AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

Centimeter

Inches

MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

PNL-8656
UC-000

SUBTIDAL EELGRASS/MACROALGAE SURVEYS FOR THE PROPOSED BREAKWATERS AT THE U.S. COAST GUARD STATION AT EDIZ HOOK, WASHINGTON, MARCH 1993

D. K. Shreffler

Battelle/Marine Sciences Laboratory
Sequim, Washington

May 1993

Prepared for
U.S. Army Corps of Engineers - Seattle District
under a Related Services Agreement
with the U.S. Department of Energy
Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

SUMMARY

In 1993, the U.S. Coast Guard proposed to construct two breakwaters and a debris boom to protect its existing pier and moored vessels inside Ediz Hook in Port Angeles Harbor, Washington. To assist the U.S. Army Corps of Engineers - Seattle District in determining the potential environmental impacts of the proposed breakwaters, Battelle/Marine Sciences Laboratory performed subtidal SCUBA surveys as specified in the Washington Department of Fisheries intermediate eelgrass/macroalgae habitat survey guidelines. The objectives of the subtidal surveys were to 1) quantify the shoot densities of eelgrass; 2) provide percent cover estimates for non-eelgrass macroalgae species; 3) develop a site map indicating the qualitative distribution of eelgrass/ macroalgae species, substrate characterization, approximate depth contours, and the approximate location of the proposed project features; and 4) document the time and date of the surveys, turbidity/visibility, presence of invertebrate/vertebrate species, and anecdotal observations pertinent to habitat characterization of the project site.

A total of 14 dives along 12 transects (T1-T12) were successfully completed between March 15 and March 17, 1993. Eelgrass was observed on all of the transects except T7 and T8 at the western debris barrier and T12 along the waterward margin of the existing T-pier. The vicinity of the proposed east breakwater had the highest eelgrass shoot densities (up to 89 shoots/m^2) observed by the divers. Macroalgae and invertebrate species diversity were also highest at the east breakwater site. The low eelgrass densities observed at the west debris barrier site (0 to 14 shoots/m^2) can be attributed mostly to the lack of suitable substrate. The existing layer of wood debris armoring the bottom at the west project site currently limits, and in the areas of heaviest deposition probably precludes, the growth of eelgrass. As was expected, no eelgrass was observed at the south breakwater site. The depths beneath this proposed breakwater exceed the documented lower depth limits (-22 ft mean lower low water) for eelgrass growth.

These subtidal survey results indicate that the proposed south breakwater is appropriately located to avoid impacts to existing eelgrass/

macroalgae. Likewise, the west debris barrier will avoid impacts to existing eelgrass/macroalgae as long as it is located at the site of the existing log boom, not to the west of the log boom as has been proposed since the completion of the diving surveys. Regardless of where it is located, the east breakwater has the potential to adversely impact eelgrass/macroalgae. Recommendations are provided on how impacts to eelgrass/macroalgae could be minimized through careful design and siting of the east breakwater.

ACKNOWLEDGMENTS

It was a pleasure to work with Merri Martz, the technical representative from U.S. Army Corps of Engineers (USACE) - Seattle District in the scoping, planning, and performance of this work. Steve Locher, the project engineer from the U.S. Coast Guard Facilities Design and Construction Center (Pacific), ensured that our diving efforts were coordinated with planned operations at the Ediz Hook Coast Guard Station. Special thanks go to Steve for arranging access to the locker room and hot showers between dives. Bernie Hargraves, the project engineer from USACE - Seattle District was quite helpful in providing maps of the proposed project site and engineering design. Bruce Higgins played an invaluable role as diving safety officer and dive team member. Karl Pohlod was the boat operator for the diving operations. Ron Thom provided a thorough technical review of this report, Ray Bienert assisted with graphical presentations of the data, and Laura Gully assisted with the formatting and final preparation of this report.

CONTENTS

SUMMARY iii

ACKNOWLEDGMENTS v

1.0 INTRODUCTION 1

2.0 METHODS 5

2.1 ORGANIZATION OF TRANSECTS 5

2.2 SURVEY DIVES 8

3.0 RESULTS AND DISCUSSION 11

3.1 SUBSTRATE CHARACTERIZATION AND SITE MAP 11

3.2 EELGRASS DENSITIES 14

3.3 MACROALGAE PERCENT COVER 17

3.4 GENERAL OBSERVATIONS 28

4.0 CONCLUSIONS 31

5.0 RECOMMENDATIONS 33

6.0 REFERENCES 35

FIGURES

1.1 Port Angeles Harbor Map Indicating the Location of the U.S. Coast Guard Station at Ediz Hook 2

2.1 Enlarged Map of the U.S. Coast Guard Station at Ediz Hook Showing the Proposed Breakwaters and Debris Barrier 6

2.2 Transect Locations for the Subtidal SCUBA Surveys in March 1993 . . . 7

3.1 Project Site Map Indicating the Qualitative Distribution of Eelgrass/Macroalgae Species, Substrate Characterization, Approximate Depth Contours, and the Approximate Location of the Proposed Project Features 13

3.2 Locations and Mean Densities of Eelgrass Observed During Subtidal SCUBA Surveys in March 1993 at the East Breakwater Site 15

3.3 Locations and Mean Densities of Eelgrass Observed During Subtidal SCUBA Surveys in March 1993 at the West Debris Breakwater Site . . . 16

3.4 Locations and Mean Densities of Eelgrass Observed During Subtidal SCUBA Surveys in March 1993 at the South Breakwater Site 18

TABLES

3.1 Summary of Diving Operations Conducted at the Ediz Hook U.S. Coast Guard Station in March 1993 12

3.2 Mean Percent Cover Observed Within a 0.25-m^2 Quadrat During Subtidal SCUBA Surveys Conducted at the Ediz Hook U.S. Coast Guard Station in March 1993 19

3.3 Algal Taxa Observed During Subtidal SCUBA Surveys Conducted at the Ediz Hook U.S. Coast Guard Station in March 1993 29

3.4 Invertebrate and Vertebrate Taxa Observed During Subtidal SCUBA Surveys Conducted at the Ediz Hook U.S. Coast Guard Station in March 1993 30

1.0 INTRODUCTION

In 1993, the U.S. Coast Guard (USCG) proposed to construct two breakwaters and a debris boom to protect its existing pier and moored vessels inside Ediz Hook in Port Angeles Harbor, Washington (Figure 1.1). The east breakwater would provide protection from severe storm waves from the northeast. The breakwater immediately south of the existing T-pier would function primarily as a buffer from vessel wakes from the south. The debris barrier west of the existing T-pier would deflect floating debris away from the pier. Because eelgrass is known to occur within the vicinity of the proposed project site (Dr. Steve Martin, U.S. Army Corps of Engineers (USACE), personal communication) and because the proposed project has the potential to disrupt or eliminate valuable eelgrass habitat, Washington Department of Fisheries (WDF) required that diving surveys be conducted using their intermediate level eelgrass/macroalgae habitat survey guidelines. The USACE - Seattle District asked Battelle/Marine Sciences Laboratory (MSL)[a] to assist them in determining the potential environmental impacts of the proposed breakwaters.

The principal objectives of this study were to conduct subtidal SCUBA surveys and provide recommendations to avoid or minimize the potential environmental impacts of the USCG breakwater project at the Ediz Hook Facility in Port Angeles, Washington. This assessment encompassed the proposed project site as well as immediately adjacent areas that have the potential to be impacted by shading effects or changes in the physical structure of the habitat. As specified in the WDF intermediate eelgrass/macroalgae habitat survey guidelines, the objectives of the subtidal survey were to 1) quantify the shoot densities of eelgrass; 2) provide percent cover estimates for non-eelgrass macroalgae species; 3) develop a site map indicating the qualitative distribution of eelgrass/macroalgae specie, substrate characterization, approximate depth contours, and the approximate location of

---

(a) The Battelle/Marine Sciences Laboratory is part of the Pacific Northwest Laboratory, which is operated for the U.S. Department of Energy by Battelle Memorial Institute.

