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by Susan A. Hinton

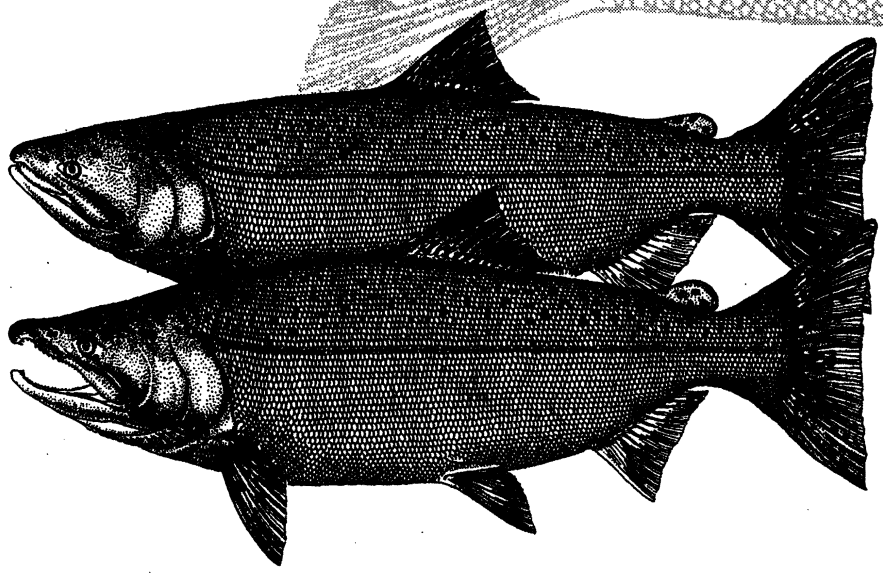
March 1998

Fish Ecology Division

Northwest Fisheries Science Center

National Marine Fisheries Service

Seattle, Washington



BENTHIC INFAUNA AND SEDIMENT CHARACTERISTICS OFFSHORE FROM THE COLUMBIA RIVER, OCTOBER/NOVEMBER 1995 AND JUNE 1996

By

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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (COE), Portland District, is responsible for maintaining the navigational channel in the lower Columbia River estuary. This maintenance involves the annual removal of 0.8 to 6.9 million m^3 (1 to 9 million yd^3) of material, which is placed in one or more of four designated Ocean Dredged-Material Disposal Sites (ODMDS-A, B, E, and F). Because material disposed of at ODMDS B had not dispersed as expected, creating a mound within 14.6 m (48 ft MLLW) of the ocean surface, temporary spatial expansions of Sites A, B, and F were initiated by the COE in 1992 while seeking a long-term solution for ocean disposal of dredged material.

To minimize negative biological effects, new ODMDSs should be located in areas with no unique biological characteristics or critical habitat and with relatively low standing crops of benthic and epibenthic invertebrates and fishes. The primary goal of the present study, which was conducted by the National Marine Fisheries Service, in October/November 1995 and June 1996, was to assess benthic invertebrate communities and sediment characteristics at stations west and north of the Columbia River entrance.

Stations were located in an area about 16 km west and 18 km north of the Columbia River mouth in depths ranging from 14.3 to 96.3 m. Benthic invertebrate and sediment samples were collected using a 0.1-m^2 modified Gray-O'Hara box corer.

During the October/November 1995 survey, 571 different organisms were identified as benthic invertebrate taxa and used for analyses. The number of taxa per station ranged from 56 to 269 and averaged 154. Densities of organisms per station ranged from 1,861 to 54,269 organisms/m^2 and averaged 13,903 organisms/m^2. Polychaetes were the most abundant taxa, averaging 9,911/m^2 and miscellaneous taxa were the least abundant, averaging 369/m^2.

Diversity (H) ranged from 2.08 to 6.13, and was considered high (≥3.50) at 31 of the 36 stations. Equitability (E) ranged from 0.30 to 0.80. Seven benthic invertebrate cluster groups (groups of stations with similar benthic invertebrate species and numbers) were identified, and one station had no group affiliation. The largest cluster group was comprised of 11 stations and was dominated by three species of polychaetes. From the sediment analysis, average median grain size was 0.117 mm, average percent silt/clay was 17.8%, and average percent volatile solids was 1.8% for all 36 stations. One station had sediment classified as coarse silt, 20 stations were classified as very fine sand, and 15 stations were classified as fine sand.

During the June 1996 survey, 502 different organisms were identified as benthic invertebrate taxa and used for analyses. The number of taxa per station ranged from 48 to 221 and averaged 132. Densities of organisms per station ranged from 1,884 to 15,945 organisms/m^2 and averaged 7,400 organisms/m^2. Polychaetes were the most abundant taxa, averaging 5,519/m^2 and miscellaneous taxa were the least abundant, averaging 286/m^2. Diversity (H) ranged from 3.07 to 5.85, and was considered high (≥3.50) at 38 of the 39 stations. Equitability (E) ranged from 0.45 to 0.80. Eight benthic invertebrate cluster groups were identified, and one station had no group affiliation. The largest cluster group was comprised of eight stations and was dominated by three species of polychaetes. From the sediment analysis, average median grain size was 0.116 mm, average percent silt/clay was 21.4%, and average percent volatile solids was 1.8% for all 39 stations. Two stations had sediment classified as coarse silt, 21 stations were classified as very fine sand, and 16 stations were classified as fine sand.

Benthic invertebrates can be important prey for juvenile and adult commercially harvested demersal fish and shellfish. Fish food habit studies from the central Oregon coast and off the mouth of the Columbia River and shellfish food habit studies off the Washington

coast identified many of the same benthic invertebrates found in our surveys as common prey. Therefore, the location of areas with a high abundance of organisms should be taken into consideration when searching for dredged-material disposal sites.

CONTENTS

INTRODUCTION

The U.S. Army Corps of Engineers (COE), Portland District, is authorized to maintain navigational channels in the Columbia River and its estuary. Four Ocean Dredged-Material Disposal Sites (ODMDS) off the mouth of the Columbia River have been designated by the Environmental Protection Agency to receive dredged material. These sites are identified as ODMDS A, B, E, and F and are used for disposal of materials dredged primarily from shoals at the mouth of the Columbia River, but may also receive dredged material from other areas in the lower estuary. Average annual dredged material quantities from the mouth of the Columbia River range from 0.8 to 6.9 million m^3 (1 to 9 million yd^3). In 1992, ODMDS A, B, and F were expanded for emergency dredged-material disposal because material disposed of at the primary ocean disposal site (ODMDS B) had not dispersed as expected, but accumulated into a mound that came within 14.6 m (48 ft MLLW) of the surface. The temporary (5-year) spatial expansions of Sites A, B, and F were initiated by the COE while searching for a long-term solution for dredged-material disposal.

One consideration when searching for dredged-material disposal sites is to minimize the impact to benthic invertebrate communities. This is because many benthic invertebrates are prey for commercially and ecologically important species of demersal fishes and shellfish. Other considerations should include that the areas have no critical or unique biological characteristics and relatively low standing crops of benthic and epibenthic invertebrates and fishes. In 1995, in a continuing effort to find disposal sites that would have the least impact on biological communities, the COE selected a study area west and north of the mouth of the Columbia River that had not been the area of focus in previous studies. The primary goal of the present study, conducted by the National Marine Fisheries Service, was to assess benthic

invertebrate communities and sediment characteristics in October/November 1995 and June 1996 in an area offshore from the Columbia River (Fig. 1).

METHODS

Sampling

Benthic Invertebrates

The benthic sampling stations were located offshore from the Columbia River, extending about 18 km north and 16 km west of the river mouth (Fig. 1). Thirty-six stations in October/November 1995 and 39 stations in June 1996 were sampled for both benthic invertebrates and sediments. Station depths ranged from 14.3 to 96.3 m (Appendix Table 1). The Global Positioning System (GPS) was used to identify station geographic coordinates.

A 0.1-m^2 modified Gray-O'Hara box corer (Pequegnat et al. 1981) was used to collect bottom samples (Appendix Fig. 1). Five benthic invertebrate samples were taken at each station. Benthic invertebrate samples were preserved in 18.9-liter buckets with a buffered 4% formaldehyde solution containing rose bengal (a protein stain). Within 2 weeks, each sample was individually sieved through a 0.5-mm mesh screen, and the residue containing the macroinvertebrates was preserved in a 70% ethanol solution. Benthic organisms were sorted from the preserved samples, identified to the lowest practical taxonomic level (usually species), and counted. All specimens were placed in vials containing 70% ethanol and stored at the National Marine Fisheries Service (NMFS) Point Adams Biological Field Station, Hammond, Oregon.

