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Coastal Zone and Estuarine Studies Division

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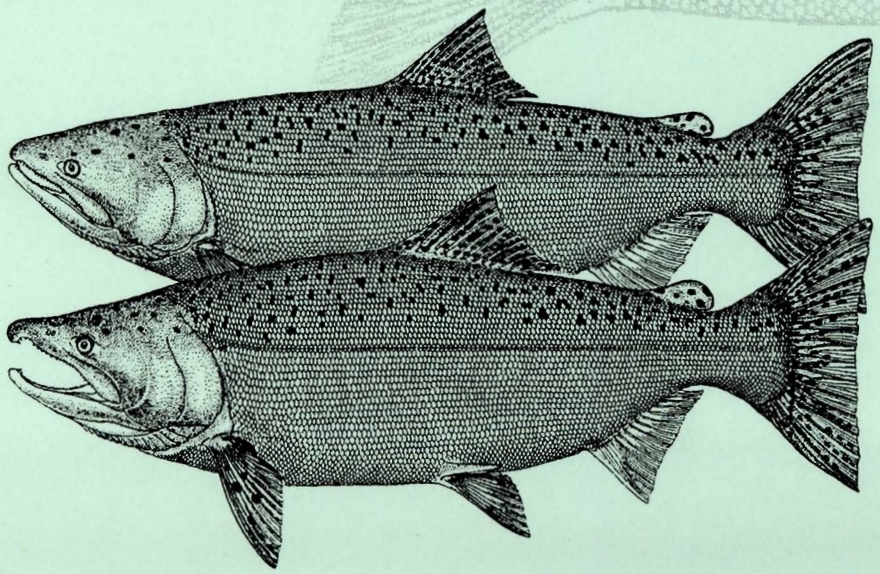
Seattle, Washington



BENTHIC INFAUNA AND SEDIMENT CHARACTERISTICS OFFSHORE FROM THE COLUMBIA RIVER, JULY 1993

By

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INTRODUCTION

The U.S. Army Corps of Engineers (COE), Portland District, is authorized to maintain navigational channels in the Columbia River and its estuary and entrance. Four Ocean Dredged-Material Disposal Sites (ODMDSs) off the mouth of the Columbia River have been designated by the Environmental Protection Agency to receive dredged material (Fig. 1). These sites are identified as ODMDSs 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 in the mouth of the Columbia River estuary range from 3 to 9 million cubic yards, with an average of 5 million cubic yards (1980-1994), with most of the material historically disposed at Sites A and B. Site F has been used little, except for disposal of material dredged during the 1989 Tongue Point Monitoring Program (Siipola et al. 1993). In 1994, ODMDSs A, B, and F were expanded to accept additional material because material disposed at the primary ocean disposal site (ODMDS B) had not dispersed, but accumulated into a mound, which came to within 48 ft of the MLLW.

This temporary (5-year) spatial expansions of Sites A, B, and F were initiated by the COE, Portland District, in 1992 while searching for a long-term solution for dredged material disposal. In 1993 material dredged from the mouth of the Columbia River was deposited at expanded ODMDSs B and F.

To minimize negative biological effects, ODMDSs should be located in areas with no unique biological characteristics and relatively low standing crops of benthic and epibenthic invertebrates and fishes. Also, candidate ODMDSs must be carefully evaluated from the standpoint of technical feasibility and economics.

A widespread benthic invertebrate survey offshore from the Columbia River was conducted during the mid 1970s under the COE's Dredged Materials Research Program (Richardson et al. 1977). A relatively recent site-specific survey of ODMDS F and its vicinity was conducted by the COE, Portland District, from 1989 to 1992 (Siipola et al. 1993).

The primary goal of the present study was to assess benthic invertebrate communities at 28 stations and sediment characteristics at 30 stations in an area offshore from the Columbia River during July 1993. Eight of the benthic invertebrate stations were previously sampled during an intensive benthic survey at ODMDS F (Siipola et al. 1993) and 11 stations previously sampled during a reconnaissance-level benthic invertebrate survey (Siipola 1994).

METHODS

Sampling

Benthic Invertebrates

The sampling stations were located offshore from the Columbia River, extending about 16 km north, 17 km south, and 16 km west of the river mouth (Fig. 1). Twenty eight stations were sampled for both benthic invertebrates and sediments; two additional stations were sampled for sediments only. Station depths ranged from 12.2 to 65.8 m (Appendix Table 1).

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 in July 1993. A 0.5 dissimilarity value was considered a significant difference between groups. The mean number of organisms/m^2 for each species per station was used in the analysis. Species that had densities less than 20 organisms/m^2 were excluded from the analysis to reduce the effect of uncommon species.

Sediments

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

Statistical Analyses

Linear and polynomial regression were used to identify significant relationships between various sediment characteristics (median grain size, percent silt/clay, and percent

Table 1 . Summary of benthic invertebrates collections, by station, offshore from the Columbia River, July 1993.

Station	Date	Number of taxa	Number/m^2	SD	H[a]	E[b]
A4	21 Jul 93	112	9,278	3,659	3.79	0.56
B2	20 Jul 93	115	8,807	1,640	4.80	0.70
B6	21 Jul 93	111	5,783	806	4.79	0.71
C5	20 Jul 93	80	1,542	525	4.97	0.79
D1	20 Jul 93	103	6,124	3,971	4.72	0.71
D7	21 Jul 93	118	12,381	4,855	3.53	0.51
E3	20 Jul 93	89	5,156	3,065	3.38	0.52
F2	20 Jul 93	92	3,101	1,843	4.42	0.68
12	19 Jul 93	89	13,171	7,645	2.70	0.42
15	19 Jul 93	80	3,239	942	4.80	0.76
30	19 Jul 93	141	12,329	3,342	4.78	0.67
31	19 Jul 93	115	9,353	3,099	4.53	0.66
32	19 Jul 93	107	7,613	1,950	4.17	0.62
33	19 Jul 93	79	5,145	1,406	4.71	0.75
36	19 Jul 93	135	13,375	2,524	4.49	0.63
37	19 Jul 93	107	3,653	590	5.13	0.76
39	19 Jul 93	81	5,937	1,214	4.14	0.65
42	21 Jul 93	65	1,392	318	4.74	0.79
45	21 Jul 93	114	9,801	1,649	4.27	0.62
52	20 Jul 93	145	14,728	2,275	3.85	0.54
53	20 Jul 93	79	9,639	1,824	3.66	0.58
54	20 Jul 93	115	7,138	2,357	4.58	0.67
55	21 Jul 93	127	13,663	3,416	3.94	0.56
56	21 Jul 93	123	11,664	889	4.31	0.62
57	21 Jul 93	98	13,006	9,890	2.60	0.39
58	21 Jul 93	140	12,204	1,237	4.10	0.57
59	21 Jul 93	127	12,646	848	4.31	0.62
60	21 Jul 93	110	13,627	5,061	3.14	0.46
Mean		107	8,768		4.19	0.63
SD		21	4,104		0.66	0.11

[a]Diversity (Shannon-Wiener function)

[b]Equitability

Table 2. Dominant benthic invertebrates found at 28 stations offshore from the Columbia River, July 1993 (all stations combined).

