Appendix A. Paleoclimate Reconstruction Investigation Guide

Driving Question: How can proxies be used to reconstruct past climate patterns?

In this lab investigation, you will reconstruct past climates using lake varves as a proxy. You will:

1. Explore the use of lake varves as a climate proxy to interpret long-term climate patterns.
2. Understand annual sediment deposition and how it relates to weather and climate patterns.

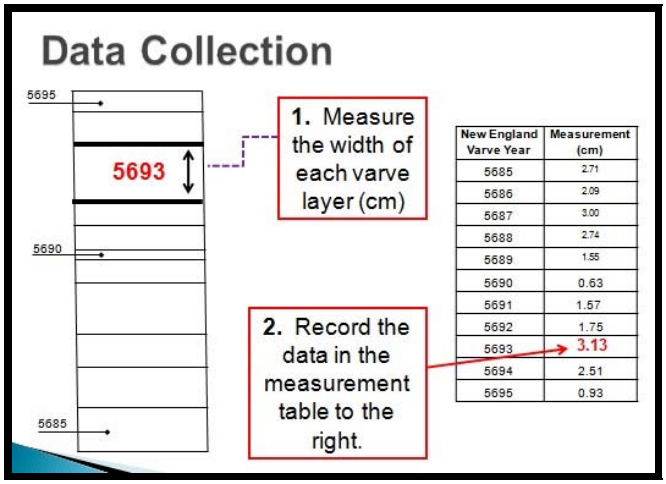
Note: The original data set used in this lab has been scaled down by a factor of 10 to ensure that both the core and Measurement Table fit on a normal 8.5" x 11" page.

Step 1: Paleoclimate Reconstruction

You will be provided with core data and a corresponding Measurement Table. The oldest year on the core is located at the bottom of the core. It is the smallest numbered year on your core. The most recent year on the core is located at the top of the core. It is the largest numbered year on your core.

1. **Measure** the thickness of each varve layer in your core (# 1 to the right). Each varve year corresponds to the distance between two line segments in a core.

2. **Record** the measurements in the associated Measurement Table beginning with the **bottom** of the core (# 2 to the right).



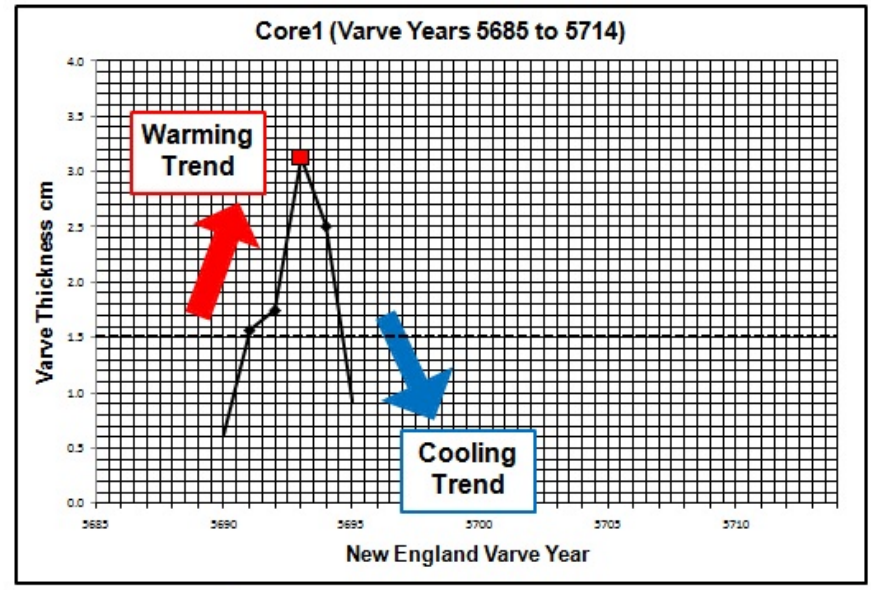
When making varve measurements, it is easier to analyze your cores by starting at the bottom of the core (oldest and smaller year number) and work upwards (youngest and higher year number).

Note: If the thickness of a varve is less than 0.1 cm, the answer has been pre-recorded in the measurement table

3. Graph the data from your Measurement Table on your core graph as shown below (#3 to the right). Varve years are displayed along the x-axis in 5 year increments. Varve thickness in centimeters should be plotted on the y-axis.

4. After you have graphed the data, connect the points with straight lines.

5. Trace over your lines with a colored marker.



3. Plot the points from the previous table onto the associated graph and connect the dots.

Important Note: Cool years and warm years are determined relative to a particular location. At **this location**, cooler years are indicated by varve thicknesses that are less than 1.5 cm. Warmer years are indicated by varve thicknesses greater than 1.5 cm.

After you have completed your graph, **answer** analysis questions **# 1-2** in complete sentences.

