North Puget Sound Ecological Assessment through Marine Microbiota Assemblages

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Introduction

The Washington State Department of Ecology has been monitoring the Puget Sound waterway for pollutants and contaminants since the late 1980s. In cooperation with NOAA, the Puget Sound Temporal Monitoring program, and the Puget Sound Spatial Monitoring program, sediment samples over a large range of times and locations have been collected and analyzed in the micropaleontolgy lab at the Burke Museum, in an effort to determine environmental controls on microbiota distribution. Due to the various sampling protocols used between the various departments, interpretation and sampling spaces have been hard to correlate. For northern coastal waterways around Bellingham Bay, a high resolution spatial survey has provided interesting results as to the controls in shallow, well mixed water, in relation to sediment substrate, depth, heavy metal and organic compound concentrations.

What is a foram?

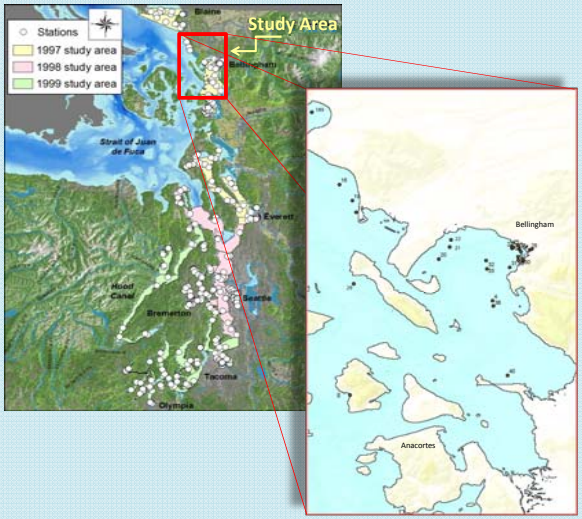
Foraminifera are unicellular eukaryotes that grow shells (called a test). Foraminifera can live at the surface of the water like plankton over deep oceans, but more commonly live in the sediment (termed benthic). Foraminifera life spans are generally on the range of 2-4 weeks. Foraminifera grow tests out of calcium carbonate like clams or grow shells by collecting sand grains around themselves in a protein matrix. Forams with sediment shells are called agglutinated, whereas the calcium carbonates are termed calcareous species.

Because foraminifera can grow calcareous shells, they become fossilized in sedimentary rocks, and are typically used geologically for stratigraphic correlation. Foraminifera are very sensitive to changes in physical parameters, and this allows us to determine environmental conditions in the water. Recent foraminifera have begun to be used extensively as ecological indicators in estuaries and fjords.

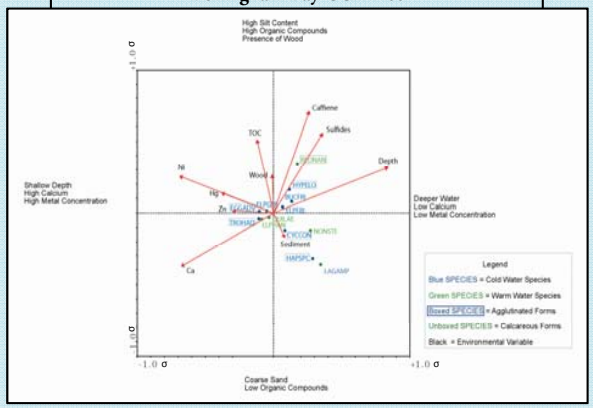
Methods

Samples were washed using 124 and 63 µm sieves, and hand picked with fine horse hair brushes under 4X optical magnification. For viable statistical analysis, each sample was picked for 150 to 300 specimens and identified. Statistics were run using Concordance Correspondence Analysis, a multivariate linear regression technique.

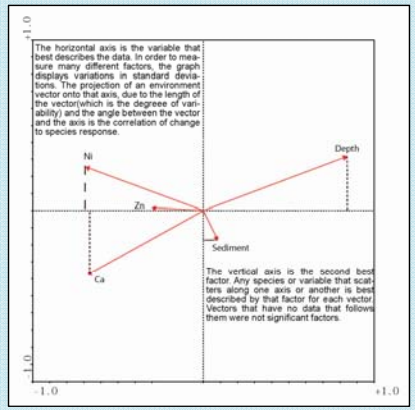
Variables used in the regression were calcium, mercury, zinc, nickel, sulfide, organic carbon and caffeine content, as well as sediment type and depth. Salinity and temperature did not vary significantly in the sample, and were not included. Dissolved oxygen would have been a desirable variable to include in the analysis, but was not measured during collection. Subsequent carbonate analysis for stable isotopes may be used as a proxy in the future.



Bellingham Bay CCA Plot



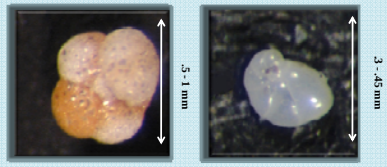
How to read a CCA plot



Data

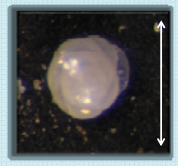
Data from the Concordance Correspondence Analysis shows a clustering of environmental and species variables corresponding to close geographic sites, particularly in very shallow water. The sample were divided into two subsets, agglutinated and calcareous, and warm and cold water species.

- The strongest environmental variables were shallow depth and high dissolved calcium, associated negatively with higher metal concentrations.
- The next important variable was sediment grain size associated with organic carbon compounds.
- Calcareous species responded more favorably to calcium and shallow water.
- Agglutinated species responded to sediment type and organics more strongly than to depth.
- Results weakly indicate that warmer water species are more susceptible to metal poisoning and the depletion of calcium in the water.



Trochammina hadai (.5 - 1 mm)

Nonionella stella (.3 - .45 mm)



Bucella frigida (.3 - .5 mm)

Elphidium groenlandica (.5 - 1 mm)

Interpretation

The mixing of California and Alaskan oceanographic currents offshore Washington result in a mixed foraminiferal population in Puget Sound.

- Since warm water foraminifera seem to be at the edge of their ecological range, we hypothesized that their tolerance for pollutants would be much lower, with distributions restricted to shallower depths. Indeed, there is a strong negative residual associated with warm water foraminifera to predicted deeper depths, and only the most tolerant and cosmopolitan species are found in the populations with heavy metal concentrations of Puget Sound.
- Agglutinated foraminifera are highly influenced by sediment type, and responded to changes in sedimentation rates from river and streams, as well as sediment disturbance due to natural or unnatural forces.
- From these results, there is an indication that larger calcareous foraminifera outcompete their smaller counterparts in the presence of excess calcium, if all other factors of variability can be accounted for.

Continuing Research

Foraminifers from other sampling sites in the Sound will be counted and analyzed against other environmental factors along the entire latitudinal profile from Bellingham Bay towards the South Sound. Foraminifers with shell deformities have been found and are assumed to be a response to pollution. Species with and without shell deformities will be analyzed using carbonate mass spectrometry to determine isotopic compositions, with applications to pollution detection and recent landscape reconstruction.

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