Final Report
Oyster Restoration for Mugu Lagoon: Preliminary Population Assessment

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Prepared by:

Thomas McCormick
Proteus SeaFarms, Inc.
P.O. Box 1528
Ojai, CA 93024
805 798-2505

Prime Contractor: Tetra Tech EM Inc.
Technical Contact: Katy Norris
Procurement Contact: Rindy Mortensen
Tetra Tech Contract No. Chadux Tt Task Number 038

Tetra Tech EM Inc.
7 W. 6th Avenue, Suite 612
Helena, MT 59601

Client:

Navy Facilities Engineering Command

Martin Ruane
311 Main Road, Suite 1
Environmental Division, Code N45V
Navy Base Ventura County
Point Mugu, CA 93042

Table of Contents

Executive Summary

Surveys were conducted on adult populations of the Native, or Olympia oyster (*Ostrea lurida*) in Mugu Lagoon, Navy Base Ventura County. In addition, collectors were placed at different locations in the lagoon to capture newly settled oyster spat, and track the growth and survival of oysters throughout the year. Surveys were conducted from July 2008 through October 2009.

The largest oyster population inhabits the concrete and steel walls of the causeway where Laguna Road crosses the lagoon. As many as 5,400 to 7,500 oysters may reside under protecting mussel beds on the sub-tidal and intertidal portions of the causeway.

Twenty-four collector bags made of plastic mesh tubes filled with dried oyster shell with an average surface area of 1.78 m^2 / bag were placed at locations around the lagoon. Fifteen oysters settled and grew to a size of 5 mm or more on these bags, resulting in a settling density of 0.36 oysters / m^2, or one oyster spat per 2.8 m^2 of substrate. Settling densities were highest at the causeway where they reached 1.8 oysters / m^2 in the bags where they did settle. Spawning occurred from June through January when temperatures averaged more then 15°C, a pattern observed at other locations in southern California. Growth of oysters from 5 – 50 mm averaged 3 mm per month. 80% of the oyster spat observed in the collectors survived for 5 months or more, some reaching shell lengths of up to 50 mm after one year.

Stressors on the population of Olympic oysters in Mugu Lagoon are as follows:

1. Low adult population – the adult population of up to 5,400 to 7,500 oysters is limited to the Laguna Road causeway (sub-tidal surveys were not conducted).

2. Lack of substrate – few hard substrates for oyster settlement exist in the lagoon.

3. Temperature extremes – extreme water temperatures resulting from the rapid heating and cooling of shallow waters within the lagoon may stress oysters and limit survival in many locations where there is hard substrate. Water temperatures adjacent to the causeway were generally between 10 – 20˚C while those in the shallower parts of the lagoon ranged from 4 – 33˚C.

Two locations within the lagoon adjacent to the causeway may be suitable for experimental restoration efforts. Low tidal elevations at these sites offer protection from temperature extremes. High velocity flows during each tidal cycle insure that sedimentation rates will be low at this location. Collector bags stacked in pyramids mimic natural reefs and may help start reef formation.

Hatchery production may be necessary to jump start colonization of experimental reefs with oyster spat. Introducing hatchery-raised spat on shell can result in dramatic population increases and the development of oyster reefs. Should natural recruitment on enhancement reefs be low, spat production at the Ormond Beach Hatchery is possible.

Project Goal:

A one-year pilot program was undertaken to survey stocks of native oysters (*Ostreola chonchapila* = *Ostrea lurida*) in Mugu Lagoon, Navy Base Ventura County. Settlement of spat (recruitment), growth, and survival were measured to develop a better understanding of stressors that may be limiting the remnant population. Continual measurements were made of seawater temperatures at two locations in the lagoon.

Background:

Mugu Lagoon, the largest salt marsh estuary in southern California, is situated on the Pacific coast of Ventura County, California. The lagoon is rich in natural resources, cultural significance, and U.S. military history. The lagoon's extensive shellfish resources supported relatively dense settlements of Native Americans until the establishment of Spanish missions in the late 1700s. The original wetland encompassed 3,000 acres, paralleling the coast for nearly four miles and extending more than a mile inland (MacDonald, 1976; Swanson 1994). The Lagoon's watershed covers 343 square miles drained by Calleguas Creek from the Oxnard plain, to the foothills and 3,500 foot peaks of the Santa Monica Mountains (USDA 1995). Calleguas Creek which ran adjacent to the lagoon was channelized and its flows diverted into the lagoon in 1884. The central lagoon has been dredged several times for fill used in military construction in adjacent marsh and uplands. The lagoon and wetlands were fenced in the 1940s for use by the Navy and is now part of Navy Base Ventura County (NBVC) Point Mugu.

At 1,943 acres, Mugu Lagoon today is 64% of its original size. Currently it consists of 231 acres of ponds/open water, 346 acres of tidal flats, 828 acres of tidal marsh, 270 acres of marsh transitioning to uplands, and 211 acres of salt pans, 57 acres of sub-tidal channel/ drainage tidal creeks (US Navy Base Mugu Biological Survey 2000). The nearest coastal salt marshes are the Carpenteria salt marsh 30 miles northwest, and Seal Beach Wetlands, 70 miles to the southeast.

A Mediterranean climate prevails with heavy winter rains and low precipitation in other seasons (14.8 inches/yr). Perennial flows from Calleguas Creek into the lagoon from runoff, irrigation return flows and NPDES permitted discharges yield a maximum flow of 11,810 cfs and annual sediment yield of 240,000 tons (USDA 1995). Reduction of the tidal prism exacerbates the succession of the wetland to non-marine upland habitats. Yet, the wetland remains an important ecological water treatment mechanism for removal of contaminants before water enters the Pacific Ocean Basin. Furthermore, the Lagoon and wetlands provide coastal resiliency to storms and flooding.

