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Restoration of the Native Oyster, *Ostrea lurida*, in Fidalgo Bay, Padilla Bay and Cypress Island

Year Fourteen Report

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Skagit County Marine Resources Committee

September 2016

Skagit MRC

Northwest Straits INITIATIVE
partners in marine conservation

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Restoration of the Native Oyster in Fidalgo Bay, Washington --Year Fourteen Report

Abstract

The native or Olympia oyster, *Ostrea lurida,* is native to the Pacific Coast of North America ranging from Sitka, Alaska to Baja California. Populations declined rapidly after the arrival of European settlers and overharvest was apparent in the late 1800's. In the early 20th century, severe pollution from pulp and paper mills heavily impacted Pacific oyster (*Crassostrea gigas*) cultivation and may have had significant adverse effects on native oyster populations, especially in South Puget Sound. In Anacortes, WA, a restoration project began in Fidalgo Bay in 2002, a cooperative project between Skagit County Marine Resources Committee, Puget Sound Restoration Fund, Washington Department of Fish and Wildlife and other partners to establish several native oyster beds. Subsequent to successful planting of seed oysters in 2002 and again in 2003, 2004 and 2006, survival rate, growth and natural recruitment have been deemed high, and additional natural recruitment has been seen in Fidalgo Bay at areas outside the seed planting sites, with exceptionally high recruitment in 2015. In 2012 and 2013, "wide area" surveys of Fidalgo Bay were undertaken at nine areas in addition to yearly monitoring of the original trestle seeding site. The trestle area around the original seeding plots was extensively surveyed beyond normal yearly efforts and an additional eight sites in Fidalgo Bay were examined for native oysters and substrate composition. An additional two sites outside of Fidalgo Bay were also surveyed in 2014: 1) The southeast shore of Guemes Island (just north of Fidalgo Bay) was surveyed for the presence/absence of native oysters that may have originated from spawning in Fidalgo Bay; none were found. Similk Bay, about two miles south of Fidalgo Bay in Skagit Bay and a historical site for native oysters, was surveyed in 2014 for the presence/absence of native oysters in a derelict Pacific oyster bed; again, no native oysters were found. Shell cultch bags to monitor natural post-larval recruitment were deployed at 19 sites around Fidalgo Bay from 2011 through 2016. Results of sampling the recruitment bags indicate that annual recruitment is highly variable and that most recruitment takes place on the eastern side of the bay, likely due to local current patterns. In an effort to improve recruitment on the western side of the bay, Skagit MRC planted seed oysters in the northwestern corner of the bay (Cap Sante Marina area) in 2016. In 2013, a small test plot of native oysters was established on the eastern shore of Padilla Bay to assess survival and growth, which have been very good as of August 2016. An additional experiment to assess survival and growth was initiated in 2016 in newly restored marsh channels at Secret Harbor, Cypress Island, about five miles northwest of Fidalgo Bay. These oysters will be assessed for survival and growth in coming years. In 2013, Skagit MRC worked with Puget Sound Restoration Fund to deploy a total of 2.5 acres of new Pacific oyster substrate in four plots on the eastern shore of Fidalgo Bay. Monitoring from 2014 to 2016 has shown native oyster recruitment to be exceptionally high in these new plots. Since 2002, the estimated abundance of native oysters in Fidalgo Bay has steadily increased from about 50,000 oysters to about 4.8 million oysters in 2016.

Introduction

Native to the marine waters from Sitka, Alaska to Baja California, the native or Olympia oyster (*Ostrea lurida*) is found on the Pacific Coast of North America (Ricketts and Calvin 1968). Native tribes recognized the native oyster's significance and settled where they could harvest the oysters and other shellfish as food resources. The Skokomish Tribe knew them as Tusa'yad (Steele 1957). Native American exploitation of the native oyster began in the pre-colonial days, although starting in the 1850's, harvest and cultivation of the beds in Willapa Bay, Puget Sound and Hood Canal began and later included diking systems that were fairly elaborate (Steele 1957). During the California gold rush of the 1850's, oyster prospectors found sparse native oyster resources in California estuaries (Ingersoll 1881) and oyster laden schooners from Puget Sound and Willapa Bay soon filled the need, transporting native oysters south and garnering as much as a dollar per oyster. In the late 1800's and early 1900's, the commercial viability of the native oyster was seriously compromised due to overharvest and wholesale destruction of their reef-like habitats (PSAT 2003). Additionally, the operation of pulp and paper mills between the 1930's and 1950's created severe water quality problems for Pacific oyster (*Crassostrea gigas*) culture (Couch and Hassler 1989) and may have helped speed the demise of native oysters in some locations, especially in South Puget Sound (Cook et al. 1998, 2000, Baker 1995, Blake and Bradbury 2012). In the 1850's in Puget Sound, 10,000 bushels of native oysters were harvested and that number rose to 130,000 bushels by 1890. During the 1900's harvests declined, and by around 1980 effectively no harvest of wild native oysters was reported.

Olympia oysters are native to Puget Sound, unlike the Pacific oyster, which was imported from Japan, and is now found naturally in many areas (Suttles 1974). Additionally imported, although unintentionally, Japanese oyster drills (*Ocenebra japonica*) and other potential oyster predators and parasites were brought to Washington from Japan with the Pacific oysters (Robinette et al. 2004; Barsh et al. 2004, Blake and Bradbury 2012). Historic native oyster beds are reported to have existed in the North Puget Sound region in Boundary Bay (just north of the Canadian border), Drayton Harbor, Bellingham Bay, Chuckanut Bay, Orcas and Shaw Island areas, Fidalgo Bay, Similk Bay, Samish Bay, Padilla Bay, Dugalla Bay, Penn Cove (Blake and Bradbury 2012), and Guemes Island (from a report of Indians living on Guemes Island providing Spanish explorers with "verdigones") (Suttles 1974). Early Guemes Island Indians were reported to have harvested oysters as reported by Ashbach and Veal (1986) and additionally from a bay on the northeastern side of Whidbey Island (*Northwest Enterprise* 1884, *Skagit News* 1888, Townsend 1893, Hatch et al. 2005). In Samish Bay (*The Coast* 1907) and perhaps Bellingham Bay (Townsend 1893), quantities of native oysters were historically found but are very rare today (Cook et al. 1998, 2000; Baker 1995). Brady Blake (WDFW, pers. comm.) has indicated that there is solid evidence that there were as many 2,000 acres (with the possibility of substantially more) of native oyster beds in both Samish and Padilla Bays prior to their wholesale exploitation (PSRF 2012). In the early 1900's in Similk Bay, an attempt to raise native oysters was made but did not continue (*Anacortes American* 1906). In recent years an occasional native oyster has been identified from various North Puget Sound locations including Bellingham Bay, Cypress Island, (Stahl 1999), Drayton Harbor (Brady Blake, WDFW, pers. comm.), Samish Bay and Lopez Island (Betsy Peabody, Puget Sound Restoration Fund, pers. comm.). Native oysters are a small oyster, with maximum sizes being reported as 75 mm (Hertlein 1959) to 90 mm (Harbo 1997). They are much smaller than the Pacific oyster and are usually smaller than the Washington recreational size limit of 2.5" for oysters.

Native oysters and their beds are valuable to the local ecosystem. They provide three-dimensional habitat for many marine species, and oysters are filter feeders, feeding on phytoplankton and purifying the water, which helps to maintain water quality in the estuaries in which they are found.

If successfully restored, they may also provide future opportunities for harvest, offering both a recreational and tribal cultural resource (Gregory and Volety 2005, Luckenbach et al. 1999). In order to identify the current populations of native oysters in Puget Sound, to improve, manage and enhance the species and its population by natural and artificial means, and to investigate their genetic integrity, the Washington Department of Fish and Wildlife (WDFW) drafted a native oyster recovery plan in the late 1990's (Cook et al. 1998), although this plan was never implemented by WDFW. However, a consortium of government agencies, tribes, non-profit organizations, industry, academia and citizen volunteers has worked with WDFW to promote native oyster restoration efforts in Puget Sound during the last decade. In 2004 and 2005, in order to advance Puget Sound restoration projects, NOAA's Community Restoration Fund awarded restoration grants to the Puget Sound Restoration Fund (PSRF). Additional funds were awarded in 2010 to Northwest Straits Foundation (NSF) by the National Fish and Wildlife Foundation to increase restoration works in North Puget Sound. Approximately 12 million native oyster seed had been planted at 80 experimental and restoration sites throughout the Puget Sound region by 2010, thanks to the involvement in restoration efforts of over 100 groups, including tribes, private tideland owners, local organizations, shellfish farmers, public agencies, and business sponsors (Blake and Bradbury 2012).

The Skagit County Marine Resources Committee (Skagit MRC) worked with the Samish and Swinomish Tribes, PSRF, Taylor Shellfish Farms, Shell Puget Sound Refinery, the City of Anacortes and others in 2002 to plant native oyster seed at two locations in South Fidalgo Bay as part of North Puget Sound Restoration efforts (Robinette and Dinnel 2003, Barsh 2003). This signified the first native oyster restoration effort in the North Sound area other than several minute plantings on Orcas Island (Betsy Peabody, PSRF, pers. comm.). Since the initial seeding of native oysters in Fidalgo Bay in 2002, various other restoration efforts have ensued in the North Puget Sound Region using broodstock from the growing population in Fidalgo Bay. These efforts include: 1) Lone Tree Point and Kiket Island lagoons in Skagit and Similk Bays being managed by the Swinomish Tribe (Barber et al. 2013, 2015, 2016; Greiner et al. 2015), 2) Fisherman Bay on Lopez Island being managed by nonprofit organization Kwiaht (*The Islands' Weekly* 2013), 3) Discovery Bay, Jefferson County managed by WDFW and the Jefferson Marine Resources Committee (Lull 2010) and 4) Sequim Bay, Clallam County managed by the Clallam County Marine Resources Committee (Clallam MRC 2015).

In 2001, both Samish Bay and Fidalgo Bay were originally considered as planting sites and Fidalgo Bay was selected when it was found to be free of Japanese oyster drills that can negatively impact restoration efforts. The first seeding took place in 2002. In 2003 and 2004, further oyster seed were planted and growth and survival were monitored (Robinette et al. 2004, Barsh et al. 2004). In 2004, evidence was found of natural spawning when cultch shells deployed to catch spat showed post-larval recruitment (Dinnel et al. 2005) and this monitoring has continued. In 2006, Fidalgo Bay received a supplement of Pacific oyster shell to increase habitat, help in oyster bed building and encourage post-larval recruitment as well as additional seed (Dinnel et al. 2006, 2009a, 2009b). In 2010 through 2016, survival and growth of the native oysters were monitored, cultch shell bags and shell strings were assessed for natural recruitment, and four future oyster seed planting locations were assessed for suitability (Dinnel et al. 2011, Gabrian-Voorhees et al. 2013). This report covers restoration and monitoring activities carried out from 2013 through 2016 and includes expansion of our restoration work in Fidalgo Bay, Padilla Bay and Cypress Island.

Project Goals

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. 2000). Although never actually implemented by WDFW, 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 the 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.

In September 2010, participants in the third West Coast Native Oyster Workshop (NOAA/PSRF 2010) held at Suquamish, WA, discussed the current status of native oyster restoration on the West Coast and considered future restoration activities. One informal agreement was that, based on the apparent success of the Fidalgo Bay restoration effort, restoration activities should be extended to up to ten new sites around the North Puget Sound region over the next 10 years once the genetic status of the Fidalgo Bay stock has been determined.

In 2012, WDFW updated their 1998 native oyster plan to provide a document that summarized the history of the native oyster in Puget Sound and to provide guidance to the many groups now involved in restoration activities (Blake and Bradbury 2012). In that document WDFW identified 19 priority restoration sites in Puget Sound, with six of those sites being in the North Puget Sound sub-basin (Drayton Harbor, Bellingham Bay, [including Portage Island and Chuckanut Bay], Samish Bay, Padilla Bay, Fidalgo Bay and Similk Bay. In 2015, a consortium of groups published "A guide to Olympia oyster restoration and conservation" that described environmental conditions and sites that support sustainable populations of Olympia oysters throughout it's entire Pacific Coast range (Wasson et al. 2015). Wasson et al. (in press) have also described environmental factors that affect natural recruitment of oysters at 37 sites from southern California to British Columbia. Also in 2015, PSRF authored a new protocol using shell strings to standardize the monitoring of post-larval recruitment of native oysters throughout all of Puget Sound (PSRF 2015).

