In-Water Restoration Between Miller Sands and Pillar Rock Island, Columbia River: Biological Surveys, 1992

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COASTAL ZONE AND ESTUARINE STUDIES

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INTRODUCTION

In 1991, the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of the Army signed a Memorandum of Agreement to restore and create fish habitat in the United States. Within NOAA, the National Marine Fisheries Service (NMFS) is responsible for conserving, managing, and developing the Nation's living aquatic resources. Within the Department of the Army, the U.S. Army Corps of Engineers (COE) is responsible for maintaining navigation channels. In addition, the COE has the authority to develop water resources, including protection and restoration of fish habitats using various means, including the beneficial use of dredged materials.

A site in the Columbia River estuary between Miller Sands and Pillar Rock Island (River Kilometers 40-42) (Fig. 1) is being investigated by the COE, Portland District under the Long-Term Management Strategy for dredged-material management in the Columbia River estuary. The proposed disposal site has been identified as an active erosion location. Since 1958, this area has eroded from a shallow subtidal habitat (0 to 1.8 m (0 to 6 ft) Columbia River Datum (CRD)) to the present depth of 7.6 m (25 ft) CRD. Approximately 9.2 million m^3 (12 million yd^3) of material have eroded. The annual erosion rate at this area is estimated to be 53,515 m^3 (70,000 yd^3) of material.

Providing that hydraulic modeling studies conducted by the COE, Portland District do not predict any adverse changes in water circulation, the COE would like to use dredged material to restore the eroded area to shallow subtidal habitat to attain benthic invertebrate and fish densities and species composition comparable to other Columbia River estuary shallow subtidal habitat. Consequently, the COE requires data regarding habitat parameters for design of the in-water fill and associated pile-dike field to stabilize the site.

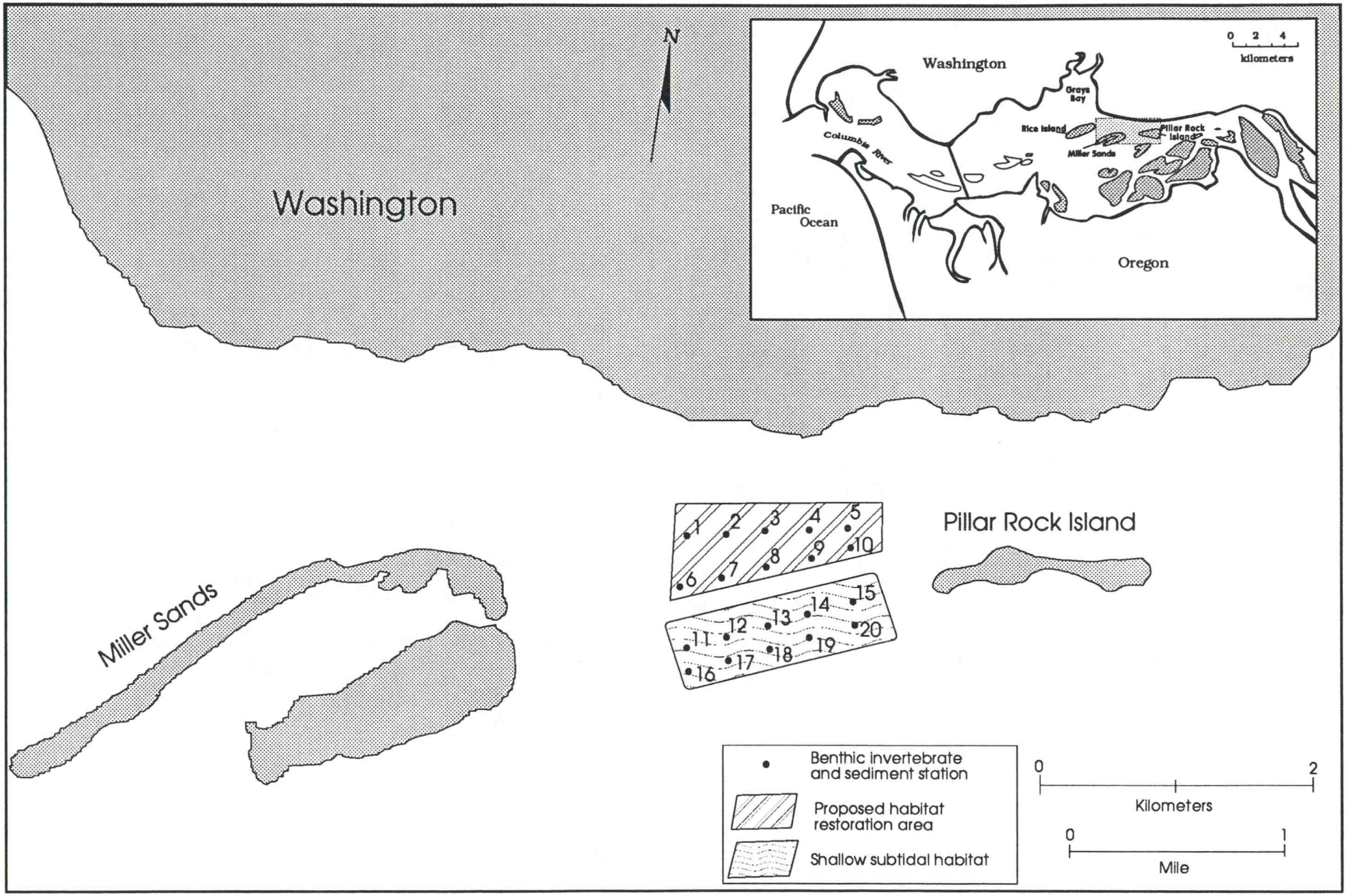

Figure 1.--Benthic invertebrate and sediment stations between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992.

Shallow subtidal and intertidal habitats in other areas of the Columbia River estuary (e.g., Rice Island, Grays Bay, and Cathlamet Bay) support high densities of benthic invertebrates, including the amphipod Corophium salmonis (Holton et al. 1984; Emmett et al. 1986; Hinton et al. 1990, 1992a, b), an important food for juvenile Pacific salmon (Oncorhynchus spp.) (McCabe et al. 1983, 1986). Annually in the Columbia River Basin, millions of juvenile Pacific salmon are produced that migrate through the Columbia River estuary en route to the Pacific Ocean. Adult returns from these outmigrating juvenile salmonids support important recreational and commercial fisheries in the ocean and Columbia River.

In 1992, NMFS initiated benthic invertebrate, fish, and sediment characterization studies at the proposed habitat restoration area and an adjacent shallow subtidal habitat, both located between Miller Sands and Pillar Rock Island (Fig. 1). The primary objectives of the research were to document existing biological communities and provide habitat criteria for disposal of dredged material at the proposed habitat restoration area.

METHODS

Sampling

Benthic invertebrate and sediment samples, fishes, and shrimp were collected at the proposed habitat restoration area and adjacent shallow subtidal habitat in July and September 1992. Initially, we planned to begin sampling in May; however, due to funding constraints, this was not possible. The shallow subtidal habitat was selected as a control site for future assessments of modifications to the proposed habitat restoration area. Also, physical data, such as depth and sediment characteristics, collected in the shallow subtidal habitat will be used to provide habitat criteria for engineering and design of the proposed habitat restoration site. Station locations (latitude and longitude) were established using the Global Positioning System, which also allowed stations to be easily reoccupied (Appendix Table 1).

Benthic Invertebrates and Sediments

Eleven core samples were taken at each of 20 stations (10 in the proposed habitat restoration area and 10 in the adjacent shallow subtidal habitat) with a polyvinyl chloride (PVC) coring device with an inside diameter of 3.85 cm, a penetrating depth of 15 cm, and a 174.6-cm^3 sample volume (Figs. 1-2). Samples were collected by scuba diving or snorkeling. Ten core samples from each station 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 benthic invertebrates were sorted from each sample, identified to the lowest practical taxon, counted, and stored in 70% ethanol. The eleventh benthic sample from each station was placed in a labeled plastic bag and refrigerated for analysis of grain size, percent silt/clay, and percent volatile solids by the COE North Pacific Division Materials Laboratory, Troutdale, Oregon.

Fishes and Shrimp

In both the proposed habitat restoration area and adjacent shallow subtidal habitat, purse seining was conducted in July and September at three stations (Fig. 3) using a shallow-water purse seine (100 x 4.6 m). The seine was constructed of knotless nylon mesh, 17 mm in the body and 13 mm in the bunt. A round-haul technique was used to deploy the net. Typically, the net, which was stacked on the stern of an 8-m boat, was pulled off by a 5-m boat. During deployment, both boats traveled in a wide arc, completing a full circle by the time the net was fully extended. The net was then closed and pulled aboard the 8-m boat; fishes were hand-forced into the bunt where they could

