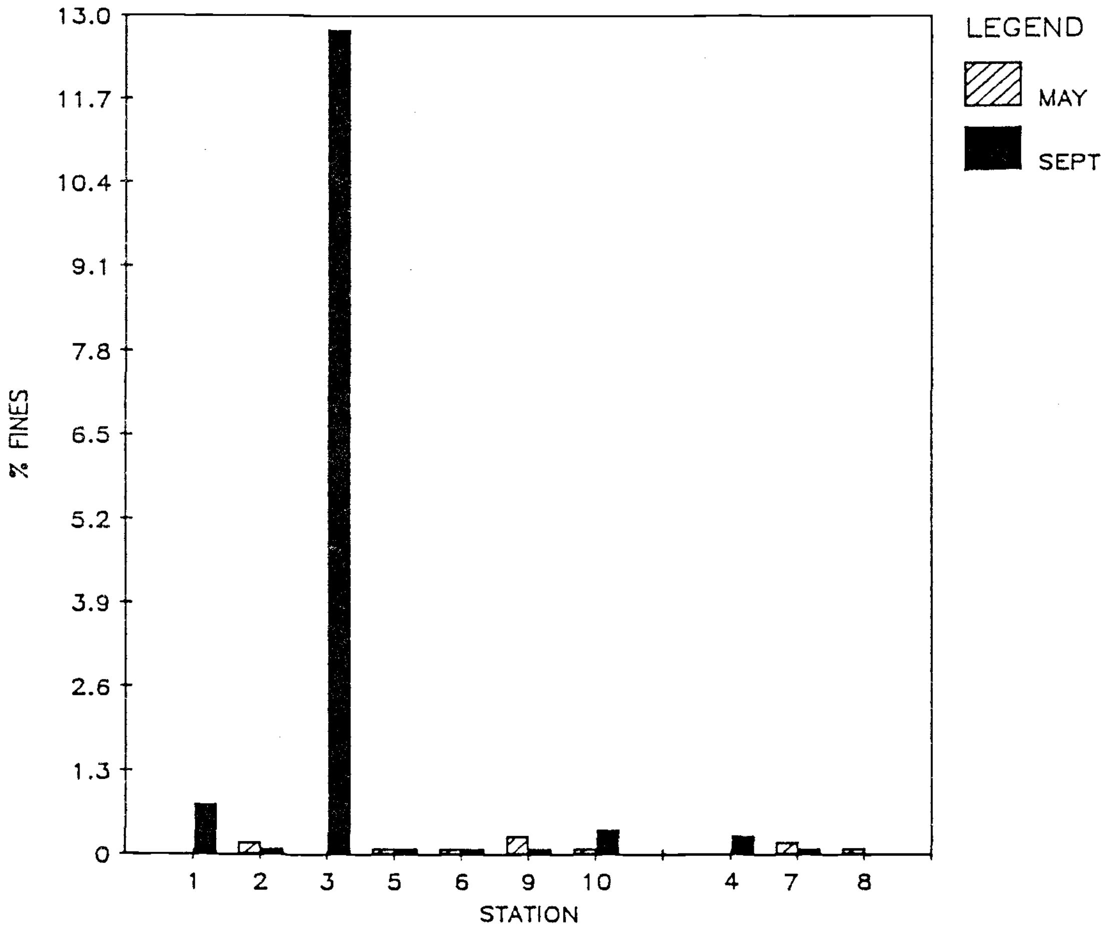

Figure 16. Sediment percent fines at each station for May and September.

Table 4. Comparison of median grain size (D50), % organics, % fines, and depth between May and September for all stations (n = 10 stations per cruise).

Sediment Parameter	May	Sept	t-value	Level of Significance
D50	2.13	0.29	1.02	.32
% Fines	0.12	1.47	-1.07	.30
% Organics	0.74	1.02	-1.56	.13
% Gravel	9.57	2.01	1.33	.20
Depth	33.2	34.2	-0.18	.85

Table 5. Pearson correlations and significance levels for relationships among sediment characteristics and depth.

May

	D50 (mm)	Percent Fines	Percent Organics	Percent Gravels	Depth
D50 (mm)	1.00 (.00)				
% Fines	-.07 (.00)	1.00 (.00)			
% Organics	-.20 (.59)	-.08 (.08)	1.00 (.00)		
% Gravels	.78 (.01)	.36 (.31)	-.15 (.68)	1.00 (.00)	
Depth	.14 (.72)	-.19 (.61)	.69 (.03)	.24 (.50)	1.00 (.00)

September

	D50 (mm)	Percent Fines	Percent Organics	Percent Gravels	Depth
D50	1.00 (.00)				
% Fines	-.68 (.03)	1.00 (.00)			
% Organics	-.76 (.01)	.95 (.00)	1.00 (.00)		
% Gravels	.29 (.42)	-.20 (.58)	-.24 (.51)	1.00 (.00)	
Depth	.46 (.18	-.24 (.50)	-.29 (.41)	.47 (.17)	1.00 (.00)

Coefficient (significance level)

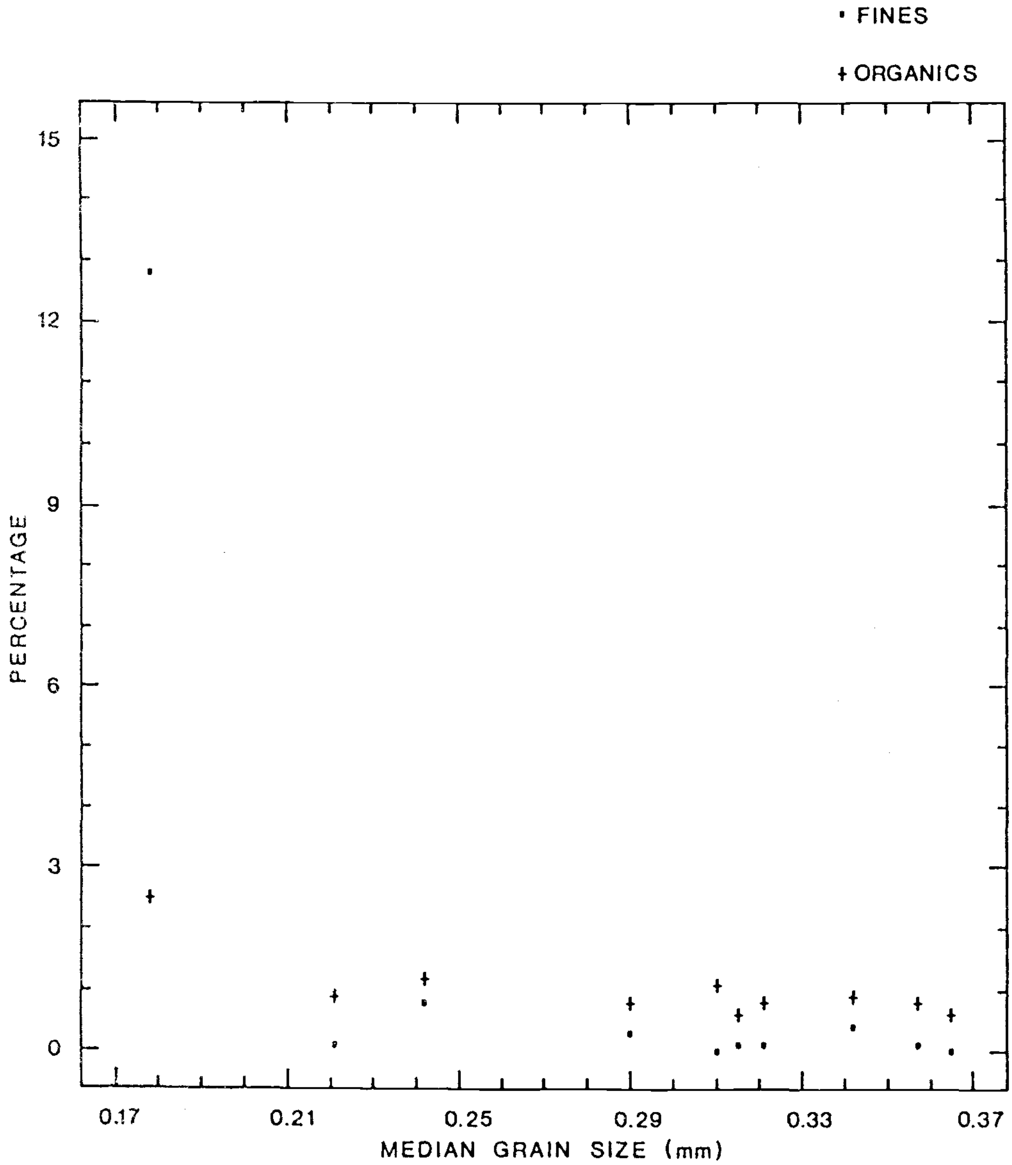

Figure 17. Sediment median grain size related to percent fines and organics.

similarity of the various parameters between stations and seasons.

Differences in the grain size distribution, organic content, percent fines, and depth at the ten Coos Bay stations were thus not sufficient to explain differences in the community structure among stations or between cruises. Two other factors which could have affected the invertebrate distribution were current patterns and sediment stability. Current velocity can affect grain size, water flow levels, the amount of suspended food transported to the area, and bottom stability. Regions with high current velocities generally have a coarser median grain size, a greater amount of flushing, and less substrate stability (Pearson, 1970). Suspension feeders are often the dominant organisms in such regions as they benefit from the constant flow of suspended food (Purdy, 1964; Gray, 1981; Woodin, 1976). Lower current velocities result in decreased sediment grain size, higher organics within the substrate, and greater sediment stability; thus, deposit feeders tend to thrive in these areas (Purdy, 1964; Thorson, 1957; Sanders, 1958). The possible influence of current velocity on grain size was not apparent at the Coos Bay study site since there were no significant differences in grain size among the ten stations or between both cruises. However, the currents may have accounted for the similarities in sediment parameters between the two cruises. Generally, currents in this region of the bay are strong so that much of the disposed material could have been eroded rapidly and removed from the area.

In addition to current patterns, the amount of material dumped, disposal time, and disposal method can affect the extent to which the benthos is impacted (Van Dolah et al., 1984). Van Dolah et al. (1984) found very little impact on the benthic infauna at an open water disposal site in the North Edisto River, South Carolina. This was attributed, in part, to the strong tidal currents present at the site and the moderate amounts of disposal material (28,475 cubic meters). The disposal occurred in autumn when many species were less active after typical periods of high spring and summer recruitment. Van Dolah et al.(1984) concluded that the surface disposal method allowed for a greater dispersal of sediments. The time of disposal may have differential effects depending on the species present at the site and their life histories. Guillou and Hily (1983), for example, determined that the polychaete, Melinna palmata, spawn during August-October and settle in late autumn and early winter. This species could be negatively affected by an autumn disposal.

Water Quality Parameters

Tables 6 and 7 include water quality parameters measured at several stations during the September, 1986 cruise. Temperature decreased only slightly with depth (0.1 - 0.4 °C). Conductivity also varied little with depth. This is typical of a well-mixed environment. Both temperature and conductivity were fairly constant throughout for all stations. Stable readings were found for pH, oxidation reduction potential, and dissolved oxygen.

Table 6. Water temperature, conductivity, pH, and oxidation reduction potential data for four stations in Coos Bay, September, 1986.

Station	Time	Depth (m)	Temp (°C)	Conductivity (mmho/cm)	pH	ORP
CBG-1	1030	0.0	12.7	.507	7.49	144
		1.9	12.7	.507	7.50	144
		3.6	12.6	.507	7.49	147
CBG-2	1050	0.0	12.8	.506	7.19	179
		8.6	12.5	.507	7.50	176
		3.1	12.7	.507	7.38	123
CBG-6	1200	0.0	12.6	.501	7.47	137
		0.0	12.4	.507	7.48	144
		3.1	12.3	.504	7.49	140
		6.3	11.9	.508	7.49	144
CBG-10	1315	0.0	11.7	.507	7.56	136

CBG = Coos Bay study area G

Table 7. Dissolved oxygen data for three stations in Coos Bay September, 1986.

Station	Time	Depth	Bottle #	DO-mg/1
CBG-4	1120	Mid	145	7.68
			877	7.68
			712	7.88
CBG-8	1240	Mid	344	8.87
			346	8.19
			380	8.86
CBG-9	1255	Bottom	164	7.97
		(6.97 m)	231	8.65
			276	8.01

Classification

Classification results for this study are described below.

Station Classification

Station clusters determined by both Ward's Method and TWINSPAN analyses of the community matrix are given in Tables 8-10. Each table contains seven station clusters. To compare clusters, the average number of individuals, number of taxa, diversity and evenness at each station have also been included in the tables. Dendrograms for both TWINSPAN and Ward's Method are given in Figures 18-20.

Table 8 contains TWINSPAN station clusters based on 85 species and abundances transformed by squareroot. The corresponding dendrogram representing the 10 stations from May and September cruises is shown in Figure 18. Stations within a cluster generally had similar averages for overall abundance, taxa richness, diversity and evenness values. With the exception of Station 2, May stations formed one group together. These stations tended to have fewer organisms and fewer species. Station 2, which had a greater number of individals, taxa richness and diversity in May, was more similar to September Stations 1,4, and 5. When seven clusters were formed from the total number of stations, September samples from Station 2 comprised a separate cluster. This station had the highest number of organisms and richness, and lowest evenness value. Similarly, in September, Station 10 had a high abundance and low evenness, although its taxa richness was approximately half the richness of Station 2; therefore, it was contained within a separate cluster.

Although there were a few differences in grain size distribution

Table 8. TWINSPAN station clusters obtained when samples were transformed by squareroot and aggregated.

	Month	Station	Average # Ind	# Taxa	He	J
Cluster 1	Sept	CBG-2	2142.0	41.6	1.576	.437
Cluster 2	May	CBG-2	143.8	19.4	2.128	.752
	Sept	CBG-1	341.4	41.6	2.590	.735
		CBG-4	650.8	34.8	2.116	.603
		CBG-5	222.6	21.2	2.212	.801
Cluster 3	Sept	CBG-10	1268.4	19.8	1.455	.647
Cluster 4	Sept	CBG-3	71.6	12.8	2.034	.809
		CBG-7	73.2	12.0	1.912	.821
Cluster 5	Sept	CBG-6	116.0	10.8	1.485	.640
		CBG-8	24.8	8.2	1.687	.814
		CBG-9	64.4	11.8	1.507	.631
Cluster 6	May	CBG-1	71.0	9.6	1.370	.633
		CBG-3	99.8	15.0	1.879	.740
		CBG-4	75.4	8.2	1.497	.738
		CBG-5	43.6	9.8	1.558	.741
		CBG-6	25.2	6.2	1.378	.768
Cluster 7	May	CBG-7	28.6	6.4	1.152	.701
		CBG-8	13.8	5.2	1.188	.816
		CBG-9	13.0	8.0	1.833	.948
		CBG-10	13.6	2.6	.620	.560

He = Shannon diversity index, log base e
J = evenness

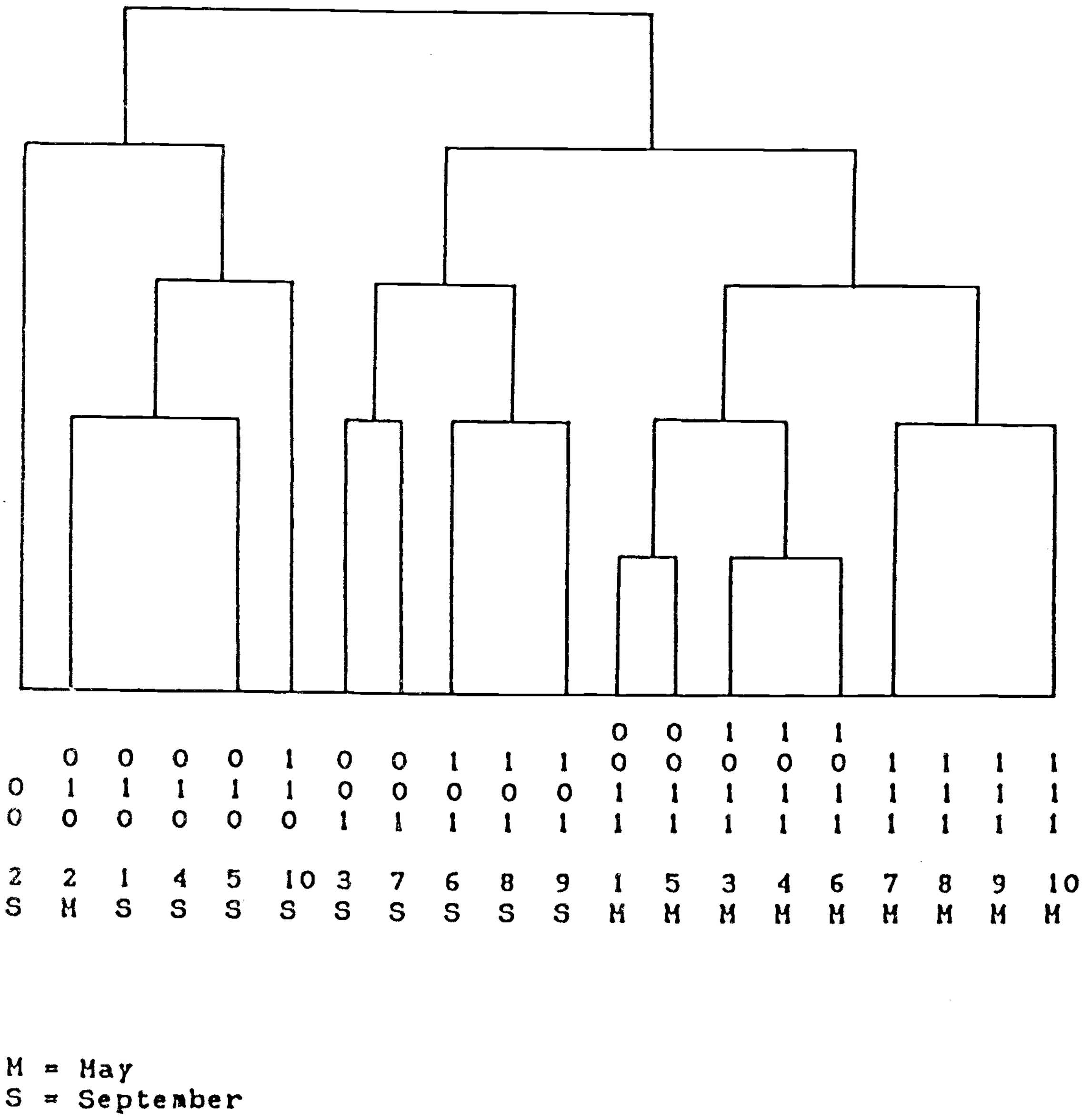

Figure 18. Dendrogram resulting from station clustering by TWINSPAN analysis (based on total abundances).

among some stations and between cruises, the clusters did not reflect these variations. Samples taken from Stations 3 and 7 in September, for example, were grouped together by similar species abundance, yet differed in percent gravel, organics, and fines. The sediment parameters would not be expected to be an important factor controlling species composition and station classification, since there were not significant differences in most sediment parameters.

Clusters obtained when proportional abundances were used in the analysis, were similar to those based on transformed taxa counts (Table 9 and Figure 19). Differences indicate that although stations may have similar counts of a particular species, the relative abundance of that species may differ. The polychaete, *Glycera tenuis*, for example, had the same average abundance at Station 10 during both cruises, while its proportional abundance was reduced from 70% of the species composition in May, to 0.7% in September. The same species increased in average abundance at Station 8 in September, while its proportional abundance decreased from 52% to 35% of the overall abundance. Thus, differences in community structure at several stations are indicated.

The station clusters in Table 10 (and Figure 20 dendrogram) were based on relative abundances of 151 species and determined by the Ward's Method of hierarchical grouping. Not all clusters obtained by this analysis are comparable to those derived through TWINSPAN analysis. Moreover, the constituents of several clusters do not conform to diversity, evenness, taxa richness and total abundance similarities. For example, Cluster 1 members are quite different

Table 9. TWINSPAN station clusters obtained when samples were transformed by squareroot, relativized and aggregated.

