Benthic Invertebrates and Sediment Characteristics in Subtidal Habitat at Rice Island, Columbia River Estuary, December 1991 and March 1992

by
Susan A. Hinton,
Robert L. Emmett,
and George T. McCabe, Jr.

October 1992

COASTAL ZONE AND ESTUARINE STUDIES

BENTHIC INVERTEBRATES AND SEDIMENT CHARACTERISTICS IN SUBTIDAL HABITAT AT RICE ISLAND, COLUMBIA RIVER ESTUARY, DECEMBER 1991 AND MARCH 1992

by

Susan A. Hinton
Robert L. Emmett
and
George T. McCabe, Jr.

Final Report

Funded by

U.S. Army Corps of Engineers
Portland District
P.O. Box 2946
Portland, Oregon 97208
(Contract E96920018)

and

Coastal Zone and Estuarine Studies Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112

October 1992

CONTENTS

INTRODUCTION

The U.S. Army Corps of Engineers (COE) Portland District is responsible for annually dredging and disposing of more than 2 million yd^3 (1.5 million m^3) of bottom sediments from the navigation channel between River Miles (RM) 4.4 and 28.8 in the Columbia River estuary. Existing island and shoreline dredged-material disposal sites are nearly filled to capacity, and options for new disposal sites for such large volumes of dredged material are extremely limited. One potential disposal site is the area just north of Rice Island, an island created with dredged material. Proposals for expanding Rice Island with dredged material include creating a 10,000-ft (3,048-m) by 500- to 1,000-ft (152- to 305-m) spit to the north of the present island. The south side of the proposed spit would be about 1,000 ft from the island, creating an island-spit configuration similar to that at Miller Sands, which is slightly upstream from Rice Island.

Major concerns associated with new dredged-material disposal sites, especially when creating islands, are the effects of such activities on aquatic communities. Therefore, in 1991, the COE contracted the National Marine Fisheries Service (NMFS) to conduct surveys in July and September to assess the aquatic communities just north of Rice Island and at Miller Sands (Hinton et al. 1992). Subsequently, the COE contracted NMFS to conduct two additional but limited benthic surveys at Rice Island in December 1991 and March 1992. Data from the two limited surveys are presented in this report, which supplements the initial report (Hinton et al. 1992).

METHODS

Benthic invertebrate and sediment samples were collected at six previously established stations in the subtidal area north of Rice Island in December 1991 and March 1992 (Fig. 1). These stations were reoccupied using the Global Positioning System (see Appendix Table 1 for station locations).

Sampling

Eleven core samples were taken at each station with a polyvinyl chloride (PVC) coring device with an inside diameter of 3.85 cm and a penetrating depth of 15 cm, and which collected a 174.6-cm^3 sample (Fig. 2). Samples were collected by scuba divers since all stations were subtidal. Ten core samples were placed in labeled jars and preserved in a buffered formaldehyde solution ($\geq$4%) containing rose bengal, a protein stain. In the laboratory, samples were washed with water through a 0.5-mm screen. All invertebrates were sorted from the preserved sample, identified to the lowest practical taxonomic level (usually species), and counted. The specimens were then stored in labeled vials containing 70% ethyl alcohol. The eleventh core sample was saved in a labeled plastic bag and refrigerated for analysis of sediment grain size and total volatile solids by the COE North Pacific Division Materials Laboratory, Troutdale, Oregon.