Taxon	Mean number/m^2
Polychaeta	
Prionospio lighti	1,323
Spiochaetopterus costarum	847
Magelona spp.	360
Phyllodoce hartmanae	327
Chaetozone setosa	318
Mediomastus californiensis	174
Nephtys caecoides	160
Pholoe minuta	157
Leitoscoloplos pugettensis	118
Glycinde spp.	100
Miscellaneous	893
Total	4,777
Mollusca	
Nitidella gouldi	175
Tellina spp.	128
Axinopsida serricata	127
Olivella pycna	120
Olivella spp.	120
Acila castrensis	98
Olivella baetica	53
Macoma spp.	34
Cylichna attonsa	29
Mytilidae	21
Miscellaneous	113
Total	1,018
Crustacea	
Euphilomedes carcharodonta	327
Diastylopsis tenuis	142
Diastylopsis spp.	131
Orchomene pinquis	91
Rhepoxynius spp.	86
Diastylopsis dawsoni	51
Callianassa californiensis	43
Leucon spp.	40
Rhepoxynius vigitegus	38
Rhepoxynius abronius	34
Miscellaneous	356
Total	1,339
Miscellaneous	
Dendraster excentricus	1,367
Nemertea	161
Echiurida	63
Amphiodia spp.	27
Miscellaneous	17
Total	1,635
Total	8,769

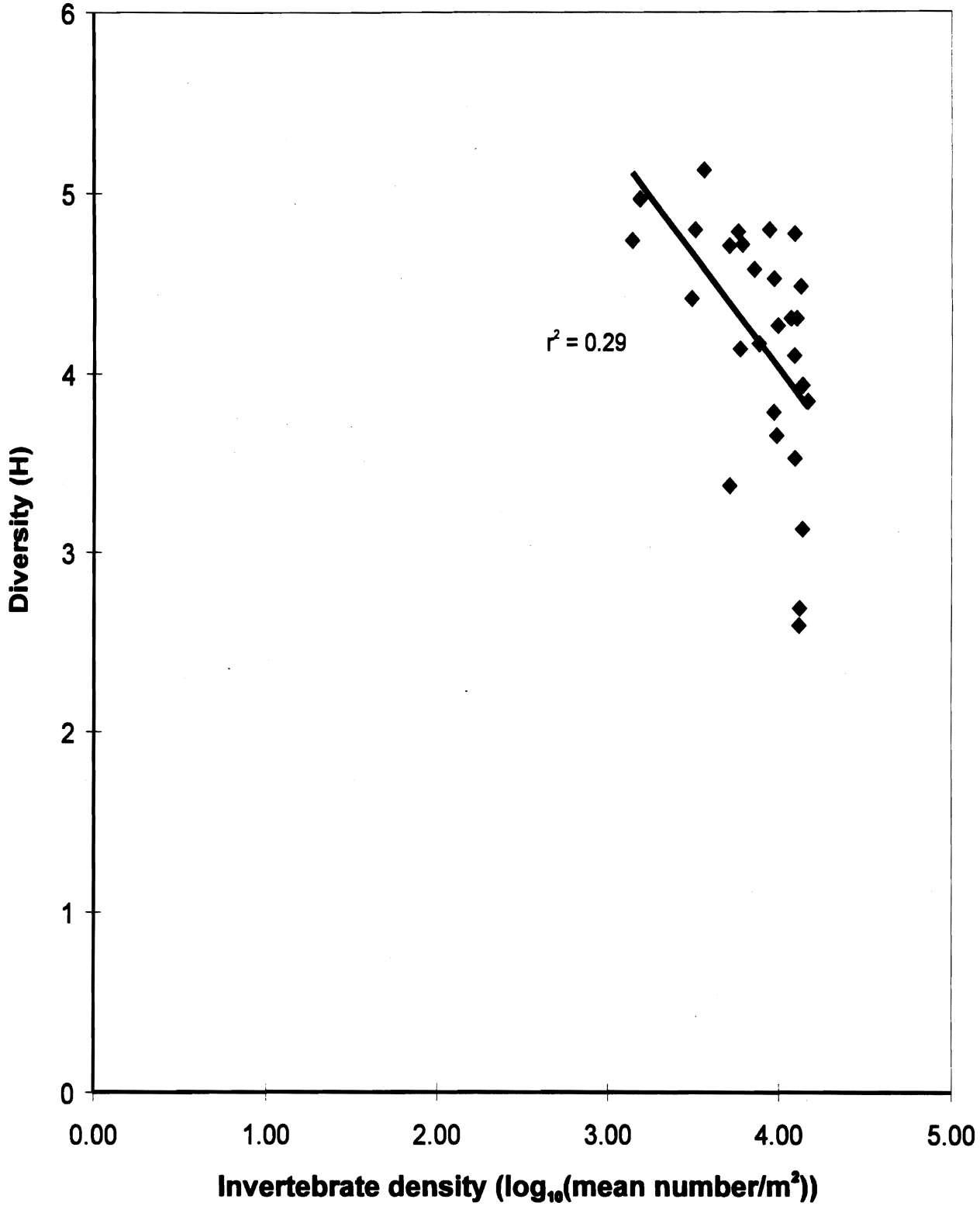

Figure 3. Regression relationship between benthic invertebrate density and diversity (H) at 28 stations offshore from the Columbia River, July 1993.