	Month	Station	Average			
			# Ind	# Taxa	He	J
Cluster 1	Sept	CBG-2	2142.0	41.6	1.576	.437
Cluster 2	May	CBG-2	143.8	19.4	2.128	.752
Cluster 3	Sept	CBG-1	341.4	41.6	2.590	.735
		CBG-4	650.8	34.8	2.116	.603
		CBG-5	222.6	21.2	2.212	.801
		CBG-10	1268.4	19.8	1.455	.647
Cluster 4	Sept	CBG-7	73.2	12.0	1.912	.821
Cluster 5	May	CBG-1	71.0	9.6	1.370	.633
	Sept	CBG-3	71.6	12.8	2.034	.809
		CBG-6	116.0	10.8	1.485	.640
		CBG-8	24.8	8.2	1.687	.814
		CBG-9	64.4	11.8	1.507	.631
Cluster 6	May	CBG-3	99.8	15.0	1.879	.740
		CBG-4	75.4	8.2	1.497	.738
		CBG-6	25.2	6.2	1.378	.768
		CBG-7	28.6	6.4	1.152	.701
		CBG-9	13.0	8.0	1.833	.948
		CBG-10	13.6	2.6	.620	.560
Cluster 7	May	CBG-5	43.6	9.8	1.558	.741
		CBG-8	13.8	5.2	1.188	.816

He = Shannon diversity index, log base e
J = evenness

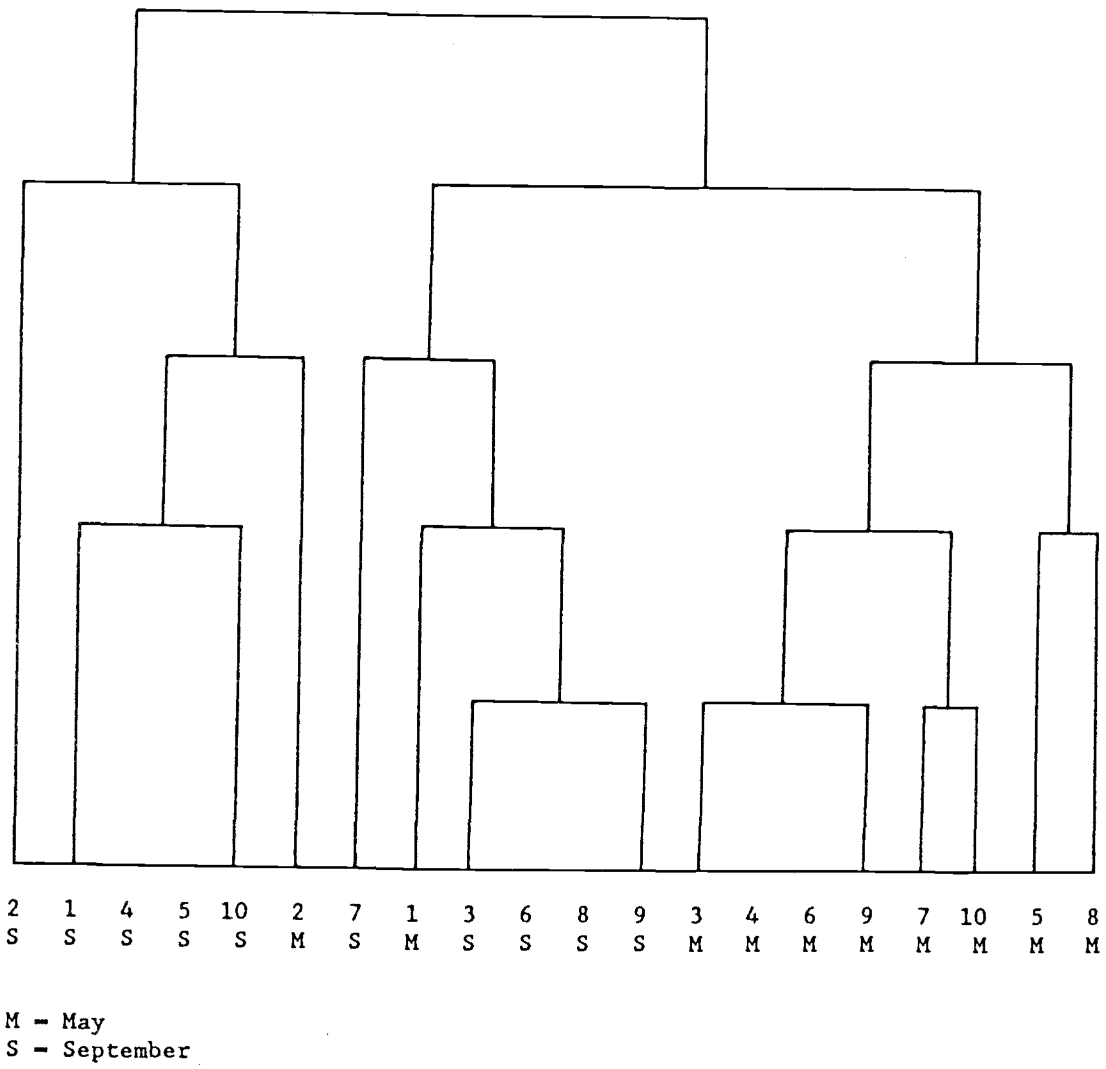

Figure 19. Dendrogram resulting from station clustering by TWINSPAN analysis (based on proportional abundances).

Table 10. Clusters formulated by Ward's Method of hierarchical grouping.

	Month	Station	Average			
			# Ind	# Taxa	He	J
Cluster 1	May	CBG-1	71.0	9.6	1.370	.633
	Sept	CBG-2	2142.0	41.6	1.576	.437
Cluster 2	May	CBG-2	143.8	19.4	2.128	.752
		CBG-3	99.8	15.0	1.879	.740
		CBG-9	13.0	8.0	1.833	.948
	Sept	CBG-10	1268.4	19.8	1.455	.647
Cluster 3	Sept	CBG-1	341.4	41.6	2.590	.735
		CBG-4	650.8	34.8	2.116	.603
		CBG-5	222.6	21.2	2.212	.801
Cluster 4	Sept	CBG-3	71.6	12.8	2.034	.809
		CBG-7	73.2	12.0	1.912	.821
		CBG-8	24.8	8.2	1.687	.814
Cluster 5	Sept	CBG-6	116.0	10.8	1.485	.640
		CBG-9	64.4	11.8	1.507	.631
Cluster 6	May	CBG-4	75.4	8.2	1.497	.738
		CBG-5	43.6	9.8	1.558	.741
		CBG-6	25.2	6.2	1.378	.768
		CBG-7	28.6	6.4	1.152	.701
		CBG-8	13.8	5.2	1.188	.816
Cluster 7	May	CBG-10	13.6	2.6	.620	.560

He = Shannon diversity index, log base e
J = evenness

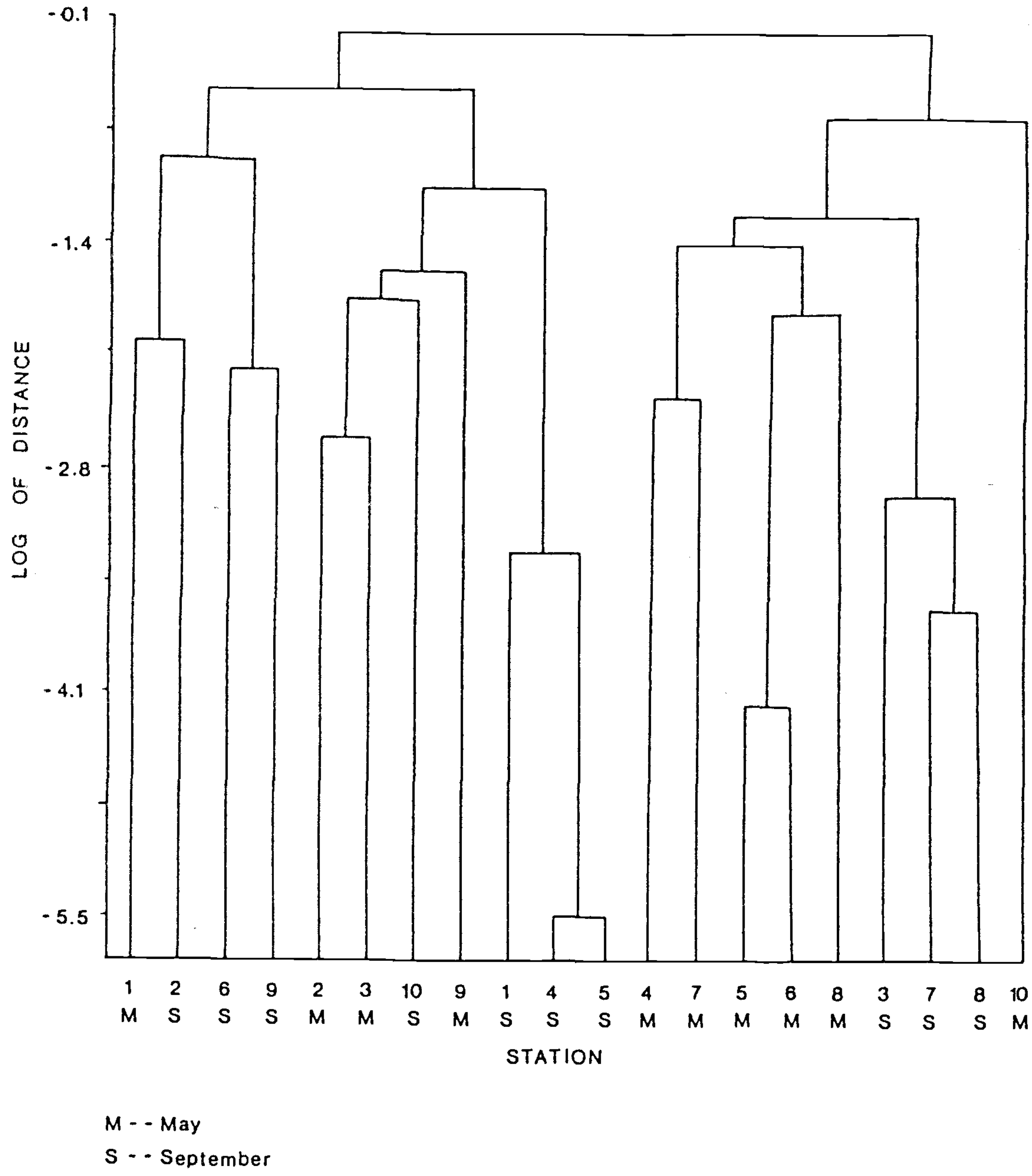

Figure 20. Dendrogram resulting from station clustering by Ward's Method.

except in diversity. Thus, very similar species types and proportional abundances were probably present. Cluster 7, contains Station 10 only. This can be explained by the fact that Station 10 in May was quite different from other stations in diversity, taxa richness and evenness.

Species Classification

The various species clusters formed by the classification analyses are given in Tables 11-13. The tables include the average and total abundance of each species in the clusters, as well as the number of samples in which each occurred at the study site. TWINSPAN results are given in Tables 11 and 12. Eight major species clusters formed by Ward's Method of hierarchical grouping are shown in Table 13. Dendrograms for the TWINSPAN species clusters analyses are also included in Figures 21 and 22.

TWINSPAN analysis has an advantage in that both taxa and stations are clustered. Eight clusters formed by the analysis based on total abundance of each species, are given in Table 11. Figure 21 contains the TWINSPAN ordered two-way table, which consists of species and station ordinations, abundance classes of each species per station and the dendrogram of the species classification. The station dendrogram is given in Figure 18.

The components of the clusters formed by TWINSPAN reflect more than overall average abundance and the number of samples in which each occurred. Several clusters are fairly distinct in their characteristics. For example, Cluster 1 contains species which were found in low abundances in September at Stations 1,2,4,5, and 10. They occurred in May only at Station 2. In contrast to Cluster 1, Cluster 6 consisted of several species which were obtained from most stations, both seasons. These species had relatively high abundances in September. They included Mediomastus californiensis, Mytilidae sp. juveniles, Nemertinea, and Nematoda. Cluster 7 contained several species such as Glycera tenuis and Heteropodarke heteromorpha which were fairly ubiquitous. Both were found in all samples with similar abundances each cruise. Cluster 8 constituants were dissimilar to those of most other clusters in that they appeared more often in May than in September samples. Abundances tended to be were low.

The TWINSPAN clusters based on proportional abundances are contained in Table 12. Many clusters were similar to those based on total abundances. For example, species which occurred only in September at Stations 1,2,4,5, and 10 (and Station 2, in May), were contained in one cluster (Cluster 1), representing a seasonal influence. Similarly, those species which were found at all stations both cruises such as Dendraster excentricus and Heteropodarke heteromorpha, tended to group together. Several species such as Mediomastus californiensis and Spiophanes bombyx had different cluster patterns resulting from each analyses, indicating that although they may have similar total abundances, their relative abundances varied among stations.

Table 13 contains the species clusters obtained by Ward's Method. Cluster 1 consists of the most dominant species. All species in this cluster were found in at least 52% of the samples.

Table 11. Eight cluster stage for TWINSPAN analysis based on total abundances of each species at each station. Values below were determined out of 100 samples. Rare species were excluded.

Taxa	Mean	Sum	Max	n	Feeding Type
Cluster 1					
Paleonotus bellis	3.27	327	60	16	
Parapleustes pugettensis	1.24	124	76	11	
Ischyrocerus pelagops	1.15	115	54	14	
Eulalia viridis	.89	89	31	11	
Ianiropsis kincaidi	.55	55	45	6	
Nicolea sp. A	.38	38	8	10	
Exogone lourei	.33	33	11	12	
Melita desdichada	.26	26	6	11	
Leptochelia dubia	.25	25	6	9	
Platyhelminthes	.21	21	11	7	
Lumbrineris sp. juvenile	.17	17	3	12	
Alvinia spp. juvenile	.13	13	10	4	
Polysp	.13	13	5	6	
Gammaridea	.13	13	5	6	
Sabellidae	.06	6	4	3	
Hiatella artica	.06	6	3	3	
Prionospio cirrifera					
Cluster 2					
Photis macinerneyi	.29	29	14	4	
Platynereis bicanaliculata	1.44	144	37	16	
Phyllodoce sp. 1	23.09	2309	501	24	
Syllidae	6.96	696	268	20	
Armandia brevis	5.55	555	96	19	DF
Pycnogonida	1.83	183	163	13	
Photis brevipes	1.72	172	78	14	
Malococerus glutaeus	1.68	168	36	19	
Nudibranchia	.62	62	21	13	
Anthozoa	.23	23	6	8	
Jassa falcata	.13	13	8	5	
Spisula falcata	.23	23	5	12	

Table 11. (continued)

Cluster 3					
Owenia fusiformis	18.42	1842	584	14	DF,SF
Tellina modesta	3.87	387	97	10	SF
Glycinde picta	2.94	294	113	10	
Clinocardium nuttallii juv.	1.79	179	39	13	SF
Oligochaeta	1.18	118	90	9	
Photis spp. juvenile	.84	84	17	14	
Capitella capitata	.40	40	10	14	
Cancer sp. megalopa	.07	7	1	7	
Lacuna vincta	.04	4	1	4	
Cluster 4					
Chone dunneri	1.46	146	120	12	
Adula diagensis	.64	64	21	11	
Cancer magister	.23	23	6	12	C
Hesionura coineaui difficilis	.19	19	11	5	
Polydora socialis	.19	19	4	11	
Gnorimosphaeroma oregoniensis	.09	9	4	4	
Olivella pycna	.05	5	2	4	
Mytilus sp. juvenile	.04	4	2	3	
Cluster 5					
Siliqua patula	2.42	242	57	23	SF
Pygospio elegans	.64	64	19	14	
Caprellidae sp.	.55	55	17	15	
Polygordius sp. indeterminate	.43	43	11	13	
Anomura sp. zoea	.12	12	2	10	
Gastropoda sp.	.10	10	2	7	
Cluster 6					
Mediomastus californiensis	73.36	7336	2459	61	DF
Mytilidae sp. juvenile	52.16	5216	4202	57	SF
Nemertinea	5.99	599	60	77	
Nematoda	1.18	118	49	22	C,DF,D
Phyllodoce sp.	.94	94	62	9	
Tapes philippinarium	.41	41	23	12	
Zirfaea pilsbryii	.16	16	6	7	
Phoxocephalidae sp.	.08	8	1	8	

Table 11. (continued)

Cluster 7

Spiophanes bombyx	12.81	1281	149	57	DF
Glycera tenuis	8.55	855	26	92	
Heteropodarke heteromorpha	7.50	750	51	73	
Dendraster excentricus	2.26	226	29	52	SF
Spio filicornis	.40	40	16	11	
Ophelia sp. juvenile	.25	25	8	11	
Nephtys caecoides	.20	20	4	16	C
Olivella biplicata	.08	8	2	6	
Tellina nuculoides	.09	9	3	6	
Glycera convoluta	.05	5	1	5	
Lamprops quadriplicata	.04	4	2	3	

Cluster 8

Protothaca staminea	2.24	224	53	18	SF
Magelona sacculata	.25	25	7	13	DF
Ammodytes hexapterus	.24	24	4	13	C
Opheliidae sp. juvenile	.22	22	3	16	
Bivalvia sp. juvenile	.15	15	9	5	
Onuphis elegans	.15	15	3	8	
Mandibulophoxus uncirostratus	.13	13	3	10	
Atylus tridens	.10	10	4	6	
Paraonella platybranchia	.10	10	2	8	
Nephtys sp. juvenile	.10	10	3	8	
Archeomysis grebnitzkii	.09	9	2	7	
Nephtys californiensis	.08	8	2	7	
Macoma sp. juvenile	.07	7	2	6	
Scoloplos armiger	.07	7	2	6	

Mean = average abundance (100 samples)
Sum = total number of individuals (100 samples)
Max = maximum number of individuals in any one sample
n = number of samples in which the taxa occurred
C = carnivore
DF = deposit feeder
SF = suspension feeder
D = detritivore

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                                      22145037689153467890

Exogone lourei                        211111--------------  000000
Lumbrineris sp. juvenile              1111----------------  000000
Prionospio cirrifera                  1-11----------------  000000
Leptochelia dubia                     1-1111--------------  000001
Eulalia viridis                       1112-1--------------  000001
Gammaridea sp.                        11-111--------------  000001
Ischyrocerus pelagops                 121212--------------  000010
Parapleustes pugettensis              111212--------------  000010
Alvinia spp. juvenile                 --1111--------------  000010
Hiatella arctica                      --1-11--------------  000010
Nicolea sp. A                         --11-1--------------  000010
Polycirrus sp. complex                --1111--------------  000010
Sabellidae                            ---111--------------  000010
Ianiropsis kincaidi kincaidi          ---112--------------  000011
Melita desdichada                     -1111---------------  0001
Paleonotus bellis                     -11321-1------------  0001
Platyhelminthes                       -1-11---------------  0001
Nudibranchia                          -11112----1---------  0010
Syllidae                              -12324-1----1-------  0010
Photis brevipes                       1121-1--1-----------  001100
Pycnogonida                           -11113-1----1-------  001100
Spisula cf. falcata                   1111-1-------1------  001100
Armandia brevis                       2-342211------------  001100
Malacocerus glutaeus                  1-12211-------------  001100
Anthozoa                              -11111------1-------  001100
Jassa falcata                         --1111----1---------  001101
Photis macinerneyi                    -12-------------1--   001101
Phyllodoce sp. I                      113541111-------1---  001101
Platynereis bicanaliculata            -12212------1----11-  00111
Photis sp. juvenile                   2121-1-----------1--  010000
Cancer sp. megalopa                   1--11-------------1-  010000
Lacuna vincta                         1-1--1----------1---  010000
Clinocardium nuttallii juv.           3-111-1-------------  010000
Glycinde picta                        4-11--1-------------  010001
Owenia fusiformis                     5-31--1----1--------  010001
Capitella capitata                    1-111--1------------  01001
Oligochaeta                           2-11--1-------------  01001
Tellina modesta                       4-1---1-1-----------  0101
Gnorimosphaeroma oregonensis          -1-1--1-------------  01100
Adula diegensis                       -12-12---11--1------  01100
Hesionura coineaui difficilis         ----11-1------------  01100
Cancer magister                       -1111--1---------1--  01101
Mytilus sp. juvenile                  --11----------1-----  01101
Olivella pycna                        1-1---------1-------  0111
Chone dunneri                         11-1-3---------1-1-1- 0111
Polydora socialis                     1-111--1----1-------  0111
Pygospio elegans                      2-11-1-1-----1--1-1-  1000
Siliqua patula                        3-11--2-1-11--------  10010
Caprellidae                           1-11111--11---------  10011
Anomura sp. zoea                      1-11-----1-------1--  10011
Gastropoda                            1--11-----1--------1- 10011
Polygordius sp. indeterminate         --1-11-1-1----------  10011
Phoxocephalidae                       1-11--------1--1---1- 1010
Tapes philippinarius                  -11-12-----1-1-1----  1010
Zirfaea pilsbryii                     --1--1--------11----  1010
Nematoda                              211111-----1111--11-  1010
Mytilidae spp. juvenile               13322512-11-1321211-  1011
Mediomastus californiensis            5323212211131121----  1011
Phyllodoce sp. juvenile               12----1-----1---1---  1011
Nemertinea                            31222222111111111111  1011
Lamprops quadriplicata                1-----1-1-----------  11000
Tellina nuculoides                    -----11-11----------  11000
Glycera convoluta                     1-----1---------1---  110010
Olivella biplicata                    11----1--11--1------  110011
Nephtys caecoides                     1-1--1--11111-------  110011
Spio filicornis                       1-1-------2----1--1-  110011
Spiophanes bombyx                     41321-22413211-1----  110011
Dendraster excentricus                111111212111111-1--   110011
Glycera tenuis                        12222222221222222212  1101
Heteropodarke heteromorpha            12112122221122221111  1101
Ophelia sp. juvenile                  1----11-1--1---1--1-  1101
Mandibulophoxus uncirostratus         ------1-111--1-1--1-  111000
Ophelia sp. I                         1-------1111------1-  111000
Archeomysis grebnitzkii               -1--------1-11---11-  111001
Paraonella platybranchia              ----------1--11---1-  111001
Ammodytes hexapterus                  -1------1--111-11-11  111001
Atylus tridens                        --1r---------1--11--  11101
Macoma spp. juvenile                  -11---1-----11------  11101
Nepthys californiensis                --1-1---1----1-1--1-  11101
Nephtys sp. juvenile                  1--------------111-1- 11101
Scoloplos armiger                     1-1---------11-1----  11110
Bivalvia sp. juvenile                 1--1----------11----  11111
Protothaca staminea                   211--2---1-1-3----11  11111
Magelona sacculata                    1-1--1----1111------  11111
Onuphis elegans                       1-1---------11------  11111

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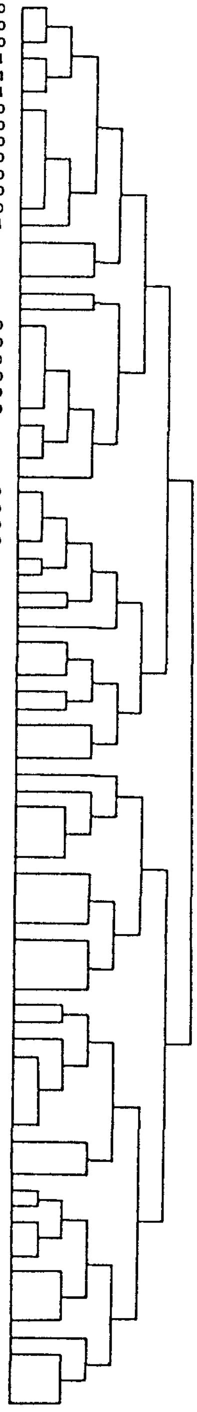

Figure 21. Community matrix and dendrogram resulting from TWINSPAN analysis (based on total abundances).

Table 12. Eight cluster stage for TWINSPAN analysis based on proportional abundances of each species at each station Values below were determined out of 10 samples. Rare species were excluded.