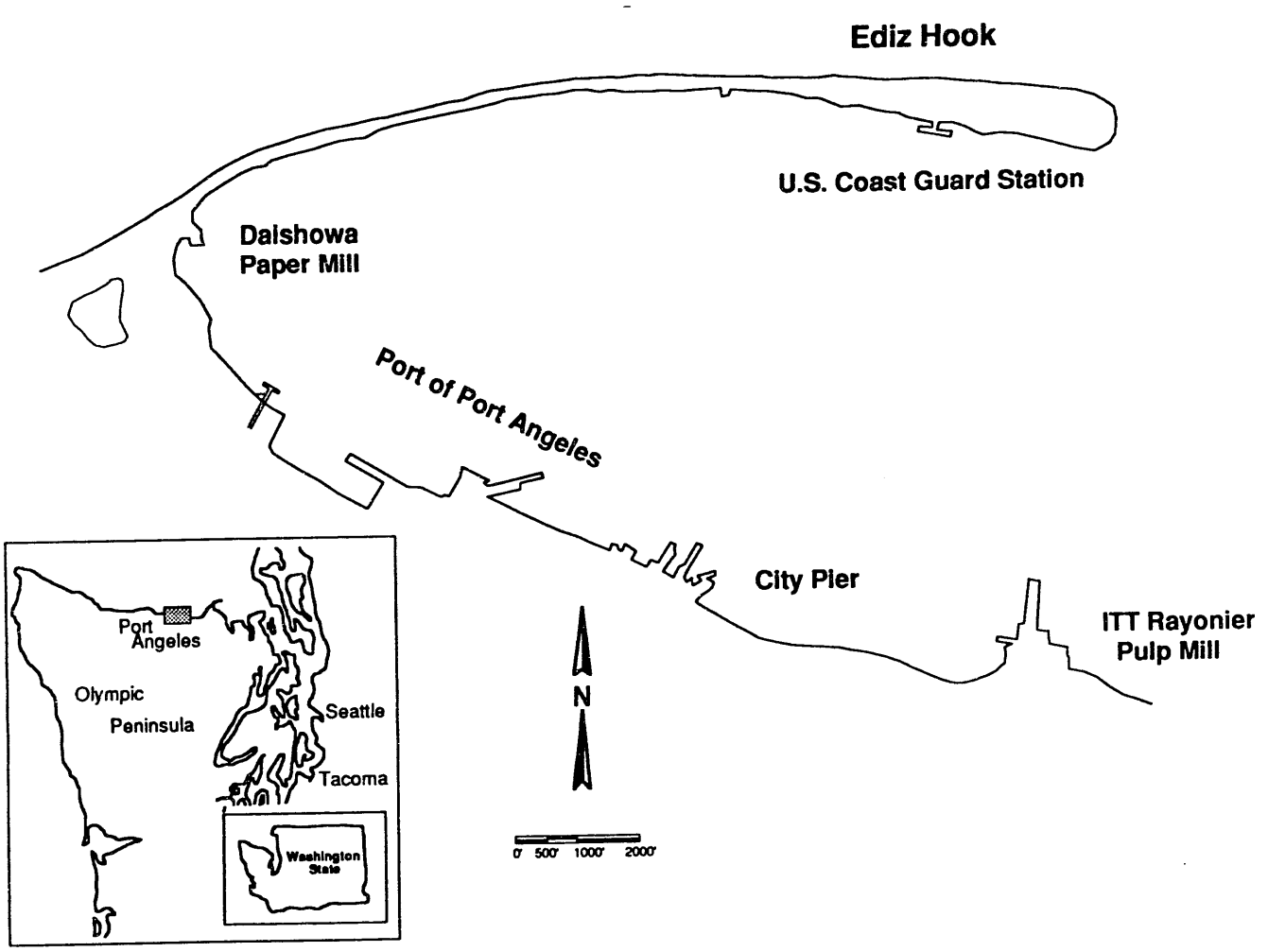


FIGURE 1.1. Port Angeles Harbor Map Indicating the Location of the U.S. Coast Guard Station at Ediz Hook

the proposed project features; and 4) document the time and date of the survey, turbidity/visibility, presence of invertebrate/vertebrate species, and anecdotal observations pertinent to habitat characterization of the project site. In addition, USACE requested that MSL evaluate whether the breakwaters and debris barrier are properly located to avoid or minimize impacts to eelgrass and macroalgae.

This report contains five sections in addition to this introduction. Section 2.0 details the methods used in this study, Section 3.0 provides the results and discussions, and Sections 4.0 and 5.0 present the conclusions and recommendations, respectively. References cited in the text are listed in Section 6.0.

2.0 METHODS

The proposed project site is located in Port Angeles Harbor on the inside (southern) bank of Ediz Hook. A detailed map of the project site showing the existing pier, shoreline features, and the proposed breakwaters and debris barrier is presented in Figure 2.1. At the proposed site for the east breakwater, six transects (designated T1 through T6) were located 40 ft apart, parallel to each other and the existing T-pier at a compass bearing of 350°, and perpendicular to the shoreline from approximately +1 to -50 ft MLLW (Figure 2.2). At the proposed site of the debris barrier, five transects (designated T7 through T11) were located 40 ft apart, parallel to each other and the existing T-pier at a compass bearing of 350°, and perpendicular to the shoreline from approximately +1 to -30 ft MLLW. One transect (designated T12) was established parallel to shore along the waterward edge of the existing USCG pier (approximately -30 ft MLLW) at the proposed site of the south breakwater. All measurements and compass bearings were recorded relative to the existing USCG T-pier.

The SCUBA transect locations were chosen to allow detailed assessment of the distribution and densities of eelgrass and macroalgae. Transects included the landward margin of the eelgrass and macroalgae as well as the outer, waterward margin. As specified in the WDF survey guidelines, one transect was located at the center line of each of the proposed structures: T3 at the east breakwater, T9 at the west debris barrier, and T12 at the south breakwater.

2.1 ORGANIZATION OF TRANSECTS

A 5-ft-long piece of 1/4-in.-diameter rebar was secured in the rock riprap to mark the onshore end of each SCUBA transect (T1 through T11) except T12. The top of each rebar stake was marked with pink or yellow flagging tape so that the stakes were highly visible from a distance. Before diving a particular transect, it was laid out with a 300-ft tape measure marked at 0.1-ft intervals by 1) looping the zero end of the tape over the correct rebar stake, 2) stretching the tape taut by swimming along the surface to the offshore edge of the project site, and 3) sighting along the tape to ensure it

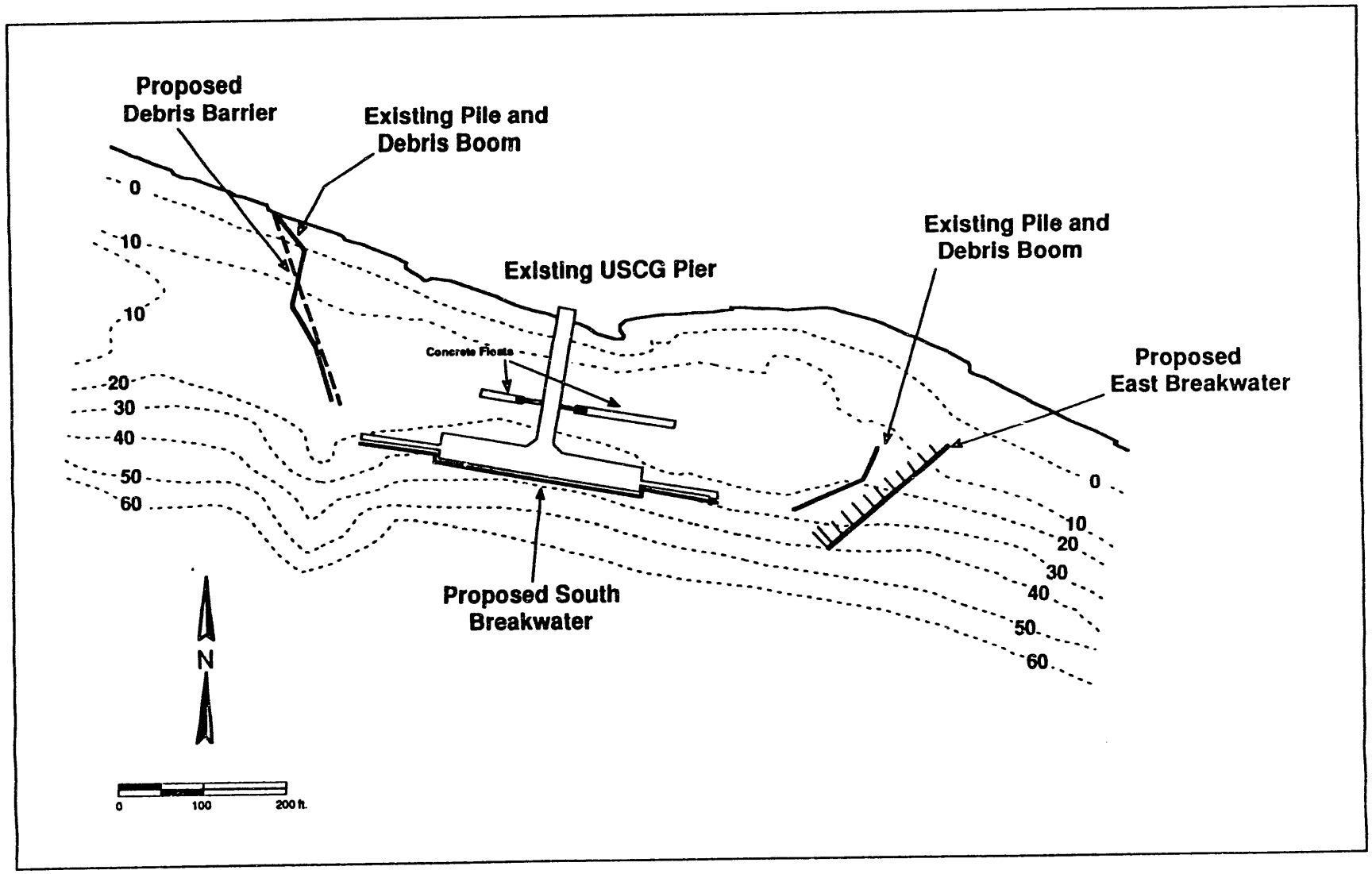


FIGURE 2.1. Enlarged Map of the U.S. Coast Guard Station at Ediz Hook Showing the Proposed Breakwaters and Debris Barrier