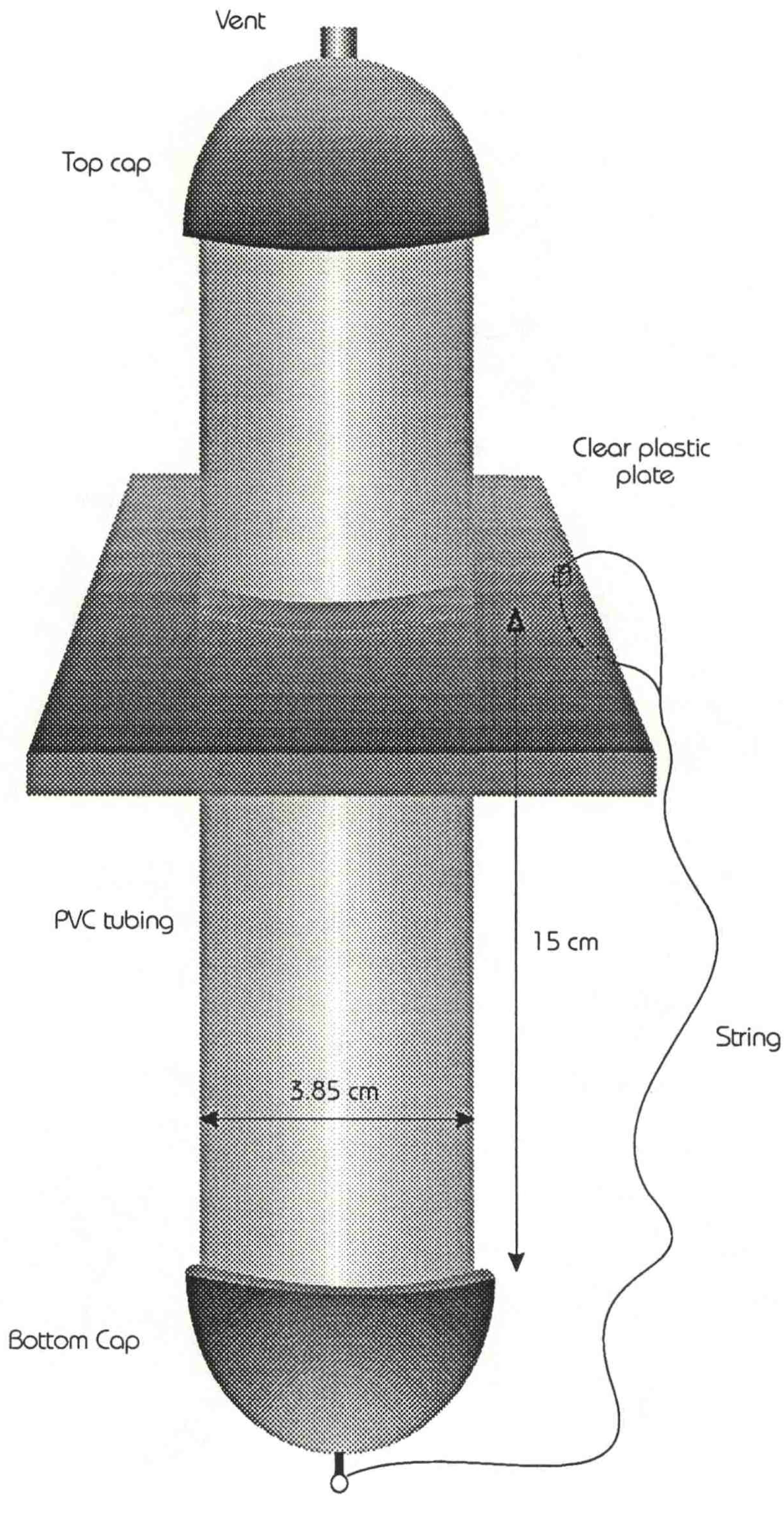

Figure 2.--PVC coring device used to collect benthic invertebrate and sediment samples in a proposed habitat restoration area and an adjacent shallow subtidal habitat located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992.

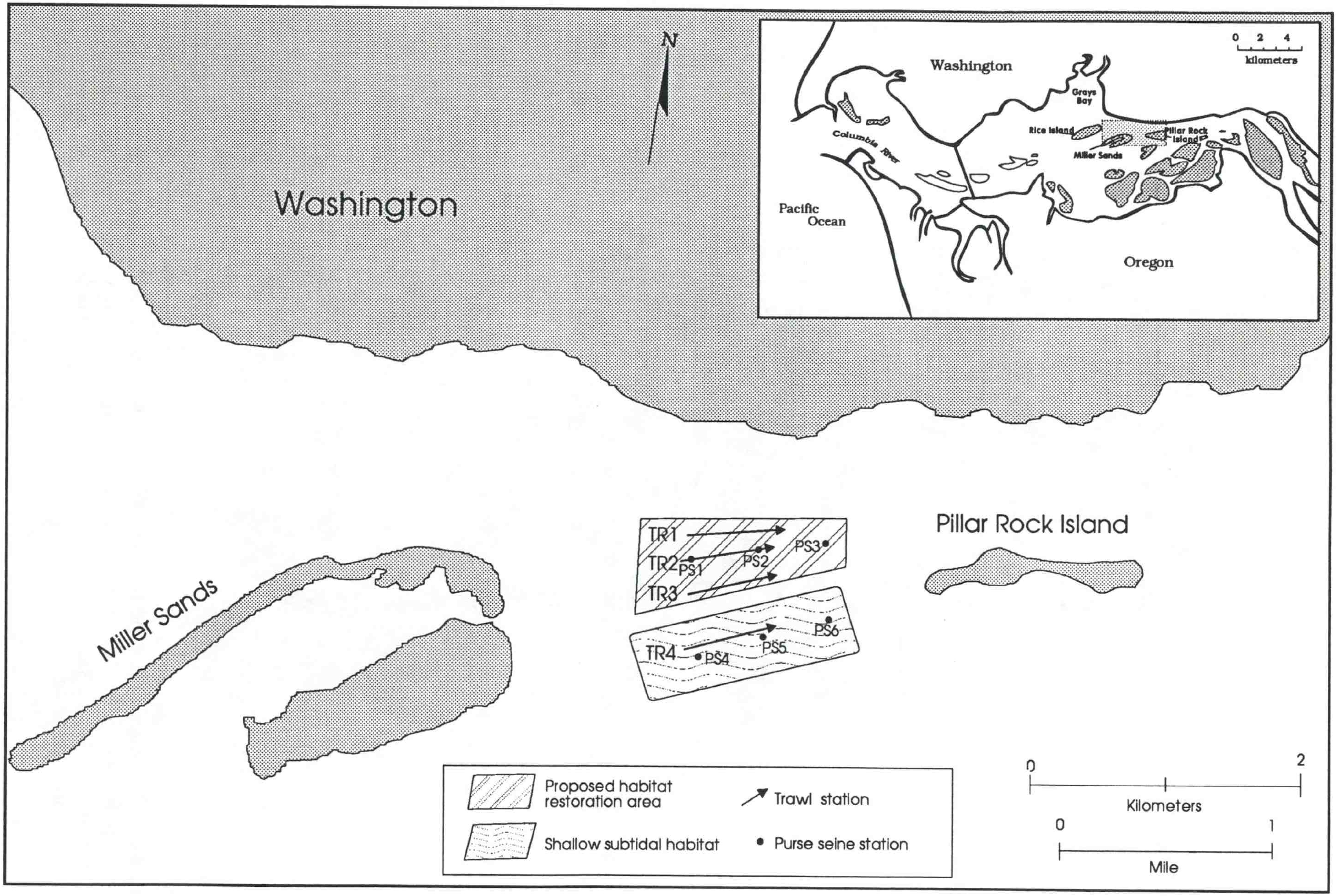

Figure 3.--Purse seine and trawling stations between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992.

be collected before bringing the bunt aboard. In the proposed habitat restoration area, the purse seine sampled only the upper portion of the water column, at most the top 4.6 m; however, in the shallow subtidal habitat, the purse seine sampled much of the water column and at times the bottom.

Demersal fishes and shrimp in the proposed habitat restoration area were sampled in July and September at three stations using an 8-m (headrope length) semiballoon shrimp trawl (Fig. 3). The trawl had 38-mm (stretched measure) mesh in the body, and a 10-mm mesh liner inserted in the cod end. The trawl was towed upstream for 5 minutes, and the distance traveled was estimated using a radar range-finder. Trawling was not routinely conducted in the shallow subtidal habitat to minimize juvenile salmonid injuries and mortalities, especially since three species of Pacific salmon in the Columbia River Basin have been listed as threatened or endangered. Capture in a shrimp trawl often badly descales juvenile salmonids. After purse seining had been completed in September and we felt confident that juvenile salmon were not present in the shallow subtidal habitat, we made one trawl in this area. Because of the deeper water ($\geq$7.5 m mean lower low water) in the proposed habitat restoration area, we were not concerned about catching juvenile salmonids in the shrimp trawl in this area. Juvenile salmonids are typically found near the surface in deep water and therefore would not be vulnerable to capture in a shrimp trawl, except when retrieving the net.

At the collection sites, fishes and shrimp were identified, counted, and a maximum of 50 individuals of each fish species was measured (total length in mm) and weighed (g). When more than 50 individuals of a species were collected at a site, the excess was counted and weighed as a group.

Data Analyses

Benthic Invertebrates

Benthic invertebrate data were analyzed by station to determine species composition, densities (by species and total), and community structure (diversity and equitability). The Shannon-Wiener function (H) was used to determine diversity (Krebs 1978). Diversity is expressed as:

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

where $p_i = n_i/N$ (n_i is the number of individuals of the ith species in the sample, and N is the total number of all individuals in the sample) and s = number of species. Equitability (E) was the second community structure index determined; E measures the proportional abundances among the various species in a sample (Krebs 1978) and ranges from 0.00 to 1.00, with 1.00 indicating all species in the sample are numerically equal. Equitability is expressed as:

$$E = H/\log_2 s$$

where H = Shannon-Wiener function and s = number of species. H and E were calculated for each sampling station.

Benthic invertebrate densities were compared between the two areas and surveys using two-way analysis of variance (ANOVA) (Ryan et al. 1985); the data were transformed ($\log_{10}$) prior to running ANOVA. Means from the 10 samples at each sampling station provided the basic data entries for the statistical tests. Overall comparisons of H and E could not be made using two-way ANOVA due to significant interaction between area and survey.

Fishes and Shrimp

For each station, individual species and total fish and shrimp densities (number/ha) and weights (g/ha) were estimated using the catch data and area sampled. The estimated sampling area of the purse seine was 795 m^2, which is the area of a circle having a 100-m (length of purse seine) circumference. The sampling area of the shrimp trawl was estimated using the distance traveled during each effort and the estimated fishing width of the trawl (5 m).

Sediments

Median grain size (mm) was calculated for each station. Two-way ANOVA was used to compare median grain size and percent volatile solids between areas and surveys. Percent silt/clay values were not compared between areas and surveys using ANOVA because of the non-normal distribution of the data.

RESULTS

Benthic Invertebrates

Benthic invertebrate densities (total) were significantly different ($P < 0.05$) spatially and temporally in the proposed habitat restoration area and the adjacent shallow subtidal habitat located between Miller Sands and Pillar Rock Island. Densities were significantly higher in the shallow subtidal habitat than in the proposed habitat restoration area (ANOVA, $P < 0.05$) (Table 1). In the shallow subtidal habitat, benthic invertebrate densities in July and September averaged 21,321 organisms/m^2 and 47,267 organisms/m^2, respectively. Benthic invertebrate densities in the proposed habitat restoration area in July and September averaged 3,419 organisms/m^2 and 15,926 organisms/m^2, respectively.

Table 1.--Summary of benthic invertebrate collections in a proposed habitat restoration area (Stations 1-10) and an adjacent shallow subtidal habitat (Stations 11-20) located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992. Depths are corrected to mean lower low water.

