2021 Particle Grain-Size and Total Organic Content Analyses of Surface Sediments from Puget Sound and Elliott Bay near Seattle, WA

Ethan Hoang, Julie Masura

Introduction

Seattle's Elliott Bay has been a particularly intriguing area in regard to anthropological activities and their effects on the surrounding environment. The construction of the city brought about the displacement of sediment around the bay, resulting in lower quality sediments that negatively impact the nutrient cycles in the benthic zone. This project's examination of total organic carbon (TOC) and particle size analysis (PSA) in sediment serves as a baseline to which scientists can refer in monitoring future sediment health. TOC is a significant measurement standard because it serves as a potential indicator of nutrients available to organisms found on the floor of water bodies (Dutch et al. 2018). Higher TOCs in shallow areas indicate high environmental productivity, as TOC depicts the presence of benthic life. High TOC in deep waters, meanwhile, demonstrates a lack of decomposition for organic material. Particle size is a physical characteristic of sediment and can provide insight into the origin of the sediment in addition to prior geologic events. Larger grain sizes are associated with high-energy events such as storms that can break down rock. Smaller grain sizes reflect upon long periods of calm conditions that slowly degrade rock. Combined, TOC and PSA should shine light upon not only the status of Elliott Bay, but also trends that may be monitored in the future.

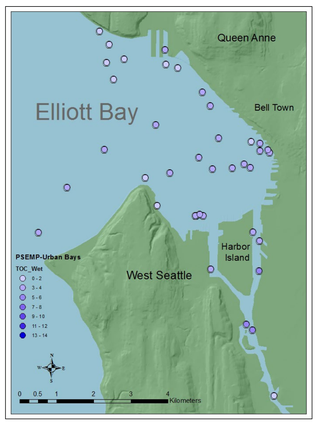

Figure 1. Wet Total Organic Content of sample sites. Color-coded key corresponds to percent organic content.

Acknowledgements

I would like to thank my professor, Julie Masura, for her guidance along with the Washington State Department of Ecology for the sediment samples themselves.

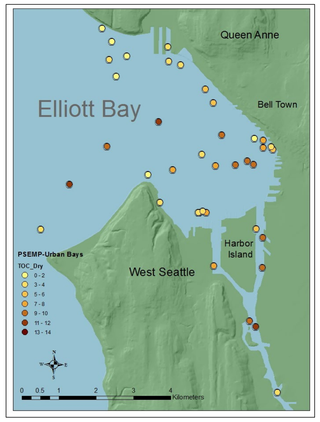

Figure 2. Dry Total Organic Content of sample sites. Color-coded key corresponds to percent organic content.

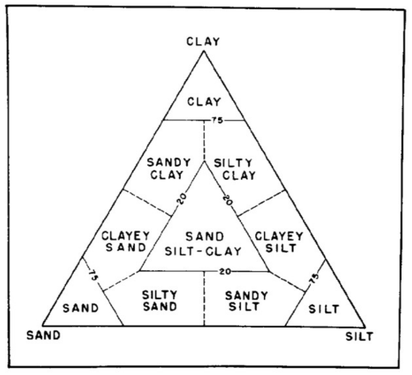

Figure 3. Ternary plot used to map particle size distribution of sample sites (Shepard 1954).

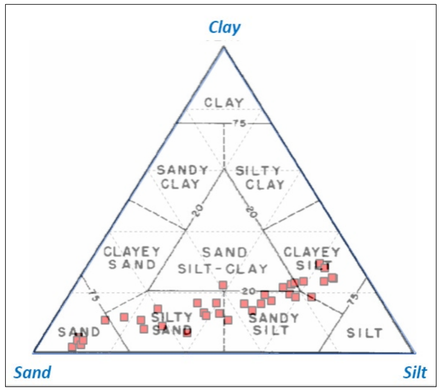

Figure 4 Ternary plot indicates the physical characteristics of sediment, as shown in Fig. 9. Sand, clay, and silt are the three categories of grain size classification. Each red square represents one sampling site.

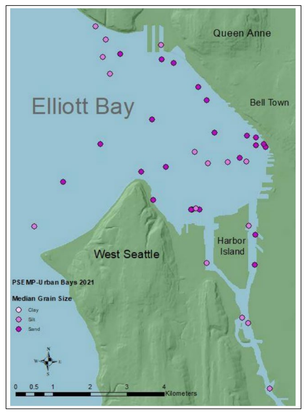

Figure 5. Median grain size of sample sites. Grain sizes are indicated by color gradient as clay, silt, or sand.