Taxa	Mean	Sum	Max	n	Feeding Type
Cluster 1					
Mediomastus californiensis	73.36	7336	2459	61	DF
Spiophanes bombyx	12.81	1281	149	57	DF
Siliqua patula	2.42	242	57	23	SF
Nephtys caecoides	.20	20	4	16	C?
Olivella biplicata	.08	8	2	6	
Tellina nuculoides	.09	9	3	6	
Lamprops quadriplicata	.04	4	2	3	
Cluster 2					
Glycera tenuis	8.55	855	26	92	
Heteropodarke heteromorpha	7.50	750	51	73	
Nemertinea	5.99	599	60	77	
Dendraster excentricus	2.26	226	29	52	SF
Spio filicornis	.40	40	16	11	
Ophelia sp. juvenile	.25	25	8	11	
Ammodytes hexapterus	.24	24	4	13	C
Opheliidae sp. juvenile	.22	22	3	16	
Mandibulophoxus uncirostratus	.13	13	3	10	
Atylus tridens	.10	10	4	6	
Paraonella platybranchia	.10	10	2	8	
Nephtys sp. juvenile	.10	10	3	8	
Archeomysis grebnitzkii	.09	9	2	7	
Nephtys californiensis	.08	8	2	7	
Glycera convoluta	.05	5	1	5	
Cluster 3					
Adula diagensis	.64	64	21	11	
Polygordius sp. indeterminate	.43	43	11	13	
Magelona sacculata	.25	25	7	13	DF
Onuphis elegans	.15	15	3	8	
Anomura sp.	.12	12	2	10	
Olivella pycna	.05	5	2	4	

Table 12. (continued)

Cluster 4

Mytilidae sp. juvenile	52.16	5216	4202	57	SF
Protothaca staminea	2.24	224	53	18	SF
Chone dunneri	1.46	146	120	12	
Nematoda	1.18	118	49	22	C,DF,D
Phyllodoce sp.	.94	94	62	9	
Pygospio elegans	.64	64	19	14	
Tapes philippinarium	.41	41	23	12	
Photis macinerneyi	.29	29	14	4	
Zirfaea pilsbryii	.16	16	6	7	
Bivalvia sp. juvenile	.15	15	9	5	
Phoxocephalidae sp.	.08	8	1	8	
Macoma sp. juvenile	.07	7	2	6	
Scoloplos armiger	.07	7	2	6	

Cluster 5

Hesionura coineaui difficilis	.19	19	11	5	
Polydora socialis	.19	19	4	11	
Caprellidae sp.	.55	55	17	15	

Cluster 6

Owenia fusiformis	18.42	1842	584	14	DF,SF
Tellina modesta	3.87	387	97	10	SF?
Glycinde picta	2.94	294	113	10	
Platynereis bicanaliculata	1.44	144	37	16	
Oligochaeta	1.18	118	90	9	
Lacuna vincta	.04	4	1	4	
Gastropoda sp.	.10	10	2	7	
Gnorimosphaeroma oregoniensis	.09	9	4	4	
Cancer sp. megalopa	.07	7	1	7	
Mytilus sp. juvenile	.04	4	2	3	

Cluster 7

Phyllodoce sp. 1	23.09	2309	501	24	
Syllidae	6.96	696	268	20	
Pycnogonida	1.83	183	163	13	
Photis spp. juvenile	.84	84	17	14	
Nudibranchia	.62	62	21	13	
Capitella capitata	.40	40	10	14	
Cancer magister	.23	23	6	12	C
Anthozoa	.23	23	6	8	
Jassa falcata	.13	13	8	5	

Table 12. (continued)

Cluster 8

Armandia brevis	5.55	555	96	19	DF
Paleonotus bellis	3.27	327	60	16	
Clinocardium nuttallii juv.	1.79	179	39	13	SF
Photis brevipes	1.72	172	78	14	
Malococerus glutaeus	1.68	168	36	19	
Parapleustes pugettensis	1.24	124	76	11	
Ischyrocerus pelagops	1.15	115	54	14	
Eulalia viridis	.89	89	31	11	
Ianiropsis kincaidi	.55	55	45	6	
Nicolea sp. A	.38	38	8	10	
Exogone lourei	.33	33	11	12	
Melita desdichada	.26	26	6	11	
Leptochelia dubia	.25	25	6	9	
Spisula falcata	.23	23	5	12	
Platyhelminthes	.21	21	11	7	
Lumbrineris sp. juvenile	.17	17	3	12	
Alvinia spp. juvenile	.13	13	10	4	
Polysp	.13	13	5	6	
Gammaridea	.13	13	5	6	
Sabellidae	.06	6	4	3	
Hiatella artica	.06	6	3	3	
Prionospio cirrifera					

Mean = average abundance (100 samples)
Sum = total number of individuals (100 samples)
Max = maximum number of individuals in any one sample
n = number of samples in which the taxa occurred
C = carnivore
DF = deposit feeder
SF = suspension feeder
D = detritivore

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                                   SSSSSHSHSSSSHHHHHHHH
                                   11112 1 1111     1
                                   21450271368934697058

Malacoceros glutaeus               11221---1-----------  111111
Armandia brevis                    12321-1-1-----------  111111
Sabellidae                         --111---------------  111110
Polycirrus sp. complex             -1111---------------  111110
Paleonotus bellis                  -133112-------------  111110
Nicolea sp. A                      -11-1---------------  111110
Hiatella arctica                   -1-11---------------  111110
Alvinia sp. juvenile               -1111---------------  111110
Leptochelia dubia                  11111---------------  111110
Ianiropsis kincaidi kincaidi       --111---------------  111110
Parapleustes pugettensis           112221--------------  111110
Platyhelminthes                    --12-2--------------  111101
Melita desdichada                  -111-2--------------  111101
Gammaridea                         1-1111--------------  111100
Exogone lourei                     111111--------------  111100
Eulalia viridis                    112-11--------------  111100
Ischyrocerus pelagops              111222--------------  111100
Prionospio cirrifera               111-----------------  11101
Lumbrineris sp. juvenile           111--1--------------  11101
Spisula cf. falcata                111-11------1-------  11101
Photis brevipes                    121-11---1----------  11101
Clinocardium nuttallii juv.        2111----1-----------  11100
Syllidae                           -233221-----------2-  1101
Jassa falcata                      -1111------1--------  1101
Cancer magister juvenile           -111-21---------2---  110011
Anthozoa                           -11111------------2-  110010
Capitella capitata                 1111--1-------------  110010
Pycnogonida                        -111211-----------2-  110010
Photis spp. juvenile               121-11-------------2  110010
Phyllodoce sp. 1                   1344113-22------2---  11000
Nudibranchia                       -11111-----2--------  11000
Platynereis bicanaliculata         -12112---------2--22  1011
Mytilus spp. juvenile              -11---------1-------  1011
Gastropoda sp.                     1-11-------1---2----  1011
Lacuna vincta                      11--1-----------2---  10101
Cancer sp. megalopa                1-11-----------2----  10101
Oligochaeta                        211-----2-----------  101001
Owenia fusiformis                  431----21-----------  101001
Glycinde picta                     211-----1-----------  101001
Tellina modesta                    31-------11---------  101001
Gnorimosphaeroma oregonensis       --1--2--1-----------  101000
Polydora socialis                  1111--2-----------2-  100
Heslonura coineaui difficilis      ---11-2-------------  100
Caprellidae                        11111---1-21--------  100
Chone dunneri                      1-1-22-------2-22---  01111
Zirfaea pilsbryii                  -1--1-------11------  01111
Nematoda                           211112-1----23-2--22  011101
Pygospio elegans                   111-1-1-----1--22---  011101
Tapes philippinarum                -1-111-1----2-3-----  011101
Protothaca staminea juvenile       21--11-1--2-4--2-3--  011100
Bivalvia sp. juvenile              1-1---------21------  011100
Phoxocephalidae                    111----1-----1-2----  011100
Scoloplos armiger                  11-----1-----1----2-  01101
Phyllodoce sp. juvenile            1----3--1-------2-2-  01101
Macoma spp. juvenile               -1---1--1---1-----2-  01101
Photis macinerneyi                 -1---1-------------3  01101
Mytilidae sp. juvenile             1323444-2-2144234-33  01100
Polygordius sp. indeterminate      -1-21-3---2---------  0101
Adula diegensis                    -1-111----222-------  0101
Olivella pycna                     11-----2------------  0101
Onuphis elegans                    11-----2----------2-  0100
Magelona sacculata                 11--1--1---21-----2-  0100
Anomura sp. zoea                   111-------2-----2---  0100
Archeomysis grebnitzkii            -----1-----11--2--22  001111
Acylus tridens                     -1----------1---3--3  001111
Spio filicornis                    11---------3--23----  001110
Ophelia sp. juvenile               1---1--211----22----  001110
Nephtys californiensis             -1-1-----1--1-22----  001110
Heteropodarke heteromorpha         11121341444135524544  001110
Glycera tenuis                     11221344344334535545  001110
Glycera convoluta                  1-------1-----2-----  001110
Nemertinea                         22222233423223333333  00110
Oendraster excentricus             111111323433213---33  00110
Ammodytes hexapterus               -----1-1-1--2-23332-  00101
Parapleustes pugettensis           -----------212-2----  00101
Nephtys sp. juvenile               1------------2232---  00101
Ophelia sp. 1                      1------2-222---2----  00100
Mandibulophoxus uncirostratus      --------11221-22----  00100
Nephtys caecoides                  11--1--2-222------2-  0001
Tellina nuculoides                 ----1---122---------  0001
Siliqua patula                     211----133-2--------  0001
Lamprope quadriplicata             1-------12----------  0001
Spiophanes bombyx                  3222-23445352-2---2-  0000
Mediomastus californiensis         522213353232232---2-  0000
Olivella biplicata                 1----1--1-211-------  0000

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                                    0000101111100000011
                                            01111000011
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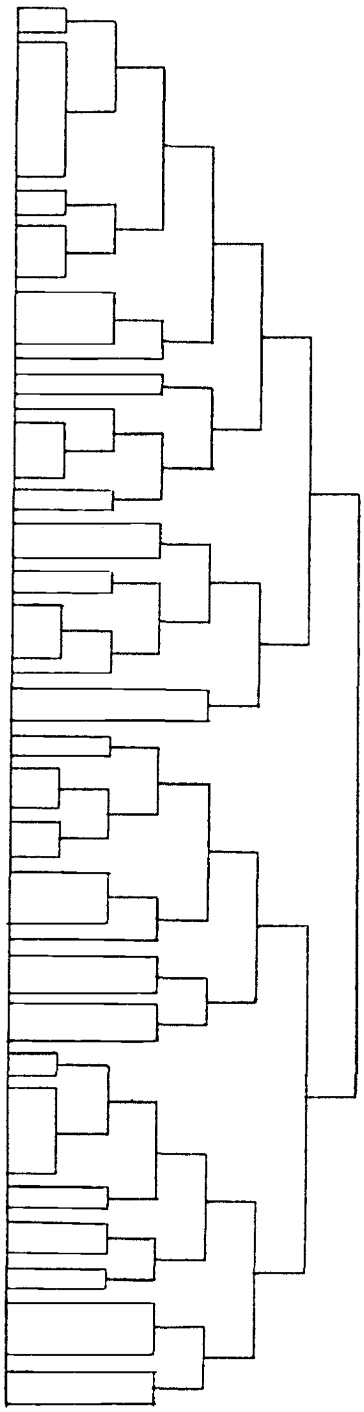

Figure 22. Community matrix and dendrogram resulting from TWINSPAN analysis (based on proportional abundances).

Table 13. Eight main species clusters obtained by Ward's Method of cluster analysis. Clusters were based on proportional abundances of each species from 100 samples. Rare species were excluded.

Taxa	Mean	Sum	Max	n	Feeding Type
Cluster 1					
Mediomastus californiensis	73.36	7336	2459	61	DF
Mytilidae sp. juvenile	52.16	5216	4202	57	SF
Spiophanes bombyx	12.81	1281	149	57	DF
Glycera tenuis	8.55	855	26	92	
Heteropodarke heteromorpha	7.50	750	51	73	
Nemertinea	5.99	599	60	77	
Dendraster excentricus	2.26	226	29	52	SF
Cluster 2					
Phyllodoce sp. 1	23.09	2309	501	24	
Syllidae	6.96	696	268	20	
Armandia brevis	5.55	555	96	19	DF
Paleonotus bellis	3.27	327	60	16	
Malococerus glutaeus	1.68	168	36	19	
Cluster 3					
Owenia fusiformis	18.42	1842	584	14	DF,SF
Tellina modesta	3.87	387	97	10	SF?
Macoma balthica	3.08	308	109	8	DF?
Glycinde picta	2.94	294	113	10	
Clinocardium nuttallii juv.	1.79	179	39	13	SF
Oligochaeta	1.18	118	90	9	
Cluster 4					
Siliqua patula	2.42	242	57	23	SF
Nudibranchia	.62	62	21	13	
Spio filicornis	.40	40	16	11	
Magelona sacculata	.25	25	7	13	DF
Ophelia sp. 1	.22	22	3	16	
Nephtys caecoides	.20	20	4	16	C?

Table 13. (continued)

Cluster 5					
Platynereis bicanaliculata	1.44	144	37	16	
Nematoda	1.18	118	49	22	C,DF,D
Photis spp. juvenile	.84	84	17	14	
Photis macinerneyi	.29	29	14	4	
Atylus tridens	.10	10	4	6	
Archeomysis grebnitzkii	.09	9	2	7	
Isaeidae sp.	.03	3	1	3	
Cluster 6					
Protothaca staminea	2.24	224	53	18	SF
Ammodytes hexapterus	.24	24	4	13	C
Crangon stylirostrus	.03	3	3	1	
Cluster 7					
Pycnogonida	1.83	183	163	13	
Photis brevipes	1.72	172	78	14	
Capitella sp. C	1.63	163	163	1	
Parapleustes pugettensis	1.24	124	76	11	
Ischyrocerus pelagops	1.15	115	54	14	
Eulalia viridis	.89	89	31	11	
Cluster 8					
Chone dunneri	1.46	146	120	12	
Phyllodoce sp. juvenile	.94	94	62	9	DF,C
Pygospio elegans	.64	64	19	14	
Cancer magister	.23	23	6	12	C
Allorchestes angustus	.05	5	3	3	
Lacuna vincta	.04	4	1	4	

Mean = average abundance (100 samples)
Sum = total number of individuals (100 samples)
Max = maximum number of individuals in any one sample
n = number of samples in which the taxa occurred
C = carnivore
DF = deposit feeder
SF = suspension feeder
D = detritivore

Their mean abundances tended to be higher than the constituents of other clusters, with the exception of the echinoderm, Dendraster excentricus. The inclusion of this species within Cluster 1 is related its constancy rather than its absolute abundance. Cluster 1 species appeared at most stations in both May and September (see Appendix C), although their proportional abundances varied among stations and between cruises. Most of these species are common to Oregon estuaries. Generally the clusters formed by Ward's Method contained species which were similar in abundance at most stations for both seasons.

Community Composition

Community structure parameters in Table 14 represent average values obtained at each site. Diversity was lowest at Station 10 during May, whereas Station 2 had the highest average diversity. Although one sample at Station 10 in September contained the highest number of taxa (67) observed at all stations during both months, the other four samples were sufficiently low that Station 10 retained the lowest diversity rank. Station 1 had the greatest diversity index in September. Figure 23 illustrates the diversity values for all stations during both sample dates. With the exception of Stations 2 and 9, diversity values increased significantly by September ($p < .05$).

Although diversity decreased at Stations 2 and 9 in September, richness increased by at least 23 taxa at Station 2. Station 1 had the greatest increase in average richness (32 taxa), while Station 4

Table 14. Averaged community structure parameters for ten Coos Bay stations in May and September, 1986.

Station	H_e	S	J	# Indiv
May				
MCBG-1	1.370	9.6	0.633	71.0
MCBG-2	2.128	19.4	0.752	143.8
MCBG-3	1.879	15.0	0.740	99.8
MCBG-4	1.497	8.2	0.738	75.4
MCBG-5	1.558	9.8	0.741	43.6
MCBG-6	1.378	6.2	0.768	25.2
MCBG-7	1.152	6.4	0.701	28.6
MCBG-8	1.188	5.2	0.816	13.8
MCBG-9	1.833	8.0	0.948	13.0
MCBG-10	0.620	2.6	0.560	13.6
September				
SCBG-1	2.590	41.6	0.735	341.4
SCBG-2	1.576	41.6	0.437	2142.0
SCBG-3	2.034	12.8	0.809	71.6
SCBG-4	2.116	34.8	0.603	650.8
SCBG-5	2.212	21.2	0.801	222.6
SCBG-6	1.485	10.8	0.640	116.0
SCBG-7	1.912	12.0	0.821	73.2
SCBG-8	1.687	8.2	0.814	24.8
SCBG-9	1.507	11.8	0.631	64.4
SCBG-10	1.455	19.8	0.647	1268.4

H_e = Shannon diversity index
S = Taxa richness- number of different taxa within a sample
J = Evenness $J = H_e/\ln(S)$
# Indiv. = Total number of individuals within a sample
MCBG = May Coos Bay study area G
SCBG = September Coos Bay study area G

*note - The above values are averages obtained from the 5 samples taken at each site.

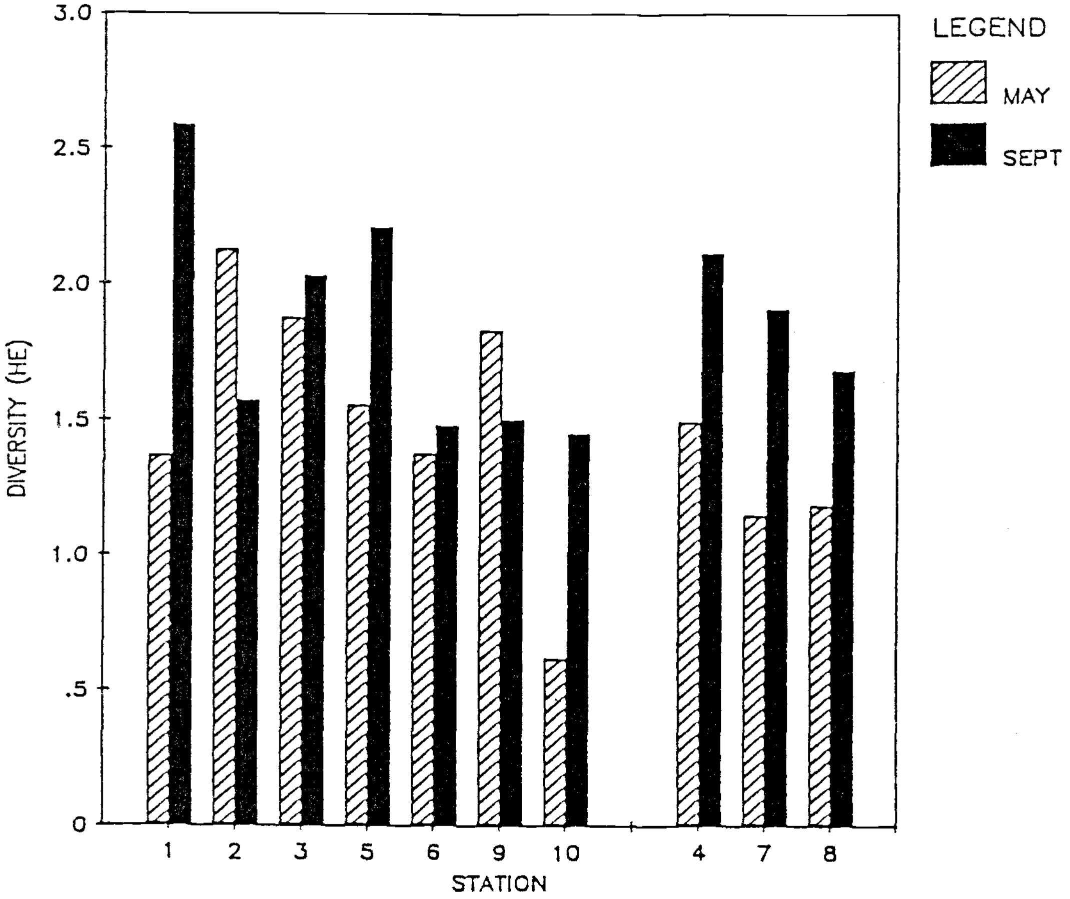

Figure 23. Diversity at each station during May and September.

increased by about 26 taxa (averaged). Figure 24 represents the number of taxa observed at all stations, on both sample dates. With the exception of Station 3, all stations increased in richness by September. Stations 1,2,4,6,7, and 8 all showed significant increases in taxa in September (Table 15, $p < .02$). Stations 1 and 2 generally had the highest average number of taxa, while Stations 6,7, and 8 had lower values. The smallest number of taxa was observed at Station 10 during May.

Station 9 had the highest evenness value ($J = .948$) in May, while the highest value ($J = .821$) was observed at Station 7 in September. Thus, at these stations abundances of the various taxa were similar and no species dominated the samples. Station 10 had the lowest evenness value in May, and Station 2 showed the least evenness in September. The low evenness value at Station 2 was due to the dominance of _Mediomastus_ _californiensis_ and _Owenia_ _fusiformis_ (average of 1311 and 329 individuals, respectively). _Glycera_ _tenuis_ dominated the samples from Station 10 in May. The remaining stations showed no trends in evenness patterns. Overall, there was not a significant difference in evenness between May and September (Table 16, $p > .05$).

Pearson correlations between the various community parameters mentioned and possible correlations with depth are included in Table 17. There were no significant correlations with depth. In May, a high correlation between numbers of individuals and number of taxa occurred ($r = .923$), and also between diversity and taxa richness ($r = .871$). Number of individuals and number of taxa were also somewhat correlated in September ($r = .649$).

