Essential Fish Habitat project status report

<u>Title</u>: Evaluation of Essential Fish Habitat Recovery at Log Transfer Facilities in southeastern Alaska by Katharine Miller, Stanley Rice, and John Hudson

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<u>Status</u>: Pilot study completed August 2006

<u>Reporting</u>: Have the project results been reported? If yes, where were the results reported? See attached report.

<u>Results</u>: What is the most important result of the study?

This was the first of a planned two-year study evaluating the recovery of Essential Fish Habitat impacted by log transfer facilities (LTFs) 10 to 30 years ago. The study focused on six LTFs and one log storage facility (LSF) located in estuaries and embayments on Baranof and Kruzof Islands in southeastern Alaska. The pilot year was designed as a survey to assess physical and biological recovery and to evaluate different sampling methods to assess recovery. Funding for a second more detailed study year was not received.

Recovery of physical habitat was noted at all LTFs, particularly with respect to bark degradation as divers often had difficulty identifying the edge of bark deposits. Non-recovery was observed at an LSF in Shulze Cove. Habitat at this site was highly impaired as evidenced by the presence of a 1 m deep gelatinous bacterial/organic layer that was anoxic and sulfide producing.

Fish and invertebrate abundance and species diversity differed between the facility sites and reference sites at six of seven locations, and the organic content of sediment samples was generally higher at LTFs than at adjacent reference sites. The results of nonparametric stepwise regression suggest that, for both fish and invertebrate assemblages, differences are correlated with a transition of species from outside to inside waters and with differences in organic content of the sediments

This pilot study indicates that benthic habitats impacted by LTFs are mostly in a recovering state, whereas habitat at the LSF has not yet begun. Additional time is needed for complete recovery at all sites and our findings suggest that biological recovery of the invertebrate and fish communities will lag behind physical recovery. The intense studies conducted 25 to 30 years ago by Shultz and Berg (1976) and O'Clair et al. (1988) should be repeated to determine the long term impacts of LTFs on essential fish habitat. This study attempted to evaluate recovery by spending one day assessing each site. A future study should spend several days at one site to evaluate recovery as a single day does not allow time for adequate study. We recommend that candidate sites for evaluation should be screened by assessing the bark content, depth, and water quality of sediments. For cost reasons, this study was restricted to a relatively small area; a more comprehensive study, not restricted to 10 field days, should focus on the most impacted sites in southeastern Alaska, as determined by volume of timber transferred to specific LTFs.

Evaluation of essential fish habitat recovery at Log Transfer Facilities in southeastern Alaska

Katharine Miller, Stanley D. Rice, and John Hudson

Introduction

Logging activities on the Tongass National Forest in southeastern Alaska were extensive from the 1950s to the 1980s, supporting two pulp mills and several saw mills for local development and export of lumber. Damage to essential fish habitat from harvest and road-building activities was obvious in the uplands as streams in affected watersheds suffered were denuded of buffer strips, and spawning and overwintering habitat was negatively impacted (USDA 1995). Less obvious were impacts to essential fish habitat at log transfer facilities (LTFs) where logs were placed into marine waters for transport to mills. These habitats were extensively surveyed in the late 1970s and early 1980s (Schultz and Berg 1976, Freese et al. 1988). These surveys revealed negative impacts to water quality and benthic communities within areas of bark deposition.

The purpose of this pilot study was to evaluate the physical, chemical, and biological characteristics of some of these log transfer facilities 25-30 years after closure. Information from this cursory study can be used to justify further study, and possibly the need for intervention in some habitats to support active restoration. Our general study design was to compare water quality, fish and invertebrate community composition, and substrate characteristics between an LTF zone of deposit and an adjacent Reference (REF) site. This study design was intended to evaluate the rate and effectiveness of natural recovery of benthic habitats near LTFs. Study methods were similar to those used in earlier studies with the addition of a fish community assessment component.

Study Approach and Site Selection

We chose six former LTFs located in estuaries and embayments on Baranof and Chichagof Islands in southeastern Alaska (Figures 1 and 2) based on the following criteria: 1) volume of timber transferred through the LTF when it was operational, 2) years since the LTF was operational, and 3) inclusion in prior studies (Schultz and Berg 1976; Freese et al. 1988). We also included a log storage facility (LSF[1]) in Schulze Cove in the study. Both the Alaska Department of Environmental Conservation and the U.S. Fish and Wildlife Service have documented habitat loss and water quality problems at this LSF.

At each location, a four person dive team and two surface biologists spent approximately one day measuring a variety of physical, chemical, and biological parameters at each LTF and a nearby REF site. After locating the zone of deposit (ZOD), the dive team marked

[1]For simplicity, the Schulze Cove LSF is herein referred to as an LTF.

the ZOD boundary, measured bark depth, and collected pore-water samples along transects established across the ZOD. At the same time, a surface team in a skiff measured several water quality parameters at the LTF and REF sites. The fish community was sampled at LTF and REF sites with a small bottom trawl. Physical and biological data from each LTF site were compared to companion REF sites to determine if adverse effects were continuing, and where possible, comparisons were made to the surveys completed 25-30 years ago. The study was conducted in July and August 2006 during a single 10-day cruise aboard the M/V *Sundance*.

OBJECTIVES AND METHODOLOGY

1. Determine the extent of bark deposit at each site: At each site (Figures 1 and 2), the location of the ZOD was determined from latitude and longitude coordinates provided in the earlier reports and from visual inspection of the upland area. A four-person dive team working in pairs was deployed to delineate the bark ZOD. ZODs were delineated in the same manner as in the earlier studies. The two-person dive teams entered the water from shore and swam away from shore until bark was encountered. Each team then swam in opposite directions until reaching the edge of the ZOD. Next, the divers swam in opposite directions along the perimeter releasing marking buoys to demarcate the ZOD. Surface biologists in a skiff used the buoys as a guide to map the ZOD using a GPS unit. Divers did not attempt to delineate the Schulze Cove ZOD due to its large size.

2. Determine the sediment depth and sediment composition at each site: Bark depth was our primary means of evaluating habitat recovery at LTF sites because depths could be compared to those measured in previous studies. During this study it became apparent to the divers that depth measurements included intact and decomposed bark as well as natural underlying sediments. Therefore, depths from this study are likely not comparable to those from earlier studies. However, in this study, sediment samples were collected and analyzed in the lab to compare the organic matter content of sediment from LTF and REF sites. Bark and other plant matter was visually sorted from the largest size fractions of these samples while the smallest size fractions were burned to determine their ash-free dry mass content, a surrogate for bark content since bark from these fractions was too small to distinguish visually.

