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***Benthic Infauna, Sediment,
and Fish Offshore
from the
Columbia River,
July 1992***

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**Coastal Zone and
Estuarine Studies
Division**

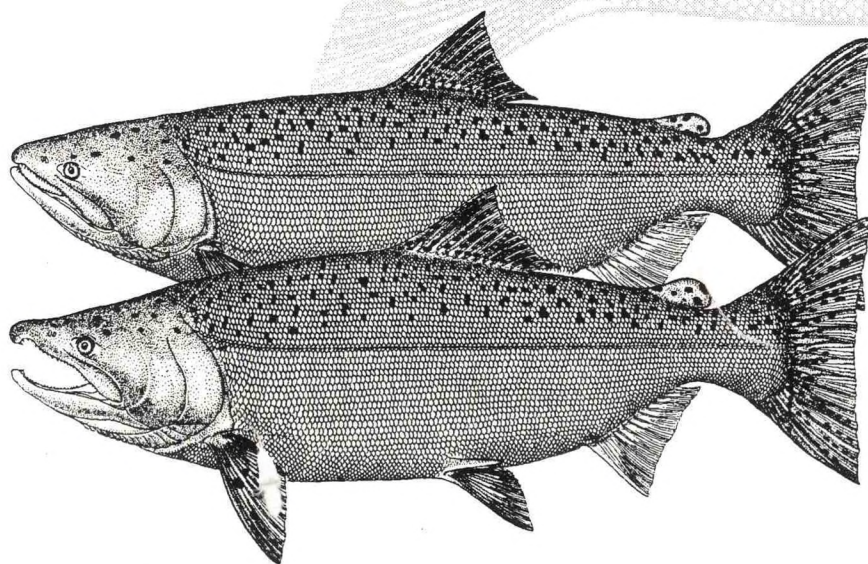
by Susan A. Hinton and Robert L. Emmett

October 1994

**Northwest Fisheries
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OFFSHORE FROM THE COLUMBIA RIVER,

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By

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INTRODUCTION

The U.S. Army Corps of Engineers (COE), Portland District, must annually dispose of from 4 to 6 million cubic yards of materials dredged from the navigation channels in the Columbia River and its estuary. Four Ocean Dredged-Material Disposal Sites (ODMDSs) off the mouth of the Columbia River, identified as ODMDSs A, B, E, and F, have been designated by the Environmental Protection Agency (EPA) to receive dredged material. Limited capacity of existing ODMDSs requires that additional candidate ODMDSs be identified. Along with other COE site selection criteria, the standing crops of benthic and epibenthic invertebrates and fishes in candidate ODMDSs must be quantified.

The National Marine Fisheries Service (NMFS) and the COE studied the benthic invertebrate community and sediment characteristics offshore from the Columbia River in July 1992, to quantify the biological community of candidate ODMDSs. The goal of this study was to identify benthic invertebrate species composition and abundance and sediment characteristics over a large area offshore from the Columbia River. The study also included a limited survey of fishes and large epibenthic invertebrates in a nearshore area north of the mouth of the Columbia River. The last widespread studies offshore from the Columbia River were conducted during the mid 1970s under the COE's Dredged Materials Research Program (DMRP) (Richardson et al. 1977). A recent site-specific survey was conducted by the COE, Portland District, at ODMDS F from 1989 to 1992 (Siipola et al. 1993). We also collected samples at benthic stations established during the DMRP in 1974-1975 and compared data between the two studies.

METHODS

Sampling

Benthic Invertebrates

Benthic invertebrate and sediment samples were collected at 51 stations in an area offshore from the Columbia River, extending approximately 16 km north, 17 km south, and 16 km west of the river mouth (Fig. 1). Station depths ranged from 10.7 to 82.0 m. The Global Positioning System (GPS) was used to locate stations previously established by the COE (Appendix Table 1). A 0.1-m² modified Gray-O'Hara box corer (Pequegnat et al. 1981) was used to collect bottom samples (Appendix Fig. 1). One benthic invertebrate sample was taken at each station, except at Stations 5, 9, 26, 31, 32, 36, and 37, where five benthic invertebrate samples were taken. Benthic invertebrate samples were preserved in 18.9-liter buckets with a buffered 4% formaldehyde solution containing rose bengal (a protein stain). Later the samples were individually sieved through a 0.5-mm mesh screen, and the residue, containing the macroinvertebrates, preserved with 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 NMFS Point Adams Biological Field Station, Hammond, Oregon.

Sediments

Sediment samples to evaluate physical characteristics were collected at the 51 stations occupied for the benthic invertebrate sampling. The samples were collected from the box corer using an acid-rinsed stainless steel spoon, being careful not to collect material in contact with the box-corer sides. Samples for physical analysis were placed in

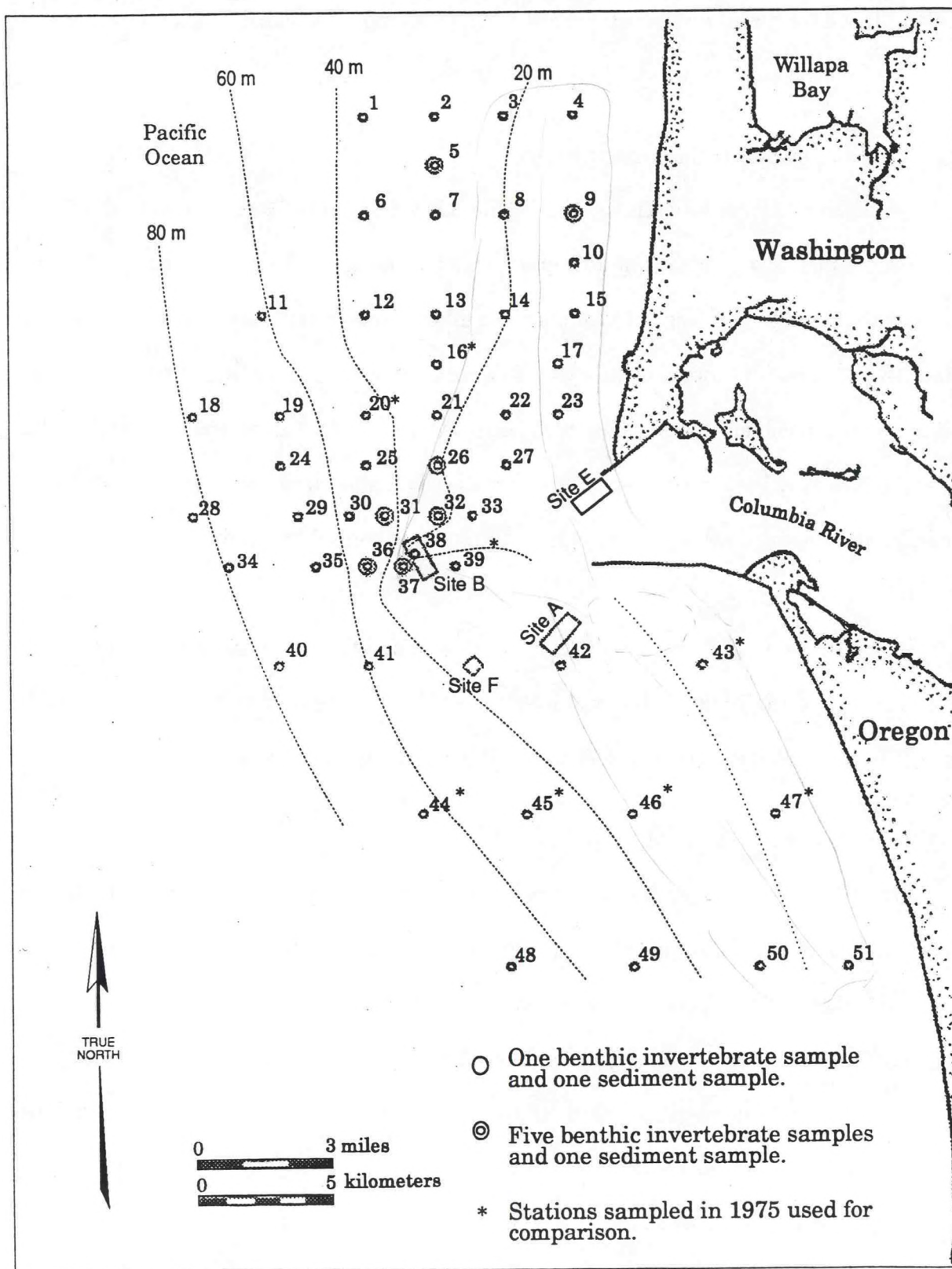


Figure 1.--Location of benthic invertebrate and sediment stations offshore from the Columbia River sampled during July 1992, with eight stations sampled in 1975 which were used for comparisons. Sites A, B, E, and F are ocean dredged-material disposal sites.

labeled plastic bags and refrigerated until delivery to the COE North Pacific Division Materials Testing Laboratory at Troutdale, Oregon.

Fishes and Large Epibenthic Invertebrates

Four bottom-trawling efforts were made during the July 1992 survey at the 9.4, 12.8, 15.5, and 18.6-m depth contours in an area just north of the North Jetty and adjacent to Peacock Spit (Fig. 2). All trawling efforts were 5 minutes long and were made against the current. Bottom trawling was done with an 8-m semiballoon shrimp trawl that had an overall mesh size of 38 mm (stretched). A 10-mm mesh liner was inserted in the cod end of the trawl to ensure retention of small fishes and large epibenthic invertebrates. Location and distance traveled for each trawling effort were determined using the GPS (Appendix Table 1).

All organisms captured by trawling were weighed (g) and measured (mm). Measurements were made of the total length for fishes, carapace width for Dungeness crabs (*Cancer magister*), and the rostrum to the distal end of the telson for shrimp.

Benthic Invertebrate Sampling--1975

In 1975, five replicate benthic invertebrate samples were collected at each station using a 0.1-m² Smith-McIntyre grab sampler (Carey et al. 1972). Contents of the grabs were washed through a 1.0-mm mesh screen. The material retained on the screen was saved in a container and fixed with a buffered formaldehyde solution for sorting at a later time. Station locations were determined using one or more of the following methods: Del Norte system, Loran-A, or radar fixes. Stations selected for comparisons to 1992 are indicated in Appendix Table 2.

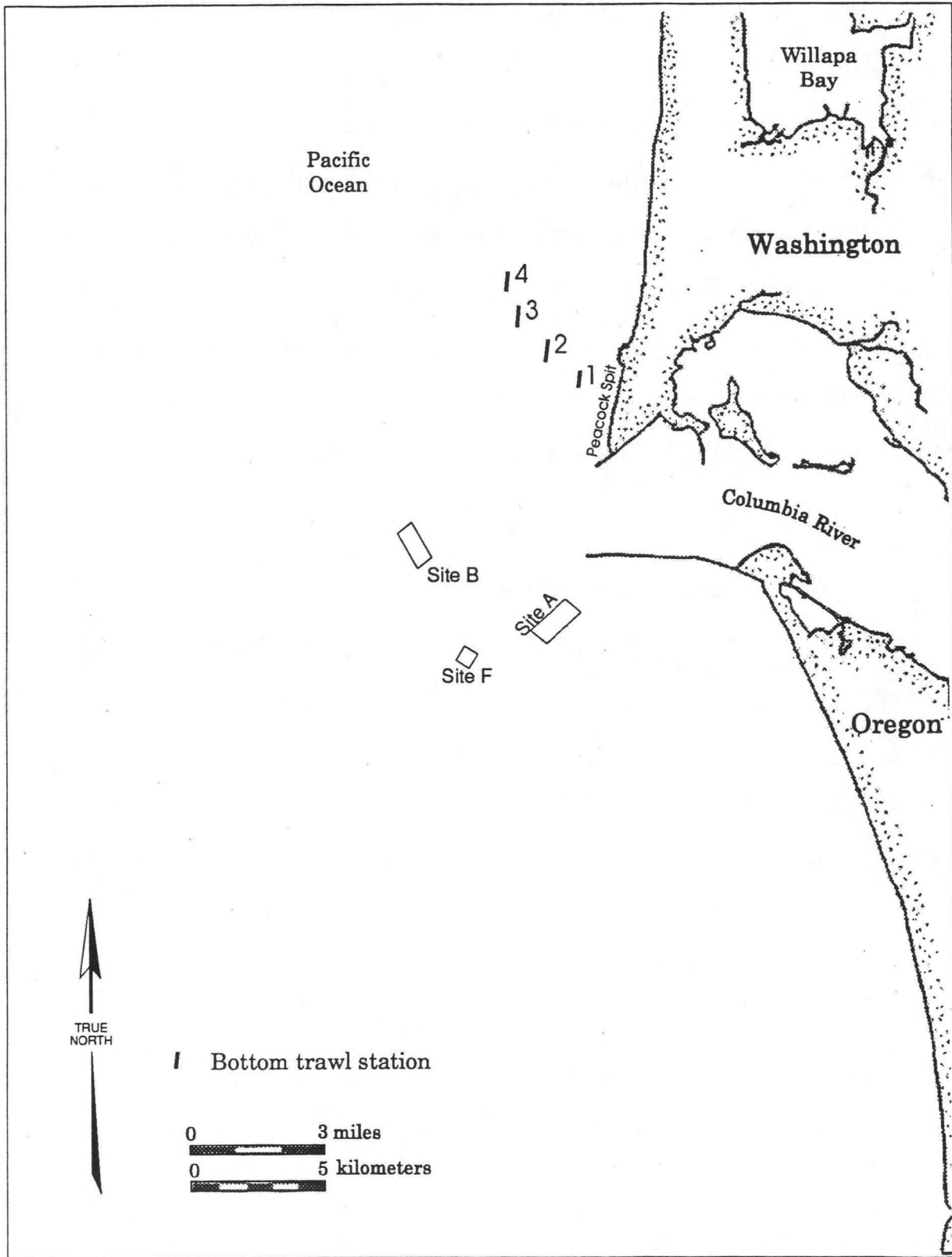


Figure 2.--Location of the 8-m bottom trawl stations offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites.