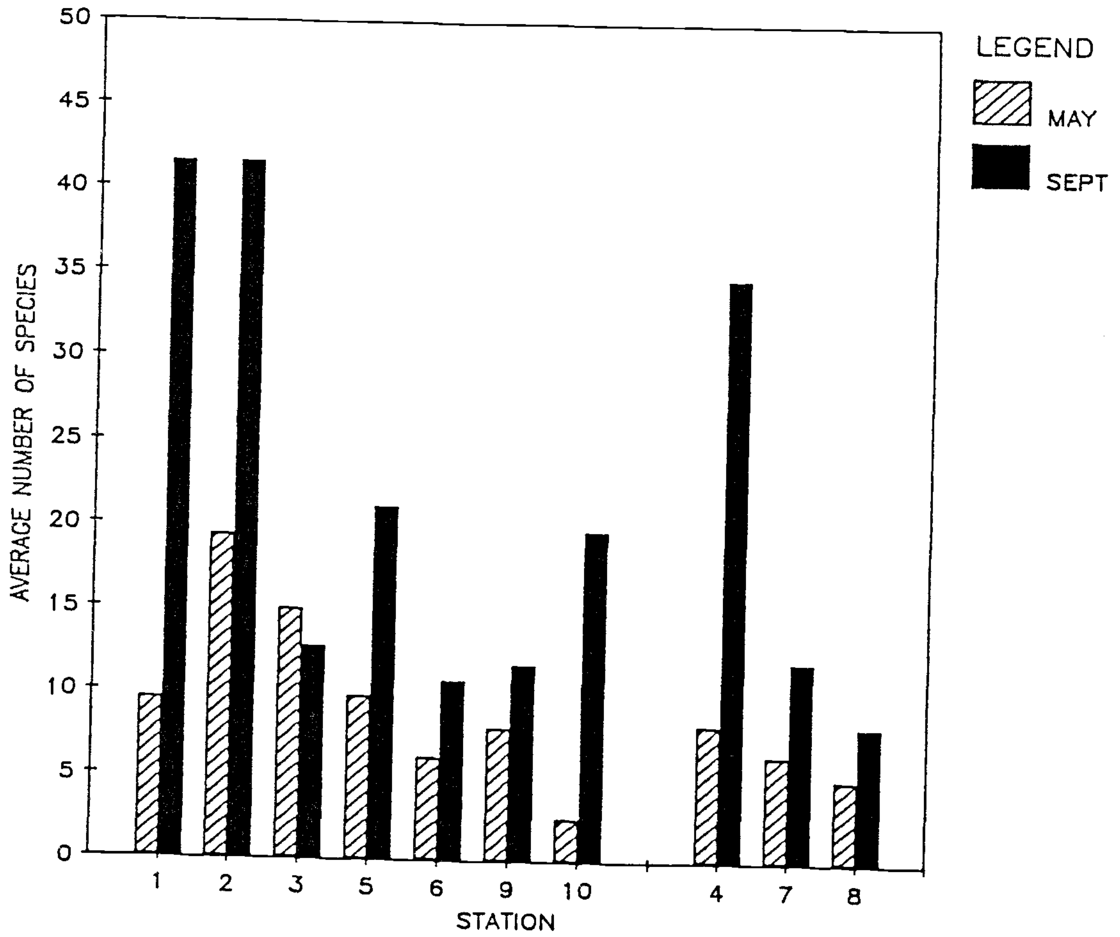

Figure 24. Average number of taxa at each station during May and September.

Table 15. Comparison of average number of taxa between May and September for individual stations (n = 5 samples per station).

Station	Average # of Taxa May	Sept	t-value	Level of Significance
CBG1	9.6	41.6	-4.57	.02
CBG2	19.4	41.6	-4.70	<.01
CBG3	15.0	12.8	0.60	.57
CBG4	8.2	34.8	-13.01	<.01
CBG5	9.8	21.2	-1.94	.09
CBG6	6.2	10.8	-4.90	<.01
CBG7	6.4	12.0	-2.97	.02
CBG8	5.0	8.2	-3.30	.01
CBG9	8.0	11.8	-1.89	.10
CBG10	2.6	19.8	-1.45	.19

Table 16. Comparison of diversity (He), evenness, number of taxa and number of individuals between May and September over all stations (n = 50 samples per season).

Averaged Community Parameters	May	Sept	t-value	Level of Significance
He	1.460	1.863	-4.23	<.01
E	.740	.694	1.38	.17
# Taxa	9.02	21.46	-5.16	<.01
# Indiv.	52.78	497.52	-2.94	<.01

Table 17. Pearson correlations and significance levels for relationships among community structure parameters and depth.

May

	H_e	S	J	# Indiv.	Depth
H_e	1.00 (.00)				
S	.87 (<.01)	1.00 (.00)			
J	.59 (.07)	.16 (.64)	1.00 (.00)		
# Indiv.	.69 (.02)	.92 (<.01)	-.12 (.74)	1.00 (.00)	
Depth	-.27 (.45)	-.13 (.71)	-.33 (.35)	-.05 (.90)	1.00 (.00)

September

	H_e	S	J	# Indiv.	Depth
H_e	1.00 (.00)				
S	.46 (.18)	1.00 (.00)			
J	.43 (.21)	-.55 (.10)	1.00 (.00)		
# Indiv.	-.28 (.43)	.65 (.04)	-.79 (.01)	1.00 (.00)	
Depth	.37 (.29)	.05 (.90)	.41 (.24)	-.05 (.90)	1.00 (.00)

Coefficient (significance level)

In September, the number of individuals and evenness were negatively correlated (r = -.795). The implication is that with an increase in abundances in September, there was a corresponding increase in dominance of certain species (lower evenness). This was observed, as mentioned, at Station 2 in September. Another example is Station 4, which contained high numbers of Phyllodoce sp. 1.

The stations contained within the disposal Site G (Stations 4,7, and 8) did not show consistent patterns or differences in diversity, taxa richness, overall abundance, or evenness from other stations or between cruises. Although Stations 7 and 8 were similar in the various community structure parameters, Station 4 was more similar to some of the controls than to Stations 7 and 8.

Spatial distribution

Several environmental factors may have caused an uneven spatial distribution. Such factors may include sediment grain size, organic content, and current velocity (Purdy, 1964). Biological factors including microbial levels, organic debris available for food, symbiotic relationships, reproduction and competition among species may also contribute to a patchy distribution (Peterson, 1979; Hogue, 1982).

The Chi-square "goodness-of-fit" to a Poisson distribution is often used as a test for departures from randomness in frequency distributions. Figures 25 (May) and 26 (September) show frequency histograms of the number of taxa occurring in individual samples with the Poisson distribution superimposed on each graph. Both May and

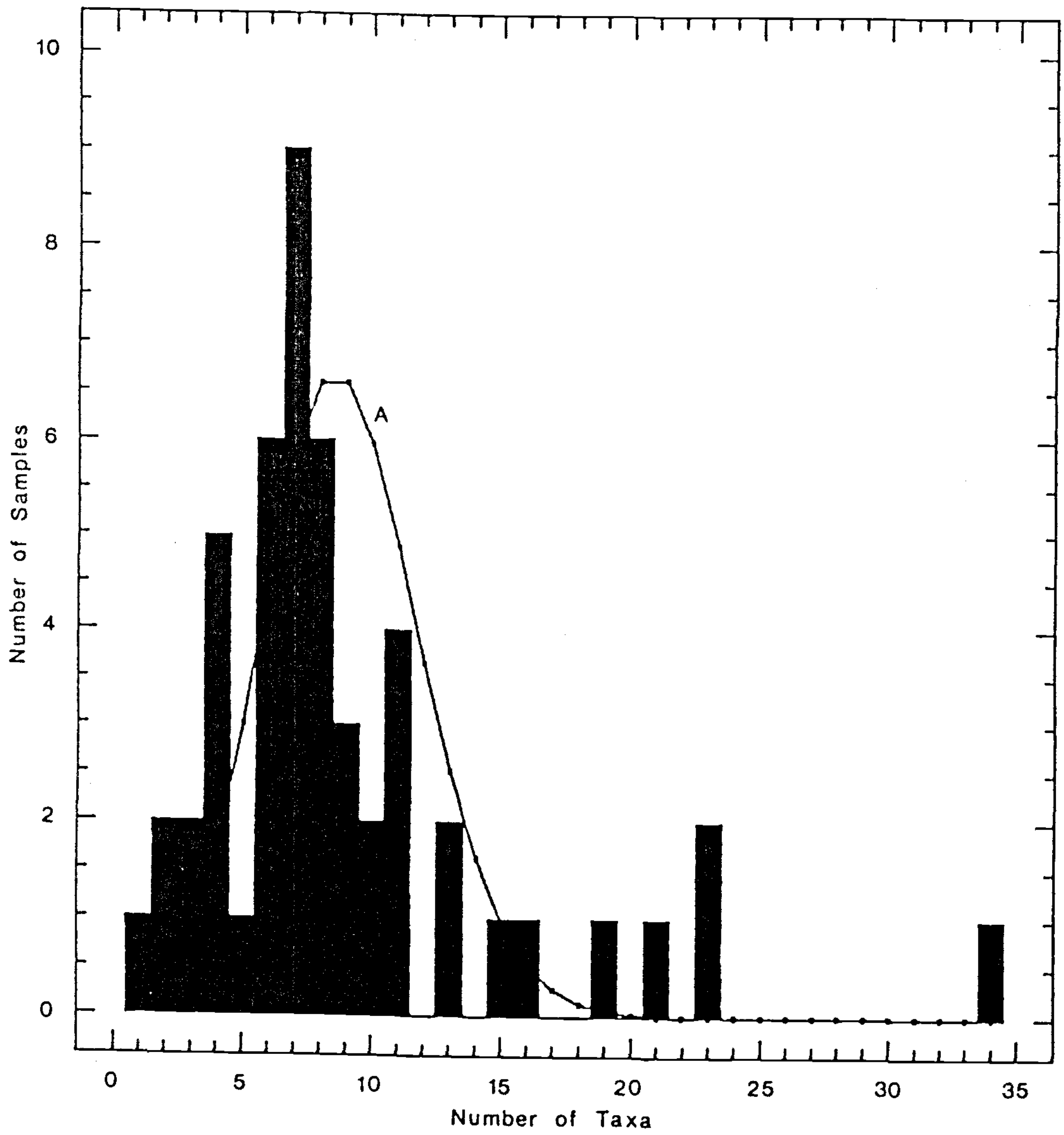

Figure 25. A frequency histogram of the number of taxa occurring in individual samples in May compared to the Poisson distribution (a).

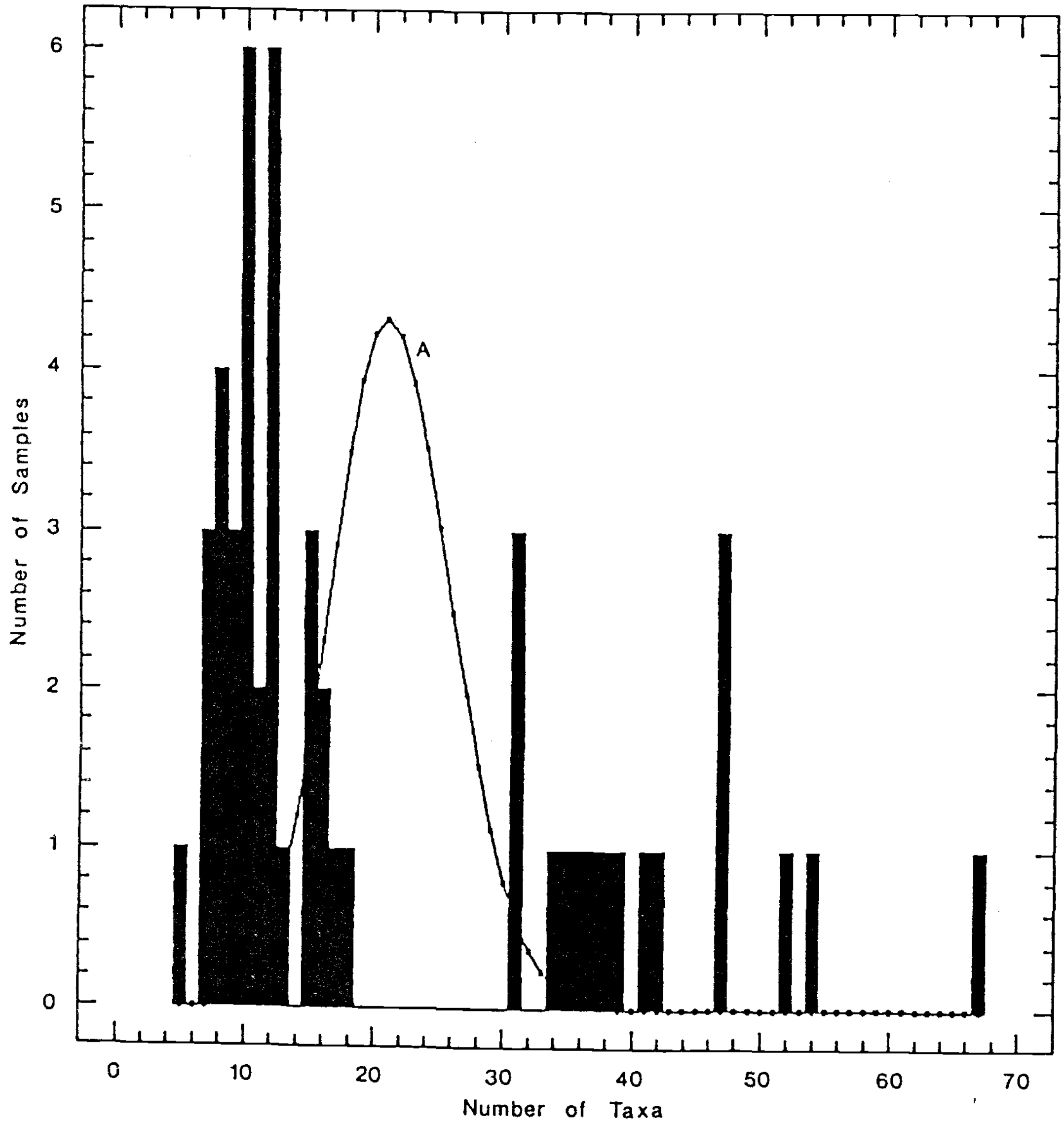

Figure 26. A frequency histogram of the number of taxa occurring in individual samples in September compared to the Poisson distribution (a).

September taxa distributions differed from the Poisson distribution ($p < .01$ and $P < .001$, respectively). Thus, the distribution of taxa among the grab samples is nonrandom and aggregated ($V/M > 1$).

Distribution of common taxa

The average numbers of individuals are shown in Figure 27. Station 2, which had the highest abundance during both cruises, increased by nearly 2000 individuals in September. Station 10 also exhibited a considerable increase; however, these high numbers were observed in one sample only and that increase was not statistically significant ($p = .329$). In a similar case, Stations 3, 5, and 8 did not differ significantly between May and September. For all other stations, the increase in numbers of individuals was significant ($p < .02$; Table 18). Stations 8 and 9 had the lowest number of individuals in both May and September. There was a significant increase from an average of 52.78 individuals per station in May to 497.52 individuals per station in September ($p < .01$; Table 18).

A list of the most common taxa is given in Table 19 (abundance data for each taxon are given in Appendix C). The majority of these species increased in abundance in September at most stations. Exceptions were *Heteropodarke heteromorpha* and *Glycera tenuis* which decreased in overall abundance between the two sample dates (Figures 28 and 29, respectively). A few species such as *Mediomastus californiensis*, *Spiophanes bombyx*, and *Phyllodoce sp. 1* are also of interest because they have been associated with high energy, disturbed and polluted environments.

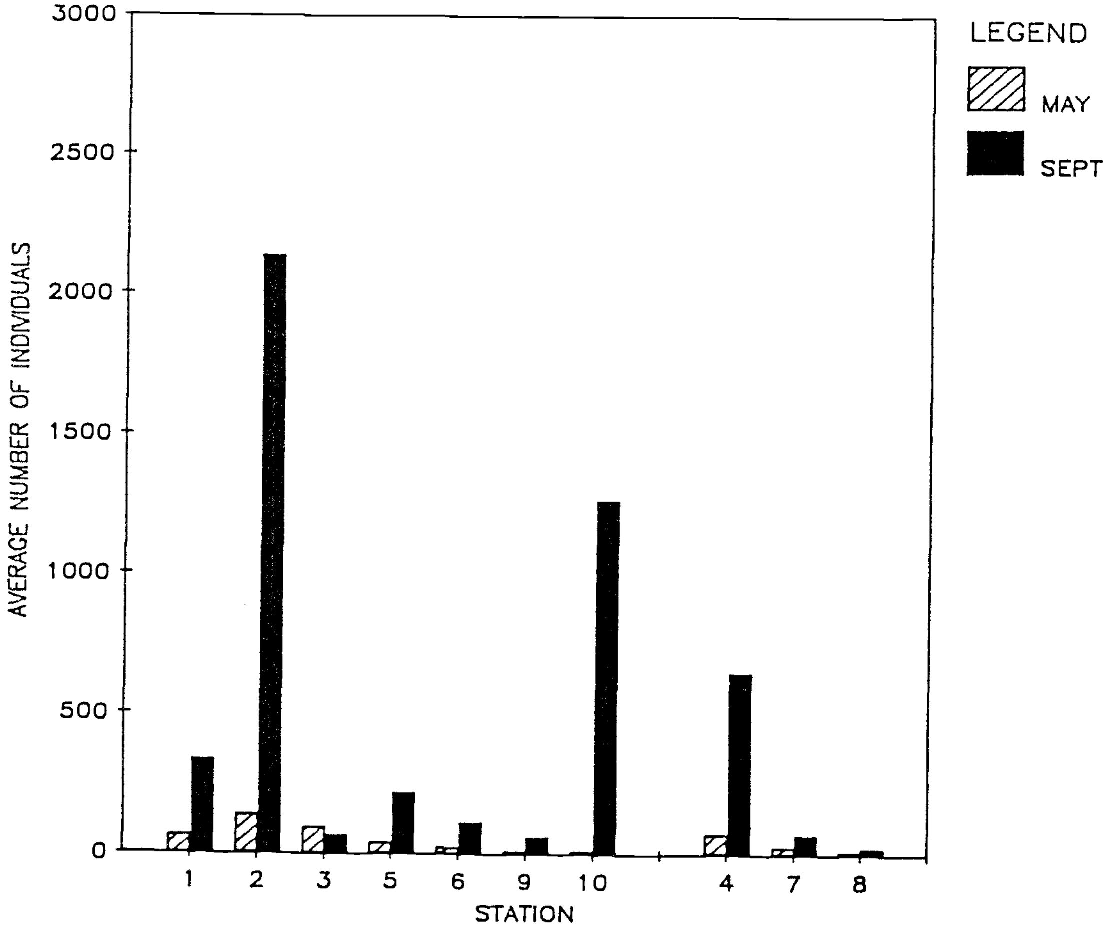

Figure 27. Average number of individuals at each station in May and September.

Table 18. Comparison of average number of individuals between May and September for individual stations (n = 5 samples per station).

Station	Average # of Individuals May	Sept	t-value	Level of Significance
CBG1	71.0	341.4	-3.03	.02
CBG2	143.8	2142.0	-4.36	<.01
CBG3	99.8	71.6	0.98	.35
CBG4	75.4	650.8	-4.67	<.01
CBG5	43.6	222.6	-1.44	.19
CBG6	25.2	116.0	-9.18	<.01
CBG7	28.6	73.2	-5.76	<.01
CBG8	13.8	24.8	-1.67	.13
CBG9	13.0	64.4	-3.50	.01
CBG10	13.6	1268.4	-1.04	.33

Table 19. List of the most common benthic macrofauna at ten stations in Coos Bay Oregon, 1986.

Taxa
Mediomastus californiensis
Mytilidae spp. juvenile
Phyllodoce sp. 1
Owenia fusiformis
Spiophanes bombyx
Glycera tenuis
Heteropodarke heteromorpha
Syllidae
Nemertinea
Armandia brevis
Tellina modesta
Paleonotus bellis
Macoma balthica
Gylcinde picta
Siliqua patula
Dendraster excentricus
Protothaca staminea
Pycnogonida
Clinocardium cf. *nuttallii* juvenile
Photis brevipes
Parapleustes pugettensis
Chone dunneri
Malacoceros glutaeus
Platynereis bicanaliculata
Nematoda
Nephtys caecoides
Ophelia sp. 1

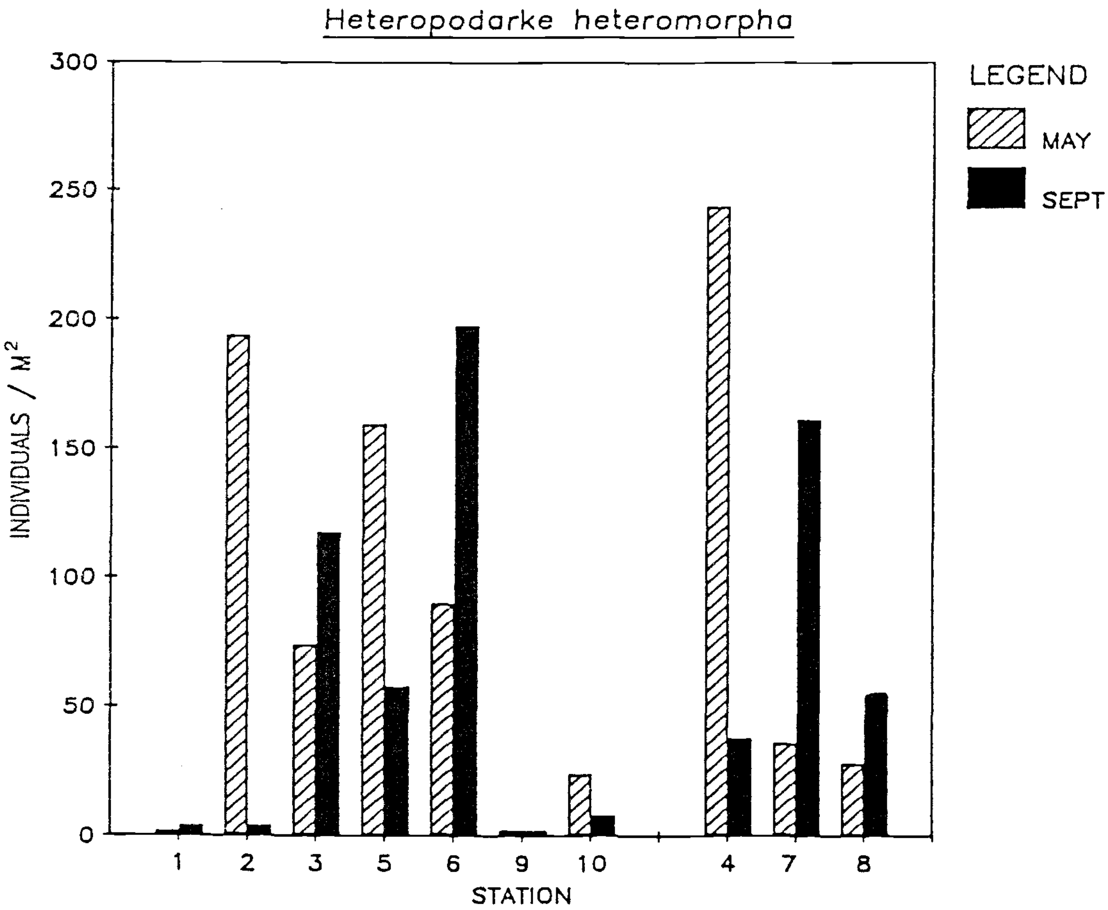

Figure 28. Density of Heteropodarke heteromorpha at each station.