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 framework 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 any 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, including:

    - Conduct test seedings at promising sites
    - Monitor survival and growth of seedlings
    - Monitor and assess the spread of native oysters from natural spawning
    - Determine the best "bed structure" for each site, and
    - 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

Monitoring Trestle Restoration Plot B for Survival and Growth

Native oyster seed set on Pacific oyster shell cultch were planted at the south Fidalgo Bay trestle restoration site in three plots, A, B and C (Figs. 1-4) in 2002, 2003, 2004 and 2006 for an estimated total of 1,429,570 seed planted. Seed survival and growth, together with subsequent natural recruits, were monitored from fall 2002 through summer 2016 in Plot B and will continue in future years. In 2006 and 2008, non-seed bearing Pacific oyster shell were added to the site because evidence indicated that oyster larvae prefer to settle on oyster shell (White et al. 2009). Subsequent to the addition of non-seed bearing shell, 1/4 m^2 quadrat (1/10 m^2 in 2016) sampling (Fig. 5) has been used in Plot B to quantify oyster densities and sizes. In years prior to 2015, two samples were collected north of each of the 14 trestle pilings next to Plot B. In 2015 and 2016, only 14 samples were collected to minimize sampling related impacts to the plot. All live native oysters, clam shells, and oyster shells were counted within each quadrat sample. During Plot B monitoring, all live native oysters in each quadrat sample were measured, their sizes recorded and the oysters returned to Plot B.

Settlement Bags - Sampling to Assess Natural Recruitment within Fidalgo Bay

Bags of clean Pacific oyster shell cultch (Fig. 6) were deployed in the spring of 2007 to 2009 and 2011 to 2016 around Fidalgo Bay and at one location each in Padilla Bay and Guemes Channel close to Fidalgo Bay (Fig. 7) to monitor for larval oyster settlement and to try to discern the extent to which larvae may be distributed from spawning at the trestle restoration site or, in recent years, other areas in Fidalgo Bay. These bags were collected in the spring of the year following deployment and all shells in each bag were checked for juvenile oysters. All juvenile oysters found in the bags were measured for shell length.

Shell String Sampling

Shell string sampling was initiated by PSRF in 2015 as a way to standardize the Sound-wide collection of annual recruitment data (PSRF 2015). Shell strings consist of 11 Pacific oyster shells, with holes drilled in them, threaded on a 1 m-long wooden dowel (Fig. 6). The bottom shell serves as a platform to keep the other 10 shells from contacting bottom sediments. The top 10 shells are the settling substrate for oyster larvae. In June 2015 and 2016, duplicate sets of shell strings were deployed at the Fidalgo Bay trestle site alongside the usual three cultch bags used in the past to monitor natural recruitment. Deployment alongside the bags will gradually allow a comparison of these two methods.

In addition to the shell strings deployed at trestle Plot B, four additional strings were also deployed alongside cultch bags at four other locations in Fidalgo Bay in 2015 and 2016 to increase the amount of data available for a cultch bag:shell string comparison. For the strings deployed in June 2015, one set of shell strings at the trestle was collected in August 2015 (per PSRF's protocol) and the other set was collected in July 2016 along with the cultch bags. Shell strings and cultch bags were collected only once (July 2016) at the four additional sites. One string each of the three pairs of shell strings deployed at trestle Plot B in June 2016 were collected in August 2016; the other strings will be collected in 2017 along with the cultch bags. After collection, each of the shells comprising the shell strings were assessed for native oyster recruits and those found were measured for shell length.

"Wide Area" Sampling to Assess Natural Recruitment

In the summer of 2012, a "wide area" survey was undertaken at the trestle restoration site and five surrounding areas (Gabrian-Vorhees 2013). This was the largest assessment of the Fidalgo Bay area undertaken since the project began and was accomplished with the assistance of Skagit County Beach Watchers, Western Washington University staff, graduate and undergraduate students as well as many community volunteers. These surveys assessed the numbers of oyster shells, clam shells and live native oysters in systematically collected ¼ m^2 quadrat samples in and around the trestle restoration plot, the rip-rapped causeway, Weaverling Spit north of the causeway, and the outfall channel and delta of Crandall Spit lagoon (Fig. 8; Gabrian-Vorhees 2013). In 2013 and 2014, additional areas were also surveyed including: East Fidalgo Bay between the two old barge structures, from the trestle to the shell berm located south of the trestle, Weaverling Spit between the east end of the spit and the Samish Tribal RV Park, the west side of the bay between the old plywood mill site and the house about 1/2 mile south of the mill site, the southeast side of Guemes Island, and Similk Bay just west of the golf course (Fig. 2). Methods used at each of these areas surveyed in 2013 and 2014 are described below.

East Side of Fidalgo Bay Between the Two Old Barge Structures. The area between the old barges (Area 8, Fig. 8) was sampled along 25 transects (50 feet apart) running perpendicular to shore starting from the mid-tide line. Eight to eleven 1/4 m^2 quadrat samples were collected along each transect at 10 foot intervals (70 to 100 feet total distance, depending on depth of the mud). All live native oysters, oyster shells and clam shells were counted in each sample, and the oysters measured.

Southeast Side of Fidalgo Bay, From the Trestle, South to the Shell Berm. This was an area (Area 7, Fig. 8) of very low native oyster density and was surveyed by walking the area (about 700 x 100 m) and generally assessing the number of oysters in this area. Six 100 m long transects,

spaced about 400 m apart, were walked to observe the numbers of native oysters present. No quadrat samples were collected.

East End of Weaverling Spit to the Tribal RV Park. The area between the east end of Weaverling Spit and the Samish Tribal RV Park (Area 2, Fig. 8) was sampled along 25 transects (50 feet apart) running perpendicular to shore starting from the mid-tide line. Eleven 1/4 m^2 quadrat samples were collected along each transect at 10 foot intervals (100 feet total distance). All live native oysters, oyster shells and clam shells were counted in each sample, and the oysters measured.

Between the Old Plywood Mill Site and the First House to the South. This area (Area 1, Fig. 8) was sampled along 25 transects (50 feet apart) running perpendicular to shore starting from the mid-tide line. Seven to eleven 1/4 m^2 quadrat samples were collected along each transect at 10 foot intervals (60 to 100 feet total distance). All live native oysters, oyster shells and clam shells were counted in each sample, and the oysters measured.

Similk Bay, West of the Golf Course. In the early 1900's, native oysters were briefly cultured in Similk Bay (*Anacortes American* 1906; Fig. 2). We briefly surveyed the remnants of an old Pacific oyster bed in Similk Bay in 2014 to learn if any of the native oysters were still present. Ten haphazard 1/4 m^2 quadrat samples were collected in the old oyster bed (all old shell, no live oysters) at about a 0 foot tidal elevation.

Southeast Guemes Island. The reason for the survey on the SE side of Guemes Island was to assess the possibility that some native oyster larvae exported by tidal currents from Fidalgo Bay might have settled in this area. This area was surveyed in July 2014 for the presence/absence of native oysters at a low tide by walking an area of shoreline from the Guemes Island ferry dock eastward for approximately 1.25 miles (Fig. 2). The persons assessing this area looked for the presence of oysters on rocks or oyster or clam shells.

Cap Sante Marina Seed Plots

Extensive monitoring of native oysters since 2002 has shown that almost all natural recruitment is limited to the eastern side of Fidalgo Bay. This is likely due to current patterns that are chiefly north-south in nature and which do not facilitate larval transport from one side of the bay to the other (Eric Grossman, USGS, pers. comm.). Given the desirability of establishing a population on the west side of the bay to serve as another larval source, Skagit MRC approved a project to plant oyster seed in the Cap Sante Marina area of northwest Fidalgo Bay (Fig. 9). This effort was funded by the Skagit Restoration Initiative (SRI) and administered by the Northwest Straits Foundation (NWSF).

Bags of native oyster seed were produced by Puget Sound Restoration Fund (PSRF) at their Manchester, WA shellfish hatchery and transferred to the marina area. These bags of seed were then assessed for juvenile oyster density in the bags, measured and then spread at one location just inside the northern rock breakwater and one location at Seafarers' Park (Fig. 9). In addition, juvenile oysters from the 2015 batch of settlement bags (collected in June 2016) were added to this site to increase the number of native oysters in this area.

East Fidalgo Bay Shell Plots to Enhance Native Oyster Settlement

In 2012, the Northwest Straits Foundation, working in conjunction with Skagit MRC, retained PSRF to enhance the east side shoreline of Fidalgo Bay with at least 1/2 acre of Pacific oyster shell

to encourage the formation of several new native oyster beds. This work was funded using Skagit Restoration Initiative funds administered by the Northwest Straits Foundation. In November 2013, PSRF personnel completed the spreading of 250 $yards^3$ of oyster shell obtained from Blau Oyster Company on Samish Island. Four shell plots were established collectively covering about 10,000 m^2 (about 2.5 acres - see Fig. 10). PSRF personnel also sampled each plot for native oyster recruitment one year later in November 2014 to assess the magnitude oyster recruitment to the new shell beds (PSRF 2014). These plots were then assessed by volunteers for settlement and growth during the summers of 2015 and 2016.

East Padilla Bay Experimental Seed Plot

Brady Blake, Washington Department of Fish and Wildlife (WDFW), has indicated that there is solid evidence that there were as many 2,000 acres or more of native oyster beds in Padilla Bay prior to their wholesale exploitation (PSRF 2012). Based on this information, Skagit MRC, in collaboration with the Padilla Bay National Research Reserve, established a very small experimental plot of native seed oysters on the east side of the bay to assess their survival and growth in this location (Fig. 2). Twenty-five bags of seed oysters were supplied by the PSRF shellfish hatchery in 2013. Annual surveys, beginning in 2014, have assessed their survival and growth by haphazardly collecting cultch shells from this plot and counting and measuring the oysters present on a subsample of shells.

Cypress Island Experimental Seed Bags

Shell middens in Secret Harbor on the southeast side of Cypress Island (about 5 miles northwest of Fidalgo Bay, Fig. 2) have been found to contain native oyster shells up to a size of 70 mm, probably dating to pre-1870 (Maurice Major, WDNR, pers. comm. by way of Lisa Kaufman, NWSF). Secret Harbor has been the site of a recent shoreline restoration project to remove an old dike and restructure a marsh/channel habitat. The partners in this effort have been the Washington Department of Natural Resources and the Samish Tribe. Given the new channel habitats at this site, Skagit MRC initiated a small experimental study to see if native oysters would survive and grow in these newly created channels. Four bags of native oyster seed on Pacific oyster cultch were purchased from PSRF's Manchester hatchery and transported to Cypress Island in July 2016 for planting in three channel locations and in one location in the offshore intertidal area (Fig. 11). Two of these bags were equipped with HOBO® U24 salinity and temperature data loggers set to collect data every hour for the next year or more.

Results

Trestle Plot B Monitoring

Native Oyster Densities, 2002 Through 2016. Plot B oyster densities averaged about $45/m^2$ in 2002 and 2003, increased to $130/m^2$ in 2011 and decreased to $39/m^2$ in 2016 (Table 1, Fig. 12). The last addition of seed to Plot B was in 2006; thus, increases in oyster density from 2008 through 2011 is due to natural recruitment. The lower densities of oysters in Plot B since 2011 were possibly due to the deterioration of the Pacific oyster shells added in several previous years. There seems to be fewer cultch shells in the samples in recent years and the shells seem to be getting smaller and more eroded through time. Other possible reasons for the decreases in Plot B oyster densities could be natural mortality due to old age, reduced natural recruitment in this area, decreased cultch shell quality due to fouling organisms, and the possible impact of many years of sampling (walking on

the bed). In terms of total numbers of native oysters in Plot B, the population has ranged from an estimated 46,184 oysters in 2002 to a high of 130,520 oysters in 2011. Since 2011, the population has gradually decreased to about 46,586 oysters in 2016 (Table 1).

Oyster Sizes. Native oysters in Plot B have been measured for size when sampled yearly. After seeding in 2006, average shell length increased until the addition of small seed oysters in August 2005 (Fig. 13). Samples from Plot B from 2008 to 2011 showed a gradually aging population of oysters with signs of varying degrees of natural recruitment over the years. In 2016, the size of native oysters sampled in Plot B ranged from 8 to 66 mm shell length with about 57% of the total being identified as spat derived from the 2015 spawning (size range = 8-40 mm). Fluctuation in average size of native oysters at the trestle will most likely be the rule as new oysters are recruited via spawning and older oysters die.

Settlement Bags – Sampling to Assess Natural Recruitment Within Fidalgo Bay

In 2004, 2005 and 2007, clean Pacific oyster cultch shells in bags were hung along the length of the trestle next to the seed planting beds and were checked for natural recruitment of native oysters at the trestle site one year after deployment. A low density of natural recruitment was found in 2005 and 2007. From 2007 through 2016, bags of clean cultch shells were placed at the trestle and around Fidalgo Bay, as well as nearby locations at northwest March's Point and in Guemes Channel (Fig. 7). No native oysters were found in any bags in 2008 and 2009, indicating recruitment failures in 2007 and 2008. In 2010, the shell bags showed high natural recruitment, which was limited to south Fidalgo Bay. Minor natural recruitment was observed in the bags in 2012, 2013 and 2014, with substantial recruitment in 2015 and very high recruitment in 2016. See Table 2 for average annual recruitment at trestle Plot B and Table 3 for a detailed listing of recruitment at all sites for all years.