Data Analyses

Benthic Invertebrates

For each station where one benthic invertebrate sample was collected, the total number of organisms was determined and the number of organisms/m² was calculated. For each station where five benthic invertebrate samples were collected, each sample was treated as a replicate, allowing calculation of a mean number of organisms/m² 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 station groupings that had similar species and densities for the July 1992 survey. A 0.5 dissimilarity value was considered a significant difference between groups. The number/m² or the mean number/m² for each species per station was used in the analysis. Species which had densities less than 10/m² were excluded from the analysis to reduce the effect of rare species.

Sediments

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

Fishes and Large Epibenthic Invertebrates

A descriptive summary of each trawling effort was produced by using distance fished, estimated fishing width of the trawl (5 m), and catch data. This summary included a species list, numbers and weights of fishes and large epibenthic invertebrates captured (by species and total), number/hectare (ha) (by species and total), weight/ha (by species and total), and the previously described community structure indices.

Benthic Invertebrate Comparisons between 1975 and 1992

We were unable to obtain a 1975 data set that corresponded exactly with the 1992 collections. The 1975 data set contained information from only eight stations, sampled in April, June, and September, that were from the geographical locations sampled in July 1992 (Fig. 1). Data from these stations were used for general comparisons with the 1992 survey.

From the limited 1975 benthic invertebrate data, we were able to determine number of taxa/station and mean number of organisms/m² using the techniques previously described. However, we could not calculate standard deviations since the 1975 data had been combined for each taxon at each station, instead of presented by individual replicate.

RESULTS

Benthic Invertebrates

During the July 1992 benthic invertebrate survey, 338 different organisms were identified (Appendix Table 3). Because 13 taxa were not considered benthic organisms they were eliminated from any data analysis. Number of taxa per station ranged from 11

(Station 33) to 130 (Station 36) (Table 1, Appendix Table 4). Densities ranged from 844 (Station 33) to 369,462 organisms/m² (Station 16). Most densities were between 5,000 and 30,000 organisms/m², and four stations had densities over 100,000/m² (Table 1). The three most abundant taxa within each major group found throughout the study area included for the polychaetes, *Spiophanes bombyx*, *Spiochaetopterus costarum*, and *Owenia fusiformis*; for the molluscs, Mytilidae (likely juveniles), *Siliqua* spp., and *Macoma* spp.; and for the crustaceans, *Diastylopsis* spp., *Diastylopsis dawsoni*, and *Diastylopsis tenuis* (Table 2).

Diversity (H) was generally high at most stations and ranged from 0.96 to 4.76, with most values greater than 2.50 (Table 1, Appendix Table 4). Equitability (E) was moderate, ranging from 0.16 to 0.76 with most values between 0.30 and 0.70. Stations with exceptionally high densities (>79,000 organisms/m²) typically had low H and E values due to an average number of taxa and the dominance of one or more of these taxa. Stations with higher H and E values most often had a high or average number of taxa, but no taxa were numerically dominant.

Benthic invertebrate cluster groups are displayed graphically in Figure 3. Dominant species were similar among the six cluster groups; however, their densities varied greatly. The largest cluster group was composed of 17 deeper water stations with an average depth of 60 m. The second largest cluster group (eight stations) was comprised of shallow-water stations, with an average depth of 21.7 m, directly north of the mouth of the Columbia River. Immediately off the mouth of the Columbia River, 11 stations had no cluster group affiliation, indicating either a widely fluctuating habitat or many different micro-habitats.

Table 1.--Summary of benthic invertebrate collections offshore from the Columbia River, July 1992. Stations with one replicate have no standard deviations.

Station	Depth (m)	Number of taxa	Number of individuals/m ²	Standard deviation	Diversity (H)	Equitability (E)
1	36.6	66	23,685	-	3.18	0.53
2	29.0	78	82,391	-	1.91	0.30
3	24.1	80	74,680	-	2.56	0.40
5	27.4	119	43,702	8,541	2.98	0.43
6	36.6	72	27,936	-	3.21	0.52
7	26.2	70	34,490	-	3.00	0.49
8	20.1	68	77,962	-	2.22	0.36
9	13.7	97	79,744	46,193	1.96	0.30
10	14.0	57	103,283	-	1.92	0.33
11	61.0	89	23,716	-	3.47	0.54
12	36.6	75	29,780	-	2.89	0.46
13	26.8	68	68,261	-	2.41	0.40
14	20.7	70	64,323	-	1.72	0.28
15	13.1	68	152,455	-	1.86	0.31
16	29.3	71	369,462	-	0.96	0.16
18	82.0	114	24,164	-	4.20	0.62
19	63.1	95	22,924	-	3.93	0.60
20	42.1	71	18,318	-	4.23	0.69
21	27.4	54	11,868	-	4.01	0.70
22	13.4	49	8,617	-	2.30	0.41
23	10.7	42	3,730	-	3.49	0.65
24	65.2	92	21,705	-	3.96	0.61
25	44.5	45	5,148	-	4.02	0.73
26	20.4	83	13,846	4,304	2.68	0.42
27	11.3	47	6,638	-	2.74	0.49
28	87.2	111	16,974	-	4.17	0.61
29	63.4	104	67,459	-	3.10	0.46
30	53.3	79	23,132	-	4.30	0.68
31	42.4	101	46,661	6,031	2.73	0.41
32	21.0	63	6,556	1,377	3.55	0.59
33	13.4	11	844	-	2.28	0.66
34	79.9	100	12,723	-	4.21	0.63
35	63.1	86	13,817	-	4.35	0.68
36	53.3	130	24,141	5,731	4.61	0.66
37	38.1	75	1,955	206	4.76	0.76
38	16.5	35	2,813	-	3.41	0.66
39	21.0	37	6,247	-	3.67	0.71
40	77.7	84	9,659	-	4.09	0.64
41	61.6	67	13,567	-	3.00	0.50
42	25.9	47	4,679	-	3.36	0.60
43	16.2	32	11,129	-	1.34	0.27
44	67.1	80	16,422	-	2.72	0.43
45	48.5	59	21,028	-	2.37	0.40
46	31.7	58	25,727	-	2.75	0.47
47	16.5	66	37,043	-	2.45	0.41
48	69.5	82	16,901	-	2.51	0.39
49	45.7	68	18,360	-	2.44	0.40
50	27.7	71	13,202	-	3.91	0.64
51	13.7	64	165,105	-	1.99	0.33

Table 2.--Dominant benthic invertebrates collected offshore from the Columbia River, July 1992. Data from all stations were combined.

Taxon	Mean number of individuals/m ²
Nemertea	251
Polychaeta	
<i>Pholoe minuta</i>	152
<i>Phyllodoce hartmanae</i>	164
<i>Nephtys</i> spp.	130
<i>Nephtys caecoides</i>	112
<i>Glycinde armigera</i>	246
Onuphidae	134
<i>Lumbrineris luti</i>	122
Orbiniidae	160
<i>Polydora brachycephala</i>	131
<i>Prionospio lighti</i>	153
<i>Spiophanes bombyx</i>	3,233
<i>Spiophanes berkeleyorum</i>	570
<i>Magelona longicornis</i>	114
<i>Magelona sacculata</i>	138
<i>Trochochaeta multisetosa</i>	161
<i>Spiochaetopterus costarum</i>	3,159
<i>Chaetozone spinosa</i>	163
<i>Heteromastus filobranchus</i>	210
<i>Mediomastus</i> spp.	341
<i>Owenia fusiformis</i>	11,498
Miscellaneous	1,156
TOTAL	22,247
Mollusca	
<i>Spiromoellaria quadrae</i>	90
<i>Olivella pycna</i>	132
<i>Acila castrensis</i>	141
Mytilidae	966
<i>Axinopsida serricata</i>	185
<i>Siliqua</i> spp.	9,016
<i>Macoma</i> spp.	550
Miscellaneous	380
TOTAL	11,460

Table 2.--Continued.

Taxon	Mean number of individuals/m ²
Crustacea	
<i>Euphilomedes carcharodonta</i>	112
<i>Diastylopsis</i> spp.	456
<i>Diastylopsis dawsoni</i>	230
<i>Diastylopsis tenuis</i>	350
<i>Ampelisca macrocephala</i>	55
<i>Photis macinerneyi</i>	125
<i>Rhepoxynius</i> spp.	63
<i>Rhepoxynius daboius</i>	60
<i>Rhepoxynius vigitegus</i>	70
Miscellaneous	402
TOTAL	1,923
Miscellaneous	
TOTAL	523
TOTAL FOR SURVEY	36,404

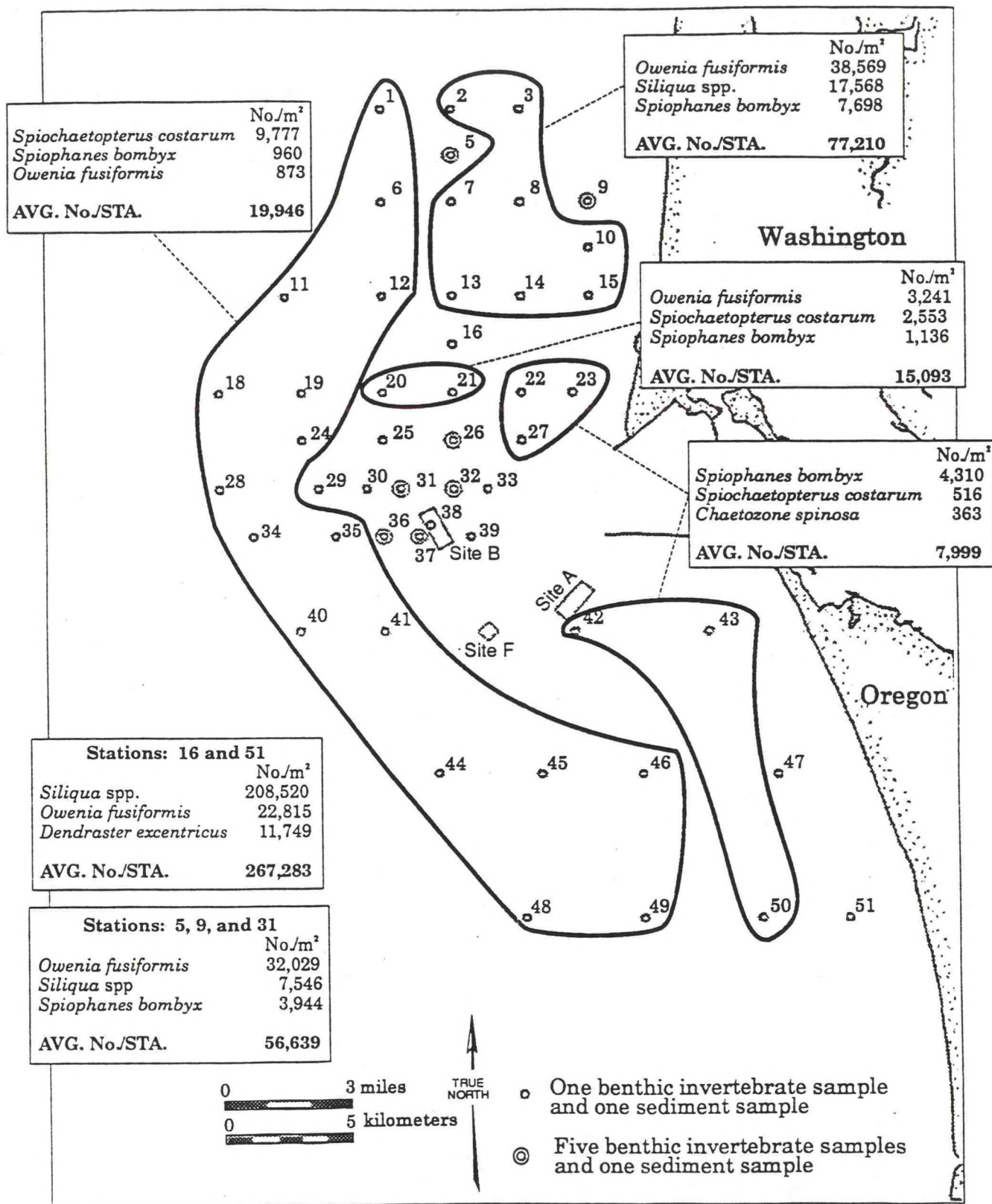


Figure 3.--Benthic invertebrate station groupings, identified using cluster analysis, and their major taxa, offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites. Average number/station (AVG. No./STA.) includes all taxa.

Sediments

Physical Analyses

Fifty-two sediment samples were collected at 51 stations; 2 of the samples were classified as "sandy silt," 37 as "silty sand," 8 as "poorly graded sand with silt," and 5 as "poorly graded sand" (Table 3, Appendix Table 5). Less than 1.5% of the material in any of the samples was coarser than 0.25 mm (#60 sieve), a medium sand. Maximum clay content was 8.9% and 28 stations had 0.0% clay.

Sediment grain size south of the mouth of the Columbia River was fairly uniform, ranging in median grain size from 0.12 to 0.18 mm. Median grain size decreased in a southerly direction (Appendix Fig. 2). Maximum median grain size was associated with the northern ebb tidal delta and ODMDS B. Northwest of ODMDS B, a distinct decreasing gradient in grain size was found. This gradient was the most pronounced feature of all physical sediment measurements. Median grain size in this area ranged from 0.06 to 0.09 mm. This area of fine-grained material forms a plume to the northwest and is bordered on the east, south, and west by coarser material (Appendix Fig. 2). The plume appears to be independent of depth contours except its association with the seaward edge of the ebb tidal delta.

Percent fines (material less than 0.0625 mm) ranged from 0.30 to 48.60%. Generally percent fines increased directly with depth, both in sediments collected north and south of the mouth of the Columbia River (Appendix Fig. 3). Stations north of the mouth of the Columbia River had higher percent fines than the southern stations at similar depths. Overall, the fines content formed a plume, or lobe of material with high silt content, that extended to the northwest from the seaward edge of the ebb tidal delta.