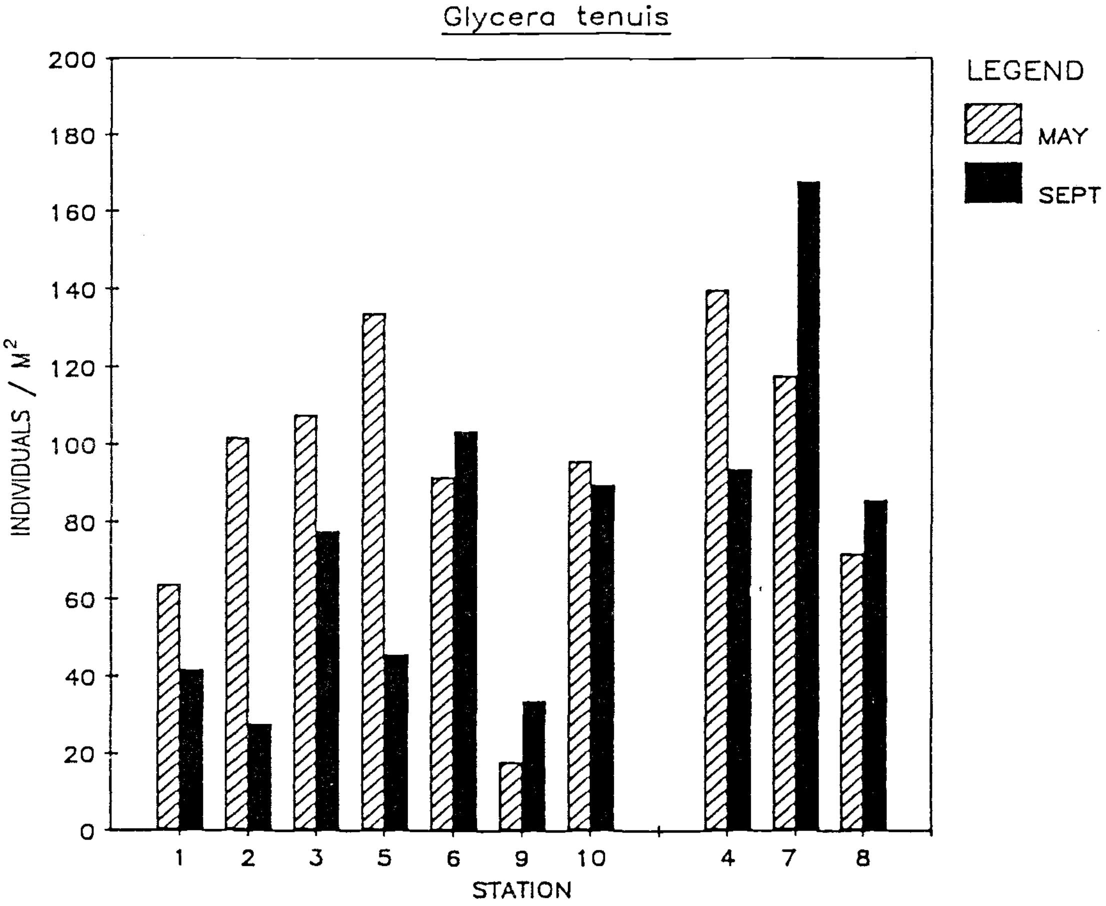

Figure 29. Density of Glycera tenuis at each station.

Mediomastus californiensis, a Capitellid polychaete, has typically been found in disturbed and organically enriched habitats, although this species has tended to be widely distributed throughout Oregon's estuaries (Bottom et al., 1985; Jefferts, 1977). This species increased in September at all stations except Station 1 (Figure 30). Within Site G, Station 4 contained a high density of M. californiensis. Yet, the other two Site G stations, 7 and 8, had similar densities of M. californiensis to other stations outside of the disposal area. Also, the greatest increase in its abundance occurred at Station 2, which was not within the disposal area. A related species, Capitella capitata, also was present in low abundances at half of the stations in September. This species has often been considered as an opportunist and an indicator of disturbed or polluted environments (Parr, 1974; McCauley et al., 1977).

Similar to Mediomastus californiensis, the polychaete Spiophanes bombyx increased in abundance in September. Yet, its abundance decreased at Station 6 from 287 to 2 individuals (Figure 31). Spiophanes bombyx has also been found in disturbed or dynamic environments. For example, it was found in offshore disposal sites at both Yaquina Bay and Coos Bay (Jones, unpub.). At the Coos Bay offshore disposal Site H, this species occurred in low abundances in predisposal studies, yet increased to approximately 650 individuals in September 1987, after several disposal seasons (Hancock et al., 1980; Jones, unpub.). Hancock et al., 1980, also found Spiophanes bombyx in the offshore region near the entrance to Coos Bay. Interim disposal sites were located within this area, so that the region had been

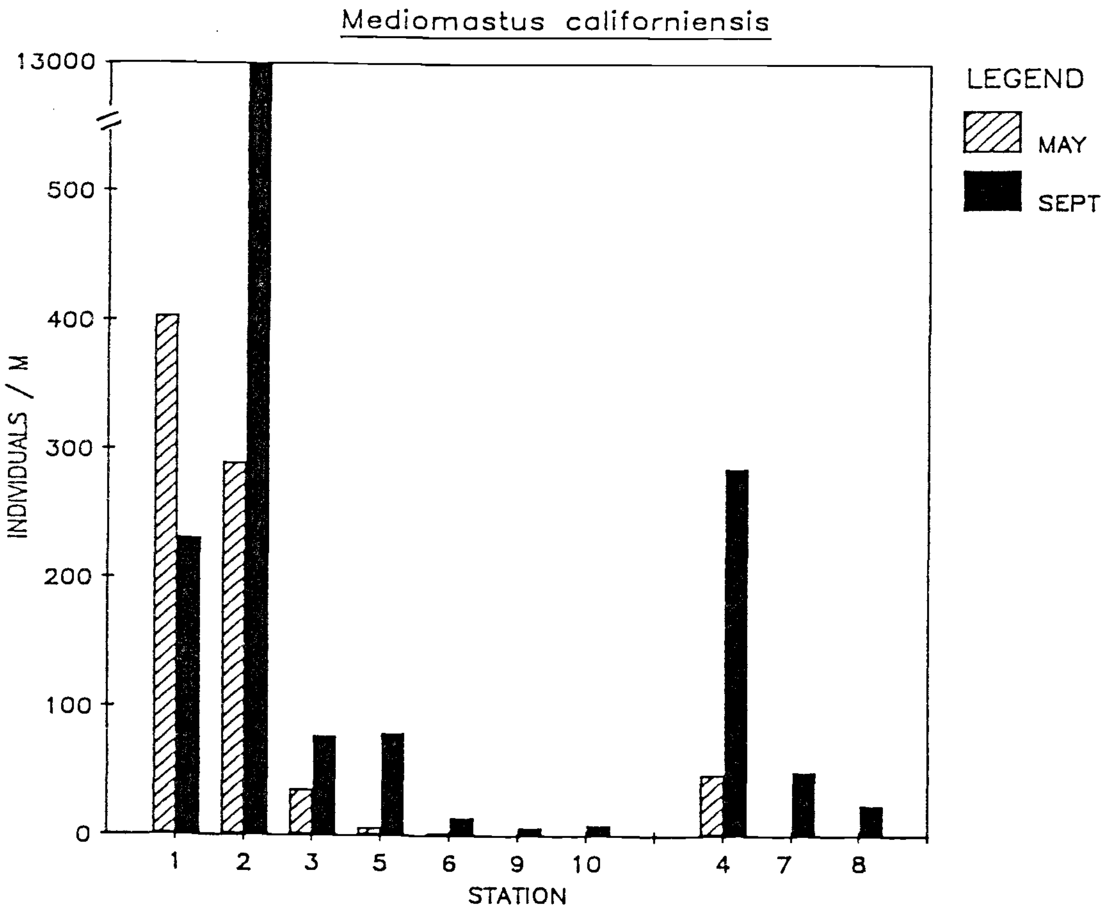

Figure 30. Density of Mediomastus californiensis at each station.

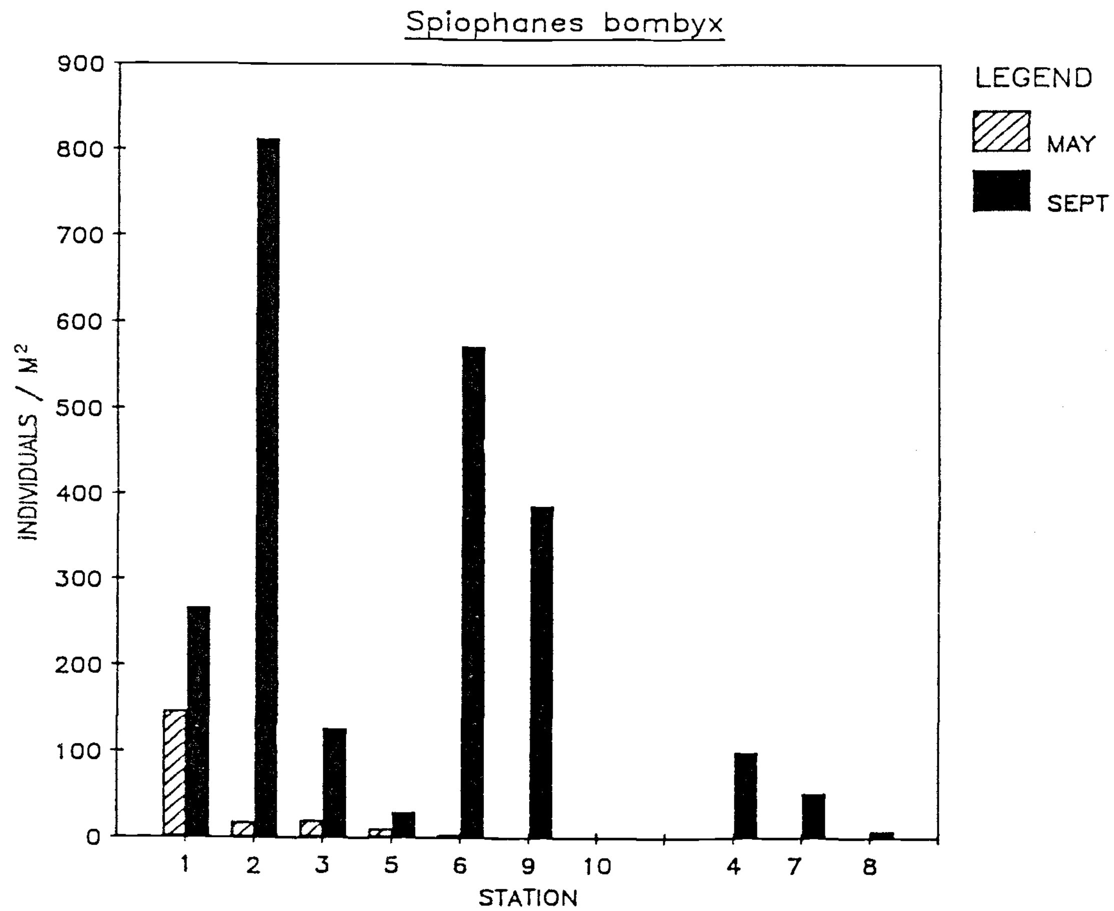

Figure 31. Density of Spiophanes bombyx at each station.

periodically disturbed. In this region, S. bombyx had low densities in April, yet were nearly ubiquitous in autumn (Hancock et al., 1980). This implies a seasonal influence, possibly due to seasonal changes in current patterns and river outflow (Hancock et al., 1980; Hancock et al., 1977; Rhoads and Young, 1970). Thus, the increase in S. bombyx at Site G may be due to a seasonal influence rather than a response to the summer disposal activities.

Other variations in species distribution and abundance patterns between the two seasons (April/May and September/October), which were similar to those observed at Site G and surrounding stations, occurred in the offshore region. The amphipod, Photis sp.; the clams, Tellina nuculoides and Tellina modesta; and the polychaetes, Pygospio elegans and Polydora socialis increased in density in the autumn samples in both the offshore and Site G studies. Both studies also had an increase in juvenile stages in the autumn samples. In contrast, Dendraster excentricus decreased in September/October samples in the offshore study (Hancock et al., 1980). There was little variation in Dendraster excentricus abundance not only between seasons but amongst stations. During September, offshore diversity and richness decreased, whereas both parameters increased at Site G. The increase in juvenile stages, species abundance and changes in species distribution patterns within the offshore area were attributed in part to seasonal changes in current patterns, river outflow and sediment differences (Hancock et al., 1980). Moreover, species such as Clinocardium nuttallii and Siliqua patula, which tend to spawn in the spring with larvae settling in late summer or autumn (Fraser, 1931;

Hirschhorn, 1962), increased in abundance in September. Thus, the variations in species composition between seasons at Site G and the control stations may be due to seasonal influences. One other factor which could cause an increase in the numbers of species and individuals would be the introduction of new species with the dredged materials.

Immature taxa and abundance

Disposal timing is important, since juveniles are susceptable to smothering (Maurer et al., 1981). Juveniles are of interest because of their importance in recruitment and recolonization of disposal sites. High numbers of juveniles at a station could be an indication of reestablishment of communities following a disturbance. Lopez-Jamar and Mejuto (1988) found an initial increase in diversity following disturbance, due to colonization of new species with many juveniles. The diversity decreased later due to an increased dominance of certain species (e.g. opportunists) after 3-4 months. Within 6 months, community structure recovery had occurred.

However, the high juvenile abundances may also represent a seasonal trend. Oliver (1980) collected more juveniles during one sampling period (October) than another (April), although numbers of species did not change. He indicated that these may represent seasonal trends. Thus, changes in the juvenile abundances and diversity may be unrelated to disturbance caused by disposal operations.

A list of the juveniles occurring at the Coos Bay study area is given in Table 20. September samples at several stations (1,2,4,8, and 10) contained many more juveniles than in May samples. For example, 18 new juvenile taxa were obtained in the September cores from Station 1. Although Station 2 samples contained a greater number of different taxa in September, there were many juveniles occurring in May, as well. Station 9 differed in that it generally had more juveniles in May. One species at this station, Spio filicornis, did have higher numbers in September, however. The remaining stations had similar numbers of taxa in both May and September.

Of all the juveniles occurring at the ten Coos Bay stations, the marine mussel family, Mytilidae, was the most ubiquitous and abundant. At Stations 1-5, this family averaged between 200 and 350 individuals/m^2 in at least one of the cruises, while at Station 10 one sample contained 8554 individuals/m^2 (see Table 20). Mytilidae juveniles were found at every station in September, although few were collected at Stations 6,8, and 9. At most stations, mussel juveniles had greater abundances in September than in May; however, the reverse was true for Stations 2,3, and 9. Moreover, at Station 4, the density of Mytilidae sp. juveniles was almost identical in both May and September (Table 20).

Other taxa which had relatively high abundances include the bivalves Clinocardium nutallii and Protothaca staminea; the amphipods Photis sp., Stenotoidae sp. and Parapleustes pugettensis; Cancer magister (Dungeness crab); and the polychaetes Phyllodoce sp., Spio filicornis, and Ophelia sp. As with Mytilidae sp., most of these taxa had higher numbers of juveniles in September than in May.

Table 20. List of juveniles of various taxa obtained from ten Coos Bay stations in May and September, 1986.

Taxa	Average # Individuals/m^2 May	Sept.
Station 1		
Adula sp.		14
Alvinia spp.		2
Anomura sp. (zoea)		8
Arenicolidae sp.	4	
Caridea (zoea)		6
Cancer magister		4
Clinocardium ciliatum		22
Clinocardium nuttallii		26
Eteone sp.		2
Glycinde sp.		2
Lumbrineris sp.		18
Macoma sp.		2
Magelona sp.		6
Mytilidae sp.		348
Mytilus spp.		4
Ophelia sp.	6	
Photis sp.		56
Protothaca staminea	2	6
Scoloplos sp.		4
Spisula falcata		4
Station 2		
Anomura sp. (zoea)		2
Bivalvia sp.		8
Cancer magister	22	
Cancer sp. (megalopa)		2
Cancer sp. (zoea)	6	
Clinocardium nuttallii		316
Diastylopsis sp.	2	
Hesionidae sp.		14
Isopoda	2	
Lumbrineris sp.	2	6
Macoma sp.	2	
Magelona sp.		4
Mya spp.		2
Mytilidae sp.	328	14

Table 20. (continued)

Ophelia sp.		34
Olivellidae sp.	2	
Photis sp.	6	64
Phyllodoce sp.	88	2
Pinnixia sp. (megalopa)		12
Polynoidae sp.	6	
Protothaca staminea		124
Scoloplos sp.		4
Spisula falcata	1	8
Solen sicarius		4
Tellinidae spp.		30
Station 3		
Adula sp.	6	
Ampharetidae sp.	2	
Arenicolidae sp.	2	
Bivalvia sp.	18	
Caridea (zoea)		4
Clinocardium nuttallii		2
Macoma sp.	4	2
Mytilidae sp.	286	6
Mytilus spp.	2	
Ophelia sp.		2
Phyllodoce sp.		2
Protothaca staminea	252	
Spisula falcata	4	
Tellina sp.		2
Station 4		
Alvinia spp.		2
Anomura sp. (zoea)		6
Bivalvia sp.	2	2
Cancer magister		8
Cancer sp. (megalopa)		8
Clinocardium nuttallii		1
Lumbrineris sp.		8
Mytilidae sp.	234	248
Mytilus spp.		2
Nephtys sp.	4	
Orbiniidae sp.		2
Photis sp.		6
Veneridae spp.	2	
Station 5		
Alvinia spp.		2
Cancer sp. (megalopa)		2
Clinocardium nuttallii		4

Table 20. (continued)

Eohaustorius sp.	2	
Macoma spp.	4	
Mytilidae sp.	18	192
Phyllodoce sp.	4	
Station 6		
Hyperoche sp.	2	
Mytilidae sp.		4
Nephtys sp.		4
Ophelia sp.	6	2
Station 7		
Cancer magister	6	
Hyperoche sp.		2
Mactra cf. *falcata*		2
Mytilidae spp.	68	106
Nephtys sp.	2	
Opheliidae sp.		2
Phyllodoce sp.	4	
Station 8		
Anomura sp. (zoea)		6
Cancer sp. (zoea)		4
Mytilidae spp.	4	6
Opheliidae sp.		2
Photis sp.	2	
Protothaca staminea		4
Station 9		
Corophium sp.	2	
Cancer sp. (megalopa)	2	
Mytilidae sp.	14	2
Nephtys sp.	8	
Ophelia sp.	2	
Protothaca staminea	4	
Spio filicornis		60
Veneridae spp.	4	
Station 10		
Aberinicolidae sp.		4
Alvinia sp.		20
Cancer oregoniensis		8
Ischyrocerus sp.		16
Melita sp.		2
Mytilidae sp.		8554

Table 20. (continued)

Ophelia sp.		2
Parapleustes pugettensis		126
Pectinidae sp.		10
Photis sp.		34
Protothaca staminea	2	52
Spisula falcata		6
Stenothoidae sp.		92

Phyllodoce sp., however, had a greater abundance in May, especially at Station 2 (176 individuals/m^2).

Recolonization

Maurer et al. (1981) discussed several possible mechanisms for disposal site recolonization. These included adult emigration from undisturbed areas, reproduction and larval recruitment from adjacent areas, as well as vertical migration through the disposed material. The authors concluded that under certain conditions, such as when small amounts of disposed materials are present, vertical migration may be important. For example, 50% of a bivalve species population, Clinocardium nuttallii, survived when buried under 10 cm of sand, but none reached the surface under 20 cm of sand. However, Maurer et al. (1981) felt that reproduction and recruitment were principal recolonization mechanisms.

Several colonization patterns by benthic macrofauna are typical of marine sediments following a disturbance. Early colonizers have high growth rates, frequent reproduction, short life spans, and high potential for dispersal (Probert, 1984; Rhoads et al., 1978; Grassle and Sanders, 1973). Generally, early colonizers are opportunistic. Opportunistic species have high abundance, although their diversity is low. Eventually, these species are replaced by slower growing, long-lived equilibrium species (Rhoads et al., 1978). The opportunistic species tend to live near the surface, feeding on suspended organic matter such as plankton and detritus, whereas equilibrium species tend to burrow, build tubes and essentially rework the sediment (Rhoads et al., 1978). Rhoads et al. (1978) postulated that opportunistic species may be more susceptible to predation and hence could be an important food source for commercial fish and crustaceans. This concept implies that disturbances such as disposal operations, could enhance commercial yields (Rhoads et al., 1978). However, Rhoads et al. (1978), commented that the opportunistic species may not be a preferred food source.

Species which are motile, rapid burrowers, and can tolerate a high sediment flux, such as Dendraster excentricus and Olivella sp., are often present in a disposal area (Hancock et al., 1980). Impacts of dredge disposal depend on the ability of the organism to migrate to the new sediment surface and its ability to withstand rapid sedimentation (Maurer et al., 1981).

CONCLUSIONS

The results of benthic studies conducted in the disposal area, Site G, Coos Bay, Oregon, indicate that:

1. The sediment physical characteristics (fines, organics and grain size distribution) varied insignificantly between sampling dates, although median grain size tended to be slightly finer in September. Stations 4,7, and 2 contained a higher percentage of gravels in May than at other stations. Differences in sediment parameters among stations were few.

