NATIVE OYSTER ARTIFICIAL REEF IN FIDALGO BAY

FINAL REPORT

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Center for the Study of Coast Salish Environments
Samish Indian Nation

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The goals of this project were to: (1) create the nucleus of a self-perpetuating and growing native oyster reef; (2) continue our previous research on the effects of substrate, depth and predators on native oyster growth, morbidity, and survival (Barsh et al. 2004); and (3) begin to study the ecological functions of oyster reefs and reef communities in North Puget Sound waters.

Although extensive reefs composed of the native "Olympia" oyster, *Ostrea lurida* (=*Ostrea conchaphila*) were traditionally protected and harvested by Coast Salish peoples in many parts of Puget Sound including Skagit Bay, Fidalgo Bay, and Samish Bay (Barsh 2004), none have survived. Clearing of farmland, logging, and the construction of dikes and roads along Skagit County's shorelines may have contributed to the demise of native oysters by increasing the accumulation of fine sediments in shallow bays; experimentally, native oysters exhibit greater growth and survival when elevated above soft substrates on rocks or shell piles. Log booms may have crushed reefs, and effluent from sawmills and canneries may also have contributed to their disappearance. Commercial over-harvesting and climate change are also possible factors. Native oysters are more heat sensitive than the introduced Pacific oyster, *Crassostrea gigas*, thus a combination of warmer summers and shallower bays may explain the failure of native oysters to rebound in recent years.

A key question in native oyster restoration is whether oyster reefs have a broader ecological significance as habitat for other organisms—for example, as a hard attachment surface for encrusting invertebrates and source of refuge, in interstitial spaces, for small fish and crustaceans. An analogy may reasonably be made to the Chesapeake Bay oyster, *Crassostrea virginica*, which, while considerably diminished in numbers, has survived to a greater extent and continues to form reefs or "bars" (Lippson & Lippson 1984; Newell 1988). Chesapeake Bay oyster bars consist of dense aggregations of partially cemented individuals on relatively hard substrates, most extensively in estuaries and tidal marshes; reefs are sensitive to extremes of temperature and salinity as well as physical disturbance. Larvae are attracted chemically to adult oysters and settle preferentially on them. Oyster bars represent a significant increase in the surface area available for attachment by other organisms, and host a diversity of fish and crustaceans, including species otherwise seen chiefly in eelgrass meadows or rocky reefs. As large aggregations of filter feeders, oyster bars process prodigious amounts of seawater, and may play a significant role in removing bacteria and other anthropogenic contaminants from the bay ecosystem.

Apparent similarities between the Chesapeake Bay oyster and our native Olympia oyster led us to hypothesize that the disappearance of Puget Sound oyster reefs facilitated the decline of "forage fish" (herring, surf smelt, sandlance), which are strongly associated with eelgrass meadows, and thereby contributed to the decline of Pacific salmon that prey on forage fish. The principal function of our artificial reef will be investigating the extent to which restoring native oyster reefs may promote local populations of forage fish and other animals favored as prey by juvenile salmon.

There are also several apparent obstacles to native oyster recovery that we hope to explore using the Fidalgo Bay artificial reef as a test-bed. Few other animals attach to the shells of native oysters, suggesting an anti-fouling mechanism that may favor conspecific spat and thus facilitate growth of the reef. However, Pacific oyster cultch, widely used as a substrate for native oyster restoration, attracts a wide variety of pioneers, which inhibits subsequent settlement by larval native oysters. Fig. 1 shows a single Pacific oyster cultch shell from a string that we set in April 2004 over the native oysters recently planted at the Trestle site in Fidalgo Bay. Retrieved after two months, the cultch shell is encrusted with the common barnacle *Balanus glandula*, but no oysters. Since the production and release of oyster larvae is not annual but only once or twice in a decade, in response to unusually warm early summers, maintaining optimal substrate conditions for the recruitment of spat will remain crucial. Larval settlement may also be mediated chemically by adult oysters, such that a minimum effective density of adults is required for the formation of a reef.

Fig. 1. Barnacle settlement on Pacific oyster cultch, Trestle site 2004.

Materials and methods

For the construction of our artificial reef, we chose the tip of an intertidal sand bar extending northwest from the end of Weaverling Spit in Fidalgo Bay (Fig. 2). The sand bar is composed of black shelly sand covered with 5-12 cm of mud. Mud is deeper and barely walkable on either side of the sand bar, like much of the bottom of the bay. Patchy eelgrass extends east and west of the project site along the same bathymetric contours, which is to say roughly –1.8 feet MWL. When observed in early April under 1-2 feet of water, the eelgrass hosted adult red rock crabs (*Cancer magister*), adult Dungeness crabs (*Cancer productus*), and numerous small hippolytid shrimp. The main tidal channel that drains Fidalgo Bay is located near the project site and provides good circulation. Most of the project is located in tax parcel P33483, owned by the Samish Indian Nation, and is at least nominally a part of the WADNR Fidalgo Bay Aquatic Reserve.

