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Some Effects of Industrial Development and Marine Log Storage on Benthic Marine Organisms at a Sawmill near Wrangell, Alaska

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INTRODUCTION

The Alaska Pulp Corporation, which owns and operates a sawmill facility near Wrangell, Alaska, applied for Federal and State permits to place approximately 418,000 m^3 of woodwaste and shotrock fill into intertidal waters along Zimovia Strait. At the request of the Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS) initiated this study to determine if past and ongoing sawmill operations had affected the abundance and diversity of the marine biota at the proposed project site. The EPA reviews and provides regulatory oversight with the Army Corps of Engineers (Corps) for proposals involving the discharge of dredge and fill materials into waters of the United States.

Study field work was accomplished from October 17-20, 1993, by representatives of the FWS, EPA, and the Corps.

STUDY AREA

The proposed 9.7-hectare woodwaste disposal area is located approximately 8 km south of Wrangell, Alaska (Figure 1). The area directly impacted would be rectangular in shape (244 m x 396 m), and would extend from the shore to the approximate minus 1.2-m tide level. The site is presently utilized for in-water storage of log and log bundles which ground in the intertidal area during low tidal stages. The substrate within the project area was predominately compacted silt and sand intermixed with bark and other organic debris. Photographs of the study and the control sites are reproduced in Figure 2.

The control site is located about 1.5 km north of the project area along Zimovia Strait, and directly seaward of the abandoned Wrangell Institute (Figure 1). The substrate at the control area was composed of unconsolidated small cobble and gravel-sized material with shell fragments, sand, and silt filling the spaces between the larger particles.

The intertidal habitat at the control site is typical of the unaltered estuarine intertidal shoreline along Zimovia Strait, and probably very similar to the study site before it was

Figure 1. Location of Study and Control Sites near Wrangell, AK.

