Mussel Power: Engaging Communities and Improving Urban Water Quality through Nutrient Bioextraction

Environmental Sustainability

Pacific Shellfish Institute

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FollowUp Form

Report Fields

Project Name*

Name of Project

Mussel Power: Engaging Communities and Improving Urban Water Quality through Nutrient Bioextraction

GRANT ADMINISTRATION

Have all the funds from The Russell Family Foundation (TRFF) been spent?*

Yes

If you answered no to the question above, have you submitted an extension request? Please contact Linsey Sauer via e-mail at linsey@trff.org to get an extension request form.

Please submit the extension request before completing the report as we may extend your report deadline as a result of the request.

OUTCOMES

Stated Goals*

For each of the goals outlined in your proposal and subsequent grant agreement, share what you could measure in terms of progress towards that goal. Use the same structure and format as you did in the application (a separate box for each goal, minimum of one goal and a maximum of four).

Goal 1: Implement a test aquaculture system and shellfish “gardens" along Thea Foss Waterway.

In February, April and June 2013, Pacific Shellfish Institute (PSI) staff and 3 students from University of Washington (UW) Tacoma affixed 65 1.5 meter nylon straps beneath existing dock structures at the Center for Urban Waters. Straps provided a substrate for wild blue mussels and other invertebrates and algae to set upon. In May 2013, PSI staff placed an additional 36 straps at Johnny’s Dock and two horizontal straps (114 ft and 120 ft lengths) at Marine Floats. Sites were selected based on willing partnerships, water depth at low tide, and suspected variations in water properties along the length of the Thea Foss Waterway.

UW-Tacoma students collected data on mussel number and weight, per strap, during summer and fall 2013 at the Center for Urban Waters. For comparison analyses, and to gain additional field sampling experience, students also assisted with data collection in Budd Inlet, as part of a separate PSI project funded through an EPA grant administered by the Washington Department Ecology. Between October 2013 and March 2014, PSI staff, UW-Tacoma students, and a student from The Evergreen State College collected monthly water quality data including temperature (˚C), salinity (ppt), dissolved oxygen (DO%), and pH. Overall site conditions, mussel growth (lengths and composite weights) and fouling communities were also recorded. Between November 2013 and January 2014, flow data was also collected at the Center for Urban Waters and Johnny’s Dock using an acoustic doppler flow meter. In mid-March, mussels were harvested and samples submitted to AmTest Laboratories for analytical testing of nutrients (nitrogen and phosphorus), metals (As, Cd, Pb, Cu, Ni, Hg), PAHs and PCBs. Six straps from Johnny’s Dock were also transferred to Foss

Waterway Seaport, and an additional 20 straps were placed to catch new mussel set, for public outreach activities described under Goal 4. All data were analyzed by PSI staff and UW-Tacoma students for comparison to PSI's Budd Inlet nutrient bioextraction project, and to determine nutrient removal services of mussels grown in Thea Foss (Goal 2).

Goal 2: Determine nutrient removal services of mussels grown in Thea Foss Waterway.

The goal of the pilot trials was to evaluate the feasibility of culturing natural mussel set to remove nutrients from an urbanized watershed such as the Thea Foss Waterway. The pilot trials helped determine the timing of natural mussel set (August-September in 2013), mussel growth rates, percent nitrogen and phosphorus in mussels, and the level of mussel contamination upon harvest. The trials also involved creating community partnerships that use the demonstration gardens as an educational tool to engage citizens in local water quality issues. Determining how many nutrients the installations removed is only important insomuch as this information can be extrapolated on a larger scale.

To this end, the amount of nitrogen and phosphorus removed from the Thea Foss Waterway was calculated by multiplying the weight of harvested mussels by the total percent nitrogen in mussels. In mid-March 2014, a total of 339 pounds were harvested at the 3 sites: 211 lbs at the Center for Urban Waters, 107 lbs at Johnny's Dock and 21 lbs at Marine Floats. Laboratory results indicated that total percent nitrogen (wet weight) in mussels was 0.41%, 0.44%, and 0.41% at the Center for Urban Waters, Johnny's Dock, and Marine Floats, respectively. Percent phosphorus was 0.03% at all 3 sites. In comparison, nitrogen and phosphorus percentages for Budd Inlet averaged 1.0% and 0.08%. Site conditions at Marine Floats including shallow water depths, increased predation by large sea stars and sedimentation making this site an unsuitable location. It should also be noted that the biomass total does not include 6 mussel straps that were transferred to Foss Waterway Seaport for fall boat-based programs.

The three demonstration sites therefore removed 1.4 lbs of nitrogen (339 lbs x .0042) and 0.1 lbs of phosphorus (339 lbs x .0003). To determine if nitrogen content increases with size, additional mussel samples were collected from Foss Waterway Seaport (45.9 mm, 8.7g) in mid-November (2014) and submitted to Amtest for nitrogen analysis. Results indicate that percent nitrogen increased from 0.42% to 0.675% (average of 3 samples) with increased growth. With these new numbers, 339 lbs of mussels would remove 2.29 lbs of nitrogen. To extract 1000 lbs of nitrogen, the average nitrogen output of 100 people per year, approximately 148,149 lbs of large mussels would need to be removed.

Goal 3: Assess the feasibility of producing marketable soil compost from the demonstration farm.

Mussels were harvested in March, chipped at Marine Floats and transferred to the Washington Corrections Center for Women in Gig Harbor, for composting. Attendees included Eric Heinitz of Washington Department of Corrections (WDOC), 3 WDOC staff, Dr. Bonnie Becker (UW-Tacoma), 3 UW-Tacoma students, Dan Barth (shellfish farmer), and 2 PSI staff. Inmates assisted with all aspects of composting. WDOC's composting facility hosts an Enviro-Drum in-vessel composting system originally designed for dairy waste. Chipped mussels and feedstocks (recycled/chipped bed mattress frames, shredded paper, kitchen waste) were loaded into a mixer and conveyed into the rotating drum via a feed auger. Drum temperatures were monitored to ensure pathogen control.

On harvest day, 3 mussel composites from each of the Thea Foss Waterway sites were delivered to AmTest Laboratories for metal, PAH, and PCB analyses. PAHs and PCBs in all mussel samples were below the detection limit, and metals were all well below limits set by Ecology's solid waste standards for composting facilities (WAC 173-350-220). Thea Foss Waterway mussel compost was not submitted to SoilTest due to the small amount generated, but two batches of mussel compost from Budd Inlet were tested for a variety of standard compost metrics. Results indicated that the mussel compost is of suitable quality for agricultural and garden use. The C/N ratios ranged from 14-22 depending on feedstocks added. Of the macronutrients, only calcium exceeded the typical range, a unique signature reflecting the calcium carbonate contained in the mussel shells. Soils west of the Cascades are often depleted in calcium, making mussel compost an attractive amendment. Heavy metals were well below compost standards and sodium levels were within a safe range.