Biological Resources: Mugu Lagoon and tidal marshes are critical nursery, adult, and transitional habitat for a rich diversity of species. Located on the Pacific Flyway, the lagoon is home to 310 species of local and migratory birds. Of these, 152 species are water-associated, including 32 sensitive and seven federal and state listed species

(Keeney 1996) such as the California Least Tern, Light-footed Clapper Rail, Western Snowy Plover and Belding's Savannah Sparrow (US Fish and Wildlife Service 1991; Caffrey 1995; Goodbreed et. al., 1996; Keeney 1996. Protected Harbor Seals and sea lions are also present. The lagoon and its tributaries harbor 27 fish species (Sakai 1994; Engle et. al. 1995). There are nine taxonomic groups of marine and brackish water invertebrates in the lagoon, with mollusks and crustaceans being the most abundant (PRC 1996). Phytoplankton suspended in the water column and on the surface of the mud flats (Fong 1986) provides an abundant food source. Historically, Mugu Lagoon's benthic community was dominated by bivalve molluscs, especially the purple clam (*Sanquinolaria nuttaili*), littleneck clam (*Protothaca staminea*), false mya (*Cryptomya californica*), California jackknife clam (*Tagelus californianus*), and bent-nose clam (*Macoma nasuta*) (INRMP 2002). Polychaete worms, gastropod molluscs, and decapod crustaceans were also numerically important. The distributions of infauna are strongly influenced by sediment characteristics such as grain size, pH, total organics, organic carbon and nitrogen, and dissolved oxygen (Zedler et al. 1992).

Changes in regional resource management are improving conditions within Mugu Lagoon. Since 1995, the US Navy has undertaken numerous wetland restoration projects, creating more than 61 acres of tidal flats, channels, ponds and salt marsh. Reduction in sediment loads entering Mugu Lagoon from Calleguas Creek is being achieved through a range of management practices including agricultural retention basins, stream bank stabilization, hillside grading ordinances, sediment control structures (Los Angeles Regional Water Control Board 1995) and periodic dredging of Calleguas Creek upstream of the lagoon. Water quality will also improve as the Calleguas Regional Salinity Management Project is implemented. Water that once flowed into the creek from imported surface water and groundwater supplies, discharges from desalination plants, water treatment plants, and agriculture will be diverted into a brine line that will carry it to the Pacific Ocean at Port Hueneme. As much as 42,300 tons of salt, as well as nitrogenous waste, fertilizers, herbicides, pesticides, and chlorine will be eliminated from the Mugu Lagoon watershed (Calleguas Regional Salinity Management Pipeline) by this brine line.

Enhancement activities: The 2002 Integrated Natural Resources Management Plan (INRMP) Navy Base Ventura County (NBVC) Point Mugu was developed to comply with the 1997 Sikes Act Improvement Act to enhance natural resources at military installations. Goals of the plan include the restoration and maintenance of ecosystem viability and improvement of water quality.

Mugu Lagoon provides critical nursery, adult, and transitional habitat for a rich diversity of species. After a century of sedimentation and dredging any preexisting intertidal oyster reefs have been destroyed.

At this time no oyster reefs are found in Mugu Lagoon. The lagoon substrate is dominated by mud / silt / sand bottoms, leaving few hard substrates for settlement of oysters. Those hard substrates that do exist are concrete bridge abutments, drain pipes, rock rip rap installed to protect the shoreline, and a scattering of rock cobble.

Approach and work accomplished:

Remnant oyster populations persist in Mugu Lagoon. The intent of this work was to define the location and density of the oyster population. In addition the study determined the timing of spawning, the recruitment of spat (newly settled oyster larvae) and subsequent growth, and survival of the spat as they matured into juvenile and adult oysters.

Fieldwork was begun in June 2008. Hard substrate habitats (concrete walls of bridge abutments and slopes, metal drainage conduits, and other structures, were surveyed for oysters during low tides. Areas where live oysters or oyster shells were discovered were noted, and oyster spat collectors were placed nearby on existing artificial substrates. Oyster spat collectors were used to determine the timing of spat settlement, and to track growth and survival. Collectors were also used to see if more substrate would result in additional settlement of oyster spat.

Oyster spat collectors were constructed of dried shell from Pacific oysters (*Crassostrea gigas*) obtained from Drakes Bay Family Farms at Point Reyes, California. The shell was air dried in direct sun an additional month prior to placement in the collectors. Each collector consisted of approximately 60 shells placed in a black plastic Vexar bag with mesh sizes of either 1/2" (12 mm) or 1.5" (38 mm), see Figure 1. The average surface area of the shells within the bags was 1.78 m^2 (s.d. 0.48, n=3). Total shell surface was determined by wrapping oyster shells in aluminum foil (Shelly 1979; Bergey and Getty 2006).