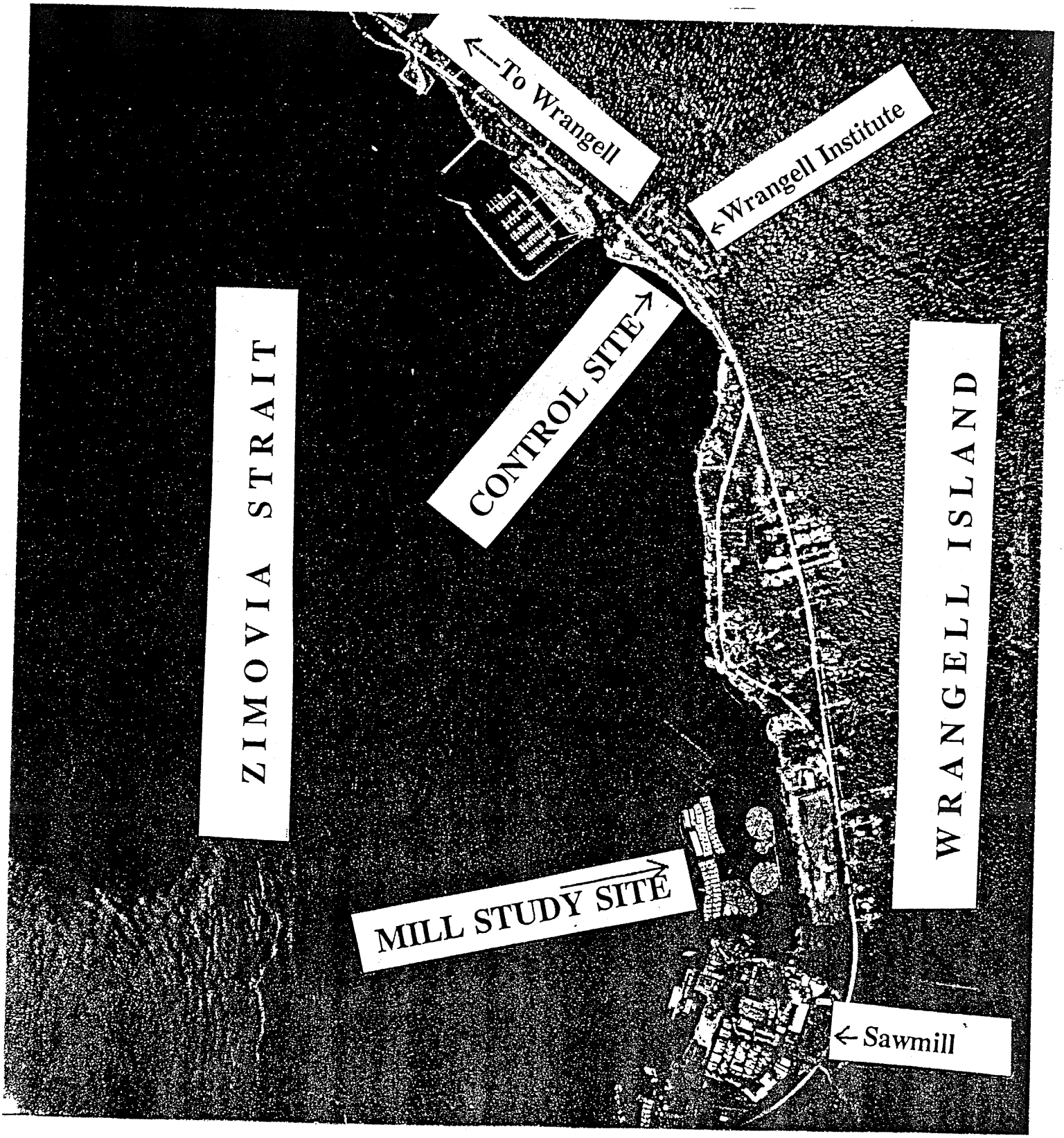

Figure 2. Study Sites for Wrangell Woodwaste Disposal Project.

Intertidal Log Storage at Wrangell Mill Study Site.

Intertidal Area at Control Site near Wrangell, Alaska.

altered by industrial development. Dominant epibenthic species include rockweed (Fucus sp.), balanoid barnacles (Balanus spp.), and blue mussels (Mytilus frossulus[1]). Infaunal assemblages are represented by several species of clams and polychaete worms.

METHODS

To minimize the high natural variability that is common to marine intertidal communities, the study and control sites were restricted to the same general isobath. The prevalence of grounded logs and log bundles restricted access to some portions of the project area. An accessible 150-m section of lower intertidal habitat, that was not covered with log bundles, was selected as representative of the project area. The selected study site was parallel to the shoreline and located between the +0.3 to +1.2-m (+1 to +4-ft) tidal levels. A similar representative 200-m section of intertidal habitat was selected at the control area.

Specific sample sites were selected by setting measured transect lines through the control and study sites. Random number tables were then used to select the sample site locations along these lines. The sample identification numbers (Table 3) reflect the location of the samples sites along the transect lines.

A 0.1-m^2 template constructed of plastic pipe was placed directly over the selected sample sites. The area within the template was excavated with a hand shovel to a depth of approximately 20 cm. The substrate and all organisms were placed in 23-liter (5 gallon) plastic buckets and transported to the support vessel. The samples were washed with salt water and screened through stacked 13, 6 and 3-mm^2 hardware cloth sorting screens. The marine macrofauna collected on the screens were enumerated and identified to species or nearest identifiable taxa. The composite biomass (whole wet weight, including shell or tube casings) of each species type was determined to the nearest gram with a OHAUS electronic balance (Model No. LS 2000). If the composite weight of a species type was less than 1 gram it was recorded as <1 g and treated as 0.0 grams for sample site biomass summations. This procedure tends to slightly underestimate the total sample biomass.

Attached algae and barnacles were not included in this study. Barnacles were omitted because of the time constraints involved with their removal from the cobble-gravel substrate.

Sample differences were compared using non-parametric Mann-Whitney test for ranking unpaired measurements (Snedecor and Cochran 1967).

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[1]. Formerly *Mytilus edulis*.

RESULTS

The numbers of individuals and composite weights of each species collected in the samples from the study (n=10) and control sites (n=9) are listed in Tables 1 and 2. The mean sample biomass, mean number of species, and mean numbers of individuals are compared in Figure 3.

The ranked samples were significantly different at $p < .05$ and $p < .01$ probability levels, for biomass and numbers of individuals respectively. The mean sample biomass for all species collected at the control site (254 $g/0.1m^2$, ±487 @ p=.05) was 5.6 times greater than at the mill study site (45.6 $g/0.1m^2$, ±116 @ p=.05). The mean number of individuals collected at the control area (211 $g/0.1m^2$, ±381 @ p=.05) was 12.6 times greater than at the mill study area (16.8 $g/0.1m^2$, ±24.6 @ p=.05). The large variances in the sample means are due to the patchy distribution and natural variance typical of intertidal communities.

