Restoration of the Native Oyster in Fidalgo Bay
Year Seven Report

Skagit County Marine Resources Committee

June 2009

Native Oyster Subcommittee:

Paul Dinnel, Neil Borman, Ivar Dolph, Dixon Elder, John Giboney, Erica Pickett, Jim Ramaglia, Tom Richards, Paul Sund and Christine Woodward

This report was funded in part through a cooperative agreement with the National Oceanic and Atmospheric Administration.

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Skagit MRC

NORTHWEST STRAITS
marine conservation initiative

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Abstract

The Olympia or native oyster, *Ostrea lurida*, is native to the Pacific Coast of North America and was common in Puget Sound prior to the arrival of European settlers. Over harvest in the late 1800s, combined with severe pollution in the first half of the 20th century from pulp and paper mills, drove many Puget Sound stocks to near extinction. Skagit County Marine Resources Committee (Skagit MRC), working in cooperation with Puget Sound Restoration Fund and other partners, initiated a project to establish several native oyster beds in Fidalgo Bay near Anacortes, Washington. One site in South Fidalgo Bay (under the railroad trestle) that has stable substrate, standing water at low tide, and an absence of oyster drills, was selected for seed planting in 2002. One-year survival (~95%) and growth (from 25 mm to 42 mm shell length) were excellent, stimulating further seed additions in 2003, 2004 and 2006. Since then, survival has remained high, growth excellent and natural recruitment of juvenile oysters has been detected within about one mile of the trestle restoration site on the eastern half of Fidalgo Bay. These natural recruits likely resulted from successful spawning of the trestle seed oysters in 2004 and 2006. Natural recruitment apparently failed in 2005, 2007 and 2008 for reasons unknown. The bed structure at the trestle site was enhanced with clean Pacific oyster shell in 2006 (5 cubic yards) and 2009 (10 cubic yards) to improve the oyster bed structure and to provide additional substrate for larvae to settle on. Two additional small sites on Weaverling Spit (west of the trestle) have also been seeded and will be monitored by the Samish Tribe. Monitoring will continue in future years and seeding may be expanded to an area in northern Fidalgo Bay and on the eastern shore of nearby Padilla Bay.

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Introduction

The native or Olympia oyster (*Ostrea lurida*) is native to the Pacific coast of North America and occurs in marine waters from Baja California to Sitka, Alaska (Ricketts and Calvin 1968). The native oyster has a history of exploitation dating back to pre-colonial days. The native oyster (called Tusa'yad by the Skokomish Tribe) was an important food resource for native tribes, which often based settlement locations on its harvest (Steele 1957). With colonization, the native oyster supported a large commercial industry. Beginning in the 1850s, native oyster beds from Puget Sound, Hood Canal and Willapa Bay were harvested extensively, and later cultivated with an elaborate system of dikes (Steele 1957). Over harvest in the late 1800s and early 1900s severely compromised the commercial viability of the native oyster. Oyster laden schooners transported native oysters from Willapa Bay and Puget Sound to gold prospectors and entrepreneurs in Northern California who had exhausted local oyster stocks and paid as much as a dollar per oyster (PSAT 2003). In addition, severe water quality problems generated by pulp and paper mills in the 1930s to 1950s drove the native oyster to near extinction in many places (Couch and Hassler 1989), thereby terminating the Washington native oyster industry (Cook et al. 1998, 2000; Baker 1995).

Unlike the Pacific oyster (*Crassostrea gigas*) imported from Japan, Olympia oysters are native to Puget Sound. In the North Sound region, historical native oyster beds have been reported to once exist from the Orcas and Shaw Island areas, Bellingham Bay, Chuckanut Bay, Samish Bay, Padilla Bay, Fidalgo Bay, Similk Bay and from a bay on the northeastern side of Whidbey Island (Hatch et al. 2005). Current locations where a few native oysters have been found include Cypress Island, Bellingham Bay (Stahl 1999), Samish Bay and Lopez Island (Betsy Peabody, pers. comm.). They are smaller than the Pacific oyster, the maximum reported size being 75 mm (Hertlein 1959), and are generally smaller than the 2.5" recreational harvest size limit for oysters. Oysters feed on phytoplankton by filtering the water and native oyster beds are considered valuable for water purification and as habitat for other species. In Puget Sound, many native oyster populations have remained close to extinction. Records show that 10,000 bushels of native oysters were harvested in Puget Sound in 1850; and by 1890 130,000 bushels. Harvests gradually shrunk during the 1900's, with essentially no harvests of wild native oysters after about 1980. In the North Puget Sound region, commercial quantities of native oysters were only known from Samish Bay, and possibly Bellingham Bay, where they are extremely scarce today (Cook et al. 1998, 2000; Baker 1995).

Native oysters are considered a valuable resource (they are a premium oyster in the half-shell trade), are important for maintaining water quality in estuaries, and oyster beds provide habitat for other marine species (Gregory and Volety 2005; Luckenbach et al. 1999). Thus, the Washington Department of Fish and Wildlife (WDFW) has initiated a program to identify the present distribution of native oysters in Puget Sound, investigate their genetic integrity, improve management of the species and enhance Puget Sound populations by both natural and artificial means (Cook et al. 1998). In addition, Puget Sound Restoration Fund received restoration grants from NOAA's Community Restoration Program to expand Puget Sound restoration efforts in 2004 and 2005. By 2003, over 100 tribes, public agencies, local organizations, commercial shellfish farmers, business sponsors and private tideland owners were involved in restoration efforts and

approximately 1.3 million native oysters were planted at 41 experimental sites (Betsy Peabody, pers. comm.).

In 2002, the Skagit County Marine Resources Committee (Skagit MRC) teamed with Puget Sound Restoration Fund, the Samish and Swinomish Tribes, Taylor United Shellfish, Shell Puget Sound Refinery and others to assist with planting native oyster seed at two locations in South Fidalgo Bay as part of the North Puget Sound restoration effort (Robinette and Dinnel 2003; Barsh 2003). Other than several small plantings on Orcas Island, this represented the first native oyster restoration effort in the North Sound area (Betsy Peabody, Puget Sound Restoration Fund, pers. comm.). Fidalgo Bay was selected as the planting site because this bay had what looked like good habitat and, unlike Samish Bay, appeared to be free of Japanese oyster drills (*Ocenebra japonica*), which were imported into Washington waters with early importation of Pacific oysters from Japan. Additional oyster seed were planted in 2003 and the growth and survival of both plantings monitored (Robinette et al. 2004, Barsh et al. 2004). Oyster seed were again planted in 2004 and monitoring efforts continued to assess the survival and growth of all three seedings and search for the first signs of any natural spawning and post-larval recruitment on cultch shells specifically distributed to catch the spat (Dinnel et al. 2005). Seed were again planted at three locations in Fidalgo Bay in 2006 and all three sites were also enhanced by the addition of Pacific oyster shell to aid bed building activities and post-larval recruitment (Dinnel et al. 2006, 2009). This report covers our monitoring and shell enhancement activities carried out in 2007, 2008 and 2009.

Project Goals

At one time, native oyster beds formed one of the "foundation" communities in Puget Sound and in coastal estuaries. Native oyster beds were important for providing 3-dimensional habitat for infaunal and encrusting invertebrates and small fishes, and provided foraging locations for larger animals including Dungeness and rock crabs, juvenile salmon, perch and a variety of bottom fishes. These oyster beds were also important for maintaining water quality by filtering large volumes of water and removing pollutants and nutrients from the water column and maintaining the water clarity so important for good growth of eelgrass and kelp. In addition, they provided a rich source of food for Native Americans and settlers until they were decimated by over harvest.

In May 1998, WDFW published the Department's plan for native oyster restoration in Washington State titled "Olympia oyster stock rebuilding plan for Washington State public tidelands" (Cook et al. 1998). The goal of this plan was "To restore and maintain native oyster populations on public tidelands in their former range." The short term goal of WDFW was to identify locations and general abundance of current populations of native oysters in Puget Sound. The long term objectives included:

- Define current and historic range of native oysters
- Develop native oyster genetic integrity guidelines for artificial stock enhancement
- Define habitat requirements and contemporary habitat limiters
- Identify areas for protection and restoration
- Define site-specific habitat limitations and species interactions that would affect native oyster stocks, and
- Restore and protect stocks as needed to achieve the stock rebuilding goal.

Much can be learned from the substantial amount of work directed at restoring decimated American oyster (*Crassostrea virginica*) populations on the East and Gulf state coastlines of the U.S. Eggleston (1995) has pointed out that a conceptual framework should be developed for guiding oyster restoration efforts and that this frame work should address two questions: 1) what are the management goals in terms of restoration efforts and 2) what spatial arrangements (e.g., bed location, size, shape) of oyster habitat best meet these management goals? The management goals of oyster restoration may include, but are not limited to, maximizing:

- Recruitment to the fishery
- Spawning output
- Species diversity of the oyster bed community, and
- Water filtration and nutrient cycling.

Given the above goals and guidelines for oyster restoration projects, the following are Skagit MRC's goals for restoration of native oysters in Skagit County waters:

1. Identify areas within Skagit County that might be good sites for restoration
2. Define site-specific habitat limitations and species interactions that would affect native oyster stocks
3. Restore and protect stocks at selected sites to achieve stock rebuilding goals:

    - Conduct test seedings at several sites
    - Monitor survival and growth of seedlings
    - Determine the best "bed structure" for each site
    - Control predators where necessary and possible

4. Identify sources and sinks for natural larval recruitment
5. Use adaptive management to modify restoration efforts based on lessons learned from local plantings and other information gleaned from other restoration efforts in Puget Sound, and
6. Conduct a public education and outreach program.