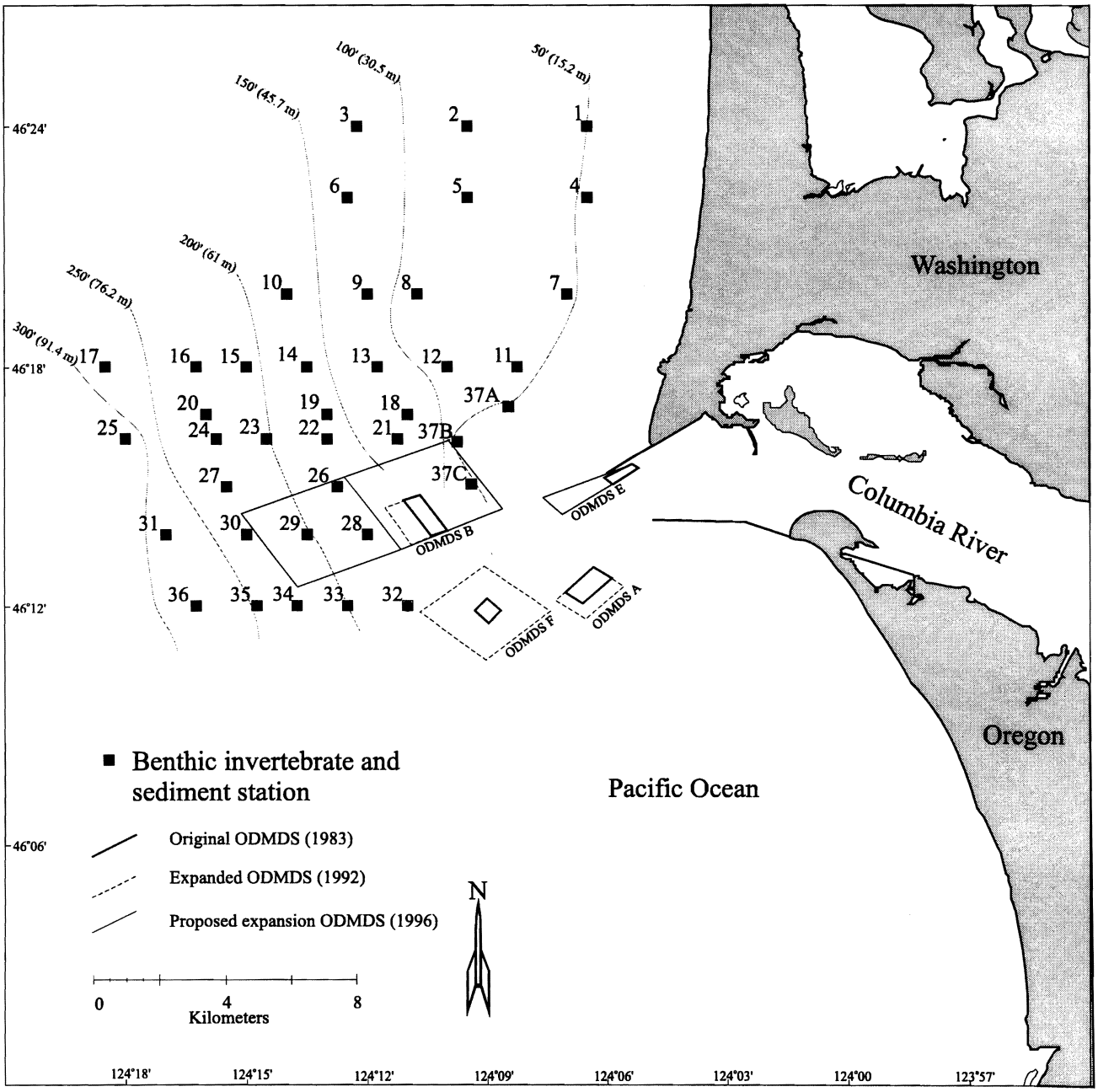

Figure 1. Location of benthic invertebrate and sediment sampling stations offshore from the Columbia River, October/November 1995 and June 1996. Stations 37A, 37B, and 37C were sampled only in June 1996. Locations of Ocean Dredged-Material Disposal Sites (ODMDS) are also shown.

Sediments

Sediment samples for physical analyses were collected at all stations. These samples were collected from the box corer using a stainless steel spoon, placed in labeled plastic bags, and refrigerated until delivery to the COE North Pacific Division Materials Testing Laboratory at Troutdale, Oregon.

Data Analyses

Benthic Invertebrates

At each station where benthic invertebrates were collected, the total number of organisms was determined and the number of organisms/m^2 was calculated. Each sample collected at a station was treated as a replicate, allowing calculation of a mean number of organisms/m^2 and standard deviation for each species and for each station. Two community structure indices were also calculated for each station. The first was diversity (H), which was determined using the Shannon-Wiener function (Krebs 1978):

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

where $p_i = n_i/N$ (n_i is the number of individuals of the *i*th taxon in the sample, and N is the total number of individuals in the sample) and s = number of taxa. The second community structure index was equitability (E), which measures proportional abundances among the various taxa in a sample (Krebs 1978):

$$E = H/\log_2 s$$

where H = Shannon-Wiener function and s = number of taxa. E has a possible range of 0.00 to 1.00, with 1.00 indicating that all taxa in the sample are numerically equal.

Cluster analysis, using the Bray-Curtis dissimilarity index with a group-averaging

fusion strategy (Clifford and Stephenson 1975), was used to identify stations that had similar species and densities. A dissimilarity value of ≤ 0.5 was considered a significant difference between groups. The mean number of individuals/m^2 for each species per station was used in the analysis. Species that had densities of less than 30 individuals/m^2 were excluded from the analysis to reduce the effect of uncommon species.

Sediments

Physical analyses of sediments included determinations of grain size and volatile solids. Median grain size and percent silt/clay were calculated for each sample.

RESULTS

Benthic Invertebrates

October/November 1995 Survey

During the October/November benthic invertebrate survey, 571 different taxa/categories were identified and used for analyses (Appendix Table 2). The number of benthic invertebrate taxa per station averaged 154 and ranged from 56 (Station 1) to 269 (Station 17) (Table 1, Appendix Table 3). Overall station densities averaged 13,903 invertebrates/m^2, and ranged from 1,861 (Station 1) to 54,269 organisms/m^2 (Station 21). All but four stations had densities that were less than 20,000 organisms/m^2.

Polychaetes were the most abundant taxa, averaging 9,911/m^2, and the miscellaneous taxa/category was the least abundant, averaging 369/m^2 (Table 2). The three most abundant taxa within each major taxonomic group found throughout the study area included the polychaetes *Owenia fusiformis*, *Mediomastus* spp., and *Prionospio lighti*; the crustaceans

Table 1. Summary of benthic invertebrates by station for samples collected offshore from the mouth of the Columbia River, October/November 1995.

Station	Date (1995)	Number of taxa/categories	Mean number/m^2	Standard deviation	H (Diversity)	E (Equitability)
1	31Oct	56	1,861	380	4.56	0.79
2	31Oct	86	8,855	3,244	3.13	0.49
3	31Oct	119	10,074	2,242	4.37	0.63
4	31Oct	58	4,304	2,053	3.72	0.63
5	31Oct	85	13,886	4,072	2.90	0.45
6	31Oct	114	7,730	1,130	4.86	0.71
7	31Oct	65	3,751	1,080	3.78	0.63
8	31Oct	89	12,840	2,818	3.25	0.50
9	31Oct	126	11,231	1,586	4.52	0.65
10	31Oct	174	16,422	2,049	5.44	0.73
11	31Oct	65	3,616	641	4.33	0.72
12	31Oct	100	10,660	1,147	3.80	0.57
13	31Oct	107	6,996	873	4.56	0.68
14	31Oct	142	10,910	1,819	4.77	0.67
15	13Oct	203	15,251	3,511	5.49	0.72
16	13Oct	213	18,145	4,169	5.68	0.73
17	19Oct	269	15,899	2,815	6.01	0.74
18	5Oct	103	30,627	14,898	2.27	0.34
19	5Oct	123	15,201	3,214	4.61	0.66
20	5Oct	236	18,506	4,161	5.98	0.76
21	5Oct	114	54,269	26,637	2.08	0.30
22	5Oct	179	29,368	4,238	4.83	0.65
23	5Oct	186	16,099	2,394	5.59	0.74
24	5Oct	235	16,193	4,785	5.89	0.75
25	5Oct	252	14,223	6,586	5.63	0.71
26	5Oct	157	22,636	1,087	4.82	0.66
27	5Oct	219	16,197	4,493	5.91	0.76
28	1Nov	149	16,589	3,132	4.90	0.68
29	1Nov	173	10,089	2,028	5.54	0.74
30	1Nov	204	9,849	2,690	6.13	0.80
31	1Nov	228	10,793	3,749	5.94	0.76
32	1Nov	151	8,555	1,168	5.69	0.79
33	1Nov	168	7,671	2,533	5.64	0.76
34	1Nov	180	9,122	793	5.80	0.77
35	1Nov	203	9,941	3,441	6.10	0.80
36	1Nov	220	12,154	2,619	5.96	0.77
Mean		154	13,903		4.85	0.67

Table 2. Dominant benthic invertebrates found at 36 stations (combined) offshore from the Columbia River, October/November 1995.

Taxon/category	Mean number/m^2
Polychaeta	
Owenia fusiformis	2,341
Mediomastus spp.	701
Prionospio lighti	600
Magelona longicornis	483
Galathowenia oculata	343
Pectinaria californiensis	318
Chaetozone columbiana	315
Scoletoma luti	261
Magelona sacculata	236
Spiophanes berkeleyorum	209
Miscellaneous (323 taxa/categories)	4,104
Total	9,911
Crustacea	
Diastylopsis spp.	1,265
Euphilomedes carcharodonta	238
Photis macinerneyi	111
Rhepoxynius daboius	105
Rhepoxynius tridentatus	75
Eohaustorius sencillus	72
Orchomene pacifica	55
Bathyleberis spp.	47
Rhepoxynius abronius	40
Americhelidium millsi	32
Miscellaneous (115 taxa/categories)	462
Total	2,502
Mollusca	
Axinopsida serricata	300
Tellina spp.	249
Mytilidae	103
Spiromoellaria quadrae	51
Mysella tumida	38
Astyris gausapata	37
Macoma spp.	35
Olivella spp.	32
Turbonilla spp.	25
Scaphopoda	23
Miscellaneous (79 taxa/categories)	228
Total	1,121

Table 2. Continued.

