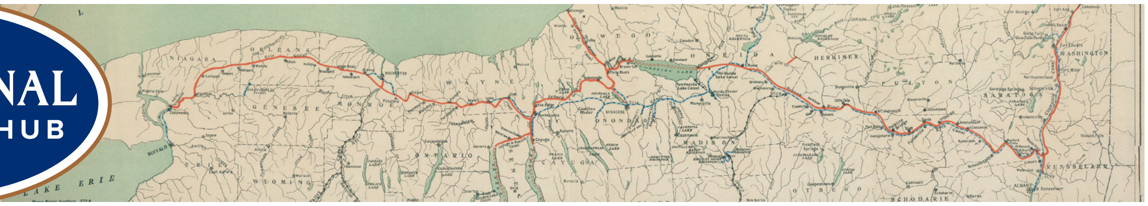
ERIE CANAL LEARNING HUB



LESSON PLAN:

The Bathymetry and Formation of Seneca Lake

OVERVIEW:

Students will examine research from the Seneca Lake Archaeological & Bathymetric Survey to understand Finger Lakes geology and the importance of collecting bathymetric data.

Grade Level: 6-8

Class Periods: One to two 45-minute class periods

ESSENTIAL QUESTIONS:

- What is bathymetric data and why is it important?
- How did the Finger Lakes form?

OBJECTIVES:

- Students will explain what bathymetry is and why it is important.
- Students will explain how the Finger Lakes formed.
- Students will use bathymetric data to make observations about the natural and human-made features of Seneca Lake.

MATERIALS NEEDED:

- Computer with internet
- Copies of student worksheets

LESSON PLAN ACTIVITIES:

- **Activity 1:** Geography of Seneca Lake
- **Activity 2:** Bathymetry
- **Activity 3:** The History of Seneca Lake Bathymetry
- **Activity 4:** Glaciers Formed the Finger Lakes
- **Activity 5:** Bathymetric Maps of Seneca Lake
- **Activity 6:** What's on the Bottom of Seneca Lake?

NEW YORK STATE EDUCATION STANDARDS:

SCIENCE STANDARDS: • **MS. Earth's Systems**	**MS-ESS2-2**—Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying temporal and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at temporal and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes could include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] **ESS2.C**—The Roles of Water in Earth's Surface Processes—Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)

Teacher Procedure & Answer Keys

ACTIVITY 1: Geography of Seneca Lake

Students will use a map to make observations about the geography of the Finger Lakes region.

INFORMATION AND INSTRUCTIONS

1. Display the map of New York State with the location of the Finger Lakes labeled in white. Major cities of the Finger Lakes region are labeled in blue.
2. Have students answer the corresponding question on **Worksheet 1: Geography of Seneca Lake.**

The Finger Lakes Region of New York State

Courtesy: Jonathan R. Hendricks for Paleontological Research Institution Earth @Home project, https://earthathome.org/hoe/ne/geology-finger-lakes/

KEY > WORKSHEET 1: Geography of Seneca Lake

1. Find Seneca Lake on the map. Compare Seneca Lake to the other Finger Lakes. List 2 observations you made while comparing.

- *Seneca Lake is the longest of the Finger Lakes.*
- *There is only one other lake (Cayuga) similar in size to Seneca Lake. The other lakes are much shorter.*

ACTIVITY 2: Bathymetry

Using information from the Seneca Lake Survey project, students will learn what bathymetry is and why it's important.

INFORMATION AND INSTRUCTIONS

Section I: What Is Bathymetric Mapping?

Bathymetry is the study or measurement of the depth of water in the ocean, sea or lake. For the sake of this report, the term 'lake' will be used to encompass all bodies of water. The most important reason to study bathymetry is to keep ships from becoming shipwrecks by striking things in shallow water.

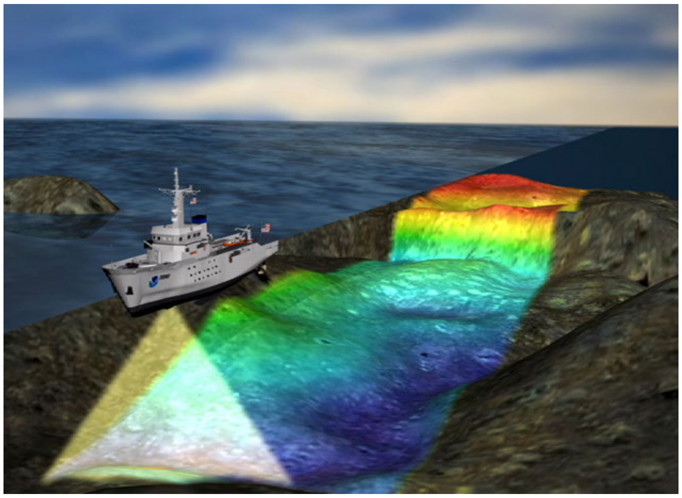
One of the most efficient ways to prevent the loss of ships in the old days was to create bathymetric maps and charts that were reliable and accessible to the nautical community. These first nautical charts were created during the mid-19th century from a technique known as lead-line observations or more simply, "lead-lining" **(Figure 1)**. The depth of the water was obtained using a marked cable with a moderately heavy lead weight at the end of the line. For the depth information to be useful, the location of this measurement also needed to be determined. Prior to 1945, a ship's location was primarily defined by triangulation to known points of land, celestial navigation, or dead reckoning. The farther away from shore and visible markers, the less precise the location.

In order to create a reliable lake chart, there was a balance between the number of observations and safe navigation for vessels, with more observations needed in shallow waters and less observations in deep water. In the NOAA chart of Seneca Lake **(Figure 2)**, the distance between observations range from a minimum of 200 meters (roughly the length of two football fields) in nearshore regions to 1100 meters (nearly ¾ mile) in the deeper, central portion of the lake. On average, the distances between most observations were in the 300–500 meter range.

From Page 84 of *Seneca Lake Archaeological & Bathymetric Survey*, 2019 Final Report

1. Provide the following definition of bathymetry and information to students.
    - **Bathymetry is the measurement of the depth of a body of water.** Beginning in 2019, a detailed data collection of the bathymetry of the lakebed was conducted, using multibeam sonar technology. This process works by sending out sound pulses and timing how long those pulses take to come back. The following images show the equipment that is towed behind a boat to collect bathymetric data. The boat drives in lines back and forth across the lake to capture a complete picture of the elevation of the lake bottom.