Vegetative growth trials using marigold and sunflower seeds were performed from July through September 2014, using a control (SunGro potting soil) and three compost treatments: SunGro combined with 1) Cedar Grove compost; 2) Budd Inlet mussel compost; and 3) Quartermaster Harbor mussel compost. All plants performed better with compost, with Quartermaster Harbor germination and seedling performance exceeding other blends. Upon completion, plants were used for classroom presentations and compost displays.

Goal 4: Increase local stakeholder awareness of, and engagement in, urban water quality mitigation needs and strategies.

The demonstration gardens were used to build partnerships among waterfront institutions, and engage citizens, by increasing awareness of local water quality issues. The project provided many opportunities for student involvement. PSI mentored 4 UW-Tacoma students under professor Bonnie Becker (UW-Tacoma), and 1 Evergreen State College student, in aspects of data collection, environmental education, and mussel composting. One student presented a poster at the Salish Sea Ecosystem Conference, held in Seattle in 2014. PSI delivered one lecture to Bonnie Becker's UWT students in spring 2013, and PSI and Dr. Becker presented to inmates at WDOC's Sustainability in Prisons Lecture Series in June 2014. One inmate in attendance at the lecture series shared that she had helped spread the mussel compost into several flower beds at the facility.

Jan Adams, Education Director at Foss Waterway Seaport, learned about the project and elected to participate in the final mussel sampling and harvest. Jan invited PSI to attend the annual STEM K-5 meeting hosted at Foss Waterway Seaport, present information about the project, and provide examples of interactive science-based activities available to students. Activities were then incorporated into 8 of Foss Waterway Seaport's boat-based programs, reaching 150 students. In addition to hosting approximately 30 mussel straps on-site, the Seaport incorporated mussel compost and interpretive sign into their landscaping.

Classroom presentations were developed for Grades 1-2 (30 min) and Grades 4-5 (50 min). Activities included handling live shellfish, viewing plankton under microscopes, acting out the process of eutrophication, modelling proper dog waste scooping procedures using PSI's Scoopy Doo mascot, and performing a mussel filtration demonstration. Presentations were delivered to over 420 K-5 students from 14 classes at Delong and Blix Elementary Schools. The presentations were very well received and PSI continues to receive additional requests. PSI further promoted the project at public events and conferences regionally, and at national shellfish research, restoration, and ecosystem services conferences. One-page information sheets and "Surf-to-Turf" mussel compost samples were distributed at public events and conferences, and the project was advertised on PSI's website and Facebook page.

Qualitative Evaluation*

Please share one story or anecdote that best illustrates a success that you had with this grant.

In October, 2014, Kainoa Higgins, Science Instructor at the Tacoma Science and Math Institute (SAMI), contacted PSI to discuss a brewing idea for a proposal. Kainoa recently traveled to New York where he visited Harbor School's Billion Oyster Project (BOP). Founded by Peter Malinowski, the BOP involves thousands of public high school students in the restoration of 1 billion oysters to New York Harbor over the next 20 years. Through core academic classes, students involve themselves in all aspects of restoration from growing algae culture and rearing oysters in the hatchery to planting oysters in the Harbor and organizing shell recycling programs.

Kainoa envisions "The Million Mussel Project" involving 100 high school students from 2 Tacoma public schools in restoring water quality in the Thea Foss Waterway and connecting students to the water. Students would establish nutrient bioextraction sites using natural mussel set along the length of the Thea Foss Waterway. Students would engage in water quality monitoring, site selection, data collection, mussel harvest, and composting. This work would build on results and partnerships developed through this project, particularly with Jan Adams at Foss Waterway Seaport. PSI would offer technical assistance as needed. Kainoa has submitted two proposals for this work.

In December 2014, PSI attended the International Conference on Shellfish Restoration in Charleston, SC, to present the Mussel Power project. Malinowski and 6 students from New York City attended the conference to learn about ongoing restoration efforts and share their experiences with the BOP. The students gave an inspirational presentation (not a dry eye in the house!) that resulted in a standing ovation from the entire audience. The students were asked to state what they learned from attending the conference. Among many insightful responses, one student commented that he was inspired by the work that others were doing and hopes that others may find inspiration from the BOP. I could not have been more pleased to tell this student how important his work was and how it is inspiring our future restoration efforts in Washington State!

While this project was successful in providing valuable information to expand this work in the future, the REAL success was in the new partnerships developed throughout the project (Washington Department of Corrections, Foss Waterway Seaport, Tacoma Science and Math Institute) and the ripple effect that this work will have for years to come.

What experience or anecdote best illustrates the challenges you encountered? Please explain.*

Overall, the mussel installations, outreach components, and composting trials were successful. The project only encountered several minor challenges along the way. First, instead of planting mussel seed from Penn Cove, the project relied on natural mussel set, based on results from Quartermaster Harbor and Budd Inlet. The timing of the mussel set was later than expected along the Thea Foss Waterway (September, as opposed to June) possibly due to cooler water temperatures in central Puget Sound. Without the productive summer growth months, UW-Tacoma students had very little mussel biomass to work with during fall and winter. In response, students collected data at both Budd Inlet and Thea Foss Waterway demonstration sites, allowing them to perform a comparative analysis between the two locations. This work was summarized in a poster, developed by a UW-Tacoma student, and displayed at the Salish Sea Ecosystems Conference in May 2014.

Second, compost trials were to be performed at the UW-Tacoma composting facility. The composing program was initiated in 2009, but is no longer in operation. In response, PSI identified WDOC's facility in Gig Harbor as a more suitable choice. While this solution was ideal in many ways, it eliminated the ability to conduct research that was originally described in the proposal (e.g. testing the length of composting treatment, various compost mixtures) due to logistical roadblocks.

Finally, PSI encountered challenges related to college student participation. Overall, the 4 UW-Tacoma students did an admirable job designing a sampling plan, collecting data and attending the mussel harvest and composting events. Still, several tasks remained unfinished and are described in more detail in the following section.

Were there unanticipated aspects of the work under this grant? If yes, how did your organization approach the work differently as a result?

Student participation, both at the college and elementary level, were some of the strongest and most rewarding aspects of the project. One unanticipated aspect of the work, however, was recognizing that professors at academic institutions are often extremely overbooked and the availability of student commitment over a longer time frame can be challenging.

In spring 2013, several UW-Tacoma students, under the guidance of Professor Bonnie Becker, designed their own sampling plan. This plan would be completed in addition to the monthly water quality, fouling community and growth measurements collected between October 2013 and March 2014. The plan included collecting mussels in July and September 2013, drying them, and submitting samples to an internal UW laboratory for nitrogen and metals analyses. The sampling was designed to answer the following questions: How do nutrient and metal concentrations differ between the shell, tissue, and mussel size? How do nutrient and metal levels in mussels vary between Budd Inlet and Thea Foss Waterway? How do nutrient levels in mussels change over time and with water depth?

The samples were never submitted to the lab for analysis which may have been due to procedural billing issues related to obtaining an internal rate. Regardless, the students were still able to compare differences between growth rates, nutrients and metals between Budd Inlet and the Thea Foss Waterway using data collected later in the season. One student presented a poster of the results at a professional conference.

Vegetative plant growth trials were also expected to take place during summer of 2014 using UW-Tacoma students. Student availability was low during this time and the trials were instead carried out by PSI staff.