The bulk of natural native oyster recruitment has taken place at and near the original seeding plot at the trestle on the eastern side of the bay. The average recruitment in the three replicate cultch bags at trestle Plot B has ranged from a low of zero to a high of 428 oysters/100 cultch shells (Table 2). Only minor recruitment has occurred at cultch bag stations along the western side of the bay and at Crandall Spit near the northeast entrance to the bay. Recruitment has yet to be observed in bags deployed at northwest March's Point or in Guemes Channel (Table 3, Fig. 14).

Shell String Sampling

The three shell string samplers collected in August 2015 (deployed in June, 2.5 months earlier) from trestle Plot B had an average of 24.0 native oyster recruits per shell, with an average length of 7.6 mm (Table 4). The second set of trestle plot shell strings collected one year after deployment (June 2016) had an average of 9.5 oysters/shell, with an average length of 19.6 mm. The three cultch bags collected the same time at the trestle had a density of 5.4 oysters/shell with an average length of 23.0 mm (Table 3). Four other shell string-cultch bag combinations were also collected in June 2016 from areas along the east side of Fidalgo Bay. A comparison of all seven shell string:cultch bag combinations shows that both the average densities and oyster lengths were similar for the 2016 samples (Table 4). A regression analysis of the shell strings vs. the bags (Fig. 15) shows a fairly weak correlation coefficient of 0.6868, possibly due to the limited amount of data at this time. Additional shell string:bag comparison data will be collected in subsequent years.

The three shell string samplers collected in August 2016 (deployed in June, 2.5 months earlier) from trestle Plot B had an average of 0.9 native oyster recruits per shell, with an average length of 4.0

mm (Table 4). Settlement on the shell strings in August 2016 was only about 4% of that seen in August 2015.

"Wide Area" Sampling to Assess Natural Recruitment

The "wide area" sampling in 2012-13 resulted in collection of 1,726 1/4 m^2 quadrat samples in seven areas noted in Fig. 8, plus southeast Guemes Island and Similk Bay just east of the golf course. The results of these sampling efforts are discussed below and itemized by sample in Appendix 1 for the 2013 samples. Results of the 2012 sampling are recorded in Appendix Table 1 in Skagit MRC's Year Ten Report (Gabrian-Voorhees et al. 2013).

East Side of Fidalgo Bay Between the Two Old Barge Structures. A total of 26 1/4 m^2 samples were collected on the east side of Fidalgo Bay in an area between the two old barge structures covering 11,613 m^2 (Area 8, Fig. 8). The majority of the samples in this area contained no native oysters while about 32% of the 265 samples collected in this area contained 1-27 oysters per 1/4 m^2. The average native oyster density was 3.8/m^2, with a total estimated population of 44,129 oysters. Most oysters in this area were nestled in mud or attached to sparse clam or oyster shells (Table 5). A detailed listing of all sampling data for this site is recorded in Appendix 1.

Southeast Side of Fidalgo Bay, From the Trestle, South to the Shell Berm. An area covering about 18,500 m^2 southeast of the trestle (Area 7, Fig. 8) was surveyed by walking six transects to assess presence/absence of native oysters in this area. No quadrat samples were collected. With few exceptions, native oysters were very sparse in this area and most of those observed were nestled in mud. The exception to this was that we observed relatively high densities (10-50) of oysters settled in small pools scoured out by waves in front of about a dozen small to medium-sized boulders. The best estimate of oyster density in this area, based on the observed number of oysters along the six transects, was 0.02 oysters/m^2. The estimated oyster population in this area is 500 (includes oysters noted in the pools near rocks).

East End of Weaverling Spit to the Tribal RV Park. A total of 275 1/4 m^2 samples were collected on the northern edge of Weaverling Spit covering 11,613 m^2 (Area 2, Fig. 8). No oysters were found in the samples collected at this location although a few were observed within the sampled plot, but outside of the quadrat samples. Clam shells were present in low numbers, and oyster shell was very sparse (Table 5).

Between the Old Plywood Mill Site and the First House to the South. A total of 238 1/4 m^2 samples were collected in this area covering 9,870 m^2 (Area 1, Fig. 8). No oysters were found in the samples collected at this location nor were any observed in the general area. Clam shells were present in low numbers, and oyster shell was very sparse (Table 5).

Similk Bay, West of the Golf Course. Ten haphazard 1/4 m^2 quadrat samples were collected in an area of an old derelict Pacific oyster bed (all dead shells now). The samples were collected in an area of roughly 600 m^2 (20 x 30 m). No native oysters were found in these samples. The old, barnacle covered oyster shell density was about 34/m^2 (Table 5).

Southeast Guemes Island, East of the Ferry Landing. An area covering about 60,000 m^2 on the southeast shoreline of Guemes Island was surveyed to assess presence/absence of native oysters in this area in July 2014. The area was walked in a haphazard manner while looking for native oysters on rocks and some sparsely occurring clam shells. No quadrat samples were collected. No native oysters were found in this area.

Cap Sante Marina Seed Plots

Puget Sound Restoration Fund delivered 24 bags of native oyster seed, set on Pacific oyster shell in their Manchester, WA laboratory, to Seafarers Memorial Park in Anacortes in March 2016. Sampling of these bags determined an estimated density of 54 oysters/bag, for a total of about 1,300 seed with an average shell length of 4.1 mm. These seed were spread in a Seafarers Memorial Park intertidal area in May 2016 (Area 2 in Fig. 9). Because the density of seed in these bags was substantially less than anticipated (target was 300 seed/bag), an additional 3,830 juvenile oysters recovered from our 2015-2016 cultch monitoring bags were also added to this area. The average size of these oysters was 20 mm.

A second batch of 10 bags of Manchester laboratory seed were obtained in June 2016 and spread inside the northern Cap Sante Marina breakwater (Area 1, Fig. 9). These bags were estimated to contain about 660 seed each, for a total of about 6,600 seed. The average size of these seed was 7.5 mm. Survival and growth of the oysters planted in both areas of the marina will monitored in future years along with searching for signs of successful spawning and natural recruitment on the western side of Fidalgo Bay.

East Fidalgo Bay Shell Plots to Enhance Native Oyster Settlement

In 2012, PSRF was tasked with deploying at least 1/2 acre of Pacific oyster shell on the east side of Fidalgo Bay. They exceeded that amount by putting out about 2.5 acres of shell in four locations (Fig. 10). Their assessment of native oyster recruits in the shell plots one year later (November 2014) showed that oysters had settled on the shell following the 2014 spawning season, and that the average density in the four plots at that time was about 60 juvenile oysters/m^2, with an average size of about 9 mm (PSRF 2014). Assessments in the summers of 2015 and 2016 found average plot densities to have substantially increased to 200 and 435 oysters/m^2, respectively. Settlement appeared to be unequal in the four plots, ranging from 6 to 90 oysters/m^2 in 2014, 50 to 397/m^2 in 2015 and 230 to 680 oysters/m^2 in 2016 (Table 6). The highest densities of oysters were consistently in the north and south shell plots, possibly due to current patterns on the east side of the bay. In June, 2016, the shell beds appeared to still be quite healthy, with a large amount of exposed shell (Fig. 16), and the amount of settlement in the beds was very impressive (Table 6, Fig. 17 and 18).

In November 2014, the average size of shell plot oysters was about 9 mm, which was the result of the 2014 summer spawning season. In July 2015, the average size was about 23 mm and was a mix of the 2014 cohort (average ~30 mm) and recent settlement of the 2015 cohort (average ~5-8 mm). In June 2016, the average size of the 2014 cohort was about 40-45 mm, the size of the 2015 cohort about 20-25 mm, with a few of the new 2016 cohort at a size of 5-8 mm (Fig. 19).

Estimated Numbers of Native Oysters in Fidalgo Bay

The yearly total number of live native oysters in Fidalgo Bay was estimated using results of the various sampling programs including: 1) routine monitoring of trestle Plot B, 2) the "wide area" surveys in 2012 and 2013, 3) sampling of the shell enhancement plots deployed in 2013 and 4) magnitude of annual post-larval recruitment from the cultch bag monitoring. The estimated number of oysters for the first few years after seeding (2002-2004) were in the 40,000 to 50,000 range and basically reflected the number of seed oysters that had survived. The numbers then gradually increased from 2005 to 2013 when the estimate was 240,000. The number of oysters then increased

dramatically from 2014 to 2016 with an estimate of 4.8 million, the recent large increases being due to heavy settlement in the new shell enhancement plots (Table 7).

East Padilla Bay Experimental Seed Plot

The east Padilla Bay experimental seed plot (Fig. 2) established in the summer of 2013 was monitored annually for survival and growth from 2014 to 2016. In 2014, we were surprised to find that 75% of the oysters present were Pacific oysters. Discussions with PSRF hatchery personnel led to the source of the Pacific oyster presence - the native oysters had been "set" in the hatchery, but then the bags of seed were moved to Hood Canal waters for temporary storage where a natural set of Pacific larvae settled on the cultch shell in the bags.

Our annual assessments of the shell plot have shown that native oysters ranged in density from 0.4 to 0.8 oysters/cultch shell, while Pacific oyster densities ranged from 1.78 to 0.2 oysters/cultch shell (Table 8). Average sizes of the native oysters ranged from 24.9 to 42.9 mm, while the Pacific oysters ranged in size from 27.4 to 101.0 mm (Table 7). Size-frequency graphs (Figs. 20 and 21) clearly show that growth of both native and Pacific oysters has been excellent in this location over the last three years.

Cypress Island Experimental Seed Bags

Four bags of native oyster seed obtained from PSRF's Manchester Shellfish Hatchery were planted in the channels at WDNR's newly restored marsh at Secret Harbor, SE Cypress Island (Fig. 11). The approximate tidal elevations of the bags was +4', 5', 6' and 7', with the lowest bag being the one in the outside channel. A census of one of the bags indicated that the density of the seed was about 4.5 seed per cultch shell with an average shell length of 7.5 mm in early June 2016. Two HOBO® salinity and temperature data loggers set to collect data every hour for the next year or more were also deployed (attached to two of the oyster bags). These bags and data recorders will be monitored yearly for the next 1-3 years.

Volunteer Hours

A total of thirty-five volunteers participated in Fidalgo Bay, Padilla Bay, Similk Bay, southeast Guemes Island and Cypress Island native oyster restoration planning, monitoring and report preparation from March 2013 through August 2016. The total estimated time spent by volunteers during this time was 370 hours. This included the following activities: planning meetings and communications with Puget Sound Restoration Fund; tribal biologists and WDFW personnel; application for Scientific Collection and Transfer permits; driving to the Manchester Shellfish Laboratory to pick up seed oysters; filling, deploying and retrieving cultch shell bags and shell strings to monitor natural recruitment; annual monitoring of trestle Plot B; “wide area” sampling in summer 2013 (including Similk Bay and Guemes Islands surveys); monitoring at the Padilla Bay experimental seed plot; establishment of two seed plots at Cap Sante Marina/Seafarers Memorial Park in Fidalgo Bay; deployment of experimental oyster seed bags and temperature and salinity recording devices at Secret Harbor on Cypress Island; oyster presentations to the 2016 Salish Sea Stewards class and Whatcom MRC; data entry and analyses; and preparation of proposals, quarterly reports and this report covering the last four years of oyster-related activities.

Discussion

Skagit MRC committed to reestablishing native oysters in Fidalgo Bay in 2002 with the first addition of hatchery-produced seed to the trestle area in the southern portion of the bay. Over the course of four years, the total number of seed added to the bay was about 1.5 million. Since 2006, the number of oysters has gradually grown to approximately 4.8 million oysters (Table 7), thanks in large part to the deployment of 250 yd^3 of Pacific oyster shell in 2013, which now covers an area of 2.5 acres (split between four plots) on the eastern shore of the bay.

Since the beginning of our seeding efforts, we have continually monitored one of the trestle seed plots (Plot B), which is situated in a shallow pool area at low tide. The number of native oysters in Plot B started at about 46,000 and gradually grew to about 130,000 in 2011, only to shrink to about 39,000 in 2016 (Table 1). The primary reasons for the decrease in the number of oysters seems to be the loss of shell substrate due to shell erosion and fragmentation and competition for settlement space from sponges, bryozoans and barnacles. The lesson here seems to be, that while the pool area keeps the oysters protected by buffering high and low temperatures, this advantage seems minimal due to the factors noted above. The four new shell plots established north of the trestle in 2013 are higher and drier than Plot B - it will be interesting to follow their progression through time and compare with the results of Plot B.