The mean numbers of different species collected at the study site (4.7) and the control site (5.8) were not significantly different ($p<.05$). Although the numbers of individuals and sample biomass were significantly greater at the control site, the numbers and types of species present at the control and study sites were similar. Nineteen different species or taxa were collected and identified at the control site and 15 at the mill study site. Eleven (46%) of the species were common to both areas.

The Shannon-Weaver species diversity index (Hair 1980) was used to evaluate the ecological diversity of the intertidal benthic communities at the study and control sites. The Shannon-Weaver indices for the control site (0.764) and mill site (0.573) were similar. However, since balanoid barnacles were not included in the study but were significant components of the intertidal communities, the diversity indices may not accurately represent the community structure at the respective sites.

The number of individuals and biomass at the study and control sites were dominated by mollusks and polychaete worms. Blue mussels (*Mytilus frossulus*) comprised 83% of the sample biomass at the control site and 63% of the biomass at the mill study site. The percentage composition by higher order taxonomic groups is given below:

Percentage Composition of Samples*

	Control Area	Study Area
Biomass of Mollusks	97%	91%
Biomass of Polychaetes	3%	3%
Biomass of Other Taxa	<1%	6%
Numbers of Mollusks	79%	81%
Numbers of Polychaetes	19%	15%
Numbers of Other Taxa	2%	4%

*Barnacles were excluded from study results.

Figure 3: Comparison of Mean Number of Species, Mean Number of Individuals, and Mean Biomass of Intertidal Substrate Samples Taken at Wrangell Sawmill and at a Control Site.