Once the bark zone of deposit (ZOD) was delineated, one or more transects were established along a depth contour within the center of the deposit. A REF site was selected near the LTF site in an area with similar bathymetric features. Buoys were used to establish a transect in the REF site at the same depth as in the LTF site. At each site except Schulze Cove, divers collected a minimum of five 250 ml sediment samples along each transect by scooping the top layers of sediment into collecting jars. The depth of the sediment at LTF sites was measured to the nearest centimeter by pushing a marked rod into the bottom to refusal. In the earlier reports, the sediment depth was equated to the depth of bark (Table 1). In this study we refer to “sediment” depth because divers could not determine to what degree they were measuring bark and natural underlying sediment. In our study, the percent organic content of the sediment was determined by dry sieving the sediment through .063, .500, 2.00, and 4.75 mm sieves. Sediment in the 2.00-4.75

mm and > 4.75 mm fractions was separated by hand with the aid of a dissecting microscope into mineral (rock and shell) and organic (bark and other organic debris) components. Each component was then weighed (0.001 g) and the percent organic fraction calculated. Percent ash-free dry mass (AFDM) was determined for the .063-.500 mm and .500-2.00 mm fractions by burning samples in a muffle furnace at 500°C for 5 to 19 hours. Because individual LTF and REF pairs were co-located within the same estuary, it is reasonable to expect that in the absence of a secondary source of organic material, the organic content of the sediment would be relatively similar at both the LTF and REF sites. Therefore, we used the difference in organic content in the smaller sediment size fractions (0.063-0.500 mm and 0.500-2.00 mm), rather than the substrate depth, to represent bark in these samples.

3. Determine water quality at each LTF and Reference site: Hydrogen sulfide concentration in sediment pore water was measured at each LTF and REF site. With the exception of Schulze Cove, pore-water samples were collected from well points inserted into the substrate at three locations along each dive transect. Immediately after inserting the point, two water samples were withdrawn into a 60 ml plastic syringe. The first sample was discharged and the second sample was retained in the syringe until analyzed. Water samples from the Schulze Cove LTF site were collected using a horizontal water sampler that was lowered into a 1 m layer of colloidal ooze overlying the natural bottom. Water samples were analyzed 2-6 hours after collection using a colorimetric test kit (Hach Company™ Model HS-WR). Dissolved oxygen (D.O.) and water temperature were measured at the sediment/water interface at three locations in each LTF and REF site with a YSI 55™ dissolved oxygen meter. Salinity and temperature profiles were obtained from the center of each site with a CTD profiler (SEACAT SBE 19 plus, Sea-Bird Electronics, Inc.).

4. Determine biological use on the surface of the bark deposit: A small-mesh otter trawl (3 m x 1 m) towed behind a skiff was used to sample fish and invertebrates near the bottom of each LTF and REF site. The trawl was towed at approximately 3 knots with a minimum of one haul in each direction along the same transect. Tow speed and bottom-time were recorded. Fish were identified, counted, and measured for length and invertebrates were identified and counted. To minimize variability between LTFs and their paired REF sites, trawl transects in the LTFs were selected to ensure the entire trawl occurred within the bark footprint or ZOD, and at a location roughly in the middle of the identified bark footprint while transects at the REF sites were selected to match the length and depth of the transects at the LTF sites as closely as possible. The length of the trawl transects at each LTF and REF site was calculated as the distance between the beginning and ending latitude and longitude coordinates of each transect.

Data Analysis:

The relationship of fish and invertebrates assemblages to water quality variables and sediment organic content were performed using nonmetric multidimensional scaling (NMDS) and step-wise analysis of weighted Spearman rank-correlations using the PRIMER 6® statistical software. Abundance data was transformed to the fourth root and standardized prior to calculation of Bray-Curtis similarity coefficients The Bray-Curtis coefficient calculates the similarity between the *j*th and *k*th samples using the following formula:

$$S_{jk} = 100 \frac{\sum_{i=1}^{p} 2 \min(y_{ij}, y_{ik})}{\sum_{i=1}^{p} (y_{ij} + y_{ik})}$$

Where y_{ij} represents the *i*th row and *j*th column of that matrix of species abundances and y_{ik} is the *i*th species in the *k*th sample. S= 0 if the two samples have no species in common and 100 if they are identical (Clark and Warwick, 2001).

Because of the differences between fish and invertebrate assemblages at sites inside and outside Peril Strait, stepwise nonparametric regression on the ranked biotic and abiotic similarity matrices was conducted separately for each group. The analysis evaluates whether biologically similar sites also are similar in terms of the environmental variables.

A similarity matrix of water quality and sediment organic content was calculated using Euclidean distance. Environmental variables included average temperature, average percent saturation, ash free dry mass (AFDM) in the .063 to .500 mm and the .500 to 2 mm sediment samples, percent organic content by weight in the 2.00 to 4.75 mm and > 4.75 mm samples. Step-wise correlations between the environmental and biotic similarity matrices were conducted, and combinations of variables with the highest Spearman rank correlation coefficient (ρ) were considered to provide the best match to the fish and invertebrate assemblage data.

Results

Bark/Sediment depth and sediment size composition

Sediment analyses indicated that bark is still present at LTFs but is showing signs of decomposition. Mean sediment depths ranged from 4 to 11 cm (Table 1). Sediment depths measured during this study were lower than those reported in earlier studies at all locations except Appleton Cove and Camp Coogan Bay. Bark depths at Hanus Bay, Mud Bay, and Rodman Bay declined by 13 to 83% compared to earlier measurements. The organic content of sediment samples varied among size fractions and locations, but was usually greater in LTF sites than in REF sites (Figures 3 and 4). Organic content was lowest in Hanus Bay and Rodman Bay and highest in Mud Bay and St. John the Baptist Bay. At the latter two sites, LTF sediment less than 2.00 mm in diameter had 2.4 to 8.7 times more AFDM content than sediment from the adjacent REF site (Figure 3). Differences in the organic content of LTF and REF sediment were more extreme in the larger size fractions (Figure 4) where most organic matter consisted of bark fragments as well as other plant material. More than one-third and one-half of large sediment from

LTF sites at Mud Bay and St. John the Baptist Bay, respectively, consisted of organic material (Figure 4). In contrast, large sediment from REF sites contained less than 15% organic matter and the large sediment from several locations was devoid of organic material. Non-organic material in sediment samples consisted of sand, gravel, and shell fragments.

Sediment samples were not obtained from Schulze Cove where the bottom of the LTF site was covered by a 1 m thick layer of diffuse organic material. Divers were not able to retrieve sediment from below this layer, and attempts to obtain samples of the organic layer itself were unsuccessful. Because the purpose of this study was to compare LTF sites with adjacent reference sites, no sediment was collected at the Schulze Cove REF site.

Water Quality

Water quality at the Schulze Cove LTF site was poor within the layer of ooze. Sulfides were detected in this layer which did not contain any dissolved oxygen (Figure 5). Water samples from this layer smelled of rotten eggs and hydrogen sulfide levels in two samples measured 5.0 and 9.6 mg/L.

Water quality at other sites was good and there were no differences in water temperature or dissolved oxygen between the LTF and REF site pairs (Figure 5). Sulfide was not detected in pore water at other sites. Percent saturation of oxygen at the sediment/water interface ranged from 58% to 69%, exceeding 83% at Hanus Bay. Bottom water temperatures ranged from 10.2 C to 12.9 C. Temperature and salinity profiles at paired LTF and REF sites were nearly identical (Figure 6).

Fish and invertebrate assemblages

Approximately half of the fish and invertebrate species were caught at both LTFs and REF sites, with the remainder caught at either type of site. Because of differences in the size of trawl areas, we could not compare species diversity between LTF and REF sites. Twenty-two species of fish and 45 species of invertebrates were caught at the LTF and REF sites (Tables 2 and 3). The most commonly caught species of fish were yellowfin sole (*Limanda aspera*), snake prickleback (*Lumpenus sagitta*), and southern rock sole (*Lepidopsetta bilineata*) which were caught at both LTFs and REFs. Sunflower sea stars (*Pycnapodia helianthoides*) were the most common invertebrate followed by shrimp (*Heptacarpus sp*), sea cucumbers *(Parastichopus californicus*) and lyre crabs (*Hyas lyratus*). These species were caught at both LTF and REF sites.