Methods

Seeding the Restoration Bed

Skagit MRC's first seeding of native oysters was at the Fidalgo Bay trestle (Figs. 1 and 2) in April 2002. This was part of a broad-based effort begun in 1999 at various locations in Puget Sound. Betsy Peabody of Puget Sound Restoration Fund (PSRF) led the Fidalgo Bay effort, together with Skagit MRC and Bill Taylor of Taylor Shellfish Farms. Details of the 2002 planting and subsequent seed survival and growth over the following seven months were reported in the Year 1 Report (Robinette and Dinnel 2003).

Approximately 20,000 native oyster seed (20 bags of cultch) were planted under or near the railroad trestle in April 2002. These seed were set on Pacific oyster shells (cultch) by Taylor Shellfish Farms and were about one year old at the time of planting. The brood stock was from Samish Bay. The 2002 seeds were primarily planted underneath the trestle in an area that had some flowing water at extreme low tide and a solid bottom of gravel and shells (Area A, Fig. 3). Some seed were

also randomly spread in areas B and C (Fig. 3). Both of these areas had standing water at extreme low tides, but were somewhat siltier than Area A. Initial seed density information and seed size measurements were gathered on a subsequent low tide series in late May, 2002 to provide a baseline of what was planted. Subsequent survival and growth monitoring data were then collected from fall 2002 through spring 2009.

A second planting of approximately 65,520 native oyster seed (39 bags of cultch) were planted under or near the railroad trestle in Fidalgo Bay in August 2003 (Fig. 3). The brood stock was from Samish Bay and seed were set on Pacific oyster cultch by the Lummi Tribal Hatchery, Bellingham. The seed were several months old at the time of planting in August 2003. The 2003 seed were planted in a variety of locations, as follows:

- Twelve bags were spread in area A (Fig. 3) to supplement those planted in this location in 2002.
- Twenty-four bags were planted in standing water in Area B. Eighteen bags were opened and the cultch shells spread on the shelly/silty bottom. Six unopened bags were also placed in Area B in case the area proved to be too silty for the seed spread directly on the bottom.
- Three bags of cultch were placed directly underneath the trestle, an area with firm gravel/shell substrate but no flowing or standing water at low tide. Two of the bags were opened and spread on the bottom and the third bag was left unopened.
- One bag was utilized in caged substrate experiments on Weaverling Spit by Samish Tribal members (see Barsh 2003 and Barsh et al. 2004 for Weaverling Spit reports).

Initial seed density and size data were gathered on the day of planting to provide a baseline of what was planted. Seed density was estimated by counting the number of seed that had set on shell subsamples from two bags of cultch shells. Seed size data were gathered by measuring seed on a haphazardly selected subset of the planted cultch. Subsequent survival and growth monitoring data for the 2003 seeding were then collected in spring 2004 through summer 2009.

For the third seeding in 2004, adult native oysters obtained by Betsy Peabody from Lopez Island in April 2004 were spawned, and the larvae set on cultch shells by the Lummi Tribal Hatchery. Approximately 37 bags of seed-containing cultch were then planted in areas A and B in August 2004. Seed planted at the trestle site in 2004, together with seed from the 2002 and 2003 plantings, were monitored for survival and growth from spring 2005 through 2009.

In summer 2006, 190 bags of native oyster seed were set on Pacific oyster shell cultch by the Lummi Tribal Hatchery. The seed source was the Fidalgo Bay trestle population, which was a mixture of seed derived from Samish Bay and Lopez Island sources. The Fidalgo Bay oysters were checked for diseases prior to shipment to the Lummi Hatchery and found to be disease free. 170 of the bags of seed were distributed along the Fidalgo Bay trestle (primarily in areas B and C in Fig. 3) in August 2006, and the balance of 20 bags was planted on the north side of Weaverling Spit at two new locations (10 bags at each site – Fig. 4). Subsamples of the native oyster seed were assessed for spat density on the cultch shells and measured for spat size at planting.

In summary, native oyster seed set on Pacific oyster cultch were planted at the south Fidalgo Bay trestle site in 2002, 2003, 2004 and 2006. The numbers of seed planted in each year are summarized in Table 1. The total number of seed planted for all four years combined is estimated to be 1,429,570. This estimate is based on an average of 240 cultch shells/seed bag for years 2002-2004 and 270 shells/seed bag in 2006.

Monitoring for Survival and Growth

Monitoring for seed survival and growth was carried on from fall 2002 through spring 2009 and will continue in future years. From 2002 through 2006, survival was largely monitored by haphazardly sampling a number of seeded cultch shells from several trestle areas and assessing the number live/dead per cultch shell, which estimated survival based on percentages of live and dead oysters in the population. In 2008 (no samples in 2007), we added haphazard 1/4 m^2 quadrat sampling in Plot B (Fig. 3) at 14 pilings along the trestle (two samples at each piling) where all cultch shells, live oysters and dead oysters (oyster scars) were counted from each quadrat sample. This method now provides estimates of survival based on density estimates in Plot B. The change to quadrat sampling for survival and density estimates was required following enhancement Plot B with non-seed bearing Pacific oyster shell. Previously, all oyster shell in Plot B had contained oyster seed, but addition of seedless oyster shell meant that we could no longer use the seed/cultch counts for survival/density estimates.

Addition of Pacific Oyster Shell for Substrate and Bed Enhancement

Experimental evidence indicates that native oyster larvae prefer to settle on oyster shell (either native or Pacific oyster) compared to gravel or bare ground (White et al. 2009). Thus, we added Pacific oyster shell to the trestle and Weaverling Spit sites to enhance the possible settlement of naturally spawned oyster larvae from the trestle restoration site. Five cubic yards of old Pacific oyster shells, donated by Blau Oyster Company on Samish Island and inspected and permitted by WDFW, was spread at the trestle restoration beds in summer 2006. Addition of the shell to the trestle site was greatly aided by the newly opened Tommy Thompson Trail built on top of the old railroad trestle. Volunteers were able to use carts and hand trucks to transport the shell along the trail to the planting location, where the shell was tossed over the side of the trestle (Fig. 5). A second batch of shell (also 5 cubic yards) was spread by volunteers at the two new Weaverling Spit sites to firm up the substrate and provide settlement substrate for any naturally spawned larvae. An additional 10 cubic yards of Pacific oyster shell was again obtained from Blau Oyster Company in spring 2009 and distributed along both the north and south sides of the trestle (west of Plot B and in and east of Plot C).

Sampling to Assess Natural Recruitment

Bags of clean cultch shell were deployed in the spring of 2003, 2004 and 2006 along the length of the trestle, the bags being spaced at about 5 piling intervals (about 50 feet) and tied to the pilings (Fig. 6). Volunteers returned to the trestle site in August 2004 and the spring of 2005 and 2007 to sample shells from the cultch bags. In 2004 and 2005, volunteers collected about 20-30 shells from each of 19 bags starting at piling set 21 and ending at set 104 next to the mid-bay channel. In 2007, entire bags were collected from pilings 35 through 90 and all shells in each bag were assessed for settlement. These shell samples were taken to Shannon Point Marine Center where they were washed, counted and assessed for spat settlement. Any juvenile oysters encountered were counted and measured to the nearest mm.

In 2007 and 2008, bags of clean Pacific oyster cultch were distributed around Fidalgo Bay and at locations in Padilla Bay and Guemes Channel close to Fidalgo Bay (Figs. 7 and 8) to monitor for larval oyster settlement and to try to discern the extent to which larvae may be distributed from a spawning at the trestle restoration bed. These bags were collected in spring 2008 and 2009 and all shells in each bag were checked for juvenile oysters. Additional haphazard monitoring for natural

native oyster recruitment was carried out in 2006 on several occasions by checking various substrates (Pacific oyster shell, wood and pieces of metal).

Over Winter Mortality, 2008-2009

Winter 2008-2009 was colder was snowier than usual with night temperatures in the low to mid-20s (ºF) and more snow than usual. Since native oysters are known to be more sensitive to temperature extremes than Pacific oysters, we checked one location for survival in the spring of 2009. The sample site was an old decayed barge structure just north of the trestle at a tidal elevation of about 2 to 3 feet above MLLW. From a survey in July 2008, this structure was known to serve as habitat for almost 500 native oysters that likely resulted from a spawn of the trestle population in 2004. We returned to this barge in March 2009 and counted the proportion of live/dead native oysters to assess the effects of any winterkill.

Exploration of Additional Planting Locations

A variety of other locations within Fidalgo Bay and in nearby Padilla Bay were investigated during the summer of 2006 and again in 2009 as possible sites for establishing future native oyster beds. Each site was checked for stability of substrate, presence of standing or flowing seawater during periods of extreme low tides, and presence or absence of native oysters.

Results

Seed Additions to the Trestle Restoration Plot

Seed oysters set on Pacific oyster cultch shells in hatcheries were added to the trestle plots in 2002, 2003, 2004 and 2006. Numbers of seed planted ranged from 24,960 to 1,124,550 for a total of 1,429,570 by the end of 2006 (Table 1). Oyster seed planted in 2002 were age 1+ with an average size of 24.8 mm. Seed planted in the following three years were age 0+ with average sizes ranging from 4.8 to 9.5 mm (Table 1).