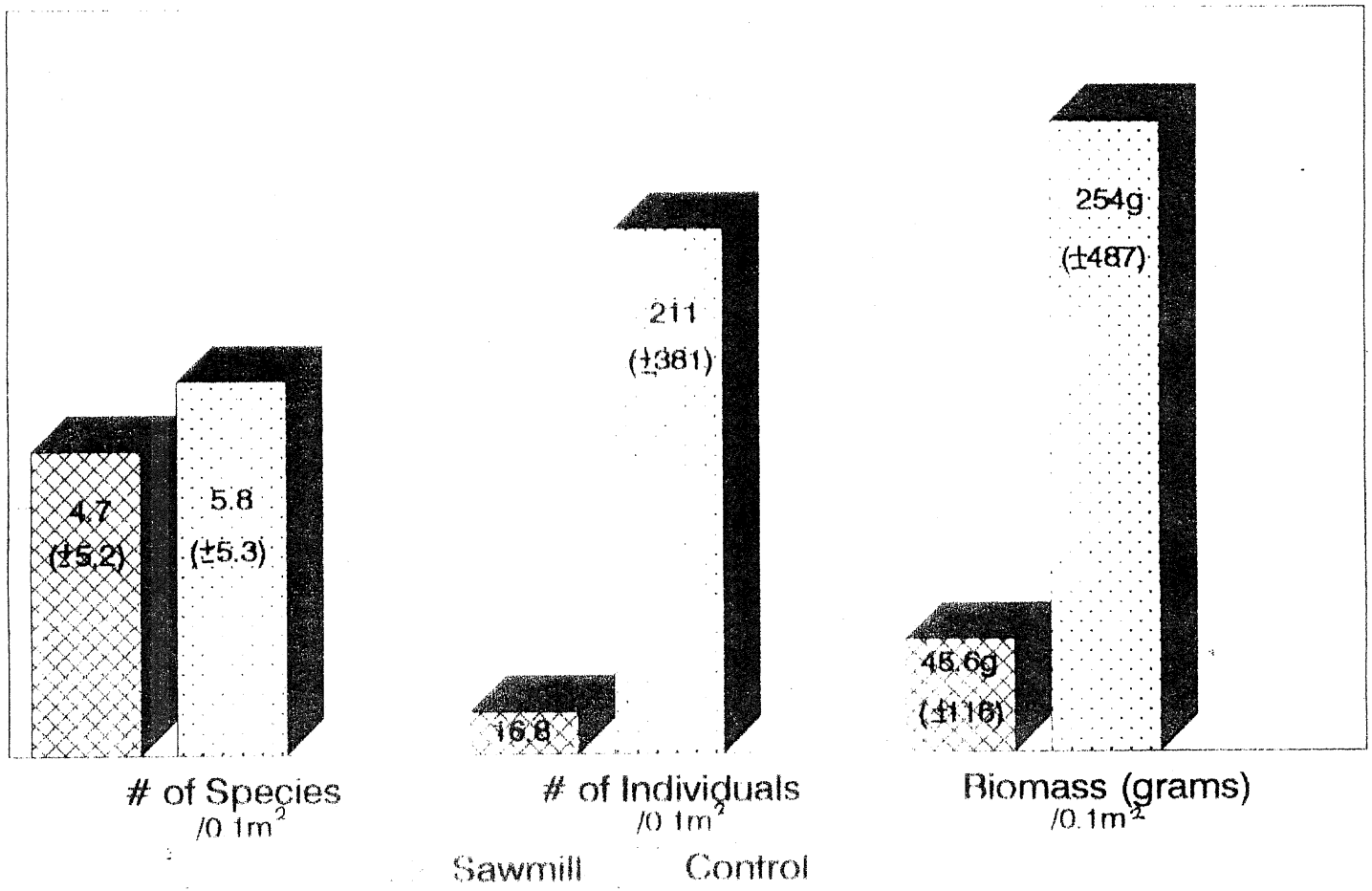

Table 1. Numbers of individuals and biomass (g) for each taxa identified in ten 0.1-meter^2 substrate samples taken experimental site area at Wrangell Sawmill.

	Z013	Z017	Z022	Z024	Z026	Z059	Z068	Z084	Z113	Z143
Mollusks										
Clinocardium nuttallii	1 (<1g)	1 (<1g)	4 (18g)	1 (<1g)	1 (<1g)					
Macoma sp.	3 (11g)	5 (4g)	2 (<1g)	1 (1g)	1 (<1g)	2 (2g)	4 (2g)	1 (<1g)		
Mytilus edulis	3 (18g)		23 (72g)	26 (100g)			1 (7g)	20 (91g)		
Protothaca staminea	3 (<1g)		2 (21g)	1 (<1g)		1 (5g)	3 (7g)	2 (29g)		
Saxidomus giganteus			1 (26g)							
Tellinidae (unident.)	8 (<1g)			2 (<1g)			12 (<1g)			
Thais sp.										
Opisthobranchiata (nudibranch)								1 (<1g)		
Polychaetes										
Cistenides granulata		3 (<1g)	2 (1g)	1 (<1g)			1 (<1g)			
Nereid (unident.)		2 (2g)	1 (<1g)	2 (11g)	2 (<1g)					
Owenia fusiformis		7 (<1g)				3 (<1g)				
Unident. Polychaete frag.	1 (<1g)									1 (<1g)
Roundworms										
Unident. Nemertean	1 (<1g)				1 (<1g)				1 (<1g)	
Crustaceans										
Cancer magister			1 (28g)							
Unident. fragments			1 (<1g)							
Fish										
Unident. juv. Prickleback			1 (<1g)							
TOTALS	20 (29g)	18 (6g)	38 (166g)	34 (112g)	5 (<1g)	6 (7g)	21 (16g)	24 (120g)	1 (<1g)	1 (<1g)

Table 2. Numbers of individuals and biomass in grams for each taxa identified in nine 0.1-meter^2 substrate samples taken at the control site in Shoemaker Bay.

	Sample Site								
	C009	C038	C050	C104	C125	C155	C181	C196	C200
Mollusks									
Clinocardium nuttallii	5 (13g)	2 (225g)	1 (<1g)						
Macoma sp.	7 (1g)	2 (1g)	9 (4g)	1 (<1g)		2 (<1g)		1 (3g)	
Mytilus edulis		1 (35g)		9 (22g)	52 (52g)	144 (170g)	323 (586g)	616 (699g)	318 (325g)
Protothaca staminea	1 (<1g)	2 (<1g)	1 (<1g)				1 (<1g)	1 (14g)	
Saxidomus giganteus		1 (43g)							
Thais sp.	1 (11g)								
Prosobranchiata (limpet)	1 (<1g)						1 (<1g)		
Polychaetes									
Cistenides granulata	5 (<1g)	5 (<1g)	1 (<1g)			1 (<1g)			
Glyceridae (unident.)	2 (<1g)								
Nereid (unident.)	1 (<1g)	1 (2g)						1 (2g)	
Owenia fusiformis	28 (3g)	318 (61g)	3 (<1g)	1 (<1g)					
Unident. Polychaete frag.			1 (<1g)						
Flatworms									
Unident. Platyhelminthes		2 (<1g)				1 (<1g)	1 (<1g)		
Roundworms									
Emplectonema sp.				3 (<1g)	3 (<1g)	7 (3g)	2 (?)		6 (1g)
Unident. Nemertean			1 (1g)						
Crustaceans									
Unident. isopoda							2 (<1g)		
Unident. pagurid								2 (<1g)	
Unident. fragments								1 (<1g)	
Anthozoa									
Metridium senile	1 (3g)		1 (3g)						
TOTAL	52 (31g)	334 (367g)	18 (8g)	14 (22g)	55 (52g)	155 (173g)	330 (586g)	621 (718g)	324 (326g)