The use of shell cultch bags to monitor native oyster post-larval recruitment has proven to be very successful in providing information on temporal and spatial settlement patterns. Natural oyster settlement was zero to minimal in Fidalgo Bay from 2005 to 2009, followed by a very strong settlement in 2010, as indicated by the recruitment bags collected in 2011. Following 2010, settlement was again minimal until 2014 and 2015, with the 2015 set being exceptionally high (Table 2).

Annual recruitment of invertebrate broadcast spawner species often tends to be highly variable, and this is no exception for the native oyster. Wasson et al. (2015), who has summarized annual native oyster recruitment patterns in 28 West Coast embayments, found that 14 of the 28 bays had occasional years without any settlement (including Fidalgo Bay) and six bays had routine recruitment failure. The causes of these failures are likely due to various reasons including: 1) bay size and configuration, 2) current patterns within and outside of the bay, 3) water temperatures and salinities, 4) abundance of food resources (algae) and 5) oyster population size. Given the dramatic increase in the numbers of native oysters in Fidalgo Bay in the last several years (about 20 times higher in 2016 compared to 2013; Table 7), it will be interesting to see if permanent bed structures will be maintained and expanded.

Spatial patterns of settlement in Fidalgo Bay have been nicely defined by annual deployment of cultch monitoring bags at 17 locations around the bay and at two locations just outside of the bay entrance. Results of the cultch bag sampling from 2008 to 2016 strongly indicate that most larvae are retained inside the bay and that settlement has almost exclusively been limited to the east side of the bay, with the focal point being the trestle and causeway area (Fig. 14). Few oyster larvae are making their way to the west side of the bay due to largely north-south flowing currents during the summer on each side of the bay with little mixing between them (Eric Grossman, USGS, pers. comm.). The observation that most larvae are being retained within Fidalgo Bay is reinforced by the total lack of juvenile oysters in the east March's Point and Guemes Channel shell cultch bags (Fig. 14) and the lack of any settlement on southeast Guemes Island. We hypothesize that the oyster settlement pattern will change in the future due to two factors: 1) many more spawning oysters now inhabit the bay and 2) the placement of seed oysters at Cap Sante marina in the

northwest portion of the bay in 2016. These seed oysters should help to export larvae into the north/south flowing current on the west side of the bay.

The four new Pacific oyster shell plots established on the eastern side of the bay by PSRF in 2013 have acted as magnets for native oyster larvae, resulting in an average of 435 oysters/m^2, which is more than four times the density (100 oysters/m^2) considered by WDFW to constitute a successful native oyster bed. So far, these new shell plots have maintained their structural integrity even though they are located in fairly silty areas. It will be interesting to follow the evolution of these plots in terms of functional structure as well as continued settlement to see if they successfully produce long-term native oyster beds. The initial success of these plots suggest that it is time to deploy additional shell plots on the west side of the bay where both shell habitat and oyster settlement have been virtually absent. Two possible locations on the west side for future shell deployment is the north side of Weaverling Spit and the area at and south of the newly restored shoreline at the old Plywood Mill site. These areas have the added advantage of fairly firm sand or silty-sand substrates and small amounts of existing shells (mostly clam) that seem to stay put.

The small experimental seed plot established in Padilla Bay in 2013 is doing well in terms of native oyster survival and growth, although we did find that about 10% of the dead native oysters in that plot had been drilled by the invasive Japanese oyster drill, *Ocinebrellus inornatus*. However, the mortality caused by *O. inoratus* has so far not invalidated the possible future expansion of seeding activities in Padilla Bay, although any future expansion will have to be thoroughly discussed by WDFW and the Padilla Bay National Estuarine Research Reserve.

We did not find any native oysters in Similk Bay (part of Skagit Bay) despite the fact that they were cultured here in the early 1900's (*Anacortes American* 1906). Similk Bay has a firm intertidal substrate and a remnant Pacific oyster shell bed that might facilitate native oyster restoration activities in this area. The Swinomish Tribe would be the lead on any efforts in this location since the Tribe now owns some of these tidelands.

Project Media Coverage

An article about the recovery of native oysters in Fidalgo Bay was written by Kimberly Cauvel, Environmental Reporter, for the Skagit Valley Herald on September 4, 2016. The internet link to this article is: http://skagit.ws/2bRaaSr

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Table 1. Estimated density and number of live native oysters in trestle Plot B based on 1/4m^2 quadrat samples collected 2002 through 2016.

Month/Year	Oysters/m^2	Total Live in Plot B
May 2002	46.0	46,184
April 2003	43.6	43,774
May 2004*		
April 2005*		
August 2006*		
May 2007*		
June 2008	84.4	84,738
May 2009	91.6	91,966
July 2010	110.8	111,243
June 2011	130.0	130,520
July 2012	112.4	112,850
July 2013	32.3	32,429
June 2014	46.4	46,586
May 2015	42.6	42,770
May 2016**	38.6	38,754

*No measurements made on a density/m^2 basis in these years.

** Collected 1/10 m^2 samples & converted to 1/4 m^2.

Table 2. Average number of native oyster recruits found in the three cultch shell bags deployed at trestle Plot B from 2005 to 2016.

Year	Oysters/100 cultch shells
2005	46.5
2006	0.0
2007	4.6
2008	0.0
2009	0.0
2010	266.4
2011	NS
2012	5.8
2013	18.3
2014	5.8
2015	93.2
2016	428.4

NS = Not sampled

Table 3. Summary table of all cultch bag monitoring data (recruits/100 cultch shells) from 19 stations in and around Fidalgo Bay, 2005-2016.

Year	NE March's Point	Crandall Spit	North Barge	South Barge	Plot B West	Plot B Middle	Plot B East	SE of Trestle	South Shell Berm	Causeway South	Causeway North	Weaverling Spit	Samish RV Park	South of Plywood Mill	Fidalgo Marina	Anacortes Marina	Seafarers Park	Cap Sante	Guemes Channel
2005	NS	NS	NS	NS	10.7	66.7	62.1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2006	NS	NS	NS	NS	0.0	0.0	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2007	NS	NS	NS	NS	13.8	0.0	0.0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	31.7	Lost	283.0	166.0	290.6	342.7	344.7	Lost	109.8	35.7	0.0	2.3	5.7	NS	NS	Lost	0.0	0.0
2011	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2012	Lost	Lost	29.1	21.7	2.6	1.2	13.6	5.9	Lost	3.9	4.3	1.2	1.2	0.0	Lost	Lost	4.5	0.0	0.0
2013	0.0	5.2	61.8	69.2	22.0	14.3	18.5	37.0	Lost	42.7	30.2	0.0	1.9	1.5	1.9	Lost	0.0	0.0	0.0
2014	0.0	Lost	Lost	Lost	2.6	1.2	13.6	5.9	Lost	83.0	66.0	12.7	0.0	2.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	Lost	132.0	66.2	69.4	87.5	122.7	105.2	Lost	161.1	191.2	18.4	1.6	1.8	0.0	0.0	1.4	1.2	0.0
2016	0.0	Lost	660.0	398.1	605.0	451.2	229.0	1234.0	61.4	611.1	609.1	128.9	Lost	0.0	Lost	10.6	0.0	0.0	0.0
Ave. =	0.0	9.2	147.2	119.7	81.1	83.0	72.9	216.6	20.5	126.5	117.1	20.2	1.0	1.4	0.4	2.1	0.8	0.2	0.0

NS = Not sampled

Table 4. Comparison of shell strings and cultch bag settlement densities (oysters/shell). Bags and shell strings were collected at the same time in June 2016, one year after deployment. The values are average number of native oysters/cultch shell.

Location	August 2015 Shell String	June 2016 Shell String	June 2016 Cultch Bag	August 2016 Shell String
Plot B, East	20.4	11.6	5.6	0.4
Plot B, Middle	21.7	9.0	4.5	2.1
Plot B, West	29.9	8.0	6.1	0.3
North Shell Plot	NS	6.2	5.8	NS
North-Middle Shell Plot	NS	3.3	3.0	NS
Southeast of Trestle	NS	16.7	12.3	NS
Causeway, North Side	NS	5.0	6.1	NS
Average density	24.0	8.5	6.2	0.9
Standard deviation	5.2	4.5	2.9	1.0
Average shell length (mm)	7.6	19.6	23.0	4.0

NS = Not sampled

Table 5. Summary table of "wide area" native oyster surveys in Fidalgo Bay, summers of 2012 and 2013. The numbers in parentheses refer to the location number in Figure 8.

Plot Location	Area of Survey Location (m^2)	Total # of Samples (1/4 m^2)	Average # of Clam Shells/m^2	Average # of Oyster shells/m^2	Average # of Native Oysters/m^2	Estimated Total # of Native Oysters in Plot
Crandall Spit Lagoon Outlet (9)	650	70	45.1	0.4	0.2	130
East Fidalgo Bay (between two derelict barges) (8)	11,613	265	14.0	0.4	3.8	44,129
Trestle (6)	7,781	698	85.9	12.3	20.4	158,732
Rip-rapped Causeway (north side) (4)	1,449	79	32.3	14.5	1.7	2,463
Rip-rapped Causeway (south side) (5)	1,115	61	69.1	6.8	3.5	3,902
South Weaverling Spit (3)	372	40	40.2	0.5	0.0	0
North Weaverling Spit(2)	11,613	275	14.0	0.0	0.0	0*
Between Plywood Mill and House to South (1)	9,870	238	13.7	0.0	0.0	0
Similk Bay, East of the Golf Course	600	10	0.0	33.6	0.0	0
Southeast of Trestle, South to the Shell Berm (7)	18,500	**	NS	NS	0.02	500[#]
Shore of Guemes Island, East of Ferry Landing	60,360	&	NS	NS	0.0	0.0

*No native oysters were found in the 275 quadrat samples but a few were observed in the vicinity. Total = 209,856

**Six walking transects, oyster density estimated.

[&] Presence/absence survey only.

[#]Includes an estimate of oysters found in isolated pools.

Table 6. Densities and total numbers of native oysters by month and year for the four east side shell plots.

	Density (oysters/m^2)			
Month/Year	North (1)	North Middle (2)	South Middle (3)	South (4)
November 2014	89.6	6.4	67.2	80.0
July 2015	284.8	49.6	68.8	396.8
July 2016	680.0	307.2	230.4	526.4
Plot size (m^2)	2,080	2,121	1,939	3,945

	Total Number of Oysters				Total in
Month/Year	North (1)	North Middle (2)	South Middle (3)	South (4)	All Plots
November 2014	186,368	13,574	130,301	315,600	645,843
July 2015	592,384	105,202	133,403	1,565,376	2,396,365
July 2016	1,414,400	651,571	446,746	2,076,648	4,589,365

Table 7. Estimated number of all native oysters in Fidalgo Bay by year.

Year	Number of Oysters
2002	50,000
2003	45,000
2004	40,000
2005	90,000
2006	80,000
2007	100,000
2008	90,000
2009	80,000
2010	140,000
2011	140,000
2012	160,000
2013	240,000
2014	850,000
2015	2,600,000
2016	4,800,000

Table 8. Summary of native and Pacific oyster average densities and sizes in the East Padilla Bay experimental seed plot, 2014-2016.

	Native Oysters		Pacific Oysters	
Year	Average # Natives/Shell	Average Size, mm	Average # Pacifics/Shell	Average Size, mm
2014	0.40	24.9	1.78	27.4
2015	0.46	31.9	1.34	42.0
2016	0.80	42.9	0.20	101.0

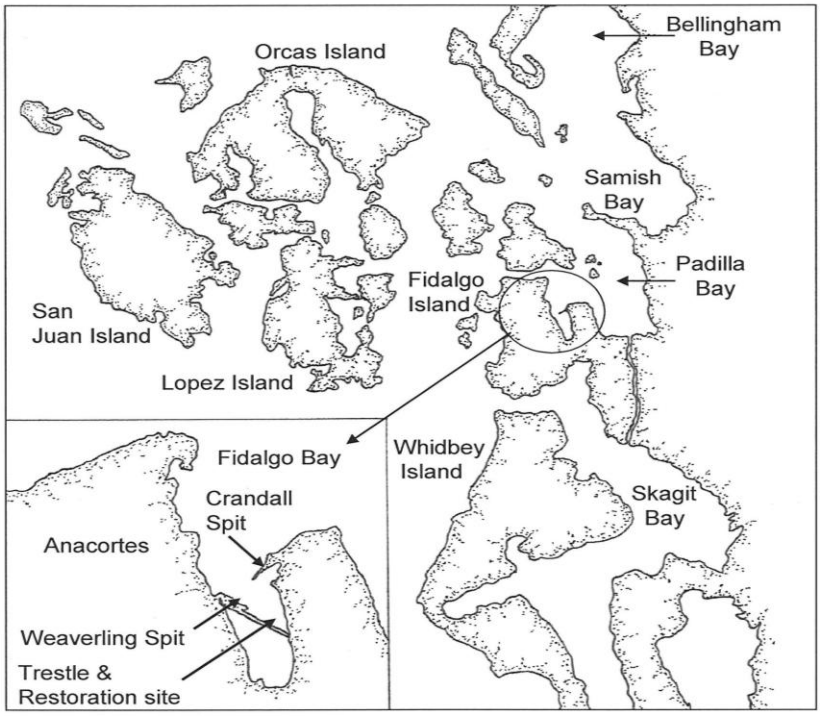

Figure 1. Map of North Puget Sound showing the location of Fidalgo Bay. Figure from Dinnel et al. 2009b.