Methods

To determine this baseline, UW Tacoma obtained sediment samples from Elliott Bay in Seattle, Washington with the help of the Washington State Department of Ecology's Puget Sound Ecosystem Monitoring Program (PSEMP). The samples were extracted from the seafloor using a van Veen grab sampler and stored in Ziploc bags at 4℃ in the dark. Samples were then analyzed in the lab with a Beckman-Coulter Particle Size Analyzer for sediment grain size, while the total organic content was found by the loss on ignition technique. To do so, the sediment samples were mixed, then 5 mL was subsampled and weighed to measure the wet mass. For TOC, the sample was placed in an oven to dry at 150℃ for five hours. To obtain the ash mass, the dried sample was placed in the oven at 650℃ for eight hours. The TOC mass was found by subtracting the ash mass from the dry mass. A Beckman-Coulter LS 13 320 Laser Diffractometer was used to conduct the PSA. After thoroughly mixing the sample, the subsample was placed into a beaker of water and stirred using a stir plate. A pipette was used to place the material into the diffractometer until a 10% critical obscuration was reached. The analysis conducted by instrument was based on the angle of the laser that diffracted off of individual sediment grains. The results were exported into files for analysis.

Results

The wet TOC provides a better sense of the spatial characteristics of the sediment compared to dry TOC. Results for wet TOC data ranged from 1.021% to 4.642% carbon, while dry TOC ranged from 1.246% to 11.013% carbon. For the wet TOC, the mean value was 2.755%. For the dry TOC, the mean value was 5.550%. No significant outliers for neither wet nor dry TOC were present. Fig. 1 indicates the location of each site and its relative wet TOC. Fig. 2 indicates the location of each site and its relative dry TOC. The lower TOC percentages were typically found near land at shallow depths.

PSA was diagrammed via ternary plot and was used to indicate the sediment composition of each site according to the percentage of particle sizes that were categorized into sand, silt and clay by the Wentworth size classes (fig. 3). According to Shepard's ternary plot (fig. 4), data obtained via PSA methods revealed that the sites ranged from predominantly sandy sediment to silty sand or sandy silt. A few of the sites also had some clayey silt sediment. Fig. 5 is a map of median grain sizes as categorized by Wentworth size classes. Particle sizes were more evenly distributed across sampling locations.

Fig. 6 and fig. 7 demonstrate a negative linear correlation between grain size and total organic content, in which total organic content decreases proportionally as grain size increases. The R-squared values of 0.5277 of wet TOC (fig. 6) and 0.6707 of dry TOC (fig. 7) demonstrate significant correlation between the data and the trendline.

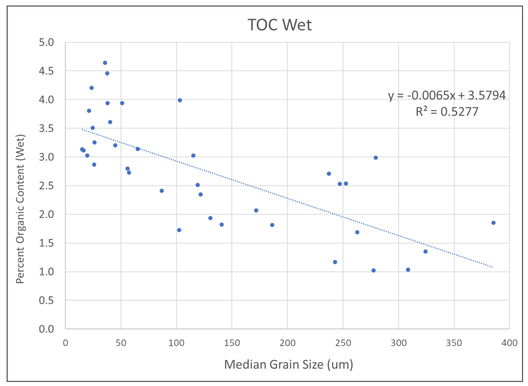

Figure 6. Wet total organic content. Percent organic content in each sediment sample as a function of median grain size of the dried sample. Each blue dot represents one sampling site.

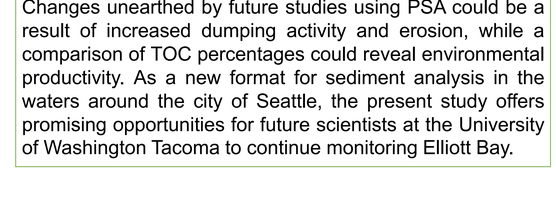

Figure 7. Dry total organic content. Percent organic content in each sediment sample as a function of median grain size of the dried sample. Each blue dot represents one sampling site.

Conclusion

The present study determined that the sediments in Elliott Bay ranged from sand to silt. Compared to Sternberg's findings of the Puget Sound, this study found marginally lower portions of clay particle sizes; the silt-heavy sediments graphed closer to the bottom edge of the ternary plot. While grain size can be associated with differing environmental events, analysis would require the grain sizes to be sorted. This procedure was not conducted in this study for time concerns.

Changes unearthed by future studies using PSA could be a result of increased dumping activity and erosion, while a comparison of TOC percentages could reveal environmental productivity. As a new format for sediment analysis in the waters around the city of Seattle, the present study offers promising opportunities for future scientists at the University of Washington Tacoma to continue monitoring Elliott Bay.