With the exception of Appleton Cove, similarity coefficients for fish and invertebrate assemblages between paired LTF and REF sites were less than 50%. Fish and invertebrate assemblages also differed between sites with more direct access to the open ocean (outside Peril Strait) and those located in interior channels and bays. Eighteen fish species were found either at inside or outside sites but not both (Table 4). The average dissimilarity of fish groups inside and outside of Peril Strait was 95.5% (100% = total dissimilarity). Invertebrate assemblages showed less of a pattern of difference between inside and outside locations than fish assemblages (Figure 8) with 23 species captured at either outside or inside sites. As with the fish assemblage data, only the Appleton Cove LTF and REF sites are similar at a 50% or greater level.

For sites inside Peril Strait, the highest correlation between the ranked environmental and fish similarities occurred for the two-variable combinations of average AFDM and percent saturation, and average percent organic component and average temperature had the same correlation coefficient (ρ = .647). Temperature and percent saturation are highly correlated, so the inclusion of one or the other of these variables in the two-variable pairs is not surprising. Similar analysis on the correlation between fish assemblages and sediment grain size did not result in a high correlation coefficients (highest ρ = .172) suggesting that size of the sediment is not an important factor in determining fish assemblages. The analysis however suggests that, for sites inside Peril Strait, the presence of organic matter may be a factor affecting fish assemblages. Relatively high correlation between environmental variables and fish assemblages was not observed for sites outside Peril Strait. The highest correlation (ρ = .153) was associated with average AFDM. This correlation is slightly smaller than the correlation between the smallest two sediment size fractions (ρ = .172) and fish assemblages.

Invertebrate assemblages had a pattern similar to fish assemblages. Average organic content and average temperature had the highest correlation (ρ = .509) with invertebrates inside Peril Strait, followed by average AFDM and average temperature (ρ = .466). For invertebrate assemblages outside Peril Strait the highest correlation (ρ = .586) was for average percent saturation. Organic content of the sediment was correlated at ρ = .193 or below. Invertebrate assemblages also showed little correlation to sediment grain size (high of ρ = .102).

Discussion

LTF ZODs

Identifying and delineating the ZOD was difficult at most locations. Bark was not always easily identified and often merged or graded into natural sediments. With the exception of Hanus Bay and Appleton Cove, the seaward edge of the ZOD occurred in water that was too deep for divers to access. The inability to identify the seaward extent of the ZOD was a concern only for the placement of the REF sites, since we wanted these to be sufficiently close to the LTFs to reduce variability while still being outside the ZOD. At most sites, the area of the ZOD was sufficiently large to accommodate trawling. Only at Camp Coogan Bay did we encounter bark at the REF site while trawling. Sediment analyzed from this site confirmed that the LTF and REF sites were not sufficiently far apart. connected.

At some sites delineation was further complicated by the inability of divers to distinguish between highly decomposed bark and natural sediment. We suspect that ZOD boundaries were more obvious during the earlier studies since the bark was less decomposed at the time. Freese et. al. (1988) indicated that bark within the ZODs at some of the LTF sites they evaluated had deteriorated and some of the bark fragments were as small as 2 mm. Identifying the bark component of such fine sediment underwater was extremely difficult. This difficulty stimulated increased effort in analyzing sediment for organic content, a surrogate for bark depth.

Recovery and non-recovery

Diver observations and water quality measurements indicate that most LTF sites (6 of 7) are recovering. At most sites bark deposits were substantially degraded and sometimes difficult to delineate. Trawl catches indicated that fish and invertebrates use LTFs, and that there are subtle differences between fish and invertebrate assemblages at LTF and REF sites. The Schulze Cove LSF was a notable exception. Divers at this site encountered a strange layer of sediment. Approximately 1 meter in thickness, this layer consisted mostly of water, lacked dissolved oxygen, and water samples contained toxic sulfides. These poor habitat conditions appear to influence fish and invertebrate diversity which was only one-third of that found at the REF site.

Problems of species diversity measurements

The difference in species diversity between impacted sites and nearby reference sites has been widely used in ecology to assess recovery based on the assumption that fewer species occur in impacted sites than non-impacted sites. This assumption has been strongly criticized (Gray 2000), and research suggests that diversity indices are useful in differentiating between communities only when the impact is severe (Mouillot et. al. 1995; Rice 2000; Cao et. al 1996). Species diversity indices also are dependent on the size of the sample area, which in our study differed between sites as a result of differences in the size of the LTF ZODs. Therefore, we could not compare diversity between LTF and REF sites.

The multivariate analyses used here are widely used in benthic ecology and are becoming more common in estuarine and demersal fish research (Mueter & Norcross 1999). These approaches are useful in detecting change in community structure given sufficient sample size. In our study, we detected differences in species assemblages between inside and outer coast sites. Estuaries on the west side of Baranof and Chichagof Islands (outside Peril Strait) tend to have more direct access to ocean water than estuaries in Peril Strait and Hoonah Sound, and this appears to affect fish and invertebrate assemblage membership. Others also have noted clines of distribution in southeastern Alaska from north to south, and from east to west (Johnson et al. 2003). With only seven sites in our pilot study; 4 inside Peril Strait and 3 outside Peril Strait, the sample size is too small to separate potential LTF effects from natural geographic effects. Future studies should consider the transition of species from inside to outside waters in site selection. Additionally, multiple samples should be taken at each LTF and REF. This may require sampling over a period of weeks or months to adequately assess fish and invertebrate usage of individual sites.

Future evaluation of habitat recovery

Day-long site visits are too cursory for measurements of habitat recovery and determination of rates of recovery. The results of this study should be considered a screening procedure, and not detailed or intense enough to compare to the earlier studies by Shultz and Berg (1976) and Freese et al. (1988). To determine the impacts and status of recovery, measurements of biological processes and better measurements of habitat use by species are needed. Although costly, focusing on infauna and less mobile invertebrates may be a better way to assess long-term impacts. Further, measuring bark depths and the size of the ZOD as a means of evaluating habitat recovery has limitations. Measures of bark depth and the ZOD boundary can be accurately determined when the deposit is young; however, over time obtaining accurate measures becomes more difficult as the bark decomposes and/or is redistributed. Organic content, as well as a chemical marker surrogate for bark combined with systematic sampling would likely be a better measurement strategy. Future studies should include a large suite of sites selected based on the amount of timber transferred through the facility. Additionally, more time should be allocated to evaluating each site than was allowed in this study.

Evaluating candidate sites for restoration

One-day site visits using a remotely operated video camera and collection of water quality measures would probably be a satisfactory screening method for establishing a group of LTF and REF sites for further study. Specific attention should be given to sites similar to Schulze Cove to determine the factors that may be inhibiting recovery. This information may lead to recommendations on appropriate locations for siting such facilities in the future to adequately protect EFH. In addition to the type of data collected for this study, a future study should evaluate benthic communities as organisms living within and on the bottom directly exposed to the physical and chemical characteristics of bark deposits. The intense studies conducted 25 to 30 yeas ago by Shultz and Berg (1976) and Freese et al. (1988) should be repeated to determine the long term impacts of LTFs on EFH. These studies should include evaluation of benthic communities to determine whether they follow the same pattern as the fish and invertebrate assemblages in this study.