In the future, PSI would take a more active role in monitoring student progress instead of relying entirely on faculty oversight. PSI would work with students to develop a plan that can be realistically completed over a shorter time frame, and urge completion of tasks according to a specific timeline.

Collaborations*

Explain any collaborations that were important to this grant and whether or not you intend to continue collaborating in the future.

PSI created several new partnerships during the course of this project including Jan Adams at Foss Waterway Seaport, Julie Vanneste and Tiffany Webb from the Sustainability in Prisons Program, and Kainoa Higgins from Tacoma's Science and Math Institute. PSI intends to collaborate with all three groups in the future and has already initiated steps to do so. For example, PSI is currently implementing the "Beach Sweepers – Keeping Debris out of the Sea" program, funded by TRFF. Jan Adams has shared both resources and activities related to the marine debris and microplastics education performed at Foss Waterway Seaport. In exchange, PSI has provided Foss Waterway Seaport with albatross boluses for their dissection activities. Both PSI and Foss Waterway Seaport share similar outreach goals and will undoubtedly maintain an ongoing relationship.

PSI's involvement with WDOC's Sustainability in Prisons Program has been extremely rewarding. PSI has conducted presentations and mussel compost trials with inmates at both the Cedar Creek (Rochester) and Washington Corrections Center for Women (Gig Harbor) facilities. Since then, PSI and WDOC have discussed partnering on future projects related to marine algae composting and testing alternatives to landfilling dog waste.

Finally, PSI looks forward to working with Kainoa Higgins on the "Million Mussel Project" along the Thea Foss Waterway, should funding be secured to do so. This bold project would be the perfect way to engage students and apply what we have learned from the Quartermaster Harbor, Budd Inlet, and Thea Foss Waterway nutrient bioextraction projects to date.

BUDGET

Please upload your actual budget compared to proposed budget for this grant. If you have any comments or narrative about the budget enter it in the text box below. Your proposed budget can be found in your original online proposal*

PSI Mussel Power Budget as Expended Jan2015.pdf

PSI's budget for this project was altered slightly to accommodate new partnerships described in the collaboration section, which filled the outreach need originally budgeted for the Puget Sound Restoration Fund. Similarly, one incomplete component (stable isotope analysis) was originally budgeted through a partnership with Taylor Shellfish, but was moved to UW-Tacoma due to their internal capacity and desire to conduct the work. Unfortunately, as described in the challenges section above, the analysis was not competed. PSI's original budget also did not include travel for conferences and regional presentations, which were ultimately essential and extremely valuable to the project (see Qualitative Evaluation section, above). Accordingly, the travel budget was exceeded to accommodate expenses associated with conference

attendance and presentations, but this amount was simply re-allocated from PSI salaries. Similarly, the supplies budget was exceeded, but was made up in reduced PSI salary costs to the project.

ATTACHMENTS

If you generated any products with our funding, please reach out to your TRFF Point of Contact (POC) to discuss if we need an electronic or paper copy. If you do not know who your POC is, please reference your award letter.

Please put any photos that you would like to share with us in one document and upload it. There is a size limit of 10 MB If you have video that you would like to share with us, please provide us with a link in the text box below or send it to your POC.

PSI Attachments For Mussel Power.pdf

CAPACITY

Provide a brief assessment of your organization's overall health and include any pressing internal capacity needs.*

Although PSI's Executive Director left the organization during this project's timeline, a new Executive Director was hired from within the organization, resulting in a leaner but ultimately more robust organization with a consistent approach to research and outreach efforts. PSI funding levels (which are dictated by grants and private contracts secured by the organization) do not currently allow additional staff to be hired, but current staff are employed to the level they desire, with the exception of one senior scientist. The funding climate for scientific research, from which PSI's budget is largely derived, remains challenging. Nonetheless, PSI continues to obtain grants and contracts that maintain necessary funding levels to retain current staff—who are highly capable, valuable assets to the organization—and periodic student interns and scientific technicians. Despite the challenging budget climate, PSI was able to expand benefits, by way of individual retirement accounts, to all regular staff (employed at ½-time or more) in late 2014, and provide a 5% raise to all PSI staff.

One pressing internal capacity need for PSI is to reinvest in personal computer hardware. PSI has maintained the same five personal computers, and two laptop computers, for nearly a decade. The machines are becoming increasingly difficult to maintain, especially given the sophisticated software we utilize on a daily basis. Because most research grants do not allow the purchase of permanent equipment, such as computers, replacing staff computers has been a budgeting challenge. We are currently seeking funding to address this need, and have identified one foundation that we hope will enable PSI to overcome this need.

FEEDBACK FOR FOUNDATION

How can TRFF better support the work of its grantees?

More networking opportunities, between existing and past grantees, might be helpful.

Please provide any comments / suggestions that may help us improve our on-line reporting process.

None at this time.

File Attachment Summary

Applicant File Uploads

- PSI Mussel Power Budget as Expended Jan2015.pdf
- PSI Attachments For Mussel Power.pdf

Mussel Power: Shellfish Bioextraction Demonstrations along the Thea Foss Waterway

	Cum Total	Total Budget	Budget Remaining
Salaries	-		
Total Salaries	39,266	40,090	824
Benefits @35%	12,095	14,031	1,936
	-		-
Supplies	4,851	2,079	(2,772)
Travel	5,198	500	(4,698)
	-		-
Registration	1,290		(1,290)
Professional-UW	9,000	9,000	-
Professional-PSRF	-	4,000	4,000
Professional-Taylor	-	2,000	2,000
	-		
Total	71,700	71,700	0