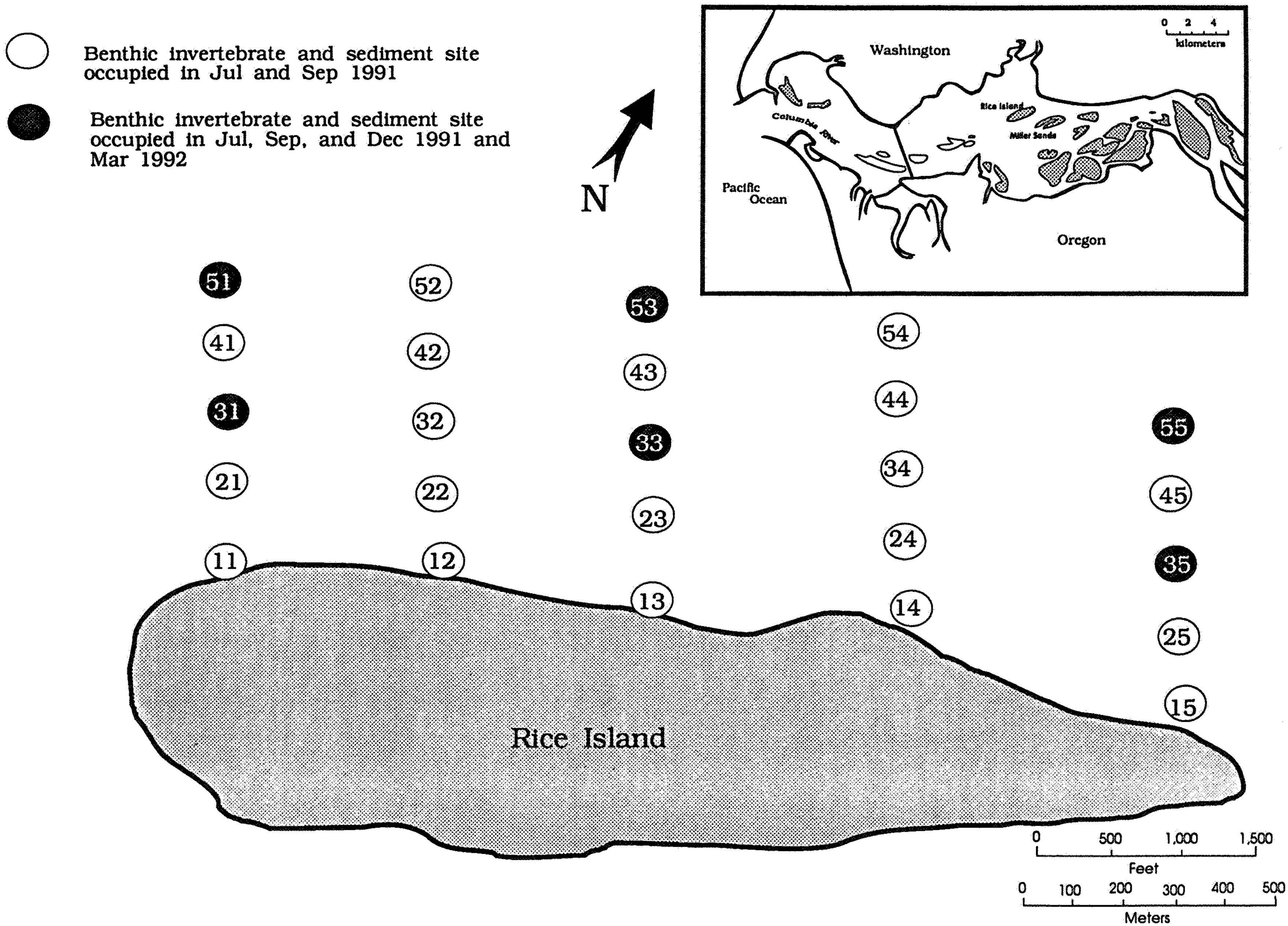

Figure 1.--Sampling locations from benthic invertebrates and sediment at Rice Island, Columbia River estuary, 1991-1992.