Figure 2. Map showing the locations of Skagit MRC native oyster operations, in and around Fidalgo Bay, 2002-2016. Photo source: Google Earth.

Figure 3. Location of the trestle native oyster restoration site (circle) in South Fidalgo Bay. Photo source: WDOE online Shoreline photo collection.

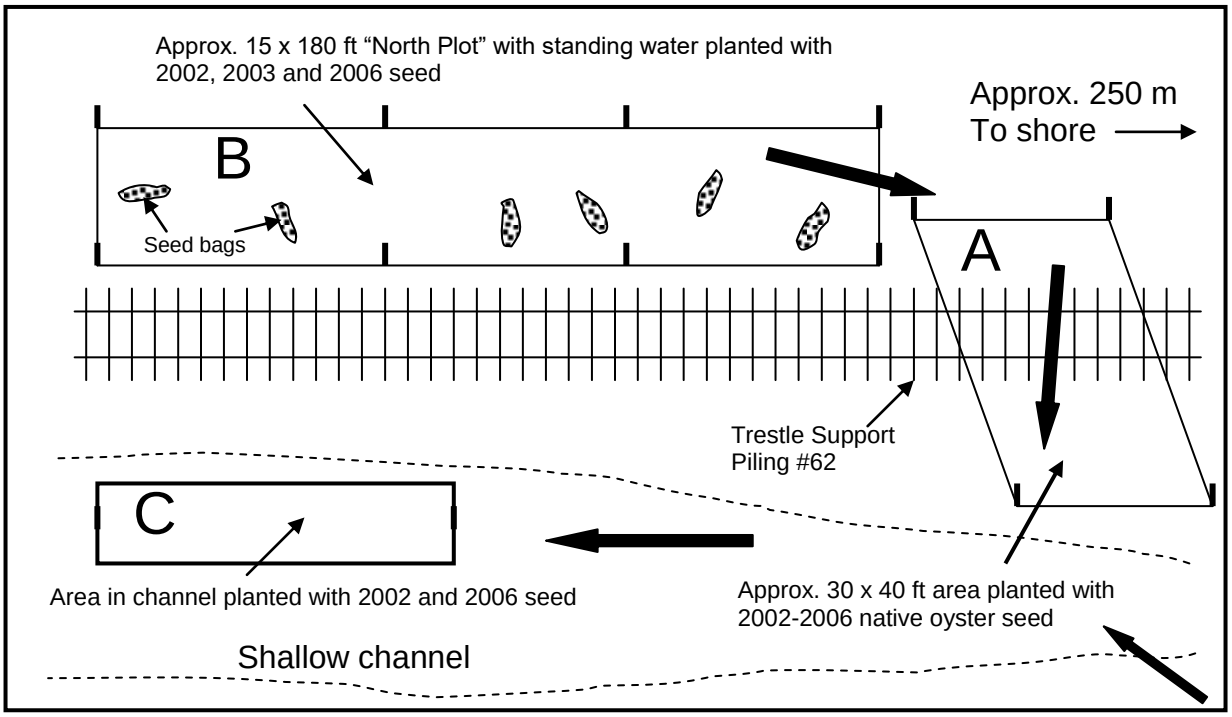

Figure 4. Trestle site plan showing the seeding locations at Plots A, B and C. Large arrows show the directions of water drainage at low tide. Map derived from a drawing by Robert Knowles.

Figure 5. Example of the ¼ m^2 quadrat used to sample native oysters, clam shells and oyster shells during trestle Plot B and "wide area" sampling. Smaller size quadrats have also been used.

Figure 6. Photograph of a new shell string sampler for sampling native oyster natural recruitment. The sampler is next to a cultch bag, which has been used in Fidalgo Bay since 2005.

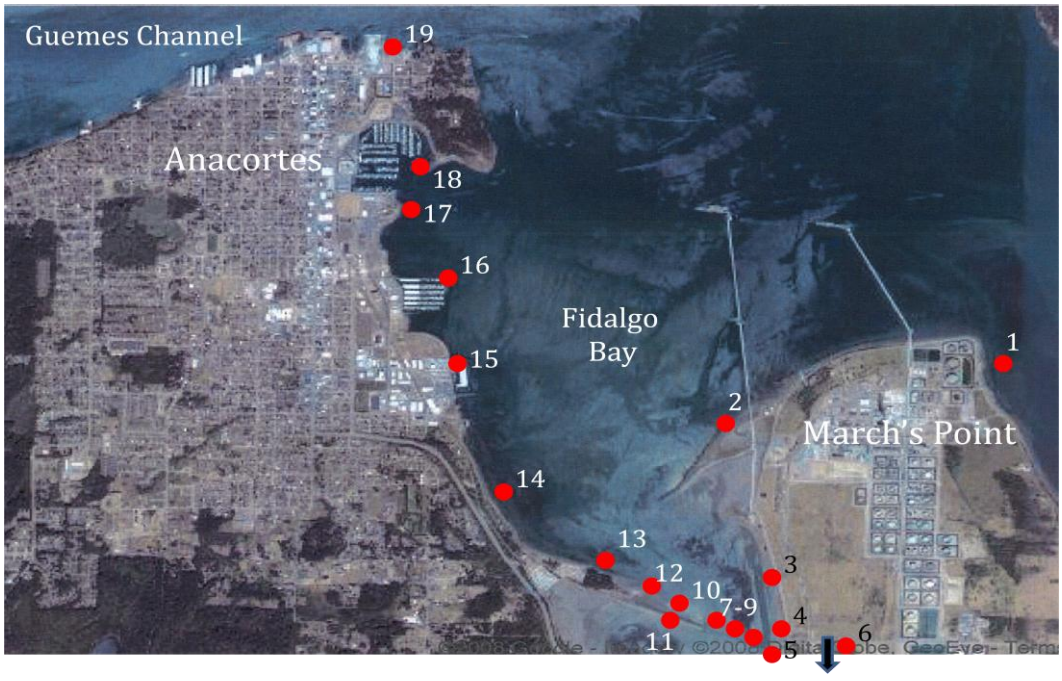

Figure 7. Photograph of Fidalgo Bay showing the locations where larval settlement cultch bags were typically deployed on an annual basis, 2011 to 2016. Station 6 was at the west end of the south Fidalgo Bay shell berm several hundered meters south of the trestle. Photo source: Google Earth

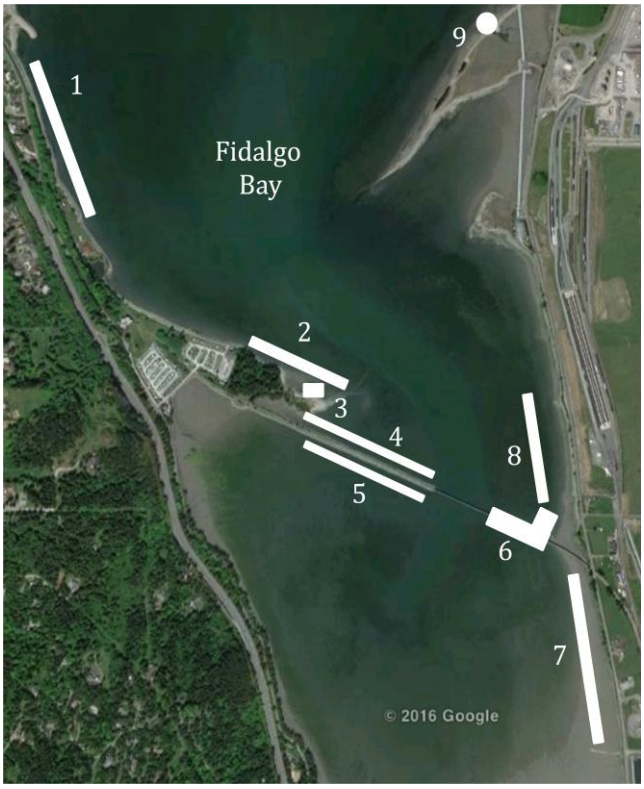

Figure 8. Map of south Fidalgo Bay showing the areas included in the 2012-2013 "wide area" sampling for native oysters and clam/oyster shell substrate. See Table 5 for location descriptions. Photo source: Google Earth.

Figure 9. Photograph of Cap Sante Marina (top) and Seafarers Memorial Park (bottom) areas of NW Fidalgo Bay where two new native oyster seed plots were established in 2016. Photo source: Google Earth.

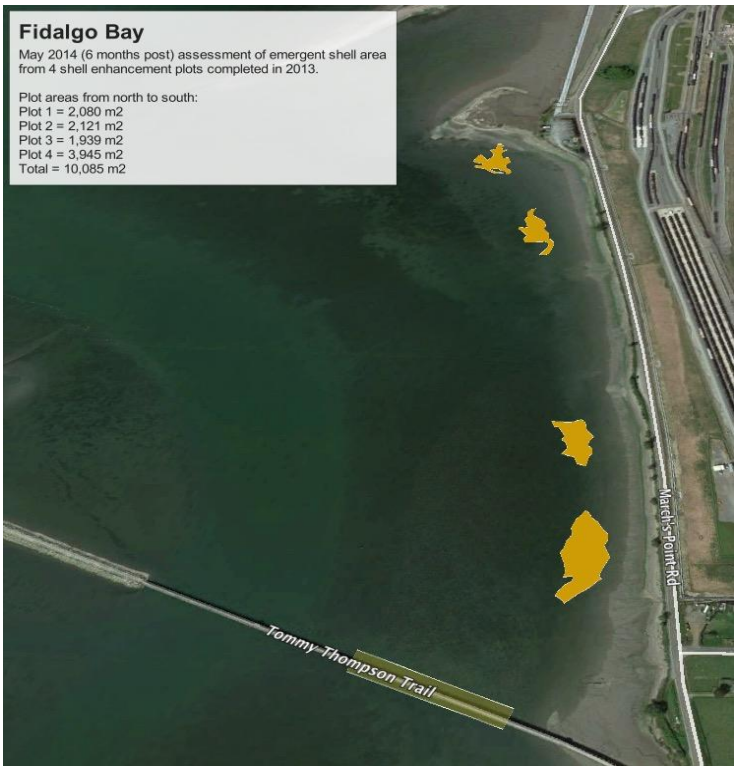

Figure 10. Locations of the shell enhancement plots on the east Fidalgo Bay shoreline established by Puget Sound Restoration Fund in November 2013. Figure from Brian Allen, PSRF.

Figure 11. Photograph of the Washington Department of Natural Resources newly restored saltwater marsh at Secret Harbor on SE Cypress Island and locations (white circles) of Skagit MRC's experimental seed bags and data loggers. Photo source: Goggle Earth.

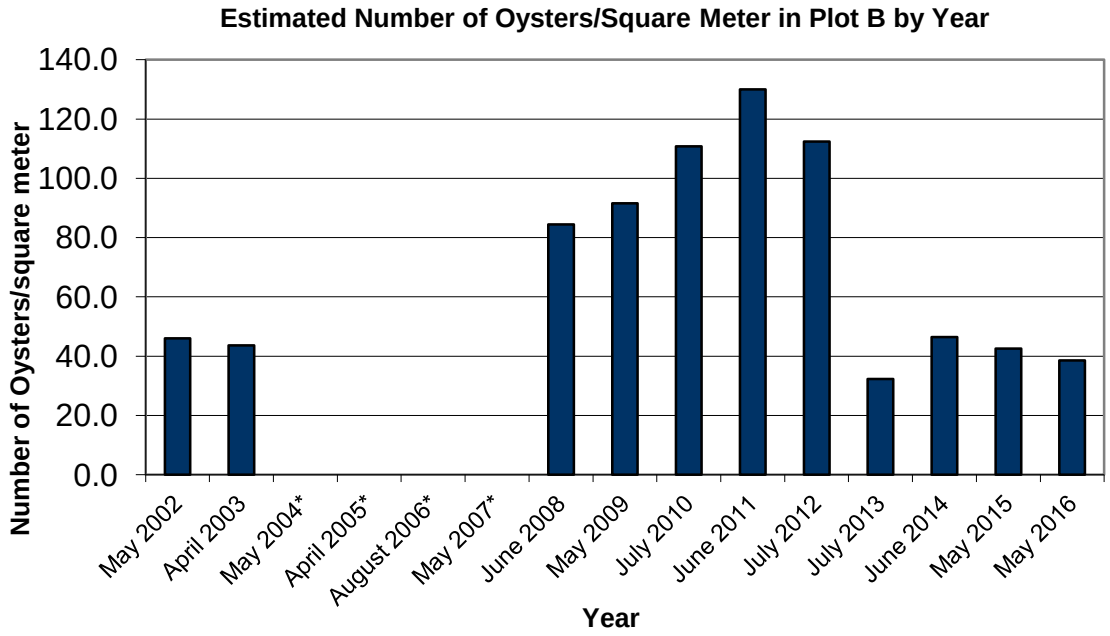

Figure 12. Estimated number of native oysters/m^2 in trestle restoration Plot B, 2002-2012. Sampling designed to estimate the number of oysters/m^2 was not conducted in 2004-2007.