Fig. 2. Location of the artificial native oyster reef in Fidalgo Bay, WA.

In August 2004, after securing the requisite State and Tribal permits, the Samish Stewards (Samish Nation undergraduate science enrichment program) constructed a two-by-three meter reef foundation of local rock and clean Pacific oyster shells. They began by collecting clean rounded cobbles from the shoreline and back beach of Samish Tribal land at Weaverling Spit, mainly failing old riprap from the 1940s. Rocks were stockpiled on the upper beach; then moved to the project site on high tide using an inflatable boat as a barge. On the following low tide, rocks were placed by hand to form the outline of the reef foundation (Fig. 3 and cover illustration).

Clean dry Pacific oyster shells were donated by Samish Bay oysterman David von Allmen. They were also moved from a stockpile on the upper beach on Weaverling Spit to the project site by inflatable boat on a high tide; dropped from the boat on the site; and subsequently re-arranged by hand. While laborious this procedure avoided any operation of barges or motor vehicles on or over the sand spit and eelgrass meadows.

The upper surface of the reef foundation was seeded evenly with surviving native oysters from our 2004 substrate experiments in Fidalgo Bay (Barsh et al. 2004; Fig. 4), to take advantage of their naturalization to Fidalgo Bay. A small number of larger, sexually mature native oysters from the “trestle site” on the opposite site of Fidalgo Bay were also placed on the foundation, and seeded and unseeded cultch on the reef was secured with a sheet of black plastic mesh netting (similar to the material used by oyster growers to suspend seeded cultch in bags above the substrate). A HOBO Temperature Pro recording temperature sensor was mounted on a PVC pipe in the center of the reef foundation to maintain a continuous record of temperature change at the reef surface; and a sediment stake was driven on one side of the reef to measure any accumulation of silt over time. A standard protocol is being used to monitor this site as well as small test plots operated by our research center in the San Juan Islands: it calls for seasonal measurement of salinity, turbidity and water quality (pH, nitrate, phosphate, fecal coliform bacteria), in addition to the number and length of surviving oysters on 20 randomly drawn cultch shells. Because of our interest in faunal associations, each seasonal monitoring visit will also record all of the fauna that is visible on and within the reef structure, and for a distance of two meters surrounding the reef foundation.

Fig. 3. Laying seeded cultch in the shell mass forming the body of the artificial reef.

The corners of the reef foundation are staked with white PVC pipes driven deep into the substrate and flagged with red tape. In May 2005 we will add an anchored buoy with two waterproof plastic signs laminated on stainless steel: "Danger – Artificial Reef" with contact information at our research center in Anacortes.

There is little likelihood that spat from our project will drift far from Fidalgo Bay and settle elsewhere. It is more likely that our oysters will cross-fertilize with the oysters already planted beneath the railroad trestle, which would probably improve the survival of both pioneer populations.

Preliminary observations

We hypothesized that the surface of the reef would attract encrusting organisms, and the interstitial spaces between shells would shelter juvenile fish and crustaceans. We observed the Fidalgo Bay artificial reef and several new San Juan County test plots on the nighttime low tides of 12-13 November 2004 in up to 15 cm of water. Local weather was still relatively warm, and many marine organisms remained active (Table 1). These data should be regarded as preliminary, since we have not yet had opportunities to observe the reef during spring and summer conditions when other animals are most active.

Table 1. Faunal associations with native oysters (November 2004)

		Fidalgo Bay	Deer Harbor	Haida Point	Buck Bay
Fish	Smelt (juvenile)	4			
	Sand lance (adult)			2	
	Salmon (chum, adult)				2
	Saddleback gunnel			1	
	Tubesnout (*A. flavidus*)	4			
	Tidepool sculpin	+		9	+
	Porichthys notatus		1		
Crustaceans	*Cancer* spp*	+		4	+
	Pugettia spp	1			
	Telmessus cheiragonus	1	1	1	
	Lophopanopeus bellus				
	Hemigrapsus spp		+		
	Hippolytid shrimp	+	+	+	+
Sea stars	*Pisaster ochraeus*				
	Leptasterias hexactis		1		
Sea urchins	S. droebachiensis		2		
Gastropods	Dogwinkle (*Nucella* spp)	+		16	
	Chitons**		7		
Nudibranchs	*Diaulula sandiegensis*		3		
	Dendronotus iris	1			

\+ Observed in large numbers (more than 20).
* Mainly *C. productus* and *C. magister*; several *C. gracilis* aobserved.
** Mainly *Mopalia muscosa*, also some *Katarina tunicata*.

Follow-up evaluation

We will continue to make seasonal surveys each year of reef macro epifauna by visual examination on very low tides and by snorkel. Beginning in May 2005, moreover, we will maintain video surveillance of wildlife activity on the living upper surface of the reef using an underwater video camera programmed for time-lapse images. Eventually, when the oysters planted on the foundation begin to reproduce, we will measure larval settlement density, survival and growth as long as the reef continues to live.

References

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