2. Display the following images and discuss technology to collect bathymetric data.



An illustration from the National Oceanic and Atmospheric Administration of how a ship collects multibeam sonar data

Courtesy: NOAA, https://oceanexplorer.noaa.gov/technology/sonar/multibeam.html

Survey crewman Matt Harrison preparing to deploy the sub-bottom profiler from the stern of the deck the R/V Folger

Courtesy: Lake Champlain Maritime Museum

- Ask students to respond to the corresponding question on **Worksheet 2: Bathymetry.**

KEY > WORKSHEET 2: Bathymetry

1. Give two (2) reasons why a detailed map of the elevation of the bottom of a lake is important information.

- *To avoid shipwrecks*
- *Navigation*
- *Monitor water levels and coast erosion*
- *For construction purposes, pipelaying*

ACTIVITY 3: The History of Seneca Lake Bathymetric Data

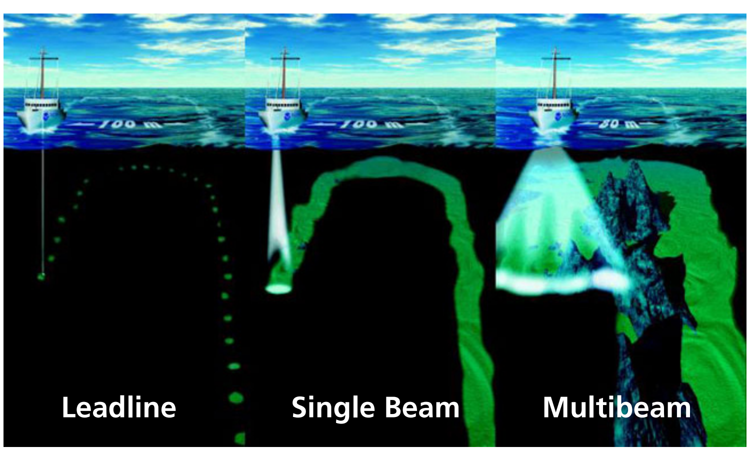
Using information from the Seneca Lake Survey project, students will explore the methods of collecting bathymetric data.

INFORMATION AND INSTRUCTIONS

Read "The Bathymetry of Seneca Lake" on pages 84-89 from the *Seneca Lake Archaeological and Bathymetric Survey*, 2019 Final Report https://americancanalsociety.org/wp-content/uploads/2020/12/Seneca_Lake_Survey_2019_ONLINE_VERSION.pdf

1. Introduce students to historical methods of collecting bathymetric data.
   a. **Lead-lining—**Ropes with lead weight on one end were lowered into the water and read manually to calculate water depth. Commonly used until 1930s.
   b. **Side-scan or single beam sonar—**Sonar (Sound Navigation and Ranging) uses pulses of sound to navigate, map the seafloor, or detect underwater objects like shipwrecks. Physical sensors of the sonar, called a transducer array, send and receive acoustic pulses and create an image of the seafloor. This array can be mounted on the ship's hull or placed on another platform. Widespread use of sonar began in 1920s and it is still used today.
   c. **Multibeam sonar—**A multibeam sonar sends out multiple, simultaneous sonar beams (or sound waves) in a fan-shaped pattern to map the seafloor or detect other objects. As with side-scan sonar, physical sensors, called a transducer array, send and receive the sound pulses A multibeam array is usually mounted directly on the ship's hull. Multibeam sonar is often used in conjunction with side-scan sonar to get a more complete picture of what's happening underwater. Developed in 1964 and still used today.

2. Display the following photo providing comparison between methods of collecting bathymetric data.



Comparing the bottom coverage achieved by the different survey methods

Courtesy: NOAA, https://nautical-charts.noaa.gov/updates/what-does-the-age-of-the-survey-mean-for-nautical-charts/

3. Have students read text on the history of Seneca Lake Bathymetry Data and answer corresponding questions on **Worksheet 3: The History of Seneca Lake Bathymetric Data.**

KEY > WORKSHEET 3: The History of Seneca Lake Bathymetric Data

1. **What are the limitations of data collection by lead-lining?**
   - *Long, tedious, and easily inaccurate process*
   - *There must be many data collection points to complete a map of the entire lake.*
   - *Since there are isolated points there could be areas not mapped with features dangerous to ships*

2. **Why is it important to collect new data on the bathymetry of the lake?**
   - *The lakebed may have changed*
   - *New technology allows us to see a greater level of detail and discover features we did not know were there*
   - *Monitor changes in water levels*

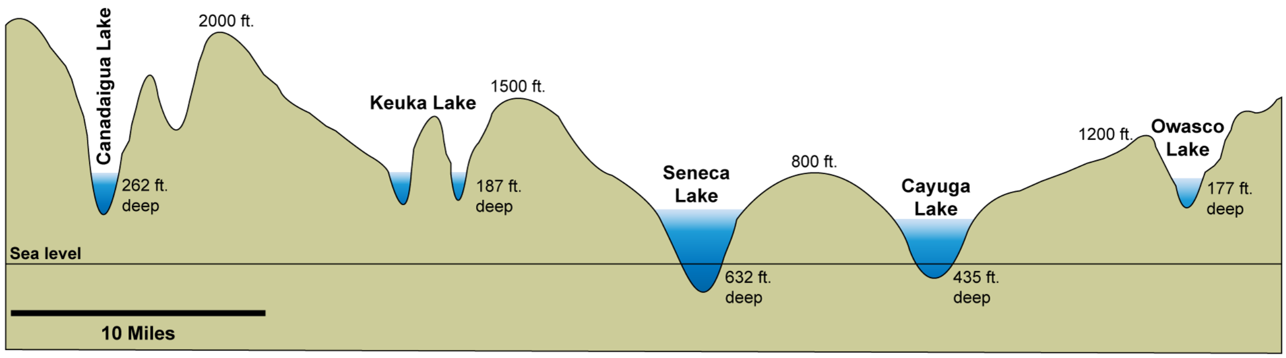
Examples from publication: Figures 14-16 and 18 found on pages 92-94

ACTIVITY 4: Glaciers Formed the Finger Lakes

Students will analyze sources to discover how the Finger Lakes formed.

INFORMATION AND INSTRUCTIONS

Glacial activity over millions of years carved out the Finger Lakes. Seneca Lake is the deepest and longest Finger Lake. The image below shows a cross section (side-view) of some of the Finger Lakes.