Conclusion

Most sites (86%) sampled in this study were recovering, as shown by difficulty in identifying the zone of deposit for bark, good water quality, and the presence of fishes and invertebrates. One-day site visits are not adequate to assess habitat recovery rates; a large-scale comprehensive survey of more sites is needed to better understand recovery of LTFs across the region. Benthic habitat at the Schulze Cove Log Storage Facility remains highly impaired, as evidenced by a 1 m layer of colloidal ooze and poor water quality. There are likely other sites like Schulze Cove where habitat recovery is not satisfactory.

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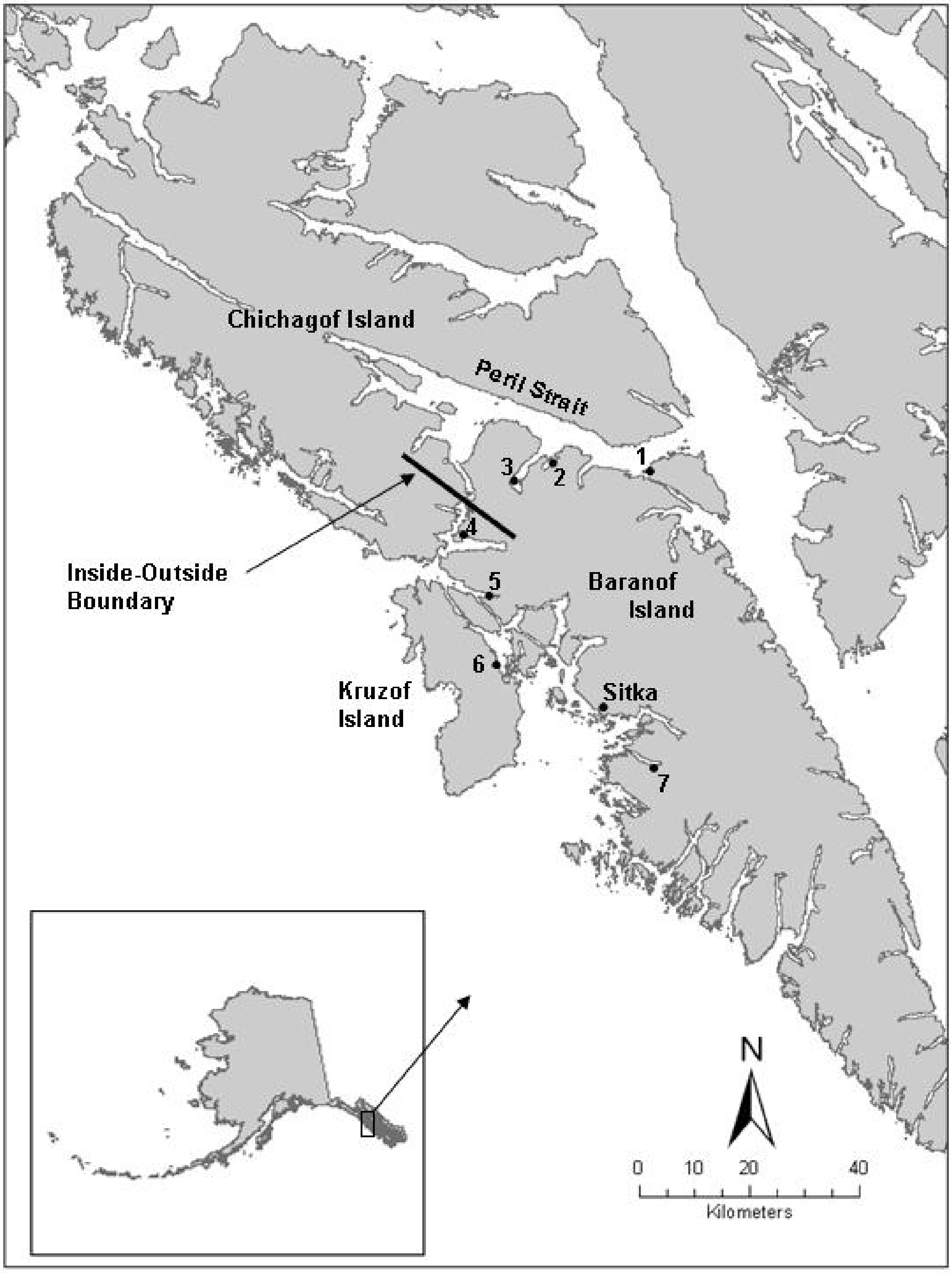
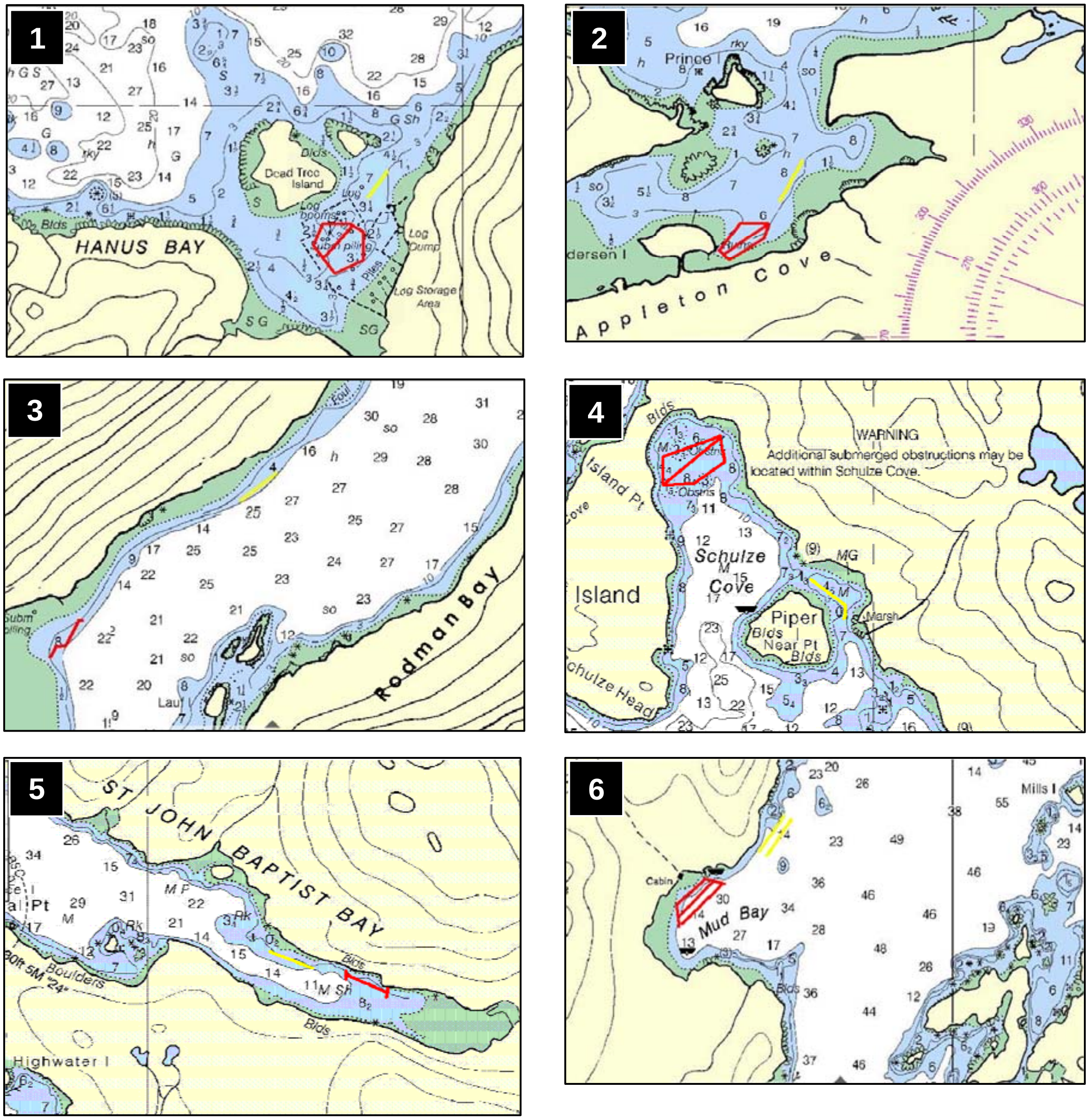


