

Update Report

Period 2/1/2013 - 1/31/2014

Project R/COCC-3 - Using Microbiota for the Evaluation and Monitoring of Puget Sound Ecosystems

STUDENTS SUPPORTED

Coberly, Jerilyn, jerilync@uw.edu, University of Washington, Earth and Space Science, status cont, field of study Geology, advisor Elizabeth Nesbitt, degree type BS, degree date 2014-06-01, degree completed this period No
Student Project Title Ecosystem Degradation as Indicated by Benthic Foraminifera in Sinclair and Dyes Inlets, Puget Sound, Washington

Involvement with Sea Grant This Period Student researcher

Post-Graduation Plans Work for an environmental consulting company

Danner, Adrienne, adann83@uw.edu, University of Washington, Earth and Space Sciences, status cont, field of study Environmental geoscience, advisor Elizabeth Nesbitt, degree type BS, degree date 2014-06-01, degree completed this period No
Student Project Title Temporal assessment of foraminiferal assemblages in Semiahmoo Bay, Puget Sound

Involvement with Sea Grant This Period Student researcher, honors project

Post-Graduation Plans Graduate school - Puget Sound Foraminifera Project

Devita, Jaqueline, jacdivita@gmail.com, University of Washington, Earth and Space Sciences, status new, field of study geology, advisor Elizabeth Nesbitt, degree type BS, degree date 2015-06-01, degree completed this period No
Student Project Title none

Involvement with Sea Grant This Period paid student research assistant

Post-Graduation Plans none

Hansen, Chase, chase44h@uw.edu, University of Washington, Earth and Space Sciences, status cont, field of study Environmental geoscience, advisor Elizabeth Nesbitt, degree type BS, degree date 2014-06-01, degree completed this period No
Student Project Title An Atlas of Puget Sound Foraminifera technical aspects of photographing microscopic subjects

Involvement with Sea Grant This Period Student Researcher

Post-Graduation Plans Graduate school

Wolfley, Raeanne, rfw4@u.washington.eduMS, University of Washington, Earth and Space Sciences, status new, field of study Geology, advisor Elizabeth Nesbitt, degree type BS, degree date 2015-06-01, degree completed this period No
Student Project Title Benthic foraminifera of Possession Sound and Everett waterways, Puget Sound

Involvement with Sea Grant This Period Student Researcher

Post-Graduation Plans none

Zhang, Bijia, bijaz@uw.edu, University of Washington, Earth and Space Sciences, status cont, field of study Economic geology, advisor Elizabeth Nesbitt, degree type BS, degree date 2014-06-01, degree completed this period No
Student Project Title Foraminiferal assemblages record anthropogenic pollution in Elliott Bay, Puget Sound, Washington.

Involvement with Sea Grant This Period Student researcher

Post-Graduation Plans Graduate school - accepted at Rice University

CONFERENCES / PRESENTATIONS

Behind the Scenes night at the Burke Museum Research Programs, public/profession presentation, 250 attendees, 2013-02-20

ADDITIONAL METRICS

K-12 Students Reached	Acres of degraded ecosystems restored as a result of Sea Grant activities
Curricula Developed	Resource Managers who use Ecosystem-Based Approaches to Management
Volunteer Hours	HACCP - Number of people with new certifications
Cumulative Clean Marina Program - certifications	

PATENTS AND ECONOMIC BENEFITS

No Benefits Reported This Period

TOOLS, TECH, AND INFORMATION SERVICES

No Tools, Tech, or Information Services Reported This Period

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Safe and sustainable seafood

Number of stakeholders modifying practices

Actual (2/1/2013 - 1/31/2014)

Anticipated (2/1/2014 - 1/31/2015)

Number of fishers using new techniques

Actual (2/1/2013 - 1/31/2014)

Anticipated (2/1/2014 - 1/31/2015)

Sustainable Coastal Development

Actual (2/1/2013 - 1/31/2014)

Anticipated (2/1/2014 - 1/31/2015)

Coastal Ecosystems

Actual (2/1/2013 - 1/31/2014)

Anticipated (2/1/2014 - 1/31/2015)

PARTNERS

Partner Name Burke Museum Geology Division

Partner Name Green River Community College, type Academic Institution, scale State