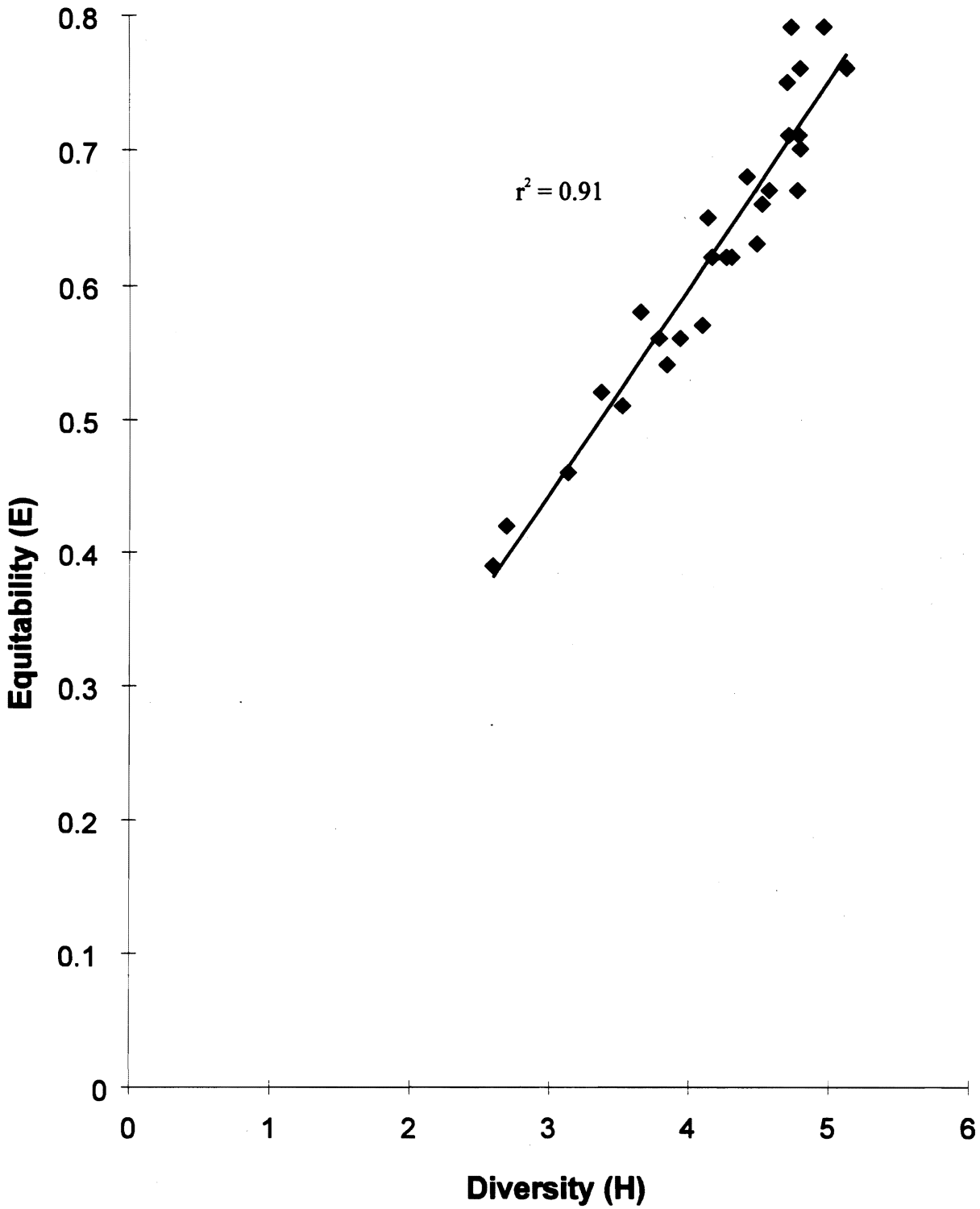

Figure 5. Linear regression between benthic invertebrate diversity (H) and equitability (E) at 28 stations offshore from the Columbia River, July 1993.

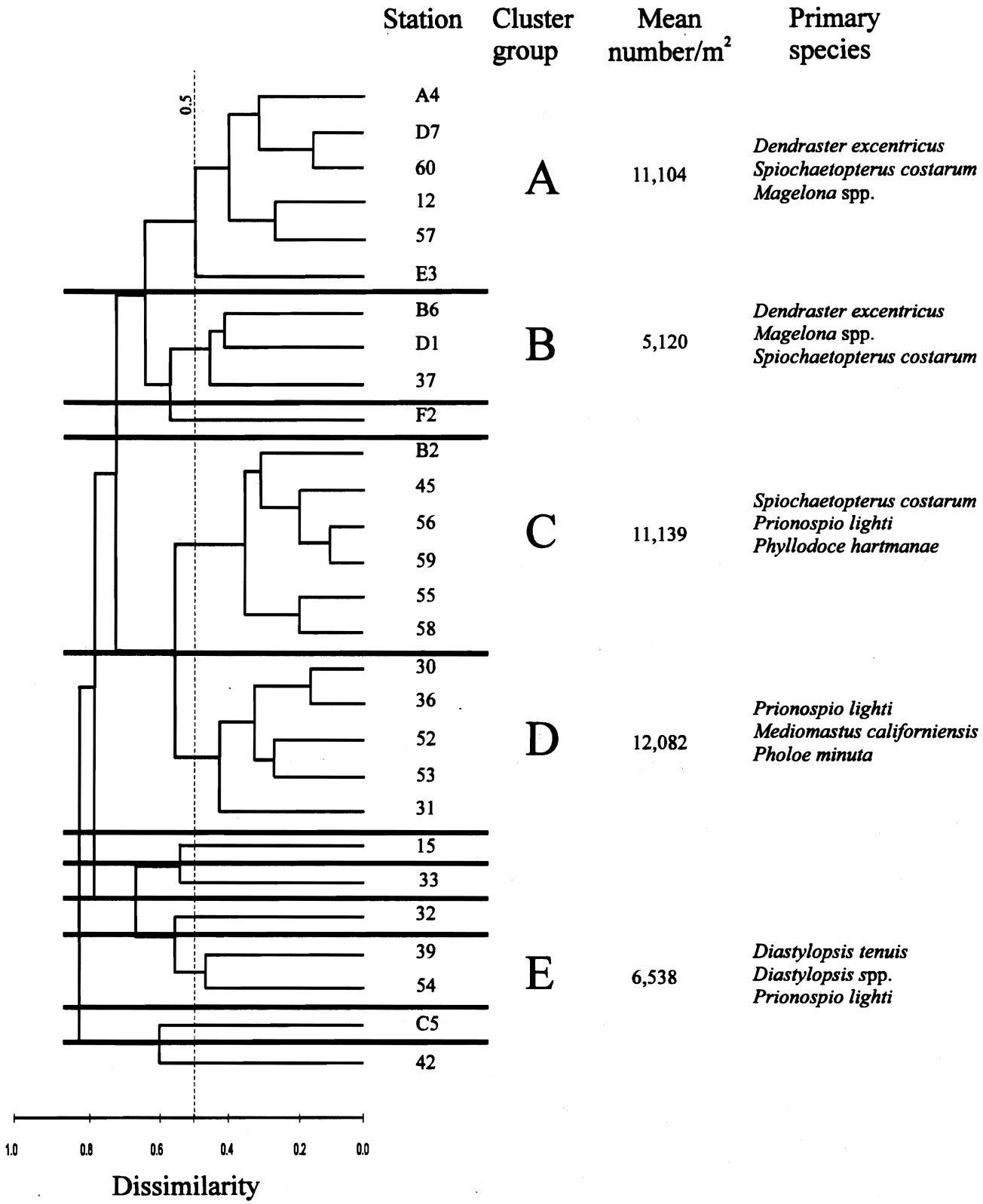

Figure 7. Dendrogram results from cluster analysis of benthic invertebrate densities at 28 stations off the mouth of the Columbia River, July 1993.