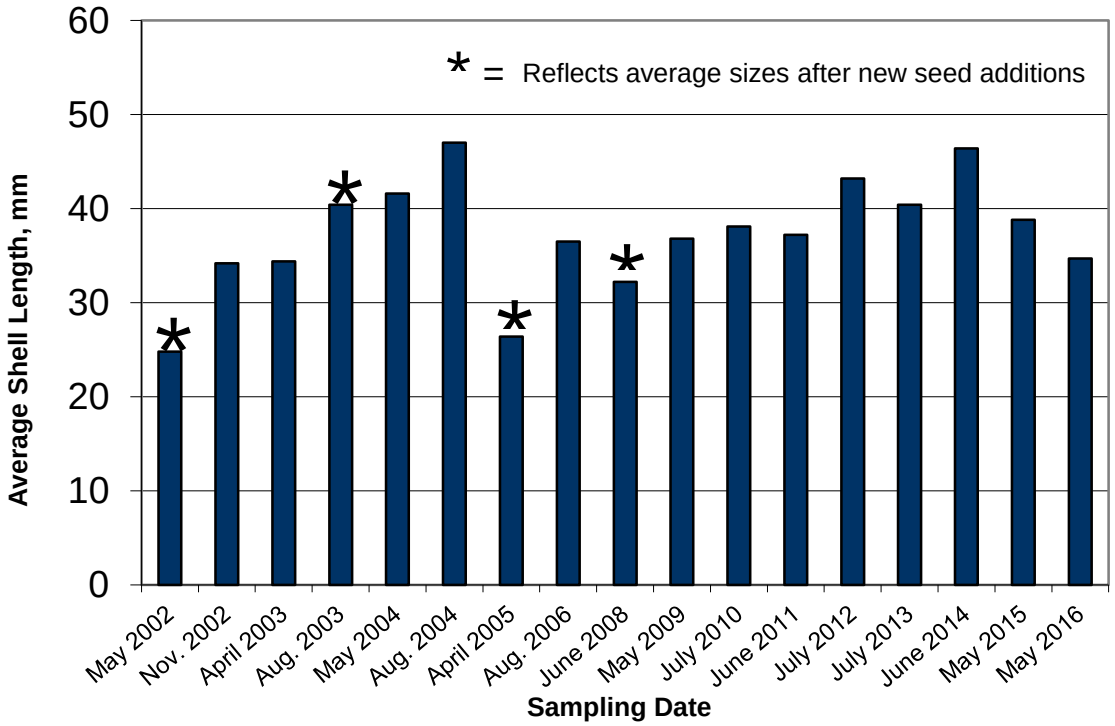

Figure 13. Average native oyster shell length by sample date for oysters sampled at the trestle restoration Plot B from May 2002 to July 2012.

Figure 14. Average number of native oyster natural recruits/100 cultch shells found in all of the annual monitoring cultch bags by location in and around Fidalgo Bay from 2011 through 2016. Number of bags sampled at each location ranged from 3 to 11 with an average of 7.4. Two locations had zero settlement while the other sites ranged from 0.2 to 216 recruits/100 cultch shells. The size of the dots on the map indicate the following average recruitment values (from small to large): 0.1-10, 10.1-50, 50.1-100, 100.1-200, and >200 recruits/100 cultch shells.

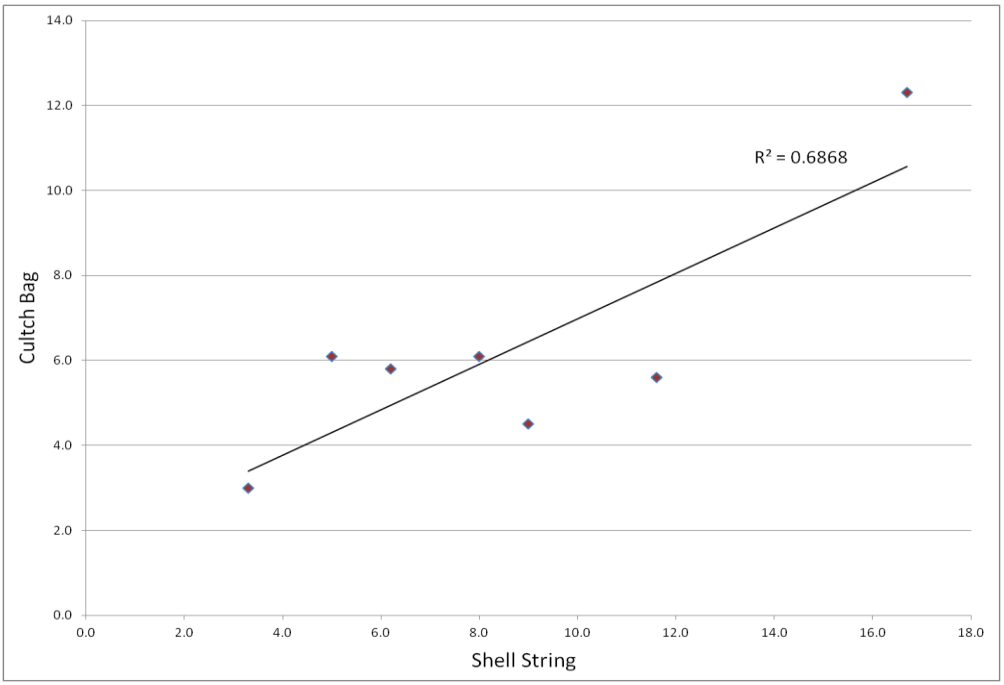

Figure 15. Regression of the density of native oyster natural recruits in cultch bags and shell string samplers, June 2016, for seven paired samples.

Figure 16. Photograph in 2016 of the southern shell enhancement plot established along the east side of Fidalgo Bay by PSRF in November 2013. A cultch shell monitoring bag is in the foreground.

Figure 17. Example of the heavy native oyster natural recruitment on one of the shell enhancement plots observed in 2016. The recruits are a mix of oysters that settled in the summers of 2014 and 2015.

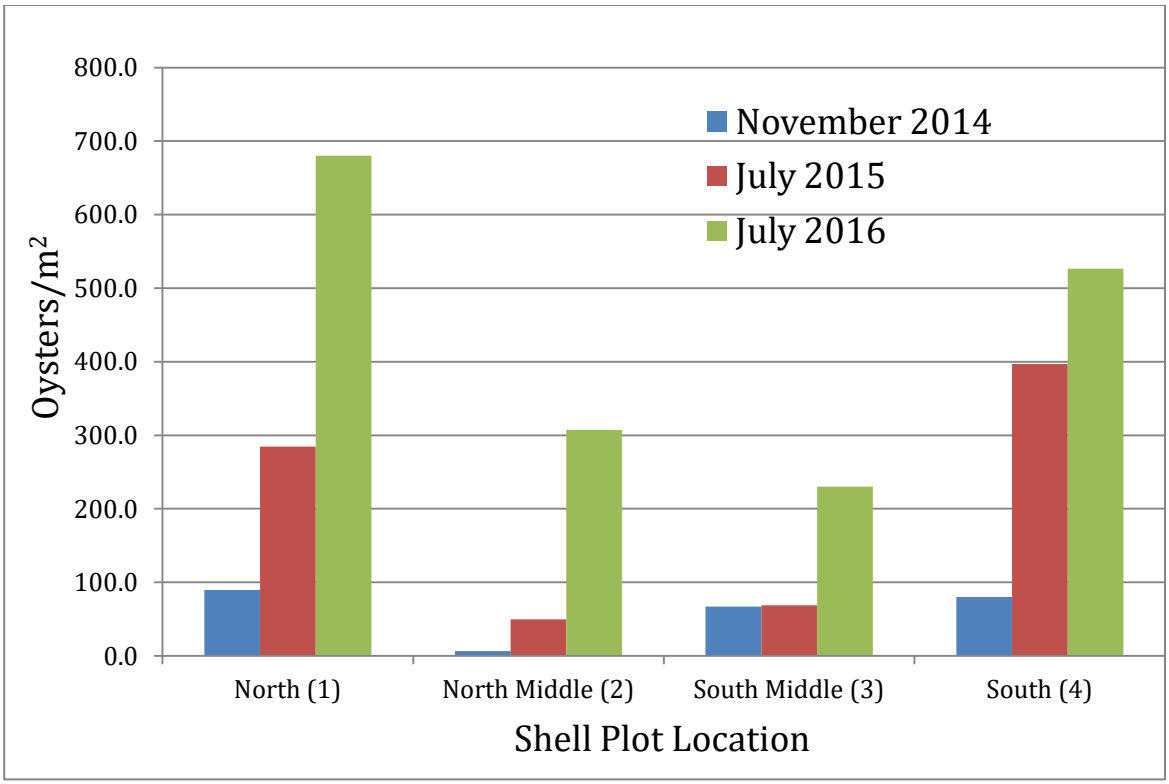

Figure 18. Graph showing increasing density of native oysters following three years of larval recruitment to the east Fidalgo Bay shell plots constructed in November 2013 by PSRF.

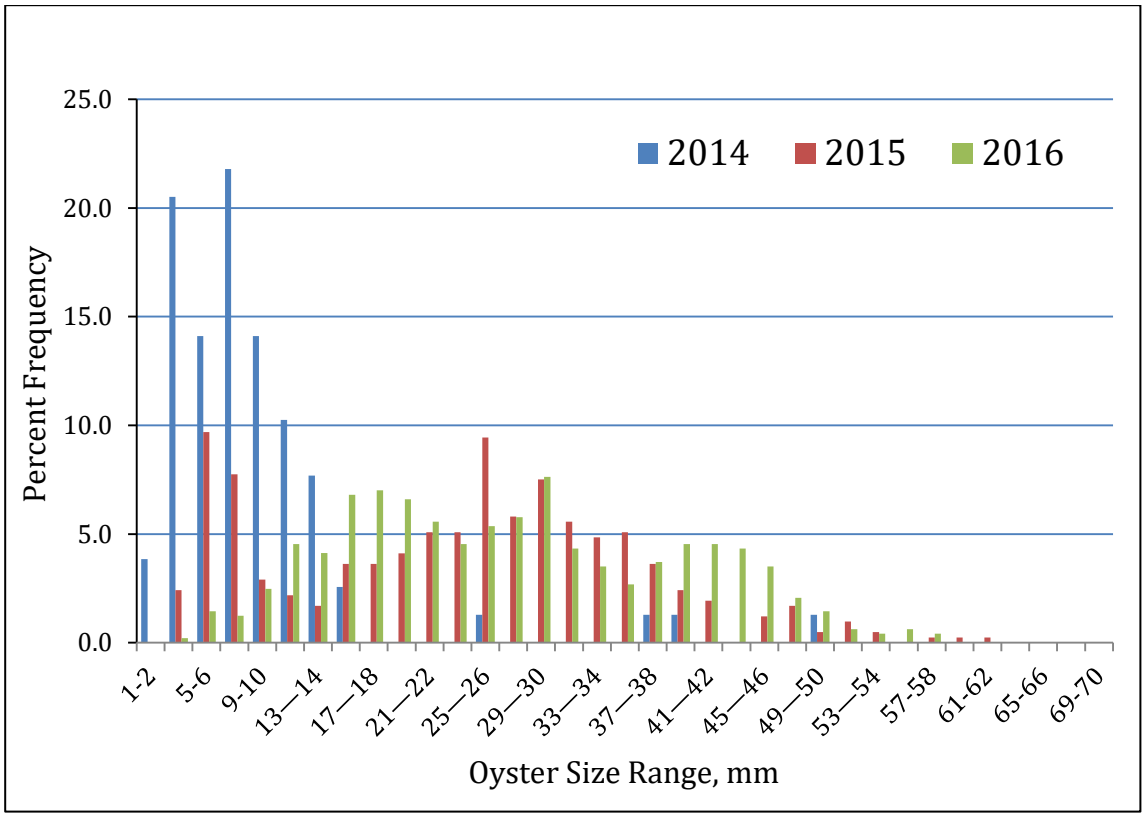

Figure 19. Length frequency histogram of native oyster sizes in the east Fidalgo shell plots during 2014, 2015 and 2016.

