Dredging and CAD Cell Investigation, Salem Harbor
GLS 470: Field Camp 1

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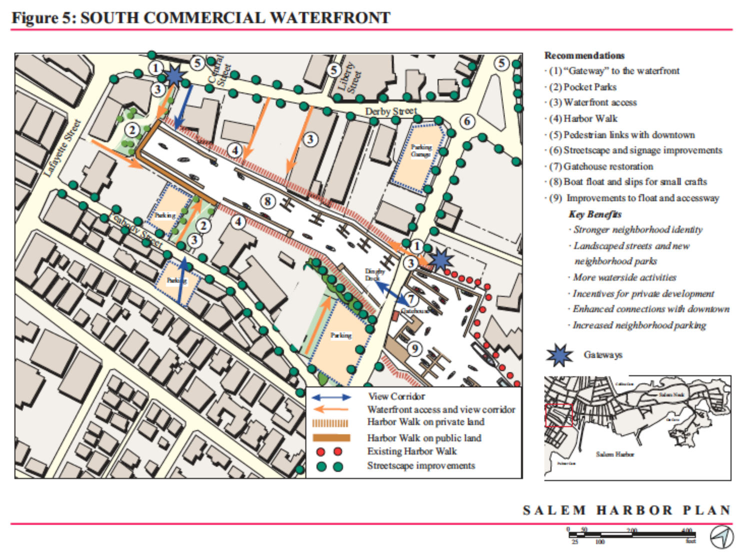
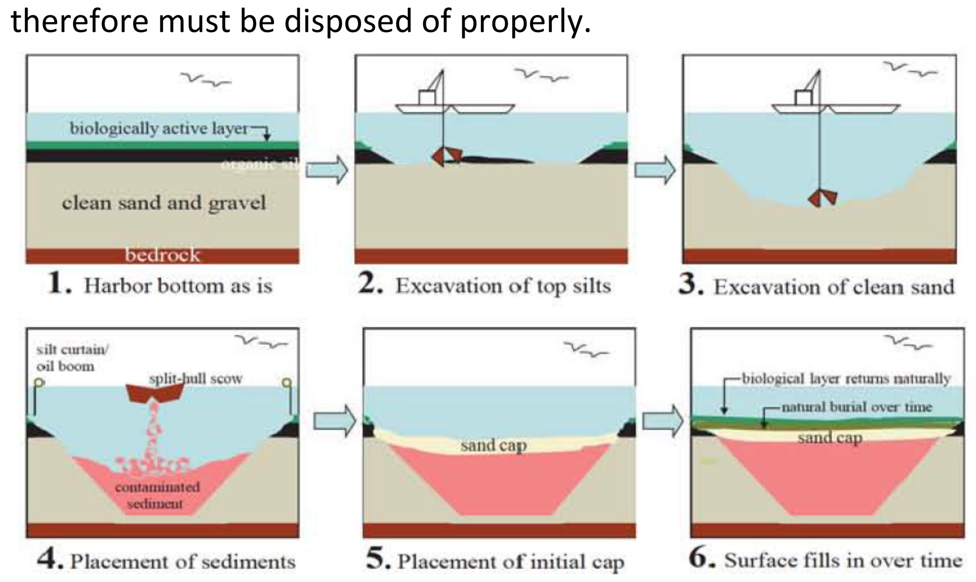
Background:

At Salem State all Geology majors participate in two 3-week long field camps. The first camp includes an environmental project in which students utilize sub-bottom SONAR to plan a disposal site for contaminated dredge spoils in Salem Harbor, MA



The City of Salem is considering dredging the South River, which is part of the harbor, in order to better utilize the city's waterfront (image above from *Salem Harbor Plan*, 2008). Sediments within the river contain legacy contaminants such as heavy metals, PCBs and PAHs, and therefore must be disposed of properly.