Taxon/category	Mean number/m^2
Miscellaneous	
Nemertea	197
Amphiuridae	54
Ophiurida	34
Nynantheae	22
Thysanocardia nigra	12
Miscellaneous (30 taxa/categories)	50
Total	369
Total	13,903

Diastylopsis spp., *Euphilomedes carcharodonta*, and *Photis macinerneyi*; and the molluscs *Axinopsida serricata*, *Tellina* spp., and Mytilidae juveniles.

For the October/November survey, diversity (H) ranged from 2.08 to 6.13, and was considered high (≥3.50) at 31 of the 36 stations (Table 1, Appendix Table 3). Equitability (E) ranged from 0.30 to 0.80 and most stations had values above 0.70. This indicates that those stations had species that were numerically similar. The two stations with the highest densities (Stations 18 and 21) also had low H values due to the lower number of taxa and the dominance of one or more of those taxa (i.e., low E values). Stations with highest H and E values typically had a higher than average number of taxa, but no numerically dominant taxa.

Seven benthic invertebrate cluster groups (groups of stations with similar benthic invertebrate species and densities) and one station (Station 4) with no group affiliation (Fig. 2, Table 3) were identified from the October/November survey. Cluster Group G contained the most stations (11), was dominated by three species of polychaetes, and had an average density of 13,369 organisms/m^2. The next largest cluster group, C, was comprised of eight stations. Group C had an average benthic invertebrate density of 10,284 organisms/m^2 and was also dominated by three species of polychaetes. Cluster groups (A, D, and E) had at least one species other than polychaetes as the dominant taxa. Station 4, which did not cluster with any other stations, had molluscs and amphipods as the dominant taxa.

June 1996 Survey

During the June 1996 benthic invertebrate survey, 502 different taxa/categories were identified and used for analyses (Appendix Table 2). The number of benthic invertebrate taxa per station averaged 132 and ranged from 48 (Station 4) to 221 (Station 36) (Table 4, Appendix Table 3). The overall station density (39 stations combined) was 7,400 organisms/m^2 and ranged from 1,884 (Station 1) to 15,945 organisms/m^2 (Station 22). Most stations (29) had densities less than 10,000 organisms/m^2.

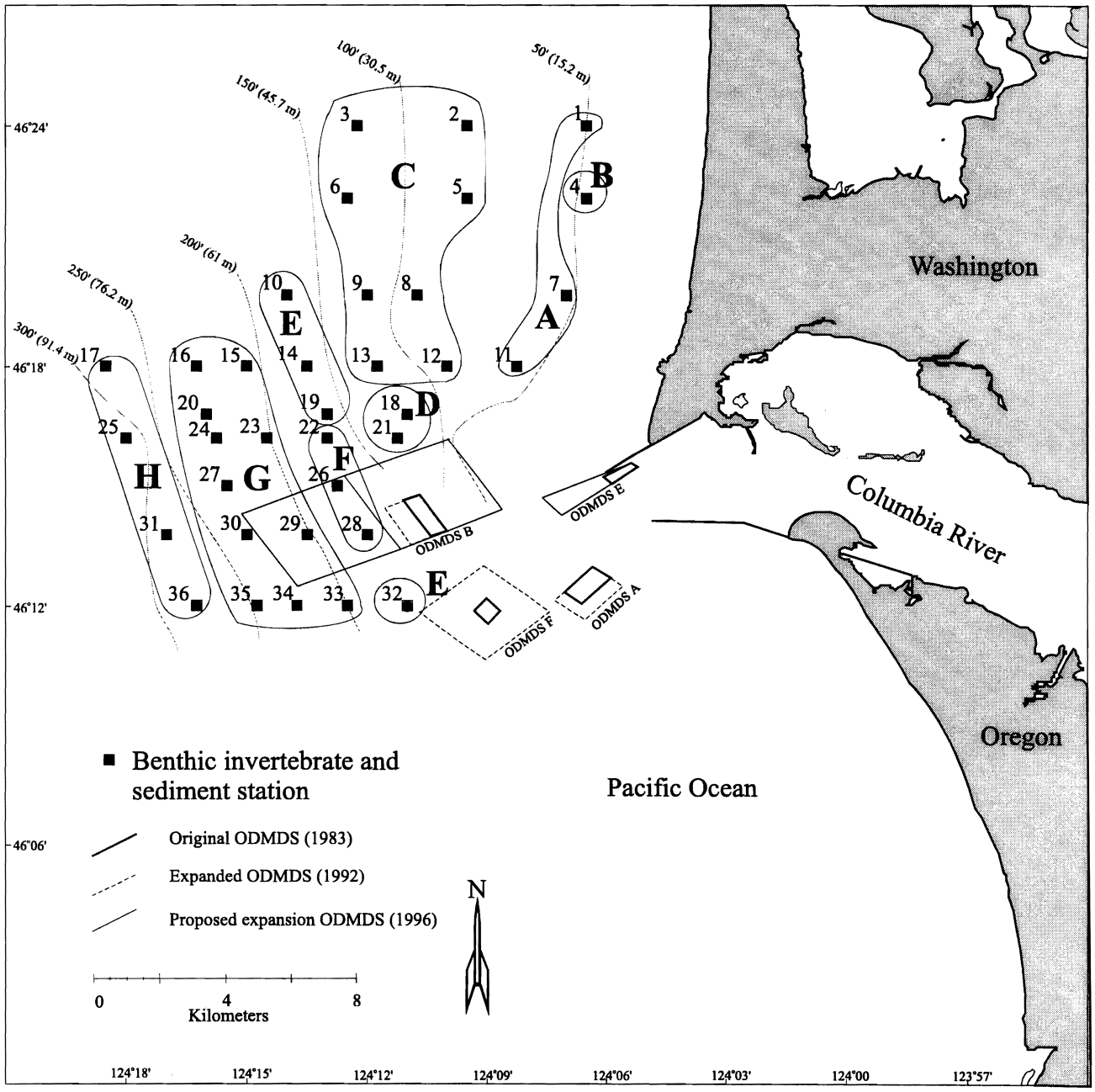

Figure 2. Locations of benthic invertebrate cluster groups (A-H) offshore from the Columbia River, October/November 1995. Station 4 did not cluster with any groups. ODMDSs are Ocean Dredged-Material Disposal Sites.

Table 3. Results from cluster analysis of benthic invertebrate densities at 36 stations off the mouth of the Columbia River, October/November 1995.

Cluster group	Mean number/m^2	Dominant taxa
A	3,076	*Diastylopsis* spp. *Magelona sacculata* *Spiophanes bombyx*
B	4,304	*Spiromoellaria quadrae* Mytilidae *Photis macinerneyi*
C	10,284	*Owenia fusiformis* *Spiophanes bombyx* *Magelona sacculata*
D	42,448	*Diastylopsis* spp. *Owenia fusiformis* *Tellina* spp.
E	12,772	*Owenia fusiformis* *Axinopsida serricata* *Prionospio lighti*
F	22,864	*Mediomastus* spp. *Owenia fusiformis* *Prionospio lighti*
G	13,369	*Mediomastus* spp. *Scoletoma luti* *Prionospio lighti*
H	13,267	*Magelona longicornis* *Prionospio lighti* *Pectinaria californiensis*

Table 4. Summary of benthic invertebrates by station for samples collected offshore from the mouth of the Columbia River, June 1996.

Station	Date (1996)	Number of taxa/categories	Mean number/m^2	Standard deviation	H (Diversity)	E (Equitability)
1	3Jun	49	1,884	325	4.02	0.72
2	3Jun	96	6,363	1,131	3.91	0.59
3	3Jun	119	6,210	590	4.84	0.70
4	3Jun	48	2,238	428	3.74	0.67
5	3Jun	88	7,638	1,648	3.97	0.61
6	3Jun	114	4,783	515	5.00	0.73
7	3Jun	53	2,440	488	3.75	0.65
8	3Jun	106	7,442	771	4.48	0.67
9	3Jun	132	5,829	1,008	5.04	0.72
10	3Jun	168	9,099	629	5.54	0.75
11	5Jun	80	4,983	1,306	3.70	0.58
12	5Jun	89	5,062	1,117	4.29	0.66
13	5Jun	91	2,886	823	4.72	0.72
14	5Jun	128	5,741	2,170	4.67	0.67
15	5Jun	183	11,202	916	5.33	0.71
16	5Jun	192	12,212	1,812	5.55	0.73
17	3Jun	217	14,736	1,415	5.29	0.68
18	6Jun	107	5,173	1,250	4.80	0.71
19	6Jun	155	10,931	4,351	5.06	0.70
20	6Jun	195	9,805	774	5.64	0.74
21	6Jun	110	11,250	1,362	3.07	0.45
22	6Jun	158	15,945	5,156	4.96	0.68
23	6Jun	170	10,766	1,382	5.25	0.71
24	6Jun	185	8,246	1,284	5.63	0.75
25	6Jun	191	11,875	998	5.01	0.66
26	6Jun	137	8,388	2,856	4.56	0.64
27	6Jun	160	7,090	122	5.66	0.77
28	7Jun	110	7,259	2,379	4.32	0.64
29	7Jun	144	8,182	2,768	5.31	0.74
30	7Jun	176	7,225	1,206	5.85	0.78
31	7Jun	207	12,135	2,340	5.39	0.70
32	7Jun	133	4,564	980	5.53	0.78
33	7Jun	125	5,135	1,272	5.57	0.80
34	7Jun	139	5,245	525	5.72	0.80
35	7Jun	186	8,469	554	5.66	0.75
36	7Jun	221	12,679	969	5.50	0.71
37A	5Jun	55	2,209	567	4.00	0.69
37B	6Jun	64	3,034	264	4.11	0.69
37C	6Jun	54	2,255	501	3.97	0.69
Mean		132	7,400		4.83	0.70

For the June 1996 survey, polychaetes were the dominant taxa throughout the study area, averaging 5,519/m^2 and the miscellaneous taxa were the least abundant with an average density of 286/m^2 (Table 5). The three most abundant taxa within each major taxonomic group were the polychaetes *Magelona longicornis*, *Mediomastus* spp., and *Owenia fusiformis*; the crustaceans, *Euphilomedes carcharodonta*, *Diastylopsis* spp., and *Rhepoxynius* spp.; the molluscs *Axinopsida serricata*, *Tellina* spp., and *Turbonilla* spp.