Station	Depth (m)	Number of taxa/ categories	Number /m²	Standard deviation	Diversity (H)	Equitability (E)
			JULY			
1	7.5	4	3,866	2,842	1.56	0.78
2	9.1	3	2,921	2,298	1.01	0.64
3	10.7	4	3,264	2,057	1.32	0.66
4	10.0	4	1,804	1,961	1.41	0.70
5	11.9	6	2,233	2,150	1.64	0.64
6	8.3	7	3,694	1,944	1.96	0.70
7	9.0	6	5,154	3,364	1.89	0.73
8	8.7	8	3,694	2,106	1.85	0.62
9	8.6	5	2,233	2,298	1.69	0.73
10	8.5	6	5,326	2,247	2.03	0.79
Mean			3,419		1.64	0.70
11	0.7	10	35,648	4,568	1.66	0.50
12	1.3	7	16,493	6,387	2.08	0.74
13	2.2	10	9,621	3,359	2.34	0.70
14	3.1	11	34,455	6,506	1.64	0.47
15	0.0	6	6,442	4,422	1.18	0.45
16	0.2	11	38,912	5,827	1.98	0.57
17	0.8	10	22,506	5,652	1.57	0.47
18	2.7	8	5,498	2,503	1.91	0.64
19	3.7	10	12,026	6,260	2.39	0.72
20	0.5	12	31,611	7,354	2.26	0.63
Mean			21,321		1.90	0.59
			SEPTEMBER			
1	8.5	7	15,634	6,953	1.24	0.44
2	10.2	5	11,425	2,106	1.38	0.59
3	10.2	4	18,382	6,922	1.07	0.54
4	11.4	7	18,812	6,757	1.11	0.40
5	12.6	5	14,431	6,112	0.86	0.37
6	8.7	6	36,164	8,876	0.62	0.24
7	9.1	4	4,381	2,160	1.26	0.63
8	8.5	7	29,292	5,888	0.34	0.12
9	8.5	4	6,872	3,265	0.48	0.24
10	8.5	4	3,866	2,504	1.25	0.62
Mean			15,926		0.96	0.42

Table 1.--Continued.

Station	Depth (m)	Number of taxa/ categories	Number /m²	Standard deviation	Diversity (H)	Equitability (E)
			SEPTEMBER			
11	0.9	11	48,189	15,654	2.15	0.62
12	2.4	9	59,356	11,159	1.14	0.36
13	2.1	8	59,786	6,632	1.29	0.43
14	2.8	11	56,178	5,511	1.65	0.48
15	2.0	7	16,149	5,354	1.85	0.66
16	0.8	9	48,275	8,777	2.15	0.68
17	1.5	6	27,230	6,630	2.05	0.79
18	2.0	8	41,804	12,269	1.79	0.60
19	2.6	8	53,429	7,420	1.10	0.37
20	0.7	11	62,277	14,243	1.93	0.56
Mean			47,267		1.71	0.56

Overall, benthic invertebrate densities were significantly higher in September than in July ($P < 0.05$).

The total number of taxa/categories collected in the proposed habitat restoration area and the adjacent shallow subtidal habitat located in the river between Miller Sands and Pillar Rock Island was higher in July (27) than in September (21) (Appendix Table 2). The totals include all organisms collected, including some not normally associated with the benthos. At individual stations in the proposed habitat restoration area, the number of benthic invertebrate taxa/categories ranged from three to eight in July and from four to seven in September (Table 1). The number of benthic invertebrate taxa/categories at individual stations in the shallow subtidal habitat was generally higher, ranging from 6 to 12 in July and from 6 to 11 in September.

The major benthic invertebrate taxa collected in the proposed habitat restoration area included the bivalve Corbicula fluminea, the amphipod Corophium salmonis, and Ceratopogonidae (= Heleidae) larvae (Table 2; Appendix Table 3). In the shallow subtidal habitat, oligochaetes, including their egg cases; the gastropod Lithoglyphus virens; Corbicula fluminea; Corophium salmonis; Chironomidae larvae; and Ceratopogonidae larvae were the major benthic invertebrate taxa.

Overall, Corophium salmonis was the most abundant benthic invertebrate in the proposed habitat restoration area and shallow subtidal habitat. Corophium salmonis densities were significantly higher in the shallow subtidal habitat than in the proposed habitat restoration area (ANOVA, $P < 0.05$), and were significantly higher in September than in July ($P < 0.05$).

Mean diversity (H) was higher in the shallow subtidal habitat than in the proposed habitat restoration area in both July and September (Table 1). Diversity averaged 1.64 and 0.96 in the proposed habitat restoration area in July and September, respectively. In

Table 2.--Abundance of major benthic invertebrate taxa/categories collected in a proposed habitat restoration area and an adjacent shallow subtidal habitat located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992. All values are mean numbers/m^2.

Taxon/category	July	September
PROPOSED HABITAT RESTORATION AREA[a]		
Bivalvia		
Corbicula fluminea	1,366	1,091
Amphipoda		
Corophium salmonis	1,168	8,195
Insecta		
Ceratopogonidae larvae	618	6,193
Others	267	447
Total	3,419	15,926
SHALLOW SUBTIDAL HABITAT[b]		
Oligochaeta	3,236	4,000
Oligochaeta egg cases	4,954	7,809
Gastropoda		
Lithoglyphus virens	468	764
Bivalvia		
Corbicula fluminea	1,770	5,258
Amphipoda		
Corophium salmonis	9,171	27,852
Insecta		
Chironomidae larvae	599	321
Ceratopogonidae larvae	312	521
Others	678	797
Total	21,188	47,322

[a] Data from 100 samples each in July and September were averaged to obtain the following values.
[b] Data from 99 samples each in July and September were averaged to obtain the following values.

the shallow subtidal habitat, H averaged 1.90 and 1.71 in July and September, respectively. The higher H values in the shallow subtidal habitat compared to the proposed habitat restoration area were due to the higher number of taxa/categories and/or the more uniform numerical abundances of taxa (i.e., E values were higher) in the shallow subtidal habitat.

Fishes and Shrimp

Eleven taxa, including 10 fish taxa and 1 shrimp taxon, were collected during the study (Appendix Table 4). Similar numbers and types of taxa were collected in July and September. Anadromous, marine, and freshwater fish species were collected in both the proposed habitat restoration area and shallow subtidal habitat. Anadromous species included American shad (Alosa sapidissima) and chinook salmon (Oncorhynchus tshawytscha). The two marine species were Pacific staghorn sculpin (Leptocottus armatus) and starry flounder (Platichthys stellatus), both of which tolerate low salinities. Juvenile starry flounder can live in fresh water for relatively long periods of time. Freshwater species collected during the surveys included two cyprinids, peamouth (Mylocheilus caurinus) and northern squawfish (Ptychocheilus oregonensis); prickly sculpin (Cottus asper); and threespine stickleback (Gasterosteus aculeatus). Although the threespine stickleback is included with freshwater fishes, it can also live in marine and brackish waters (Hart 1973).

Based on purse seine and shrimp trawl catches in the proposed habitat restoration area and shallow subtidal habitat, total fish densities in July were higher in the shallow subtidal habitat than in the proposed habitat restoration area (Table 3). In September, total fish densities were similar in the proposed habitat restoration area and the shallow subtidal habitat, assuming that the shrimp trawl was the most effective means of

Table 3.--Species composition and abundance of fishes and shrimp captured in a proposed habitat restoration area and an adjacent shallow subtidal habitat located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992. All values are mean numbers/hectare, except the trawl values for the shallow subtidal area are numbers/hectare.

Species	Proposed habitat restoration area		Shallow subtidal habitat	
	July	September	July	September
	PURSE SEINE			
American shad	13	0	0	50
Chinook salmon (subyr.)	335	0	369	0
Peamouth	0	0	101	180
Northern squawfish	0	0	4	4
Threespine stickleback	0	21	356	71
Prickly sculpin	0	0	8	4
Unidentified sculpin	0	0	0	4
Starry flounder	0	0	239	13
Total	348	21	1,077	326
	SHRIMP TRAWL			
American shad	5	76		18
Chinook salmon (subyr.)	0	1		0
Peamouth	68	545		500
Unidentified cyprinid	2	0		0
Threespine stickleback	2	0		0
Prickly sculpin	20	146		9
Pacific staghorn sculpin	5	13		0
Unidentified sculpin	1	0		0
Starry flounder	82	282		441
California bay shrimp	9	79		0
Total	194	1,142		968

collecting all species in September, except threespine stickleback (Table 3). Because of bottom depth differences (Appendix Table 5), it is difficult to compare fish catches, particularly purse seine catches, between the two areas. In the proposed habitat restoration area, the purse seine sampled only the upper portion of the water column, at most the top 4.6 m; however, in the shallow subtidal habitat, the purse seine sampled much of the water column and at times the bottom. Because juvenile salmon are typically surface-oriented even in deeper water, purse seine catches of subyearling chinook salmon can be legitimately compared between the two areas. Densities of subyearling chinook salmon were similar in the two areas in July, averaging 335 fish/ha and 369 fish/ha in the proposed habitat restoration area and shallow subtidal habitat, respectively (Table 3; Appendix Table 5). In September, no juvenile salmon were captured in the purse seine.

Catches of starry flounder, a species that uses both deep and shallow subtidal habitats, were higher in the shallow subtidal habitat (mean = 239 fish/ha in purse seine) than in the proposed habitat restoration area (mean = 82 fish/ha in shrimp trawl) in July. Estimated densities of starry flounder in July probably would have been higher if the shrimp trawl had been used in the shallow subtidal habitat, since the shrimp trawl is more effective in collecting starry flounder than the purse seine. In September, the mean density of starry flounder collected in the purse seine in the shallow subtidal habitat dropped to 13 fish/ha; however, the density of starry flounder estimated from the shrimp trawl was 441 fish/ha. In the proposed habitat restoration area, the mean density of starry flounder estimated from the shrimp trawl was 282 fish/ha.

Small numbers of California bay shrimp (Crangon franciscorum), a euryhaline species, were captured in the shrimp trawl in the proposed habitat restoration area in July and September (Table 3).

Length-frequency histograms of the most abundant fishes captured in both the proposed habitat restoration area and shallow subtidal habitat indicated that most fishes were juveniles (Figs. 4 and 5). All chinook salmon collected in the two areas were subyearlings. All starry flounder collected during the two surveys were juveniles, most of which were subyearlings and yearlings. With the exception of starry flounder, the length ranges of the most abundant species (by survey) in the two areas were similar.

Sediments

Median grain size was significantly higher in the proposed habitat restoration area than in the shallow subtidal habitat (ANOVA, $P < 0.05$; Table 4). There was no significant difference in median grain size between the July and September surveys ($P > 0.05$). Overall, median grain size in the proposed habitat restoration area and shallow subtidal habitat averaged 0.2150 mm and 0.1413 mm, respectively. In the proposed habitat restoration area, percent volatile solids were significantly lower than in the shallow subtidal habitat (ANOVA, $P < 0.05$). Percent volatile solids were not significantly different between July and September ($P > 0.05$). Overall, percent volatile solids in the proposed habitat restoration area and shallow subtidal habitat averaged 0.5 and 1.0, respectively. Mean percent silt/clay was higher in the shallow subtidal habitat (overall 8.5%) than in the proposed habitat restoration area (overall 0.2%) (Table 4). During each survey, three or four stations in the shallow subtidal habitat had unusually high silt/clay percentages.