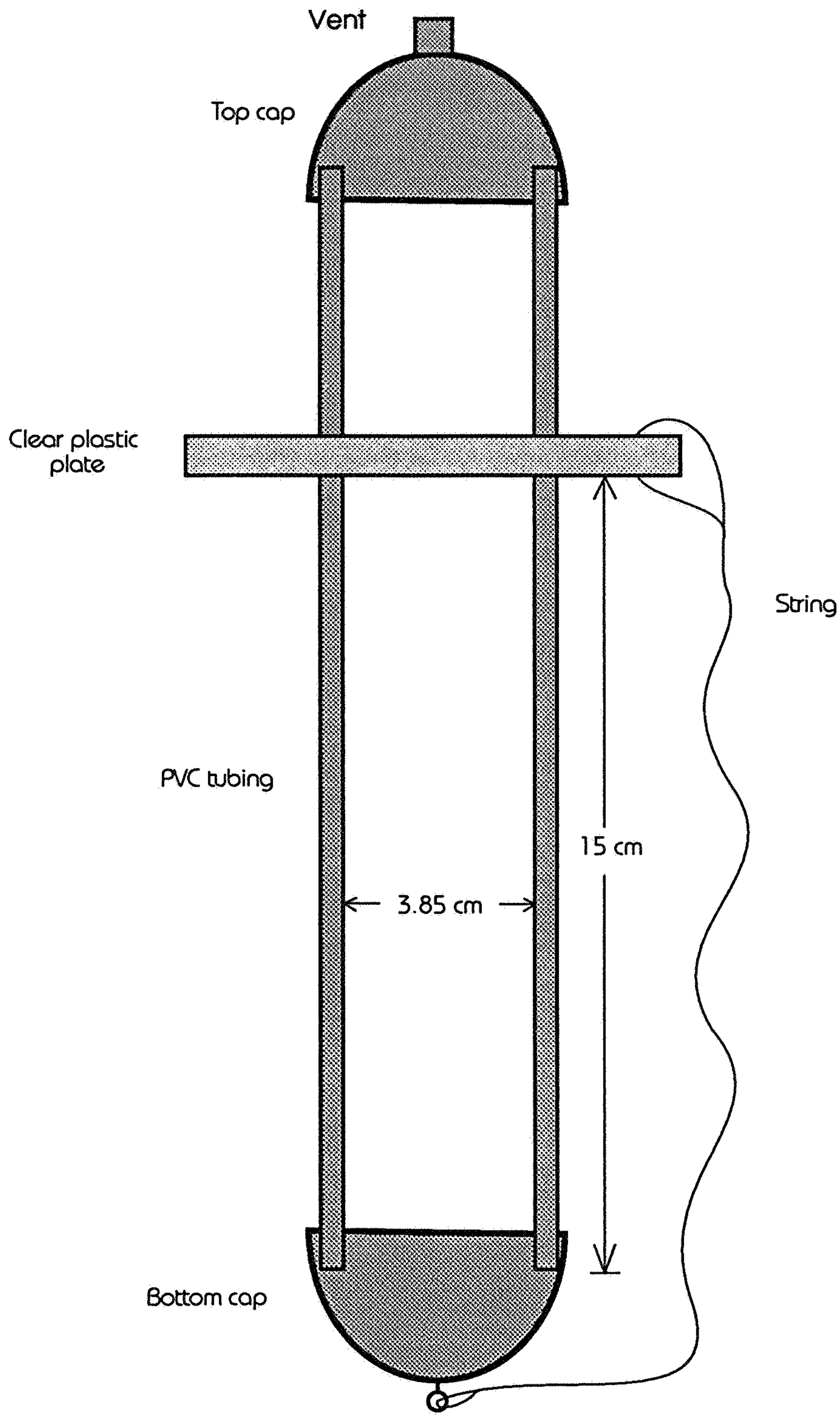

Figure 2.--PVC coring device used to collect benthic invertebrate and sediment samples in the Columbia River estuary.

Data Analyses

Benthic Invertebrates

The 10 benthic invertebrate replicates from each station allowed calculation of a mean number/m^2 and standard deviation for each species, and total mean number/m^2 and standard deviation for each station.

Two community structure indices, diversity and equitability, were calculated for each sampling station. Diversity was calculated using the Shannon-Wiener function (H) (Krebs 1978).

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

where p_i = Xa/n (Xa is the number of individuals of a particular species in the sample, and n is the total number of all individuals in the sample) and s = number of species. Equitability (E), the second community structure index, measures the proportional abundances among the various species in a sample (Krebs 1978). E ranges from 0.00 to 1.00, with 1.00 indicating all species in the sample are numerically equal.

$$E = H/\log_2 s$$

where H = Shannon-Wiener function and s = number of species.

Sediments

Median grain size (mm), percent silt/clay, and percent volatile solids were calculated for each station.

RESULTS

Benthic Invertebrates

For December 1991, 11 benthic invertebrate taxa were identified at the six stations at Rice Island. Benthic invertebrate densities at all stations exceeded 117,000 organisms/m^2 with the exception of Station 33 (3,866 organism/m^2) (Table 1, Appendix Table 2). The highest density was 199,458 organisms/m^2 at Station 51. Diversity ranged from 0.73 (Station 51) to 1.60 (Station 33). Equitability ranged from 0.26 (Station 51) to 0.80 (Station 33) but was usually 0.40 or less. The lower diversity values resulted from fewer taxa or low equitability (i.e., unequal proportional abundances among the taxa). The higher equitability value at Station 33 indicated the taxa were more equally distributed.