1. Display the image showing elevations of the Finger Lakes.

   Elevations of the Finger Lakes

   Courtesy: Paleontological Research Institution, Earth @Home project, https://earthathome.org/hoe/ne/wine-geology/

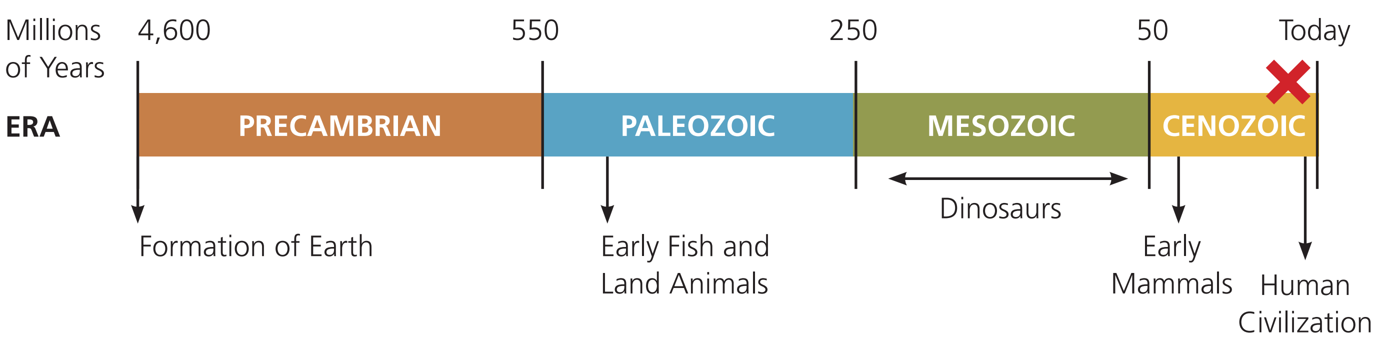
2. Have students read the excerpt from the Paleontological Research Institution: Earth at Home web-site and answer corresponding questions on **Worksheet 4: Glaciers Formed the Finger Lakes.**

   Source of text: https://earthathome.org/hoe/ne/geology-finger-lakes/

KEY > WORKSHEET 4: Glaciers Formed the Finger Lakes

1. **List two (2) reasons why the Finger Lakes might vary so much in the depth and length.**
   - *Rock layer type (softer rock is carved out by glaciers more easily)*
   - *Rock layer thickness*
   - *Ice thickness*
   - *Number of advances and retreats*
   - *Depth of the pre-existing river channels*
   - *Varying speed of advances and retreats*
2. **What natural feature were the Finger Lakes before the glacial advances?**
   - *Rivers*
3. **The Finger Lakes flow and drain the same way the rivers before them did. Which direction do the lakes flow?**
   - *North*
4. **The Earth formed 4.6 billion (4,600,000,000) years ago. The glacial advances and retreats that formed the Finger Lakes was approximately 20,000 years ago. This means that the Finger Lakes have been in existence for 0.0004% of Earth's entire history.**

   Place an "X" on the Timeline of Earth to indicate the approximate time when the formation of the Finger Lakes occurred.



ACTIVITY 5: Bathymetric Maps of Seneca Lake

Using maps from the Seneca Lake Survey project, students will analyze bathymetric maps and data.

INFORMATION AND INSTRUCTIONS

Review Figures 12 (page 90), 14 (page 92), and 15 (page 93) from the Seneca Lake Archaeological and Bathymetric Survey, 2019 Final Report https://americancanalsociety.org/wp-content/uploads/2020/12/Seneca_Lake_Survey_2019_ONLINE_VERSION.pdf

1. Explain to students that the Seneca Lake Survey team has collected bathymetric data using multibeam sonar and created updated bathymetric maps of the lake.

2. Have students review images of bathymetric maps from the Seneca Lake Survey, 2019 Final report and answer corresponding questions on **Worksheet 5: Bathymetric Maps of Seneca Lake.**

KEY > WORKSHEET 5: Bathymetric Maps of Seneca Lake

1. Which colors represents the shallowest and deepest parts of the lake shown on the map?

- *Red is shallow. Blue and purple are deep.*

2. The pale blue color represents areas where no sonar data was collected. Why was sonar equipment not able to be used in these areas?

- *The areas close to shore are too shallow to be mapped by multibeam sonar equipment. Note: There are plans to use LIDAR equipment by air to collect bathymetric data from water less than 10m deep (page 90)*

3. Think about what a bathymetric map of other Finger Lakes would look like. How would it compare to Seneca Lake? List similarities and differences in the chart.

Similarities

i. Shallowest part on the sides and deepest in the middle

ii. The lake would be the similar shape, but shorter

Differences

i. Would not be as deep, might only be green color at deepest part

ii. Shallow part would be wider

4. **If there were more glacial advances in the Finger Lakes region in the future, how might this map change?**
   - *The lake could get deeper*
   - *The sides of the lakebed could get steeper*
   - *The lake could increase in length and width*

5. **The image shows a section of Seneca Lake. Which side of the lakebed is steeper?**

   Claim:

   The west side of Seneca Lake is steeper than the east side

   Evidence:
   - *The west side of Seneca Lake changes elevation more quickly than the east side*
   - *The colors (which represent different elevations) are closer together on the west side*
   - *Blue is a deep elevation, and the blue color is closer to the shore on the west side*

6. **This image shows a northern section of Seneca Lake. What type of natural landform is located at location A?**

   Claim:

   The landform shown at location A is a hole (depression)

   Evidence:
   - *The purple color is the deepest elevation of the lake. This color is shown at A*
   - *The areas around A are a higher elevation*
   - *Location A is circular in shape and is deep*

ACTIVITY 6: What's on the Bottom of Seneca Lake?

Using maps and images from the Seneca Lake Survey project, students will explore how bathymetry can be used to identify shipwrecks and artifacts on the bottom of the lake.

INFORMATION AND INSTRUCTIONS

Review Target 12 (pages 66-67), and Figures 15 (page 93) and 21 (page 95) from the Seneca Lake Archaeological & Bathymetric Survey, 2019 Final Report https://americancanalsociety.org/wp-content/uploads/2020/12/Seneca_Lake_Survey_2019_ONLINE_VERSION.pdf

1. Explain to students that bathymetric mapping can also be useful to identify human-made objects and natural features at the bottom of Seneca Lake. The Seneca Lake Survey team has identified several objects and features using bathymetric collection methods.

2. Have students review multibeam sonar images included in the Seneca Lake Survey, 2019 Final Report, attempt to identify the object and provide evidence for their identification on **Worksheet 6 What's on the Bottom of Seneca Lake?**

KEY > WORKSHEET 6: What's on the Bottom of Seneca Lake?