One solution to the dredge spoil sequestration problem is to construct a confined aqueous disposal (CAD) cell elsewhere in the harbor to contain the material (image above from EPA, 2012). Students are charged with finding an adequate location for a CAD cell in Salem Harbor (see below)

Goal:

The ultimate goal of this assignment is to gain valuable experience in conducting an environmental assessment of a real-world problem. You will be working for *Viking Consulting, LLC* as an environmental geologist. Your company has been hired by the City of Salem to assess an appropriate location for contaminated dredge spoils from the proposed dredging of the South River, Salem, MA. Your boss has made you the project manager. You are hired to answer the following questions:

1. What will be the volume of dredge spoils that will need to be disposed of?
2. Assuming the dredge spoils are contaminated, will it be feasible to dispose of the material in a confined aqueous disposal (CAD) cell located in one of the city's three target areas?

Learning Objectives:

Students will:

- Plan and conduct coastal marine seismic surveys (bathymetry and sub-bottom sonar)
- Adjust bathymetry data for tidal stage and produce a bathymetric chart
- Calculate the volume of sediment to be dredged to achieve the goals of the client.
- Process and interpret sub-bottom sonar data using state-of-the art processing software
- Interpret seismic reflectors and produce isopach maps of sediment unit thicknesses
- Address the theory of seismic reflection sub-bottom analyses, and the strengths and weaknesses of different seismic frequencies
- Produce lithologic logs of sediment cores
- Identify and interpret the correlations between litho-stratigraphic units and seismic-stratigraphic units
- Read a bathymetric chart
- Accurately locate yourself in a marine field environment (without GPS!)
- Accurately measure, record, and summarize data in the field
- Take thorough and organized field and lab notes
- Synthesize and interpret data
- Work in a safe and productive manner on the water and on land
- Write a professional-quality environmental geologic report that synthesizes data collected and interpreted, and provides recommendations to the client regarding the original question of concern

Resources:

Sub-bottom surveys are conducted on a pontoon research vessel (*R/V Valhalla*) with a SyQwest Stratabox 3510. All survey planning, acquisition, and post-processing of sub-bottom data are done with the SonarWiz5 software. Surfer software is utilized for isopach map construction

SonarWiz 5

Part 1: What is the dredge spoil volume?

Figure 2 – South River Basin and Navigation Channel

Salem's plan specifically calls for the South River Basin (west of the Congress Street bridge) to be dredged six feet below the MLLT (mean low low tide) depth and at least ten feet away from any sea walls. The South River channel (east of the Congress Street Bridge) and Salem Wharf are to be dredged twelve feet below the MLLT value. Students use a bathymetric chart of the South River corrected to MLLW (above) to calculate volume of sediment that needs to be removed to achieve desired depths

Final Product

A final report to the client will be due at 5:00 PM on XXX. The report should have the following sections:

Abstract (200 word maximum)
Introduction and Background (what does Salem want to do; what were you hired to do; background information on CAD cells, contaminated seds, etc)
Methods (sub-bottom collection, bathy survey, geophysical processing, volume calculations, etc)
Results (Present all of your results for the project. I suggest organizing results into two sections: 1) what is the nature of the proposed dredged spoils (volume, contaminated?), and 2) data on the stratigraphy in the potential CAD locations, isopach maps, etc)
Discussion (This is where you discuss your recommended sites for a CAD cell with pros and cons for the various sites; also discuss uncertainties here)
Conclusions (brief 1-2 paragraphs summarizing your findings and recommendations)
References Cited (use GSA Bulletin format, found on their web page)
Appendix 1: Optimum sonar configuration report for each target site
Appendix 2: All sub-bottom data in your SonarWiz project burned to CD or DVD.

Part 2: Where can a CAD cell be located?