Percent volatile solids ranged from 0.3 (Station 47) to 6.6% (Station 18) (Table 3). Percent volatile solids generally increased with depth and in a northerly direction,

Table 3.--Sediment characteristics offshore from the Columbia River, July 1992.

Station	Depth (m)	Median grain size (mm)	Silt/clay (%)	Volatile solids (%)	Classification
1	36.6	0.09	5.5	0.9	Silty Sand
2	29.0	0.10	4.6	0.5	Silty Sand
3	24.1	0.11	3.3	0.5	Silty Sand
4	14.9	0.12	1.6	0.9	Silty Sand
5	27.4	0.10	9.1	0.9	Silty Sand
6	36.6	0.10	11.8	0.9	Silty Sand
7	26.2	0.10	4.2	0.8	Silty Sand
8	20.1	0.13	2.5	0.7	Silty Sand
9	13.7	0.14	1.1	0.8	Poorly graded sand with silt
10	14.0	0.10	3.6	1.1	Silty Sand
11	61.0	0.07	36.8	2.8	Silty Sand
12	36.6	0.09	20.7	0.8	Silty Sand
13	26.8	0.09	8.8	1.0	Silty Sand
14	20.7	0.12	5.5	0.5	Silty Sand
15	13.1	0.13	1.8	0.7	Silty Sand
16	29.3	0.08	23.2	1.0	Silty Sand
17	13.4	0.12	0.4	0.7	Silty Sand
18	82.0	0.13	20.4	6.6	Silty Sand
19	63.1	0.09	36.7	3.7	Poorly graded sand with silt
20	42.1	0.08	26.4	1.4	Poorly graded sand
21	27.4	0.09	18.4	1.3	Silty Sand
22	13.4	0.15	0.4	0.6	Silty Sand
23	10.7	0.17	0.3	4.3	Silty Sand
24	65.2	0.12	34.8	4.2	Silty Sand
25	44.5	0.08	20.4	1.5	Silty Sand
26	20.4	0.10	2.6	0.8	Silty Sand
27	11.3	0.16	0.5	0.7	Poorly graded sand with silt
28	87.2	0.15	19.1	1.8	Silty Sand
29	63.4	0.09	20.3	2.1	Silty Sand
30	53.3	0.07	45.4	3.8	Sandy Silt
31	42.4	0.06	48.6	3.7	Sandy Silt
32	21.0	0.12	9.3	1.0	Silty Sand
33	13.4	0.15	3.4	0.8	Poorly graded sand with silt
34	79.9	0.11	16.6	2.1	Silty Sand
35	63.1	0.15	17.6	2.1	Silty Sand
36	53.3	0.12	31.2	2.7	Silty Sand
37	38.1	0.18	1.2	0.8	Poorly graded sand
38	16.5	0.21	1.2	0.6	Poorly graded sand
39	21.0	0.21	4.5	0.6	Poorly graded sand with silt
39A	21.0	0.08	37.5	2.4	Silty Sand
40	77.7	0.15	15.6	2.2	Silty Sand
41	61.6	0.16	9.1	1.5	Silty Sand
42	25.9	0.17	0.5	0.5	Poorly graded sand
43	16.2	0.18	0.4	0.6	Poorly graded sand
44	67.1	0.13	7.4	1.3	Silty Sand
45	48.5	0.16	0.5	0.7	Poorly graded sand with silt
46	31.7	0.13	0.4	0.6	Poorly graded sand with silt
47	16.5	0.12	0.5	0.3	Silty Sand
48	69.5	0.14	0.8	3.0	Poorly graded sand with silt
49	45.7	0.12	5.2	1.5	Silty Sand
50	27.7	0.13	0.4	0.6	Silty Sand
51	13.7	0.12	0.3	0.7	Silty Sand

following the same trend as the fine-grained material (Appendix Fig. 4).

Due to variations in sediment characteristics noted during sampling, two sediment samples were collected at Station 39 for physical and chemical analyses. The first grab collected a very fine-grained material, but was discarded due to contamination. The second grab produced a clean sandy material (median grain size 0.21 mm, percent fines 4.5%, volatile solids 0.6%) as expected at this location and depth. The third grab at the same station produced fine-grained material, similar to the first grab. This sample was retained for benthic analysis. A fourth grab produced fine-grained material, similar to grabs 1 and 3. This sample (Sample 39A) was retained for both physical and chemical sediment analyses. Sample 39A had a median grain size of 0.08 mm, fines of 37.5%, and volatile solids of 2.4%.

Fishes and Large Epibenthic Invertebrates

In the July 1992 survey, 7,186 fishes and epibenthic invertebrates were captured, representing 22 taxa (Appendix Table 6). The number and weight of fishes for the four trawls ranged from 5,240 to 11,804/ha and 34,399 to 148,170 g/ha, respectively (Table 4, Appendix Table 7). Diversity and equitability were moderate for all trawls, except for Trawl 2, which had lower values and lower densities. The lower H and E values for Trawl 2 reflected the unequal proportional abundances among the taxa that were captured, with 85% of the catch composed of Pacific tomcod (*Microgadus proximus*). Pacific tomcod was the most abundant fish in all four trawls (Table 5, Appendix Table 6).

Benthic Invertebrate Comparisons between 1975 and 1992

Richardson et al. (1977) identified 425 organisms, most to the species level (Appendix Table 8). Of those identified, 192 occurred in 1975 at the eight stations used for comparisons with 1992 data. Since eight of these taxa were not considered benthic

Table 4.--Summary of fish and large epibenthic invertebrate catches for four trawling stations north of the Columbia River adjacent to Peacock Spit, July 1992.

Station [depth(m)]	Number of taxa	Total fish captured	Total wt. (g)	Number/ha	Wt. (g)/ha	Diversity (H)	Equitability (E)
1 (9.4)	14	1,433	17,362	5,946	72,043	2.50	0.66
2 (12.8)	15	1,310	8,599	5,240	34,399	1.13	0.29
3 (15.5)	20	2,078	26,077	11,804	148,170	2.59	0.60
4 (18.6)	20	2,365	27,296	8,507	98,189	2.87	0.66

invertebrates during the 1992 survey, they were eliminated from any analysis. For April, June, and September 1975, the number of taxa per station ranged from 22 to 89 and densities ranged from 234 to 43,802 organisms/m² (Table 6, Appendix Table 9).

In 1992, the number of taxa at the eight stations used for comparison were similar to those in 1975 (Table 6). For each station, densities were higher in 1992 than in 1975, except for Station 39 where densities were higher in April and June 1975 (Table 6).

Benthic invertebrate densities in 1992 were expected to be higher than in 1975 due to the smaller mesh size used to sieve the samples in 1992. Mean densities in 1975 ranged from 4,390 to 6,456 organisms/m², whereas in 1992 the mean was 63,172 organisms/m².

Few benthic invertebrates that were dominant in the 1975 surveys were dominant in the July 1992 survey (Table 7). The polychaetes *Spiophanes bombyx*, *Spiophanes berkeleyorum*, and *Magelona sacculata* were the only dominant organisms that occurred both in 1975 and 1992. Overall, the 1975 and 1992 surveys had many taxa in common, but densities of these taxa were not similar.

DISCUSSION

The benthic invertebrate community offshore from the Columbia River is subjected to a variety of influences: river flow, upwelling, downwelling, seasonal winds, and currents, all of which affect species diversity and densities. Benthic invertebrate composition and densities throughout the study area in July 1992 varied widely as exemplified by the cluster analysis. The largest benthic invertebrate cluster group was determined primarily by the overwhelming dominance of the polychaete *Spiochaetopterus costarum*, a tube-building surface deposit feeder. Its presence is consistent with the findings of Siipola et al. (1993) during the Tongue Point Monitoring Program, where this polychaete was the dominant organism in 1992, but was virtually non-existent in 1989-

Table 5.--Major fish and large epibenthic invertebrates captured by bottom trawl at four stations north of the Columbia River adjacent to Peacock Spit, July 1992.

Common name	Mean number/ha	Mean wt. (g)/ha
Smelt (unidentified juvenile)	523	572
Whitebait smelt	951	5,128
Pacific tomcod	3,501	24,495
California bay shrimp	539	456
Smooth bay shrimp	1,264	230
Miscellaneous taxa	1,097	57,320

Table 6.--Summary of benthic invertebrate collections for eight stations used for 1975 and 1992 comparisons, offshore from the Columbia River.

1992 Station	April 1975		June 1975		September 1975		July 1992	
	No. of taxa	No./m ²	No. of taxa	No./m ²	No. of taxa	No./m ²	No. of taxa	No./m ²
44	64	2,368	80	2,878	89	4,142	80	16,422
45	56	728	64	1,340	77	5,302	59	21,028
46	37	500	56	1,262	59	5,112	58	25,727
47	25	578	38	800	37	3,118	66	37,043
43	25	234	30	478	36	890	32	11,129
16	49	1,086	48	2,802	42	4,392	71	369,462
20	61	2,352	60	11,004	54	15,670	71	18,318
39	44	43,802	39	14,554	22	2,262	37	6,247
Mean	45	6,456	52	4,390	52	5,111	59	63,172

Table 7.--Dominant benthic invertebrates found at the eight stations used for comparisons between 1975 and 1992, offshore from the Columbia River. All values are numbers of organisms/m².

Taxon	1975			1992
	April	June	September	July
Polychaeta				
<i>Nephtys caecoides</i>	33	37	41	219
Orbiniidae	0	0	0	310
<i>Leitoscoloplos pugettensis</i>	62	112	109	94
<i>Spiophanes bombyx</i>	22	167	1,361	2,737
<i>Spiophanes berkeleyorum</i>	41	75	210	654
<i>Magelona sacculata</i>	25	32	75	391
<i>Spiochaetopterus costarum</i>	1	2	2	5,805
<i>Chaetozone setosa</i>	24	41	59	0
<i>Owenia fusiformis</i>	1	<1	2	8,124
Miscellaneous	70	147	246	1,753
Mollusca				
<i>Olivella</i> spp.	0	0	0	77
<i>Olivella pycna</i>	31	20	15	26
<i>Acila castrensis</i>	187	175	169	59
<i>Nucula tenuis</i>	14	18	16	5
<i>Axinopsida serricata</i>	41	48	46	63
Mytilidae	0	0	0	297
<i>Siliqua</i> spp. (juveniles)	0	0	0	39,640
<i>Siliqua patula</i>	4	146	169	0
<i>Macoma</i> spp.	0	0	0	597
<i>Tellina</i> spp.	0	<1	0	63
<i>Tellina modesta</i>	17	22	18	9
Miscellaneous	43	59	61	166
Crustacea				
<i>Euphilomedes carcharodonta</i>	9	7	19	182
<i>Diastylopsis</i> spp.	0	0	0	149
<i>Diastylopsis dawsoni</i>	281	1,310	2,308	12
<i>Tecticeps convexus</i>	37	11	2	12
<i>Ampelisca macrocephala</i>	59	98	36	95
<i>Eohaustorius sencillus</i>	36	31	20	20
<i>Photis macinerneyi</i>	0	0	0	113
<i>Protomedeia</i> spp.	3	27	11	23
<i>Rhepoxynius</i> spp.	0	0	0	125
<i>Rhepoxynius fatigans</i>	23	43	31	0
<i>Rhepoxynius daboius</i>	0	0	0	142
Miscellaneous	151	172	96	412
Miscellaneous				
<i>Amphiodia</i> spp.	0	0	0	111
<i>Amphiodia periercta-urtica</i>	52	45	35	0
Echinoidea	0	0	0	353
Miscellaneous	10	18	33	333
Total for each survey	1,280	2,867	5,190	63,171

1991 at ODMDS F. Siipola et al. (1993) speculated that environmental conditions were exceptionally favorable for this organism (i.e., abundant food resources and stable substrate), resulting in excellent recruitment.

Benthic invertebrate densities at four stations during the July 1992 survey were some of the highest ever observed in Oregon and Washington coastal waters (Emmett et al. 1987, Miller et al. 1988, Emmett and Hinton 1992, Hinton and Emmett 1993, Siipola et al. 1993). At Stations 10 (103,283 organisms/m²), 16 (365,462 organisms/m²), and 51 (165,105 organisms/m²), bivalves (*Siliqua* spp.) were responsible for the high values. All the *Siliqua* spp. were recently settled juveniles. At Station 15 (152,455 organisms/m²), the high densities were primarily due to the polychaete *Owenia fusiformis*, although unidentified mytilids and *Siliqua* spp. also contributed substantially.

The distribution of sediment types offshore from the Columbia River observed during this survey agrees with sediment distributions described in previous studies of the area (Kulm et al. 1975, Sternberg et al. 1977). South of the entrance to the Columbia River, sediment grain size decreases with increasing depth, as expected.

The zone of organically enriched fine-grained sediments to the west and northwest of ODMDS B found in this survey was described by Sternberg et al. (1977):

Immediately west of Disposal Site B both the clay- and silt-size fractions constituted abnormally greater proportions of the bottom samples as compared to samples from equivalent depths to the south. A narrow zone of high clay content sediments trends north-northwest to join the area of higher than normal offshore concentrations. The bottom sediments north of Disposal Site B had a high concentration of silt-size particles and in combination with the high silt content sediments west of the disposal site formed the southeastern end of a lobe of high silt content sediment that trended northwest from Site B.

Kulm et al. (1975) stated that the Cascadia Channel receives sediment from the Columbia River through the Willapa Canyon, which has its head on the outer edge of the continental shelf 45 km north of the mouth of the Columbia River. A northwest offshore transport of coarse silt and very fine sand is required to supply Willapa Canyon with

sediment for periodic submarine slumps. Radionuclide studies of fine-grained, river-borne particulate matter in the shelf sediments derived from the Columbia River show a net northward and westward transport toward the vicinity of Willapa Canyon. The same net transport is indicated by near-bottom current studies.

Sediments south of the mouth of the Columbia River appear unchanged from material collected by Sternberg et al. (1977). Median grain size ranged from fine sand (0.15 mm) to very fine sand (0.11 mm) in the Sternberg et al. study, while during our preliminary study, the median grain size ranged from 0.16 to 0.12 mm. Sternberg et al. (1977) noted that this area showed little seasonal change during their sampling survey. Sediment characteristics at other areas were more dynamic, especially around the mouth of the river.