1. **Found Object #1**

   Object Identification:

   - *Boat*

   Evidence for Identification:

   - *Boat shape. Widest in the middle, tapering ends*
   - *Objects scattered around the boat could be cargo or pieces of the boat*

   Information from publication can be found on page 95. ROV images found on pages 66-67

2. **Found Object #2**

   Object Identification:

   - *Leftover debris from the excavation of a pipeline*

   Evidence for Identification:

   - *Bumpy raised and irregular area. The surrounding area is flat*
   - *Protrudes outward into the lake from the shoreline*
   - *Linear (straight line)*

   Information from publication found on page 92.

SOURCES

PUBLICATIONS:

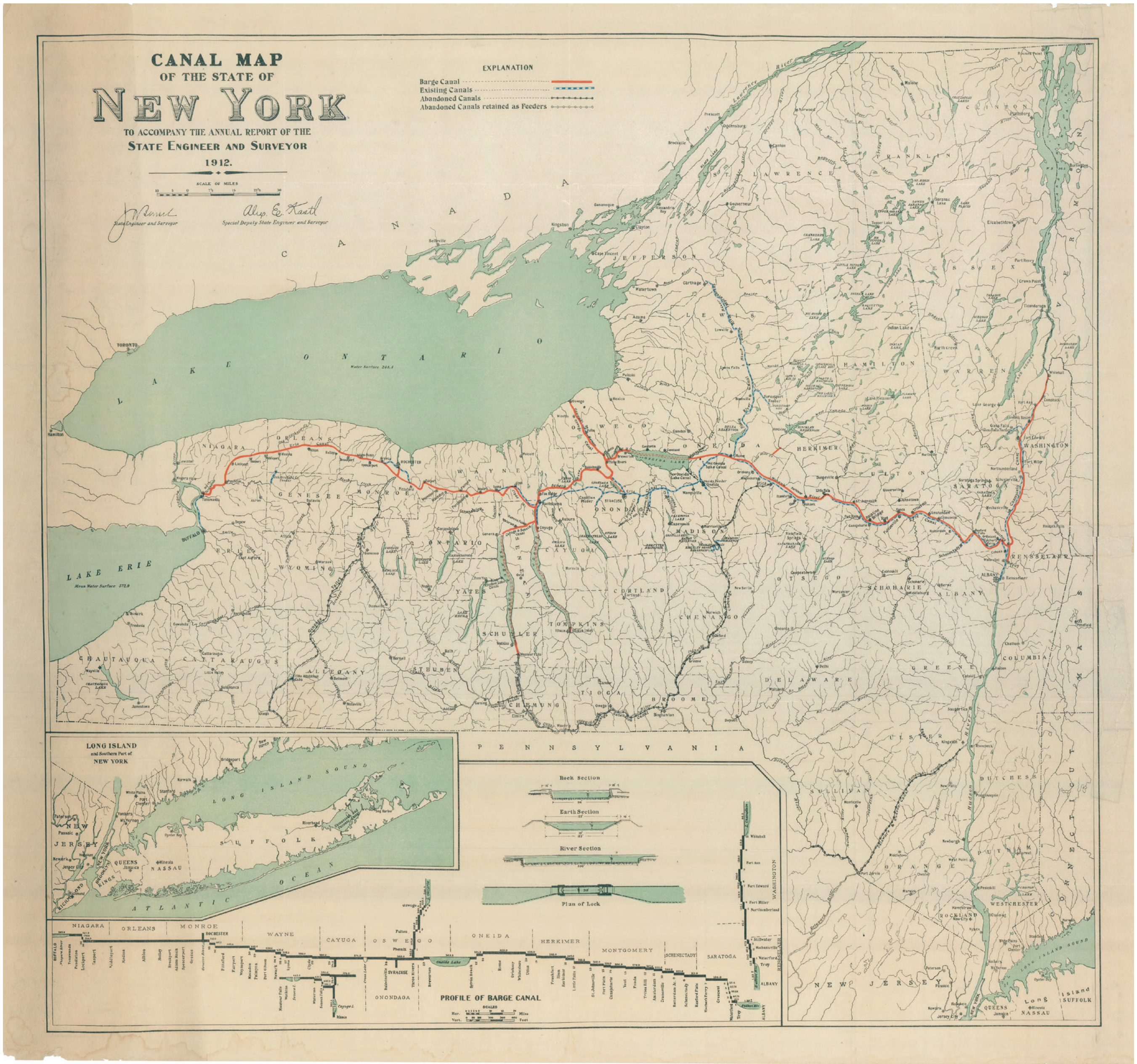
Cohn, Art, Principal Investigator and Dr. Tom Manley, Chief Scientist. Seneca Lake Archaeological & Bathymetric Survey, 2019 Final Report. Published June 2020. https://americancanalsociety.org/wp-content/uploads/2020/12/Seneca_Lake_Survey_2019_ONLINE_VERSION.pdf