Oyster Seed Survival and Densities, 2002 Through 2009

Survival and densities of native oysters at the trestle restoration site were monitored one or two times per year with the exception of 2007. Most monitoring took place in Plot B (Fig. 3), the northern plot containing standing water at extreme low tides. Survival of the seed oysters planted from 2002 through 2006 was roughly 90 % for the first several years (Table 2) and gradually decreased to about 40 % by May 2009. The density of native oysters on a live oyster per cultch shell basis ranged from 4 to 5 in 2002/2003 to a high of 22.5 in May 2004. Recent estimates (2008 and 2009) were about 1 oyster per cultch shell, but one reason for this low number is that about three cubic yards of seedless Pacific oyster shells were added to Plot B in 2006, effectively diluting the oysters/shell estimates. On the basis of number of live oysters per ¼ m^2 quadrat sampling, oyster densities averaged about 10 per 1/4 m^2 in 2002 and 2003 and increased to 21 and 23 per sample in 2008 and 2009 (Table 2, Figs. 9 and 10). Estimated total number of oysters at the trestle restoration site, based on the total number of seed planted and their survival rates, ranged from 21,790 in 2002 to a high of 560,391 in 2009 (Table 3).

Oyster Sizes

Native oysters sampled in Plot B were measured each year for their sizes. Average shell length was 24.8 mm in May 2002, which reflected the average size of the age 1+ seed planted that year (Table 2, Fig. 11). Average size then increased through August 2004 to a high of 47.0 mm and decreased in April 2005 to 26.4 mm due to the addition of small seed oysters in August 2005 (Fig. 11). Average sizes in spring 2008 and 2009 were 32.2 and 36.8 mm, respectively (Figs. 12 and 13). The average size of native oysters at the trestle should continue to increase unless new seed oysters are added in subsequent years.

Natural Recruitment

A series of bags of clean cultch shells hung along the length of the trestle next to the seed planting beds were checked in August 2004 and spring of 2005 and 2007 for any signs of natural recruitment of native oysters from spawning at the trestle site. No signs of post-larval recruitment were found in 2004, but a low density of natural spat was observed on the cultch shells in April 2005. Volunteers returned to the trestle in late June 2005 to collect samples of shells from the shell bags. Assessment of 442 shells resulted in a total of 104 juvenile oysters that had to have set from natural spawning, for an average density of 0.24 spat/cultch shell (Fig. 14). Initially, these juvenile oysters were identified as Pacific oysters by MRC and Puget Sound Restoration Fund personnel (Dinnel et al. 2006), but later information pointed to the fact that these were actually native oyster recruits. The sizes of these recruits ranged from 6 to 40 mm, with an average size of 14.7 mm shell length (Fig. 15). Shell in bags set out in 2005 and sampled in spring 2006 did not contain any native oyster recruits, indicating a lack of successful spawning in 2005.

Shell bags were again deployed along the trestle in spring 2006 and recovered in spring 2007. These bags contained moderate numbers of juvenile native oysters (0.18 oysters/cultch shell – Fig. 16), indicating a successful spawn at the trestle in summer 2006. These oysters ranged in size from 14 to 26 mm shell length and averaged 19.4 mm (Fig. 17).

In spring 2007 and 2008, bags of clean Pacific oyster cultch were distributed around Fidalgo Bay and nearby locations in Padilla Bay and Guemes Channel (Figs. 7 and 8). These bags were retrieved and checked for settlement of juvenile native oysters in spring 2008 and 2009. No native oysters were found in any of these bags, indicating that the oysters at the trestle failed to spawn successfully in 2007 and 2008. Additional bags were deployed in spring 2009; these will be recovered and checked in spring 2010.

Several checks of old Pacific oyster shell, clam shells, wood and metal debris were made during the summer of 2006. Low densities of native oysters, some fairly large in size, were found attached to these substrates. These juvenile native oysters had set in the last several years and had to have come from naturally set native oyster larvae since some juveniles were found on old seed cultch and on top of seed oysters planted in the last few years. These juveniles were likely recruits from a 2004 spawning at the trestle restoration site.

Fidalgo Bay Surveys for Native Oyster Settlement

Surveys of possible native oyster habitats in Fidalgo Bay were conducted in summer 2008 and spring 2009 for an assessment of native oyster recruitment originating from spawn from the trestle restoration bed. The number of native oysters found at these locations ranged from 0 to 494, with the highest numbers being found closest to the trestle (Fig. 18). These oysters ranged in size from

18 to 74 mm. Both the density and size data suggest that these oysters originated from successful spawning at the trestle in the summers of 2004 and 2006.

Over Winter Mortality, 2008-2009

Over winter mortality was assessed at one site (south barge site, just north of the trestle) in spring 2009 following the winter of 2008-09 when night temperatures ranged into the low to mid 20ºs (F) and the Fidalgo Bay area received about 1 ½ feet of snow over a two week period. When checked in March 2009, we found that for 361 oysters checked, 72.3 % were alive, 27.2 % dead. Although dead oysters were not recorded at this site previously, our impression was that the percentage of dead shells at the south barge site was likely <10 %. Thus, the cold winter temperatures and snow of 2008-09 may have been responsible for up to about 18 % mortality at this site.

An additional check of live/dead native oysters was made on the north side of the Weaverling Spit causeway (the western solid end) in April 2009. We found 131 native oyster natural recruits at this location of which 60.3 % were alive, 39.7 % dead. This reaffirms that winter kill of native oysters at a second site where low to mid intertidal native oysters occurred (unprotected by standing water) was less than 40 %. Hence, most native oysters that are at least a few years old can tolerate periodic exposures to temperatures as low as about 20º F when unprotected by standing seawater or seepages.

Exploration of Additional Planting Locations

Two new sites were considered for future plantings of native oyster seed. The first site is in Fidalgo Bay at the north end of the bay near the entrance to Cap Sante Marina. The Port of Anacortes, in conjunction with the Washington Department of Ecology and Kimberly Clark Corporation, is cleaning up historical soil and sediment contamination at this site and will be restoring forage fish habitat. Part of the project will be the installation of two wave attenuator structures (constructed of rock riprap) offshore of Seafarer's Park to protect the restored shoreline. Intertidal beaches on the landward sides of the riprap may offer areas on which native oyster seed might survive, grow and reproduce. If so, then two "source" populations would have been established in Fidalgo Bay and the eventual distribution distance of spawned larvae may be increased.

The second site under consideration is the eastern intertidal flats of Padilla Bay in an area where Hatch et al. (2005) have documented a historically occurring population of native oysters. This area is approximately mid way between the town of Bay View to the south and Joe Leary Slough to the north. This area has firm substrate and pools of standing water at low tide. However, a number of Japanese oyster drills have also been observed in this area, which may require the need for predator control.

Education and Outreach

Education and outreach on native oyster restoration was an ongoing task during 2007-2009 and included the following:

- Poster presentation at the second West Coast Native Oyster Workshop held in Shelton, Washington, 13-15 August 2007. An abstract of the poster was published in the workshop proceedings (Dinnel et al. 2008).
- Presentation to Skagit Beach Watchers class, Padilla Bay Reserve, 24 March 2008.

- Poster presentations at Northwest Straits Commission/Marine Resources Committee Annual Workshops, 2007 and 2008.
- Poster presentation, Samish Tribe Fidalgo Bay Science Conference, 21 January 2009.
- Platform presentation, Pacific Estuarine Research Society Annual Conference, Bellingham, Washington, 3 April 2009.
- Presentation to Skagit Beach Watchers class, Padilla Bay Reserve, 3 April 2009.
- Interview with Skagit Valley Herald and publication of an article on 28 May 2009.
- Presentation to Anacortes Newcomers Club at Padilla Bay Reserve, 14 June 2009.
- Peer reviewed publication in Journal of Shellfish Research, March 2009 (Dinnel et al. 2009).

Volunteer Hours

Approximately 25 volunteers participated in native oyster restoration efforts from July 2007 through June 2009. The estimated time spent by volunteers doing field work (filling and deploying shell bags, collecting shell bags, assessing oysters in shell bags, obtaining trestle density and survival data, shell enhancement at the trestle site, monitoring for natural post-larval recruitment, project coordination, data analyses, report writing and oral/poster presentations) is 205 hours.

Discussion

The trestle site in South Fidalgo Bay was originally chosen by Betsy Peabody (PSRF) and Bill Taylor (Taylor Shellfish Farms) because of the site's firm substrate, standing water at low tide, absence of oyster drills and minimal recreational use. The initial success of the 2002, 2003 and 2004 seedings, both in terms of survival and growth, validated this location as a viable restoration site in North Puget Sound (see Robinette and Dinnel, 2003 for results of our first year's work at the trestle site, Robinette et al., 2004 for the second year and Dinnel et al., 2005 for the third year). Discovery of significant numbers of naturally recruited native oysters at the trestle site and surrounding areas in Fidalgo Bay further validates this site. Since there are no other documented concentrations of native oysters in the North Puget Sound region (a few remnant native oysters have been found in Bellingham and Samish bays and on Lopez Island), then the natural recruits found in Fidalgo Bay are almost certainly from spawnings at the trestle restoration site.

The area underneath the trestle, and within about 3 meters on either side, has a very firm substrate composed of gravel and accumulations of clam and oyster shells. Areas further from the trestle (about 3 to 10 meters) still have fairly firm substrate and good standing water at extreme low tides, but also have increased siltation that has caused a minor amount of mortality of very small seed oysters. Predation by crabs, drills, diving ducks and other predators continues to be very low so far, although the potential for eventual predation by some crabs is certainly possible (Henoch 2004). Most seed appear to be staying on site and are not being carried very far by currents or waves.