2. Sediment parameter comparisons between May and September averaged for all stations indicated that differences between seasons were not significant at the study site.

3. There was no apparent relationship between depth and other sediment parameters as indicated by correlation analyses. Therefore, differences in grain size distribution, organic content, percent fines, and depth could not explain differences in community structure among stations or between cruises.

4. Water quality parameters varied little with depth, which is typical of a well-mixed environment.

5. Station classification by TWINSPAN resulted in clusters containing

stations which had similar averages for overall abundance, taxa richness, diversity and evenness values. May stations, which tended to have fewer organisms and species, form one group. Clusters did not reflect variations in grain size distribution among stations or between seasons. The disposal site stations (4,7, and 8) did not cluster together.

6. Species classification by TWINSPAN resulted in several distinct clusters. One cluster consisted of species which were found mainly in September at Stations 1,2,4,5, and 10. These species occurred in May only at Station 2. Another cluster contained species which were found at all stations such as Heteropodarke heteromorpha and Glycera tenuis. Cluster 8 contained species which appeared more often in May than in September.

7. Components of species clusters formed by Ward's Method tended to have similar abundances and frequency.

8. Diversity, taxa richness, and number of individuals increased significantly in September. There was no significant difference in evenness between May and September.

9. There were no significant correlations between community composition parameters and depth.

10. The stations within disposal Site G did not show consistent

patterns or differences in diversity, richness, overall abundance, or evenness from other stations or between sample periods.

11. Organims obtained at the Site G were those typically found in high energy, coarse grained environments. These species, Mediomastus californiensis and Spiophanes bombyx, increased in abundance in September. Increases in several species were consistent with seasonal variations observed in other studies.

12. Many juveniles were obtained in the September samples. This finding could be indicative of either seasonal recruitment or recolonization following a disturbance.

13. Based on the information and data collected, it is unclear as to whether or not changes in community structure and composition were due to disturbance by disposal activities or to seasonal environmental and biological influences. Since increases in species abundance, diversity, and richness occurred, detrimental effects related to disposal of 11,632 m^3 of coarse grained sediment at Site G were not apparent.

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APPENDICES

APPENDIX A

APPENDIX A

Sediment Grain Size Classification

Table A-1. Sediment classification with corresponding sieve sizes and grain diameter, based on the Unified Soil Classification scheme and U.S. standard sieve sizes.

Unified Soil Classification (USC)		Grain Size Class	Grain Diameter (mm)	Sieve Size Coos Bay G Analysis
Cobble		1	250.0	10.0 in.
			125.0	5.0 in.
Gravel	Coarse	2	75.0	3.0 in.
			62.5	2.5 in.
			31.25	1.25 in.
	Fine	3	15.63	5/8 in.
			7.81	5/16 in.
Sand	Coarse	4	4.0	No. 5
	Medium	5	2.0	No. 10
			1.0	No. 18
			0.5	No. 35
	Fine	6	0.25	No. 60
			0.125	No. 120
			0.062	No. 230
Silt or Clay		7	< 0.062	< No. 230

APPENDIX B

Data Analysis Methods

Data Analysis

Community composition parameters such as species diversity, species richness, abundance and evenness were used for spatial and temporal comparisons of communities. Other procedures included correlation and cluster analyses. The various analyses used in this study are discussed below.

Community structure parameters

Species diversity, abundance, evenness and richness were determined for each station and cruise. Diversity is a measure of both richness (number of taxa in a sample) and evenness. Diversity was calculated using Shannon's index (Shannon and Weaver, 1949):

$$He = - \sum_{i=1}^{S} P_i \cdot \ln(P_i)$$

He = taxa diversity
S = total number of taxa in a sample
P_i = observed proportion of individuals belonging to the i^{th} taxa

Evenness measures the distribution of individuals among the taxon or the relative abundance of each species. Evenness is the ratio of the observed Shannon diversity index to the theoretical maximum diversity:

$$J = He/(He\ max|s)$$

J = evenness
He = observed taxa diversity
$He\ max|s = \ln(S)$

Both proportional and total (number of individuals within a sample) taxa abundance were determined for each replicate at all stations for both cruises.

Spatial Distribution

The dispersion of the benthic infaunal population among samples at the Coos Bay study site was examined using a Poisson model as a standard for randomness (Elliott, 1977). Frequency distributions were constructed for the number of taxa in individual samples. A chi-square test was used to determine "goodness-of-fit" of the observed frequency distribution of the number of taxa in a sample to the Poisson distribution.

Tests of significance

Student's t-tests of the difference between two means performed on May vs. September station data for taxa richness, taxa diversity, evenness, total number of individuals, median grain size, percent fines (fraction of sediment consisting of particles <.0625 mm in diameter), percent organics, and depth. The t-test was also used to determine differences in the average number of taxa in May and September at each station.

Pearson correlations

To determine relationships among the community structure parameters and physical sediment characteristics, Pearson correlations were calculated.

Cluster analysis and ordination

A multivariate analysis system, PC-ORD (McCune, 1987), was used for species and station classification as well as ordination. Classification assigns species and samples into classes. Ordination orders these variables by their degree of similarity. In other words, similar species (or samples) are close together in sample sequence and dissimilar species are far apart. Two hierarchical methods of classification used in this study were Two-way Indicator Species Analysis (TWINSPAN) and Ward's Method of cluster analysis. TWINSPAN arranges samples and species by reciprocal averaging ordination. Analyses were run several times using various data transformations. In some cases, the data were squareroot transformed only, while in other runs the data were both squareroot transformed and relativized. Squareroot transformations were done in order to reduce positive skew in the frequency of the counts and reduce the impact of dominant species. The data were relativized so that proportional abundances of the species within a sample could be considered. The 5 samples taken at each station per cruise were aggregated for the analysis.

TWINSPAN is a polythetic divisive hierarchical method which classifies both species and samples simultaneously. The resulting dendrograms depend upon the taxa which samples have in common. TWINSPAN analysis approximates quantitative abundance data in that it uses abundance classes defined by "pseudospecies cut levels" (Gauch, 1982). Rare species (those with 1 or 2 individuals only) were not included in the analysis, leaving 151 of the original 218 taxa. To facilitate interpretation, the data were further reduced to 85 species by eliminating those which occurred in fewer than 3 samples.

Another method of cluster analysis used to identify both species and station groups was Ward's Method of hierarchical grouping. The method joins groups which result in the least error sum of squares (or variation) (Ward, 1963). The cluster analysis resembles TWINSPAN in that it is polythetic, hierarchical, and utilizes Euclidean distance as the distance measure. However, it does not simultaneously classify both species and stations. Moreover it is agglomerative, in that it joins groups rather than creating them by division as in TWINSPAN. As with the TWINSPAN analysis, data were squareroot transformed, relativized and aggregated. One hundred and fifty-one taxa were used for the analysis after rare species were excluded.

APPENDIX C

Species Abundance Data

Table C-1. Abundance data for each taxon identified in each grab from Station 1, Coos Bay, May 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Phoxocephalidae		0	0	1	0	0	1	0.2	0.45
Natantia									
Crangon sp.		0	0	1	0	0	1	0.2	0.45
Cirripedia		0	0	p	0	0			
Gastropoda									
Olivella pycna		0	2	0	1	0	3	0.6	0.89
Pelecypoda									
Prototheca cf. staminea juvenile		1	0	0	0	0	1	0.2	0.45
Siliqua patula		0	0	1	0	0	1	0.2	0.45
Tapes philippinarium		1	0	0	0	0	1	0.2	0.45
Polychaeta									
Arenicolidae sp. juvenile		1	1	0	0	0	2	0.4	0.54
Glycera tenuis		8	7	6	9	2	32	6.4	2.70
Heteropodarke heteromorpha		0	0	1	0	0	1	0.2	0.45
Magelona sacculata		0	0	1	0	0	1	0.2	0.45
Mediomastus californiensis		115	42	24	8	13	202	40.4	43.70
Nephtys caecoides		2	1	0	0	0	3	0.6	0.89
Onuphis elegans		0	2	0	0	2	4	0.8	1.10
Ophelia sp. 1		1	2	2	1	1	7	1.4	0.55
Ophelia sp. juvenile		0	1	0	2	0	3	0.6	0.89
Owenia fusiformis		2	0	0	0	0	2	0.4	0.89
Scoloplos armiger		0	0	1	0	0	1	0.2	0.45
Spiophanes bombyx		9	18	16	25	6	74	14.8	7.53
Echinodermata									
Dendraster excentricus		1	0	0	0	2	3	0.6	0.89
Pices									
Ammodytes hexapterus		0	0	0	1	0	1	0.2	0.45
Nematoda		0	0	1	0	0	1	0.2	0.45
Nemertinea		1	1	5	0	3	10	2.0	2.00
TOTAL		142	77	60	47	29	355		

Table C-2. Abundance data for each taxon identified in each grab from Station 2, Coos Bay, May 1986.

SPECIES GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda								
Allochestes angusta	0	3	0	1	0	4	0.8	1.30
Gammaridea	0	0	0	1	0	1	0.2	0.45
Isaeidae	0	0	0	1	0	1	0.2	0.45
Ischyrocerus pelagops	0	1	0	13	10	24	4.8	6.22
Ischyrocerus sp.	0	0	0	1	0	1	0.2	0.45
Melita desdichada	0	0	1	1	4	6	1.2	1.64
Parapleutes pugettensis	0	0	0	2	0	2	0.4	0.89
Photis brevipes	0	0	0	0	1	1	0.2	0.45
Photis macinerneyi	0	0	0	0	1	1	0.2	0.45
Photis sp. juvenile	0	1	0	0	2	3	0.6	0.89
Brachyura								
Cancer magister juvenile	0	6	1	0	4	11	2.2	2.68
Cancer sp. zoea	0	3	0	0	0	3	0.6	1.34
Mysidacea								
Archeomysis grebnitzkii	0	0	0	1	0	1	0.2	0.45
Pycnogonida	0	0	1	1	3	5	1.0	1.22
Isopoda								
Gnorimosphaeroma oregonensis	0	0	0	2	4	6	1.2	1.79
Isopoda juvenile	0	0	0	0	1	1	0.2	0.45
Gastropoda								
Nudibranchia	0	1	0	0	0	1	0.2	0.45
Olivella biplicata	0	0	0	2	0	2	0.4	0.89
Olivellidae sp. juvenile	1	0	0	0	0	1	0.2	0.45
Pelecypoda								
Adula diegensis	0	0	0	2	0	2	0.4	0.89
Macoma spp. juvenile	0	0	1	0	0	1	0.2	0.45
Mytilidae spp. juvenile	17	9	39	76	23	164	32.8	26.54
Protothaca cf. staminea	0	0	0	1	0	1	0.2	0.45
Spisula cf. falcsata juvenile	0	1	0	0	0	1	0.2	0.45
Tapes philippinarium	0	0	0	0	1	1	0.2	0.45
Polychaeta								
Chone dunneri	0	0	1	9	2	12	2.4	3.78
Eulalia viridis	0	0	0	2	0	2	0.4	0.89
Exogone lourei	0	0	0	1	1	2	0.4	0.55
Glycera americana	1	0	0	2	0	3	0.6	0.89
Glycera tenuis	10	14	10	17	0	51	10.2	6.42
Heteropodarke heteromorpha	12	20	13	51	1	97	19.4	18.93
Idanthyrsus ornamentatus	0	0	0	0	1	1	0.2	0.45
Lumbrineris sp. juvenile	0	0	0	1	0	1	0.2	0.45
Mediomastus californiensis	22	8	34	78	3	145	29.0	29.97
Paleonotus bellis	0	0	0	1	0	1	0.2	0.45
Phyllodoce sp. 1	0	0	0	2	0	2	0.4	0.89
Phyllodoce sp. juvenile	1	12	5	62	8	88	17.6	25.15
Platynereis bicanaliculata	0	0	0	2	11	13	2.6	4.77
Polydora sp. indeterminate	0	0	0	1	0	1	0.2	0.45
Polynoidae sp. juvenile	0	0	0	1	2	3	0.6	0.89
Spiophanes bombyx	0	1	2	5	1	9	1.8	1.92
Syllis sp. 1	0	0	1	0	0	1	0.2	0.45
Syllidae	1	0	0	6	2	9	1.8	2.49
Terebellidae	0	0	0	1	0	1	0.2	0.45

Table C-2. (continued)

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Echinodermata									
Dendraster excentricus		0	1	0	0	0	1	0.2	0.45
Pices									
Ammodytes hexapterus		1	0	0	0	0	1	0.2	0.45
Nematoda		0	0	4	3	0	7	1.4	1.95
Nemertinea		2	5	2	6	0	15	3.0	2.45
Platyhelminthes		0	1	0	5	0	6	1.2	2.17
Anthozoa		1	0	1	0	0	2	0.4	0.55
TOTAL		69	87	116	361	86	719		

Table C-3. Abundance data for each taxon identified in each grab from Station 3, Coos Bay, May 1986.

SPECIES GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda								
Atylus tridens	1	0	0	0	0	1	0.2	0.45
Mandibulophoxus uncirostratus	1	0	0	0	0	1	0.2	0.45
Decapoda	1	0	1	0	0	2	0.4	0.55
Mysidacea								
Archeomysis grebnitzkii	2	0	0	0	0	2	0.4	0.89
Gastropoda								
Odostomia spp.	0	1	0	0	0	1	0.2	0.45
Olivella biplicata	0	0	0	0	1	1	0.2	0.45
Spiromoelleria quadrae	0	0	1	0	0	1	0.2	0.45
Pelecypoda								
Adula diegensis	0	6	10	0	1	17	3.4	4.4
Adula spp. juvenile	3	0	0	0	0	3	0.6	1.34
Bivalvia spp. juvenile	9	0	0	0	0	9	1.8	4.02
Lysonia californica	1	0	1	0	0	2	0.4	0.55
Macoma spp. juvenile	0	0	2	0	0	2	0.4	0.89
Mysella tumida	2	0	6	0	0	8	1.6	2.61
Mytilidae spp. juvenile	40	56	35	9	3	143	28.6	22.14
Mytilus spp. juvenile	1	0	0	0	0	1	0.2	0.45
Pholadidae spp.	3	0	1	0	0	4	0.8	1.30
Protothaca cf. staminea juvenile	40	29	53	2	2	126	25.2	22.82
Spisula cf. falcata juvenile	1	0	1	0	0	2	0.4	0.55
Tapes philippinarium	1	1	1	2	0	5	1.0	0.71
Zirfaea pilsbryii	0	2	1	0	0	3	0.6	0.89
Polychaeta								
Ampharetidae sp. juvenile	0	0	1	0	0	1	0.2	0.45
Arenicolidae sp. juvenile	0	1	0	0	0	1	0.2	0.45
Glycera tenuis	9	7	13	11	14	54	10.8	2.86
Heteromastus filiformis	0	0	0	0	1	1	0.2	0.45
Heteropodarke heteromorpha	0	7	11	6	13	37	7.4	5.03
Idanthyrsus ornamentatus	1	0	1	0	0	2	0.4	0.55
Magelona sacculata	1	0	0	0	0	1	0.2	0.45
Mediomastus californiensis	0	6	5	6	1	18	3.6	2.88
Nephtys californiensis	1	0	0	0	0	1	0.2	0.45
Paraonella platybranchia	0	1	2	0	0	3	0.6	0.89
Pygospio elegans	1	1	0	0	0	2	0.4	0.55
Spiophanes bombyx	5	0	4	1	0	10	2.0	2.35
Echinodermata								
Dendraster excentricus	6	0	2	0	0	8	1.6	2.61
Pices								
Ammodytes hexapterus	4	0	3	0	0	7	1.4	1.95
Nematoda	0	0	4	0	0	4	0.8	1.79
Nemertinea	2	1	8	4	0	15	3.0	3.16
TOTAL	136	119	167	41	36	499		

Table C-4. Abundance data for each taxon identified in each grab from Station 4, Coos Bay, May 1986.

SPECIES GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda								
Eohaustorius sawyeri	0	1	0	0	0	1	0.2	0.45
Phoxocephalidae	1	0	0	0	0	1	0.2	0.45
Cirripedia	0	0	p	0	0			
Pelecypoda								
Bivalvia sp. juvenile	0	0	0	1	0	1	0.2	0.45
Mytilidae spp. juvenile	27	15	9	16	50	117	23.4	16.23
Veneridae spp. juvenile	0	1	0	0	0	1	0.2	0.45
Zirfaea pilsbryii	0	0	0	0	1	1	0.2	0.45
Polychaeta								
Chone dunneri	1	0	0	1	0	2	0.4	0.55
Glycera tenuis	3	14	7	26	20	70	14.0	9.35
Heteropodarke heteromorpha	7	16	24	25	50	122	24.4	16.04
Mediomastus californiensis	0	3	4	9	8	24	4.8	3.70
Nephtys sp. juvenile	0	0	0	1	1	2	0.4	0.55
Paraonella platybranchia	0	1	0	0	1	2	0.4	0.55
Scoloplos armiger	0	0	0	0	1	1	0.2	0.45
Echinodermata								
Dendraster excentricus	0	0	0	0	1	1	0.2	0.45
Nematoda	7	0	0	5	3	15	3.0	3.08
Nemertinea	9	1	2	1	3	16	3.2	3.35
TOTAL	55	52	46	85	139	377		

Table C-5. Abundance data for each taxon identified in each grab from Station 5, Coos Bay, May 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Eohaustorius sp. juvenile		0	0	0	0	1	1	0.2	0.45
Cirripedia		0	0	p	0	0			
Decapoda		0	2	0	0	0	2	0.4	0.89
Mysidacea									
Archeomysis grebnitzkii		0	0	0	1	0	1	0.2	0.45
Pycnogonida		1	0	0	0	0	1	0.2	0.45
Pelecypoda									
Macoma spp. juvenile		0	1	0	0	1	2	0.4	0.55
Mytilidae spp. juvenile		2	6	0	1	0	9	1.8	2.49
Polychaeta									
Glycera tenuis		12	12	14	13	16	67	13.4	1.67
Heteropodarke heteromorpha		6	11	22	31	10	80	16.0	10.27
Magelona sacculata		0	2	0	0	0	2	0.4	0.89
Mediomastus californiensis		0	2	1	0	0	3	0.6	0.89
Nephyts caecoides		0	1	0	0	0	1	0.2	0.45
Onuphis elegans		1	0	0	0	0	1	0.2	0.45
Phyllodoce sp. juvenile		0	2	0	0	0	2	0.4	0.89
Platynereis bicanaliculata		0	3	0	0	0	3	0.6	1.34
Platycirrus sp. complex		0	1	0	0	0	1	0.2	0.45
Polydora socialis		0	1	0	0	0	1	0.2	0.45
Scoloplos armiger		1	0	0	0	0	1	0.2	0.45
Spiophanes bombyx		0	2	1	0	2	5	1.0	1.00
Syllidae		0	4	0	0	0	4	0.8	1.79
Echinodermata									
Dendraster excentricus		4	2	2	2	8	18	3.6	2.61
Pices									
Ammodytes hexapterus		1	0	0	2	0	3	0.6	0.89
Nematoda		0	1	0	0	0	1	0.2	0.45
Nemertinea		0	1	2	2	2	7	1.4	0.89
Holothuroidea		0	1	0	0	0	1	0.2	0.45
Anthozoa		0	1	0	0	0	1	0.2	0.45
?Nemertinea		0	0	0	0	1	1	0.2	0.45
TOTAL		28	56	42	52	40	218		

Table C-6. Abundance data for each taxon identified in each grab from Station 6, Coos Bay, May 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Mandibulophoxus uncirostratus		0	0	0	1	0	1	0.2	0.45
Pelecypoda									
Mytilidae spp. juvenile		1	0	0	1	0	2	0.4	0.55
Tapes philippinarium		0	0	0	0	5	5	1.0	2.24
Polychaeta									
Glycera convoluta		0	0	0	0	1	1	0.2	0.45
Glycera tenuis		9	10	10	8	9	46	9.2	0.84
Heteropodarke heteromorpha		22	7	3	3	10	45	9.0	7.84
Mediomastus californiensis		1	0	0	0	0	1	0.2	0.45
Nephtys californiensis		0	0	1	0	0	1	0.2	0.45
Nephtys sp. juvenile		0	1	0	0	1	2	0.4	0.55
Ophelia sp. juvenile		0	0	1	0	0	1	0.2	0.45
Spio filicornis		1	0	0	0	0	1	0.2	0.45
Spiophanes bombyx		0	0	1	0	1	2	0.4	0.55
Echinodermata									
Dendraster excentricus		4	2	2	0	2	10	2.0	1.41
Pices									
Ammodytes hexapterus		0	0	0	0	1	1	0.2	0.45
Nemertinea		3	2	2	0	0	7	1.4	1.34
TOTAL		41	22	20	13	30	126		

Table C-7. Abundance data for each taxon identified in each grab from Station 7, Coos Bay, May 1986.

SPECIES	GRAB NUMBER:	1	ANIMALS 2	PER 3	GRAB 4	5	TOTAL	AVG	STD
Amphipoda									
Atylus tridens		0	0	0	4	1	5	1.0	1.73
Allorchestes angustus		0	0	0	0	1	1	0.2	0.45
Eohaustorius washingtonianus		0	1	1	0	0	2	0.4	0.55
Anomura									
Anomura zoea		0	0	0	0	1	1	0.2	0.45
Pachygrapus crassipes		0	0	0	1	0	1	0.2	0.45
Brachyura									
Cancer magister juvenile		2	0	0	1	0	3	0.6	0.89
Gastropoda									
Lacuna vincta		0	0	0	0	1	1	0.2	0.45
Pelecypoda									
Mytilidae spp. juvenile		1	23	3	7	0	34	6.8	9.44
Polychaeta									
Chone dunneri		0	2	0	0	0	2	0.4	0.89
Glycera tenuis		13	2	11	10	23	59	11.8	7.53
Heteropodarke heteromorpha		1	2	8	7	0	18	3.6	3.65
Nephtys sp. juvenile		1	0	0	0	0	1	0.2	0.45
Phyllodoce sp. 1		0	1	0	0	0	1	0.2	0.45
Phyllodoce sp. juvenile		0	2	0	0	0	2	0.4	0.89
Pygospio elegans		0	1	0	0	0	1	0.2	0.45
Tharyx multifilis		0	0	0	0	1	1	0.2	0.45
Pices									
Ammodites hexapterus		4	0	0	0	0	4	0.8	1.79
Nemertinea		0	1	0	5	0	6	1.2	2.17
TOTAL		22	35	23	35	28	143		

Table C-8. Abundance data for each taxon identified in each grab from Station 8, Coos Bay, May 1986.