WEBSITES

https://earthathome.org/hoe/ne/geology-finger-lakes/

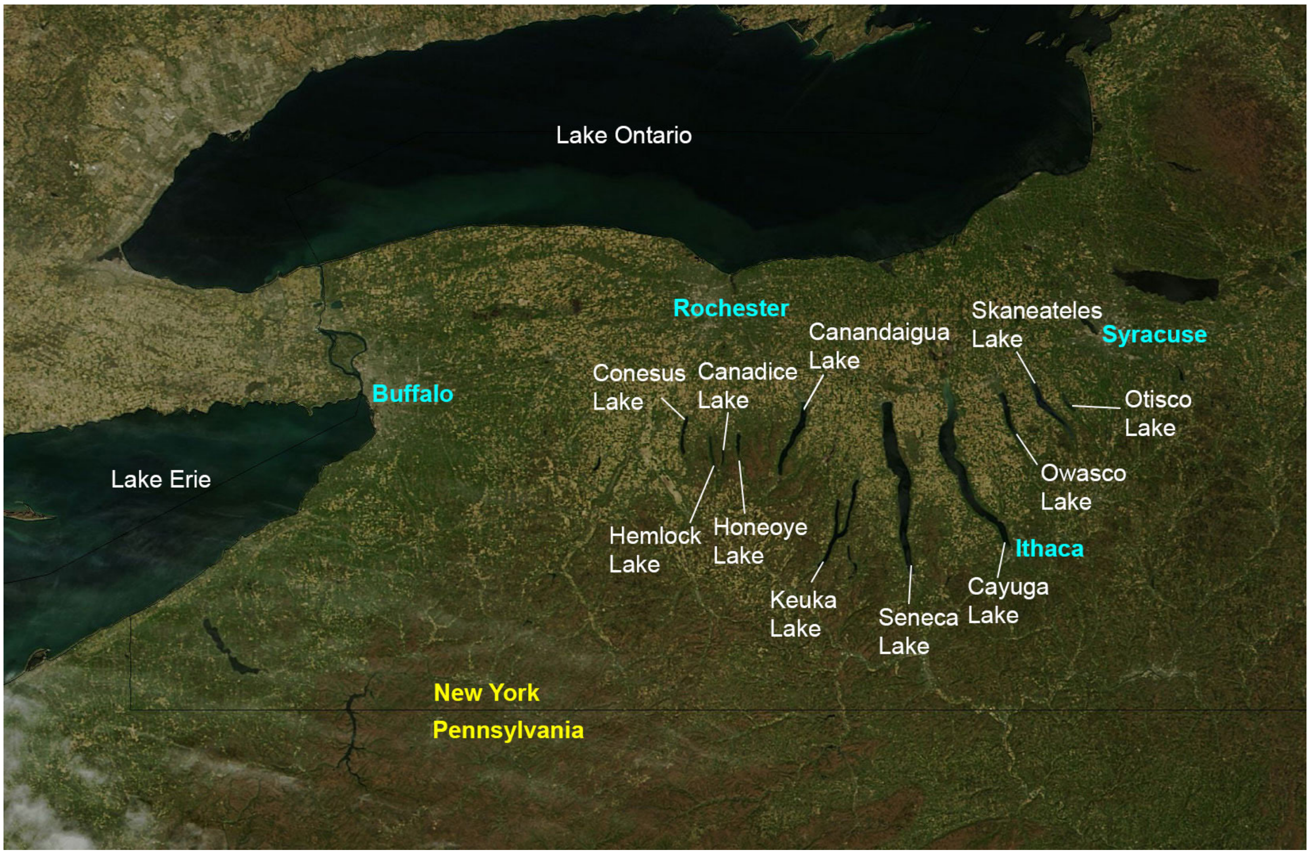
https://earthathome.org/hoe/ne/wine-geology/

Student Worksheets



NAME ______________________________

▶ WORKSHEET 1: Geography of Seneca Lake



1. **Find Seneca Lake on the map. Compare Seneca Lake to the other Finger Lakes. List two (2) observations you made while comparing.**

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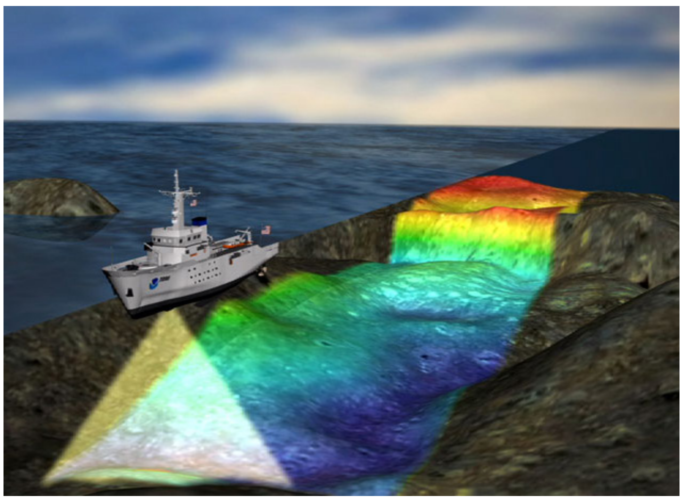
NAME ______________________________

WORKSHEET 2: Bathymetry

Bathymetry is the measurement of the depth of a body of water. Beginning in 2019, a detailed data collection of the bathymetry of the lakebed was conducted, using multibeam sonar technology. Sonar technology works by sending out sound pulses and timing how long those pulses take to come back. The following images show the equipment that is towed behind a boat to collect bathymetric data. The boat drives in lines back and forth across the lake to capture a complete picture of the elevation of the lake bottom.



An illustration from the National Oceanic and Atmospheric Administration of how a ship collects multibeam sonar data

Courtesy: NOAA, https://oceanexplorer.noaa.gov/ technology/sonar/ multibeam.html

Survey crewman Matt Harrison preparing to deploy the sub-bottom profiler from the stern of the deck the R/V Folger

Courtesy: Lake Champlain Maritime Museum

1. Give two (2) reasons why a detailed map of the elevation of the bottom of a lake is important information.

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NAME ______________________________

WORKSHEET 3:

The History of Seneca Lake Bathymetric Data

The waterways of the Finger Lakes have been an important transportation route from the time of human settlement, when the region's rivers and lakes provided the best option for travel, to construction of the New York State Canal System in the 1800s.

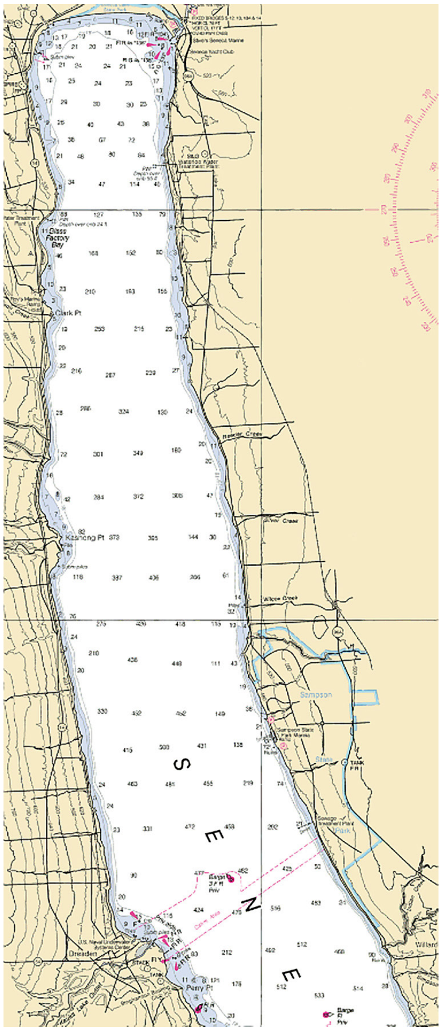
Data about the depth of Seneca Lake was first collected in the mid-1800s, using a method called "lead-lining". This process involved dropping a string with a weight into the water. Once the weight reached the bottom of the lake the distance of the string was measured. The process was repeated many times to cover as much of the lake as possible.