For March 1992, 11 invertebrate taxa were identified at Rice Island. Benthic invertebrate densities ranged from 2,319 organisms/m^2 (Station 33) to 182,879 organisms/m^2 (Station 53). Most stations exceeded 130,000 organisms/m^2 (Table 1, Appendix Table 2). Diversity ranged from 0.81 (Station 53) to 1.52 (Station 55) and equitability ranged from 0.33 (Station 31) to 0.66 (Station 55). Overall, diversity and equitability values in March were low, indicating few taxa and the unequal proportional abundances of these taxa.

The amphipod <u>Corophium</u> <u>salmonis</u> was the dominant benthic invertebrate at Rice Island during the December 1991 and March 1992 surveys, comprising 82 and 80% of the total number of

Table 1.--Summary of benthic invertebrates at Rice Island, Columbia River estuary, December 1991 and March 1992. Depths are corrected to mean lower low water.

Station	Depth (m)	Number of taxa	Number /m²	Standard deviation	Diversity (H)	Equitability (E)
			DECEMBER 1991			
31	0.4	7	140,531	28,685	1.13	0.40
51	3.0	7	199,458	61,261	0.73	0.26
33	3.5	4	3,866	3,394	1.60	0.80
53	1.7	6	117,682	42,841	0.79	0.30
35	3.3	8	162,091	44,308	1.08	0.36
55	2.4	5	177,639	36,585	0.90	0.39
			MARCH 1992			
31	0.4	8	130,996	22,124	1.00	0.33
51	3.0	8	158,054	24,780	1.13	0.38
33	3.5	5	2,319	1,571	1.26	0.54
53	1.7	5	182,879	26,989	0.81	0.35
35	3.3	8	181,934	33,003	1.07	0.36
55	2.4	5	10,050	2,657	1.52	0.66

organisms per survey (Table 2). Other abundant taxa found in the study area were Turbellaria, Oligochaeta, the bivalve Corbicula fluminea, and Heleidae (Ceratopogonidae) larvae.

Sediments

The dominant median grain size in the Rice Island study area during December 1991 and March 1992 was fine sand (0.125 to <0.25 mm in diameter) (Table 3). Very fine sand (0.0625 to <0.125 mm in diameter) occurred at Stations 31 and 51 in March 1992. The amount of silt/clay for each station ranged from 0.0 (Station 33) to 14.5% (Station 51) during the two surveys. Percent volatile solids per station for both surveys was never greater than 1.7%, and usually 1.0% or less.

DISCUSSION

Benthic invertebrate densities at Stations 31, 51, 53, 35, and 55 in December 1991 and Stations 31, 51, 53, and 35 in March 1992 at Rice Island were the highest ever reported in the estuary. Generally, benthic invertebrate densities in December 1991 and March 1992 were much higher than densities at the same stations in July and September 1991 (Fig. 3; Hinton et al. 1992). The dramatic increase in abundance of Corophium salmonis numbers was the cause of the incredibly high invertebrate densities in the area. Peak densities of C. salmonis typically occur during December through March (Emmett et al. 1986).

In three out of the four surveys, benthic invertebrate densities were the lowest at Station 33 (Fig. 3). In addition,

Table 2.--Abundance of major benthic invertebrate taxa at Rice Island, Columbia River estuary, December 1991 and March 1992. All values are mean numbers/m^2; data from six stations were combined for each survey.

Taxon	Dec 91	Mar 92
Turbellaria	11,654	7,101
Oligochaeta	7,817	10,938
Polychaeta		
Neanthes limnicola	115	158
Bivalvia		
Corbicula fluminea	1,847	2,849
Ostracoda	29	200
Amphipoda		
Corophium salmonis	109,793	88,533
Corophium spinicorne	72	86
Insecta		
Chironomidae larvae	14	29
Heleidae larvae	2,176	1,117
Miscellaneous	14	14
Others	14	14
Total	133,544	111,039

Table 3.--Sediment characteristics at Rice Island, Columbia River estuary, December 1991 and March 1992. Depths are corrected to mean lower low water.