SPECIES	GRAB NUMBER:	1	ANIMALS 2	PER 3	GRAB 4	5	TOTAL	AVG	STD
Amphipoda									
Atylus tridens		0	1	0	0	2	3	0.6	0.89
Isaeidae		0	1	0	1	0	2	0.4	0.55
Photis macinerneyi		0	3	0	0	0	3	0.6	1.34
Photis sp. juvenile		0	0	1	0	0	1	0.2	0.45
Mysidacea									
Archeomysis grebnitzkii		0	0	1	0	0	1	0.2	0.45
Pelecypoda									
Mytilidae spp. juvenile		0	0	1	0	1	2	0.4	0.55
Polychaeta									
Glycera tenuis		4	6	11	2	13	36	7.2	4.66
Heteropodarke heteromorpha		3	8	1	1	1	14	2.8	3.03
Platynereis bicanaliculata		0	1	0	0	0	1	0.2	0.45
Echinodermata									
Dendraster excentricus		0	0	2	0	0	2	0.4	0.89
Nematoda		0	0	0	0	1	1	0.2	0.45
Nemertinea		0	0	1	1	1	3	0.6	0.55
TOTAL		7	20	18	5	19	69		

Table C-9. Abundance data for each taxon identified in each grab from Station 9, Coos Bay, May 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Corophium sp. juvenile		0	1	0	0	0	1	0.2	0.45
Mandibulophoxus uncirostratus		0	0	0	1	1	2	0.3	0.55
Monocludes zernovi		0	0	1	0	0	1	0.2	0.45
Phoxocephalidae		0	0	1	0	0	1	0.2	0.45
Synchelidium shoemakeri		0	0	0	0	1	1	0.2	0.45
Brachyura									
Cancer sp. megalopa		0	0	0	0	1	1	0.2	0.45
Mysidacea									
Archeomysis grebnitzkii		0	1	0	0	2	3	0.8	0.89
Isopoda									
Idotea fewkesi		1	0	0	0	0	1	0.2	0.45
Gastropoda		0	2	0	0	0	2	0.8	0.89
Pelecypoda									
Mytilidae spp. juvenile		0	0	2	0	5	7	4.8	2.19
Protothaca cf. staminea juvenile		0	0	2	0	0	2	0.8	0.89
Veneridae spp. juvenile		0	0	0	0	2	2	0.8	0.89
Polychaeta									
Chone dunneri		0	0	1	0	0	1	0.2	0.45
Glycera tenuis		2	3	0	0	2	7	1.8	1.34
Heteropodarke heteromorpha		0	1	0	0	0	1	0.2	0.45
Nephtys californiensis		0	1	0	0	1	2	0.3	0.55
Nephtys sp. juvenile		1	0	3	0	0	4	1.7	1.30
Ophelia sp. 1		0	2	0	0	0	2	0.8	0.89
Ophelia sp. juvenile		1	0	0	0	0	1	0.2	0.45
Paraonella platybranchia		0	0	0	0	1	1	0.2	0.45
Platynereis bicanaliculata		1	0	0	0	0	1	0.2	0.45
Pygospio elegans		0	0	1	0	0	1	0.2	0.45
Spio filicornis		2	0	2	2	0	6	1.2	1.10
Pices									
Ammodytes hexapterus		0	0	1	0	3	4	1.7	1.30
Nematoda		0	1	1	1	0	3	0.3	0.55
Nemertinea		0	4	2	1	0	7	2.8	1.67
TOTAL		8	16	17	5	19	65		

Table C-10. Abundance data for each taxon identified in each grab from Station 10, Coos Bay, May 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Natantia									
Crangon stylirostrus		0	0	0	0	3	3	0.6	1.34
Pelecypoda									
Prototheca cf. staminea juvenile		0	1	0	0	0	1	0.2	0.45
Polychaeta									
Glycera tenuis		12	12	7	10	7	48	9.6	2.51
Heteropodarke heteromorpha		0	3	0	4	5	12	2.4	2.30
Pices									
Ammodytes hexapterus		1	1	0	0	0	2	0.4	0.55
Nemertinea		0	0	0	2	0	2	0.4	0.89
TOTAL		13	17	7	16	15	68		

Table C-11. Abundance data for each taxon identified in each grab from Station 1, Coos Bay, September 1986.

SPECIES		ANIMALS PER GRAB							
	GRAB NUMBER:	1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Allogaussia sp.		0	3	0	0	0	3	0.6	1.34
Aoroides sp.									
Atylus tridens		0	1	0	0	0	1	0.2	0.45
Caprellidae		0	7	1	0	1	9	1.8	2.95
Caprella sp.		1	0	0	0	0	1	0.2	0.45
Ischyroceridae		6	0	0	0	0	6	1.2	2.68
Ischyrocerus pelagops		0	0	1	0	0	1	0.2	0.45
Jassa falcata		0	0	2	0	0	2	0.4	0.89
Melita desdichada		6	2	3	0	0	11	2.2	2.49
Parapleustes pugettensis		0	0	1	0	0	1	0.2	0.45
Photis brevipes		78	18	18	1	0	115	23.0	31.97
Photis macinerneyi		11	0	14	0	0	25	5.0	6.93
Photis sp. juvenile		0	12	15	1	0	28	5.6	7.30
Phoxocephalidae		0	0	1	1	0	2	0.4	0.55
Anomura									
Anomura zoea		2	1	0	1	0	4	0.8	0.84
Porcellanidae		0	1	0	0	0	1	0.2	0.45
Brachyura									
Cancer magister juvenile		0	1	1	0	0	2	0.4	0.55
Pinnotheridae		0	1	1	0	0	2	0.4	0.55
Decapoda (other)									
Caridea zoea		3	0	0	0	0	3	0.6	1.34
Heptacarpus brevirostris		0	0	0	0	2	2	0.4	0.89
Cirripedia		P	P	P	P	P			
Cumacea									
Diastylopsis tenuis		0	1	1	0	0	2	0.4	0.55
Lamprops carinata		0	1	1	0	0	2	0.4	0.55
Isopoda									
Ianiropsis sp.		3	0	0	0	0	3	0.6	1.34
Munna sp.		1	0	0	0	0	1	0.2	0.45
Tanaidacea									
Leptochelia dubia		4	6	0	3	1	14	2.8	2.39
Pycnogonida		2	1	5	0	0	8	1.6	2.07
Gastropoda									
Alvinia spp. juvenile		0	1	0	0	0	1	0.2	0.45
Lacuna vincta		0	1	0	0	0	1	0.2	0.45
Nudibranchia		2	4	4	0	0	10	2.0	2.00
Olivella pycna		0	0	0	1	0	1	0.2	0.45
Pelecypoda									
Adula diegensis		3	16	0	0	1	20	4.0	6.82
Adula spp. juvenile		0	0	7	0	0	7	1.4	3.13
Clinocardium cf. ciliatum juvenile		9	2	0	0	0	11	2.2	3.90
Clinocardium cf. nuttallii juvenile		0	0	4	9	0	13	2.6	3.97
Hiatella arctica		0	0	0	0	1	1	0.2	0.45
Macoma balthica		2	1	1	0	0	4	0.8	0.84
Macoma sp. juvenile		0	0	0	1	0	1	0.2	0.45
Mytilidae spp. juvenile		23	116	16	19	0	174	34.8	46.22
Mytilus spp. juvenile		0	0	2	0	0	2	0.4	0.89
Protothaca cf. staminea juvenile		0	3	0	0	0	3	0.6	1.34
Siliqua patula		0	0	2	0	0	2	0.4	0.89
Spisula cf. falcata juvenile		0	0	1	1	0	2	0.4	0.55
Tapes philippinarium		0	2	0	1	0	3	0.6	0.89
Tellina modesta		0	2	1	9	0	12	2.4	3.78
Zirfaea pilsbryii		1	1	4	0	0	6	1.2	1.64

Table C-11. (continued)

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Polychaeta									
Armandia brevis		63	19	64	21	0	167	33.4	28.68
Capitella capitata complex		4	2	10	1	0	17	3.4	3.97
Chone mollis		1	1	2	0	0	4	0.8	0.84
Cirratulus cirratus		0	1	0	0	0	1	0.2	0.45
Eteone longa		3	8	0	2	0	13	2.6	3.29
Eteone sp. juvenile		1	0	0	0	0	1	0.2	0.45
Eulalia viridis		2	2	2	0	0	6	1.2	1.10
Exogone lourei		2	3	0	1	0	6	1.2	1.30
Glycera tenuis		9	0	4	3	5	21	4.2	3.27
Glycinde armigera		0	1	0	1	0	2	0.4	0.55
Glycinde picta		0	4	1	0	0	5	1.0	1.73
Glycinde sp. juvenile		0	0	1	0	0	1	0.2	0.45
Harmothoe imbricata		1	0	0	0	0	1	0.2	0.45
Heteropodarke heteromorpha		0	0	0	1	1	2	0.4	0.55
Leitoscoloplos pugettensis		0	0	0	1	0	1	0.2	0.45
Lumbrineris sp. juvenile		1	3	2	2	1	9	1.8	0.84
Magelona sacculata		3	0	1	0	0	4	0.8	1.30
Megalona sp. juvenile		0	1	0	2	0	3	0.6	0.89
Malacoceros glutaeus		9	1	6	2	0	18	3.6	3.78
Mediomastus californiensis		34	39	10	21	12	116	23.2	12.95
Nephtys caecoides		1	0	0	0	0	1	0.2	0.45
Nephtys californiensis		2	0	0	0	0	2	0.4	0.89
Nereis zonata		1	0	0	0	0	1	0.2	0.45
Nicolea sp. A		8	3	5	1	0	17	3.4	3.21
Odontosyllis phosphorea		6	0	0	0	0	6	1.2	2.68
Onuphis elegans		0	0	0	0	2	2	0.4	0.89
Onuphidae		1	0	0	0	0	1	0.2	0.45
Owenia fusiformis		31	24	23	109	1	188	37.6	41.47
Paleonotus bellis		4	8	4	1	0	17	3.4	3.13
Platynereis bicanaliculata		10	6	7	1	0	24	4.8	4.21
Phyllodoce sp. 1		66	8	163	5	0	242	48.4	69.46
Polycirrus sp. complex		1	5	0	1	0	7	1.4	2.07
Polydora cardalia		2	0	0	0	0	2	0.4	0.89
Polydora socialis		0	1	0	1	0	2	0.4	0.55
Prionospio (Minuspio) cirrifera		1	0	0	0	0	1	0.2	0.45
Prionospio steenstrupi		0	0	0	1	0	1	0.2	0.45
Pygospio elegans		1	0	0	1	0	2	0.4	0.55
Scolelepsis foliosa		9	6	1	2	0	18	3.6	3.78
Scoloplos armiger		1	0	0	2	0	3	0.6	0.89
Scoloplos sp. juvenile		0	0	2	0	0	2	0.4	0.89
Spio filicornis		1	0	0	0	0	1	0.2	0.45
Spiophanes bombyx		41	2	52	33	6	134	26.8	21.92
Syllidae		10	36	18	0	1	65	13.0	14.80
Oligochaeta		1	0	0	0	0	1	0.2	0.45
Archiannelida									
Polygordius sp. indeterminate		1	0	0	0	1	2	0.4	0.55
Phoronida		1	0	0	0	0	1	0.2	0.45
Echinodermata									
Dendraster excentricus		0	1	0	1	0	2	0.4	0.55
Ophiuroidea		0	0	1	0	0	1	0.2	0.45
Nematoda		0	4	0	0	0	4	0.8	1.79
Nemertinea		16	6	5	3	1	31	6.2	5.81
Anthozoa		0	5	0	0	0	5	1.0	2.24
TOTAL		506	405	491	268	37	1707		

Table C-12. Abundance data for each taxon identified in each grab from Station 2, Coos Bay, September 1986.

SPECIES GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda								
Caprellidae	0	0	0	0	2	2	0.4	0.89
Corophium brevis	0	0	0	0	1	1	0.2	0.45
Gammaridea	0	0	0	0	1	1	0.2	0.45
Grandidierella japonica	0	0	0	0	1	1	0.2	0.45
Ischyrocerus pelagops	0	0	0	1	0	1	0.2	0.45
Parapleustes pugettensis	1	0	0	0	0	1	0.2	0.45
Photis brevipes	1	0	2	0	16	19	3.8	6.87
Photis spp. juvenile	5	4	5	2	16	32	6.4	5.50
Phoxocephalidae	0	0	0	1	0	1	0.2	0.45
Anomura								
Anomura zoea	0	1	0	0	0	1	0.2	0.45
Brachyura								
Cancer sp. megalopa	1	0	0	0	0	1	0.2	0.45
Pinnixa sp. megalopa	0	3	0	0	3	6	1.2	1.64
Cumacea								
Cyclaspis sp.	0	3	0	1	1	5	1.0	1.22
Diastylopsis dawsoni	0	1	1	0	0	2	0.4	0.55
Diastylopsis tenuis	4	3	3	2	0	12	2.4	1.52
Diastylopsis sp. juvenile	0	1	0	0	0	1	0.2	0.45
Lamprops quadriplicata	0	0	0	1	0	1	0.2	0.45
Tanaidacea								
Leptochelia dubia	0	0	3	0	0	3	0.6	1.34
Gastropoda	1	2	2	0	0	5	1.0	1.00
Lacuna vincta	0	0	1	0	0	1	0.2	0.45
Olivella biplicata	0	0	2	0	0	2	0.4	0.89
Olivella pycna	0	0	0	0	1	1	0.2	0.45
Pelecypoda								
Bivalvia sp. juvenile	0	1	0	0	3	4	0.8	1.30
Clinocardium cf. nuttallii juvenile	32	39	30	19	38	158	31.6	8.02
Macoma balthica	49	63	57	26	109	304	60.8	30.38
Mya spp. juvenile	1	0	0	0	0	1	0.2	0.45
Mysella tumida	0	0	0	2	0	2	0.4	0.89
Mytilidae spp. juvenile	0	0	5	0	2	7	1.4	2.19
Protothaca cf. staminea juvenile	14	27	9	7	5	62	12.4	8.82
Pesphidia lordi	0	2	2	0	1	5	1.0	1.00
Siliqua patula	37	57	49	15	24	182	36.4	17.29
Solen cf. sicarius juvenile	0	1	1	0	0	2	0.4	0.55
Spisula cf. falcata juvenile	0	0	0	0	4	4	0.8	1.79
Tellina modesta	69	97	92	33	81	372	74.4	25.53
Tellinidae spp. juvenile	9	3	3	0	0	15	3.0	3.67
Transennella tantilla	1	0	0	0	0	1	0.2	0.45
Polychaeta								
Armandia brevis	7	9	9	4	16	45	9.0	4.42
Capitella capitata complex	0	0	2	1	1	4	0.8	0.84
Chaetozone "setosa"	0	0	1	0	0	1	0.2	0.45
Chone dunneri	1	0	0	0	0	1	0.2	0.45
Cirratulus cirratus	0	0	2	0	0	2	0.4	0.89
Eteone fauchaldi	0	0	0	1	0	1	0.2	0.45
Eulalia viridis	0	0	0	0	1	1	0.2	0.45
Exogone lourei	3	2	11	0	4	20	4.0	4.18
Glycera capitata	0	0	5	1	3	9	1.8	2.17
Glycera convoluta	1	0	1	0	1	3	0.6	0.55
Glycera tenuis	5	6	0	2	1	14	2.8	2.59

Table C-12. (continued)

SPECIES GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Glycinde picta	38	26	80	26	113	283	56.6	38.56
Hesionidae sp. juvenile	0	0	0	0	7	7	1.4	3.13
Heteropodarke heteromorpha	0	0	1	0	1	2	0.4	0.55
Leitoscoloplos pugettensis	0	0	0	0	1	1	0.2	0.45
Lumbrineris sp. juvenile	1	0	1	0	1	3	0.6	0.55
Magelona sacculata	7	1	0	0	1	9	1.8	2.95
Megalona sp. juvenile	0	2	0	0	0	2	0.4	0.89
Malacoceros glutaeus	2	3	1	2	2	10	2.0	0.71
Mediomastus californiensis	939	651	1752	753	2459	6554	1310.8	774.23
Nephtys caecoides	1	1	1	0	0	3	0.6	0.55
Nephtys sp. juvenile	1	0	0	0	0	1	0.2	0.45
Nereis zonata	0	0	4	2	4	10	2.0	2.00
Onuphis elegans	2	2	3	0	1	8	1.6	1.14
Ophelia sp. 1	1	0	1	1	1	4	0.8	0.45
Ophelia sp. juvenile	6	8	1	2	0	17	3.4	3.44
Owenia fusiformis	277	286	348	152	584	1647	329.4	159.11
Phyllodoce hartmanae	0	0	0	3	1	4	0.8	1.30
Phyllodoce sp. 1	0	7	5	0	0	12	2.4	3.36
Phyllodoce sp. indeterminate	1	0	0	0	0	1	0.2	0.45
Phyllodoce sp. juvenile	0	1	0	0	0	1	0.2	0.45
Polydora socialis	0	0	0	2	0	2	0.4	0.89
Prionospio (Minuspio) cirrifera	0	0	3	0	0	3	0.6	1.34
Pygospio elegans	6	19	6	11	10	52	10.4	5.32
Scoloplos armiceps	0	0	1	0	0	1	0.2	0.45
Scoloplos armiger	1	0	0	0	0	1	0.2	0.45
Scoloplos sp. juvenile	0	0	0	1	1	2	0.4	0.55
Spio cirrifera	0	0	0	0	1	1	0.2	0.45
Spio filicornis	2	0	0	0	0	2	0.4	0.89
Spiophanes bombyx	88	149	50	99	21	407	81.4	48.88
Syllis elongata	0	0	1	0	0	1	0.2	0.45
Syllis sp. indeterminate	0	0	1	0	0	1	0.2	0.45
Terebellidae	1	0	0	0	0	1	0.2	0.45
Oligochaeta	2	5	13	3	90	113	22.6	37.92
Phoronida	3	1	2	1	1	8	1.6	0.89
Echinodermata								
Dendraster excentricus	4	2	0	3	0	9	1.8	1.79
Nematoda	1	0	21	0	49	71	14.2	21.42
Nemertinea	40	29	26	20	11	126	25.2	10.76
Nemertinea?	2	1	1	5	1	10	2.0	1.73
TOTAL	1668	1519	2621	1205	3697	10710		

Table C-13. Abundance data for each taxon identified in each grab from Station 3, Coos Bay, September 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Caprellidae		0	0	2	0	0	2	0.4	0.89
Mandibulophoxus uncirostratus		0	0	1	0	0	1	0.2	0.45
Decapoda									
Caridea zoea		0	2	0	0	0	2	0.4	0.89
Cumacea									
Lamprops quadriplicata		0	1	0	0	0	1	0.2	0.45
Isopoda									
Gnorimosphaeroma oregonensis		2	0	0	0	0	2	0.4	0.89
Gastropoda									
Olivella biplicata		0	1	0	0	0	1	0.2	0.45
Pelecypoda									
Clinocardium cf. nuttallii juvenile		0	1	0	0	0	1	0.2	0.45
Macoma spp. juvenile		1	0	0	0	0	1	0.2	0.45
Mytilidae spp. juvenile		1	0	0	1	1	3	0.6	0.55
Siliqua patula		8	17	4	1	1	31	6.2	6.69
Tellina modesta		0	2	0	0	0	2	0.4	0.89
Tellina nuculoides		0	1	0	0	0	1	0.2	0.45
Tellina spp. juvenile		1	0	0	0	0	1	0.2	0.45
Polychaeta									
Armandia brevis		1	0	0	0	0	1	0.2	0.45
Glycera convoluta		0	0	0	1	0	1	0.2	0.45
Glycera tenuis		6	8	13	7	5	39	7.8	3.11
Glycinde picta		1	0	0	0	0	1	0.2	0.45
Heteromastus filiformis		2	1	1	1	0	5	1.0	0.71
Heteropodarke heteromorpha		7	15	20	7	10	59	11.8	5.63
Malacoceros glutaeus		0	0	0	0	2	2	0.4	0.89
Mediomastus californiensis		17	12	6	3	1	39	7.8	6.61
Ophelia sp. juvenile		0	1	0	0	0	1	0.2	0.45
Owenia fusiformis		1	0	0	0	0	1	0.2	0.45
Phyllodoce sp. 1		2	0	0	0	1	3	0.6	0.89
Phyllodoce sp. juvenile		0	0	1	0	0	1	0.2	0.45
Spiophanes bombyx		15	13	5	6	25	64	12.8	8.07
Oligochaeta		2	0	1	0	0	3	0.6	0.89
Echinodermata									
Dendraster excentricus		3	10	12	3	1	29	5.8	4.87
Nemertinea		30	4	12	6	8	60	12.0	10.49
TOTAL		100	89	78	36	55	358		

Table C-14. Abundance data for each taxon identified in each grab from Station 4, Coos Bay, September 1986.