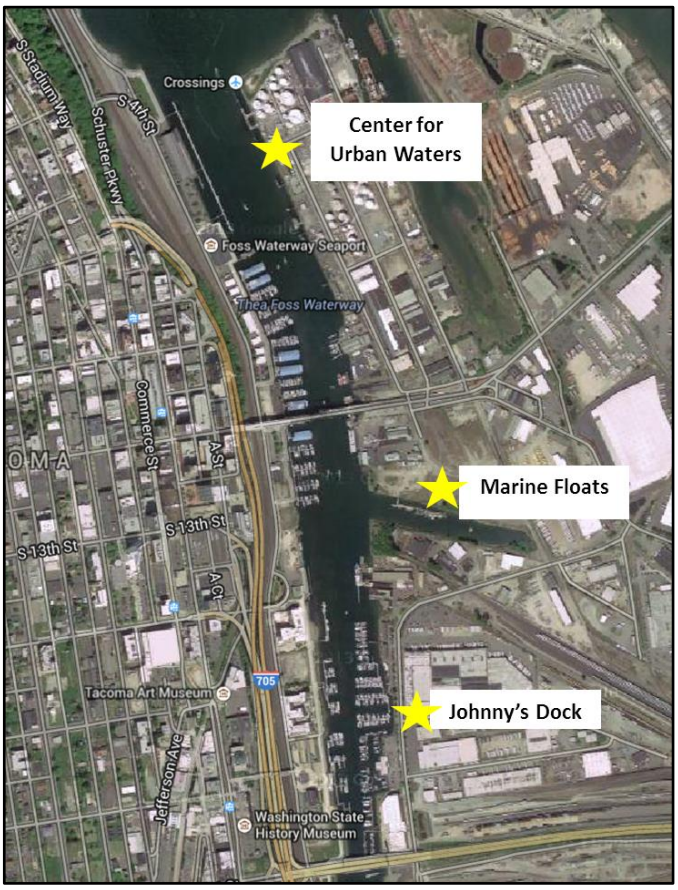


Figure 1. Mussel demonstration sites, Thea Foss Waterway

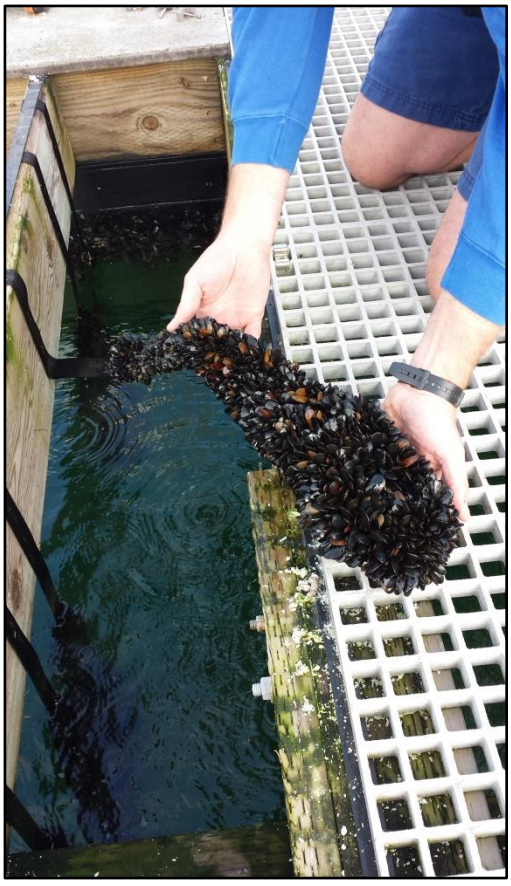


Figure 2. Mussel strap, Center for Urban Waters

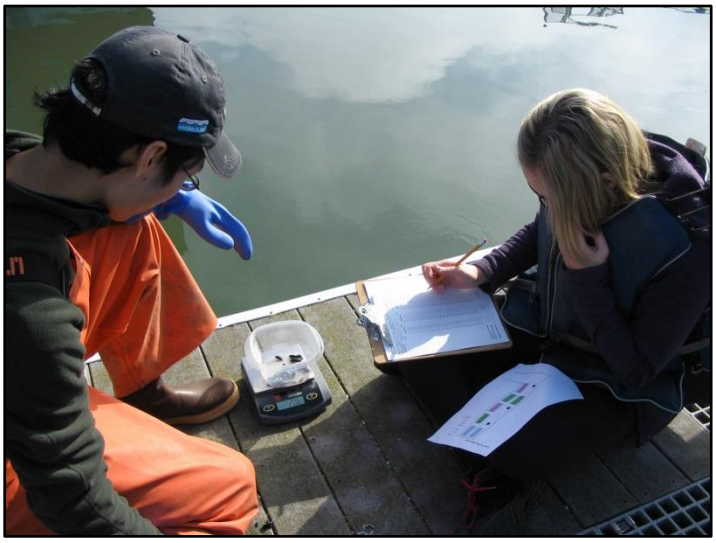


Figure 3. William, Megan (UWT) and Terence (PSI) checking straps and collecting data

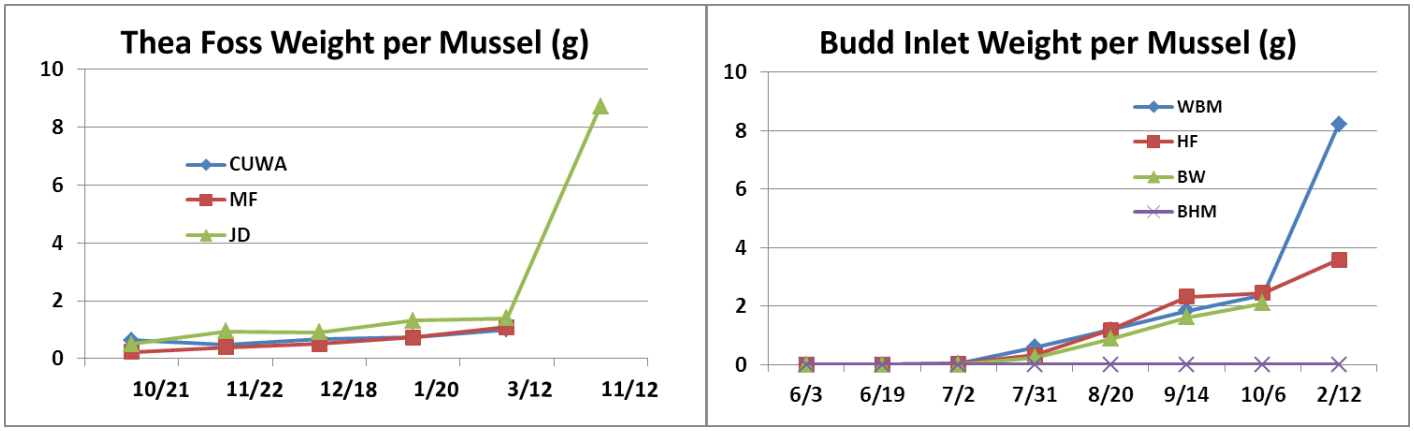


Figure 4. Weights/mussel (live) at Thea Foss and Budd Inlet. In spring, 6 straps were relocated to Foss Waterway Seaport and retested in fall.