Station	Depth (m)	Median grain size (mm)	Percent silt/clay	Percent volatile solids
		DECEMBER 1991		
31	0.4	0.1340	1.3	1.0
51	3.0	0.1340	5.8	1.0
33	3.5	0.2500	0.0	0.5
53	1.7	0.1768	1.6	0.5
35	3.3	0.2176	1.5	0.7
55	2.4	0.2176	1.6	0.8
		MARCH 1992		
31	0.4	0.1088	7.3	1.0
51	3.0	0.0769	14.5	1.7
33	3.5	0.2500	0.2	0.5
53	1.7	0.1539	10.3	0.7
35	3.3	0.1436	9.5	0.9
55	2.4	0.2333	0.3	0.5

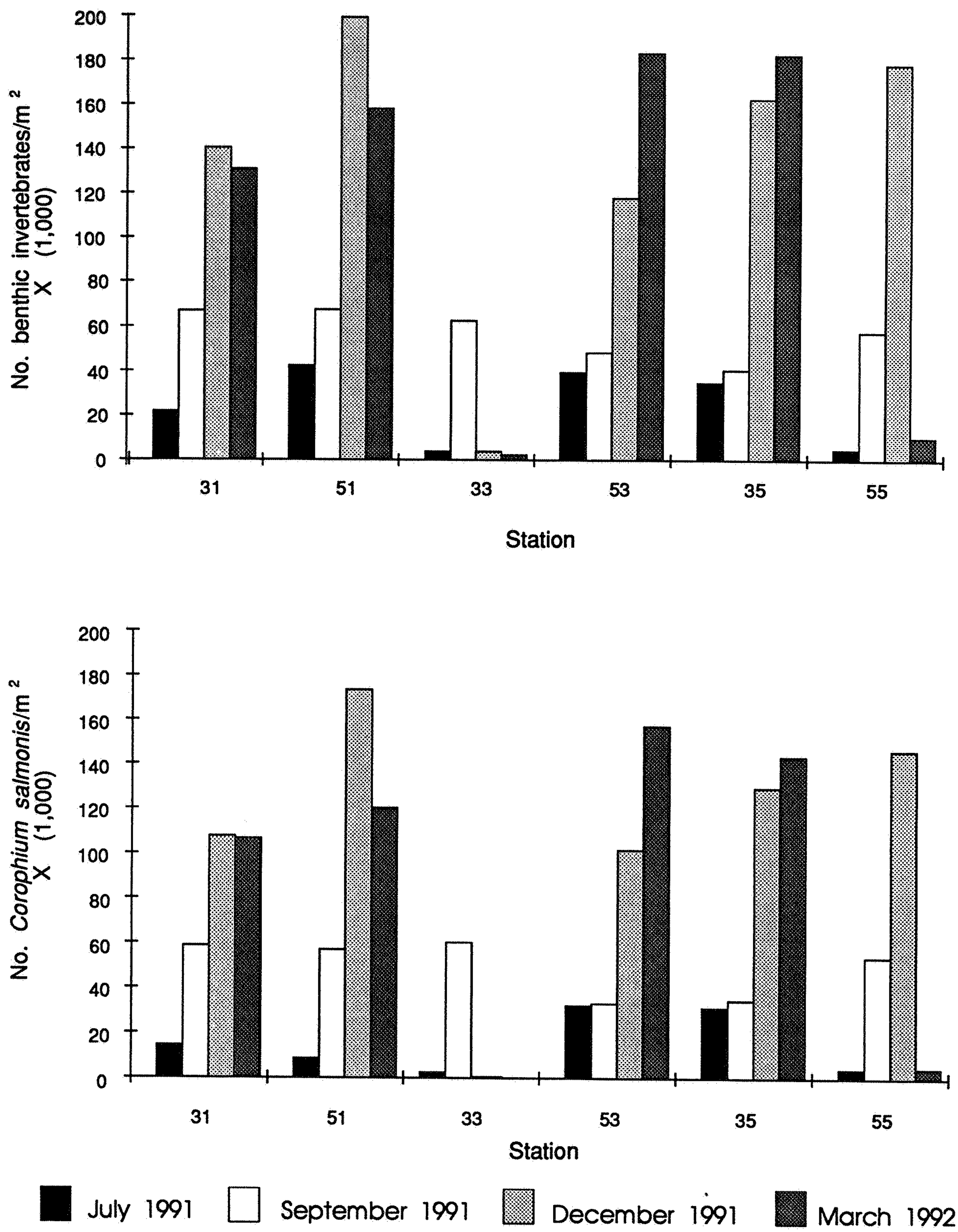

Figure 3.--Mean number of benthic invertebrates/m² and mean number of <u>Corophium salmonis</u>/m² for six stations sampled at Rice Island, Columbia River estuary, 1991-1992.