Growth of all four batches of oyster seed, together with new natural recruits, is gradually providing the beginnings of a structured oyster bed at the trestle site. The main seeding sites at the trestle (areas A, B and C – Fig. 3), as well as some of the outer fringes of the trestle site, were enhanced in 2006 by adding Pacific oyster shells to the somewhat silty substrate to provide more solid support for small native oyster seed and to provide additional settlement substrate for any naturally-spawned larvae that might settle. A second oyster shell enhancement effort (10 cubic yards) was

undertaken in 2009 to increase the amounts of oyster shell substrate in the area west of Plot B and inside Plot C.

An experimental bed structure using both rocks and oyster shell was constructed by the Samish Tribe on Weaverling Spit and seeded with native oyster seed in 2003 and 2004 (Barsh 2003; Barsh et al. 2004). However, assessment of this site in 2006 showed that there were few, if any, surviving native oysters. This site was higher than the trestle site and did not have any standing water present during periods of very low tides. Therefore, this site was abandoned in 2006 in favor of two other sites that do have standing water at extreme low tides (Fig. 4). Each of these two sites were "firmed up" by the addition of approximately five cubic yards of Pacific oyster shell obtained from Samish Island. Subsequently, each site was seeded with 10 bags (~65,000 seed) of native oyster seed in August 2006. These sites will be monitored by the Samish Tribe for survival and growth in 2009 to determine if either or both of these sites will support a native oyster bed.

The goal of any native oyster project is to establish a bed that successfully spawns, produces larvae, and acts as a "source population" that exports larvae to other areas. The larval stage lasts about 11 to 16 days (Imai et al. 1954), during which time they will be distributed by water currents. However, there is virtually no information about how far native oyster larvae will be dispersed, and dispersion is most certainly a function of the specific locale and larval behavior. Since the trestle population is so far the only significant concentration of native oysters in this region, we should be able to trace settlement patterns within and outside Fidalgo Bay and determine the extent of larval transport during subsequent years. However, care will have to be taken to differentiate native oyster seed from Pacific oyster seed since Pacific oysters cultured in Samish Bay can spawn in rare years and distribute larvae as far south as Fidalgo Bay (as evidenced by Pacific oysters that have settled on rocks from a spawning in the late 1990s).

Evidence to date strongly suggests that native oysters at the trestle restoration bed successfully spawned in 2004 and 2006 and recruited to intertidal areas of eastern Fidalgo Bay within about one mile of the source (trestle) population, with the highest settlement taking place at sites nearest the trestle (Fig. 18). Why spawning and/or recruitment were apparently unsuccessful in 2005, 2007 and 2008 is presently unknown. Monitoring for natural recruitment will continue in future years of this project.

One concern about restoration of native oysters in Fidalgo Bay and North Puget Sound was that temperatures may not be sufficiently high enough for successful spawning and larval production. Given our observations in 2006, this does not seem to be a significant issue. According to the scientific literature (as cited by Allen 2005), native oysters start to spawn when water temperatures are consistently greater than 12.5 ºC, and the larvae settle about 30 days later. Temperature profile data collected at three sites in Fidalgo Bay clearly show that temperatures are high enough by about mid to late May to allow spawning (Dinnel et al. 2006). Indeed, one native oyster was found to contain brooding larvae in June 2006.

Currently, native oysters have only been planted at the South Fidalgo Bay sites (trestle and Weaverling Spit) and represent the only restoration location in the North Puget Sound region (except for a few small plantings on private property on Orcas Island). Restoration of native oysters in the North Sound region will require more restoration sites so that naturally-spawned larvae are produced at a "network" of sites. Additional sites in Skagit County where successful seeding might be accomplished include the numerous shallow channels and tidal flats of Padilla and Samish bays. Skagit MRC did propose to plant a few bags of native oyster seed in south Padilla

Bay in 2006. However, lack of a formalized restoration plan for the Padilla Bay Research Reserve has caused a postponement of any seeding activities until 2010 or later.

Restoration activities planned for 2010 and 2011 include continued monitoring of survival and growth of oysters seeded from 2002 through 2006, monitoring for spawning and larval recruitment, addition of new seed oysters to an area in north Fidalgo Bay (at a cleanup/restoration site adjacent to Cap Sante Marina) and the possible planting of seed in one or several locations in Padilla Bay.

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Table 1. Number of bags of native oyster seed, average seed density on cultch shells, total number of seed planted and size and age at planting at the South Fidalgo Bay trestle site, 2002-2006.

Year	# of Bags Seeded	Average # Seed/shell	# of Seed Planted*	Ave. Length, mm	Age
2002	20	5.2	24,960	24.8	1+
2003	39	7.0	91,360	5.1	0+
2004	37	17.0	188,700	9.5	0+
2006	170	24.5	1,124,550	4.8	0+
Total	266	-----	1,429,570	------	-----

* Based on an average of 240 cultch shells/bag for 2002-2004 and 270 shells/bag for 2006.

Table 2. Summary of native oyster densities, live and dead per cultch shell and sizes in Trestle Plot B, 2002-2009.

Month/Year	Ave. # Live Per ¼ m^2	Ave. # Live Per Cultch Shell	Ave. # Dead Per Cultch Shell	Percentage Live Oysters	Ave. Length, mm	Comments
May 2002	46.0	4.8	0.7	87.3	24.8	Size of seed at plant
Nov. 2002	27.6	3.4	0.1	97.1	34.2	
April 2003	43.6	4.6	0.8	85.2	34.4	
Aug. 2003	44.8	4.7	1.2	79.7	40.4	Prior to 2003 seed addition
May 2004	NM*	22.5	2.4	90.4	41.6	
Aug. 2004	NM	NM	NM	NM	47.0	Prior to 2004 seed addition
April 2005	NM	8.7	2.6	77.0	26.4	
Aug. 2006	NM	10.5	3.7	73.9	36.5	Prior to 2006 seed addition
June 2008	84.4	1.0**	NM	NM	32.2	
May 2009	91.6	0.7	1.0	39.2	36.8	

* NM = Not Measured.

** Large reduction in number of oysters/shell due to enhancement of Plot B in August 2006 with several cubic yards of non-seed bearing Pacific oyster shell.

Table 3. Summary of the estimated number of live oysters remaining at the Fidalgo Bay restoration site from May 2002 through May 2009. Estimates are based on the numbers of seed oysters planted in 2002, 2003, 2004 and 2006, and the percentage of live oysters for each date. Estimates are based on sampling in Plot B with survival rates and density estimates extrapolated to the rest of the trestle area. These estimates do not include natural recruits that originated from spawning of the trestle site oysters and now reside around Fidalgo Bay.

Month/Year	Percent Live Oysters	Total Live Oysters
May 2002	87.3	21,790
Nov. 2002	97.1	24,236
April 2003	85.2	21,265
Aug. 2003	79.7	19,893
May 2004	90.4	105,153
April 2005	77.0	234,865
Aug. 2006	73.9	225,410
May 2009	39.2	560,391

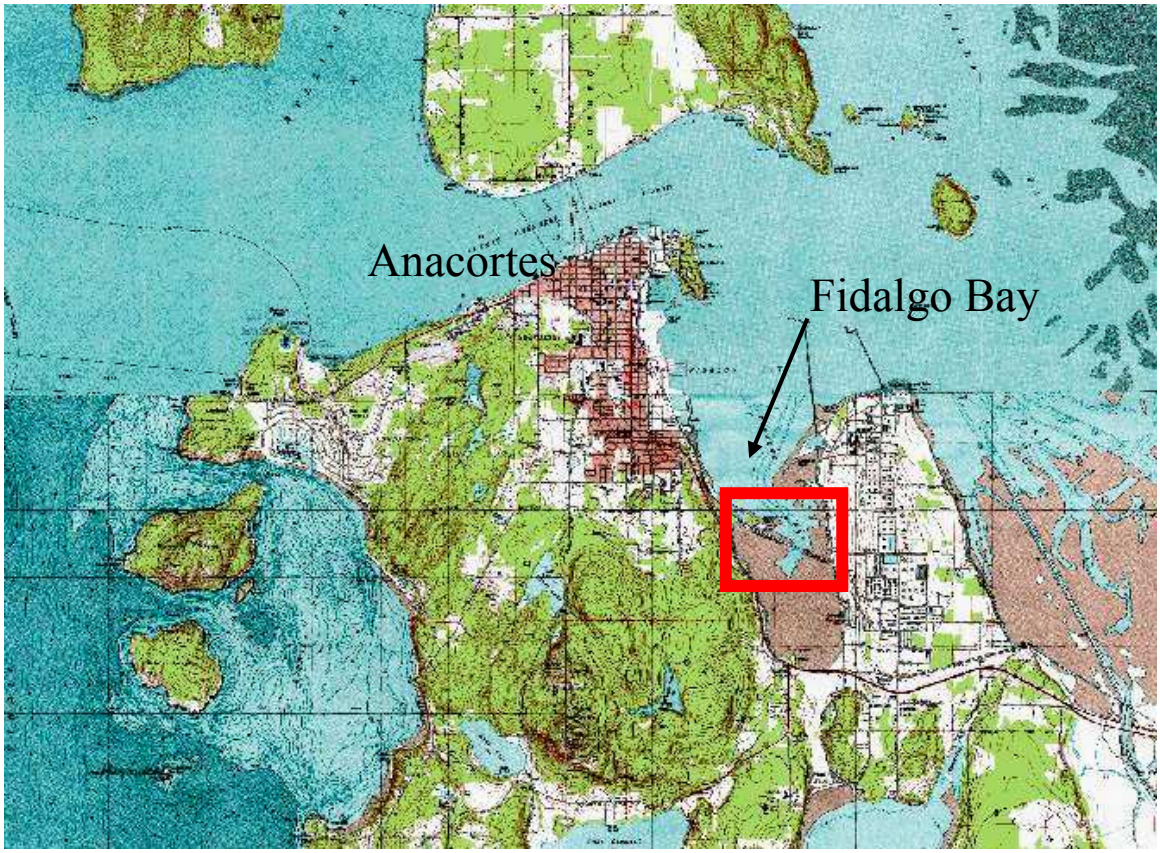

Figure 1. Location of the native oyster restoration project in Fidalgo Bay.