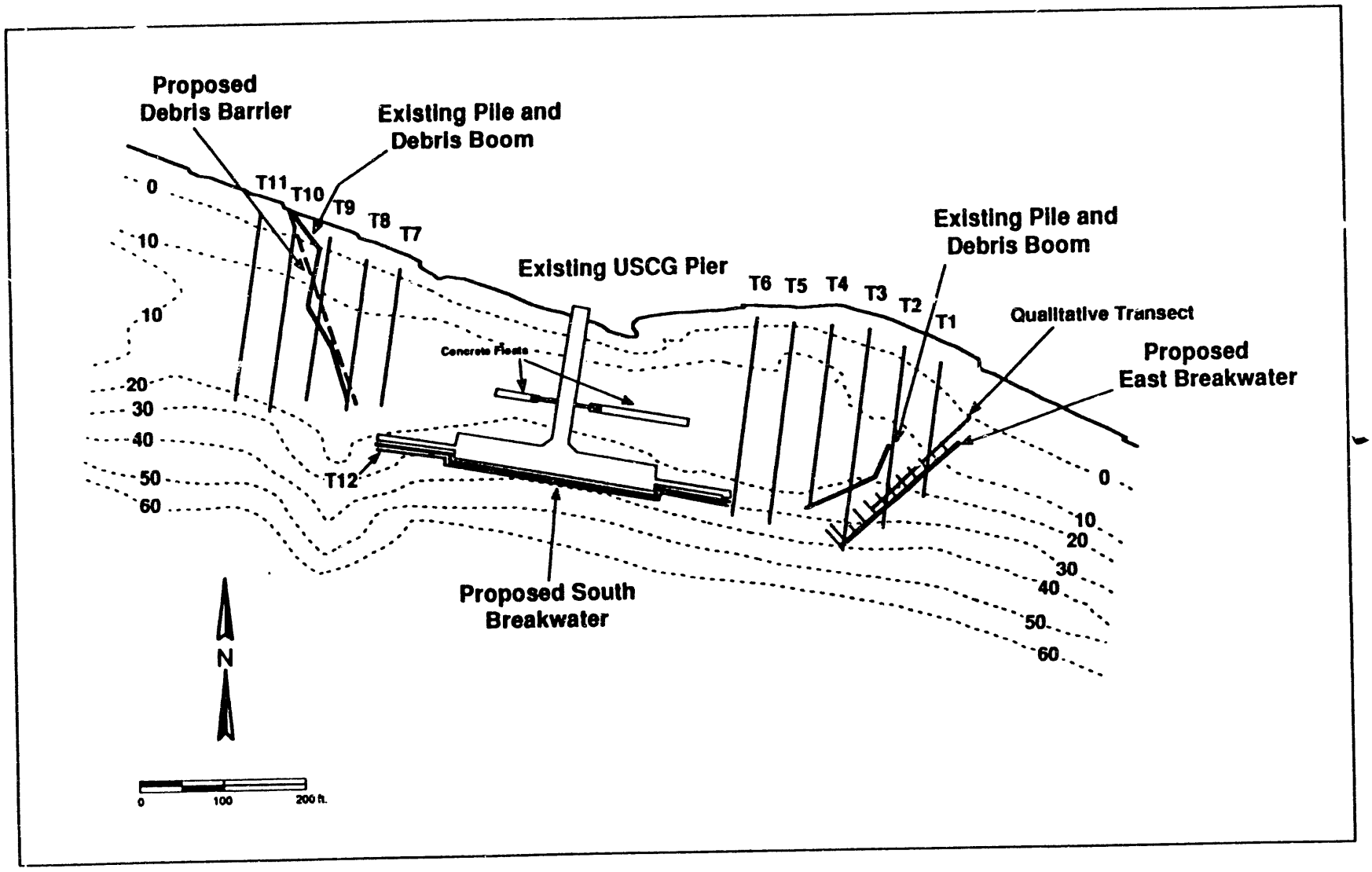


FIGURE 2.2. Transect Locations for the Subtidal SCUBA Surveys in March 1993

was close to the desired 350° compass bearing. The divers then descended to the bottom with the tape retrieval spool and reeled the tape onto the spool as they proceeded toward shore. On the transect along the outside edge of the existing T-pier (T12), the tape was secured to an existing piling and reeled off the spool as the divers progressed along the bottom, instead of being laid on the surface in advance. Because of the length of the T-pier, two dives were required to complete T12. At the end of the first dive, the 0.25 m^2 quadrat (a pvc frame used for quantifying eelgrass shoot densities and macroalgae percent cover) was left on the bottom to mark the starting point for the second drive.

2.2 SURVEY DIVES

One practice survey dive was performed on transect T1 on March 15 to ensure that all planned technical and safety procedures were adequate for the diving operation. The remaining survey dives were completed between March 15 and March 17, 1993, and were of sufficient intensity to provide full coverage of the potential impact area. All transects were surveyed by the same pair of divers as follows: Transects T1, T3, and T5 were completed on March 15; transects T2, T4, T6, T7, and T9 were completed on March 16; and transects T8, T10, T11, and T12 were completed on March 17. Survey dives of transects T1 through T11 were initiated from the offshore end of the project site and completed at the onshore stake. The survey dives for transect T12 was initiated from the western edge of the existing T-pier and completed at the eastern edge. The divers always stayed opposite one another and within 5 ft of the transect tape.

Using waterproof data sheets attached to clipboards, the divers recorded the following information at each 20-ft interval (hereafter referred to as stations) along a transect:

- distance along the transect
- depth (measured with the divers' depth gauges)
- substrate characterization

- eelgrass shoot densities, which included three counts within a 0.25-m^2 quadrat pivoted around the 20-ft interval count point at approximately the 2, 6, and 10 o'clock positions

- percent cover estimates, which included three visual estimates within a 0.25-m^2 quadrat pivoted around the 20-ft interval count point at approximately the 2, 6, and 10 o'clock positions.

In addition, both divers recorded sightings of invertebrate and vertebrate species and general observations pertinent to habitat characterization of the project site for everything within visual range of each transect. Following each dive, the divers reviewed their data sheets and made any necessary clarifications.

At the request of Merri Martz, the USACE environmental coordinator for the project, who was onsite the third day of the diving operation (March 17, 1993), one additional dive was made east of, and parallel to, the existing log boom and pilings at the east breakwater site. The purpose of this dive was to provide qualitative observations on the presence or absence of eelgrass.

3.0 RESULTS AND DISCUSSION

A total of 14 dives were successfully completed between March 15 and March 17, 1993—six survey dives along transects T1 through T6 and one additional qualitative dive at the proposed site for the east breakwater, five survey dives along transects T7 through T11 at the proposed site for the west debris barrier, and two dives along transect T12 at the proposed site for the south breakwater (Table 3.1). Favorable weather conditions and careful planning of the diving operation around the tides allowed us to complete the work safely and efficiently. Visibility was in excess of 10 ft on all dives, which enhanced the divers' ability to accurately record quantitative data and qualitative observations.

3.1 SUBSTRATE CHARACTERIZATION AND SITE MAP

Based on the divers' observations, the substrate within the project site is quite variable (Figure 3.1). At the east breakwater site, the substrate changed from muddy sand to cobble to rock riprap moving from the offshore edge of the project site toward shore, but in some areas the substrate was intergraded. The bottom topography was characterized by a series of terraces with depositional areas indicated by accumulation of fine sediment at the lowest elevation of each terrace and patches of eelgrass where the slope of the terrace leveled off. The substrate within these depositional areas tended to be wood debris with a surface layer of drift macroalgae and benthic diatoms. The west debris barrier site was probably a former log storage area. The substrate changed from muddy sand to a thick layer of bark, branches, logs, wood chips, and woody debris to cobble to rock riprap moving from the offshore edge of the existing debris barrier toward shore. The substrate at the south breakwater site was predominantly muddy sand, but the bottom was littered with garbage (e.g., metal pipes, plastic, a toilet, extension ladder, chains). Shell fragments were widely dispersed throughout all three project sites but represented a small fraction of the total bottom cover.

Eelgrass was observed on all of the transects except T7 and T8 at the western debris barrier and T12 along the waterward margin of the existing

TABLE 3.1. Summary of Diving Operations Conducted at the Ediz Hook U.S. Coast Guard Station in March 1993

Date	Dive Location	Time	Visibility (ft)	Weather Conditions
3/15/93	T1 (training)	1157-1225	15-20	light surface chop
3/15/93	T1	1301-1328	15-20	gusty, light chop
3/15/93	T3	1444-1525	10-15	light surface chop
3/15/93	T5	1557-1633	10-15	light surface chop
3/16/93	T2	1011-1044	10	calm
3/16/93	T4	1105-1141	10	light surface chop
3/16/93	T6	1217-1256	15	light surface chop
3/16/93	T7	1353-1420	15	light surface chop
3/16/93	T9	1435-1459	15	light surface chop
3/17/93	T12	1022-1105	10-15	calm
3/17/93	T12[a]	1128-1152	10-15	calm, light rain
3/17/93	T8	1403-1421	15-20	calm
3/17/93	T10	1451-1513	15	calm
3/17/93	T11	1523-1548	15-20	calm

(a) This dive includes the qualitative transect added on-site by Merri Martz of USACE.