One interesting observation made during our survey was the range of material collected during successive grab samples at Station 39. This station is located east of ODMDS B on the ebb tidal delta in 21 m of water. The first sample had a median grain size of 0.21 mm (fine sand) and 4.5% fines; the second sample had a median grain size of 0.08 mm (very fine sand) and 37.5% fines. Sternberg et al. (1977) noted similar dissimilarities in samples collected the same day, but at different times (1 hour and 14 minutes apart) and "supposedly at the same location" (their Station 27, located in 30 m of water southeast of ODMDS B--1,853 m south and 640 m east of our study's Station 39).

Annual variations in sediment characteristics were noted at Station G1 during the Tongue Point Monitoring Program (Siipola et al. 1993). This station is directly north of ODMDS F and southeast of ODMDS B and is within navigational or coordinate computational error and should be considered the same location as Sternberg et al.'s (1977) Station 27. Percent fines at Station G1 in 1990, 1991, and 1992 were 1.2, 19.6,

and 0.8%, respectively. These variations are independent of any dredged-material disposal event. The origin, fate, and significance of these transitory fine-grained deposits are unknown.

Fish species captured by trawling north of the mouth of the Columbia River in 1992 were similar to those found in previous surveys in other areas offshore from the Columbia River (Durkin and Lipovsky 1977, Siipola et al. 1993). However, fish densities varied greatly among surveys, which most likely is related to the different study locations.

This project provided an excellent example of the difficulties and limitations of comparing historical and recent benthic invertebrate surveys. The lack of historical raw benthic invertebrate data and changes in sampling techniques and timing of sampling restricted our ability to perform statistical comparisons between data collected in 1975 and 1992. This difficulty also exemplifies the need for long-term monitoring to permit an accurate description of benthic invertebrate populations and to help discern annual variations from environmental impacts. For example, benthic invertebrate densities at ODMDS F essentially doubled during each survey from 1989 to 1992 (Siipola et al. 1993). This event would have been undetectable with a short-term study.

It is difficult to draw any definitive conclusion concerning benthic invertebrate community structure offshore from the Columbia River from a single sample at each station. However, our goal was to provide a general description of the benthic invertebrate community and sediment structure in the nearshore area around the mouth of the Columbia River. NMFS input into ODMDS selection would occur during the site evaluation and designation process through review of draft documents and consultation under the Endangered Species Act. As a result of the 1992 benthic invertebrate survey, benthic sampling was conducted in July 1993 directly west and south from the mouth of the Columbia River, an area of generally lower benthic invertebrate densities. The 1993

survey should help identify variations in the benthic invertebrate community offshore from the Columbia River. The 1993 information is expected in spring 1994.

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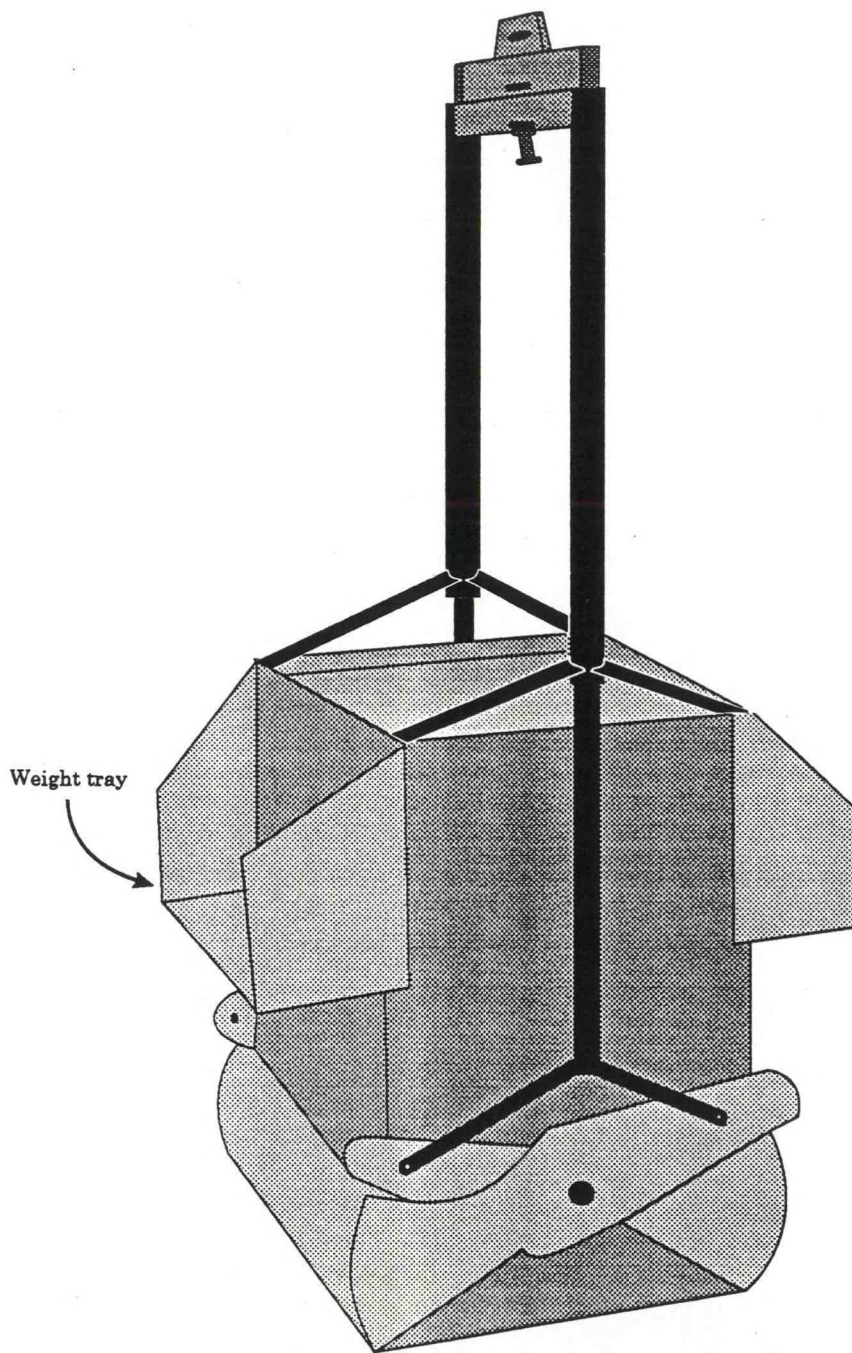
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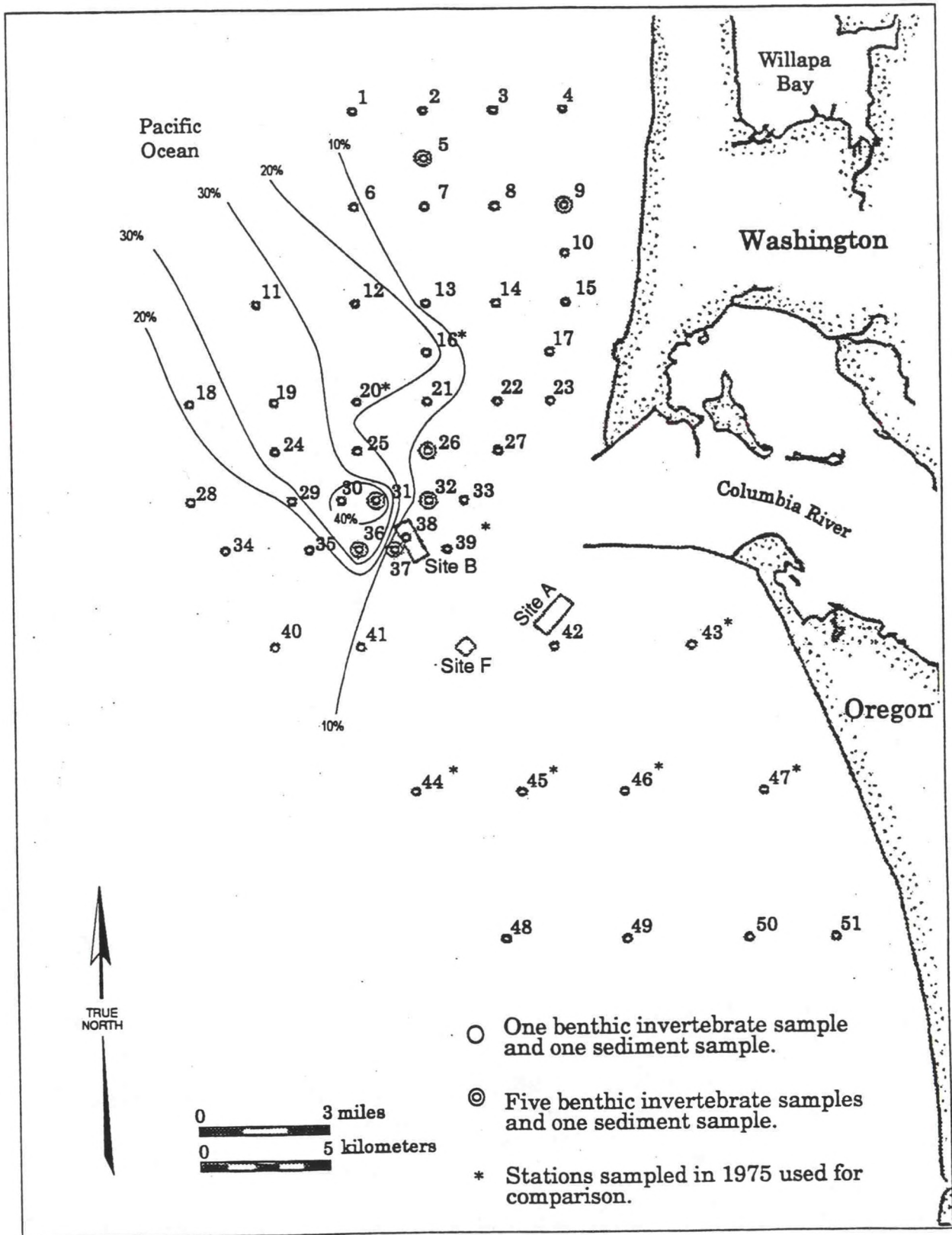
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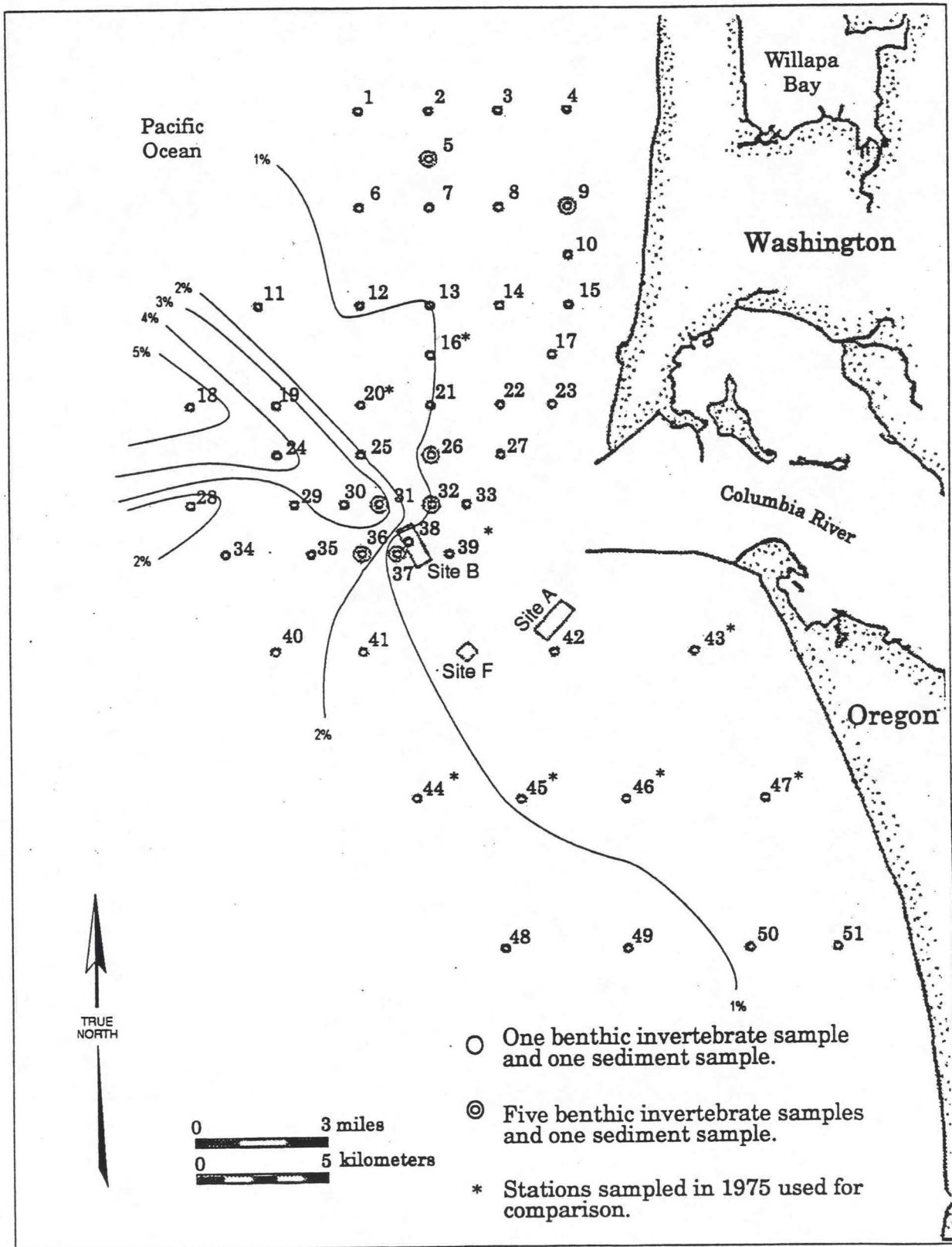
APPENDIX FIGURES



Appendix Figure 1.--The 0.1-m² box corer (Gray-O'Hara modification of a standard box corer) used for benthic invertebrate sampling offshore from the Columbia River, Oregon, July 1992. For deeper penetration 113 kg (250 lb) weights were placed in each tray located on opposite sides of the sampler.



