

Annual Report to Alaska Department of Transportation and Public Facilities

Project Title: Lynn Canal Marine Habitat Enhancement

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Project Summary:

DOT&PF is planning on constructing a road along Upper Lynn Canal from Echo Cove to just beyond the Katzeihin River. This project would bury or otherwise impact approximately 36.4 acres of intertidal and subtidal habitat. UAF-SFOS developed a plan for artificial reefs as a partial mitigation measure for this impacted estuarine and marine habitat. This project has two phases: Phase 1 selected sites for placement of artificial reef(s), proposed site(s) layout, and designed the monitoring plan to be used after construction of artificial reef(s). Phase 2 is in progress and consists of monitoring and testing whether fish and invertebrate habitat is enhanced at the artificial reef(s).

Project Goals:

Phase I

- 1) Review literature on artificial reef design and effectiveness in temperate latitudes.
- 2) Document the marine community at natural rocky reefs in the Upper Lynn Canal region.
- 3) Survey candidate sites for placement of artificial reef(s).
- 4) Evaluate and recommend site location, layout, and methods for artificial reef construction.

Phase II

- 5) Document the establishment of the marine community at the artificial reef (s).
- 6) Assess if artificial reef communities enhance the immediate marine environment.
- 7) Assess artificial reefs as a fish and invertebrate habitat restoration tool.

Progress in Phase I:

An intensive review of the literature on artificial reefs provided the following key conclusions.

- Quarry rocks provide a natural, environmentally benign substrata and a cheaper alternative to imported, engineered concrete structures.
- The provision of edges and habitat heterogeneity provide for greater recruitment of kelps and greater diversity of benthic organisms, respectively.
- Reference sites must be located a minimal distance from the artificial reef sites to minimize spatial variation.

- Artificial reefs should be provided with a close source of colonizers for a variety of organisms.
- Artificial reefs should lie within the range of historical herring spawning sites.
- Sedimentation at the site must be held to a minimum such that kelp species and the species depending upon their structure can flourish.
- Urchin densities must be minimized at the site to prevent overgrazing.

With such stipulations, we selected candidate sites that: 1) included level, coarse sandy site(s) at roughly 6-8 m below mean low low water (MLLW); 2) contained natural reefs with dense assemblages of kelp species reefs adjacent to the sandy area; 3) host herring spawn currently and historically; and 4) provide convenient access to divers. Divers evaluated candidate sites using SCUBA. While several sites more than satisfied all criteria, Yankee Cove proved uniquely amenable. It hosted two sandy areas directly adjacent to two rocky reefs. The apex of sand and rock commences at a depth of 4 m and gently slopes downward. The site has dense understory kelp beds on the natural reefs, with very few benthic organisms resting on the sandy area. It also lies within the historical and current range wherein Pacific herring spawn on subtidal vegetation as spawning habitat. Lastly, it is highly utilized by Steller sea lions and convenient for SCUBA.

Prior to reef installation, we deployed two permanent transects on each of two natural reefs adjacent to artificial reef sites. We surveyed these transects in July 2007 in addition to two transects on sandy sites flagged for artificial reef installation. In order to qualify these sites as representative of productive rocky reefs within the local vicinity, we surveyed kelp, benthic invertebrates, other algae, as well as mobile invertebrates and fish species at two transects at each of four additional reference sites. The chosen natural reefs at Yankee Cove have a similar density of benthic species compared to the reference reefs. In general, greater variation exists between plots within each transect than between different transects or between reefs, indicating that the natural reefs at Yankee Cove are similar in community composition and species abundance to the reference reefs. However, exceptions include densities of one of the three dominant kelp species (*Laminaria yezoensis*), which was most abundant at Yankee Cove and the subtidal barnacle *Balanus crenatus*, which was abundant only at Colt Island. Fish were extremely sparse at each location, with the greatest number of encounters at Yankee Cove sites. Kelp cover on sandy sites at Yankee Cove was zero, along with abundance of nearly all macroorganisms with the exception of several seastars, giant sea cucumbers, and English sole. Results from these surveys indicate that the reference reefs at Yankee Cove provide adequate representations of the outlying areas.

Also prior to reef installation, a series of tiles were deployed near the benthos at the rock-sand apex at Yankee Cove to evaluate the influence of timing on settlement of macroalgae and invertebrates. Sets of tiles were deployed in July, August, September, October, December of 2007, and March 2008. Tiles were photographed in March and June 2008 for kelp recruitment. Tiles from all time periods except March 2008 hosted dense kelp recruitment, indicating recruitment of kelps can occur between summer and mid-winter, if conditions are adequate.

Progress in Phase II:

Two artificial reefs extending from 5-8 m below MLLW were installed December 19-21, 2007 at Yankee Cove by Trucano Construction, Inc (Figures 1-4). The artificial reefs are composed of

natural rock roughly 0.5-1.0 m in diameter and were placed on sandy substrates directly adjacent to existing rocky reefs. The reefs are 1-3 rock layers deep (~1 m in relief), with maximum dimensions of 30 m alongshore by 10 m perpendicular to shore.