T-pier. The qualitative dive at the proposed site for construction of the east breakwater revealed one fairly large eelgrass bed extending from roughly -10 to -15 ft MLLW. Because of the size of this eelgrass bed, avoidance of direct impacts during construction of the east breakwater will be difficult. Overall, the eelgrass beds observed by the divers were quite variable in size and the extent of epiphyte growth. Epiphytes are the diverse assemblage of plants and animals that grow on the leaves of eelgrass. The total biomass of epiphytes can exceed that of the eelgrass leaves and reduce eelgrass productivity, even though the algal component of the epiphyte assemblage may contribute significantly to the overall primary production of the system. In addition, the eelgrass beds were characterized by markedly different densities, as reported in Section 3.2. The beds at the east breakwater site were larger (i.e., covered more of the bottom surface area) than those at the west debris barrier site. Within the east breakwater site, the eelgrass

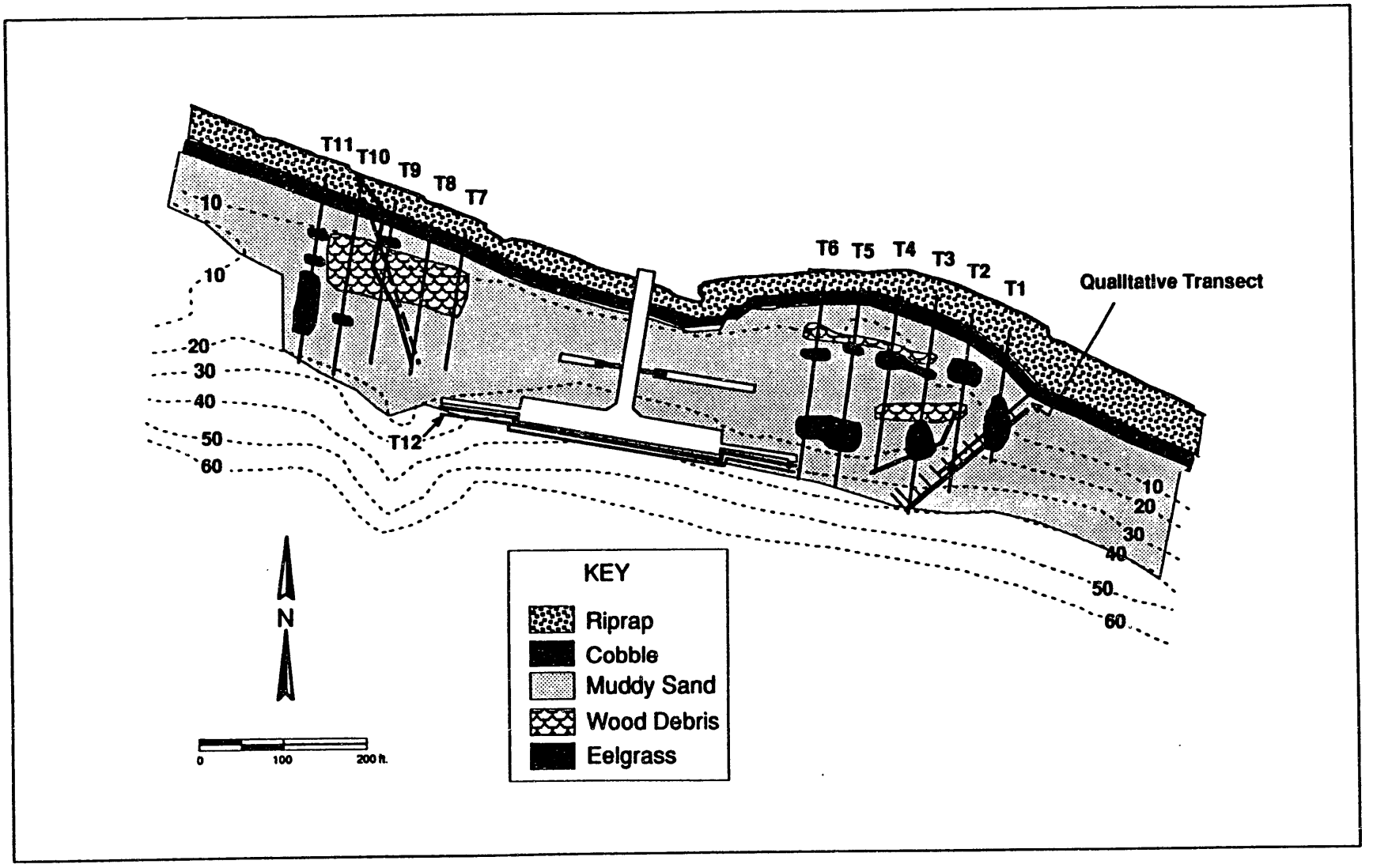


FIGURE 3.1. Project Site Map Indicating the Qualitative Distribution of Eelgrass/Macroalgae Species, Substrate Characterization, Approximate Depth Contours, and the Approximate Location of the Proposed Project Features

shoots that were present east of the existing log boom along T1 and T2 were 6 in. to 1 ft shorter and more heavily epiphytized than the eelgrass present along T3, T4, T5, or T6.

3.2 EELGRASS DENSITIES

The vicinity of the proposed east breakwater had the highest eelgrass shoot densities (up to 89 shoots/m^2) observed by the divers (Figure 3.2). The densities observed at the Ediz Hook USCG station in March were comparable to the lower range of mean annual shoot densities reported for other subtidal eelgrass beds around Puget Sound. For example, Phillips (1984) reported the following mean densities of eelgrass: Grays Harbor 74 shoots/m^2, Hood Canal 62 to 287 shoots/m^2, and Whidbey Island 71 to 861 shoots/m^2. Thom (1990a) reported eelgrass densities that ranged from 400 to 700 shoots/m^2 at Padilla Bay, which has one of the three largest eelgrass beds in the Pacific Northwest. Eelgrass beds at MSL, near the mouth of Sequim Bay, show a mean annual range of 150 to 410 shoots/m^2 (R. M. Thom, Marine Resources Technical Group Leader, MSL, unpublished data). It is worth noting, however, that peak shoot density typically coincides with peak shoot biomass in temperate seagrass systems and seasonal biomass peaks are observed between June and August. Thus, the eelgrass shoot densities observed by divers in March at Ediz Hook are probably somewhat lower than what could be expected in the June to August window, when light energy, water temperature, and net primary productivity reach a maximum.

The low eelgrass densities observed at the west debris barrier site (0 to 14 shoots/m^2) can be attributed mostly to the lack of suitable substrate (Figure 3.3). Eelgrass transplanting experiments in the Pacific Northwest have shown that mixed sand and mud with ample inorganic nitrogen and phosphate is the optimal substrate for eelgrass (reviewed in Thom 1990b). The existing layer of wood debris armoring the bottom at the west project site currently limits, and in the areas of heaviest deposition probably precludes, the growth of eelgrass. The only eelgrass patches that were observed at this site were in areas where the wood debris layer was absent.

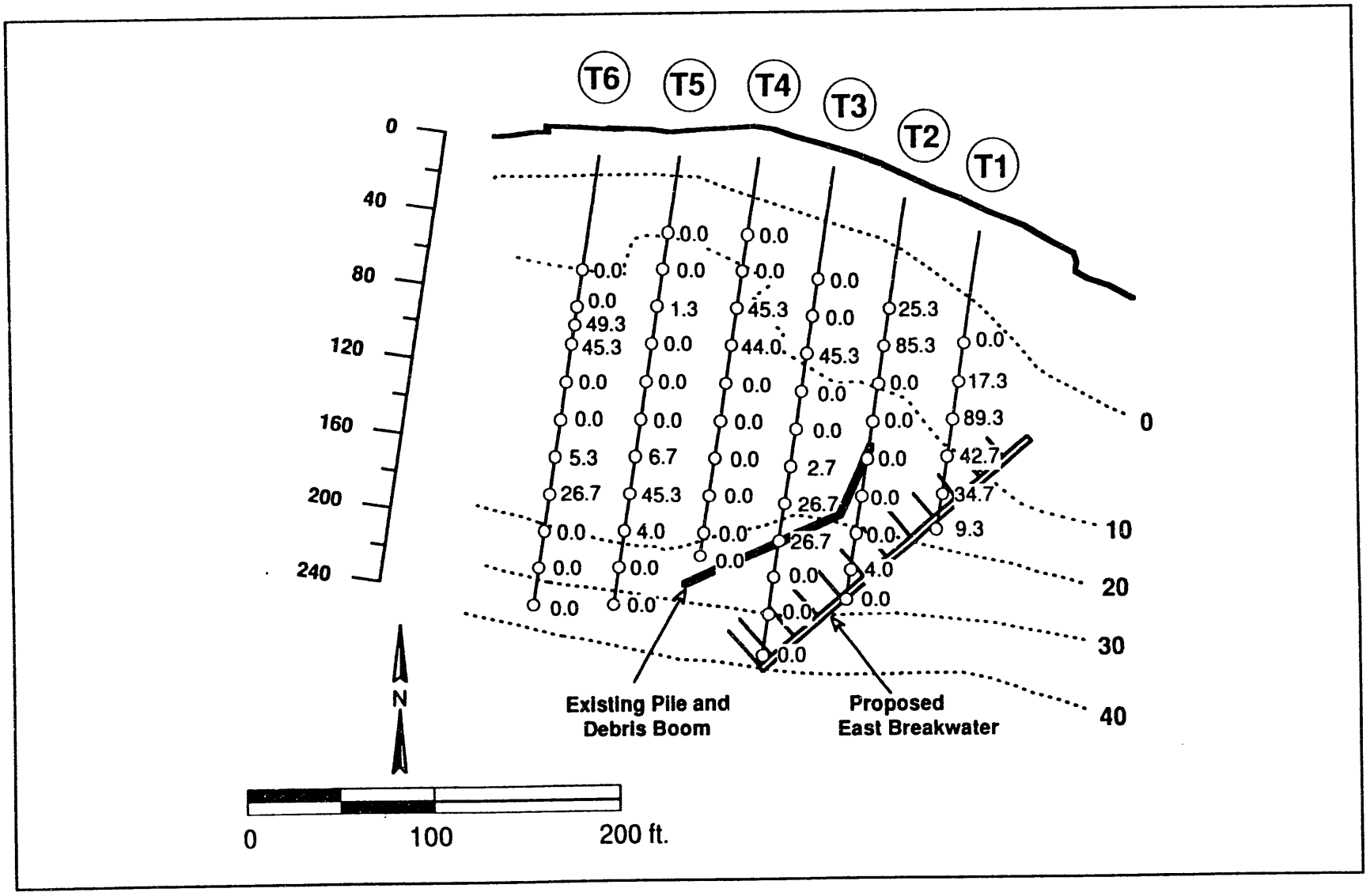
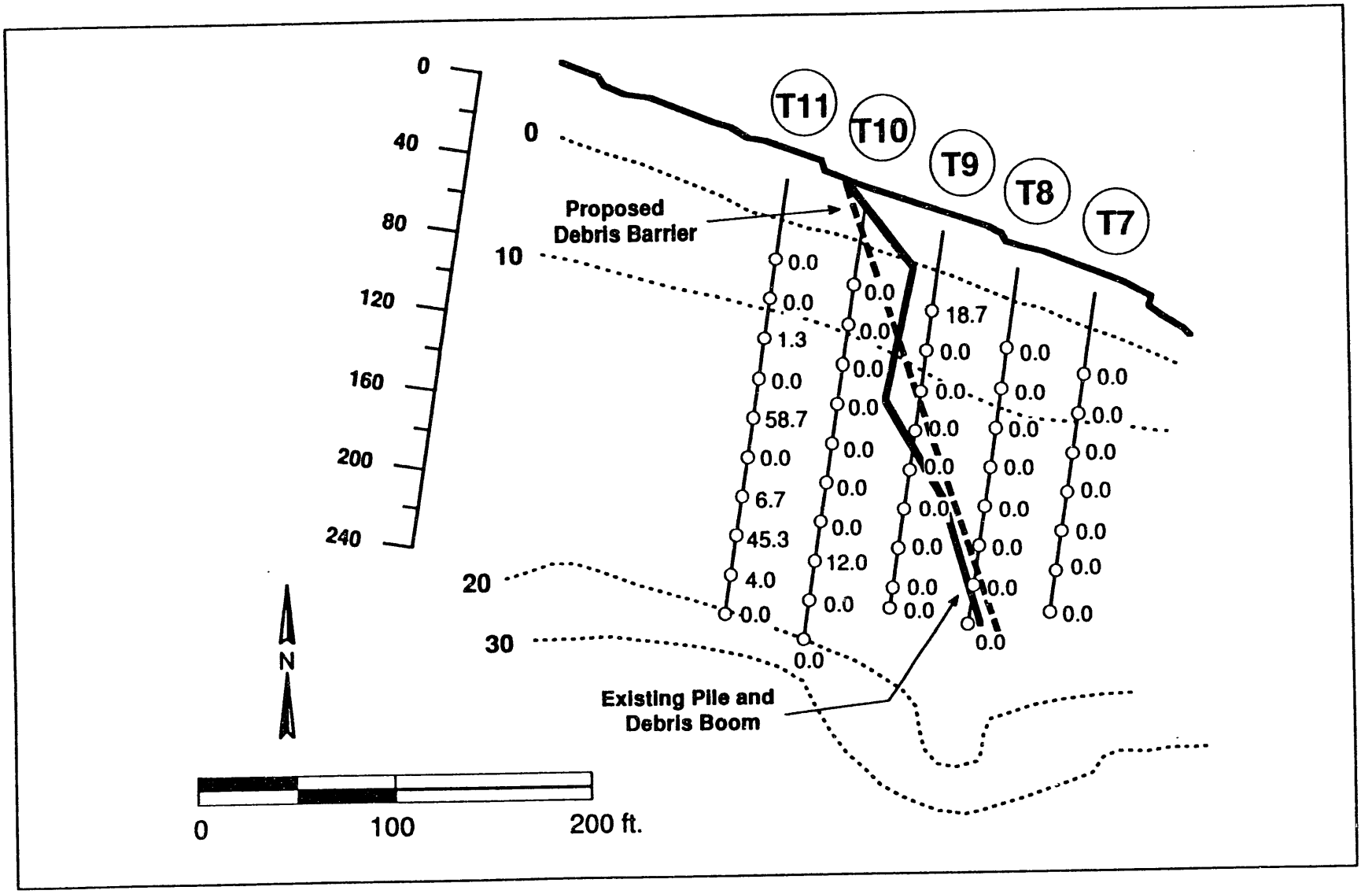


