Morphology and Particle Size Across the Three Basins of Walden Pond - A Reconstruction of Landscape Changes and Mass Wasting Events of the Past 700 Years

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Background

Walden Pond is the deepest lake in Massachusetts and famous for its association with Henry David Thoreau. The three basins of Walden Pond hold a Late Pleistocene to Holocene sedimentary record of environmental change. The goal of this study is to identify earthquake induced mass wasting events.

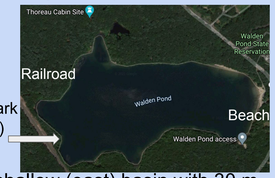


Figure 1: Google satellite photo of Walden Pond

Amusement Park (1866 - 1902)

There is the deep (west), intermediate (central), and shallow (east) basin with 30 m, 20 m, and 16 m depth, respectively. In the 1800's a railroad was built near the lake and also an amusement park that closed in the 1900s. The lake is now protected by the state and has a beach and boat ramp for recreational use.

Methods

In 2015, seven short gravity cores were taken from the center of each of Walden Pond's three basins. This study focuses on three cores from each of the basins. Core WAL15GC1 was taken in the deepest basin, core WAL15GC5 was recovered from the intermediate basin, and core WAL15GC7 from the shallow basin.

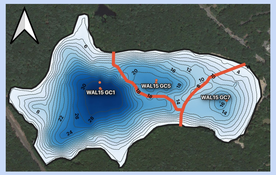


Figure 2: **Bathymetric Map**. Satellite image is from Google Earth. Sediment core locations are marked.

Grain Size Analysis: Grain sizes were measured using a Laser Diffraction Particle Size Analyzer (LDPSA). Samples were first digested with hydrogen peroxide and sodium hydroxide, to remove any organic content such as organic matter and diatoms. The remaining clastic particles were immersed in a Calgon solution to prevent clumping of fine particles before measurement on the LDPSA.

Pollen Stratigraphy: Samples were processed for palynomorphological analysis and studied under a light microscope (Pilkington, 2019).

GIS Analysis: QGIS and ArcGIS software were used to create slope maps and bathymetric maps to visualize and gain information about the lake's slope stability.

Morphology

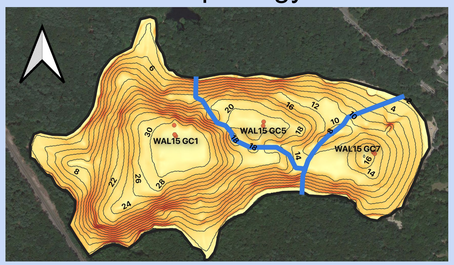


Figure 3: **Slope Map of Walden Pond.** The contour lines are in intervals of 2m. The basins are separated by lines (modified from Knights, 2017)

The slope map helps to visualize locations of potentially unstable slopes between 10-20 degrees, which is the ideal steepness found in other lakes for sediments to both accumulate and eventually fail. Walden Pond has several areas with such slopes. Slopes in the lake vary between 0 - 23 degrees. When compared with the other basins, the deep basin has larger areas of steep slopes.

Age Model

An age model was created for each of the three cores by using radiocarbon dating, pollen stratigraphy and concentrations of Vanadium. The collected data indicate different sedimentation rates with the highest in the deep basin and the lowest in the shallow basin.

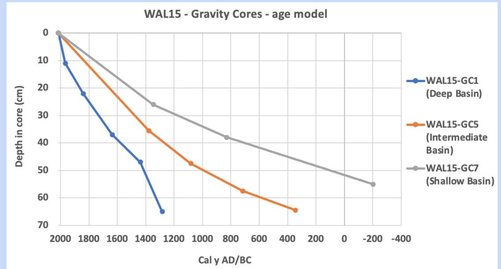
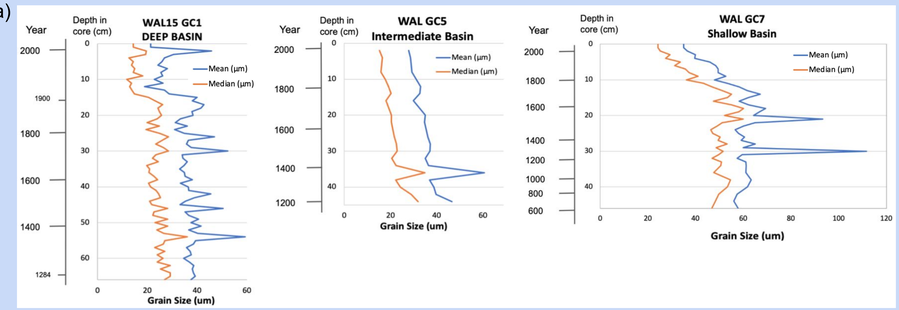


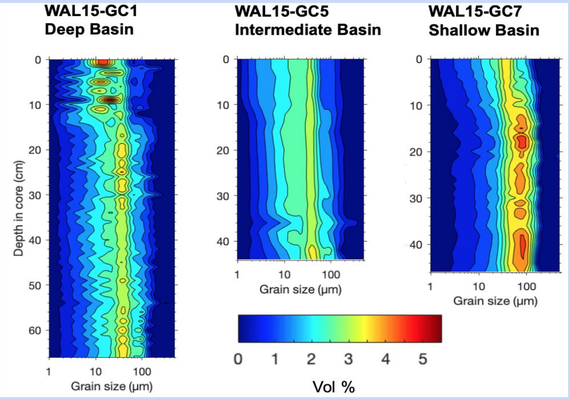
Figure 4: **Age model.** C14 dates for WAL15GC4 (Stager et al., 2018) transferable to WAL15GC5. WAL15GC1, 23 and 37 cm, mark the phytoplankton decline and Ambrosia rise (Pilkington, 2019). C14 dates were obtained at NOSAMS, WHOI.

Grain Size

(5a)



(5b)



(5c)

Figure 5: **Grain size results and sediment core image**. a) Mean and median grain size of the three cores measured for every centimeter on GC1 and GC7 and every other centimeter on GC5. b) 3D plot of grain size data c) WAL15-GC1 sediment core (length: 66 cm)

The sediments are composed of dark brown to black organic-rich silts that appear relatively homogenous.

The finer clastic component deposited since the 1800's is likely due to the erosion of soils from heavy recreational land-use and nearby logging.

The thin horizons of distinctly coarser material in the record suggest occasional mass wasting events. One potential trigger could be ground shaking from strong earthquakes that are known historically or suspected in the prehistoric record.

Note the more homogeneous grain size record of the intermediate basin. A contributing factor could be its position in the center of the lake and partial shielding from nearshore processes.

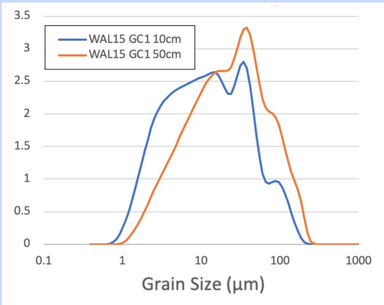


Figure 6: **Grain Size distributions** of WAL15-GC1 at 10 cm and 50 cm depth

Future Work

- Refine grain size data by measuring every centimeter of WAL15-GC5 and WAL15-GC7
- Obtain more radiocarbon dates for a more detailed age model
- Remeasure certain horizons to confirm grain size data

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