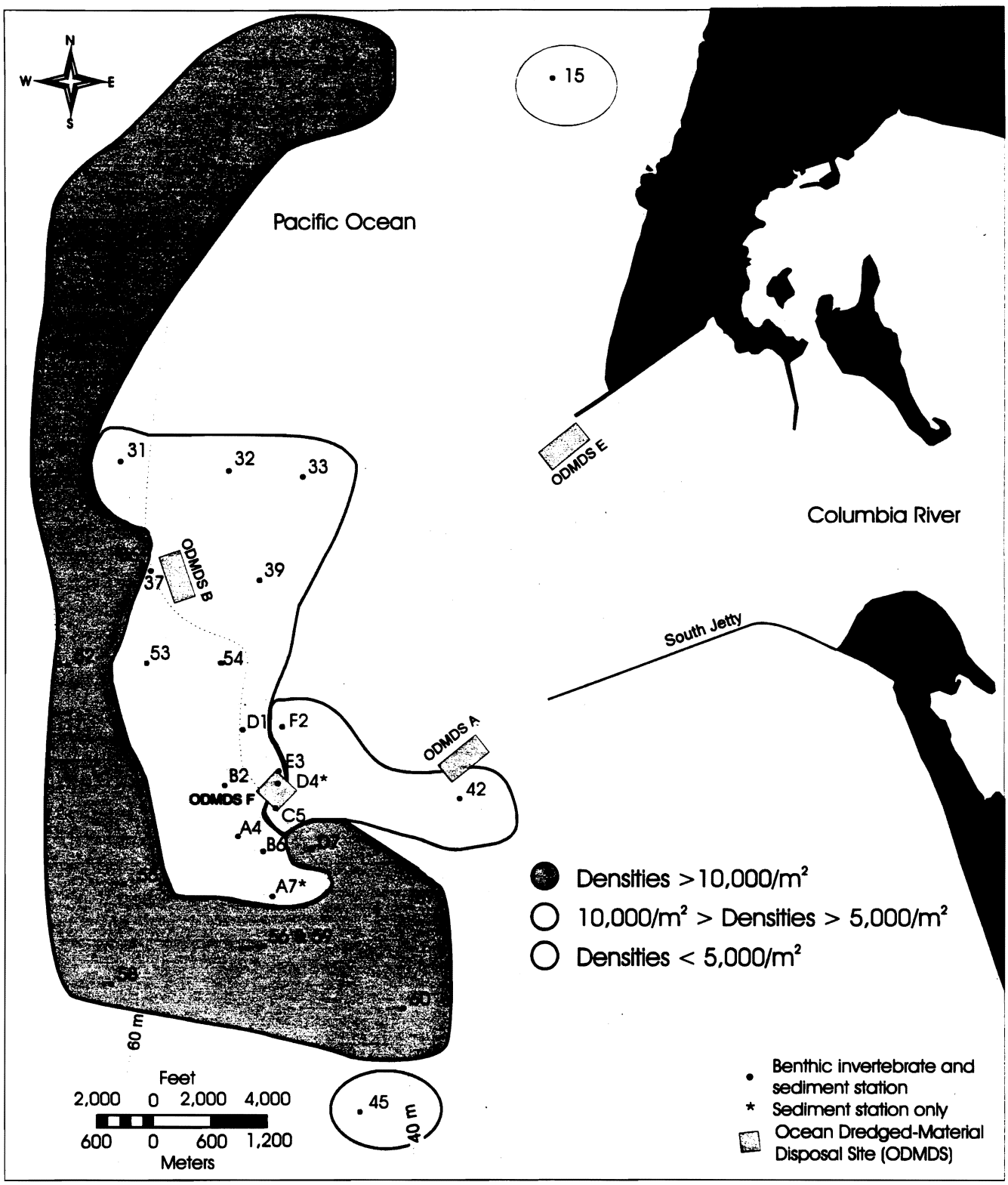

Figure 8. Benthic invertebrate densities at 28 stations offshore from the Columbia River July 1993. Stations 56 and 59 were in the same location.