FIGURE 3.2. Locations and Mean Densities (no. m^{-2})of Eelgrass Observed During Subtidal SCUBA Surveys in March 1993 at the East Breakwater Site


T11
T10
T9
T8
T7
Proposed Debris Barrier
Existing Pile and Debris Boom
0
40
80
120
160
200
240
0
10
20
30
N
0
100
200 ft.
0.0
0.0
1.3
0.0
58.7
0.0
6.7
45.3
4.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
12.0
0.0
0.0
18.7
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0

As was expected, no eelgrass was observed at the south breakwater site (Figure 3.4). The depths beneath this proposed breakwater exceed the documented lower depth limits (-22 ft MLLW) for eelgrass growth (Phillips 1984).

3.3 MACROALGAE PERCENT COVER

Based on divers' observations of percent cover within a 0.25 m^2 quadrat, macroalgae were distributed throughout the three project sites (Table 3.2). Since macroalgae need a hard substrate for attachment, they were found in patches only where cobbles or shell fragments occurred in the sediments. *Ulva* sp. and *Gracilaria pacifica* were observed either on, or in the vicinity of, all of the transects. *Desmarestia viridis* was attached to cobbles on the nearshore end of transects T1, T2, T4, and T5, but never represented more than 30% of the total cover at any station. The red algae, *Iridea cordata*, *Porphyra perforata*, *Constantinea simplex*, *Kallymenia* sp., and *Polysiphonia* sp. were found in small patches on only a few transects, and none of these species represented greater than 20% of the total cover at any station. Another red algae, *Fauchea* sp., was observed on 8 of the 12 transects, but never represented greater than 10% of the total cover at any station. The brown algae *Laminaria saccharina* and *Nereocystis luetkeana* were found both attached and drifting, but these species were neither widely dispersed nor dense. Several other brown algae species, *Macrocystis integrifolia*, *Fucus gardneri*, and *Egregia menziesii*, were observed along the transects, but never within the 0.25-m^2 quadrat.

The percent cover data also show that benthic diatoms were patchy in distribution, but quite dense within those patches. At some stations, benthic diatoms represented up to 86% of the total cover. The contribution of benthic diatoms to annual gross primary productivity of an estuarine system such as Port Angeles Harbor is probably significant. In Padilla Bay, primary productivity of benthic diatoms has been shown to exceed that of macroalgae and eelgrass during early spring (Thom 1989). There is some evidence to suggest that benthic diatoms are better adapted than macrophytes or eelgrass

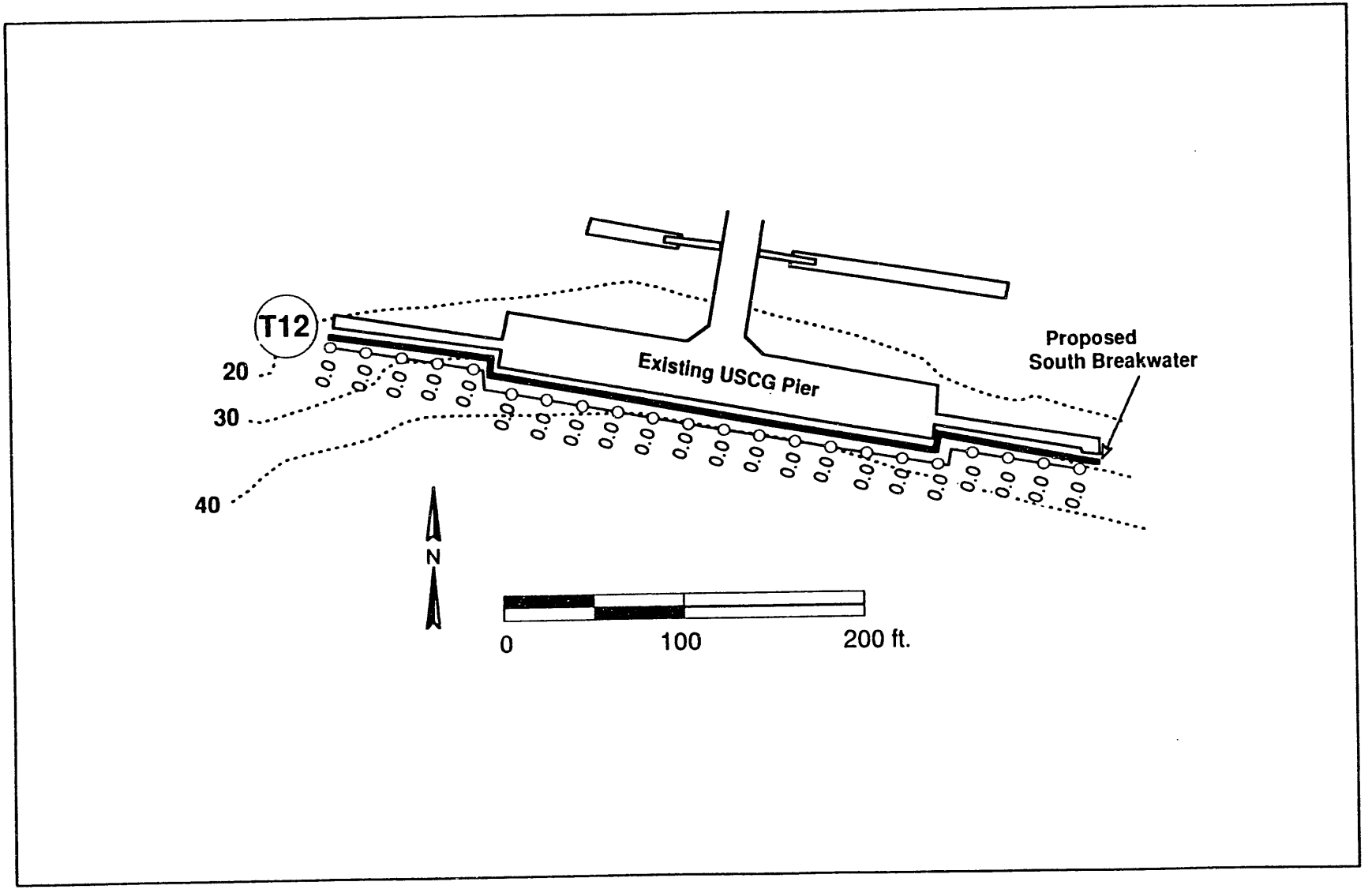


FIGURE 3.4. Locations and Mean Densities (no. m^{-2}) of Eelgrass Observed During Subtidal SCUBA Surveys in March 1993 at the South Breakwater Site