Appendix Figure 3.--Percent of fine-grain material (<math><0.0625\text{ mm}</math>) found offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites.



Appendix Figure 4.--Percent volatile solids found offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites.

APPENDIX TABLES

Appendix Table 1.--Locations of benthic invertebrate, sediment, and trawling stations offshore from the Columbia River, July 1992.

<u>BENTHIC INVERTEBRATE AND SEDIMENT LOCATIONS</u>					
Station	Date	DMRP No. ^a	Depth m (ft)	Latitude	Longitude
1	15 Jul		36.6 (120)	46° 23.0'N	124° 12.0'W
2	15 Jul		29.0 (95)	46° 23.0	124° 10.0
3	15 Jul		24.1 (79)	46° 23.0	124° 8.0
4 ^b	15 Jul		14.9 (49)	46° 23.0	124° 6.0
5	20 Jul		27.4 (90)	46° 22.0	124° 10.0
6	20 Jul		36.6 (120)	46° 21.0	124° 12.0
7	20 Jul		26.2 (86)	46° 21.0	124° 10.0
8	20 Jul		20.1 (66)	46° 21.0	124° 8.0
9	20 Jul		13.7 (45)	46° 21.0	124° 6.0
10	20 Jul		14.0 (46)	46° 20.0	124° 6.0
11	20 Jul	150	61.0 (200)	46° 19.0	124° 15.0
12	20 Jul	151	36.6 (120)	46° 19.0	124° 12.0
13	20 Jul	152	26.8 (88)	46° 19.0	124° 10.0
14	20 Jul		20.7 (68)	46° 19.0	124° 8.0
15	20 Jul		13.1 (43)	46° 19.0	124° 6.0
16	20 Jul	145	29.3 (96)	46° 18.0	124° 10.0
17 ^b	20 Jul	98	13.4 (44)	46° 18.0	124° 6.5
18	20 Jul	144	82.0 (269)	46° 17.0	124° 17.0
19	20 Jul	143	63.1 (207)	46° 17.0	124° 14.5
20	20 Jul	142	42.1 (138)	46° 17.0	124° 12.0
21	20 Jul	141	27.4 (90)	46° 17.0	124° 10.0
22	20 Jul		13.4 (44)	46° 17.0	124° 8.0
23	20 Jul	149	10.7 (35)	46° 17.0	124° 6.5
24	20 Jul	99	65.2 (214)	46° 16.0	124° 14.5
25	20 Jul	100	44.5 (146)	46° 16.0	124° 12.0
26	20 Jul	101	20.4 (67)	46° 16.0	124° 10.0
27	20 Jul	102	11.3 (37)	46° 16.0	124° 0.8
28	27 Jul	97	87.2 (286)	46° 15.0	124° 17.0
29	27 Jul	96	63.4 (208)	46° 15.0	124° 14.0
30	27 Jul		53.3 (175)	46° 15.0	124° 12.5
31	27 Jul	95	42.4 (139)	46° 15.0	124° 11.5
32	27 Jul	103	21.0 (69)	46° 15.0	124° 10.0
33	27 Jul	94	13.4 (44)	46° 15.0	124° 9.0
34	27 Jul	67	79.9 (262)	46° 14.0	124° 16.0
35	27 Jul	66	63.1 (207)	46° 14.0	124° 13.5
36	27 Jul		53.3 (175)	46° 14.0	124° 12.0
37	27 Jul	65	38.1 (125)	46° 14.0	124° 11.0
38	27 Jul	117	16.5 (54)	46° 14.3	124° 10.7
39	27 Jul	64	21.0 (69)	46° 14.0	124° 9.5
40	22 Jul	55	77.7 (255)	46° 12.0	124° 14.6
41	22 Jul	56	61.6 (202)	46° 12.0	124° 12.0
42	22 Jul	58	25.9 (85)	46° 12.0	124° 6.5
43	22 Jul	59	16.2 (53)	46° 12.0	124° 2.5
44	22 Jul	53	67.1 (220)	46° 9.0	124° 10.5
45	22 Jul	52	48.5 (159)	46° 9.0	124° 7.5
46	22 Jul	51	31.7 (104)	46° 9.0	124° 4.5
47	22 Jul	60	16.5 (54)	46° 9.0	124° 0.5
48	22 Jul	48	69.5 (228)	46° 6.0	124° 8.0
49	22 Jul	49	45.7 (150)	46° 6.0	124° 4.5
50	22 Jul	50	27.7 (91)	46° 6.0	124° 1.0
51	22 Jul	61	13.7 (45)	46° 6.0	123° 58.5

^a Dredged Material Research Program (DMRP) identification number from 1975-1977 surveys.

^b Benthic invertebrate sample destroyed, not used in any analysis.

Appendix Table 1.--Continued.

Station	Mean depth m (ft)	<u>TRAWLING LOCATIONS</u>			
		Beginning		Loran-C readings Ending	
1	9.4 (31)	12064.6	28033.6	12062.8	28033.8
2	12.8 (42)	12063.1	28023.3	12061.1	28032.8
3	15.8 (52)	12059.6	28032.2	12058.2	28032.5
4	18.6 (61)	12057.0	28031.7	12054.8	28032.1

Appendix Table 2.--Stations (locations and numbers) for April, June, and September 1975 and July 1992 which were used for comparisons, offshore from the Columbia River.

Latitude	Longitude	1975 Station numbers			1992 Station numbers
		April	June	September	July
46° 9.0'N	124° 10.5'W	160	209	284	44
9.0'	7.5'	161	208	285	45
9.0'	4.5'	162	207	286	46
9.0'	0.5'	163	206	271	47
12.0'	2.5'	164	203	272	43
18.0'	10.0'	168	215	287	16
17.0'	12.0'	169	214	288	20
14.0'	9.5'	178	189	277	39

Appendix Table 3.--Epibenthic and benthic invertebrate taxa collected by box corer offshore from the Columbia River, July 1992.

Taxon	July 1992
Anthozoa	x
Pleurobrachidae	x
Platyhelminthes	x
Nemertea	x
Polychaeta	x
Aphroditidae	
<i>Aphrodita</i> spp.	x
Polynoidae	x
<i>Gattyana treadwelli</i>	x
<i>Hesperone complanata</i>	x
<i>Lepidasthenia berkeleyae</i>	x
<i>Enipo canadensis</i>	x
<i>Tenonia priops</i>	x
Sigalionidae	x
<i>Pholoe minuta</i>	x
<i>Sthenelais berkeleyi</i>	x
<i>Sthenelais tertiaglabra</i>	x
<i>Sigalion mathildae</i>	x
Phyllodoceidae	x
<i>Eteone</i> spp.	x
<i>Eteone fauchaldi</i>	x
<i>Eteone longa</i>	x
<i>Eulalia</i> spp.	x
<i>Phyllodoce</i> spp.	x
<i>Phyllodoce groenlandica</i>	x
<i>Phyllodoce hartmanae</i>	x
<i>Paranaitides polynoides</i>	x
<i>Eumida</i> spp.	x
<i>Eumida sanguinea</i>	x
Hesionidae	x
<i>Microphthalmus sczelkowi</i>	x
<i>Heteropodarke heteromorpha</i>	x
<i>Podarke pugettensis</i>	x
<i>Podarkeopsis glabrus</i>	x
Pilargidae	
<i>Sigambra bassi</i>	x
<i>Pilargis berkeleyae</i>	x
<i>Parandalia fauveli</i>	x
Syllidae	x
<i>Proceraea cornutus</i>	x
<i>Syllis alternata</i>	x
<i>Syllis elongata</i>	x
<i>Exogone gemmifera</i>	x
<i>Sphaerosyllis brandhorsti</i>	x
<i>Ehlersia heterochaeta</i>	x
Nereidae	x
<i>Nereis</i> spp.	x
<i>Nereis zonata</i>	x

Appendix Table 3.--Continued.

Taxon	July 1992
Nephtyidae	x
<i>Nephtys</i> spp.	x
<i>Nephtys caeca</i>	x
<i>Nephtys cornuta cornuta</i>	x
<i>Nephtys rickettsi</i>	x
<i>Nephtys ferruginea</i>	x
<i>Nephtys californiensis</i>	x
<i>Nephtys caecoides</i>	x
<i>Nephtys signifera</i>	x
Sphaerodoridae	
<i>Sphaerodoropsis minuta</i>	x
<i>Sphaerodoropsis spaerulifer</i>	x
Glyceridae	
<i>Glycera</i> spp.	x
<i>Glycera americana</i>	x
<i>Glycera robusta</i>	x
<i>Glycera convoluta</i>	x
<i>Glycera nana</i>	x
<i>Glycinde</i> spp.	x
<i>Glycinde armigera</i>	x
<i>Glycinde picta</i>	x
Goniadidae	
<i>Goniada brunnea</i>	x
Onuphidae	
<i>Onuphis</i> spp.	x
<i>Onuphis iridescens</i>	x
Lumbrineridae	
<i>Lumbrineris</i> spp.	x
<i>Eranno bicirrata</i>	x
<i>Lumbrineris luti</i>	x
<i>Lumbrineris cruzensis</i>	x
<i>Ninoe gemmea</i>	x
Arabellidae	
<i>Drilonereis nuda</i>	x
Dorvilleidae	
Orbiniidae	
<i>Scoloplos armiger</i>	x
<i>Leitoscoloplos pugettensis</i>	x
<i>Orbinia</i> (Phylo) <i>felix</i>	x
Paraonidae	
<i>Aedicira pacifica</i>	x
<i>Aricidea</i> spp.	x
<i>Aricidea</i> (=Acesta) <i>catherinae</i>	x
<i>Aricidea ramosa</i>	x
<i>Aricidea</i> (=Acesta) <i>pacifica</i>	x
<i>Paraonella platybranchia</i>	x
<i>Levinsenia gracilis</i>	x
Apistobrachidae	
<i>Apistobranchus ornatus</i>	x
Spionidae	
<i>Laonice cirrata</i>	x
<i>Polydora</i> spp.	x
<i>Polydora socialis</i>	x
<i>Polydora brachycephala</i>	x
<i>Polydora cardalia</i>	x
<i>Prionospio pinnata</i>	x
<i>Prionospio steenstrupi</i>	x

Appendix Table 3.--Continued.

Taxon	July 1992
<i>Prionopsio lighti</i>	X
<i>Spio</i> spp.	X
<i>Spio filicornis</i>	X
<i>Spio butleri</i>	X
<i>Boccardia pugettensis</i>	X
<i>Spiophanes</i> spp.	X
<i>Spiophanes bombyx</i>	X
<i>Spiophanes berkeleyorum</i>	X
<i>Paraprionospio pinnata</i>	X
<i>Scolelepis</i> spp.	X
<i>Scolelepis squamata</i>	X
<i>Scolelepis foliosa</i>	X
Magelonidae	
<i>Magelona</i> spp.	X
<i>Magelona longicornis</i>	X
<i>Magelona berkeleyi</i>	X
<i>Magelona sacculata</i>	X
<i>Magelona hobsonae</i>	X
Trochochaetidae	
<i>Trochochaeta</i> spp.	X
<i>Trochochaeta multisetosa</i>	X
Chaetopteridae	
<i>Spiochaetopterus</i> spp.	X
<i>Spiochaetopterus costarum</i>	X
<i>Mesochaetopterus taylori</i>	X
Cirratulidae	
<i>Cirratulus cirratus</i>	X
<i>Aphelochaeta</i> spp.	X
<i>Aphelochaeta multifilis</i>	X
<i>Aphelochaeta secunda</i>	X
<i>Chaetozone</i> spp.	X
<i>Chaetozone spinosa</i>	X
<i>Cossura</i> spp.	X
<i>Cossura longocirrata</i>	X
<i>Cossura pygodactylata</i>	X
Flabelligeridae	
<i>Flabelligera affinis</i>	X
Scalibregmidae	
<i>Asclerocheilus beringianus</i>	X
Opheliidae	
<i>Ophelina acuminata</i>	X
<i>Armandia brevis</i>	X
<i>Ophelia</i> spp.	X
<i>Travisia</i> spp.	X
<i>Travisia japonica</i>	X
Sternapsidae	
<i>Sternapsis scutata</i>	X
Capitellidae	
<i>Capitella capitata</i> complex	X
<i>Heteromastus filiformis</i>	X
<i>Heteromastus filobranchus</i>	X
<i>Notomastus tenuis</i>	X
<i>Notomastus lineatus</i>	X
<i>Mediomastus</i> spp.	X
<i>Mediomastus californiensis</i>	X
<i>Decamastus gracilis</i>	X
<i>Barantolla americana</i>	X

Appendix Table 3.--Continued.

Taxon	July 1992
Arenicolidae	
<i>Arenicola marina</i>	x
Maldanidae	x
<i>Asychis</i> spp.	x
<i>Maldane glebifex</i>	x
<i>Praxillella gracilis</i>	x
<i>Rhodine biforquata</i>	x
<i>Euclymene</i> spp.	x
<i>Euclymene zonalis</i>	x
Oweniidae	
<i>Owenia fusiformis</i>	x
<i>Myriochele heeri</i>	x
<i>Galathowenia oculata</i>	x
Pectinoridae	
<i>Pectinaria</i> spp.	x
<i>Pectinaria granulata</i>	x
<i>Pectinaria californiensis</i>	x
Ampharetidae	
<i>Ampharete</i> spp.	x
<i>Ampharete acutifrons</i>	x
Terebellidae	
<i>Pista brevibranchiata</i>	x
<i>Pista estevanica</i>	x
<i>Polycirrus</i> spp. complex	x
<i>Lanassa venusta venusta</i>	x
<i>Terebellides stroemi</i>	x
Sabellidae	
<i>Chone dunneri</i>	x
<i>Euchone incolor</i>	x
<i>Euchone hancocki</i>	x
Oligochaeta	x
Gastropoda	x
Turbinidae	
<i>Spiromoellaria quadrae</i>	x
Cerithiidae	
<i>Bittium</i> spp.	x
Epitoniidae	
<i>Epitonium</i> spp.	x
Naticidae	
<i>Polinices</i> spp.	x
Muricidae	
<i>Urosalpinx cinereus</i>	x
<i>Nitidella gouldi</i>	x
Nassariidae	
<i>Nassarius</i> spp.	x
<i>Nassarius mendicus</i>	x
<i>Nassarius fossatus</i>	x
Olivellidae	
<i>Olivella</i> spp.	x
<i>Olivella biplicata</i>	x
<i>Olivella baetica</i>	x
<i>Olivella pycna</i>	x
Turridae	
<i>Oenopota</i> spp.	x
<i>Kurtziella plumbea</i>	x

Appendix Table 3.--Continued.