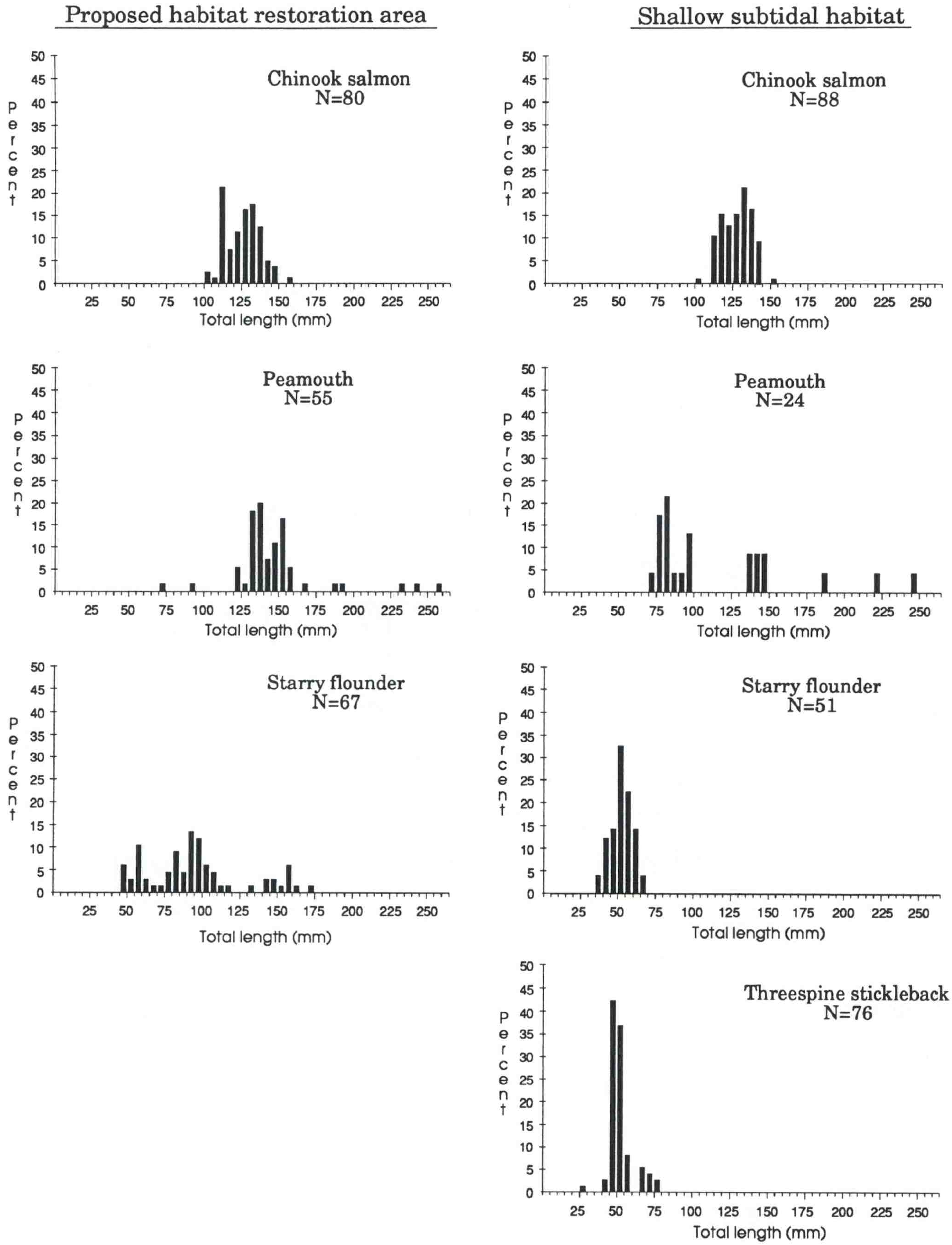

Figure 4.--Length-frequency distributions of the most abundant fishes collected in two areas between Miller Sands and Pillar Rock Island, Columbia River estuary, July 1992. N = the number of individuals measured.

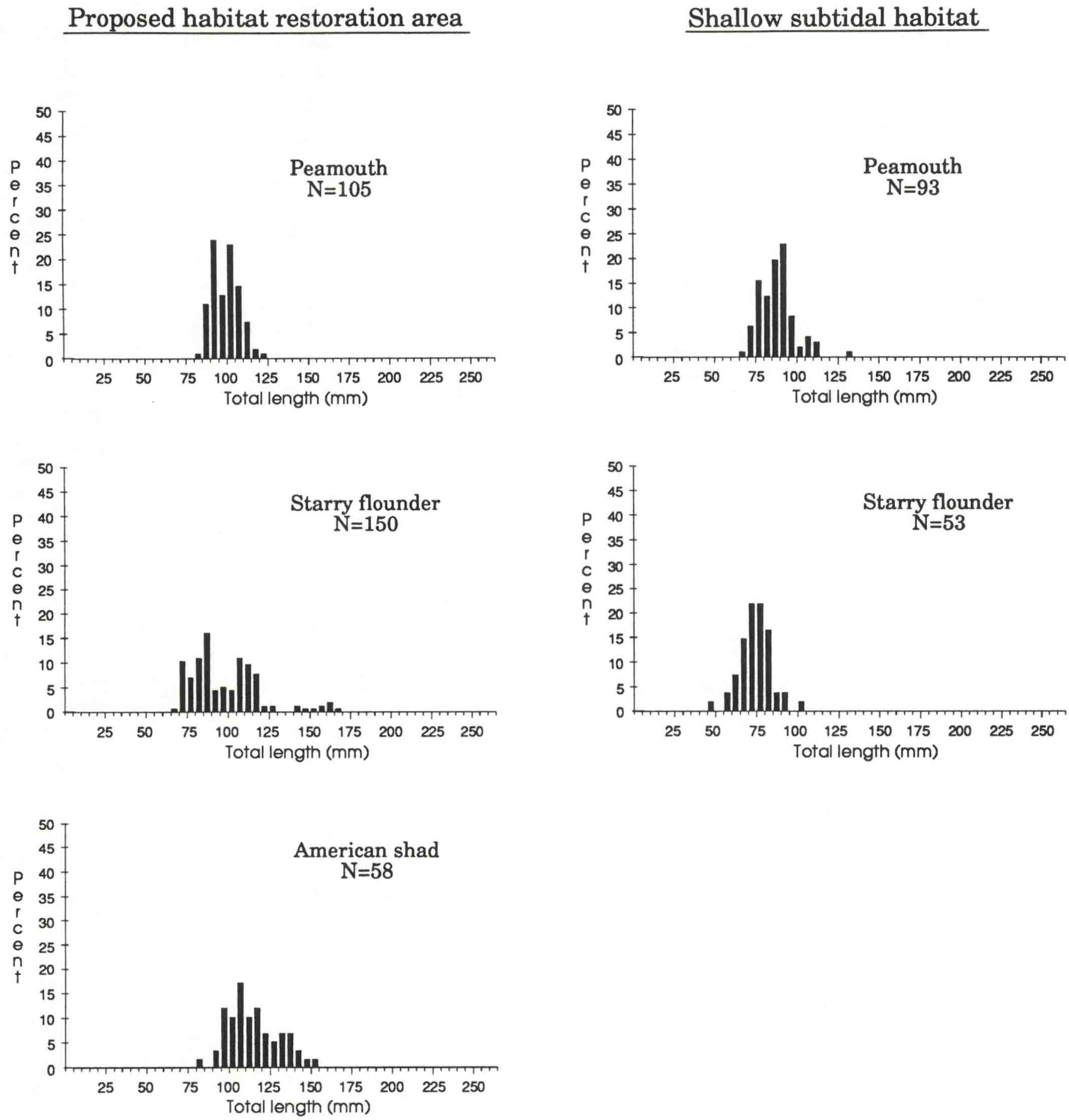

Figure 5.--Length frequency distributions of the most abundant fishes collected in two areas between Miller Sands and Pillar Rock Island, Columbia River estuary, September 1992. N = the number of individuals measured.

Table 4.--Sediment characteristics in a proposed habitat restoration area (Stations 1-10) and an adjacent shallow subtidal habitat (Stations 11-20) located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992.

	July			September		
Station	Median grain size (mm)	silt/clay (%)	Volatile solids (%)	Median grain size (mm)	silt/clay (%)	Volatile solids (%)
1	0.2500	0.1	0.5	0.3299	0.1	0.5
2	0.3299	0.1	0.5	0.3078	0.3	0.3
3	0.2872	0.4	0.4	0.3299	0.2	0.4
4	0.3299	0.3	0.4	0.2500	0.2	0.7
5	0.2031	0.1	0.6	0.2872	0.1	0.4
6	0.1436	0.0	0.6	0.1649	0.3	0.6
7	0.1436	0.1	0.5	0.1539	0.1	0.6
8	0.1250	0.3	0.5	0.1340	0.5	0.7
9	0.1539	0.2	0.5	0.1340	0.3	0.7
10	0.1088	0.1	0.8	0.1340	0.2	0.6
Mean	0.2075	0.2	0.5	0.2226	0.2	0.6
11	0.0583	30.3	2.6	0.0883	16.3	1.1
12	0.1166	12.5	0.9	0.1895	1.2	0.8
13	0.1649	5.7	0.8	0.1539	5.8	0.7
14	0.0825	7.5	1.4	0.1166	11.6	1.2
15	0.2031	3.5	0.7	0.1649	5.2	1.0
16	0.1088	13.9	1.0	0.1015	12.6	1.3
17	0.1166	12.0	1.0	0.1340	7.4	1.1
18	0.2031	0.3	0.5	0.1436	6.6	0.9
19	0.1539	4.3	0.7	0.2176	1.0	0.9
20	0.1539	7.7	0.8	0.1539	5.5	1.0
Mean	0.1362	9.8	1.0	0.1464	7.3	1.0

DISCUSSION

One of the most important means of comparing the habitat values of areas of the Columbia River estuary for fishes, particularly migrating juvenile salmonids, is to assess the standing crops of benthic invertebrates, particularly Corophium salmonis, an important food for juvenile salmonids (McCabe et al. 1983, 1986). Benthic invertebrate communities are relatively stable on a short-term basis, in contrast to fish communities in the Columbia River estuary, which change rapidly, often daily. In addition, it is unknown how fishes utilize the habitat in the two distinctly different areas. For example, juvenile salmonids in the proposed habitat restoration area may have been simply migrating through the area, whereas many of the juvenile salmonids in the shallow subtidal habitat may have slowed their migration and been actively feeding. We feel that if the proposed habitat restoration area was physically modified by proper placement of dredged material to create a habitat similar to the adjacent shallow subtidal habitat, the standing crop of C. salmonis would increase significantly, increasing the food supply for migrating juvenile salmonids.

