AN EXAMINATION OF THE SMALLER BENTHIC INVERTEBRATES IN HYLEBOS WATERWAY, TACOMA, WASHINGTON.

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INTRODUCTION

The Port of Tacoma has proposed the development of a marina and marine terminal on Hylebos Waterway located in Commencement Bay, Tacoma, Washington. Both projects would involve dredging and filling of intertidal and subtidal lands. Considerable debate has been generated over the environmental impact of these projects because of their location in a large industrial port.

Hylebos Waterway is located along the mouth of Hylebos Creek, 1.3 miles northeast of the mouth of the Puyallup River (Figure 1). Both of these streams support important runs of Pacific salmon and anadromous trout. Enhancement of these runs is being conducted by both the Puyallup Tribe and the Washington Department of Fisheries with emphasis on chum salmon.

The Olympia Ecological Services Office of the U.S. Fish and Wildlife Service (USFWS) requested that the Fisheries Assistance Office in Olympia investigate the value of the sites, particularly with regard to salmonids. The Puyallup Indian Tribe, which has treaty fishing rights in the project area, has also expressed concern about the impact of these projects. The proposed project sites are shown in Figure 2. The inner site consists of approximately 70 acres of intertidal land. Project plans call for dredging and filling this area to create a marine terminal. Much of the substrate at the site is composed of fine mud and sand. Logs have been or are being stored throughout the area. The outer site contains approximately 25 acres of intertidal and subtidal lands. Project plans for this site require dredging for the construction of a marina. The substrate at this site is similar to that found at the inner site except that it is bounded on the west side by a sand bar. Logs are being rafted immediately to the north of the project site.

A baseline survey of both sites was conducted in October, 1973 by Northwest Environmental Consultants for the Port of Tacoma. Results of their survey suggest a greater biological value at the outer site because of the presence of a subtidal eelgrass bed and greater numbers of fish, birds and clams. However, the presence and value of small benthic and epibenthic invertebrates were not investigated. Substrate samples were sorted through quarter-inch mesh sieves (much too large for retaining small invertebrates) and no samples were taken between the sand bar and shoreline at the outer site.

Recent studies have revealed the importance of the intertidal zone during the estuarine residency of juvenile salmonids. The USFWS feels that any encroachment on such an area may damage its unique ecosystem, particularly its capacity for forage production for fishery resources. In addition, dredging or filling of intertidal areas forces juvenile salmonids into deeper water where they are more vulnerable to large predatory fish (Heiser and Finn, 1970).