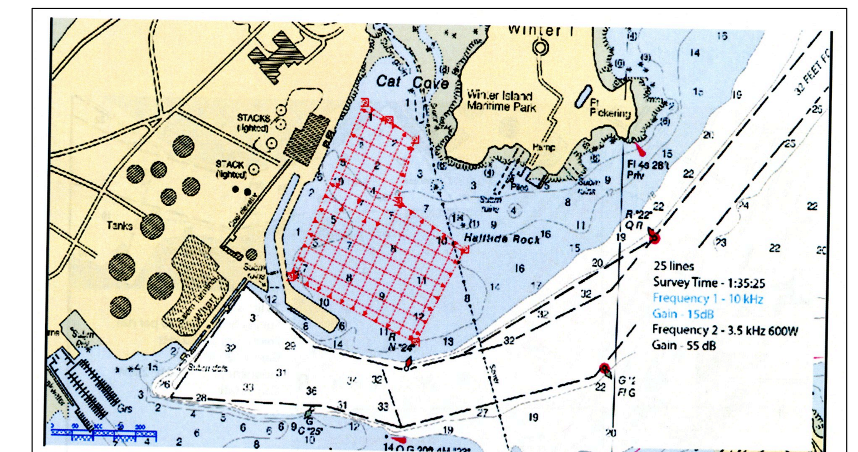


Figure 1. Cat Cove survey plan for Sub-bottom data collection. Line spacing: 30 meters

Part 2 is a multi-step process that is largely driven by sub-bottom sonar data interpretations. Students are directed to three potential CAD cell locations in Salem Harbor and propose survey plans prior to heading out into the field (figure on left from student report). Survey plans include plans lines as well as suggested frequency, gain, and power settings. Students work in groups of 3-5 and have a 4-hour time slot in which to cover each field location. The Stratabox 3510 can operate one of two frequencies: 3.5kHz or 10kHz.

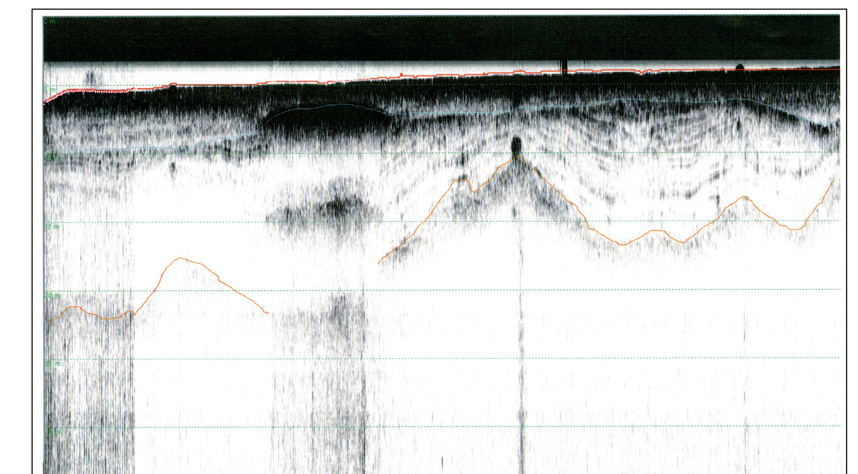
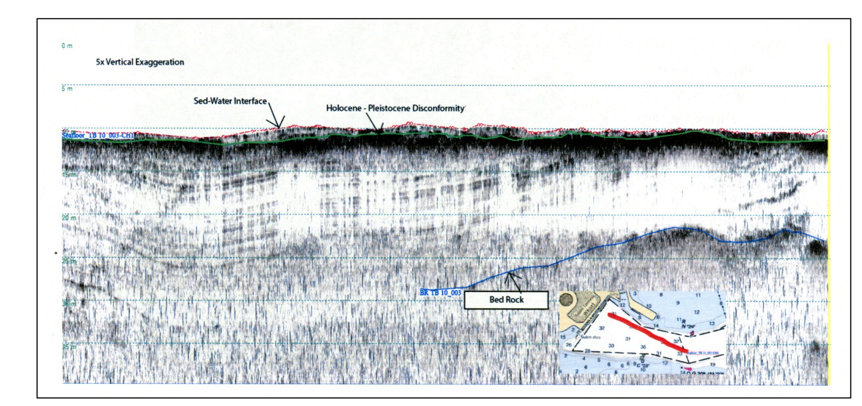