Although C. salmonis constitutes a large part of the diet of juvenile salmonids in the Columbia River estuary, its importance can change temporally. McCabe et al. (1986) observed that C. salmonis was the dominant prey for subyearling chinook salmon in intertidal areas of the upper estuary from March through July; however, in August and September, Daphnia spp. and insects, respectively, were the dominant prey. Stomach analyses of a small number of juvenile chinook salmon collected in a shallow subtidal habitat adjacent to Rice Island in the Columbia River estuary indicated that C. salmonis was the dominant prey in August (Hinton et al. 1992a). In future research in the proposed habitat restoration area and the adjacent shallow subtidal habitat between

Miller Sands and Pillar Rock Island, it will be important to conduct biological surveys earlier in the year than in 1992 to assess the standing crops of C. salmonis.

Considering the limited research that was conducted in the proposed habitat restoration area and the adjacent shallow subtidal habitat between Miller Sands and Pillar Rock Island in 1992, it should be emphasized that the data provide only general descriptions of the proposed habitat restoration area and shallow subtidal habitat. Additional and more frequent sampling is needed to confirm the 1992 research results.

CONCLUSIONS AND RECOMMENDATIONS

Major differences between the proposed habitat restoration area and shallow subtidal habitat were identified in 1992. Total benthic invertebrate and C. salmonis densities were significantly higher in the shallow subtidal habitat than in the proposed habitat restoration area ($P < 0.05$). In addition, there were major differences in the sediment characteristics between the proposed habitat restoration area and the shallow subtidal habitat. Median grain size was significantly higher in the proposed habitat restoration area than in the shallow subtidal habitat, whereas percent volatile solids were significantly lower in the proposed habitat restoration area than in the shallow subtidal habitat. Percent silt/clay was also lower in the proposed habitat restoration area (mean 0.2%) than in the shallow subtidal habitat (mean 8.5%).

Although densities of juvenile salmonids in the proposed habitat restoration area and shallow subtidal habitat were similar in both months of this study, the shallow subtidal habitat is probably more valuable to salmonids because of the larger standing crops of C. salmonis.

Results from 1992 research suggest that the habitat value of the proposed habitat restoration area could be enhanced by proper placement and stabilization of dredged material from the Columbia River. However, additional sampling is required to substantiate 1992 results. In addition, hydraulic modeling studies in progress by the COE need to be completed to determine if any adverse changes in water circulation in the Columbia River estuary would result from the proposed habitat modification.

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APPENDIX

Appendix Table 1.--Station locations in a proposed habitat restoration area (Stations 1-10) and an adjacent shallow subtidal habitat (Stations 11-20) located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992.

BENTHIC INVERTEBRATE AND SEDIMENT SAMPLING

Station	Latitude	Longitude
1	46°15.305	123°37.254
2	15.301	37.024
3	15.297	36.795
4	15.290	36.565
5	15.283	36.335
6	15.126	37.276
7	15.149	37.047
8	15.171	36.808
9	15.190	36.569
10	15.208	36.330
11	46°14.896	123°37.276
12	14.929	37.038
13	14.959	36.802
14	14.989	36.572
15	15.022	36.341
16	14.799	37.274
17	14.829	37.036
18	14.862	36.802
19	14.896	36.564
20	14.922	36.335

FISH SAMPLING

Station	Beginning		Ending	
	Latitude	Longitude	Latitude	Longitude
	Trawling			
TR1	46°15.279	123°37.908	46°15.280	123°36.412
TR1	15.228	37.994	15.239	36.520
TR3	15.156	37.024	15.176	36.582
	Purse Seining			
PS1	46°15.216	123°37.157		
PS2	15.230	36.800		
PS3	15.238	36.411		
PS4	14.851	37.157		
PS5	14.903	36.800		
PS6	14.955	36.432		

Appendix Table 2.--Invertebrate taxa/categories found in a proposed habitat restoration area (Restor.) and an adjacent shallow subtidal habitat (Subtd.) located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992.

Taxon/category	JULY		SEPTEMBER	
	Restor.	Subtd.	Restor.	Subtd.
Hydra spp.	x	x		
Turbellaria		x	x	x
Polychaeta				
Neanthes limnicola	x	x	x	x
Oligochaeta	x	x	x	x
Oligochaeta egg cases		x		x
Gastropoda				
Juga plicifera		x		x
Lithoglyphus virens		x		x
Bivalvia				
Corbicula fluminea	x	x	x	x
Ostracoda		x		x
Mysidacea				
Neomysis mercedis	x			x
Amphipoda				
Corophium salmonis	x	x	x	x
Pontoporeia hoyi	x	x		x
Isopoda				
Porcellio scaber	x			
Saduria entomon	x		x	
Cladocera	x	x	x	
Daphnia spp.	x	x	x	x
Copepoda	x	x	x	x
Calanoida	x	x	x	x
Cyclopoida	x	x		
Insecta				
Odonata				x
Diptera adult		x	x	
Chironomidae larvae	x	x	x	x
Chironomidae pupae	x	x		
Chironomidae adult	x			
Ceratopogonidae		x		
Ceratopogonidae larvae	x	x	x	x
Collembola	x			
Miscellaneous				
Arachnida	x	x	x	x
Total number of taxa/categories	20	22	14	18

Appendix Table 3.--Summaries of benthic invertebrate surveys (by station) conducted in July and September 1992 in a proposed habitat restoration area (Stations 1-10) and an adjacent shallow subtidal habitat (Stations 11-20) located between Miller Sands and Pillar Rock Island, Columbia River estuary.

Station: 1   Date: 13 Jul 92   Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	2	20.0	171.8	362.2
Corbicula fluminea	26	80.0	2,233.4	2,297.8
Corophium salmonis	8	50.0	687.2	887.2
Ceratopogonidae larvae	9	50.0	773.1	1,028.4

Number of taxa/categories: 4

Mean number/sample: 4.5   Standard deviation/sample: 3.3

Mean number/m² : 3,865.5   Standard deviation: 2,841.7

H = 1.56   E = 0.78

Station: 2   Date: 13 Jul 92   Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Corbicula fluminea	26	80.0	2,233.4	2,225.3
Corophium salmonis	3	30.0	257.7	414.9
Ceratopogonidae larvae	5	20.0	429.5	927.8

Number of taxa/categories: 3

Mean number/sample: 3.4   Standard deviation/sample: 2.7

Mean number/m² : 2,920.6   Standard deviation: 2,297.8

H = 1.01   E = 0.64

Appendix Table 3.--Continued.

Station: 3 Date: 13 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Corbicula fluminea	6	30.0	515.4	1,086.5
Corophium salmonis	26	90.0	2,233.4	1,727.5
Ceratopogonidae larvae	5	40.0	429.5	607.4
Collembola	1	10.0	85.9	271.6

Number of taxa/categories: 4

Mean number/sample: 3.8 Standard deviation/sample: 2.4

Mean number/m^2 : 3,264.2 Standard deviation: 2,056.8

H = 1.32 E = 0.66

Station: 4 Date: 13 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	1	10.0	85.9	271.6
Corbicula fluminea	12	40.0	1,030.8	1,391.0
Corophium salmonis	1	10.0	85.9	271.6
Ceratopogonidae larvae	7	60.0	601.3	579.8

Number of taxa/categories: 4

Mean number/sample: 2.1 Standard deviation/sample: 2.3

Mean number/m^2 : 1,803.9 Standard deviation: 1,960.9

H = 1.41 E = 0.70

Appendix Table 3.--Continued.

Station: 5 Date: 13 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	1	10.0	85.9	271.6
Corbicula fluminea	17	60.0	1,460.3	1,672.0
Neomysis mercedis	2	20.0	171.8	362.2
Corophium salmonis	4	20.0	343.6	829.9
Porcellio scaber	1	10.0	85.9	271.6
Ceratopogonidae larvae	1	10.0	85.9	271.6

Number of taxa/categories: 6

Mean number/sample: 2.6 Standard deviation/sample: 2.5

Mean number/m^2 : 2,233.4 Standard deviation: 2,150.3

H = 1.64 E = 0.64

Station: 6 Date: 13 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Hydra spp.	1	10.0	85.9	271.6
Corbicula fluminea	17	80.0	1,460.3	1,517.8
Corophium salmonis	16	100.0	1,374.4	600.6
Pontoporeia hoyi	1	10.0	85.9	271.6
Saduria entomon	1	10.0	85.9	271.6
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	6	40.0	515.4	724.4

Number of taxa/categories: 7

Mean number/sample: 4.3 Standard deviation/sample: 2.3

Mean number/m^2 : 3,693.7 Standard deviation: 1,944.1

H = 1.96 E = 0.70

Appendix Table 3.--Continued.

Station: 7 Date: 13 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	2	10.0	171.8	543.3
Corbicula fluminea	22	60.0	1,889.8	2,489.6
Corophium salmonis	22	90.0	1,889.8	1,448.7
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	12	70.0	1,030.8	1,130.9
Collembola	1	10.0	85.9	271.6

Number of taxa/categories: 6

Mean number/sample: 6.0 Standard deviation/sample: 3.9

Mean number/m^2 : 5,153.9 Standard deviation: 3,363.6

H = 1.89 E = 0.73

Station: 8 Date: 13 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Hydra spp.	2	20.0	171.8	362.2
Neanthes limnicola	1	10.0	85.9	271.6
Oligochaeta	1	10.0	85.9	271.6
Corbicula fluminea	6	30.0	515.4	923.4
Corophium salmonis	27	90.0	2,319.3	1,405.6
Chironomidae adult	1	10.0	85.9	271.6
Chironomidae pupae	1	10.0	85.9	271.6
Ceratopogonidae larvae	4	40.0	343.6	443.6

Number of taxa/categories: 8

Mean number/sample: 4.3 Standard deviation/sample: 2.5

Mean number/m^2 : 3,693.7 Standard deviation: 2,106.0

H = 1.85 E = 0.62

Appendix Table 3.--Continued.

Station: 9   Date: 13 Jul 92   Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Corbicula fluminea	15	50.0	1,288.5	1,528.6
Corophium salmonis	5	40.0	429.5	607.4
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	4	30.0	343.6	600.6
Arachnida	1	10.0	85.9	271.6

Number of taxa/categories: 5

Mean number/sample: 2.6   Standard deviation/sample: 2.7

Mean number/m^2 : 2,233.4   Standard deviation: 2,297.8

H = 1.69   E = 0.73

Station: 10   Date: 13 Jul 92   Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	3	30.0	257.7	414.9
Corbicula fluminea	12	60.0	1,030.8	1,055.9
Corophium salmonis	24	90.0	2,061.6	1,159.5
Chironomidae larvae	1	10.0	85.9	271.6
Chironomidae pupae	3	30.0	257.7	414.9
Ceratopogonidae larvae	19	80.0	1,632.1	1,309.0

Number of taxa/categories: 6

Mean number/sample: 6.2   Standard deviation/sample: 2.6

Mean number/m^2 : 5,325.7   Standard deviation: 2,247.3

H = 2.03   E = 0.79

Appendix Table 3.--Continued.