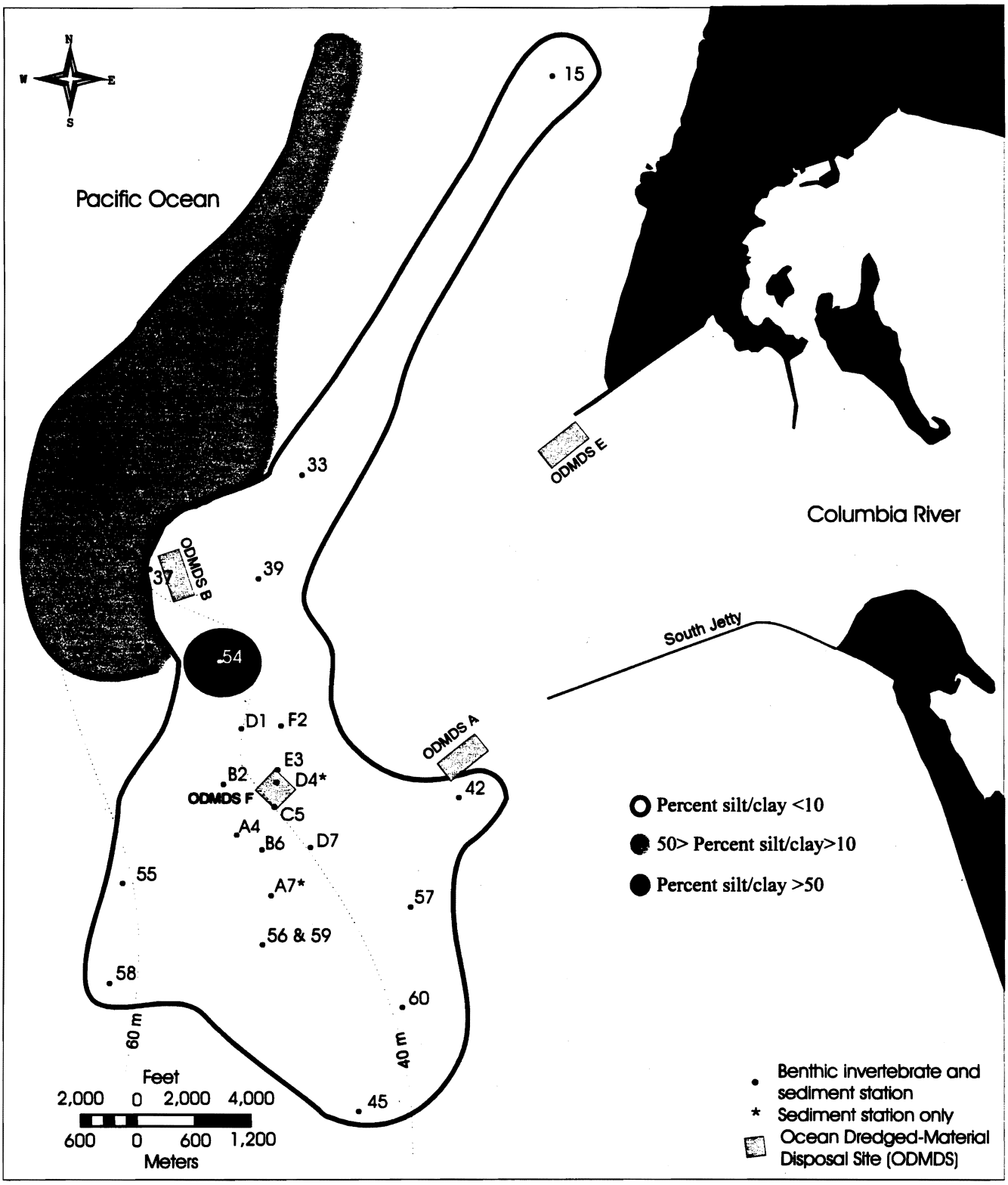

Figure 9. Percent silt/clay at 30 stations offshore from the Columbia River, July 1993. Stations 56 and 59 were in the same location.

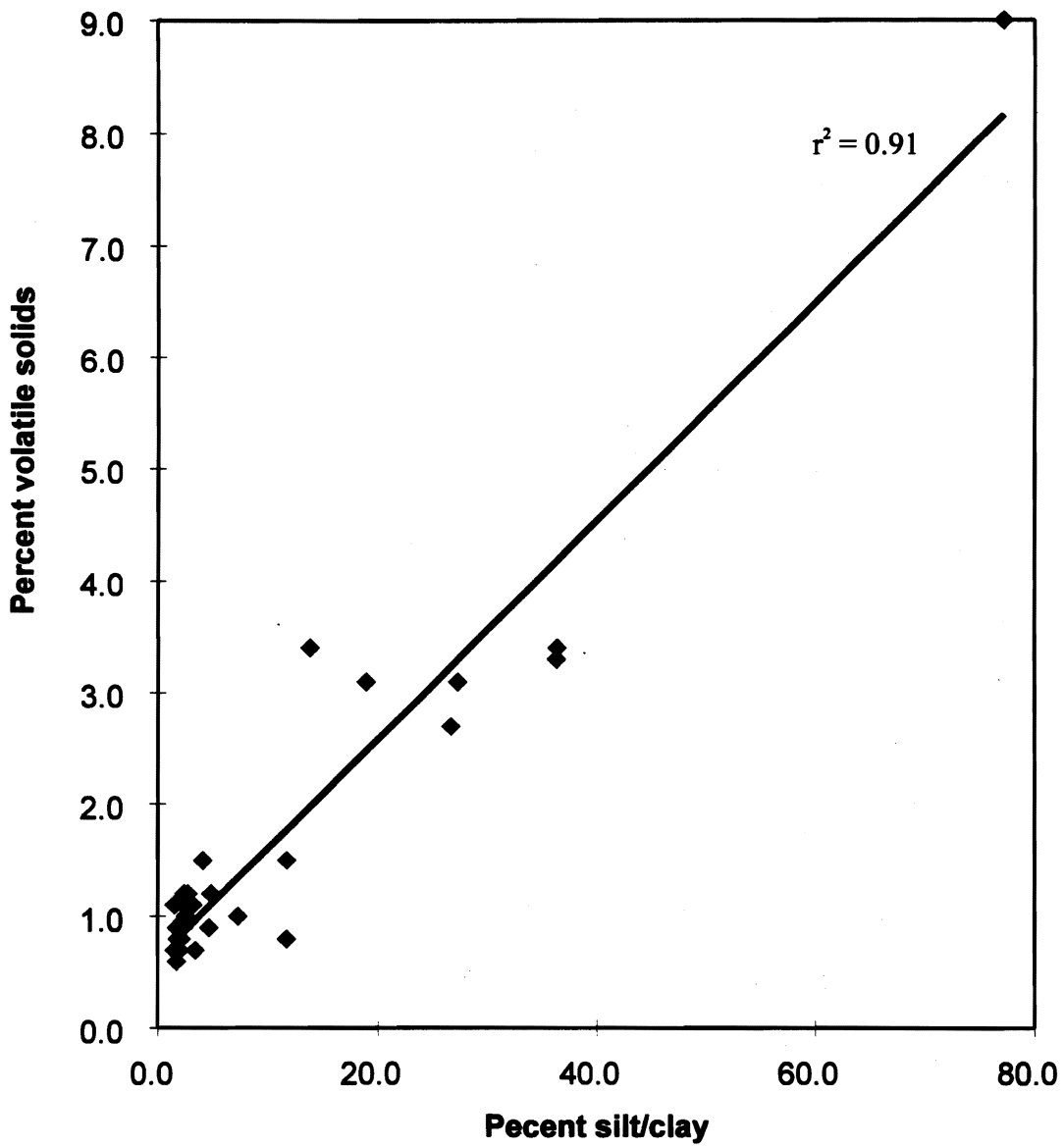

Figure 11. Regression relationship between percent silt/clay and percent volatile solids at 30 benthic stations offshore from the Columbia River, July 1993.

Table 4. Densities (mean number/m^2) of benthic invertebrates at and adjacent to ODMDS F, offshore from the Columbia River, June/July 1989 through 1993. Station densities were calculated by averaging replicates from each station.