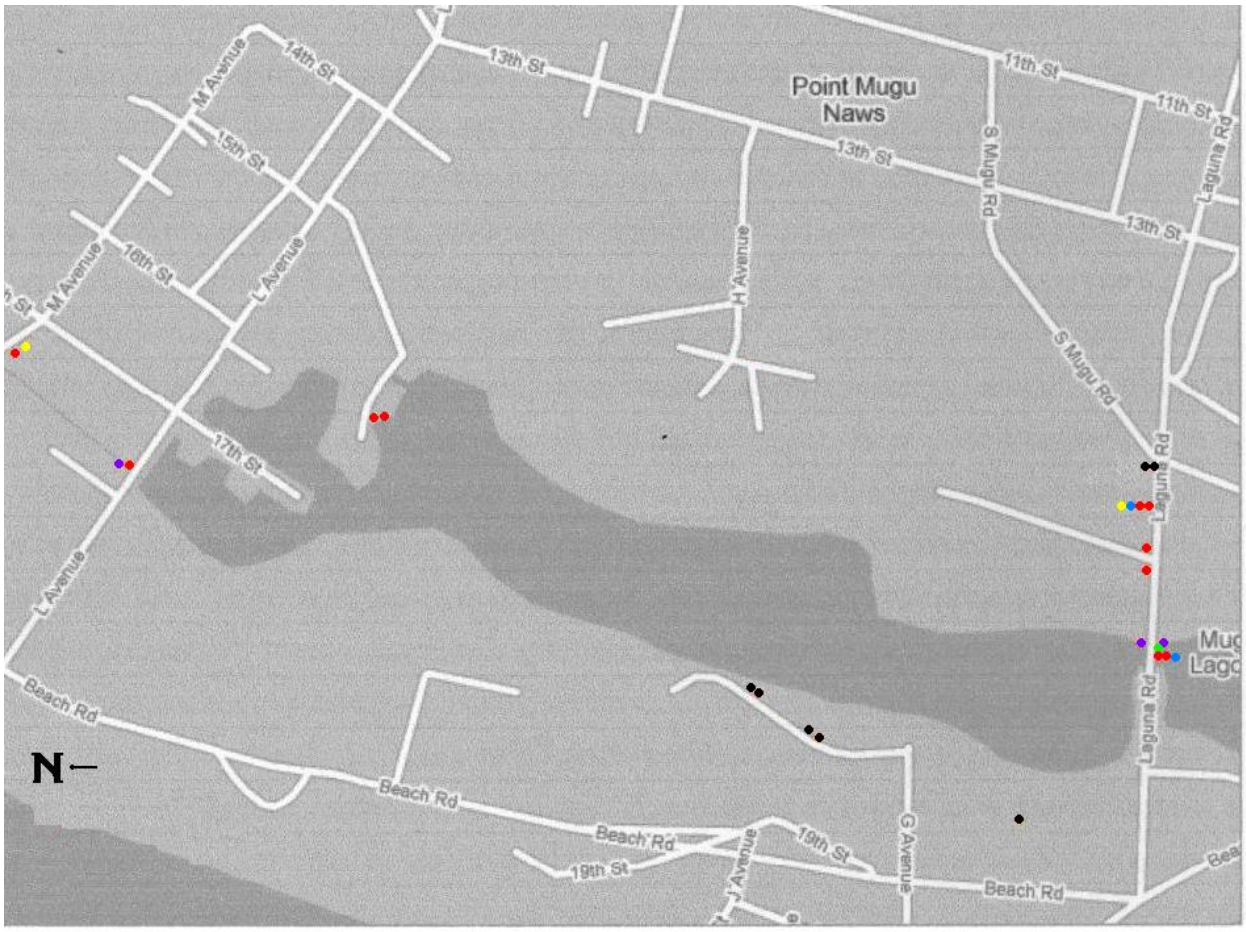
Figure 1. Field technician Holly Bovey loads dried shells from Pacific oysters into plastic mesh spat collectors.

Temperature Tidbit digital temperature recorders (Onset Corporation) were placed within a perforated bait container which was then placed in two collectors to provide a continuous record of water and air temperatures. One temperature sensor was placed inside a metal conduit pipe in the drainage ditch on the west side of Laguna Road, described as Laguna Road (middle). The second temperature sensor was placed adjacent to the south east concrete abutment of the causeway where Laguna Road crosses over the lagoon. This causeway on Laguna Road will be simply referred to as "the causeway' in this report. The temperature sensor at the causeway is described as Causeway (SE).

Oyster shell collector locations

On July 8, 2008, 30 spat collectors were placed at eight locations throughout the lagoon. At least two collectors were placed at each location. Figure 2. shows locations of oyster spat collectors within the western section of Mugu Lagoon as of December 2008. The figure also indicates the presence or absence of settled oyster spat.

Figure 2. Collector positions and presence of oyster spat – December 2008



December 2008 results:
Red Dots: represent a 1 ½" bag.
Purple Dots: represent a 1 ½" bag found with spat.
Yellow dots (Yellow): represent a ½" bag.
Green dots: represent a ½" bag found with spat.
Blue dots: represent locations of temperature sensors.
Black dots: represent bags pulled due to lack of activity.

Figure 3 shows locations of oyster spat collectors on northern Laguna road and Calleguas Creek at the 11th Street viaduct bridge as of December 2008. The figure also indicates the presence or absence of settled oyster spat.

Figure 3. Collector positions and the presence of oyster spat, Laguna Road and Calleguas Creek at the 11th street bridge as of December 2008

December 2008 results:
Red Dots: represent a 1 ½" bag.
Purple Dots: represent a 1 ½" bag found with spat.
Yellow dots: represent a ½" bag.
Green dots: represent a ½" bag found with spat.
Blue dots: represent locations of temperature sensors
Black dots: represent bags pulled due to lack of activity.

Monitoring dates

Spat collectors we examined every 4 – 6 weeks through October 5, 2009 to check for the presence on newly settled spat. Initially, several days were required to survey all bags. Survey dates were:

September 3, 2008
September 15, 2008
September 17, 2008
October 29, 2008
October 30, 2008
December12, 2008
December 13, 2008

February 9, 2009
February 11, 2009
March 9, 2009
April 8, 2009
May 2, 2009
June 26, 2009
August 21, 2009
October 5, 2009

For each survey, spat collectors were disassembled and each oyster shell was examined for the presence of oyster spat. Figure 4 shows a newly settled native oyster on the shell of a Pacific oyster from a spat collector. To the right notice the white interior of a spat that had settled then died.