Partner Name North Seattle Community College

Partner Name Washington Department of Ecology

IMPACTS AND ACCOMPLISHMENTS

Title Washington Sea Grant research explores use of foraminifera as ecosystem health indicators in Puget Sound

Type accomplishment

Description Relevance Foraminifera are microscopic shelled organisms that inhabit marine sediment. Their sensitivity to environmental stress makes them useful indicators of ecosystem health. Puget Sound is the only major American industrialized estuary whose forams have not been comprehensively studied. Response Washington Sea Grant-funded researchers are inventorying foraminifera in impacted bays and waterways to develop a low-cost tool for monitoring Puget Sound's health. They collected 715 sediment grab samples, analyzed their foraminifera content, and correlated findings to water quality and pollution data. Their initial focus was Bellingham Bay, site of both past industrial pollution and current hypoxia problems, followed by four other Puget Sound locations that can be characterized by their histories of pollution, effluent, and urban and agricultural issues. The team shared its work with the public through an online atlas, a museum demonstration, and partnerships with two community colleges on student-designed research projects. Results Bellingham Bay exhibited a dramatic decline in foraminifera from 1997 to 2010, with one section losing the organisms entirely. Contrary to initial expectations, heavy metals did not appear to be responsible; only one metal, zinc, showed even a weak correlation. Instead, a shift from calcareous to agglutinated foram species pointed to hypoxia and higher acidity as factors. Two Bremerton inlets and Seattle's Elliott Bay and Duwamish waterway showed similar

declines in foraminifera abundance and diversity.

Recap Washington Sea Grant-supported researchers catalogue declining foraminifera and develop a tool for monitoring Puget Sound's health.

Comments Primary Focus Area OCEH (HCE) State Goal Improve understanding and management of emerging and cumulative threats to ocean and coastal health (HCE, Science).

Related Partners Burke Museum Geology Division, Washington Department of Ecology, ,

PUBLICATIONS

Title Puget Sound Foram Project

Type Internet Resources, Topical Websites Publication Year 2013 Uploaded File none URL none

Abstract There's a whole world in Puget Sound that you can't even see – kind of like Horton Hears a Who! Foraminifera, or forams for short, are tiny one-celled critters that may be small, but they help us learn a lot about the environment.

Citation Nesbitt E, Martin R (2013) Puget Sound Foram Research Project. http://www.burkemuseum.org/paleontology/foram_project.

Copyright Restrictions + Other Notes

Journal Title none

Title Distribution of Foraminifera In Puget Sound, Western Washington,U.S.A

Type Reprints from Peer-Reviewed Journals, Books, Proceedings and Other Documents Publication Year 2013 Uploaded File [Martin_NesbittMartin_2013.pdf](#) URL none

Abstract Puget Sound, the southern portion of the Salish Sea, has been intensely studied for its macrofauna, but lacks a comprehensive study of its benthic foraminifera. The Sound is a fjord-like lowland consisting of numerous smaller estuaries. Much of it has been heavily impacted by anthropogenic activities, and two locations have been designated as federal Superfund sites. The purpose of this investigation was to survey the benthic foraminifera present in Puget Sound and relate their distribution to environmental parameters. The 64 grab samples used were provided by the Washington Department of Ecology through their annual Puget Sound Ambient Monitoring Program and span the years 1997 to 2010. The investigation recorded 46 species of benthic foraminifera, with four species dominating the assemblages *Eggerella advena* (Cushman, 1921), *Elphidiella hannai* (Cushman and Grant, 1927), *Elphidium excavatum* (Terquem, 1875), and *Bucella frigida* (Cushman, 1922). Agglutinated taxa were dominant in the northern Sound and parts of the south Sound, but nearly absent in samples from the central Sound. Density and diversity indices were extremely variable throughout the Sound, even in samples taken from the same site over a number of years. Canonical correspondence analysis indicated that no single environmental

parameter analyzed was responsible for the distribution of foraminifera. Cluster analysis yielded four main groups dominated by the four taxa listed above. These clusters were heterogeneous in their distribution, with samples from the same sample site grouped in different clusters in different years. The extreme heterogeneity of the results indicates the need for a series of smaller-scale investigations focusing on individual embayments in order to better understand the foraminiferal distributions and to develop a foraminiferal monitoring tool unique to Puget Sound.