TABLE 3.2. Mean Percent Cover Observed Within a 0.25-m^2 Quadrat During Subtidal SCUBA Surveys Conducted at the Ediz Hook Coast Guard Station in March 1993

Transect	Distance Along Transect (ft) 260	240	220	200	180	160	140	120	100	80	60	40	20
T1													
Zostera marina	nd[a]	nd	nd	nd	nd	6.7	16.7	16.7	63.3	10.0	0	0	exp[b]
Gracilaria pacifica	nd	nd	nd	nd	nd	6.7	0	0	0	0	0	0	exp
Desmarestia viridis	nd	nd	nd	nd	nd	0	0	0	0	26.7	3.3	0	exp
Ulva sp.	nd	nd	nd	nd	nd	0	0	0	0	3.3	23.3	0	exp
Iridea cordata	nd	nd	nd	nd	nd	0	0	0	0	3.3	0	0	exp
Nereocystis[c]	nd	nd	nd	nd	nd	0	0	0	0	0	6.7	0	exp
muddy sand	nd	nd	nd	nd	nd	86.6	80.0	56.7	30.0	43.3	13.3	0	exp
shell	nd	nd	nd	nd	nd	0	3.3	0	3.3	0	0	0	exp
diatom mat	nd	nd	nd	nd	nd	0	0	23.3	0	0	26.7	0	exp
cobble	nd	nd	nd	nd	nd	0	0	3.3	0	13.3	26.7	100	exp
moon snail collar	nd	nd	nd	nd	nd	0	0	0	3.3	0	0	0	exp
T2													
Zostera marina	nd	nd	nd	0	0	0	0	0	0	60.0	6.7	0	0
Gracilaria pacifica	nd	nd	nd	30.0	40.0	26.7	3.3	16.7	63.3	0	0	0	0
Desmarestia viridis	nd	nd	nd	0	0	0	0	0	0	0	6.7	0	0
Ulva sp.	nd	nd	nd	0	0	0	0	0	3.3	0	30.0	0	0
Nereocystis[c]	nd	nd	nd	0	0	0	0	0	0	3.3	0	0	0
Nereocystis[d]	nd	nd	nd	0	0	0	3.3	3.3	0	0	0	0	0
Fauchea sp.	nd	nd	nd	0	0	3.3	0	0	0	0	0	0	0
Porphyra perforata	nd	nd	nd	0	0	0	0	0	0	0	3.3	0	0
muddy sand	nd	nd	nd	70.0	60.0	70.0	23.3	33.3	33.3	40.0	0	0	0
diatom mat	nd	nd	nd	0	0	0	0	20.0	0	0	0	0	0
Navicula sp.	nd	nd	nd	0	0	0	30.0	0	0	0	3.3	0	0
cobble	nd	nd	nd	0	0	0	0	6.7	0	0	46.7	0	0
wood debris	nd	nd	nd	0	0	0	40.0	20.0	0	0	0	0	0
rock riprap	nd	nd	nd	0	0	0	0	0	0	0	0	100	100

(a) nd = no data.
(b) exp = exposed.
(c) live *Nereocystis luetkeana*.
(d) dead *Nereocystis luetkeana* stipe.

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 260	240	220	200	180	160	140	120	100	80	60	40	20
T3													
Zostera marina	0	0	0	40.0	30.0	3.3	0	0	40.0	0	0	0	exp[a]
Gracilaria pacifica	0	53.3	3.3	0	0	10.0	6.7	46.7	0	0	0	0	exp
Ulva sp.	0	0	0	6.7	16.7	6.7	3.3	10.0	0	20.0	20.0	0	exp
Fauchea sp.	0	0	10.0	0	3.3	0	0	0	0	0	0	0	exp
Polysiphonia sp.	0	0	3.3	0	0	0	0	0	0	0	0	0	exp
muddy sand	100	46.7	76.7	53.3	50.0	3.3	26.7	43.3	36.7	56.7	26.7	0	exp
shell	0	0	0	0	0	0	0	0	0	3.3	0	0	exp
diatom mat	0	0	0	0	0	76.7	63.3	0	0	0	0	0	exp
Navicula sp.	0	0	6.7	0	0	0	0	0	0	0	0	0	exp
cobble	0	0	0	0	0	0	0	0	0	10.0	50.0	100	exp
wood[b]	0	0	0	0	0	0	0	0	23.3	10.0	3.3	0	exp
T4													
Zostera marina	nd[c]	nd	nd	0	0	0	0	0	36.7	40.0	0	0	0
Gracilaria pacifica	nd	nd	nd	13.3	10.0	13.3	10.0	0	0	0	0	0	0
Desmarestia viridis	nd	nd	nd	0	0	0	0	0	0	0	16.7	0	0
Ulva sp.	nd	nd	nd	0	0	3.3	40.0	13.3	0	0	33.3	13.3	0
Fauchea sp.	nd	nd	nd	0	0	0	6.7	0	0	0	0	0	0
muddy sand	nd	nd	nd	83.3	30.0	40.0	33.3	0	0	60.0	0	0	0
shell	nd	nd	nd	0	6.7	0	0	0	0	0	0	0	0
diatom mat	nd	nd	nd	3.3	10.0	40.0	0	0	0	0	0	0	0
Navicula sp.	nd	nd	nd	0	0	3.3	0	0	0	0	0	0	0
cobble	nd	nd	nd	0	0	0	0	0	0	0	50.0	66.7	100
wood debris	nd	nd	nd	0	20.0	0	10.0	76.7	63.3	0	0	20.0	0
wood	nd	nd	nd	0	20.0	0	0	0	0	0	0	0	0
metal	nd	nd	nd	0	3.3	0	0	10.0	0	0	0	0	0

(a) exp = exposed.
(b) wood = solid wood (e.g., logs, branches).
(c) nd = no data.

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 260	240	220	200	180	160	140	120	100	80	60	40	20
T5													
Zostera marina	nd[a]	nd	0	0	30.0	3.3	0	0	0	0	0	0	exp[b]
Gracilaria pacifica	nd	nd	63.3	46.7	0	6.7	10.0	86.7	86.7	0	0	6.7	exp
Desmarestia viridis	nd	nd	0	0	0	0	0	0	3.3	0	0	0	exp
Ulva sp.	nd	nd	0	0	0	6.7	6.7	10.0	6.7	63.3	10.0	56.6	exp
Fauchea sp.	nd	nd	0	0	0	0	0	3.3	0	0	0	0	exp
Laminaria saccharina	nd	nd	0	3.3	0	0	0	0	0	3.3	0	0	exp
Iridea cordata	nd	nd	0	0	0	0	0	0	0	0	6.7	0	exp
muddy sand	nd	nd	36.7	50.0	70.0	23.3	0	0	3.3	10.0	20.0	0	exp
shell	nd	nd	0	0	0	0	3.3	0	0	0	0	0	exp
diatom mat	nd	nd	0	0	0	50.0	80.0	0	0	0	0	0	exp
cobble	nd	nd	0	0	0	0	0	0	0	0	63.3	36.7	exp
wood debris	nd	nd	0	0	0	0	0	0	0	23.3	0	0	exp
T6													
Zostera marina	nd	0	0	0	13.3	3.3	0	0	33.3	0	0	0	0
Gracilaria pacifica	nd	0	16.7	90.0	10.0	6.7	6.7	60.0	26.7	3.3	0	43.3	0
Ulva sp.	nd	0	6.7	0	0	13.3	6.7	30.0	3.3	16.7	16.6	26.7	0
Fauchea sp.	nd	0	0	0	3.3	0	0	0	3.3	0	0	0	0
Kallymenia sp.	nd	0	0	0	0	0	0	10.0	0	0	0	0	0
muddy sand	nd	100	73.3	10.0	73.3	13.3	0	0	33.3	13.3	16.7	30.0	0
diatom mat	nd	0	0	0	0	63.3	86.6	0	0	66.7	6.7	0	0
cobble	nd	0	3.3	0	0	0	0	0	0	0	0	0	100
wood debris	nd	0	0	0	0	0	0	0	0	0	60.0	0	0

(a) nd = no data.
(b) exp = exposed.

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 260	240	220	200	180	160	140	120	100	80	60	40	20
T7													
Zostera marina	nd[a]	nd	nd	nd	nd	0	0	0	0	0	0	0	0
Gracilaria pacifica	nd	nd	nd	nd	nd	20.0	6.7	3.3	0	16.7	0	3.3	0
Ulva sp.	nd	nd	nd	nd	nd	10.0	16.7	3.3	0	16.7	0	3.3	0
Fauchea sp.	nd	nd	nd	nd	nd	0	0	0	0	3.3	0	0	0
muddy sand	nd	nd	nd	nd	nd	20.0	50.0	83.3	0	20.0	0	93.3	0
shell	nd	nd	nd	nd	nd	0	0	6.7	0	0	0	0	0
diatom mat	nd	nd	nd	nd	nd	50.0	23.3	0	96.7	0	0	0	0
Navicula sp.	nd	nd	nd	nd	nd	0	3.3	0	0	0	0	0	0
wood[b]	nd	nd	nd	nd	nd	0	0	3.3	3.3	0	0	0	0
wood debris	nd	nd	nd	nd	nd	0	0	0	0	43.3	100	0	0
rock riprap	nd	nd	nd	nd	nd	0	0	0	0	0	0	0	100
T8													
Zostera marina	nd	nd	nd	nd	0	0	0	0	0	0	0	0	0
Gracilaria pacifica	nd	nd	nd	nd	40.0	0	3.3	3.3	10.0	0	0	0	0
Ulva sp.	nd	nd	nd	nd	30.0	0	0	3.3	0	0	0	16.7	0
muddy sand	nd	nd	nd	nd	13.3	46.6	73.3	20.0	0	0	0	3.3	0
diatom mat	nd	nd	nd	nd	0	6.7	23.3	73.3	0	0	0	80.0	0
wood debris	nd	nd	nd	nd	10.0	0	0	0	90.0	100	96.7	0	0
wood	nd	nd	nd	nd	0	40.0	0	0	0	0	0	0	0
Parastichopus[c]	nd	nd	nd	nd	6.7	0	0	0	0	0	0	0	0
rusty cans	nd	nd	nd	nd	0	6.7	0	0	0	0	0	0	0
anemone	nd	nd	nd	nd	0	0	0	0	0	0	3.3	0	0
rock riprap	nd	nd	nd	nd	0	0	0	0	0	0	0	0	100

(a) nd = no data.
(b) wood = solid wood (e.g., logs, branches).
(c) *Parastichopus californicus*.

