Sediment Characterization in Shelburne and Missisquoi Bay

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Introduction

Primary objective: Analyze bottom sediment characteristics of Shelburne and Missisquoi Bay to advance future studies of phosphorous in Lake Champlain.

Specific goals:

I. Conduct multibeam bathymetric surveys
II. Collect grab samples of the bottom sediments
III. Produce sediment characterization catalogues by correlating the multibeam data with the grab samples

Data Acquisition

Bathymetric Survey

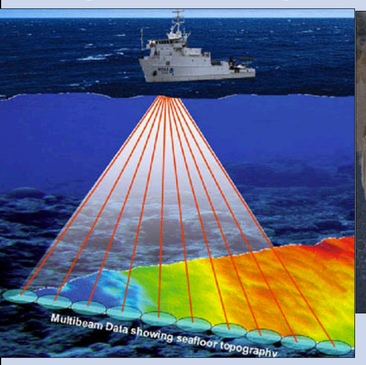


Figure 1: Multibeam echo sounder collects bottom characteristics via a sound beam swath [1].

Grab Samples

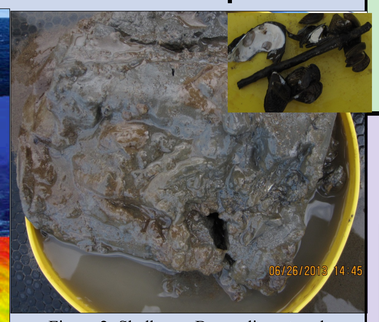


Figure 2: Shelburne Bay sediment grab sample with burrows, detrital matter, mussels, snails, a thin biological surface layer and a organic-rich bottom layer.

Data Processing

Swathview (QTC)

1. Cleaning: faulty beam removal
2. Compensation: backscatter adjustment

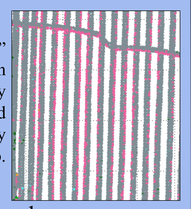


Figure 3: "Gaps" in a section of an insufficiently interpolated Missisquoi Bay map.

3. Clustering: the classes

CLAMS (QTC) – Interpolation

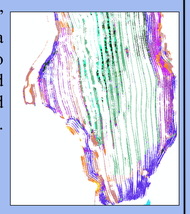


Figure 4: "Striping" in a section of a poorly cleaned (no beam removal) and compensated Missisquoi Bay map.

Sediment Analysis

1. Biological Features
2. Grain Size Distribution
   a) 5 g of dried sample + 60 ml of calgon
   b) Horiba Particle Analyzer

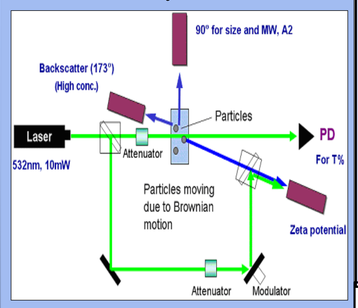


Figure 5: The Horiba Particle Analyzer calculates grain size through laser diffraction and Mie scattering [2].

Shelburne (114 Lines, 7 Samples)

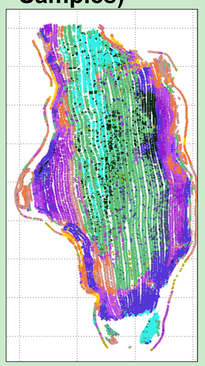


Figure 6: Swathview map with 75 outer beams removed on the port and starboard sides, rectangle size of 513x33 pings and 12 sediment classes distinguished.

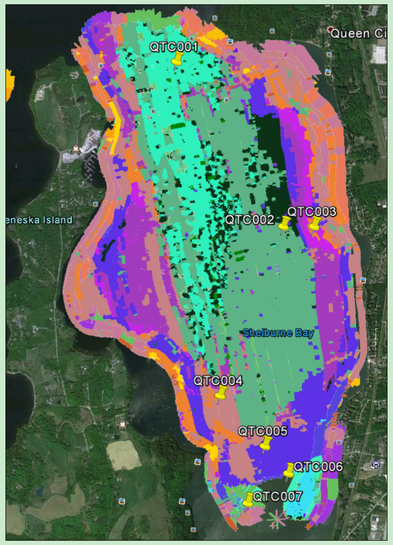


Figure 7: CLAMS map with search size of 3, search radius of 30m and 2 out of 4 sectors required.