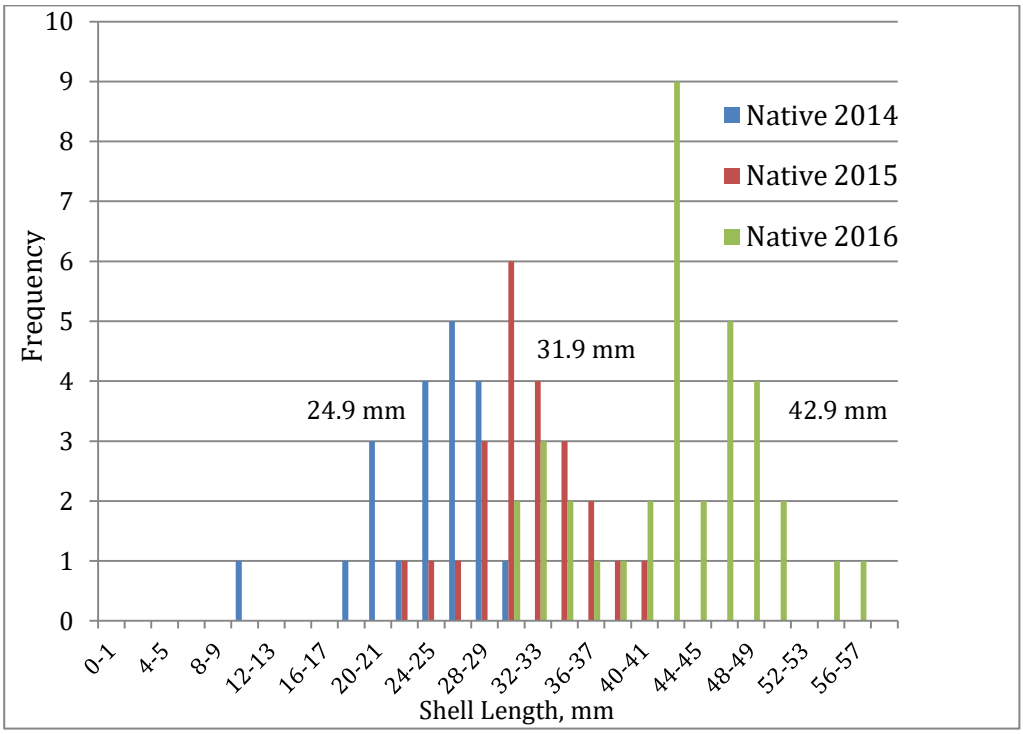

Figure 20. Length frequency histogram of native oysters by year in the east Padilla Bay experimental seed plot established with hatchery seed in 2013.

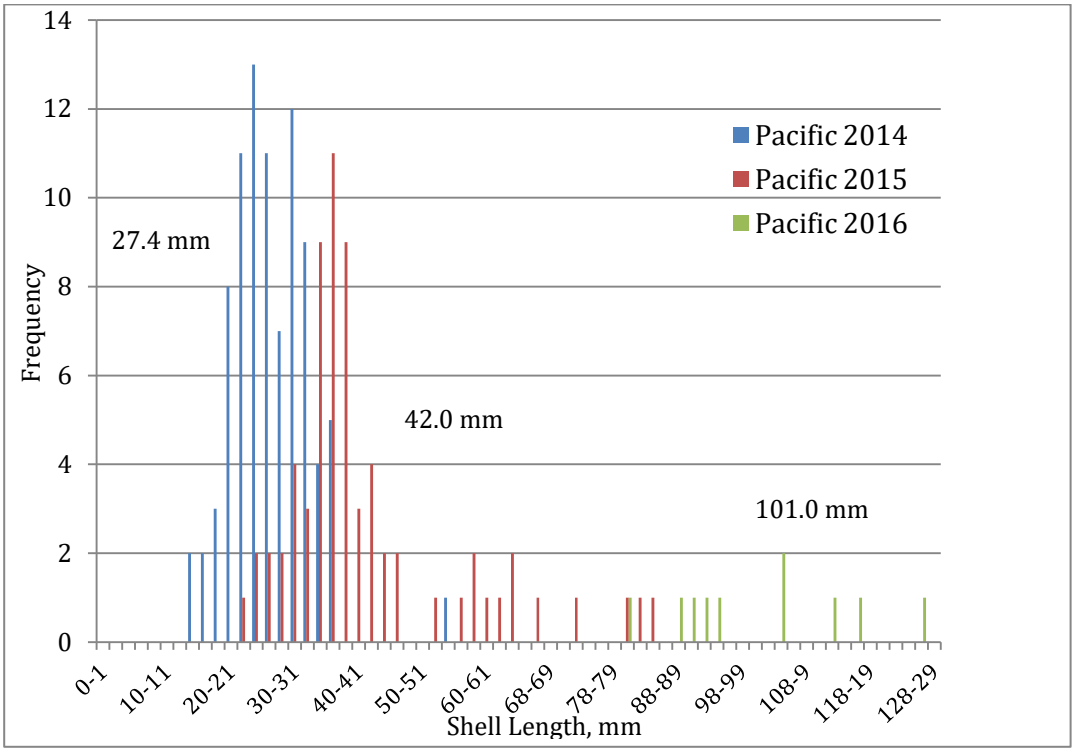

Figure 21. Length frequency histogram of Pacific oysters by year in the east Padilla Bay experimental seed plot established with native oyster hatchery seed in 2013. The Pacific oysters settled in the shell bags while being held in Hood Canal waters.

APPENDIX

Appendix Table 1. Numbers of native oysters, clam shells and oysters shells collected in 1/4 m^2 quadrat samples along the west shore of March's Point between the old south barge and the north barge, at Weaverling Spit (north side) and between the old Plywood Mill and the house to the south of the old mill site.

Sample Number	Number of Clam Shells	Number of Oyster Shells	Number of Native Oysters
East Shore of Fidalgo Bay between the south and north old barge structures			
1-0	2	0	0
1-10	1	0	0
1-20	2	0	0
1-30	4	0	0
1-40	2	0	0
1-50	4	0	0
1-60	5	0	0
1-70	3	0	0
1-80	3	0	0
1-90	1	0	0
1-100	1	0	0
2-0	6	0	0
2-10	7	0	0
2-20	1	0	0
2-30	4	0	0
2-40	0	0	0
2-50	1	0	0
2-60	0	0	0
2-70	0	0	0
3-0	0	0	0
3-10	0	0	0
3-20	1	0	0
3-30	3	0	0
3-40	8	0	0
3-50	8	1	0
3-60	6	0	0
3-70	4	0	0
3-80	1	0	0
3-90	0	0	0
3-100	3	0	0
4-0	3	0	0
4-10	2	0	0
4-20	6	0	0
4-30	4	0	0
4-40	2	0	0
4-50	0	0	0
4-60	9	0	7
4-70	1	0	0
4-80	4	0	0
4-90	5	0	1
4-100	0	0	0
5-0	1	0	0
5-10	3	0	1
5-20	5	0	0
5-30	6	0	0
5-40	3	0	0
5-50	5	0	0
5-60	3	1	2
5-70	7	0	0
5-80	2	0	0

5-90	3	0	2
5-100	6	2	14
6-0	3	0	0
6-10	3	0	0
6-20	2	0	0
6-30	2	0	0
6-40	0	0	0
6-50	1	0	0
6-60	2	0	0
6-70	2	0	0
6-80	3	0	0
6-90	2	0	0
6-100	2	0	0
7-0	1	0	0
7-10	3	0	0
7-20	6	0	0
7-30	0	0	0
7-40	4	0	0
7-50	6	0	0
7-60	3	0	0
7-70	2	0	0
7-80	3	0	0
7-90	1	0	0
7-100	5	0	0
8-0	3	0	0
8-10	0	0	0
8-20	3	0	0
8-30	1	0	0
8-40	4	0	0
8-50	0	0	0
8-60	2	0	0
8-70	6	0	0
8-80	8	0	0
8-90	5	0	0
8-100	3	0	1
9-0	2	0	0
9-10	0	0	0
9-20	0	0	0
9-30	2	0	0
9-40	1	0	0
9-50	3	0	0
9-60	3	0	0
9-70	3	0	0
9-80	0	0	0
9-90	0	0	0
9-100	2	0	0
10-0	0	0	0
10-10	1	0	0
10-20	2	0	0
10-30	0	0	0
10-40	1	0	0
10-50	1	0	0
10-60	2	0	0
10-70	2	1	14
10-80	5	0	0
10-90	6	0	0
10-100	2	0	1
11-0	7	0	0
11-10	1	0	0
11-20	2	0	0
11-30	2	0	0
11-40	0	0	0
11-50	4	0	0
11-60	1	0	0
11-70	1	0	0
11-80	2	0	0

11-90	5	0	4
11-100	3	0	2
12-0	8	0	0
12-10	3	0	0
12-20	6	0	0
12-30	1	0	0
12-40	4	0	0
12-50	4	0	0
12-60	6	0	0
12-70	4	0	6
12-80	2	0	1
12-90	4	0	0
13-0	6	0	0
13-10	4	0	1
13-20	3	0	6
13-30	7	1	1
13-40	2	0	0
13-50	4	0	0
13-60	7	1	0
13-70	3	1	6
13-80	2	0	1
13-90	5	0	27
13-100	2	0	1
14-0	8	0	0
14-10	8	0	4
14-20	4	0	6
14-30	3	0	2
14-40	5	1	0
14-50	3	0	0
14-60	6	1	5
14-70	7	0	2
14-80	3	0	3
14-90	6	0	1
14-100	7	0	5
15-0	5	0	0
15-10	4	1	0
15-20	3	3	2
15-30	0	0	3
15-40	4	0	1
15-50	8	0	1
15-60	6	0	3
15-70	9	1	7
15-80	5	1	11
15-90	5	0	8
16-0	8	0	0
16-10	6	0	1
16-20	8	0	3
16-30	5	0	0
16-40	4	0	0
16-50	6	0	1
16-60	3	1	9
16-70	6	0	3
16-80	7	0	4
16-90	4	0	2
16-100	4	0	0
17-0	4	0	2
17-10	3	2	2
17-20	0	0	1
17-30	3	0	0
17-40	5	0	3
17-50	10	0	3
17-60	3	0	0
17-70	1	0	1
17-80	2	1	1
17-90	1	0	0
17-100	3	0	1

18-0	4	0	0
18-10	4	0	1
18-20	7	0	0
18-30	4	0	1
18-40	6	0	1
18-50	3	0	0
18-60	5	0	0
18-70	8	0	1
18-80	8	0	1
19-0	1	0	0
19-10	3	1	1
19-20	6	0	1
19-30	6	0	1
19-40	3	0	0
19-50	1	0	0
19-60	7	0	0
19-70	2	0	0
19-80	4	0	0
19-90	6	0	0
19-100	7	0	0
20-0	2	0	1
20-10	3	0	0
20-20	1	0	0
20-30	3	0	1
20-40	4	0	1
20-50	2	0	0
20-60	1	0	0
20-70	2	0	0
20-80	6	1	0
20-90	3	0	0
20-100	1	0	0
21-0	1	0	0
21-10	6	0	0
21-20	7	0	0
21-30	3	0	1
21-40	6	0	1
21-50	0	1	2
21-60	4	1	3
21-70	1	0	0
21-80	1	0	0
21-90	2	0	0
21-100	9	0	0
22-0	6	0	0
22-10	0	1	0
22-20	4	0	0
22-30	1	0	0
22-40	3	0	0
22-50	4	0	0
22-60	7	0	0
22-70	5	0	0
22-80	5	0	0
23-0	1	0	0
23-10	6	0	0
23-20	4	0	0
23-30	10	0	0
23-40	1	0	0
23-50	4	1	5
23-60	3	0	1
23-70	3	0	1
23-80	1	0	1
23-90	4	0	0
23-100	1	0	0
24-0	2	0	0
24-10	2	0	0
24-20	2	0	1
24-30	6	0	2

24-40	2	0	0
24-50	3	0	0
24-60	7	0	7
24-70	5	0	2
24-80	4	0	6
24-90	1	0	0
25-0	5	0	2
25-10	2	0	1
25-20	8	0	1
25-30	7	0	0
25-40	7	0	0
25-50	3	0	1
25-60	1	0	0
25-70	7	0	3
25-80	3	0	0
25-90	2	1	0
25-100	1	0	0