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 260	240	220	200	180	160	140	120	100	80	60	40	20
T9													
Zostera marina	nd[a]	nd	nd	nd	0	0	0	0	0	0	0	23.3	0
Gracilaria pacifica	nd	nd	nd	nd	0	3.3	6.7	30.0	0	0	0	0	0
Ulva sp.	nd	nd	nd	nd	16.7	26.7	0	6.7	0	0	3.3	0	0
Nereocystis[b]	nd	nd	nd	nd	0	0	0	6.7	0	0	0	0	0
muddy sand	nd	nd	nd	nd	23.3	50.0	20.0	33.3	26.7	0	0	76.7	0
shell	nd	nd	nd	nd	0	0	0	0	0	0	0	0	0
diatom mat	nd	nd	nd	nd	56.7	16.7	73.3	0	66.7	0	0	0	0
Navicula sp.	nd	nd	nd	nd	0	3.3	0	0	0	0	0	0	0
wood debris	nd	nd	nd	nd	0	0	0	13.3	3.3	96.7	96.7	0	0
wood[c]	nd	nd	nd	nd	0	0	0	0	3.3	0	0	0	0
glass bottle	nd	nd	nd	nd	3.3	0	0	0	0	0	0	0	0
metal chain	nd	nd	nd	nd	0	0	0	10.0	0	0	0	0	0
tin can	nd	nd	nd	nd	0	0	0	0	0	3.3	0	0	0
rock riprap	nd	nd	nd	nd	0	0	0	0	0	0	0	0	100

(a) nd = no data.
(b) dead *Nereocystis luetkeana* stipe.
(c) wood = solid wood (e.g., logs, branches).

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 260	240	220	200	180	160	140	120	100	80	60	40	20
T10													
Zostera marina	nd[a]	nd	nd	0	0	0	0	0	0	0	0	0	0
Gracilaria pacifica	nd	nd	nd	0	3.3	0	20.0	0	6.7	0	0	0	0
Ulva sp.	nd	nd	nd	3.3	10.0	0	0	0	0	0	0	25.7	0
Fauchea sp.	nd	nd	nd	0	0	0	0	3.3	0	0	0	0	0
muddy sand	nd	nd	nd	20.0	70.0	30.0	26.7	73.3	93.3	0	50.0	0	0
cobble	nd	nd	nd	0	0	0	0	0	0	0	50.0	0	0
coarse sand	nd	nd	nd	0	0	0	0	0	0	0	0	66.6	0
diatom mat	nd	nd	nd	10.0	13.3	70.0	53.3	0	0	0	0	0	0
Navicula sp.	nd	nd	nd	66.7	0	0	0	0	0	0	0	0	0
wood debris	nd	nd	nd	0	0	0	0	0	0	93.3	0	0	0
wood[b]	nd	nd	nd	0	0	0	0	23.3	0	0	0	0	0
aluminum can	nd	nd	nd	0	0	0	0	0	0	3.3	0	0	0
plastic bottle	nd	nd	nd	0	0	0	0	0	0	3.3	0	0	0
moon snail collar	nd	nd	nd	0	3.3	0	0	0	0	0	0	0	0
anemone	nd	nd	nd	0	0	0	0	0	0	0	0	6.7	0
rock riprap	nd	nd	nd	0	0	0	0	0	0	0	0	0	100

(a) nd = no data.
(b) wood = solid wood (e.g., logs, branches).

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 260	240	220	200	180	160	140	120	100	80	60	40	20
T11													
Zostera marina	nd[a]	nd	0	0	0	0	0	36.7	0	0	0	0	0
Gracilaria pacifica	nd	nd	0	0	0	0	0	0	0	0	0	0	0
Ulva sp.	nd	nd	0	0	3.3	0	0	0	0	0	0	0	30.0
Laminaria saccharina	nd	nd	0	0	3.3	0	0	0	0	0	0	0	0
Iridea cordata	nd	nd	0	0	0	0	0	0	0	0	0	0	20.0
muddy sand	nd	nd	36.7	36.7	0	53.3	33.3	46.6	76.7	56.7	0	0	0
cobble	nd	nd	46.6	10.0	0	0	0	0	0	0	0	0	50.0
coarse sand	nd	nd	0	0	0	6.7	0	0	0	0	0	0	0
diatom mat	nd	nd	0	0	56.7	40.0	66.7	16.7	0	0	0	0	0
Navicula sp.	nd	nd	16.7	53.3	36.7	0	0	0	0	0	0	100	0
wood debris	nd	nd	0	0	0	0	0	0	0	43.3	100	0	0
wood[b]	nd	nd	0	0	0	0	0	0	23.3	0	0	0	0

(a) nd = no data.
(b) wood = solid wood (e.g., logs, branches).

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 0	20	40	60	80	100	120	140	160	180	200	220	240	260
T12														
Zostera marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laminaria saccharina	0	0	0	0	0	0	0	6.7	0	0	0	0	0	10.0
Nereocystis[a]	0	0	0	0	16.7	0	0	0	0	0	0	0	0	0
muddy sand/shell	100	100	90.0	93.3	76.6	26.7	93.3	90	100	60.0	96.7	93.3	96.7	80.0
wood debris	0	0	0	0	0	0	0	0	0	6.7	0	0	0	0
wood[b]	0	0	0	0	0	6.7	0	0	0	0	0	0	0	0
metal pipe	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0
metal chain	0	0	0	6.7	6.7	0	0	0	0	0	0	0	0	0
broken off piling	0	0	0	0	0	33.3	0	0	0	0	0	0	0	0
plastic bread tray	0	0	0	0	0	33.3	0	0	0	0	0	0	0	0
rug	0	0	0	0	0	0	6.7	0	0	0	0	0	0	0
aluminum can	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0
roof tile	0	0	0	0	0	0	0	0	0	0	0	0	0	6.7
Mytilus californianus	0	0	6.7	0	0	0	0	0	0	0	0	0	0	3.3
living sponge	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0
Eudistylia vancouveri	0	0	0	0	0	0	0	0	0	33.3	3.3	3.3	0	0
anemone	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0

(a) dead *Nereocystis luetkeana* stipe.
(b) wood = solid wood (e.g., logs, branches).

TABLE 3.2. (contd)

Transect	Distance Along Transect (ft) 280	300	320	340	360	380	400	420
T12 (contd)								
Zostera marina	0	0	0	0	0	0	0	0
Ulva sp.	0	0	0	0	0	0	3.3	0
Laminaria saccharina	0	0	0	6.7	0	0	0	0
Nereocystis[a]	5.0	0	0	0	0	0	0	0
Fauchea sp.	0	0	0	0	0	3.3	0	0
muddy sand/shell	80.0	96.7	93.3	86.6	73.3	80.0	83.3	100
wood debris	0	0	0	0	0	0	0	0
wood[b]	0	0	0	6.7	20.0	6.7	0	0
cobble	0	0	0	0	6.7	3.3	0	0
metal pipe	0	0	0	0	0	6.7	0	0
metal	0	0	0	0	0	0	3.3	0
aluminum can	5.0	0	0	0	0	0	0	0
tin can	0	0	0	0	0	0	3.3	0
concrete	0	0	0	0	0	0	6.7	0
anemone	0	0	0	0	0	0	0	0
Parastichopus[c]	10.0	0	6.7	0	0	0	0	0
Patiria miniata	0	3.3	0	0	0	0	0	0

(a) dead *Nereocystis luetkeana* stipe.
(b) wood = solid wood (e.g., logs, branches).
(c) *Parastichopus californicus*.

for rapid growth during the low temperatures and lower light conditions of late winter/early spring (Thom 1990a; Thom and Albright 1990).

3.4 GENERAL OBSERVATIONS

More than 15 species of brown, red, and green algae were observed during the subtidal SCUBA surveys (Table 3.3). Brown and red algae were represented by more species than green algae. In addition, benthic diatoms were observed in dense mats along each of the transects except T12. In general, algal species diversity and abundance were higher at the east breakwater site than at either the west barrier site or the south breakwater site. Similarly, invertebrate diversity and abundance were also highest at the east breakwater site. Of the more than 30 invertebrate taxa observed by the divers, nudibranchs, hermit crabs, and giant sea cucumbers were the most abundant (Table 3.3). During the 14 dives, only 3 vertebrate species were observed: 1 painted greenling on T12; 1 high cockscomb on T7; and 10 juvenile flatfish of unidentified species (Table 3.4).