Figure 8: Grain size distribution of Shelburne Bay grab samples.

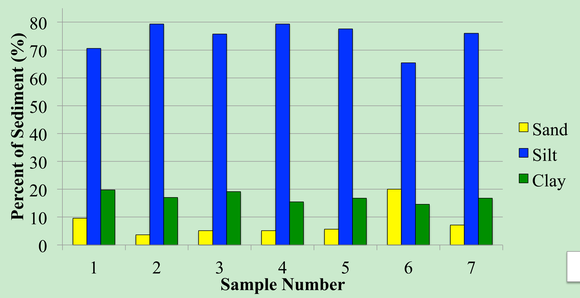


Table 1: Class descriptions based on sample sediment analysis.

Class	Sample Number	Major Location(s)	Defining Characteristics
Blue	2	Middle of bay	•Lowest % of sand, highest % of silt •Some macroinvertebrate activity
Pink	7	Near sediment output region	•Zebra mussel shell fragments •High macroinvertebrate activity
Dark Purple	5	Edge of littoral zone	•Relatively high % of silt
Sea Green	1	Mouth of bay	•Highest % of sand, highest % of clay
Light Orange	4	Near the littoral zone	•Lowest % of clay, highest % of silt
Light Purple	3	Littoral zone	•Mussels, some macroinvertebrate activity •Some detrital matter

Conclusions

- Predominantly silt
- Highest % of sand in littoral zones
- Highest % of clay in the middle of the bays
- High percentage of sand and silt near sources of sediment input
- Sediments with pebbles are found near the littoral zones
- Thin biological surface and organic rich bottom layers are prevalent throughout the lake
  - -Slightly less prevalent in western Missisquoi Bay littoral and proximal-littoral zones (sites with few snail shells)
- High productivity in littoral zones and near sources of sediment input

Missisquoi (339 Lines, 369 Samples)

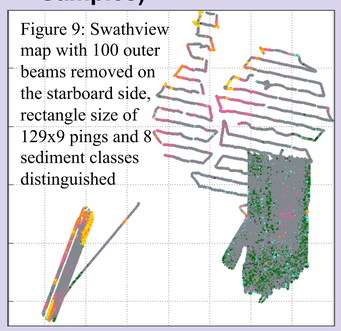


Figure 9: Swathview map with 100 outer beams removed on the starboard side, rectangle size of 129x9 pings and 8 sediment classes distinguished

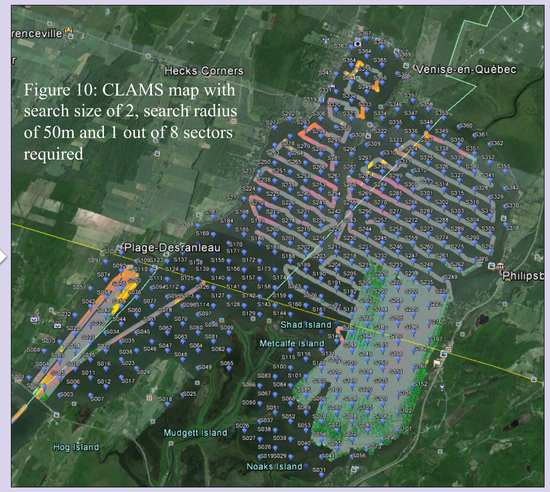


Figure 10: CLAMS map with search size of 2, search radius of 50m and 1 out of 8 sectors required