median grain size was the highest at Station 33 in these three surveys (Fig. 4).

Median grain size and percent volatile solids remained fairly consistent when comparing the six stations occupied in July, September, and December 1991 and March 1992. Percent silt/clay varied more than median grain size or percent volatile solids, but was never exceedingly high (Fig. 4).

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

ACKNOWLEDGMENTS

We thank Loretta Clifford for her assistance in analyzing the biological samples. The COE Portland District conducted the sediment analysis.

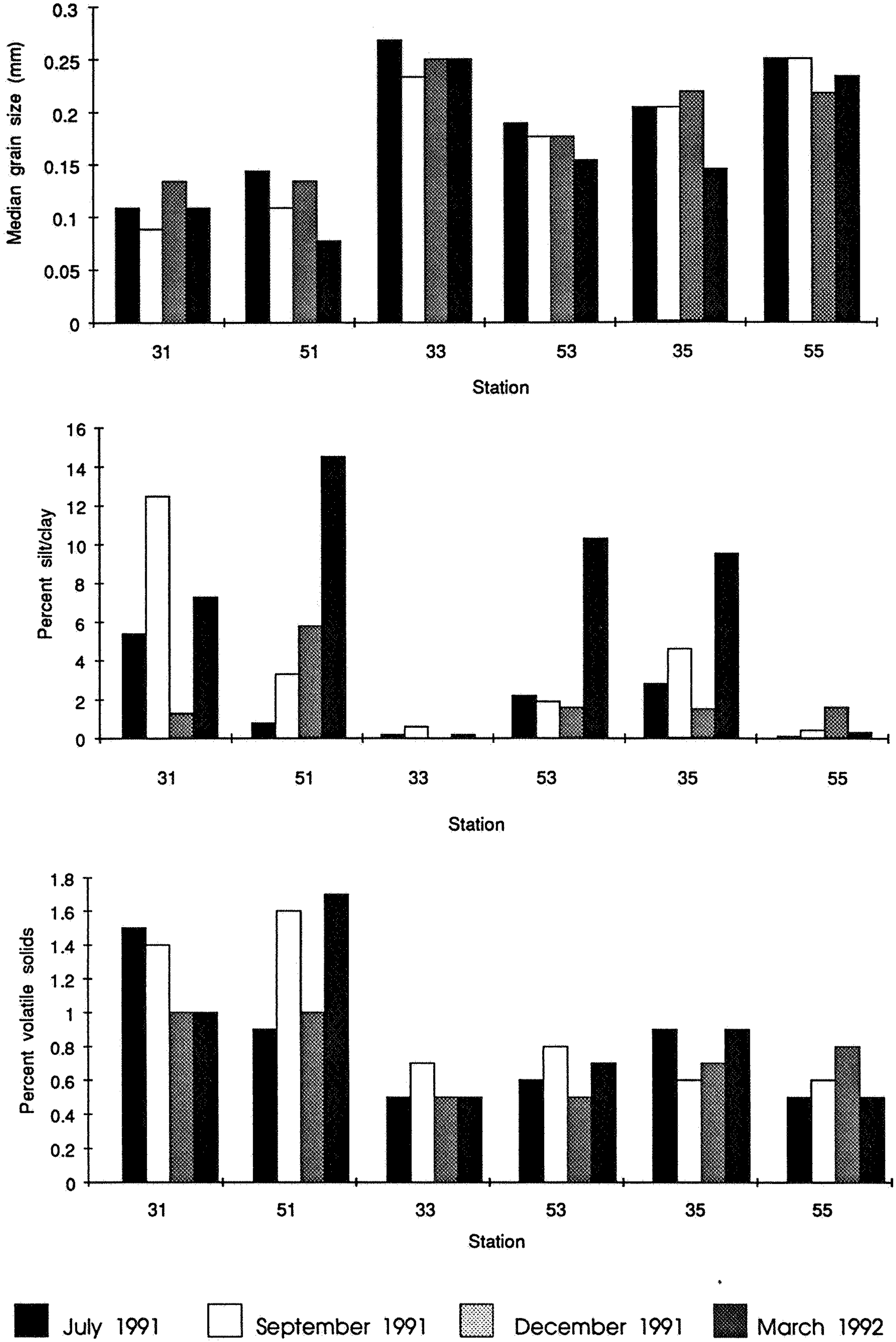

Figure 4.--Sediment characteristics for six stations sampled at Rice Island, Columbia River estuary, 1991-1992.

LITERATURE CITED

Emmett, R. L., G. T. McCabe, Jr., T. C. Coley, R. J. McConnell, and W. D. Muir.
1986. Benthic sampling in Cathlamet Bay, Oregon--1984. Report to U.S. Army Corps of Engineers, Contract DACW57-84-F-0348, 11 p. plus appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Hinton, S. A., R. L. Emmett, and G. T. McCabe, Jr.
1992. Fishes, shrimp, benthic invertebrates, and sediment characteristics in intertidal and subtidal habitats at Rice Island and Miller Sands, Columbia River estuary. Report to U.S. Army Corps of Engineers, Contract E96910025, 53 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Krebs, C. J.
1978. Ecology: the experimental analysis of distribution and abundance. Harper and Row. New York, NY. 678 p.

APPENDIX

Appendix Table 1.--Station locations at Rice Island, Columbia River estuary, 1991-1992.

Benthic/sediment station	Latitude	Longitude
31	46°15.245	123°43.032
51	15.401	43.150
33	46°15.442	123°42.108
53	15.600	42.194
35	46°15.464	123°41.434
55	15.591	41.550