Taxon	July 1992
Pyramidellidae	
<i>Odostomia</i> spp.	x
<i>Turbonilla</i> spp.	x
Schaphandridae	
<i>Acteocina culcitella</i>	x
<i>Cylichna attonsa</i>	x
<i>Scaphander willetti</i>	x
Aglajidae	
<i>Melanochlamys diomedea</i>	x
Gastropteridae	
<i>Gastropteron pacificum</i>	x
Corambidae	
<i>Corambe pacifica</i>	x
Aplacophora	x
Pelecypoda	x
Nuculidae	
<i>Acila castrensis</i>	x
<i>Nucula tenuis</i>	x
<i>Yoldia</i> spp.	x
<i>Yoldia scissurata</i>	x
Mytilidae	x
<i>Megacrenella columbiana</i>	x
<i>Musculus</i> spp.	x
Thyasiridae	
<i>Axinopsida serricata</i>	x
<i>Thyasira gouldi</i>	x
Montacutidae	
<i>Neaeomya rugifera</i>	x
<i>Mysella tumida</i>	x
Carditidae	
<i>Cyclocardia ventricosa</i>	x
Cardiidae	
<i>Clinocardium</i> spp.	x
Cultellidae	
<i>Siliqua</i> spp.	x
<i>Siliqua patula</i>	x
<i>Siliqua sloati</i>	x
<i>Solen sicarius</i>	x
Tellinidae	
<i>Macoma</i> spp.	x
<i>Macoma calcarea</i>	x
<i>Macoma nasuta</i>	x
<i>Macoma balthica</i>	x
<i>Tellina</i> spp.	x
<i>Tellina nuculoides</i>	x
<i>Tellina carpenteri</i>	x
<i>Tellina modesta</i>	x
<i>Tellina bodegensis</i>	x
Veneridae	
<i>Compsomyax subdiaphana</i>	x
Hiatellidae	
<i>Hiatella arctica</i>	x
Thraciidae	
<i>Thracia trapezoides</i>	x

Appendix Table 3.--Continued.

Taxon	July 1992
Scaphopoda	x
<i>Cadulus</i> spp.	x
Gadilidae	x
Crustacea	
Ostracoda	x
Cylindroleberididae	x
Cyprinidae	
<i>Euphilomedes</i> spp.	x
<i>Euphilomedes carcharodonta</i>	x
Calanoida (Copepoda)	x
Harpacticoida (Copepoda)	x
Cyclopoida (Copepoda)	x
<i>Corycaeus</i> spp.	x
Cirripedia	x
Nebaliidae	
<i>Nebalia pugettensis</i>	x
Mysidae	
<i>Acanthomysis</i> spp.	x
<i>Acanthomysis columbiae</i>	x
<i>Archaeomysis grebnitzkii</i>	x
<i>Neomysis</i> spp.	x
Lampropidae	x
<i>Hemilamprops californica</i>	x
Leuconidae	
<i>Leucon</i> spp.	x
Diastylidae	x
<i>Diastylis</i> spp.	x
<i>Diastylopsis</i> spp.	x
<i>Diastylopsis dawsoni</i>	x
<i>Diastylopsis tenuis</i>	x
Colurostylidae	
<i>Colurostylis occidentalis</i>	x
Nannastacidae	
<i>Cumella vulgaris</i>	x
Tanaidae	
<i>Pseudotanaeis oculatus</i>	x
Paratanaidae	
<i>Leptognathia gracilis</i>	x
Isopoda	
Sphaeromatidae	
<i>Tecticeps convexus</i>	x
<i>Gnorimosphaeroma oregonensis</i>	x
<i>Ancinus</i> spp.	x
Idoteidae	
<i>Synidotea</i> spp.	x
<i>Synidotea angulata</i>	x
Munnidae	
<i>Munna</i> spp.	x
Amphipoda	x
Gammaridea	x
Ampeliscidae	
<i>Ampelisca</i> spp.	x
<i>Ampelisca macrocephala</i>	x
<i>Ampelisca careyi</i>	x

Appendix Table 3.--Continued.

Taxon	July 1992
Aoroidae	
<i>Aoroides</i> spp.	x
Atylidae	
<i>Atylus tridens</i>	x
Corophiidae	
<i>Corophium</i> spp.	x
<i>Corophium spinicorne</i>	x
Gammaridae	
<i>Maera</i> spp.	x
Haustoridae	
<i>Eohaustorius</i> spp.	x
<i>Eohaustorius washingtonianus</i>	x
<i>Eohaustorius estuarius</i>	x
<i>Eohaustorius sencillus</i>	x
Hyalidae	
<i>Parallorchestes</i> spp.	x
Isaetae	
<i>Photis</i> spp.	x
<i>Photis macinerneyi</i>	x
<i>Photis parvidons</i>	x
<i>Protomedeia</i> spp.	x
<i>Protomedeia articulata</i>	x
<i>Podoceropsis</i> spp.	x
Lysianassidae	
<i>Orchomene</i> spp.	x
<i>Orchomene pacifica</i>	x
<i>Orchomene pinquis</i>	x
<i>Pachynus</i> c.f. <i>barnardi</i>	x
<i>Psammonyx longimerus</i>	x
Oedicerotidae	
<i>Monoculodes</i> spp.	x
<i>Synchelidium shoemakeri</i>	x
<i>Westwoodilla caecula</i>	x
Phoxocephalidae	
<i>Mandibulophoxus gilesi</i>	x
<i>Rhepoxynius</i> spp.	x
<i>Rhepoxynius abronius</i>	x
<i>Rhepoxynius daboius</i>	x
<i>Rhepoxynius vigitegus</i>	x
<i>Foxiphalus major</i>	x
Pleustidae	
<i>Parapleustes</i> spp.	x
<i>Parapleustes pugettensis</i>	x
<i>Podocerus</i> spp.	x
Stenothoidae	
Decapoda	
Decapoda zoea	x
Caridea	x
Caridea zoea	x
Crangonidae	
<i>Crangon</i> spp.	x
<i>Crangon nigricauda</i>	x
<i>Lissocrangon stylirostris</i>	x
Callianassidae	
<i>Callianassa californiensis</i>	x
Paguridae	
<i>Pagurus</i> spp.	x

Appendix Table 3.--Continued.

Taxon	July 1992
Brachyura	
<i>Brachyura zoea</i>	x
Cancridae	
<i>Cancer</i> spp.	x
<i>Cancer magister</i>	x
Pinnotheridae	
<i>Pinnixa</i> spp.	x
<i>Pinnixa eburna</i>	x
Aphididae	x
Collembola	x
Sipunculidae	x
Echiurida	x
Phoronida	x
Brachiopoda	x
Asteroidea	x
Ophiuroidea	x
<i>Ophiura</i> spp.	x
Amphiuridae	x
<i>Amphiodia</i> spp.	x
<i>Amphiura</i> spp.	x
Echinoidea	x
<i>Dendraster excentricus</i>	x
Holothuroidea	x
<i>Pentamera</i> spp.	x
Chaetognatha	x
<hr/>	
Total number of taxa/categories identified	338

Appendix Table 4.--Summaries of benthic invertebrate collections by station, offshore from the Columbia River, July 1992 (available upon request from National Marine Fisheries Service, Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121).

Appendix Table 5.--Summary of sediment physical analyses by station, offshore from the Columbia River, July 1992.

Station no.	Grain Size		Grain Size Distribution										Clay (%)	TOC %	Voidal Solids %	ASTM D 2487 Classification
	Mean (mm)	Median (mm)	V	Coarse sand	Coarse sand	Medium sand	Fine sand	V	Silt (< 0.075 mm)	V	Silt (< 0.0425 mm)	V				
1	0.10	0.09	100.00	100.00	100.00	99.80	99.8	75.8	5.5	0.0	0.14	0.90	SM Silty Sand			
2	0.11	0.10	100.00	100.00	100.00	100.00	99.8	64.3	4.6	0.0	0.10	0.50	SM Silty Sand			
3	0.12	0.11	100.00	100.00	100.00	100.00	99.6	58.2	3.3	0.0	0.10	0.50	SM Silty Sand			
4	0.13	0.12	100.00	100.00	100.00	99.80	99.5	54.3	1.6	0.0	0.21	0.90	SM Silty Sand			
5	0.11	0.10	100.00	100.00	100.00	99.60	99.3	66.4	9.1	0.0	0.11	0.90	SM Silty Sand			
6	0.11	0.10	100.00	100.00	100.00	100.00	99.9	72.1	11.8	0.9	0.11	0.80	SM Silty Sand			
7	0.12	0.10	100.00	100.00	100.00	99.90	99.5	62.9	4.2	0.0	0.10	0.80	SM Silty Sand			
8	0.14	0.13	100.00	100.00	100.00	99.90	98.8	49.7	2.5	0.0	0.10	0.70	SM Silty Sand			
9	0.15	0.14	100.00	100.00	100.00	99.80	99.2	39.7	1.1	0.0	0.10	0.80	SP-SM Poorly graded Sand with silt			
10	0.11	0.10	100.00	100.00	100.00	99.60	98.9	69.0	3.6	0.0	0.14	1.10	SM Silty Sand			
11	0.07	0.07	100.00	100.00	100.00	99.70	98.8	95.2	36.8	3.7	0.04	2.80	SM Silty Sand			
12	0.09	0.09	100.00	100.00	100.00	100.00	99.9	82.5	20.7	2.6	0.18	0.80	SM Silty Sand			
13	0.10	0.09	100.00	100.00	100.00	99.70	99.4	77.0	8.8	0.0	0.15	1.00	SM Silty Sand			
14	0.13	0.12	100.00	100.00	100.00	99.60	98.9	55.5	5.5	0.0	0.12	0.50	SM Silty Sand			
15	0.14	0.13	100.00	100.00	100.00	99.70	98.4	49.9	1.8	0.0	0.10	0.70	SM Silty Sand			
16	0.09	0.08	100.00	100.00	100.00	100.00	99.9	91.0	23.2	1.7	0.13	1.00	SM Silty Sand			
17	0.13	0.12	100.00	100.00	100.00	99.90	97.8	52.6	0.4	0.0	0.06	0.70	SM Silty Sand			
18	0.12	0.13	100.00	100.00	100.00	99.80	98.5	48.6	20.4	5.9	0.64	6.60	SM Silty Sand			
19	0.09	0.09	99.70	99.50	99.00	99.00	97.6	69.1	36.7	7.7	0.75	3.70	SP-SM Poorly graded Sand with silt			
20	0.09	0.08	100.00	100.00	100.00	99.90	99.7	89.8	26.4	2.2	0.20	1.40	SP Poorly graded Sand			
21	0.09	0.09	100.00	100.00	100.00	99.90	99.8	87.5	18.4	2.5	0.27	1.30	SM Silty Sand			
22	0.16	0.15	100.00	100.00	100.00	99.50	96.6	31.3	0.4	0.0	0.08	0.60	SM Silty Sand			
23	0.18	0.17	100.00	100.00	100.00	99.50	91.5	16.6	0.3	0.0	0.06	4.30	SM Silty Sand			
24	0.11	0.12	99.70	99.60	99.30	97.7	51.3	34.8	8.9	8.9	0.67	1.50	SM Silty Sand			
25	0.08	0.08	100.00	100.00	100.00	100.00	99.8	67.1	20.4	1.7	0.32	1.50	SM Silty Sand			
26	0.11	0.10	100.00	100.00	100.00	99.50	96.7	60.0	2.6	0.0	0.09	0.80	SM Silty Sand			
27	0.16	0.16	100.00	100.00	100.00	99.40	95.2	32.2	0.5	0.0	0.06	0.70	SP-SM Poorly graded Sand with silt			
28	0.13	0.15	100.00	100.00	100.00	99.80	98.8	37.7	19.1	5.0	0.49	1.80	SM Silty Sand			
29	0.09	0.09	99.70	99.60	99.30	97.4	80.6	20.3	5.3	5.3	0.78	2.10	SM Silty Sand			
30	0.07	0.07	99.90	99.80	99.50	91.1	82.3	45.4	45.4	7.5	1.40	3.80	ML Sandy Silt			
31	0.06	0.06	100.00	100.00	100.00	99.1	98.7	48.6	5.8	5.8	1.50	3.70	ML Sandy Silt			
32	0.13	0.12	100.00	100.00	100.00	99.70	93.1	55.3	9.3	1.8	0.37	1.00	SM Silty Sand			
33	0.15	0.15	100.00	100.00	100.00	99.20	94.4	34.0	3.4	0.0	0.21	0.80	SP-SM Poorly graded Sand with silt			
34	0.11	0.11	99.70	99.60	99.50	97.6	61.6	16.6	4.3	4.3	0.40	2.10	SM Silty Sand			
35	0.14	0.15	100.00	100.00	100.00	99.90	97.7	33.5	17.6	3.5	0.66	2.10	SM Silty Sand			
36	0.12	0.12	100.00	100.00	100.00	99.90	97.6	53.5	31.2	6.0	0.96	2.70	SM Silty Sand			
37	0.19	0.18	100.00	100.00	100.00	99.60	83.7	9.9	1.2	0.0	0.09	0.80	SP Poorly graded Sand			
38	0.24	0.21	100.00	100.00	100.00	98.50	64.1	7.4	1.2	0.0	0.05	0.80	SP Poorly graded Sand			
39	0.22	0.21	99.90	99.90	99.50	65.0	16.5	4.5	4.5	0.0	0.10	0.60	SP-SM Poorly graded Sand with silt			
39A	0.11	0.08	100.00	100.00	100.00	99.70	91.1	65.2	37.5	2.9	0.42	2.40	SM Silty Sand			
40	0.14	0.15	100.00	100.00	100.00	99.90	98.7	30.1	15.6	5.3	0.71	2.20	SM Silty Sand			
41	0.15	0.16	100.00	100.00	100.00	100.00	98.8	24.6	9.1	3.6	0.64	1.50	SM Silty Sand			
42	0.18	0.17	100.00	100.00	100.00	99.50	86.9	18.0	0.5	0.0	0.08	0.50	SP Poorly graded Sand			
43	0.20	0.18	99.90	99.90	99.00	72.2	23.7	0.4	0.4	0.0	<0.05	0.60	SP Poorly graded Sand			
44	0.14	0.13	99.9	99.90	99.80	98.6	44.5	7.4	3.3	3.3	0.27	1.30	SM Silty Sand			
45	0.16	0.16	100.00	100.00	100.00	99.70	98.7	24.3	0.5	0.0	0.20	0.70	SP-SM Poorly graded Sand with silt			
46	0.14	0.13	100.00	100.00	100.00	99.60	98.2	43.5	0.4	0.0	0.09	0.60	SP-SM Poorly graded Sand with silt			
47	0.13	0.13	96.70	96.60	96.50	96.0	52.2	0.5	0.0	0.0	0.08	0.30	SM Silty Sand			
48	0.15	0.14	100.00	100.00	100.00	99.3	36.0	0.8	0.0	0.0	0.30	3.00	SP-SM Poorly graded Sand with silt			
49	0.13	0.12	100.00	100.00	100.00	100.00	99.8	53.7	5.2	2.2	0.13	1.50	SM Silty Sand			
50	0.14	0.13	100.00	100.00	100.00	99.70	98.4	49.7	0.4	0.0	0.07	0.60	SM Silty Sand			
51	0.13	0.12	100.00	100.00	100.00	99.60	98.6	54.5	0.3	0.0	0.07	0.70	SM Silty Sand			
	MAX	0.24	100.00	100.00	100.00	99.90	98.70	98.70	48.60	8.90	1.50	6.60				
	MIN	0.06	98.70	98.60	98.50	64.10	7.40	0.30	0.00	0.05	0.30	0.30				