Table 3. Summary of results from intertidal samples taken from control site in Shoemaker Cove and experimental site at Wrangell Sawmill.

Control Site

Sample Number	Number of Species ($0.1m^2$)	Number of Individuals ($0.1m^2$)	Biomass grams ($0.1m^2$)
C-009	10	52	31
C-038	9	334	367
C-050	8	18	8
C-104	4	14	22
C-125	2	55	52
C-155	5	155	173
C-181	6	330	586
C-196	6	621	718
C-200	2	324	326
Average (n_1=9)	5.8 (±5.3)	211 (±381)	254 (±487)

Wrangell Sawmill Site

Z-013	7	20	29
Z-017	5	18	6
Z-022	10	38	166
Z-024	7	34	112
Z-026	4	5	<1
Z-059	3	6	7
Z-068	5	21	16
Z-084	4	24	120
Z-113	1	1	<1
Z-143	1	1	<1
Average (n_2=10)	4.7 (±5.2)	16.8 (±24.6)	45.6 (±116)

If balanoid barnacles had been included in the study results, they would have been significant contributors to the sample biomass and numbers of individuals. Balanoid barnacles were especially numerous at the control area, and their inclusion in the study results would have increased the observed differences between the study and the control areas.

DISCUSSION

The mean sample biomass and numbers of individuals collected at the control and study sites are within the range of results reported from other Southeast Alaska nearshore areas. Comparison of pooled results from this study and selected similar study areas are listed below:

	Biomass (g/m^2)	No. Individ./m^2
Wrangell Control Site	2540	2110
Wrangell Study Site	456	168
Corner Bay, Shallow[1]	1165	121
Cube Cove[2]	4092	1136
Thomsen Harbor, Sitka[3]	3007	4713
Jamestown Bay, Sitka[3]	126	81
Letnikof Cove, Haines[4]	124	22

1. Jackson 1986; 2. USFWS 1983; 3. USFWS 1988; 4. USFWS 1986.

The biomass and numbers of individuals at the control site are comparable to those reported from other study areas with high biomass and numbers of individuals. Likewise, the mill study site compares to the areas exhibiting low biomass and numbers (i.e., Jamestown Bay and Letnikof Cove). The relatively low results reported from the Jamestown Bay study (USFWS 1988) are attributable to two factors: 1) no epifaunal organisms were included in the study, and 2) the substrate was primarily bedrock which does not provide suitable habitat for most infaunal organisms. The other study area listed above with low biomass and numbers, Letnikof Cove (USFWS 1986), was subjected to the stresses of glacial sediments and high turbidity levels at the mouth of the Chilkat River near Haines, Alaska.

The results of this study show that the intertidal habitat for marine macroinvertebrates at the mill study site has been seriously degraded. The decline in numbers and biomass of marine macrobenthic fauna is probably due to a combination factors, including operation of the mill, marine log storage, and woodwaste disposal on the adjacent uplands.

A major cause of the habitat degradation is due to changes in the composition and nature of the natural intertidal substrate. The substrate at the control area, and other similar undisturbed beach areas along this section of Zimovia Strait is primarily composed of gravel and cobble-sized materials with sand, coarse

fines, and shell debris filling the interstitial spaces. This substrate provides suitable stable habitat for the attachment of sessile epibenthic invertebrates (e.g., mussels and barnacles) as well as habitat for infaunal organisms such as clams and worms.