Figure 1. Map of the study area showing the location of study sites and the boundary between the outside and inside waters of Peril Strait. Log transfer facilities sampled in this study were located in Hanus Bay (1), Appleton Cove (2), Rodman Bay (3). Schulze Cove (4), St. John the Baptist Bay (5), Mud Bay (6), and Camp Coogan Bay (7).



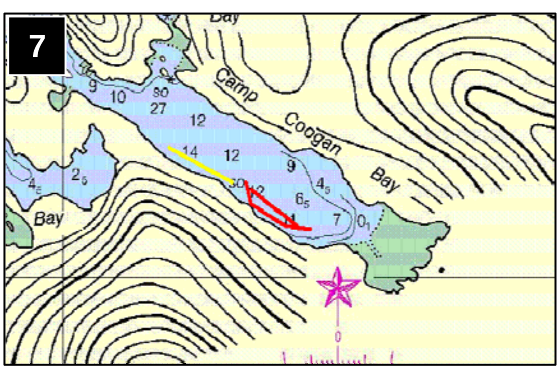


Figure 2. Study sites showing the log transfer facility (LTF) zone of deposit (red polygon) and location of trawl transects at each LTF (red line bisecting polygon) and REF (yellow line) site. Only a partial delineation of the ZOD was completed at sites 4 – 7. Hanus Bay (1), Appleton Cove (2), Rodman Bay (3), Schulze Cove (4), St. John the Baptist Bay (5), Mud Bay (6), and Camp Coogan Bay (7).

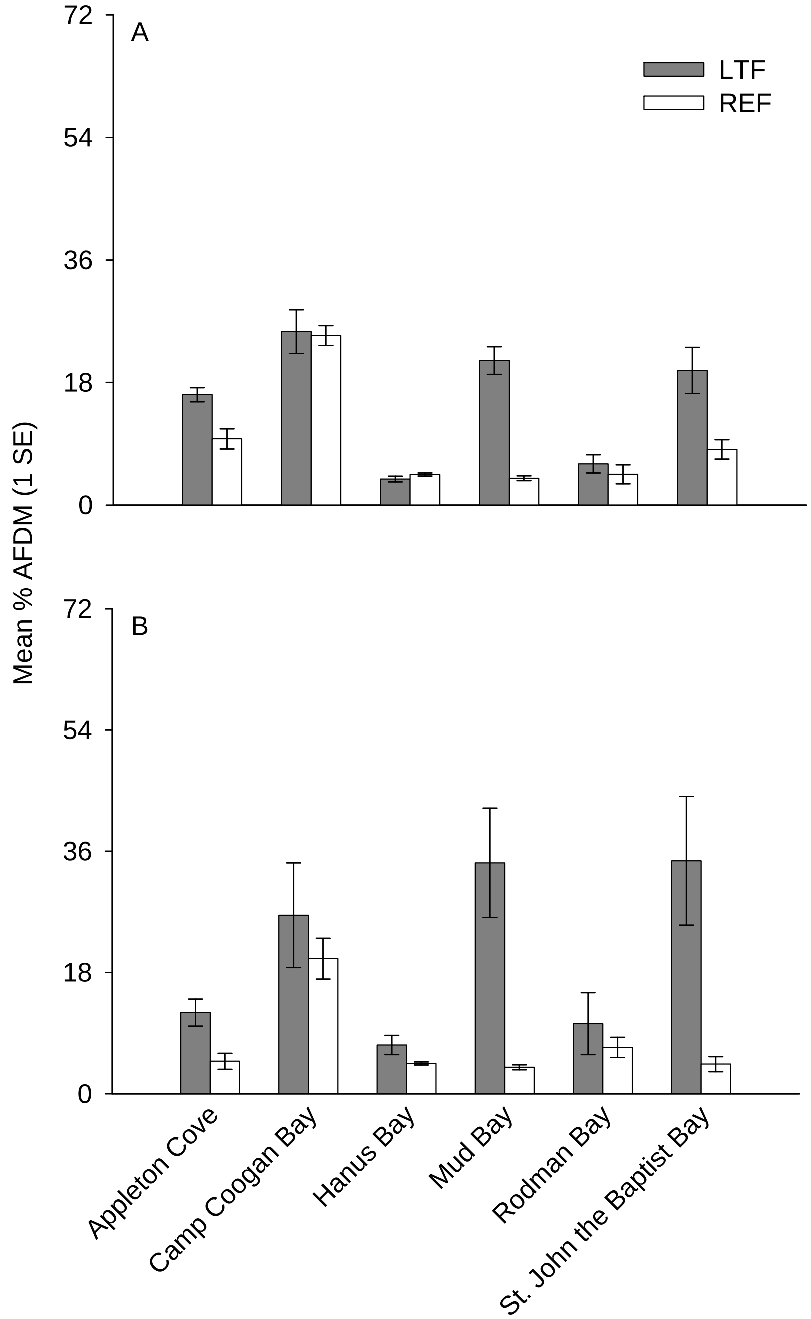


Figure 3. Ash-free dry mass content (%) of sediment (A, .063-.500 mm; B,.500-2.00 mm) collected from log transfer facility (LTF) and reference (REF) sites in July and August 2007 at six locations in southeastern Alaska. (SE = standard error)