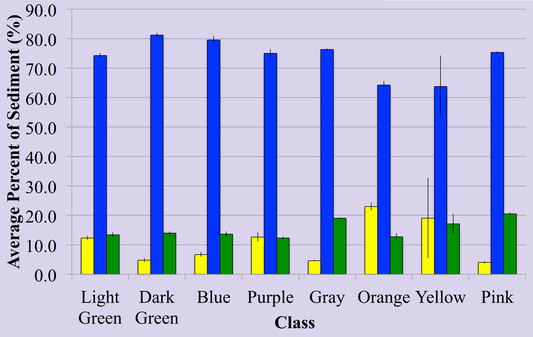


Figure 11: Grain size distributions of Missisquoi Bay sediment classes. Average values (calculated from class grab samples) and standard error bars are shown.

Table 2: Class descriptions based on sample sediment analysis. Sample 6 did not correspond with a sediment class and thus, was not considered in this analysis.

Class	Number of Samples	Major Location (s)	Defining Characteristics
Light Green	17	Southeastern region, littoral zone	•Relatively high % of sand •Some detrital matter
Dark Green	15	Southeastern region, near littoral zone	•Highest % of silt, pebbles, burrows
Blue	10	Southeastern region, edge of littoral zone	•Highest % of silt •Some burrowing •Most snail shells
Purple	4	Edge of littoral zone	•Pebbles, burrows
Gray	114	Middle of bay	•Lowest % of sand, highest percentage of clay •Some detrital matter, burrows
Orange	6	Western bay, littoral zone	•Highest % of sand
Yellow	6	Western bay, littoral zone and edge of littoral zone	•Least snail shells
Pink	29	Middle of bay	•Highest percentage of clay, lowest percentage of sand •Some detrital matter

Figure 12 (below): Distribution of biological and sedimentary features among Missisquoi Bay sediment classes. Values on the y axis represent the percent of a class's grab samples with a particular feature.

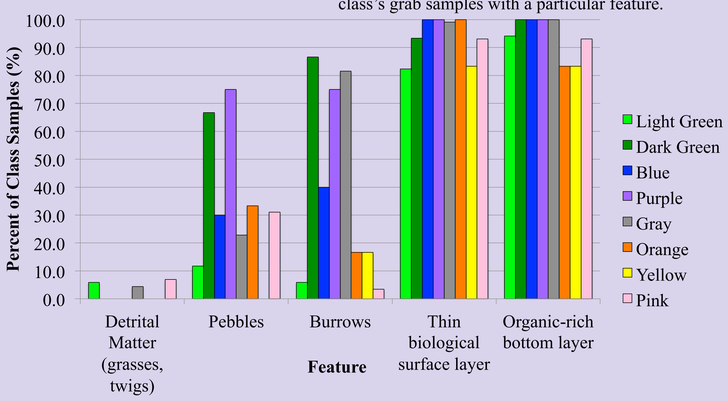
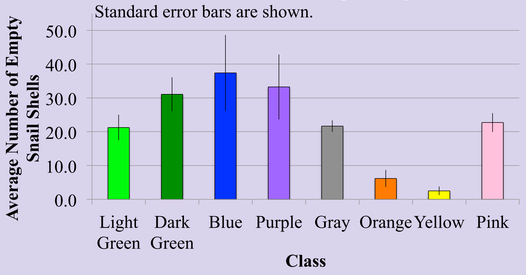


Figure 13 (below): Average number of empty snail shells observed in Missisquoi Bay sediment classes. Average values were calculated from class grab samples. Standard error bars are shown.



Future Research

- Conduct a unified sediment class analysis of Missisquoi and Shelburne Bay
- Perform a multivariate analysis of the data presented in this study
- Investigate whether a correlation exists between sediment classes and endogenous phosphorous levels
- Investigate whether a correlation exists between sediment classes and zebra mussel populations
- Monitor how sediment classes change over time

Literature Cited

[1] Gibbons, Helen (2010). The Magic of Multibeam Sonar. U.S. Extended Continental Shelf Project

[2] HORIBA (2013). Particle Characterization: Measurement Techniques. HORIBA Scientific

Acknowledgements

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