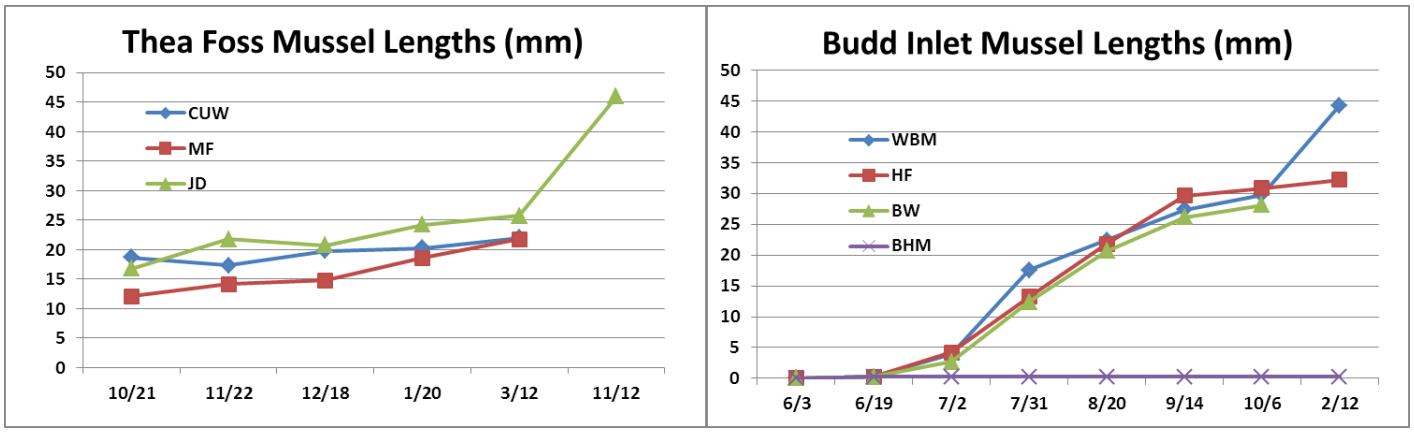


Figure 5. Mussel lengths at Thea Foss and Budd Inlet

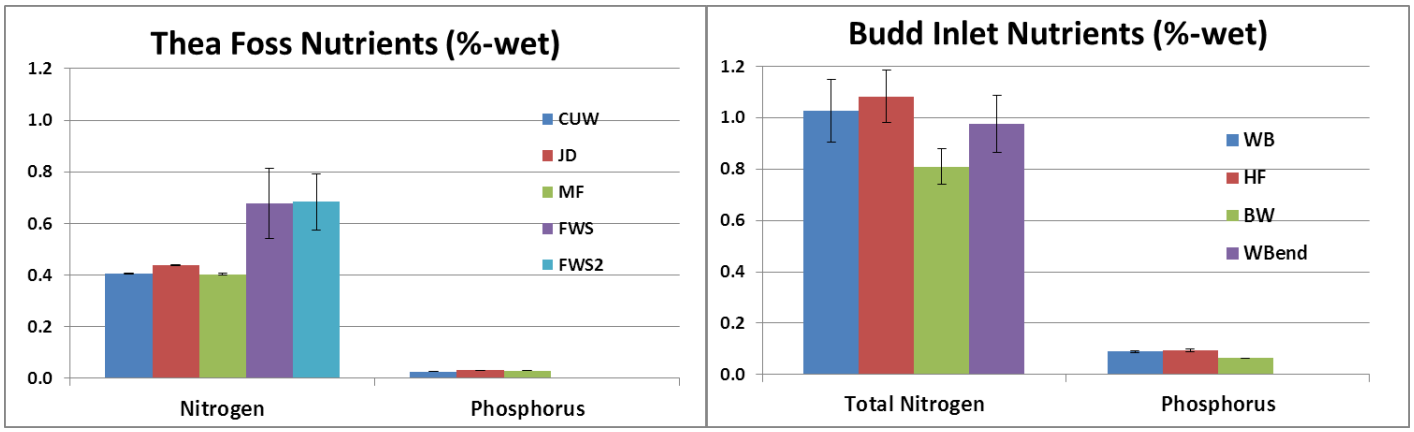


Figure 6. Percent nutrients (wet weight) in mussels (tissue and shell combined) at Thea Foss and Budd Inlet. Mussels transferred from Johnny's Dock (JD) to Foss Waterway Seaport (FWS) were retested for Nitrogen in November.

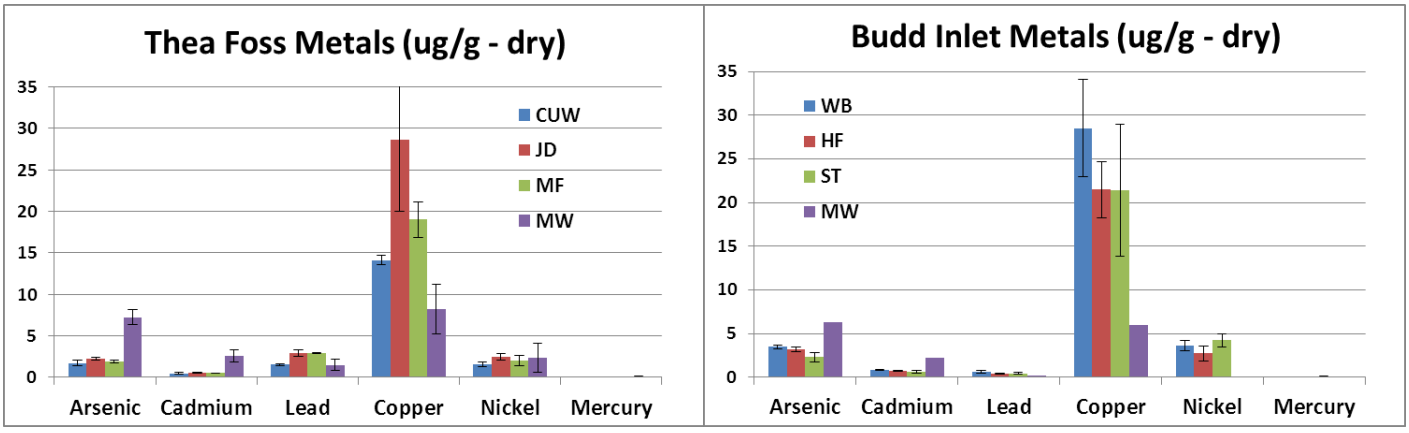


Figure 7. Metal concentrations in mussels (tissue and shell combined). MW=Mussel Watch. Nickel values are below Detection Limit.

Figure 8. Andy Suhrbier and Steven Booth chipping mussels at Marine Floats location

Figure 9. Composting mussels at the Washington Correction Center for Women, Gig Harbor.

Figure 10. WDOC's Earth Drum composting system by DT Environmental

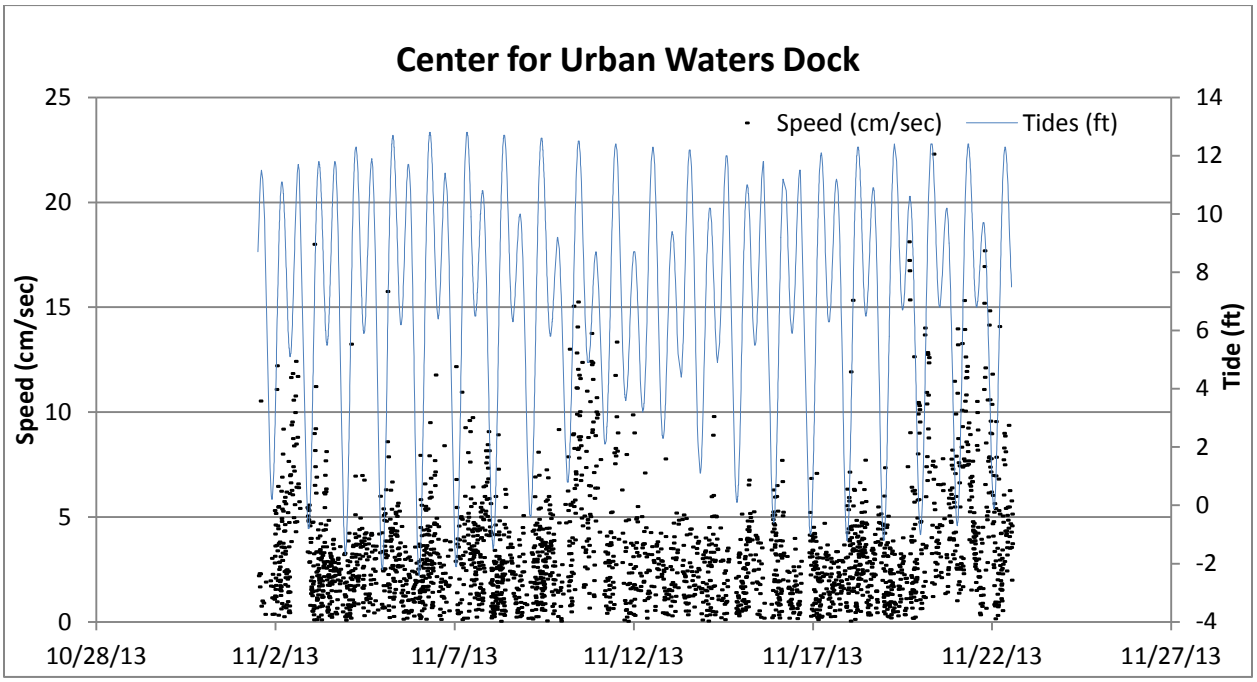
Figure 11. Vegetative growth trials (July-Sept 2014). From left to right: Green Pet dog waste compost, Quartermaster Harbor mussel compost (vermicomposted), Budd Inlet compost, Cedar Grove compost, SunGro potting soil.