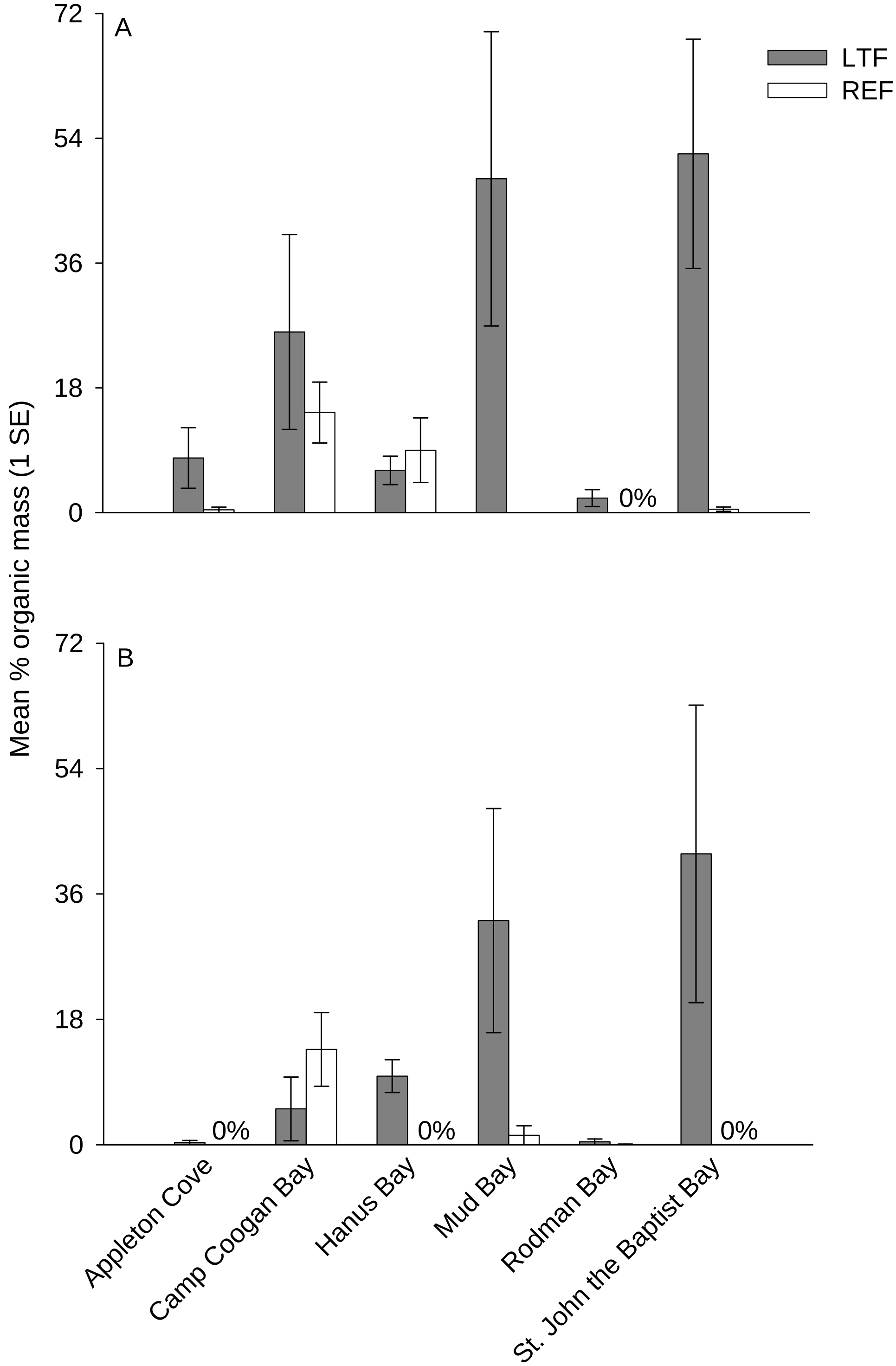


Figure 4. Percent organic mass of sediment (A, 2.00-4.75 mm; B, > 4.75 mm) collected from log transfer facility (LTF) and reference (REF) sites in July and August 2007 at 6 locations in southeastern Alaska. (SE = standard error)

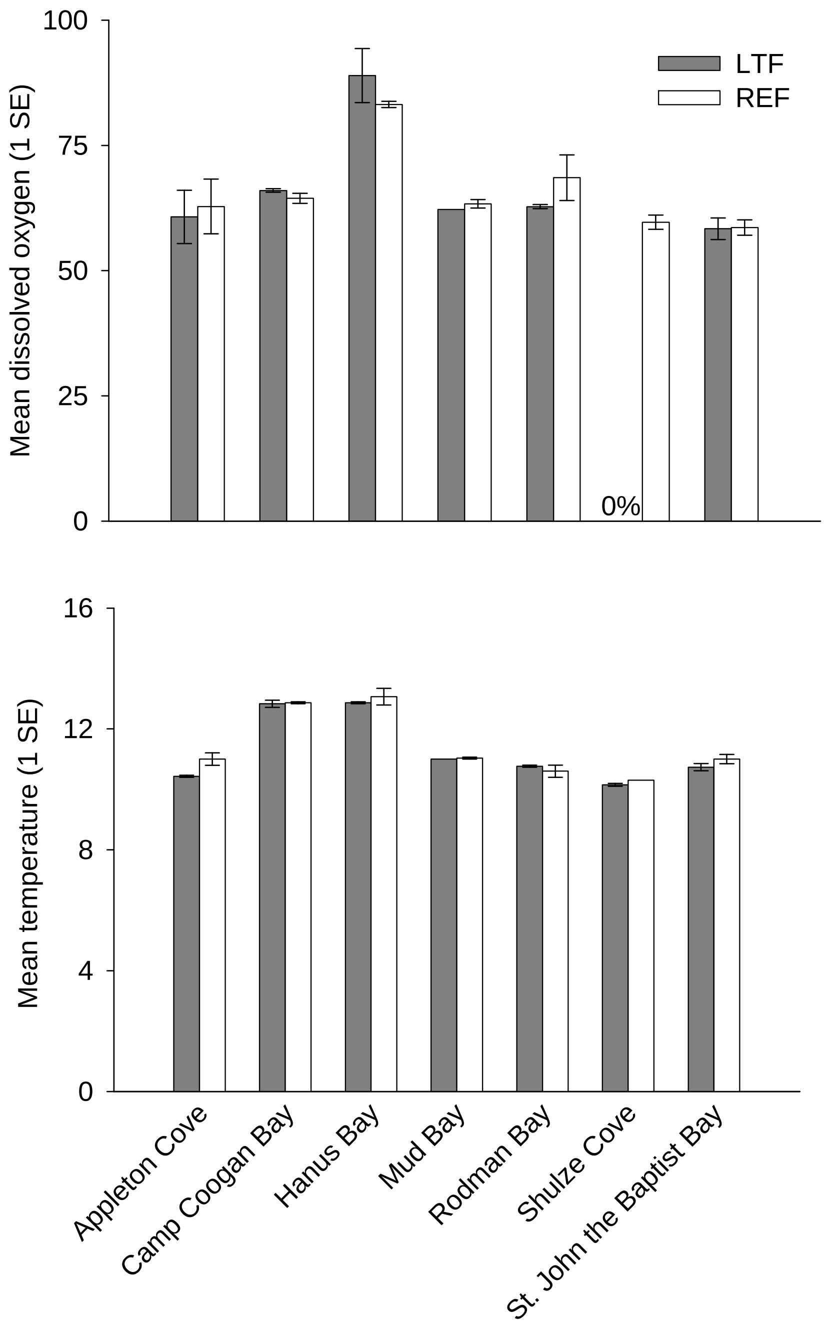


Figure 5. Dissolved oxyen (% saturation) and water temperature (Celcius) at the sediment/water interface of log transfer facility (LTF) and reference (REF) sites in July and August 2007 at six locations in southeastern Alaska. (SE = standard error)