SPECIES GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda								
Cheirimedeia zotea	3	0	0	0	0	3	0.6	1.34
Caprellidae	0	0	7	4	6	17	3.4	3.29
Eobroigus spinosus	1	0	0	1	0	2	0.4	0.55
Gammaridea	0	0	3	0	0	3	0.6	1.34
Ischyrocerus pelagops	2	5	7	1	8	23	4.6	3.05
Jassa falcata	0	0	1	0	0	1	0.2	0.45
Melita desdichada	0	1	3	2	2	8	1.6	1.14
Parapleustes pugettensis	1	6	6	5	16	34	6.8	5.54
Photis brevipes	1	3	9	5	0	18	3.6	3.58
Photis spp. juvenile	0	1	0	0	2	3	0.6	0.89
Phoxocephalidae	0	0	1	0	1	2	0.4	0.55
Anomura								
Anomura zoea	0	0	1	1	1	3	0.6	0.55
Brachyura								
Cancer magister juvenile	0	2	0	2	0	4	0.8	1.10
Cancer sp. megalopa	1	1	1	0	1	4	0.8	0.45
Cirripedia	0	0	0	p	p			
Pycnogonida	0	0	0	1	1	2	0.4	0.55
Isopoda								
Gnorimosphaeroma oregonensis	1	0	0	0	0	1	0.2	0.45
Ianiropsis kincaidi kincaidi	0	2	4	0	2	8	1.6	1.67
Munna stephenseni	0	0	0	1	0	1	0.2	0.45
Tanaidacea								
Leptochelia dubia	0	0	2	0	1	3	0.6	0.89
Gastropoda								
Alvinia spp. juvenile	0	0	1	0	0	1	0.2	0.45
Gastropoda	0	0	1	0	0	1	0.2	0.45
Nudibranchia	1	0	2	4	5	12	2.4	2.07
Pelecypoda								
Bivalvia sp. juvenile	0	0	1	0	0	1	0.2	0.45
Clinocardium cf. nuttallii juvenile	1	2	1	1	0	5	1.0	0.71
Mytilidae spp. juvenile	16	11	25	33	39	124	24.8	11.58
Mytilus spp. juvenile	1	0	0	0	0	1	0.2	0.45
Siliqua patula	0	1	0	0	0	1	0.2	0.45
Spisula cf. falcata	2	2	2	5	0	11	2.2	1.79
Polychaeta								
Armandia brevis	25	25	96	84	37	267	53.4	34.03
Capitella capitata complex	3	2	8	3	1	17	3.4	2.70
Chone dunneri	0	0	2	0	1	3	0.6	0.89
Eulalia viridis	5	3	31	10	18	67	13.4	11.41
Exogone lourei	0	0	0	1	0	1	0.2	0.45
Glycera tenuis	6	15	17	6	3	47	9.4	6.19
Glycinde picta	0	0	4	1	0	5	1.0	1.73
?Hesionidae	1	0	0	0	0	1	0.2	0.45
Heteropodarke heteromorpha	6	5	2	2	4	19	3.8	1.79
Lumbrineris sp. juvenile	0	0	1	1	2	4	0.8	0.84
Malacoceros glutaeus	10	36	10	31	6	93	18.6	13.81
Mediomastus californiensis	15	36	39	23	30	143	28.6	9.76
Micropodarke dubia	0	1	1	0	0	2	0.4	0.55
Nicolea sp. A	1	2	5	5	4	17	3.4	1.82
Orbiniidae sp. juvenile	0	0	0	0	1	1	0.2	0.45
Owenia fusiformis	0	2	2	0	0	4	0.8	1.10

Table C-14. (continued)

SPECIES	GRAB NUMBER:	ANIMALS 1	PER 2	GRAB 3	4	5	TOTAL	AVG	STD
Paleonotus bellis		16	21	45	49	60	191	38.2	18.89
Phyllodoce sp. 1		323	43	501	438	297	1602	320.4	176.03
Platynereis bicanaliculata		10	1	37	18	14	80	16.0	13.32
Polycirrus sp. complex		2	0	0	0	0	2	0.4	0.89
Polydora socialis		4	1	0	3	0	8	1.6	1.82
Prionospio (Minuspio) cirrifera		0	0	0	1	0	1	0.2	0.45
Pygospio elegans		0	0	0	0	1	1	0.2	0.45
Sabellidae		0	1	0	0	0	1	0.2	0.45
Spiophanes bombyx		2	17	17	12	2	50	10.0	7.58
Syllidae		39	13	65	54	50	221	44.2	19.77
Tenonia kitsapensis		1	0	0	0	0	1	0.2	0.45
Oligochaeta		0	0	0	1	0	1	0.2	0.45
Echinodermata									
Dendraster excentricus		0	1	0	0	1	2	0.4	0.55
Nematoda		2	0	1	0	2	5	1.0	1.00
Nemertinea		27	13	14	23	18	95	19.0	5.96
Platyhelminthes		0	0	1	1	1	3	0.6	0.55
Anthozoa		0	0	2	0	0	2	0.4	0.89
TOTAL		529	275	979	833	638	3254		

Table C-15. Abundance data for each taxon identified in each grab from Station 5, Coos Bay, September 1986.

SPECIES	GRAB NUMBER: 1	ANIMALS PER GRAB 2	3	4	5	TOTAL	AVG	STD
Amphipoda								
Caprellidae	1	1	0	0	3	5	1.0	1.22
Gammaridea	0	0	0	1	2	3	0.6	0.89
Ischyrocerus pelagops	0	1	0	1	10	12	2.4	4.28
Jassa falcata	0	1	0	0	0	1	0.2	0.45
Melita desdichada	0	0	0	0	1	1	0.2	0.45
Parapleustes pugettensis	0	0	0	2	8	10	2.0	3.46
Brachyura								
Cancer magister	1	0	0	1	0	2	0.4	0.55
Cancer sp. megalopa	0	0	0	1	0	1	0.2	0.45
Decapoda (other)								
Heptacarpus brevirostris	0	0	0	0	1	1	0.2	0.45
Cirripedia	P	P	P	P	P			
Isopoda								
Ianiropsis kincaidi kincaidi	0	0	0	1	1	2	0.4	0.55
Tanaidacea								
Leptochelia dubia	0	0	0	1	0	1	0.2	0.45
Pycnogonida	0	2	0	1	0	3	0.6	0.89
Gastropoda								
Alvinia spp. juvenile	0	0	0	0	1	1	0.2	0.45
Gastropoda	0	0	1	0	0	1	0.2	0.45
Nudibranchia	0	0	0	3	6	9	1.8	2.68
Pelecypoda								
Adula diegensis	1	0	0	0	0	1	0.2	0.45
Clinocardium cf. nuttallii juvenile	0	0	0	2	0	2	0.4	0.89
Hiatella arctica	0	0	0	0	2	2	0.4	0.89
Mytilidae spp. juvenile	3	4	2	52	35	96	19.2	22.99
Tapes philippinarium	0	0	0	0	1	1	0.2	0.45
Polychaeta								
Armandia brevis	0	0	0	36	6	42	8.4	15.65
Axiothella rubrocincta	0	0	0	2	0	2	0.4	0.89
Capitella capitata complex	0	0	0	1	0	1	0.2	0.45
Chone mollis	1	0	0	2	2	5	1.0	1.00
Eumida sanguinea	1	0	0	4	7	12	2.4	3.05
Exogone lourei	0	0	0	0	1	1	0.2	0.45
Glycera tenuis	8	1	4	6	4	23	4.6	2.61
Hesionura coineaui difficilis	0	0	0	4	0	4	0.8	1.79
Heteropodarke heteromorpha	1	1	1	19	7	29	5.8	7.82
Malacoceros glutaeus	0	0	0	26	3	29	5.8	11.37
Mediomastus californiensis	1	0	0	36	3	40	8.0	15.70
Micropodarke dubia	0	0	0	1	0	1	0.2	0.45
Nephtys californiensis	0	0	1	0	0	1	0.2	0.45
Odontosyllis phosphorea	0	1	0	0	0	1	0.2	0.45
Paleonotus bellis	8	0	0	54	50	112	22.4	27.25
Phyllodoce sp. 1	10	0	1	263	150	424	84.8	118.13
Platynereis bicanaliculata	0	0	0	0	1	1	0.2	0.45
Polycirrus sp. complex	0	0	0	2	0	2	0.4	0.89
Polydora socialis	0	0	0	2	2	4	0.8	1.10
Sabellidae	0	0	0	0	1	1	0.2	0.45
Spiophanes bombyx	7	0	0	4	4	15	3.0	3.00
Spio butleri	0	0	0	1	0	1	0.2	0.45
Syllidae	6	2	0	73	36	117	23.4	31.33
Archiannelida								
Polygordius sp. indeterminate	0	0	2	3	11	16	3.2	4.55
Saccocirrus exoticus	0	0	0	4	0	4	0.8	1.79

Table C-15. (continued)

SPECIES	GRAB NUMBER:	1	2	3	4	5	TOTAL	AVG	STD
			ANIMALS PER GRAB						
Echinodermata									
Dendraster excentricus		1	3	4	1	0	9	1.8	1.64
Nematoda		0	0	0	3	0	3	0.6	1.34
Nemertinea		3	3	4	22	11	43	8.6	8.20
Platyhelminthes		0	0	0	1	11	12	2.4	4.83
Anthozoa		0	0	0	3	0	3	0.6	1.34
TOTAL		53	20	20	639	381	1113		

Table C-16. Abundance data for each taxon identified in each grab from Station 6, Coos Bay, September 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Mandibulophoxus uncirostratus		0	0	1	0	0	1	0.2	0.45
Photis brevipes		1	0	0	0	0	1	0.2	0.45
Decapoda									
Crangon franciscorum franciscorum		1	0	0	0	0	1	0.2	0.45
Cumacea									
Cumacea		0	0	0	1	0	1	0.2	0.45
Lamprops quadriplicata		0	0	0	0	2	2	0.4	0.89
Pelecypoda									
Siliqua patula		1	4	3	4	4	16	3.2	1.30
Tellina modesta		1	0	0	0	0	1	0.2	0.45
Tellina nuculoides		0	0	1	1	0	2	0.4	0.55
Polychaeta									
Glycera tenuis		13	8	10	11	10	52	10.4	1.82
Heteropodarke heteromorpha		10	21	18	14	36	99	19.8	9.96
Mediomastus californiensis		3	1	1	0	2	7	1.4	1.14
Nephtys caecoides		1	1	0	1	0	3	0.6	0.55
Nephtys californiensis		0	0	0	1	0	1	0.2	0.45
Ophelia sp. 1		0	0	1	0	2	3	0.6	0.89
Ophelia sp. juvenile		1	0	0	0	0	1	0.2	0.45
Phyllodoce sp. 1		0	2	1	0	0	3	0.6	0.89
Scolelepsis squamata		0	0	2	0	3	5	1.0	1.41
Spiophanes bombyx		23	78	48	78	60	287	57.4	23.06
Echinodermata									
Dendraster excentricus		29	15	24	5	11	84	16.8	9.71
Nemertinea		1	0	2	3	2	8	1.6	1.14
Pices									
Ammodytes hexapterus		0	0	0	0	1	1	0.2	0.45
TOTAL		85	131	112	119	133	580		

Table C-17. Abundance data for each taxon identified in each grab from Station 7, Coos Bay, September, 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Brachyura									
Cancer magister		1	0	0	0	0	1	0.2	0.45
Cirripedia		0	p	0	p	p			
Pycnogonida		1	0	0	0	0	1	0.2	0.45
Pelecypoda									
Mactra cf. falcata juvenile		1	0	0	0	0	1	0.2	0.45
Mytilidae spp. juvenile		8	5	16	4	20	53	10.6	7.06
Mytilus edulis		0	0	0	0	1	1	0.2	0.45
Polychaeta									
Armandia brevis		0	0	0	0	1	1	0.2	0.45
Capitella capitata complex		1	0	0	0	0	1	0.2	0.45
Glycera tenuis		19	17	17	14	17	84	16.8	1.79
Hesionura coineaui difficilis		0	0	1	1	0	2	0.4	0.55
Heteropodarke heteromorpha		14	22	18	9	18	81	16.2	4.92
Mediomastus californiensis		6	6	1	8	4	25	5.0	2.65
Opheliidae sp. juvenile		1	0	0	0	0	1	0.2	0.45
Paleonotus bellis		2	0	0	0	0	2	0.4	0.89
Phyllodoce sp. 1		15	0	0	1	0	16	3.2	6.61
Polydora socialis		1	0	0	0	1	2	0.4	0.55
Pygospio elegans		0	0	0	0	1	1	0.2	0.45
Spiophanes bombyx		2	0	5	14	5	26	5.2	5.36
Syllidae		1	0	0	0	0	1	0.2	0.45
Archiannelida									
Polygordius sp. indeterminate		1	3	7	1	1	13	2.6	2.61
Echinodermata									
Dendraster excentricus		8	1	3	3	4	19	3.8	2.59
Nemertinea		10	2	11	2	7	32	6.4	4.28
Holothuroidea		1	0	0	0	0	1	0.2	0.45
TOTAL		93	56	80	57	80	366		

Table C-18. Abundance data for each taxon identified in each grab from Station 8, Coos Bay, September 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Caprellidae		0	0	0	0	1	1	0.2	0.45
Mandibulophoxus uncirostratus		0	0	0	0	1	1	0.2	0.45
Anomura									
Anomura zoea		1	0	2	0	0	3	0.6	0.89
Brachyura									
Cancer sp. zoea		0	0	1	1	0	2	0.4	0.55
Gastropoda									
Olivella biplicata		0	1	0	0	0	1	0.2	0.45
Pelecypoda									
Adula diegensis		0	1	0	0	0	1	0.2	0.45
Mytilidae spp. juvenile		0	0	0	0	3	3	0.6	1.34
Protothaca cf. staminea juvenile		0	1	0	0	1	2	0.4	0.55
Tellina nuculoides		0	1	0	2	0	3	0.6	0.89
Polychaeta									
Glycera tenuis		9	13	6	10	5	43	8.6	3.21
Heteropodarke heteromorpha		0	3	0	20	4	27	5.4	8.35
Mediomastus californiensis		2	1	2	7	0	12	2.4	2.70
Nephtys caecoides		0	0	1	0	1	2	0.4	0.55
Ophelia sp. 1		0	1	1	0	0	2	0.4	0.55
Opheliidae sp. juvenile		1	0	0	0	0	1	0.2	0.45
Spiophanes bombyx		1	0	2	1	0	4	0.8	0.84
Archiannelida									
Polygordius sp. indeterminate		0	0	0	3	0	3	0.6	1.34
Echinodermata									
Dendraster excentricus		1	3	0	0	1	5	1.0	1.22
Nemertinea		2	0	1	3	2	8	1.6	1.14
TOTAL		17	25	16	47	19	124		

Table C-19. Abundance data for each taxon identified in each grab from Station 9, Coos Bay, September 1986.

SPECIES	GRAB NUMBER:	ANIMALS PER GRAB 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda									
Caprellidae		0	0	0	1	0	1	0.2	0.45
Eohaustorius sawyeri		0	0	1	0	0	1	0.2	0.45
Jassa falcata		0	0	0	0	1	1	0.2	0.45
Mandibulophoxus uncirostratus		2	0	0	1	3	6	1.2	1.30
Synchelidium shoemakeri		0	1	0	0	1	2	0.4	0.55
Mysidacea									
Archeomysis grebnitzkii		1	0	0	0	0	1	0.2	0.45
Gastropoda									
Gastropoda		0	0	1	0	0	1	0.2	0.45
Olivella baetica		1	0	0	0	0	1	0.2	0.45
Olivella biplicata		0	0	0	1	0	1	0.2	0.45
Nudibranchia		0	0	0	3	6	9	1.8	2.68
Pelecypoda									
Adula diegensis		0	0	0	2	0	2	0.4	0.89
Mytilidae spp. juvenile		0	0	1	0	0	1	0.2	0.45
Siliqua patula		3	3	1	1	1	9	1.8	1.10
Polychaeta									
Glycera tenuis		3	5	4	5	0	17	3.4	2.07
Heteropodarke heteromorpha		0	0	1	0	0	1	0.2	0.45
Lumbrineris sp. indeterminate		0	0	1	0	0	1	0.2	0.45
Magelona sacculata		2	0	1	1	3	7	1.4	1.14
Mediomastus californiensis		0	0	0	1	2	3	0.6	0.89
Nephtys caecoides		0	0	4	1	1	6	1.2	1.64
Ophelia sp. 1		0	0	3	1	0	4	0.8	1.30
Paraonella platybranchia		1	1	2	0	0	4	0.8	0.84
Scoloplos acmeceps		0	0	2	0	1	3	0.6	0.89
Spio filicornis juvenile		1	1	3	9	16	30	6.0	6.48
Spiophanes bombyx		10	30	55	72	27	194	38.8	24.55
Echinodermata									
Dendraster excentricus		1	2	3	6	2	14	2.8	1.92
Nemertinea		0	0	0	2	0	2	0.4	0.89
TOTAL		25	43	83	107	64	322		

Table C-20. Abundance data for each taxon identified in each grab from Station 10, Coos Bay, September 1986.

SPECIES	ANIMALS PER GRAB — GRAB NUMBER: 1	2	3	4	5	TOTAL	AVG	STD
Amphipoda								
Caprellidae	0	17	1	0	0	18	3.6	7.50
Caprella A	0	199	0	0	0	199	39.8	88.99
Caprella B	0	224	0	0	0	224	44.8	100.18
Caprella C	0	163	0	0	0	163	32.6	72.90
Caprella D	0	28	0	0	0	28	5.6	12.52
Eobrolgus spinosus	0	28	0	0	0	28	5.6	12.52
Gammaridea	0	5	0	0	0	5	1.0	2.24
Ischyrocerus pelagops	0	54	0	0	0	54	10.8	24.15
Ischyrocerus litotes	0	32	0	0	0	32	6.4	14.31
Ischyrocerus spp. juvenile	0	8	0	0	0	8	1.6	3.58
Jassa falcata	0	8	0	0	0	8	1.6	3.58
Melita sp. juvenile	0	1	0	0	0	1	0.2	0.45
Parapleustes pugettensis	0	13	0	0	0	13	2.6	5.81
Parapleustes pugettensis juvenile	0	63	0	0	0	63	12.6	28.17
Photis brevipes	0	18	0	0	0	18	3.6	8.05
Photis spp. juvenile	0	17	0	0	0	17	3.4	7.60
Pontogeneia rostrata	0	7	0	0	0	7	1.4	3.13
Stenothoidae sp. juvenile	0	46	0	0	0	46	9.2	20.57
Brachyura								
Cancer oregonensis juvenile	0	4	0	0	0	4	0.8	1.79
Cirripedia	0	p	p	0	0			
Isopoda								
Ianiropsis kincaidi kincaidi	0	45	0	0	0	45	9.0	20.12
Munna stephenseni	0	3	0	0	0	3	0.6	1.34
Synidotea pettibonae	0	4	0	0	0	4	0.8	1.79
Tanaidacea								
Leptochelia dubia	0	4	0	0	0	4	0.8	1.79
Tanais normani	0	1	0	0	0	1	0.2	0.45
Pycnogonida	0	163	0	0	0	163	32.6	72.90
Gastropoda								
Alvinia spp. juvenile	0	10	0	0	0	10	2.0	4.47
Lacuna vincta	0	1	0	0	0	1	0.2	0.45
Mitrella gouldi	0	1	0	0	0	1	0.2	0.45
Nudibranchia	0	21	0	0	0	21	4.2	9.39
Odostomia spp.	0	26	0	0	0	26	5.2	11.63
Pelecypoda								
Adula diegensis	0	21	0	0	0	21	4.2	9.39
Hiatella arctica	0	3	0	0	0	3	0.6	1.34
Lyonsia californica	0	1	0	0	0	1	0.2	0.45
Mytilus edulis	0	2	0	0	0	2	0.4	0.89
Mytilidae spp. juvenile	0	4202	73	0	2	4277	855.4	1871.07
Pectinidae spp. juvenile	0	5	0	0	0	5	1.0	2.24
Protothaca cf. staminea juvenile	0	26	0	0	0	26	5.2	11.63
Spisula cf. falcata juvenile	0	2	0	0	1	3	0.6	0.89
Tapes philippinarium	0	23	2	0	0	25	5.0	10.10
Tellina nuculoides	0	0	0	3	0	3	0.6	1.34
Zirfaea pilsbryii	0	6	0	0	0	6	1.2	2.68
Polychaeta								
Aberinicolidae sp. juvenile	0	2	0	0	0	2	0.4	0.89
Armandia brevis	0	32	0	0	0	32	6.4	14.31
Chone dunneri	0	120	5	0	0	125	25.0	53.15
Eulalia viridis	0	13	0	0	0	13	2.6	5.81

Table C-20. (continued)

SPECIES	GRAB NUMBER:	1	ANIMALS PER GRAB 2	3	4	5	TOTAL	AVG	STD
Eumida sanguinea		0	1	0	0	0	1	0.2	0.45
Exogone lourei		0	3	0	0	0	3	0.6	1.34
Glycera tenuis		9	0	0	20	16	45	9.0	9.11
Halosydna brevisetosa		0	9	0	0	0	9	1.8	4.02
Hesionura coineaui difficilis		0	0	0	2	11	13	2.6	4.77
Heteropodarke heteromorpha		1	0	0	3	0	4	0.8	1.30
Lumbrineris sp. indeterminate		0	5	0	0	0	5	1.0	2.24
Magelona sacculata		1	0	0	0	0	1	0.2	0.45
Malacoceros glutaeus		0	9	7	0	0	16	3.2	4.44
Mediomastus californiensis		0	1	0	3	0	4	0.8	1.30
Nephtys caecoides		0	0	0	0	1	1	0.2	0.45
Nicolea sp. A		0	4	0	0	0	4	0.8	1.79
Ophelia sp. juvenile		0	0	0	1	0	1	0.2	0.45
Paleonotus bellis		0	2	2	0	0	4	0.8	1.10
Platynereis bicanaliculata		0	21	0	0	0	21	4.2	9.39
Phyllodoce sp. 1		0	4	0	0	0	4	0.8	1.79
Polycirrus sp. complex		0	2	0	0	0	2	0.4	0.89
Protoaricia sp.1		0	11	0	0	0	11	2.2	4.92
Pygospio elegans		0	0	4	0	0	4	0.8	1.79
Sabellidae		0	4	0	0	0	4	0.8	1.79
Schistocomus hiltoni		0	1	0	0	0	1	0.2	0.45
Syllidae		0	268	11	0	0	279	55.8	118.71
Thelepus setosus		0	1	0	0	0	1	0.2	0.45
Archiannelida									
Polygordius sp. indeterminate		0	4	0	0	5	9	1.8	2.49
Sipunculida		0	2	0	0	0	2	0.4	0.89
Echinodermata									
Dendraster excentricus		1	0	0	0	9	10	2.0	3.94
Asteroidea		0	5	0	0	0	5	1.0	2.24
Nematoda		0	2	1	0	0	3	0.6	0.89
Nemertinea		2	60	15	2	27	106	21.2	24.06
Anthozoa		0	4	6	0	0	10	2.0	2.83
TOTAL		14	6095	127	34	72	6342		