Figure 4. Newly settled Native Oyster spat on the shell of a Pacific Oyster from a oyster spat collector.

Size of oyster spat was determined by measuring the longest shell dimension to the nearest millimeter with dial calipers as shown in Figure 5.

Figure 5. Measurement of spat from the native oyster that has settled on the shell of a Pacific Oyster from a collector.

Beginning in April 2009 oysters were identified with individual labels to facilitate tracking their growth and survival. The upper valve of the oyster was cleaned then a two-part epoxy was applied to the shell. A plastic numbered tag was pressed into the epoxy.

Results

Occurrence of Adult Oysters

Live adult native oysters were most abundant on the concrete walls of the causeway where Laguna Avenue crosses Mugu Lagoon. These oysters were not immediately apparent as they were usually located on the vertical concrete or metal walls of causeway beneath dense mussel beds composed of both California Mussels (*Mytilus californianus)* and Bay Mussels (*Mytilus galloprovincialis*). Mussels were removed from three random patches of wall (0.25m^2 each) to reveal densities of 22.7 oysters /m^2. The total number of oysters possibly present was estimated by calculating the submerged intertidal area of the concrete and metal walls and seawater conduits of the causeway. The substrate available for oyster habitat and the resulting number of oysters on the causeway depends upon the height of the intertidal band inhabited by the oysters as follows:

Height of Intertidal Band Inhabited by oysters	# Oysters on Causeway
3 feet	5,425
4 feet	6,492
5 feet	7,536

The numbers of oysters on the causeway assumes that oysters are evenly distributed over the causeway habitat. The causeway represents the largest oyster habitat in the lagoon. Only one or two oysters were found at other sites within the lagoon, although old oyster shell was found at a number of locations on corrugated drainage pipes, rock riprap, or cobble from the bottom of the lagoon.

Location and number of oyster spat settled

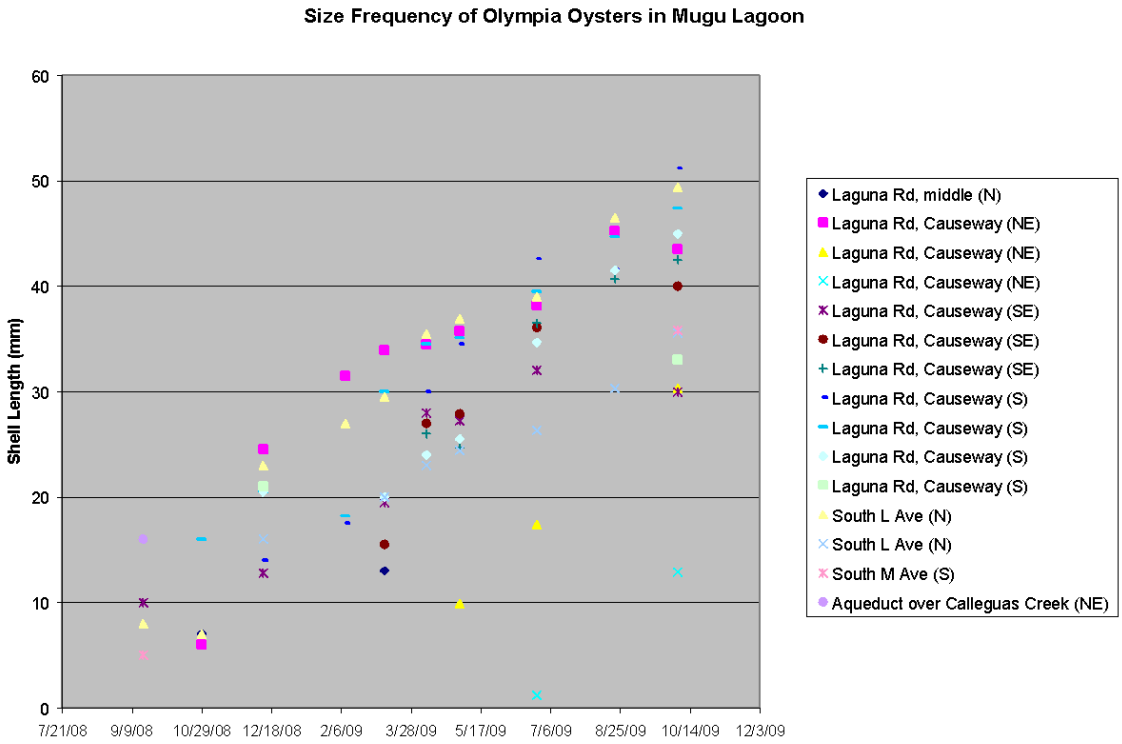
A total of 15 settled oyster spat were found in the course of this study. Of these, 10 67%) were found adjacent to the causeway, one was found in the drainage ditch that runs parallel to Laguna Road, two were found on South L Avenue, one on South M, and one at the aqueduct over Calleguas Creek at the end of 11th Street. Most collectors had zero spat, Three spat settled in collectors at Laguna Road, Causeway (NE); Laguna Road, Causeway (SE); and South L Avenue. Four oysters were found at Laguna Road, Causeway (S). With an average surface area of 1.78 m^2 per collector, the average densities of oysters at these four locations (3.25 oysters) was thus 1.8 oysters / m^2 of collector surface area (or 0.55 m^2 per oyster).

Appendix A shows locations where the collectors were deployed and the number of oysters, if any, settled. Surveys of the sand /cobble lagoon bottom to the east and west of the causeway revealed the presence of oyster shell and several live oysters.