Figure 2. Location of the trestle native oyster restoration site in South Fidalgo Bay, 2002-2009 (WDOE Shoreline photo).

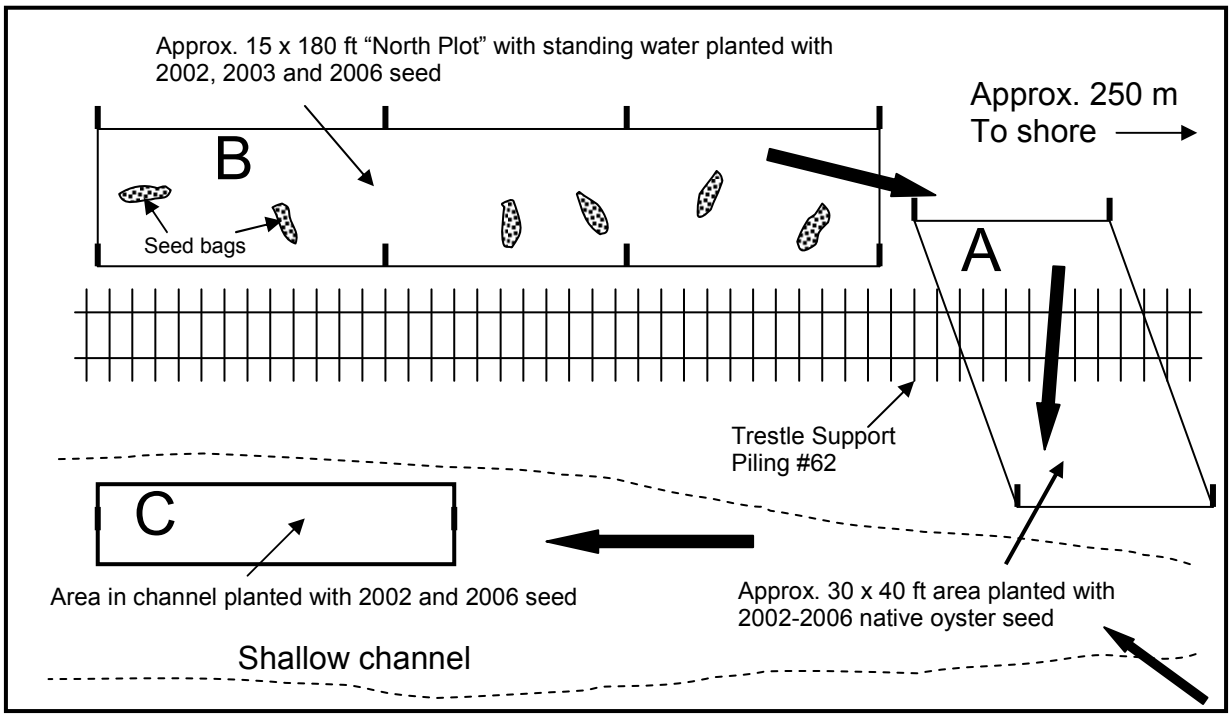

Figure 3. Trestle site plan showing the seeding locations, 2002-2006. Large arrows show the directions of water drainage at low tide. Map derived from site drawings by Robert Knowles.

Figure 4. Photo of Weaverling Spit showing the two new locations where native oyster seed were planted in August 2006 (WDOE shoreline photo).

Figure 5. Photo showing distribution of cultch shells to the tidelands beneath the trestle by volunteers in May 2009.

Figure 6. Bags of Pacific oyster shells (cultch) being tied to one of the trestle pilings. The bags were collected one year later (2005, 2006 and 2007) and the shells assessed for native oyster post-larval recruits.

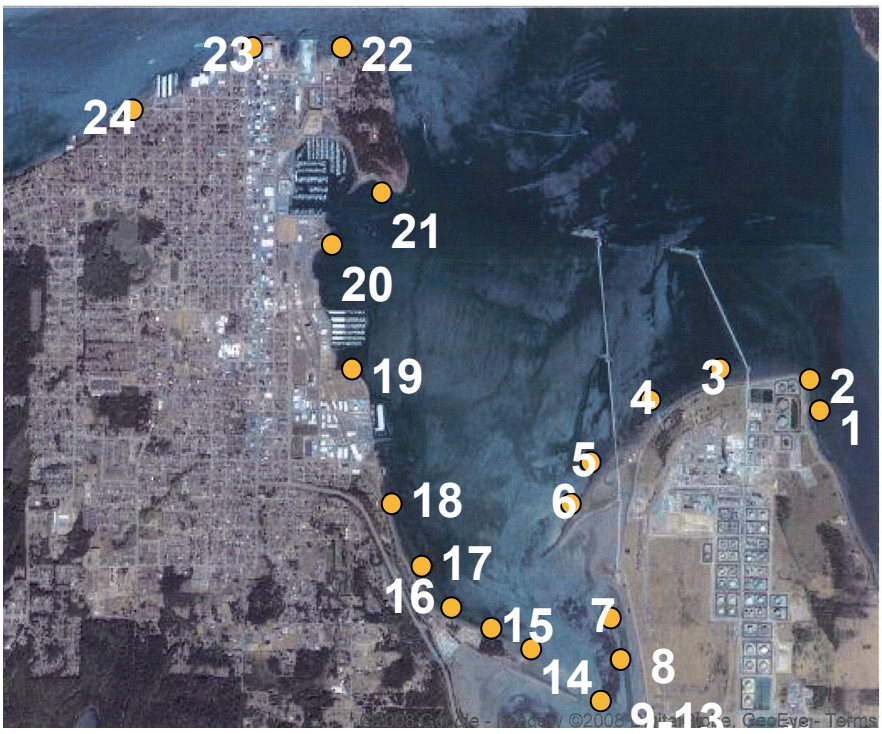

Figure 7. Locations of 24 cultch bags deployed in spring 2007 in and around Fidalgo Bay to monitor recruitment of native oysters from possible 2007 spawning at the trestle.

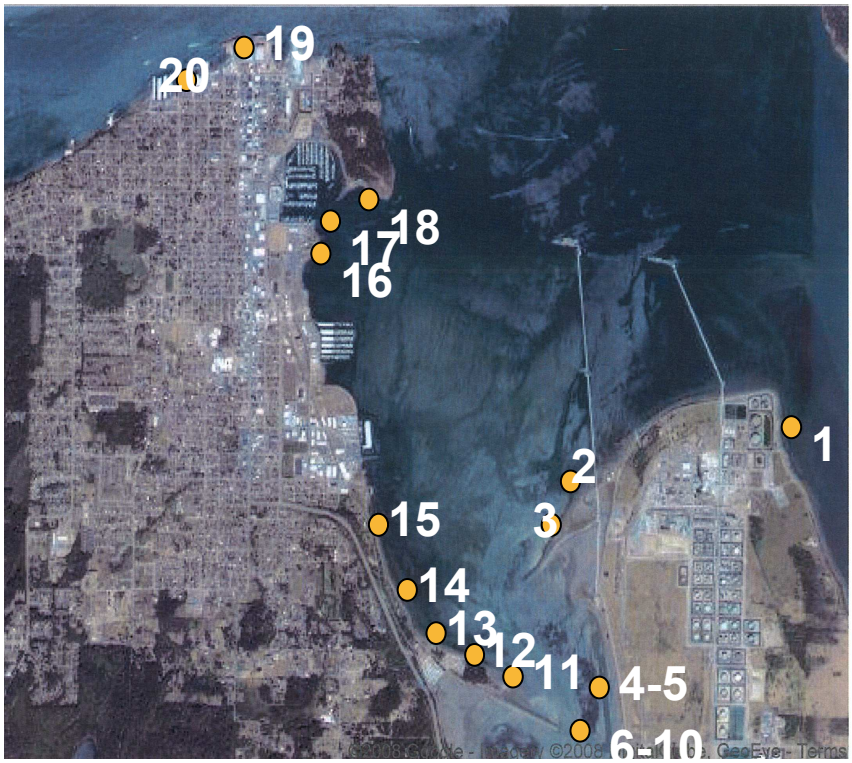

Figure 8. Locations of 20 cultch bags deployed in spring 2008 in and around Fidalgo Bay to monitor recruitment of native oysters from possible 2008 spawning at the trestle.