In May, 2007 we marked 48 permanent, horizontal, 30 x 30 cm plots on each natural reef. These will serve as fixed reference plots to evaluate the trajectory of benthic communities over time. We surveyed each plot in the fall of 2007. In December of 2007, we scraped ten plots bare on each natural reef, removed macroalgae from eight on one reef, and left the remainder unmanipulated to be able to compare colonization on bare space in the natural reef to the artificial reef and to evaluate the presence of macroalgae. Comparison plots on the artificial reef were marked in April 2008. Surveys on the artificial reef plots and all natural reef plots will take place annually, and the first annual survey of all plots was completed in May 2008. In March 2008, we installed two parallel, permanent, 30 m transect lines on each of the two artificial reefs, which were identical to the ones established at the natural reef in summer 2007. In addition, we deployed five to ten 1 ft² slate tiles on each natural and artificial reef to test for spatial differences in colonization among reefs. To measure physical parameters, we installed temperature loggers and three sediment traps on each natural and artificial reef.

Project Findings:

In July, 2008 we surveyed fish, invertebrate, and macroalgal abundance along each transect (a 1 m high, 1 m wide swath) on artificial and natural reefs at Yankee Cove (Figures 5-7).

Recruitment by new kelps (plants less than 6 cm) dominated artificial reefs (averaging 228 and 296 recruits per m²), and was low on natural reefs (averaging 8 and 25 recruits per m²) due to competition from encrusting algae dominating the substrata and from adult kelps (with average densities of 3.3 to 14.1 per m² depending upon the species and the location). We also documented percent cover of kelp and red algae via video surveys of each permanent transect during July 2007, November 2007, and July 2008. While video has yet to be analyzed from 2008, the kelp canopy covers only a small percentage of the artificial reefs as recruits from this year have yet to grow into mature plants. In contrast, this year's cohort will likely grow substantially by summer 2009 to form a full canopy resembling that on the natural reefs.

In addition to kelps, species documented on artificial reefs during quantitative surveys are listed in TABLE 1. Fish densities on natural and artificial reefs are low (1-6 fish per transect), though invertebrate abundances, especially of giant cucumbers (averaging 1 per 6.66 m) and sunflower stars (averaging 1 per 5 m) are high. In addition to quantitative surveys, considerable Pacific herring spawn events occurred on May 15, 2007, and May 6, 2008. Herring egg deposition upon subtidal vegetation was documented by UAF divers, and the spawn events were observed by the Alaska Department of Fish and Game aerial surveys, as well as Marion and Naomi Hobbs, the owner of Adlersheim Wilderness Lodge overlooking Yankee Cove.

Preliminary Recommendations:

Reef monitoring and data collection for the colonization experiments will continue for the 3rd year of the project. Our preliminary conclusions are that the artificial reefs enhance the immediate marine environment and will serve as an effective habitat restoration tool.

Table 1: Fish, invertebrate and algae species encountered on quantitative transects at Yankee Cove artificial reefs in July, 2008, grouped by major taxa.

Group	Common Name	Scientific
Fish	Kelp Greenling	<i>Hexagrammos decagrammus</i>
	Buffalo Sculpin	<i>Enophris bison</i>
	Pacific Cod	<i>Gadus macrocephalus</i>
	Quillback Rockfish	<i>Sebastes maliger</i>
	Dark Dusky Rockfish	<i>Sebastes ciliatus</i>
	Great Sculpin	<i>Myoxocephalus polyacanthocephalus</i>
	Crested Sculpin	<i>Blepsias bilobus</i>
	Red Irish Lord	<i>Hemilepidotus hemilepidotus</i>
	Sturgeon Poacher	<i>Agonus acipenserinus</i>
	Arctic Shanny	<i>Sticheus punctatus</i>
	Northern Ronquil	<i>Ronquilus jordani</i>
Invertebrates	Green Urchin	<i>Strongylocentrotus droebachiensis</i>
	California Sea Cucumber	<i>Parastichopus californianus</i>
	Six Armed Star	<i>Leptasterias hexactis</i>
	Sunflower Star	<i>Pycnopodia helianthoides</i>
	Red King Crab	<i>Paralithodes camtschaticus</i>
	Subtidal Acorn Barnacle	<i>Balanus crenatus</i>
	Purple Margerite	<i>Margarites pupillus</i>
	Mottled Sea Star	<i>Evasterias troschelii</i>
	Epilithic Encrusting Bryozoan	Cheilostomata
	Unidentified unbranched hydroid	
Algae	Split Kelp	<i>Saccharina bongardiana f. subsimplex</i>
	Rockweed Brush	<i>Odonthalia setacea</i>
	Sea Lettuce	<i>Ulva spp.</i>
	Nori	<i>Porphyra spp.</i>
	Triple Rib Kelp	<i>Cymathere triplicata</i>



Figure 1: Barge carrying quarry rock anchored at Yankee Cove with the Chilkat mountains behind. Photo Credit: Allan Culbreath.



Figure 2: The barge loaded with rock ready to travel to the construction site. Rock sources were Juneau's Hidden Valley and excess rock from roadbuilding at the Lake Dorothy hydropower project in Taku inlet.



Figure 3: Yankee Cove, Adlersheim Wilderness Lodge, and the Lynn Canal.



Figure 4: Boulders forming the artificial reefs in Yankee Cove, ranging in size from 0.5 to 1 meter in minimum diameter.



Figure 6: A juvenile king crab perched upon a natural reef adjacent to the artificial reef.



Figure 5: Kelp species on natural reefs adjacent to artificial reefs at Yankee Cove.



Figure 7: UAF graduate student Daniel Okamoto surveys a plot on the natural reef adjacent to the artificial reef.