Growth of Native Oyster spat and juveniles

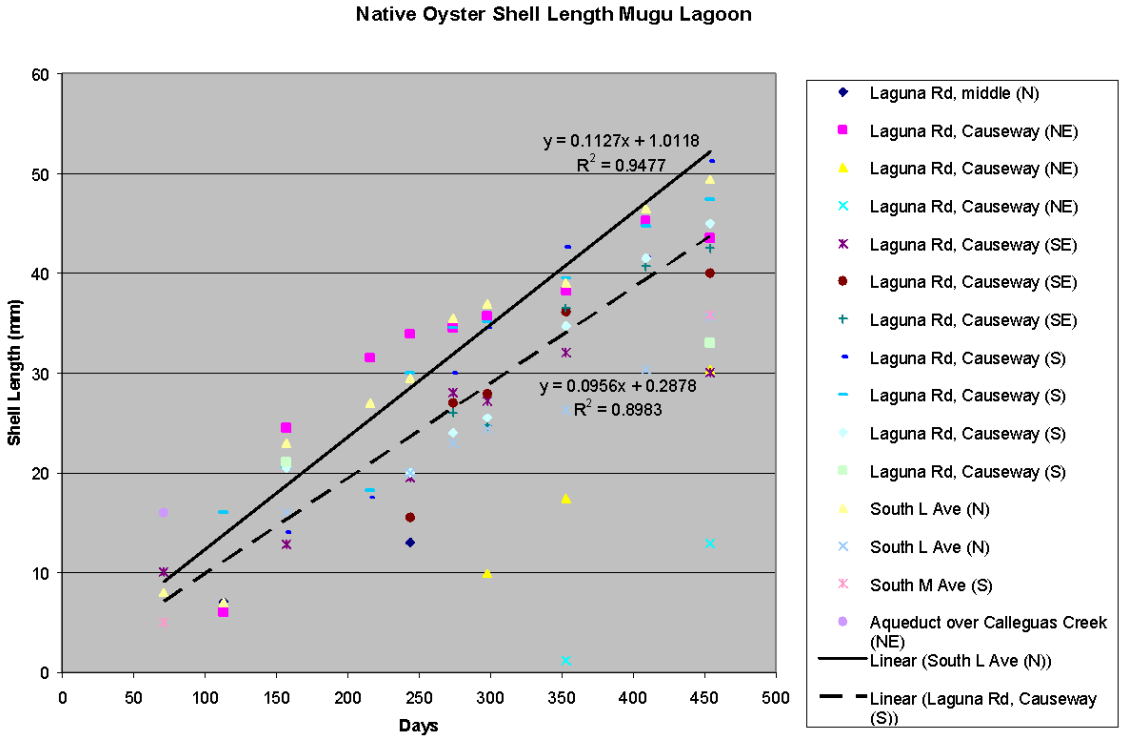
Newly settled native oysters were observed on shell in the collectors during the first survey in September 2008, two months after deployment. Oysters 10 mm in length or less were seen in September and October 2008, and April and June of 2009. During the study period, the smallest spat observed was 1.2 mm in length, although the average minimal size was 6 mm. Biofouling of the shell substrate by other organisms such as bryozoans, and the white and brown coloration of the oyster spat made it difficult to detect oysters at shell lengths less than 5 mm. Figure 6 shows changes in oyster shell lengths from July 2008 through October 2009 for the 15 oysters that settled in the collectors.

Figure 6. Change in shell length for 15 Olympia Oysters that settled on collectors in Mugu Lagoon.



Newly settled oyster spat were observed during the first survey in September 2008 through July 2009. Figure 6 suggests that oysters growth rates were similar among individuals and remained steady throughout the year. To determine growth rates, monthly dates from Figure 6 were converted to the number of days from the initial deployment of the collectors as shown in Figure 7.

Figure 7. Shell size versus the number of days from the initial deployment of collectors on July 8, 2008.



The first spat were measured on September 9, 2008, that is, 71 days after the collectors were deployed. The final measurement occurred on October 5, 2009, 454 days from the date the collectors were first deployed. Some oysters grew from 7 to 50 mm during this period, or 0.11 mm per day, 3.4 mm per month, or 40 mm per year. The relationship between time and shell length for South L Avenue is:

$$\text{Shell length} = 0.1127\text{Days} - 1.0118$$

This growth curve is equivalent to a growth rate of 40 mm per year.

The time shell length relationship for Laguna Road Causeway (S) is:

$$\text{Shell length} = 0.0956\ \text{Days} + 0.2878$$

This growth curve is equivalent to a growth rate of 34 mm per year.

Over 13 months oysters grew at an average rate of 3 mm per month (36 mm per year).

At a growth rate of 3 mm per month, newly settled oysters 6 mm in length would be 2 months old. Coe and Hassler (1989) noted that after spawning Olympia oysters brood fertilized eggs for 10 – 12 days. The larval veliger stage lasts another 11 – 16 days. Given this time table, 6 mm spat first found in the collectors in September had grown in place for two months preceded by 3 – 4 weeks of egg and veliger development. This would place the first spawning in June 2008.