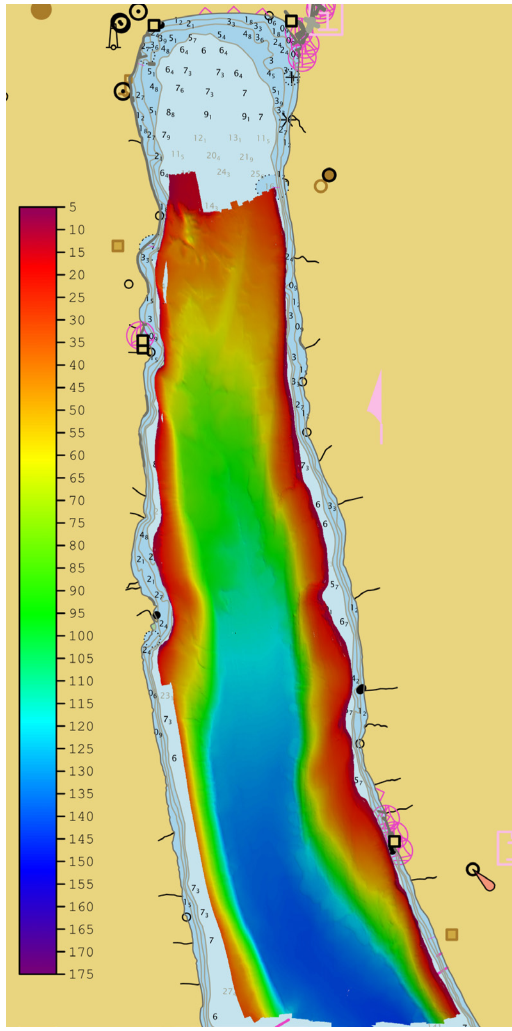
This photograph below shows an example of lead-lining. Prior to 2019, the bathymetric maps of Seneca Lake had not been updated since the lead line data was collected in the 1800s. The maps on the following page show a comparison between the lead-lining data on the left, and the recent sonar data on the right.

Example of a lead-line observation in a lake.

Courtesy: NOAA

WORKSHEET 3: THE HISTORY OF SENECA LAKE BATHYMETRIC DATA





Comparison between the mid-1800s NOAA chart on the left and the two-week multi-beam survey from Middlebury College's R/V Folger.

Courtesy: The Seneca Lake Survey Project

1. What are the limitations of data collection by lead-lining?

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2. Why is it important to collect new data on the bathymetry of the lake?

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NAME ______________________________

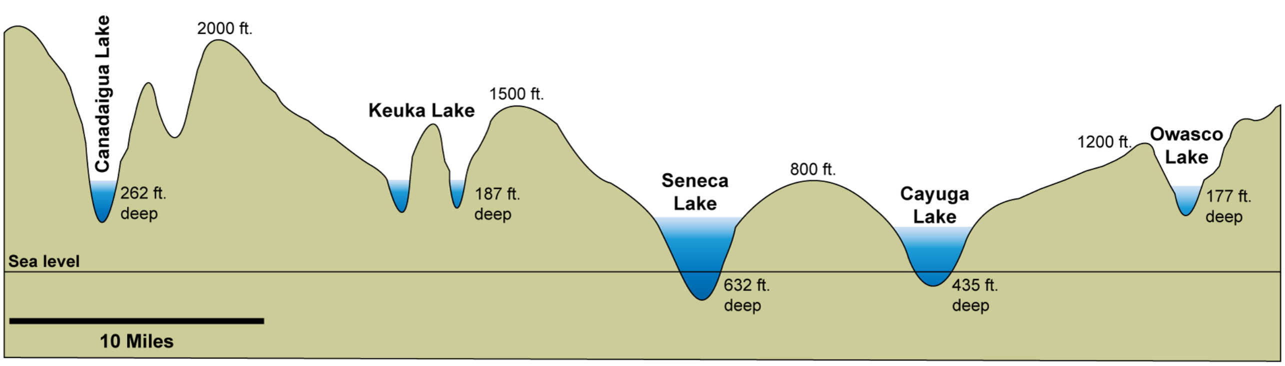
WORKSHEET 4: Glaciers Formed the Finger Lakes

Read this except from the Paleontological Research Institution: Earth at Home website

"The Finger Lakes originated as a series of northward-flowing rivers that existed in what is now central New York State (today central New York south of Ithaca drains to the south, toward the Cheasapeake Bay, while the rest drains north and east to the St. Lawrence Seaway). Around two million years ago the first continental glaciers moved southward from the Hudson Bay area, initiating the Pleistocene glaciation, commonly known as the Ice Age. The Ice Age was really a series of many advances of glaciers (one approximately every 100,000 years). The advances are called glacials, and the retreats are called interglacials. Today we live during an interglacial.

The Finger Lakes were probably carved by several of these episodes. Ice sheets more than 2 miles (3 kilometers) thick flowed southward, parallel but opposite to the flow of the rivers, gouging deep trenches into these river valleys. Traces of most of the earlier glacial events have been eroded away, but much evidence remains of the last one or two glacials that covered New York.

The latest glacial episode was most extensive around 21,000 years ago, when glaciers covered almost the entire state. Around 19,000 years ago, the climate began to warm, and the glaciers began to retreat, disappearing entirely from New York most recently around 11,000 years ago."



1. **List 2 reasons why the Finger Lakes might vary so much in the depth and length.**