Diversity (H) for the June 1996 survey ranged from 3.07 to 5.85 and was considered high (≥3.50) at 38 of the 39 stations. Equitablility (E) ranged from 0.45 to 0.80 with 36 stations with values between 0.60 and 0.80. Most stations had high values for H and E indicating that the benthic communities were very diverse and several of the species were numerically similar.

Eight benthic invertebrate cluster groups were identified from the June 1996 survey (Fig. 3, Table 6). Station 21 did not cluster with any other group. Group H had the most stations of any cluster group (8) and was dominated by three species of polychaetes. In general, the cluster groups located in the shallower areas usually had at least one species of crustaceans or molluscs included as dominant taxa.

Sediments

October/November 1995 Survey

For the 36 stations sampled in October/November 1995, the average median grain size was 0.117 mm, average percent silt/clay was 17.8%, and average percent volatile solids was 1.8% (Table 7). Sediments from 15 stations were classified as fine sand (median grain size 0.125-0.250 mm), 20 stations were classified as very fine sand (median grain size 0.0625-0.125 mm) and one station as coarse silt (median grain size 0.0313-0.0625 mm). Percent silt/clay ranged from 3.0 to 51.8% with most values less than 20%. Volatile solids

Table 5. Dominant benthic invertebrates found at 39 stations (combined) offshore from the Columbia River, June 1996.

Taxon/category	Mean number/m^2
Polychaeta	
Magelona longicornis	452
Mediomastus spp.	420
Owenia fusiformis	416
Spiophanes bombyx	401
Heteromastus filobranchus	382
Scoletoma luti	254
Spiophanes berkeleyorum	214
Prionospio lighti	212
Chaetozone columbiana	196
Galathowenia oculata	146
Miscellaneous (247 taxa/categories)	2,426
Total	5,519
Crustacea	
Euphilomedes carcharodonta	212
Diastylopsis spp.	110
Rhepoxynius spp.	108
Bathyleberis californica	44
Eohaustorius sencillus	43
Ampelisca agassizi	36
Ampelisca careyi	28
Rhepoxynius vigitegus	26
Photis macinerneyi	26
Rhepoxynius tridentatus	26
Miscellaneous (123 taxa/categories)	397
Total	1,056
Mollusca	
Axinopsida serricata	163
Tellina spp.	72
Turbonilla spp.	28
Pseudopythina rugifera	27
Olivella pycna	26
Macoma spp.	24
Mysella tumida	21
Nucula tenuis	14
Mytilidae	14
Tellina modesta	14
Miscellaneous (74 taxa/categories)	131
Total	534

Table 5. Continued.

Taxon/category	Mean number/m^2
Miscellaneous	
Nemertea	156
Amphiuridae	24
Amphiodia spp.	22
Thysanocardia nigra	18
Echinoidea	16
Miscellaneous (19 taxa/categories)	55
Total	286
Total	7,400

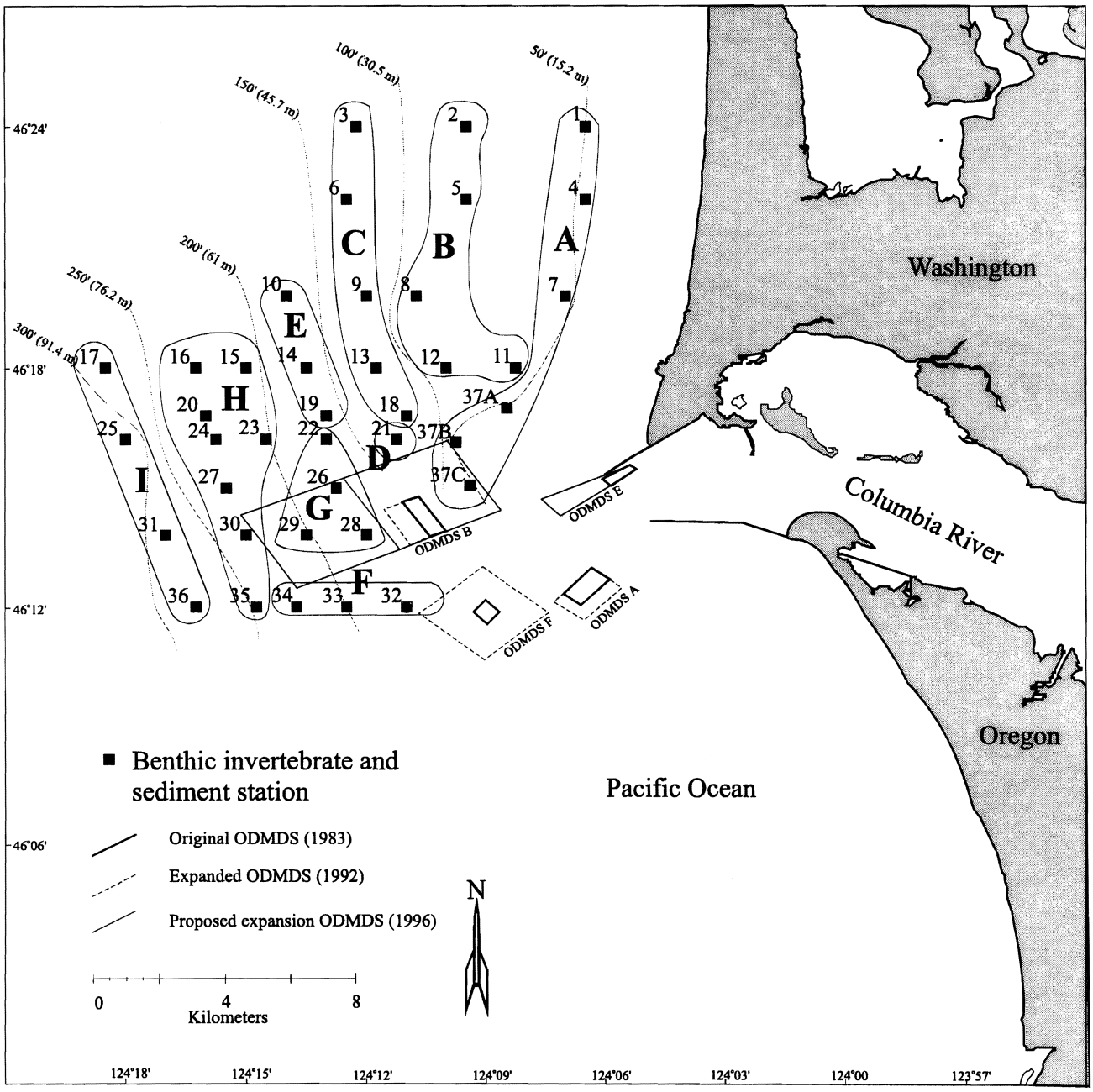

Figure 3. Locaton of benthic invertebrate cluster groups (A-I) offshore from the Columbia River, June 1996. Station 21 did not cluster with any group. ODMDSs are Ocean Dredged-Material Disposal Sites.

Table 6. Results from cluster analysis of benthic invertebrate densities at 39 stations off the mouth of the Columbia River, June 1996.

Cluster group	Mean number/m^2	Dominant taxa
A	2,344	*Spiophanes bombyx* *Magelona sacculata* *Rhepoxynius vigitegus*
B	6,297	*Spiophanes bombyx* *Owenia fusiformis* *Tellina* spp.
C	4,976	*Spiophanes berkeleyorum* *Owenia fusiformis* *Euphilomedes carcharodonta*
D	11,249	*Owenia fusiformis* *Diastylopsis* spp. *Spiophanes berkeleyorum*
E	8,590	*Axinopsida serricata* *Euphilomedes carcharodonta* *Chaetozone columbiana*
F	4,982	*Chaetozone columbiana* *Mediomastus* spp. *Euphilomedes carcharodonta*
G	10,036	*Heteromastus filobranchus* *Mediomastus* spp. *Owenia fusiformis*
H	9,377	*Scoletoma luti* *Mediomastus* spp. *Magelona longicornis*
I	12,856	*Magelona longicornis* *Prionospio lighti* *Mediomastus* spp.

Table 7. Sediment characteristics at stations offshore from the mouth of the Columbia River, October/November 1995.