Survival

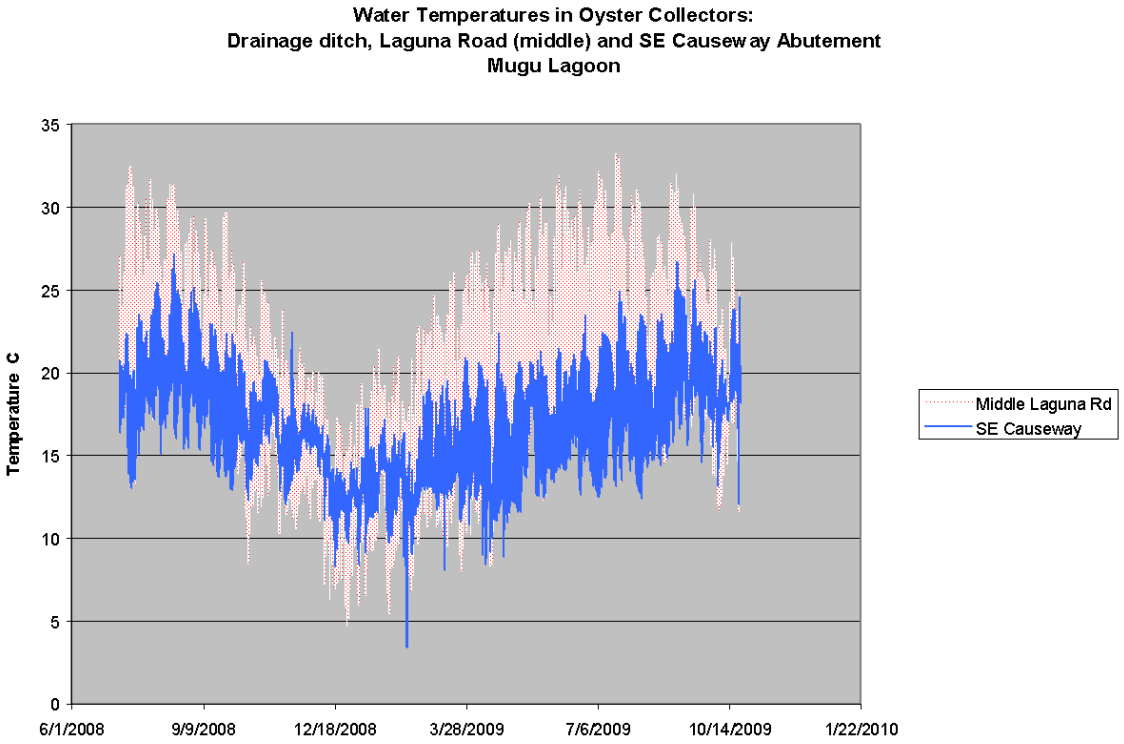
Of the 15 spat that have settled, twelve (80%) survived for at least five months attaining shell lengths of 30 mm or larger.

Seawater temperatures within Mugu Lagoon

Continuously recording temperature sensors (Tidbit V2Temp Loggers, Onset Computer Corp., www.onsetcomp.com) were set to record temperature every 30 minutes and placed in a plastic bait container with screw top and perforated sides. The container was then placed in the collectors with oyster shells. Temperature was monitored at two locations in the lagoon where either live oysters or oyster shells had been found. One location, Laguna Road (middle), a shallow drainage ditch paralleling Laguna Road, was in a large metal conduit under a former dirt road. This location was indicative of a number of shallow channels in the lagoon that drain tidal areas. The second temperature recorder was placed at the Causeway (SE) where Laguna Road crosses Mugu Lagoon. This sensor was adjacent to the deep channel and a concrete abutment that hosts a community of mussels and oysters. Both sensors were submerged. See Figure 2 for temperature sensor locations.

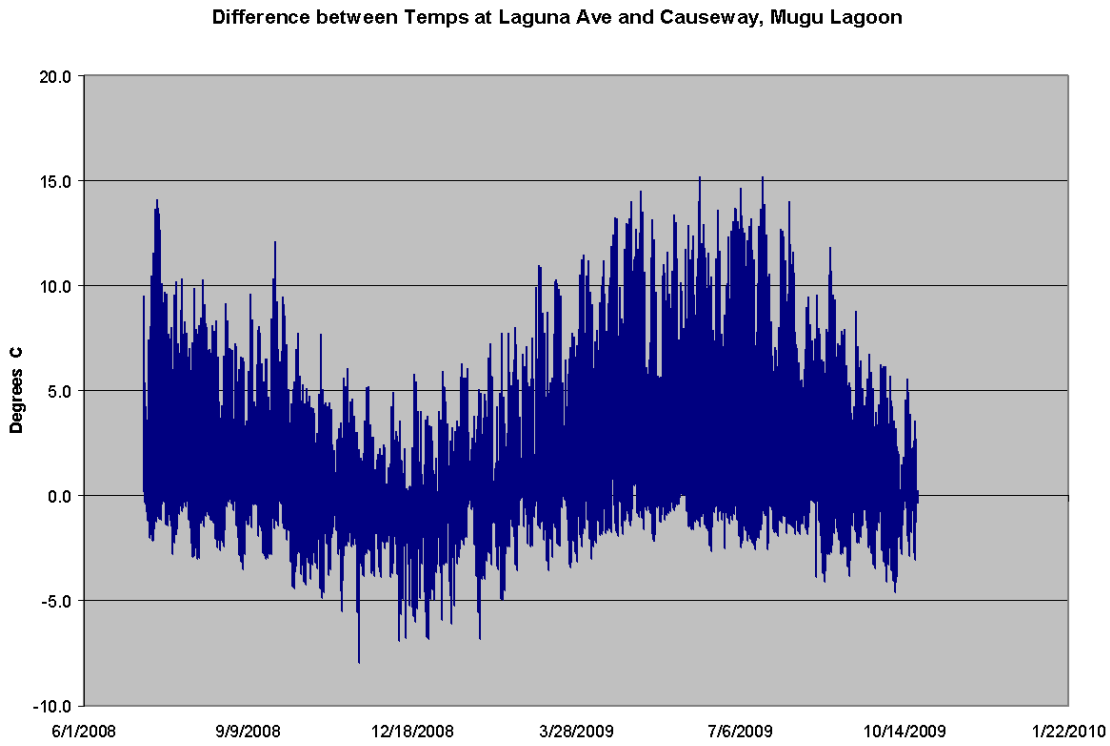
Figure 6 shows temperatures in the collectors from July 8, 2009 through October 22, 2009

Figure 6. Seawater temperatures in two collectors in Mugu Lagoon.