The greater species diversity and abundance observed by the divers at the east breakwater site relative to the other two sites can probably be attributed to the presence of eelgrass beds. Although eelgrass beds appear to be simple systems dominated by a single plant species, they are in reality highly complex structural and functional ecosystems. This complexity is manifested as high species and trophic diversity and one of the highest annual productivity rates of any ecosystem in the world. It is well documented that functioning eelgrass beds provide critical support to invertebrate and vertebrate species through high primary productivity, nutrient effects, sediment stabilization, shelter, and food web linkages (reviewed in Phillips 1984). The eelgrass present at the east breakwater site appeared to be healthy and the length of the blades (up to 2.5 ft) suggested that these plants are actively growing. Thus, the eelgrass beds at the east breakwater site appear to be functioning in support of the associated epifauna and macrofauna.

TABLE 3.3. Algal Taxa Observed During Subtidal SCUBA Surveys Conducted at the Ediz Hook U.S. Coast Guard Station in March 1993

Common Name	Scientific Name
Brown Algae	Phylum Phaeophyta
sugar wrack	*Laminaria saccharina*
bull kelp	*Nereocystis luetkeana*
giant kelp	*Macrocystis integrifolia*
feather boa	*Egregia menziesii*
rockweed	*Fucus gardneri*
thin desmarestia	*Desmarestia viridis*
Red Algae	Phylum Rhodophyta
iridescent seaweed	*Iridea cordata*
porphyra	*Porphyra perforata*
cup and saucer	*Constantinea simplex*
coralline algae	various unidentified species
gracilaria	*Gracilaria pacifica*
fauchea	*Fauchea* sp.
kallymenia	*Kallymenia* sp.
polysiphonia	*Polysiphonia* sp.
Green Algae	Phylum Chlorophyta
sea lettuce	*Ulva* sp.
eelgrass	*Zostera marina*
Diatoms	Phylum Bacillariophyta
tube dwelling diatoms	*Navicula* sp.
brown diatom mat	Unidentified species

TABLE 3.4. Invertebrate and Vertebrate Taxa Observed During Subtidal SCUBA Surveys Conducted at the Ediz Hook U.S. Coast Guard Station in March 1993

Common Name	Scientific Name
Invertebrates	
plumose anemone	*Metridium senile*
comb jellies	various unidentified species
polychaetes	various unidentified species
feather duster worm	*Eudistylia vancouveri*
giant sea cucumber	*Parastichopus californicus*
green urchin	*Strongylocentrotus droebachiensis*
bat star	*Patiria miniata*
sunflower star	*Pycnopodia helianthodes*
purple seastar	*Pisaster ochraceous*
flabby seastar	*Pisaster brevispinus*
spiny seastar	*Orthasterias koehleri*
chitons	various unidentified species
limpets	various unidentified species
snails	various unidentified species
moon snail	*Polinices lewisii*
hooded nudibranch	*Melibe leonina*
frosted nudibranch	*Dirona albolineata*
opalescent nudibranch	*Hermissenda crassicornis*
dorid nudibranch	*Discodoris sandiegensis*
horse clam	*Tresus* sp.
California mussel	*Mytilus californianus*
pink scallop	*Chlamys hastata*
crangon shrimp	one unidentified species
shrimp	various unidentified species
gammarid amphipods	various unidentified species
eelgrass isopod	*Idotea resecata*
hermit crab	*Pagurus* sp.
red rock crab	*Cancer productus*
kelp crab	*Pugettia producta*
decorator crab	*Oregonia gracilis*
hairy crab	*Telmessus cheiragonus*
Vertebrates	
juvenile flatfish	various unidentified species
high cockscomb	*Anoplarchus purpurescens*
painted greenling	*Oxylebius pictus*

4.0 CONCLUSIONS

Based on subtidal eelgrass/macroalgae surveys conducted at the U.S. Coast Guard Station at Ediz Hook in March 1993, the potential impacts of the proposed breakwater projects are as follows:

East Breakwater

1. Initial impacts at the east breakwater site may result from the direct loss of eelgrass/macroalgae habitat and increased turbidity resulting from breakwater construction.

2. Long-term impacts may result from shading effects, as well as changes in water circulation and littoral movement of sediments. Shading experiments have shown that rapid reductions in density and standing stock can occur as a result of decreased irradiance (Backman and Barilotti 1976; Dennison and Alberte 1982). Furthermore, Thom and Albright (1990) have shown that irradiance is the primary factor controlling the standing stock of benthic macroalgae, sediment-associated microalgae, and eelgrass in central Puget Sound.

3. Neither initial nor long-term impacts are quantifiable based on the limited scope of this study.

West Debris Barrier

1. If the debris barrier is constructed at the site of the existing log boom as originally proposed, no direct loss of eelgrass/macroalgae habitat is foreseen and initial impacts from construction activity should be minimal.

2. Eelgrass does not presently exist in the immediate vicinity of the proposed barrier and is unlikely to colonize the area because of the existing substrate, which is comprised of bark, wood chips, and wood debris several inches thick. The existing macroalgae within this site were primarily drift or detached species (Ulva sp., *Gracilaria pacifica*, *Laminaria saccharina*) that will be minimally impacted by the proposed debris barrier.

South Breakwater

1. No impacts are anticipated to eelgrass/macroalgae.

2. No eelgrass was observed in the vicinity of the breakwater site. The depths beneath this proposed breakwater exceed the documented lower depth limits (-22 ft MLLW) for eelgrass growth (Phillips 1984). Few macroalgae species were observed at this site probably because of the lack of hard substrate.

These subtidal survey results indicate that the proposed south breakwater is appropriately located to avoid impacts to existing eelgrass/macroalgae. Likewise, the west debris barrier will avoid impacts to existing eelgrass/macroalgae as long as it is located at the site of the existing log boom, not to the west of the log boom as has been proposed since the completion of the diving surveys. Regardless of where it is located, the east breakwater has the potential to adversely impact eelgrass/macroalgae. Recommendations are provided in Section 5.0 on how impacts to eelgrass/macroalgae could be minimized through careful design and siting of the east breakwater.

5.0 RECOMMENDATIONS

East Breakwater

Because of the extent of the existing eelgrass at the east breakwater site, total avoidance of impacts will be difficult. The impacts to eelgrass/macroalgae should be minimized to the greatest extent possible through careful design and siting of the breakwater. One siting option worth considering is to place the new breakwater just east of the existing pilings and log boom where less eelgrass currently exists. This option would minimize impacts to the eelgrass beds both east and west of the existing structures. Alternatively, removal of the existing pilings and log boom may allow the large eelgrass bed observed along transects T3, T4, T5, and T6 to slowly spread east and colonize the area that was previously shaded. The colonization rate might be enhanced through transplantation of eelgrass. If the USACE decides to proceed as planned and site the breakwater to the east of the existing structures, the project engineers may want to consider having divers available during the breakwater construction to assist with the exact siting of the new structure.

West Debris Barrier

Historically, this area was probably used for log storage and the heavy layer of bark, wood chips, and wood debris armoring the bottom is currently limiting the productivity of this habitat. Any efforts to enhance this area for eelgrass/macroalgae should focus on removal or capping of the wood waste.

South Breakwater

The habitat off the end of the existing T-pier could be dramatically improved by the removal of all the accumulated garbage. This habitat presently supports a diverse assemblage of invertebrates and removal of the tires, metal pipes, toilet, cans, bottles, extension ladder, scrap metal, plastic, etc. that were observed along transect T12 would enhance the overall productivity of this habitat.

6.0 REFERENCES

Backman, T. W., and D. C. Barilotti. 1976. "Irradiance Reduction: Effects on Standing Crops of the Eelgrass *Zostera marina* in a Coastal Lagoon." Marine Biology 34:33-40.

Dennison, W., and R. S. Alberte. 1982. "Photosynthetic Responses of *Zostera marina* L. (Eelgrass) to *in situ* Manipulations of Light Intensity." Oecologia 55:137-144.

Phillips, R. C. 1984. The Ecology of Eelgrass Meadows in the Pacific Northwest: A Community Profile. FWS/OBS-84/24, U.S. Fish and Wildlife Service, Portland, Oregon.

Thom, R. M. 1989. Plant Standing Stock and Productivity on Tidal Flats in Padilla Bay, Washington: a Temperate North Pacific Estuarine Embayment. NOAA Technical Report Series OCRM/MEMD. FRI-UW-8909, Fisheries Research Institute, School of Fisheries, University of Washington, Seattle, Washington.

Thom, R. M. 1990a. "Spatial and Temporal Patterns in Plant Standing Stock and Primary Production in a Temperate Seagrass System." Botanica Marina 33:497-510.

Thom, R. M. 1990b. "A Review of Eelgrass (*Zostera marina* L.) Transplanting Projects in the Pacific Northwest." The Northwest Environmental Journal 6:121-137.

Thom, R. M., and R. G. Albright. 1990. "Dynamics of Benthic Vegetation Standing-Stock, Irradiance, and Water Properties in Central Puget Sound." Marine Biology 104:129-141.

DISTRIBUTION

No. of Copies	OFFSITE
2	DOE/Office of Scientific and Technical Information
13	Merri Martz U.S. Army Corps of Engineers Seattle District 4735 E. Marginal Way So. Seattle, WA 98124-2255

No. of Copies	ONSITE	
	DOE Richland Operations Office	
	D. R. Segna	A5-90
12	**Pacific Northwest Laboratory**	
	D. K. Shreffler	SEQUI
	R. M. Thom	SEQUI
	R. M. Ecker	SEQUI
	W. R. Gorst	K6-86
	J. A. Trelstad	SEQUI
	Publishing Coordination	K1-06
	Technical Report Files (5)	
	Routing	
	M. J. Graham	K6-78
	P. M. Irving	K6-98
	R. L. Skaggs	K6-77
	C. S. Sloane	K6-04
	P. C. Hays (last)	K6-86

DATE
FILMED
8/17/93

END