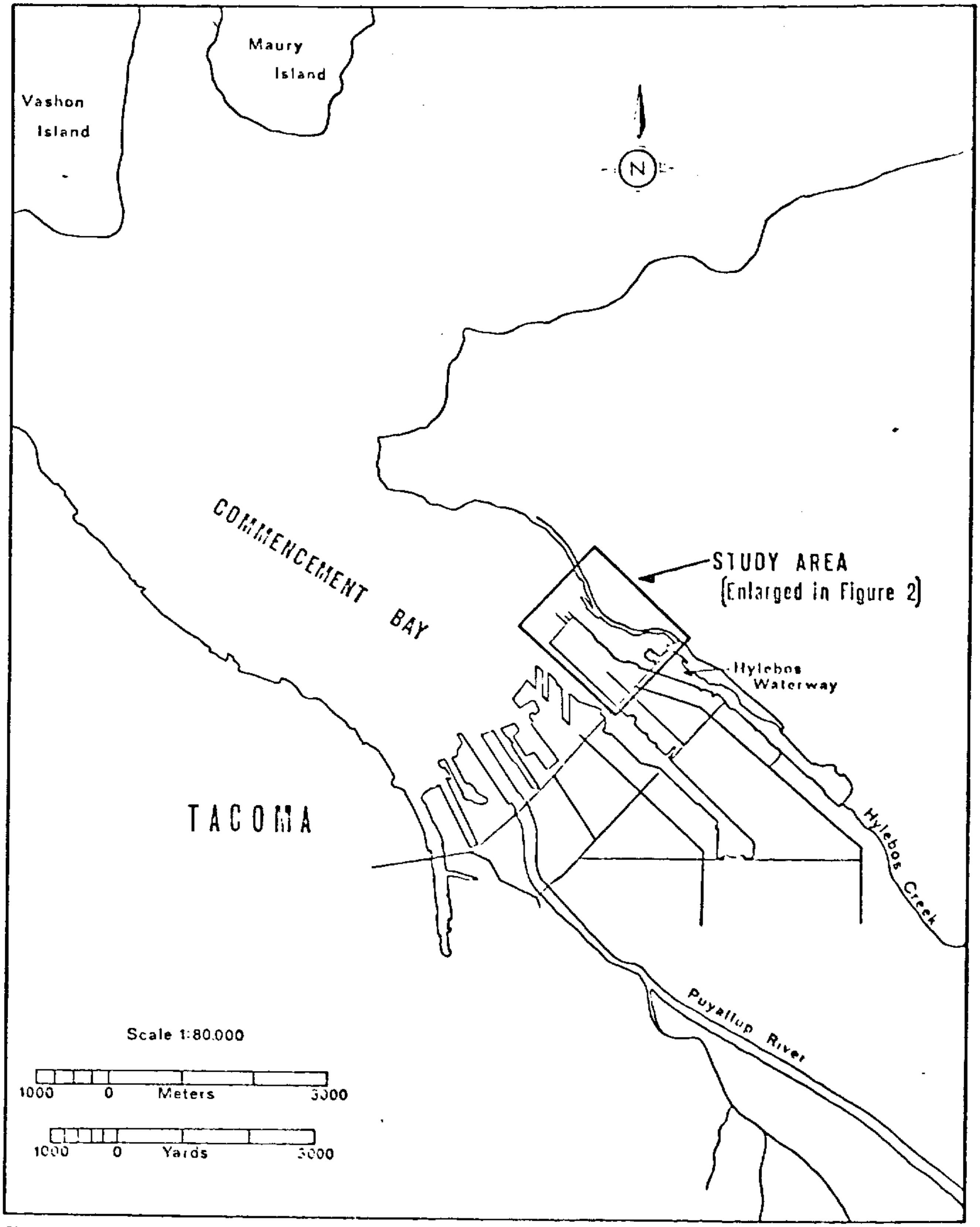

Figure 1. Commencement Bay near Tacoma, Washington with the location of the study area on Hylebos Waterway (taken from National Ocean Survey chart 18448).

MATERIALS AND METHODS

A preliminary examination was conducted on February 3, 1978 to obtain some qualitative and quantitative information on the benthic fauna present in the area of the proposed Hylebos Waterway project. The initial sampling stations were chosen to represent the diverse substrate present throughout the proposed project area and in three intertidal zones: +7.5 feet, 4.0 feet, and 1.0 feet above MLLW (mean lower low water). It was intended to examine a variety of habitats available to benthic and epibenthic invertebrates. Invertebrates of particular importance were those available as a food source for juvenile salmonids.

It was determined from the preliminary examination of both inner and outer proposed project areas that more detailed study should be made at stations 1 and 2 (Figure 2), where notable numbers of gammarid amphipods were found. Sampling of the large sand bar shown in Figure 2 near station 2 produced very few small invertebrates in the core samples. However, the previously mentioned baseline survey in 1973 which concentrated mainly on the larger marine organisms found invertebrates in this area that are believed to play an integral part in the area's ecosystem. The subtidal eel grass (Zostera sp.) beds along the western edge of this sand bar (Figure 2) were also not sampled in the present study. However, areas such as these have been shown to be highly productive and are an important constituent to marine ecosystems (Thayer and Phillipps, 1977).