Figure 12. Seastar predation at Marine Floats

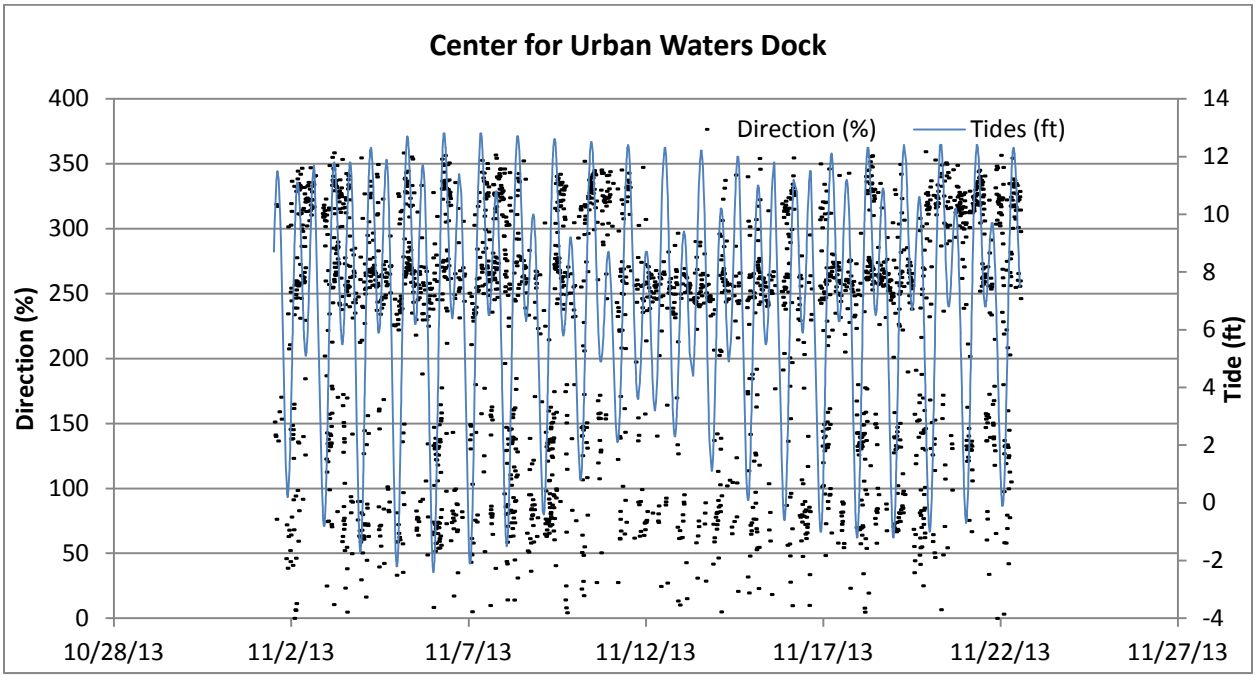
Figure 13. Amy Maarsingh's 1st and 2nd graders from DeLong Elementary, Tacoma, learn about shellfish, plankton and what they can do to protect Puget Sound water quality.

Figure 14. Jan Adams checks mussel straps at Foss Waterway Seaport

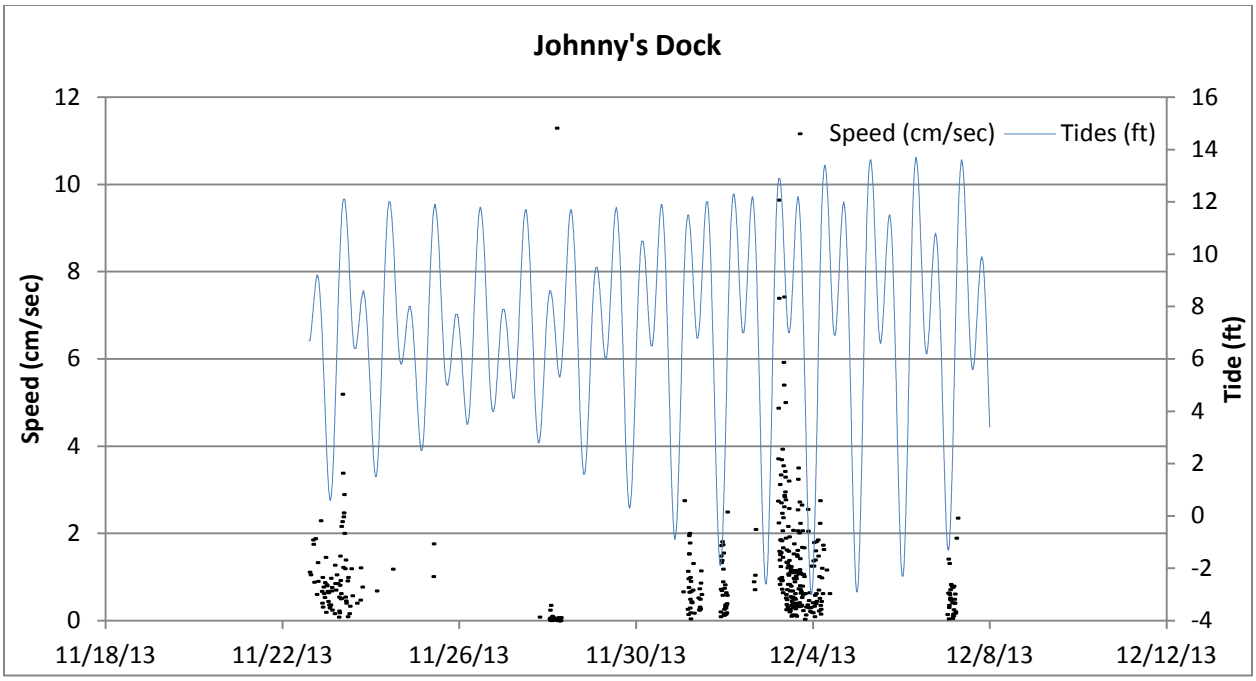
2013 Current Meter Growout Site Data.