Station: 11 Date: 14 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	11	60.0	944.9	1,028.4
Neanthes limnicola	7	50.0	601.3	707.2
Oligochaeta	72	100.0	6,184.7	3,358.7
Lithoglyphus virens	10	60.0	859.0	905.5
Corbicula fluminea	6	40.0	515.4	724.4
Ostracoda	10	50.0	859.0	1,071.3
Corophium salmonis	279	100.0	23,965.8	5,646.6
Pontoporeia hoyi	1	10.0	85.9	271.6
Chironomidae larvae	17	70.0	1,460.3	1,346.1
Oligochaeta egg cases	2	20.0	171.8	362.2

Number of taxa/categories: 10

Mean number/sample: 41.5 Standard deviation/sample: 5.3

Mean number/m^2 : 35,648.1 Standard deviation: 4,567.8

H = 1.66 E = 0.50

Station: 12 Date: 14 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Oligochaeta	51	90.0	4,380.8	3,676.9
Corbicula fluminea	24	100.0	2,061.6	829.9
Corophium salmonis	28	90.0	2,405.2	1,557.8
Chironomidae larvae	3	20.0	257.7	579.8
Chironomidae pupae	1	10.0	85.9	271.6
Ceratopogonidae larvae	5	50.0	429.5	452.7
Oligochaeta egg cases	80	90.0	6,871.9	5,138.0

Number of taxa/categories: 7

Mean number/sample: 19.2 Standard deviation/sample: 7.4

Mean number/m^2 : 16,492.6 Standard deviation: 6,387.1

H = 2.08 E = 0.74

Appendix Table 3.--Continued.

Station: 13 Date: 14 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Hydra spp.	1	10.0	85.9	271.6
Turbellaria	1	10.0	85.9	271.6
Oligochaeta	18	90.0	1,546.2	975.2
Lithoglyphus virens	1	10.0	85.9	271.6
Corbicula fluminea	11	60.0	944.9	945.3
Corophium salmonis	52	100.0	4,466.7	1,267.6
Chironomidae larvae	3	30.0	257.7	414.9
Chironomidae pupae	1	10.0	85.9	271.6
Ceratopogonidae larvae	10	70.0	859.0	809.9
Oligochaeta egg cases	14	70.0	1,202.6	1008.3

Number of taxa/categories: 10

Mean number/sample: 11.2 Standard deviation/sample: 3.9

Mean number/m² : 9,620.7 Standard deviation: 3,358.7

H = 2.34 E = 0.70

Station: 14 Date: 14 Jul 92 Sample size: 9

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Neanthes limnicola	1	11.1	95.4	286.3
Oligochaeta	46	100.0	4,390.4	2,557.0
Lithoglyphus virens	6	44.4	572.7	743.9
Corbicula fluminea	10	55.6	954.4	1,090.3
Ostracoda	2	22.2	190.9	378.8
Corophium salmonis	57	100.0	5,440.3	2,429.6
Chironomidae larvae	3	33.3	286.3	429.5
Chironomidae pupae	1	11.1	95.4	286.3
Ceratopogonidae larvae	1	11.1	95.4	286.3
Oligochaeta egg cases	233	100.0	22,238.3	4,942.8
Arachnida	1	11.1	95.4	286.3

Number of taxa/categories: 11

Mean number/sample: 40.1 Standard deviation/sample: 7.6

Mean number/m² : 34,455.0 Standard deviation: 6,505.7

H = 1.64 E = 0.47

Appendix Table 3.--Continued.

Station: 15 Date: 14 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Oligochaeta	5	50.0	429.5	452.7
Corbicula fluminea	59	90.0	5,068.0	4,216.9
Corophium salmonis	3	20.0	257.7	579.8
Pontoporeia hoyi	1	10.0	85.9	271.6
Ceratopogonidae larvae	1	10.0	85.9	271.6
Oligochaeta egg cases	6	50.0	515.4	600.6

Number of taxa/categories: 6

Mean number/sample: 7.5 Standard deviation/sample: 5.1

Mean number/m^2 : 6,442.4 Standard deviation: 4,421.9

H = 1.18 E = 0.45

Station: 16 Date: 14 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	1	10.0	85.9	271.6
Neanthes limnicola	6	50.0	515.4	600.6
Oligochaeta	80	100.0	6,871.9	3,733.3
Juga plicifera	2	10.0	171.8	543.3
Lithoglyphus virens	5	20.0	429.5	927.8
Corbicula fluminea	21	50.0	1,803.9	2,342.0
Ostracoda	1	10.0	85.9	271.6
Corophium salmonis	219	100.0	18,811.9	2,759.8
Diptera adult	1	10.0	85.9	271.6
Chironomidae larvae	6	60.0	515.4	443.6
Oligochaeta egg cases	111	100.0	9,534.8	3,275.9

Number of taxa/categories: 11

Mean number/sample: 45.3 Standard deviation/sample: 6.8

Mean number/m^2 : 38,912.2 Standard deviation: 5,826.7

H = 1.98 E = 0.57

Appendix Table 3.--Continued.

Station: 17 Date: 14 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	1	10.0	85.9	271.6
Neanthes limnicola	2	10.0	171.8	543.3
Oligochaeta	20	80.0	1,718.0	1,619.7
Lithoglyphus virens	4	40.0	343.6	443.6
Corbicula fluminea	17	100.0	1,460.3	910.0
Ostracoda	3	20.0	257.7	579.8
Corophium salmonis	186	100.0	15,977.2	4,173.0
Chironomidae larvae	25	80.0	2,147.5	1,581.3
Chironomidae pupae	3	30.0	257.7	414.9
Oligochaeta egg cases	1	10.0	85.9	271.6

Number of taxa/categories: 10

Mean number/sample: 26.2 Standard deviation/sample: 6.6

Mean number/m² : 22,505.5 Standard deviation: 5,651.7

H = 1.57 E = 0.47

Station: 18 Date: 14 Jul 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	3	30.0	257.7	414.9
Lithoglyphus virens	1	10.0	85.9	271.6
Corbicula fluminea	11	50.0	944.9	1,370.2
Corophium salmonis	37	100.0	3,178.3	1,346.1
Chironomidae pupae	2	20.0	171.8	362.2
Ceratopogonidae	1	10.0	85.9	271.6
Ceratopogonidae larvae	8	40.0	687.2	975.2
Oligochaeta egg cases	1	10.0	85.9	271.6

Number of taxa/categories: 8

Mean number/sample: 6.4 Standard deviation/sample: 2.9

Mean number/m² : 5,497.5 Standard deviation: 2,502.7

H = 1.91 E = 0.64

Appendix Table 3.--Continued.

Station: 19　　Date: 14 Jul 92　　Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	2	20.0	171.8	362.2
Oligochaeta	40	80.0	3,436.0	4,089.6
Lithoglyphus virens	4	10.0	343.6	1,086.5
Corbicula fluminea	27	80.0	2,319.3	2,026.7
Ostracoda	1	10.0	85.9	271.6
Corophium salmonis	49	100.0	4,209.1	945.3
Chironomidae larvae	6	40.0	515.4	724.4
Chironomidae pupae	2	20.0	171.8	362.2
Ceratopogonidae larvae	5	50.0	429.5	452.7
Oligochaeta egg cases	4	30.0	343.6	600.6

Number of taxa/categories: 10

Mean number/sample: 14.0　　Standard deviation/sample: 7.3

Mean number/m^2 : 12,025.9　　Standard deviation: 6,260.1

H = 2.39　　E = 0.72

Station: 20　　Date: 14 Jul 92　　Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	2	20.0	171.8	362.2
Neanthes limnicola	1	10.0	85.9	271.6
Oligochaeta	38	90.0	3,264.2	4,045.3
Lithoglyphus virens	23	90.0	1,975.7	1,283.7
Corbicula fluminea	18	90.0	1,546.2	1,130.9
Ostracoda	5	40.0	429.5	607.4
Corophium salmonis	147	100.0	12,627.2	2,921.4
Pontoporeia hoyi	2	20.0	171.8	362.2
Chironomidae larvae	6	30.0	515.4	923.4
Ceratopogonidae larvae	6	50.0	515.4	600.6
Oligochaeta egg cases	119	80.0	10,222.0	5,846.3
Arachnida	1	10.0	85.9	271.6

Number of taxa/categories: 12

Mean number/sample: 36.8　　Standard deviation/sample: 8.6

Mean number/m^2 : 31,610.8　　Standard deviation: 7,353.7

H = 2.26　　E = 0.63

Appendix Table 3.--Continued.

Station: 1 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	3	20.0	257.7	579.8
Oligochaeta	1	10.0	85.9	271.6
<u>Corbicula fluminea</u>	16	80.0	1,374.4	1,471.2
<u>Corophium salmonis</u>	25	70.0	2,147.5	2,663.0
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	135	100.0	11,596.4	4,531.8
Arachnida	1	10.0	85.9	271.6

Number of taxa/categories: 7

Mean number/sample: 18.2 Standard deviation/sample: 8.1

Mean number/m^2 : 15,633.6 Standard deviation: 6,952.6

H = 1.24 E = 0.44

Station: 2 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	1	10.0	85.9	271.6
<u>Corbicula fluminea</u>	17	70.0	1,460.3	1,672.0
<u>Corophium salmonis</u>	29	100.0	2,491.1	1,831.2
Ceratopogonidae larvae	85	100.0	7,301.4	2,504.4
Arachnida	1	10.0	85.9	271.6

Number of taxa/categories: 5

Mean number/sample: 13.3 Standard deviation/sample: 2.5

Mean number/m^2 : 11,424.6 Standard deviation: 2,106.0

H = 1.38 E = 0.59

Appendix Table 3.--Continued.

Station: 3 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	13	10.0	1,116.7	3,531.3
Corbicula fluminea	18	90.0	1,546.2	1,201.2
Corophium salmonis	14	60.0	1,202.6	1,293.2
Ceratopogonidae larvae	169	100.0	14,516.9	4,764.6

Number of taxa/categories: 4

Mean number/sample: 21.4 Standard deviation/sample: 8.1

Mean number/m^2 : 18,382.4 Standard deviation: 6,921.8

H = 1.07 E = 0.54

Station: 4 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	1	10.0	85.9	271.6
Neanthes limnicola	1	10.0	85.9	271.6
Corbicula fluminea	17	70.0	1,460.3	1,570.9
Corophium salmonis	30	90.0	2,577.0	2,142.7
Saduria entomon	1	10.0	85.9	271.6
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	168	100.0	14,431.0	6,098.2

Number of taxa/categories: 7

Mean number/sample: 21.9 Standard deviation/sample: 7.9

Mean number/m^2 : 18,811.9 Standard deviation: 6,757.0

H = 1.11 E = 0.40

Appendix Table 3.--Continued.