Appendix Table 2.--Summary of benthic invertebrate surveys (by station) during December 1991 and March 1992 at Rice Island, Columbia River estuary.

Station: 31 Date: 19 Dec 91 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	187	100	16,063	6,920
Neanthes limnicola	6	50	515	601
Oligochaeta	159	100	13,658	4,967
Corbicula fluminea	30	100	2,577	2,361
Ostracoda	1	10	86	272
Corophium salmonis	1,252	100	107,546	23,656
Corophium spinicorne	1	10	86	272

Number of taxa: 7

Mean number/sample: 164 Standard deviation/sample: 33
Mean number/m²: 140,531 Standard deviation: 28,685

H = 1.13 E = 0.40

Station: 51 Date: 19 Dec 91 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	116	100	9,964	10,837
Neanthes limnicola	2	20	172	362
Oligochaeta	168	100	14,431	4,973
Corbicula fluminea	12	80	1,031	887
Corophium salmonis	2,020	100	173,516	52,409
Corophium spinicorne	3	30	258	415
Ephemeroptera	1	10	86	272

Number of taxa: 7

Mean number/sample: 232 Standard deviation/sample: 71
Mean number/m²: 199,458 Standard deviation: 61,261

H = 0.73 E = 0.26

Station: 33 Date: 19 Dec 91 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	4	20	344	724
Oligochaeta	10	60	859	992
Corophium salmonis	5	40	430	607
Heleidae larvae	26	70	2,233	2,298

Number of taxa: 4

Mean number/sample: 5 Standard deviation/sample: 4
Mean number/m^2: 3,866 Standard deviation: 3,394

H = 1.60 E = 0.80

Station: 53 Date: 19 Dec 91 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	39	90	3,350	2,638
Oligochaeta	114	100	9,793	4,691
Corbicula fluminea	28	90	2,405	2,173
Corophium salmonis	1,182	100	101,533	40,045
Collembolla	1	10	86	272
Heleidae larvae	6	50	515	601

Number of taxa: 6

Mean number/sample: 137 Standard deviation/sample: 50
Mean number/m^2: 117,682 Standard deviation: 42,841