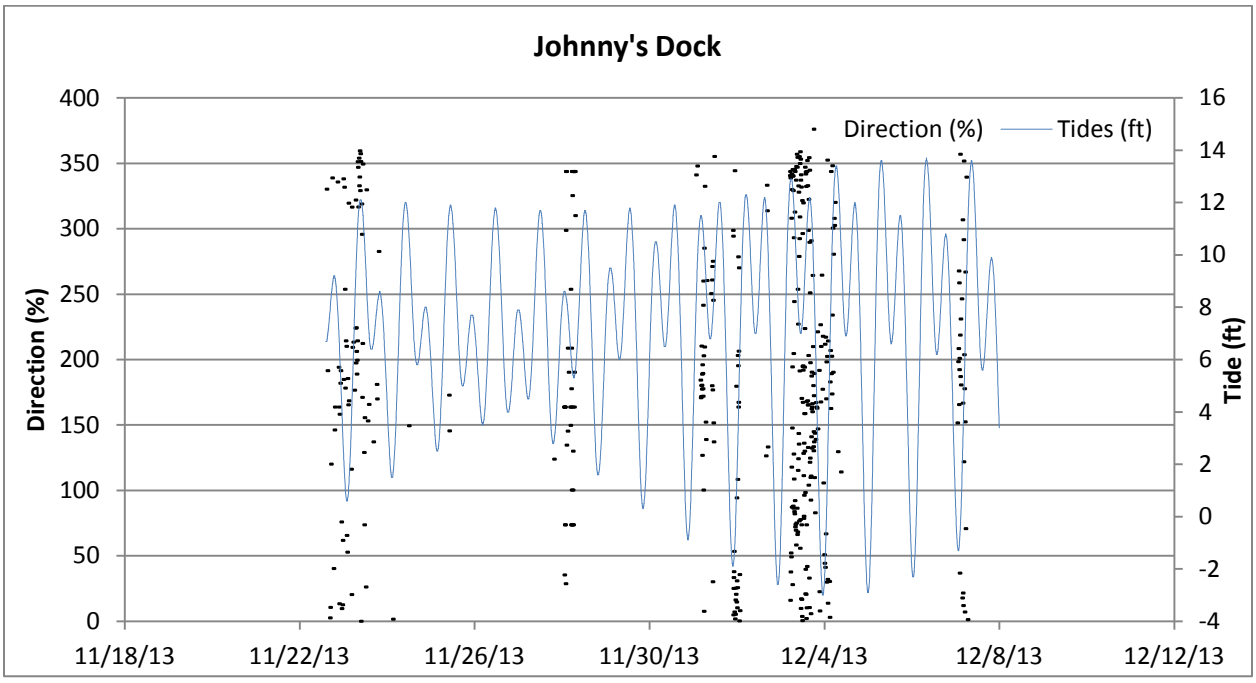
Average Speed 3.29 cm/sec.



Flow consistently traveled diagonally under the dock E/SE and W/NW.



Average Speed 1.22 cm/sec. (Data was limited due to Macroalgae fouling.)

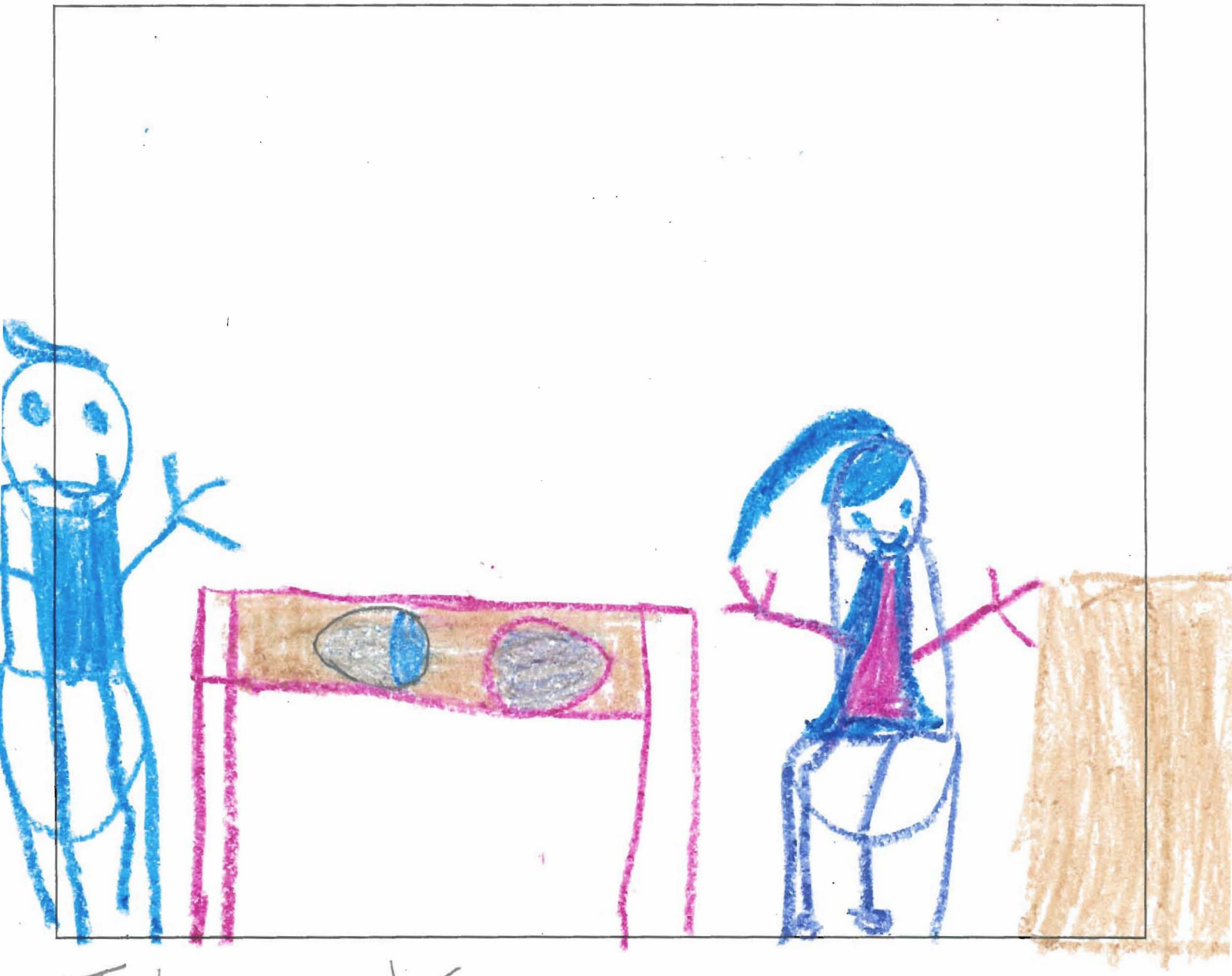


Flow was oriented transverse under the dock in N and S direction. (Data was limited due to Macroalgae fouling.)