Station	1989	1990	1991	1992	1993
A4	1,223	2,238	3,599	13,759	9,278
B2	1,294	3,262	4,362	14,027	8,807
B6	871	2,574	3,872	11,479	5,783
C5	1,142	2,978	3,833	7,821	1,542
D1	1,517	3,587	4,001	14,819	6,124
D7	788	2,584	3,660	6,646	12,381
E3	992	2,793	6,823	9,820	5,156
F2	1,046	1,588	5,760	9,422	3,101
Mean	1,109	2,701	4,489	10,974	6,522
SD	237	617	1,172	3,036	3,510

Table 6. Diversity (H) of benthic invertebrate taxa at eight stations at and adjacent to ODMDS F offshore from the Columbia River, June/July 1989-1993.

Station	1989	1990	1991	1992	1993
A4	4.88	4.75	5.13	3.81	3.79
B2	4.97	4.90	4.95	3.50	4.80
B6	5.08	4.28	5.27	3.98	4.79
C5	4.92	5.20	5.17	4.17	4.97
D1	4.89	4.84	4.60	3.66	4.72
D7	5.02	4.19	4.70	3.96	3.53
E3	4.71	4.33	4.95	4.04	3.38
F2	4.94	4.71	4.03	3.46	4.42
Mean	4.93	4.65	4.85	3.82	4.30
SD	0.11	0.35	0.40	0.26	0.64

Table 8. Numbers of benthic invertebrate taxa and densities at 11 stations offshore from the Columbia River, 1992 and 1993. Most density values from 1992 are numbers/m^2 (single grabs) 1993 density values are mean numbers/m^2 (five replicates).

Station	1992		1993	
	Number of taxa	Density	Number of taxa	Density
12	75	29,780	89	13,171
15	68	152,455	80	3,239
30	79	23,132	141	12,329
*31	101	46,661	115	9,353
*32	63	6,556	107	7,613
33	11	844	79	5,145
*36	130	24,141	135	13,375
*37	75	1,955	107	3,653
39	37	6,247	81	5,937
42	47	4,679	65	1,392
45	59	21,028	114	9,802
Mean	68	28,862	101	7,728
SD	31	43,373	24	4,200

* mean values from five grabs in 1992.

Table 9. Benthic invertebrate diversity (H) and equitability (E) at 11 stations offshore from the Columbia River 1992 and 1993. Most values from 1992 were from single grab samples, whereas 1993 mean values were calculated using five replicates from each station.

Station	1992		1993	
	H	E	H	E
12	2.89	0.46	2.70	0.42
15	1.86	0.31	4.80	0.76
30	4.30	0.68	4.78	0.67
*31	2.73	0.41	4.53	0.66
*32	3.55	0.59	4.17	0.62
33	2.28	0.66	4.71	0.75
*36	4.61	0.66	4.49	0.63
*37	4.76	0.76	5.13	0.76
39	3.67	0.71	4.14	0.65
42	3.36	0.60	4.74	0.79
45	2.37	0.40	4.27	0.62
Mean	3.31	0.57	4.41	0.67
SD	0.98	0.14	0.64	0.10

* mean values from five grabs in 1992.

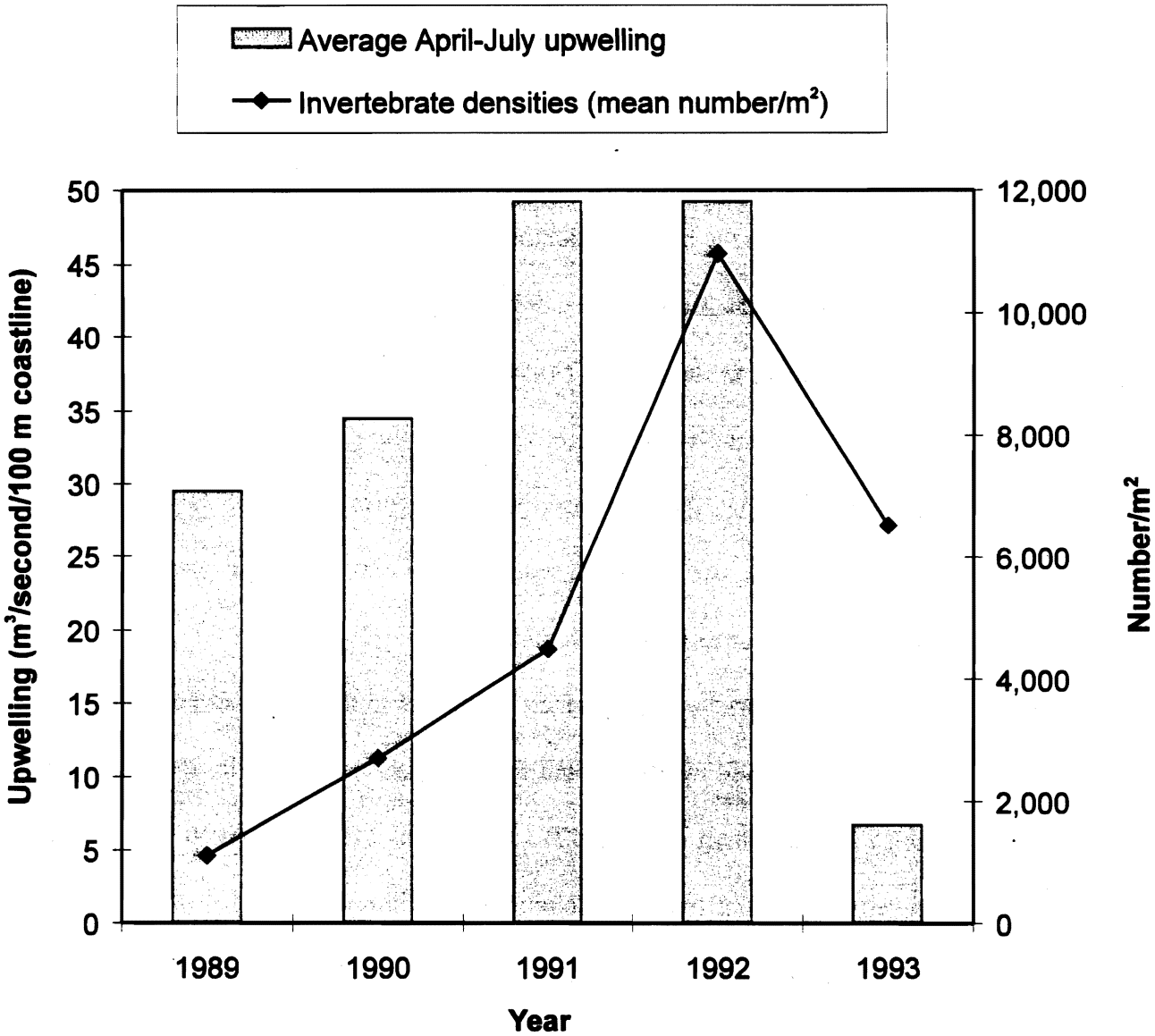

Figure 12. Plot of average upwelling during April through July and benthic invertebrate densities at eight stations offshore from the Columbia River, 1989-1993. Upwelling values are for 45N and 125W and were obtained from the Pacific Fisheries Environmental Group, Monterey, CA.