Station	Median grain size (mm)	Percent silt/clay	Percent volatile solids
1	0.130	3.0	0.6
2	0.120	6.3	0.7
3	0.096	8.0	0.9
4	0.130	4.6	0.7
5	0.110	9.9	0.6
6	0.096	12.2	0.9
7	0.120	6.3	0.6
8	0.110	6.9	0.7
9	0.096	12.7	0.8
10	0.091	13.9	1.6
11	0.120	5.0	1.0
12	0.096	10.2	0.9
13	0.091	12.9	1.1
14	0.092	15.7	1.4
15	0.081	41.2	4.1
16	0.054	51.8	4.6
17	0.140	23.9	3.1
18	0.090	18.7	1.6
19	0.089	17.0	1.8
20	0.150	19.5	2.2
21	0.081	31.0	2.4
22	0.087	28.2	2.8
23	0.084	39.9	3.9
24	0.160	13.4	2.1
25	0.130	30.8	3.3
26	0.099	22.3	1.7
27	0.150	21.5	2.2
28	0.150	30.1	1.8
29	0.160	15.0	1.9
30	0.160	11.3	1.5
31	0.140	22.0	2.3
32	0.160	9.5	1.3
33	0.160	8.9	1.5
34	0.160	9.4	1.7
35	0.150	15.7	1.6
36	0.093	33.7	3.7
Mean	0.117	17.8	1.8

were generally low, ranging from 0.6 to 4.6%, with most values less than 2.0%. Stations located at depths less than 25.3 m had the lowest percentages of silt/clay and volatile solids. However, sediment types were similar throughout the study area and did not seem to be depth related. This was also true for percent silt/clay, which varied greatly with no consistent pattern. Generally, stations that had the highest percent silt/clay also had the highest percent volatile solids.

June 1996 Survey

For the 39 stations sampled in June 1996, the average median grain size was 0.116 mm, average percent silt/clay was 21.4%, and average percent volatile solids was 1.8% (Table 8). Sediments from 16 stations were classified as fine sand, 21 stations were classified as very fine sand, and 2 stations as coarse silt. Percent silt/clay ranged from 4.3 to 54.5% and volatile solids ranged from 0.4 to 4.2%. Stations with the lowest percentage of silt/clay (<10.0%) and volatile solids (<1.0%) were located at depths less than 25.3 m, which were the shallowest depths sampled during this survey. Sediment types were similar throughout the study area and did not seem related to any particular depth.

DISCUSSION

The benthic invertebrate surveys conducted in October/November 1995 and June 1996 intensely sampled an area west and north of the mouth of the Columbia River that had not received such attention during previous offshore surveys (Siipola et al. 1993; Hinton and Emmett 1994, 1996; Emmett and Hinton 1995). Benthic invertebrate densities, species composition, and dominant taxa were not unusual in this area when compared to the earlier surveys. However, diversity (H) values were some of the highest ever observed. Even though overall densities were much lower in June 1996 than in October/November, diversity and equitability remained high and remarkably consistent between the two surveys.

Table 8. Sediment characteristics at stations offshore from the mouth of the Columbia River, June 1996.

Station	Median grain size (mm)	Percent silt/clay	Percent volatile solids
1	0.120	5.2	0.6
2	0.110	6.9	0.7
3	0.097	9.2	0.8
4	0.120	6.6	0.9
5	0.110	12.7	0.7
6	0.099	10.9	0.7
7	0.110	8.6	0.7
8	0.110	10.7	0.6
9	0.098	13.6	1.1
10	0.081	27.0	2.6
11	0.100	9.5	1.0
12	0.092	17.0	1.2
13	0.082	27.6	1.3
14	0.085	22.9	2.1
15	0.080	40.8	3.3
16	0.130	34.9	3.7
17	0.130	47.3	4.2
18	0.089	18.3	1.3
19	0.081	30.3	2.3
20	0.140	44.9	3.5
21	0.083	27.1	1.8
22	0.046	54.5	3.4
23	0.043	50.9	3.9
24	0.140	24.7	2.7
25	0.130	29.3	2.8
26	0.120	13.5	1.9
27	0.140	23.5	2.7
28	0.160	16.9	1.8
29	0.140	31.3	2.5
30	0.150	17.1	2.1
31	0.130	32.1	3.1
32	0.160	10.2	1.0
33	0.150	21.7	1.0
34	0.160	11.2	1.0
35	0.150	17.9	1.9
36	0.120	30.9	2.6
37a	0.140	4.3	0.4
37b	0.120	4.8	0.8
37c	0.160	6.5	0.7
Mean	0.116	21.4	1.8

Dominant taxa for each major taxonomic category were similar between the 1995 and 1996 surveys as well as to previous surveys (1989 to 1992). The polychaete families (Spionidae, Magelonidae, Capitellidae, and Oweniidae) represented the majority of the total number of invertebrates and occurred over a wide range of depths and sediment types. The cumaceans *Diastylopsis* spp. and the ostracod *Euphilomedes carcharodonta* were the most common crustaceans. These polychaetes and crustaceans are suspension and surface deposit feeders (Fauchald and Jumars 1979, Jumars and Banse 1989) and are dependent on organic material (detritus and phytoplankton) settling on or near the bottom. Their presence in these areas is likely a response to high amounts of suspended particulate matter (nutrients) contributed by the Columbia River, Willapa Bay, and seasonal upwelling/downwelling conditions (Small et al. 1989). Benthic invertebrate biomass has been directly related to pelagic productivity in the Bering and Chukchi Seas (Grebmeir et al. 1988).

The nearshore coastal waters along Oregon and Washington support a variety of juvenile and adult stages of commercially and ecologically important demersal fishes and shellfish. Studies from the central Oregon coast and near the mouth of the Columbia River concerned with the feeding habits of demersal fishes (English sole, *Parophrys vetulus*; rex sole, *Glyptocephalus zachirus*; Dover sole, *Microstomus pacificus*; slender sole, *Lyopsetta exilis*; butter sole, *Isopsetta isolepis*; sand sole, *Psettichthys melanostictus*; rock sole, *Lepidopsetta bilineata*; Pacific sanddab, *Citharichthys sordidus*; and speckled sanddab, *Citharichthys stigmaeus*) revealed a variety of prey preferences. These prey items included: polychaetes; polychaete palps; crustaceans, including gammarid amphipods and cumaceans; juvenile bivalves; bivalve siphons; and ophiurids (Durkin and Lipovsky 1977, Kravitz et al. 1977, Pearcy and Hancock 1978, Hogue and Carey 1982). From Grays Harbor, Washington, Dungeness crab prey preferences included bivalves, crustaceans, and juvenile fishes (Stevens and Armstrong 1985). Many of these prey items are found in high densities throughout the

area sampled in October/November 1995 and June 1996. To minimize the possible adverse impacts of dredged-material disposal, areas that have a high abundance of organisms are likely biologically important therefore should be avoided.

The distributions of sediment types observed offshore from the Columbia River were similar between the October/November 1995 and June 1996 surveys. Fine and very fine sands and increasing amounts of silt/clay in a northwesterly direction from the mouth of the Columbia River is consistent with observations from previous surveys (Kulm et al. 1975, Sternberg et al. 1977, Kachel and Smith 1989). The location, characteristics, and composition of sediments appear to vary annually and are influenced by varying intensity of ocean currents and waves (Harmon 1972, Gray 1981).

CONCLUSION

Benthic invertebrate densities were higher in October/November 1995 than in June 1996. However, diversities (H) for both surveys were some of the highest ever observed when compared to other surveys conducted offshore from the mouth of the Columbia River. Cluster analysis identified seven groups in 1995 and eight groups in 1996. These cluster groups had several species of polychaetes and crustaceans in common and although dominant species varied between years, the groupings were somewhat similar. Many of the dominant species can be important prey for commercially and ecologically important demersal fishes and shellfish. Therefore, avoiding areas with high abundance of organisms should be taken into consideration when searching for new locations of ocean dredged-material disposal sites.

This report does not constitute NMFS's formal comments under the Fish and Wildlife Coordination Act or the National Environmental Policy Act.

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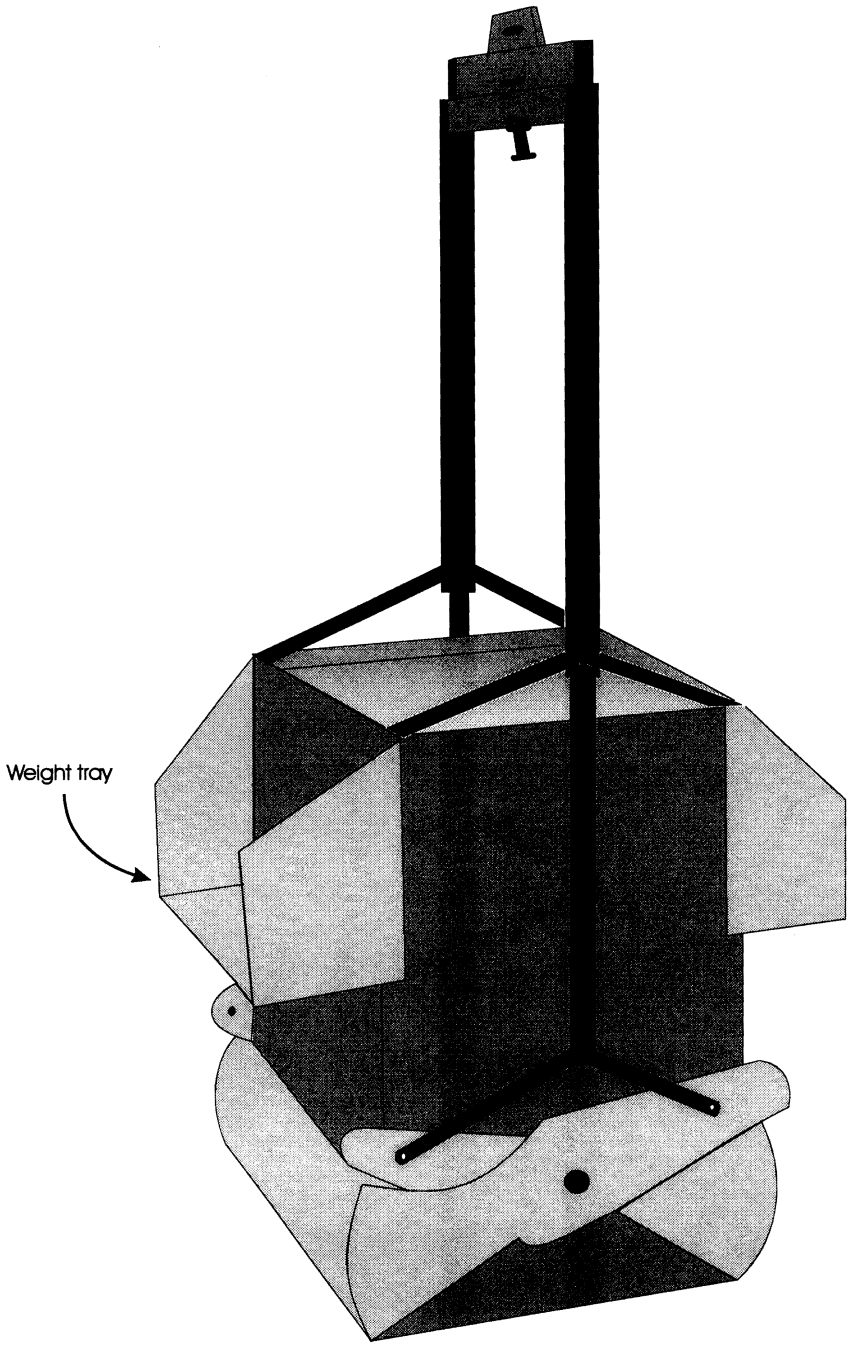
APPENDIX FIGURE