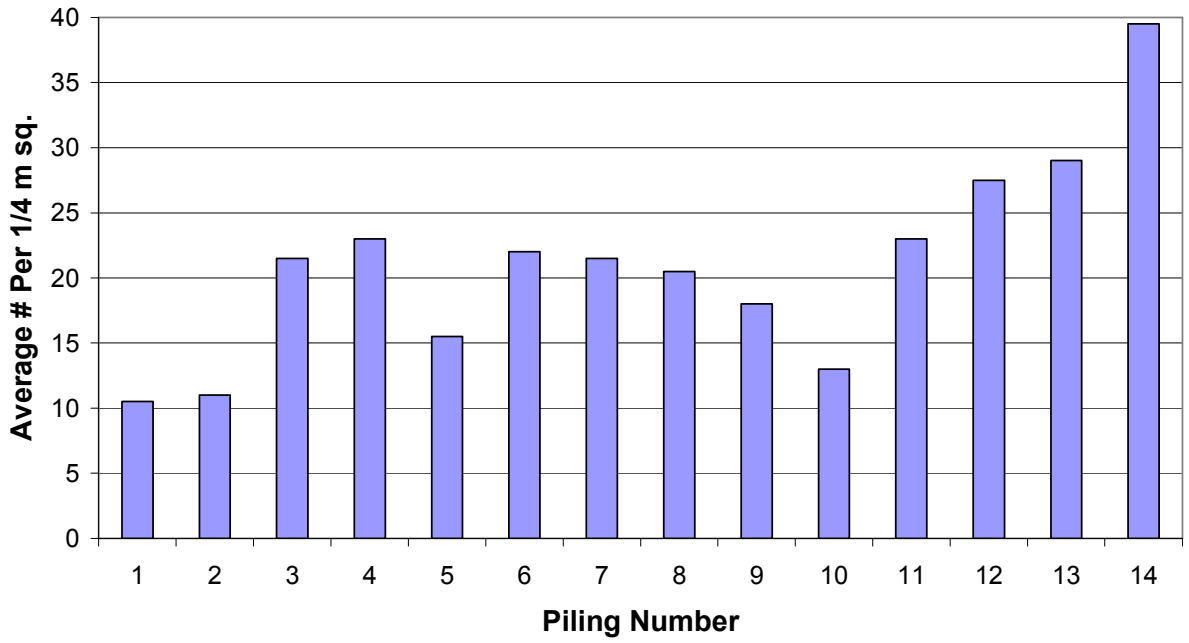

Figure 9. Average number of oysters per ¼ m^2 at pilings 1-14 in Plot B in spring 2008.

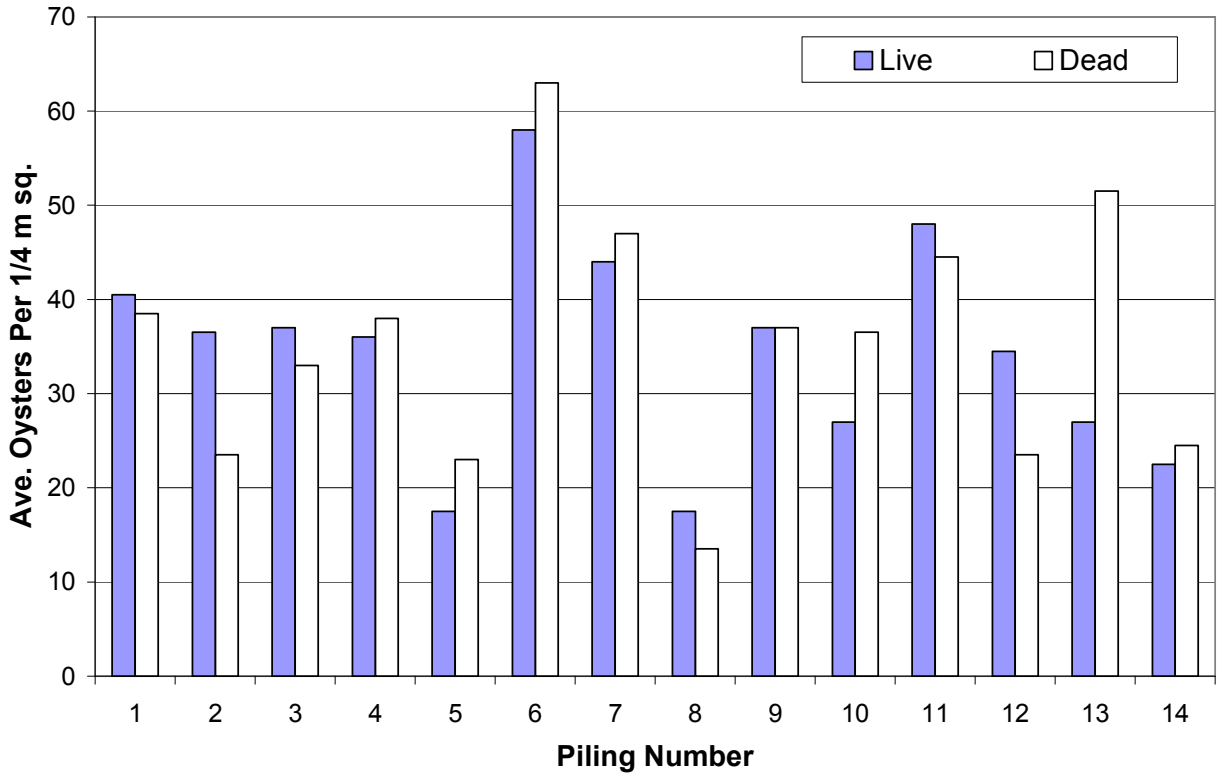

Figure 10. Average number of live and dead oysters per ¼ m^2 at pilings 1-14 in Plot B in spring 2009.

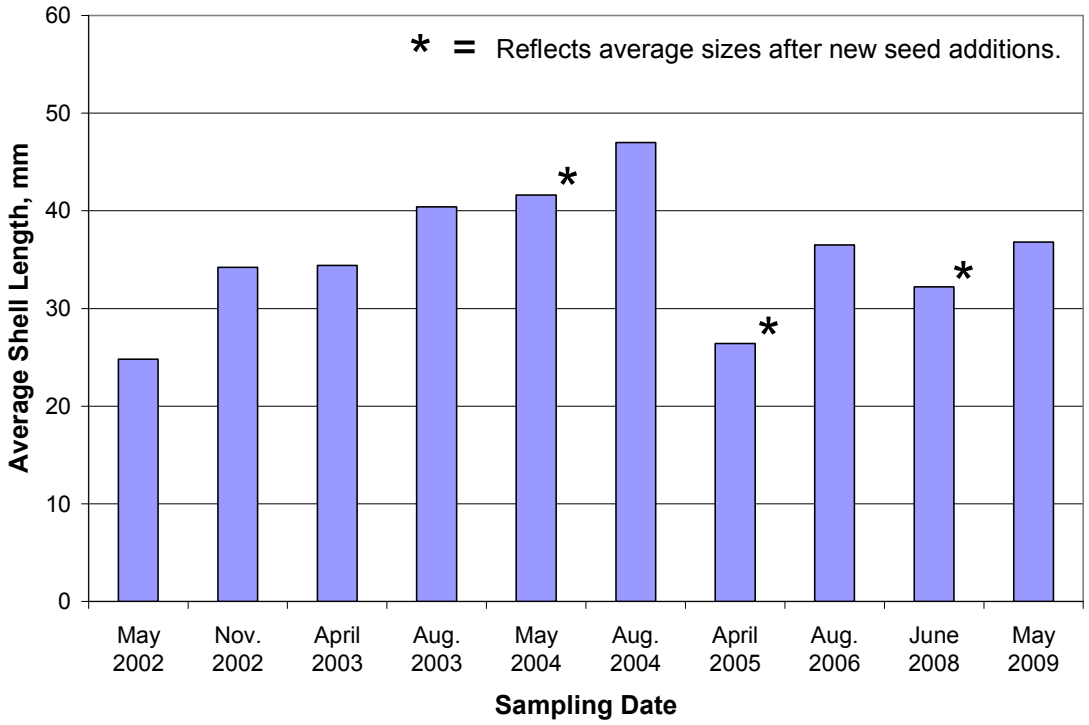

Figure 11. Average shell lengths of native oysters sampled at the trestle restoration Plot B from May 2002 through May 2009. Average sizes decrease on some occasions due to additions of small new seed oysters.

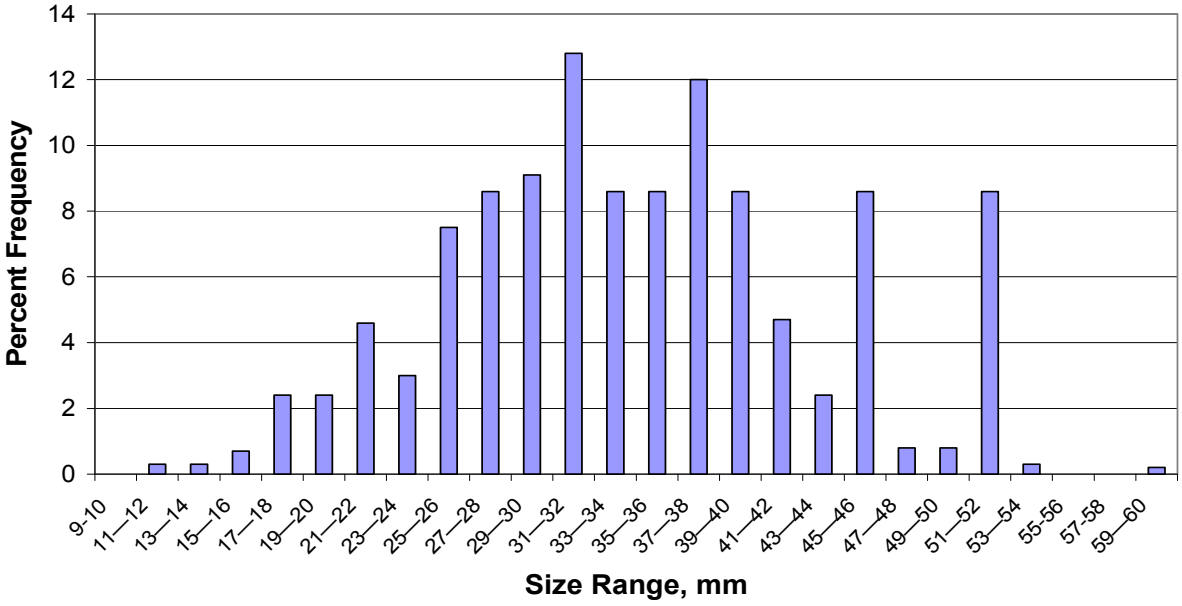

Figure 12. Size-frequency histogram of native oysters sampled from trestle Plot B in spring 2008.