Benthic sediment characteristics near the mouth of the Columbia River often vary annually. For example, percent fines at one benthic station in 1990, 1991, and 1992 were 1.2, 19.6, and 0.8%, respectively (Siipola et al. 1993). These variations are independent of any dredged-material disposal event. The origin, fate, and significance of these transitory fine-grained deposits are unknown, but were also noted by Kulm et al. (1975).

Benthic invertebrates are important prey for many species of demersal fish and shellfish, especially juveniles, which are abundant off the Columbia River (Durkin and Lipovsky 1977). Annual and longer-term fluctuations in benthic invertebrate abundance undoubtedly have direct effects on fish and shellfish populations, yet no long-term research or monitoring program has been established to identify these relationships. For example, Dungeness crab, *Cancer magister*, populations and landings fluctuate at roughly 10-year intervals. The exact cause of these population fluctuations is unknown, but variations in benthic invertebrate standing crop, an important food for juvenile crabs, may be important.

Benthic invertebrate abundance at individual stations appears to be related to specific physical and biological habitat parameters such as sediment grain size, percent silt/clay, percent volatile solids, frequency of disturbance, and predation, while overall population abundances within a large area reflect broad environmental factors, such as upwelling and primary production. A similar phenomenon was identified in the Bering and Chukchi Seas (Grebmeier et al. 1989).

Benthic invertebrate populations often cycle at various time scales (Gray and Christie 1983). Only by monitoring invertebrate species and populations over a wide area and long time periods can effects of dredging be separated from overall annual population fluctuations.

ACKNOWLEDGMENTS

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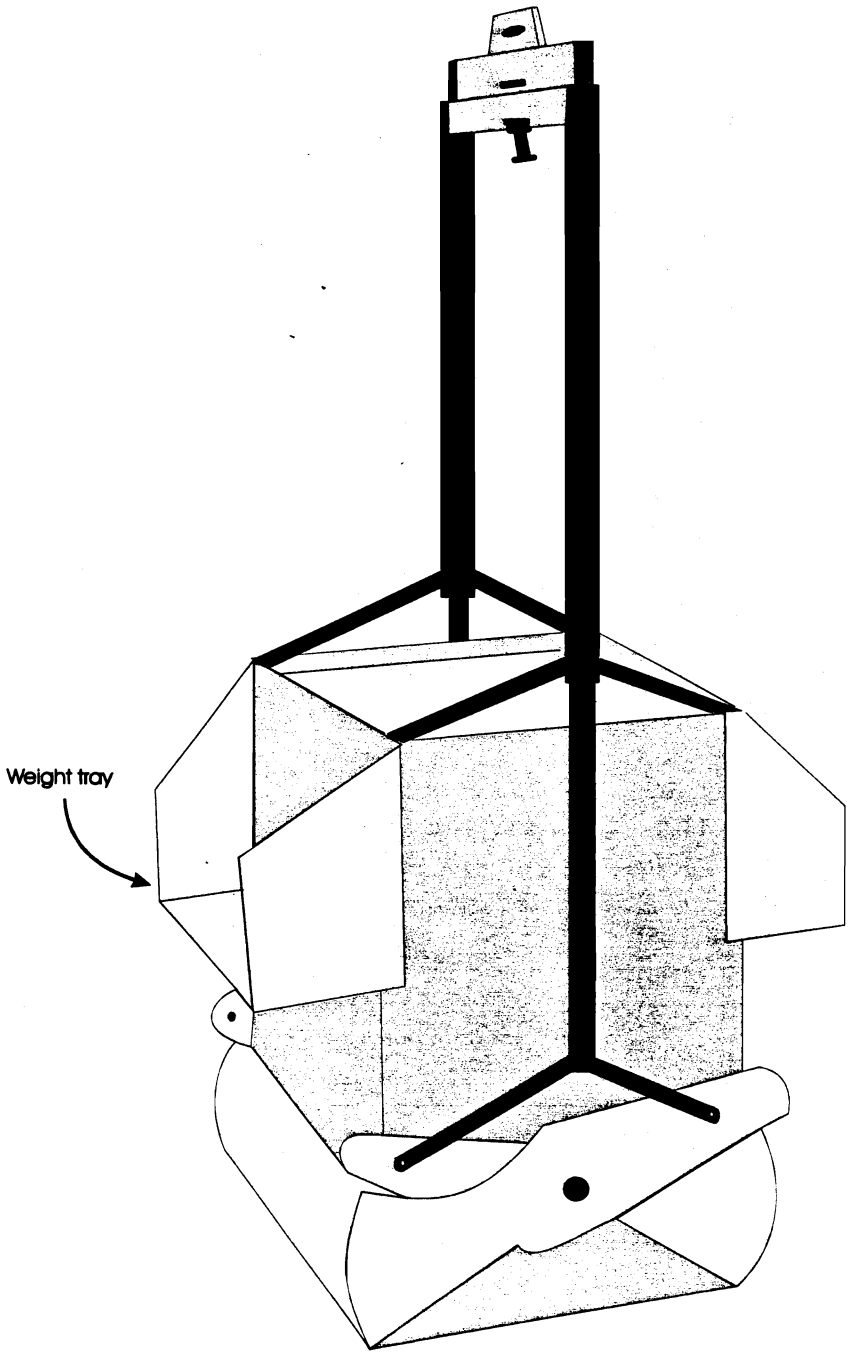

Appendix Figure 1. The 0.1-m^2 box corer (Gray-O'Hara modification of a standard box corer) used for benthic invertebrate sampling offshore from the Columbia River July 1993. For deeper penetration, 113-kg (250-lb) weights were placed in each tray located on opposite sides of the sampler.

Appendix Table 2. Benthic and epibenthic invertebrate taxa collected by box corer offshore from the Columbia River, July 1993.