Appendix Figure 1. The 0.1-m^2 box corer (Gray-O'Hara modification of a standard box corer) used for benthic invertebrate sampling offshore from the Columbia River, October/November 1995 and June 1996. For deeper penetration, 113-kg (250-lb) weights were placed in each tray located on opposite sides of the sampler.

APPENDIX TABLES

Appendix Table 1. Geographic locations and water depths of benthic invertebrate and sediment stations sampled offshore from the Columbia River, October/November 1995 and June 1996. Stations with * were only sampled in June 1996.

Station	Latitude	Longitude	Depth ft (m)
1	46° 24.00	124° 6.50	50 (15.2)
2	24.00	9.50	83 (25.3)
3	24.00	12.25	122 (37.2)
4	22.00	6.50	47 (14.3)
5	22.00	9.50	81 (24.7)
6	22.00	12.50	120 (36.6)
7	20.00	7.00	54 (16.5)
8	20.00	10.75	92 (28.0)
9	20.00	12.00	121 (36.9)
10	20.00	14.00	171 (52.1)
11	18.00	8.25	64 (19.5)
12	18.00	10.00	93 (28.3)
13	18.00	11.75	118 (36.0)
14	18.00	13.50	155 (47.2)
15	18.00	15.00	210 (64.0)
16	18.00	16.25	240 (73.0)
17	18.00	18.50	289 (88.1)
18	17.00	11.00	110 (33.5)
19	17.00	13.00	160 (48.8)
20	17.00	16.00	233 (71.0)
21	16.00	11.25	118 (36.0)
22	16.00	13.00	180 (54.9)
23	16.00	14.50	202 (61.6)
24	16.00	15.75	230 (70.1)
25	16.00	18.00	316 (96.3)
26	15.00	12.75	174 (53.0)
27	15.00	15.50	230 (70.1)
28	14.00	12.00	175 (53.3)
29	14.00	13.50	201 (61.3)
30	14.00	15.00	238 (72.5)
31	14.00	17.00	297 (90.5)
32	12.00	11.00	180 (54.9)
33	12.00	12.50	200 (61.0)
34	12.00	13.75	225 (68.6)
35	12.00	14.75	249 (75.9)
36	12.00	16.25	294 (89.6)
37A*	17.00	8.44	50 (15.2)
37B*	16.00	9.69	50 (15.2)
37C*	15.00	9.41	50 (15.2)

Appendix Table 2. Benthic invertebrate taxa (used for analyses) collected by Gray-O-Hara box corer offshore from the mouth of the Columbia River, October/November 1995 and June 1996.

Taxon	October/November 1995	June 1996
Cnidaria		
Anthozoa	x	
Ceriantharia	x	x
Pachycerianthus fimbriatus	x	
Virgulariidae	x	
Virgularia spp.	x	x
Actiniaria	x	
Nynantheae	x	x
Edwardsiidae		
Edwardsia sipunculoides		x
Halcampidae		
Halcampa decemtentaculata		x
Actiniidae		x
Pleurobrachiidae		
Pleurobrachia bachei		x
Platyhelminthes	x	
Turbellaria	x	x
Polycladida	x	x
Nemertea	x	x
Annelida - Polychaeta		
Aphoditidae		
Aphrodita japonica	x	
Polynoidae	x	x
Harmothinae	x	x
Harmothoe spp.	x	
Eunoe spp.	x	
Bylgides spp.		x
Bylgides macrolepidus		x
Malmgreniella baschi		x
Malmgreniella scriptoria	x	x
Lepidonotus squamatus	x	
Hesperone spp.	x	
Hesperone complanata	x	
Hesperone laevis	x	x
Lepidasthenia spp.	x	
Lepidasthenia berkeleyae	x	x
Lepidasthenia longicirrata	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Tenonia priops	x	x
Malmgreniella spp.	x	x
Malmgreniella nigralba	x	x
Sigalionidae	x	x
Pholoe spp.	x	x
Pholoe minuta		x
Pholoe glabra	x	x
Sthenelais spp.	x	x
Sthenelais berkeleyi	x	x
Sthenelais tertiaglabra	x	x
Sthenelais verruculosa	x	x
Sigalion spp.	x	x
Sigalion spinosus	x	x
Amphinomidae		
Chloeia entypa		x
Phyllodocidae	x	x
Phyllodoce williamsi	x	
Phyllodoce groenlandica	x	x
Phyllodoce mucosa	x	x
Phyllodoce maculata	x	x
Phyllodoce longipes	x	x
Eteone spp.	x	x
Eteone californica		x
Eteone pacifica	x	
Eteone lighti	x	
Eteone spilotus	x	x
Hypereteone fauchaldi	x	x
Eteone sp. N-1	x	x
Eulalia spp.	x	x
Eulalia bilineata	x	
Eulalia levicornuta	x	x
Notophyllum imbricatum	x	
Notophyllum tectum	x	
Mystides spp.	x	
Mystides borealis	x	
Nereiphyla castanea	x	
Paranaitis polynoides	x	x
Paranaitis wahlbergi	x	x
Eumida spp.	x	
Eumida longicornuta	x	x
Phyllodoce spp.	x	x
Phyllodoce hartmanae	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Phyllodoce cuspidata	x	x
Phyllodoce multipapillata	x	
Sige bifoliata	x	
Lugia spp.	x	
Hesionidae	x	
Gyptis brunnea		x
Gyptis lobatus		x
Microphthalmus sczelkowii	x	x
Microphthalmus aberrans	x	
Micropodarke dubia	x	x
Podarke pugettensis	x	x
Podarkeopsis glabrus	x	x
Podarkeopsis perkinsi		x
Pilargidae		
Sigambra spp.	x	
Sigambra tentaculata	x	x
Sigambra bassi	x	
Pilargis spp.	x	
Pilargis maculata	x	x
Parandalia fauveli	x	x
Autolytinae	x	
Proceraea cornutus	x	x
Syllidae	x	x
Syllis elongata	x	x
Ehlersia hyperioni	x	x
Typosyllis spp.	x	x
Typosyllis alternata	x	x
Typosyllis harti	x	x
Exogone dwisula	x	x
Exogone lourei	x	x
Exogone molesta	x	x
Sphaerosyllis spp.	x	x
Sphaerosyllis ranunculus	x	x
Syllides longocirrata		x
Odontosyllis spp.	x	
Dioplosyllis spp.	x	
Ehlersia heterochaeta	x	x
Nereidae	x	x
Cheilonereis cyclurus	x	
Nereis spp.	x	x
Nereis procera	x	x
Nereis zonata	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Nephtyidae		
Nephtys spp.	x	x
Nephtys caeca	x	x
Nephtys cornuta	x	x
Nephtys punctata	x	x
Nephtys ferruginea	x	x
Nephtys californiensis	x	x
Nephtys caecoides	x	x
Nephtys assignis	x	x
Sphaerodoridae	x	
Sphaerodoropsis minuta	x	x
Sphaerodoropsis spaerulifer	x	x
Glyceridae	x	
Glycera spp.	x	x
Glycera capitata	x	
Glycera tenuis	x	
Glycera tesselata	x	
Glycera americana	x	x
Glycera robusta	x	x
Glycera convoluta	x	x
Glycera nana	x	x
Goniadidae	x	x
Glycinde spp.	x	x
Glycinde armigera	x	x
Glycinde polygnatha	x	x
Goniada spp.	x	
Goniada maculata	x	x
Goniada brunnea		x
Onuphidae	x	x
Onuphis spp.	x	x
Onuphis geophiliformis	x	
Onuphis iridescens	x	x
Onuphis elegans	x	x
Diopatra spp.		x
Diopatra ornata	x	x
Epidiopatra hupferiana monroi	x	x
Lumbrineridae	x	x
Lumbrineris spp.	x	
Eranno spp.	x	x
Eranno bicirrata	x	x
Lumbrineris latreilli	x	x
Lumbrineris inflata	x	