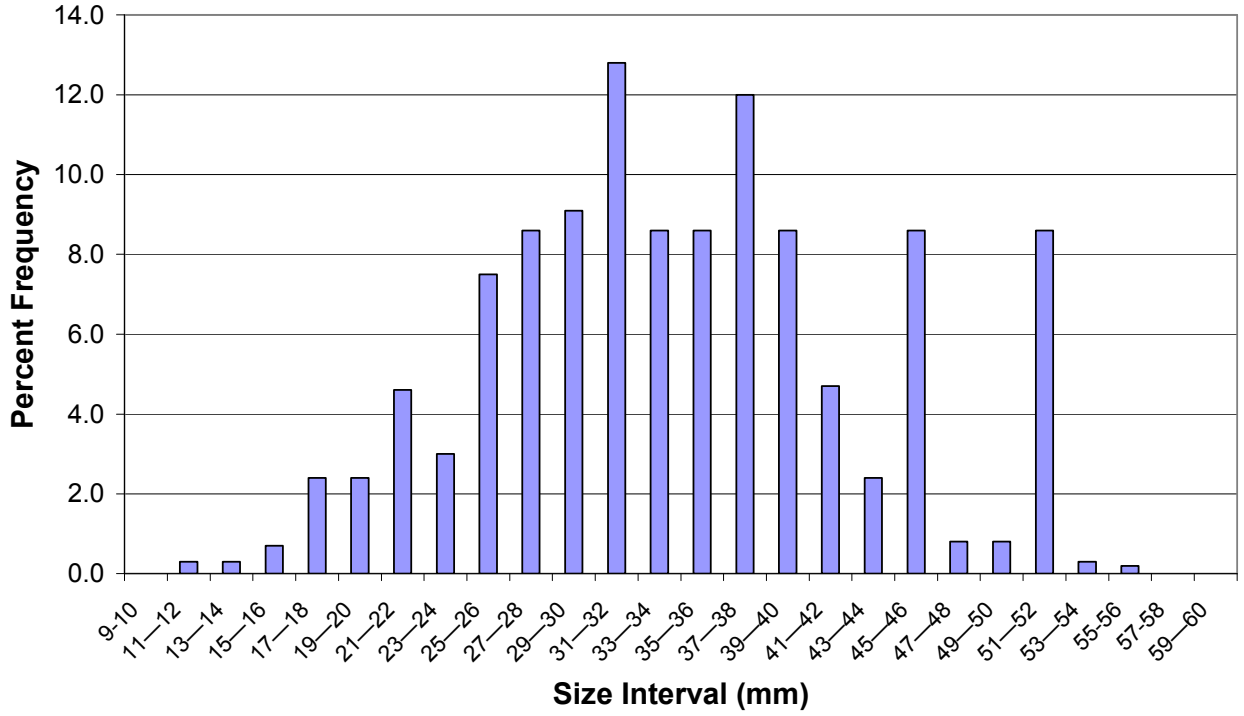

Figure 13. Size-frequency histogram of native oysters sampled from trestle Plot B in spring 2009.

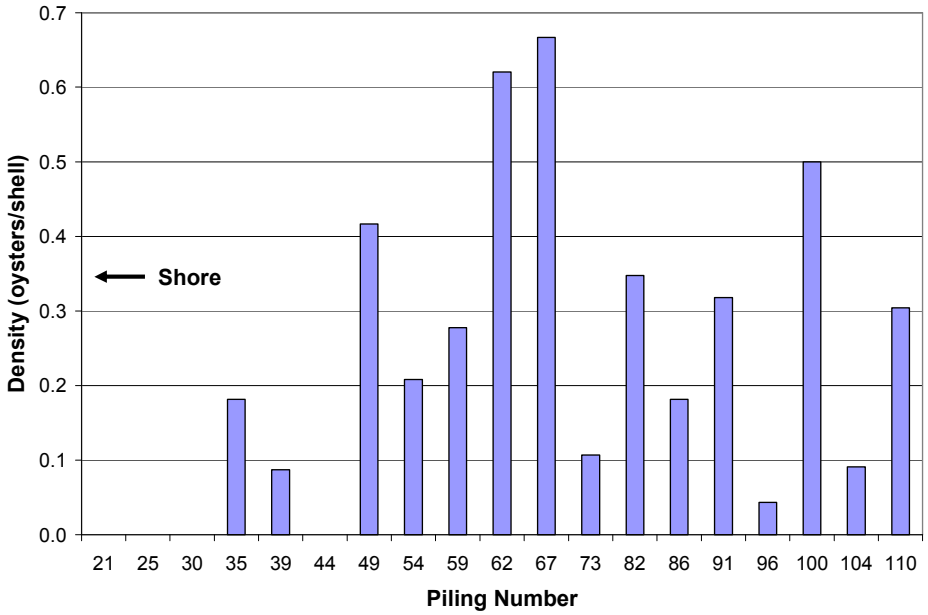

Figure 14. Density of native oyster natural recruits found on cultch shells from bags deployed along the trestle in spring 2004 and recovered in spring 2005. These oysters likely originated from a spawning of the trestle seed oysters in summer 2004.

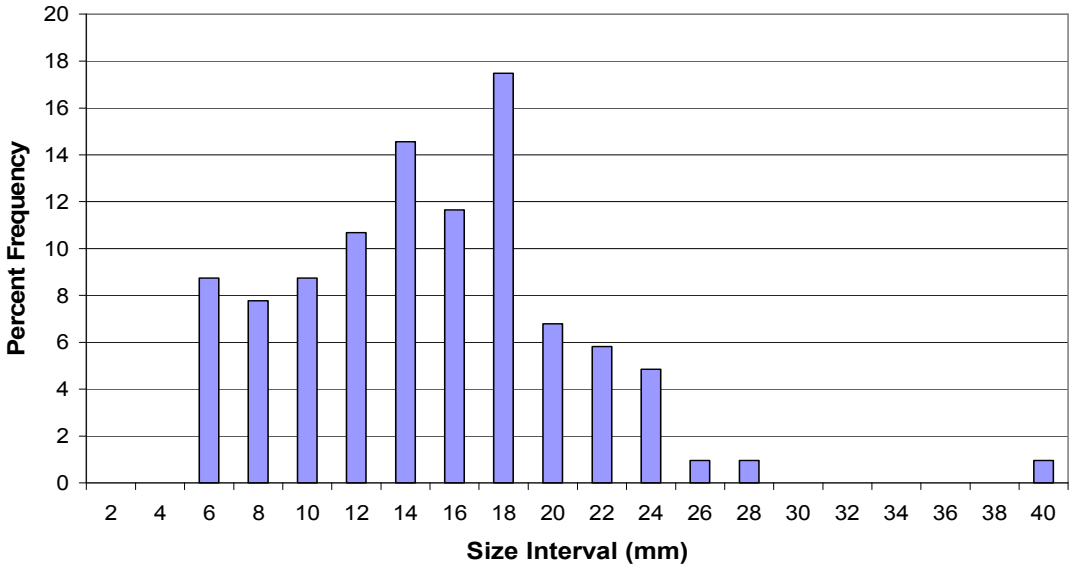

Figure 15. Size-frequency histogram of native oyster recruits recovered from the cultch bags deployed in spring 2004 and sampled in April 2005.

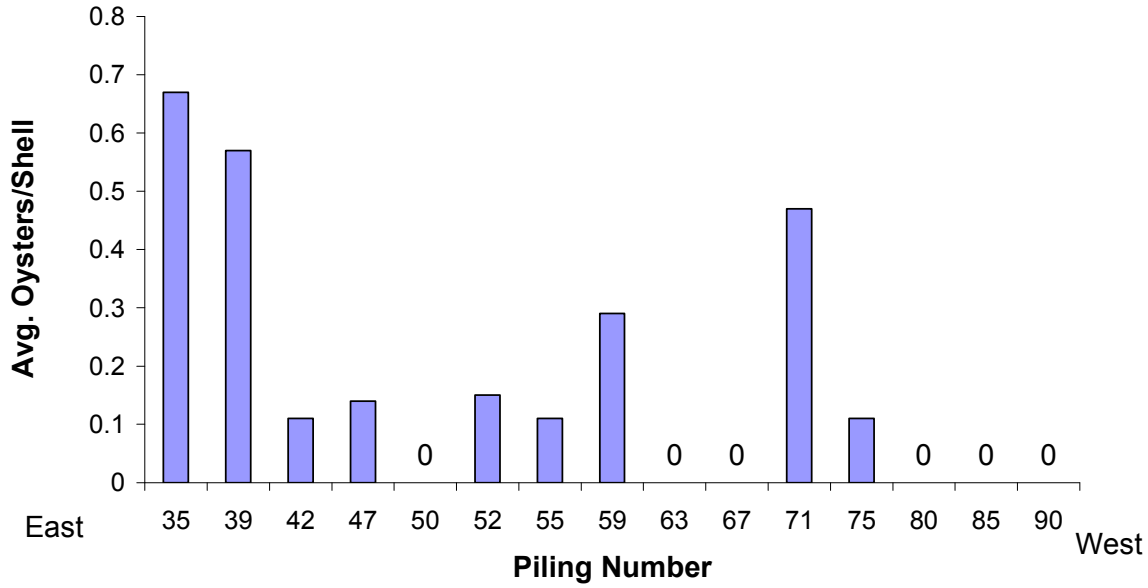

Figure 16. Density of native oyster recruits found in the shell bags deployed along the trestle in spring 2006 and recovered in spring 2007. These data indicate that there was a successful spawning at the trestle restoration bed in summer 2006.