Citation Martin, R.A., Nesbitt, E.A., Martin D.E. 2013 Distribution of Foraminifera In Puget Sound, Western Washington,U.S.A. Journal of Foraminiferal Research, 43 291-304.

Copyright Restrictions + Other Notes

Journal Title Journal of Foraminiferal Research

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

No Leveraged Funds Reported This Period

UPDATE NARRATIVE

Uploaded File [Nesbitt_5615_update_na....4.pdf](#)

Using Microbiota for the Monitoring and Evaluation of Puget Sound Ecosystems

INTRODUCTION

The Puget Sound Foram Research Project (PSFRP) was designed to add to the body of information on Puget Sound and its ecosystems and to develop a low-cost, reproducible monitoring tool for evaluating and monitoring the health of the Sound. In order to do this, we are utilizing benthic foraminifera, microscopic shelled protists that inhabit the sediment, on or under the surface or creep up vegetation. Further details of intent, methodology and goals of the project are in our narrative for 2/1/2012 – 2/1/2013.

WHAT WE HAVE ACCOMPLISHED

Four undergraduate students who worked on the PSFRP during its first year returned to the project after summer break which was a bonus as they did not need any training. We found that overall, the students worked fewer hours than anticipated and none were able to work over summer. With the remaining funds we added one more student at the beginning of the academic year, and another at the beginning of the calendar year. All these students have been remarkable in their dedication to the project in spite of very heavy academic loads and other jobs outside of the campus. They are each examples of the quality of undergraduate students that the University of Washington produces. Three of the original 4 students are going to graduate school for geoscience degrees, and one is applying to local environmental consultancy companies to gain experience in the commercial world. One of these three has been accepted into the UW Earth & Space Sciences Department to continue to work on this WA SeaGrant project. All of them presented their research at the UW Undergraduate Research Symposium in Spring Quarter 2013, and will be doing so again this May.

The post-doc on the project, Dr. Ruth Martin, has been remarkably successful as a scientist, supervisor and mentor for the undergraduate students. The project would not run without her. The first year was challenging as we developed the project, the background knowledge needed for our goals, and worked with undergraduates who had no prior knowledge. The last year, the system has been working smoothly and we have made contact with other researchers working in Puget Sound waters to discuss the problems arising from unanticipated results

In April and June, 2013, we received 87 more sediment grab samples from the Washington Department of Ecology, Sediment Monitoring Program bringing the total of samples we have to 715. Of these, 250 have been processed and ~175 have been analyzed. For our first published paper (2013*) the data from 64 samples was reported, and this became the first published regional inventory of foraminifera in Puget Sound. For the paper currently in preparation for publication, 82 samples from the Department of Ecology and 12 samples from an orphaned community college collection have been analyzed. To date the students have analyzed a further 71 samples which will be discussed in their Undergraduate Research symposium posters, and in further papers for publication.

Our first study focusing on a single embayment in the Sound was done in Bellingham Bay. This documents a striking deterioration of foraminiferal assemblages in the bay between 1997 and 2010. Our data indicate the reduction or even total loss of foraminifera in many sample sites during those years, and throughout the Bay there was a dramatic decrease in species diversity. The Washington Department of Ecology reports a similar pattern in the benthic invertebrate fauna. Our study cannot pinpoint a single factor as being responsible; however correlation with a study on hypoxia in Bellingham Bay done by Dr. Jude Apple, Western Washington University, suggests that low oxygen levels may be at least partly responsible for the decline. This paper, "Rapid deterioration of sediment surface ecosystems in Bellingham Bay as indicated by benthic Foraminifera" will shortly be submitted to the journal *Marine Pollution Bulletin*. In addition, we are giving two presentations at the Salish Sea Conference in May 2014.