The procedure employed by Smith (1977) was used as a general guideline for a more detailed sampling of the benthic and epibenthic invertebrates on February 17, 1978. Sampling was restricted to the upper intertidal zones of +7.5 feet and +4.0 feet (A and B respectively, Figure 2) where the largest numbers of organisms were found in preliminary samples. Horizontal plots 100 feet in length were established at each station and seven core samples (38.5 cm^2) were taken within each plot. The exact location of each sample in the plots was chosen from a random numbers table. Although the cores were taken to a minimum depth of 7 centimeters, the majority of invertebrates were assumed to be within the upper 4 centimeters of the substrate. All samples were preserved in a solution of 10% formalin with 0.01% concentration of Phloxine B stain, then screened through a 0.208 mm mesh. Because of the extremely high numbers and small size of the marine worms present in the samples, they were not enumerated in this study.

RESULTS AND DISCUSSION

The number of organisms found in the core samples varied widely within and between stations. Standard deviations were large for each organism at every station (Table 1). It is believed that the large intra-station fluctuation in numbers of organisms (Tables 2 and 3) was mostly, if not entirely, attributable to variations in substrate within stations. Some core samples had noticeably higher organic content and/or different sediment size than others which would account for the variations in numbers and dominance of organisms. Inter-station variations could be attributable to a multitude of environmental parameters besides substrate; included may be the effects of salinity and related water chemistry, log rafting, temperature, dissolved oxygen, photoperiod, and many other factors related to tide height.

The highest numbers of gammarid amphipods were found at the upper tidal height (i.e., +7.5 feet) at the inner and outer sites (20,260 and 29,833 gammarid amphipods/m^2 for 1A and 2A respectively). However, using Student's t-test, no significant difference was found between these numbers. The same was also true for cumaceans. There was a significant difference at the 1% level for tanaidacean numbers at this tidal height with the outer site exhibiting the higher density (i.e., 31,651 tanaidaceas/m^2). In contrast, sampling at the +4.0-foot tidal height at the inner and outer sites (i.e., 1B and 2B) showed no significant difference between stations for numbers of tanaidaceas. However, at this same tidal height, the station in the outer site showed significantly higher concentrations of gammarid amphipods (17,440/m^2, $\alpha = 0.05$) and cumaceans (73,877/m^2, $\alpha = 0.01$) than the inner site.

No statistical comparisons were made with harpacticoid copepods because of the difficulty in obtaining representative numbers within stations. However, there was a noticeable trend for samples collected from the lower tidal height to exhibit the highest numbers of harpacticoids at the inner (25,640/m^2) and outer (30,909/m^2) sites. Because of the large size of the cores and the extremely small size of the harpacticoid copepods there was little confidence that all could be sorted from the samples. For this reason, the numbers of harpacticoid copepods shown in Tables 2 and 3 should be treated as only a minimum and therefore a probable underestimate of the actual numbers present.

The density of organisms found at both sites were considered appreciable but could not be accurately compared to densities elsewhere in Puget Sound because of extreme variations in environmental conditions between intertidal localities. Considering that the density of epibenthic fauna can vary widely within a year (Smith, 1977), sampling during only one season cannot accurately indicate the characteristics of the invertebrate population. In general, Smith (1977) found greater densities of gammarid amphipods during August than in February in intertidal areas near Everett, Washington. If the same trend is true near Hylebos Waterway, the densities of amphipods shown in Table 1 would be less than that found during late summer.

Table 1. Mean number of organisms per square meter (standard deviation in parentheses) at sampling stations in the inner and outer proposed development sites on Hylebos Waterway. Numbers were expanded from core samples by a factor of 259.7 (does not include polychaetes, oligochaetes, and nematodes which were too numerous to count.)

Organism	Station			
	1A	1B	2A	2B
Gammarid amphipods	20,260 (9,232)	10,167 (2,281)	29,833 (9,520)	17,440 (7,937)
Harpacticoid copepods	11,763 (11,715)	25,640 (15,154)	5,798 (6,789)	30,909 (18,091)
Cumacea	1,818 (874)	10,390 (9,437)	1,039 (750)	73,877 (32,378)
Tanaidacea	1,558 (2,691)	74 (127)	31,651 (22,665)	1,447 (2,965)
Isopoda	74 (127)	a/	a/	37 (98)

a/ Not present in samples.