The substrate at the study area has been altered with deposits of compacted silt, bark, and other woody debris associated with operation of the mill (i.e., log storage, log handling, surface runoff from the mill site and woodwaste storage areas). The bark and silt deposits do not provide a stable substrate for many sessile intertidal marine organisms. Although soft bottom habitats can be extremely rich in both numbers and types of marine organisms, the environmental conditions in the substrate at the project area are not conducive to marine life.

Several investigators (Pease 1974, Jackson 1986, and Conlan and Ellis 1979) have reported a decrease in the abundance of infauna at log transfer and log storage areas. Log bundles, which are stored at the site, contribute to the silt and organic load. Bark and other organic and inorganic fines are sloughed from the log bundles and deposited on the bottom. When bark decomposes in poorly flushed areas, it can increase the biological oxygen demand and lower dissolved oxygen conditions in the sediments and overlying water column (Pease 1974). A strong odor of hydrogen sulfide, an indicator of anoxic conditions, was noted while collecting samples in the study area.

Pease (1974) reported that the grounding of log bundles at a study site in Rodman Bay resulted in the compaction of sediments and the near elimination of benthic infauna. The weight and grounding action of logs and log bundles at the study area is apparently having a similar adverse effect on the benthic fauna.

Water quality was not evaluated in this study, but it is probable that chronic and acute pollution problems (e.g., turbidity, petroleum product spills, organic leachates, etc.) associated with the operation of the mill also contribute to the sparsity of marine organisms at the mill study site.

The operators at the Wrangell mill have taken some corrective actions to reduce and control surface runoff of sediments, leachates, and petroleum product spills at the mill site. Although these measures may improve water quality and somewhat lessen the stress on the adjacent biological communities, the practice of storing log bundles in shallow nearshore waters will continue to seriously degrade the affected habitat.

ACKNOWLEDGEMENTS

Bill Hughes (FWS), Sitka, Alaska, was the principal investigator for the study and is responsible for the preparation of this report. Deb Rudis (FWS), Susan Cantor (EPA), and Houston Hannafious (Corps) assisted in the task of collecting, transporting, washing and sorting the samples. Deb Rudis also provided the photographs of the project areas and helped edit the report. Ted Estrada (FWS) served as skipper aboard the support vessel M/V CURLEW.

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APPENDIX

Log Transfer Facility Siting, Construction and Operation Guidelines.

SITING GUIDELINES*

1. Proximity to Rearing and Spawning Areas: Siting of log transfer and log raft storage facilities within 300 feet of the mouths of anadromous fish streams, or in areas known to be important for fish spawning or rearing, is normally prohibited.

2. Protected Locations: Log transfer and log storage facilities should be sited in weather protected waters with bottoms suitable for anchoring and with at least 20 acres for temporary log storage and log booming.

3. Upland Facility Requirements: Log transfer facilities generally should be sited in proximity to at least five acres of relatively flat uplands. There should also be a body of water sufficient to provide a minimum of 60 lineal feet of facility face.

4. Safe Access to a Facility from the Uplands: To provide safe access to the log transfer facility and adjoining log sort yard, the facility should be sited where access roads to the facility can maintain a grade of 10% or less for trucks and 4% for specialized equipment.

5. Bark dispersal: LTF should be sited along or adjacent to straits and channels or deep bays where currents may be strong enough to disperse sunken or floating wood debris. Siting LTF in embayments with sills or other natural restrictions to tidal exchange should be avoided.

6. Site Productivity: Sites for in-water storage and of transfer of logs should be located in areas having the least productive intertidal and subtidal zones.

7. Sensitive Habitat: LTFs and log raft storage areas should not be sited on or adjacent to (i.e., near enough to affect) extensive tideflats, salt marshes, kelp or eelgrass beds seaweed harvest areas of shellfish concentration areas.

8. Safe Marine Access to Facilities: Log rafting and storage facilities should be safely accessible to tug boats with log rafts at most tides and on most winter days.

9. Storage and Rafting: Logs, log bundles, and log rafts should be stored in areas where they will not ground at low tide. A minimum depth of 40 feet or deeper measured at mean lower low water for log raft storage is preferred.

10. Avoid Bald Eagle Nest Trees: Site LTFs to avoid bald eagle nests. No project construction or operations should be closer that 330 feet to any bald eagle nest tree.

*Taken from "Log Transfer Facility Siting, Construction, Operation and Monitoring/Reporting Guidelines," by the Alaska Timber Task Force Subcommittee, 1985. State of Alaska, Juneau, AK. 19 pp.

Approval Page

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