H = 0.79 E = 0.30

Station: 35 Date: 19 Dec 91 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	206	100	17,695	5,496
Oligochaeta	70	100	6,013	3,265
<u>Corbicula fluminea</u>	34	90	2,921	2,150
Ostracoda	1	10	86	272
<u>Corophium salmonis</u>	1,507	100	129,450	40,974
<u>Corophium spinicorne</u>	1	10	86	272
Heleidae larvae	67	100	5,755	2,397
Chironomidae larvae	1	10	86	272

Number of taxa: 8

Mean number/sample: 189 Standard deviation/sample: 52
Mean number/m^2: 162,091 Standard deviation: 44,308

H = 1.08 E = 0.36

Station: 55 Date: 19 Dec 91 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	262	100	22,506	13,749
Oligochaeta	25	80	2,148	1,777
<u>Corbicula fluminea</u>	25	90	2,148	1,682
<u>Corophium salmonis</u>	1,703	100	146,286	31,193
Heleidae larvae	53	80	4,553	3,316

Number of taxa: 5

Mean number/sample: 207 Standard deviation/sample: 43
Mean number/m^2: 177,639 Standard deviation: 36,585

H = 0.90 E = 0.39

Station: 31 Date: 17 Mar 92 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	116	100	9,964	5,436
Oligochaeta	123	100	10,566	4,706
Corbicula fluminea	41	90	3,522	2,235
Ostracoda	4	40	344	444
Corophium salmonis	1,238	100	106,343	20,371
Corophium spinicorne	1	10	86	272
Heleidae larvae	1	10	86	272
Chironomidae larvae	1	10	86	272

Number of taxa: 8

Mean number/sample: 153 Standard deviation/sample: 26
Mean number/m^2: 130,996 Standard deviation: 22,124

H = 1.00 E = 0.33

Station: 51 Date: 17 Mar 92 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	145	100	12,455	5,284
Neanthes limnicola	7	70	601	415
Oligochaeta	262	100	22,506	8,482
Corbicula fluminea	16	80	1,374	1,160
Ostracoda	10	40	859	1,215
Corophium salmonis	1,398	100	120,087	16,252
Corophium spinicorne	1	10	86	272
Heleidae larvae	1	10	86	272

Number of taxa: 8

Mean number/sample: 184 Standard deviation/sample: 29
Mean number/m^2: 158,054 Standard deviation: 24,780

H = 1.13 E = 0.38

Station: 33   Date: 17 Mar 92   Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	1	10	86	272
Oligochaeta	4	40	344	444
Heleidae larvae	20	90	1,718	1,145
Chironomidae larvae	1	10	86	272
Hydracarina	1	10	86	272

Number of taxa: 5

Mean number/sample: 3   Standard deviation/sample: 2
Mean number/m²: 2,319   Standard deviation: 1,571

H = 1.26   E = 0.54

Station: 53   Date: 17 Mar 92   Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	77	100	6,614	4,688
Oligochaeta	137	100	11,768	4,809
Corbicula fluminea	84	100	7,216	3,781
Corophium salmonis	1,829	100	157,109	22,940
Corophium spinicorne	2	20	172	362

Number of taxa: 5

Mean number/sample: 213   Standard deviation/sample: 31
Mean number/m²: 182,879   Standard deviation: 26,989

H = 0.81   E = 0.35

Station: 35 Date: 17 Mar 92 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	155	100	13,314	7,224
Neanthes limnicola	4	30	344	601
Oligochaeta	232	100	19,929	5,637
Corbicula fluminea	54	100	4,639	3,245
Corophium salmonis	1,668	100	143,280	32,440
Corophium spinicorne	2	10	172	543
Heleidae larvae	2	20	172	362
Ephemeroptera	1	10	86	272

Number of taxa: 8

Mean number/sample: 212 Standard deviation/sample: 38
Mean number/m²: 181,934 Standard deviation: 33,003

H = 1.07 E = 0.36

Station: 55 Date: 17 Mar 92 Sample size: 10

Taxon	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	2	20	172	362
Oligochaeta	6	40	515	724
Corbicula fluminea	4	40	344	444
Corophium salmonis	51	100	4,381	2,122
Heleidae larvae	54	100	4,639	2,333

Number of taxa: 5

Mean number/sample: 12 Standard deviation/sample: 3
Mean number/m²: 10,050 Standard deviation: 2,657

H = 1.52 E = 0.66