Table 2. Number of organisms per 38.5 square centimeter core sample at the inner collection site on Hylebos Waterway (does not include polychaetes, oligochaetes, and nematodes which were too numerous to count).
Intertidal zones: A = +7.5 feet; B = +4.0 feet.

Organism	Station and Sample Number						
	1A - 1	1A - 2	1A - 3	1A - 4	1A - 5	1A - 6	1A - 7
Gammarid amphipods	77	36	45	79	68	143	98
Harpacticoid copepods	90	15	127	15	36	19	15
Cumacea	3	5	9	12	10	4	6
Tanaidacea	29	1	1	4	0	6	1
Isopoda	0	0	1	0	0	0	1
	1B - 1	1B - 2	1B - 3	1B - 4	1B - 5	1B - 6	1B - 7
Gammarid amphipods	41	31	44	40	31	55	32
Harpacticoid copepods	34	130	137	84	196	67	43
Cumacea	18	41	35	25	120	24	17
Tanaidacea	1	0	1	0	0	0	0

Table 3. Number of organisms per 38.5 square centimeter core sample at the outer collection site on Hylebos Waterway (does not include polychaetes, oligochaetes, and nematodes which are too numerous to count).
Intertidal zones: A = +7.5 feet; B = +4.0 feet.

Organism	Station and Sample Number						
	2A - 1	2A - 2	2A - 3	2A - 4	2A - 5	2A - 6	2A - 7
Gammarid amphipods	88	168	106	142	107	58	135
Harpacticoid copepods	9	15	13	36	5	2	76
Cumacea	0	6	4	2	4	3	9
Tanaidacea	264	224	78	114	79	44	50
	2B - 1	2B - 2	2B - 3	2B - 4	2B - 5	2B - 6	2B - 7
Gammarid amphipods	29	59	76	87	54	44	121
Harpacticoid copepods	112	44	99	162	30	159	227
Cumacea	328	155	241	231	157	387	492
Tanaidacea	6	1	0	1	0	0	31
Isopoda	0	1	0	0	0	0	0

Several diet studies are available which indicate a dependence of juvenile pink and chum salmon on epibenthic invertebrates. Gerke and Kaczynski (1972) looked at juvenile chum and pink stomach contents in Puget Sound and found harpacticoid copepods to be a primary food item. They also noted gammarid amphipods, cumaceans, and isopods as being utilized, although in smaller numbers. Simenstad (In press) examined juvenile chum salmon stomachs in Hood Canal and noted the presence of the same organisms. He goes on to suggest that chum salmon may be selecting harpacticoid copepods and gammarid amphipods during the period of their nearshore residency. Manzer (1969) reports similar findings for pink, chum and sockeye salmon in British Columbia. Sibert and Kask (1977) examined stomachs of juvenile chinook and coho salmon captured in British Columbia estuaries and found epibenthic invertebrates (harpacticoid copepods, gammarid amphipods and cumaceans) to comprise an important part of their diet. In his Hood Canal studies, Simenstad (In press) noted gammarid amphipods and polychaetes in cutthroat trout and chinook salmon stomachs, respectively.

SUMMARY

Both Hylebos project sites were found to produce large numbers of small benthic and epibenthic invertebrates. Both sites also provide considerable shallow water areas over which juvenile salmonids may feed on these organisms. These areas (including the large sand bar at the outer site) are a valuable interface for the influx of tidally-induced nutrient-rich water. Such areas are vitally needed to supply salmonids with an abundant food supply and provide protection from predation during critical stages of their early life history in the estuary.