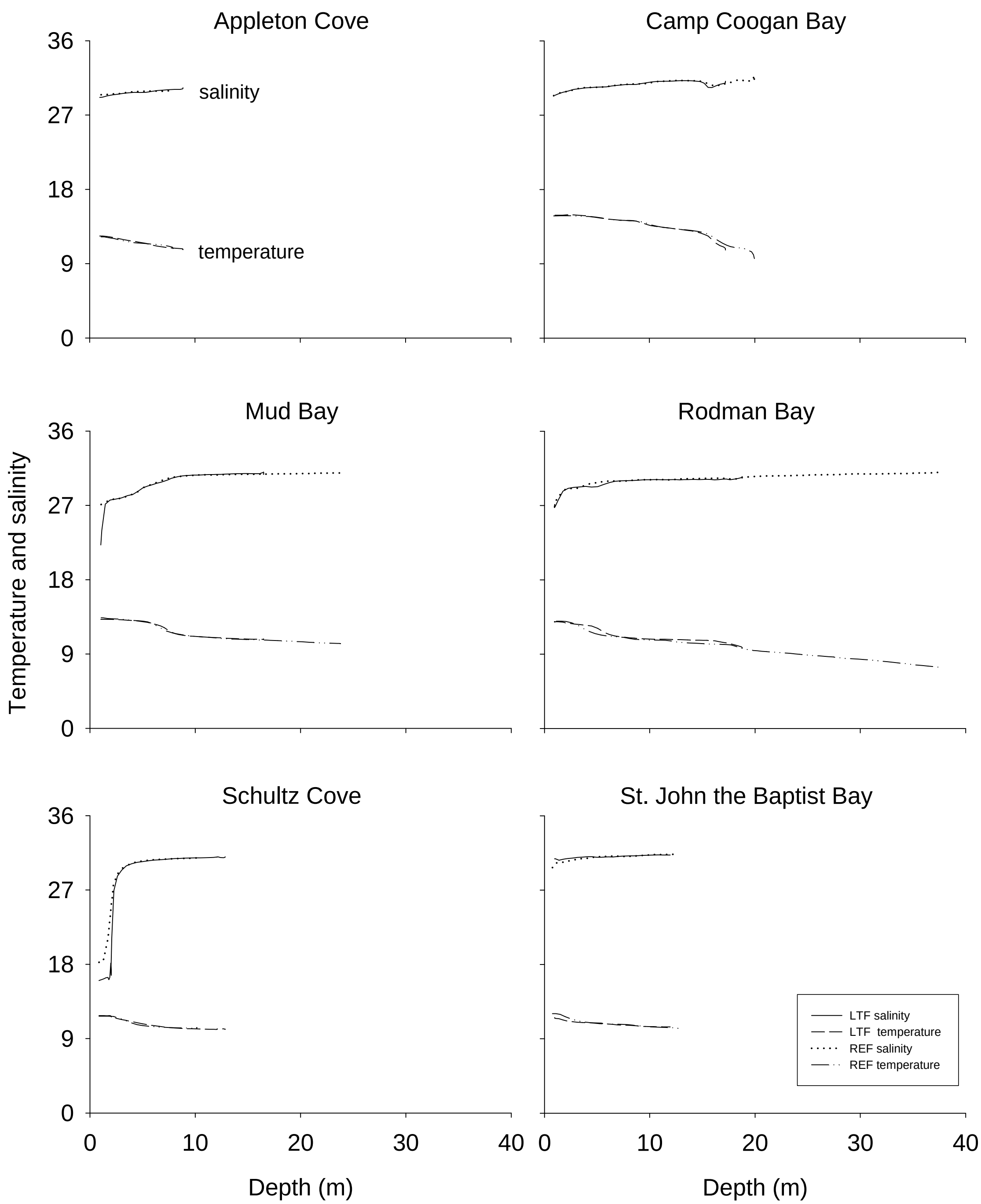


Figure 6. Salinity (parts per thousand) and water temperature (Celcius) profiles at log transfer facility (LTF) and reference (REF) sites studied in July and August 2007 at six sites in southeastern Alaska. Data from Hanus Bay were not available.

Figure 7. Plots of the first two axes from an NMDS (multidimensional scaling) ordination of fish trawl catch for LTF and REF sites. Distances between two points in the ordination diagram approximately reflect their dissimilarity in terms of species composition.

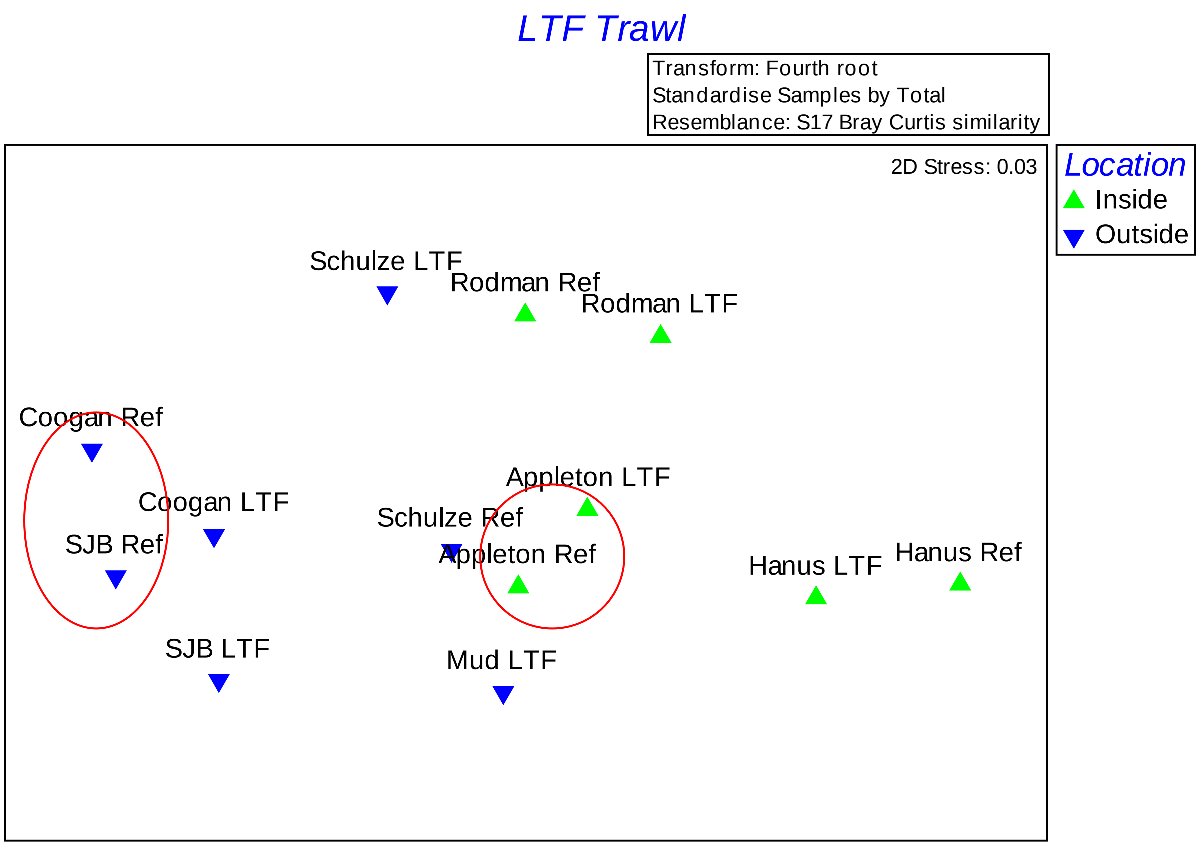


Figure 8. Plots of the first two axes from an NMDS (multidimensional scaling) ordination of invertebrate trawl catch for LTF and REF sites. Distances between two points in the ordination diagram approximately reflect their dissimilarity in terms of species composition.