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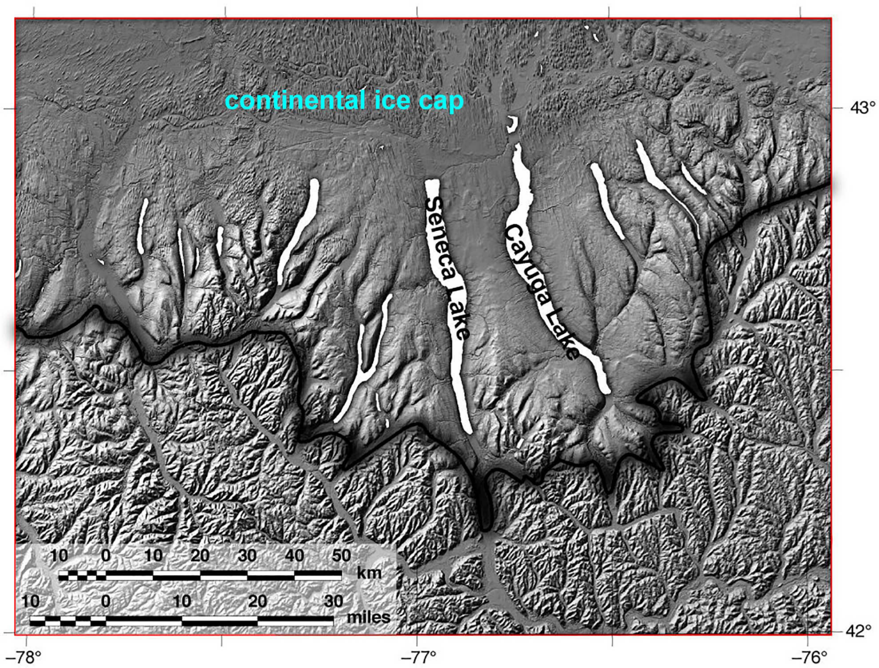
WORKSHEET 4: GLACIERS FORMED THE FINGER LAKES



Courtesy:
Paleontological Research Institution,
https://earthathome.org/hoe/ne/geology-finger-lakes/

2. What natural features were the Finger Lakes before the glacial advances?

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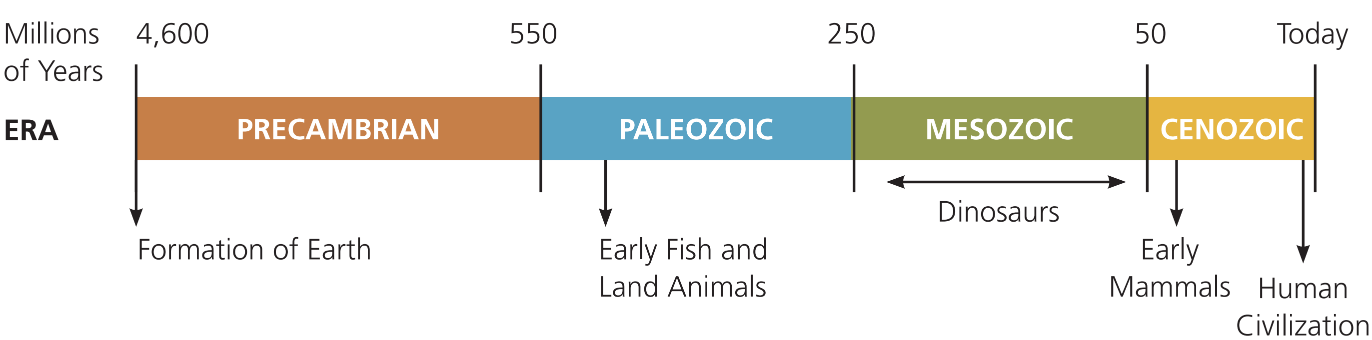
3. The Finger Lakes flow and drain the same way the rivers before them did. Which direction do the lakes flow?

____

4. The Earth formed 4.6 billion (4,600,000,000) years ago. The glacial advances and retreats that formed the Finger Lakes were approximately 20,000 years ago. This means that the Finger Lakes have been in existence for 0.0004% of Earth's entire history.

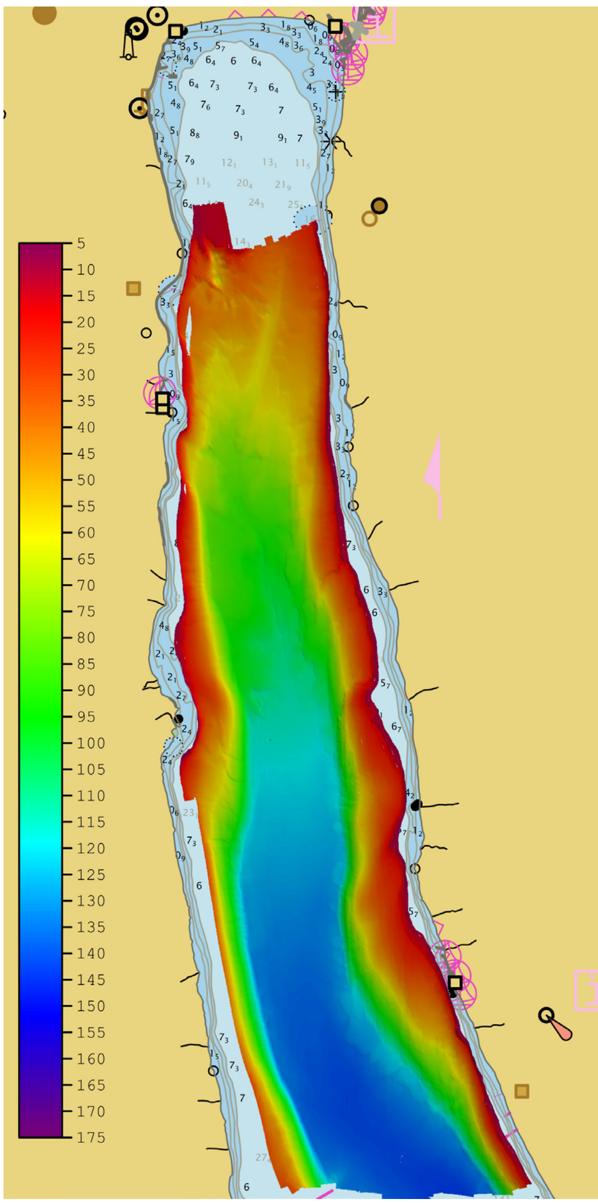
Place an "X" on the Timeline of Earth to indicate the approximate time when the formation of the Finger Lakes occurred.



NAME ______________________________

WORKSHEET 5: Bathymetric Maps of Seneca Lake

Shown below is the most detailed bathymetric map of the floor of Seneca Lake. The colors indicate the depth of the lake in meters.



1. Which colors represents the shallowest and deepest parts of the lake shown on the map?

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2. The pale blue color represents areas where no sonar data was collected. Why was sonar equipment not able to be used in these areas?

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3. Think about what a bathymetric map of other Finger Lakes would look like. How would it compare to Seneca Lake? List similarities and differences below.