A striking difference can be seen in the range of seawater temperatures at the two locations. At Laguna Road (middle), temperatures (light lines) are more extreme that at the Causeway. This can be expected as a result of the more rapid heating and cooling of shallower waters in the tidal flats. During the summer months seawater temperatures at Laguna Road were in excess of 30˚C (86˚F), while temperatures less than 10˚C (50˚F) occurred during the winter. Temperatures at the causeway were less extreme. This difference in temperatures between the two sites are shown in Figure 7.

Figure 7. Difference in water temperatures between Laguna Road (middle) and the causeway. Difference calculated by subtracting temperatures at the causeway from those at Laguna Road.



While the average temperature difference between the Laguna Road and the Causeway was only 1.4˚C from July 2008 to October 2009, temperatures at the shallower Laguna Road location were often 10˚C, and sometimes 15˚C higher in summer than the Causeway. In winter, temperatures at the shallower site averaged 2˚C cooler with extremes 7˚C cooler.

Olympia oysters are sensitive to extremes in water temperature and these extremes, especially high summer temperatures, may prevent Olympia oysters from colonizing shallower waters of the lagoon. In Puget Sound, where the oyster is still abundant, summer temperatures are 18 – 20˚C and winter temperatures 6 – 9˚C. Laboratory research (Davis 1955) found winter mortalities of 100% at -1 – 5˚C.

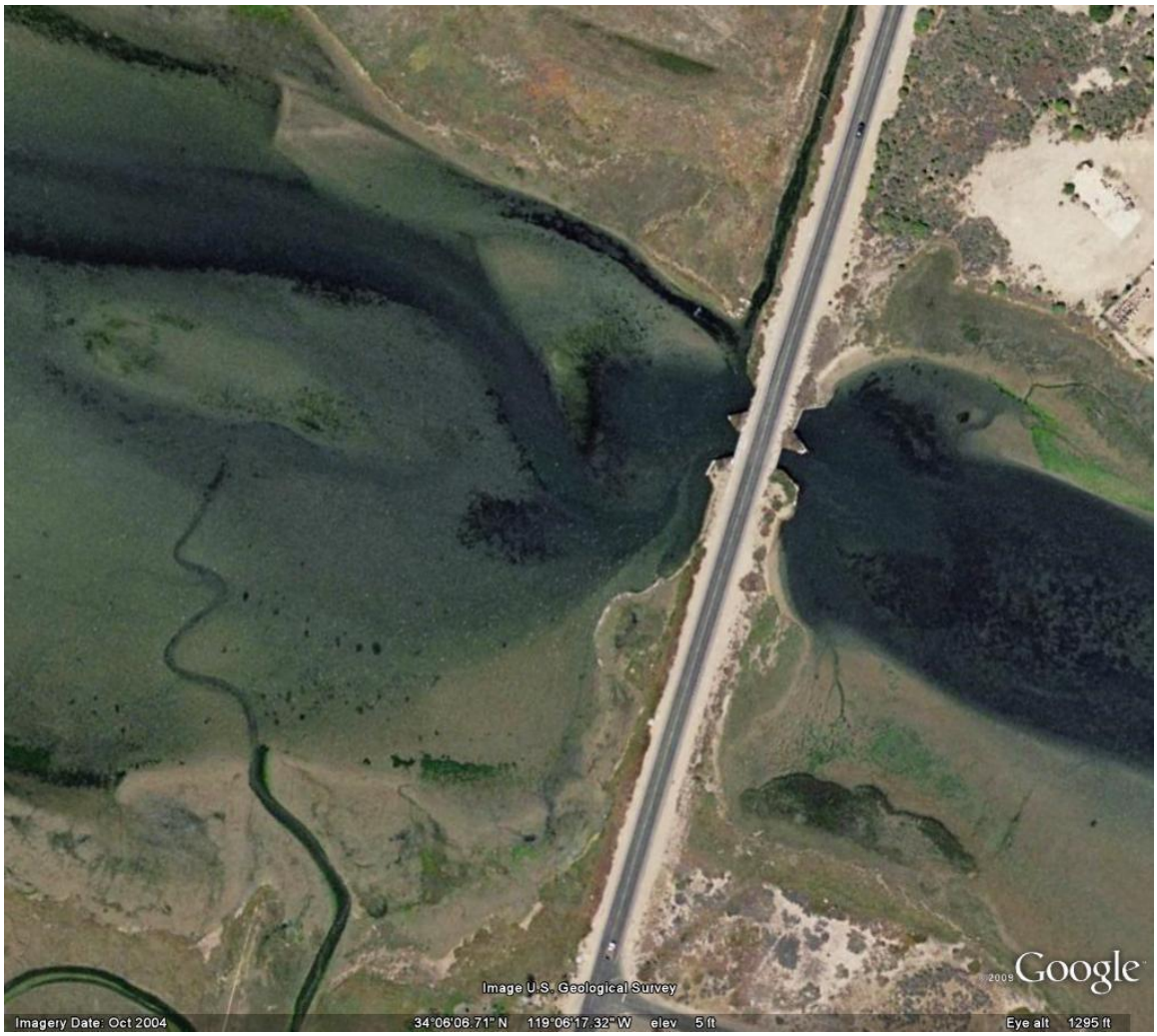
Other oyster species:
Shells and live individuals of Pacific Oysters, *Crassostrea gigas* were found at several locations within the lagoon. The oysters, or shell, were always lone individuals. The locations were as follows:

Shells: Adjacent to the Laguna Road causeway
Live Oysters: Dirt road between Laguna and South G Avenue
Missile site of L Avenue by Building 530

Oyster reef restoration areas in Mugu Lagoon

Surveys of intertidal and sub-tidal flats and bars to the east and west of the Laguna Road causeway found live oysters and oyster shell attached to rock cobble. This cobble remains exposed as a result of the rapid movement of water through the restricted openings of the causeway. Live oysters and many shells were found on the funnel-shaped shoal to left (west) of Laguna Road, Figure 8. The area of this shoal is 2,800 m^2. The larger but lower shoal SW of the funnel shoal is 6,400 m^2. The area to the right (E) of the Laguna Road causeway contains an intertidal shoal 600 – 750 m^2. This shoal is lower than the one to the east and exposed only at the lowest tides. Total area of all three shoals is approximately 1 hectare (2.47 acres).