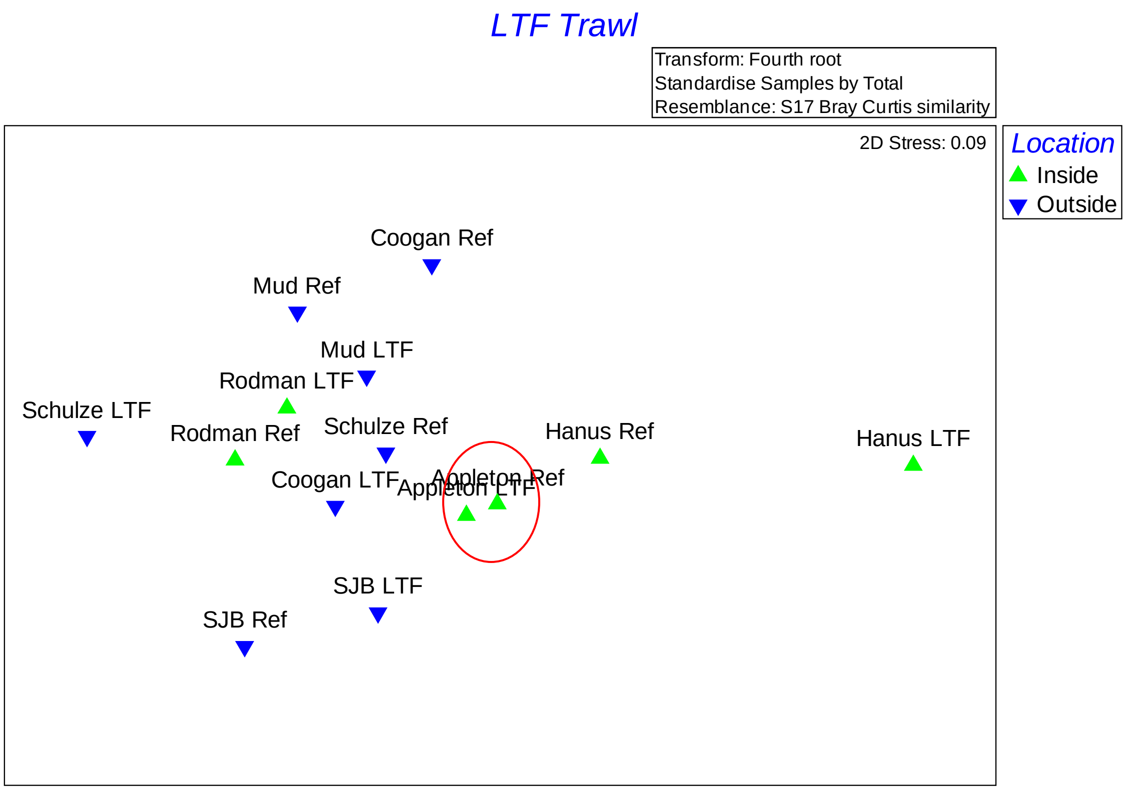


Table 1. Comparison of sediment depths at LTF sites in present study to bark depths reported from the same sites in earlier studies.

LTF Location	Present study mean sediment depth (cm, 1 SD)	Mean bark depth (cm)	
		Freese et. al. 1988	Schultz and Berg 1976
Appleton Cove	3.96 (2.29)		3
Camp Coogan Bay	10.67 (4.76)		2
Hanus Bay	3.43 (1.73)		20
Mud Bay	8.75 (2.94)	35	25
Rodman Bay	6.17 (2.39)	20	15
St. John the Baptist Bay	9.54 (3.92)		11

Table 2. Fish taxa collected at log transfer facility (LTF) and reference (REF) sites studied in July and August 2006 at seven locations in southeastern Alaska.

	Appleton Cove		Camp Coogan Bay		Hanus Bay		Mud Bay		Rodman Bay		Schulze Cove		St. John the Baptist Bay	
Taxon	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF
Aulorhynchus flavidus					x	x								
Citharichthys stigmaeus			x	x										x
Enophrys bison									x					
Eopsetta jordani									x					
Eumicrotremus orbis		x							x					
Gadus macrocephalus		x									x			
Glyptocephalus zachirus												x		
Hexagrammos decagrammus												x		
Lepidopsetta bilineata	x	x					x					x		
Limanda aspera	x								x	x	x	x		
Lumpenus sagitta		x	x									x	x	
Microstomus pacificus												x		
Myoxocephalus polyacanothocephalus		x					x					x		
Oligocottus maculosus	x	x			x									
Ophiodon elongatus												x		
Parophrys vetulus													x	
Podothecus accipenserinus											x			
Psychrolutes paradoxus	x	x												
Sebastes flavidus														x
Sebastes maliger			x										x	x
Stichaeus punctatus		x								x				
Theragra chalcogramma			x								x			

Table 3. Invertebrate taxa collected at log transfer facility (LTF) and reference (REF) sites studied in July and August 2006 at seven locations in southeastern Alaska.

	Appleton Cove		Camp Coogan Bay		Hanus Bay		Mud Bay		Rodman Bay		Schulze Cove		St. John the Baptist Bay	
Taxon	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF
Amphipoda											X			
Actinaria	X													
Cancer gracilis	X		X				X		X					
Cancer magister		X										X		
Cancer oregonensis												X		
Chlamys spp			X	X			X	X						
corumba pacifica													X	
Crangon alaskensis	X	X	X	X		X								
ebasteria									X	X				
Platyhelminthes													X	
H. tenuissimus						X								
Heptacarpus carinatus						X								
Heptacarpus spp.	X	X	X			X	X	X	X	X		X		
Heptacarpus brevirostris						X								
Hyas lyratus	X	X				X						X	X	
hyppolyte spp						X								
Scyphozoa			X				X		X			X		
Lebbeus spp		X												
Lophopanopeus bellus									X	X	X			
Ophiura spp			X										X	X
Oregonia gracilis						X						X		
Paguridae		X			X					X				
Pandalus danae	X	X												
Pandalus goniurus	X	X												
Pandalus hypsinotus						X								
Pandalus platyceros						X								

Pandalus spp		x				x								
Parastichopus californicus	x							x	x	x		x		
Pluerobranchia spp.	x			x			x							
polychaete	x						x							
Pycnapodia helianthoides	x		x							x		x	x	x
scale worm	x	x					x						x	
Schlerocrangon boreas		x												
sipunculid														x
Solaster spp								x				x		
Strongylocentrotus spp			x	x				x				x		
Telemesus cheiraonus	x				x									
Tonicella lineata								x				x		
tunicate			x	x			x							

Table 4. Fish species collected inside and outside of Peril Strait in July and August 2006 in southeastern Alaska.

Species	Inside	Outside
Aulorhynchus flavidus	X	
Citharichthys stigmaeus		X
Enophrys bison	X	
Eopsetta jordani	X	
Eumicrotremus orbis	X	
Gadus macrocephalus	X	
Glyptocephalus zachirus		X
Hexagrammos decagrammus		X
Microstomus pacificus		X
Oligocottus maculosus	X	
Ophiodon elongatus		X
Parophrys vetulus		X
Podothecus accipenserinus		X
Psychrolutes paradoxus	X	
Sebastes flavidus		X
Sebastes maliger		X
Stichaeus punctatus	X	
Theragra chalcogramma		X