Station: 5 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number $/m^2$	Standard deviation $/m^2$
Turbellaria	3	30.0	257.7	414.9
Oligochaeta	1	10.0	85.9	271.6
Corbicula fluminea	14	60.0	1,202.6	1,414.4
Corophium salmonis	8	50.0	687.2	789.4
Ceratopogonidae larvae	142	100.0	12,197.7	5,086.7

Number of taxa/categories: 5

Mean number/sample: 16.8 Standard deviation/sample: 7.1

Mean number/m^2 : 14,431.0 Standard deviation: 6,111.7

H = 0.86 E = 0.37

Station: 6 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number $/m^2$	Standard deviation $/m^2$
Turbellaria	10	50.0	859.0	1,343.0
Corbicula fluminea	13	80.0	1,116.7	814.9
Corophium salmonis	382	100.0	32,813.4	8,177.2
Diptera adult	2	20.0	171.8	362.2
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	13	70.0	1,116.7	996.0

Number of taxa/categories: 6

Mean number/sample: 42.1 Standard deviation/sample: 10.3

Mean number/m^2 : 36,163.5 Standard deviation: 8,875.8

H = 0.62 E = 0.24

Appendix Table 3.--Continued.

Station: 7 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Corbicula fluminea	13	90.0	1,116.7	579.8
Corophium salmonis	34	100.0	2,920.6	1,525.9
Chironomidae larvae	2	10.0	171.8	543.3
Ceratopogonidae larvae	2	20.0	171.8	362.2

Number of taxa/categories: 4

Mean number/sample: 5.1 Standard deviation/sample: 2.5

Mean number/m^2 : 4,380.8 Standard deviation: 2,159.8

H = 1.26 E = 0.63

Station: 8 Date: 10 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	2	20.0	171.8	362.2
Neanthes limnicola	1	10.0	85.9	271.6
Oligochaeta	1	10.0	85.9	271.6
Corbicula fluminea	9	50.0	773.1	1,105.2
Corophium salmonis	326	100.0	28,003.1	6,196.9
Diptera adult	1	10.0	85.9	271.6
Ceratopogonidae larvae	1	10.0	85.9	271.6

Number of taxa/categories: 7

Mean number/sample: 34.1 Standard deviation/sample: 6.9

Mean number/m^2 : 29,291.6 Standard deviation: 5,888.2

H = 0.34 E = 0.12

Appendix Table 3.--Continued.

Station: 9   Date: 10 Sep 92   Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Oligochaeta	1	10.0	85.9	271.6
Corbicula fluminea	4	30.0	343.6	600.6
Corophium salmonis	74	100.0	6,356.5	3,344.1
Chironomidae larvae	1	10.0	85.9	271.6

Number of taxa/categories: 4

Mean number/sample: 8.0   Standard deviation/sample: 3.8

Mean number/m^2 : 6,871.9   Standard deviation: 3,264.7

H = 0.48   E = 0.24

Station: 10   Date: 10 Sep 92   Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Corbicula fluminea	6	40.0	515.4	724.4
Corophium salmonis	32	100.0	2,748.8	1,504.3
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	6	30.0	515.4	1,086.5

Number of taxa/categories: 4

Mean number/sample: 4.5   Standard deviation/sample: 2.9

Mean number/m^2 : 3,865.5   Standard deviation: 2,504.4

H = 1.25   E = 0.62

Appendix Table 3.--Continued.

Station: 11 | Date: 11 Sep 92 | Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Neanthes limnicola	2	20.0	171.8	362.2
Oligochaeta	68	100.0	5,841.1	3,157.4
Lithoglyphus virens	12	40.0	1,030.8	1,708.4
Corbicula fluminea	84	100.0	7,215.5	3,089.2
Ostracoda	13	50.0	1,116.7	1,570.9
Corophium salmonis	276	100.0	23,708.1	8,486.2
Pontoporeia hoyi	1	10.0	85.9	271.6
Chironomidae larvae	12	80.0	1,030.8	789.4
Ceratopogonidae larvae	1	10.0	85.9	271.6
Oligochaeta egg cases	91	100.0	7,816.8	4,950.3
Arachnida	1	10.0	85.9	271.6

Number of taxa/categories: 11

Mean number/sample: 56.1 Standard deviation/sample: 18.2

Mean number/m^2 : 48,189.3 Standard deviation: 15,653.9

H = 2.15 E = 0.62

Station: 12 | Date: 11 Sep 92 | Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	5	20.0	429.5	927.8
Oligochaeta	81	100.0	6,957.8	4,730.1
Corbicula fluminea	52	100.0	4,466.7	1,267.6
Neomysis mercedis	2	20.0	171.8	362.2
Corophium salmonis	538	100.0	46,213.7	7,723.5
Chironomidae larvae	2	10.0	171.8	543.3
Ceratopogonidae larvae	2	20.0	171.8	362.2
Invertebrate eggs	8	40.0	687.2	1,330.7
Arachnida	1	10.0	85.9	271.6

Number of taxa/categories: 9

Mean number/sample: 69.1 Standard deviation/sample: 13.0

Mean number/m^2 : 59,356.2 Standard deviation: 11,159.2

H = 1.14 E = 0.36

Appendix Table 3.--Continued.

Station: 13 Date: 11 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
Turbellaria	6	40.0	515.4	829.9
Oligochaeta	61	100.0	5,239.8	3,446.7
<u>Lithoglyphus virens</u>	3	30.0	257.7	414.9
<u>Corbicula fluminea</u>	31	100.0	2,662.9	854.2
<u>Corophium salmonis</u>	524	100.0	45,011.1	5,540.3
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	4	30.0	343.6	600.6
Oligochaeta egg cases	66	100.0	5,669.3	3,511.5

Number of taxa/categories: 8

Mean number/sample: 69.6 Standard deviation/sample: 7.7

Mean number/m^2 : 59,785.7 Standard deviation: 6,631.5

H = 1.29 E = 0.43

Station: 14 Date: 11 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m²	Standard deviation /m²
<u>Neanthes limnicola</u>	1	10.0	85.9	271.6
Oligochaeta	60	100.0	5,153.9	2,561.0
<u>Juga plicifera</u>	2	20.0	171.8	362.2
<u>Lithoglyphus virens</u>	11	60.0	944.9	1,105.2
<u>Corbicula fluminea</u>	23	90.0	1,975.7	1,570.9
Ostracoda	1	10.0	85.9	271.6
<u>Corophium salmonis</u>	379	100.0	32,555.7	3,122.2
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	1	10.0	85.9	271.6
Odonata	1	10.0	85.9	271.6
Oligochaeta egg cases	174	100.0	14,946.4	4,053.4

Number of taxa/categories: 11

Mean number/sample: 65.4 Standard deviation/sample: 6.4

Mean number/m^2 : 56,177.9 Standard deviation: 5,510.6

H = 1.65 E = 0.48

Appendix Table 3.--Continued.

Station: 15 Date: 11 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Neanthes limnicola	1	10.0	85.9	271.6
Oligochaeta	9	70.0	773.1	633.8
Corbicula fluminea	78	100.0	6,700.1	2,828.7
Corophium salmonis	77	90.0	6,614.2	3,531.3
Chironomidae larvae	10	60.0	859.0	905.5
Ceratopogonidae larvae	3	30.0	257.7	414.9
Oligochaeta egg cases	10	80.0	859.0	572.7

Number of taxa/categories: 7

Mean number/sample: 18.8 Standard deviation/sample: 6.2

Mean number/m^2 : 16,149.0 Standard deviation: 5,353.7

H = 1.85 E = 0.66

Station: 16 Date: 11 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number /m^2	Standard deviation /m^2
Turbellaria	2	20.0	171.8	362.2
Neanthes limnicola	1	10.0	85.9	271.6
Oligochaeta	51	90.0	4,380.8	2,818.6
Juga plicifera	3	30.0	257.7	414.9
Lithoglyphus virens	14	70.0	1,202.6	1,159.5
Corbicula fluminea	88	100.0	7,559.1	2,096.3
Ostracoda	26	90.0	2,233.4	1,471.2
Corophium salmonis	257	100.0	22,076.0	4,343.4
Oligochaeta egg cases	120	100.0	10,307.9	5,726.6

Number of taxa/categories: 9

Mean number/sample: 56.2 Standard deviation/sample: 10.2

Mean number/m^2 : 48,275.2 Standard deviation: 8,776.8

H = 2.15 E = 0.68

Appendix Table 3.--Continued.

Station: 17 Date: 11 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number $/m^2$	Standard deviation $/m^2$
Oligochaeta	44	100.0	3,779.6	1,414.4
Lithoglyphus virens	17	90.0	1,460.3	814.9
Corbicula fluminea	75	100.0	6,442.4	3,952.0
Ostracoda	1	10.0	85.9	271.6
Corophium salmonis	43	100.0	3,693.7	1,813.2
Oligochaeta egg cases	137	100.0	11,768.2	3,989.1

Number of taxa/categories: 6

Mean number/sample: 31.7 Standard deviation/sample: 7.7

Mean number/m^2 : 27,230.0 Standard deviation: 6,629.6

H = 2.05 E = 0.79

Station: 18 Date: 11 Sep 92 Sample size: 9

Taxon/category	Total number	Frequency of occurrence (%)	Mean number $/m^2$	Standard deviation $/m^2$
Oligochaeta	29	100.0	2,767.9	1,272.5
Lithoglyphus virens	4	22.2	381.8	757.6
Corbicula fluminea	43	100.0	4,104.1	2,304.0
Ostracoda	2	22.2	190.9	378.8
Corophium salmonis	238	100.0	22,715.5	6,181.0
Chironomidae larvae	2	11.1	190.9	572.7
Ceratopogonidae larvae	6	33.3	572.7	859.0
Oligochaeta egg cases	114	100.0	10,880.5	5,566.9

Number of taxa/categories: 8

Mean number/sample: 48.7 Standard deviation/sample: 14.3

Mean number/m^2 : 41,804.2 Standard deviation: 12,268.8

H = 1.79 E = 0.60

Appendix Table 3.--Continued.