Figure 5. This sub-bottom profile of Cat Cove was obtained with a configuration of 10 kHz, 300 W, and a gains 30 dB were used in order to better see the disconformity (marked in blue) between the sediment of the Holocene and the Pleistocene sediment. The bedrock, indicated by an orange marker, juts up and is clearly visible almost throughout the entire profile. VE=15.152X

Once data are collected, students process the data and identify the seafloor, Holocene/Pleistocene disconformity, and acoustic basement. Examples of students' interpreted lines are illustrated in the figures below and to the left.



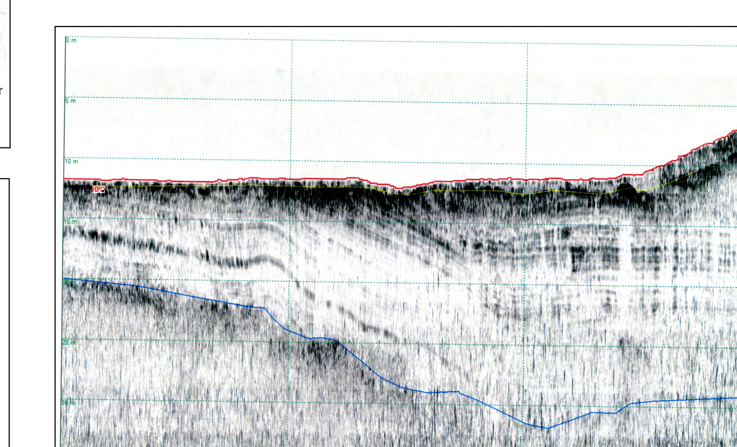
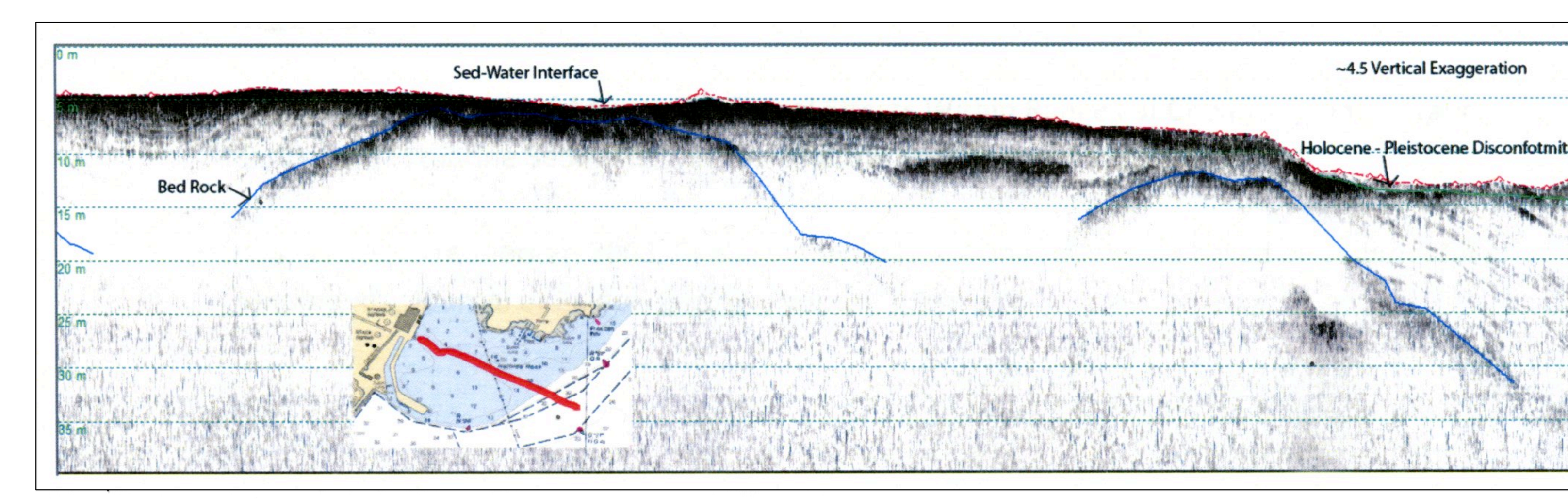
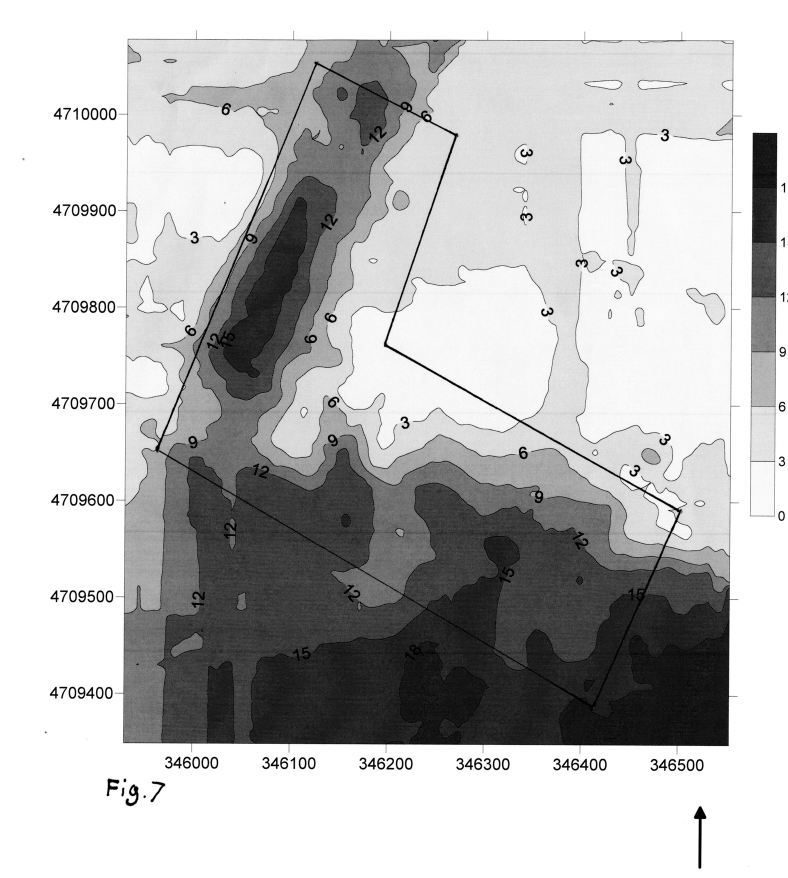


Figure 3. (TB07_10: 10Khz, 200W, 30db) sub-bottom record from Turing Basin. Red reflector defines the sed-water interface, yellow reflector defines the Holocene Pleistocene Disconformity, Blue reflector defines bedrock interface. Note low volume of Holocene sediment and deep bedrock depth. [V.E.= 3.9x]



Cat Cove Pleistocene Thickness Contour Map



Students export sediment thickness values from SonarWiz and produce isopach maps of both Holocene (estuarine) and Pleistocene (glaciomarine) thickness in Surfer (student figure on left). Isopach maps are used to compute the volume of Pleistocene material for each site in order to determine if there is enough space to accommodate the dredge spoils. Holocene sediments are assumed to be contaminated, and their volume is added to the volume of dredge spoils from the South River.

Finally, potential CAD cell locations are evaluated in regard to the capacity of clean material as compared to the volume of contaminated dredge spoils needed to be sequestered.