Taxon	Identified
Cnidaria	
Anthozoa	x
Ctenophora	
Pleurobrachiidae	
Pleurobrachia bachei	x
Platyhelminthes	
Turbellaria	x
Nemertea	x
Annelida	
Polychaeta	x
Aphroditidae	
Aphrodita spp.	x
Polynoidae	x
Bylgides macrolepidus	x
Gattyana spp.	x
Gattyana treadwelli	x
Tenonia priops	x
Sigalionidae	x
Pholoe minuta	x
Sthenelais tertiaglabra	x
Sigalion mathildae	x
Thalenessa spinosa	x
Phyllodocidae	x
Eteone fauchaldi	x
Eteone longa	x
Eteone pacifica	x
Eteone spilotus	x
Eteone spp.	x
Eumida sanguinea	x
Eumida spp.	x
Paranaitides (Phyllodoce) *polynoides*	x
Phyllodoce groenlandica	x
Phyllodoce hartmanae	x
Phyllodoce mucosa	x

Appendix Table 2. Continued.

Taxon	Identified
Glycinde picta	x
Goniada brunnea	x
Onuphidae	x
Onuphis iridescens	x
Onuphis elegans	x
Lumbrineridae	x
Eranno bicirrata	x
Lumbrineris spp.	x
Lumbrineris californiensis	x
Lumbrineris limnicola	x
Lumbrineris luti	x
Arabellidae	
Notocirrus californiensis	x
Dorvilleidae	
Dorvillea pseudorubrovittata	x
Orbiniidae	x
Leitoscoloplos pugettensis	x
Orbinia (Phylo) *felix*	x
Scoloplos armiger	x
Paraonidae	
Aricidea (Acesta) *catherinae*	x
Levinsenia gracilis	x
Paraonella platybranchia	x
Spionidae	x
Boccardia pugettensis	x
Laonice cirrata	x
Paraprionospio pinnata	x
Polydora spp.	x
Polydora brachycephala	x
Polydora socialis	x
Prionopsio lighti	x
Prionospio pinnata	x
Prionospio steenstrupi	x
Pseudopolydora spp.	x
Scolelepis squamata	x
Spio spp.	x
Spio butleri	x
Spio filicornis	x
Spiophanes spp.	x

Appendix Table 2. Continued.

Taxon	Identified
Mediomastus californiensis	x
Aberinicolidae	x
Maldanidae	x
Asychis spp.	x
Euclymene spp.	x
Euclymene zonalis	x
Oweniidae	
Galathowenia oculata	x
Owenia fusiformis	x
Pectinariidae	
Pectinaria spp.	x
Pectinaria californiensis	x
Ampharetidae	x
Ampharete spp.	x
Ampharete acutifrons	x
Asabellides lineata	x
Melinna elisabethae	x
Terebellidae	x
Pista estevanica	x
Polycirrus spp. complex	x
Sabellidae	
Chone dunneri	x
Euchone hancocki	x
Euchone incolor	x
Polygordiidae	
Polygordius spp.	x
Oligochaeta	x
Hirudinea	x
Mollusca	
Gastropoda	x
Turbinidae	
Spiromoellaria quadrae	x
Rissoidae	
Alvania compacta	x
Epitoniidae	
Epitonium spp.	x

Appendix Table 2. Continued.

Taxon	Identified
Cuthonidae	
Cuthona spp.	x
Bivalvia	x
Nuculidae	
Acila castrensis	x
Nucula tenuis	x
Yoldia spp.	x
Yoldia scissurata	x
Mytilidae	x
Thyasiridae	
Axinopsida serricata	x
Kellidae	
Pseudopythina rugifera	x
Montacutidae	
Mysella tumida	x
Solenidae	
Siliqua spp.	x
Siliqua sloati	x
Tellinidae	
Macoma spp.	x
Macoma balthica	x
Macoma calcarea	x
Macoma nasuta	x
Tellina spp.	x
Tellina carpenteri	x
Tellina modesta	x
Tellina nuculoides	x
Veneridae	
Saxidomus giganteus	x
Compsomyax subdiaphana	x
Pandoridae	
Pandora filosa	x
Pandora punctata	x
Lyonsiidae	
Lyonsia californica	x

Appendix Table 2. Continued.

Taxon	Identified
Malacostraca	
Leptostraca	
Nebaliidae	
Nebalia pugettensis	x
Mysidacea	
Mysidae	x
Acanthomysis columbiae	x
Acanthomysis macrops	x
Archaeomysis grebnitzkii	x
Neomysis spp.	x
Neomysis kadiakensis	x
Cumacea	
Lampropidae	x
Hemilamprops spp.	x
Hemilamprops californica	x
Leuconidae	x
Leucon spp.	x
Eudorellopsis longirostris	x
Colurostylidae	
Colurostylis occidentalis	x
Diastylidae	x
Diastylis spp.	x
Diastylopsis spp.	x
Diastylopsis dawsoni	x
Diastylopsis tenuis	x
Campylaspidae	
Campylaspis spp.	x
Nannastacidae	
Cumella vulgaris	x
Tanaidacea	
Paratanaidae	
Leptognathia gracilis	x
Isopoda	
Sphaeromatidae	
Ancinus granulatus	x

Appendix Table 2. Continued.

Taxon	Identified
Photis macinerneyi	x
Photis parvidons	x
Podoceropsis spp.	x
Protomedeia spp.	x
Protomedeia articulata	x
Lysianassidae	x
Anonyx liljeborgi	x
Lepidepecreum gurjanovae	x
Opisa tridentata	x
Orchomene spp.	x
Orchomene pacifica	x
Orchomene pinquis	x
Pachynus c.f. *barnardi*	x
Psammonyx longimerus	x
Prachynella spp.	x
Oedicerotidae	
Monoculodes spinipes	x
Synchelidium spp.	x
Synchelidium shoemakeri	x
Westwoodilla caecula	x
Pardaliscidae	x
Pardalisca spp.	x
Phoxocephalidae	
Foxiphalus major	x
Grandifoxus grandis	x
Mandibulophoxus spp.	x
Mandibulophoxus gilesi	x
Rhepoxynius spp.	x
Rhepoxynius abronius	x
Rhepoxynius bicuspidatus	x
Rhepoxynius daboius	x
Rhepoxynius tridentatus	x
Rhepoxynius vigitegus	x
Pleustidae	x
Parapleustes spp.	x
Parapleustes den	x
Pleusymtes spp.	x
Pleusmytes subglaber	x

Appendix Table 2. Continued.

Taxon	Identified
Sipuncula	
Sipunculidae	x
Sipunculus nudus	x
Golfingiidae	
Golfingia pugettensis	x
Echiurida	x
Phoronida	x
Echinodermata	
Ophiuroidea	x
Ophiura spp.	x
Amphiuridae	
Amphiodia spp.	x
Amphiura spp.	x
Echinoidea	x
Dendraster excentricus	x
Holothuroidea	x
Chaetognatha	x
Sagittidae	
Sagitta spp.	x
Urochordata	
Oikopleuridae	
Oikopleura spp.	x