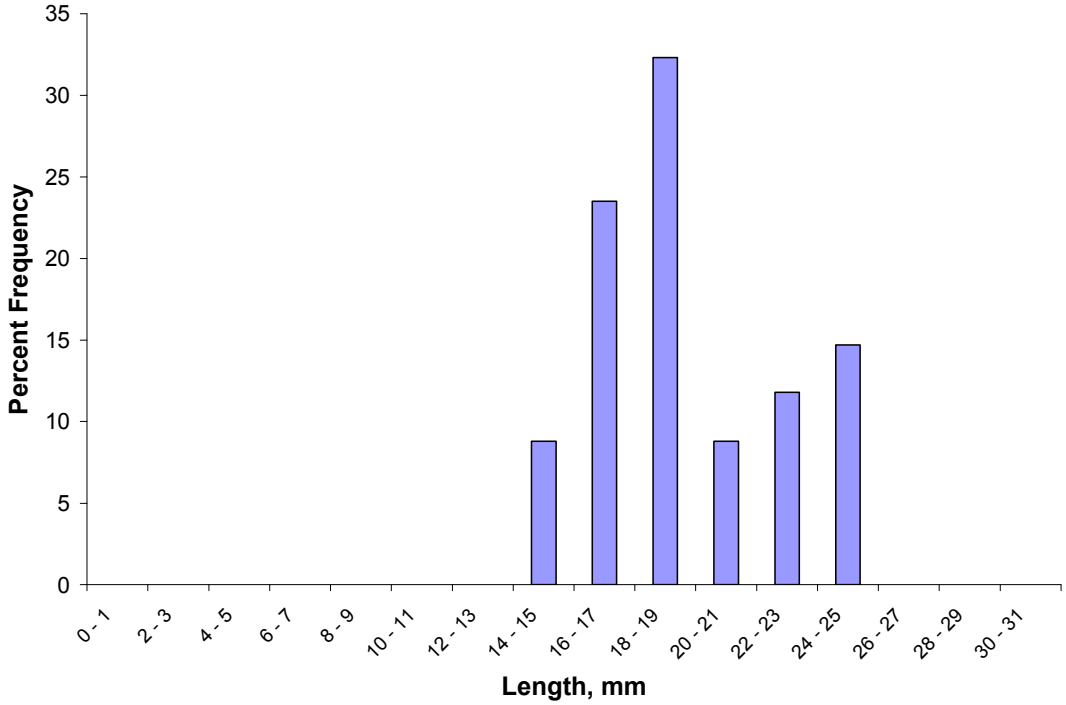

Figure 17. Size-frequency histogram of native oysters recovered from the settlement bags deployed along the trestle in 2006 and recovered in 2007.

Figure 18. Numbers of native oysters found in Fidalgo Bay in 2008 and 2009 at the locations marked by the orange circles. The **X** marks the location of the trestle restoration bed.

Appendix 1

Media Coverage of Skagit MRC's Native Oyster Restoration Project

On the Hunt for Oysters

May 28, 2009 - 08:43 AM
by Marta Murvosh

ANACORTES - As empty clamshells crunched and tidal mud squished under their rubber boots, Christine Woodward and Pamela Maxwell scrutinized their finds, looking for signs that the native Olympia oyster is reproducing in Fidalgo Bay.

Vicki McNeil of Anacortes and Dixon Elder of Guemes Island search for Olympia oysters Tuesday, May 26 at low tide in Fidalgo Bay near the trestle on the Tommy Thompson Parkway in Anacortes. Skagit County Marine Resources Committee, Northwest Straits Commission and other groups have been working since 2002 to restore the native oysters to the bay.

Woodward, director of natural resources for the Samish Indian Nation, measured the size of each live native oyster. Maxwell, a volunteer with Beach Watchers, a shoreline stewardship group, recorded the measurements and tracked the number of living and dead native oysters.

The two women watched for signs - such as a smaller oyster growing on a larger one's shell — that the half-dollar-sized bivalves "seeded" in the bay between 2002 and 2006 had reproduced.

"It's a question of do we have enough seed in the right place to reproduce and repopulate the bay, or do we need to put more out or in a different place," said Paul Dinnel, a marine scientist who volunteers with the Skagit County Marine Resources Committee.

Dinnel and other volunteers took advantage of low tides earlier this week to check on the progress of the marine committee's effort to re-introduce the oysters to the bay. They checked at least 14 areas along the trestle on the Tommy Thompson Parkway over the bay.

Known for their slight coppery taste, the Olympia oyster is prized by shellfish lovers, Dinnel said.

"They are definitely good eating oyster," Dinnel said. "They are a gourmet oyster."

But the species is in trouble. The number of oysters in Washington has declined from historic levels by as much as 90 percent, said Dinnel, who specializes in marine invertebrates and toxicology at Western Washington University's Shannon Point Marine Center.

In Canada, the species has been identified as at risk of extinction. But in the United States, no one has petitioned the National Marine Fisheries Service to place the Olympia oyster on the Endangered Species List, according to Brian Gorman, a federal fisheries service spokesman.

Olympia oysters were once found from Baja, Calif., to Sitka, Alaska. In Fidalgo Bay, the native oysters were eaten by indigenous people between 2,400 and 3,400 years ago, according to a 2006 report by Cascadia Archeology, a contractor that evaluated a midden site on the shore.

The hunger of Gold Rush millionaires in the late 19th Century and pollution from paper mills in the early 20th Century decimated the Olympia oyster population, Dinnel said.

"Schooners full of oysters would head south to San Francisco in the gold mining days," Dinnel said. "They wiped oysters out in San Francisco and worked their way north. An Olympia oyster, which is a small little guy, went for $1 apiece, in those days."

The annual harvest of Olympia oysters in Washington reached 130,000 bushels by the 1890s, according to The Nature Conservancy. By 1910, the harvest had dropped to 16,000 bushels a year, similar to declines in Oregon and California, according to the conservancy.

Then water pollution took its toll.

"There was enough untreated waste from paper mills in Bellingham to kill oysters living here," Dinnel said.

The Olympia isn't the only native oyster species at risk. Around the world, oyster reef habitat has declined by at least 90 percent from historic levels, and 85 percent of the oyster reefs have been lost, according to "Shellfish Reefs at Risk," a report by The Nature Conservancy. "Based on these data, we conclude that shellfish reefs are one of, and likely the most, imperiled marine habitat on earth."

The conservancy is calling for resource managers to recognize that shellfish habitats need protecting and have asked government agencies to expand the listing of oysters as an imperiled species.

"Perhaps the biggest challenge is the perception among managers that there is not a problem," the authors wrote.

The conservancy and the Puget Sound Restoration Fund have partnered to re-introduce the oyster to South Puget Sound.

The Skagit marine resource committee's project is the first such effort in the North Sound and was funded by the Northwest Straits Commission, Dinnel said. Besides efforts made by marine resource committees and environmental groups, commercial and hobbyist shellfish growers also are working on bringing the Olympia back at various locations in the Sound.

Sheltered from storms and extreme temperature ranges, the firm tidal flats of Fidalgo Bay offer an ideal site for the oysters, Dinnel said. The Skagit committee planted 1.5 million "seeds" of the bivalves in the bay annually from 2002 to 2006, Dinnel said.

Volunteers also shoveled yards of empty Pacific oyster shells into various spots along the bay to provide places for the Olympia oyster larva to attach to and grow. Laboratory tests indicate that oysters prefer to attach to oyster shells, rather than rocks or other structures, Dinnel said.

As the Olympia oyster species re-establish, each subsequent generation of oysters will attach to the shells of deceased or older oysters, forming flat reefs. Pacific oysters build freeform sculptural reefs of the Pacific oyster colonies. Reefs of that species, imported from Japan by shellfish growers, can be seen at Bay View State Park at low tide.

On Wednesday, Dinnel's volunteers counted all the oysters found in a quarter-meter-square area at one of the sites.

Woodward, who represents the Samish on the Skagit marine resources committee, said that the tribe, the Port of Anacortes and various state agencies have been working hard to improve the bay's water quality. Recovery of the native oyster beds could be an indicator of improved water quality, she said.

"To the Samish people, being able to harvest native oysters once again will kind of be like recreating what was here during pre-settlement times," Woodward said. "We're just really supportive of the efforts of the (marine resources committee) and Shannon Point."

Over the past few years, volunteers also have placed nylon net bags of oyster shells at various spots, including the Guemes Channel, Padilla Bay and nailing them to the Thompson trestle pilings.

The volunteers later check the oyster bags, counting the new oysters they found inside. They've also found native oysters along Crandall spit and other places in the bay that weren't seeded, Dinnel said. Those are signs that the seeded Olympia oysters have reproduced in the wild.

But Dinnel said that he and the marine committee don't know whether they have seeded enough oysters or placed them in the best spots to ensure that the bivalves will repopulate the bay without human help. It could take four or five years to have those answers.

"It takes a long time with a population like this," Dinnel said.

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