Station: 19 Date: 11 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number $/m^2$	Standard deviation $/m^2$
Turbellaria	6	30.0	515.4	923.4
Oligochaeta	21	80.0	1,803.9	1,370.2
Lithoglyphus virens	3	20.0	257.7	579.8
Corbicula fluminea	35	90.0	3,006.5	1,952.5
Corophium salmonis	506	100.0	43,464.9	5,657.5
Chironomidae larvae	8	60.0	687.2	789.4
Ceratopogonidae larvae	42	100.0	3,607.8	1,708.4
Oligochaeta egg cases	1	10.0	85.9	271.6

Number of taxa/categories: 8

Mean number/sample: 62.2 Standard deviation/sample: 8.6

Mean number/m^2 : 53,429.2 Standard deviation: 7,420.3

H = 1.10 E = 0.37

Station: 20 Date: 11 Sep 92 Sample size: 10

Taxon/category	Total number	Frequency of occurrence (%)	Mean number $/m^2$	Standard deviation $/m^2$
Turbellaria	7	50.0	601.3	814.9
Oligochaeta	37	100.0	3,178.3	814.9
Juga plicifera	1	10.0	85.9	271.6
Lithoglyphus virens	24	90.0	2,061.6	1,008.3
Corbicula fluminea	97	100.0	8,332.2	3,085.2
Ostracoda	5	50.0	429.5	452.7
Corophium salmonis	372	100.0	31,954.4	9,850.8
Chironomidae larvae	1	10.0	85.9	271.6
Ceratopogonidae larvae	1	10.0	85.9	271.6
Oligochaeta egg cases	179	100.0	15,375.9	5,747.3
Arachnida	1	10.0	85.9	271.6

Number of taxa/categories: 11

Mean number/sample: 72.5 Standard deviation/sample: 16.6

Mean number/m^2 : 62,276.8 Standard deviation: 14,243.3

H = 1.93 E = 0.56

Appendix Table 4.--Fish and shrimp taxa found in a proposed habitat restoration area and an adjacent shallow subtidal habitat located between Miller Sands and Pillar Rock Island, Columbia River estuary, July and September 1992.

Scientific name	Common name	July	September
Clupeidae			
Alosa sapidissima	American shad	x	x
Cyprinidae	Unid. cyprinid	x	
Mylocheilus caurinus	Peamouth	x	x
Ptychocheilus oregonensis	Northern squawfish	x	
Salmonidae			
Oncorhynchus tshawytscha	Chinook salmon	x	x
Gasterosteidae			
Gasterosteus aculeatus	Threespine stickleback	x	x
Cottidae	Unid. sculpin	x	x
Cottus asper	Prickly sculpin	x	x
Leptocottus armatus	Pacific staghorn sculpin	x	x
Pleuronectidae			
Platichthys stellatus	Starry flounder	x	x
Crangonidae			
Crangon franciscorum	California bay shrimp	x	x
	Total number of taxa	11	9

Appendix Table 5.--Summaries of individual fishing efforts (by station) conducted in July and September 1992 in a proposed habitat restoration area and an adjacent shallow subtidal habitat located between Miller Sands and Pillar Rock Island, Columbia River estuary.

Station:TR1
Gear: 8-m trawl
Date: 28 Jul 1992
Time: 1126
Tide stage: Flood
Depth: 10.4 m
Distance traveled: 543 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	1	75	4	276
Peamouth	3	133	11	490
Prickly sculpin	1	11	4	41
Starry flounder	5	154	18	567
TOTALS	10	373	37	1,374

H = 1.69 E = 0.84

Station:TR2
Gear: 8-m trawl
Date: 28 Jul 1992
Time: 1038
Tide stage: Flood
Depth: 9.1 m
Distance traveled: 556 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	2	82	7	295
Peamouth	4	65	14	234
Unidentified cyprinid	2	2	7	7
Prickly sculpin	6	95	22	342
Starry flounder	21	262	76	942
TOTALS	35	506	126	1,820

H = 1.71 E = 0.74

Appendix Table 5.--Continued.

Station:TR3
Gear: 8-m trawl
Date: 28 Jul 1992
Time: 1059
Tide stage: Flood
Depth: 9.1 m
Distance traveled: 537 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	1	0	4	0
Peamouth	48	1,486	179	5,534
Threespine stickleback	2	0	7	0
Prickly sculpin	9	49	34	182
Pacific staghorn sculpin	4	47	15	175
Unidentified sculpin	1	0	4	0
Starry flounder	41	375	153	1,397
California bay shrimp	7	0	26	0
TOTALS	113	1,957	422	7,288

H = 1.99 E = 0.66

Station:PS1
Gear: 100-m purse seine
Date: 29 Jul 1992
Time: 1145
Tide stage: Flood
Depth: 7.6 m
Turbidity: 2.0 NTU
Temperature: 22.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	2	11	25	138
Chinook salmon (subyear.)	45	804	566	10,113
TOTALS	47	815	591	10,251

H = 0.25 E = 0.25

Appendix Table 5.--Continued.

Station:PS2
Gear: 100-m purse seine
Date: 29 Jul 1992
Time: 1100
Tide stage: Flood
Depth: 7.6 m
Turbidity: 3.0 NTU
Temperature: 20.8°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Chinook salmon (subyear.)	30	478	377	6,013
TOTALS	30	478	377	6,013

H = 0.00 E = 0.00

Station:PS3
Gear: 100-m purse seine
Date: 29 Jul 1992
Time: 1030
Tide stage: Flood
Depth: 7.0 m
Turbidity: 3.0 NTU
Temperature: 20.8°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	1	12	13	151
Chinook salmon (subyear.)	5	75	63	943
TOTALS	6	87	76	1,094

H = 0.65 E = 0.65

Appendix Table 5.--Continued.

Station:PS4
Gear: 100-m purse seine
Date: 29 Jul 1992
Time: 1440
Tide stage: Late flood
Depth: 1.8 m
Turbidity: 2.2 NTU
Temperature: 21.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Chinook salmon (subyear.)	27	443	340	5,572
Northern squawfish	1	10	13	126
Peamouth	24	378	302	4,755
Threespine stickleback	4	16	50	201
Starry flounder	1	1	13	13
TOTALS	57	848	718	10,667

H = 1.51 E = 0.65

Station:PS5
Gear: 100-m purse seine
Date: 29 Jul 1992
Time: 1350
Tide stage: Late flood
Depth: 4.0 m
Turbidity: 3.0 NTU
Temperature: 21.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Chinook salmon (subyear.)	24	349	302	4,390
Threespine stickleback	59	120	742	1,509
TOTALS	83	469	1,044	5,899

H = 0.87 E = 0.87

Appendix Table 5.--Continued.

Station:PS6
Gear: 100-m purse seine
Date: 29 Jul 1992
Time: 1300
Tide stage: Late flood
Depth: 2.1 m
Turbidity: 3.0 NTU
Temperature: 21.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Chinook salmon (subyear.)	37	581	465	7,308
Threespine stickleback	22	50	277	629
Prickly sculpin	2	6	25	75
Starry flounder	56	33	704	415
TOTALS	117	670	1,471	8,427

H = 1.59 E = 0.79

Appendix Table 5.--Continued.

Station:TR1
Gear: 8-m trawl
Date: 9 Sep 1992
Time: 952
Tide stage: Early flood
Depth: 9.4 m
Distance traveled: 463 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Peamouth	5	53	22	229
Prickly sculpin	3	44	13	190
Starry flounder	52	831	225	3,590
California bay shrimp	11	3	48	13
TOTALS	71	931	308	4,022

H = 1.21 E = 0.60

Station:TR2
Gear: 8-m trawl
Date: 9 Sep 1992
Time: 1022
Tide stage: Early flood
Depth: 8.2 m
Distance traveled: 444 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	8	113	36	509
Peamouth	267	2,147	1,203	9,671
Prickly sculpin	6	46	27	207
Pacific staghorn sculpin	2	73	9	329
Starry flounder	89	985	401	4,437
California bay shrimp	10	3	45	14
TOTALS	382	3,367	1,721	15,167

H = 1.24 E = 0.48

Appendix Table 5.--Continued.

Station:TR3
Gear: 8-m trawl
Date: 9 Sep 1992
Time: 1123
Tide stage: Late flood
Depth: 10.1 m
Distance traveled: 556 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	53	653	191	2,349
Chinook salmon (subyear.)	1	20	4	72
Peamouth	114	1,113	410	4,004
Prickly sculpin	111	720	399	2,590
Pacific staghorn sculpin	8	277	29	996
Starry flounder	61	535	219	1,924
California bay shrimp	40	20	144	72
TOTALS	388	3,338	1,396	12,007

H = 2.32 E = 0.83

Station:PS1
Gear: 100-m purse seine
Date: 8 Sep 1992
Time: 945
Tide stage: Low slack
Depth: 11.3m
Turbidity: 1.3 NTU
Temperature: 20.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
No fish captured	0	0	0	0
TOTALS	0	0	0	0

H = 0.00 E = 0.00

Appendix Table 5.--Continued.

Station:PS2
Gear: 100-m purse seine
Date: 8 Sep 1992
Time: 1035
Tide stage: Early flood
Depth: 11.0 m
Turbidity: 1.0 NTU
Temperature: 20.0 °C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Threespine stickleback	1	2	13	25
TOTALS	1	2	13	25

H = 0.00 E = 0.00

Station:PS3
Gear: 100-m purse seine
Date: 8 Sep 1992
Time: 1014
Tide stage: Early flood
Depth: 11.0 m
Turbidity: 1.0 NTU
Temperature: 20.0 °C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Threespine stickleback	4	8	50	101
TOTALS	4	8	50	101

H = 0.00 E = 0.00

Appendix Table 5.--Continued.

Station:PS4
Gear: 100-m purse seine
Date: 8 Sep 1992
Time: 1215
Tide stage: High slack
Depth: 1.5 m
Turbidity: 1.0 NTU
Temperature: 20.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	1	2	13	25
Threespine stickleback	12	34	151	428
Starry flounder	1	2	13	25
TOTALS	14	38	177	478

H = 0.73 E = 0.46

Station:PS5
Gear: 100-m purse seine
Date: 8 Sep 1992
Time: 1145
Tide stage: High slack
Depth: 3.4 m
Turbidity: 1.5 NTU
Temperature: 20.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Threespine stickleback	3	5	38	63
TOTALS	3	5	38	63

H = 0.00 E = 0.00

Appendix Table 5.--Continued.

Station:PS6
Gear: 100-m purse seine
Date: 8 Sep 1992
Time: 1115
Tide stage: Flood
Depth: 2.7 m
Turbidity: 2.5 NTU
Temperature: 19.0°C

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	11	69	138	868
Peamouth	43	226	541	2,843
Threespine stickleback	2	6	25	75
Prickly sculpin	1	13	13	164
Unidentified sculpin	1	1	13	13
Starry flounder	2	17	25	214
TOTALS	60	332	755	4,177

H = 1.32 E = 0.51

Station:TR4
Gear: 8-m trawl
Date: 9 Sep 1992
Time: 1306
Tide stage: High slack
Depth: 3.7 m
Distance traveled: 444 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
American shad	4	17	18	77
Peamouth	111	782	500	3,523
Prickly sculpin	2	11	9	50
Starry flounder	98	483	441	2,176
TOTALS	215	1,293	968	5,826

H = 1.18 E = 0.59