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Scoletoma luti	x	x
Scoletoma spp.	x	
Lumbrineris cruzensis	x	x
Lumbrineris limicola	x	x
Eranno lagunae	x	
Lumbrineris californiensis	x	x
Ninoe spp.	x	
Ninoe gemmea	x	x
Arabellidae		
Drilonereis longa	x	x
Dorvilleidae	x	x
Dorvillea spp.		x
Dorvillea pseudorubrovittata	x	x
Dorvillea annulata		x
Protodorvillea gracilis	x	
Schistomeringos longicornis	x	
Dorvillea rudolphi	x	x
Parougia caeca	x	x
Orbiniidae	x	x
Naineris spp.	x	
Scoloplos spp.	x	x
Scoloplos armiger	x	x
Leitoscoloplos pugettensis	x	x
Scoloplos acmeceps	x	x
Phylo felix	x	x
Orbinia (*Phylo*) *felix*	x	
Protoariciella spp.	x	
Paraonidae	x	x
Aricidea spp.	x	x
Aricidea antennata	x	
Aricidea catherinae	x	x
Aricidea lopezi	x	x
Aricidea ramosa	x	x
Aricidea pacifica	x	x
Aricidea simplex	x	
Paraonella platybranchia	x	x
Cirrophorus spp.	x	
Levinsenia gracilis	x	x
Paradoneis spp.	x	x
Paradoneis eliasoni		x
Paradoneis spinifera	x	x
Paradoneis lyra	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Apistobranchidae		
Apistobranchus ornatus	x	x
Spionidae	x	x
Laonice cirrata	x	
Polydora spp.	x	x
Dipolydora socialis	x	x
Dipolydora caulleryi	x	x
Polydora limicola	x	
Polydora quadrilobata		x
Dipolydora cardalia	x	x
Prionospio spp.	x	x
Prionospio jubata	x	x
Prionospio lighti	x	x
Prionospio multibranchiata	x	x
Spio spp.	x	x
Spio filicornis	x	x
Spio cirrifera	x	x
Spio butleri		x
Boccardia polybranchia	x	
Boccardia proboscidea		x
Boccardia pugettensis	x	x
Spiophanes spp.	x	x
Spiophanes bombyx	x	x
Spiophanes berkeleyorum	x	x
Paraprionospio pinnata	x	x
Spiophanes duplex	x	
Scolelepis spp.	x	x
Scolelepis squamata	x	
Scolelepis foliosa	x	
Aonides spp.	x	
Aonides glandulosa		x
Magelonidae		
Magelona spp.	x	x
Magelona longicornis	x	x
Magelona sacculata	x	x
Magelona hobsonae		x
Trochochaetidae		
Trochochaeta spp.		x
Trochochaeta multisetosa	x	x
Chaetopteridae	x	x
Phyllochaetopterus spp.	x	x
Phyllochaetopterus claparedii	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Phyllochaetopterus prolifica		x
Phyllochaetopterus limicolus		x
Spiochaetopterus costarum	x	x
Mesochaetopterus taylori	x	x
Cirratulidae	x	x
Cirratulus spp.	x	
Cirratulus spectabilis	x	x
Chaetozone acuta	x	x
Chaetozone spp.	x	x
Chaetozone columbiana	x	x
Monticellina cryptica	x	
Monticellina serratiseta		x
Aphelochaeta spp.	x	x
Aphelochaeta glandaria		x
Aphelochaeta williamae	x	
Aphelochaeta tigrina	x	x
Aphelochaeta petersenae	x	
Aphelochaeta monilaris	x	x
Tharyx parvus	x	x
Monticellina tesselata	x	x
Cossuridae		
Cossura spp.	x	x
Cossura candida	x	
Cossura bansei		x
Cossura pygodactylata	x	x
Cossura rostrata	x	
Flabelligeridae	x	x
Brada villosa	x	x
Brada sachalina	x	x
Flabelligera affinis	x	x
Pherusa spp.	x	
Pherusa plumosa	x	x
Pherusa negligens	x	
Pherusa capulata		x
Scalibregmidae		
Scalibregma spp.	x	
Scalibregma inflatum	x	
Asclerocheilus beringianus	x	x
Opheliidae	x	
Ophelina acuminata	x	x
Ophelina limacina		x
Armandia brevis	x	

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Travisia brevis	x	x
Travisia forbesi	x	
Sternaspidae		
Sternaspis scutata	x	x
Capitellidae	x	x
Capitella capitata "hyperspecies"	x	x
Heteromastus spp.	x	
Heteromastus filiformis	x	x
Heteromastus filobranchus	x	x
Notomastus spp.	x	x
Notomastus giganteus	x	
Notomastus tenuis	x	x
Notomastus lineatus	x	x
Notomastus latericius	x	x
Notomastus magnus	x	
Mediomastus spp.	x	x
Mediomastus ambiseta	x	x
Decamastus gracilis	x	x
Barantolla americana	x	x
Arenicolidae		
Branchiomaldane spp.	x	x
Maldanidae	x	x
Asychis spp.	x	
Metasychis disparidentata	x	x
Maldane sarsi	x	x
Axiothella rubrocincta	x	
Praxillella gracilis	x	x
Praxillella pratermissa	x	
Praxillella affinis	x	
Praxillella pacifica	x	x
Rhodine biforquata	x	x
Euclymeninae	x	
Euclymene spp.	x	x
Euclymene zonalis	x	x
Clymenura spp.	x	
Clymenura gracilis	x	x
Clymenura columbiana	x	
Chirimia spp.	x	
Chirimia lacera	x	
Chirimia bicips	x	
Isocirrus longiceps	x	

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Oweniidae		
Owenia fusiformis	x	x
Myriochele heeri	x	x
Galathowenia oculata	x	x
Pectinariidae		
Pectinaria spp.	x	x
Pectinaria granulata	x	x
Pectinaria californiensis	x	x
Ampharetidae	x	x
Amage spp.	x	
Amage anops	x	
Ampharete spp.	x	x
Ampharete crassiseta	x	x
Ampharete acutifrons	x	x
Ampharete finmarchica	x	x
Amphicteis spp.	x	
Amphicteis glabra	x	
Amphicteis macronata	x	
Amphicteis scaphobranchiata		x
Melinna oculata	x	x
Anobothrus gracilis	x	x
Asabellides lineata	x	
Samytha californiensis	x	
Terebellidae	x	x
Amphitrite spp.	x	
Eupolymnia heterobranchia	x	
Pista spp.	x	x
Pista bansei	x	x
Pista brevibranchiata	x	
Pista moorei	x	x
Pista estevanica		x
Pista wui	x	
Polycirrus spp. complex	x	x
Polycirrus californicus		x
Thelepus spp.		x
Artacama conifera	x	x
Artacamella hancocki	x	x
Lanassa spp.	x	x
Lanassa venusta venusta	x	x
Loimia medusa	x	
Amaeana occidentalis	x	x
Streblosoma bairdi	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Trichobranchidae	x	
Terebellides spp.	x	x
Terebellides stroemi	x	x
Terebellides californica	x	x
Terebellides reishi	x	x
Sabellidae	x	x
Chone spp.	x	x
Chone infundibuliformis	x	
Chone duneri	x	x
Euchone spp.		x
Euchone incolor	x	x
Euchone hancocki	x	x
Annelida - Oligochaeta	x	x
Hirudinea	x	x
Mollusca - Gastropoda	x	x
Turbinidae		
Spiromoellaria quadrae	x	x
Epitoniidae		
Epitonium spp.	x	x
Epitonium indianorum	x	
Epitonium sawinae	x	x
Melanellidae		
Balcis spp.		x
Naticidae		
Polinices spp.	x	
Euspira pallida		x
Nucellidae		
Nucella spp.	x	x
Boreotrophon spp.		x
Columbellidae		
Astyris gausapata	x	x
Neptuneidae		
Neptunea tabulata		x
Nassariidae		
Nassarius spp.	x	x
Nassarius mendicus	x	x
Nassarius fossatus	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Olividae		
Olivella spp.	x	x
Olivella baetica	x	x
Olivella pycna	x	x
Turridae	x	
Oenopota spp.	x	x
Oenopota cf. *excurvata*	x	
Oenopota fidicula		x
Oenopota viridula	x	x
Antiplanes catalinae	x	
Kurtziella plumbea	x	x
Pyramidellidae		
Odostomia spp.	x	x
Turbonilla spp.	x	x
Cephalaspidea	x	x
Actionidae		
Rictaxis punctocaelatus	x	x
Acteocina spp.	x	
Acteocina culcitella	x	x
Acteocina harpa	x	
Cylichna attonsa	x	x
Scaphander spp.		x
Philinidae		
Philine spp.	x	x
Aglajidae		
Melanochlamys diomedea	x	x
Gastropteridae		
Gastropteron pacificum	x	x
Diaphanidae		
Diaphana spp.	x	
Atyidae		
Haminoea spp.	x	
Rutisidae		
Volvulella cylindrica	x	x
Elysiidae		
Elysia hedgpethi	x	x
Nudibranchia	x	x
Onchidorididae		
Onchidoris bilamellata	x	