Appendix Table 6.--Fishes and large epibenthic invertebrates captured offshore from the Columbia River, July 1992.

Scientific name	Common name	July
Squalidae		
<i>Squalus acanthias</i>	spiny dogfish	x
Rajidae		
<i>Raja binoculata</i>	big skate	x
Clupeidae		
<i>Clupea pallasii</i>	Pacific herring	x
Osmeridae		
<i>Allosmerus elongatus</i>	whitebait smelt	x
<i>Spirinchus thaleichthys</i>	longfin smelt	x
<i>Spirinchus starksi</i>	night smelt	x
Unidentified smelt		x
Gadidae		
<i>Microgadus proximus</i>	Pacific tomcod	x
Cottidae		
<i>Leptocottus armatus</i>	Pacific staghorn sculpin	x
Agonidae		
<i>Ocella verrucosa</i>	warty poacher	x
<i>Stellerina xyosterna</i>	pricklebreast poacher	x
Cyclopteridae		
<i>Liparis pulchellus</i>	showy snailfish	x
Bothidae		
<i>Citharichthys sordidus</i>	Pacific sanddab	x
<i>Citharichthys stigmaeus</i>	speckled sanddab	x
Pleuronectidae		
<i>Isopsetta isolepis</i>	butter sole	x
<i>Pleuronectes vetulus</i>	English sole	x
<i>Platichthys stellatus</i>	starry flounder	x
<i>Psettichthys melanostictus</i>	sand sole	x
<i>Microstomus pacificus</i>	Dover sole	x
Invertebrates		
Canceridae		
<i>Cancer magister</i>	Dungeness crab	x
Crangonidae		
<i>Crangon franciscorum</i>	California bay shrimp	x
<i>Lissocrangon stylirostris</i>	smooth bay shrimp	x
Total number of taxa		22

Appendix Table 7.--Summary of 8-m trawling efforts offshore from the Columbia River,
July 1992.

Station: 1
 Gear: 8-m trawl
 Date: 20 Jul 1992
 Time: 658
 Tide stage: Ebb
 Depth: 9.4 m
 Distance traveled: 482 m

Species	No. captured	Total wt. (g)	No./ hectare	Wt. (g) / hectare
Longfin smelt	71	220	295	913
Unidentified juv. smelt	197	123	817	512
Whitebait smelt	345	2,037	1,432	8,452
Pacific tomcod	570	10,712	2,365	44,448
Pacific staghorn sculpin	75	2,693	311	11,174
Pricklebreast poacher	3	16	12	66
Speckled sanddab	17	85	71	353
Butter sole	4	69	17	286
English sole	22	320	91	1,328
Starry flounder	3	231	12	959
Sand sole	13	330	54	1,369
Dungeness crab	11	486	46	2,017
California bay shrimp	7	12	29	51
Smooth crangon	95	27	394	115
TOTALS	1,433	17,362	5,946	72,043

H = 2.50 E = 0.66

Appendix Table 7.--Continued.

Station: 2

Gear: 8-m trawl

Date: 20 Jul 1992

Time: 719

Tide stage: Ebb

Depth: 12.8 m

Distance traveled: 500 m

Species	No. captured	Total wt. (g)	No./ hectare	Wt. (g) / hectare
Longfin smelt	8	28	32	112
Night smelt	18	71	72	284
Unidentified juv. smelt	12	8	48	34
Whitebait smelt	61	360	244	1,440
Pacific tomcod	1,101	5,048	4,404	20,192
Pacific staghorn sculpin	20	720	80	2,880
Pricklebreast poacher	2	11	8	44
Speckled sanddab	10	49	40	196
Butter sole	6	128	24	512
English sole	4	60	16	240
Starry flounder	8	1105	32	4,420
Sand sole	2	43	8	172
Dungeness crab	2	948	8	3,792
California bay shrimp	10	11	40	48
Smooth crangon	46	8	184	33
TOTALS	1,310	8,599	5,240	34,399

H = 1.13 E = 0.29

Appendix Table 7.--Continued.

Station: 3

Gear: 8-m trawl

Date: 20 Jul 1992

Time: 738

Tide stage: Late ebb

Depth: 15.5 m

Distance traveled: 352 m

Species	No. captured	Total wt. (g)	No./ hectare	Wt. (g)/ hectare
Spiny dogfish	1	1,814	6	10,307
Big skate	2	9,072	11	51,545
Pacific herring	4	136	23	773
Longfin smelt	81	248	460	1,409
Night smelt	27	82	153	466
Unidentified juv. smelt	103	79	585	451
Whitebait smelt	294	1,502	1,670	8,534
Pacific tomcod	978	4,309	5,557	24,483
Pacific staghorn sculpin	65	3,015	369	17,131
Warty poacher	8	21	45	119
Pricklebreast poacher	14	133	80	756
Pacific sanddab	6	373	34	2,119
Speckled sanddab	45	117	256	665
Butter sole	27	2,142	153	12,170
English sole	3	72	17	409
Starry flounder	7	1,628	40	9,250
Sand sole	5	806	28	4,580
Dungeness crab	5	359	28	2,040
California bay shrimp	109	102	619	581
Smooth crangon	294	67	1,670	382
TOTALS	2,078	26,077	11,804	148,170

H = 2.59 J = 0.60

Appendix Table 7.--Continued.

Station: 4

Gear: 8-m trawl

Date: 20 Jul 1992

Time: 758

Tide stage: Late ebb

Depth: 18.6 m

Distance traveled: 556 m

Species	No. captured	Total wt. (g)	No./ hectare	Wt. (g) / hectare
Spiny dogfish	1	1,253	4	4,507
Big skate	10	6,777	36	24,378
Longfin smelt	141	441	507	1,586
Night smelt	23	96	83	345
Unidentified juv. smelt	178	358	640	1,291
Whitebait smelt	127	580	457	2,086
Pacific tomcod	466	2,462	1,676	8,856
Pacific staghorn sculpin	15	761	54	2,737
Warty poacher	19	19	68	68
Pricklebreast poacher	59	639	212	2,299
Showy snailfish	2	46	7	165
Pacific sanddab	7	1,103	25	3,968
Speckled sanddab	15	26	54	94
Butter sole	54	6,337	194	22,795
English sole	3	245	11	881
Starry flounder	1	102	4	367
Dover sole	1	126	4	453
Dungeness crab	54	5,499	194	19,781
California bay shrimp	408	317	1,468	1,142
Smooth crangon	781	108	2,809	390
TOTALS	2,365	27,296	8,507	98,189

H = 2.87 E = 0.66

Appendix Table 8.--Benthic invertebrate taxa densities (mean number/m²) found in April, June, and September 1975 and July 1992 at the eight stations used for comparison, offshore from the mouth of the Columbia River.

Taxon	1975			1992
	April	June	September	July
Pleurobrachidae				2.6
Cnidaria				
Anthozoa	0.5	0.5	0.3	
Platyhelminthes				
Turbellaria		0.3		
Nemertinea				
Nemertea	4.0	9.0	20.8	233.1
Nematoda		0.5	0.8	
Annelida				
Polychaeta				
Polynoidae				18.2
<i>Bylgides macrolepid</i> ?		1.0		
<i>Harmothoe lunulata</i>		0.5		
<i>Eunoe</i> spp.	0.3			
<i>Tenonia priops</i>		0.5	0.8	13.0
Sigalionidae				3.9
<i>Pholoe minuta</i>	4.3	9.0	7.0	93.8
<i>Sigalion mathildae</i>				7.8
<i>Sthenelais berkeleyi</i>				3.9
<i>Sthenelais tertiaglabra</i>	2.0	3.8	2.0	
<i>Thalenessa spinosa</i>	1.5	5.3	4.8	
Phyllodocidae				5.2
<i>Anaitides</i> spp.		0.3	0.5	
<i>Eteone</i> spp.	0.5	0.5	1.0	
<i>Eteone californica</i>		1.3	4.0	
<i>Eteone longa</i>		0.3	2.3	20.8
<i>Phyllodoce</i> spp.				2.6
<i>Phyllodoce hartmanae</i>				175.8
<i>Phyllodoce mucosa</i>		0.3	0.3	
<i>Phyllodoce groenlandica</i>		1.0	1.0	
<i>Paranaitides polynoides</i>			0.3	1.3
<i>Mysta barbata</i>	0.3			
<i>Eumida sanguinea</i>				35.2
Hesionidae				1.3
<i>Microphthalmus szcelkowi</i>				19.5
<i>Podarkeopsis glabrus</i>				1.3
<i>Sigambra bassi</i>				3.9
Syllidae				16.9
<i>Proceraea cornutus</i>				7.8
Nereidae				7.8
<i>Nereis zonata</i>	0.5		4.0	11.7
Nephtyidae				250.1
<i>Nephtys</i> spp.				
<i>Nephtys caeca</i>	1.5	2.0	1.0	
<i>Nephtys californiensis</i>	2.8	1.8	6.5	2.6
<i>Nephtys caecoides</i>	32.5	36.5	41.0	218.8
<i>Nephtys ferruginea</i>			0.3	19.5
<i>Nephtys glabra</i>		0.3		
Glyceridae				
<i>Glycera capitata</i>	1.8	2.3	2.8	
<i>Glycera nana</i>				2.6

Appendix Table 8.--Continued.

Taxon	1975			1992
	April	June	September	July
Goniadidae				
<i>Glycinde</i> spp.	4.0	17.5	19.8	48.2
<i>Glycinde armigera</i>				214.9
<i>Glycinde picta</i>	3.3	3.3	10.3	28.7
<i>Goniada brunnea</i>				5.2
<i>Goniada maculata</i>	1.8	3.5	2.3	
Onuphidae				44.3
<i>Onuphis iridescens</i>	4.3	9.3	17.0	11.7
Lumbrineridae				3.9
<i>Errano bicirrata</i>	2.0	2.3	3.0	3.9
<i>Lumbrineris latreilli</i>		1.3	0.8	
<i>Scoletoma luti</i>	3.3	4.5	2.8	5.2
Arabellidae				
<i>Notocirrus californiensis</i>	0.3	0.3		
Orbiniidae				310.0
<i>Leitoscoloplos pugettensis</i>	61.5	111.8	108.5	93.8
<i>Scoloplos armiger</i>	7.3	10.5	8.3	2.6
<i>Orbinia</i> (Phylo) <i>felix</i>		0.8		5.2
Paraonidae				
<i>Aedicira</i> spp.			0.3	
<i>Aricidea</i> (Acesta) <i>catherinae</i>				10.4
<i>Aricidea</i> (Acesta) <i>pacifica</i>				1.3
<i>Levinsenia gracilis</i>		0.3		
<i>Paraonella platybranchia</i>	0.5	1.0	0.5	3.9
Spionidae				
<i>Laonice cirrata</i>	0.3	1.5	2.5	1.3
<i>Polydora brachycephala</i>				2.6
<i>Polydora caulleryi</i>		10.0	25.5	
<i>Prionospio lighti</i>				74.2
<i>Prionospio steenstrupi</i>	3.8	3.3	1.8	
<i>Spio butleri</i>				1.3
<i>Spio filicornis</i>	3.5	2.8	11.3	11.7
<i>Spio cirrifera</i>	0.5	1.3	2.0	
<i>Boccardia basilaria?</i>		2.0	1.5	
<i>Boccardia pugettensis</i>				1.3
<i>Spiophanes bombyx</i>	21.8	166.8	1,361.3	2,736.6
<i>Spiophanes berkeleyorum</i>	40.8	74.5	209.8	653.9
<i>Paraprionospio pinnata</i>	0.5			2.6
<i>Scolelepis foliosa</i>				15.6
<i>Scolelepis squamata</i>	0.3		0.8	1.3
Magelonidae				
<i>Magelona</i> spp.				104.2
<i>Magelona hobsonae</i>				3.9
<i>Magelona longicornis</i>	1.0	0.8	0.8	11.7
<i>Magelona pitelkai</i>	0.3	1.0		
<i>Magelona sacculata</i>	25.3	31.5	74.8	390.8
Chaetopteridae				19.5
<i>Trochochaeta franciscanum</i>		0.8	2.3	
<i>Spiochaetopterus costarum</i>	0.8	1.5	1.5	5,805.2
<i>Mesochaetopterus taylori</i>				7.8
Cirratulidae				2.6
<i>Aphelochaeta</i> spp.	0.3	1.0	0.5	
<i>Aphelochaeta multifilis</i>	0.5	0.5		1.3
<i>Chaetozone setosa</i>	24.3	41.3	58.8	
<i>Chaetozone spinosa</i>				171.9
<i>Cirratulus cirratus</i>				1.3
<i>Pherusa plumosa</i>			1.5	
Flabelligeridae				1.3

Appendix Table 8.--Continued.