Similarities:

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Differences:

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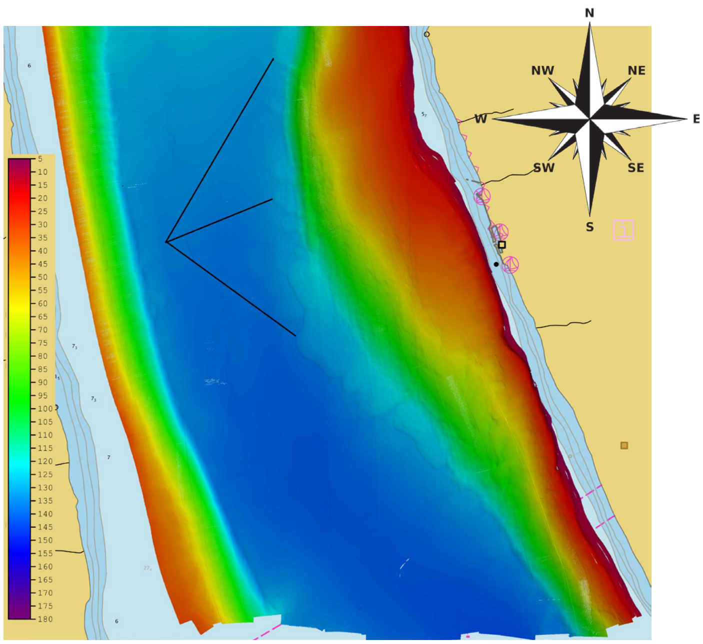
WORKSHEET 5: BATHYMETRIC MAPS OF SENECA LAKE

Write a one sentence response that answers the question but does not attempt to explain the answer (claim). Then, provide evidence to support your claim.



Courtesy: The Seneca Lake Survey Project

The image below shows a section of Seneca Lake. Which side of the lakebed is steeper?

Claim: ____________________________________

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Evidence:___________________________________

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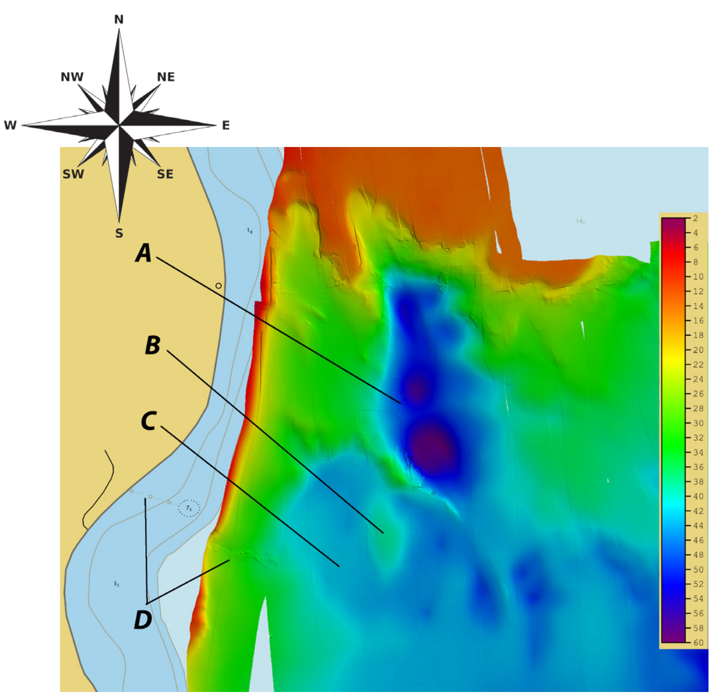

Courtesy: The Seneca Lake Survey Project

This image below shows a northern section of Seneca Lake. What type of natural landform is located at A?

Claim: ____________________________________

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Evidence:___________________________________

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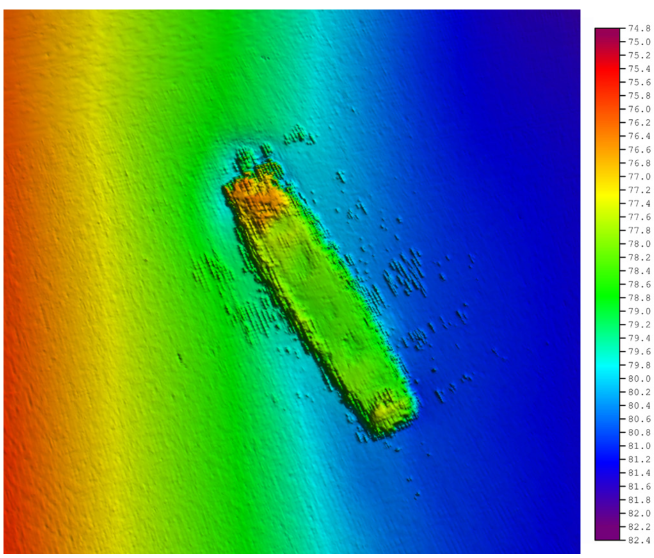
NAME ____

WORKSHEET 6:

What's on the Bottom of Seneca Lake?

The bathymetric survey of Seneca Lake has provided many interesting images of natural and human-made features. In this task you will be shown a sonar image of a found object, given some information, and then asked to give an identification of the object, and provide a piece evidence for your identification.

FOUND OBJECT #1: This object is on the bottom of the western edge of Seneca Lake. It is approximately 30 meters (100ft) long. Identify the object in the picture, be a specific as you can. Then record the evidence that supports your identification.



Courtesy: The Seneca Lake Survey Project

Object Identification: ______________________

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Evidence for Identification:

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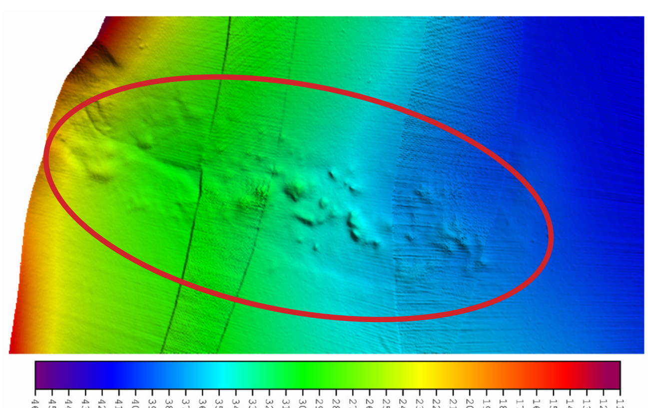
FOUND OBJECT #2: The feature at the bottom of the lake in this image is in the red oval. This feature was caused by construction/digging of an object. Ignore the thin vertical lines running through the image.



Courtesy: The Seneca Lake Survey Project

Object Identification: ______________________

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Evidence for Identification:

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