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Corambidae		
Corambe spp.		x
Corambe pacifica		x
Flabellinidae		
Flabellina spp.	x	
Aeolididae		
Aeolidia papillosa	x	
Chaetodermatidae		
Chaetoderma sp.	x	x
Mollusca - Pelecypoda	x	x
Nuculidae	x	x
Acila castrensis	x	x
Nucula tenuis	x	x
Yoldiidae		
Yoldia spp.	x	x
Yoldia scissurata	x	x
Nucinellidae		
Huxleyia munita	x	x
Mytilidae	x	x
Mytilus spp.		x
Megacrenella columbiana	x	x
Lucinidae	x	
Parvilucina tenuisculpta		x
Lucinoma annulatum	x	x
Thyasiridae	x	
Adontorhina cyclia		x
Axinopsida serricata	x	x
Thyasira spp.	x	
Thyasira gouldi	x	x
Montacutidae		
Pseudopythina rugifera	x	x
Mysella tumida	x	x
Aligena compressa	x	
Carditidae		
Cyclocardia spp.	x	x
Cyclocardia ventricosa	x	x
Mactridae		
Mactromeris polynyma	x	x
Mactra spp.	x	

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Solenidae		
Siliqua spp.	x	x
Siliqua patula		x
Siliqua sloati	x	x
Solen sicarius	x	
Tellinidae		x
Macoma spp.	x	x
Macoma calcarea	x	x
Macoma elimata	x	x
Macoma moesta	x	x
Macoma nasuta	x	x
Macoma carlottensis		x
Macoma inquinata		x
Tellina spp.	x	x
Tellina nuculoides	x	x
Tellina carpenteri	x	
Tellina modesta	x	x
Tellina bodegensis	x	x
Veneridae		
Saxidomus giganteus		x
Compsomyax subdiaphana	x	x
Hiatellidae		
Saxicavella pacifica		x
Myidae		
Mya arenaria	x	
Pandoridae		
Pandora spp.	x	
Pandora filosa	x	x
Lyonsiidae		
Lyonsia spp.	x	
Lyonsia californica	x	x
Thraciidae		
Thracia trapezoides	x	x
Cuspidaridae		
Cardiomya pectinata		x
Cuspidaria spp.	x	x
Mollusca - Scaphopoda	x	x
Dentalium cf. *pretiosum*	x	x
Rhabdus rectius	x	x
Gadilida aberrans	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Arachnida		x
Halacaridae	x	
Tardigrada		
Pycnogonida		
Achelia nudiuscula	x	
Arthropoda - Ostracoda	x	
Cylindroleberididae	x	x
Bathyleberis spp.	x	
Bathyleberis californica		x
Rutidermatidae		
Rutiderma spp.	x	x
Philomedidae	x	
Euphilomedes spp.	x	
Euphilomedes carcharodonta	x	x
Euphilomedes producta		x
Arthropoda - Poecilostomatoida Copepoda	x	x
Clausidiidae		
Clausidium spp.	x	
Cirripedia	x	x
Balanidae		
Balanus spp.	x	x
Arthropoda		
Nebaliacea		
Nebalia spp.	x	x
Nebalia pugettensis		x
Cumacea		
Lampropidae		
Lamprops spp.		x
Hemilamprops spp.	x	x
Hemilamprops californica	x	x
Leuconidae		x
Leucon spp.	x	x
Leucon subnasica	x	x
Eudorella pacifica	x	x
Eudorellopsis spp.	x	x
Eudorellopsis biplicata		x
Eudorellopsis longirostris	x	
Hemileucon californiensis		x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Diastylidae		
Diastylis spp.	x	x
Diastylis alaskensis	x	x
Diastylis bidentata		x
Diastylis paraspinulosa		x
Diastylopsis spp.	x	x
Colurostylidae		
Colurostylis spp.	x	x
Anchicolurus occidentalis	x	x
Nannasticidae		x
Campylaspis spp.	x	x
Campylaspis rufa		x
Campylaspis canaliculata	x	
Campylaspis nodulosa	x	
Campylaspis crispa	x	
Campylaspis rubromaculata	x	
Cumella spp.	x	
Cumella vulgaris	x	
Tanaidacea		
Paratanaidae		
Leptognathia spp.	x	
Leptognathia savignyi		x
Isopoda		
Anthuridae		
Haliophasma geminata	x	x
Flabellifera		x
Sphaeromatidae		
Tecticeps spp.	x	x
Tecticeps pugettensis		x
Gnorimsphaeroma oregonensis		x
Ancinus granulatus	x	x
Idoteidae		
Synidotea spp.	x	x
Synidotea sp. CSA		x
Synidotea consolidata	x	
Synidotea nebulosa	x	x
Synidotea angulata	x	x
Idotea spp.		x
Idotea fewkesi		x
Edotea sublittoralis	x	x
Janiridae		
Caecianiropsis spp.	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Munnidae	x	
Austrosignum spp.	x	
Pleurogonium spp.	x	x
Pleurogonium rubicundum	x	x
Austrosignum tillerae	x	
Pleurogonium californiense	x	
Acanthonotozomatidae		x
Amphipoda		
Ampeliscidae		
Ampelisca spp.	x	x
Ampelisca sp. A		x
Ampelisca agassizi	x	x
Ampelisca hancocki	x	x
Ampelisca brevisimulata	x	x
Ampelisca careyi	x	x
Byblis spp.		x
Amphilochidae	x	
Ampithoidae		x
Aoridae		
Aoroides spp.	x	x
Aoroides secunda	x	
Aoroides columbiae	x	
Argissidae		
Argissa hamatipes	x	x
Atylidae		
Atylus tridens	x	x
Dexaminidae		
Guernea reduncans	x	x
Eusiridae		
Pontogeneia intermedia		x
Rhachotropis spp.	x	x
Gammaridae		x
Eogammarus confervicolus		x
Maera spp.		x
Melitidae		
Megaluropus spp.	x	
Melita spp.	x	
Melita desdichada	x	x
Haustoridae		
Eohaustorius spp.	x	x
Eohaustorius sencillus	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Isaeidae	x	x
Photis spp.	x	x
Photis brevipes	x	x
Photis californica	x	
Photis lacia	x	
Photis macrotica	x	
Photis macinerneyi	x	x
Photis parvidons	x	x
Protomedeia spp.	x	x
Cheirimedeia macrodactyla	x	
Protomedeia articulata	x	x
Protomedeia prudens	x	x
Gammaropsis spp.	x	x
Cheirimedia spp.		x
Ischyroceridae	x	x
Ischyrocerus spp.		x
Ischyrocerus pegalops	x	
Lilljeborgiidae		
Listriella albinia	x	
Lysianassidae		x
Hippomedon spp.	x	x
Lepidepecreum gurjanovae		x
Lepidepecreum garthi	x	
Opisa tridentata	x	x
Orchomene spp.	x	x
Orchomene pacifica	x	x
Orchomene decipiens	x	
Orchomene pinquis	x	x
Pachynus barnardi		x
Psammonyx longimerus		x
Pachynella lodo		x
Oedicerotidae	x	x
Pacificolodes spp.		x
Pacificolodes levingsi	x	x
Bathymedon spp.	x	
Monoculodes spp.		x
Monoculodes spinipes	x	x
Synchelidium spp.	x	x
Americhelidium millsi	x	x
Westwoodilla spp.	x	
Westwoodilla caecula	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Pardaliscidae		
Nicippe tumida	x	
Phoxocephalidae		
Harpiniopsis fulgens	x	
Heterophoxus oculatus	x	
Metaphoxus frequens	x	x
Majoriphalus major	x	x
Foxiphalus spp.		x
Foxiphalus major		x
Foxiphalus obtusidens	x	x
Mandibulophoxus mayi	x	x
Rhepoxynius spp.	x	x
Rhepoxynius abronius	x	x
Rhepoxynius daboius	x	x
Rhepoxynius lucubrans	x	x
Rhepoxynius tridentatus	x	x
Rhepoxynius vigitegus	x	x
Rhepoxynius fatigans		x
Pleustidae	x	x
Parapleustes spp.		x
Pleusymtes spp.	x	x
Pleusymptes coquilla	x	x
Podoceridae		
Dyopedos spp.	x	x
Dyopedos arcticus	x	x
Stenothoidae		x
Metopella spp.	x	
Synopiidae		
Tiron biocellata	x	x
Caprellidea	x	x
Caprellidae		x
Caprella spp.	x	x
Caprella augusta	x	
Decapoda		
Caridea		x
Paguridae		x
Pagurus spp.	x	x
Brachyura		x
Majidae		x
Cancridae		
Cancer magister	x	x

Appendix Table 2. Continued.

Taxon	October/November 1995	June 1996
Pinnotheridae		x
Pinnixa spp.	x	x
Pinnixa occidentalis	x	x
Pinnixa schmitti		x
Grapsidae		x
Sipuncula		
Sipunculidae	x	x
Golfingiidae	x	x
Thysanocardia nigra		x
Golfingia spp.	x	
Golfingia pugettensis	x	
Echiurida	x	x
Echiuridae		
Arhynchite pugettensis	x	x
Echiurus echiurus alaskanus	x	x
Phoronida	x	
Phoronopsis harmeri	x	
Phoronis spp.	x	
Echinodermata		
Asteroidea	x	
Ophiuroidea	x	
Ophiurida	x	x
Ophiura spp.	x	x
Ophiura lutkeni		x
Amphiuridae	x	x
Amphiodia spp.	x	x
Amphiodia periercta	x	
Amphiodia digitata	x	x
Amphioplus strongyloplax		x
Echinoidea	x	x
Dendraster excentricus	x	x
Spatangoida	x	
Brisaster latifrons	x	x
Pentamera spp.	x	x
Pentemera populifera	x	x
Pentamera cf. *pseudopopulifera*	x	
Caudinidae		
Paracaudina chilensis	x	x
TOTAL (taxon/category used for analysis)	571	502

Appendix Table 3. Summaries of benthic invertebrate collections by station offshore from the Columbia River, October/November 1995 and June 1996. (Because of its length, this Appendix Table was not included in this report but can be obtained from the author at Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121.)