Taxon	1975			1992
	April	June	September	July
Opheliidae				19.5
<i>Armandia brevis</i>				20.8
<i>Ophelia</i> spp.	1.3	2.0	2.0	
<i>Ophelina</i> spp.	0.3			
<i>Ophelina acuminata</i>		0.3	0.5	
<i>Travisia japonica</i>		0.8	0.3	1.3
Sternaspida			0.3	
<i>Sternaspis scutata</i>		0.3		2.6
Capitellidae			0.5	1.3
<i>Capitella capitata</i> complex			1.5	
<i>Heteromastus filobranchus</i>	0.5	2.5		2.6
<i>Heteromastus filiformis</i>				6.5
<i>Decamastus gracilis</i>	1.3	6.3	3.8	16.9
<i>Mediomastus</i> spp.				5.2
<i>Mediomastus californiensis</i>		5.5	7.3	3.9
<i>Notomastus lineatus</i>			2.5	
<i>Barantolla americana</i>			0.3	
Arenicolidae				9.1
<i>Arenicola marina</i>				
<i>Abarenicola</i> spp.		0.5		
Maldanidae		1.3		
<i>Asychis disparidentata</i>		0.3		
<i>Euclymene zonalis</i>				22.1
Oweniidae				8,123.7
<i>Owenia fusiformis</i>	0.5	0.3	2.3	44.3
<i>Galathowenia oculata</i>	6.0	8.8	37.3	
<i>Myriochele heeri</i>		0.3		
Pectinariidae			0.5	16.9
<i>Pectinaria</i> spp.				10.4
<i>Pectinaria californiensis</i>	0.3			
<i>Pectinaria granulata</i>		0.5		
Ampharetidae				1.3
<i>Ampharete acutifrons</i>	5.8	8.0	12.5	5.2
Terebellidae				6.5
<i>Pista cristata</i>	0.5		0.3	
<i>Polycirrus</i> spp. complex	0.5	0.8	4.3	3.9
<i>Lanassa</i> spp.			18.3	
Sabellidae			0.3	
<i>Chone albocincta</i>				
Hirudinea			0.3	
Gastropoda				1.3
Naticidae				19.5
<i>Nitidella gouldi</i>	7.8	2.3	5.0	
Nassariidae				14.3
<i>Nassarius</i> spp.				1.3
<i>Nassarius mendicus</i>	2.3	1.8	1.5	
<i>Nassarius fossatus</i>	0.5	0.8	3.5	36.5
Olividae				76.8
<i>Olivella</i> spp.				
<i>Olivella biplicata</i>	3.3	1.8	2.5	
<i>Olivella baetica</i>	8.8	8.5	7.5	9.1
<i>Olivella pycna</i>	30.8	19.5	15.3	26.1

Appendix Table 8.--Continued.

Taxon	1975			1992
	April	June	September	July
Turridae				
<i>Kurtziella plumbea</i>				5.2
<i>Oenopota</i> spp.				1.3
<i>Oenopota turriculata</i>			0.3	
Pyramidellidae				
<i>Odostomia</i> spp.	6.8	4.3	6.8	11.7
<i>Turbonilla</i> spp.		0.3		
<i>Turbonilla aurantia</i>	2.0	0.8	1.0	
Cylichnidae				
<i>Acteocina</i> spp.	0.3			
<i>Cylichna attonsa</i>	1.8	6.3	4.5	10.4
Scaphandridae				
<i>Scaphander willetti</i>				27.4
Aglajidae				
<i>Melanochylamys diomedea</i>		5.5	4.8	
Gastropteridae				
<i>Gastropteron pacificum</i>			1.3	13.0
Pelecypoda		0.3		2.6
Nuculidae				
<i>Acilla castrensis</i>	187.0	174.5	169.3	58.6
<i>Nucula tenuis</i>	13.5	18.0	16.0	5.2
<i>Yoldia seminuda</i>	1.5	3.0	3.5	
Mytilidae				297.0
<i>Musculus</i> spp.	0.3	0.5	4.0	
Thyasiridae				
<i>Axinopsida serricata</i>	41.0	48.0	46.3	62.5
<i>Thyasira flexouosa</i>		0.5		
Cardiidae				
<i>Clinocardium</i> spp.				2.6
Cutellidae				
<i>Siliqua</i> spp.				39,640.3
<i>Siliqua patula</i>	3.8	145.8	168.5	
<i>Siliqua sloati</i>				1.3
<i>Solen sicarius</i>				7.8
Tellinidae				
<i>Macoma</i> spp.				596.5
<i>Macoma moesta alaskana</i>	4.5	16.5	11.3	
<i>Macoma elimata</i> ?	0.5	0.5		
<i>Macoma calcarea</i>		0.5		
<i>Tellina</i> spp.		0.3		62.5
<i>Tellina modesta</i>	16.8	22.0	17.5	9.1
<i>Tellina bodegensis</i>				1.3
Pandoridae				
<i>Pandora punctata</i>		0.3		
Lysoniidae				
<i>Lyonsia californica</i>			0.5	
Dentaliidae	3.0	4.5	3.3	
Gadilidae				2.6

Appendix Table 8.--Continued.

Taxon	1975			1992
	April	June	September	July
Crustacea				
Cylindroleberididae				15.6
<i>Bathyleberis</i> spp.	1.5	1.8	1.0	
Cypridinidae				35.2
<i>Euphilomedes</i> spp.				182.4
<i>Euphilomedes carcharodonta</i>	8.8	7.0	18.8	
<i>Euphilomedes productus</i>		0.3		
Cirripedia				2.6
Nebaliidae				
<i>Nebalia bipes</i>			0.5	
<i>Nebalia pugettensis</i>				16.9
Mysidacea				
Mysidae				
<i>Acanthomysis</i> spp.				1.3
<i>Alienacanthomysis macropsis</i>	0.3			
<i>Exacanthomysis davisi</i>		0.5		
<i>Exacanthomysis alaskensis</i>		0.3		
<i>Pacificanthomysis nephrophthalma</i>	0.5	1.8	0.8	
<i>Archaeomysis grebnitzkii</i>	3.0	0.5	0.5	2.6
<i>Neomysis kadiakensis</i>	0.5			
Cumacea				
Lampropidae				
<i>Mesolamprops</i> spp.	4.8	11.5	2.0	
<i>Lamprops</i> spp.	0.3	0.5	0.3	
<i>Hemilamprops californica</i>	17.3	7.5	7.5	22.1
Leuconidae				
<i>Eudorellopsis longirostris</i>			0.3	
<i>Leucon</i> spp.		0.3		39.1
Diastylidae				
<i>Diastylis</i> spp.		0.3		
<i>Diastylis alaskensis</i>	4.8	0.8	3.8	
<i>Diastylis bidentata</i>	1.8	5.0	1.0	
<i>Diastylopsis</i> spp.				148.5
<i>Diastylopsis dawsoni</i>	280.8	1,310.3	2,307.5	11.7
<i>Diastylopsis tenuis</i>	7.0	4.5	1.8	20.8
Colurostylidae				
<i>Colurostylis occidentalis</i>	14.0	3.3	0.8	7.8
<i>Campylaspis rubromaculata</i>		0.3		
Isopoda				
Sphaeromatidae				
<i>Tecticeps convexus</i>	37.3	10.5	2.0	11.7
<i>Bathycopea daltonae</i>	5.3	3.3	2.3	
Idoteidae				
<i>Synidotea bicuspidata</i>	4.8	4.8	1.3	
<i>Synidotea angulata</i>			0.3	3.9
<i>Edotea sublittoralis</i>			0.3	
Munnidae				
<i>Munna</i> spp.				2.6
<i>Pleurogonium rubicundum</i>	0.3		1.3	

Appendix Table 8.--Continued.

Taxon	1975			1992
	April	June	September	July
Amphipoda				22.1
Ampeliscidae				
<i>Ampelisca</i> spp.				11.7
<i>Ampelisca hancocki</i>			0.3	
<i>Ampelisca macrocephala</i>	59.0	97.8	35.5	95.1
Argissidae				
<i>Argissa hamatipes</i>	0.8	1.8	2.0	
Atylidae				
<i>Atylus tridens</i>	7.3	12.0	0.5	
Corophidae				
<i>Corophium</i> spp.			0.3	
Podoceridae				
<i>Dulichia</i> spp.	0.5	1.5	0.3	
Eusiridae				
<i>Rhachotropis oculata</i>			0.8	
Haustoridae				
<i>Eohaustorius</i> spp.				33.9
<i>Eohaustorius sencillus</i>	35.8	31.0	20.0	19.5
Hyalidae				
<i>Allorchestes</i> spp.		1.5		
<i>Parallorchestes</i> spp.				7.8
Anisogammaridae				
<i>Anisogammarus pugettensis</i>		0.3	0.3	
Isaeidae				
<i>Photis brevipes</i>	7.0	14.3	4.5	
<i>Photis lacia</i>	4.0	10.8	3.0	
<i>Photis macinerneyi</i>				113.3
<i>Photis parvidons</i>				13.0
<i>Protomeдея</i> spp.	2.5	27.3	11.3	23.4
<i>Cheirimedia zotea</i>	0.3	1.0	1.0	
Ischyroceridae				
<i>Ischyrocerus megalops</i>	0.3	13.0	0.5	
Lysianassidae				
<i>Anonyx adoxus</i>	0.3	3.0		
<i>Hippomedon</i> spp.	1.3	1.3	2.3	
<i>Opisa tridentata</i>		0.3		
<i>Orchomene</i> spp.	0.5	0.5	0.5	5.2
<i>Orchomene pacifica</i>		1.3	3.3	
<i>Orchomene pinquis</i>				26.1
<i>Pachynus</i> c.f. <i>barnardi</i>		0.3		1.3
<i>Wecomedon wecomus</i>		0.3		
Oedicerotidae				
<i>Monoculodes</i> spp.	2.0	3.5	6.0	6.5
<i>Monoculodes spinipes</i>	15.3	8.5	5.5	
<i>Synchelidium shoemakeri</i>	5.0	5.5	8.0	13.0
<i>Synchelidium rectipalmun</i>	0.3	0.8	1.0	
<i>Westwoodilla caecula</i>	0.5	1.0	0.8	
Phoxocephalidae				
<i>Paraphoxus</i> spp.		0.8		
<i>Foxiphalus major</i>	13.8	10.8	4.8	23.4
<i>Rhepoxynius fatigans</i>	23.3	42.5	31.3	
<i>Mandibulophoxus gilesi</i>				7.8
<i>Mandibulophoxus uncistrostratus</i>	3.3	4.8	6.3	

Appendix Table 8.--Continued.

Taxon	1975			1992
	April	June	September	July
<i>Rhepoxynius</i> spp.				125.0
<i>Rhepoxynius abronius</i>				15.6
<i>Rhepoxynius daboius</i>				142.0
<i>Rhepoxynius epistomus?</i>	11.0	11.0	6.0	
<i>Rhepoxynius variatus</i>	1.3	2.5	1.5	
<i>Rhepoxynius vigitegus</i>	7.8	9.5	6.8	44.3
Pleustidae				
<i>Parapleustes</i> spp.				10.4
<i>Pleusymtes coquilla</i>	1.8	2.5	3.8	
Stenothoidae				5.2
Aeginellidae				
<i>Mayerella banskia</i>		0.3	0.5	
<i>Tritella pilimana</i>			0.5	
Decapoda				
Callianassidae				
<i>Callianassa californiensis</i>				11.7
Paguridae				
<i>Pagurus</i> spp.				2.6
<i>Pagurus armatus</i>	0.3			
<i>Pagurus ochotensis</i>	0.5			
<i>Pagurus caurinus</i>	0.8			
<i>Pagurus quaylei</i>			0.5	
Canridae				
<i>Cancer magister</i>		2.3	1.3	
Onychophora				
Pinnotheridae				
<i>Pinnixa</i> spp.	1.3	0.3	2.5	5.2
Sipunculidae				1.3
Echuirida		0.5		37.8
Phoronida				18.2
Phoronidae				
<i>Phoronis psammophila?</i>	1.3	2.5	1.5	
Ophiuroidea				1.3
Amphiuridae				1.3
<i>Amphiodia</i> spp.				110.7
<i>Amphiodia periercta-urtica</i>	54.5	45.0	34.5	
Echinoidea				353.0
Dendrasteridae				
<i>Dendraster excenticus</i>	0.8		0.8	10.4
Holothuroidea				
<i>Paracaudina chilensis</i>	7.3	9.0	8.3	
Mean total	1,277	2,864	5,190	63,171
Number of taxa	119	152	146	163

Appendix Table 9.--Summaries of benthic invertebrate collections by station, for eight stations selected for comparison offshore from the Columbia River, April, June, and September 1975 (available upon request from National Marine Fisheries Service, Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121).