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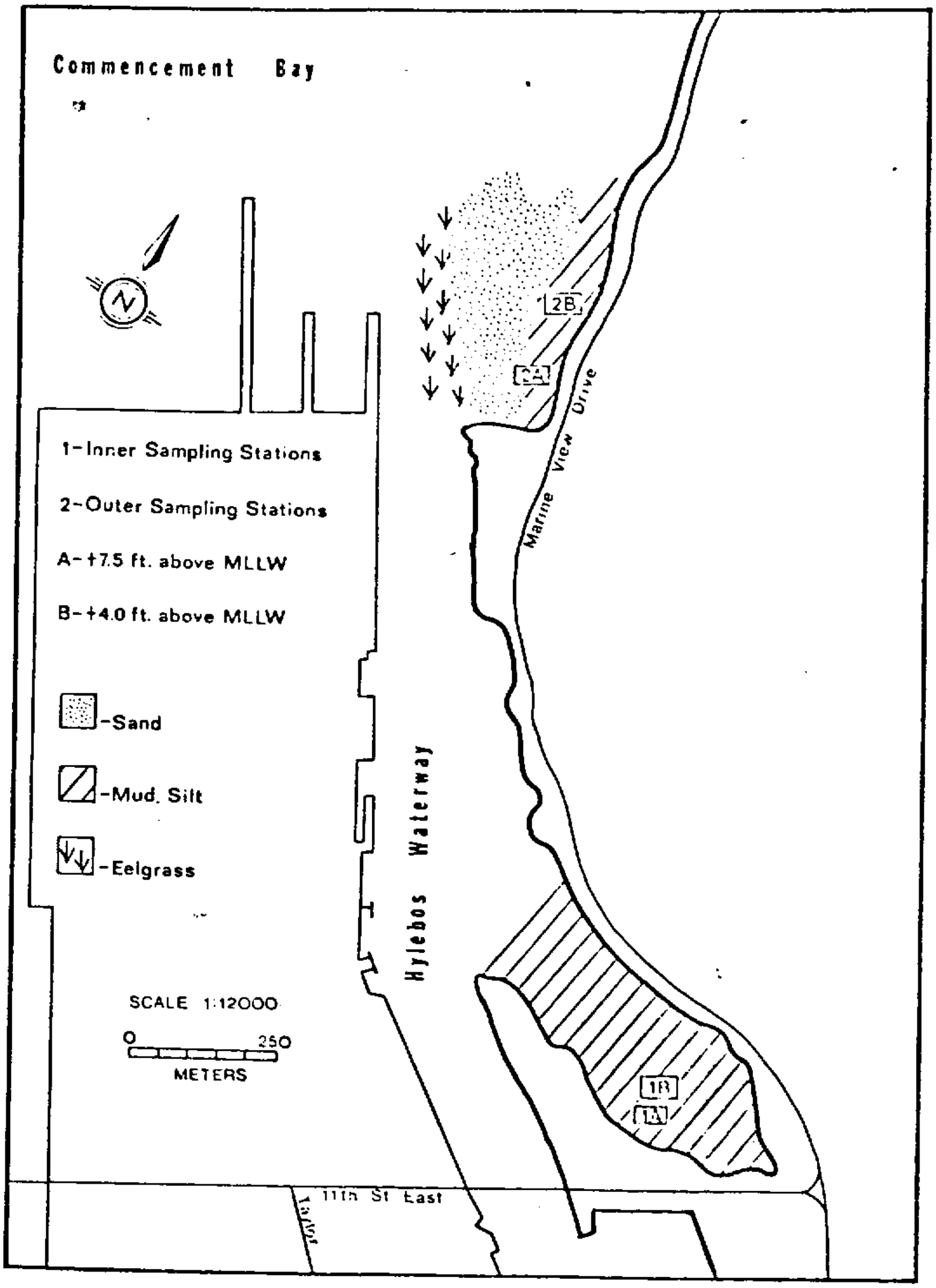

Figure 2. Map of Hylebos Waterway indicating benthic invertebrate sampling stations (enlarged from U.S.G.S Tacoma North Quadrangle, 7.5 minute series).