Figure 8. View of Mugu Lagoon intersected by causeway at Laguna Road. Live oysters and many shells found on the 2,800 m^2 funnel-shaped shoal to left (west) of Laguna Road. Larger shoal SW of the funnel shoal is 6,400 m^2. The area to the right (E) of the causeway contains an intertidal shoal 600 – 750 m^2. Area of all three shoals is approximately 1 hectare (2.47 acres).



Summary and Recommendations

Stressors on the population of Olympic oysters in Mugu Lagoon are as follows:

4. Low adult population – almost the entire adult population of as many as 5,000 to 7,000 oysters is limited to the Laguna Road causeway (note: sub-tidal surveys were not conducted).

5. Lack of substrate – very few hard substrates exist in the lagoon.

6. Temperature extremes – extreme water temperatures resulting from the rapid heating and cooling of shallow waters within the lagoon may stress oysters in many locations where there is hard substrate.

Any restoration effort must address these stressors. Two locations within the lagoon may be suitable for experimental restoration efforts. The shoal to the east of the Laguna Road causeway presents the best location for additional monitoring and initial restoration efforts. Its low elevation is well suited to the Olympia oysters as they favor sub-tidal habitats that offer protection from temperature extremes. Seawater temperatures near the causeway are more moderate than other shallower waters of the lagoon. High velocity flows during each tidal cycle insure that sedimentation rates will be low at this location.

Restoration of native oyster reefs in Mugu Lagoon will provide a range of ecosystem services, as well as educational and social benefits. Reef habitat increases biodiversity, enhancing populations of invertebrates, fishes, birds, and mammals within the lagoon and in adjacent coastal waters as juvenile fishes move offshore as they mature. Oyster reefs filter algae and suspended solids from the water column, forming a food web link between planktonic and benthic communities. Removal of suspended solids increases water clarity, encouraging the growth of eelgrass in surrounding areas. As oyster reefs are established, restoration of eelgrass beds, already planned by the Navy, will have a greater chance of success.

Experimental restoration reefs that are being used with some success in other places are constructed of oyster shell placed in tubes of plastic mesh, a design similar to the collectors used in this survey. These bags are stacked in pyramids three or for wide and high. Bags may be placed on a pallet for easy movement and to keep them out of bottom mud. Bags are secured together. These mini-reefs offer large surface areas and good water flow, much like natural reefs. These reefs should initially be placed to the east of the causeway.

Hatchery production may be necessary to jump start colonization of experimental reefs with oyster spat. Providing suitable shell habitat for oyster settlement in Newtarts Bay, Washington resulted in little increase in the oyster population. Introducing hatchery-raised spat on shell resulted in dramatic population increases and the development of oyster reefs. Should natural recruitment on enhancement reefs be low, spat production at the Ormond Beach Hatchery is possible.

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Appendices

Appendix 1. Total Number of collectors deployed in Mugu Lagoon

24 Vexar Bags filled with shell from Pacific Oysters were deployed at sites in Mugu Lagoon

Bag Location	Mesh Size Inches	Oysters Yes / No	# of Oysters	Date Bag Pulled
Laguna Rd/ So Mugu Rd Intersection (N)	1.5	No	0	12/12/2008
Laguna Rd/ So Mugu Rd Intersection (N)	0.5	No	0	12/12/2008
Laguna Rd, middle (N)	0.5	No	0	10/5/2009
Laguna Rd, middle (N)	1.5	No	0	10/5/2009
Laguna Rd, middle (N)	1.5	Yes	1	10/5/2009
Laguna Rd, dirt road (N)	1.5	No	0	10/5/2009
Laguna Rd, dirt road (N)	1.5	Yes	1	10/5/2009
Laguna Rd, Causeway (NE)	1.5	Yes	3	10/20/2009
Laguna Rd, Causeway (SE)	1.5	Yes	3	10/20/2009
Laguna Rd, Causeway (S)	1.5	Yes	4	10/20/2009
Laguna Rd, Causeway (SW)	1.5	No	0	10/20/2009
Laguna Rd, Causeway (SW)	1.5	No	0	10/20/2009
South G Ave, dirt road (S)	1.5	No	0	12/12/2009
Le Mar St, closer to South G Ave (E)	1.5	No	0	12/13/2008
Le Mar St, closer to South G Ave (E)	1.5	No	0	12/13/2008
Le Mar St, further down (E)	1.5	No	0	12/13/2008
South L Ave (N)	1.5	Yes	3	10/5/2009
South L Ave (N)	1.5	No	0	10/5/2009
South M Ave (S)	1.5	Yes	1	10/5/2009
South M Ave (S)	0.5	No	0	10/5/2009
Missile Site, by building 530 (E)	1.5	No	0	6/26/2009
Missile Site, by building 530 (E)	1.5	No	0	6/26/2009
Aqueduct over Calleguas Creek (SE)	1.5	No	0	8/25/2009
Aqueduct over Calleguas Creek (NE)	1.5	Yes	1	8/21/2009