Sample Number	Number of Clam Shells	Number of Oyster Shells	Number of Native Oysters
Weaverling Spit between the eastern end of the spit west to the Samish Tribal headquarters building			
1-0	0	0	0
1-10	2	0	0
1-20	3	0	0
1-30	4	0	0
1-40	2	0	0
1-50	10	0	0
1-60	5	0	0
1-70	1	0	0
1-80	3	0	0
1-90	1	0	0
1-100	1	0	0
2-0	6	0	0
2-10	6	0	0
2-20	7	0	0
2-30	4	0	0
2-40	2	0	0
2-50	3	0	0
2-60	0	0	0
2-70	4	0	0
2-80	4	0	0
2-90	0	0	0
2-100	9	0	0
3-0	1	0	0
3-10	0	0	0
3-20	3	0	0
3-30	3	0	0
3-40	2	0	0
3-50	2	0	0
3-60	2	0	0
3-70	0	0	0
3-80	0	0	0
3-90	0	0	0
3-100	0	0	0
4-0	3	0	0
4-10	6	0	0
4-20	0	0	0
4-30	4	0	0
4-40	2	0	0
4-50	6	0	0
4-60	4	0	0
4-70	8	0	0
4-80	1	0	0
4-90	0	0	0

4-100	1	0	0
5-0	4	0	0
5-10	3	0	0
5-20	3	0	0
5-30	5	0	0
5-40	4	0	0
5-50	1	0	0
5-60	3	0	0
5-70	0	0	0
5-80	1	0	0
5-90	2	0	0
5-100	3	0	0
6-0	9	0	0
6-10	7	0	0
6-20	3	0	0
6-30	3	0	0
6-40	9	0	0
6-50	2	0	0
6-60	8	0	0
6-70	1	0	0
6-80	3	0	0
6-90	3	0	0
6-100	4	0	0
7-0	2	0	0
7-10	2	0	0
7-20	2	0	0
7-30	7	0	0
7-40	0	0	0
7-50	3	0	0
7-60	2	0	0
7-70	3	0	0
7-80	1	0	0
7-90	0	0	0
7-100	0	0	0
8-0	3	0	0
8-10	3	0	0
8-20	4	0	0
8-30	4	0	0
8-40	7	0	0
8-50	10	0	0
8-60	7	0	0
8-70	9	0	0
8-80	2	0	0
8-90	1	0	0
8-100	0	0	0
9-0	7	0	0
9-10	6	0	0
9-20	9	0	0
9-30	2	0	0
9-40	13	0	0
9-50	7	0	0
9-60	8	0	0
9-70	3	0	0
9-80	5	0	0
9-90	5	0	0
9-100	10	0	0
10-0	3	0	0
10-10	2	0	0
10-20	0	0	0
10-30	3	0	0
10-40	0	0	0
10-50	1	0	0
10-60	2	0	0
10-70	5	0	0
10-80	2	0	0
10-90	5	0	0

10-100	0	0	0
11-0	7	0	0
11-10	8	0	0
11-20	11	0	0
11-30	9	0	0
11-40	11	0	0
11-50	2	0	0
11-60	8	0	0
11-70	12	0	0
11-80	0	0	0
11-90	2	0	0
11-100	5	0	0
12-0	9	0	0
12-10	4	0	0
12-20	11	0	0
12-30	8	0	0
12-40	12	0	0
12-50	9	0	0
12-60	7	0	0
12-70	6	0	0
12-80	1	0	0
12-90	0	0	0
12-100	4	0	0
13-0	4	0	0
13-10	1	0	0
13-20	0	0	0
13-30	2	0	0
13-40	0	0	0
13-50	0	0	0
13-60	0	0	0
13-70	0	0	0
13-80	0	0	0
13-90	0	0	0
13-100	3	0	0
14-0	13	0	0
14-10	8	0	0
14-20	17	0	0
14-30	8	0	0
14-40	17	0	0
14-50	3	0	0
14-60	5	0	0
14-70	5	0	0
14-80	4	0	0
14-90	3	0	0
14-100	6	0	0
15-0	3	0	0
15-10	12	0	0
15-20	7	0	0
15-30	9	0	0
15-40	7	0	0
15-50	7	0	0
15-60	7	0	0
15-70	7	0	0
15-80	1	0	0
15-90	3	0	0
15-100	0	0	0
16-0	1	0	0
16-10	1	0	0
16-20	6	0	0
16-30	4	0	0
16-40	3	0	0
16-50	1	0	0
16-60	4	0	0
16-70	4	0	0
16-80	1	0	0
16-90	5	0	0

16-100	2	0	0
17-0	13	0	0
17-10	4	0	0
17-20	6	0	0
17-30	8	0	0
17-40	4	0	0
17-50	0	0	0
17-60	7	0	0
17-70	4	0	0
17-80	3	0	0
17-90	4	0	0
17-100	9	0	0
18-0	22	1	0
18-10	9	0	0
18-20	13	0	0
18-30	5	0	0
18-40	11	0	0
18-50	12	0	0
18-60	4	0	0
18-70	2	0	0
18-80	4	0	0
18-90	0	0	0
18-100	0	0	0
19-0	3	0	0
19-10	9	0	0
19-20	3	0	0
19-30	5	0	0
19-40	1	0	0
19-50	2	0	0
19-60	0	0	0
19-70	0	0	0
19-80	2	0	0
19-90	0	0	0
19-100	0	0	0
20-0	8	0	0
20-10	10	0	0
20-20	1	0	0
20-30	2	0	0
20-40	3	0	0
20-50	0	0	0
20-60	0	0	0
20-70	2	0	0
20-80	1	0	0
20-90	4	0	0
20-100	12	0	0
21-0	2	0	0
21-10	5	0	0
21-20	6	0	0
21-30	1	0	0
21-40	6	0	0
21-50	5	0	0
21-60	3	0	0
21-70	3	0	0
21-80	0	0	0
21-90	0	0	0
21-100	1	0	0
22-0	3	0	0
22-10	6	0	0
22-20	15	0	0
22-30	4	0	0
22-40	15	0	0
22-50	5	0	0
22-60	3	0	0
22-70	2	0	0
22-80	2	0	0
22-90	3	0	0

22-100	3	0	0
23-0	17	0	0
23-10	6	0	0
23-20	5	0	0
23-30	2	0	0
23-40	4	0	0
23-50	0	0	0
23-60	0	0	0
23-70	1	0	0
23-80	1	0	0
23-90	1	0	0
23-100	0	0	0
24-0	10	0	0
24-10	3	0	0
24-20	11	0	0
24-30	4	0	0
24-40	5	0	0
24-50	7	0	0
24-60	2	0	0
24-70	5	0	0
24-80	3	0	0
24-90	3	0	0
24-100	5	0	0
25-0	8	0	0
25-10	4	0	0
25-20	3	0	0
25-30	5	0	0
25-40	2	0	0
25-50	2	0	0
25-60	0	0	0
25-70	1	0	0
25-80	4	0	0
25-90	0	0	0
25-100	0	0	0

Sample # Number	Number of Clam Shells	Number of Oyster Shells	Number of Native Oysters
West shore of Fidalgo Bay between the old plywood mill site and the house to the south of the mill site			
1-0	0	0	0
1-10	0	0	0
1-20	1	0	0
1-30	0	0	0
1-40	1	0	0
1-50	3	0	0
1-60	4	0	0
1-70	0	0	0
1-80	5	0	0
1-90	4	0	0
1-100	3	0	0
2-0	2	0	0
2-10	1	0	0
2-20	4	0	0
2-30	2	0	0
2-40	3	0	0
2-50	2	0	0
2-60	4	0	0
2-70	1	0	0
2-80	0	0	0
2-90	0	0	0
2-100	2	0	0
3-0	3	0	0
3-10	6	0	0
3-20	5	0	0
3-30	3	0	0

3-40	3	0	0
3-50	2	0	0
3-60	2	0	0
3-70	2	0	0
3-80	4	0	0
3-90	2	0	0
4-0	2	0	0
4-10	3	0	0
4-20	5	0	0
4-30	7	0	0
4-40	1	0	0
4-50	2	0	0
4-60	4	0	0
4-70	3	0	0
4-80	4	0	0
4-90	2	0	0
4-100	1	0	0
5-0	6	0	0
5-10	8	0	0
5-20	3	0	0
5-30	3	0	0
5-40	5	0	0
5-50	3	0	0
5-60	1	0	0
5-70	2	0	0
5-80	3	0	0
5-90	3	0	0
6-0	2	0	0
6-10	2	0	0
6-20	3	0	0
6-30	0	0	0
6-40	4	0	0
6-50	1	0	0
6-60	2	0	0
6-70	3	0	0
6-80	2	0	0
6-90	3	0	0
6-100	2	0	0
7-0	4	0	0
7-10	6	0	0
7-20	7	0	0
7-30	2	0	0
7-40	2	0	0
7-50	2	0	0
7-60	2	0	0
7-70	3	0	0
7-80	2	0	0
7-90	1	0	0
7-100	2	0	0
8-0	6	0	0
8-10	3	0	0
8-20	12	0	0
8-30	7	0	0
8-40	4	0	0
8-50	8	0	0
8-60	6	0	0
8-70	2	0	0
8-80	0	0	0
8-90	5	0	0
8-100	2	0	0
9-0	1	0	0
9-10	1	0	0
9-20	2	0	0
9-30	3	0	0
9-40	3	0	0
9-50	1	0	0

9-60	1	0	0
9-70	2	0	0
9-80	3	0	0
9-90	3	0	0
9-100	1	0	0
10-0	2	0	0
10-10	1	0	0
10-20	8	0	0
10-30	6	0	0
10-40	4	0	0
10-50	4	0	0
10-60	4	0	0
10-70	4	0	0
10-80	4	0	0
10-90	5	0	0
11-0	3	0	0
11-10	3	0	0
11-20	4	0	0
11-30	3	0	0
11-40	4	0	0
11-50	5	0	0
11-60	5	0	0
11-70	3	0	0
11-80	4	0	0
11-90	4	0	0
11-100	0	0	0
12-0	5	0	0
12-10	7	0	0
12-20	1	0	0
12-30	1	0	0
12-40	3	0	0
12-50	1	0	0
12-60	3	0	0
12-70	2	0	0
12-80	0	0	0
12-90	7	0	0
12-100	2	0	0
13-0	0	0	0
13-10	2	0	0
13-20	3	0	0
13-30	2	0	0
13-40	4	0	0
13-50	3	0	0
13-60	7	0	0
13-70	4	0	0
13-80	2	0	0
13-90	4	0	0
13-100	2	0	0
14-0	4	0	0
14-10	5	0	0
14-20	6	0	0
14-30	10	0	0
14-40	2	0	0
14-50	3	0	0
14-60	4	0	0
14-70	5	0	0
14-80	3	0	0
15-0	5	0	0
15-10	3	0	0
15-20	4	0	0
15-30	5	0	0
15-40	3	0	0
15-50	7	0	0
15-60	4	0	0
15-70	4	0	0
15-80	1	0	0

15-90	1	0	0
16-0	3	0	0
16-10	3	0	0
16-20	2	0	0
16-30	2	0	0
16-40	2	0	0
16-50	5	0	0
16-60	5	0	0
16-70	4	0	0
17-0	5	0	0
17-10	4	0	0
17-20	6	0	0
17-30	10	0	0
17-40	7	0	0
17-50	1	0	0
17-60	6	0	0
18-0	8	0	0
18-10	5	0	0
18-20	5	0	0
18-30	7	0	0
18-40	8	0	0
18-50	2	0	0
18-60	1	0	0
18-70	3	0	0
19-0	2	0	0
19-10	1	0	0
19-20	0	0	0
19-30	1	0	0
19-40	3	0	0
19-50	2	0	0
19-60	4	0	0
19-70	4	0	0
20-0	0	0	0
20-10	5	0	0
20-20	2	0	0
20-30	4	0	0
20-40	2	0	0
20-50	6	0	0
20-60	8	0	0
20-70	6	0	0
21-0	2	0	0
21-10	2	0	0
21-20	2	0	0
21-30	5	0	0
21-40	0	0	0
21-50	2	0	0
21-60	4	0	0
21-70	3	0	0
22-0	1	0	0
22-10	1	0	0
22-20	1	0	0
22-30	3	0	0
22-40	12	0	0
22-50	6	0	0
22-60	6	0	0
22-70	10	0	0
22-80	10	0	0
23-0	3	0	0
23-10	1	0	0
23-20	2	0	0
23-30	5	0	0
23-40	3	0	0
23-50	3	0	0
23-60	1	0	0
23-70	16	0	0
24-0	1	0	0

24-10	3	0	0
24-20	3	0	0
24-30	3	0	0
24-40	4	0	0
24-50	2	0	0
24-60	2	0	0
24-70	4	0	0
25-0	8	0	0
25-10	5	0	0
25-20	2	0	0
25-30	7	0	0
25-40	4	0	0
25-50	3	0	0
25-60	5	0	0