1. Look at **your** core graph. What are the warmest and coldest varve years in your core?

Core 1a:	**Coldest-** *5690*	**Warmest-** *5693*
Core 1b:	**Coldest-** *5700 or 5708*	**Warmest-** *5697 or 5702*
Core 2:	**Coldest-** *5720 or 5744*	**Warmest-** *5733*
Core 3:	**Coldest-** *5754*	**Warmest-** *5751*
Core 4:	**Coldest-** *5793*	**Warmest-** *5781*
Core 6:	**Coldest-** *5839, 5855, 5856, or 5862*	**Warmest-** *5861*
Core 7:	**Coldest-** *5873, 5888, or 5891*	**Warmest-** *5870*
Core 8:	**Coldest-** *5905 or 5910*	**Warmest-** *5919*
Core 9:	**Coldest-** *5932, 5934, 5937, 5943, 5944, 5950, or 5951*	**Warmest-** *5936*
Core 10:	**Coldest-** *5963, 5972, or 5982*	**Warmest-** *5980*

2. What patterns do you observe in your core graph data? Does your data tend to show warming patterns, cooling patterns, or variable patterns within your core? Provide specific information about your observed trends in the data.

   Core 1a: *Warming trend since most of the years contain thicker varve sections, but students may say Variable due to the fluctuations between thick and thin.*

   Core 1b: *Cooling trend since the varves tend to be under the 1.5 cm line. Students may also answer the trend is variable since there are fluctuations between warmer and cooler years.*

   Core 2: *The trend is cold since most of the years are below the 1.5 cm line. Students may answer Variable as well due to the peak in thickness at varve year 5733.*

Core 3: *The trend is cold since most of the years are below the 1.5 cm line.*

Core 4: *The trend is cold since most of the years are below the 1.5 cm line. Students may also answer Variable as well due to the two peaks over the 1.5cm line.*

Core 6: *The trend is cold since most of the years are below the 1.5 cm line.*

Core 7: *The trend is cold since most of the years are below the 1.5 cm line.*

Core 8: *The trend is cold since most of the years are below the 1.5 cm line.*

Core 9: *The trend is cold since most of the years are below the 1.5 cm line.*

Core 10: *The trend is cold since most of the years are below the 1.5 cm line.*

Use the entire 300-year paleoclimate class graph to answer analysis questions **# 3-8.**
Note: Each individual core contains 30 varve years.

3. According to the varve record, which core(s) show the warmest years? Support your claim with evidence from the varve record.

   Core 1 shows the warmest years. It contains the most number of varve years that are thicker than 1.5 cm

4. Where is the **first extended** cool period in the core record that is greater than 15 years?

   The first extended cooling period is from varve year 5708 to 5732. All of the varves in this section are less than 1.5 cm in thickness.

5. What patterns do you observe in the data of the **first four cores** (Varve years 5685-5804)? Where do warming patterns, cooling patterns, or variable patterns occur? Provide specific information about your observed trends in the data.

   In general, a warming trend is observed from varve years 5685-5607. The varve layers tend to be thicker during this time period. The record then indicates a general cooling trend from varve year 5708 to 5731. The varve layers tend to be thinner during this time period. The record then indicates a variable pattern from varve years 5732 to 5782; the varve layers tend to alternate between cooling and warming years. In varve years 5782 to 5804, the varve layers are much thinner indicating a cooling period.

6. What patterns do you observe in the data of **Cores 5-10**, (Varve years 5805-5984)? Where do warming patterns, cooling patterns, or variable patterns occur? Provide specific information about your observed trends in the data.

   In the last six cores, the data suggests that the climate is in a cooling trend. This is indicated by the thin varve layers (less than 1.5 cm) within these 5 cores.

A team of paleoclimatologists conducted a study of oxygen isotopes in the same location that your core data came from. Their published findings show that varve years 5782-5984 were **warm climate years (Cores 5-10).** Their data from the previous years (**Cores 1-4**) matches the climate pattern observed in your core data graphs.

7. Based on the information above, what do you think is causing the data pattern in your graph for **Cores 5-10**?

   When we look at the entire paleoclimate record with this new information, we know that the climate trend is warming. As we examine our data within Cores 5-10 of the paleoclimate record, the varves gradually become thinner. This is due to the warming of the climate. As the temperature increases, the glacier begins to retreat away from the glacial lake. This decreases the sediment supply to the lake that in turn causes thinner varve layers.

8. How is the annual sediment deposition in the varve record related to weather and climate patterns?

   The annual sediment deposition is related to the weather during each varve year. A thinner varve generally indicates a cooler climate with less meltwater and hence less sediment transported to the lake, while a thicker varve generally indicates a warmer climate with more meltwater and hence more sediment transported to the lake. Eventually the annual sediment layers accumulate in a lake leaving a long term record. Since varve thickness is a proxy for the general weather, a long term record (greater than 30 years) can be used to infer past climate history.