Name Kyleigh Date 10-24-14

Thank you For all you Help with the puget Sound and all the athere Diffint kinds fo animal and plants leting us talk a loch in - - microscopes.

• Betania ④ 10-24-14



Thank you for teaching us about mussels.

NIKY 10-2014

THANK YOU for teaching us about

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Thank you for teaching us about microscopes.

Mussel cultivation as a mitigation tool for eutrophic waters in Puget Sound, Washington

Ashley Clements, Megan Hintz, Aimee Christy, Andy Suhrbier, Dan Cheney, and Bonnie Becker
Interdisciplinary Arts and Sciences, University of Washington Tacoma, WA
Pacific Shellfish Institute

Problem Statement

- Eutrophication can cause hypoxia and loss of biodiversity in coastal ecosystems (Hammer 1996)
- Nitrogen contributes significantly to the nutrient enrichment of coastal ecosystems (McKinney et al. 2001)
- Mussels have been cultivated and used as a mitigation tool for the removal of nutrients to help restore eutrophic waters (Hammer 1996)

Project Objectives

- Determine nutrient remediation as a tool for remediation in Puget Sound, Washington
  - At Thea Foss, Tacoma and Budd Inlet, Olympia nylon straps were used to harvest the native bay mussel, *Mytilus trossulus*
- Determine how much nitrogen can be removed from mussel biomass
- Evaluate best management practices by examining various factors; time of deployment, mussel growth along depth, and variability among locations
- Recycle remaining mussels for composting purposes

Figure 2. Line placed in Thea Foss before mussel settlement

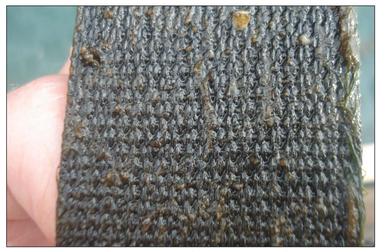


Figure 3. Up close image of nylon strap after deployment before mussel settlement

Amount of Nitrogen in Mussel Biomass

- Our goal is to compare nitrogen from the biomass of mussels to the overall influx of nitrogen entering Thea Foss Waterway
- Analysis of nutrient content of mussels is pending
- Compare the literature amount of nitrogen to the overall biomass of each line at Thea Foss
- Approximately 1% of mussel weight is nitrogen (Peterson et al. 2004 as cited by Stadmark and Conley 2011)
- Looking at average wet mussel weight per line
  - 8,784.8 ± 1,595 grams = 87.8 ± 15.9 grams of nitrogen
  - 66 lines were put out
  - Total 5.80E+05 ± 1.05E+05 grams of nitrogen
- Approximately 580,000 grams of nitrogen from mussel biomass
- This is equivalent to more than twice the base flow runoff of nitrogen from a square km of residential area for a year (Roberts and Kolosseus 2011)

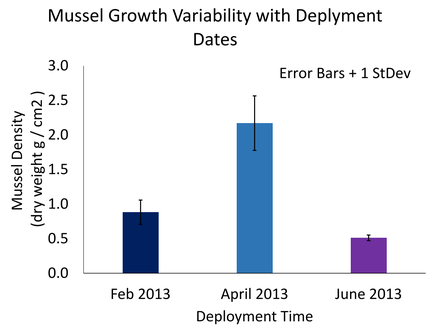
Figure 3. Mussel line form the Thea Foss during the September sampling

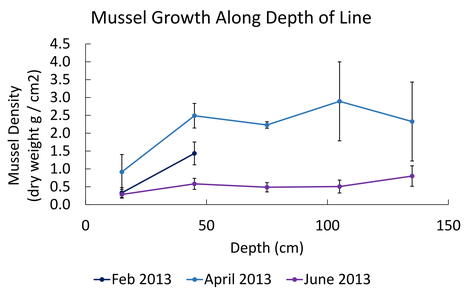
Determining Best Management Practices

- Lines were placed off the dock at the Center for Urban Waters in the Thea Foss
- Lines were placed in the water during February, April, and June 2013.
- The purpose is to understand season peaks in mussel growth

Deployment of Lines

- The lines placed in April did the best with an average mussel dry weight density of 2.17 ± 0.39 g/cm^2 , where February lines had an average mussel dry weight density of 0.88 ± 0.17 g/cm^2 , and June lines 0.51 ± 0.04 g/cm^2



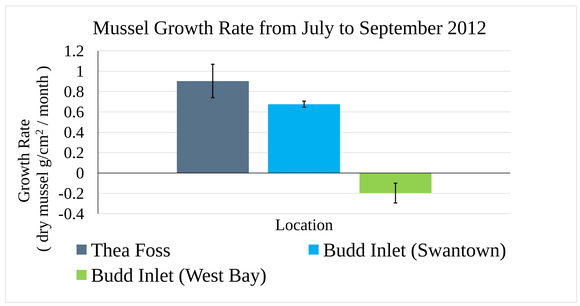


Length of Lines

- The top 15 cm of the line had the least growth for all deployment months
- Growth continued through the length of the lines with a length of 143 cm

Variability Among Locations

- In addition to the lines placed in the Thea Foss we sampled lines placed at West Bay and Swantown in Budd Inlet
- The lines in Budd Inlet were placed in May 2013
- Lines were sampled in July 2013 and September 2013
- July 2013 Sampling
  - There was no growth on the lines in the Thea Foss
  - There was more growth in West Bay with an average dry weight mussel density of 0.74 ± 0.04 g/cm^2 than Swantown of 0.14 ± 0.02 g/cm^2



- September 2013 Sampling
  - Highest growth density was in the Thea Foss 2.17 ± 0.39 g/cm^2
  - Growth at Swantown increased 1.76 ± 0.09 g/cm^2
  - Growth at West Bay declined to 0.27 ± 0.26 g/cm^2 , the mussels had grown two heavy and started falling off the lines
- Mussel settlement occurred earlier in Budd Inlet than Thea Foss
- Growth started earlier in Budd Inlet than Thea Foss

Composting Resulting Mussels

- Mussel biomass was removed from the waterway, and will be composted for landscaping purposes
  - Mussels were chipped in wood chipper
  - Organic material, sawdust, and woodchips were combined with mussel waste to provide nutrients in the soil
  - Mussel shells can be identified in fertilizer depending on equipment
- Analysis of contamination of mussels is still ongoing, but mussels collected near by as part of Mussel Watch were not found to contain harmful contaminants

Figure 4. Mussels were mixed with other materials at the Washington Corrections Center for Women using their Enviro-Drum for composting

Recommendations

- Mussel farming is a viable option for removal of excess nutrients, but certain best practices should be applied
- Harvesting mussels in Budd Inlet, Olympia will have a larger biomass than Thea Foss, Tacoma
- Deployment of lines should be during spring season
- Lines should be periodically checked and removed before too much growth falls off of the lines

Figure 5. Line that was removed with limited mussel growth

Figure 6. Mussels that are falling off of line

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