Student work continues by also focusing on specific areas, with the intention of using foraminiferal assemblages and sediment parameters supplied by WADOE to identify problem areas and assess probable causes as well as assess effects of any mitigation efforts that have been undertaken. The areas being studied by students and the significance of each are:

- Sinclair and Dyes Inlets –Naval Shipyard and associated manufacturing. Superfund sites. Also agricultural and recreational effluent.
- Elliott Bay and the Duwamish Waterway – Heavy anthropogenic impact, including manufacturing, recreation, urban run-off. Superfund sites
- Possession Sound – manufacturing and recreation effluent, agricultural and urban run-off.
- Hood Canal – agricultural and domestic effluent, hypoxia due to slow circulation, Bangor Naval base, superfund site.

OUTREACH

Poster presentations UW Undergraduate Research Symposium on May 24, 2013 were given on Semiahmoo Bay, on Sinclair and Dyes Inlets, and on the preparation of the *Atlas of Puget Sound Foraminifera*. Four abstracts have been submitted to the 2014 Symposium highlighting work in Elliott Bay, Possession Sound, Sinclair and Dyes inlets, and technical aspects of photographing microscopic subjects for the Atlas.

Each year the Burke Museum hosts a "Behind the Scenes" evening in which museum members are allowed to explore the usually unseen areas of the museum and talk to researchers. An entire room in the Geology Division was devoted to the Puget Sound Foram Research Project, where we set out microscopes, cameras linked to *Ipads*, photographs, research posters, and equipment. All the students participated in the evening, interacting with the public, explaining various aspects of our work and demonstrating equipment and techniques. That evening 525 members of the public toured the museum, and it seemed that most of them visited the Foram Project room.

Another aspect of outreach is our association with Dr. Kathryn Hoppe (Green River Community College) and Dr. Tracy Furutani (North Seattle Community College) who are using our project to design their own research projects for their community college students. They will share their results with us for incorporation into our data. In

February Dr. Hoppe and Dr. Furutani presented their plans at the joint ASLO/AGU/Ocean Society Science Meeting in Hawaii, with encouraging responses.

Finally, on April 12, 2014, a new exhibit opens at the Burke Museum focusing on work being done in-house by members of the museum staff. The Foram Project will be highlighted in an interactive exhibit. Our undergraduate students, and others trained by us, will be present in the exhibit gallery, to explain the work and assist members of the public with microscopes and other equipment. The exhibit will run until October 26, 2014.

CHALLENGES

The biggest challenge we have met is time. Many aspects of the project are taking much longer than we anticipated at the start. For example, many samples are so full of organic matter that they are extremely difficult to pick. Others have very few foraminifera compared with the sediment and it is necessary to float these in trichloroethylene before they can be picked. We have also run up against scheduling conflicts in the mass spectrometry labs, where we hope to find evidence confirming low pH was responsible for dissolution of foraminifera in Bellingham Bay and Sinclair Inlet. When the lab becomes available, we intend to pursue this.

The *Atlas of Puget Sound Foraminifera*, which we hoped to have published by now, is also taking far longer than expected. This is due to difficulties with producing publishable photographs of these microscopic organisms and to widespread taxonomic confusion in the literature amongst foram workers. The student doing our photography has now refined his technique and is producing good quality images. For the publication these are augmented with scanning electron microscope images for each taxon. It is intended that the first half of the Atlas, focusing on agglutinated taxa, will be submitted for publication before the end of 2014.

Development of a monitoring tool is also challenging; the heterogeneity in the different areas of the Sound makes a universal tool unlikely. In addition, researchers in other parts of the world use a pollution index that utilizes species not present in Puget Sound. Thus, our monitoring tool will be unique to this area, but will add substantially to the body of knowledge using foraminifera as tools for environmental assessment. For example, it is clear from work in Bellingham Bay that the presence of large numbers of the agglutinated taxon *Eggerella advena*, coupled with a paucity of calcareous species, or a high percentage of partially dissolved calcareous specimens, is indicative of poor bottom conditions. Our hypothesis is that this is due to a combination of factors such as high acidity and low oxygen, and perhaps the combination of numerous organic pollutants. Our work continues to analyze data from embayments further south in the Sound.

*Martine, R.A., Nesbitt, E.A., Martin, D.E., 2013. Distribution of Foraminifera in Puget Sound, Western Washington, U.S.A. *Journal of Foraminiferal Research*, v. 43, p. 291-304.